Industrial Emissions Directive – Burnley Sludge Treatment Centre (STC)

Secondary Containment Modelling Assessment

31/10/2023

Prepared for:

United Utilities Water

Prepared by:

Stantec

INDUSTRIAL EMISSIONS DIRECTIVE – BURNLEY SLUDGE TREATMENT CENTRE (STC)

Secondary Containment Modelling Assessment

Revision	Description	Author		Quality Check		Independent Review	
1	First Issue	Chaitanya Lakeshri	16/05/2022	Phil Warburton	16/05/2022	P. Duncan	
2	Second Issue	S Jamadar	03/10/2022	Phil Warburton	03/10/2022	P. Duncan	03/10/2022
3	Third Issue - Minor text amendment.	Phil Warburton	30/10/2023	Phil Warburton	30/10/2023		

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1.0 INTRODUCTION

Stantec have been commissioned by United Utilities (UU) to complete the spill analysis as part of the environmental permit application for Burnley Sludge Treatment Centre (STC). Part of the environmental permit application requires an assessment of the potential environmental risks associated with a loss of containment of process vessels.

This report details the 2D hydraulic modelling that has been carried out to assess the failure of process vessels, subsequent overland flows paths of the vessel contents and the containment measures necessary to prevent flows from reaching a receptor.

Figure 1 below shows an aerial view of Burnley STC.

Figure 1 Burnley STC Aerial View

2.0 ADBA RISK ASSESSMENT TOOL FINDINGS

The Anaerobic Digestion & Bioresources Association (ADBA) Risk Assessment Tool and the CIRIA C736: *Containment systems for the prevention of pollution* have been applied to provide requirements for the prevention of pollution: including secondary and tertiary containment, and other measures for industrial and commercial premises. The ADBA Risk Assessment is presented in Appendix 1 and the findings are summarised in this chapter.

2.1 CLASS OF REQUIRED SECONDARY CONTAINMENT FOR BURNLEY STC

To identify the class of containment deemed to provide sufficient environmental protection in the ADBA Risk Assessment, the tool uses a source, pathway, receptor model. This identifies hazards posed to the environment and assigns a class of containment based on the site hazard rating and likelihood of loss of primary containment. The approach is summarized in Figure 2 below.

Figure 2 ADBA Risk Assessment Classification Flowchart

The ADBA Risk Assessment Tool scored the source element as ‘High risk’, pathway elements as ‘High risk’ and the receptor element as ‘Medium risk’ for the Burnley STC owing to the significant volumes of sewage sludge stored on site and site drainage pathways to the sensitive receptor, river Calder. In summary, this assessment approach indicates that Burnley STC has an overall site hazard rating of ‘High’. The likelihood of failure was ‘Low Risk’ due to the type of infrastructure involved and the mitigations at the site to include regular tank inspections and level sensors.

According to Table 4 within the ADBA tool (box 2.2 CIRIA C736), reproduced in Figure 3 below, the combination of a high site hazard rating and a low likelihood rating, gives the overall site risk as medium. The indicated class of secondary containment for **Burnley STC was therefore deemed as Class 2.**

Table 4: Overall site risk rating as defined by combining ratings of site hazard and probability of containment failure *(Box 2.2 CIRIA 736)*

Possible combination	Overall Risk Rating	Indicated class of secondary containment
HH, HM, OR MH	HIGH	Class 3
MM, HL, OR LH	MEDIUM	Class 2
LL, ML, OR LM	LOW	Class 1

Figure 3 ADBA Classification Matrix

The ‘Burnley STC ADBA Secondary Containment Risk Assessment’ outlines the information and data utilised in greater detail, as well as the assumptions applied to undertake a secondary containment risk assessment. The requirement for ‘Class 2’ type secondary containment within Burnley STC will be used to inform the next stage of the secondary containment assessment (See Section 8). The assessment above considers the whole Burnley STC. The secondary containment requirement for each group of tanks will also be reviewed individually.

3.0 ASSETS TO BE ASSESSED

For this assessment above ground storage assets have been assessed, as referenced in Table 1 and Figure 4.

Table 1 : Assets

Group	Asset Description	No. of units	Total Capacity (m3)	Comments
1	2 No. Digesters (1 No. operational)	1	2,025	Above ground concrete tanks
2	Screened Sludge Tank	1	2,500	Above ground concrete tank
3	2 No. Digested Sludge Tanks	2	763	Above ground glass fused to steel
4	Thickened Sludge Silo	1	353	Above ground glass reinforced steel
5	Thickening Centrate Storage Tank	1	200	Above ground glass reinforced steel tank
6	Dewatering Centrate Buffer Tank	1	217	Above ground glass fused to steel tank

The tanks have been grouped into six areas as shown in Table 1 and Figure 5. Each group of tanks will be assessed separately using the 2D model to determine any source – pathway – receptor linkages.

Figure 4 Burnley STC Asset Plan

4.0 ASSETS EXCLUDED FROM ASSESSMENT

This section considers the assets that have been excluded from the spill modelling exercise with the necessary justifications.

Non-storage assets and storage assets not assessed

Asset Description	No. of units	Total Capacity (m^3)	Comments/Justifications
Strain Presses	2	N/A	Non-storage asset; effective secondary containment present; any leaks drain to impervious hardstanding with containment kerbs leading to a sealed drainage system.
Thickening Centrifuges	2	N/A	Non-storage asset; The centrifuges are covered and located above ground inside an enclosed building on impermeable surfacing. In the event of asset failure, feed shut off valves will be activated, closing off the flow to the asset. The door to the building will be kept closed except for ingress/egress and a 'sleeping policeman' will be provided across the door entrance.
Combined Polymer Mixing and Storage Tank (Thickening)	1	Between $1m^3$ and $10m^3$	Located above ground inside an enclosed building on impermeable surfacing and bunded to 110% containment.
Antifoam IBC	1	1000 litres	Located on a bunded pallet.
Potable Water Tank (Dewatering)	1	Between $100m^3$ and $1000m^3$	Located above ground inside an enclosed building on impermeable surfacing and bunded to 110% containment.
DAF Treated Centrate Collection Tank	1	$2.5m^3$	Above ground glass fused to steel tank

Secondary Containment Modelling Assessment - assets excluded from assessment

Poly Storage Tank (Dewatering)	1	Between $1m^3$ and $10m^3$	Located above ground inside an enclosed building on impermeable surfacing and bunded to 110% containment.
Dewatering Centrifuges	2	N/A	Non-storage asset located above ground inside an enclosed building on impermeable surfacing
Waste Oil Tank	1	4,600 litres	Purpose designed double skinned storage tank.
Clean Oil Tank	1	~4,600 litres	Purpose designed double skinned storage tank.
Pumps/pipework	multiple	N/A	Non storage asset with flow shut-down systems in place.

5.0 HYDRAULIC MODEL BUILD

A 2D model of the Burnley STC site has been built in InfoWorks ICM to assess the impact of failure or loss of containment on site. Use of a 2D hydraulic model allows the failure of a containment vessel to be represented, including the subsequent overland flow and ponding of released flow.

The model extends to the River Calder bounding the STC on the southern and western sides, and Wood End Road on the northern side.

Figure 5 below shows the extent of the 2D hydraulic model both in terms of the receptors and the grouped source assets. The full list of receptors considered for this analysis are:

- Watercourses and bodies
    - River Calder
    - Superficial deposits - Secondary A Aquifer
    - Bedrock – Secondary 'A' Aquifer
    - Abstraction
    - Lomeshay Marsh LNR and Lowerhouse Lodges LNR WwTW
    - Wastewater Treatment Works
- Habitation
    - Storage barn
    - Highway; Wood End Road A5117
    - Farms (and associated dwellings)

Further details of the receptors considered in this analysis are contained in Appendix A - ADBA Assessment Tool.

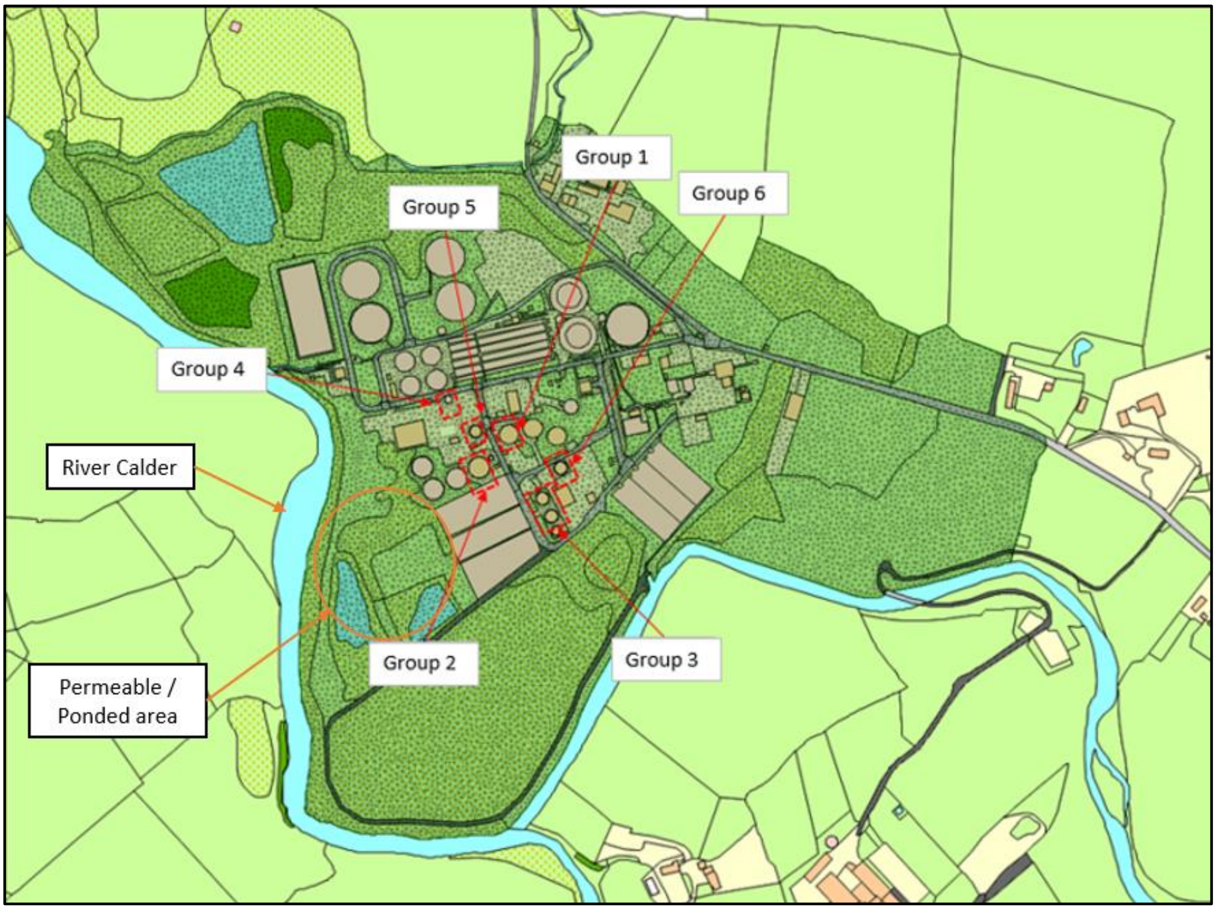


Figure 5 Burnley STC Extent of InfoWorks ICM 2D Model

The 2D hydraulic model uses 1metre Light Detection and Ranging (LiDAR) Digital Terrain Model (DTM) data downloaded from the DEFRA Survey Data Download site. The LiDAR data provides elevation data at 1m spacings and has vertical accuracy of +/-15cm. The OS Master map and site photographs were also used in the model build process.

6.0 HYDRAULIC MODEL ASSESSMENT

6.1 METHODOLOGY AND ASSUMPTIONS

The following methodology has been adopted to assess the impact of asset failures and the subsequent discharge of contents across the site.

- Assets have been modelled under catastrophic failure scenario. For the assets identified in Section 2, 110% of the largest tank capacity, or 25% of the aggregate capacity (whichever is greater) have been modelled. The tank contents will be modelled with an inflow file and assumed to empty instantaneously in line with CIRIA C736.
- An allowance for rainfall will be made as per CIRIA C736 guidance, section 4.3.3, based on an event with an annual exceedance probability (AEP) of 10% (1 in 10-year return period). This includes allowance for the total volume of accumulated rainfall for the 24 hours preceding the incident and an eight-day period following an incident.
- No allowance for fire-fighting water will be made, on the assumption that most of the assets being modelled contain sludge which has a low combustible nature. Digesters could require fire-fighting water in the eventuality of an explosion on the headspace that communicates with the gas system, but in such a scenario the main pollution is likely to be to air.
- No allowance for river levels have been accounted for in the modelling as the proposed mitigation measures will be to retain contaminants on site.

Site drainage has been reviewed and confirmed to drain back to the inlet works through a sealed drainage system and is therefore ruled out as a pathway to a receptor. It is assumed that the benefit provided by the drainage system in a catastrophic failure scenario will be minimal and has not been modelled.

Existing site drainage pipes and manholes are regularly inspected and maintained. This will ensure that all minor or catastrophic sludge spills draining to the existing site drainage network has a low risk of entering the soil store through cracks or defects. Site inspection tours of the impermeable surface, storage tanks and above ground drainage system are carried out daily by site-based staff and monthly by the site's Environmental Regulatory Adviser (ERA). These tours include visual inspection of the site drains to ensure they are working as expected. Regular CCTV inspections will also be carried out (every 5 years) on the drainage systems, with the first inspection being completed by 31 March 2023. If any issues or concerns are identified, they will be logged on the corporate action tracker for prompt remediation.

6.2 MODELLING LIMITATIONS

ICM is designed to model the overland flow of water; as such it is not able to account for the typically higher viscosities associated with sludge, this limitation results in a larger modelled inundation extent than would be expected. Therefore, the modelled outputs are a worst-case inundation scenario resulting from sludge spills at Burnley STC.

6.3 ASSESSMENT RESULTS

The containment requirements have been calculated in accordance with CIRA 736 and documented in table 2 below.

Table 2: Containment Requirements

Group	Asset Description	No. of units	Total Capacity (m3)	110% of largest tank	25% of aggregate
1	2 No. Digesters (1 No. operational)	1	2,025 each	2,228	N/A
2	Screened Sludge Tank	1	2,500	2,750	N/A
3	2 No. Digested Sludge Tanks	2	763 each	839	N/A
4	Thickened Sludge Silo	1	353	388	N/A
5	Thickening Centrate Storage Tank	1	200	220	N/A
6	Dewatering Centrate Buffer Tank	1	217	239	N/A

5.3.1 Group 1 – Digester

The Digester tank is the largest tank with a capacity of 2,025m^3. An inflow file of 2,228m^3 (110% of the 2,025 m^3 tank volume) was created and applied to the model simulation. Figure 7 below shows the modelled point of discharge for the inflow file representing the release of flow from the digester tank.

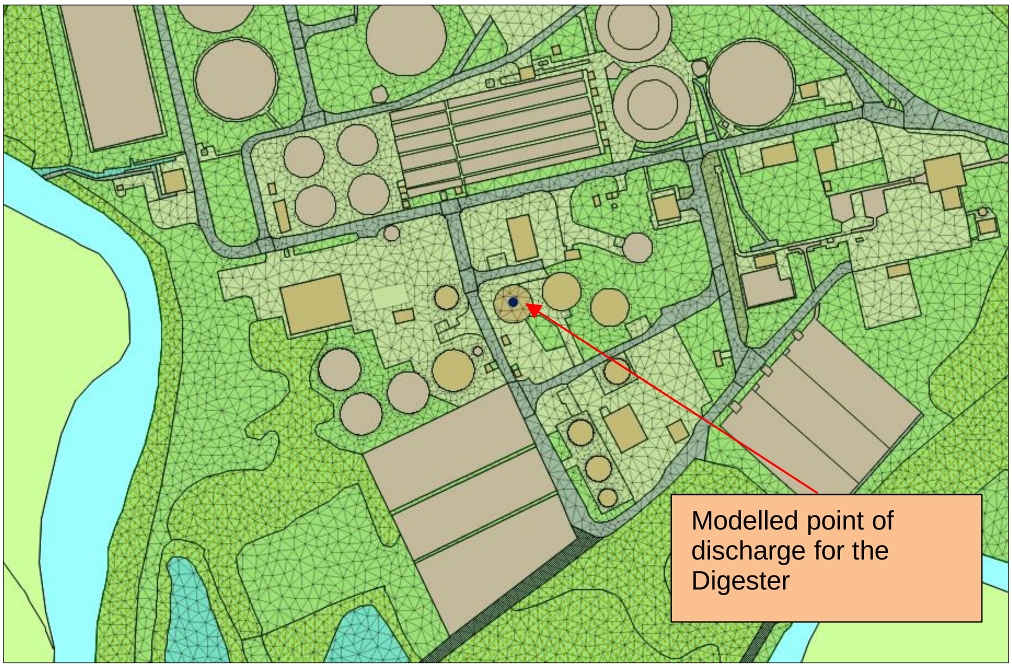


Figure 6 Burnley STC Modelled Point of Discharge for Digester Tank Burst

The results of this simulation are shown in Figure 7 with the blue color showing the presence of released flow on the surface and the red arrows showing the direction of overland flow from the tank.

The simulation indicates that flow from the digester tank reaches the River Calder and permeable / ponded area receptors.

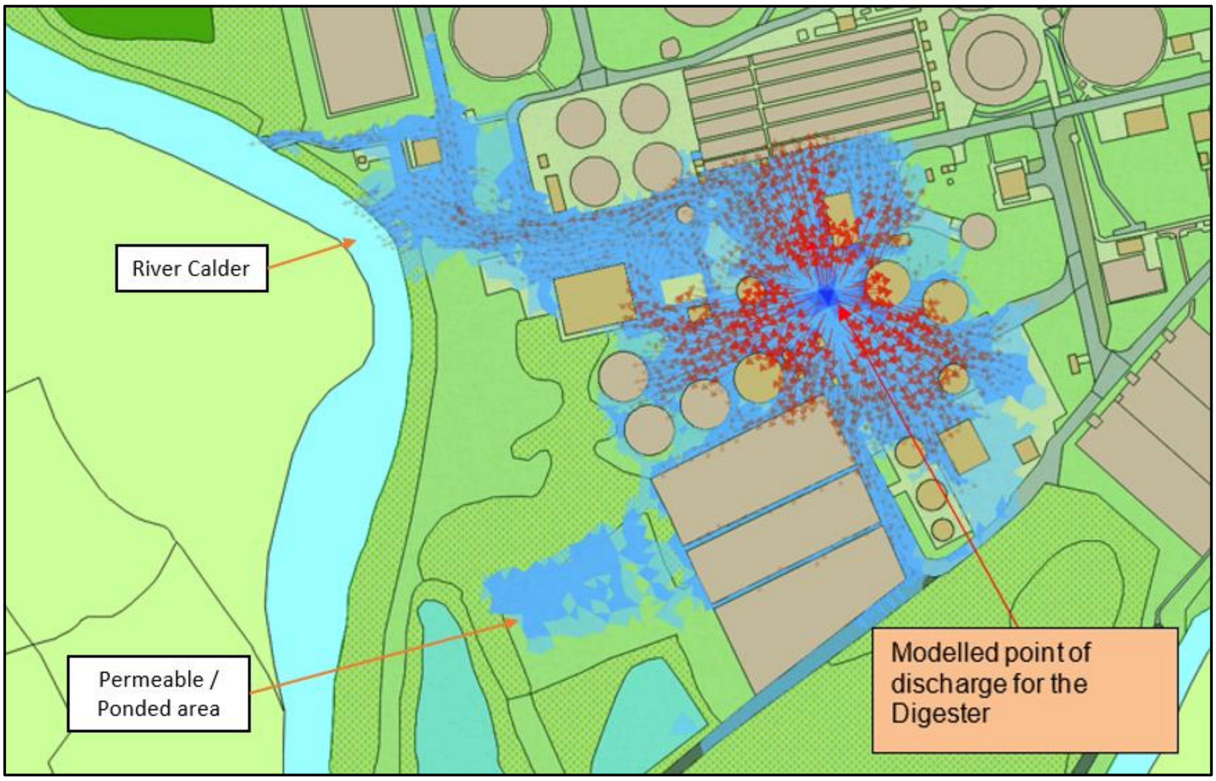


Figure 7 Burnley STC Predicted Flow Paths following Digester Tank Burst

5.3.2 Group 2 – Screened Sludge Tank

The Screened Sludge Tank has the second highest capacity of 2,500m^3 and within close proximity of the River Calder to the south. An inflow file of 2,750m^3 was created (110% of 2,500m^3 tank volume) and applied to the model in a simulation. Figure 8 shows the modelled point of discharge for the inflow file representing the release of flow from the Screened Sludge Tank.

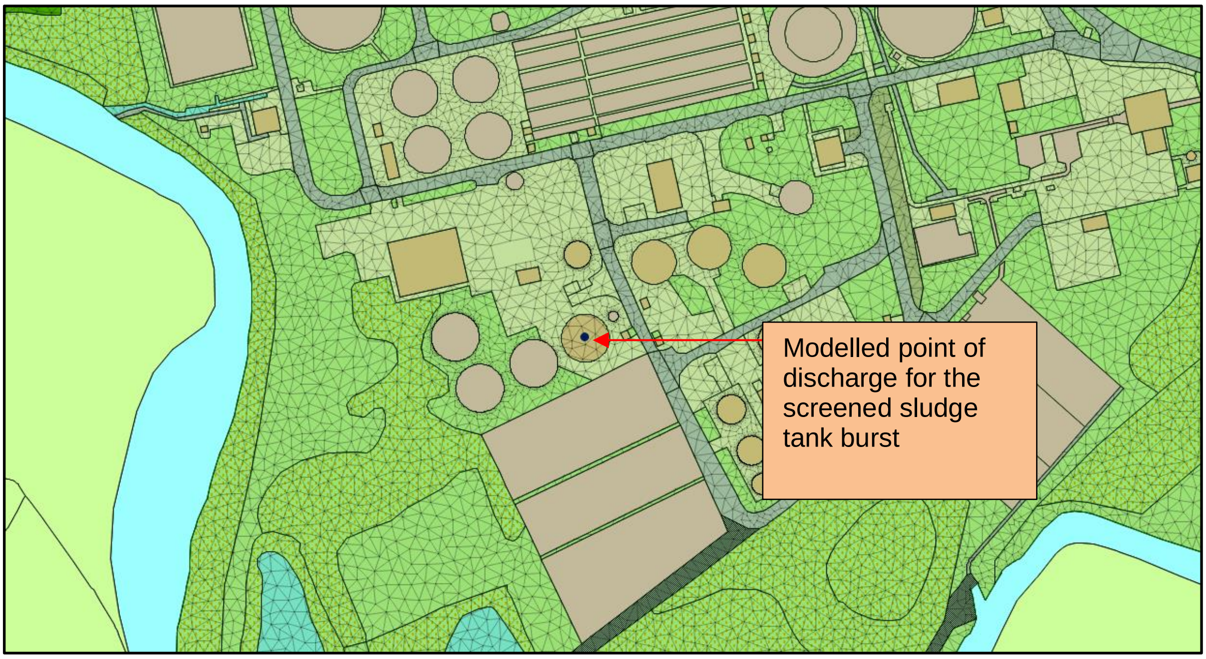


Figure 8 Burnley STC Modelled Point of Discharge for Screened Sludge Tank

The results of this simulation are shown in Figure 9 indicating that the flow from the screened sludge tank reaches the River Calder and permeable / ponded area receptors.

Figure 9 Burnley STC Predicted Flow Paths following Screened Sludge Tank Burst

5.3.3 Group 3 – Digested Sludge Tank

The digested sludge tank has a capacity of 763 m^3. This was chosen as a critical asset due to its location and proximity to River Calder. An inflow of 839 m^3 (110% of 763m^3) was created and applied to the model simulation. Figure 10 shows the modelled point of discharge for the inflow into the model.

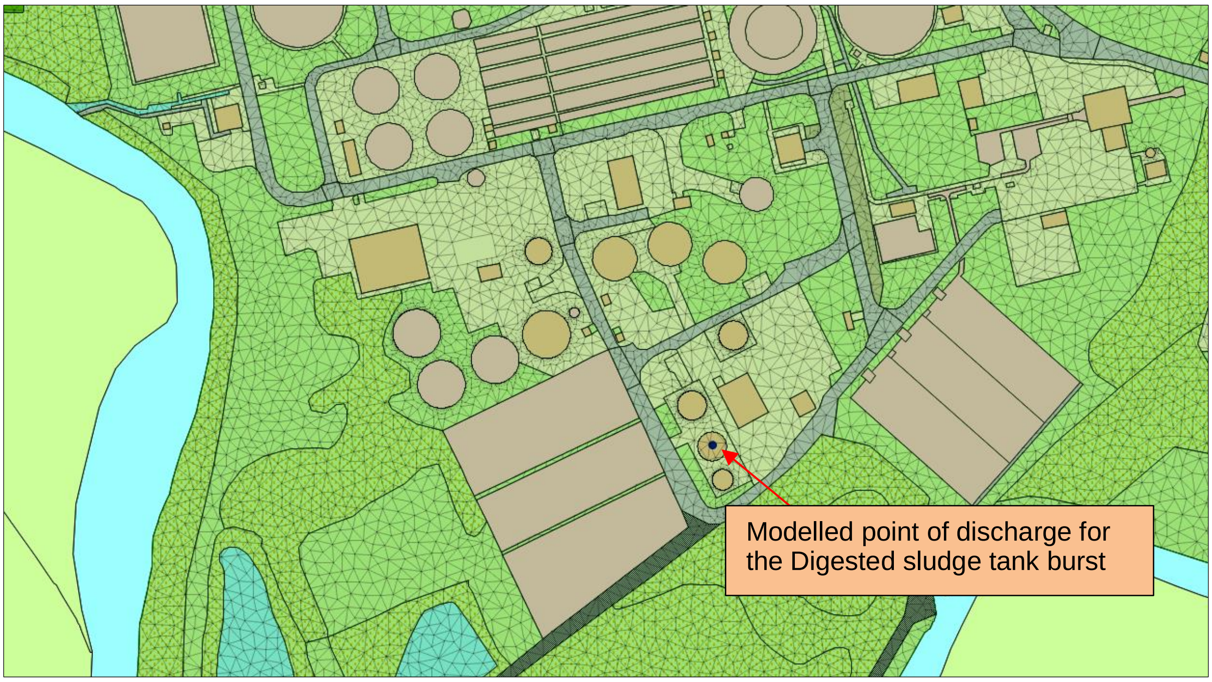


Figure 10 Burnley STC Modelled Point of Discharge for Digested Sludge Tank Burst

The results of this simulation are shown in Figure 11 indicating that flow from the digested sludge tank reaches the River Calder receptor.

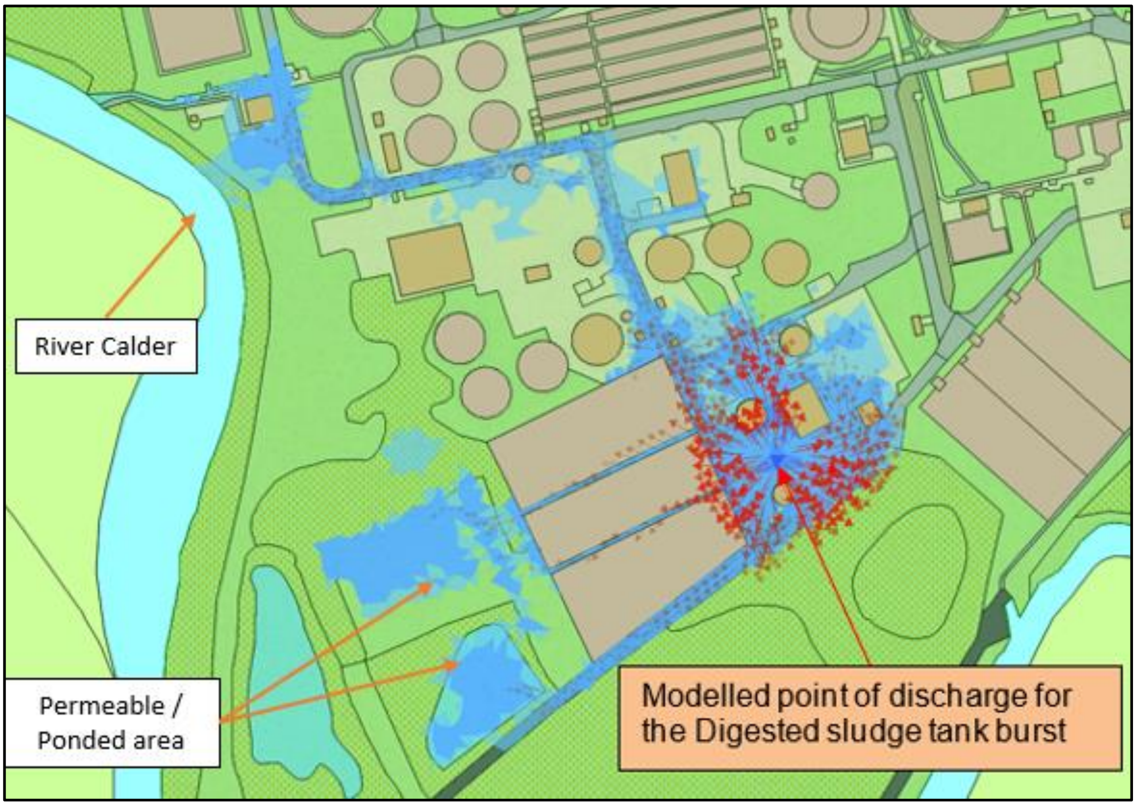


Figure 11 Burnley STC Predicted Flow Paths following Digested Sludge Tank Burst

5.3.4 Group 4 - Thickened Sludge Silo

Thickened Sludge Silo has a capacity of 353 m^3. This was chosen as critical asset due to its location and proximity to River Calder. An inflow file of 388m^3 (110% of 353m^3) was created and applied to the model simulation. Figure 12 below shows the location of this inflow into the model.

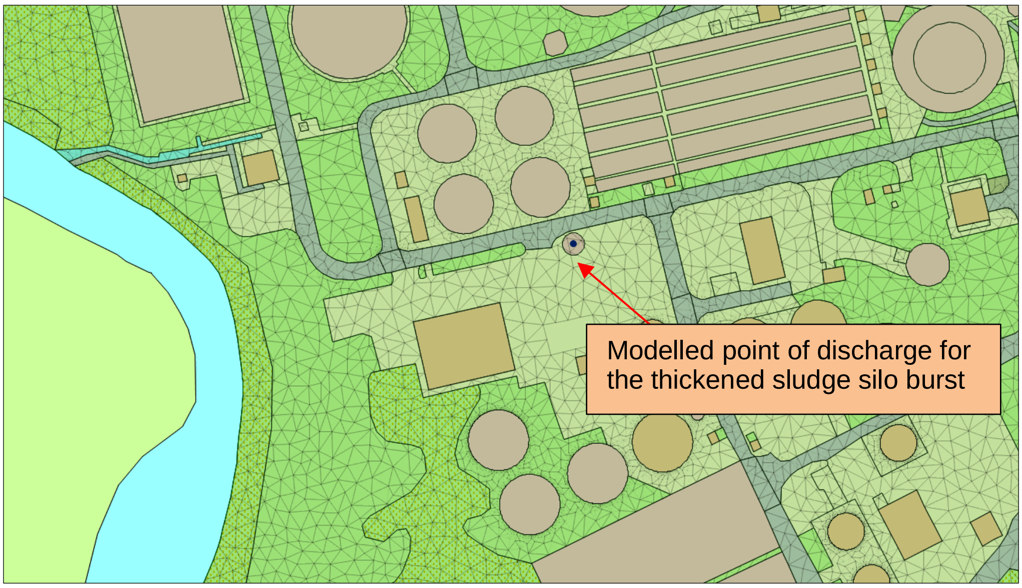


Figure 12 Burnley STC Modelled Point of Discharge for Thickened Sludge Silo

The results from the simulation are shown in Figure 13 indicating that flow from the Thickened Sludge Silo reaches the River Calder and permeable areas receptors.

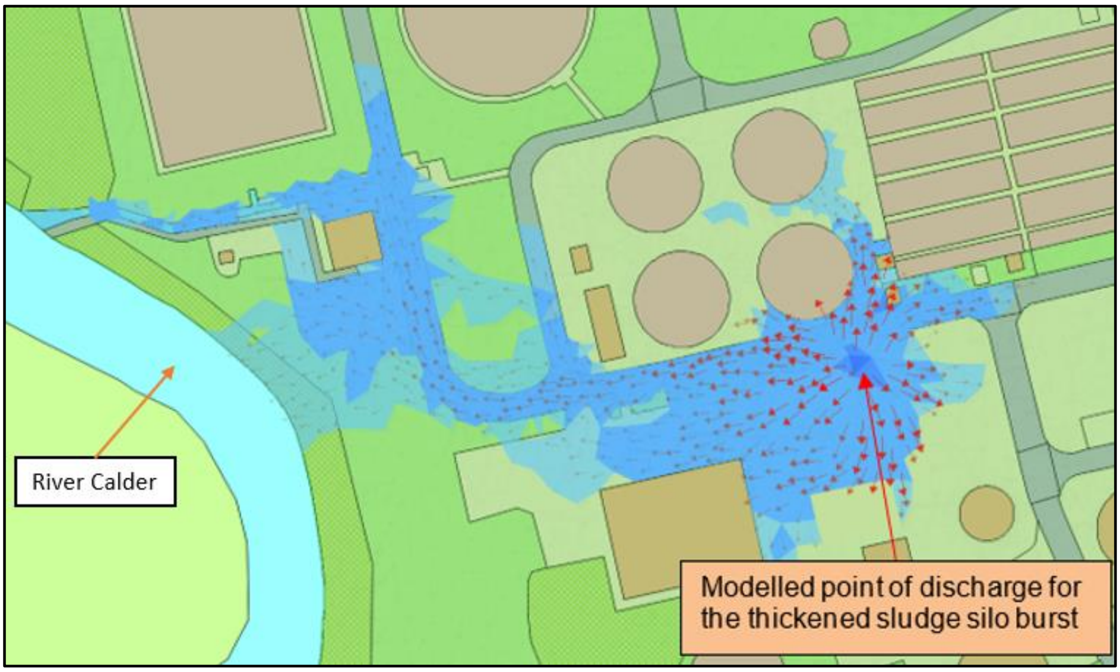


Figure 13 Burnley STC Predicted Flow Paths following Thickened Sludge Silo Burst

5.3.5 Group 5 – Dewatering Centrate Buffer Tank

Dewatering Centrate Buffer has a capacity of 217m^3. This was chosen as critical asset due to its location and proximity to River Calder. An inflow file was 239m^3 (110% of 217m^3) was created and applied to the model simulation. Figure 14 shows the location of this inflow into the model.

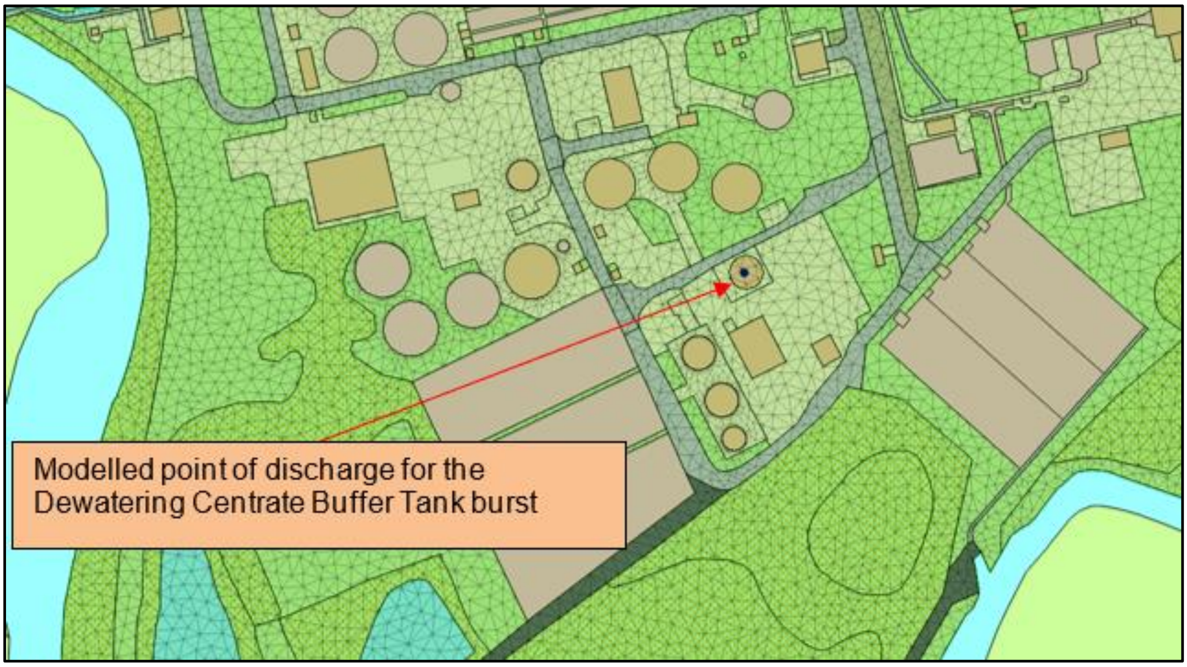


Figure 14 Burnley STC Modelled Point of Discharge for Dewatering Centrate Buffer Tank

The results of this simulation are shown in Figure 15 indicating that flow from dewatering centrate buffer tank reaches some permeable areas within the STC but does not reach the River Calder receptor.

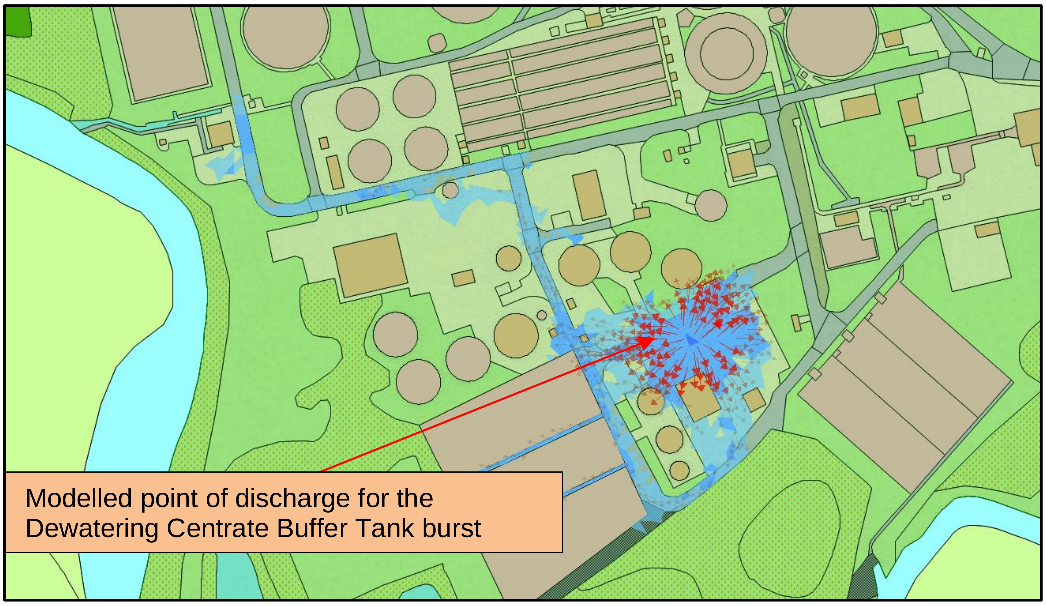


Figure 15 Burnley STC Predicted Flow Paths following Dewatering Centrate Buffer Tank Burst

5.3.5 Group 6 – Thickening Centrate Storage Tank

Thickening Centrate Storage Tank has a capacity of 200m³. This was chosen as critical asset due to its location and proximity to River Calder. An inflow file of 217m³ (110% of 200m³) was created and applied to the model simulation. Figure 16 shows the location of this inflow into the model.

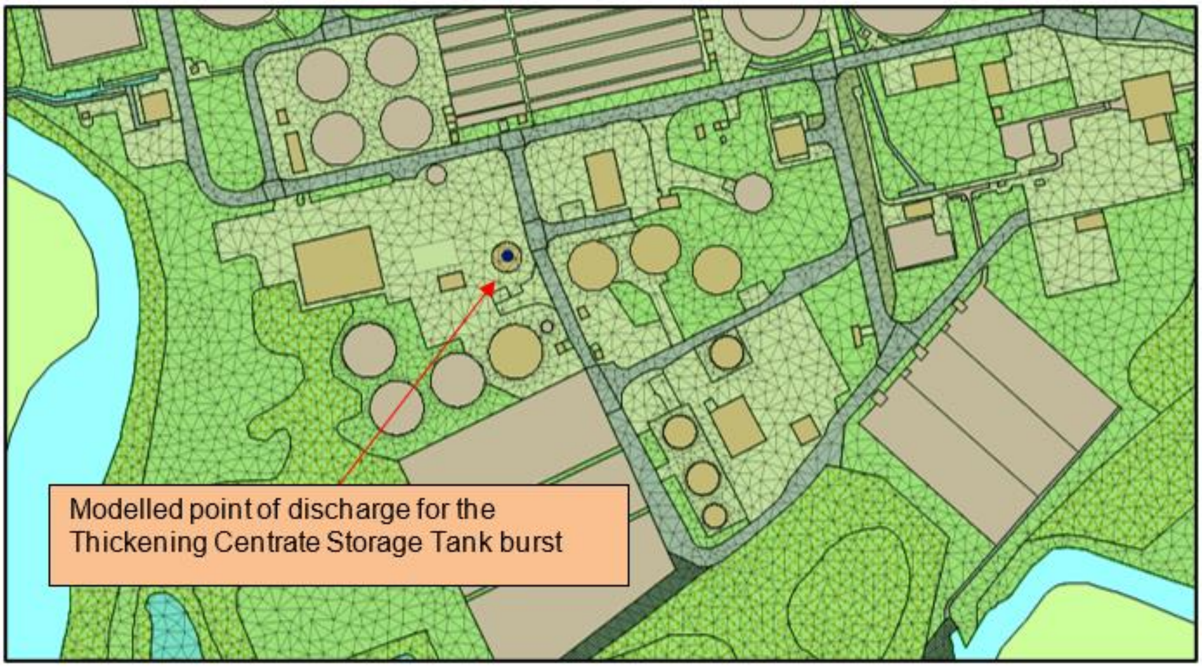


Figure 16 Burnley STC Modelled Point of Discharge for Thickening Centrate Storage Tank

The results from the simulation are shown in Figure 17 indicating that flow from the Thickening Centrate Storage tank reaches permeable area within the STC and the River Calder receptor.

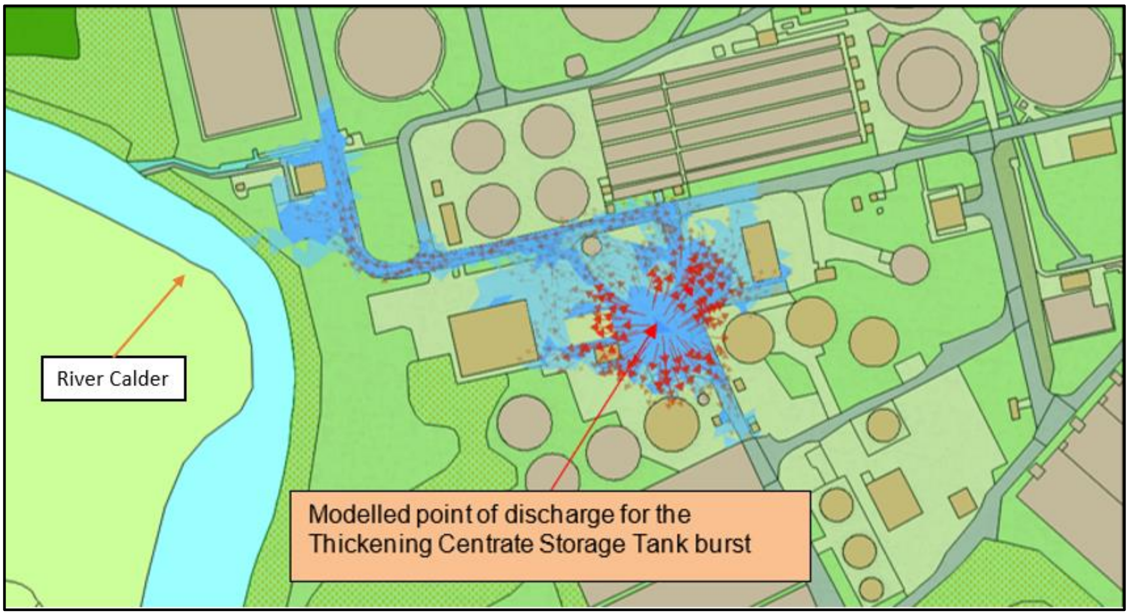


Figure 17 Burnley STC Predicted Flow Paths following Thickening Centrate Storage Tank Burst

7.0 RAINFALL ALLOWANCE

Guidance provided in CIRIA C736 recommends that an allowance should be made for rainfall within any containment solution sizing. The following guidance is given:

'The allowance for accumulated rainfall should be based on an event (storm) with an annual exceedance probability (AEP) of 10 per cent (1 in 10). This is commonly referred to as the 1 in 10-year return period event.

The containment capacity should allow for rain falling over the containment area immediately preceding an incident (i.e., before it could be removed as part of routine operations) and immediately after an incident (i.e., before a substance, which had escaped from the primary, could be removed from the bund).

The containment volume should include an allowance for the total volume of accumulated rainfall in response to a 10 per cent AEP event for:

- *a 24-hour period preceding an incident*
- *the duration of the incident (advice on the duration should be sought from the Fire and Rescue Service)*
- *an eight-day period following an incident or other time period as dictated by site specific assessment.'*

As recommended in the guidance the Flood Estimation Handbook (FEH) has been used to estimate rainfall depths for Burnley STC.

The rainfall estimates from FEH for Burnley STC are as follows:

Table 3: Rainfall Estimates for Burnley STC

Rainfall Event	Rainfall depth (mm)
1 in 10 year (24 hr. duration)	63
1 in 10 year (8-day duration)	139
Total	**202**

Extracts from the FEH calculations are provided in Appendix B.

The total rainfall depth to be accounted for within the solution is 202mm. The containment solution must therefore ensure that there is sufficient freeboard (at least 202mm) between the predicted top water level after the spilled flow has ponded and the top of any proposed retaining structure at the STC.

8.0 CONTAINMENT SOLUTION

The modelling for the critical assets assessed in Section 6 show that receptors are at potential risk of contamination and that the STC would benefit from remedial work to limit the impact of potential spills.

Modelling shows that spills pool and flow to permeable and impermeable areas of the STC, as referenced in Section 6.3. The indicated class of secondary containment for the STC is class 2 based on the ADBA risk assessment tool (See Section 2). Potential improvement options considered as part of this assessment include controls as set out in CIRIA C736. Proposed mitigation measures include pre-cast concrete retaining walls, sacrificial areas and a flood gate.

- **Containment walls**: Where containment walls have been proposed, these will be in accordance with Chapter 7 of CIRIA C736 and additionally "BS EN 1992-3:2006 Eurocode 2 Design of concrete structures. Liquid retaining and containment structures". Detailed design will determine the best design solution (i.e., in-situ reinforced concrete or pre-cast units) including material, dimensions and finishes. The walls currently proposed will be 0.5m, 1.0m or 1.5m in height above existing finished ground level on the spill side of the wall with suitable panel widths and watertight construction joints. The design life of the wall will be a minimum of 50 years. Following installation, detailed inspection shall be completed by a competent person every five years and following a spill event.

- **Sacrificial areas** – All sacrificial area will be reprofiled to include an impermeable membrane which will prevent spilled sludge entering the soil store until the cleanup operation can be completed. The proposal is to place an impermeable geosynthetic barrier beneath all existing permeable areas with the potential to be impacted within the installation boundary. In the event of a spill all material above the barrier would be treated as a sacrificial media as per the guidance in CIRIA C736.

  The outline design of the system is as follows:

  - The geosynthetic barrier shall conform to the relevant provisions of BS EN 13362:2018.
  - A 50 Year service life is proposed for the barrier.
  - The barrier shall be resistant to water, hydrocarbons and any anticipated chemicals used in the proximity of proposed location.
  - The barrier shall be laid in accordance with manufacturer's instructions by experienced and suitably qualified staff (British Geomembrane Association (BGA) accredited or equivalent).
  - Prior to placing the barrier, the existing surface layer shall be removed and the sub-base appropriately prepared. As necessary, the barrier lining shall be protected from damage with use of appropriate geotextiles and/or fill material. Above any protective layers there shall be a minimum of 150mm of cover material.
  - The barrier shall be anchored in accordance with manufacturer's instructions and overlap all existing impermeable surfaces to ensure continuity in impermeable surface.
  - The permeable cover layer shall be drained via perforated land drainage connected into the existing closed site drainage system. The land drainage shall be laid in trenches lined with the impermeable geosynthetic barrier jointed and anchored as necessary to ensure continuity in impermeable surface.

  On completion of the required mitigation works, a detailed inspection shall be completed by a competent person every five years.

- **Flood Gate** – The proposed flood gate has been provided to comply with the containment requirement and provide a fully contained bund, whilst allowing operational and maintenance vehicular access to the assets. The flood gate will be a fully automated proprietary system set as normally closed. The system will include open and close sensors and set to alarm in the open position.
  The gates will be designed in accordance with various and relevant standards, including, but not limited to, BS EN 12453:2001 – Industrial, commercial and garage doors and gates, as well as PAS 1188:2014 Flood Protection products. Typically, the coating provided to the gates are based on 25–30-year design life with the main gate material having a design life of 40-50 years. Following installation, routine inspection shall be undertaken by the operational team during regular site walkovers and following a spill event.

- **Speed humps** – The proposed speed humps have been provided with two objectives:

  1. Containment; the 150mm high speed humps are to be located to provide containment of any spill on the site access roads.

  2. Baffle; where the speed humps have been proposed in series, this is to reduce the velocity of the spill and to channel flow to achieve containment within the identified areas of the site.

  The design of the speed humps will be in accordance with "The Highways (Road humps) Regulations 1999" in relation to approach gradients and crest widths. As a minimum, the ramp will be the full width of the access road to tie-in with kerbing and to a height of 150mm (deviation from above regulation) above the existing finished surface level over a minimum length of 1m, in either concrete or tarmac (to be determined during detailed design) to create an impermeable surface. Following installation, routine inspection shall be undertaken by the operational team during regular site walkovers and following a spill event.

- **Existing Hard standing area containment** – All existing hard standing areas being used as secondary / tertiary containment will be routinely checked for cracks and defects to ensure it is compliant with CIRIA C736 secondary containment class 2. Site inspection tours of the impermeable surface are carried out daily by site-based staff and monthly by the site's Environmental Regulatory Adviser (ERA).

- **Leak and Spillage Detection** - A programme of leak and spillage detection monitoring, which for Burnley includes the use of flow meters or periodical surveys and interlock connection of various high-level alarms to feed pumps as outlined below:

  - Pipework: where no flow meters are installed, pipework with buried mechanical fittings will be surveyed every 2 years and every 5 years where not present, using techniques such as thermal cameras, magnetic flux leakage and in pipe crack detection technology.
  - Sludge storage tanks: the high-level alarms installed on the sludge storage tanks (which do not currently inhibit feeds) will be interlocked to the feed pumps to allow automatic shut offs to prevent tank overflow when a high-level alarm is triggered.

Further design details are specified in Appendix C. Other consideration in addition to the mitigation measures that will be introduced are:

- United Utilities engineering standards and ongoing maintenance plans ensure that asset health issues associated with tanks are rare, and if they were to occur, are dealt with promptly.

- Catastrophic failure of a tank, or multiple tanks, is a high consequence but extremely rare event.

- Burnley STC is either manned, or when not, monitored by the Integrated Control Centre (ICC) on a 24/7 basis using SCADA and critical process alarms. A significant spill would be identified quickly, and the spill management procedure initiated, ensuring a rapid clean up. SCADA controls would also, via a number of surrogate metrics, such as level monitoring, transfer, pump and valve status, provide rapid process control indications of certain loss of containment scenarios.

- United Utilities has a fleet of sludge tankers across their region which form part of the operational response to sludge spills to be utilised rapidly in the event of a spill at Burnley STC.

- Existing site drainage pipes and manholes are regularly inspected and maintained. This will ensure that all minor or catastrophic sludge spills draining to the existing site drainage network has a low risk of entering the soil store through cracks or defects. Site inspection tours of the impermeable surface, storage tanks and above ground drainage system are carried out daily by site-based staff and monthly by the site's Environmental Regulatory Adviser (ERA). These tours include visual inspection of the site drains to ensure they are working as expected. Regular CCTV inspections will also be carried out (every 5 years) on the drainage systems, with the first inspection being completed by 31 March 2023. If any issues or concerns are identified, they will be logged on the corporate action tracker for prompt remediation.

8.1 CONTAINMENT FOR GROUP 1, 2, 3, 4, 5 & 6 ASSETS

Failure of the six groups of assets have similar impacts on receptors. Simulations show that spilled sludges will flow to permeable areas of the STC, to the permeable / ponded area to the west and to the River Calder receptor through treatment outlet located at north-west of the STC boundary.

Proposed mitigation for Burnley STC is detailed in Appendix C. The proposed mitigation measures include the construction of a 1.5m and 1m high reinforced concrete retaining walls, a flood gate, sacrificial areas with permeable membranes and existing hard standing areas of the site which will be compliant with class 2 storage requirements. See Figure 18 and Table 5 below.

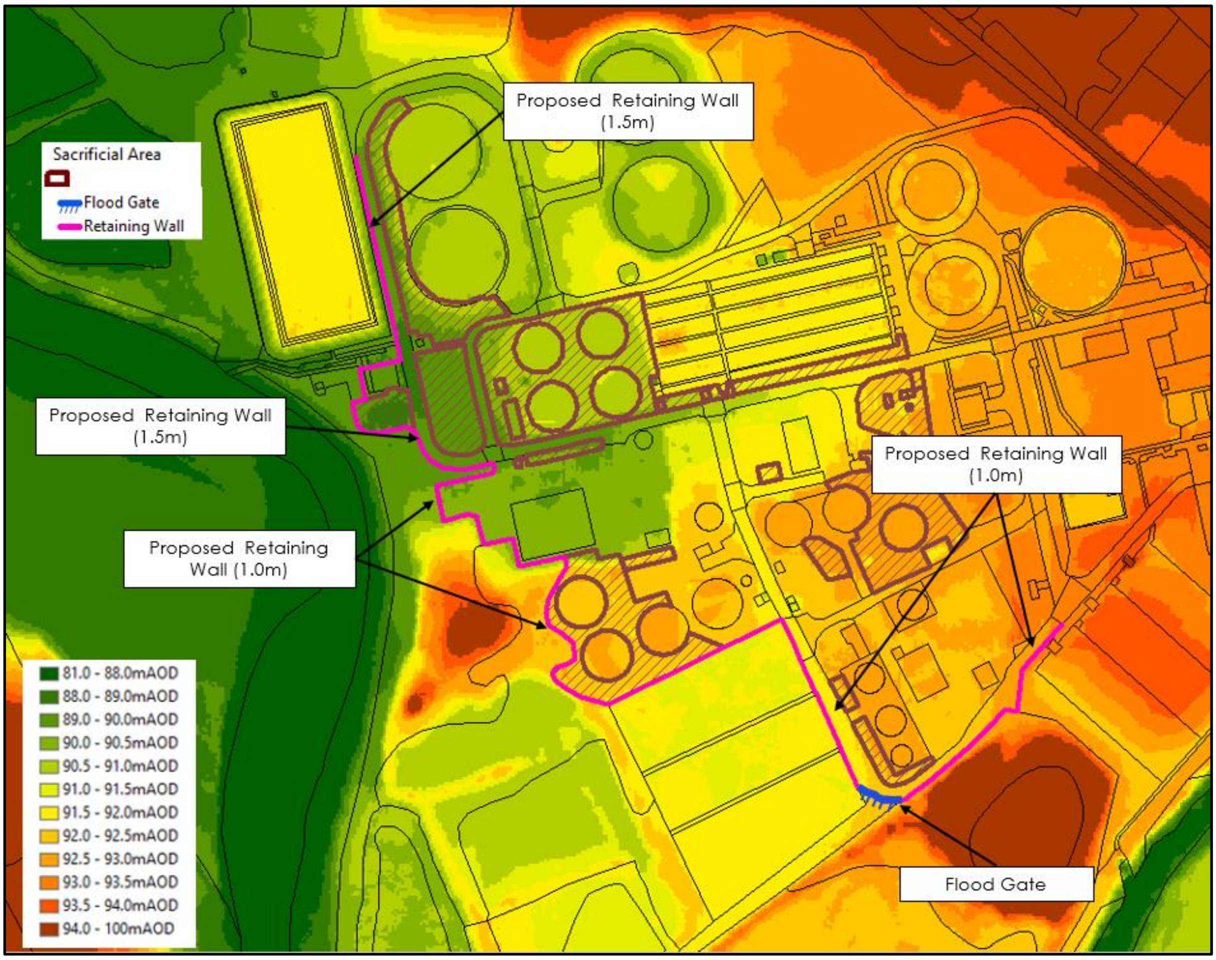


Figure 18 Ground Levels and Propose Mitigation Measures

Table 4: Containment measures quantities

Mitigation	Length (m)	Area (m^2)
Retaining Wall (1.5m)	234	N/A
Retaining Wall (1.0m)	426	N/A
Flood Gate	17	N/A
Sacrificial area	N/A	8,000

Existing Hardstanding	N/A	15,000

Solution modelling has been completed on all tanks to show the simulated flood extents and the depths of the settled sludge. The ICM modelling software is not suitable to assess the surge as it is only possible to model water which has a significantly lower viscosity than sludge. The model assumes that all spill volume is contained by the retaining walls and shows that existing hard standing areas and proposed sacrificial areas have sufficient capacity to contain the full volume of sludge in the event of a catastrophic failure. All spilled sludge flow that enters the existing site drainage will be returned to the inlet works through a sealed pipe network. The simulated flood extent results for the 6 groups of tanks are shown in Figures 19-24.

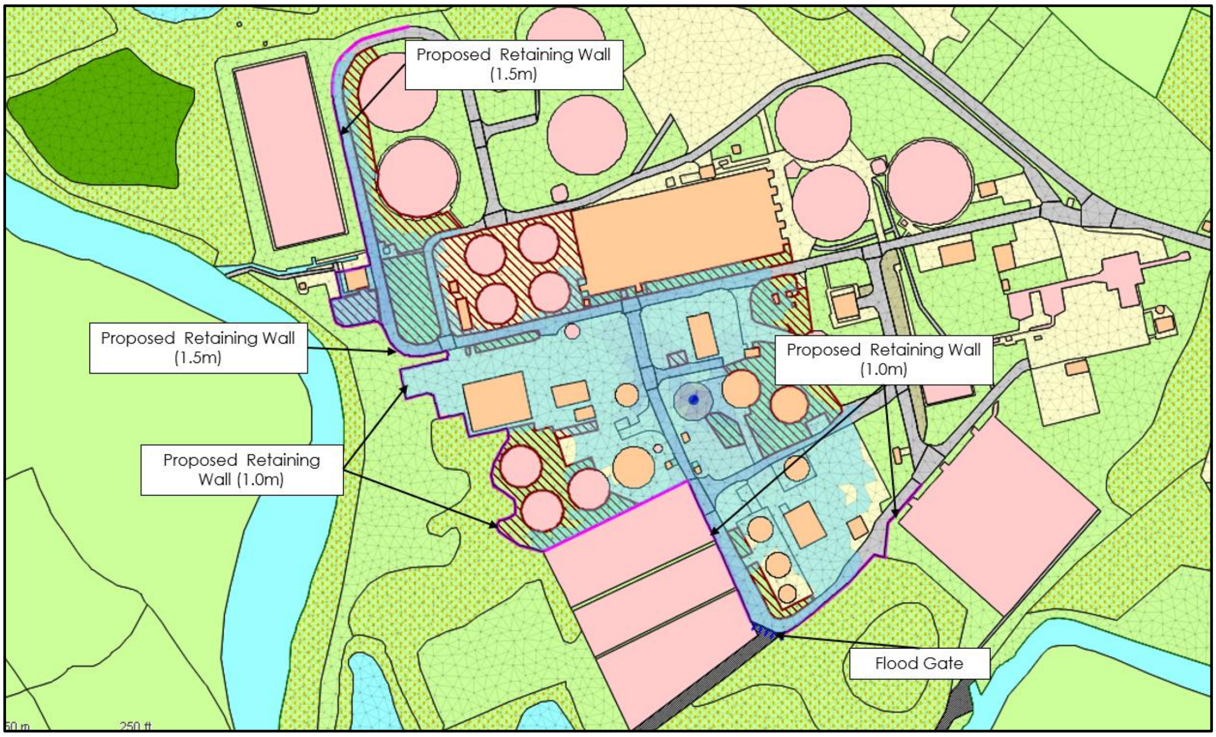


Figure 19: Proposed Mitigation and flood extent for Digester Tank

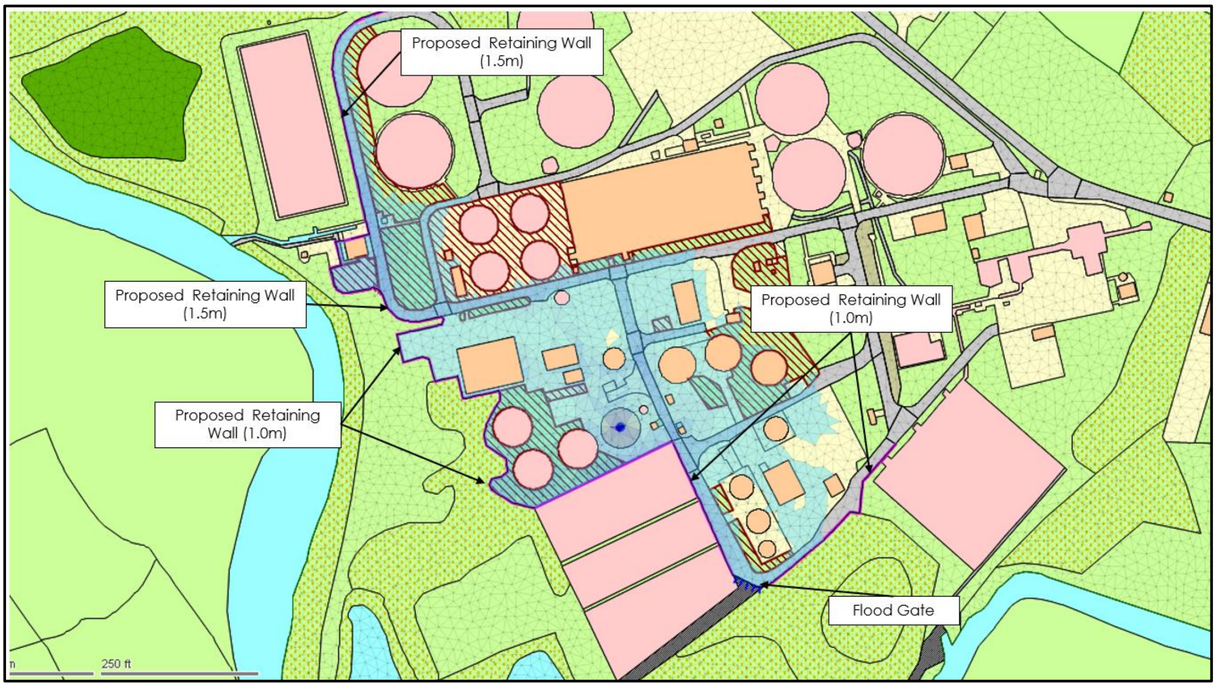


Figure 20: Proposed Mitigation and flood extent for Screened Sludge Tank

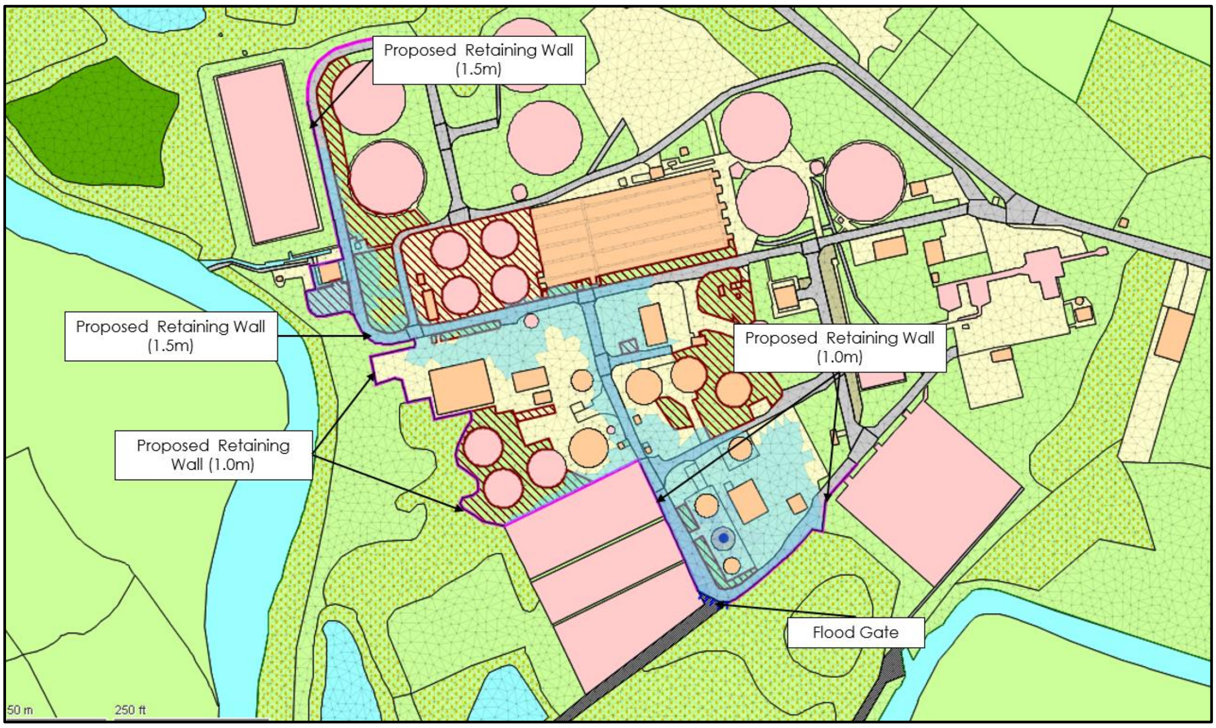


Figure 21: Proposed Mitigation and flood extent for Digested Sludge Tank

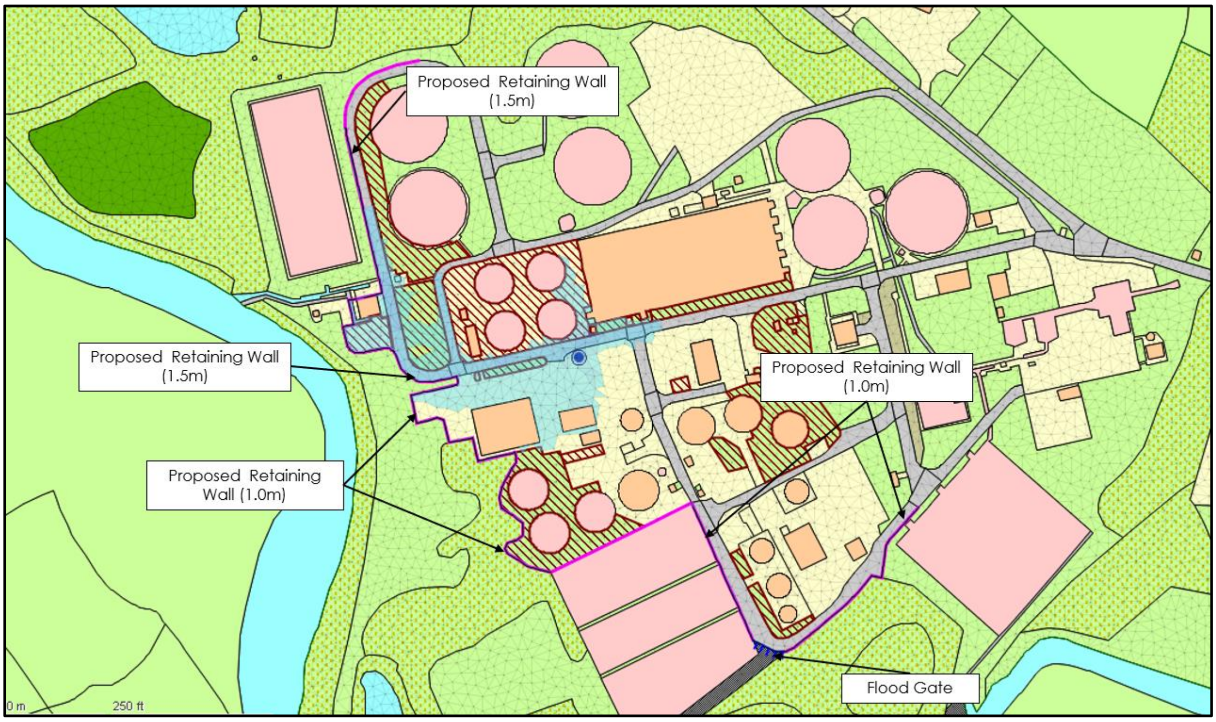


Figure 22: Proposed Mitigation and flood extent for Thickened Sludge Silo

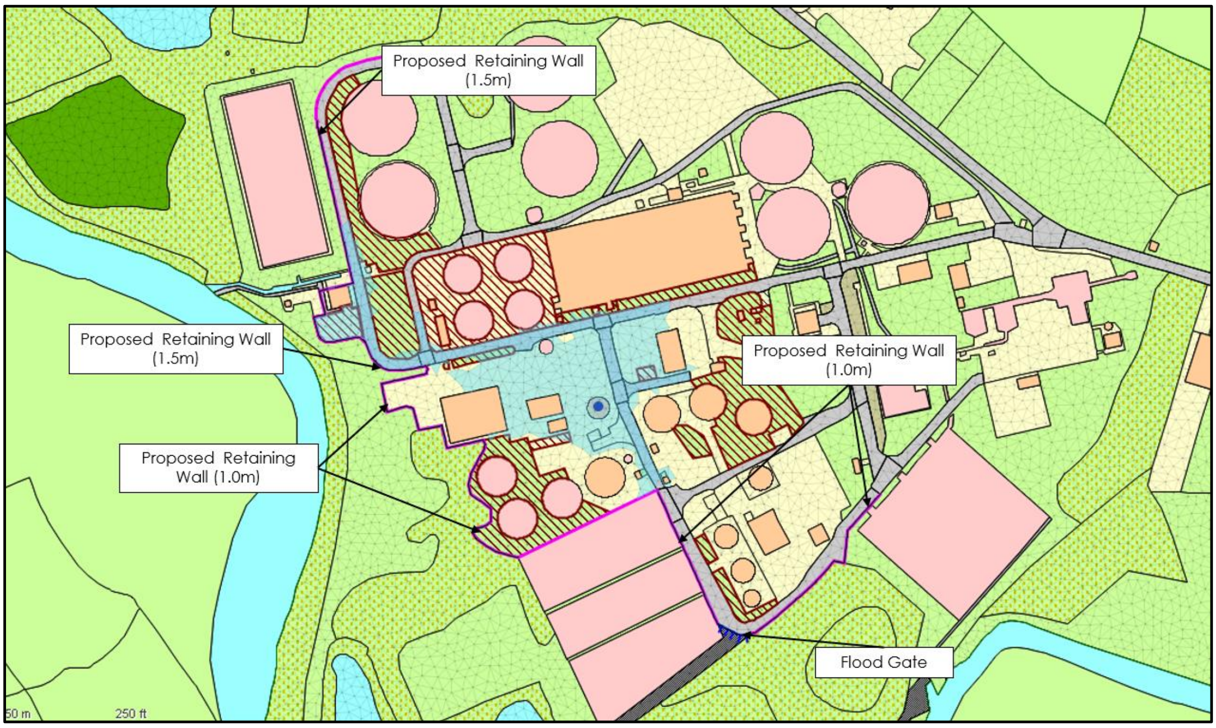


Figure 23: Proposed Mitigation and flood extent for Thickening Centrate Storage Tank

Figure 24: Proposed Mitigation and flood extent for Dewatering Centrate Buffer Tank

The settled sludge depths for the 6 groups of tanks with mitigation modelled are shown in Figures 25-30.

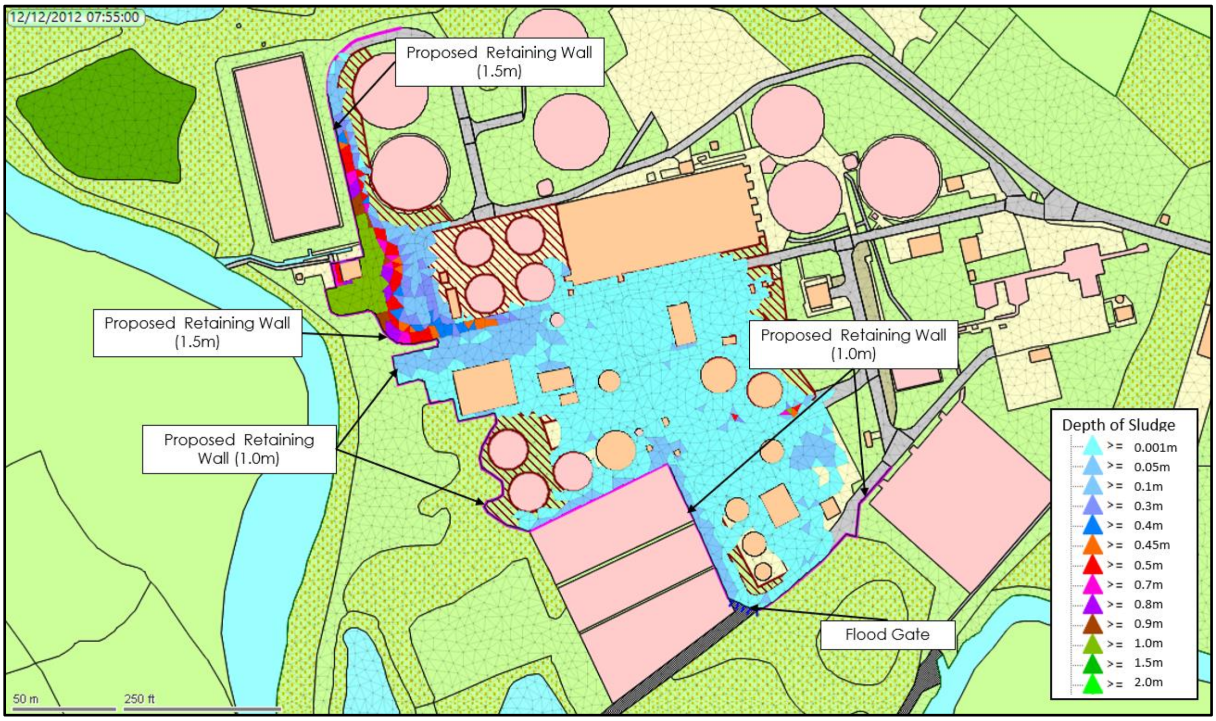


Figure 25: Proposed mitigation and settled sludge depth for Digester Tank

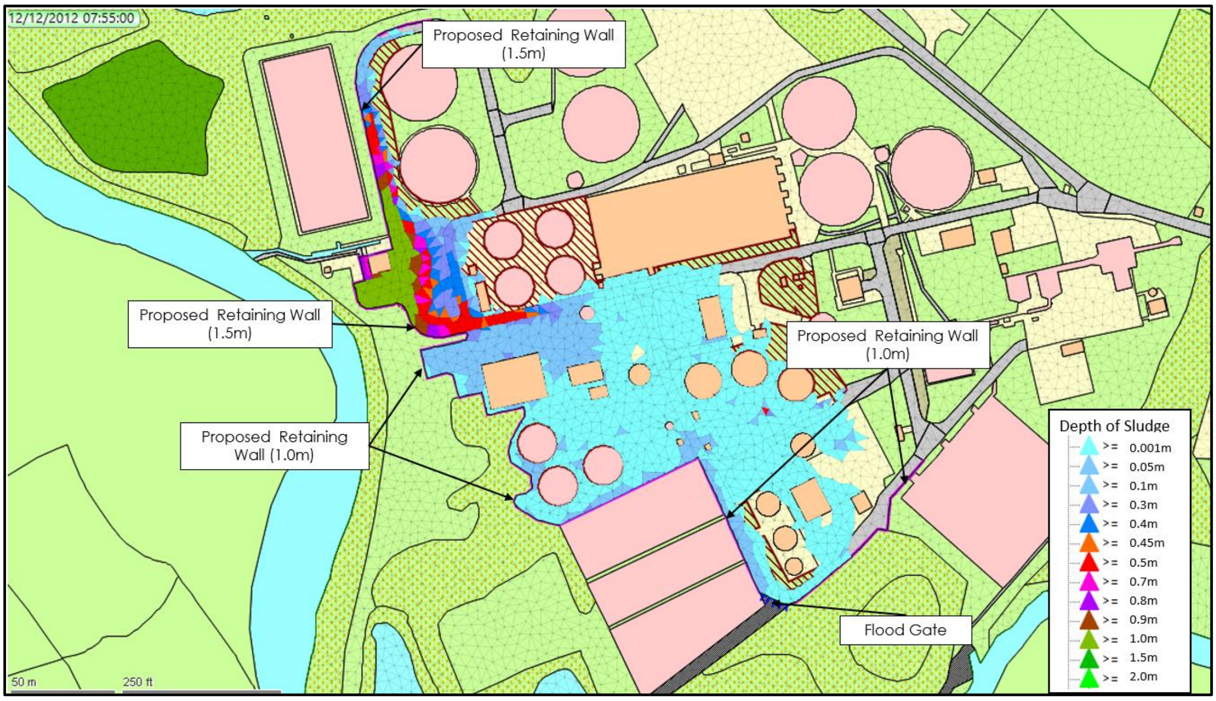


Figure 26: Proposed mitigation and settled sludge depth for Screened Sludge Tank

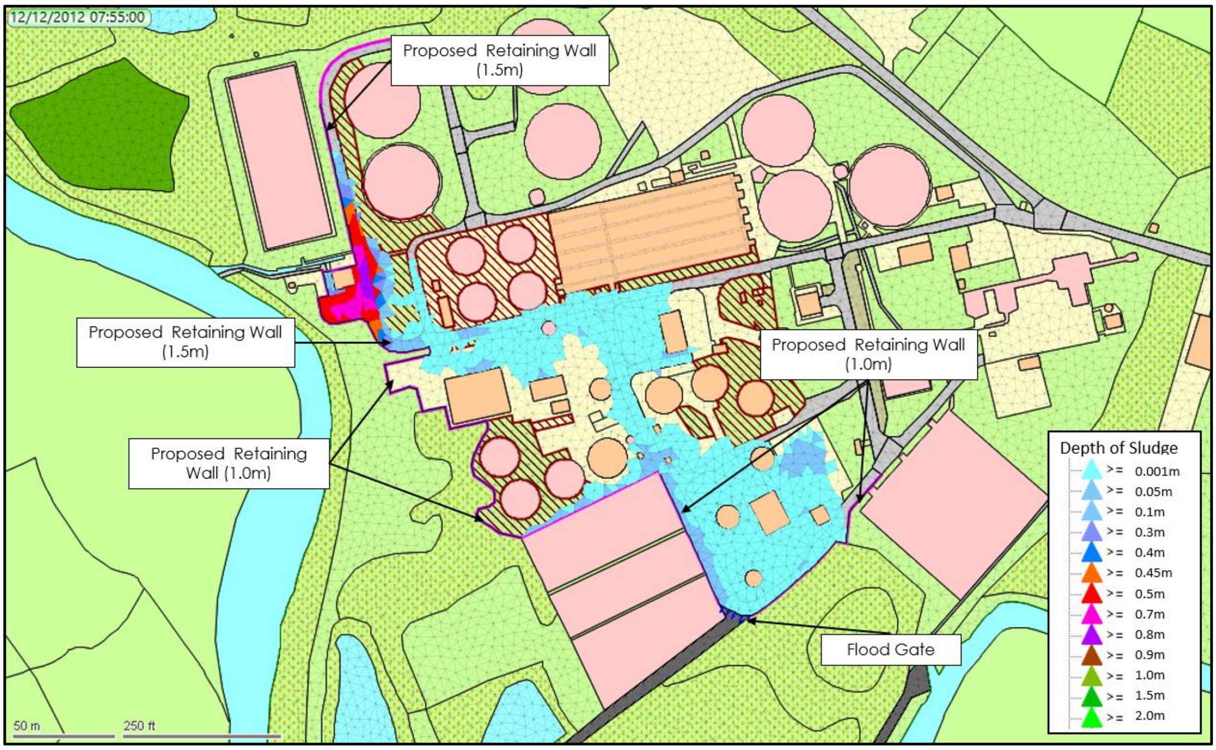


Figure 27: Proposed mitigation and settled sludge depth for Digested Sludge Tank

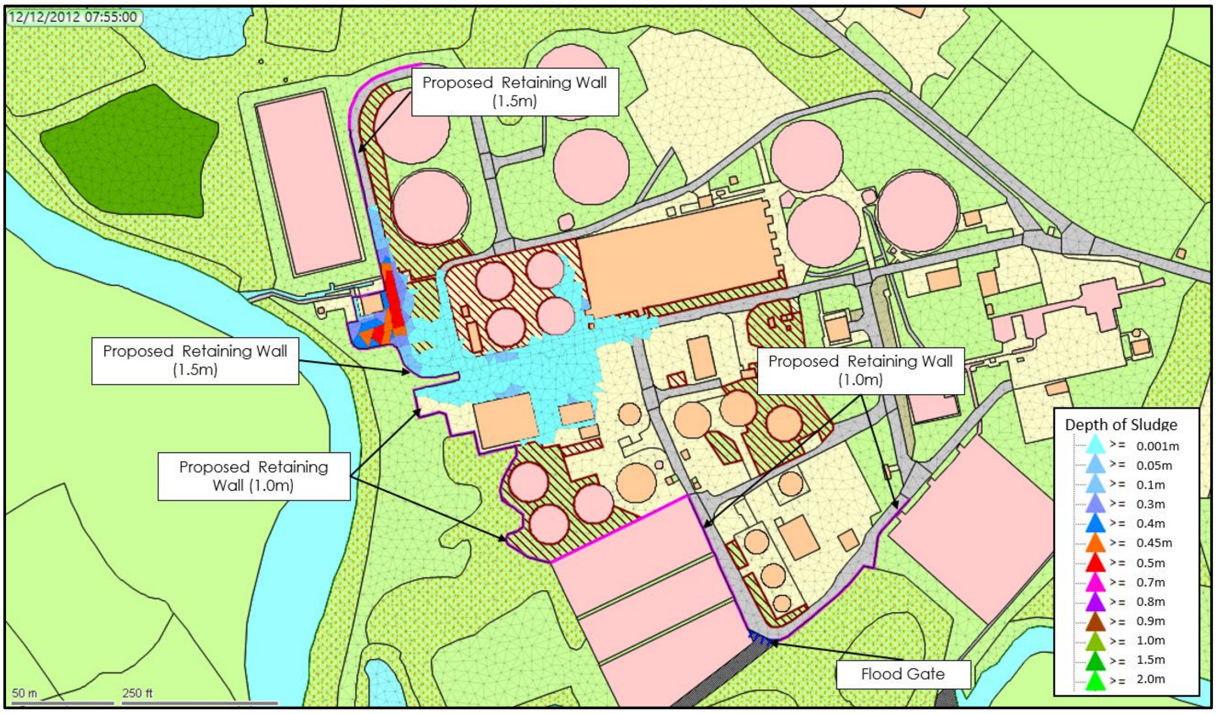


Figure 28: Proposed mitigation and settled sludge depth for Thickened Sludge Silo

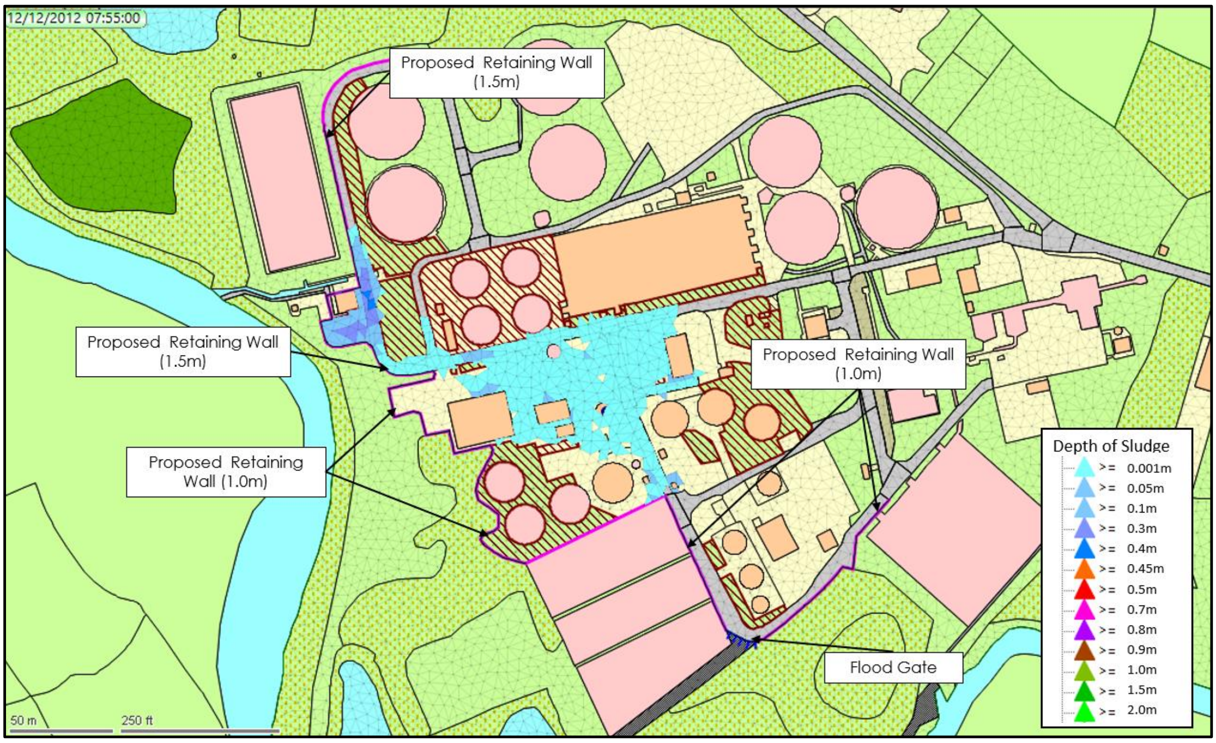


Figure 29: Proposed mitigation and settled sludge depth for Thickening Centrate Storage Tank

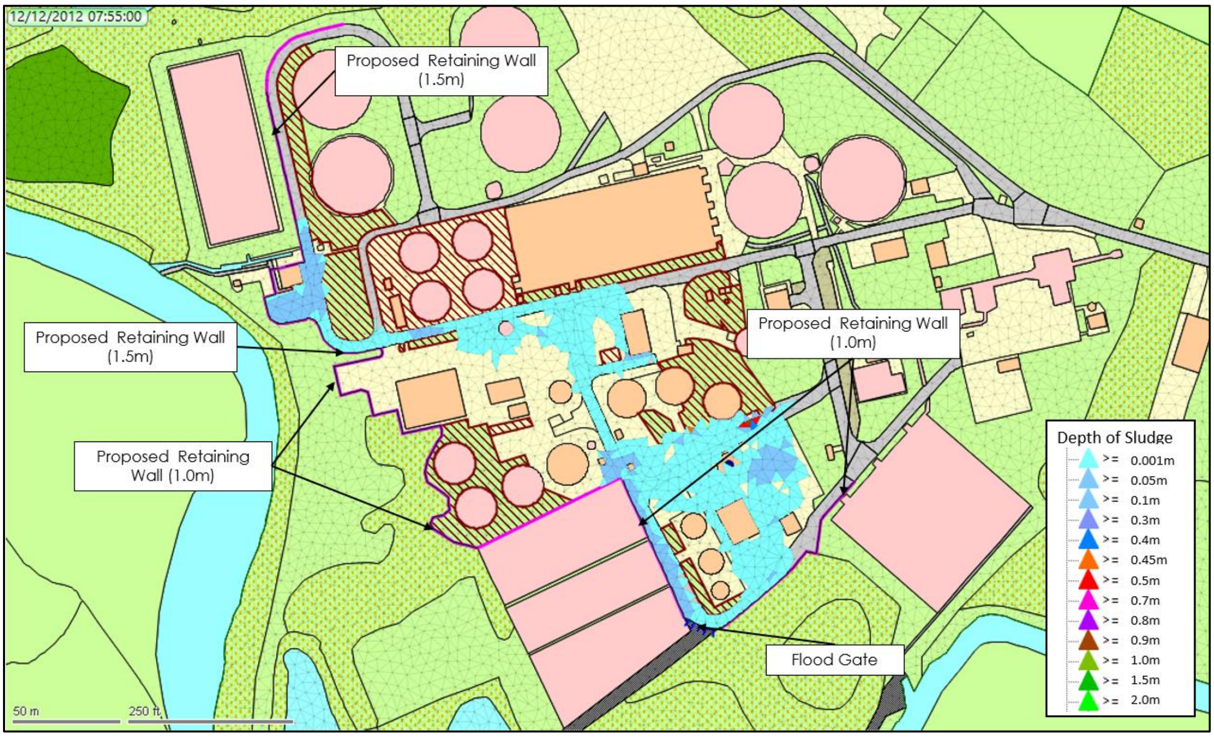


Figure 30: Proposed mitigation and settled sludge depth for Dewatering Centrate Buffer Tank

The recommended surge allowance for reinforced concrete bunds is 250mm, see extract from CIRIA C736 below. The model shows that the settled depth of sludge does not exceed 0.5m along the edge of the proposed 1.0m high retaining walls or 1.0m for the 1.5m high proposed retaining wall for all simulations.

Table 4.7 Surge allowance (in the absence of detailed analysis)

Type of structure (see Part 3)	Allowance
In situ reinforced concrete and blockwork bunds	250 mm
Secondary containment tanks	250 mm
Earthwork bunds	750 mm

CIRIA 736 Box 6.1 (below) recommends that the I (distance between the storage vessel and bund) should be at least 'H' (Max Liquid level) – 'h' (height of the bund) to prevent jetting. The Digesters tank has a maximum liquid level of 8m and the proposed wall high is 1.0m. The proposed reinforced concrete wall is least 27m from the tank therefore meets the recommendation.

The Screened Sludge Tank has a maximum liquid level of 6m and the proposed reinforced concrete retaining wall height is 1.0m. The wall is at least 7m from the tank therefore meets the recommendation.

The Digested Sludge Tank has a maximum liquid level of 7.3m and the proposed reinforced concrete retaining wall height is 1.0m. The wall is at least 16m from the tank therefore meets the recommendation.

The Thickened Sludge Silo has a maximum liquid level of 9.2m and the proposed reinforced concrete retaining wall height is 1.5m. The wall is at least 60m from the tank therefore meets the recommendation.

The Thickening Centrate Storage Tank has a maximum liquid level of 2.3m and the proposed reinforced concrete retaining wall height is 1.0m. The wall is at least 40m from the tank therefore meets the recommendation.

The Dewatering Centrate Buffer Tank has a maximum liquid level of 2.1m and the proposed reinforced concrete retaining wall height is 1.0m. The wall is at least 50m from the tank therefore meets the recommendation.

Box 6.1 ***Method for calculating bund geometry to prevent jetting***

For a small diameter sharp edged discharge orifice, it can be demonstrated that:

$l^2 = 4\,C_v^{\,2}\,(z-h)\,(H-z)$

where C_v = coefficient of velocity

In practice, $C_v \cong 0.99$. Assuming $C_v = 1$ leads to the conservative solution:

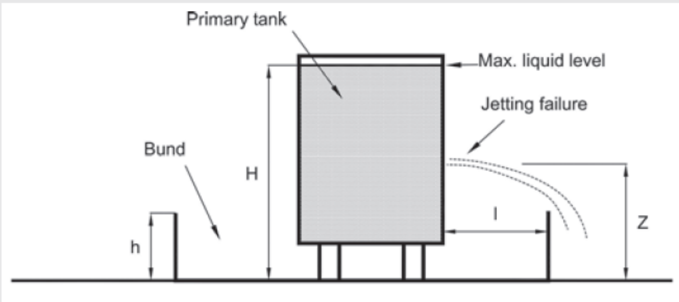
$l^2 = [4(z-h)(H-z)]^{0.5}$

For a given value of h, it may be shown the l is a maximum when:

$z = 0.5H + 0.5h$

which leads to the solution:

$\boldsymbol{l_{max} = H-h}$



The proposed wall heights allow for freeboard of at least 202mm between the top water level of the ponded water after the event and the top of the containment wall as detailed in Section 7.

The DTM used form this assessment is based on Lidar data; it is therefore recommended that further survey work in the area is completed prior to detail design.

9.0 CONCLUSIONS

A 2D InfoWorks ICM hydraulic model has been built for Burnley STC to represent the failure of specific site assets and the resulting overland flow paths for the spilled flow. The aim of the modelling was to check whether failure of the identified tanks would result in spilled flow reaching the adjacent receptors.

The hydraulic model has been built from existing site information including OS mapping, photos and LiDAR data to represent the path of overland flows. It is recommended that the areas identified as flow paths, especially areas recommended for mitigation measures, are covered by a topographical survey. This will give confidence of protection measures already in place and confirm the extent of any additional mitigation measures that may be required.

Simulation have been carried out for all the critical assets representing the release of 110% of asset volume. Results from the simulations indicate that the spilled flows from these tanks were predicted to reach receptors.

High-level containment solutions for each critical asset have been developed to meet the requirements set out in CIRIA C736. The proposed mitigation measures aim to give indicative locations and dimensions of secondary containment requirements; further investigation and discussions with a multidiscipline team will be required to refine any final design requirements. All remedial structures will be constructed in compliance with applicable British Standards and United Utilities Asset Standards.

An allowance for the impact of rainfall has been made for the proposed retaining wall solution in accordance with the guidance in CIRIA C736. For Burnley STC, the containment wall has allowed for freeboard of at least 202mm between the top water level of the ponded water after the event and the top of the containment wall.

Solution modelling has been undertaken to show that the proposed mitigation measures provide sufficient area / volume to contain sludge spills within existing hard standing areas or sacrificial areas. Sacrificial areas will be reprofiled with impermeable membranes to satisfy the class 2 recommendations from CIRIA C736. Solution modelling has not been undertaken to assess the impact of surge following a catastrophic failure.

APPENDIX A

Appendix A ADBA ASSESSMENT TOOL

Screenshot from spreadsheet containing full assessment. Full document included as part of permit submission.

Although this tool works as a standalone tool, we recommend you read this first: ADBA CIRIA736 Bund Classification Assessment

There are 5 steps to follow:

1) Identify the hazard posed to the environment by the inventory of materials held on the site and the location of the site
   a. Categorise the source
   b. Identify the pathways
   c. Identify the receptor

2) The Site Hazard Rating is derived by this tool from the combination of the hazards assessed above

3) Calculate the likelihood of a loss of primary containment event occurring

4) The combination of the Site Hazard Rating and the likelihood of a loss of containment occuring gives the site risk rating and required secondary containment classification

5) From the class of containment needed, identify suitable designs from the 'Standard Containment Designs' sheet

Additional Guidance

As detailed in section 2.4 of CIRIA C736, determining an overall hazard rating for the site is largely subjective, and assessing the combined effects is a judgement based on knowledge, experience and the degree of confidence in the information available.

Section 2.4 of CIRIA C736 states: "*where there is uncertainty about the correct categorisation of any of the individual source, pathway or receptor hazard ratings, it may be appropriate to move the overall site hazard category to the next higher rating*".

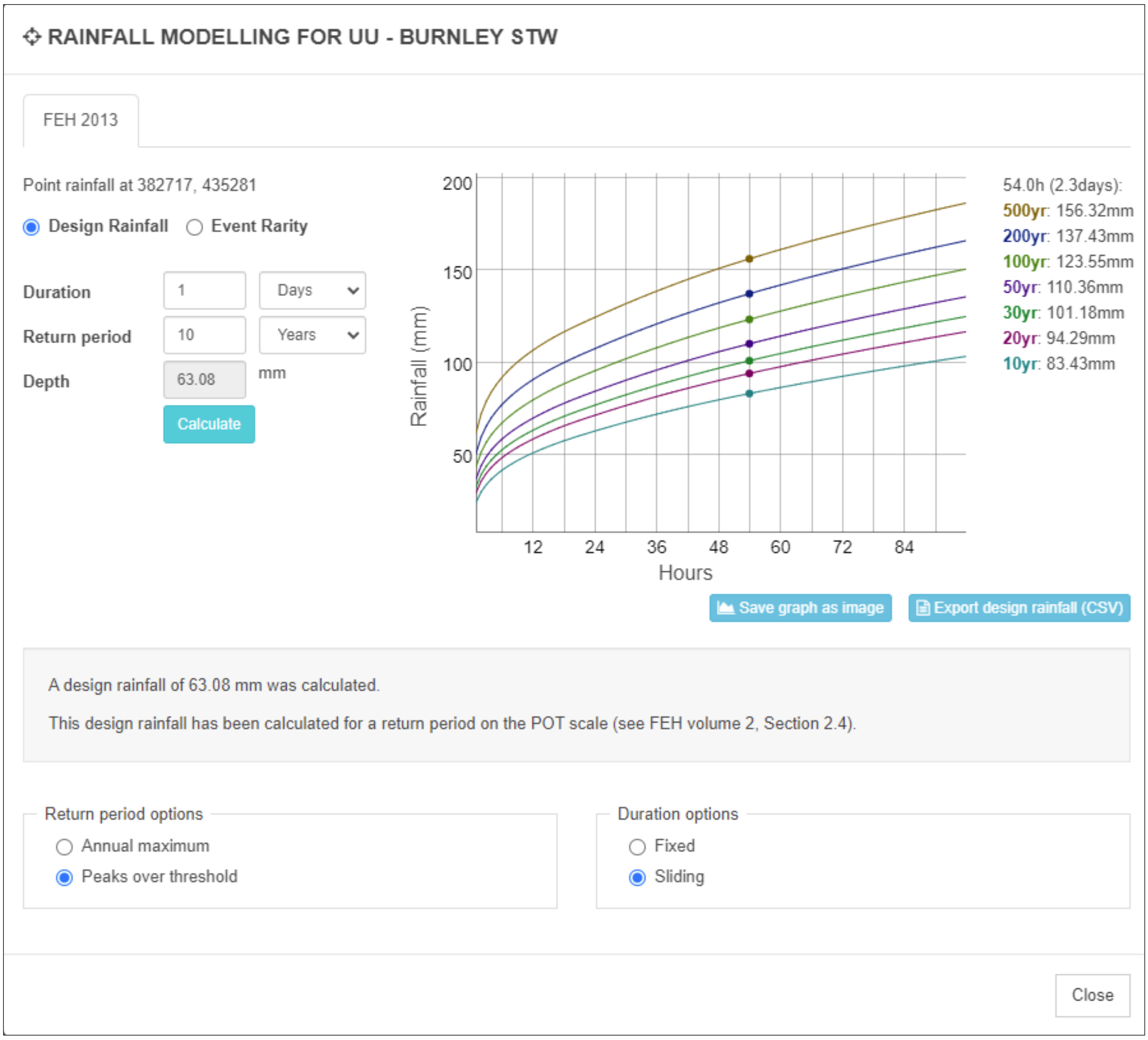
The worksheets in this spreadsheet are protected to prevent inadvertant damage to the tool. To remove the protection, the password is CIRIA736

Appendix Figure 1. ADBA Spreadsheet Screenshot

APPENDIX B

Appendix B BURNLEY STC – FEH RAINFALL CALCULATION

1 in 10 Year 24hr rainfall depth



1 in 10 Year 8-day rainfall depth

RAINFALL MODELLING FOR UU - BURNLEY STW

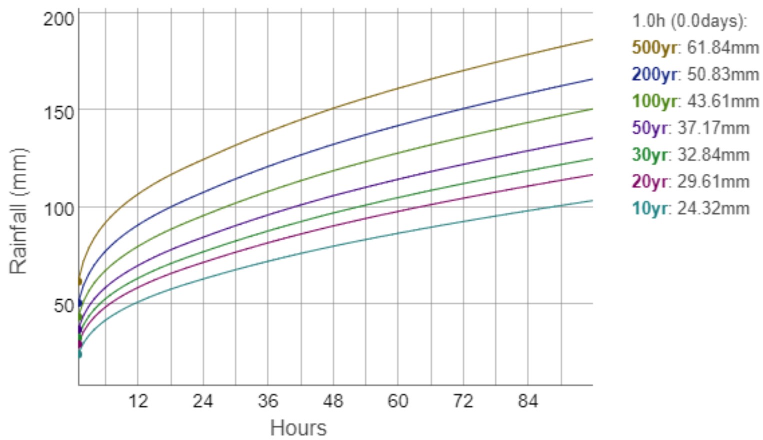
FEH 2013

Point rainfall at 382717, 435281

(●) **Design Rainfall** ( ) **Event Rarity**

Duration	8	Days
Return period	10	Years
Depth	138.92	mm

Calculate



Save graph as image | Export design rainfall (CSV)

A design rainfall of 138.92 mm was calculated.

This design rainfall has been calculated for a return period on the POT scale (see FEH volume 2, Section 2.4).

Return period options
( ) Annual maximum
(●) Peaks over threshold

Duration options
( ) Fixed
(●) Sliding

Close

APPENDIX C

BURNLEY STC – UU STANDARD DETAIL