J840 – STC IED Containment

Reading STC – Containment Options Report

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Document history and status

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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 (STW) and any neighbouring receptor. Twenty-five Sludge Treatment Centres (STC) have been identified where containment proposals are required. This report deals with the proposals for Reading.

Reading STW serves a population equivalent of 264,000 taking in sewage from Reading and surrounding area. 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.

Reading STW holds some 11,660m³ of liquid within the sludge treatment centre. The liquid sludge is stored in 14 tanks with individual volumes varying between 15 to 1775m³, refer to section 3.4.1 for details of the tanks and volumes, the majority of the tanks are concrete. The site is generally low lying and flat. The containment volume of 2915m³ is driven by the 25% rule (25% of total tank volumes) rather than 110% (of the largest single tank) of the total tanks volume. The STW when constructed in early 2000's with a bund around the STW and this will act as tertiary containment.

Two wide area options for containment have been identified and reviewed with Operations to confirm that the working of the sewage treatment work is not compromised by proposals, for details of the options refer to section 4.1 and section 4.3 for preferred option:

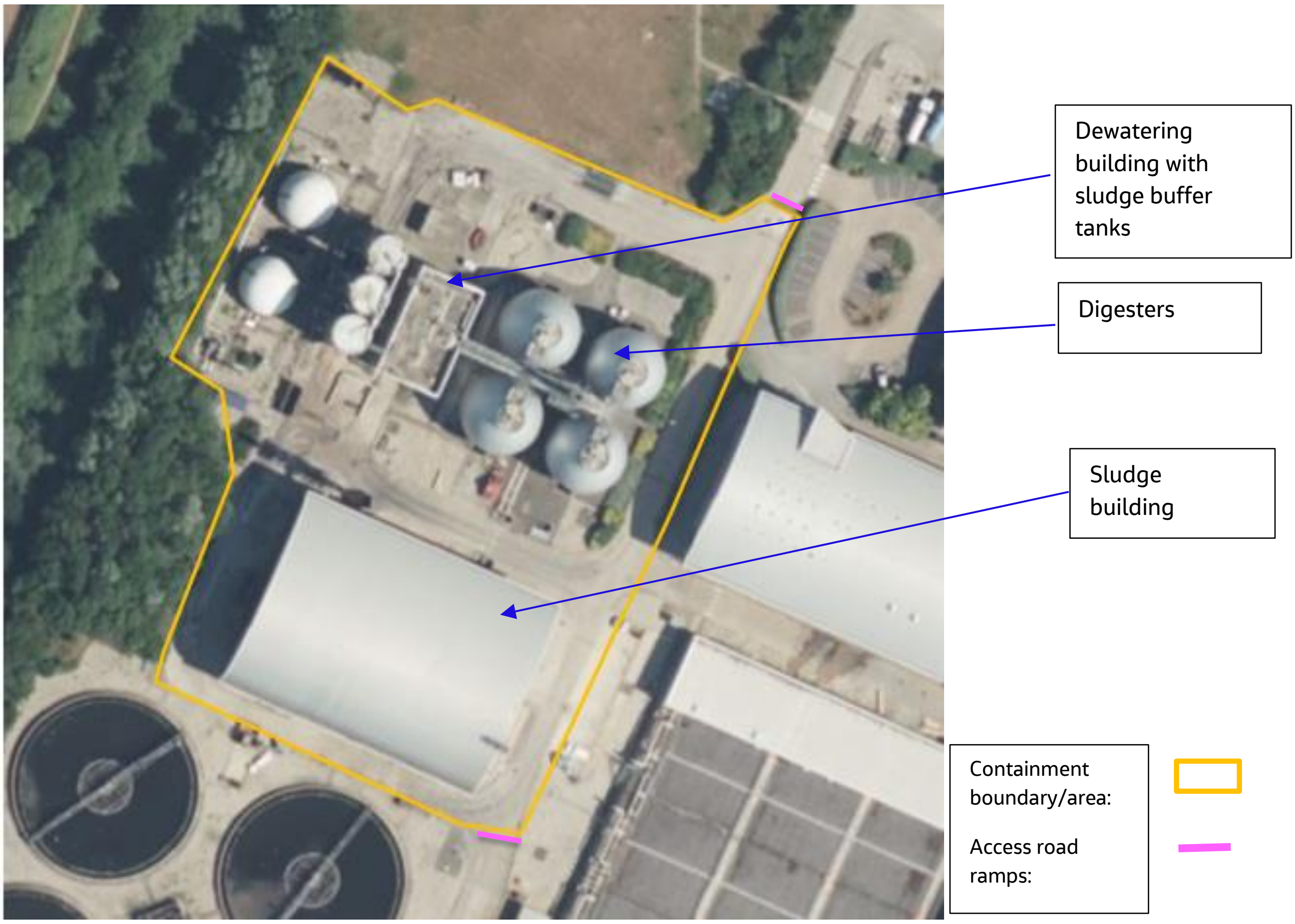
1. Wide area containment whereby the sludge tanks are contained within a bunded boundary with sufficient area to generate depth that does not deny emergency access to equipment when the spill has been contained.

2. Increased the wide area containment area utilising the available land on site, whereby the 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 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.

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 Option



The modelling highlights that the design detailing may need to consider flood gates instead of ramps to access the containment area due to the standing depth of the sludge and height of the containment walls. The other consideration is any spill over the ramps will be contained onsite by the sites boundary bunds tertiary containment and conveyance to the site drainage network which discharges back to the head of works.

Grassed and gravel areas within the yellow area to be replaced by concrete. Some of the concrete roads in the yellow area may need to be 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 ABDA risk assessment tools this containment report addresses the site-specific risks at Reading STW 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 Reading 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 Reading STW were identified through a desktop study, Light Detection and Ranging Analysis (LiDAR) analysis and a site visit.

Reading Sewage Treatment Works (STW) (Figures i-iv) is located south of the town of Reading, close to the A33 which links the town with the M4 motorway. To the south of the site, separated by a dual carriageway road, is the Green Park business park which consists of a few commercial office properties. To the west and south is agricultural land and to the west and north is a local council household waste and recycling centre, closed landfill, and local council waste transfer station. To the north is commercial properties consisting of large warehouse type premises. Immediately to the east of the site is derelict land and then the A33. The STW serves a population equivalent of 264,000 taking in sewage from Reading and surrounding area.

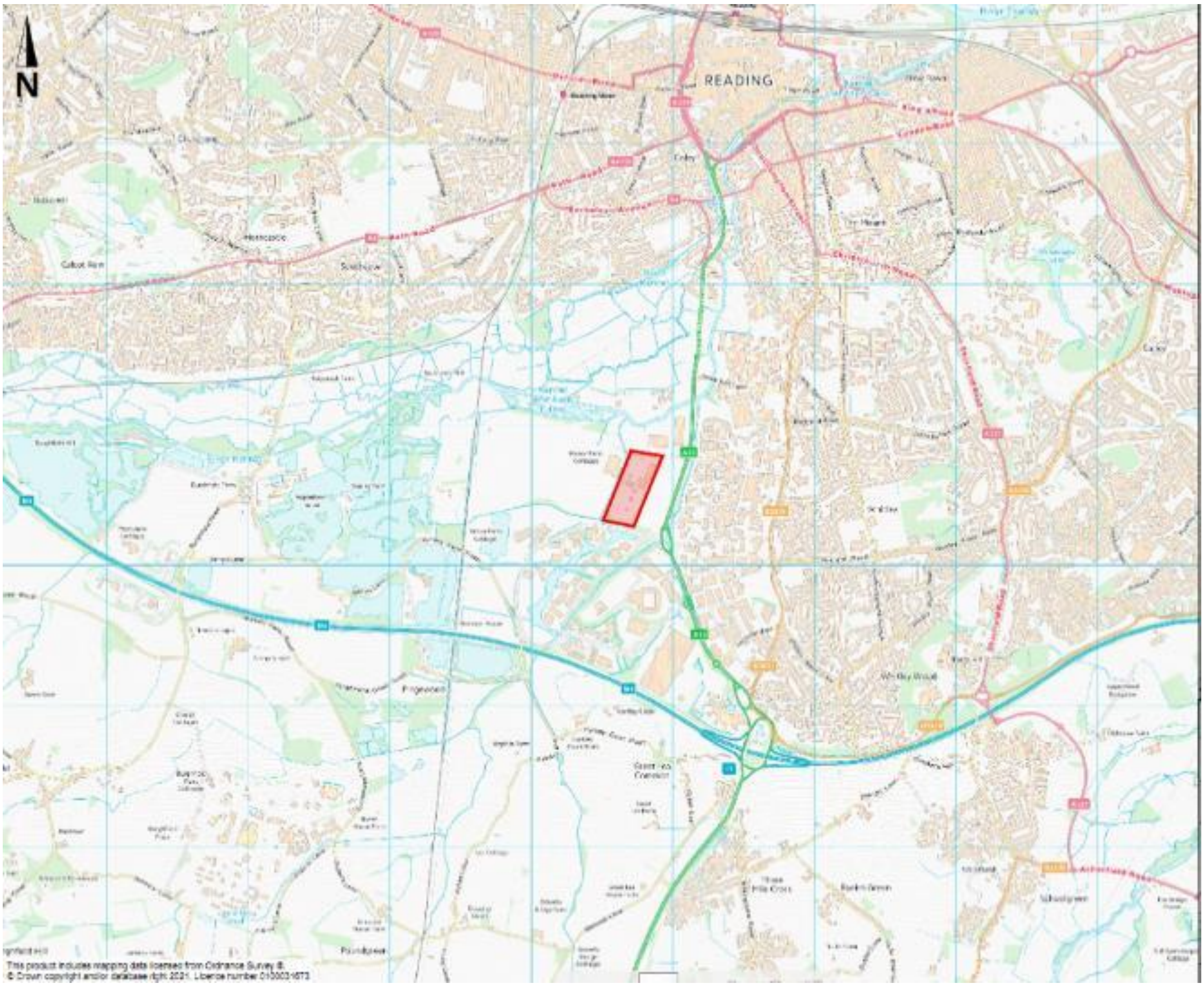


Figure i Location Plan Reading Sewage Treatment Works

Figure ii Satellite view of Reading Sewage Treatment Works

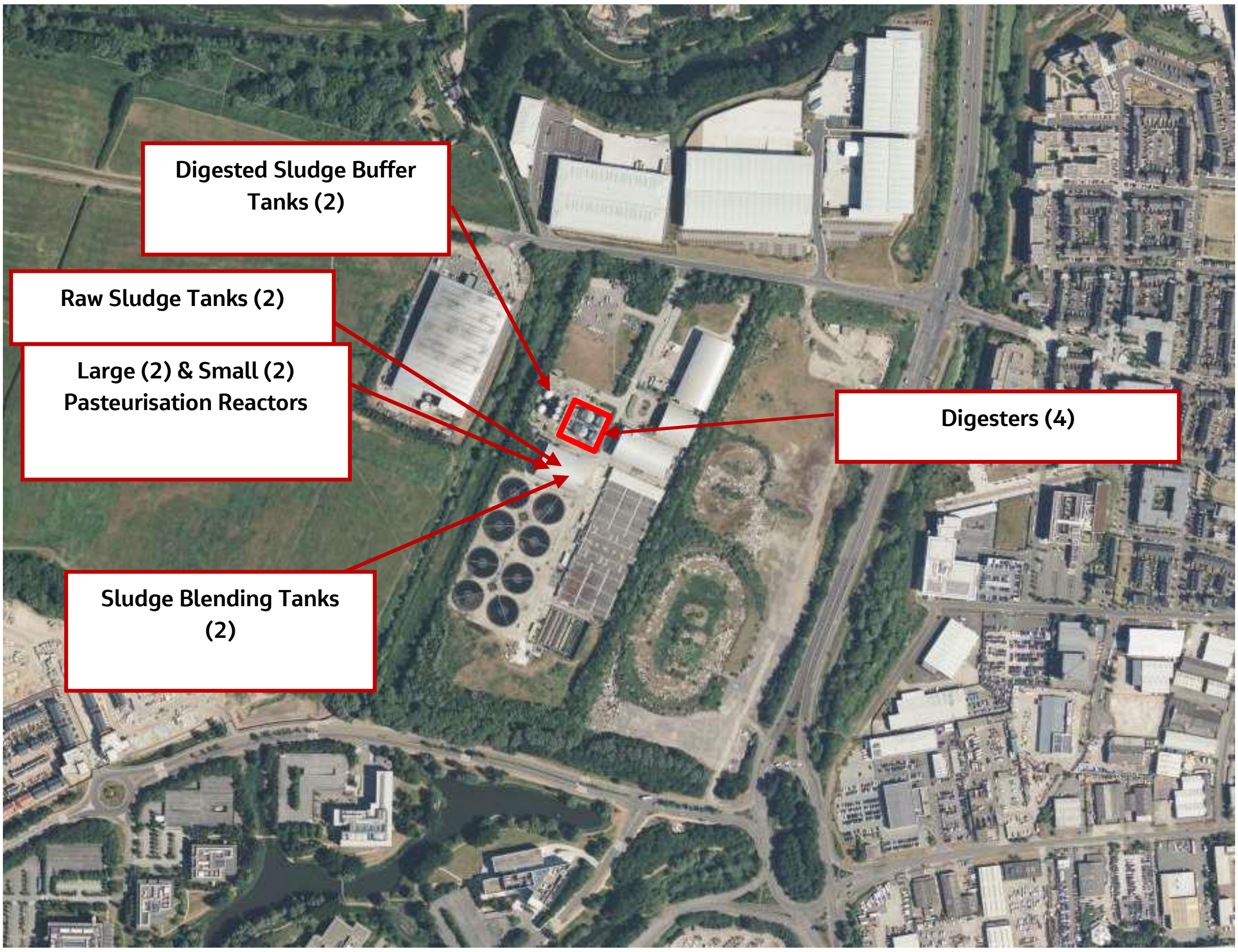


Figure iii Reading Sewage Treatment Works – Digester Area plan

This document should be read in conjunction with; Reading STW, Risk Identification and Containment Assessment Report, revision OA dated 09/05/2022. This report outlines the impact of an uncontained spill and the risk assessment completed.

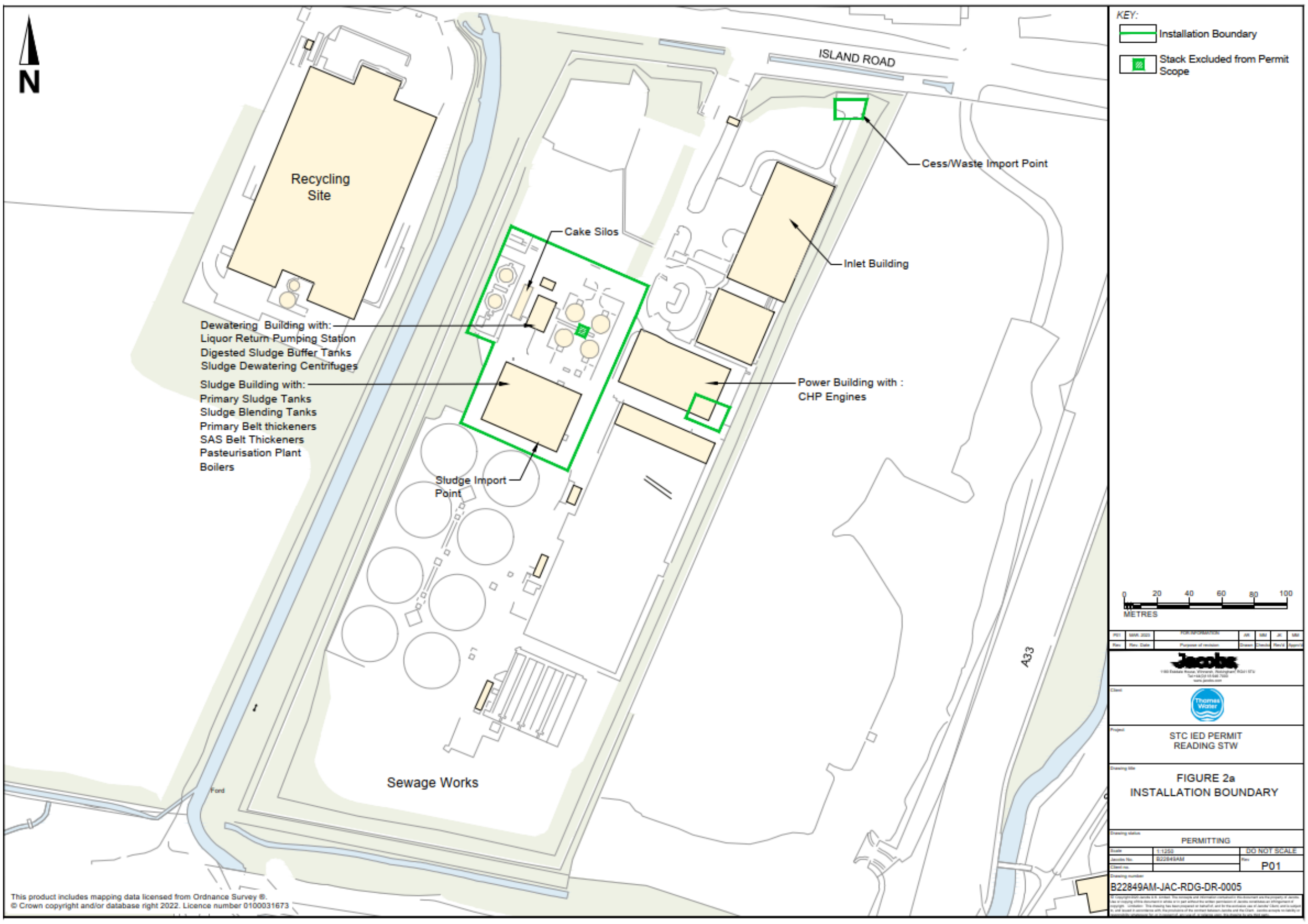


Figure iv Boundary of the permitted IED area and the assets contained within Reading STW.

This document has been developed from Reading STW, Risk Identification and Containment Assessment Report, which outlines the impact of an uncontained spill and the risk assessment completed.

3. Proposed Containment at Reading 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;

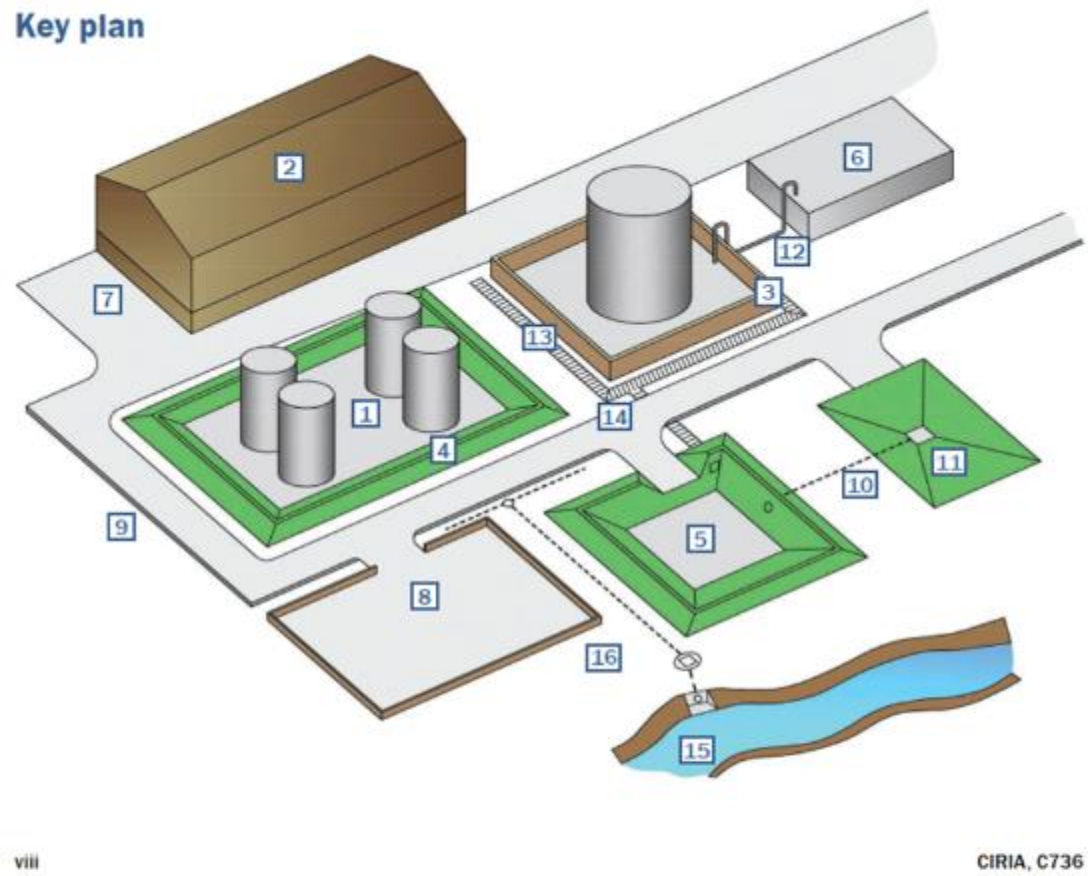


Figure 3.3-1 Diagram of primary, secondary and tertiary containment examples

-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

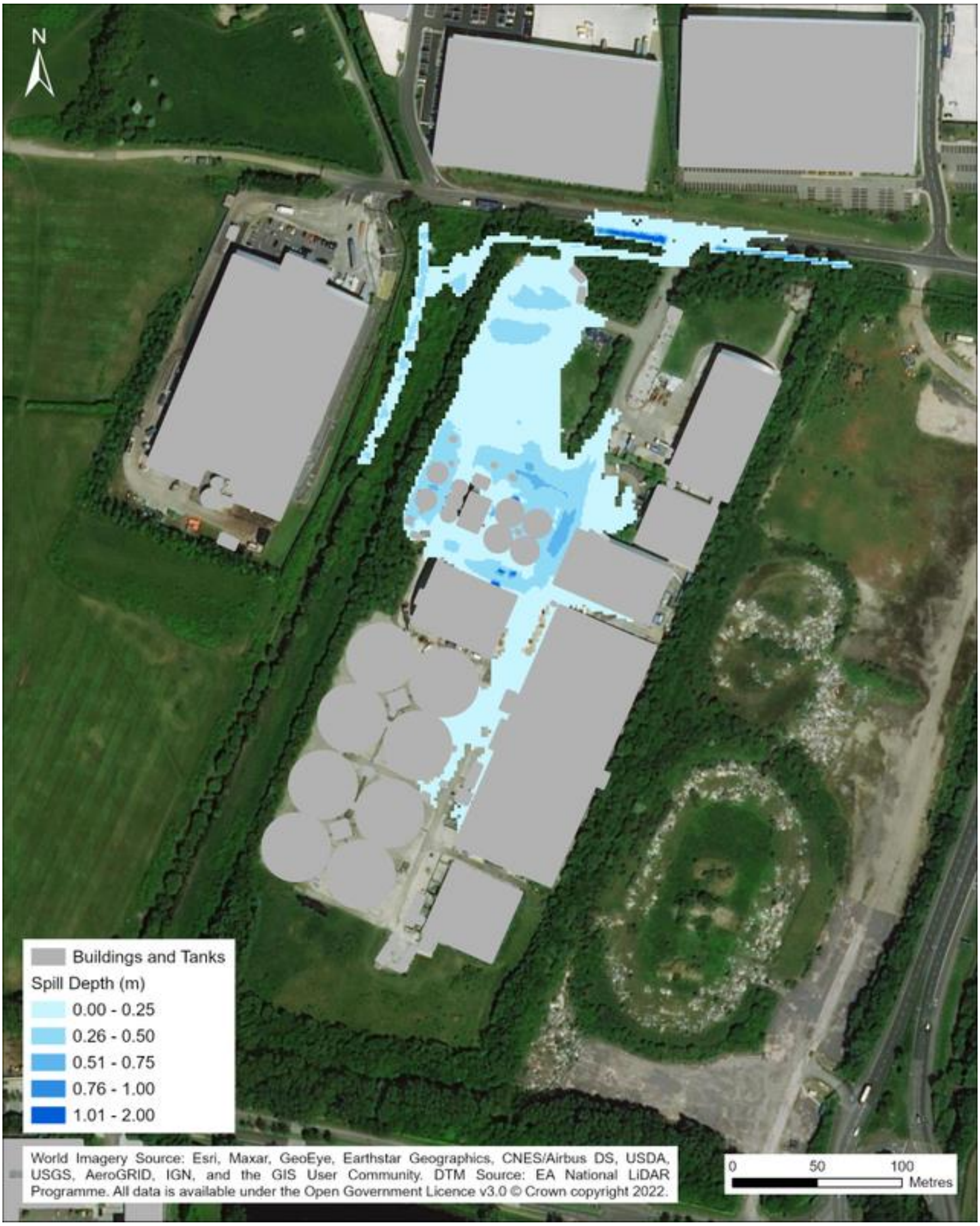


Figure 3.2 Uncontained Spill Model Results

As seen from Figure 3.2 the sludge spill mapping of an uncontained event in Reading STW showed that the potential sludge spill from 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 (the northwest site boundary) in approximately 15 minutes following failure of one of the digesters.

The sludge content will initially spread within the sludge and digester area including the Dewatering and Sludge Buildings and the Power building containing the Combined Heat and Power engines. It is expected that the flow will further travel north bound and overfill the site's carpark space with some sludge partially spilling over to adjacent grassland next to RE3 Waste Management Site, northwest of the site boundary. Most of the sludge will then spread to the road entering the site and will eventually spill onto Island Road, north of the site boundary which could potentially prevent access to the nearby Amazon and DHL warehouses. The spill will also travel south of the digesters within the STW; however, this run-off will not spill over the southern site boundary and therefore will be contained within the southern side of the Reading STW.

3.3 Site Classification Reading

Based on the use of the ABDA risk assessment, considering the source, pathway and receptor risk, Reading 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 ABDA 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. This document has been developed from Reading STW, Risk Identification and Containment Assessment Report, which outlines the impact of an uncontained spill and the risk assessment completed.

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

The containment volume has been checked against the 110 and 25% rule and the 25% rule applies.

The total design contained volume is 2915m^3 (25% of the total volume of all tanks (11660m^3) within the containment area), compared to largest single tank failure of 1,775m^3 and total rainfall 683 m^3 rainfall from Flood estimating handbook over catchment area, which gives a lesser volume of 2458m^3.

3.4 Reading STW Summary of Containment volumes and assets

3.4.1 Assets for Containment

The tanks for which containment is required are summarised below:

Tanks within containment area	No. of tanks	Effective Volume per Tank (m3)	Total Effective Volume (m3)
Raw sludge tanks	2	1200	2400
Sludge blending tanks	2	500	1000
Small Pasteur reactor	2	30	60
Large Pasteur reactor	2	100	200
Digesters	4	1775	7100
Digested buffer tanks	2	450	900
Total	**14**	**-**	**11660**
Rainfall (mm)			69.55
Catchment Area (m^2)			9825
Total Rainfall (m^3)			**683**
Largest Tank plus Rainfall (m^3)			2458
110% of Largest Tank (m^3)			1953
25% of all tanks within containment area (m^3)			2915
Design Spill Volume (m^3)			**2915**

3.4.2 Digital Terrain Model

The terrain model (Figure 3.3) shows that Reading STW was constructed to have an internal bund around the site, with the only low spot is at the entrance to the site.

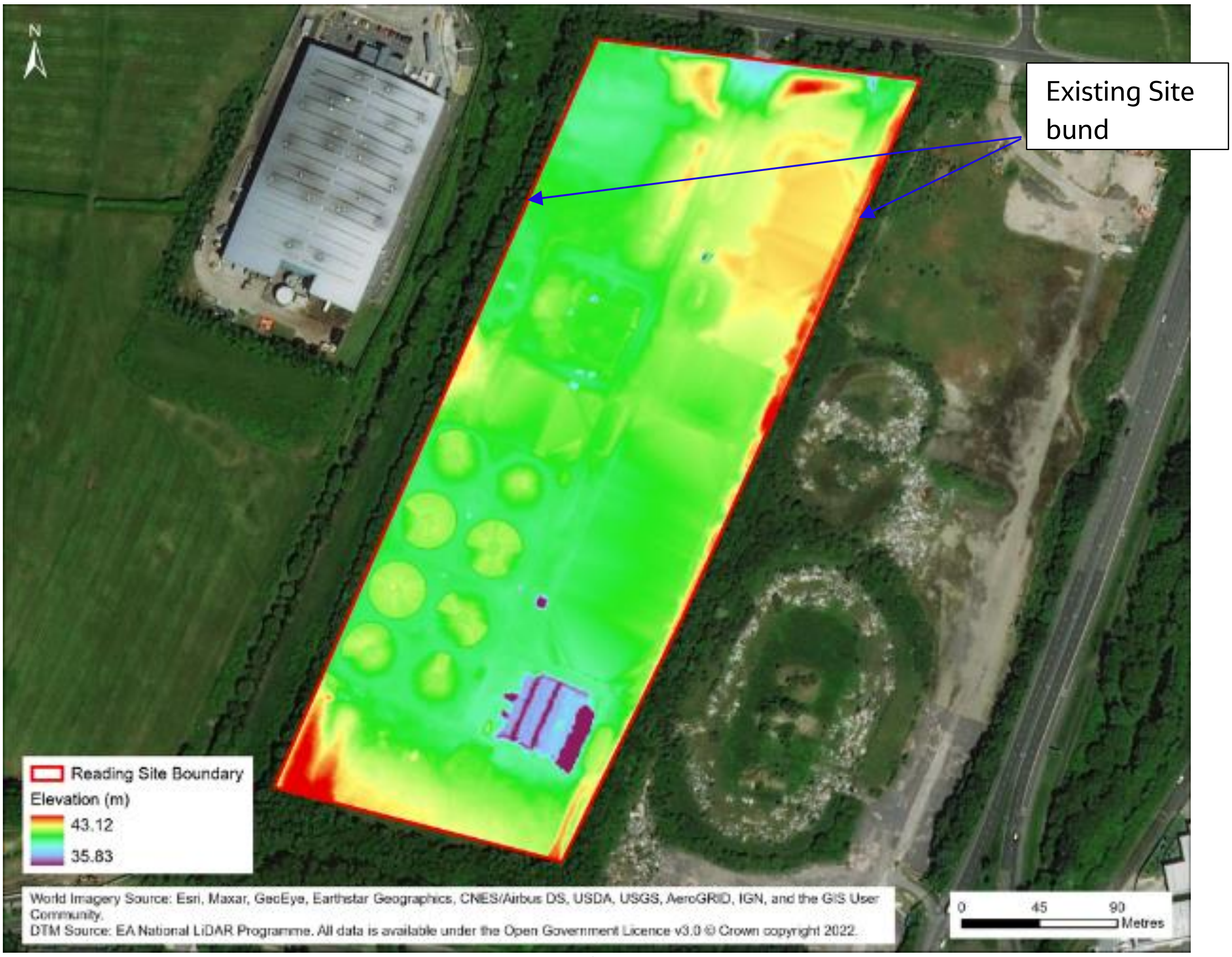


Figure 3.3 Digital Terrain Model of Reading Sewage Treatment Works

The contained model output is shown in Figure 3.4. This identifies the flow will be contained at a fairly uniform depth across the site. The containment model shows that for 100% volume loss the top water level will settle at 41.36m A.O.D. Therefore, allowing for 250mm freeboard on the bund wall the bund height will vary between 0.5 – 1m with the higher bund wall along the northern and eastern sides of the containment area.

Figure 3.5 shows the contour plot for the containment area. Some of the potential depths at the northern limit of the containment area are in excess of that which ramps can hold. Final design development of the bunded area will consider the provision of floodgates instead of ramps.

3.4.3 Contained Model

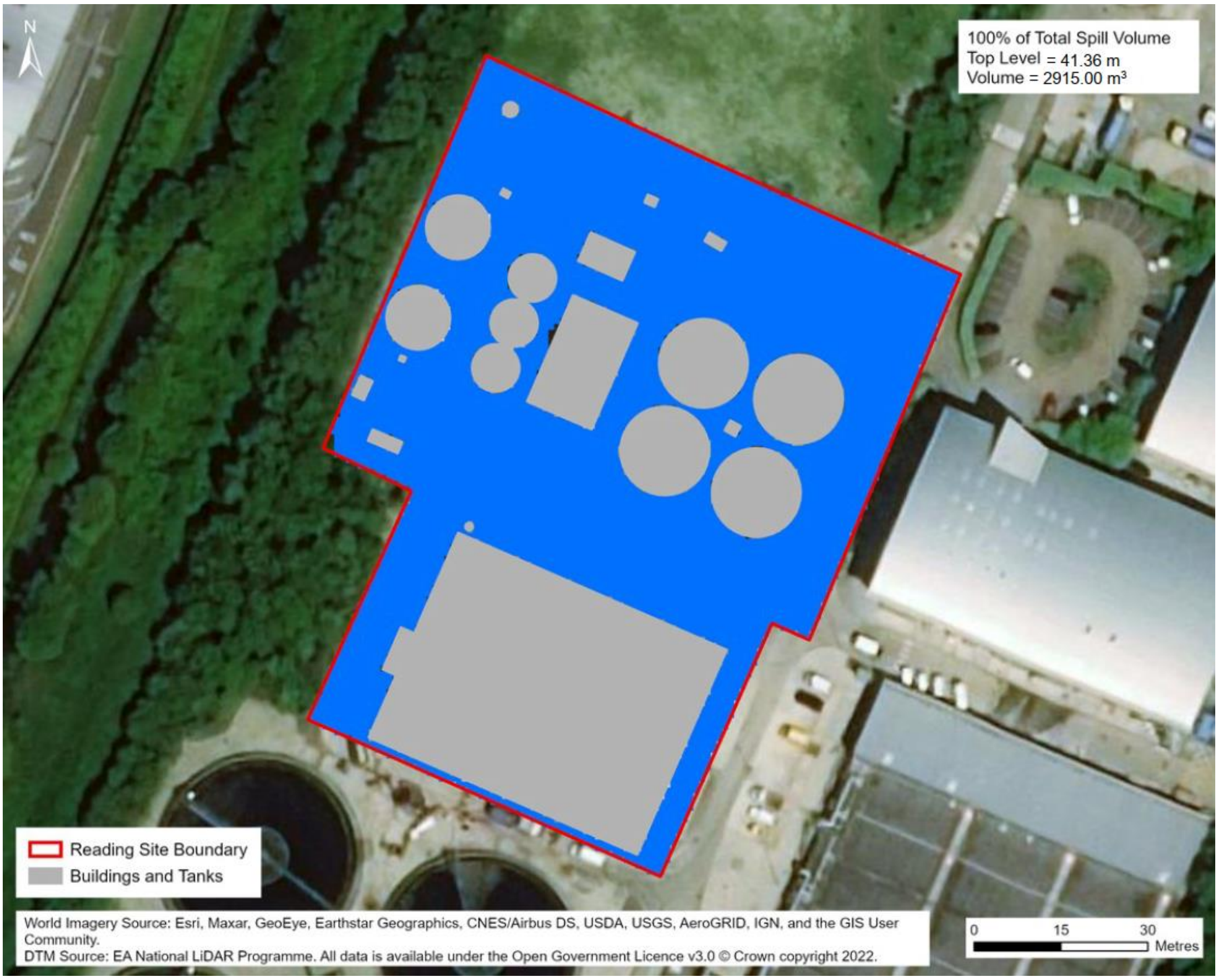


Figure 3.4 Containment spill model

Figure 3.5 contour map of the contained area

3.5 Identified Constraints

3.5.1 Operational constraints

The existing ground surfaces are mainly grass and gravel and this will need to be replaced with 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 3-4 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.

3.5.2 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.

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.

3.5.3 Other constraints

None identified

3.6 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 Reading is 69.55mm. It should be noted that the rainfall depths for Reading 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 Reading, 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 Reading 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 250-300mm 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 any equipment inside must be raised off the ground to level above the top water level.

4.1 Containment Options

4.1.1 Containment Option 1 – wide area containment Approach

This option utilises containment surrounding the total containment permit area, providing secondary containment to the sludge processing facilities. The containment area is approximately 9825m^2 but the actual available containment area will be less than this as areas such as the tanks and sludge and dewatering buildings will not be included in the storage volume.

The containment volume has been checked against the 110 and 25% rule and the 25% rule applies.

The total design contained volume comprises 2915m^3 (25% of the total volume of all tanks within the containment area), LiDAR spill modelling calculated the top water level (TWL) when 2915m^3 is contained in this area to be at 41.36AOD.

Summary of the recommended containment for Digestion area is described below and shown in Figure 4.1.

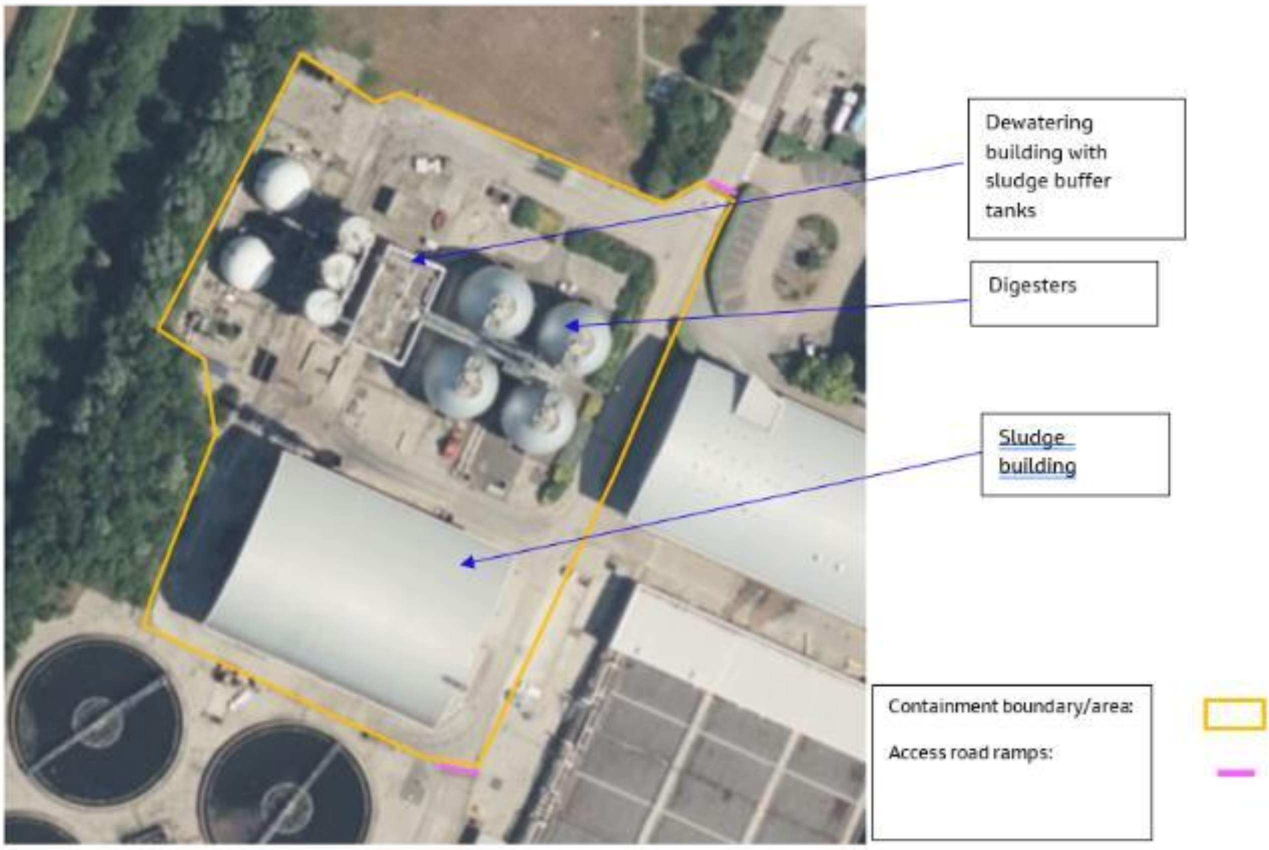


Figure 4.1 – Containment Option 1 – Wide area containment option

Bunds will be utilised around containment boundary and ramps constructed across roads to enable vehicular access. Maximum height of ramps is 300mm and bunds between 500mm to 1000mm. All grass and gravel areas will be excavated and resurfaced with concrete (Figure 4.2) to mitigate seepage into the local ground and soil. This also aids cleaning procedures following a spill. 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. The existing planted / grass within the containment area shall be removed and the area infilled with concrete.

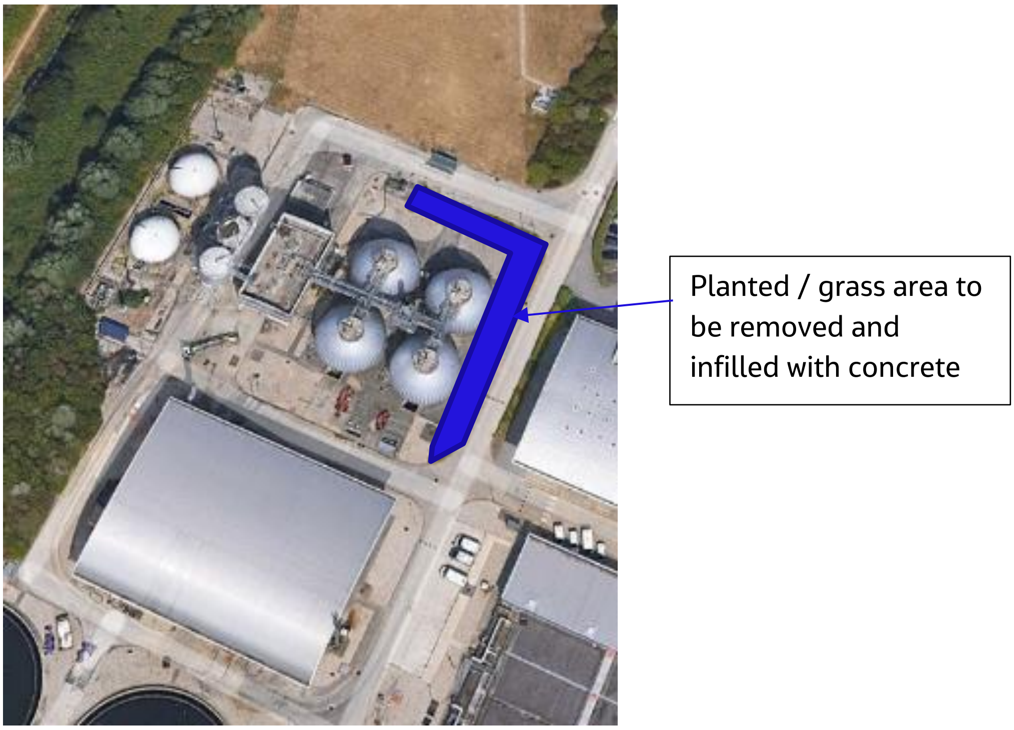


Figure 4.2 – Planted area to be replaced with concrete

4.1.2 Containment Option 2

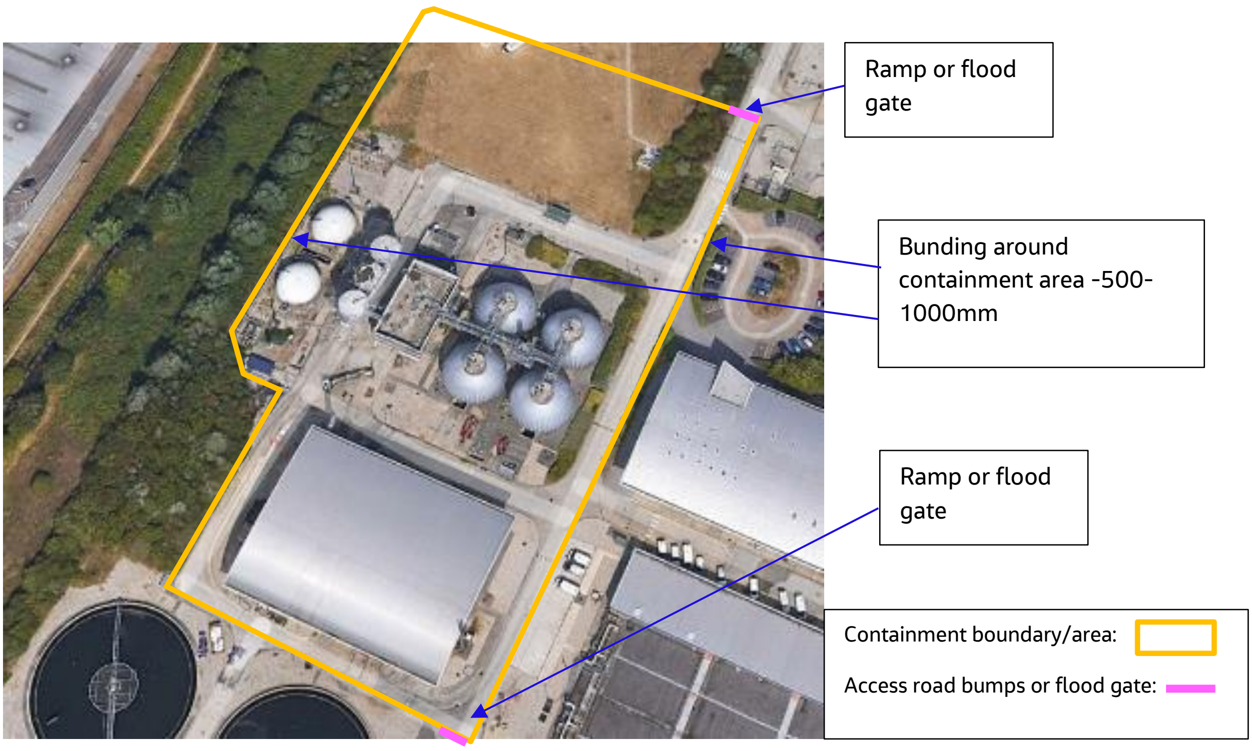


Figure 4.3 – Containment Option 2 – Wide area containment option

This option is similar to option 1 but with a larger containment area to utilise the open area to the north of the site (Figure 4.3).

Bunds will be utilised around containment boundary and ramps constructed across roads to enable vehicular access. Maximum height of ramps is 300mm and bunds 500- 1000mm. All grass 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. The existing drainage network on site is pumped back to the head of the works, as per confirmation from TW Operations of Reading. The existing planting / grass area within the containment area shall be removed and the area infilled with concrete.

This option was discounted as Thames Water has confirmed the open area at the north of the proposed containment area has been ring fenced for future projects.

4.1.3 Tertiary Containment Option

Reading STW was constructed with a bund around the site, and this will be utilised to provide tertiary containment. The low spot on the site is around the site entrance (ref Figure 3.3) and the proposal is to install a ramp across the site 12m wide site access road.

Figure 4.4 – Road Ramp for tertiary containment

4.2 Mitigation of Site-Specific Risks

4.2.1 Jetting and Surge Flows

Due to the location of the tanks and their distance from the boundary of the containment area, there is no risk of contamination through jetting.

There is a low risk of jetting occurring as the majority of the digester tanks are concrete construction, for which catastrophic failure is deemed to be less of an issue. 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, Reading STW is situated in Flood Zone 1 as shown in Figure 4.4. Areas situated in flood zone 1 have a low probability of flooding and have an annual probability of river flooding of less than 0.1%. Therefore, no modifications need to be made to Reading STW to accommodate this risk.

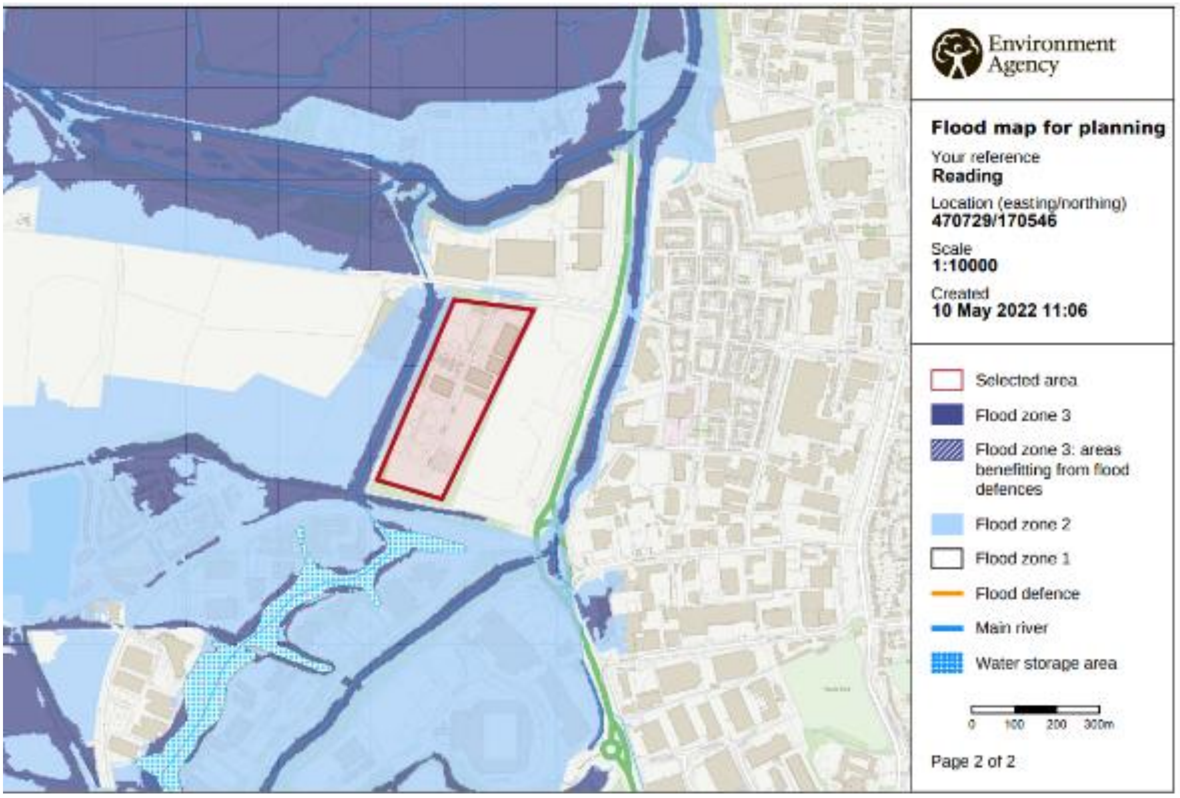


Figure 4.4 Extent of Fluvial flooding in Reading due to extreme weather events

4.3 Identification of Preferred Option

The preferred containment option is wide area containment option 1, constructing a low bund wall (500 - 1000mm high) around the wide containment area and constructing ramps at road crossings.

4.3.1 H&S and CDM risks

- Cable ducts and fibre ducts act as conduit to transport sludge around site.

5. Site Drainage and liquor returns

5.1 Process flow diagram

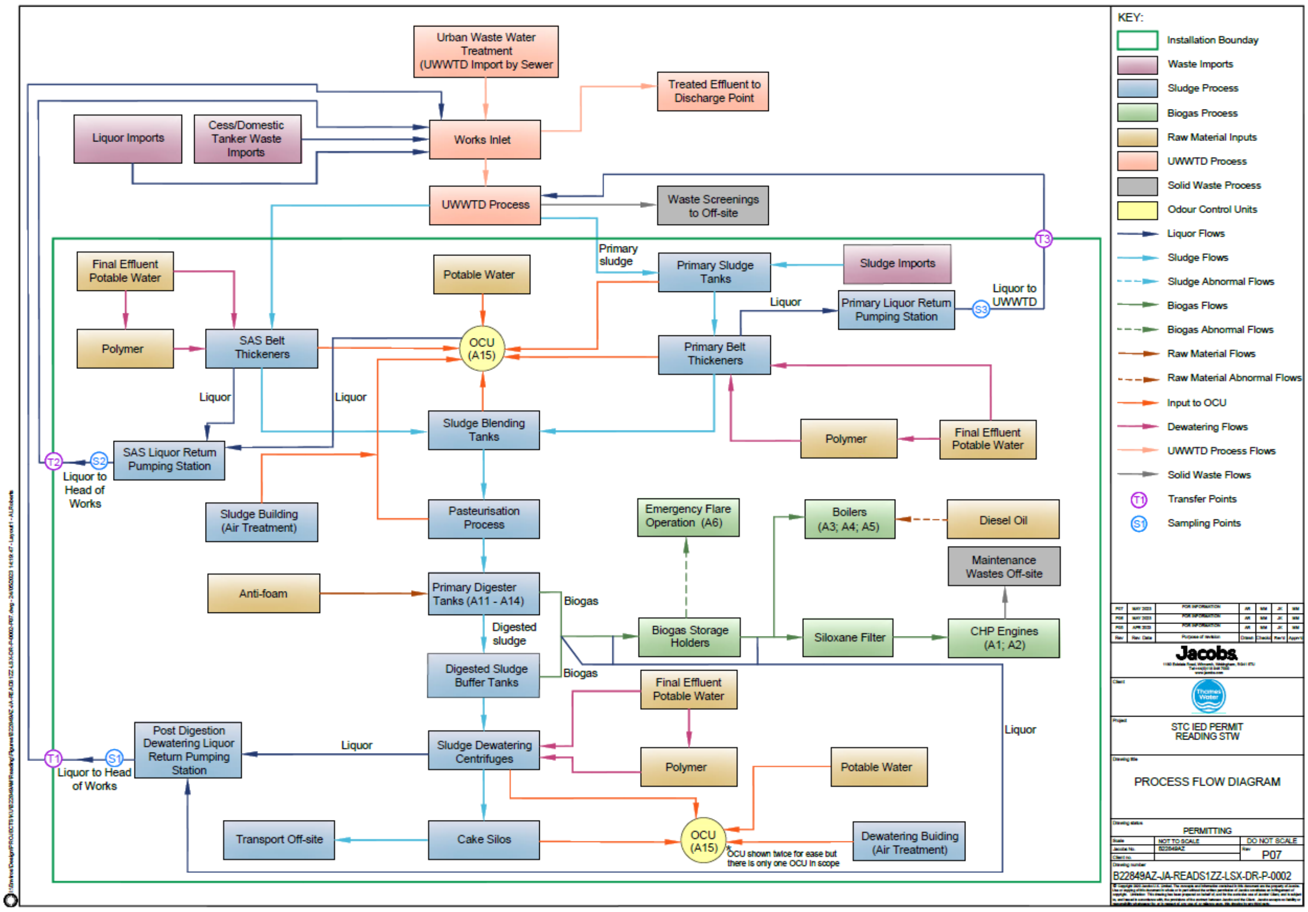


Figure 5-1 Process Flow Diagram

5.2 Foul, Process and Effluent Drainage

Site drainage assessments are based on Reading Sewage Works Layout Plan Drawing Numbers READS1ZZ-DPL-001

The Sewage Works Layout Plan for Reading shows all Foul/ Combined/ Process/ Effluent drainage pipes, indicated by green lines, go to the head of the works shown in Figure 5.3. 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 orange 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.

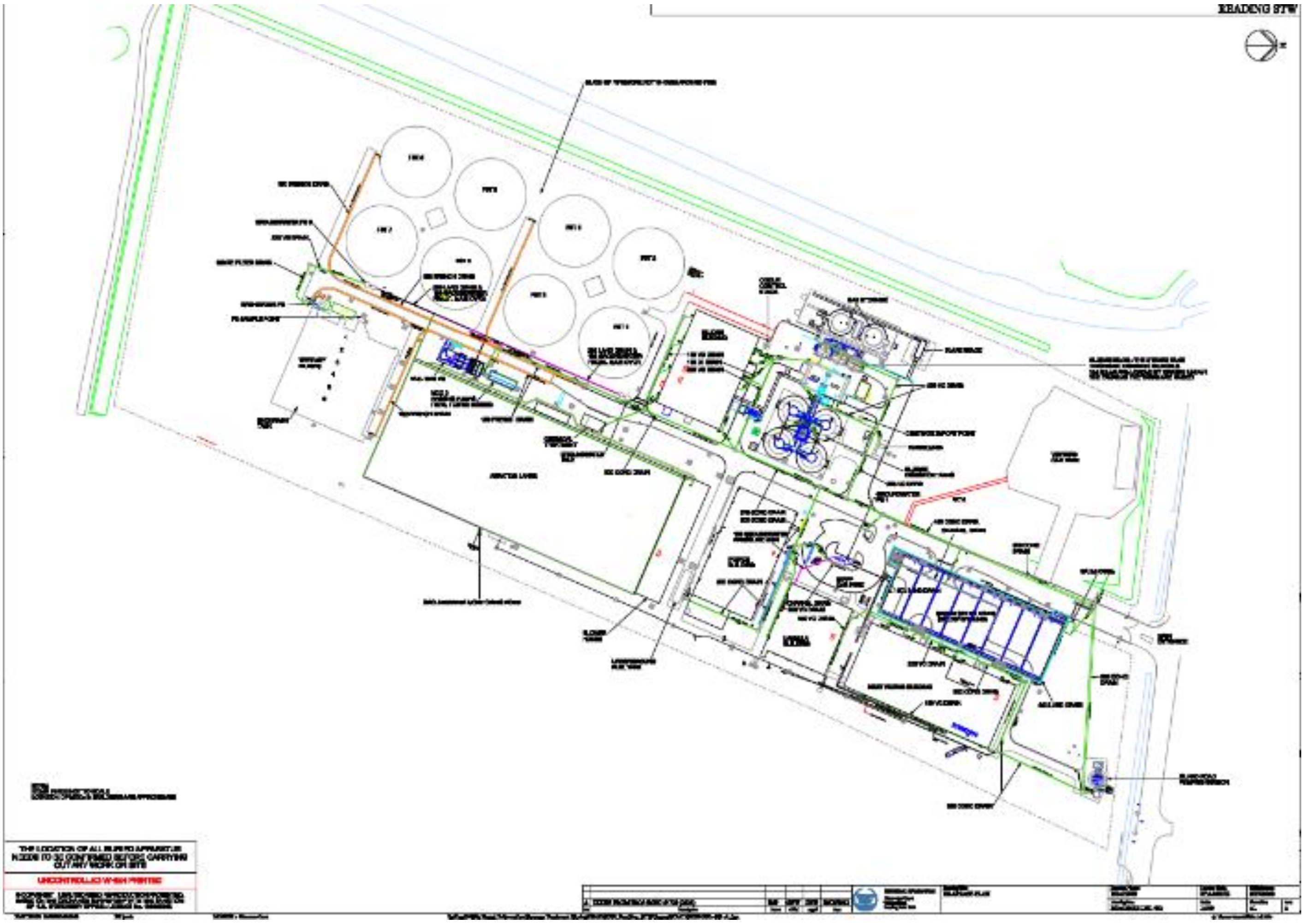


Figure 5.3 Drainage plans

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

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 at the inlet.

6. Conclusions

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

In the Risk Identification Report for Reading a containment classification report was carried out. An overall site risk rating of Medium was determined meaning that Class 2 containment is needed. The detailed requirements for Class 2 containment have been outlined in the Risk Identification Report in section 3.3.

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

The preferred option is option 1 – wide containment approach as outlined in section 4.1.1, to construct a 350m long bund wall (500 - 1000mm high) around the wide containment area.   Containment ramps will be constructed across the road crossings. Tertiary containment to be provide by the existing site wide boundary bund and installation of a 250mm high ramp across the main site access road 12m length.   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.

The results of the uncontained spill mapping 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 to a depth of 300-500mm. The volume for containment is driven by the 25% rule.

Appendix 1 ABDA Site Hazard Risk assessment summary for Reading 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 Reading 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.

The Source Hazard rating was determined as High.

Pathway – There are three 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. There are several areas where a sludge spill could pass over permeable ground.

3. The river Kennet and Foundry Brook to the north and east can impact downstream.

The site inventory has a runoff time of 15 minutes if unconstrained.

Consequently, the Pathway Hazard rating was determined as High.

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

1. The site drainage system and the head of the works.

2. There is a “Medium-High” groundwater vulnerability in this location.

3. The River Kennet and its stream to the north and west of the site, at a lower elevation and Foundry Brook to the east, also at a lower elevation.

4. The A33 to the east at a lower elevation.

5. The Hilton hotel (commercial) and Kennet Island Housing (residential) across the A33.

6. The Amazon and DHL warehouse immediately north of the site.

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 risk, 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.

Appendix 2 Tank Covering High Level Commitment

There are no open top tanks within the permit boundary at Reading STC.