J840 – STC IED Containment

Chertsey STC – Containment Options Report

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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 have been identified where containment proposals are required. This report deals with the proposals for Chertsey.

Chertsey STW serves the areas of Chertsey, Egham, Lyne, Addlestone and parts of Weybridge with a population equivalent of 89,000. 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.

Chertsey holds some 8778m^3 of liquid within the sludge treatment centre. The liquid sludge is stored in 15 tanks with individual volumes varying between 12-2166m^3, refer to section 3.4.1 for details of the tanks and volumes, and the majority of the tanks are steel. The site slopes from the east of the site. The containment volume of 3659m^3 is driven by the volume of the largest tank plus site specific rainfall allowance which exceeds both the 110% rule (of the largest single tank) and 25% of the total tanks volume.

One option for containment has been identified and will be reviewed with Operations to confirm that the working of the sewage treatment work is not compromised by proposals, refer to section 4.1 for details on the option and section 4.3 for preferred option:

1. Wide area containment whereby the primary digesters and other sludge tanks are contained within a bunded boundary with sufficient area to generate shallow depth that does not deny emergency access to equipment when the spill has been contained.

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 four-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 use concrete (with no liner) on the basis of the impermeability of the concrete, inherent strength and long-term mechanical resistance.

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.

General layout of proposed solution

The modelling highlights that the design detailing will need to incorporate localised road raising in addition to vehicular ramps to ensure access is maintained.

Grassed and gravel areas within the containment boundary are to be replaced by concrete. Some of the concrete roads in the containment area will require replaced/repaired to enable them to be impermeable.

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". 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 25 Thames Water sites. Based on CIRIA C736 and ADBA risk assessment tools this containment report addresses the site-specific risks at Chertsey 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 Chertsey 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 Chertsey STW were identified through a desktop study, Light Detection and Ranging Analysis (LiDAR) analysis and a site visit.

Chertsey STC is contained within Chertsey Sewage Treatment Works (Figure 1 to Figure 3) and is located next to Junction 2 of M3/Junction 12 of M25 in the north of Surrey. The Southwestern railway line passes the south of the site next to the Thermal Hydrolysis Plant (THP). The immediate surroundings are mainly farmland and some wooded areas. The River Bourne (a tributary of the River Thames), flows approximately 300 meters west to the site. There is a waste recycling site next to the works. Chertsey STW serves the areas of Chertsey, Egham, Lyne, Addlestone and parts of Weybridge with a population equivalent of 89,000. The existing processes involves the settlement of solids and treatment of the remaining water using a biological process where bacteria breakdown organic matter in the sewage through the activated sludge treatment process.

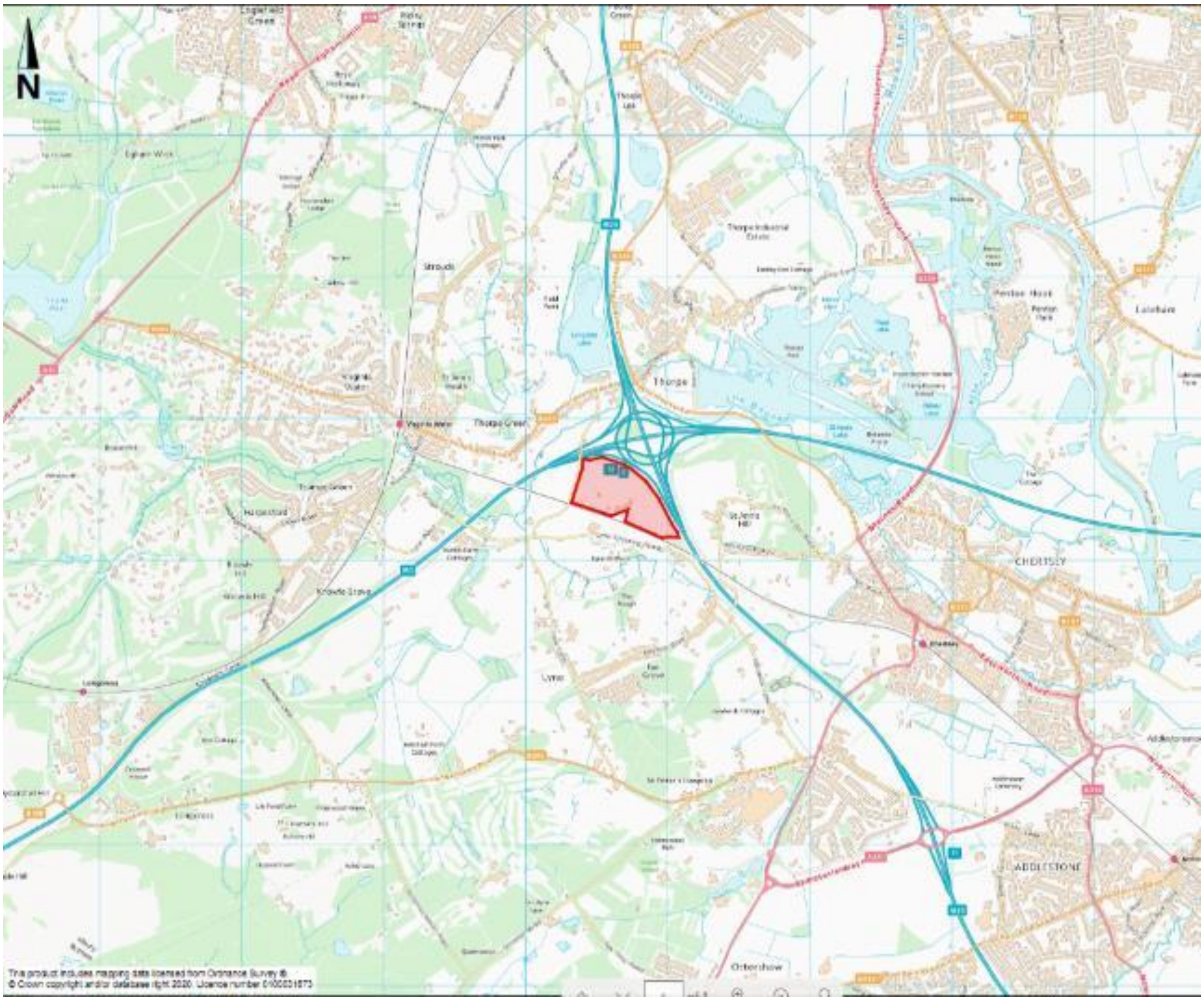

Figure 1-Site location plan of Chertsey Sewage Treatment Works

Figure 2- Satellite view of Chertsey Sewage Treatment Works

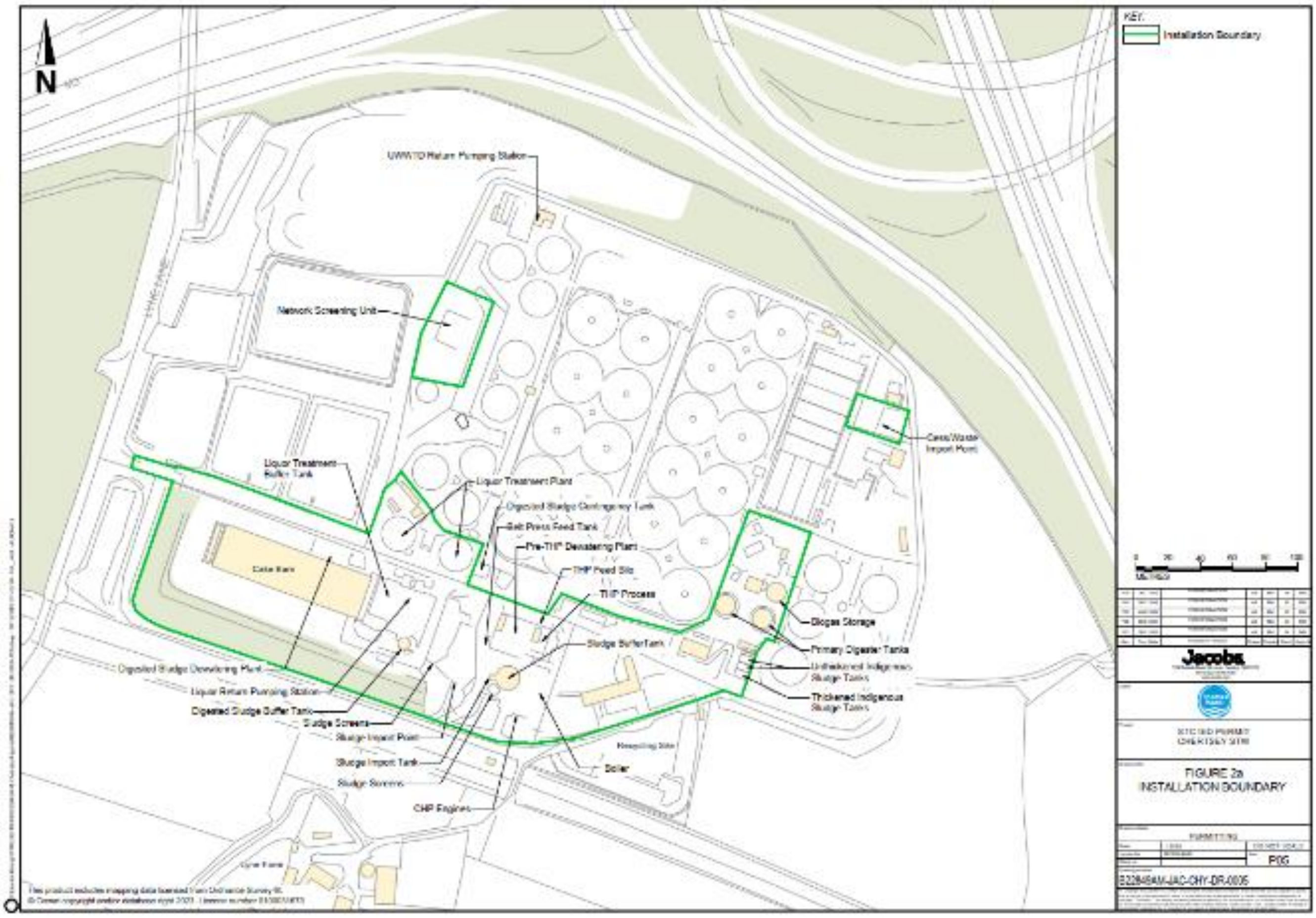

Figure 3- Boundary of the permitted IED area and the assets contained within Chertsey STW

3. Proposed Containment at Chertsey 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;

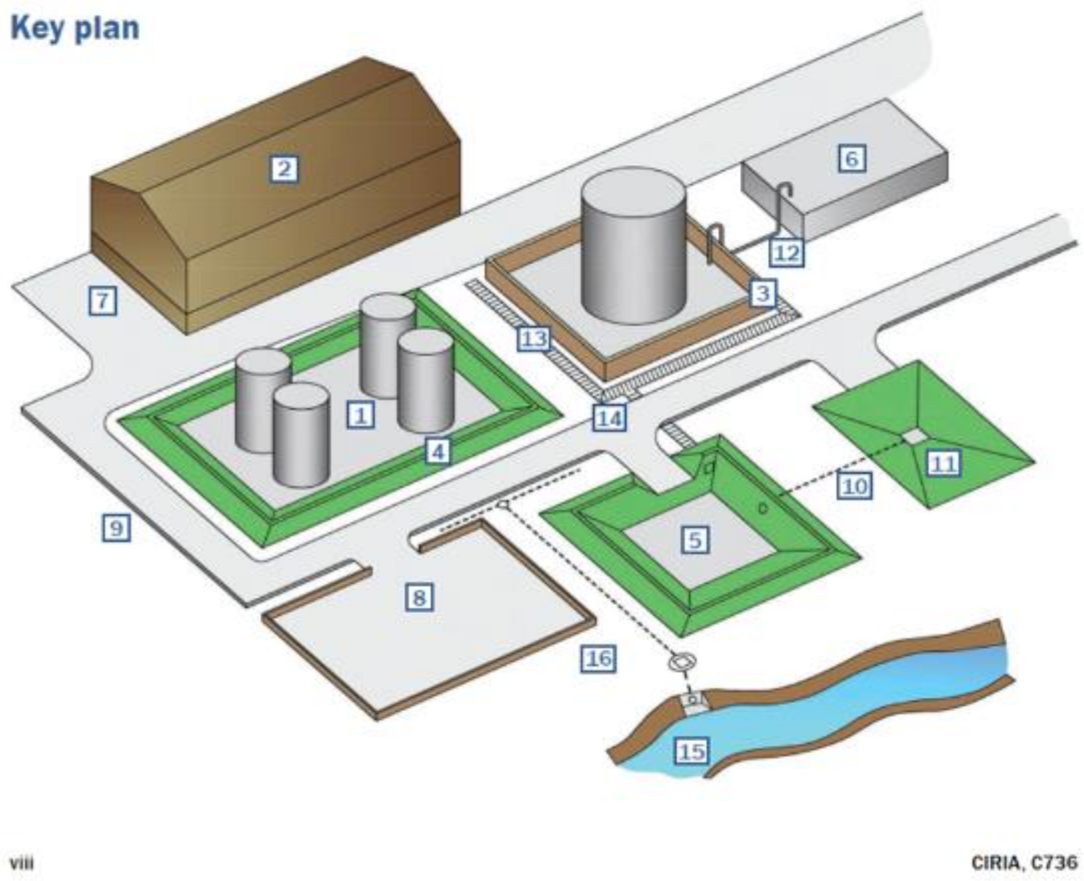

Figure 4- Diagram of primary, secondary and tertiary containment examples

-**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 model Modelling

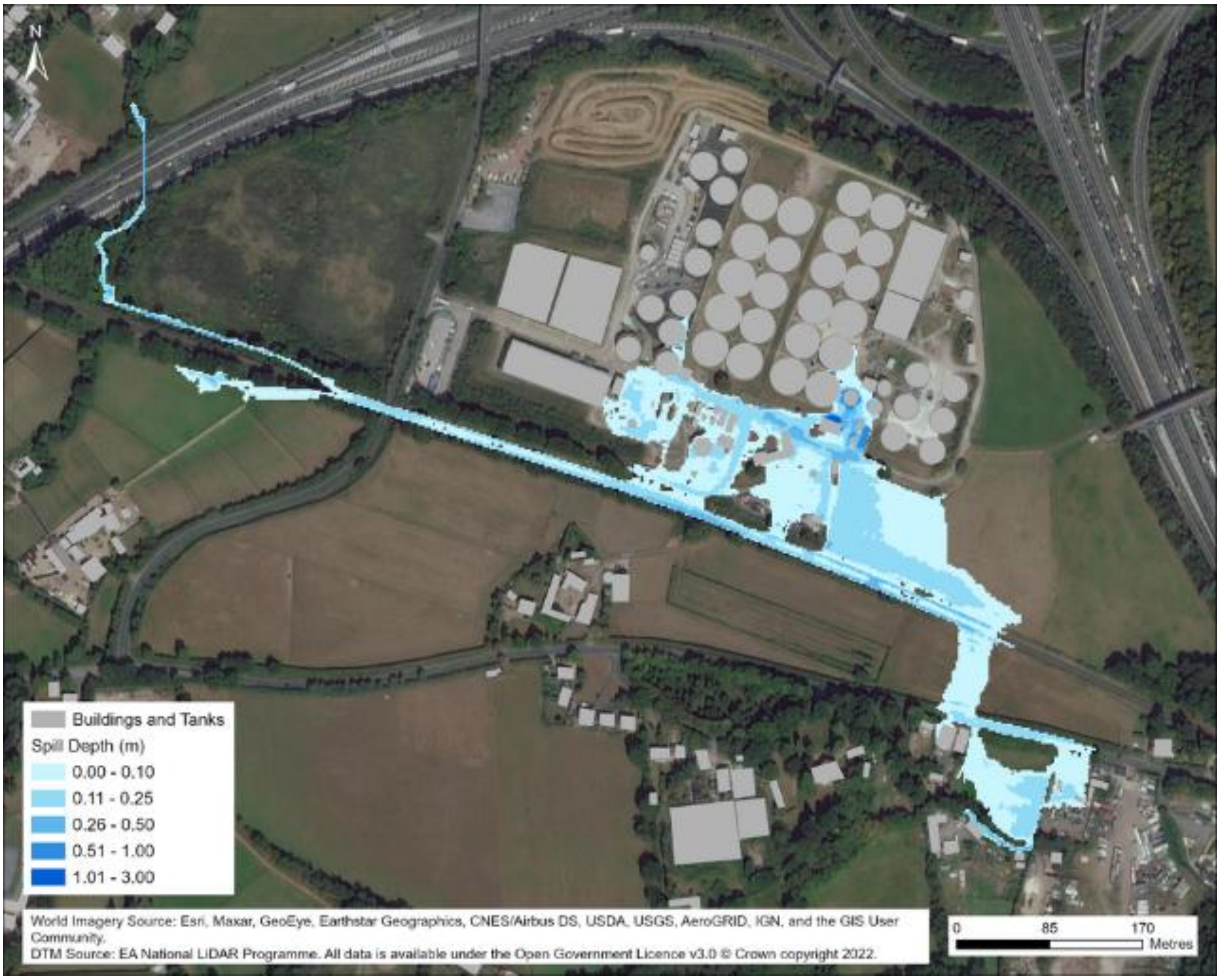

Figure 5- Uncontained Spill Model Results

As seen from Figure 5, the sludge spill mapping of an uncontained event in Chertsey STW showed that a potential sludge spill from the one of the 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 (from the southern site boundary) in approximately 4 minutes after the failure of one of the digesters.

Assuming the spilled sludge originate from the failure of one of the Primary Digester on site, the spilled content will first travel south bound to reach the internal road in the STW. Here the flow splits in two; part of it travels west and majority travels south bound. Travelling along the internal road, some of the sludge flows westward engulfing the site office building area, it then flows into the THP units' area; eventually reaching the Cake Storage area within site. Some sludge will overflow northward to the SBR tanks with in the STW. But most will pool around the Cake Storage area and THP area, eventually overflow onto the railway tracks behind the Sludge Import Tank.

The rest of the sludge will travel south bound into the Lyne Community Recycling Centre and the green field east of it. The flow will split with the majority continuing to the south easterly direction reaching the railway tracks and flow over the land of Lyne Farm (Reaching the Lyne Crossing Road and the private property located there). The sludge also travels east and southeast across the field next to the property to reach Hamilton's Nursery. Other part of the flow will flow westward along the railway tracks, passing under the bridge Lyne Lane and reach the River Bourne, a Thames tributary.

It should be noted that the railway line south of the site acted as a channel during the spill mapping.

3.3 Site Classification Chertsey

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

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

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

3.4 Chertsey STW Summary of Assets and Secondary Containment Requirements

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 of the guidance 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 of the CIRIA guidance 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. Sections 4.3 and 4.4 of CIRIA 736 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.

3.4.1 Assets for containment

The tanks for which containment is required are summarised below:

Table 1- Tanks for containment

List of Tanks within Containment Area	Number of Tanks	Individual Effective Tank Volume m^3	Total Effective Tanks Volume m^3	Material
Unthickened Indigenous Sludge Tanks	2	86	172	Concrete
Thickened Indigenous Sludge Tanks	1	86	86	Concrete
Sludge Buffer Tank	1	600	600	Concrete
Pre THP-Dewatering Feed Tank	1	30	30	Steel
THP Feed Silo	1	50	50	Steel
THP Process	1	Consisting of the following:		
THP Process -Tanks Pulper	1	25	25	Steel
THP Process- Tanks Reactor Tanks	1	12	12	Steel
THP Process Tanks- Flash Tank	1	35	35	Steel
Primary Digester Tanks	2	1,562	3,124	Steel
Digested Sludge Buffer Tank	1	156	156	Steel
Digested Sludge Contingency Tank	1	156	156	Concrete
Liquor Treatment Plant	2	2,166	4,332	Steel
Total Tanks Volume within Containment Area	15	-	8,778	-

3.4.2 Design allowance for rainfall

The containment volume, when not dictated by the 110% or 25% containment rules includes an 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 an incident and for an eight-day period following an incident or other time period as dictated by site specific assessment. Thames Water has indicated that the clean-up and return to operation is feasible in 3 to 4 days. Therefore, a three-day period following an incident has been allowed for in the design allowance for rainfall following the incident. The arising average rainfall depths for a 1 in 10-year storm over the event period for Chertsey is 78 mm. It should be noted that the rainfall depths for Chertsey 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.

3.5 Identified Constraints

3.5.1 Operational constraints

The existing ground surfaces within the containment area that are grass and gravel and will need to be replaced with an impermeable surface e.g. concrete from which sludge can be cleared up easily.

TW operations have stated that it would be difficult to clean up sludge from gravel areas as the gravel would also sucked up with the sludge.

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.

The solution will need to keep site main road open during a spill as it is used frequently by Operations and Samplers dropping of samples to the lab.

3.5.2 Geotechnical and Environmental constraints

Ground conditions need to be considered during excavating and backfilling activities.

Regarding the construction works, there are no significant environmental constraints as these will all be completed within a Thames Water site.

3.5.3 Topographical Constraints

The digital terrain model (Figure 6) shows that the site slopes down from the east.

Figure 6- Digital Terrain Model of Chertsey Sewage Treatment Works

3.5.4 Other constraints

None identified

4. Secondary Containment Solution

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 Chertsey, where possible, existing features of the site (e.g., suitable 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 Chertsey 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 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 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.
- Raised kerbs on roadways to channel spill to the remote containment area.
- All buildings within the containment and transfer areas must either have doors that lie above the top water levels detailed in Section 4.1 or do not contain sensitive equipment below the anticipated the top water level.

4.1 Containment Options

4.1.1 Containment Option 1 – Wide Area Approach

A single option has been identified. Early review indicated that close containment of individual tanks was not practicable for daily operation. Containment option 1 for the site considers a wide area containment solution. This helps reduce the average bunding height to 650mm which provides sufficient containment depth for the average 400mm sludge depth. A low bunding height reduces the cost of the works, disruption to operational, maintenance and future site expansion activities on site. Due to the gradient across the site, some sections of the bunds may approach 1.35m in height. Earth bunding has not been considered as this is more difficult to clean and maintain for site operators.

The total design contained volume comprises 2166m^3 from catastrophic SBR tank failure, and 1493m^3 from the 1 in 10 year rainfall falling on the catchment area, giving a total volume of 3659m^3.

The containment volume was also checked against the 110 and 25% rule and the largest tank plus rainfall exceeds both due to the rainfall influence. Table 2 below summarises the check of the total design containment volume against the 110 and 25% rules as well as the largest tank plus rainfall.

Table 2: Design Spill Volume Summary

Summary Sheet	
Largest Tank plus Rainfall (m^3)	**3659**
110% of Largest Tank within Containment Area (m^3)	2355
25% of All Tanks within Containment Area (m^3)	2369

4.1.2 Contained Model Output

The contained model output is shown in Figure 7 and Figure 8. This identifies that the flows will naturally seek to flow south and west. The bunds in the east will act to contain the initial surge and then aid conveyance to the remainder of the storage and containment area to the west. The top water level (standing stored level) for the tank and rainfall volume is 27.22mAOD. Therefore, allowing for 250mm freeboard on the bund wall the bund height will vary between 0.25 – 1.35m with the higher bund wall along the northern sides of the containment area.

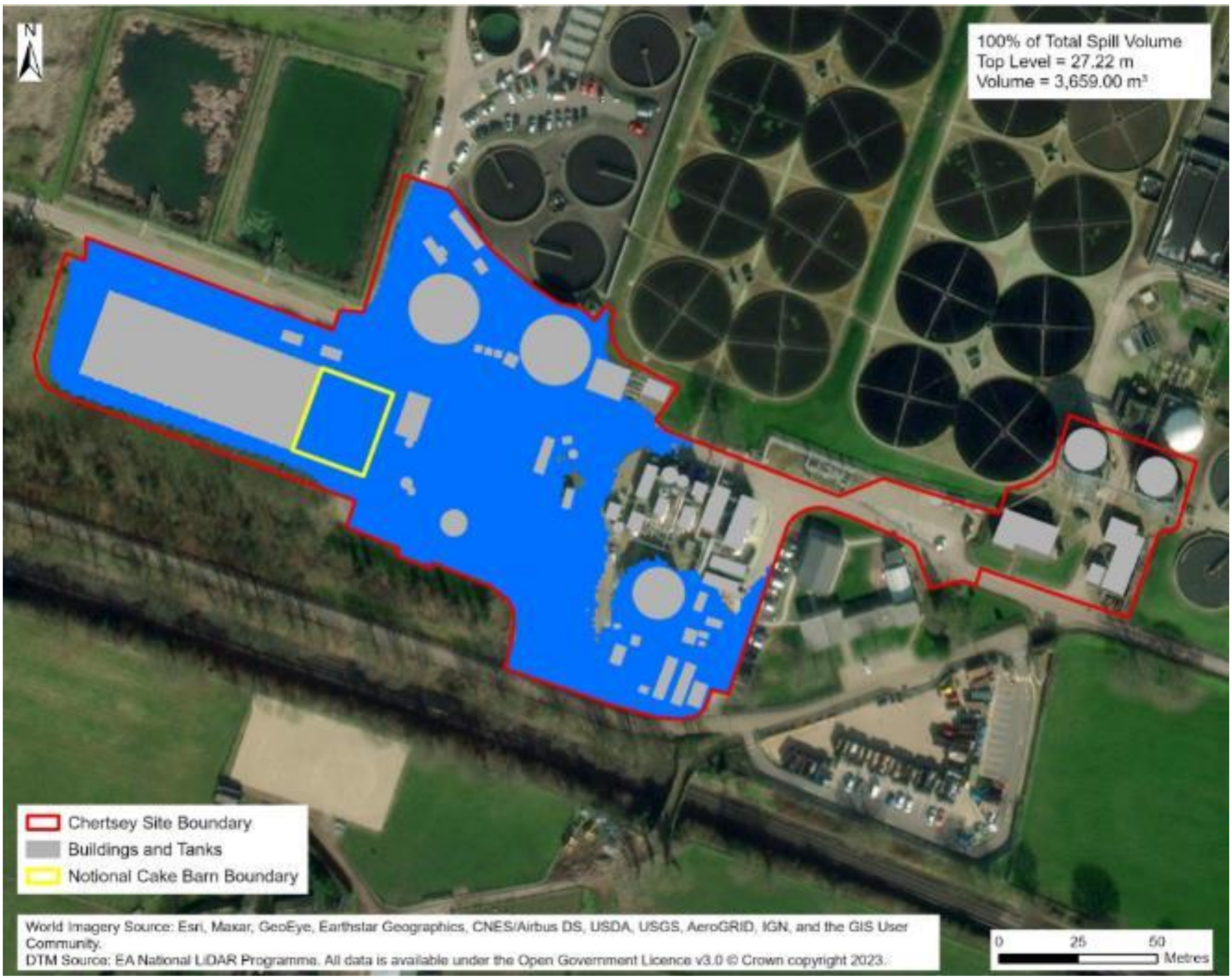

Figure 7- Containment Spill Model Output

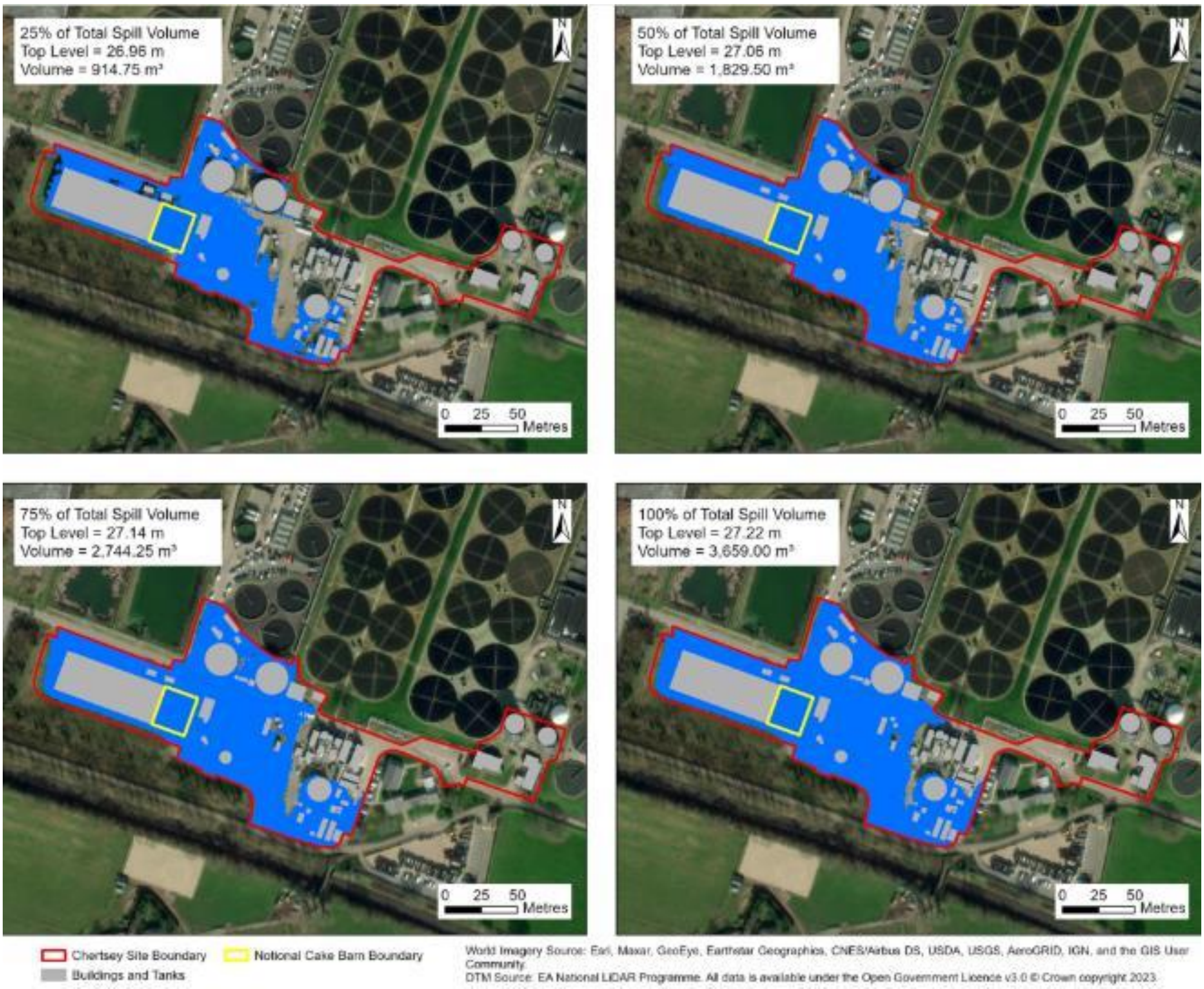

Figure 8 - Containment Spill Model Output at 25%, 50%, 75% and 100% Volumes.

Figure 9**Error! Reference source not found.** shows spot levels at the boundary of the containment area. Some of the potential depths at the two road crossings along the northern edge of the containment area are slightly more than what the ramps can hold and will therefore require some local road raising to accommodate the ramps in these locations. Along the southern edge of the containment boundary there are 2 entrances to the site one of which will be blocked as it is understood that this is not normally used and the other will be maintained using a ramp.

Figure 9- Spot Levels along Containment Boundary

Summary of the recommended containment for sludge area is described below and shown in

- Approximately 1055m of low concrete bund wall ranging between 0.25m and 1.35m high with an average height of 540mm. The foundation for the bund wall will extend 300mm below ground level.
- 5no. 300mm high road ramps across existing access to maintain access
- Local road raising at 2no. locations to keep road ramps to 300mm high max.
- 110m of locally high jetting screens fixed to the top of the containment boundary wall.
- All vegetation and gravel areas will be excavated and resurfaced with concrete to mitigate seepage into the local ground and soil. This also aids cleaning procedures following a spill.

- Any sludge that spills over the ramps will follow the road and end up in the site drainage and go back to the head of the works.

Figure 10- Containment Area

4.2 Mitigation of Site-Specific Risks

4.2.1 Jetting and Surge Flows

There is a medium risk of jetting occurring as the digester tanks are glass coated steel tank construction, for which catastrophic failure is deemed to be more of an issue. Failure is more likely to begin with major seeping from the tanks panels which would be spotted during routine site walkabout tours each day.

Due to the location of the Primary Digesters and the SBR tanks and their distance from the boundary of the containment area, there is some risk of contamination through jetting. One potential mitigation is the attachment of deflecting screen to the access staircase between the Primary Digesters and filter.

Surge effects have been mitigated by the bund profile (recurved to return flows back on itself) and the distance of the bund wall to the tanks.

4.2.2 Flooding

According to the UK Government's Flood Map for Planning, Chertsey STW is not within any potential flooding zone as shown in Figure 11 therefore, no modifications need to be made to Chertsey STW to accommodate this risk.

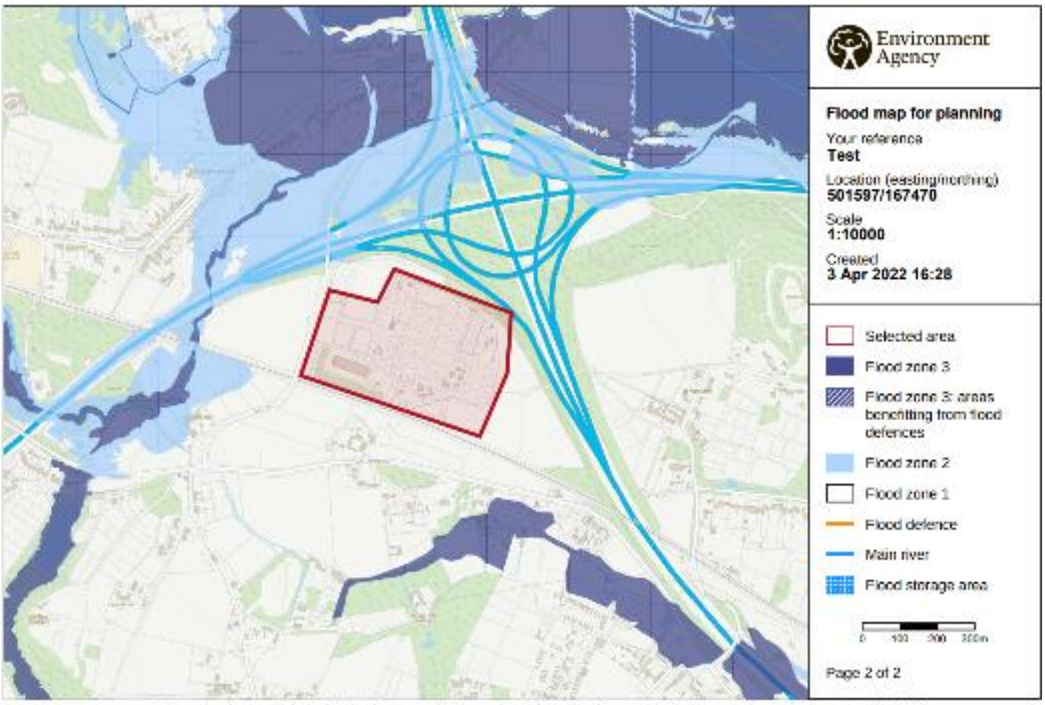

Figure 11- Extent of Fluvial flooding in Chertsey due to extreme weather events

4.3 Identification of Preferred Option

The preferred option is option 1, wide area containment, constructing a low bund wall (250-1350mm high) around the wide containment area and constructing ramps at road crossings.

4.3.1 Potential issues for solution detail (Inc H&S)

- Cable ducts and fibre ducts acting as conduits to transport the sludge spilt around the site. Work will be required to seal covers (installation of sealing plate) or sealing of ducts required.

![Jacobs logo]

5. Site Drainage and liquor returns

5.1 Process flow diagram

The process flow diagram is presented in Figure 12 below.

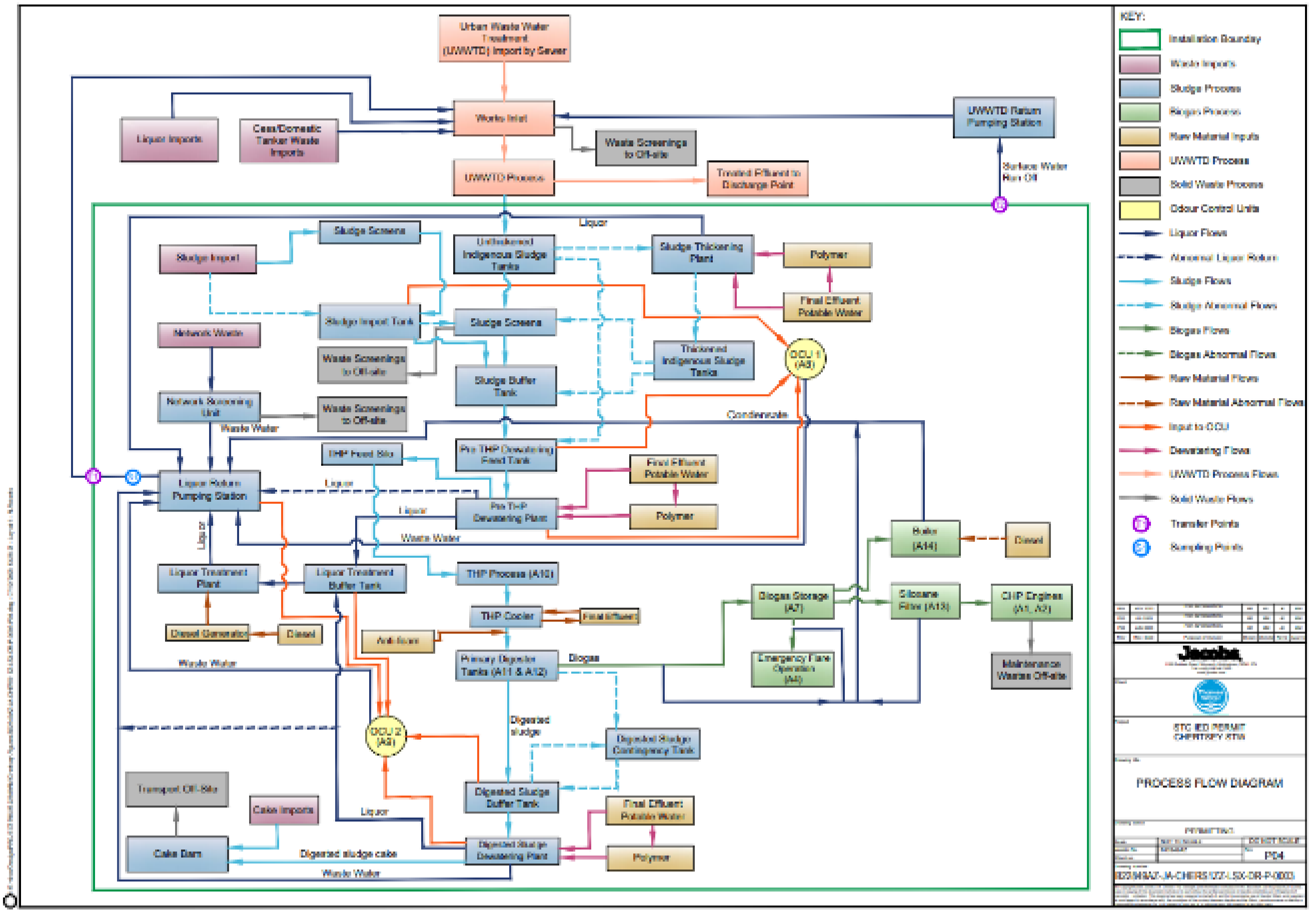

Figure 12- Process Flow Diagram

5.2 Foul, Process and Effluent Drainage

Site drainage assessments are based on Chertsey Sewage Works Layout Plan Drawing Number CHERS1ZZ-DPL-001.

The Sewage Works Layout Plan for Chertsey shows all Foul/ Combined/ Process/ Effluent drainage pipes, indicated by the green and blue lines in Figure 13 go to the head of the works. In the event of sludge entering the head of the works, the shock load could adversely impact the sewage works treatment process. Therefore, in the event of a catastrophic loss of containment, this line should be isolated or pumping should be inhibited.

The surface water drains, shown as the dark green lines, are also mixed with the process drains and go to the head of the works. As both systems combine, the surface water drains have been reviewed as part of this section.

As the proposed containment solution includes the sludge import area towards the western side of the site, further surveying is required in this area. Operations have stated all drainage pipework returns to the head of the works. However, additional surveying will confirm this. Referring to the topographical survey of the site, the lowest ground levels are to the west of the site and sludge will flow towards the lowest ground levels. There is an access road on the west side, which could be an exit point for spilled sludge and poses significant risk to external contamination. The yellow box on the site drainage plan overleaf highlights the suggested area to survey to inform final detailing.

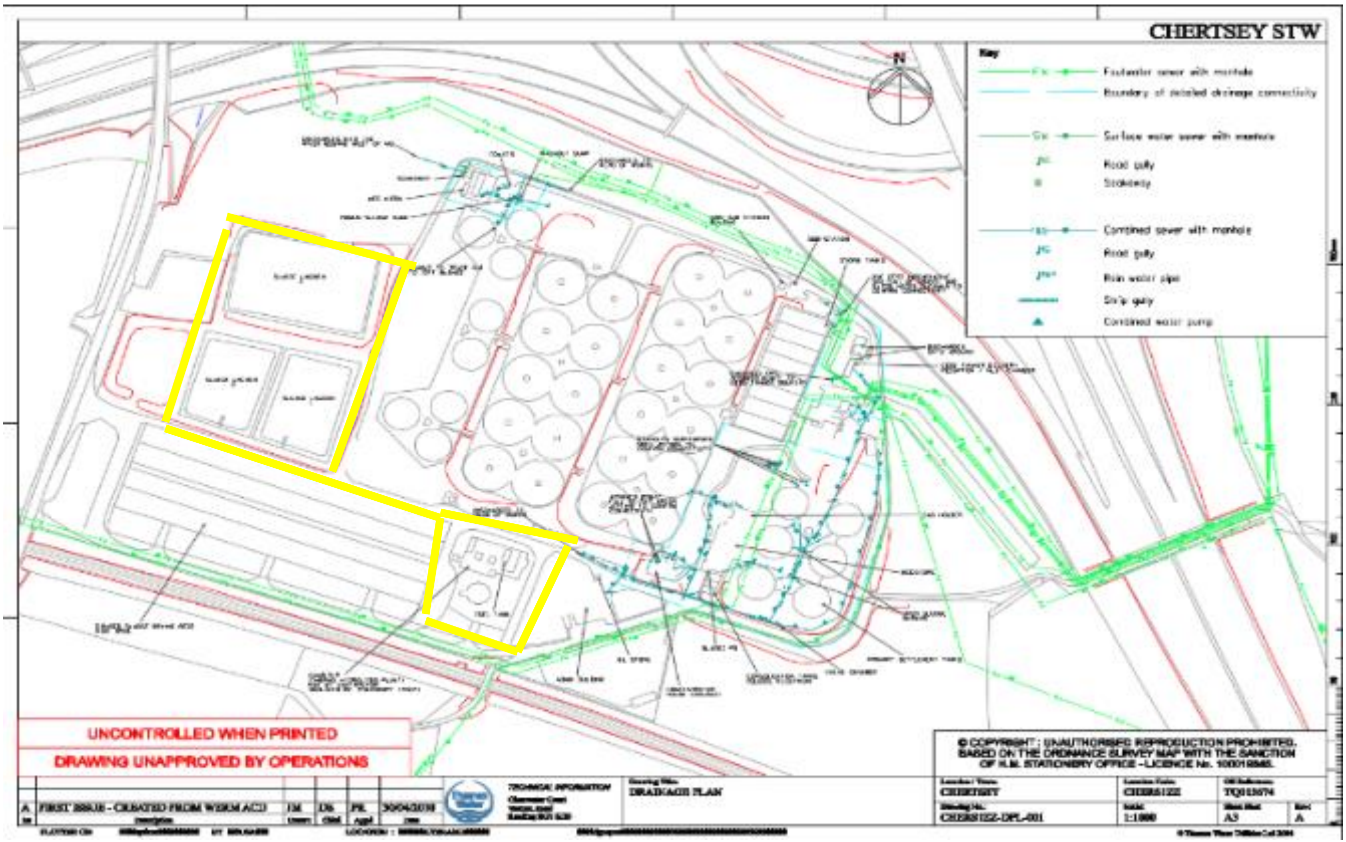

Figure 13- Site drainage plan

5.3 Liquor Returns

The existing liquor return system is not being altered by the containment system, other than the control modifications proposed in 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 – Site Drainage and Tanks

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 automatically prevent any adverse impact on sewage treatment. There are two options for this;

A. Level signal automatically isolates the at-risk pipes. This would prevent large flows of digestate from entering the drainage lines to the inlet channel or river. This option requires an automatically actuated isolation valve to be installed on each of these pipes.

B. Level signal automatically inhibits sludge being returned back to the head of the i.e., allow catastrophic spillages to enter the inlet channel but prevent it from being pumped back to the head of the works. This option requires no hardware or infrastructure, only software modifications.

Option B is cheaper and easier to implement as it will use current equipment and require only software modifications only. However, operators on site should be consulted to further understand the surface water drainage system to explore any automatic isolation solutions that involve software modifications only.

The option of the level sensor signal from an abnormal rate of change triggering an alarm system for an operator has been considered.

Once the spillage has been stopped and contained, any sludge in the drainage system can be released back into the head of the work in a controlled manner therefore, not creating adverse effects to the operation of the treatment works.

6. Conclusions

This section summarises the findings of the containment assessment options report for Chertsey Sludge Treatment Centre.

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 assessment focuses on site-specific risks and outlines the options available for providing secondary containment of a catastrophic tank or digester failure.

The results of the uncontained spill modelling show that a catastrophic spill will not be contained with the boundary.

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. Due to gradients across the site, water may pond in non-critical areas to a depth of of up to 1100mm. The volume for containment is driven by the largest tank plus rainfall.

The preferred option is option 1 – wide containment approach as outlined in Section 4.1.1 to construct a 1055m long low bund wall (250-1350mm high) around the wide containment area. Containment ramps will be constructed across the road crossings. 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. 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.

Freeboard allowances and the profile of the containment bund wall provides mitigation against surge effects. Jetting escape is mitigated due to the location of the tanks being remote to the containment boundary, except for the potential for primary digesters and one of the SBR to jet onto the percolating biological filters. A deflection screen option exists as potential mitigation during the detailing stage.

Appendix 1 ADBA Site Hazard Risk assessment for Chertsey STW

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

Source – There are two sources that have been identified:

1. Domestic and trade effluent Wastewater sludges, both in a raw, semi-treated and treated state.
2. Polyelectrolyte chemicals for sludge thickening.
3. Caustic chemical storage located between the buffer tank and the THP.

The Source Hazard rating was determined as High.

Pathway – There are two pathways that have been identified:

1. The process and site drains take both process and surface water to the head of the works which would negatively impact the process stability on site and would eventually impact on the receiving watercourse.
2. There are several areas where a sludge spill could pass over permeable ground.
3. The railway tracks south of the site will act as a channel guiding the spread of sludge in the event of a spillage.

Consequently, the Pathway Hazard rating was determined as High.

Receptor – There are two potential receptors which have been identified:

1. The site drainage system and the head of the works.
2. There is a "High" groundwater vulnerability in this location.

The site is in not near populated area being surrounded by farmland. However, the site is bordered by the motorway and railway line. Spillage can potentially cause damages to these infrastructures causing disruptions. No SSSI/SPA/SAC/RAMSAR Sites identified within trigger distances from the STC.

The Receptor Hazard rating was determined as High.

Likelihood – For the purpose of this assessment the likelihood for mitigated and unmitigated risks was calculated based on the assumption that the likelihood hazard rating is low.

Pre-mitigation measures, operational failures were highlighted as a high, shortfalls in design (provision of alarms and monitoring) together with structural failure were highlighted as a medium risk.

Post-mitigation measures operational failures were re-scored as a low risk. Therefore, the final Likelihood Hazard rating was determined as low.

Based on the information above the overall site risk rating was calculated to be medium which means that Class 2 secondary containment is required. (per CIRIA736 Chapter 2.2).