
*Figure 27. DW area: model showing unmitigated result of spills from existing tanks in DW area's 1 to 4.*

### 3.6 Spill pathways

Figure 28 illustrates the potential pooling of sludge from the AD area in the central access section of hardstanding surface south of the THP plant which is met by grassy permeable surface west of consolidation tank 5. This section is a legacy discharge channel and has been dammed by two earth bunds directly adjacent to Consolidation Tank 5, however the potential spill over topples this and creates a direct pathway to the River Aire.

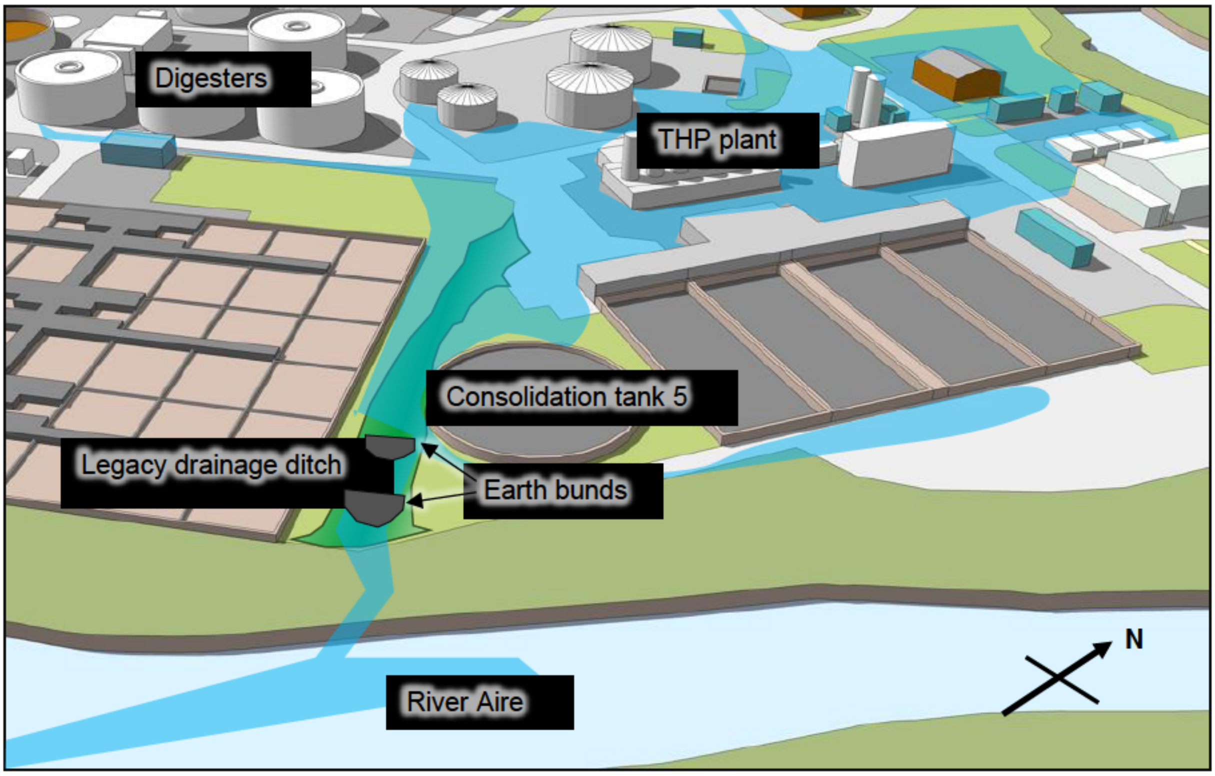



*Figure 28. Central access section of the AD area.*

Tanks within DW area 2 shows the potential for sludge spills from the export dewatering tanks to pool on the hardstanding surfaces directly adjacent to the tank, and alongside the west side of the cake barn leading up to the small sections of grassy areas as shown in Figure 29.

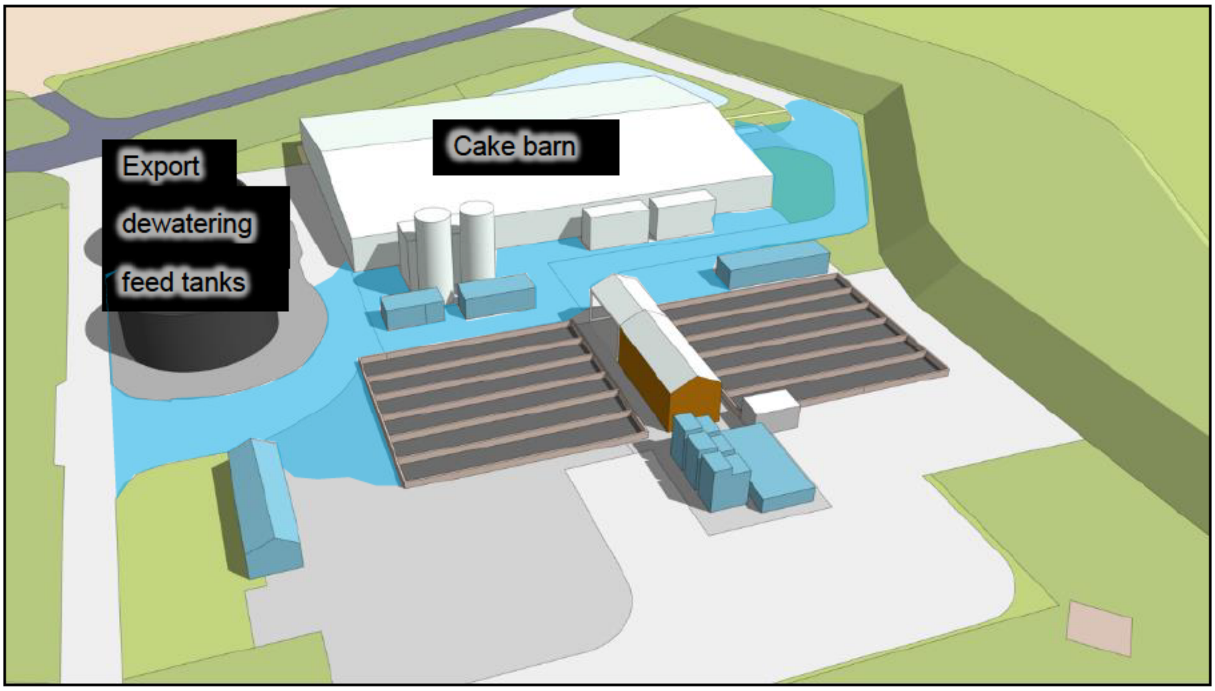



*Figure 29. Hardstanding areas surrounding and alongside the export dewatering tanks and cake barn in the DW area (east).*

Spill modelling shown for DW area 4, namely from the north conditioning feed tank has the potential to inundate half the surface area surrounding the final settlement tanks (FSTs), as shown in Figure 30. Due to the limitation of the LIDAR data, the FST lip height was not accurately represented in the modelling result. As shown in Figure 31, the FSTs themselves have 1.1m high concrete walls around their perimeter, therefore sludge will not flow into the tanks.

There is no surface water drainage around the FSTs, any surface water will run-off from areas of hardstanding towards surrounding areas of gravel. A surge or spill emanating from this tank to this area will need to be mitigated to avoid sludge from contaminating permeable sections of land. A sludge surge will also have minimal impact to nearby assets (recirculation pump building) due to sufficient ground clearance via concrete lips and slopes, and entrances to the building utilise steel roller shutters strong enough to deflect sludge.

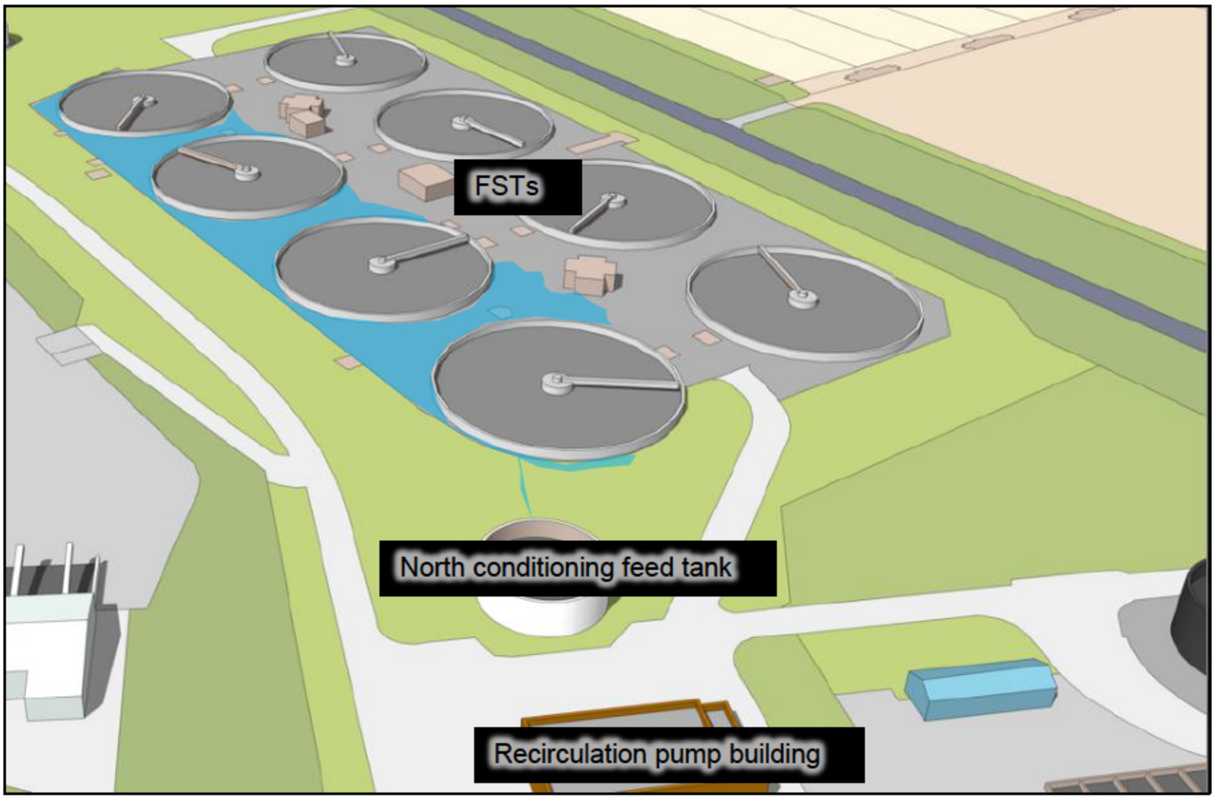



*Figure 30. FSTs located north to the north conditioning feed tank in the DW area (east)*

*Figure 31 - Photo showing height of FST walls. There is no realistic pathway for sludge to enter these.*

A direct pathway to the River Aire exists from the south conditioning feed tank, where sludge has the potential to pool and lead though the channels between the grass banks toward the river, as shown in Figure 32. Whilst a pathway to the river exists, the likelihood of the loss of containment via this route is low due to the vegetation cover and the permeable surface along the route. PondSIM cannot model porous surfaces and treats all ground surfaces as hardstanding.

Whilst surge from these tanks creates the potential for a pathway to nearby receptors, catastrophic failure is highly unlikely due to the construction of the tanks. The north conditioning tank is constructed with post-tensioned panels lined with in-situ poured concrete. The south conditioning feed tank, closest to the river, has double thickness poured concrete walls in its lower section, meaning even direct vehicle impact would be unlikely to rupture the tank walls. Surface water drainage in these areas is initially captured on hardstanding before passing to soakaways.

Although not shown in modelling, our review of the area around the south conditioning feed tank identified that in the highly unlikely event of catastrophic failure, a sludge surge has the potential to reach the final effluent chamber wet well as shown in Figure 33. Mitigation against this has been considered, including spill to permeable sections of land.


*Figure 32. Direct spill pathway to River Aire via the south conditioning feed tank in the DW area (east).*

*Figure 33. Final effluent chamber near the south conditioning feed tank in the DW area (west).*

An unmitigated spill from the centrate balance tanks is predicted to travel along the hardstanding road surfaces leading toward, and pooling within, the permeable surface surrounding the five humus settlement tanks treating trade effluent, as shown in Figure 34. There is potential in this scenario for the spill to enter the humus tanks feed channel along several sections of open decking, see Figure 35 for an example. Therefore, an indirect pathway to the River Aire exists.

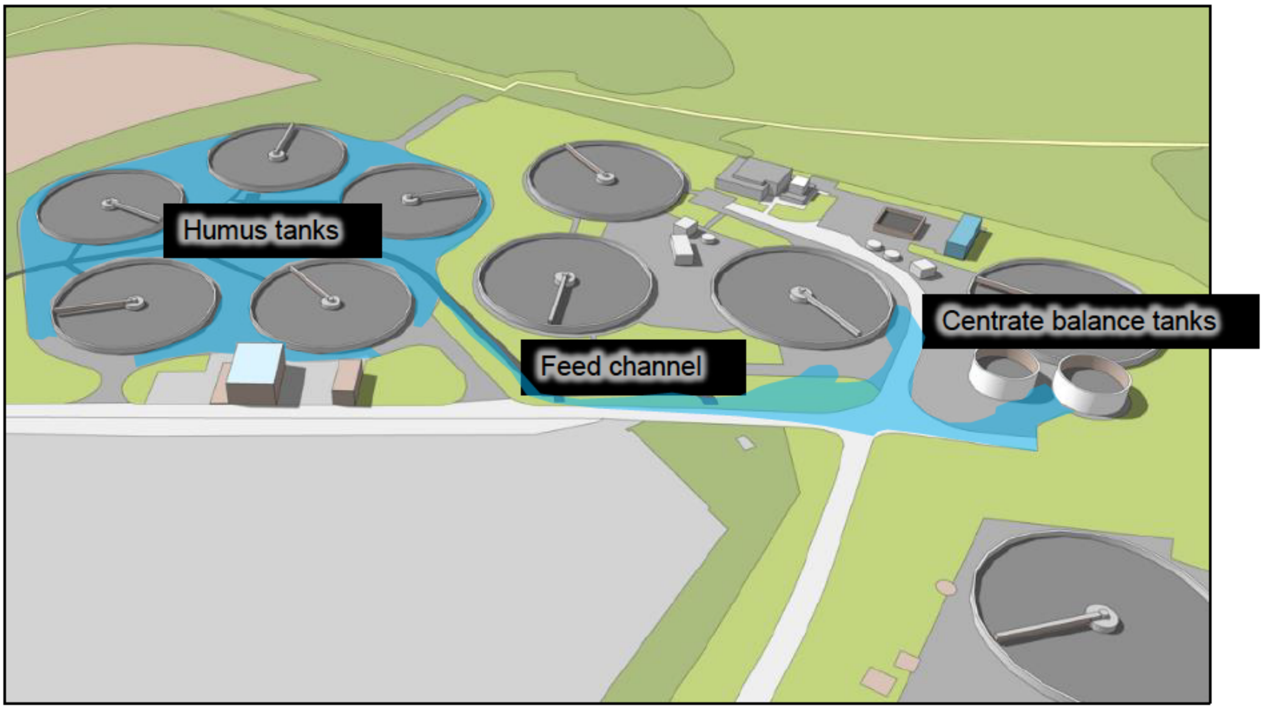



*Figure 34.Centrate balance tanks spill pathway to humus settlement tanks in the DW area (west).*

*Figure 35. Sections of open decking on the channel feeding the humus tanks in the DW area (west).*

### 3.6.1 Surface drainage

Surface water drainage routes at Esholt are shown in Figure 36 and Figure 37. Surface water drainage routes shown in red which are routed to the inlet of the WwTW i.e., contained. Routes shown in blue are for uncontaminated roof water, which is released to the environment without further treatment.

No requirements for rerouting of surface water drainage have been identified at Esholt. This issue will also be considered during detailed design of secondary containment to ensure that any new assets installed do not adversely affect existing drainage infrastructure.

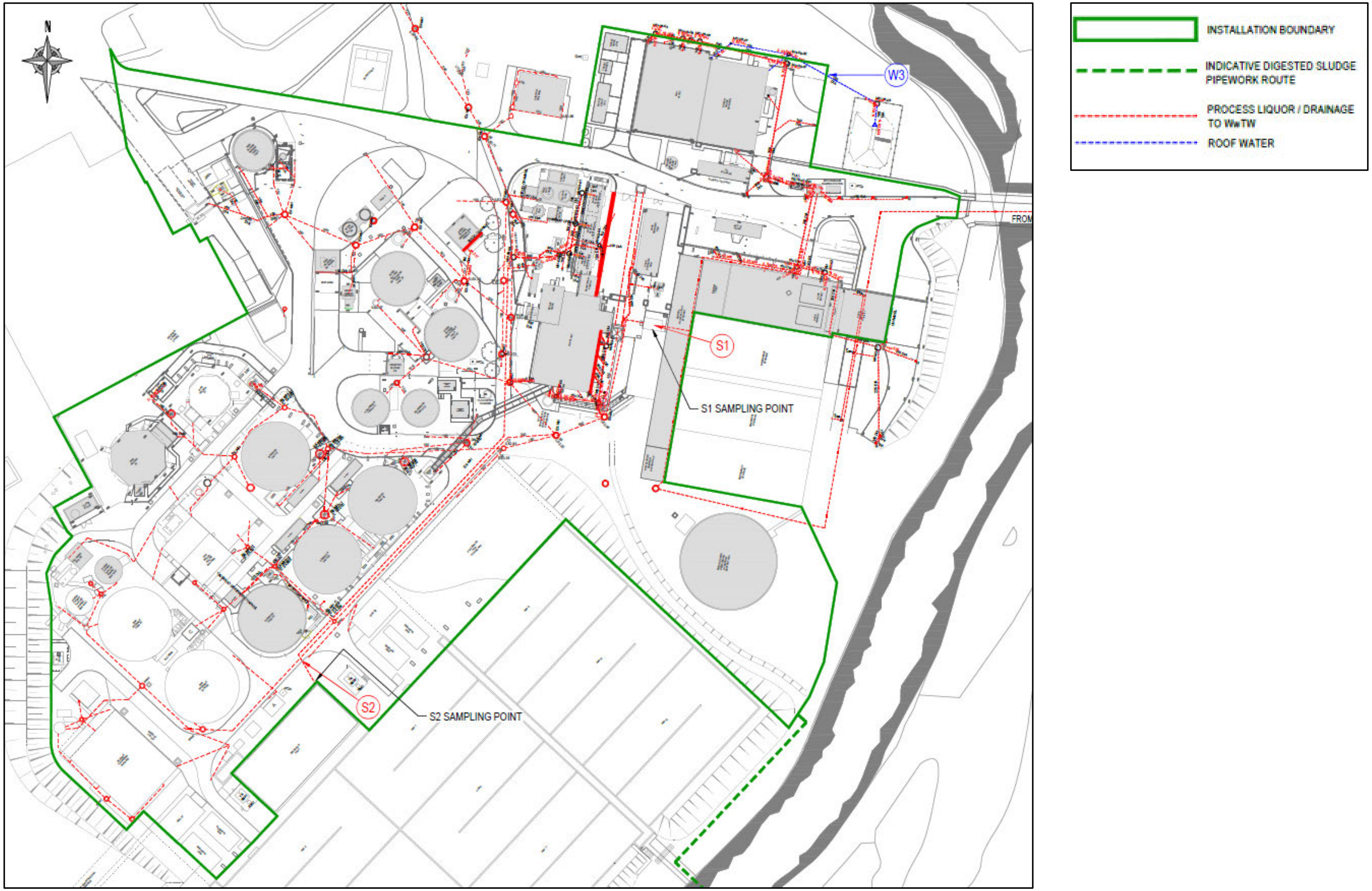



*Figure 36. Drainage in main AD area.*

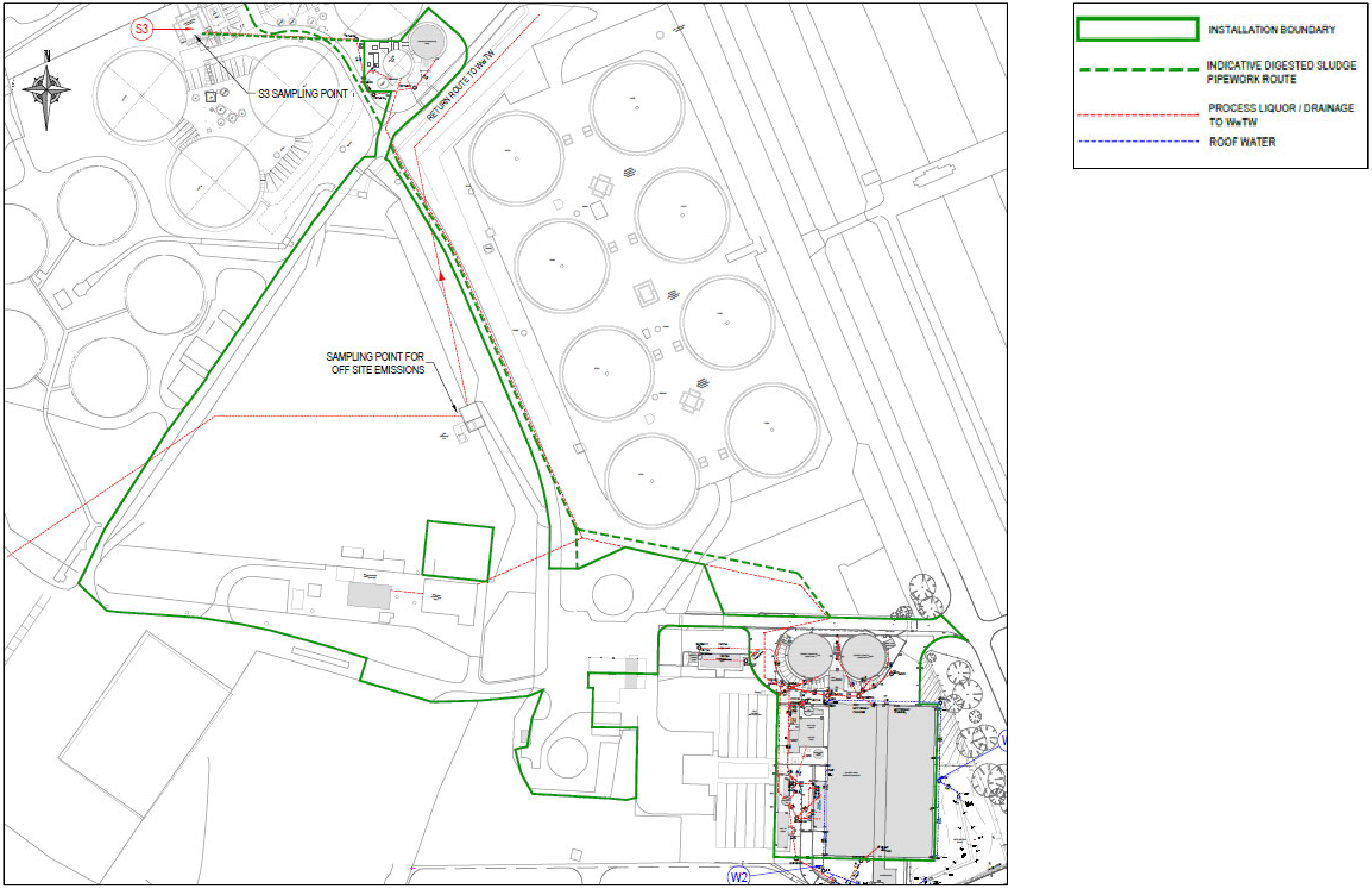



*Figure 37. Drainage in DW area.*

### 3.6.2 Spill pathway summary

The table below lists the resulting pathways associated with tank failure at Esholt determined using the PondSIM model. Full model results are presented in Section 3.5.

*Table 3. Surface pathways from the key assets at Esholt.*

| Area | Tank / Tank Area | Surface Pathways | Comments |
|---|---|---|---|
| AD Area | Sludge screen feed tank (1 no.)<br><br>Consolidation tank 5 (1 no.)<br><br>Mixed sludge tanks (2 no.)<br><br>SAS storage tanks (2 no.)<br><br>Thickener polymer tanks (3 no.)<br><br>SAS transfer tanks (2 no.)<br><br>THP polymer tanks (3 no.)<br><br>THP feed silos (2 no.)<br><br>THP feed hopper (1 no.)<br><br>THP reactor vessels (6 no.)<br><br>Digestate buffer tank (1 no.)<br><br>Digesters (4 no.)<br><br>Degassing tanks (2 no.) | Overland run-off over mostly sealed surface to:<br><br>• North of the site surrounding the CHP plant and control building.<br><br>• East of the mixed sludge tanks surrounding the THP plant.<br><br>• North of the ASP unit and surrounding the westerly section of consolidation tank 5.<br><br>• Under limited circumstances, from SE side of consolidation 5 tank, over grassed area and into former drainage ditch. | Principal spill volume captured on existing site hardstanding area adjacent to THP plant.<br><br>Some spill pooling on permeable grassy section near ASP and consolidation tank 5.<br><br>Surface water drainage in this area is connected to the main WwTW.<br><br>Spill from the main AD area and consolidation tank 5 to drainage ditch over topples existing earth bunds, therefore a route to river exists. |
| DW Area | Export dewatering tanks (2 no.) | **DW Area 2**<br>Overland run-off to:<br><br>• Northwest, west and south area of the sludge cake storage barn. | Spill flows and is captured on a mix of existing site roads, hardstanding, and a small section of grassy area south of the barn in DW area 2.<br><br>Surface water drainage in these areas is connected to the main WwTW. |
| | Conditioning feed tanks (2 no.) | **DW Area 1**<br>South tank overland run-off to:<br><br>• South of the site through earth bank into River Aire. | South tank spill flows across permeable grassy area, between mound and into the River Aire in DW area 1. |
| | | **DW Area 4**<br>North tank overland run-off to:<br><br>• North of the site to areas around FSTs | North tank spill flows down grassy bank and surrounds the FSTs on areas of gravel and hardstanding surfaces in DW area 4. There is no surface drainage for the hardstanding sections around the FSTs, surface water will run off into the gravel. |
| | Centrate balance tanks (2 no.) | **DW Area 3**<br>Overland run-off to:<br><br>• South westerly leading to and surrounding trade effluent treatment assets. | Spill mostly flows across hardstanding and road surfaces and surrounds the humus tanks treating trade effluent in DW area 3.<br><br>There is no surface drainage for around the humus tanks, surface water will run off into the gravel. |

## 3.7 Receptors

To complete the source pathway receptor model, a review of sensitive receptors was conducted. These were identified based on judgement, modelling results and potential flow paths which may take any cardinal direction. Figure 38 shows the receptors identified which could theoretically be impacted by a loss of containment of process vessels at Esholt.

Table 4 lists the type of pathway potentially leading to each receptor e.g., indirect, such as via FSTs or permeable surfaces or direct to the environment, e.g., a flow path into the River Aire.

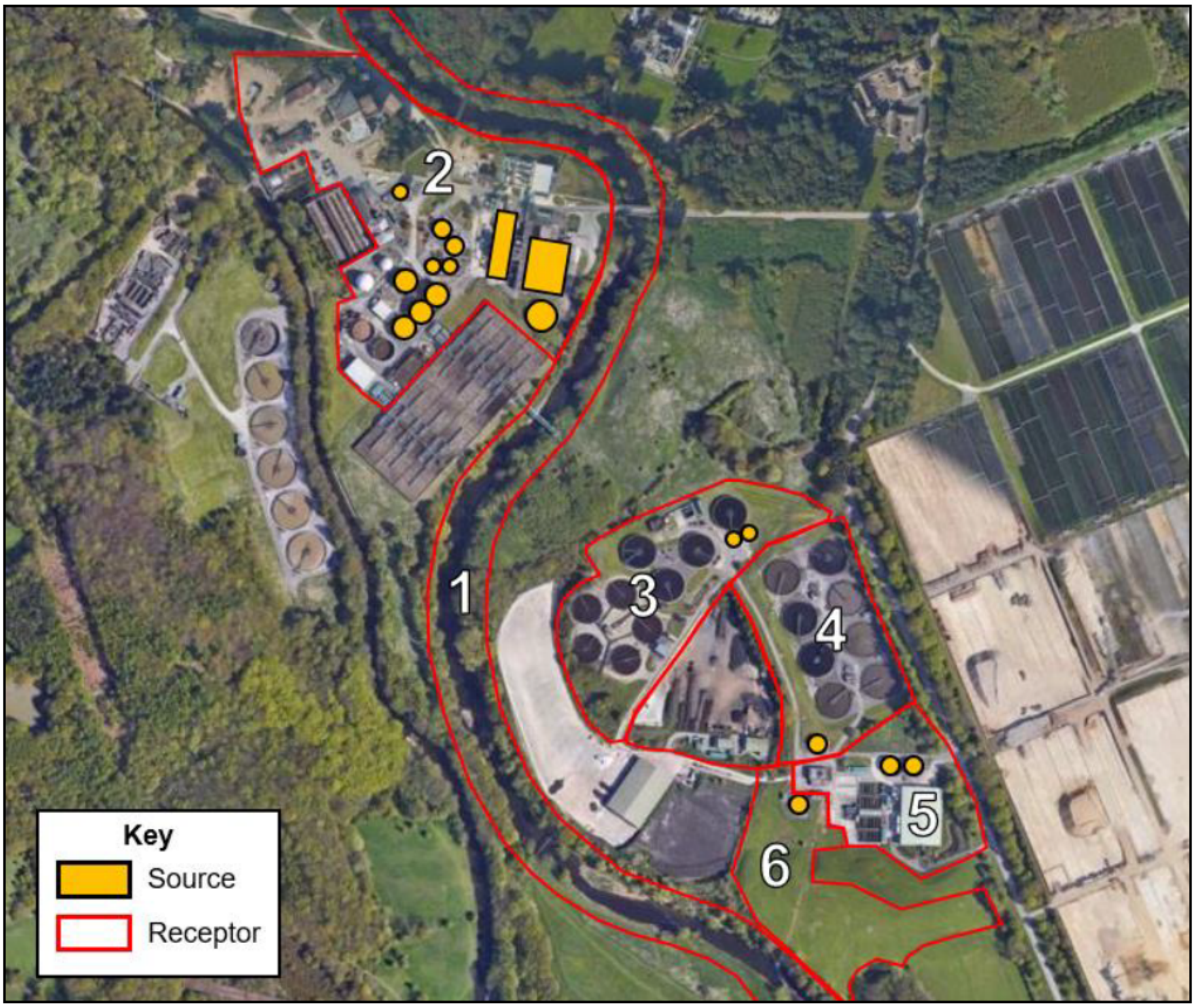



*Figure 38. Map of numbered receptors at Esholt. © Google, 2021*

*Table 4. Receptors*

| Receptor No. | Receptor |
|---|---|
| 1 | River Aire (including adjacent habitats). |
| 2 | Ground / groundwater – areas within the AD Area (sludge screening, pre-treatment, digestion area). |
| 3 | Ground / groundwater - area around liquor treatment assets and humus tanks (DW Area 3). |
| 4 | Ground / groundwater - areas around final settlement tanks (DW Area 4). |
| 5 | Ground / groundwater - areas around export dewatering tanks and sludge barn (DW Area 2). |
| 6 | Ground / groundwater - areas south of south conditioning tank (DW Area 1). |

### 3.8 Source-pathway-receptor summary

The outcome of the source pathway receptor identification is summarised in Table 5.

*Table 5. Source-pathway-receptor summary*

| Area | Tank / Tank Area | Pathways | Receptors at risk |
|---|---|---|---|
| AD area | Sludge screen feed tank (1 no.)<br>Consolidation tank 5 (1 no.)<br>Mixed sludge tanks (2 no.)<br>SAS storage tanks (2 no.)<br>Thickener polymer tanks (3 no.)<br>SAS transfer tanks (2 no.)<br>THP polymer tanks (3 no.)<br>THP feed silos (2 no.)<br>THP feed hopper (1 no.)<br>THP reactor vessels (6 no.)<br>Digestate buffer tank (1 no.)<br>Digesters (4 no.)<br>Degassing tanks (2 no.) | Overland run-off over mostly sealed surface to:<br>• North of the site surrounding the CHP plant and control building.<br>• East of the mixed sludge tanks surrounding the THP plant.<br>• North of the ASP unit and surrounding the westerly section of Consolidation tank 5.<br>• SE side of Consolidation 5 tank, over grassed area and over former drainage ditch into River Aire. | • Receptor 1 – River Aire (including adjacent habitats).<br>• Receptor 2 - Ground / groundwater areas within the AD Area (sludge screening, pre-treatment, digestion area). |
| DW area | Export dewatering tanks (2 no.) | **DW Area 2**<br>Overland run-off to:<br>• Northwest, west and south area of the sludge cake storage barn. | • Receptor 5 - Ground / groundwater - areas around export dewatering tanks and sludge barn (DW Area 2). |
| | Conditioning feed tanks (2 no.) | **DW Area 4**<br>North tank overland run-off to:<br>• North of the site to areas around FSTs | North tank:<br>• Receptor 4 - Ground / groundwater - areas around final settlement tanks in DW area 4.<br>• In the event of surge; Receptor 5 - Ground / groundwater - areas around export dewatering tanks and sludge barn (DW Area 2). |
| | | **DW Area 1**<br>South tank overland run-off to:<br>• South of the site through earth bank into River Aire. | South tank:<br>• In the event of surge; Receptor 5 - Ground / groundwater - areas around export dewatering tanks and sludge barn (DW Area 2).<br>• Receptor 6 - Ground / groundwater - areas south of south conditioning feed tank (DW Area 1).<br>• Receptor 1 - River Aire (including adjacent habitats). |
| | Centrate balance tanks (2 no.) | **DW Area 3**<br>Overland run-off to:<br>• South westerly leading to and surrounding trade effluent treatment assets. | • Receptor 3 - Ground / groundwater area around liquor treatment assets and humus tanks (DW Area 3).<br>• Receptor 1 - River Aire (including adjacent habitats). |

### 3.9 Mitigation solutions

An iterative process was completed to develop bunding options that provide environmental protection in accordance with CIRIA C736, including different methods for achieving impermeable surfaces within the bunded area. Determination of the preferred solution considered financial viability, sustainability to reduce impacts from embodied carbon and availability of materials to allow timely implementation given the timeframes of meeting compliance.

The solutions identified is illustrated in Figure 39, Figure 40 and Figure 42 with further specification and dimensions given in Appendix Table 1. This solution achieves CIRIA C736 compliance, including approaches for improving the sustainability of construction in the following ways:

- **Bund height:** calculated using the CIRIA 25/110 percent rule, divided by the area encompassing the bunded area not including the footprint of tanks, buildings, and other obstructions. Rainwater handling was also considered.
- **Surge allowance:** CIRIA C736 table 6.3 specifies the freeboard required to protect against surge. Recognising these recommendations, an allowance of 0.25m for walling and 0.75m for earth works has been added to the bund heights to protect against surge.
- **Drainage**: all surface drainage infrastructure will be assessed during the design phase to confirm sufficient capacity is available to deal with rainwater falling into the bund.
- **Walling**: in-situ or pre-cast products are considered to allow for installation where space is limited and considers pre-existing walling as part of the installation.
- **Permeable areas:** all permeable areas of land (as represented in 3.3 Existing site surfaces, and shown within Figure 39, Figure 40 and Figure 42 as red areas) will be made impermeable using solutions such as poured concrete and matting or bentonite clay matting.
- **Ramps & flood gates:** will be used as required to provide access into bunds. Ramps are the preferred solution, as they provide access without affecting the integrity of the bund. Floodgates may be installed where the need for access is very infrequent, and installation of a ramp is not practical. Where floodgates are required an appropriate management system will be implemented to ensure an appropriate level of environmental protection is maintained when they are in use.
- **Hardstanding areas:** existing areas of hardstanding that will form part of the containment solution (in-situ concrete, access roads) will be assessed to ensure that they provide a level of containment consistent with the requirements of CIRIA C736.

YW have committed to install these containment solutions that complies with CIRIA C736, as discussed in the next section. The current preferred designs are shown below but may be subject to minor modifications and amendments during detailed design phase.

The total containment volume required within the bund was calculated as per Table 6. Following the CIRIA requirement to contain the larger volume of 110% of the largest tank or 25% of all tanks, bund volumes of 6,199 $m^3$, 1,764 $m^3$ and 1,100 $m^3$ are necessary for sludge containment within the AD area, DW areas 1,2 and 4, and DW area 3 respectively. Additional volumes will be allowed for freeboard to handle surge (Appendix Table 1).

*Table 6. Containment volume calculations.*

| Tank | Area | Hydraulically linked to another tank? | Volume m³ (per tank) | Total volume m³ (group) | 110% size m³ |
|---|---|---|---|---|---|
| 1 sludge screen feed tank | AD | No | 655 | 655 | 721 |
| Console tank 5 | | No | 1,250 | 1,250 | 1,375 |
| 1 mixed sludge tank (1 of 2) | | No | 1,200 | 1,200 | 1,320 |
| 1 mixed sludge tank (2 of 2) | | No | 1,130 | 1,130 | 1,243 |
| 2 un-thickened SAS storage tanks | | No | 2,155 | 4,310 | 2,371 |
| 1 thickening polymer tanks (storage) | | No | 10 | 10 | 11 |
| 2 thickening polymer tanks (make-up + prep) | | Yes | 3 | 6 | 6.6 |
| 2 thickened SAS storage tanks | | No | 400 | 800 | 440 |
| 1 pre THP centrifuges polymer make-up tank | | No | 25 | 25 | 28 |
| 1 post THP centrifuges polymer make-up tank (stream a) | | No | 16 | 16 | 18 |
| 1 post THP centrifuges polymer make-up tank (stream b) | | No | 1 | 1 | 1 |
| 2 THP feed silo | | No | 210 | 420 | 231 |
| 1 THP feed hopper | | No | 16 | 16 | 18 |
| 6 THP reactor vessels | | No | 23 | 136 | 25 |
| 1 digestate buffer tank | | No | 40 | 40 | 43 |
| 4 digesters | | No | 3,353 | 13,412 | 3,688 |
| 2 de-gassing tanks | | No | 685 | 1,370 | 754 |
| | | | Largest 110% size | | 3,688 |
| | | | Total volume | 24,797 | |
| | | | 25% of total volume | 6,199 | |
| 2 export dewatering tanks | DW 1,2,4 | No | 1,604 | 3,208 | 1,764 |
| 1 conditioning tank (1 of 2) | | No | 1,200 | 1,200 | 1,320 |
| 1 conditioning tank (2 of 2) | | No | 1,130 | 1,130 | 1,243 |
| | | | Largest 110% size | | 1,764 |
| | | | Total volume | 5,538 | |
| | | | 25% of total volume | 1,385 | |
| Centrate balance tanks (1 of 2) | DW3 | Yes | 400 | 1,000 | 1,100 |
| Centrate balance tanks (2 of 2) | | | 600 | | |
| | | | Largest 110% size | | 1,100 |
| | | | Total volume | 1,000 | |
| | | | 25% of total volume | 250 | |

Figure 39 illustrates a wide bunding solution for the AD area, particularly due to the number of STF tanks in this area and requirements for operational access of vehicles. The natural bowl shape of the sites topography is utilised, and the proposed mitigation protects potential inundation of spill within main access routes, including the direct route to the River Aire.

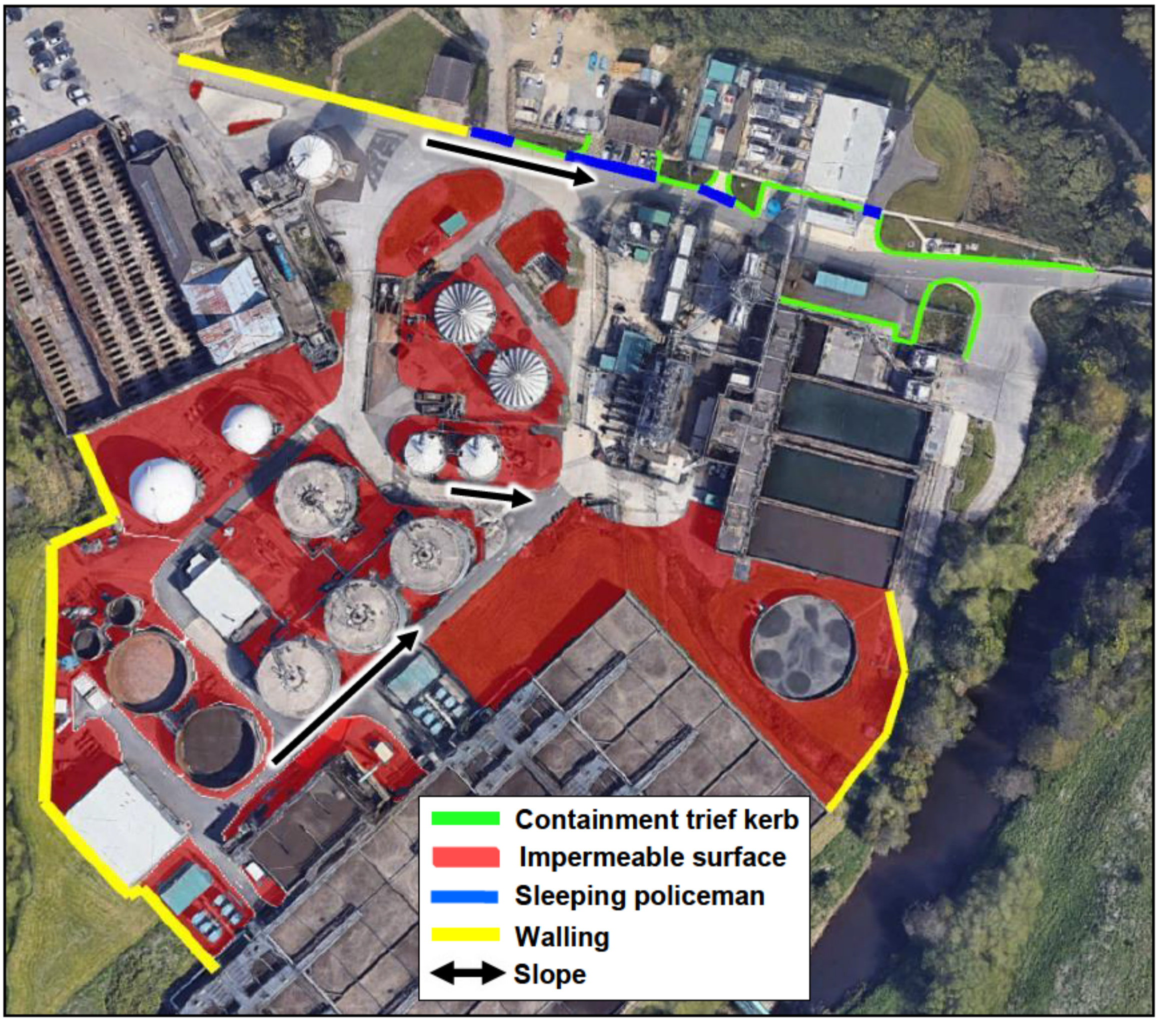



*Figure 39. Mitigation solution for Esholt AD area.*

Figure 40 illustrates a localised bunding solution for multiple tanks in the dewatering and cake barn area. Given the site topography the bunding boundary has been extended to utilise most of the flat surface available to avoid pooling against a section of bund wall where alleviation drops. Additionally, the cake barn has been utilised since it contains an engineered impermeable surface and using this approach increases the containment area sufficiently to reduce the wall height requirements and allow for sleeping policemen across the multiple access road entry points. The use of long ramps on access roads is not suitable in these areas as the turning circles for articulated lorries is tight and narrow. Furthermore, a sloping hardstanding access road is utilised as containment, this is evidenced in Figure 41, where the road shows a significant gradient with a retaining wall adjacent to the tanks.

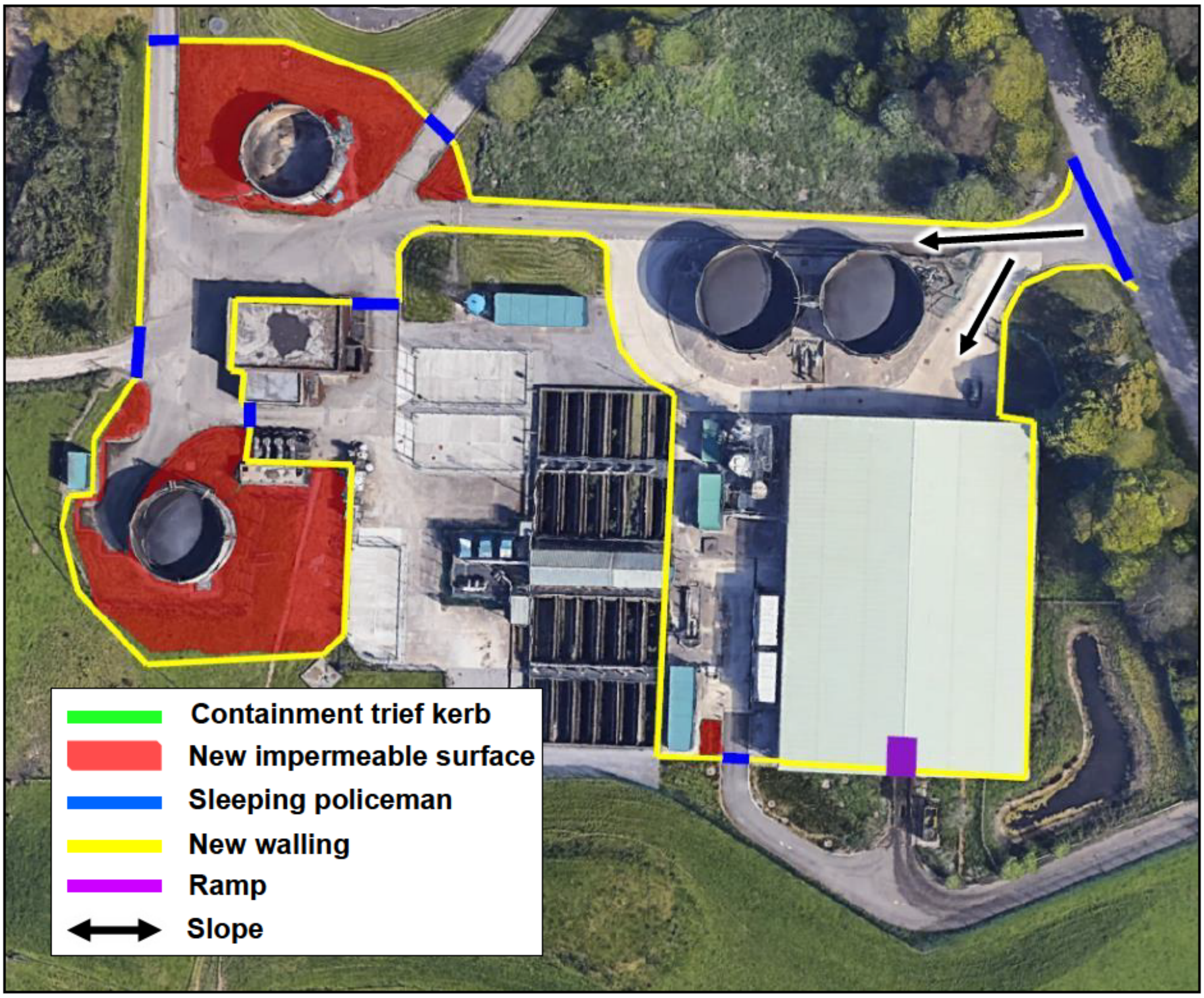



*Figure 40. Mitigation solution for Esholt DW areas 1,2 and 4.*

*Figure 41. Access road slope and retaining wall utilised within bunding solution.*

Finally, Figure 42, shows a mitigative solution for the centrate balance tanks (DW area 3). This solution is a localised bund wall with a sleeping policeman to maintain operational access. A localised bund was chosen as to keep a potential spill within the permit boundary.

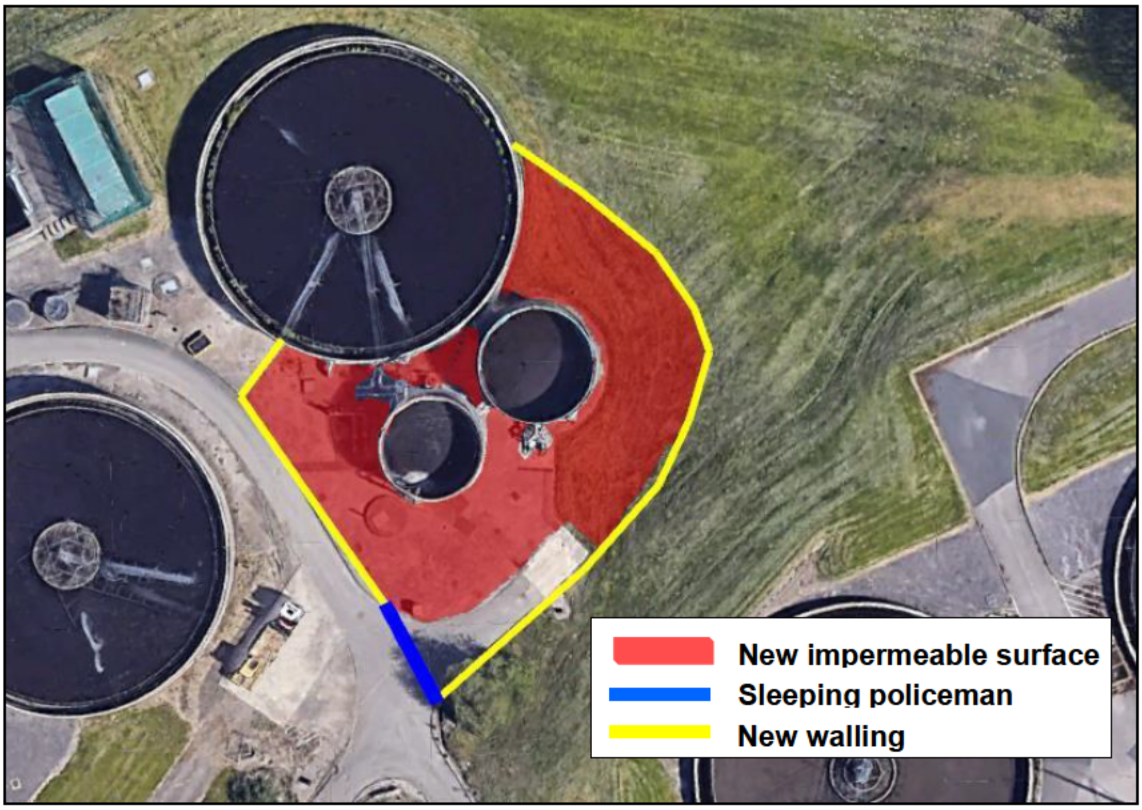



*Figure 42. Mitigation solution for Esholt DW area 3, centrate balance tanks.*

### *3.9.1 Surge*

The catastrophic collapse of a tank would lead to a rapid release of sludge which will then flow across the surrounding area. This is particularly true on steep gradients, which will encourage flow to travel further. As flow travels across flat ground, it will lose speed and the risk from surge will rapidly decrease.

Sludge released in this way will tend to flow over obstacles, but physics limits the height of barrier which it can pass. It is possible, but complex to calculate the extent of flow over obstacles using specialist software, but it would be prohibitively expensive to do this for every site where containment is being considered. The options considered within this document have been developed with surge protection as a key functional requirement and in the absence of detailed modelling, CIRIA C736 provides guidance on the additional height of bund wall (Figure 43), above settled spill level, that is required to ensure surge flow does not pass containment walls.

***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 |

*Figure 43. Surge protection requirements. Taken from CIRIA C736 pg. 54.*

Esholt is a large site, with significant distances between assets. The gradient of the site is relatively flat which means sludge has a reduced potential to travel a significant distance, furthermore the velocity of the flow is expected to decrease rapidly because of its rheology, ground conditions and surface drainage features.

A surge flow from south conditioning feed tank has been identified a potential for surge of sludge to flow over existing kerbing and enter a wet well containing final effluent, providing a pathway to the River Air. Figure 44 shows a mitigative solution in the form of legator concrete blocks that focuses on deflecting and redirecting any surge flows which travel in a northerly direction from the south conditioning feed tank towards the wet well and onto areas of hardstanding from where a full clean up can take place.

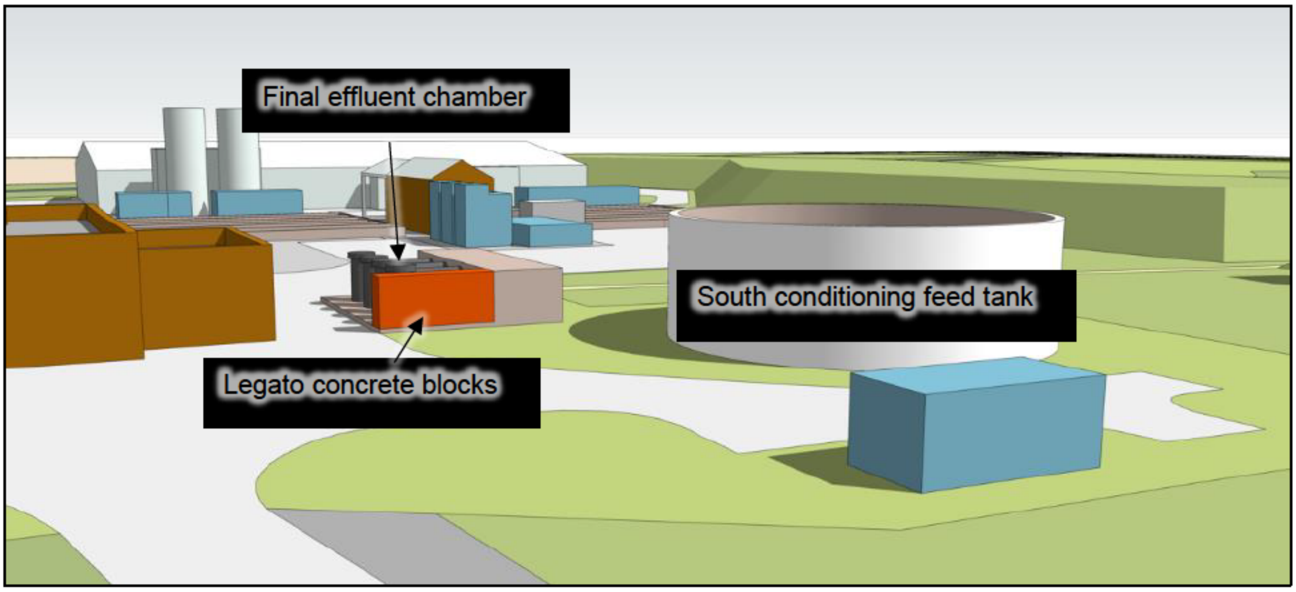



*Figure 44. South conditioning feed tank surge containment concrete wall solution.*

### 3.9.2 Jetting

The recently issued EA guidance on spills to permeable surfaces means YW is reconsidering its approach to jetting and recognises that surfaces which could receive a sludge spill because of tank failure will require an impermeable surface. This means tank leaks, including jetting, within the tank locations at Esholt will be contained as the immediate and surrounding surfaces will be made impermeable.

The risk of environmental harm as a result of jetting from these tanks has been assessed as low for the following reasons:

- YW design, construction and monitoring controls ensure tanks are constructed to a high standard and would identify any critical weaknesses at an early stage, and well before catastrophic failure occurred.
- The concrete tank construction means that formation of a hole large enough to allow jetting, but small enough to avoid total tank collapse is hard to envisage. If failure were to occur, it is much more likely to initially show as cracking, giving time to respond before significant sludge escaped.
    - A technical note has been provided in Appendix 3 that validates the failure mechanism of a tank constructed from concrete.
- The sludge in the concrete digesters is relatively viscous and this is likely to reduce the extent of jetting as viscous materials will travel relatively slowly through an orifice.
- The most likely cause, albeit it still very unlikely, of a tank wall puncture that would allow jetting is a direct impact. If this were to happen, it would almost certainly be at ground level. The impermeable surfaces and trief kerbing which YW have committed to build would contain this kind of release, deflect the sludge from infiltrating permeable land and protect the sensitive receptors.

Yorkshire Water understand that while risk is low, consideration of jetting remains a requirement of CIRIA C736.

The blue circles in Figure 45, Figure 46 and Figure 47 show areas which could be affected by jetting from external non-bunded tanks. These have been calculated according to CIRIA C736 guidelines, Appendix 4.

Within the AD area, Figure 45 shows that jetting will be contained within the bunded area and will land of either existing hand standing/ road surfaces or new sections of impermeable surfaces (red areas). The drainage system is believed to have sufficient capacity to deal with the relatively high volume, but short duration, flow typical of a jetting event, this will be confirmed during detailed design work on the bund area.

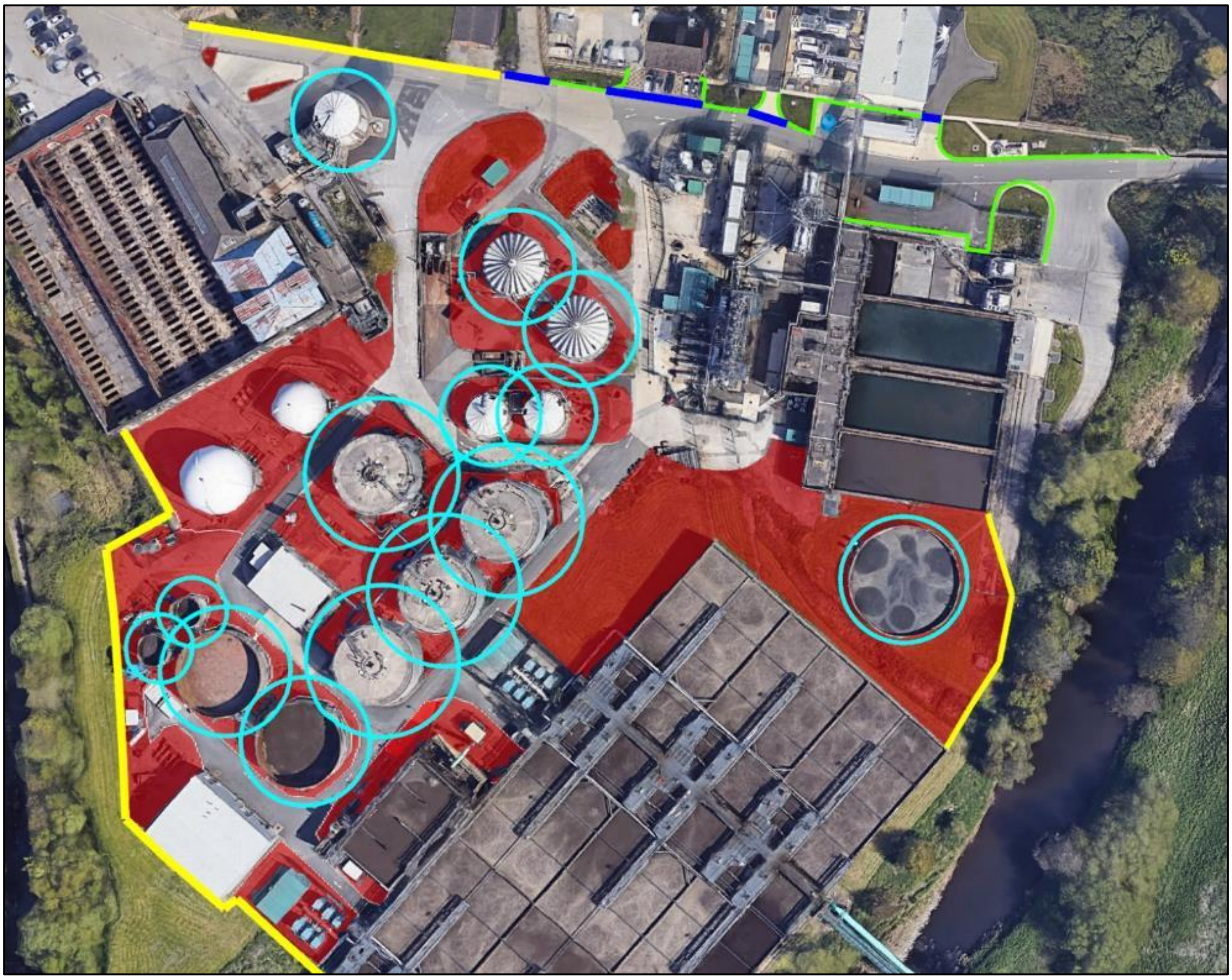


*Figure 45. Jetting potential in the AD area (blue circles).*

There are two jetting concerns within the DW area. Figure 46 and Figure 47 show a slight overlap of the jetting areas of the export dewatering tanks to the adjacent new walling, and northern centrate balance tank adjacent to the settlement tank. The walling section here will be made taller to accommodate the increased risk of jetting overtopping the new bund walling and settlement tank respectively. To satisfy the CIRIA C736 jetting calculation (Appendix Figure 2) the 0.45m bund wall adjacent to the export dewatering tanks, which is adequate in contain a spill in this area will be raised at least 1m high as mitigation. Similarly, to provide sufficient jetting protection from the centrate balance tank the existing settlement tank lip walling will be increased by also 1m.

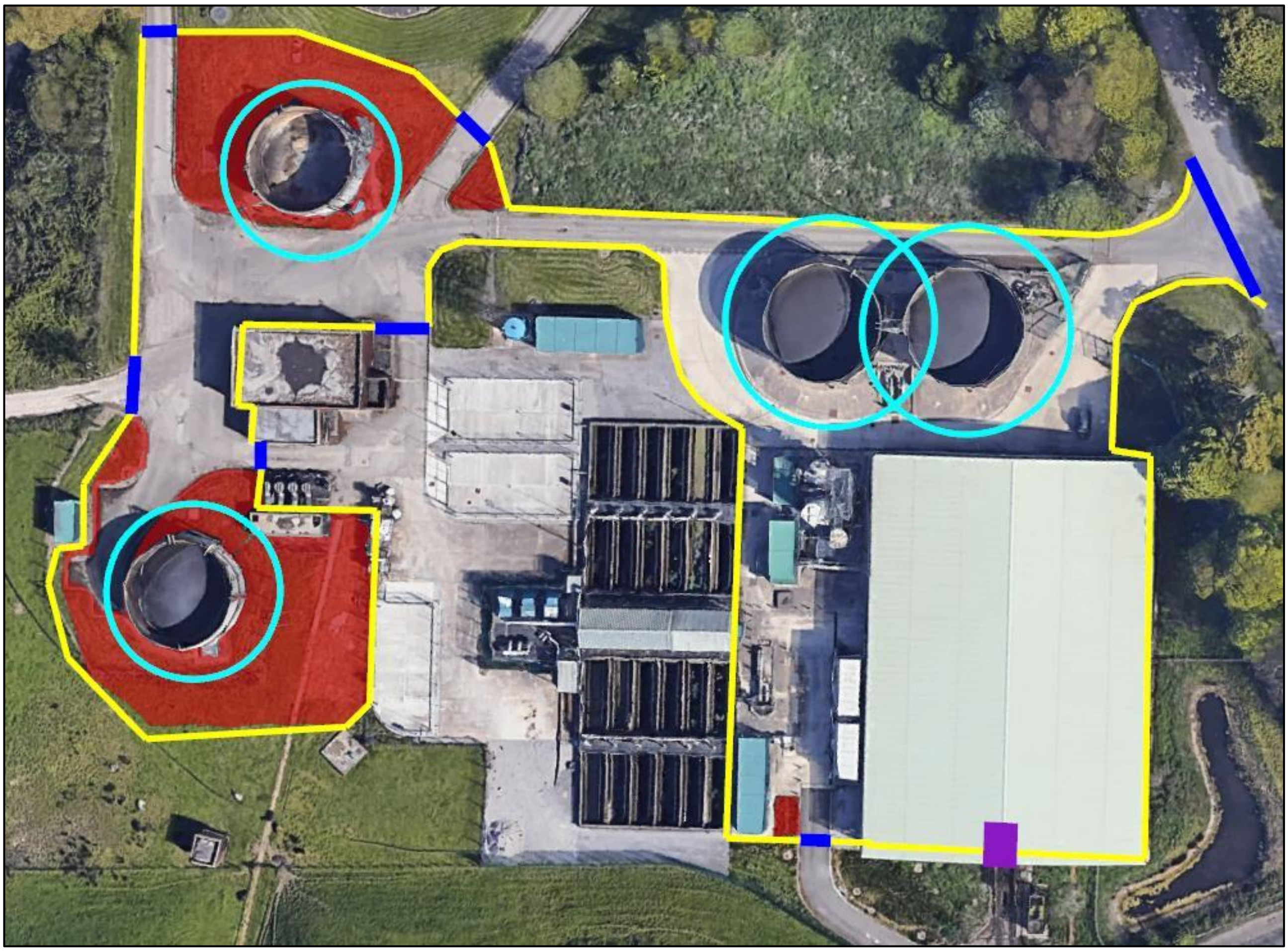


*Figure 46. Jetting potential in the dewatering and cake barn area (DW areas 1,2 and 4) (blue circles).*

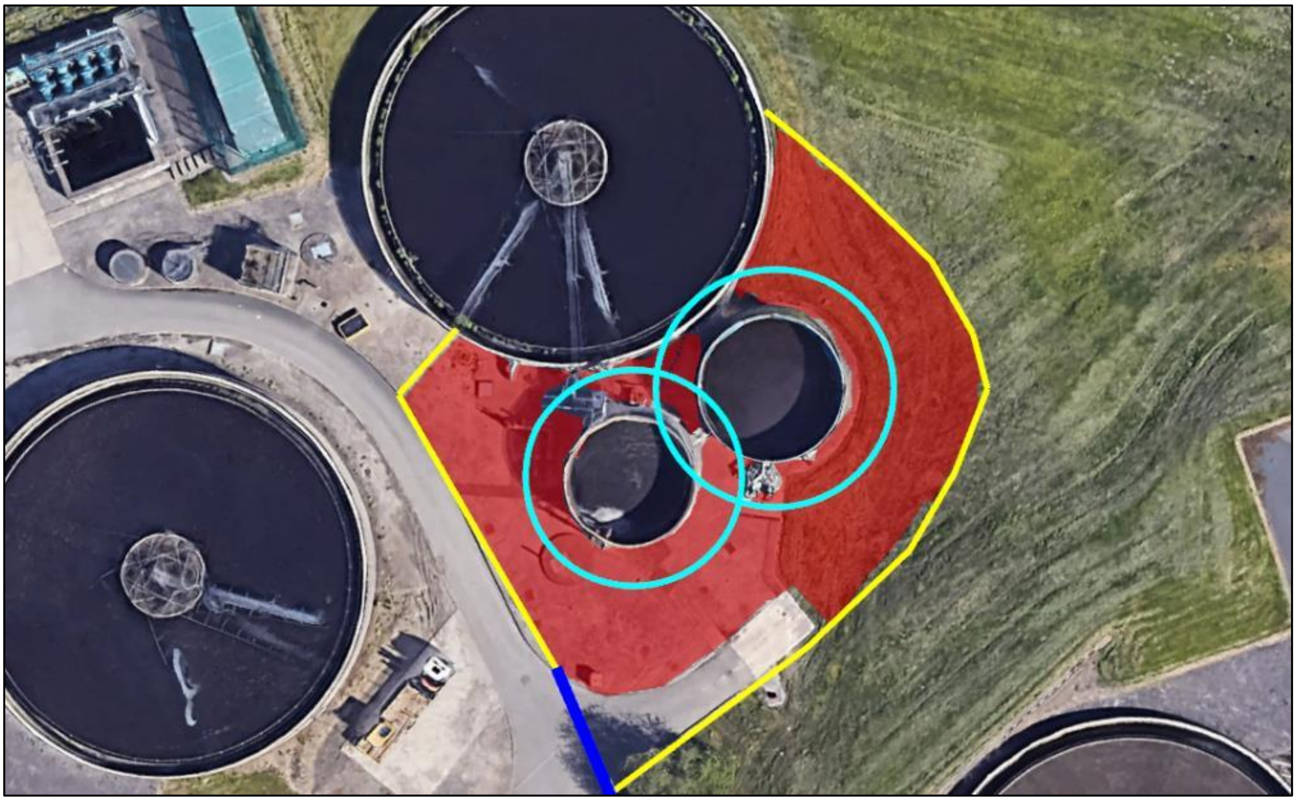


*Figure 47. Jetting potential in the dewatering area, centrate balance tanks (DW area 3) (blue circles).*

In summary, all tanks in the AD area show no risk of jetting directly or indirectly into sensitive receptors. Whilst there are two areas of concern in the DW area. Additionally, land that could be affected by jetting i.e., the area within the blue circles will have an impermeable surface, protecting the underlying ground from contamination. It is also important to note the screen feed, consolidation, digesters (with aluminium cladding and insulation), degassing, conditioning feed and northern centrate balance tanks are constructed of concrete. Concrete is a structurally robust material, but in the unlikely event that it does start to fail, it would typically crack rather than develop a hole. This would lead to a very slow release of contained material, not a long jet of liquid. See Appendix 3 for additional information on this.

YW understand the CIRIA C736 requirements linked to jetting, their relevance to environmental protection and commit to complying with CIRIA736 requirements on jetting as part of secondary containment design.

### 3.10 CIRIA C736 compliance and construction

The secondary containment solution at Esholt will be implemented by contractors chosen via YW's procurement process. This process is designed to ensure contractors have the knowledge and experience to build a secondary containment solution that complies with CIRIA C736.

The effectiveness of the containment and jetting solution will be confirmed using a 3D model and spill modelling software. YW will confirm that the final bunding solution is acceptable to the EA prior to commencement of the build.

# 4 Preventative maintenance and inspection regime

## 4.1 Above ground tanks

All tanks are tested and inspected as part of initial construction quality assurance checks; an example of a tank check is shown in Appendix 6.

The tanks at Esholt are regularly inspected by a qualified engineer. As part of these inspections, the reinspection period of each tank will be determined by the inspection engineer (anywhere from 6-months to 3 years depending on the condition of the tank). Any defects identified during inspections will be actioned and remedial works carried out as soon as possible.

Visual checks on tanks also form part of daily/weekly operational checks. These ensure that any damage or major degradation of tanks is identified as a risk and is reported before a hazard can develop.

## 4.2 Below ground level tanks/chambers

Yorkshire Water understand the environmental risk associated with underground structures and are committed to identifying and rectifying any leaks from them at the earliest possible opportunity. To support this aim, YW commit to the following:

- Daily visual inspection (Mon-Fri on certain sites) of subsurface tanks, wells, and surrounding ground by site operational team. These checks will identify major structural issues visible above liquid/ground level and any changes in ground conditions.
- Monthly visual inspection of subsurface tanks, wells, and surrounding ground by a technically competent manager.
- Apply additional monitoring.
    - Three monitoring techniques have been identified as appropriate for subsurface tanks/chambers. For each subsurface, liquid containing structure, the single most appropriate monitoring technique will be confirmed and implemented.
        - Borehole monitoring – sampling of up- and down-hydraulic gradient boreholes located around a tank perimeter will allow leaks from the tank to be detected and investigated as required. Following an initial period of monitoring to establish a baseline, trigger levels will be set and agreed with the EA.
        - Drop testing - the chamber/tank will be filled to normal maximum operating level, covered to prevent loss by evaporation, and left for 24 hours. For each tank an acceptable drop in level will be specified, if this is passed during the test, a repair will be completed
        - Empty and inspect – tanks will be emptied, cleaned and a visual inspection completed.
- Risk assessments in line with CIRIA C736 will be completed to confirm inspection frequencies on all subsurface tanks.
- Repair timescales.
    - Where a leak is detected using any of the above techniques, YW will isolate the source of the leak e.g., empty or bypass the tank as soon as practicable, with a target time of less than 14 days. The tank will not be returned to service until a repair has been completed

The use of inlet/outlet flowmeters to detect leaks has been considered, but the large volumes of flow passing through pipes combined with accuracy limitations of the instrument mean that leaks are likely to have already had an environmental impact, visible at ground level, by the time they are large enough to be detected. On this basis YW do not consider flow comparison to be a useful tool for leak detection

## 4.3 Pipe bridge

Digested sludge from the main AD area at Esholt is transferred to the dewatering area via a pipe. The pipe route includes a crossing over the river Aire. If this pipe were damaged, it is likely that there would be a significant release of sludge directly into the river Aire.

YW recognise that this presents an unacceptable environmental risk and commit to installing secondary containment on existing single-skinned pipework carrying liquids entirely related to sludge treatment over the pipe bridge at Esholt by the end of 2024.

## 4.4 Underground pipes

To mitigate the risk of failure of underground pipework, e.g., cracks and splits, surveys are completed using in-pipe crack detection technology every 2 years if mechanical joints are present, and 5 years if they are not. For future pipe installations, underground pipework will be avoided. Where this is not possible, pipes will be installed with secondary containment and leak detection.

In the event of an incident/ accident a team will be deployed immediately to isolate the damaged pipe and a spill management procedure will be followed. Thereafter, repairs to the damaged pipework will be arranged. Additionally, the incident will be logged, and hazard assessed to reduce or eliminate the risk of occurrence.

## 4.5 Impermeable surfaces

Appropriate containment of potential spills in large part relies on capturing them on impermeable surfaces that protect underlying ground. At Esholt these surfaces are typically made of concrete and YW are committed to keeping these in good condition to ensure that any potentially polluting liquids cannot pass the impermeable layer. The most likely path for liquids is through cracks and other damaged areas.

Responsibility for monitoring the condition of impermeable surfaces sits with two roles within YW.

- Site operators will carry out daily visual inspection of impermeable surfaces as part of their normal duties.

- The Technically Competent Manager (TCM) with responsibility for the site will carry out a monthly inspection of impermeable surfaces.

Where damage is identified a high priority job will be raised for repairs to be completed through the YW reactive maintenance system. In cases of severe damage, temporary protection will be installed around the damaged area to ensure that effective liquid capture is maintained.

# 5 Implementation and timescales

## 5.1 Monitoring

- At present YW do not have any boreholes installed for leak detection. YW commit to completing site surveys to confirm where these are an appropriate monitoring technique by 31st November 2023.
- After completion of surveys, YW commit to providing the EA with an updated list of all subsurface tanks, with detail of monitoring technique, frequency and how results will be recorded by 31st November 2023.
- YW commit to supplying detailed procedures covering the three key monitoring techniques of borehole testing, drop testing and emptying and inspection, by 31st November 2023.

## 5.2 Construction

A plan outlining the implementation of containment solutions identified is shown in Table 7. The timescales and estimated dates are indicative, and subject to timely external contract appointment, including acceptance of the procedures and ideal weather conditions for construction. Furthermore, bottlenecks, such as resource availability due to ongoing number of installations has not been factored in. These will be revisited once contractors are appointed, and capacities understood.

*Table 7. Secondary containment implementation stages and schedule.*

| **Stage** | **Estimated date complete** |
|---|---|
| Procurement, tender and award of contractor for outline bunding design | 28th February 2023 |
| Completed outline design | 1st July 2023 |
| Procurement, tender and award of contractor for detailed bunding design | 1st September 2023 |
| Completed detailed final design | 1st Jan 2024 |
| Commence construction | 30th April 2024 |
| Complete construction | December 2024 |

# 6 Conclusions and recommendations

This study has considered risks associated with credible worst-case loss of containment scenarios in each of the two main working areas of the Esholt STF installation, through the adoption of the widely used source-pathway-receptor model. A computation modelling study has been undertaken, which has adopted conservative assumptions to address known limitations of this type of modelling tool. This enabled the potential effects of a substantial, unmitigated loss of containment to be considered; in doing so a need for enhanced mitigation was identified to achieve an equivalent level of environmental protection for the identified sensitive receptors (the metric of compliance being an equivalence to a traditional 25 / 110 per cent capacity secondary containment bund in line with CIRIA 736 via the ADBA study).

An appropriately skilled and experienced working group was established to identify control options based on the application of engineering judgement. Selection of an appropriate solution for environmental protection through secondary containment at Esholt had to consider many different factors, including:

**Operability**

- The construction of a standard, complete concrete bund around all tanks within the STF would introduce significant operational issues around vehicle access to those assets and a health and safety risk in the event of a catastrophic failure associated with potentially trapped personnel.

**Buildability**

- Adding secondary containment to an existing, operational, site presents significant challenges. Whilst a solution may 'on paper' present itself as a viable and effective candidate option, reality and practicality dictates that it must be deliverable, or it would not fall under the 'available' definition of BAT.

**Likelihood**

- Whilst the potential for catastrophic tank failure can never be wholly mitigated when sites are operated with large tank inventories, the likelihood of substantial failure is very low, as evidenced by YW's own track record of operating sludge storage/treatment vessels across its asset base.
- In support of likelihood of failure YW has reviewed actual failure data. YW has over 40 years of experience in operating AD plants and STF's. YW has 14 AD sites. In this time YW has not experienced the catastrophic collapse of a storage vessel.
- YW has found from experience that 'failures' of concrete tanks are generally associated with ancillaries such as joints, waterstops, seals, etc, rather than any inherent defect with the actual civil structure. YW has experienced one incident of note, and this was at Hull STF digester number 5. This example is a case in point; the release of sludge that occurred was caused by the failure of a 'link seal' mechanical coupling that should have provided a watertight seal around the outside of a mixer pipe intrusion. In comparison with a catastrophic collapse scenario, this resulted in relatively controlled spill of small volume.

**Environmental impact**

- Receptors in the area must be protected from the effects of major sludge spills.
- The carbon impact of creating entirely impermeable containment areas is significant and counter to YW's aim of achieving net zero carbon emissions by 2030, it also potentially alters the catchment flow characteristics of what is a very large site in immediate proximity to a major river, with a demonstrable history of flooding in recent years.

Considering the conservative assumptions of the modelling (such as the viscosity of sludge compared to water) and the scoring approach which considers multiple decision factors including the significant carbon impact of the CIRIA 736 standard options, YW concludes that the identified combination of potential solutions will deliver an optimal balance between:

**Use of existing infrastructure**

  - Site drains in the AD area are able to return liquid to the inlet works for treatment, providing containment and flow mitigation.
  - The cake pad has been engineered to drain liquid contents, which returns to the inlet works of the WwTW, acting as remote containment.
  - For most spills, leaks and catastrophic pipe failures the site surfacing and drainage would transfer liquid to the WwTW, which would contain and minimise potential effects of loss of containment.

- **Continuation of the measures already in place** to minimise the likelihood of catastrophic failure of sludge vessels, through the use of stringent technical standards and regular visual inspections.

- **Minimising the potential impact to sensitive receptors** from sludge spills resulting from a worst-case scenario of catastrophic tank failure.

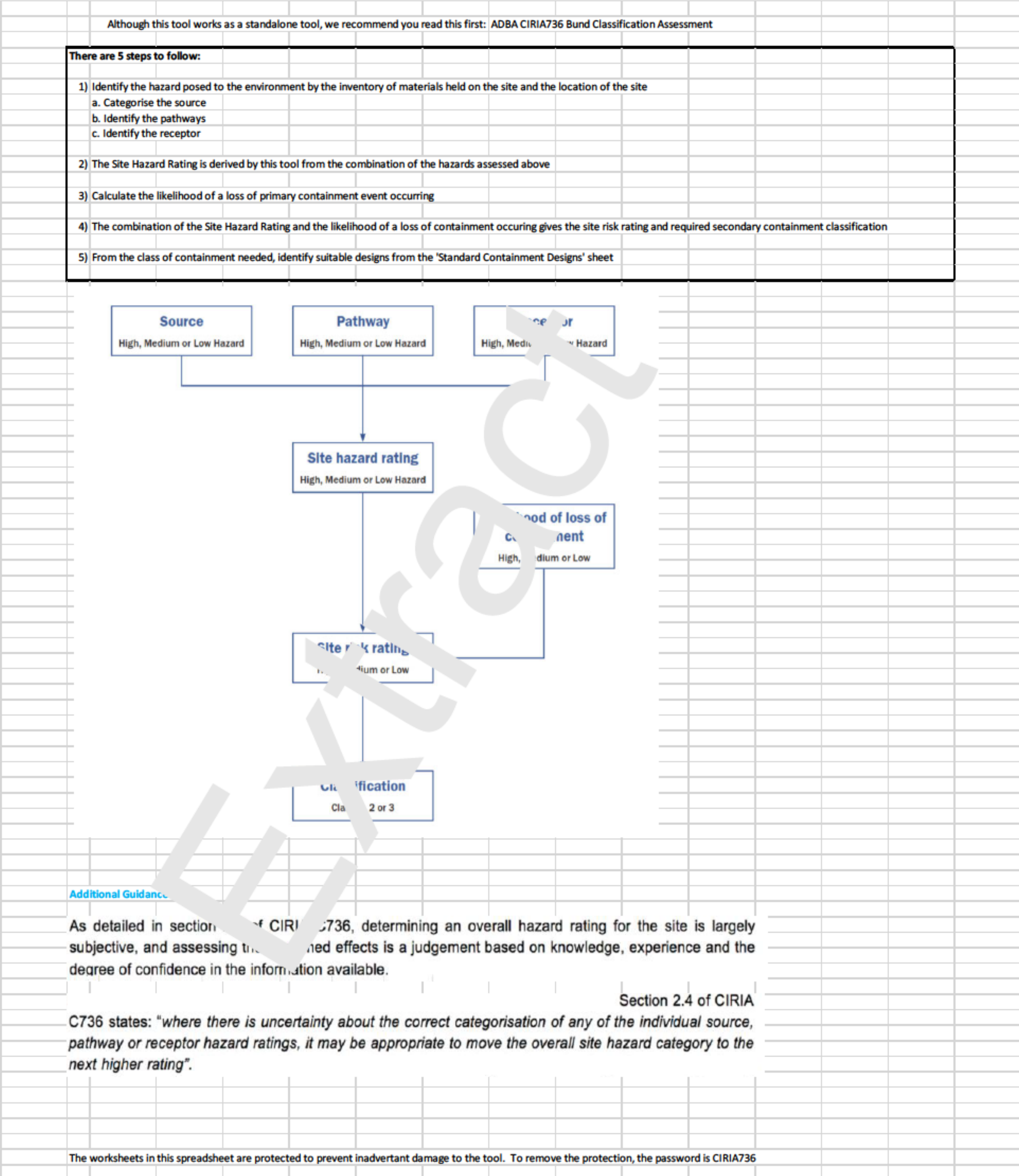
- **Reducing the carbon footprint** associated with the construction and operation of the solution; and

- Ensuring that the solution has **no negative health and safety implications** for staff on the site.

The study undertaken, although considered comprehensive and robust, does represent an initial feasibility / conceptual stage design exercise and extensive further work will be required to validate a solution for a potential build. Once it is confirmed that the preferred options put forward in this report are acceptable in principle to the EA, YW commits to commence a technical feasibility and detailed design study, with associated timetable for implementation of the resulting final mitigation measures. This will allow remaining uncertainties regard engineering integrity, modelled flow extents, design safety, cost engineering and constructability to be resolved.

# Appendices

# Appendix 1 - ADBA assessment tool


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 … of CIRI… 736, determining an overall hazard rating for the site is largely subjective, and assessing th… …ned 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 2 – CIRIA C736 compliant solution

*Appendix Table 1. Esholt bunding solution design specification and dimensions.*

| Category | Criteria | Unit | Value |
|---|---|---|---|
| **AD AREA** | | | |
| Design specification | CIRIA C736 spill volume [25/110%] | $m^3$ | 6,195 |
| | Bund perimeter length | m | 1,252 |
| | Total containment surface area | $m^2$ | 26,244 |
| | Maximum final spill depth | m | 0.24 |
| Bunding requirements | Concrete bund height | m | 0.49 |
| | Total concrete wall length | m | 1,252 |
| Build required | Required concrete walling length | m | 486 |
| | Impermeable surfacing area | $m^2$ | 11,072 |
| **DW AREAS (1,2,4) - Dewatering zone** | | | |
| Design specification | CIRIA C736 spill volume [25/110%] | $m^3$ | 1,764 |
| | Bund perimeter length | m | 640 |
| | Total containment surface area | $m^2$ | 9,009 |
| | Maximum final spill depth | m | 0.20 |
| Bunding requirements | Concrete bund/ sleeping policemen height | m | 0.45 |
| | Total concrete wall length | m | 640 |
| Existing bunding | Existing concrete walling length | m | 105 |
| Build required | Required concrete walling/ sleeping policemen length | m | 535 |
| | Impermeable surfacing area | $m^2$ | 2,325 |
| | No. ramps | | 1 |
| **DW AREA (3) - Centrate balance tanks** | | | |
| Design specification | CIRIA C736 spill volume [25/110%] | $m^3$ | 1,100 |
| | Bund perimeter length | m | 489 |
| | Total containment surface area | $m^2$ | 1,489 |
| | Maximum final spill depth | m | 0.74 |
| Bunding requirements | Concrete bund/ sleeping policemen height | m | 0.99 |
| | Total concrete wall length | m | 1,447 |
| Existing bunding | Existing concrete walling length | m | 42 |
| Build required | Required concrete walling / sleeping policeman length | m | 489 |
| | Impermeable surfacing area | $m^2$ | 1,116 |

# Appendix 3 – Structural integrity note for concrete tanks

## Technical Note

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Project: Yorkshire Water – IED

Title – Leakage of water through concrete sections.

Author – Imran Nawaz MEng CEng MICE

Date 08/06/2022

1. Introduction

This Technical Note discusses the possibility of concrete tank walls developing an aperture through which fluids could be ejected at speeds resembling a jet. In fluid terms a jet develops when laminar flow is achieved at significant velocity at 90 degrees from the plane of the aperture.

2. Concrete section construction

Concrete is formed from angular aggregate suspended in a matrix of cement paste and sand. Upon pouring and vibrating fresh concrete the aggregates settle at the bottom of the mixture while being fully surrounded and immersed in the cement and sand paste. During this process the excess water and cement paste rises to the top and careful mix design and match management is needed to ensure this paste is not too much or too little; in both cases the result would be poor surface finish and weaker concrete.

The final product is well compacted angular aggregate with a good degree of interlock bound by the hardened cement paste.

3. Concrete in service.

Concrete in service is subject to many effects that cause expansion and contraction. These include drying shrinkage as the water which is not chemically bound by hydration evaporates; autogenous shrinkage as the product of the chemical reaction takes up a smaller volume than the constituents; thermal strain; and differential settlement. In addition to these, the structural stresses in the concrete cause tension and bending, both of which cause a tension force in the concrete. All the effects described here contribute to cracks developing on the face and within the interior of the concrete. In all reinforced concrete section including those that are structurally sound, the concrete will crack and redistribute the tension force to the steel reinforcement by a combination of chemical bonding (between steel and cement paste) and aggregate interlock with the ribbed bars. Cracks are generally designed to be 0.3mm, although acceptable crack width will be less than 0.2m for water retaining concrete, which will allow water retention while keeping water egress through the cracks to a small an acceptable level.

4. Concrete deterioration.

Concrete hardens and strengthens over time as the hydration reaction continues along an asymptotic curve. However, processes such as chlorine attach, carbonation and freeze-thaw can cause weakening and deterioration of the concrete. In addition to this, acidity, ground conditions and the nature of the retained material within a tank can accelerate deterioration.

# Technical Note

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In extreme cases the effects of this can be:

- Severe weakening of the concrete leading to crushing failure.
- Severe delamination of surface layers over a great length exposing the steel reinforcement, causing it to corrode so the section fails in tension.
- Severe steel and/or concrete deterioration at junctions i.e., slab/wall/beam/column interfaces leading to shear failure and adjacent sections becoming detached.

Although exceedingly rare, the cases above describe total failure conditions. In these cases, leakage of fluids is not so much of a problem as structural collapse. Less extreme cases allowing water or fluid egress a tank are described below.

- Significant damage or corrosion to reinforcement leading to excessive crack width and significant leakage. In this situation the crack can be significant and even penetrate the full section of concrete wall. The water flowing through follows a tortuous path around the aggregate before it leaks out of the surface.
- Significant spalling and loss of material from a zone on the inside and outside of the concrete wall. In this situation the remaining thickness can retain the water. If this location also coincides with a crack, water will flow through a tortuous path as described above.

This type of damage allows water leakage, water jetting would not occur as long as a small intact section of concrete is present to impede laminar flow.

Considering the possibility of an aperture opening in the wall, this could in theory occur if spalling, and loss of cement and aggregate became so severe that it penetrated the section. Although it is not rare for severe material loss to occur, for conditions to be this aggressive they would affect a large area or the majority of the structure, causing significant loss of section leading to structural failure in stages preceding development of a full thickness aperture.

## 5. Conclusions

When the concrete is in service or subject to significant concrete deterioration, spalling and loss of section, the condition of laminar flow through an aperture will not develop.

Under severe concrete deterioration, any conditions approaching aperture formation will lead to structural failure before an aperture can form therefore the likelihood of this happening are considered to be negligible.

- End -

# Appendix 4 – CIRIA C736 jetting calculation

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:

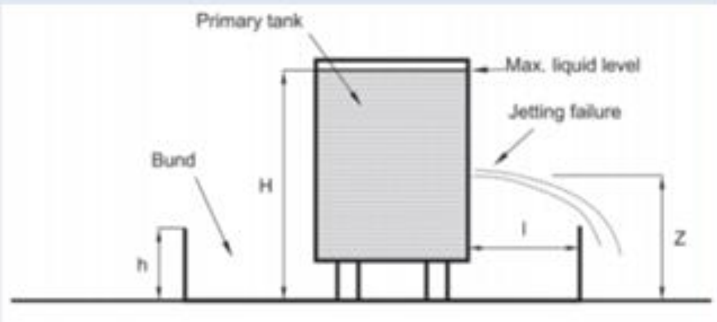
$$l^2 = [4(z-h)(H-z)]^{0.5}$$

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:

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




*Appendix Figure 2. CIRIA C736 jetting calculation to determine jetting solution.*

# Appendix 5 – Example tank inspection report

A full copy of the example document below is included as an attachment with the RFI response.

Form No: YW-INSP-FRM-1, Issue 1, 2018 08 09

**Yorkshire Water Limited**
**INSPECTION GROUP**

YorkshireWater

**EQUIPMENT INSPECTION REPORT**
*Knostrop Top Site New Sulphuric Acid Tank Inspection*

| | | | |
|---|---|---|---|
| Report Number: | KNO2-INSP-003 | Written Scheme No. | N/A |
| Equipment Number: | N/A | Category: | Visual |
| Service: | Sulphuric Acid Tank | Equipment Used: | Camera |
| P&ID Number: | N/A | Site Operator: | N/A |
| Associated IAN's | | Site Manager: | N/A |

**Inspection to be as defined in the INSPECTION MANUAL**

| Type of Inspection: | Scheduled Interval (months): | Date of Last Inspection (mth-YYYY): | Next Inspection Date (mth-YYYY): | Maximum Interval (months): |
|---|---|---|---|---|
| Thorough External Inspection: | 5 | Nov-2018 | March-2019 | 60 |
| Thorough Internal Inspection: | N/A | N/A | N/A | N/A |
| On-Stream Thickness Survey: | N/A | N/A | N/A | N/A |

An Opportunistic site visit to the Knostrop Top Site was undertaken on the 26/11/2018 on available equipment where access allowed. The purpose of the visit was to review the condition of the new Sulphuric Acid Tank after repairs to the Tee's was carried out by the manufacturer. The Plant was built in 2018, Due to be commissioned 2019.

The site is situated within the Knostrop Site Complex.

*Appendix Figure 3. Example equipment inspection report.*

# Appendix 12 Medium Combustion Plant Directive Requirements

## Form C2.5 Appendix 1 Specific questions for the MCP / SG

**Medium Combustion Plant checklist**

| MCP Site specific identifier | Bradford Esholt MCP CHP No. 1 (Guascor 200125) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418715 | 439542 |
| Rated thermal input (MW) | 1.53 | |
| Type of MCP | Combined Heat and Power (CHP), not designated as Specified Generator | |
| Type of fuels used | Biogas | |
| Date of first operation | 01/03/2009 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (this can vary depending on site electricity demand and bio-gas availability) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

| MCP Site specific identifier | Bradford Esholt MCP CHP No. 2 (Guascor 200126) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418715 | 439542 |
| Rated thermal input (MW) | 1.53 | |
| Type of MCP | Combined Heat and Power (CHP), not designated as Specified Generator | |
| Type of fuels used | Biogas | |
| Date of first operation | 12/03/2010 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (this can vary depending on site electricity demand and bio-gas availability) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

| MCP Site specific identifier | Bradford Esholt MCP CHP No. 3 (TCG 2020V16) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418715 | 439542 |
| Rated thermal input (MW) | 3.63 | |
| Type of MCP | Combined Heat and Power (CHP), not designated as Specified Generator | |
| Type of fuels used | Biogas | |
| Date of first operation | 18/11/2013 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (this can vary depending on site electricity demand and bio-gas availability) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

| MCP Site specific identifier | Bradford Esholt MCP CHP No. 4 (TCG 2020V16) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418715 | 439542 |
| Rated thermal input (MW) | 3.63 | |
| Type of MCP | Combined Heat and Power (CHP), not designated as Specified Generator | |
| Type of fuels used | Biogas | |
| Date of first operation | 18/11/2013 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (this can vary depending on site electricity demand and bio-gas availability) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

| MCP Site specific identifier | Bradford Esholt MCP Boiler 1 (Cochran) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418732 | 439537 |
| Rated thermal input (MW) | 6.2 | |
| Type of MCP | Boiler | |
| Type of fuels used | Gas oil (primary), Biogas (back up) | |
| Date of first operation | 03.01.2014 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8,424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (this depends on site demand) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

| MCP Site specific identifier | Bradford Esholt MCP Boiler 2 (Cochran) | |
|---|---|---|
| Grid reference of the location of the MCP | Easting | Northing |
| | 418732 | 439537 |
| Rated thermal input (MW) | 6.2 | |
| Type of MCP | Boiler | |
| Type of fuels used | Gas oil (primary), Biogas (back up) | |
| Date of first operation | 04.01.2014 | |
| Sector of activity (NACE code) | 3700 | |
| Expected number of annual operating hours of the MCP | 8,424 (this figure is assuming 2 weeks downtime for maintenance) | |
| Average load in use (%) | 100% (This depends on site demand) | |
| Where the option of an exemption… | N/A | |
| Stack height (m) | 15 | |
| Distance to nearest human receptor (m) | 200 m | |
| Distance to nearest ecological receptor (m) | 2km | |

# Appendix 2 Emission Limit Values

**To apply from 1 January 2025**

| New / Existing | Emission Point Ref | Source | Location | Emissions parameter | Quantity / unit[31] | | Techniques to minimise emissions |
|---|---|---|---|---|---|---|---|
| Existing plant | A2 | Boiler No. 1 (Gas oil or Natural Gas) | Energy Centre | NOx | 200 | Mg/Nm$^3$ | Low NOx burner |
| | A4 | Boiler No. 2 (Gas oil or Natural Gas) | Energy Centre | NOx | 200 | Mg/Nm$^3$ | Low NOx burner |
| | A2 | Boiler No. 1 (Biogas) | Energy Centre | NOx | 250 | Mg/Nm$^3$ | Low NOx burner |
| | | | | $SO_2$ | 170 | Mg/Nm$^3$ | Sludge management techniques |
| | A4 | Boiler No. 2 (Biogas) | Energy Centre | NOx | 250 | Mg/Nm$^3$ | Low NOx burner |
| | | | | $SO_2$ | 170 | Mg/Nm$^3$ | Sludge management techniques |

[31] CHP ELV applies at 15% O2

**To apply from 1 January 2030**

| New / Existing | Emission Point Ref | Source | Location | Emissions parameter | Quantity / unit[32] | | Techniques to minimise emissions |
|---|---|---|---|---|---|---|---|
| Existing plant | A5 | CHP 1 (Biogas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | | | | $SO_2$ | 60 | Mg/Nm$^3$ | Sludge management techniques |
| | A6 | CHP 2 (Biogas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | | | | $SO_2$ | 60 | Mg/Nm$^3$ | Sludge management techniques |
| | A1 | CHP 3 (Biogas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | | | | $SO_2$ | 60 | Mg/Nm$^3$ | Sludge management techniques |
| | A3 | CHP 4 (Biogas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | | | | $SO_2$ | 60 | Mg/Nm$^3$ | Sludge management techniques |
| | A5 | CHP 1 (Natural gas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | A6 | CHP 2 (Natural gas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | A1 | CHP 3 (Natural gas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |
| | A3 | CHP 4 (Natural gas) | Energy Centre | NOx | 190 | Mg/Nm$^3$ | Low NOx Combustion Control |

[32]. Boiler ELV applies at 3% O2

# Monitoring

## Describe the measures you use for monitoring emissions

### MCP Proposed emissions monitoring requirements

Monitoring will be undertaken within 4 months of the date of MCPD phase-in and will continue with the frequency indicated below.

| Emission point | Parameter | Monitoring technique | Monitoring frequency |
|---|---|---|---|
| **Emissions to air** | | | |
| A1 (previously N.A1) CHP 3 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |
| A2 (previously N.A2) Boiler 1 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |
| A3 (previously N.A3) CHP 4 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |
| A4 (previously N.A4) Boiler 2 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |
| A5 (previously N.A5) CHP 1 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |
| A6 (previously N.A6) CHP 2 | NOx (NO and $NO_2$ expressed as $NO_2$) | Extractive emissions testing in line with TGN M1 and BS EN 14792 | Every 3 years |
| | Sulphur dioxide ($SO_2$) | Extractive emissions testing in line with TGN M1 and EN 14791 | Every 3 years |
| | Carbon monoxide (CO) | Extractive emissions testing in line with TGN M1 and EN 15058 | Every 3 years |

# Appendix 13 Waste Pre-acceptance and Acceptance Procedure

# Waste pre-acceptance, acceptance and rejection Procedure for Anaerobic Digestion

YorkshireWater

## Document Control

| | |
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## Document Approval

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| **Document Owner (Author)** | **Document Approval Manager (Tier 3)** |

## Document Revision History

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| **2** | | | | |
| **3** | | | | |

**Business areas affected by this document**
This applies to colleagues that are operating an IED STF or colleagues moving sludge on behalf of Yorkshire Water (YW) into a YW Anaerobic Digestion (AD) Site. It may also be applicable to any YW colleague that wants to export an abnormal sludge load into an IED AD facility.

## 1. Introduction

This document details the waste pre-acceptance, acceptance and rejection procedures for wastes received for anaerobic digestion (AD) at the Sludge Treatment Facility (STF) located at Yorkshire Water (YW) Esholt Waste Water Treatment Works Site (WwTW).

This details how YW has established procedures that align with the guidance in the Best Available Techniques Reference (BREF) Document for Waste Treatment, for operational techniques to improve environmental performance.

This procedure is written using guidance produced by the Environment Agency on 'Biological waste treatment: Appropriate measures for permitted facilities' (September 2022).

### 1.1. Waste steams treated by AD

The YW IED AD facility treats only sewage sludges arising from waste water treatment works (WwTW). These non-hazardous waste water sludges arrive at the AD facility via two routes:

- ***Indigenous sludges***. Originating from the adjacent WwTW on the wider YW site and transferred to the AD facility via above or below ground pipes as liquid sludge.
- ***Imported sludges***. Arriving via sludge tanker from smaller WwTWs that have limited or no capacity for AD treatment. Imported sludges arrive as either liquid (typically 2-6%dry solids) or as cake (typically >16% dry solids).

No commercial waste will be treated at the STF.

The only wastes that will be accepted for AD will be the EWC code wastes listed in the environmental permit in schedule 2, table 2.2, reproduced in table 1 below.

| **19** | **Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use** |
|---|---|
| **19 02** | **wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)** |
| 19 02 06 | sludges from physico/chemical treatment other than those mentioned in 19 02 05 (sewage sludge only) |
| 19 08 | |
| 19 06 06 | digestate from anaerobic treatment of animal and vegetable waste (sewage sludge only) |
| **19 08** | **wastes from waste water treatment plants not otherwise specified** |
| 19 08 05 | sludges from treatment of urban waste water |

Table 1 –Permitted wastes

Table 2 provides a summary of the wastes accepted at the AD facility by waste stream, EWC code and origin.

| Waste Stream | EWC code | Origin |
|---|---|---|
| Indigenous sludges | 19 08 05 sludges from treatment of urban waste water | Sewage sludge arising from Esholt WwTW. |
| Imported sludges | 19 08 05 sludges from treatment of urban waste water | Sewage sludge originating from other WwTW sites, delivered directly to the AD facility by tanker, comprising raw sludge. |
| | 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05 | Thickened sludge arising from dewatering activities originating from other WwTW sites, delivered directly to the AD facility by tanker. |
| | 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05 | Sludge cake that may originate from other WwTW sites and is stored on Esholt cake pad as a contingency measure (Note 1). This sludge cake may be digested or undigested and require treatment at the AD facility. |

*Note 1: Sludge cake may need to be relocated for environmental protection reasons (e.g. flood risk to site) or if an unforeseen breakdown with the cake import facility has occurred.*

Table 2 – Description of wastes

### 1.2. Key site personnel and responsibilities

This document details the characteristics of the sludge to be treated and confirms the conditions in which the sludge would be rejected. It is a requirement of the site permit that this document is in place and adhered to.

It is the responsibility of the Site Manager, the Site's Technically Competent Manager (TCM) and the Site Operators to ensure this procedure is adhered to.

### 1.3. Tracking system

This waste pre-acceptance and acceptance procedure is part of the YW Management System. The company's Sludge Delivery Scheduling system together with its WaSP software (for logging the delivery of sludges by individual tankers), the Technical Evaluation Form and Waste Acceptance Review Forms, ensures that a system is in place to track waste from the point of sludge pre-acceptance enquiry through to delivery at the AD facility.

## 2. Waste Pre-acceptance procedure

Waste pre-acceptance activities will be undertaken to determine if the waste is suitable for treatment at the AD facility. A risk-based approach will be undertaken to characterise the waste, assess the risks to process safety/occupational safety/the wider environment and to assess the impact of the waste stream on the AD process and outputs. These activities will take place prior to waste acceptance at the facility.

### 2.1. Legal suitability checks

An initial legal check will be undertaken on the waste. The waste type must be listed in the environmental permit for it to be suitable for AD. Information on the source, nature and point of origin of the waste will be obtained, and verified against the permit EWC codes and the information presented in Table 2.

Only waste arising from WwTW sites will be treated by AD. Any enquiry from a commercial customer to deliver waste for treatment by AD will be rejected.

The proposed method for delivering the wastes to the STF will be assessed to determine if it complies with the YW safety procedures. Imported waste must be delivered in an appropriate tanker that can discharge safely into the sludge import tank.

Information on the source, nature and point origin of the waste will be recorded on the Technical Evaluation Review Form. This will be undertaken by the Site Operator, under the instruction of the Technically Competent Manager. If the waste does not meet any of the EWC codes descriptions of waste within the permit and safety measures are compromised, then the pre-acceptance application will be rejected.

If the waste is legally suitable, then further information will be requested on the potential quantities and characteristics of the waste, as described in this procedure.

### 2.2. Sampling procedures

YW commits to pre-acceptance testing of indigenous and imported sludge in order to determine its suitability for AD. This testing will also provide a bank of information that will enable YW to monitor the consistency and variability of waste from different origins.

Indigenous sludges are generally fresher in age than imported sludges. The age of indigenous sludge ranges from a few hours old up to 10 days in normal operation. Imported sludges are generally anywhere from 1 day – 6 months for the smallest WwTW sites. The sludge age is important as it can lower the sludge calorific value and affect digester health and in turn the amount of biogas that is generated. It is worth noting that smaller sites, which have a relatively older sludge age, will produce a much smaller quantity of sludge than larger WwTWs and have a lesser impact on digester health.

A representative sample of sludge will be collected for testing. The following information will be recorded for each sludge sample:

- Origin of waste – indigenous or imported, including the name of the originating WwTW
- EWC code/method of production – filter works, activated sludge, thickened sludge

- Size of sample
- Age of the sludge sampled
- Date of sample

Esholt STF currently accepts sludge from ~100 smaller WwTW. The sludge is deemed to be consistent and therefore samples for waste characterisation will be carried out on a risk based approach.

Sludge samples will be taken from a minimum of 10 of the 100 exporting sites. These will be selected on a risk basis and shall include sites that:

- Are the largest contributors of sludge (by volume)
- Have industrial customers within their catchment whose effluent could contain compounds with potential to disrupt/impact AD biology.

These sites would have the greatest potential to negatively impact on AD operations and therefore it is important to understand their waste characteristics.

The sampling will be undertaken by the TCM or appropriately trained Site Operator and tested at a third party laboratory with a documented management system accredited to EN ISO 17025.

### 2.3. Waste Characterisation

Information on the characteristics of the waste will be obtained prior to acceptance of the waste at the STF. These characteristics fall into three groupings:

- Visual – colour, cake or liquid
- Physical – thickness (pumpability), total solids
- Level of acidity/alkalinity - measurement of pH
- Chemical – e.g. lab test results for contamination with heavy metals

Table 3 lists the test parameters for sludge samples taken during pre-acceptance. These parameters will provide information on the consistency of the sludge, the biodegradability and alert YW to any contamination/toxicity that may cause it to be unsuitable or inhibit biological activity.

These parameters have been selected as the most relevant to sewage sludge because they have the greatest potential to impact on the digestion process and on the quality of the digestate, the end product. The selection of the testing approach and acceptable ranges/trigger points is informed by operational experience, guidance on input material testing in PAS110:2014[1] and the Inhibition Values for anaerobic processes in section 13 of the EA guidance 'Biological waste treatment: Appropriate measures for permitted facilities'.

[1] PAS 110:2014 – Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials.

| Parameter | Testing Standard /Approach | Acceptable Range |
|---|---|---|
| Colour | Qualitative testing | Within typical colour range |
| Particle Size distribution and physical contaminants | Qualitative testing | Evidence of rags and large contaminants will be rejected unless sludge passes through a screening system |
| pH value | BS EN 13037 | Sewage sludge is usually slightly acidic<br><br>pH hydrolysis and fermentation acido and aceto genesis – optimal pH 5-7<br><br>Methanogenesis – optimal pH7-8; operational 6.5-8.5<br><br>Typical pH range of sewage sludge 6.5-8 |
| Total solids | BS EN 14346 | WaSP system records total solids.<br><br>Sludges greater than 20%ds have a reduced capacity for being pumped through the system. |
| Potentially toxic elements (PTEs)<br>Heavy metals<br>• chromium<br>• zinc<br>• copper<br>• nickel<br>• cadmium<br>• lead | Various EN standards available (e.g. EN ISO 11885, EN ISO 17294-2, EN ISO 15586) | Heavy metals, if above acceptable levels, may cause a toxic effect on the digester biology. |
| Ammonia and total nitrogen content | EN 12260, EN ISO 11905-1 | Ammonium build up may inhibit the anaerobic process<br><br>No threshold data provided |

***Note: It is Recognised that the inhibitory values are under review and may be added, removed or amended. This table will be updated when data is available or otherwise in agreement with the Environment Agency.***

Table 3 – Test parameters

This information will assist YW in understanding how each waste type would be processed, the effect of the different waste streams/sources on the AD process, in order to manage the facility more efficiently, predicting gas generation and digested sludge properties.

The likely weekly volumes, delivery frequencies and estimated annual quantities of each waste identified for AD treatment will also be recorded.

### 2.4. Record keeping

The pre-acceptance waste characteristics information will be obtained in writing or electronic form. All information will be stored electronically on a central database system called ROD.

The pre-acceptance records will be retained for at least 3 years using the YW computerised waste tracking systems following receipt of the waste. If an enquiry does not lead to receipt of the waste, a record does not need to be kept. The pre-acceptance information will be assessed on an annual basis.

### 2.5. Reassessment of waste

Wastes will be reassessed should the following occur:

- There are significant changes in the waste e.g. the physical description is different to previous samples taken from the site source
- There are process changes at the WwTW that results in changes to the waste changes e.g. a different type of sludge thickening agent is used
- There are significant changes to industrial waste water sources
- The waste received does not confirm to the pre-acceptance information

Irrespective of the above, an annual pre-acceptance review will be undertaken on each waste source identified as suitable for AD.

### 2.6. Confirmation of suitability

The Site Operator, under the instruction of the TCM, will determine if the pre-acceptance information received meets the legal and technical requirements of the AD facility. A Technical Evaluation Review Form will be completed and if the waste is in the EWC list in the permit and is within the acceptable range for the technical test parameters listed in Table 3 then the waste is deemed to be suitable for AD.

## 3. Acceptance

The AD facility treats only sludges arising from WwTW sites. These are known sources and the waste will be consistent in its characteristics. Only on rare occasions will waste need to be rejected.

In accordance with Section 6.8 of guidance produced by the Environment Agency on 'Biological waste treatment: Appropriate measures for permitted facilities' (September 2022), acceptance sampling requirements do not apply to sewage sludge and septic tank sludge. Instead, visual checks and periodic audits against pre-acceptance characteristics will be undertaken.

The following sections of this procedure detail how visual acceptance checks will be undertaken, the waste rejection process, record keeping and periodic testing.

### 3.1. Characteristic checks prior to tanker/tipper loading

Tankers are used to deliver liquid sludges from smaller YW WwTW sites to a STF for AD. This should be consistent in colour and odour. The tanker driver will undertake a visual/odour check on the waste prior to loading. If the waste has a typical appearance and odour it will be loaded and delivered for AD.

The waste will be rejected for AD if it:

- Has a darker colour than usual
- Appears to be contaminated with oil
- Has a different/unusual odour suggesting the waste is septic or has other contamination

Tipper vehicles are used to transport sludge cake from smaller YW WwTW sites to a STF for AD. Prior to loading, the tipper driver will inspect the cake to ensure it is not too wet/has high dry solids and therefore will not seep out of the vehicle onto the road. The waste will be rejected if the water content is too high or if it has weeds growing on it.

These visual and odour checks take place prior to transportation of the waste being delivered for AD.

### 3.2. Visual and physical characteristic inspection at the STF

Waste is only received and accepted under the supervision of a suitably qualified operational team member. A visual inspection of both solid and liquid feedstocks is carried out before any waste is unloaded. This will check for any unusual malodours and visual appearance differences, to confirm the waste is consistent with agreed pre-acceptance parameters.

Under normal operation, every liquid sludge waste load received on site will enter the AD import facility via a WaSP logger, a software data management system. This records the total quantity of waste and the %dry solids (total solids) in addition to the time and date on when the waste was unloaded. The system will only permit the waste to be unloaded if there is sufficient storage capacity in the holding tank. Insufficient storage capacity will cause the valve to close, which will automatically turn off the tanker pumps and unloading will cease as a result.

### 3.3. Storage of sludge cake

Any sludge that has failed acceptance testing and needs to be quarantined must not be stored on site for longer than 5 working days.

In exceptional operating circumstances, for example where cake import facility is unavailable due to mechanical downtime, sludge cake may be imported onto the cake pad awaiting further processing through the AD. Any imported cake must be stored appropriately on the cake pad to ensure no contamination, from the sludge or the leachate, to other waste stored on the pad.

### 3.4. Rejection of waste in import tank

Sludge that does not meet the agreed quality criteria must not enter AD treatment. Through the visual inspection process, early identification of issues should eliminate problems. However, imported liquid and sludge cake are soon fed into the process. Any problem not identified at visual inspection stage may have entered the process by the time a problem has been identified. If this occurs the following steps will be undertaken:

1- Waste will be isolated in the tank
2- A tanker will couple up to the appropriate tank and empty it of its contents
3- No further imports will be accepted whilst this emptying is occurring
4- The tank will not be put back in service until all contents are removed. Only at this point will the site be open to imports

### 3.5. Treatment of septic sludges

Treating a high load of septic sludges can cause increased foaming, reduce biogas yield and produce more carbon dioxide and hydrogen sulphide. In addition, sludges may be higher in metal concentration due to evaporation of sludges, which can be toxic to the digester bacteria causing rapid bacterial poisoning and a reduction in biogas yield. Sludges may be outside of a normal pH range, a shock impact of which could affect digester health and impact biogas yield.

Sludges that are septic in nature, and where the load is deemed significant, will be subject to testing prior to acceptance at the AD import facility. A sample of the waste must be taken before it has left the exporting site and the results submitted to the TCM for review*. The results will be used in a digester toxicity calculator to determine the correct course of action. The possible outcome of this toxicity analysis are as follows:

- Acceptance of the sludge at the requested site
- Acceptance of the sludge at another YW AD site (where the toxicity calculator demonstrates there will be no issue to digester health)
- Reduced load acceptance at the requested site (i.e. part load acceptance to enable blending with normal sludges)
- Acceptance of load over a longer period of time
- Combination of the above
- Rejection of the sludge in its entirety and another outlet (i.e. landfill) to be found**

* At minimum, Sludges will be tested for the following… pH, volatile solids concentration, ammonia, potential toxic elements (PTEs).

**Sludge will be rejected if a reduction in the sludge load and / or increase of import time makes no difference to the waste's toxicity and it continues to fail toxicity limits.

Rejected loads will be sent to a suitable facility for processing and any records of the decision to reject abnormal loads and the associated digester toxicity calculation will be kept for no less than 3 years.

### 3.6. Waste tracking

Waste deliveries will be checked against the expected delivery schedule, to confirm the origin, type and quantity of waste delivered. A Waste Acceptance Form will be completed to confirm the waste delivered is as expected and suitable for AD. This form will be completed by the Site Operator, under the instruction of the TCM.

All Imported sludge loads are tracked through the WaSP import facility. In the event of an issue arising with digester health, the WaSP system can be interrogated to identify the sludge origin. The outcome of any investigation will be to minimise the reoccurrence of an issue arising in the future.

### 3.7. Periodic sampling

Testing will be carried out on the parameters listed in table 3 annually and/or when a problem with a waste source has been identified at the STF. Sampling and inspection may only be carried out by operators with appropriate technical knowledge to identify and deal with non-conforming feedstocks.

This test results will be used to ensure the waste characterisation in section 2 remains accurate.

## 4. Definitions

| Definitions of Terms Used: | |
|---|---|
| **Yorkshire Water** | Yorkshire Water is used in this document to refer to Yorkshire Water Services Limited and all other subsidiary companies within Kelda Holdings. |
| **Anaerobic Digestion** | AD is used to refer to anaerobic digestion. The process which imported waste is subject to at this sewage treatment facility. |

## 5. Compliance with this document

Colleagues shall comply with the requirements of this document, in line with the company Conduct Policy.

## 6. Assurance

Regular monitoring of compliance with these requirements shall be undertaken by the assurance providers documented as part of the Assurance Framework.

Any sampling that is undertaken will be taken in accordance with sampling procedures as documented in the internal guidance document Operator Self Monitoring, which can be found on the Integrated Management System. Samples must be tested at a UKAS accredited laboratory.

## 7. Related Documents

# Appendix 14 Leak Detection and Repair (LDAR) Plan

**Management Procedure**

**Esholt Leak Detection and Repair (LDAR) Plan**

Document Control

| | |
|---|---|
| Document Control Ref: | Version 1 |
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| Document Custodian: | IMS Team |
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Document Approval

| | |
|---|---|
| **Ed Sutherland**<br>Project Sponsor<br>Bioresource Asset Management<br>**Document Owner (Author)** | **Gavin Stowell**<br>Site Manager<br>Energy and Recycling Bradford<br>**Document Approval Manager (Tier 3)** |

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| 1 | 04/07/2022 | Ed Sutherland | Hazel Morgan | |
| 2 | | | | |
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| 4 | | | | |

# Contents

# 1. Introduction to LDAR

## 1.1 Purpose

As operators of Sludge Treatment Facilities (STFs), Yorkshire Water (YW) shall comply, as applicable, with the Environment Agency's document 'Appropriate Measures for the Biological Treatment of Waste' which provides guidance on how to comply with legislation governing anaerobic digestion of sewage sludge. One specific requirement in the appropriate measures document is the provision of an LDAR (Leak Detection and Repair) Plan to control emissions of organic compounds, including biogas, to air from the STF and associated infrastructure (for example, pipework, conveyors, lagoons or tanks).

*"Leak detection and repair (LDAR) programme'' means a structured approach to reduce fugitive emissions of organic compounds by detection and subsequent repair or replacement of leaking components. Currently, sniffing (described by EN 15446) and optical gas imaging methods are available for the identification of leaks as set out in BAT 14 and section 6.6.2 of the Waste Treatment BAT Conclusions.*

This management procedure outlines the overarching requirements of Yorkshire Water's LDAR programme and specifically how these shall be applied at the Esholt STF.

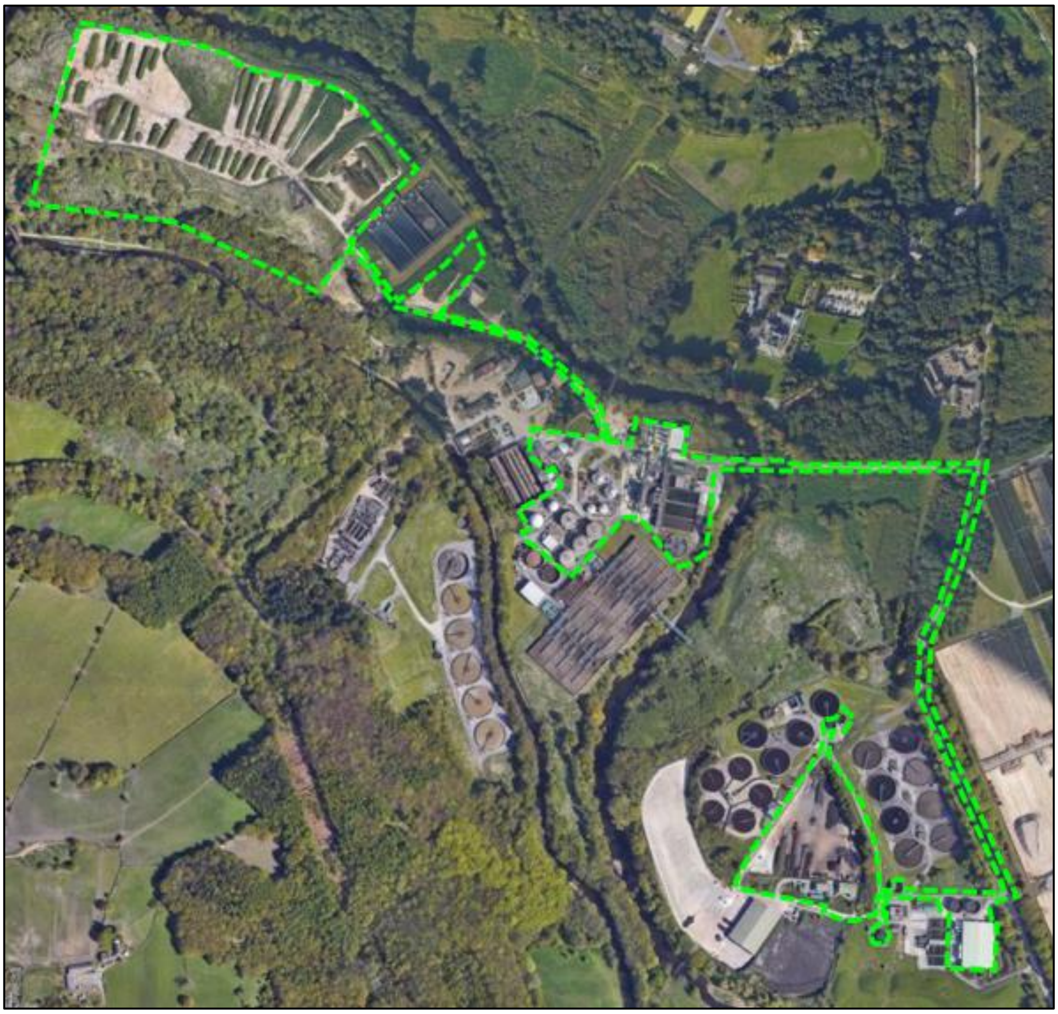

*Figure 1 – Site layout IED permit boundary*

### 1.2 Scope

This Management Procedure shall apply to all plant and equipment within the boundary of the STF which has the potential in normal (or abnormal) operating conditions to result in the release of potentially polluting or nuisance causing substances arising from the unintentional releases. This plant and equipment, includes, but is not limited to the following:

- Anaerobic Digester Tanks
- Pressure Relief Valves
- Biogas pipework from AD to biogas treatment and storage
- Natural gas pipework
- Biogas storage
- Pipework from biogas treatment to flare stack and engine
- CHPs
- Boilers
- Flare Stack

And all such related connections, pipework, valves, pumps and other connections

### 1.3 Responsibilities

It is the responsibility of the Site Operations Manager to ensure the implementation of the LDAR plan.

### 1.4 Assurance

Regular monitoring of procedure compliance shall be undertaken by the assurance providers documented as part of the Assurance Framework.

# 2 LDAR Considerations

The LDAR programme provides a structured approach to identifying and controlling releases of volatile organic compounds to air from equipment within the IED permit boundary. Typical causes of these releases would be damage to or degradation of items such as pipework, joints and other equipment linked to the transport, storage or processing of biogas or natural gas.

## 2.1 Biogas

Biogas is produced by bacteria within the anaerobic digester. Its composition is variable but will typically be within the following range.

| Compound | Formula | % |
|---|---|---|
| Methane | $CH_4$ | 50–75 |
| Carbon dioxide | $CO_2$ | 25–50 |
| Nitrogen | $N_2$ | 0–10 |
| Hydrogen | $H_2$ | 0–1 |
| Hydrogen sulphide | $H_2S$ | 0–3 |
| Oxygen | $O_2$ | 0–0.5 |

From an environmental and H&S perspective the key concern associated with uncontrolled releases of biogas are levels of methane (an explosive gas that is also environmentally damaging) and $H_2S$ (typically found in low concentrations, but extremely toxic).

## 2.2 Natural Gas

Natural (mains) gas is used as a backup fuel on anaerobic digestion sites when insufficient biogas is available due to process limitations or disruption. It is most commonly used as a supplemental fuel source for boilers.

## 2.3 Leak Detection Equipment

Scheduled inspections under the LDAR programme shall be carried out using optical imaging devices with appropriate filters to detect methane and/or 'sniffer' style devices that detect methane directly.

The standard YW equipment for detecting release of gases is an FLIR GF77 camera fitted with an appropriate lens for detecting biogas and/or natural gas.

The scheduled inspection shall be supported by regular inspections by the site operational team. Although the focus is on prevention of leaks, in the event that one does develop, site staff are likely to identify this by its distinctive smell. As an additional detection measure, standard operational H&S requirements include the wearing of personal gas monitors at all times within the STF, these will alarm in the event of a large-scale release of gas.

## 2.4 Leak Volume Measurement

Should a leak be identified, an estimation of the measurement of fugitive emissions of volatile organic compounds (VOCs) shall be undertaken by Yorkshire Water with assistance of technical experts as required. The estimation shall be based on the known gas composition and the concentration of VOC's (ppm) at the interface of the leak. It will then be converted to a mass emission rate to quantify the estimated release of VOCs in kilograms per hour (kg/h). This calculation will be undertaken using the correlation values detailed within the European Standard EN 15446:2008.

The estimation may be determined utilising the following information:

- Calculation based on flow rate, pressure and size of leak area.
- Leak definitions adopted e.g. mass emission rates detailed within EN 15446:2008.

If point source monitoring is undertaken using portable detection equipment, the average value of the total mass emission over the reporting period shall be taken as the average between the total emission rate at the beginning of the reporting period and the total emission rate at the end of the reporting period, multiplied by the duration of the reporting period.

The site operations team are responsible for ensuring that the estimated size of the fugitive emission is recorded on a Schedule 5 notification and sent to the EA, as well as arranging repair of the leak.

As part of normal operations, the gas composition from the digesters (in the case of biogas leaks) will be obtained and can be used in conjunction with the results of the methane leak detection rate to calculate the leak of all biogas constituents based on a percentage basis.

## 2.5 Maintenance Schedule

YW follow a risk-based maintenance schedule to ensure that their assets are functional and safe.

## 2.6 DSEAR

AD sites operate under the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). This legislation defines duties related to the control of dangerous substances, including biogas. There is significant overlap between DSEAR requirements and LDAR, all activities described in this document shall comply with DSEAR requirements.

## 3 Site

This management procedure details the process for LDAR at the Esholt site.

### 3.1 Site Plan- Emission Sources

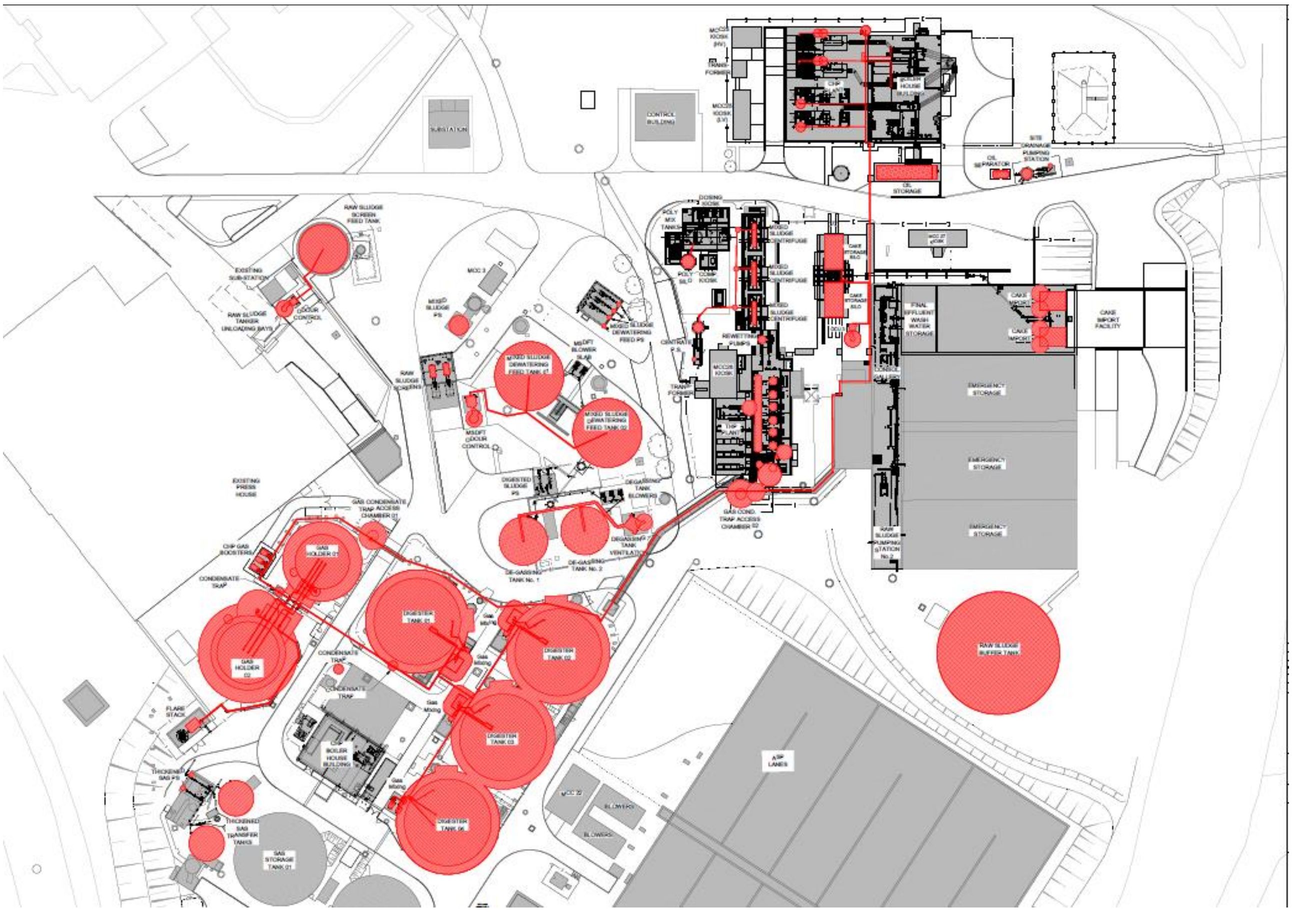

Figure 2: Site Biogas Emissions Sources

### 3.2 Key site information

e.g. typical daily methane production, gas consumers, normal operating pressure(s) of gas lines, over/under pressure setting on PRVs

| | |
|---|---|
| Typical daily biogas production | 52,000 m3/day @ 60% methane |
| Gas consumers | CHP x 4<br>Boilers x 3<br>Flare Stack |
| Normal biogas operating pressure (unboosted) | 20mbar |
| Digester PRV over-pressure release (mb) | 24mbar |
| Biogas holder PRV over-pressure release (mb) | -2.5mbar |

### 3.3 Site Specific LDAR Plan

The following actions shall be completed as part of LDAR work:

### 3.4 Routine operational checks

Visual checks of biogas systems are a daily task for site operational staff. These are recorded on the operational daily spreadsheet.

The purpose of these checks is to identify large scale leaks from the biogas system. They are unlikely to detect minor leaks. To ensure these are addressed, pro-active checks are carried out according to the maintenance schedule.

Staff wear personal gas monitors, although these are primarily a H&S tool, they will provide an audible alert if significant levels of biogas are detected.

### 3.5 STF Tanks (Anaerobic Digesters)

The only tanks in which biogas would routinely be found are the anaerobic digesters. These tanks are fully cleaned and inspected by competent engineers from the YW Asset Integrity team as per the frequency determined. Currently this means a full internal and external inspection every 10 years.

Any defects that are picked up by the 10-year inspection are addressed immediately via remedial works before the digester is approved to be put back into service for another 10 years.

### 3.6 Pressure Relief Valves

Pressure relief valves ensure a fail-safe route for gas escape that prevents catastrophic failure of other components within the gas system as a result of excessive pressure build up. They typically also provide under-pressure protection i.e. they prevent a vacuum forming within the gas system. Gas passing through the valves in a genuine high-pressure situation should not be considered a fault, and it is important that PRVs are never isolated from the rest of the system.

PRV's are serviced and calibrated every 12 months via removal from the digester roof and bench-testing to ensure they will relieve at the correct pressure setpoints. There are duty/standby valves on each digester to allow this service/calibration to take place while the digester is still in operation.

### 3.7 Biogas pipework from AD to biogas treatment and storage

All inspections are scheduled as per the YW Asset Integrity inspection data base. The assets are all inspected using a FLIR GF77 camera with filters specifically designed for detecting methane gas releases. Each AD site is inspected annually. After inspection, any leaks or defects detected will be rectified as a matter of urgency.

#### 3.7.1 Biogas storage

Site equipment includes 2no biogas holders installed at ground level. These are a double membrane design, with an outer layer that is constantly inflated using fans and an inner membrane that rises and falls depending on the amount of gas held within it. The positive pressure within the outer membrane ensures that under normal operation no biogas will pass from the inner membrane to the pressurised void.

The space between the inner and outer membranes at Esholt are fitted with a methane detector which generates an alarm if the inner membrane becomes damaged, allowing biogas to escape.

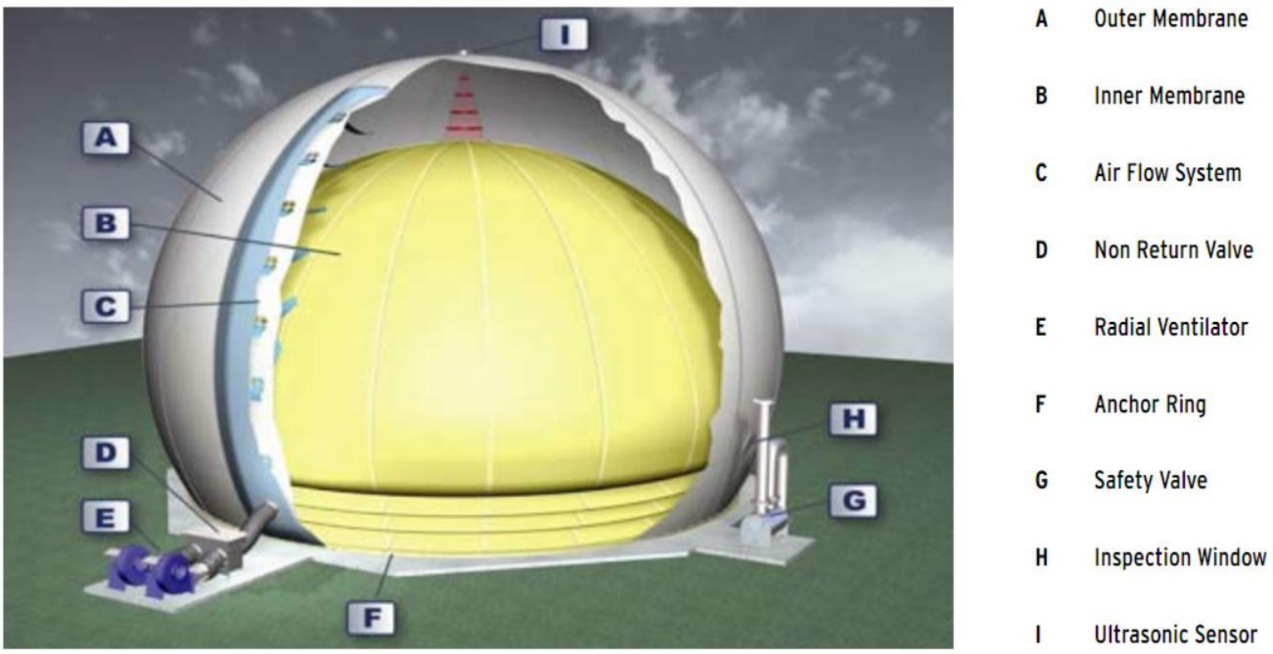


*Figure 3: Gas holder construction. Copyright Utile https://www.utileengineering.co.uk/gas-holders/*

The first inspection of a biogas holder is completed 5 years after installation. After this point, inspections take place every 2 years, with frequency increasing further if recommended by the inspecting company. The interval will be recommended by the specialist contractors completing work and agreed with the Yorkshire Water asset integrity team.

Inspection of the gas holder is a specialist task with significant H&S risks, as a result YW use a third-party to complete these inspections.

### 3.7.2 Pipework from biogas treatment to flare stack and engine

All inspections are scheduled as per the YW Asset Integrity inspection data base. The assets are all inspected using a FLIR GF77 camera with filters specifically designed for detecting methane gas releases. Each AD site is inspected annually. After inspection, any leaks or defects detected will be rectified as a matter of urgency.

### 3.7.3 Biogas Engine

Routine servicing and inspection of the biogas CHP engines is carried out by specialist contractors as per the recommended servicing schedule and include emergency responses to alarms and breakdowns. The internal compartment housing the engine contains gas leak detection which generates an alarm, isolates the fuel supply, and shuts down the engine on detection. The system also electrically isolates the engine, with the exception of the ventilation fans which will keep running to clear any hazardous gases.

The biogas CHP engines are also included in the annual inspection carried out by the YW Asset Integrity team using the FLIR GF77 camera with filters specifically designed for detecting methane gas releases.

It is the responsibility of the Site Operations Manager in collaboration with the Bioresource Asset Management team to deal with any recommendations or actions from the biogas CHP engine contractors.

**Exhaust emissions**

A poorly calibrated or maintained engine can lead to methane passing through the engine unburnt and being released to atmosphere as part of exhaust emissions. Annual emissions monitoring at site includes measurement of methane within exhaust gases to ensure that it remains within specified limits and as required by environmental permits.

### 3.7.4 Boilers (including boiler house)

Routine servicing and inspection of the boilers is carried out by specialist boiler contractors as per the recommended servicing schedule and include emergency responses to alarms and breakdowns. The boiler house contains gas leak detection which generates an alarm and shuts down electrical systems and isolates fuel supplies to the boiler on detection.

The boilers are also included in the annual inspection carried out by the YW Asset Integrity team using the FLIR GF77 camera with filters specifically designed for detecting methane and/or natural gas releases.

It is the responsibility of the Site Operations Manager in collaboration with the Bioresource Asset Management team to deal with any recommendations or actions from the biogas CHP engine contractors.

### 3.7.5 Flare Stack

Routine servicing and inspection of the flare stack is carried out by specialist flare stack contractors as per the recommended servicing schedule and includes safety interlocks as part of a valve proving sequence to prevent leakage of biogas.

The flare stack is also included in the annual inspection carried out by the YW Asset Integrity team using the FLIR GF77 camera with filters specifically designed for detecting methane and/or natural gas releases.

It is the responsibility of the Site Operations Manager in collaboration with the Bioresource Asset Management team to deal with any recommendations or actions from the biogas CHP engine contractors.

### 3.8 Natural gas pipework from mains network to gas consumers.

All inspections are scheduled as per the YW Asset Integrity team asset inspection data base. The assets are all inspected using a FLIR GF77 camera with filters specifically designed for detecting natural gas releases. Each AD site is inspected annually.

# Appendix 15 STF Processing Capacity Calculations

**Site:** Esholt STF

**Overall Summary:**
The figures provid a high level summary of Esholt STF's peak throughput capacity. Under normal circumstances the plant runs at a lower throughput than this, which is moderated by the amount of liquid imports that are brought into the site.

**1) Digesters Commentary:**
There are 4no digesters at Esholt.

At peak throughput, they are able to process up to 36,686 **tDS/year, or 386,864 m3/year** at 10% dry solids feed.

**2) THP Commentary:**
The THP at Esholt comprises 6 no. 22.7 m3 reactor vessels, which operate in pairs.

The THP is the bottleneck in the process.

At peak throughput, the THP process 89.66 TDS/d which is then fed forward

**3) Dewatering Centrifuges Commentary:**
The 2 pre THP centrifuges thicken the site indigenous primary and liquid imports. At peak throughput, the centrifuges process a sludge feed flow of up to **325m3/day.** They thicken this up to a target output of **22%** dry solids, which is then mixed with the rewetted cake to produce a feed into the THP at 16%.

**3) Imports and Sludge Screening:**
Screens and pumps are sized large to ensure screens do not cause process bottlenecks.

| Digesters | | |
|---|---|---|
| Individual Digester Volume | **3,533** | m3 |
| Total Digester Volume (@90% active) | **12,719** | m3 |
| Peak feed rate @ 12 days HRT (day) | **1,060** | m3/d |
| Peak feed rate @ 12 days HRT (year) | **386,864** | m3/yr |
| Peak Digester Throughput at 10% ds (day) | **106.0** | tDS/d |
| Peak Digester Throughput at 10% ds (year) | **38,686** | tDS/Yr |

**THP**: Sludge is fed into the THP at 16%.
Thermal Hydrolysis Process (THP) is capable of treating 89.66

| Dewatering Centrifuges | | |
|---|---|---|
| Peak sludge output at 22% ds | **325** | M3/d |
| Peak sludge output at 22% ds | **118,675** | M3/Yr |

**Thickeners**: 4 drum thickeners each sized to process **162m3/hr.** So able to process up to **2592m3/day operating 16 hours a day.**

Optimised Rewetting with disinfected final effluent

| Site Indigenous Primary Sludge | | |
|---|---|---|
| Peak amount produced by site | **13,323** | tDS/Yr |
| Minimum sludge thickness | 2.4 | % |
| Maximum sludge volume (per day) | **1,521** | m3/day |
| Maximum sludge volume (per year) | **555,104** | m3/year |
| Maximum sludge thickness | 8 | % |
| Minimum sludge volume (per day) | **456** | m3/day |
| Minimum sludge volume (per year) | **166,531** | m3/year |

| Liquid Sludge Imports from other treatment works | | |
|---|---|---|
| Peak amount produced by site | **7,464** | tDS/Yr |
| Minimum sludge thickness | 2.2 | % |
| Maximum sludge volume (per day) | **930** | m3/day |
| Maximum sludge volume (per year) | **339,273** | m3/year |
| Maximum sludge thickness | 6 | % |
| Minimum sludge volume (per day) | **341** | m3/day |
| Minimum sludge volume (per year) | **124,400** | m3/year |

| Site Indigenous SAS Sludge | | |
|---|---|---|
| Peak amount produced by site | **5,322** | tDS/Yr |
| Minimum sludge thickness | 0.4 | % |
| Maximum sludge volume (per day) | **3,645** | m3/day |
| Maximum sludge volume (per year) | **1,330,500** | m3/year |
| Maximum sludge thickness | 1 | % |
| Minimum sludge volume (per day) | **1,458** | m3/day |
| Minimum sludge volume (per year) | **532,200** | m3/year |

| Cake Sludge Imports from other treatment works | | |
|---|---|---|
| Peak amount produced by site | **5,449** | tDS/Yr |
| Average sludge thickness | **21** | % |
| Maximum sludge volume (per day) | **71** | m3/day |
| Maximum sludge volume (per year) | **25,948** | m3/year |

**4) Indigenous Primary Sludge Commentary:**
The indigenous primary sludge coming off Esholt wastewater treatment works and being passed forward for centrifugin peaks at 13,323 **tDS/year.**
The thickness and therefore the volume of the sludge being passed forward for thickening varies between **555,104m3/year** when the dry solids are at their minimum **2.4%**. Down to **166,531m3/year** when the dry solids are at their maximum **8%.**

**5) Liquid Sludge Imports Commentary:**
The liquid sludge imports coming from other wastewater treatment works and being passed forward for centrifuging peaks at **7,464tDS/year.**
The thickness and therefore the volume of the sludge being passed forward for thickening varies between 339,273 **m3/year** when the dry solids are at their minimum **2.2%**. Down to **124,400m3/year** when the dry solids are at their maximum **6%.**

**6) Indigenous SAS Sludge Commentary:**
The indigenous SAS sludge coming off Esholt wastewater treatment works and being passed forward for thickening peaks at 5,322 **tDS/year.**
The thickness and therefore the volume of the sludge being passed forward for thickening varies between **1,330,500m3/year** when the dry solids are at their minimum **0.4%**. Down to **532,200m3/year** when the dry solids are at their maximum **1%.**

**7) Cake sludge imports commentary:**
The cake sludge imports coming from other wastewater treatment works and being passed forward for thickening peaks at **5,449 tDS/year.**
The thickness of the sludge being passed forward is fairly consistent and therefore the volume of the sludge being passed forward for rewetting is 25,948 **m3/year** at a dry solids of **21%.**

# Appendix 16 Materials Safety Data Sheets

## Form 34 - COSHH Assessment Form

| **Substance Name:** | **Gas Oil** | | |
|---|---|---|---|
| REACH Registration Number: | Not supplied | Last Review: | 09/09/2020 |
| Assessed By: | Richard Jelfs | Review Due: | 08/09/2025 |
| Name of Site: | Waste Water | Reference No: | CW-WW-023 v1 |

| | | |
|---|---|---|
| 1 | Physical Description | Straw to amber fluid; may be dyed red |
| 2 | Usage - General | Depending on the process application & used for cleaning – estimated 1 x weekly |
| | a. Risk from Chemical | Medium |
| | b. Specific Use | Fuel for plant and equipment e.g. generators |
| | c. Process Description | When fuel is required for on-site use, it is pumped from the bunded tank, into a vehicle or Gerry can. If this fuel is used on site, it is then carried to the required location and distributed from the Gerry can. The mandatory 5 points of PPE are worn during this process. |
| | d. Exposure Times | Less than 30 minutes, approximately 1000 litres per week |
| | e. Substitution | Due to the nature of the product and its use - no substitution possible. |

| | | Operators | | | Maintenance | | | Office Based | | | Contractors | | | Visitors | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Staff / Persons at Risk | Operators | | | Maintenance | | | Office Based | | | Contractors | | | Visitors | | |
| | Staff Numbers Exposed | **16** | | | | | | | | | | | | | | |
| | Final Risk Ratings | | **M** | | | | | | | | | | | | | |

| | | |
|---|---|---|
| 4 | Hazards Identification<br>a. Pictograms |  |
| | b. Hazard Statements<br>As per EC 1272/2008 | These oils, particularly when catalytically and thermally cracked hydrocarbons are present, may contain polycyclic aromatic hydrocarbons (PCAs); some PCAs have been shown to have a potential to cause skin cancer (category 3 carcinogen). There are small concentrations of cetane no. improvers, flow improvers, anti-foam and detergent additives and marker/dye that are not considered to represent a health risk. Injection of fuel under the skin may have serious medical effects. Classified as dangerous for the environment |
| 5 | Tasks | **A) Delivery:** |
| | a. Controls | The chemical (fuel), is ordered via the SRM by the Product & Process Engineer (PPE). It is delivered by contractor direct to site, where they fill up the existing tank. This is witnessed by the Yorkshire Water PPE. |
| | b. PPE | • Eye protection BS EN 166<br>• Hand and skin protection - Hand and skin protection recommended at all times. Where<br>• exposure is likely protective clothing must be worn, including nitrile gloves approved to BS EN 374 with a breakthrough time of >360 minutes. |
| | c. Documents | • Material Safety Data Sheet.<br>• Task Specific Risk Assessment<br>• Specific site procedures |
| | | **B) Fuel for internal combustion engines:** |
| | a. Controls | • Stored in line with MSDS in well ventilated area<br>• Wash hands well after use<br>• Use mechanical lifting aid where possible |
| | b. PPE | • Eye protection BS EN 166<br>• Hand and skin protection - Hand and skin protection recommended at all times. Where<br>• exposure is likely protective clothing must be worn, including nitrile gloves approved to BS EN 374 with a breakthrough time of >360 minutes. |
| | c. Documents | • Material Safety Data Sheet.<br>• Task Specific Risk Assessment |
| 6 | Exposure Limits | Long term exposure limit - (8 hour TWA reference period) 5 milligrams per cubic metre.<br>Short term exposure limit - (15 minute reference period) - 10 milligrams per cubic metre. |
| | a. Estimation of Risk | Low |
| 7 | Health Surveillance Required | No |
| | Health Surveillance Details | Not applicable |

## Form 34 - COSHH Assessment Form

| | | |
|---|---|---|
| | **Substance Name:** | **Gas Oil** |
| 8 | First Aid | |
| | a. Skin Contact | • Wash skin as soon as possible with soap and water.<br>• Change contaminated clothing and launder before reuse. Get medical advice if irritation persists. |
| | b. Eye Contact | • Wash out thoroughly with large amounts of water. If redness and/or irritation continues get medical advice. |
| | c. Inhalation | • If inhalation of vapour causes irritation or drowsiness remove to fresh air. Get medical advice if the symptoms continue. |
| | d. Ingestion | • Wash mouth out with water and give water to drink.<br>• If a large amount has been swallowed get medical advice.<br>• DO NOT INDUCE VOMITING BECAUSE OF THEDANGER OF ASPIRATION. |
| 9 | a. Storage General | • The design, construction and maintenance of bulk storage and handling facilities are covered by codes of practice published by the Institute of Petroleum, British Standards<br>• Institution and the Health and Safety Executive.<br>• Drums should be stored on their sides on racks preferably under cover, out of direct sunlight, in well ventilated conditions.<br>• Other types of containers should be stored under cover out of direct sunlight, in well ventilated conditions. Care should be taken to avoid over-stacking. |
| | b. Storage Specific | The chemical (fuel) is stored in a bunded tank, which is locked off with the key stored in a key safe - PPE's are the only personnel whom have access. The tank is fitted a gauge on it and a spill kit is stored near to the area |
| 10 | Spillage | • Treat any spillage as a fire hazard. Spray, vapour or mist can be a potential fire or explosion hazard.<br>• Contain spillage - do not wash spillage down drain. Absorb using absorbent clay, diatomaceous clay or other suitable absorbent. |
| 11 | Disposal | • Container to be segregated on site and disposed on as hazardous waste Must not be disposed together with household garbage. Do not allow product to reach sewage system<br>• Should a spillage occur on site, this should be cleaned by using a spill kit, this should then be classed as hazardous waste and disposed of on-site at the recycling hub.<br>• Disposal must be made according to official regulations. |
| 12 | Additional Site Specific Information | • The design, construction and maintenance of bulk storage and handling facilities are covered by codes of practice published by the Institute of Petroleum, British Standards<br>• Institution and the Health and Safety Executive.<br>• Drums should be stored on their sides on racks preferably under cover, out of direct<br>• sunlight, in well ventilated conditions.<br>• Other types of containers should be stored under cover out of direct sunlight, in well ventilated conditions.<br>• Care should be taken to avoid over-stacking. |

# Form 34 - COSHH Assessment Form

| | | | |
|---|---|---|---|
| **Substance Name:** | **Diesel** | | |
| REACH Registration Number: | Not supplied | Last Review: | 23/08/2017 |
| Assessed By: | Lisa Cuthbert | Review Due: | 22/08/2022 |
| Name of Site: | Waste Water | Reference No: | CA-WW-030 v1 |

| | | |
|---|---|---|
| 1 | Physical Description | Liquid |
| 2 | Usage - General | Fuel for on-road diesel-powered engines. Fuel for use in offroad diesel engines, boilers, gas turbines and other combustion equipment. |
| | a. Risk from Chemical | Low |
| | b. Specific Use | Fuel for pumps and machines |
| | c. Process Description | When the fuel is needed, it is funnelled from the fuel can into the pumps or machines where it is required |
| | d. Exposure Times | 30 minutes |
| | e. Substitution | No substitution |

| | | Product & Process Engineers | | | Maintenance | | | Office Based | | | Contractors | | | Visitors | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Staff / Persons at Risk | Product & Process Engineers | | | Maintenance | | | Office Based | | | Contractors | | | Visitors | | |
| | Staff Numbers Exposed | **1-5** | | | **1-5** | | | **0** | | | **0** | | | **0** | | |
| | Final Risk Ratings | **L** | | | **L** | | | | | | | | | | | |

| | | |
|---|---|---|
| 4 | Hazards Identification<br>a. Pictograms |  |
| | b. Hazard Statements As per EC 1272/2008 | H226 Flammable liquid and vapour.<br>H227 Combustible liquid.<br>H304 May be fatal if swallowed and enters airways.<br>H315 Causes skin irritation.<br>H332 Harmful if inhaled.<br>H351 Suspected of causing cancer.<br>H373 May cause damage to organs or organ systems through prolonged or repeated exposure.<br>H401 Toxic to aquatic life.<br>H411 Toxic to aquatic life with long lasting effects. |
| 5 | Tasks | **A) Delivery, Storage & Use:** |
| | a. Controls | • Avoid inhaling vapour and/or mists.<br>• Avoid prolonged or repeated contact with skin.<br>• When using do not eat or drink.<br>• Extinguish any naked flames. Do not smoke. Remove ignition sources.<br>• Avoid sparks. Earth all equipment.<br>• Properly dispose of any contaminated rags or cleaning materials in order to<br>• prevent fires.<br>• Use local exhaust ventilation if there is risk ofinhalation of vapours, mists or aerosols. The vapour is heavier than air, spreads along the ground and distant ignition is<br>• possible. |
| | b. PPE | • Chemical resistant gloves/gauntlets,<br>• boots, and<br>• apron (where risk of splashing). |
| | c. Documents | • Task Specific Risk Assessment.<br>• Material Safety Data Sheet. |
| 6 | Exposure Limits | Not applicable |
| | a. Estimation of Risk | Low risk – exposure at point of transferring fuel |
| 7 | Health Surveillance Required | No |
| | Health Surveillance Details | No |
| 8 | First Aid | **GENERAL:** In all cases of doubt, seek medical attention. |