# Industrial Emissions Directive – Blackburn Sludge Treatment Centre (STC)

Secondary Containment Modelling Assessment

30/10/2023

Prepared for:

United Utilities Water

Prepared by:

Stantec

**INDUSTRIAL EMISSIONS DIRECTIVE – BLACKBURN SLUDGE TREATMENT CENTRE (STC)**

Secondary Containment Modelling Assessment

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**INDUSTRIAL EMISSIONS DIRECTIVE – BLACKBURN SLUDGE TREATMENT CENTRE (STC)**

Secondary Containment Modelling Assessment

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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 Blackburn 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 flow paths of the vessel contents and the containment measures necessary to prevent flows from reaching a receptor.

The modelling software used for this analysis is Infoworks ICM. Infoworks 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.

In addition, the ICM model has not been used to assess the initial surge of sludge flows against the proposed retaining walls that arise from catastrophic failure of sludge tanks/digesters. Therefore, any outputs from ICM will not account for this. Proposed retaining walls in the model are assumed to contain all sludge therefore the depths shown provide a worst-case scenario for settled sludge depths.

CIRIA C736 recommendations have been used to assist in the reports, in particular with rainfall and surge allowance.

This report has been compiled with the assumption that the modelling outputs are for indicative solutions/cost activities. Further design work, which is not in Stantec's scope, will be required to confirm the solution, especially the wall structures, considering the surge flows of the sludge and wind impacts.

Figure 1 below shows an aerial view of Blackburn STC.


**Figure 1: Blackburn STC Aerial View**


**Figure 2:- Site Layout Plan**

# 2.0 ADBA RISK ASSESSMENT TOOL FINDINGS

The Anaerobic Digestion & Bioresources Association (ADBA) Risk Assessment Tool is based on CIRIA c736: *Containment systems for the prevention of pollution* and provides requirements for the prevention of pollution: including secondary and tertiary containment, and other measures for industrial and commercial premises. An assessment is presented in Appendix A and the findings are summarised in this chapter.

## 2.1 CLASS OF REQUIRED SECONDARY CONTAINMENT FOR BLACKBURN 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 summarised in Figure 3 below.

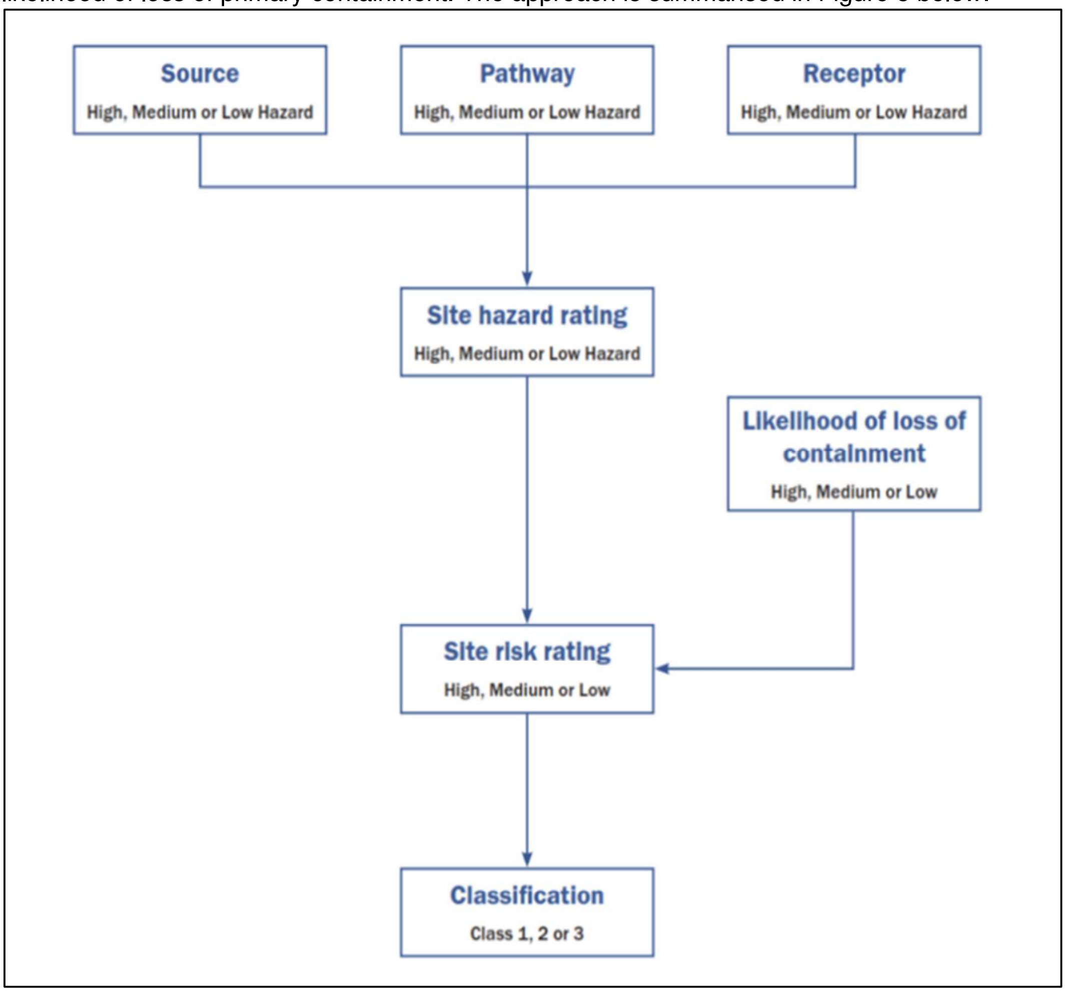



**Figure 3: ADBA Risk Assessment Classification Flowchart**

The ADBA Risk Assessment Tool scored the source element as 'High risk', pathway elements as 'Medium risk' and the receptor element as 'High risk' for the Blackburn STC owing to the significant volumes of sewage sludge stored on site and site pathways to receptors. In summary, this assessment approach indicates that Blackburn 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 e.g., regular tank inspections.

According to Table 4 within the ADBA tool (box 2.2 CIRIA c736), reproduced in Figure 4 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 **Blackburn 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 4: ADBA Classification Matrix**

The 'Blackburn 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 Blackburn STC will be used to inform the next stage of the secondary containment assessment (See Section 8). The assessment above considers the whole Blackburn 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 5.

**Table 1: Assets**

| Group | Asset Description | No. of units | Total Capacity ($m^3$) | Comments |
|---|---|---|---|---|
| 1 | Digester No. 1 | 1 | 2,500 | |
| | Digester No. 2 | 1 | 2,500 | |
| | Digester No. 3 | 1 | 2,500 | |
| | Digester No. 4 | 1 | 2,500 | |
| | Post Digestion Tank No. 3 | 1 | 1,200 | Glass fused to steel, Above the ground unit |
| 2 | Post Digestion Tank No. 1 | 1 | 900 | Partially buried Concrete, Photo suggest around 2m above ground on front side hence **350m$^3$** of above ground |
| | Post Digestion Tank No. 2 | 1 | 900 | |
| 3 | EEH Feed Tank | 1 | 1,400 | Glass fused to steel above ground asset |
| | Lamella Plant | 1 | 19 | Steel, above ground |
| 4 | High Rate Enzymic Hydrolysis (EEH) No. 1 | 1 | 280 | Glass fused to steel above the ground assets |
| | High Rate Enzymic Hydrolysis (EEH) No. 2 | 1 | 280 | |
| | High Rate Enzymic Hydrolysis (EEH) I No. 3 | 1 | 280 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 4 | 1 | 280 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 5 | 1 | 280 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 6 | 1 | 280 | |
| 5 | Unthickened Sludge Storage tank | 1 | 1,800 | Glass fused to steel, above ground |
| 6 | Centrate and Filtrate Tank | 1 | 1200 | Concrete, **540m$^3$** above ground |
| 7 | Drum Thickener Feed Tank 1 | 1 | 400 | Glass fused to steel, Above ground |
| | Drum Thickener Feed Tank 2 | 1 | 400 | Glass fused to steel, Above ground |

The tanks have been grouped into 7 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.

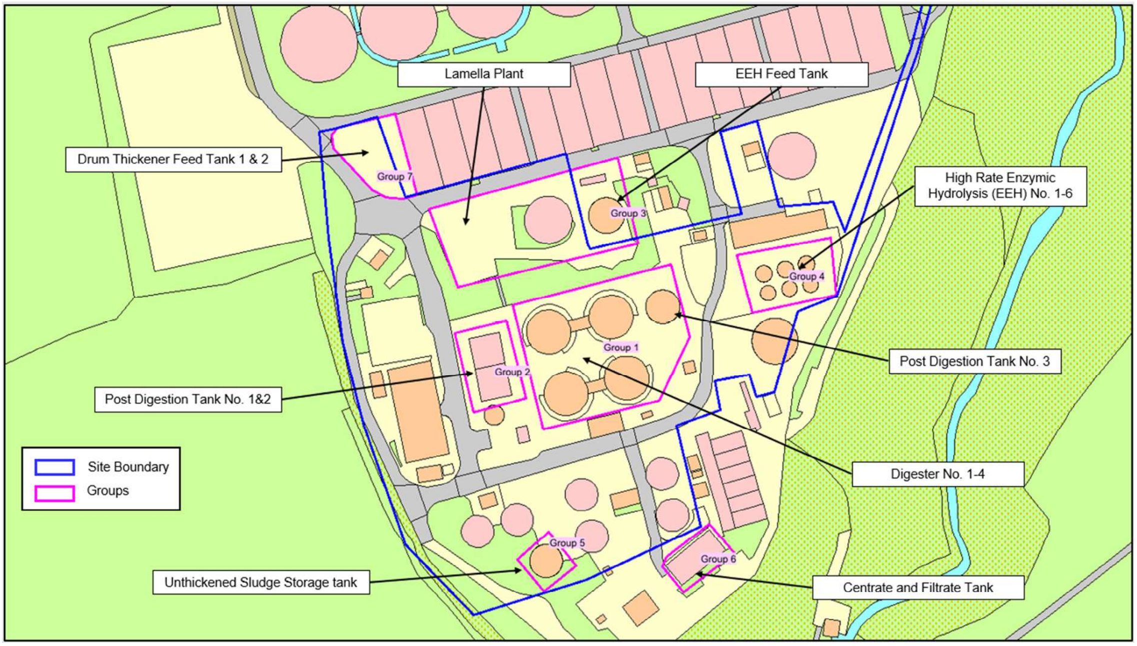



**Figure 5: Blackburn STC Asset Plan**

# 4.0 ASSETS EXCLUDED FROM ASSESSMENT

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

All Non-storage assets are excluded from the modelling exercise, as follows:

**Non-storage assets and storage assets not assessed**

| Asset Description | No. of units | Total Capacity ($m^3$) | Comments/Justifications |
|---|---|---|---|
| Centrifuge Feed Tank | 1 | 600 | Located below ground |
| Balancing Tanks 1 - 4 | 4 | 2000 | Located below ground (500$m^3$ each) |
| Unthickened Sludge Tank | 1 | 10 | Located below ground |
| Pumps/pipework | multiple | N/A | Non storage asset with flow shut-down systems in place. |
| Imported Sludge Tank | 1 | 500 | Redundant tank. |
| Liquor Balancing Tanks | 2 | 1000 | Redundant tanks. |

# 5.0 HYDRAULIC MODEL BUILD

A 2D model of the Blackburn 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 Cuerdale Lane and Spring Lane to the north, Hole Brook to the eastern side and the River Darwen to the south.

Figure 6 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
    - Hole Brook
    - Bedrock - Secondary A Aquifer
    - Abstractions
    - SSSI
    - WwTWs
- Habitation
    - Commercial
    - Highway - A59
    - Residential dwellings

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

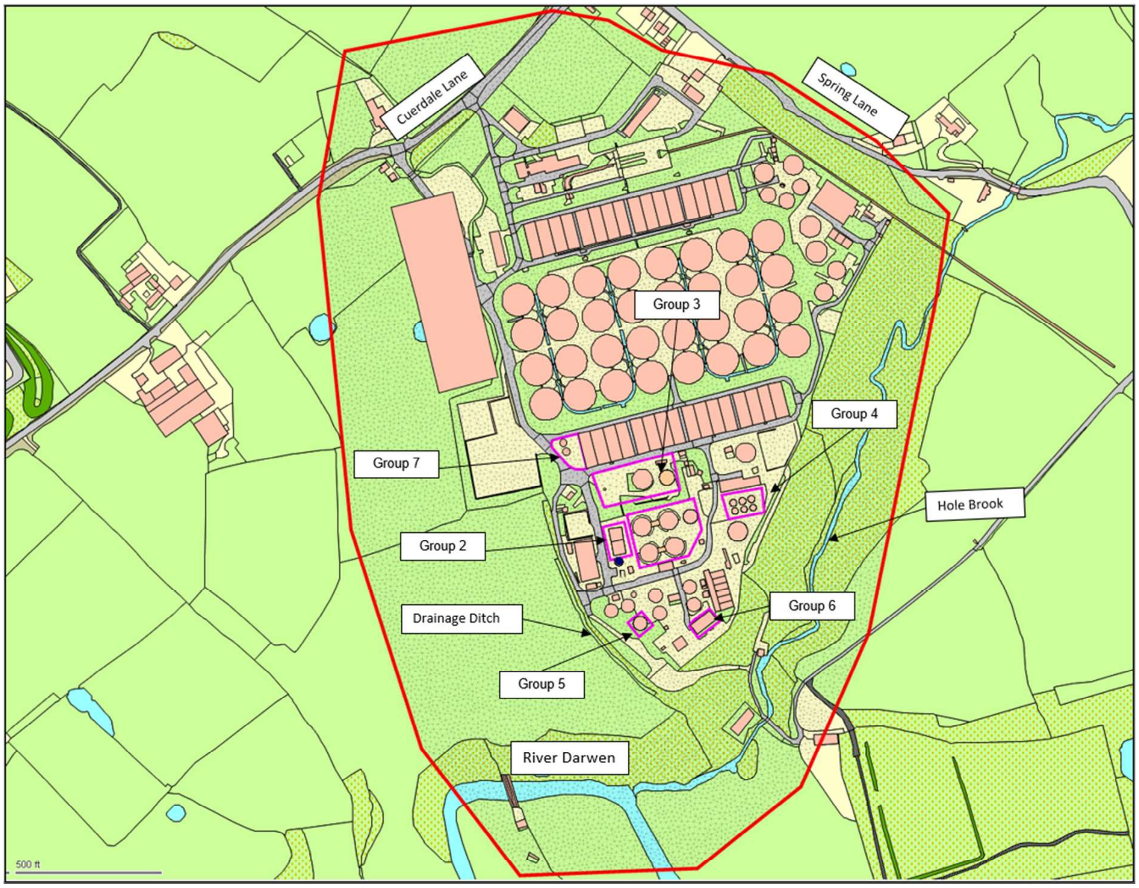



**Figure 6: Blackburn STC Extent of ICM 2D Model**

The 2D hydraulic model uses 1 meter Light Detection and Ranging (LiDAR) Digital Terrain Model (DTM) (year 2020) 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 photos 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 at the site.

- Assets have been modelled under a 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); the tank contents will be assumed to empty instantaneously in line with guidance within CIRIA C736.
- An allowance for rainfall will be made as per CIRIA C736 (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 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, 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 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. 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 Blackburn STC.

## 6.3 ASSESSMENT RESULTS

The containment requirements have been calculated in accordance with CIRA c736 and documented in Table 2 below.

**Table 2: Secondary Containment Requirements**

| Group | Asset Description | No. of units | Total Capacity above ground ($m^3$) | 110% of largest tank | 25% of aggregate |
|---|---|---|---|---|---|
| 1 | Digester No. 1 | 1 | 2,500 | 2,750 | **2,800** |
| | Digester No. 2 | 1 | 2,500 | 2,750 | |
| | Digester No. 3 | 1 | 2,500 | 2,750 | |
| | Digester No. 4 | 1 | 2,500 | 2,750 | |
| | Post Digestion Tank No. 3 | 1 | 1,200 | 1,320 | |
| 2 | Post Digestion Tank No. 1 | 1 | 350 | 385 | 175 |
| | Post Digestion Tank No. 2 | 1 | 350 | **385** | |
| 3 | EEH Feed Tank | 1 | 1,400 | **1,540** | 355 |
| | Lamella Plant | 1 | 19 | 4.75 | |
| 4 | High Rate Enzymic Hydrolysis (EEH) No. 1 | 1 | | 308 | **420** |
| | High Rate Enzymic Hydrolysis (EEH) No. 2 | 1 | 280 | 308 | |
| | High Rate Enzymic Hydrolysis (EEH) I No. 3 | 1 | 280 | 308 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 4 | 1 | 280 | 308 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 5 | 1 | 280 | 308 | |
| | High Rate Enzymic Hydrolysis (EEH) No. 6 | 1 | 280 | 308 | |
| 5 | Unthickened Sludge Storage tank | 1 | 1,800 | **1,980** | N/A |
| 6 | Centrate and Filtrate Tank | 1 | 540 | **594** | N/A |
| 7 | Drum Thickener Feed Tank 1 | 1 | 400 | **440** | 100 |
| | Drum Thickener Feed Tank 2 | 1 | 400 | 440 | |

The worst-case scenario is highlighted in green in Table 2, above. Tanks in Group 1 and 4 are all hydraulically independent to each other therefore the CIRIA 25% rule has been applied.

### 6.3.1 Group 1 – Digesters No. 1, 2, 3, 4 / Post Digestion Tank No. 3

The Digesters No 1, 2, 3 and 4 have an above ground volume of 2,500m$^3$ each and Post Digestion Tank No 3 has an estimated above ground volume of 1,200m$^3$. These tanks are all hydraulically independent therefore an inflow file of 2,800m$^3$ was created (25% of cumulative 2,500 x 4 + 1,200 m$^3$ tank volume) and applied to the model in a simulation. Figure 7 shows the modelled point of discharge for the inflow file representing the release of flow from the Digester No 4.


**Figure 7: Blackburn STC Modelled Point of Discharge for Digester no 4 Burst**

The results of this simulation are shown in Figure 8 with the blue colour 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 No 4 reaches two receptors, the River Darwen and Hole Brook.

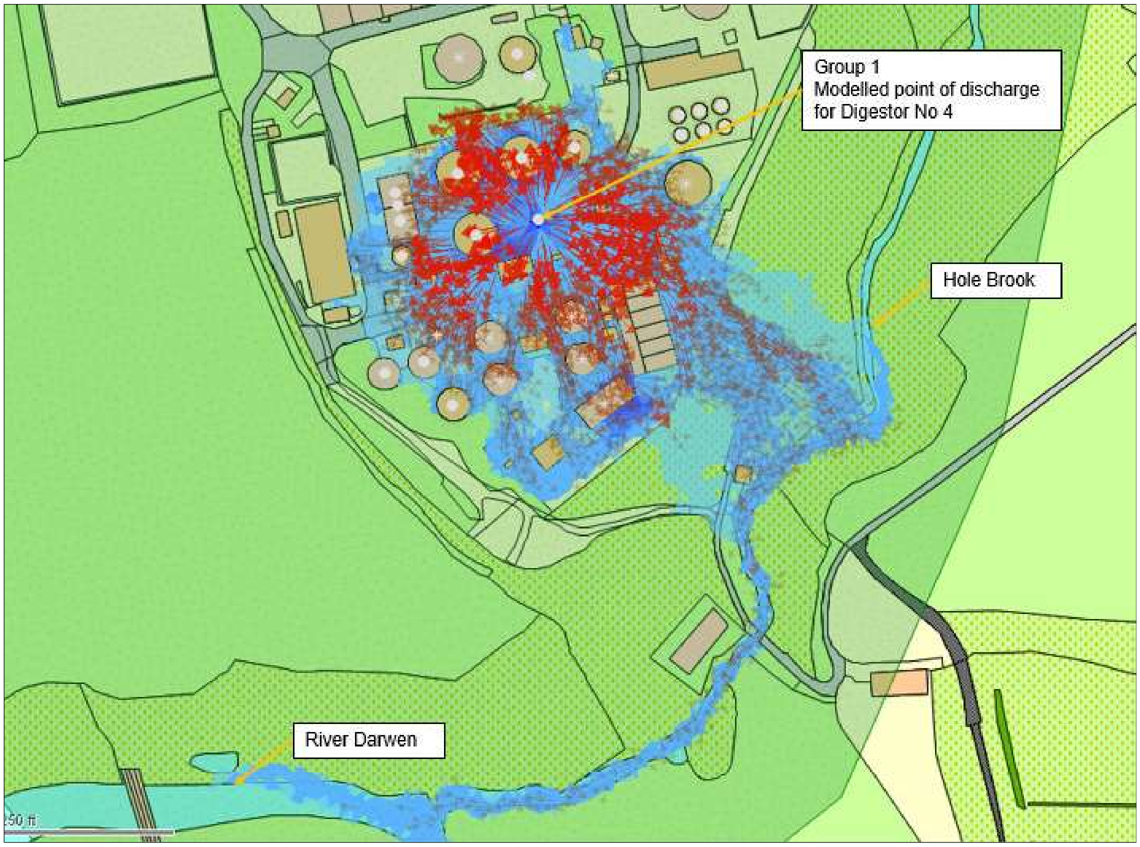



**Figure 8: Blackburn STC Predicted Flow Paths following Digester No 4 Burst**

### 6.3.2 Group 2 – Post Digestion Tank No 1 and 2

The Post Digestion Tanks No 1 and 2 both have a volume of 900m$^3$, however only 2m of tank height is above ground level hence the volume assumed for failure is 350m$^3$. An inflow file of 385m$^3$ (110% of the 350m$^3$ tank volume) was created and applied to the model simulation. Figure 9 shows the modelled point of discharge for the inflow file representing the release of flow from the Post Digestion Tank No 2.


**Figure 9: Blackburn STC Modelled Point of Discharge for Post Digestion Tank no 2 Burst**

The results of this simulation are shown in Figure 10. The simulation indicates that flow from the Post Digestion Tank no 4 is retained within the STC but extends to some permeable areas.

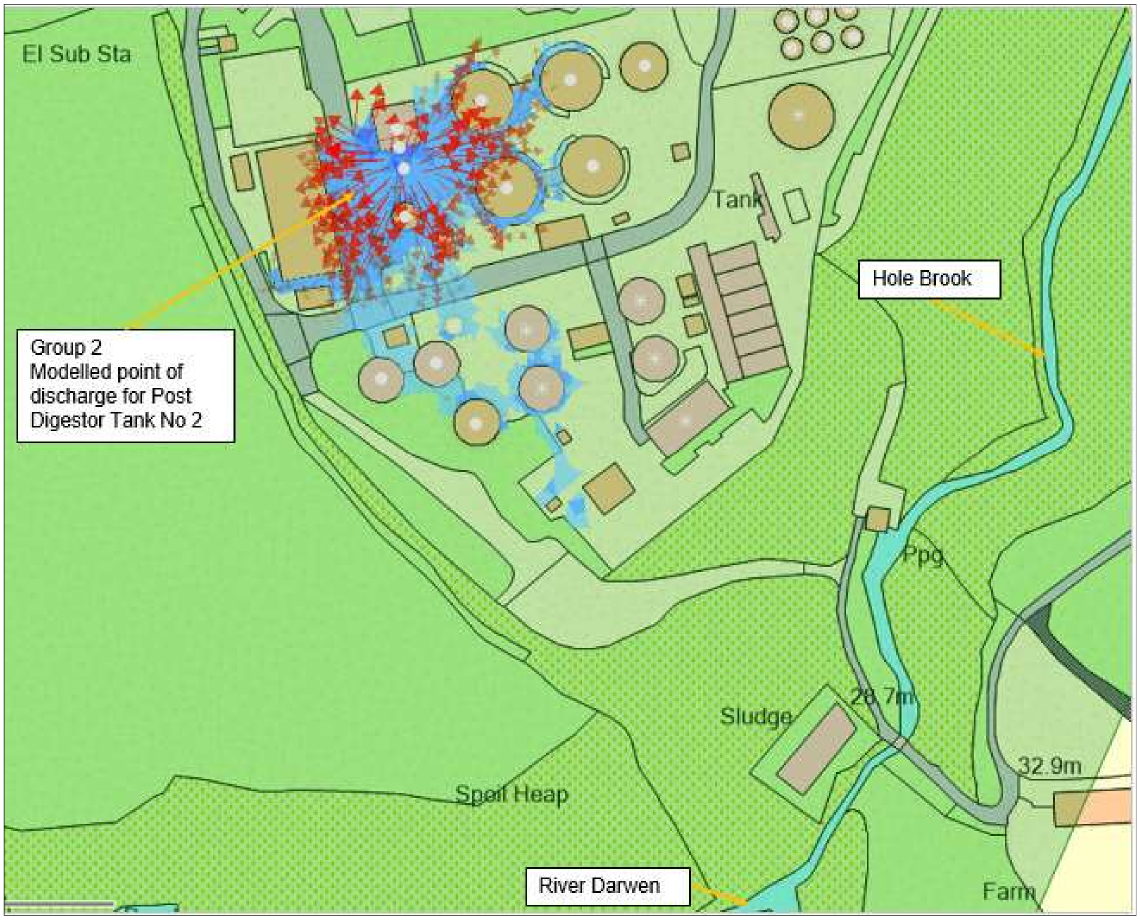



**Figure 10: Blackburn STC Predicted Flow Paths following Post Digestion Tank no 2 Burst**

### 6.3.3 Group 3 – EEH Feed Tank

The EEH Feed Tank has a volume of 1,400m$^3$ while Lamella Plant volume is 19m$^3$ hence an inflow file of 1,540m$^3$ was created (110% of 1,400m$^3$ tank volume) and applied to the model simulation. Figure 11 shows the modelled point of discharge for the inflow into the model.


**Figure 11: Blackburn STC Modelled Point of Discharge for EEH Feed Tank Burst**

The results of this simulation are shown in Figure 12. The simulation indicates that flow from the EEH Feed Tank reaches to the Hole Brook receptor which will ultimately discharge to the River Darwen.


**Figure 12: Blackburn STC Predicted Flow Paths following EEH Feed Tank Burst**

### 6.3.4 Group 4 - High Rate Enzymic Hydrolysis (EEH) No 1, 2, 3, 4, 5 and 6

The High Rate Enzymic Hydrolysis (EEH) No 1, 2, 3, 4, 5 and 6 are near Hole Brook and each have a capacity of 280m$^3$. An inflow file of 420m$^3$ (25% of 280 x 6) was created and applied to the model. Figure 13 shows the location of this inflow into the model.


**Figure 13: Blackburn STC Modelled Point of Discharge for High Rate Enzymic Hydrolysis (EEH) No. 6 Tank Burst**

The results of this simulation are shown in Figure 14 below. The simulation indicates that flow from High Rate Enzymic Hydrolysis (EEH) No. 6 tank burst is predicted to reach the Hole Brook receptor and ultimately discharge to the River Darwen.


**Figure 14: Blackburn STC Predicted Flow Paths following High Rate Enzymic Hydrolysis (EEH) No. 6 Tank Burst**

### 6.3.5 Group 5 – Unthickened Sludge Storage Tank

The Unthickened Sludge Storage Tank has a capacity of 1,800m³. An inflow file of 1,980m³ (110% of 1,800 tank volume) was created and applied to the model simulation. Figure 15 shows the modelled point of discharge for the inflow into the model.


**Figure 15: Blackburn STC Modelled Point of Discharge for Unthickened Sludge Storage Tank Burst**

The results of the simulation are shown in Figure 16 indicating that flow from the Unthickened Sludge Storage Tank burst is predicted to reach the drainage ditch, Hole Brook and River Darwen receptors.


**Figure 16: Blackburn STC Predicted Flow Paths following Unthickened Sludge Storage Tank Burst**

### 6.3.6 Group 6 – Centrate and Filtrate Tank

The Centrate and Filtrate Tank has capacity of 1,200m$^3$ out of which 540m$^3$ above ground. Hence an inflow file of 594m$^3$ (110% of 540m$^3$ i.e. above ground tank volume) was created and applied to the model simulation. Figure 17 shows the modelled point of discharge for the inflow into the model.


**Figure 17: Blackburn STC Modelled Point of Discharge for Centrate and Filtrate Tank Burst**

The results of the simulation are shown in Figure 18 indicating that flow from the Centrate and Filtrate tank burst is predicted to reach the drainage ditch, Hole Brook receptor.

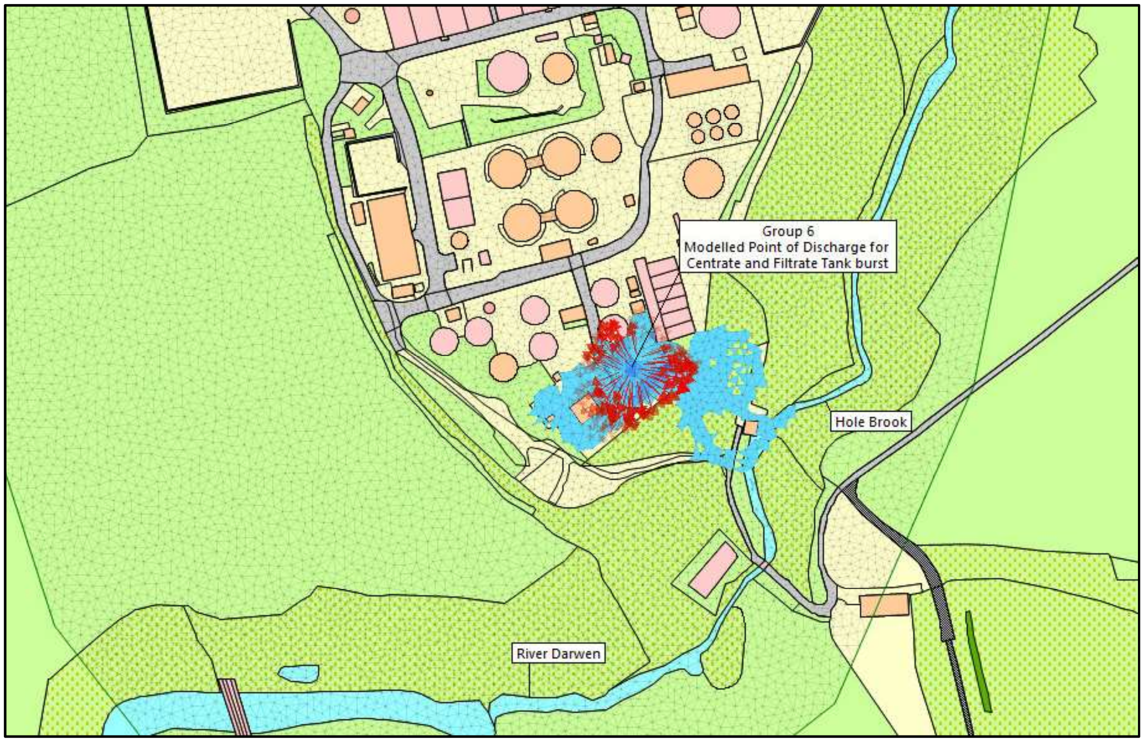



**Figure 18: Blackburn STC Predicted Flow Paths following Centrate and Filtrate Tank Burst**

### 6.3.7 Group 7 – Drum Thickener Feed Tank

There are two Drum Thickener Feed Tanks, each of 400 m³ volume located above ground. An inflow file of 440m³ (110% of 440 cum) was created and applied to the model simulation. Figure 19 shows the modelled point of discharge for the inflow into the model.


**Figure 19: Blackburn STC Modelled Point of Discharge for Drum Thickener Feed Tank No 1 Burst**

The results of the simulation are shown in Figure 20 indicating that flow from the Drum Thickener Feed Tank No 1 burst is predicted to reach the drainage ditch and eventually the River Darwen receptor.

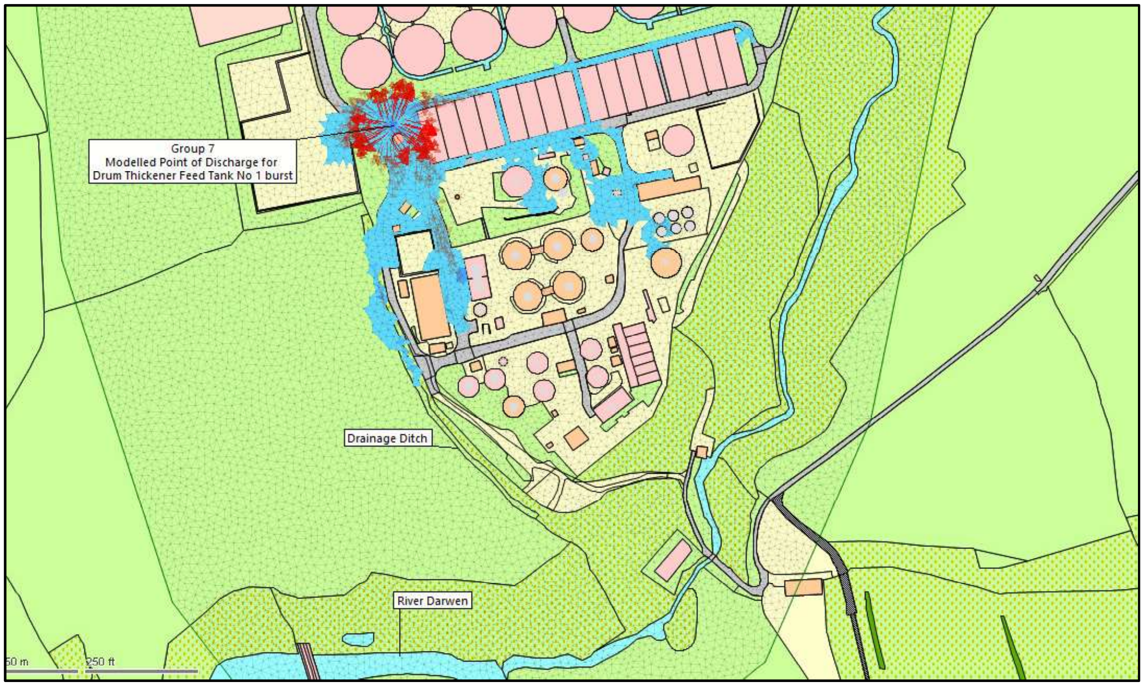



**Figure 20: Blackburn STC Predicted Flow Paths following Drum Thickener Feed Tank no 1 Burst**

# 7.0 RAINFALL ALLOWANCE

Guidance provided in CIRIA *C736 Containment systems for the prevention of pollution* 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 Blackburn STC.

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

**Table 3: Rainfall Estimates for Blackburn STC**

| Rainfall Event | Rainfall depth (mm) |
|---|---|
| 1 in 10 year (24 hr. duration) | 60 |
| 1 in 10 year (8-day duration) | 119 |
| **Total** | **179** |

Extracts from the FEH calculations are provided in Appendix A.

The total rainfall depth to be accounted for within the solution is 179mm. The containment solution must therefore ensure that there is sufficient freeboard (at least 179mm) 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 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 as well as alternative control options which are considered to provide an equivalent level of environmental protection. Proposed mitigation measures include pre-cast concrete retaining walls flood gates and sacrificial areas.

- **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 1.0m 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 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 gates have 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.

- **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 Blackburn 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.

- Blackburn 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 Blackburn 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. 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 AND 7 ASSETS

The failure of Digester no 4 (Group 1), EEH Feed Tank (Group 3), High Rate Enzymic Hydrolysis (EEH) Tanks (Group 4), Unthickened Sludge Storage Tank (Group 5), Centrate and Filtrate Tank (Group 6) and Drum Thickener Feed Tank (Group 7) shows that spilled sludge will flow back into the site and down the embankment on the south-eastern edge of the site to the Hole Brook and River Darwen receptors. Group 5 and 7 also shows that sludge will reach the drainage ditch to the south-western edge of the site.

Proposed mitigation will include constructing a precast concrete 1m high retaining wall on the southeastern and southwestern edges of the site to contain the spillage within impermeable areas wherever possible and a flood gate on the southern most part of the boundary wall. Also, for Group 7 a 1m high enclosed retaining wall all along the boundary, sacrificial area and a flood gate is proposed.


**Figure 31: Ground Levels and Proposed Mitigation Measures**

**Table 4: Containment measures quantities**

| Mitigation | Length (m) | Area ($m^2$) |
|---|---|---|
| Retaining Wall (1.0m) | 305 | N/A |
| Retaining Wall (1.5m) | 225 | N/A |
| Mechanical Flood gate | (6 and 5) 11 | N/A |
| Sacrificial area | N/A | 16,100 |
| Existing Hardstanding | N/A | 7,710 |

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 the 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 seven groups of tanks are shown in Figures 22-28.

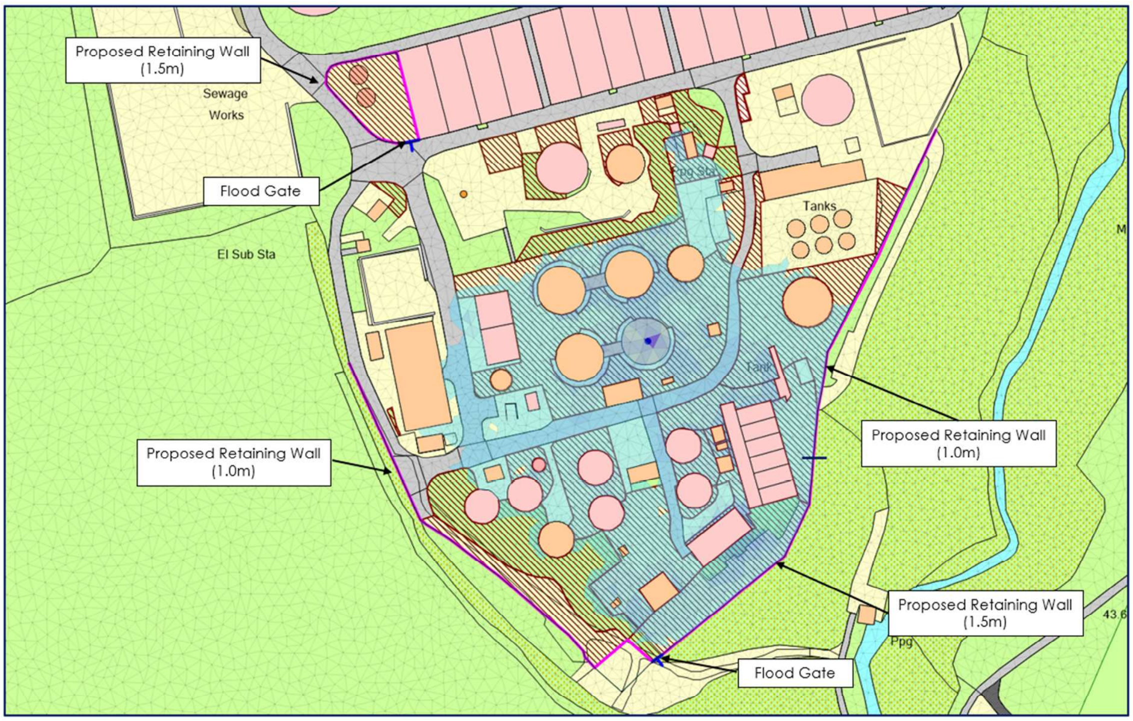


**Figure 22: Proposed mitigation and flood extent for Group 1- Digester**


**Figure 23: Proposed mitigation and flood extent for Group 2- Post Digestion Tank**

**Figure 24: Proposed mitigation and flood extent for Group 3- EEH Feed Tank**

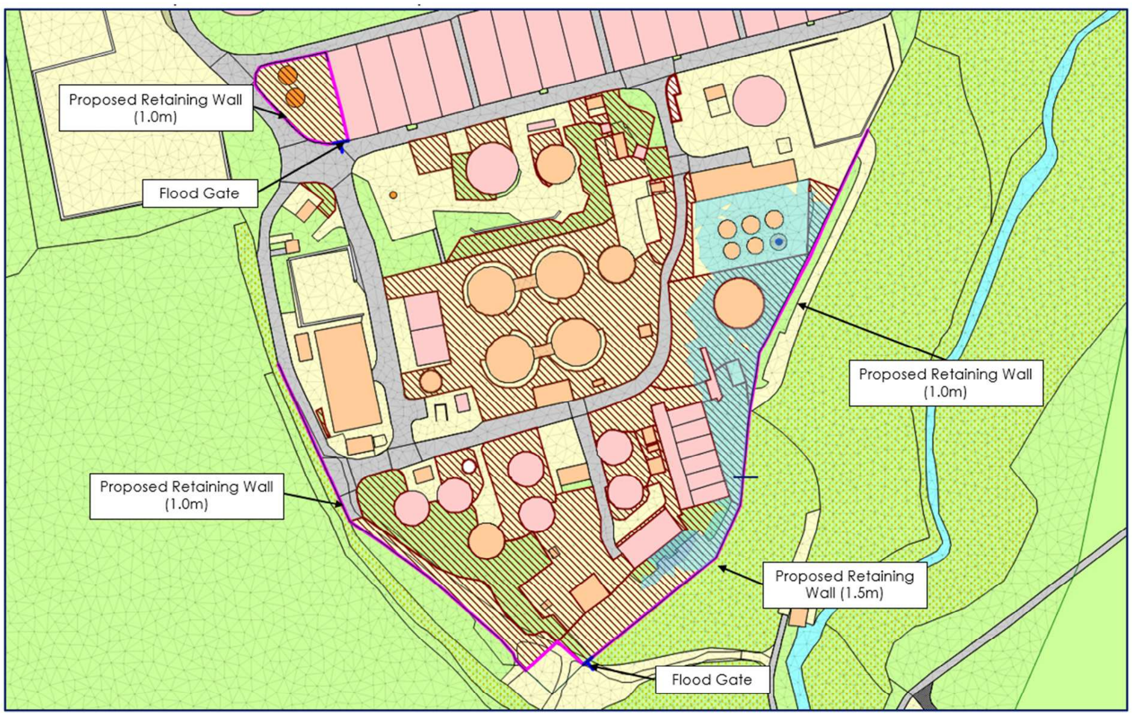



**Figure 25: Proposed mitigation and flood extent for Group 4 - High Rate Enzymic Hydrolysis (EEH) Tanks**

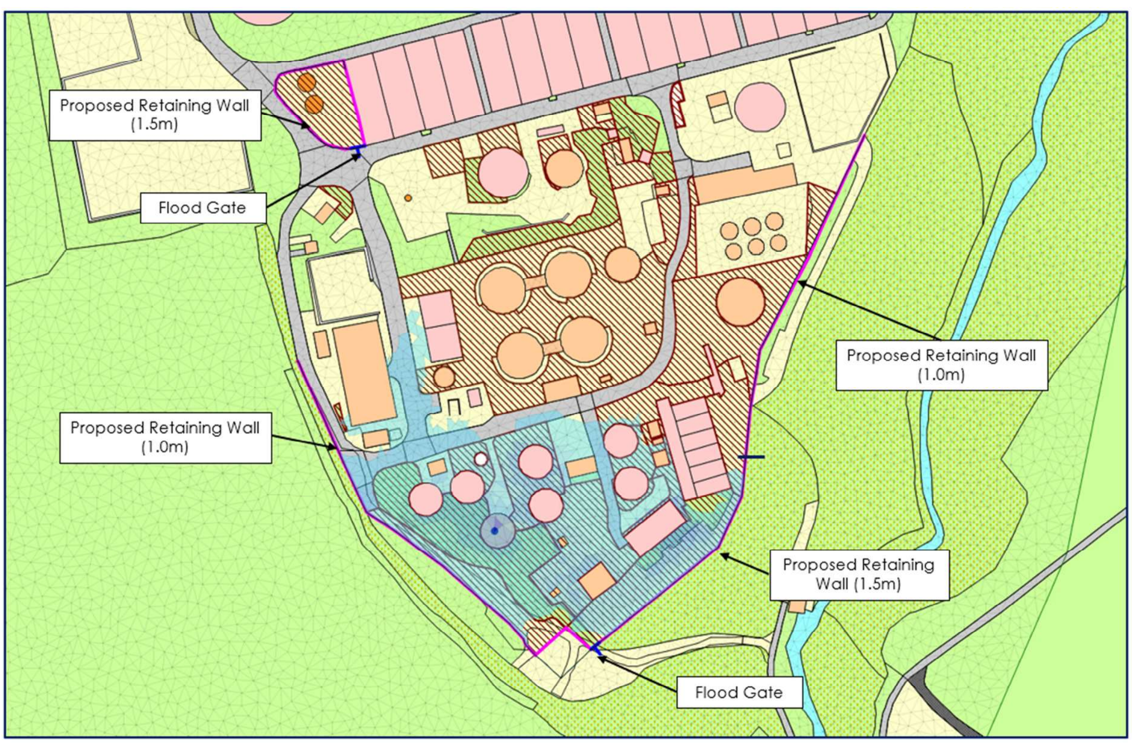


**Figure 26: Proposed mitigation and flood extent for Group 5 – Unthickened Sludge Storage Tank**


**Figure 27: Proposed mitigation and flood extent for Group 6 – Centrate and Filtrate Tank**

**Figure 28: Proposed mitigation and flood extent for Group 7 – Drum Thickener Feed Tank**

The settled sludge depths for the seven groups of tanks with mitigation modelled are shown in Figures 29-35.


**Figure 29: Proposed mitigation and settled sludge depth for Group 1- Digester**

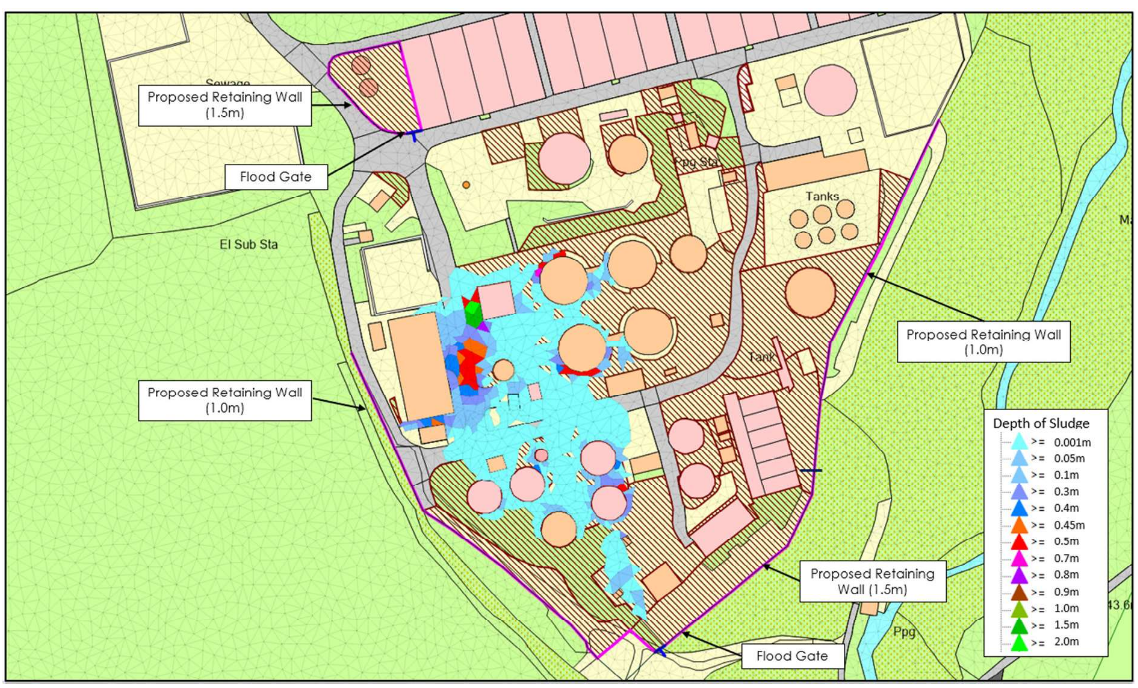


**Figure 30: Proposed mitigation and settled sludge depth for Group 2- Post Digestion Tank**

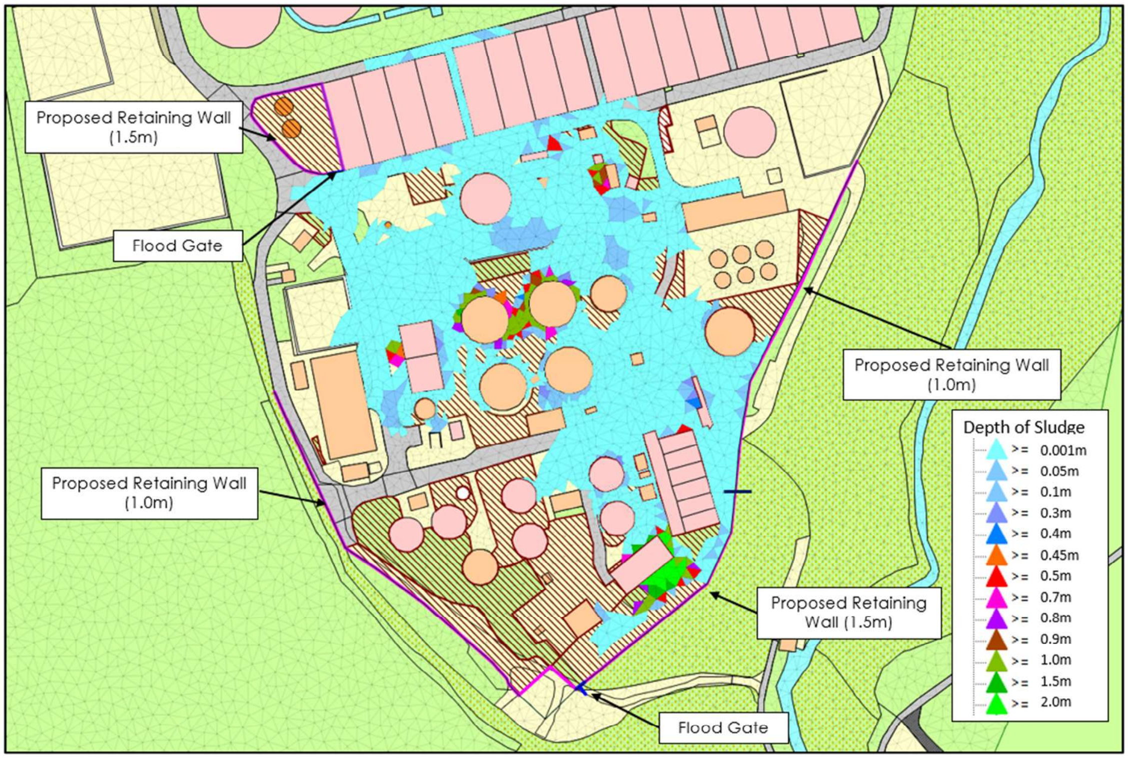



**Figure 31: Proposed mitigation and settled sludge depth for Group 3- EEH Feed Tank**

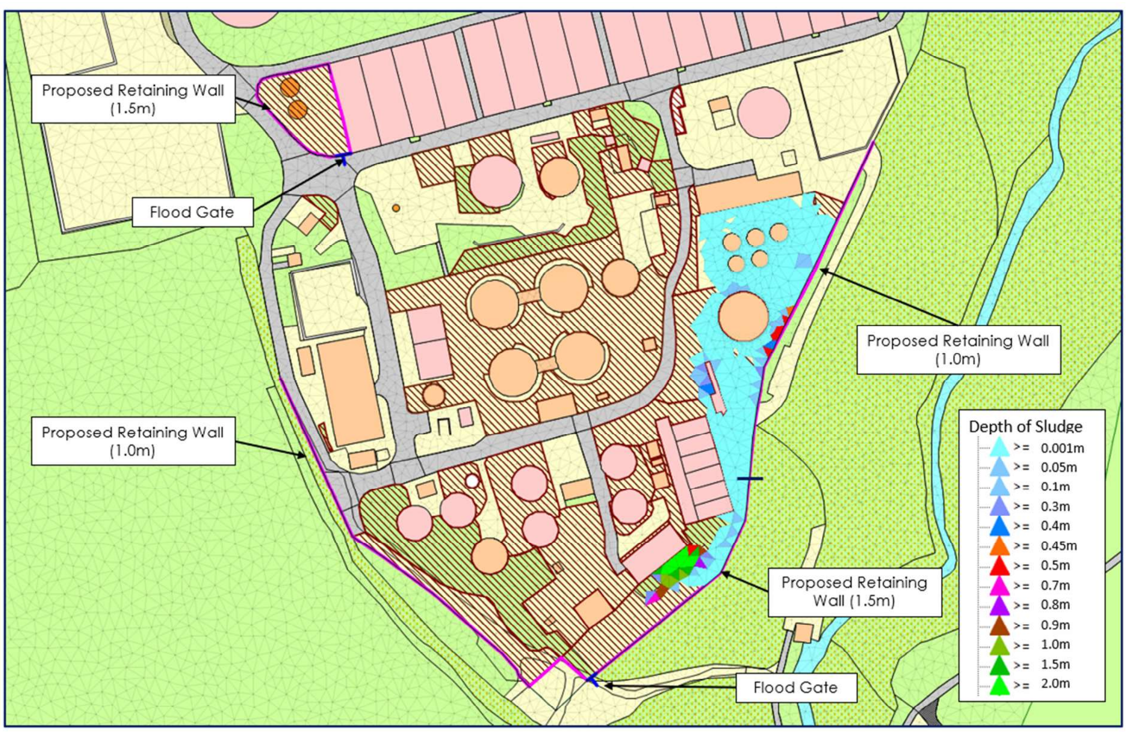


**Figure 32: Proposed mitigation and settled sludge depth for Group 4 - High Rate Enzymic Hydrolysis (EEH) Tanks**

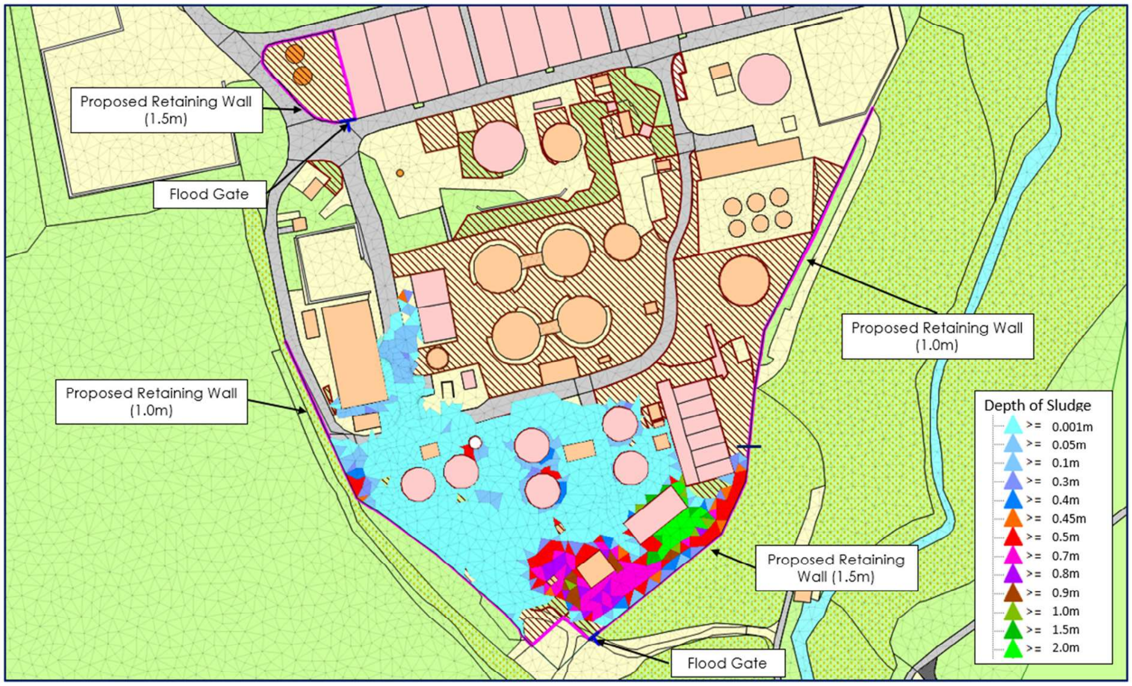



**Figure 33: Proposed mitigation and settled sludge depth for Group 5 – Unthickened Sludge Storage Tank**

**Figure 34: Proposed mitigation and settled sludge depth for Group 6 – Centrate and Filtrate Tank**


**Figure 35: Proposed mitigation and settled sludge depth for Group 7 – Drum Thickener Feed Tank**

The model shows that the settled depth of sludge does not exceed 0.8m along the edge of the proposed retaining wall for any of the simulations.

The recommended surge allowance for reinforce concrete bunds is 250mm see extract from CIRIA C736 below. It is recommended that a wall height of 1.5m is constructed at locations closest to the Drum Thickener Feed tank to minimise the risk of surge and jetting. Also, a 1.5m section of wall is recommended where the higher depths are predicted from the flood gate for 107m North. The remaining sections of wall have a recommended wall height of 1.0m as shown in the figures above.

*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 C736 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 Drum Thickener Feed Tank has a maximum liquid level of 9.2m and the proposed wall high is 1.5m. The proposed reinforced concrete wall is 2m from the tank therefore the tank does not meet the recommendation. Baffle plates will be considered along these sections of the wall during detailed design.

For rest of the tanks the recommended distance between the storage vessel and the bund is sufficient, refer Table 5 below for recommended distance and actual distance available on site.

**Table 5: Distance between the storage vessel and bund**

| | **Max Liquid Height (H), m** | **Height of Wall (h), m** | **Recommended distance between storage Tanks and bund (l = H - h), m** | **Minimum distance available on site from Tank, m** |
|---|---|---|---|---|
| Group 1 – Digester | Approx. 12 | 1 | 11 | 62 |
| Group 2 - Post Digestion Tank | Approx 2.5 | 1 | 1.5 | 50 |
| Group 3 - EEH Feed Tank | Approx. 12 | 1 | 11 | 99 |
| Group 4 - High Rate Enzymic Hydrolysis (EEH) Tanks | Approx 10 | 1 | 9 | 10 |
| Group 5 - Unthickened Sludge Storage Tank | Approx. 12 | 1 | 11 | 18 |
| Group 6 – Centrate and Filtrate Tank | 1.8 | 1.5 | 0.3 | 17 |
| Group 7 – Drum Thickener Feed Tank | 9.2 | 1.5 | 7.7 | 2 |

*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:

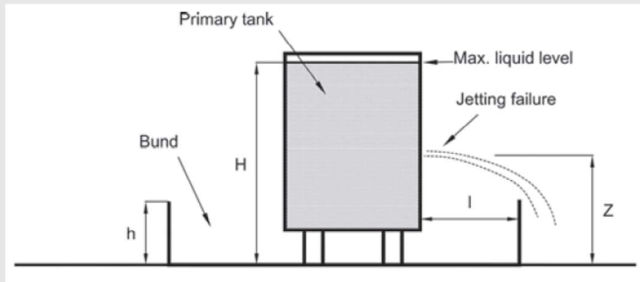
$$l^2 = [4(z-h)(H-z)]^{0.5}$$

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 179mm 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 Blackburn 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 likely 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.

The above ground storage assets have been grouped into seven areas. A simulation has been carried out for each group of tanks representing the release of 110% of the largest tank within the group or 25% of the aggregate capacity (whichever is greatest). Results from the simulations indicate that the spilled flows from these tanks were predicted to reach the receptors nearby.

High-level containment solutions for each critical asset have been developed to meet or provide equivalent protection to 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 will need to be made to for the proposed retaining wall solution in accordance with the guidance in CIRIA *C736*. For Blackburn STC, the containment solution should therefore allow for freeboard of at least 179mm 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 prove 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.

The modelling software used for this analysis is infoworks ICM. Infoworks 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.

In addition, the ICM model has not been used to assess the initial surge of sludge flows against the proposed retaining walls that arise from catastrophic failure of sludge tanks/digesters. Therefore, any outputs from ICM will not account for this. Proposed retaining walls in the model are assumed to contain all sludge therefore the depths shown provide a worst-case scenario for settled sludge depths.

CIRIA C736 recommendations have been used to assist in the reports, in particular with rainfall and surge allowance.

This report has been compiled with the assumption that the modelling outputs are for indicative solutions/cost activities. Further design work, which is not in Stantec's scope, will be required to confirm the solution, especially the wall structures, considering the surge flows of the sludge and wind impacts.

# 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:**

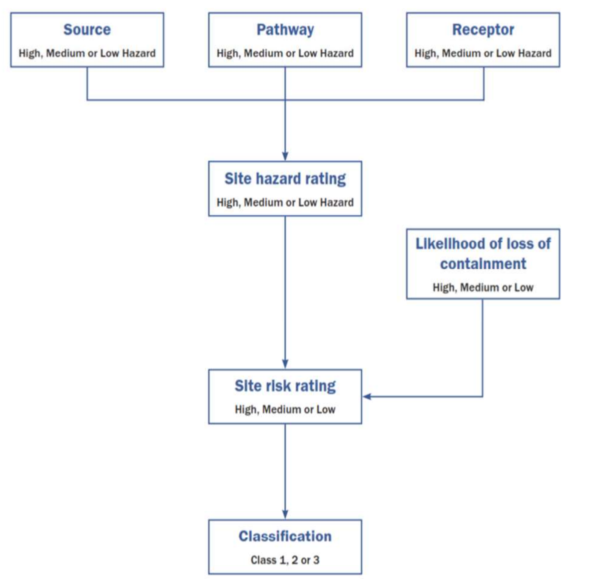
1) Identify the hazard posed to the environment by the inventory of materials held on the site and the location of the site
   a. Categorise the source
   b. Identify the pathways
   c. Identify the receptor

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

**Figure 36: ADBA Spreadsheet Screenshot**

# APPENDIX B

# Appendix B BLACKBURN STC – FEH RAINFALL CALCULATION

**1 in 10 Year 24hr rainfall depth**


**Figure 37: Rainfall Depth for 1 in 10-year Return Period and for 24 hours**

**1 in 10 Year 8-day Rainfall Depth**

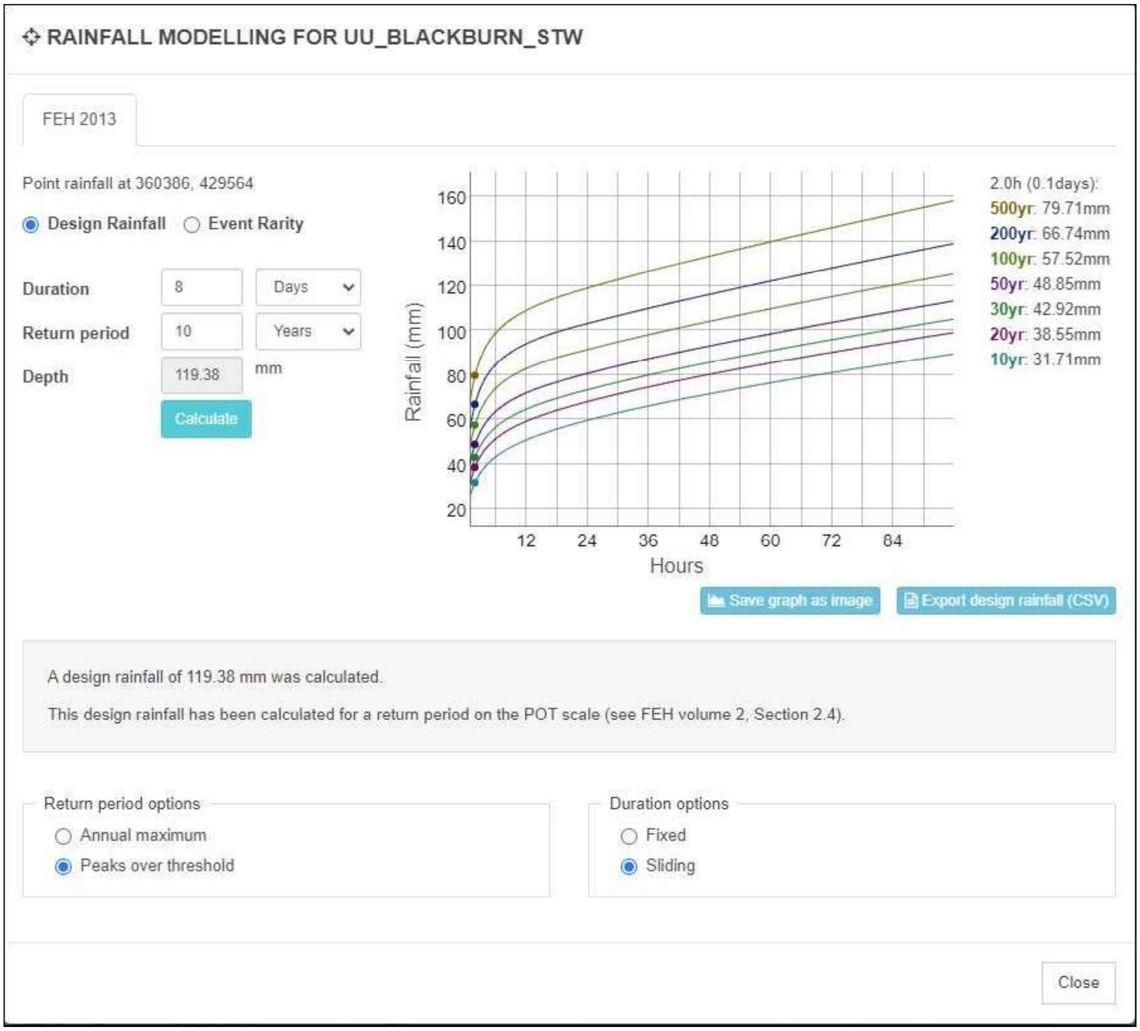



**Figure 38: Rainfall Depth for 1 in 10-year Return Period and for 8 days**

# Appendix C BLACKBURN STC – UU STANDARD DETAIL