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J840 – STC IED Containment

Crossness 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 (STC) 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 Crossness.

Crossness STW serves a population equivalent of 2.1 million covering the majority of the South London Boroughs and its environs. 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.

Crossness has the potential for some 94,490m^3 of liquid to escape from the sludge treatment centre in the event of tanks failure. The liquid sludge is stored in 33 tanks with individual volumes varying between 250-4000m^3, refer to section 4.2.1 for details on the tanks and volumes. The majority of the tanks are concrete. The site is manned and subject to regular tours by operations staff. The site is relatively flat with local highpoints around the stormwater tanks (northwest corner) and primary sedimentation tanks (southeast). There are local low points around the site offices and primary treatment works (southwest corner).

Two options for containment were identified and reviewed with representatives from Thames Water Operations, these include:

1. Wide area containment and utilisation of the existing storm tanks
2. Wide area containment with high bund walls

The preferred option to progress is Option 1 (refer to Figure i-1) - Wide area containment and utilisation of the existing storm tanks. This option represents the best use of existing infrastructure onsite and a practical bund wall height which has long term and short-term operational benefits.

In addition to the creation of a wide area containment bund, 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 an eight-day recovery period. Vehicular access into the containment areas is by ramps (long-approach speed humps) restricted to nom 300 mm 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) based on the permeability 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.

Bund heights are being set to provide freeboard (0.25m) considering both static conditions when the containment has been filled and during the transient condition at initial failure. The containment volume identified reflects the potential escape volume from 25% of net volume of sludge tanks which exceeds the 110% rule and the largest tank volume plus 1 in 10-year rainfall volume that could arrive during the recovery period.

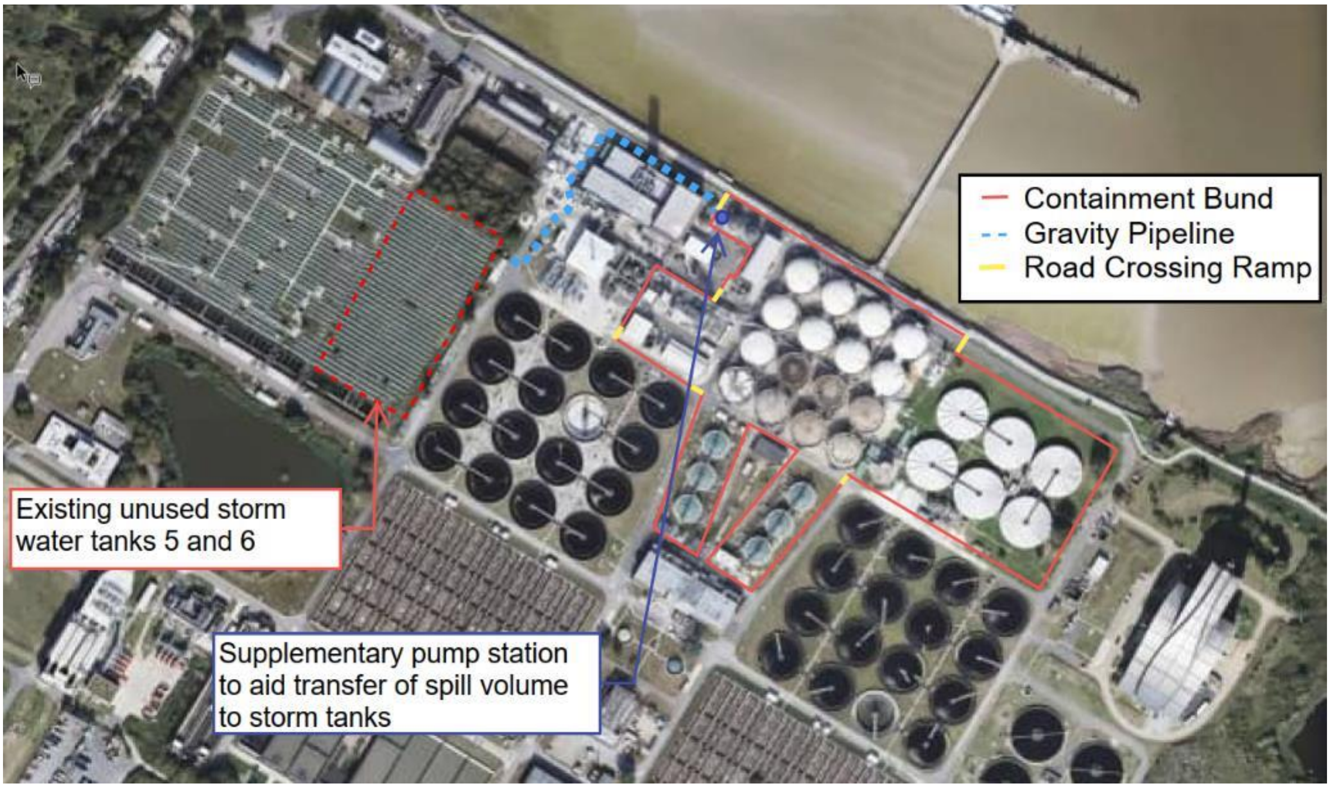

Figure i - 1 – General Layout of Proposed Solution (Option 1)

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

Crossness Sewage Treatment Works (STW), shown in Figure 2-1 and Figure 2-2, is located on the south bank of the River Thames in Thamesmead East, London Borough of Bexley. The site sits between Crossness Nature Reserve to the east and housings to the west. The Sewage Treatment Works serves for most of the south London Boroughs. The catchment area is approximately $240km^2$ and serves a population equivalent of 2.1 million people. 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. The sludges are treated using the Thermal Hydrolysis Plant (THP) plant to generate biogas for energy generation on site. The liquid sludge is stored in 43 tanks with individual volumes varying between $13\text{-}4000m^3$. The boundary of the permitted Industrial Emissions Directive (IED) area is shown in green in Figure 2-3 which also identifies the sludge assets.

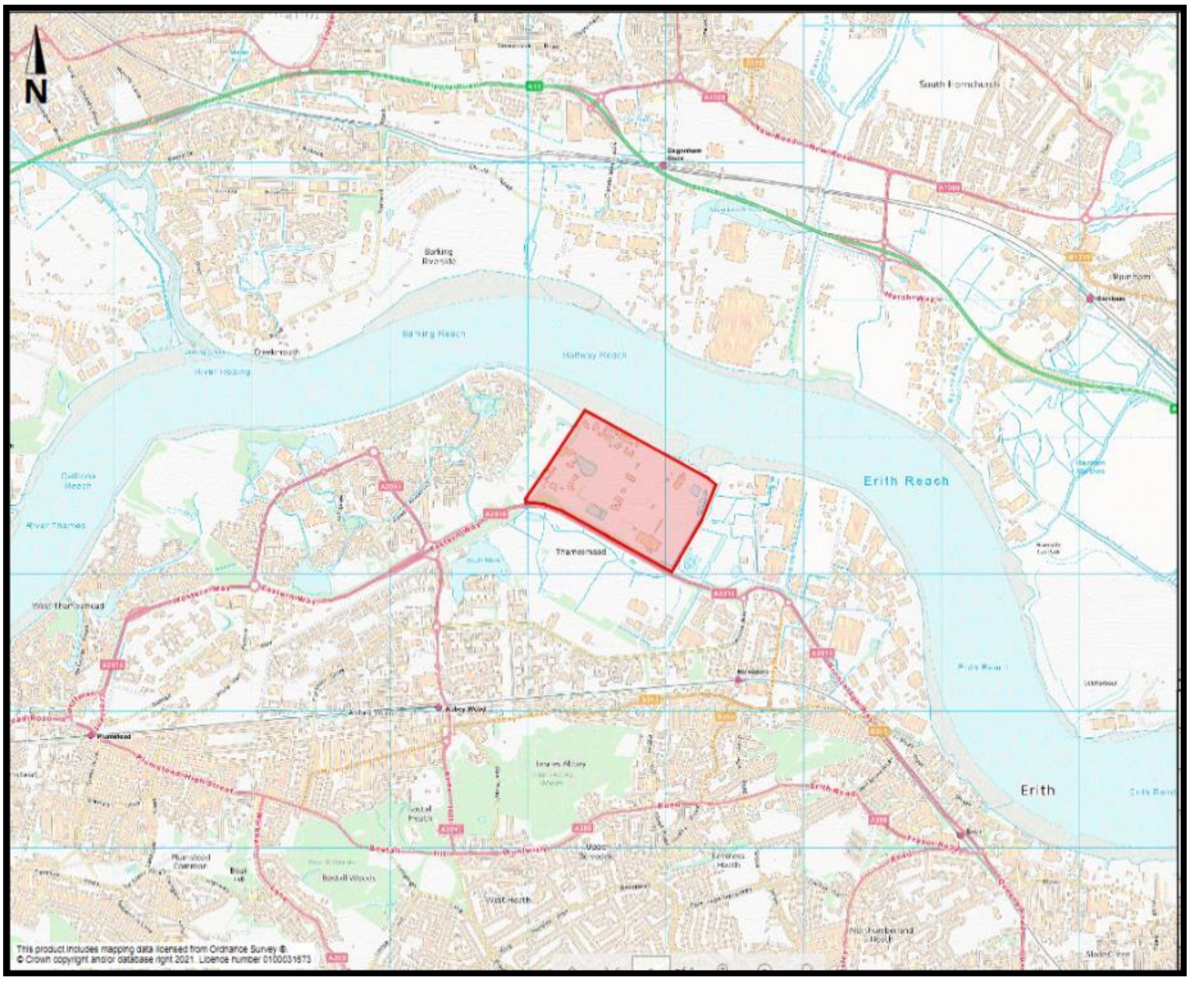

Figure 2-1- Location Plan Crossness Sewage Treatment Works

Figure 2-2 – Aerial Image of Crossness Sewage Treatment Works

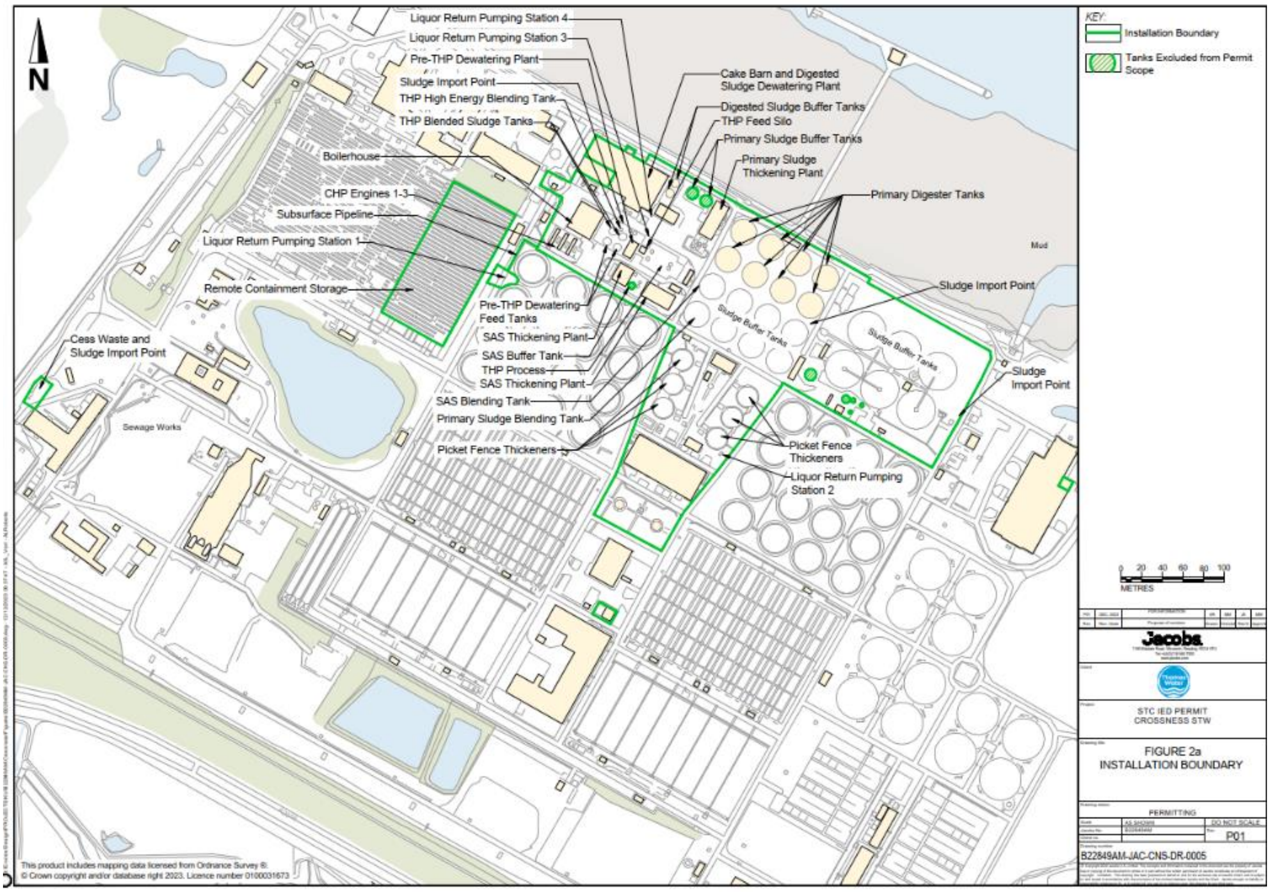

Figure 2-3 - Boundary of the permitted IED area and the assets contained within Crossness STW

3. Proposed Containment at Crossness

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 refers to a key plan, reproduced in Figure 3-1.

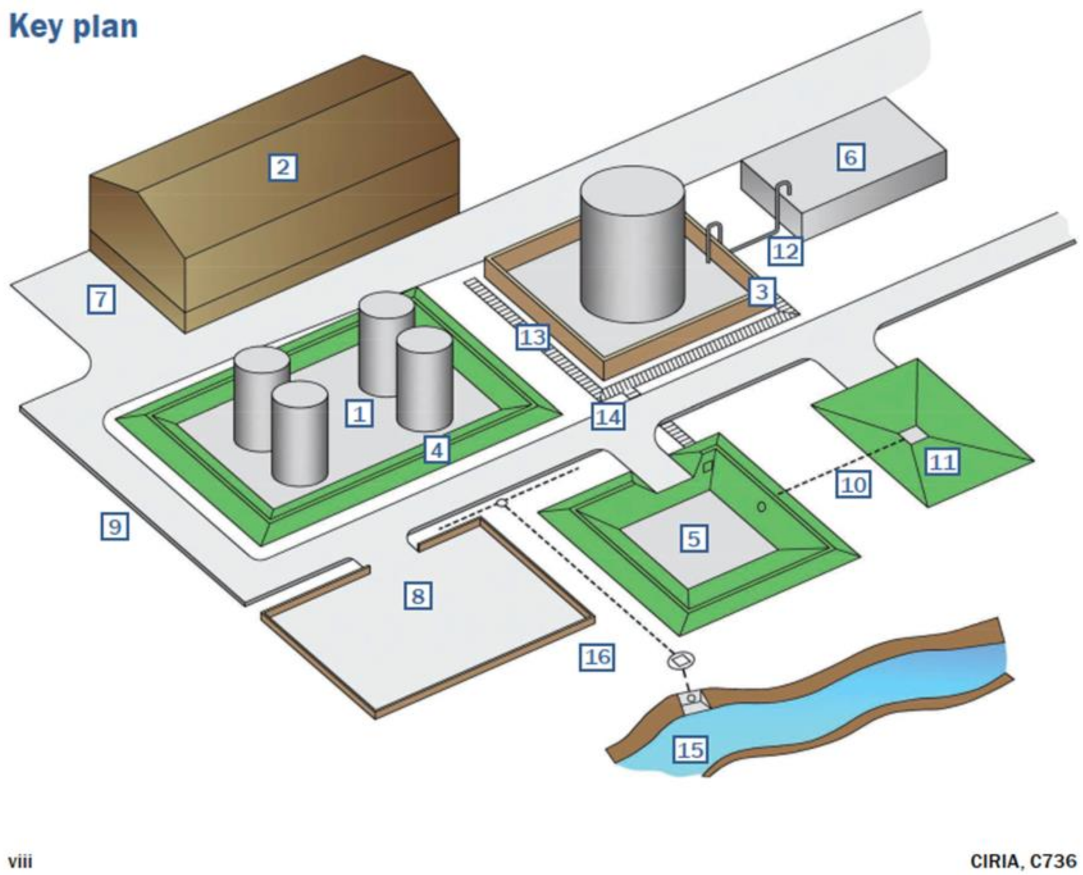

Figure 3-1- Diagram of primary, secondary and tertiary containment examples

The key definitions from the CIRIA containment options are as follows:

- **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 several 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 can provide the necessary degree of environmental protection. The overriding concern is not the terminology but the robustness and reliability of the system which depends on several factors such as;

- 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 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 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

The sludge spill mapping of an uncontained event in Crossness STW shows that a potential sludge spill will not be self-contained within the desired area and therefore passive containment needs to be implemented to safeguard the nearby receptors, refer to Figure 3-2. According to the modelling results, the spill will leave the site boundary (northside) approximately 12 minutes after the failure of one of the tanks. The immediate receptors of the spill will be the surrounding sludge assets and pathways within the STW, and the Thames Path Road to the north of the site and the nature reserve to the northeast of the site. Assuming the point of failure is one of the Sludge Buffer storage tanks, the sludge will predominantly accumulate around the buffer tanks. Low level flows will extend to the west towards the pumping station and east towards the nature reserve. The modelling indicates that existing riverside wall will prevent flow from entering the river Thames as surface flow.

Figure 3-2 - Map of Uncontained spill event at Crossness STW

3.3 Site Classification Crossness

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk Crossness the overall site risk rating is medium for which class 2 secondary containment is required.

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 more detailed summary of the ADBA risk assessment tool.

4. Spill Scenario

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 CIRIA 736] 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.

4.1 Design Spill Volume

The total design spill volume comprises of 23,623m^3 from 25% of the total sludge tank inventory volume. The 25% scenario exceeds both the 110% rule and 100% of the largest tank plus site specific rainfall volumes and hence becomes the critical Design Spill Volume.

The largest tank plus site specific rainfall over an 4-day period (one day rain plus three days recovery) would yield a containment requirement of some 8,860m^3.

4.2 Crossness STW Summary of Containment volumes and assets

4.2.1 Assets for Containment

The tanks for containment are summarised overleaf.

Tank Purpose	Number	Operational Volume (m^3)	Total Operational Volume (m3)	Material
Picket Fence Thickeners	6	1,856	11,136	Steel
Primary Sludge Blending Tank	1	3,655	3,655	Concrete
SAS Blending Tank	1	3,655	3,655	Concrete
Sludge Buffer Tanks (not part of normal operation)	12	4,000	48,000	Concrete
THP High Energy Blending Tank	1	30	30	Steel
THP Blended Sludge Tanks	2	235	470	Steel
Pre-THP Dewatering Feed Tanks	2	183	366	Steel
THP Feed Silo	2	85	170	Steel
THP Process	1	Consisting of the following:		
Pulper Tank (THP Process)	1	34	34	Steel
Reactor Tank (THP Process)	4	13	52	Steel
Flash Tank (THP Process)	1	42	42	Steel
Primary Digester Tanks	8	3,330	26,640	Concrete
Digested Sludge Buffer Tanks	2	250	500	Steel

4.2.2 Existing Storm Tank Usage

As discussed with Thames Water Operations, there is potential to repurpose and utilise the existing (unused) stormwater tanks 5 and 6.

The usable volume of these stormwater tanks for sludge storage, assuming a gravity pipe connection is in excess 15,000 m^3.

Connection into the storm tank will be a below ground penetration existing tank wall. This connection will not disturb the solar panels situation on top of the storm tanks.

Detailed design to confirm isolation details between sludge spill storm tanks (5 and 6) and the active storm retention tanks (1 to 4).

4.2.3 Contained Model Output

The contained model output is shown in Figure 4-2 - Digital Terrain Model of Crossness Sewage Treatment Works. The top water level (standing stored level) for the wide area containment bund is 4.99mAoD, this allows 8,932m^3 to be held in the containment area in addition to 14,691m^3 stored in the existing repurposed storm tanks 5 and 6. Noted that the volume contained within the bunded area exceeds the volume of the single largest tank plus rainfall during a 4-day recovery period.

Figure 4-1 – Contained Model at Crossness

As can be interpreted from Figure 4-2 and Figure 4-3 the North West corner of the site (near the cake barn and sludge buffer storage tanks) is the local low point within the containment area and the majority of flows will gravitate to this point. For this reason, this is the proposed commencement of the gravity line connection to the stormwater tanks, as well as the location which will require the highest bund wall height (1.32m inc. freeboard).

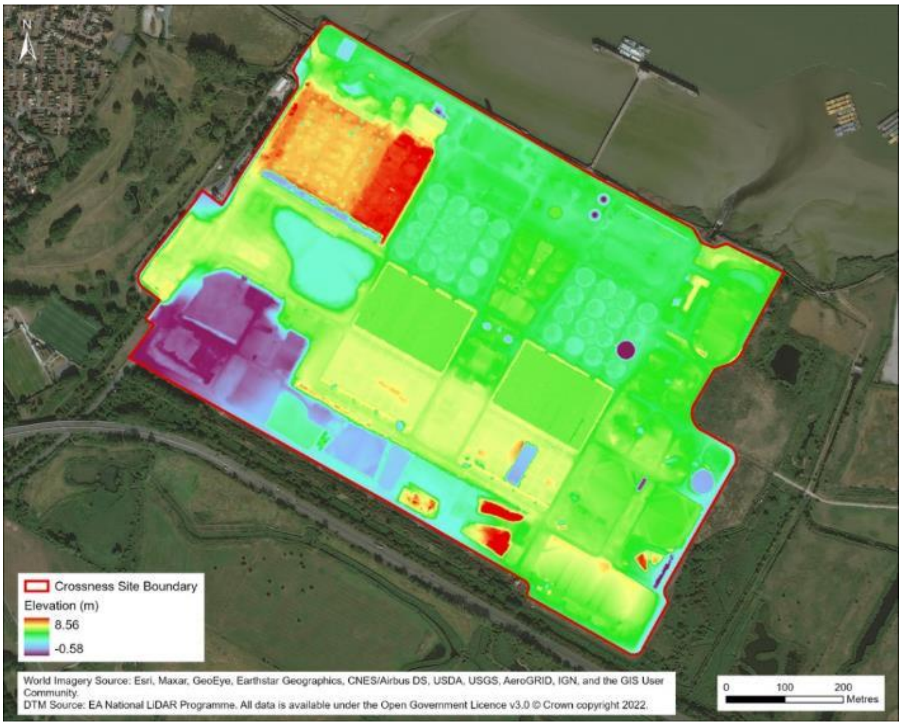

Figure 4-2 - Digital Terrain Model of Crossness Sewage Treatment Works

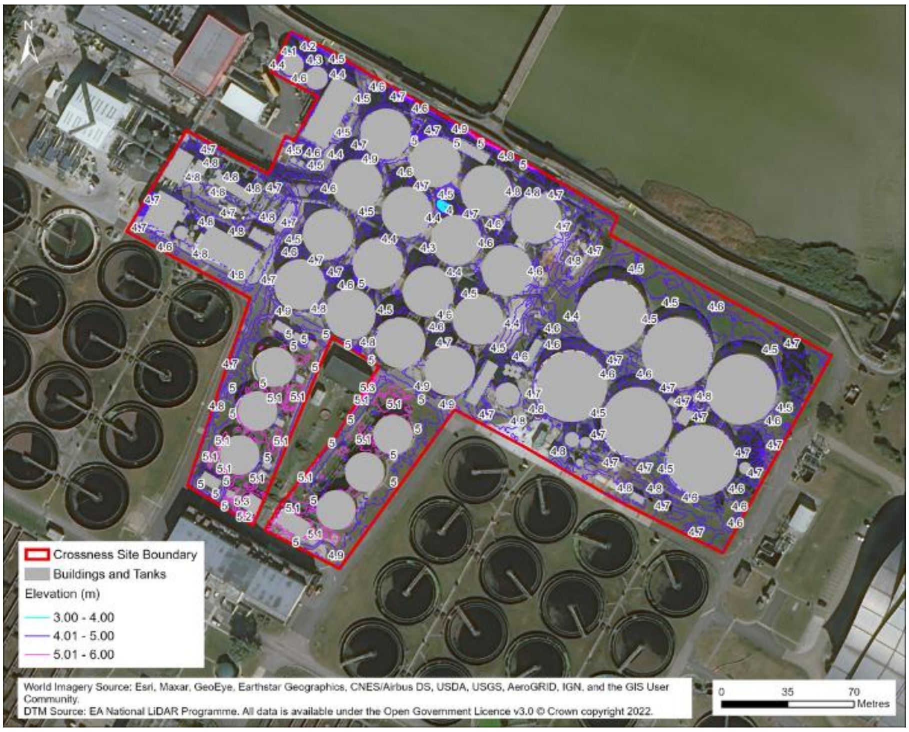

Figure 4-3 – Contour Model of Crossness Sewage Treatment Works Wide Containment Area

4.2.4 Bund Wall Height

Due to the topography of the site, the bund wall height will vary across the length. Figure 4-4 shows the wall spot heights which should be interpreted in relation to the modelled Top Water Level of 4.99m. The northwest corner of the site (near the cake barn and sludge buffer storage tanks) is the local low point within the containment area which will require the highest bund wall height of 1.32m (inc. 0.25m freeboard). The lowest wall height will be 0.42m (inc. 0.25m freeboard) on the southern edge of the site around the PFTs.

Bund height have been designed to provide freeboard (0.25m) 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.

Figure 4-4 – Bund Wall Spot Heights

4.3 Identified Constraints

4.3.1 Operational Constraints

4.3.1.1 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.

4.3.1.2 Surface Cleaning

There is a portion of grass around the 6No. Primary Sludge Buffer Storage Tanks and the 6No. PFTs. These surfaces should be upgraded to an impermeable surface (e.g. concrete) to ease clean-up effort in the event of a spill. TW operations have stated that it would be difficult to clean up sludge from gravel areas.

For Crossness STW, the estimated grass/gravel area that is intended to be concreted is 12,000 m^2. It is noted that concreting this area may slow 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.

4.3.1.3 Clean-up Area

The sludge cake barn has not been included in the proposed containment area. This is because any spills onto the dried sludge cake would be difficult to clean up and take a long time, the sludge cake would need to be passed through a centrifuge again to dry it and re-thicken it or sent back to the head of the works.

4.3.1.4 Access and Traffic Thoroughfare

Vehicular access into the containment areas is by ramps (long-approach speed humps) restricted to nom 300 mm in height; traffic movements on site make the use of permanent flood gates impracticable. In order to prevent restriction to the existing traffic routes onsite, 6No. access ramps have been allowed for as can be seen in Figure 5-1. The standing water level at the ramps location is less than 290mm.

4.3.1.5 Existing Services

Crossness is expected to have a high density of existing underground services. The proposed gravity pipeline route from the northwest corner of the containment area to the stormwater tanks may require relocation of existing service in order to meet the desired levels.

4.3.1.6 Existing Storage Tanks

It is noted that these storm tanks will need to be cleaned out and inspected as part of the proposed return to service as emergency containment storage. Operations has no evidence to suggest that the tanks are experiencing major issues and the containment storage duty is similar to their original function. Detail design will need to review existing isolation arrangements from live Storm Tanks 1-4.

It is assumed that spill volumes transferred into these tanks can be pumped back to the head of the works in a similar manner to storm tanks 1-4. Else for the emergency duty, operations will bring in temporary pumps to effect return.

The existing storm tanks grassed roof area houses solar panels. The proposed pipeline to convey flow into the tanks will not require the solar panels to be disturbed. The proposed pipeline will enter via the north-east corner from the side the inlet culvert area.

4.3.2 Geotechnical and Environmental constraints

Ground conditions need to be considered during excavating and backfilling activities. Soil types and ground water levels are not reported to present abnormal risks to the proposed works.

Construction of the bund on the eastern boundary is in proximity to the Crossness Nature Reserve and will need considerate construction practise to ensure no adverse environmental impacts to this sensitive area.

4.4 Design allowance for rainfall

Due to the larger net operational volume of sludge assets at Crossness STW, 25% of the total sludge tank inventory is the critical volume.

For comparison purposed, the arising average rainfall depths for a 1 in 10-year storm over the four-day event period for Crossness is estimated to be 69mm. The rainfall depths for Crossness have been estimated using the depth-duration-frequency rainfall model contained in the Flood Estimation Handbook (FEH), which provides location specific rainfall totals for given durations and return periods.

5. 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 Crossness, 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 Crossness STW are listed below:

- Bund/walls to contain liquid. The heights of bund/walls given in Section 4.2.4. A 250mm freeboard has been incorporated along the length of the bund wall due to 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 3.2.1 or do not contain sensitive equipment below the anticipated the top water level.

5.1 Containment Options

5.1.1 Wide area containment and utilisation of the existing storm tanks

Containment option 1 repurposes and utilises out of service storm tanks 5 and 6 for storage as well as low level sludge storage within the bund as can be seen in Figure 5-1. The available storm tank volume from the two tanks is some 15,000m^3. The total containment area within the bunding is approximately 51,814m^2.

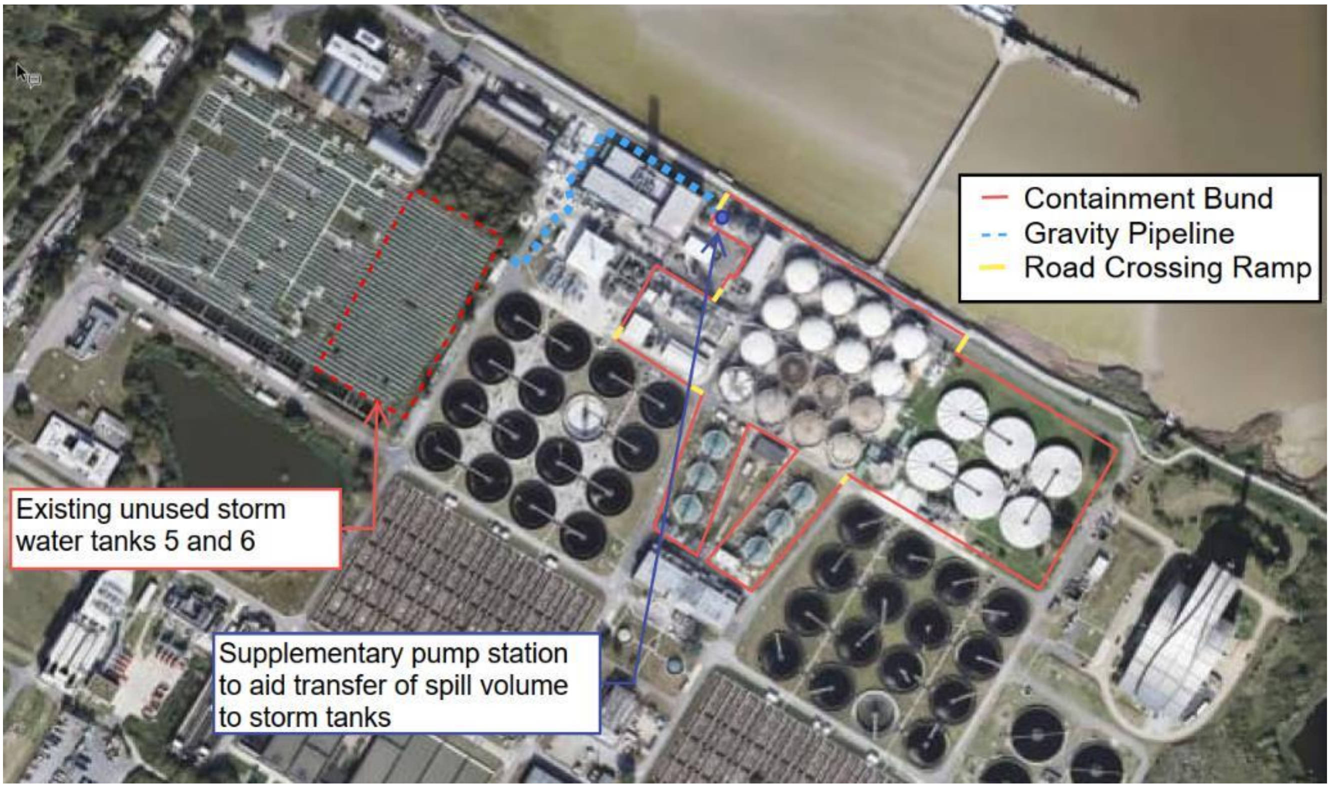

Figure 5-1- Option 1 wide area containment and utilisation of the existing storm tanks

The total design spill volume is nom 23,623 m^3. LiDAR spill modelling calculates a top water level (TWL) 4.99 mAOD when 8,932 m^3 is contained within the bund and 14,691 m^3 is contained within storm tanks 5 and 6.

At locations where the bunding will cross an access road, a ramp will be installed at a maximum height of 300mm to enable full site access. Any permeable area which is mostly the grass areas within the containment boundary will be excavated and filled with bound concrete. Operations are then able to clean the containment area in a practicable way.

5.1.2 Wide area containment with high bund walls

Containment option 2 contains the entire design spill volume within the containment area bund in Figure 5-2. This option will require bund walls to be up to 1.66m (inc. 0.25m freeboard) in some locations to contain flow. The lowest bund wall height with this option will be 0.41m (inc. 025m freeboard) in the southern area wound the PFTs. This option generated depths of water at the access roads in excess of that which could be addressed by ramps (for example in excess of 750mm high with long approach lengths) and the use of floodgates (required to be normally closed) had unsatisfactory implications for practical day to day running of the site.

Figure 5-2 – Option 2 Wide Containment Area with High bund walls

5.2 Mitigation of Site-Specific Risks

5.2.1 Jetting and Surge Flows

In some locations, notably around the PFTs the minimum distance between the tank and bund has not been met due to space and access constraints. Where this is the case, the existing site infrastructure (e.g., site roads and site drainage) provide equivalent tertiary containment.

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.

5.2.2 Flooding

According to the UK Government's Flood Map for Planning the sludge area is in Flood Zone 3 (an area with a high probability of flooding that benefits from flood defences) as shown in Figure 5-3. As such the managed flooding risk does not need further mitigation.

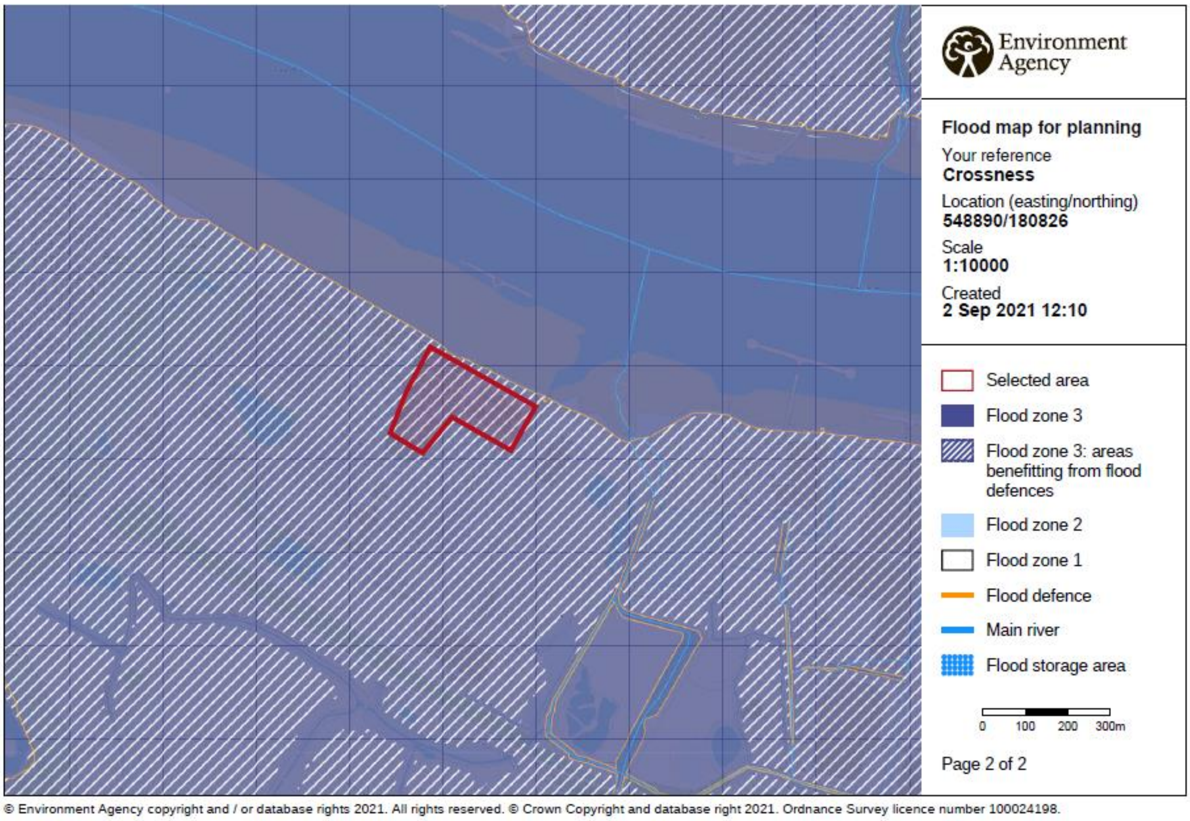

Figure 5-3 - Extent of Fluvial flooding in Crossness due to extreme weather events

5.3 Identification of Preferred Option

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

- Efficient use of assets/space (utilising the existing unused stormwater tanks)
- 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 to cross containment lines rather than by the use of floodgates

5.3.1 H&S and CDM risks

The following site-specific H&S and CDM risks associated with the preferred proposal (Option 1) have been identified:

- Preparing the storm tanks for usage and after spill clean-up is likely to involve confined space work.
- Installing the gravity pipeline in a high-density service area which may not have accurate existing service route records.
- Concreting over existing permeable areas will increase the difficulty of accessing existing underground assets in the event of maintenance, failures or future upgrades.
- Confirm that the bunding does not impact the DSEAR rating of existing plant

6. Site Drainage and liquor returns

6.1 Process flow diagram

The process flow diagram is shown below.

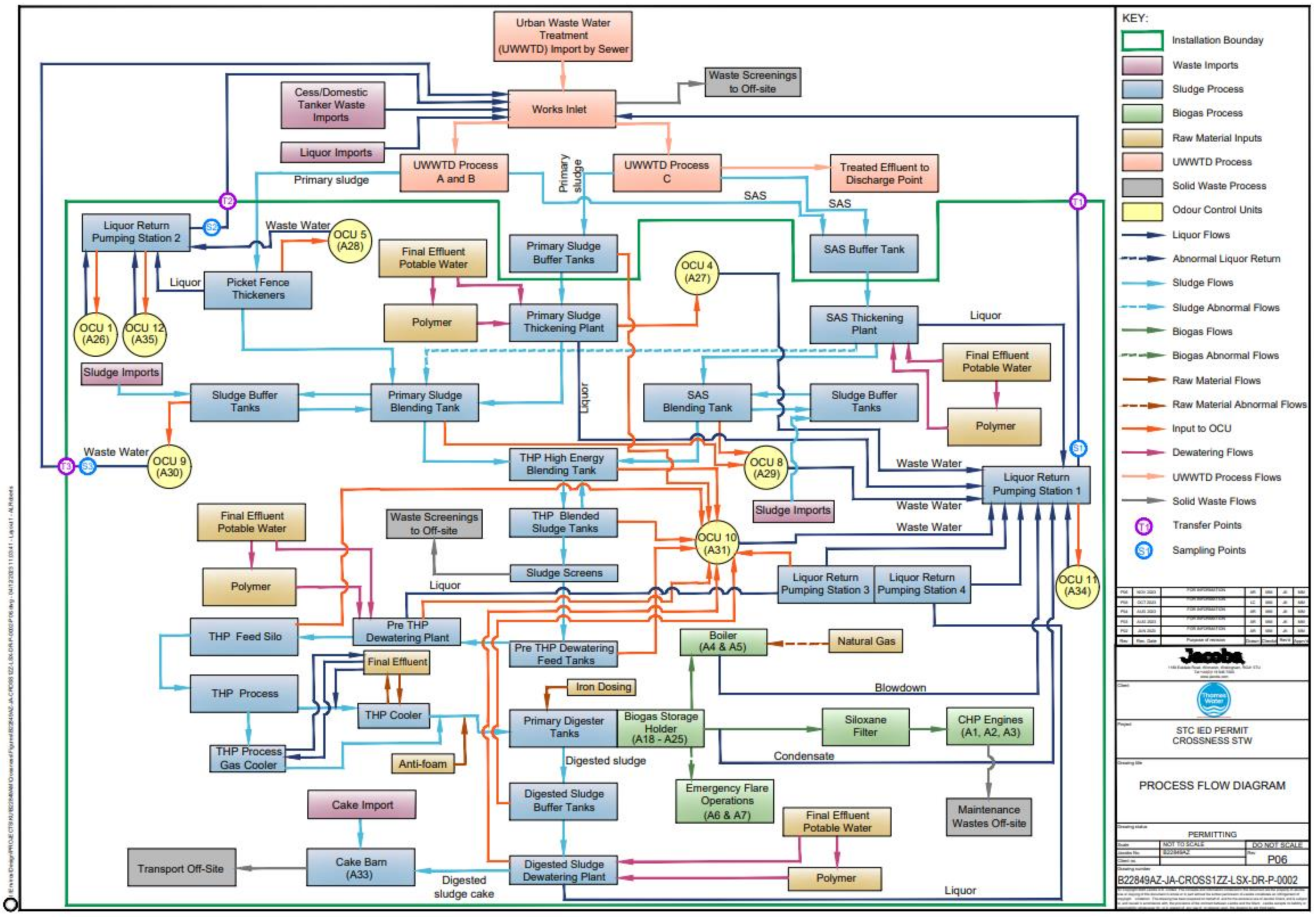

Figure 6-1 - Process Flow Diagram

6.2 Existing Drainage Interface

Site drainage assessments are based on Crossness Sewage Works Layout Plan Drawing Number: CROSS1ZZ-DPL-001.

The Sewage Works Layout Plan for Crossness shows all Combined/ Process/ Effluent drainage pipes, indicated by the pink lines, drain back to the inlet works as shown by Figure 6-2. Some of the drainage lines appear disjointed and there are notes indicating that many drainages connections have not been surveyed which creates uncertainty in the absence of updated survey.

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 Crossness.

In the event of sludge entering the head of the works, the shock load could adversely impact the sewage works treatment process. Therefore, it is recommended that the ability to isolate drainage within the containment area is included in the scope of works.

It is recommended that float operated isolation valves are installed on all outgoing drainage lines from the containment area (this is estimated to be 7No. valves total based on CROSS1ZZ-DPL-001). 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. This may happen several times a year and become a burden for operators onsite.
- In minor or slow flow tank spill events, the sludge spill will flow into the exiting 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 Crossness 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.

The new gravity pipeline and supplementary pump station (to overcome potential routing issues that may arise during detail design) will be constructed in the northwest corner of the site (low point) to transfer potential sludge spills. This system will naturally convey some surface water into storm tank 5 and 6. A small pump will be required to return the rainwater to the head of the works. The pump operation would incorporate the ability for operations to allow the pump to run in response to a prompt via SCADA rather than having the pump responding to a level signal alone.

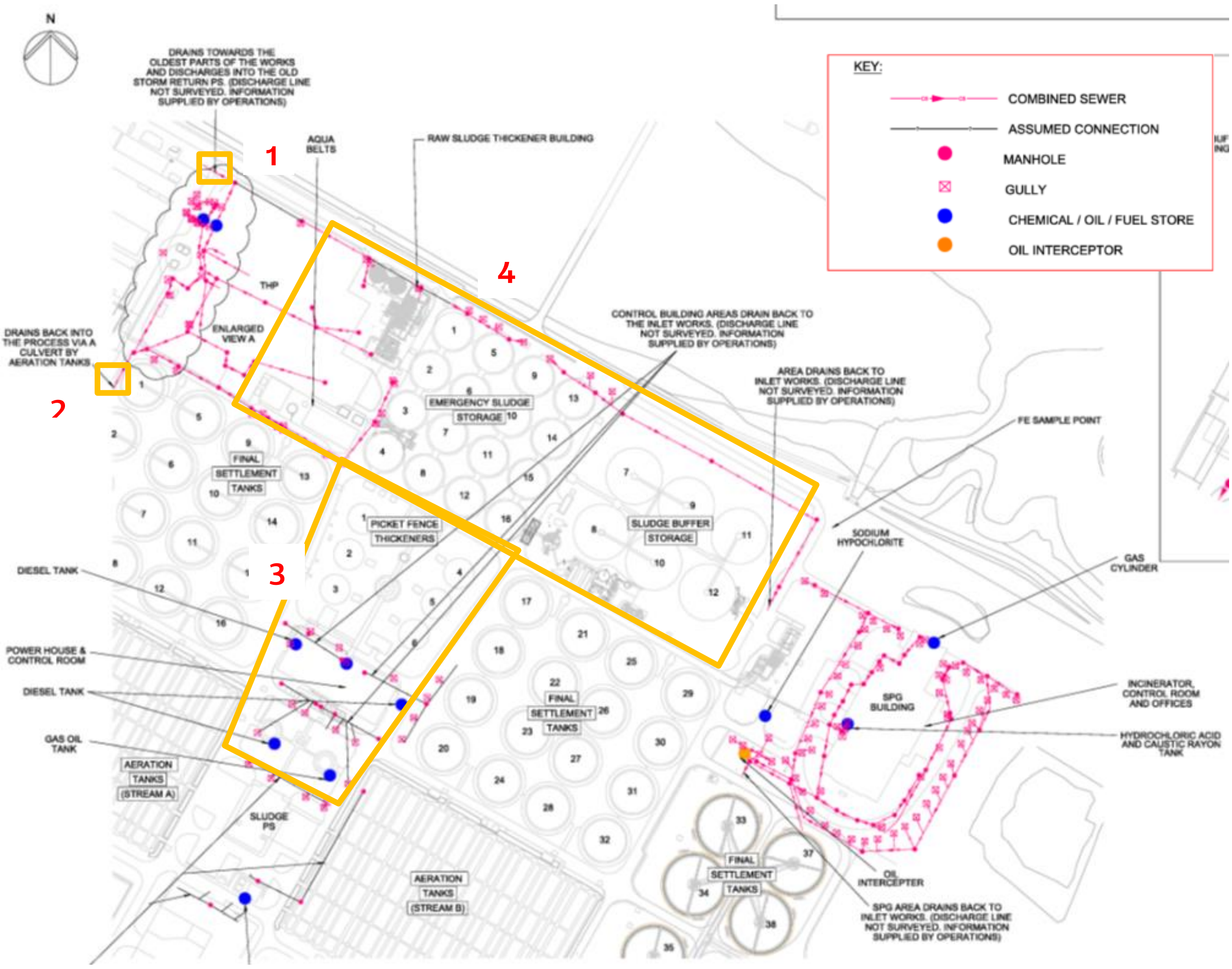

Figure 6-2 – Crossness Drainage Plan

6.3 Liquor Returns

The existing liquor return system is not being altered by the containment system.

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

6.4 Tank Failure Alarms

For significant failures from the existing sludge tanks, 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 alert operators that there were an abnormal event occurring.

7. Conclusions

This section summarises the findings of the containment assessment options report for Crossness Sewage Treatment Works. This follows the results of the uncontained spill mapping which show that a catastrophic spill will not be contained within the site.

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 preferred option to progress is Option 1 - Wide area containment and utilisation of the existing storm tanks. This option represents the best use of existing infrastructure onsite and a practical bund wall height which has long term and short-term operational benefits. The depths avoid the use of flood gates in a part of the site that is subject to high levels of vehicle movement. The solution draws upon gravity conveyance to link the secondary contained area with the remote storage provided by the repurposed storm tanks. Provision for a pumping station has been included should detail design identify that the gravity operation is impacted by existing services. The secondary containment storage volume is able to accommodate the volume arising from the failure of the single largest tank on site together with the rainfall associated with the 4-day recovery period.

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

The total design spill volume comprises of 23,623 m^3 from 25% of the total sludge tank inventory volume. The 25% scenario exceeds both the 110% and largest tank plus site specific rainfall volumes and hence becomes the critical Design Spill Volume.

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 one secondary digester which has been mitigated using tertiary containment.

Appendix 1 ADBA Site Hazard Risk Assessment Summary for Crossness 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 Crossness 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 (Ferric Sulphate) for sludge thickening.

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

Pathway – There are three pathways that have been identified.

1. The inventory run off if unconstrained is short, however the proposal incorporates containment and a guarded interface with the site drainage system.
2. The site's location by the river Thames sits in a flood plain but enjoys the protection of the Thames flood walls.
3. The site forms part of the sewage treatment works.

Consequently, the Pathway Hazard rating was determined as **Medium**.

Receptor – There are three notable potential receptors which have been identified.

1. There is a "Medium-High" groundwater vulnerability in this location by the River Thames.
2. The site is near the Crossness Nature Reserve (managed by Thames Water).
3. The Thames Path adjacent to the northern boundary of the site

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

The arising **Site Hazard Rating** from the above is **High**

Likelihood – The combination of operator training and alarms with the tank construction, use of designs to British Standards and installation by competent contractors mitigate the likelihood.

The final Likelihood Hazard rating was determined as **Low**.

The overall arising Site Risk Rating is **Medium (Class 2 Containment)**