J840 – STC IED Containment

Bishops Stortford STC – Containment Options Report

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Project Manager: Harindra Gunasinghe
Author: Carl Rendora
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1.0	27/03/2023	First Issue	CR	SMNS	SC	HG
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Contents

1. Executive Summary

Thames Water is required by the Environment Agency to provide secondary containment to their sludge treatment centres to satisfy provisions of the Industrial Emissions Directive and to safeguard the operation of the adjacent sewage treatments works. Twenty-five sludge treatment centres (STC) have been identified where containment proposals are required. This report deals with the proposals for Bishops Stortford.

Bishops Stortford STW is located southeast of the town of Bishop's Stortford and serves a population equivalent of 71,000 receiving sewage from the nearby Bishops Stortford Town, Birchanger Village and Stansted Airport. The sludge treatment centre shares the same site as the sewage treatment works. CIRIA Report 736 – Containment systems for the prevention of pollution sets out principles and direction. This report sets out options to apply the CIRIA 736 principles within the accepted constraints of a retrofitted solution.

There are 8 tanks containing sludge that fall within the IED permitting area, constructed in both steel and concrete, the total operational sludge volume is 6,069 m^3, with individual volumes varying between 115 to 1,072m^3, refer to section 3.4.1 for details on tanks and volumes. The containment volume to consider at Bishops Stortford is set by the 25 % rule and is 1,135m^3.

An initial review, together with TW Site Operations, was carried out to confirm that the working of the sewage treatment work would not be compromised by any proposal. Within the discussions, failure of a primary digester tank (largest spilled tank) was addressed by adopting a wide containment area for all sludge assets and diverting flow to remote storage. The storage options considered unused areas of land and redundant sludge lagoons tanks with the former being preferred due to its proximity to the sludge assets and reduced construction needs. Refer to Section 4.1 for details on the options reviewed and Section 4.3 for the preferred option. Below a summary of the preferred option:

Table 1 Summary of preferred containment option

Containment Area	Description of containment
Wide containment area to Lagoon	• Wide containment with low diversion bund walls between 0.3m high that will retain spillage within the site and divert towards secondary containment. • 4 large ramps will provide access for vehicles as main access routes are included within the containment area. • Steps to be installed for access to foot traffic. • 1 flood-gate will be installed to allow infrequent access to vehicles where space precludes the use of ramps.
Summary	• Option reduces impact to operational access as no individual tanks are isolated within a high bund. • Minimal conveyance routes that require regular and onerous maintenance. • Uses natural topography of the site to divert spillages to the proposed lagoon location. • Repurposes old sludge lagoon, reducing excavation.

Float valves will also be installed onto surface water drains to prevent spilled sludge from returning immediately to the head of the works.

Bund heights are being set to provide freeboard considering both static conditions when the containment has been filled and during the transient condition at initial failure. There is the potential for some flow to overtop the access ramps during the conditions of the initial burst which is addressed by tertiary containment and conveyance to the site drainage system which discharges to the inlet works.

In addition to the creation of bunds, which due to space constraints are likely to be formed from concrete, existing grass or gravelled areas will be replaced with a bound impermeable material (high cement replacement concrete) to provide a surface that can be cleared of sludge to meet a 3-4 day recovery period. Vehicular access into the containment areas is by ramps (speed humps) restricted to nom 250-300mm in height; traffic movements on site make the use of permanent flood gates impracticable. Whilst the site is identified as requiring Class 2 containment (impermeable soil with a liner), the proposed solution is intending to concrete (with no liner) on the basis of the impermeability of the concrete, inherent strength, and long-term mechanical resistance.

The general layout of the proposed solution is presented below:

Figure 1.1 General layout of containment for Bishops Stortford STW

2. Background

Following initial audits by the Environment Agency (EA) in 2019 that examined the primary, secondary, and tertiary containment provisions for Thames Water's anaerobic digestion (AD) process and associated tanks, the EA reported *"there is no provision of secondary containment for the AD process at any of Thames Water's sites. Catastrophic tank failure may impact nearby receptors and the operation of adjacent sewage treatment activities".* Jacobs were appointed to assess site risks and outline the options available for providing remote secondary containment of a catastrophic tank or digester failure across 28 Thames Water sites. Based on CIRIA C736 and ADBA risk assessment tools this containment report addresses the site-specific risks at Bishops Stortford and outlines the options available for providing remote secondary containment in the event of a catastrophic tank or digester failure.

The current assessment identified gaps between the existing conditions of the sludge assets in Bishops Stortford STW and the requirements to meet the industrial standard (i.e., CIRIA C736 and The Anaerobic Digestion and Bioresources Association Limited (ADBA)). Site-specific risks, credible failure scenario and design containment volume for the Bishops Stortford STW were identified through a desktop study, Light Detection and Ranging Analysis (LiDAR) analysis and a site visit.

Bishops Stortford STC, contained within Bishops Stortford Sewage Treatment Works (Figure 2.1) is off Jenkins Lane along A1060 road, it lies to the west of M11 main road and is surrounded by green fields to the east, south and west. To the north, it is adjacent to a residential area, recreational area, and green fields.

Figure 2.1 Location of Bishops Stortford STW

Figure 2.2 Satellite image of Bishops Stortford STW

Figure 2.3 Labelled image of the assets within Bishops Stortford STW

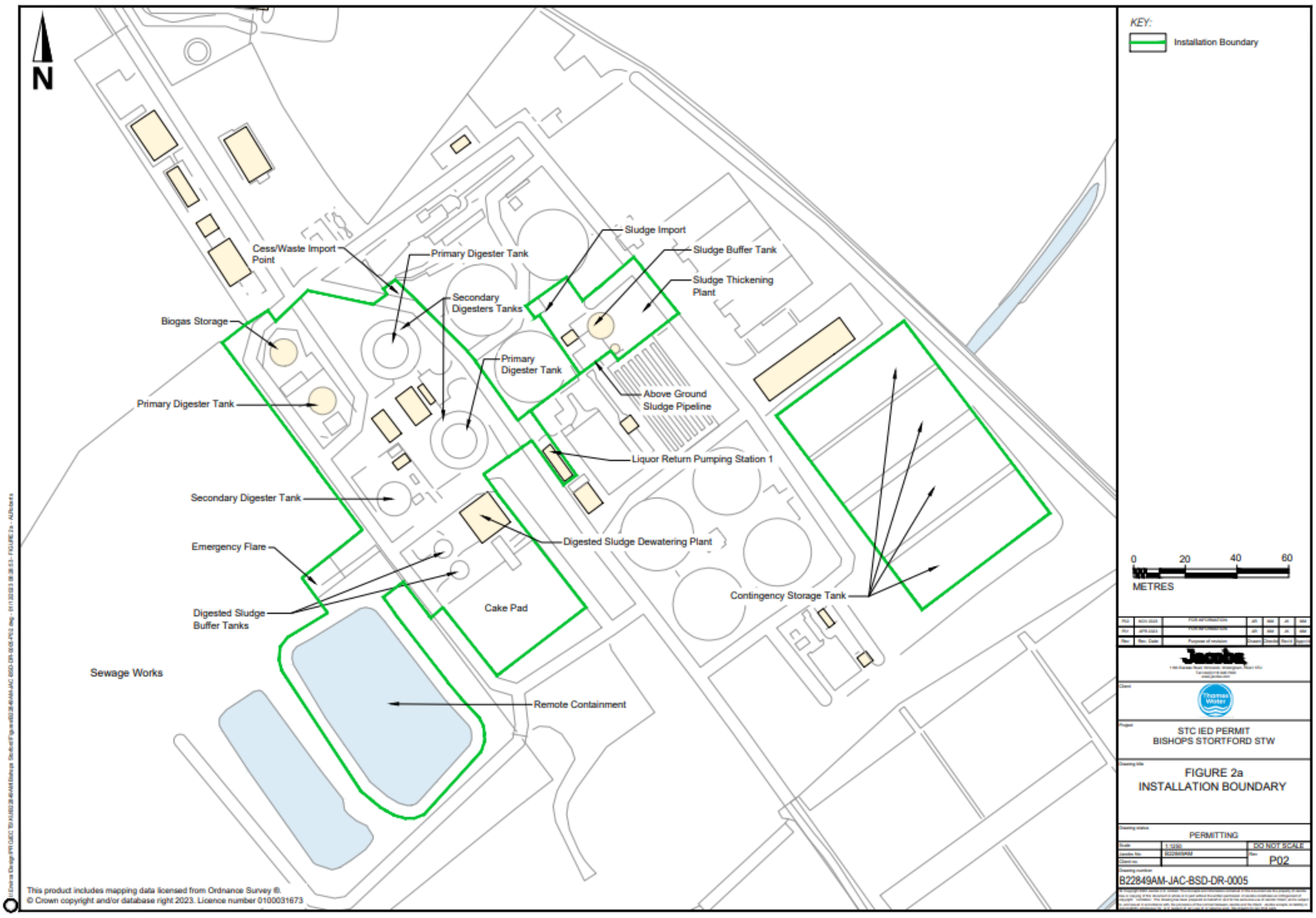

Figure 2.4 Boundary of permitted IED area and the assets

3. Proposed Containment at Bishops Stortford STW

3.1 CIRIA C736

This containment option report has been prepared using CIRIA C736 as the basis of design and guidelines. Where a deviation from C736 has been recommended it is highlighted in the text.

CIRIA guidance document C736 *(Containment systems for the prevention of pollution – Secondary, tertiary, and other measures for industrial and commercial premises, 2014)* describes various options for containment of spillages from a credible failure scenario. It makes reference to a key plan, reproduced below;

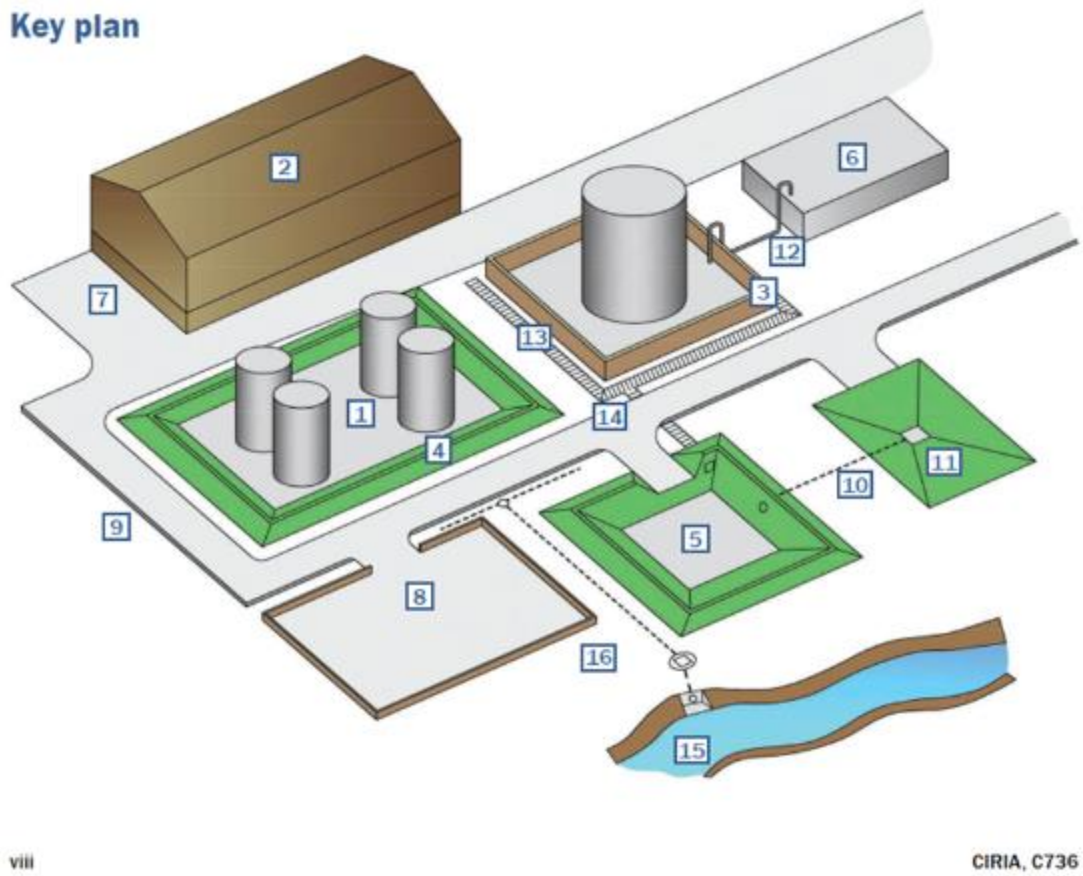

Figure 3.1 Diagram of primary, secondary and tertiary containment examples

-Primary containment is provided by the actual tank or vessel [1].

-**Secondary containment** is provided by a bund immediately surrounding the primary vessel e.g. [3] and [4], or by a lagoon [5] or tank [6]. If containment is provided away from the primary vessels this is known as **remote containment** and may be considered as either **remote secondary** or **tertiary containment**.

-**Tertiary containment** can be provided by a number of means including lagoons [5], or impermeable areas such car parks [8]. Roadways with high kerbing of sufficient height [9] can also form part of a tertiary containment system, or the **transfer system** to the remote containment.

The distinction between *remote secondary* and *tertiary* containment is not always clear but, if properly designed, a combined system can be provided that is capable of providing the necessary degree of environmental protection. The overriding concern is not the terminology but the robustness and reliability of the system which depends on a number of factors such as;

- Its complexity – the more there is to go wrong, the greater the risk. Passive systems relying solely on gravity are more reliable than pumped.
- Whether manual intervention is relied on to make the system work or whether the system can be automated to include fail-safes and interlocks.
- The ease of maintenance and monitoring of the system's integrity, and repair of any defects.

During and after an incident any rainfall runoff from the remote secondary storage areas, from the spillage catchment areas and from the transfer systems must also be prevented from reaching any outfall(s) to surface water by closure of control valve(s).

3.2 Objectives of remote secondary containment

The objectives of the remote secondary containment measures proposed in this report are to safely contain spillages from credible failure scenarios and prevent them from:

- escaping off site
- entering surface waters
- percolating into groundwater
- being pumped back to the inlet of the sewage works in an uncontrolled manner.

The remote secondary containment will be provided by maximising the use of existing impermeable surfaced areas to provide a fail-safe passive system that relies on gravity rather than pumps. A means of leak detection that will automatically trigger isolation valves at key locations in the drainage system is also proposed.

3.2.1 Uncontained Spill modelling

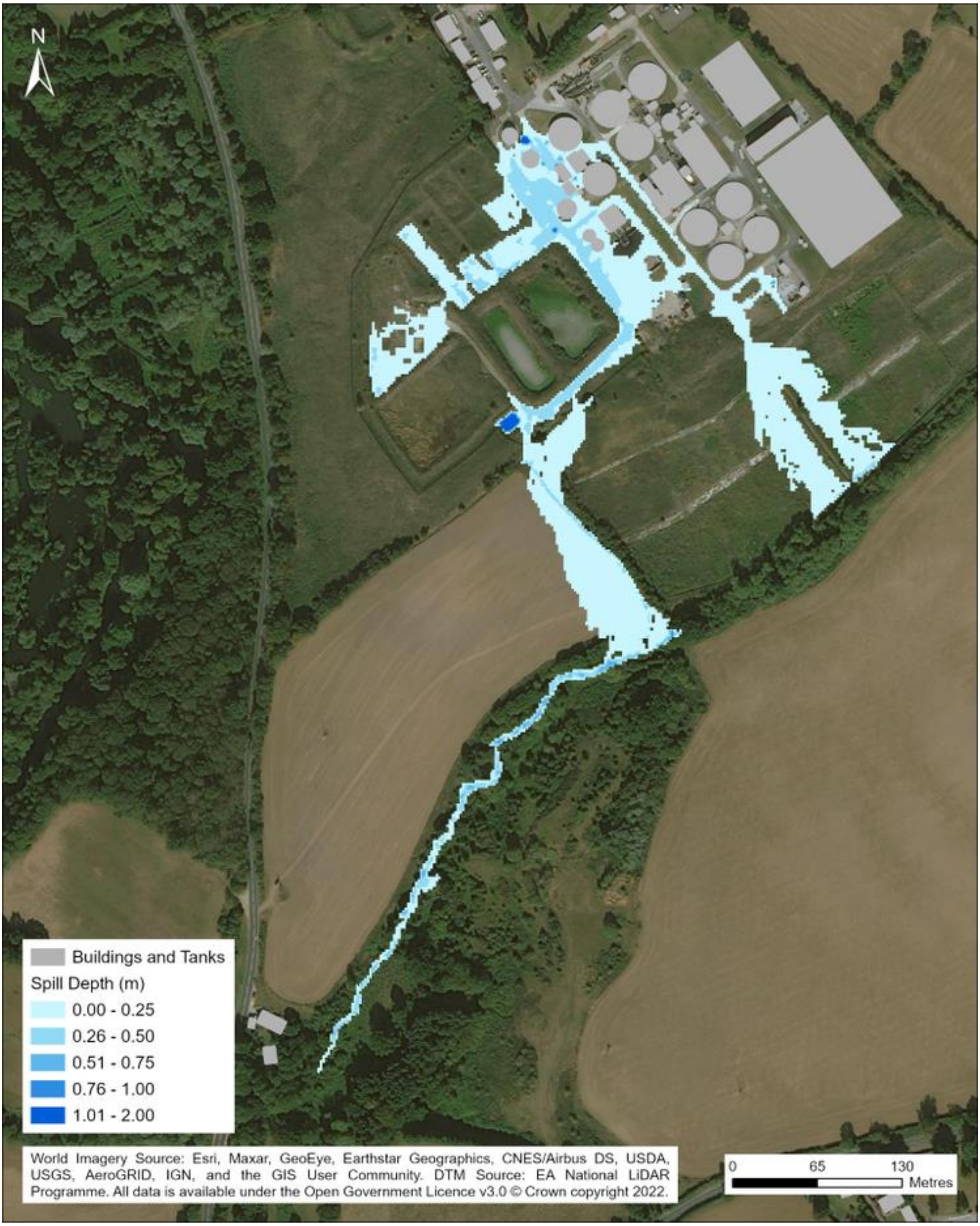

Figure 3.2 Uncontained Spill Model Results

Figure 3.2 shows the sludge spill mapping of an uncontained event at Bishop's Stortford STW. The modelling results showed that a potential sludge spill from the one of the Primary Digesters will not be self-contained within the site and therefore passive containment needs to be implemented to safeguard the nearby receptors. According to the model the spill will leave the site boundary (in the south and south-east site boundaries) in approximately 9 minutes following failure of one of the digesters.

The uncontained modelling results highlighted that due to the location of the drainage system within the Cake Pad area and the disused site drainage system in the south and west on the STW site, the velocity of the sludge spill is expected to be relatively high towards the southern exit. Some sludge will flow west, past the flare stack, and into the disused sludge lagoon area west of the STW. The majority of the sludge will flow to the southeast, past the Cake Pad area where it will take a turn by the disused lagoon to the southwest. The sludge will then flow south, spreading partially into the private farm field to the west and eventually reaching the Great Hallingbury Brook where it will follow the waterway and travel approximately 400m downstream. Leaving the digesters area, part of the sludge is expected to flow south eastward and over the grass land southeast of the STW, which will also reach and empty into the Great Hallingbury Brook.

3.3 Site Classification Bishops Stortford

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk Bishops Stortford site hazard rating is deemed to be High. When considering the mitigated likelihood as low a Class 2 secondary containment is required.

Table 2 Risk rating

Source Risk	Pathway Risk	Receptor Risk	Site Hazard Rating	Likelihood	Overall Site Risk Rating
High	Medium	High	High	Low	Medium (Class 2)

Refer to Appendix 1 for summary of the ADBA risk assessment tool.

3.3.1 Spill Volume Summary

There are two components that contribute to the required capacity of secondary containment, the source spill volume requiring containment and rainfall. Section 4 of CIRIA 736 forms the basis of this assessment. Section 4.2 reviews current industry practice relating to source spill volume, section 4.2.8 then summarises current industry practice relating to source spill volume in a tabular form. It can be seen from section 4.2.8 that sewage sludges and associated regulations / guidance are not listed.

Within section 4.2.1 there is detailed reference to the use of 110% of the largest tank or 25% of the total tank inventory volume, whichever is greater, and the rationale for this. CIRIA recognises that this approach is not quantitative or based on a risk assessment and are arbitrary methods. Section 4.3 and 4.4 provide guidance on a quantitative risk assessment methodology and this is what is being used for the calculation of the required capacity for containment in this report.

3.3.2 Total Spill Volumes

For each containment area assessed, the containment volume has been checked against the largest tank + rainfall, the 110% and 25% rule and for the preferred option the 25% rule applies.

Note that at Bishops Stortford a donut arrangement is used, with the primary digester sitting within the secondary digesters. For that reason, only the volume sitting above the secondary digesters has been counted in case of failure as the secondary digester acts as partial containment for the primary digester. So, of the total 1,072m^3 of the primary digester only 308m^3 has been counted as spill in case of failure of the tank.

Table 3 Estimating critical spill volumes for the preferred option

Wide containment area		
25% Rule	1,135m^3	Emerging critical case
110% Rule	339m^3	
Largest + rainfall	934m^3	

3.4 Bishops Stortford STW Summary of Containment volumes and assets

3.4.1 Assets for Containment

The tanks for which containment is required are summarised below:

Table 4 List of tanks and volumes

Tank Purpose	Qty	Vol of tank (m^3)	Total Volume (m^3)	Material
Sludge Buffer Tank	1	577	577	Steel
Primary Digester Tanks	2	1,072	2,144	Concrete
Primary Digester Tank	1	987	987	Steel
Secondary Digester Tanks	2	976	1,952	Concrete
Secondary Digester Tank	1	756	756	Steel
Digested Sludge Buffer Tanks	2	115	230	Steel

3.4.2 Digital Terrain Model

Figure 3.3 Digital Terrain Model of Bishops Stortford Sewage Treatment Works

Given the topography of the sludge area, the results of the high-resolution contouring revealed that the digesters are elevated compared to the rest of the site and in the event of catastrophic failure of one of the digesters, spilled sludge would flow towards the south and west direction of the site.

3.5 Contained Model Output

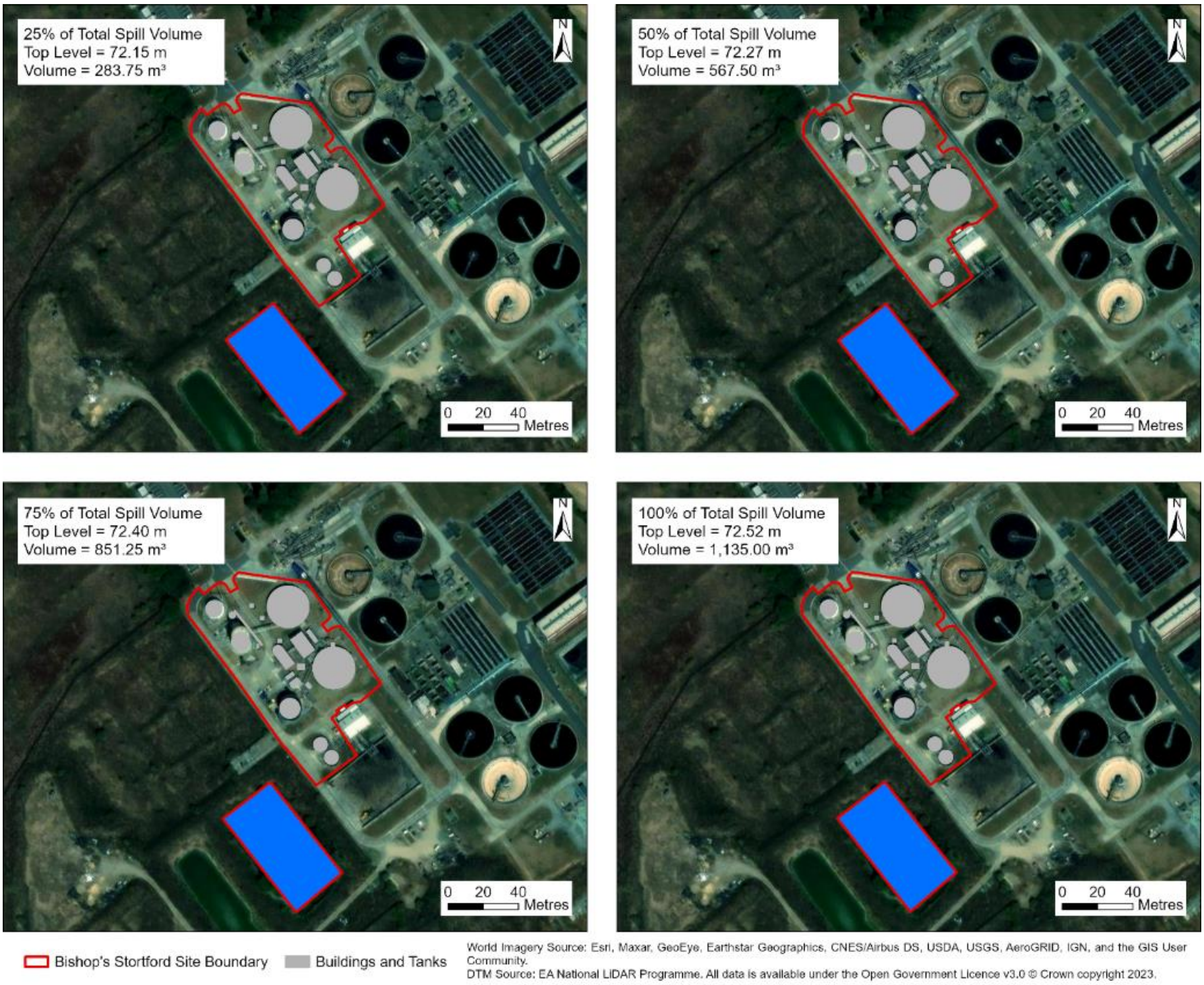

Figure 3.4 – Contained model output: wide containment area showing flow of spillage into Lagoon

The model above shows that any spillage from a sludge tank will flow towards the lagoon due to the topography of the site. With this in mind, the bunding around the site can be kept low, as it is used to divert flow to the lagoon rather than contain standing sludge.

The containment bunding is set by adding 250mm to the top water level to provide freeboard to prevent overtopping from the surge effects. Some local low spots may be reprofiled to prevent operational issues.

Please note that these values are derived from 1m LIDAR data which has an accuracy of +/- 150mm.

3.6 Identified Constraints

3.6.1 Operational constraints

3.6.1.1 Clean-up time

The time to recovery and return site back to operation has been set at 3 days following direction by Thames Water. The containment volume, when not dictated by the 110% or 25% containment rules allows for three days of rain during the recovery period and one day of rain immediately preceding an event.

3.6.1.2 Surface cleaning

The existing ground surfaces around the sludge treatment tanks consist mainly of grass and gravel that will need to be replaced with an impermeable surface, such as concrete, to facilitate the cleanup. The impermeable surface will be gently sloped to aid with the sludge spill flow path towards the drainage network.

It is noted that concreting these areas may slow emergency access to underground surfaces and there is a trade-off between the advantages of digging up existing surfaces (in grass or gravel) vs. decreasing the clean-up effort required in the event of a sludge spill.

Whilst the site is identified as requiring Class 2 containment (impermeable soil with a liner), the proposed solution is intending to use concrete (with no liner) based on the impermeability of the concrete, inherent strength, and long-term mechanical resistance. Remedial works to existing concrete slabs/roads will be undertaken to ensure that they provide a competent surface, for example resealing of joints.

3.6.1.3 Access and Traffic Thoroughfare

Vehicular access through the flow guiding walls will be via ramps (speed humps) restricted to nom 300mm in height and 1:15 slope, reprofiling of some local low spots may be necessary in order to achieve the 300mm height of the ramps.

Flood gates have been included at the proposed entry points into the close containment areas around the secondary digesters, where there is a need for non-frequent access need and where geometry precludes the use of ramps.

To allow access on foot, steps with handrails will be constructed to allow workers to traverse the walls.

3.6.1.4 Existing Services

Several above ground pipes can be seen from aerial images which may need to be relocated during construction/excavation.

3.6.2 Geotechnical and Environmental constraints

The existing shrubbery within the containment area shall be removed and area infilled with concrete. To compensate for the loss of shrubbery, alternative areas shall be identified onsite for compensation planting or planting containers installed onsite.

3.6.3 Other constraints

None.

3.7 Design allowance for rainfall

In addition to the maximum volume arising from a credible failure scenario, extra allowance for rainfall that may accumulate within the contained area before and after an incident has been made. The CIRIA guidance recommends that the containment volume should include an allowance for the total rainfall accumulated in response to a 1 in 10-year return period events for the 24 hours preceding the incident and for the duration of the incident, a three-day period in this case. The arising average rainfall depths for a 1 in 10-year storm over the event period for Bishops Stortford is 69 mm. It should be noted that the rainfall depths for Bishops Stortford have been estimated using the depth-duration-frequency rainfall model contained on the Flood Estimation Handbook (FEH), which provides location specific rainfall totals for given durations and return periods.

4. Secondary Containment

The constituent parts of secondary containment are;

- The contained area itself.
- The transfer system.
- Isolation of the drainage from both the contained area and from the transfer system.

For Bishops Stortford, where possible, existing features of the site (e.g., building structures and impermeable surfaces) are used as much as possible to provide the remote secondary containment to reduce cost. The options considered, modifications and their functionality at Bishops Stortford STW are listed below:

- Bund/walls to contain liquid. The heights of bund/walls given in Section 4.1 are the minimum heights required such that that top of the bund/wall is equal to the top water level plus a 250mm freeboard consideration for potential surge (to reflect the planned use of concrete walls with a recurved profile to return flow back on itself) in accordance with CIRIA.
- Containment ramps to provide a barrier for the liquid on roads that still need to be accessible to vehicles for site operation. The maximum height of these will be nom 300mm to avoid issues with vehicle passage. The risk of spill at the ramps is mitigated by conveyance of the flow to site drainage and return to the head of the works.
- Local infill of grass/gravel to create an impermeable surface and facilitate containment and conveyance.
- Steps will provide a containment barrier and allow access in and out of the containment area where foot traffic is high, but vehicular access is not needed. These steps will have handrails to facilitate safe passage over them.
- Flood gates to installed where areas with foot traffic are low, but where vehicular access may be necessary.

4.1 Containment Options

Two lagoon options were investigated with operations, the first considered using existing sludge lagoons to the east of the site. Following a study of the topography of the land it was decided that this option was unfeasible, as there would be insufficient head to allow a spillage to flow to the lagoons, it would also require substantial tunnelling below existing structures. For these reasons, this option was not explored further.

4.1.1 Wide containment area to Lagoon

Small containment areas around each tank were also considered but deemed to impact substantially the workability of the site. For this reason, a wide containment solution for the whole sludge treatment area with a lagoon to the south west of the site was adopted. Table 5 below provides a summary of Option 1.

Table 5 – Summary of option 1 containment area option

Containment Area	Description of containment
Wide containment area to Lagoon	• Wide containment with low diversion bund walls between 0.3m high that will retain spillage within the site and divert towards secondary containment. • 4 large ramps will provide access for vehicles as main access routes are included within the containment area. • Steps to be installed for access to foot traffic. • 1 flood-gate will be installed to allow infrequent access to vehicles where space precludes the use of ramps.
Summary	• Option reduces impact to operational access as no individual tanks are isolated within a high bund. • Minimal conveyance routes that require regular and onerous maintenance. • Uses natural topography of the site to divert spillages to the proposed lagoon location. • Repurposes old sludge lagoon, reducing excavation.

4.2 Mitigation of Site-Specific Risks

4.2.1 Jetting and Surge Flows

There is a potential for jetting from the southern primary digester to overshoot the bund wall. The impact of any flow should be mitigated by the operation of the site's road drainage providing a conveyance pathway to the head of the works.

The likelihood of jetting occurring however is deemed low as failure is more likely to begin with major seeping from the tanks which would be spotted during routine site walkabout tours each day.

The natural topography of the site and the distance to the boundaries of the containment area results in a low risk of surge overwhelming the containment.

4.2.2 Flooding

According to the UK Government's Flood Map for Planning, the sludge area is in Flood Zone 1, as shown in Figure 4.3. The Flood Zone definitions listed in Table 3.1 provide additional detail of the areas of concern, which in the case of Bishop's Stortford STW, have a 1 in 1000 or less probability of river flooding. Mitigation measures are not to be considered for fluvial flooding given that the probability of flooding in the area is low.

Additionally, in the Flood Risk Vulnerability Classification sewage works are classified as 'less vulnerable', if adequate measures to control pollution and manage sewage during flooding events are in place.

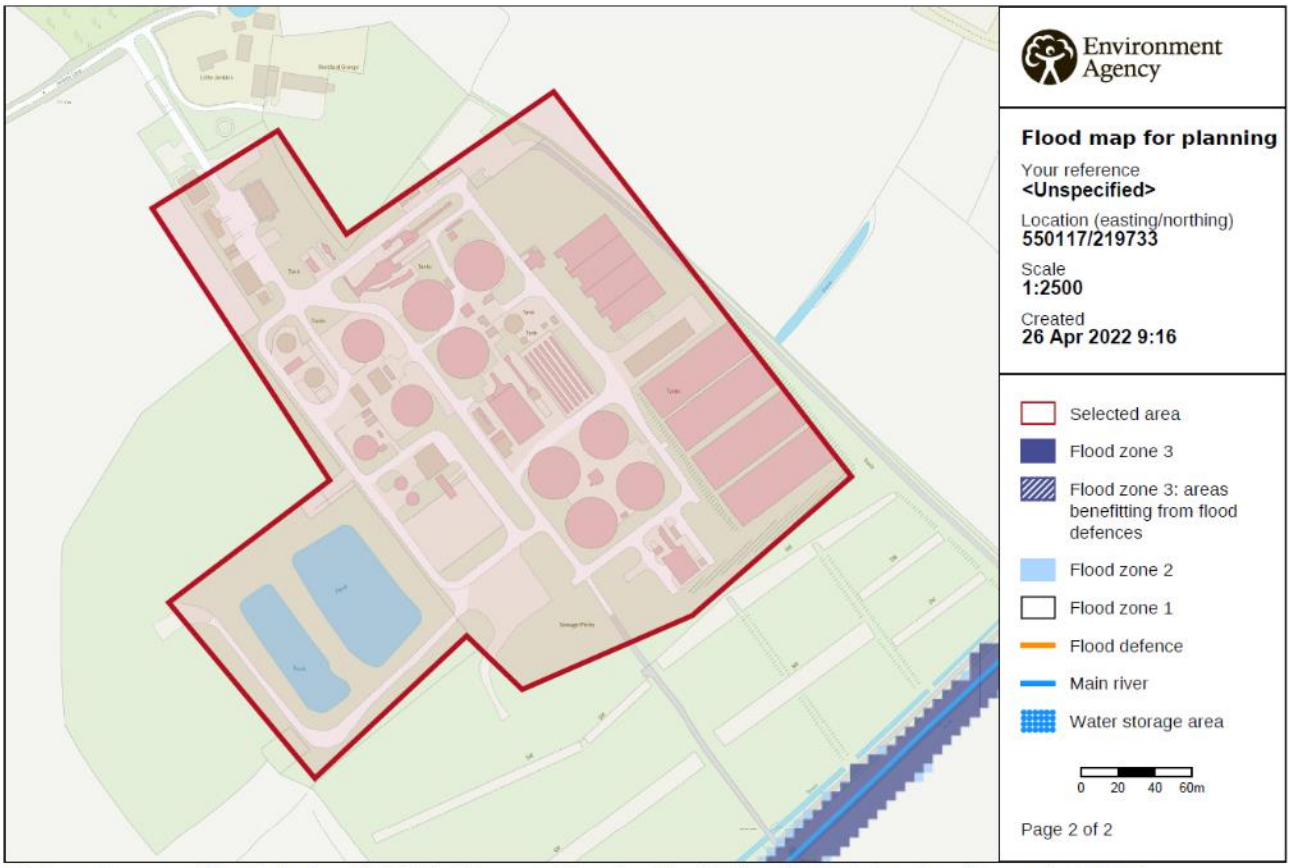

Figure 4.1 Extent of Fluvial flooding in Bishops Stortford due to extreme weather events

4.3 Identification of Preferred Option

The preferred containment proposal is Option 1 which considers the following advantages:

- Efficient use of assets/space (using roads and elevated areas to act as natural bunding).
- Practicality of installation (lower containment bund construction required).

- A lower bund wall will minimise long term site operational impacts including line of sight and ease of access.
- Access road operation simplified by use of ramps on regularly trafficked site roads to cross containment lines rather than by the use of floodgates.
- High ground provides natural barrier to spilt sludge reducing need for bunding
- Topography of site allows practical design within minimal need for excavation for pipework.

H&S and CDM risks

- Confirm that the containment walls do not impact the existing DSEAR equipment rating.

5. Site Drainage and liquor returns

5.1 Process flow diagram

The process flow diagram is show in Figure 5-1 below.

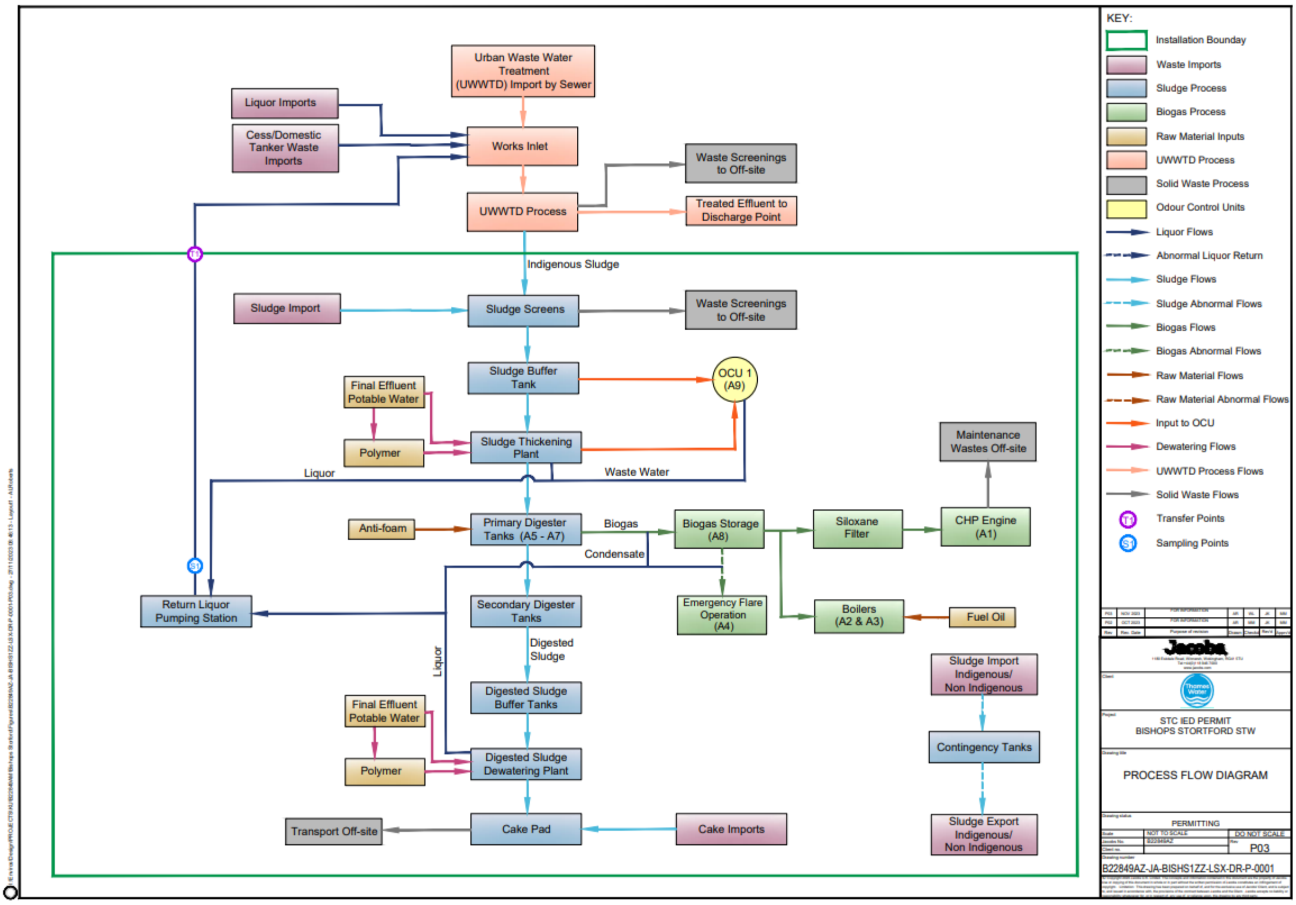

Figure 5.1 Process flow diagram for Bishops Stortford STW

5.2 Foul Process and Effluent Drainage

There are two site drainage and return liquor pumping stations on site. The main Return Liquor Pumping Station and the Foul Water Pumping Station. All surface drains are reported to drain to one or the other. Supplementary survey work has been undertaken to confirm the discharge at Bishops Stortford. The existing drainage is detailed on drawing BISHS1ZZ-SSP-001 and an image of this is shown in Figure 5-2 below.

Figure 5.2 Services Plan Covering Bishops Stortford Containment Area

Containment options onsite involve replacing existing impervious areas with concrete. This will result in a small increase in site surface waters, which are likely to have a negligible additional effect on the head of the works given the scale of flow to full treatment at Bishops Stortford.

5.3 Liquor Returns

The existing liquor return system is not being altered by the containment system, other than the control modifications proposed in Section 5.4.

Details of the liquor returns sampling are being developed outside of this report for incorporation within the permit submission.

5.4 Automatic Isolation Valves

For the catastrophic loss of containment scenarios for digester area discussed, such a loss could be automatically detected by the level sensors in the tanks. A catastrophic failure would be identified by the rate of change in tank level being larger than expected at normal operation. The signal from the sensors would be used to generate an alarm.

In the event of a catastrophic sludge spill, flows entering the head of the works via the drainage pipes could adversely impact the sewage works treatment process. Therefore, in the event of a catastrophic loss of containment, this line should be isolated.

It is recommended that float operated isolation valves are installed on all outgoing drainage lines from the containment area. These valves will remain normally open but will close when high levels in the existing drainage system are encountered. This drainage configuration will have the following impacts:

- In heavy or intense rain events these drainage isolation valves may be triggered, and operators onsite will need to manual operate these valves to release flows into the existing drainage network.
- In minor or slow flow tank spill events, the sludge spill will flow into the existing drainage network (and into the head of the works) unless operators intervene to isolate the drainage networks. Due to the flow to full treatment at Bishops Stortford being large, minor spill flows will not adversely impact the process.
- In most locations, to accommodate the new isolation valves, new manholes need to be constructed over the existing drainage lines.

6. Conclusions

This section summarises the findings of the containment assessment options report for Bishops Stortford Sewage Treatment Works.

Based upon the Anaerobic Digestion Bioresources Association (ADBA) containment assessment tool; the site carries an overall site risk rating of Medium meaning that Class 2 containment is needed. The total contained volumes comprise:

Containment Area	Volume	Rule
Wide containment area	**1,135m3**	25%

Containment Area	Description of containment
Wide containment area to Lagoon	• Wide containment with low diversion bund walls min. 0.3m high that will retain spillage within the site and divert towards secondary containment. • 4 large ramps will provide access for vehicles as main access routes are included within the containment area. • Steps to be installed for access to foot traffic. • 1 flood-gate will be installed to allow infrequent access to vehicles where space precludes the use of ramps.
Summary	• Option reduces impact to operational access as no individual tanks are isolated within a high bund. • Minimal conveyance routes that require regular and onerous maintenance. • Uses natural topography of the site to divert spillages to the proposed lagoon location. • Repurposes old sludge lagoon, reducing excavation.

The contained spill modelling retains the tank contents and associated rainfall within the site boundary and the flows can be managed by TW operations for return to treatment.

Existing gravelled and grass areas within the containment will be replaced with concrete. Elements of the site roads will be replaced/repaired to allow them to present an impermeable surface.

In addition to the containment elements, isolation of the site drainage system linked to the containment area will be required to mitigate the risk of unmanaged flows impacting the sewage treatment works.

Freeboard allowances and the profile of the containment bund wall provides mitigation against surge effects. Jetting escape is low and the potential impact is mitigated by the action of the site drainage system conveying flow to treatment.

Appendix 1 ADBA Site Hazard Risk assessment summary for Bishops Stortford STW

ADBA Industry Guidance and CIRIA C736 state how the site hazard rating of the site risk and classification are to be calculated. A summary of the hazard risks for Bishops Stortford STW are as follows:

Source – There is one main source that has been identified:

1. Sludge digestate

The Source Hazard rating was determined as **High**.

Pathway – There are two pathways that have been identified:

1. The process and site drains take any liquid to the head of the works which would negatively impact the process stability on site and would eventually impact on the receiving watercourse.
2. Sludge treatment centre is integrated with large sewage works; as a consequence,

The Pathway Hazard rating was determined as **Medium**.

Receptor – There is one potential receptors which have been identified:

1. There is a residential area <250m to the north of the sludge assets

The Receptor Hazard rating was determined as **High**

Likelihood – The mitigated likelihood is **low**, which reflects the use of materials, the tank systems do not have a history of failure, the tanks are designed to British Standards and installed by competent contractors and Thames Water undertake regular site tours giving the opportunity to identify early indications of potential issues.

Based on the information above the overall site risk rating was calculated to be **Medium** which means that **Class 2 secondary containment** is required.