# Wessex Water Enterprises Limited

### Avonmouth Renewable Energy Centre (REC)

### Reg 61 CIRIA C736 IED Report – Secondary Containment Assessment

### Addendum to Environmental Permit Application (Ref: PP3734LK)

| | Author | Checked | Approved |
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| **Revision** | **Date** | **Revision Description** |
| 1 | 30/09/2022 | First Issue |
| 2 | November 2025 | Updated to reflect 25% rule and exclude demolished Food Liquid Waste Tank and new (replacement) Hydrolysis Buffer Tank. |

# Contents

# 1. Addendum Context and Scope

This report has been prepared to support the Application for Environmental Permit Variation at Avonmouth Renewable Energy Centre (REC), issued in June 2021, Permit Ref PP3734LK.

> *As the primary containment assets are in the same area and the secondary containment proposals are logically combined, it should be read alongside the similar report prepared for the Avonmouth Bioresources Centre (BC), 'Avonmouth Bioresources Centre, CIRIA 736 IED Report - Secondary Containment Assessment' (19th December 2023).*

The Environmental Permitting (England and Wales) Regulations 2016 (EPR) application was submitted due to changes to the Environment Agency (EA) interpretation of the environmental permitting exclusion for Urban Wastewater Activities (under (EPR) Schedule 1, Part 2, Chapter 5, Section 5.4). The EA interpretation now requires that anaerobic digestion (AD) plants treating over 100 tonnes/day (t/d) are classified as installations for the purposes of EPR.

The primary purpose of the report is to secure stakeholder agreement of the method, logic, assumptions and outputs in the risk assessment and the general level of intervention deemed necessary to achieve BAT 19c compliance at Avonmouth REC and specifically emissions to soil and water due to overflows and failures from tanks, vessels and associated pipework.

This addendum includes:

- A full environmental risk assessment (ERA) of all existing primary and secondary containment measures at Avonmouth REC, to safeguard against the impacts of catastrophic containment failure scenarios.
- Consideration of credible modes of failure to emphasise the actual level of risk associated with each primary containment asset.
- Spill modelling of the complete loss of the inventory to demonstrate the potential to reach key receptors.
- The nature and extent of improvements deemed necessary to contain catastrophic and credible spill volumes and satisfy BAT 19 of the Waste Treatment BREF.

The ERA has been developed in line with CIRIA C736 'Containment Systems for the Prevention of Pollution' guidelines (CIRIA C736) and the 'ADBA Secondary Containment at AD plants: An Industry Guide' document (ADBA Guidance). Solutions align with the guidance outlined in CIRIA C736 where it is practicable to do so on an existing operational site. Where it is not practicable, alternative best available techniques are proposed for acceptance. The 110% and 25% rule outlined in the CIRIA C736 guidance is adhered to as a minimum requirement.

## 2. General Approach

The Source-Pathway-Receptor model as prescribed by CIRIA C736, and in accordance with sector guidance, has been used to establish the level of risk of failure of REC assets containing large volumes of food waste and food waste liquors, and the subsequent impact on local receptors. The class of containment required is based on this risk assessment.

### 2.1 Source

One of the key elements for determining the site hazard rating is as described in CIRIA C736 Section 2.3.1 – defining the Source of the pollution. It is the inventory of waste, surface water runoff that is contaminated by the inventory, firefighting agents that are harmful to the environment, and firefighting and cooling water contaminated by the inventory.

The potential pollutants present on site are assessed by the physical properties such as density and viscosity (percentage dry solids of the inventory) and the flammability.

Loss of containment scenarios and the subsequent total volume of inventory released are based on catastrophic failure of REC assets, regardless of whether the mode of failure is credible or not. The minimum volume assumed for a catastrophic failure is based on the 110% and 25% rule outlined in Chapter 4 of CIRIA C736.

### 2.1.1 Credible Failure Modes

Credible modes of failure are considered to emphasise the actual level of risk associated with each primary containment asset. This approach is important when assessing the probability of a failure mode occurring within a risk assessment to determine the required class of containment. It also helps to emphasise the design and inspection and maintenance safeguards needed to minimise the risk of smaller spills associated with higher probability events.

Credible failure modes of a tank or vessel have been established by considering the following factors:

- Containment material
- Height to width aspect ratio
- Working volume
- Current structural condition
- Dry Solids content of the inventory
- Vulnerability to vehicle collision
- Site security risk with respect to an intruder causing irreparable damage
- Operating requirements of a given REC asset

***For example:***

A worst-case scenario – A rapid and complete loss of containment would be reasonably expected for a glass coated steel digester (pressurised) tank which has exceeded its design life and is showing clear signs of severe corrosion and fatigue.

A low-risk scenario – Any loss of containment from a reinforced concrete digester would be considered highly unlikely where the structure has been designed to the relevant water retaining codes, constructed under supervision, built with industry standard safeguards in place, and is routinely inspected and maintained in accordance with a robust inspection and maintenance regime.

The risk assessment will normally only include REC assets containing large working volumes, as these are likely to define the containment solution for the site. Small REC tanks / vessels, mechanical plant, and interconnecting pipework are not normally included within the assessment unless their position or alignment, in relation to the containment solution, results in a significant residual risk to receptors.

### 2.1.2 Inventory

For the purposes of the spill modelling, the inventory will either be raw food waste, food waste liquors or digested food waste. Section 3.5 of the ADBA Guidance notes that CIRIA C736 suggests raw food waste should be classed as a hazardous substance given its influence on the oxygen balance (of aquatic environments) and microbial contamination.

- Raw food waste is therefore classed as high risk in the risk assessment.

The ADBA guidance does acknowledge that the hazard rating for fully digested food waste may be reduced given that it may be safely spread on fields under controlled conditions.

- Fully digested food waste is therefore classed as medium risk if considered in the risk assessments.

Section 4.3.4 of CIRIA C736 focusses on recommendations for quantifying firefighting water and agents and emphasises the need to adequately provide for a resultant volume for a secondary containment solution. However, Section 3.21 of ADBA Guidance acknowledges that:

- Food waste inventory at a REC is not flammable.
- Biogas will be produced through the digestion process at relatively low volumes and pressures and accidental ignition will lead to short lived fire/explosion.
- Firefighting foam and water is therefore not anticipated to be used in significant volumes for fighting a fire or cooling a tank in this scenario.

Firefighting foam or water is therefore not normally considered for the purposes of the spill modelling. The exception would be if there is potential for a fire caused by the ignition of WRC asset near the REC assets. In this case the fire itself may credibly cause failure of the REC asset. In this scenario, firefighting agents, and loss of inventory would be considered.

## 2.2 Pathways

Following a catastrophic failure of above ground primary containment, the escaped inventory will follow the natural topography of the ground before it reaches access points to underground drainage, duct services, surface water bodies, or permeable areas of ground.

Once a spill reaches the permeable ground it will continue to migrate according to the ground topography. However, a proportion of the inventory now in contact with the ground will also start to infiltrate into the ground. The rate of infiltration will vary depending on the properties of the inventory and the permeability of the ground. From here, the escaped inventory has the potential to migrate towards receptors such as groundwater or surface water bodies.

Buried tanks or above ground tanks with features that partially extend below ground also need to be considered. These tanks will typically be reinforced concrete construction. The credible modes of failure are limited to gradual degradation caused by potentially aggressive ground conditions or the slightly corrosive nature of the inventory. This is likely to lead to leaks rather than large scale spill events.

Spill simulations are therefore focussed on the routes of the spill migration overland to identify the proportion of volume (if any) reaching surface water bodies or permeable ground. The spill simulations are then used to confirm the suitability of proposed bund solutions.

Note: The inventory volume held below ground within an asset is not included in the overland spill simulations.

Vertical and horizontal migration potential of lost inventory in the ground has been considered in the ERA. This is based on the local geology and hydrogeology described in Section 6 of this document.

### 2.2.1 Spill Simulation Method

Overland spill simulations from the REC assets of interest are generated using a Geographical Information Systems (GIS) "rolling ball" tool. For each REC asset, an Esri ASCII grid file is created from 1km Lidar Digital Terrain Model data (point density of 1 point per square metre) with a 1km radius from the selected spill position.

The potential spillage route is determined by following the path of least resistance from the selected spill position. From this spill position, the tool will look up the eight adjacent 1m square cells and spill into the cell with the lowest ground elevation. In the next iteration, the tool will look at all cells adjacent to the two cells currently containing the spill and spill into the adjacent cell with the lowest elevation and so on.

Each iteration adds a 1 metre x 1 metre x 0.1 metre spill volume and iterations will continue until:

- The simulation reaches the end of the number of iterations, defined by the total credible spill volume determined by the risk assessment or,
- The spill reaches water.

For any given iteration, if adjacent cells do not have a ground elevation lower than the cells containing the spillage, then the simulation adds 0.1m to the cells featuring the spillage and adjusts the remaining number of iterations based on the residual spill volume.

### 2.2.2 Simplification

The model simulation is simplified in the following ways, to generate a conservative but reasonably accurate overland spill route for the loss of containment from a given source.

- All surfaces behave as impermeable surfaces, so flows are not lost to ground in simulation.
- Small chambers such as drainage features and cabling drawpits are not included for the purposes of the rolling ball simulation.
- Buildings and structures have 100 metres added to their Lidar value so the spill cannot travel through them.
- Water in the Lidar has a negative elevation value and once the spill reaches water, 100% of the residual inventory volume is assumed to also spill into the water.
- If a bund is proposed for a solution, then 0.3 metres is added to the relevant Lidar cells along the suggested perimeter of the bund to represent a shallow reinforced concrete wall in the first instance.

### 2.2.3 Limitations

The failure mode of an asset can significantly influence how the spill volume migrates from the primary containment. For example, overtopping of a tank will normally cause flows to spill around the complete perimeter whereas tank corrosion leading to the localised rupture will result in flows discharging from a single position. The rolling ball method always assumes a point source discharge regardless of the established failure mode. A worst-case spill position is selected based on surrounding topography and proximity to nearby receptors. In certain instances, more than one spill position is required to prove that a containment solution is effective; for example, when the ground levels fall in more than one direction away from the asset.

The model simulation does not account for percentage dry solids of the spill. However, the rolling ball method described above closely represents the behaviour of water or food waste with a very low dry solids content. The model is therefore likely to overpredict the extent of a spill where the percentage dry solids of the source’s contents is higher.

### 2.2.4 Other Pathway Considerations

The GIS “rolling ball” tool will generally overpredict the extent of the overland spill and therefore the risk to local receptors. However, below ground services such as surface water drainage routes or duct routes do have the potential to rapidly carry a spill to local receptors, or to bypass containment solutions. Site services are therefore acknowledged as part of the risk assessments to highlight any potential short circuiting and this will be considered further when developing a detailed solution.

The GIS “rolling ball” tool cannot model dynamic effects caused by a relatively rapid loss of containment. It also does not account for pressurised ejections or “jetting” from a source. This could be crucial when considering containment solutions if:

- The asset is close to a defined bund perimeter,
- The asset is close to a receptor and,
- An established credible failure mode could cause surge or jetting effects.

Table 6.5 in CIRIA C736 recommends that the requirement to assess the implications of these events depends on the overall site hazard rating and hence the class of containment required. The key recommendations are summarised below:

| Recommendation | Class1 | Class2 | Class3 |
|---|---|---|---|
| c. No structure within the bund to be closer than its own height to the bund wall | Not necessary | Desirable | Recommended |
| g. Take account of possible jetting failure | Desirable | Recommended | Recommended |
| h. Take account of surge effects | Desirable | Recommended | Recommended |

**Figure 2.1: Extract from the ADBA Guidance Summarising Examples of Key Performance Recommendations by Class from Table 6.5 CIRIA C736.**

Given that the volumes of inventory stored are significant at the Avonmouth REC, the impact of dynamic and jetting effects are always considered in addition to the spill modelling regardless of the containment class. The potential for dynamic and jet effects are based only on the established credible failure modes of assets and subsequent movement of the escaped inventory. In certain cases, this may mean that the intended bund position does not need to align with recommendation c in Figure 2a for class 2 and class 3 containment. For this assessment, the requirements are assessed by inspection. However, at detailed design, assertions will be demonstrated by calculation for jetting where appropriate.

The REC is situated within Avonmouth WRC. WRCs are often situated in low lying areas close to water bodies and can therefore be at risk of fluvial flooding, which may introduce an additional and more direct pathway to a receptor. Avonmouth REC is not at risk of fluvial flooding as indicated in Figure 2.2 unless the flood defences that serve the site and surrounding area are breached. In this scenario, the site largely resides within flood zone 3. The ERA does therefore acknowledge the extremely remote possibility of flooding and approaches to containment will be developed to mitigate the risk of floodwater ingress.

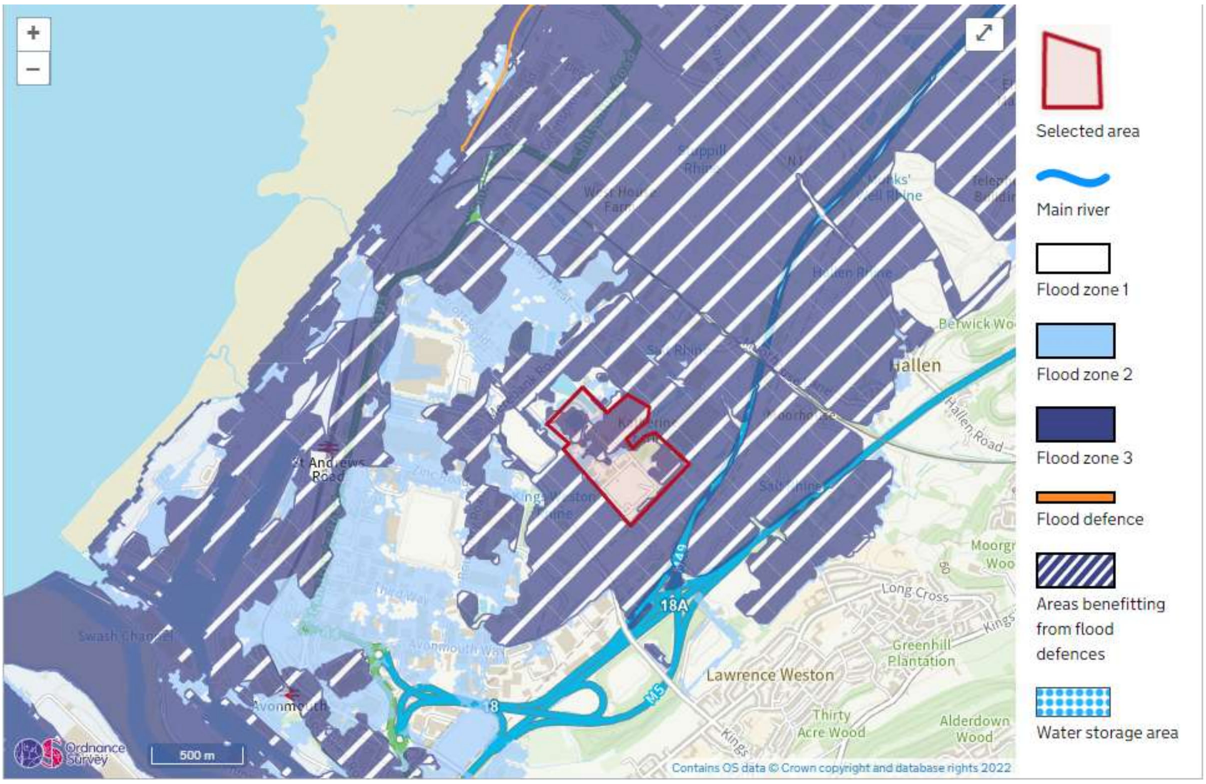


**Figure 2.2: Flood Risk Map for Avonmouth REC from https://flood-map-for-planning.service.gov.uk/**

## 2.3 Receptors

The location and significance of receptors will normally consist of permeable ground and water bodies within or near to the site, sites with environmental designations, and commercial or residential properties. The treatment works itself is not normally considered to be a direct receptor but could act as a pathway if the spill overwhelms the treatment processes and leads to a final effluent consent failure and subsequent pollution event. Its ability to effectively treat following a spill event is therefore considered in the risk assessment. Section 3.36 of the ADBA Guidance indicates the type of receptors that could lead to a higher hazard rating than “Low”. This information is principally used to justify the hazard ratings for receptors in the risk assessments.

## 2.4 Approaches to Solutions

Proposed secondary containment solutions shall be developed, in accordance with the 110% and 25% rule outlined in CIRIA C736. Additional volume allowances for rainwater and firefighting agents will be considered where applicable. Solutions shall also include appropriate measures to safeguard against specific failure modes such as a vehicle collision leading to jetting from a pipe.

Two principal approaches have been taken to reach a practicable solution:

1) Fully compliant Secondary Containment solution in accordance with CIRIA C736.

   This approach is based on constructing a reinforced concrete structure locally around one or several existing primary assets to contain a volume of inventory in accordance with the 110% and 25% rules outlined in CIRIA. The impact of the solution on the operability and maintainability of the tank itself and surrounding assets is then considered with the site operators.

2) Solution that prevents sludge from leaving site following Catastrophic Failure.

   This is not necessarily a ‘pure’ CIRIA C736 secondary containment solution but can achieve an equivalent level of containment appropriate to BAT 19c. The approach is based on maximising the benefits of existing site infrastructure, such as forming shallow bunds and ramps around existing impermeable hardstanding and road areas to minimise impact on the operability and maintainability of the site. The solution will incorporate measures to demonstrate that containment infrastructure, including existing impermeable hardstanding and drainage, is in an appropriate condition.

   It is acknowledged that this approach will often involve much larger impermeable surface areas and therefore the potential for significant rainfall volumes accumulating following the catastrophic failure of an asset. Alternative methods of managing additional run off are therefore considered with this approach, which includes a controlled pumped discharge back to Avonmouth WRC for treatment, or the use of the tankers to maintain a volume in the bund until the 1 in 10-year storm event subsides.

   It is also acknowledged that this type of solution will result in numerous primary containment assets within a common containment bund. In this case, containment volume may be based on 25 percent of the total asset volume rule outlined in CIRIA C736 if the calculated volume is greater than the volume based on 110% of the largest tank within the bund.

   The Environment Agency were consulted about whether they would accept this approach in principle on 15/06/22. The EA confirmed that they would accept such proposals as long as the solution provides an equivalent level of containment appropriate to BAT 19c, and clear supporting justification and evidence is provided.

It should be noted that the primary containment assets of the Avonmouth REC are in close proximity and interspersed with the primary containment assets of the Avonmouth Bioresources Centre (BC). Therefore, for the second approach, it is necessary to consider all of these assets as the secondary containment solution will be common.

Secondary containment solutions will be designed to provide an equivalent level of containment appropriate to BAT 19c and justification will be provided alongside the preferred approach. The detailed design of the proposed containment solution, including walls, paving, joint details, refurbishment of existing assets, and maintenance regime specification will be reviewed by a chartered structural engineer.

Any areas designated as part of a primary or secondary containment system will be classed as such on Wessex Water's asset database and will be subject to a routine inspection / maintenance regime to ensure ongoing structural integrity. This will include monthly checks by trained operators who will refer signs of deterioration to a chartered structural engineer for review. A chartered structural engineer will also carry out their own review on a suggested two-yearly basis to verify the integrity of the containment assets.

## 3. Information Sources

The following information sources have been used for the study presented in this report:

- General and site-specific information provided by the Operator relating to the food waste treatment process; infrastructure details / records and other relevant operational information and Process Flow Diagram, tank condition reports and P&IDs.

- Environmental data report and mapping provided by GroundSure based on various publicly available information sources.

- Information provided by the Environment Agency following a specific data request which included license abstraction, rainfall data (not used), discharge consents, water quality data (but nothing near the site and therefore not used).

- Additional publicly accessible information from the UK Government and the British Geological Survey (BGS).

A site visit was also conducted on 23rd August 2022. The purpose of this visit was to obtain additional information from the Operator, undertake a visual inspection of the REC assets and infrastructure and the immediate surrounding area to provide contemporary information for the purposes of this assessment. It was also used to present and discuss draft secondary containment solutions with the Operator.

# 4. Site Context

## 4.1 Location

The Avonmouth Site is located Northwest of Bristol at National Grid Reference ST5339179395. The site covers an area of approximately 20 Ha, which includes the assets that comprise Avonmouth BC, WRC where wastewater is treated, and the renewable energy centre (REC). These are collectively referred to as 'the Avonmouth Site' or 'the Site' in this report.

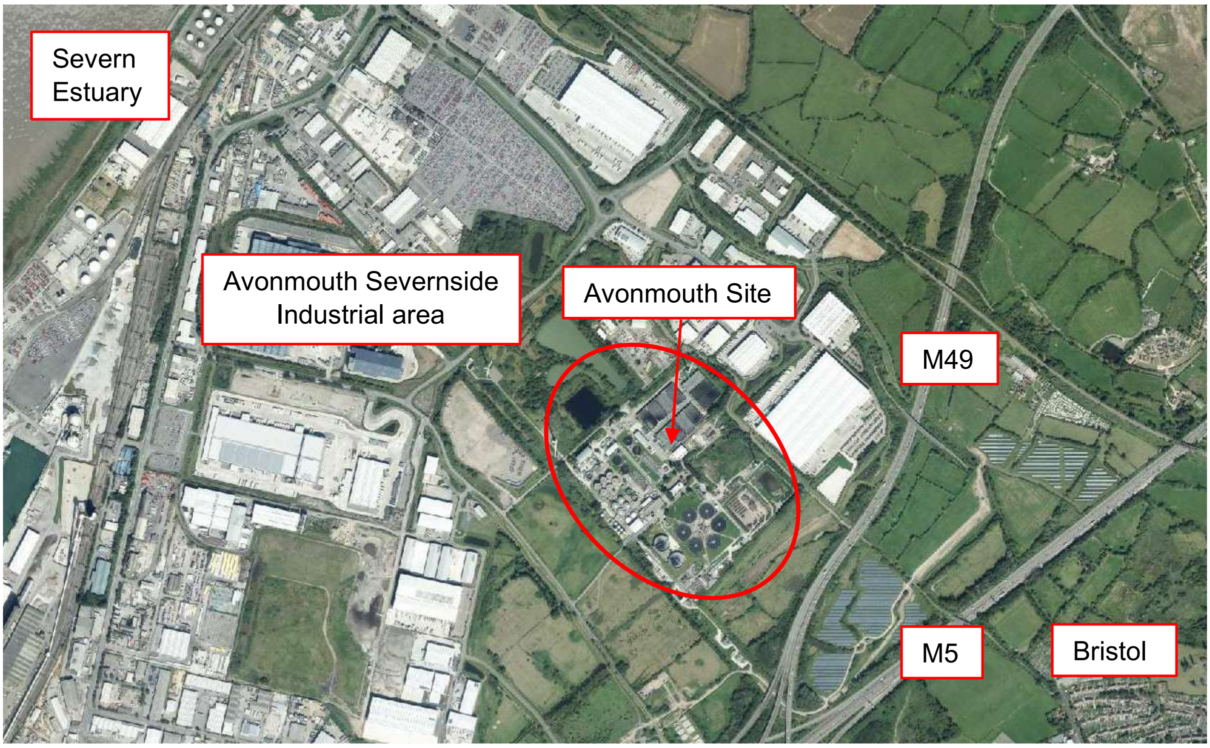


**Figure 4.1 Avonmouth Site Location**

## 4.2 Site Setting

The Severn Estuary is located approximately 2 km to the west of the site, and the Bristol Channel is located approximately 2 km to the west and northwest of the site.

## 5. Renewable Energy Centre Overview

This section provides a summary of the Renewable Energy Centre (REC) food waste treatment process including the key assets and associated infrastructure. It also summarises the general topography, ground finishes, and drainage features serving the REC.

The location of the assets and infrastructure referred to are shown in Figure 5.1 on the following page.

REC assets that are considered as part of the CIRIA C736 ERAs are indicated in Table 5.1 below.

**Table 5.1 Assets Considered for CIRIA C736 ERAs**

| Asset name | Ref |
|---|---|
| Hydrolysis Buffer Tank | 40 |
| Post Digestion Storage Tank | 41 |
| Digester Nr. 1 | Q |
| Digester Nr. 3 | Q |

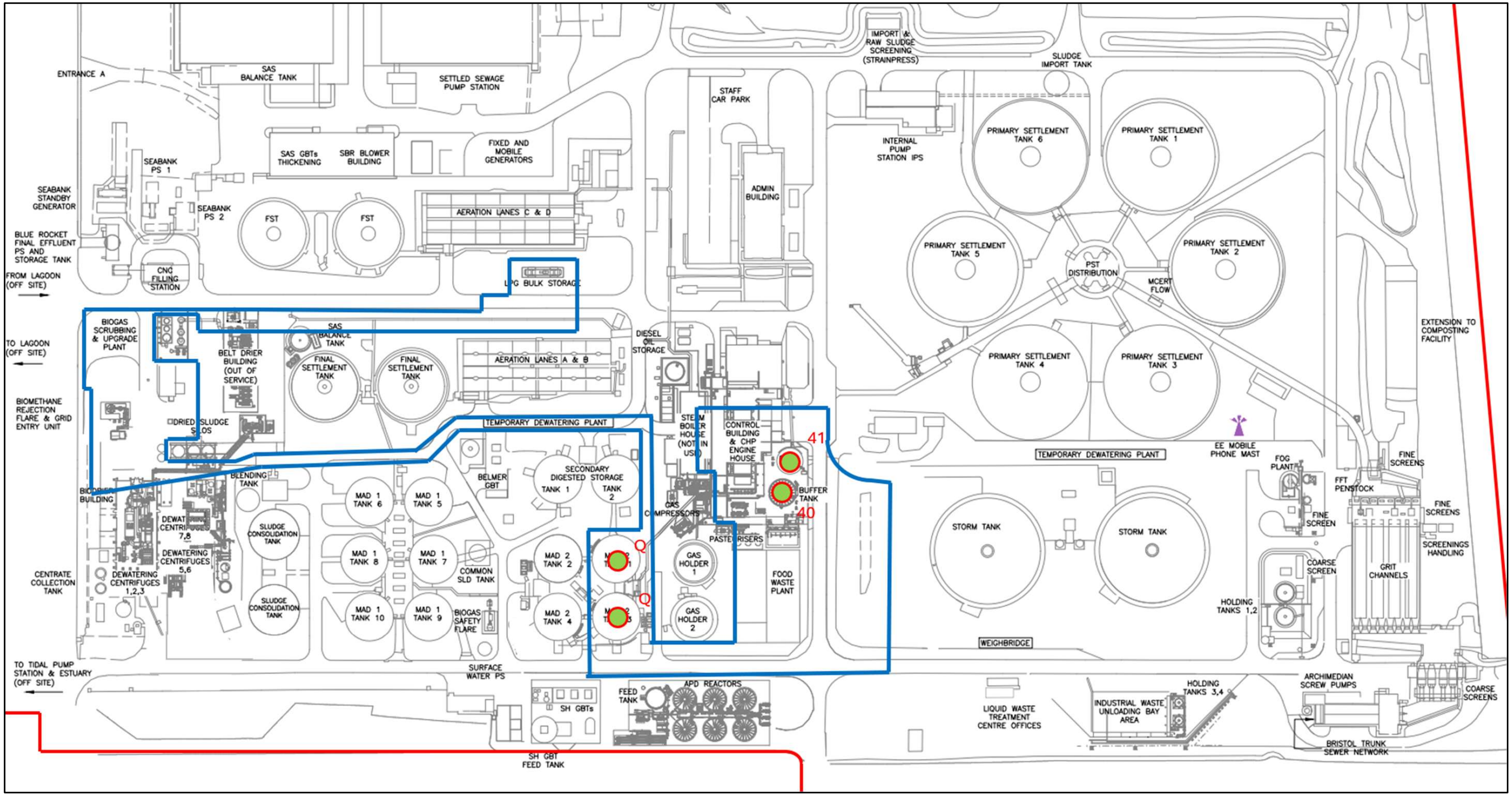


**Figure 5.1 – Site and Installation Boundary, and position of REC Assets**

### 5.1 Food Waste Treatment Process

The REC / food waste plant at Avonmouth (site 10409) is capable of handling up to 70,000 tonnes per year of solid food wastes. It is approved to handle animal by-products (ABP) category 3 material. It has 4 main stages as follows.

**1st Stage: Reception and de-packaging**

Source-segregated food waste is delivered in solid form by skips tipped into the food waste reception hall and fed into a coarse shredder to split the bags.

It is then fed to the "Turbodissolver" batch tanks in the building and screened to remove material over 10mm. The screenings are pulped in a hammer mill with an 8mm screen and plastic packaging is removed as a waste stream.

The waste next passes through a grit settling channel and is then pumped to the hydrolysis buffer tank.

**2nd Stage: Hydrolysis and pasteurisation**

The de-packaged food waste slurry is stored (1-4 days) in a pump-mixed 800m3 capacity tank. Hydrolysis is the natural first stage of digestion and larger molecules are broken down by bacteria with some carbon dioxide released but not methane in the acidic conditions (pH 3.5-4.5).

Heat exchangers are used to raise the waste to over 70°C using 3 batch pasteuriser vessels in parallel. The waste is held at over 70°C for an hour then each batch is pumped over to the digesters via a heat recovery heat exchanger at 45-55°C.

**3rd Stage: Digestion and biogas production**

The pasteurised food waste is mixed into the two digesters by injection into the pump-mixing loop. The digesters are also thoroughly mixed by injection of compressed biogas into draught-tube mixing tubes. The whole digester contents are sealed and remain anaerobic and operate at pH 7.6 to 8.0 naturally without adding any pH-adjusting chemicals. The bacteria (archaea) break down most of the organic material into methane and carbon dioxide (biogas) which is collected from the tops of the digesters. The residence time is between 18 and 30 days in the digesters. The digested waste overflows into a side chamber and is pumped via two strain-presses (5mm and 3mm screens) to the post digestion storage tank (PDST).

**4th Stage: Digestate dewatering**

The digestate is stored in the PDST for 1 to 4 days and this 863m3 capacity tank is aerated to stop the methane production and to mix the liquid.

The waste is then pumped to one of two duty/standby decanter centrifuges using polyelectrolyte solution to separate solid (separated fibre) from liquid (centrate). Some centrate is recycled to the de-packaging stage via the Turbodissolvers, the rest is sent to the WRC for treatment. The solid material is collected in skips and satisfies the PAS110 standard of the anaerobic digestion quality protocol (ADQP), so the nutrients and fibre are recycled to farmland to grow food crops.

## 5.2 Topography, Surfacing, and Drainage

The topography of the site is generally flat with the REC at an elevation of approximately 7 to 8 mAOD.

The REC consists of impermeable surfacing, sealed drainage, and kerbing that directs spills and surface run off to the Internal Pumping station (IPS). The IPS then transfers all flows upstream of the Primary Settlement tanks (PSTs).

The approximate impermeable surface extents are indicated in Figure 5.2. This infrastructure has been designed principally for appropriate access and management of surface water run-off and small spills associated with general operation and maintenance. A portion of area of the REC is bunded with sealed drainage and is capable of containing larger spill volumes. This area is shown within the red containment area in Figure 5.2. These extents have the potential to be incorporated into a wider bund solution subject to a condition assessment and any required repairs.

Figure 5.3 displays the below ground site drainage arrangements which highlight the storm water sewers and pipelines in blue and foul water sewers and pipelines in red. The route of the outfall culvert is also shown. Foul water drainage is returned to the IPS, which is in turn transferred downstream the preliminary treatment stage of the WRC, assuring that no returned drainage will escape to the environment by spilling over the storm overflow.

Roof rainwater run-off discharges to the outfall culvert and then the lagoon that is located west of the Site. The lagoon is used for the site’s washwater supply and as storage for the Seabank power station.

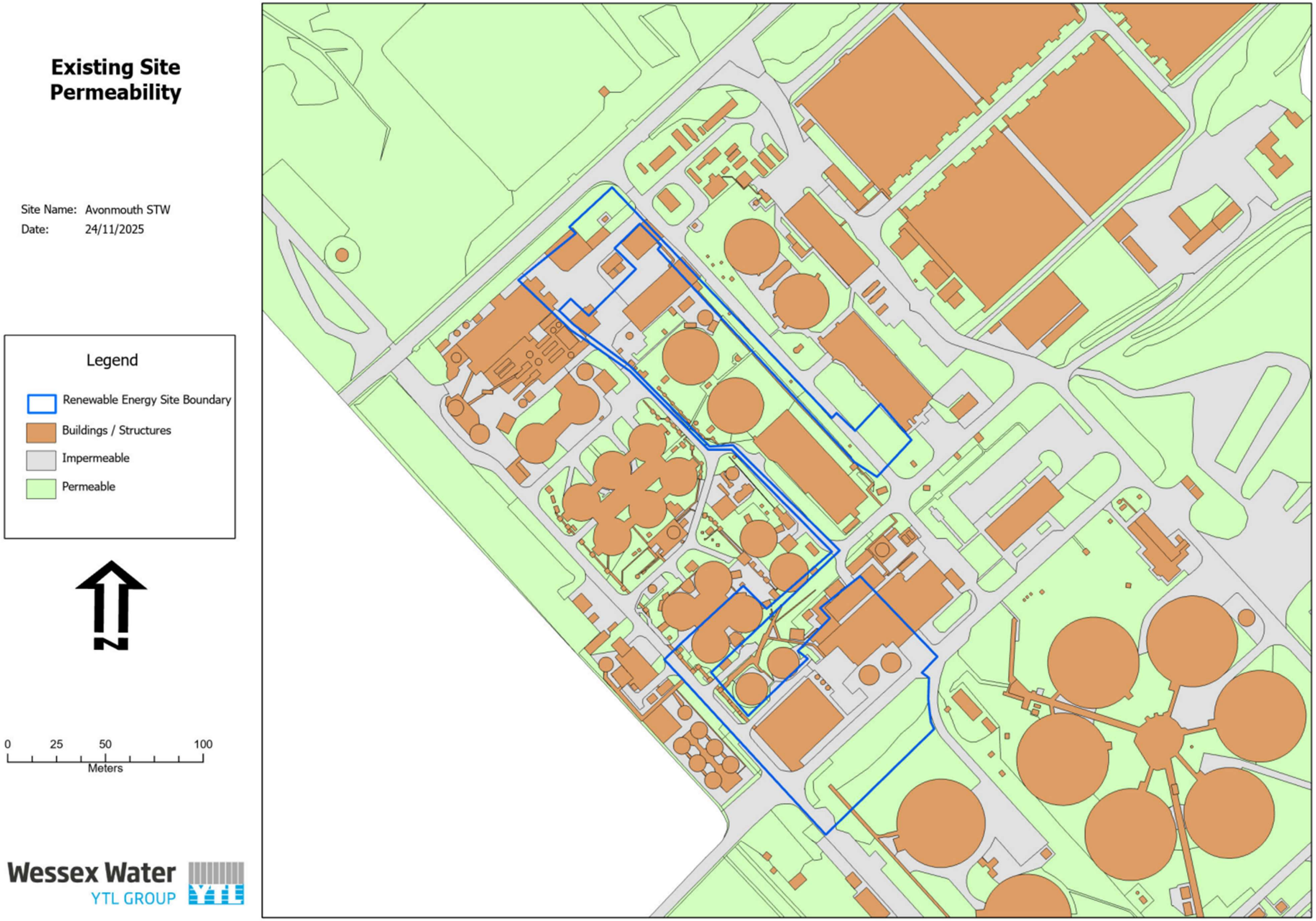


**Figure 5.2 – Existing Site Permeability Plan**

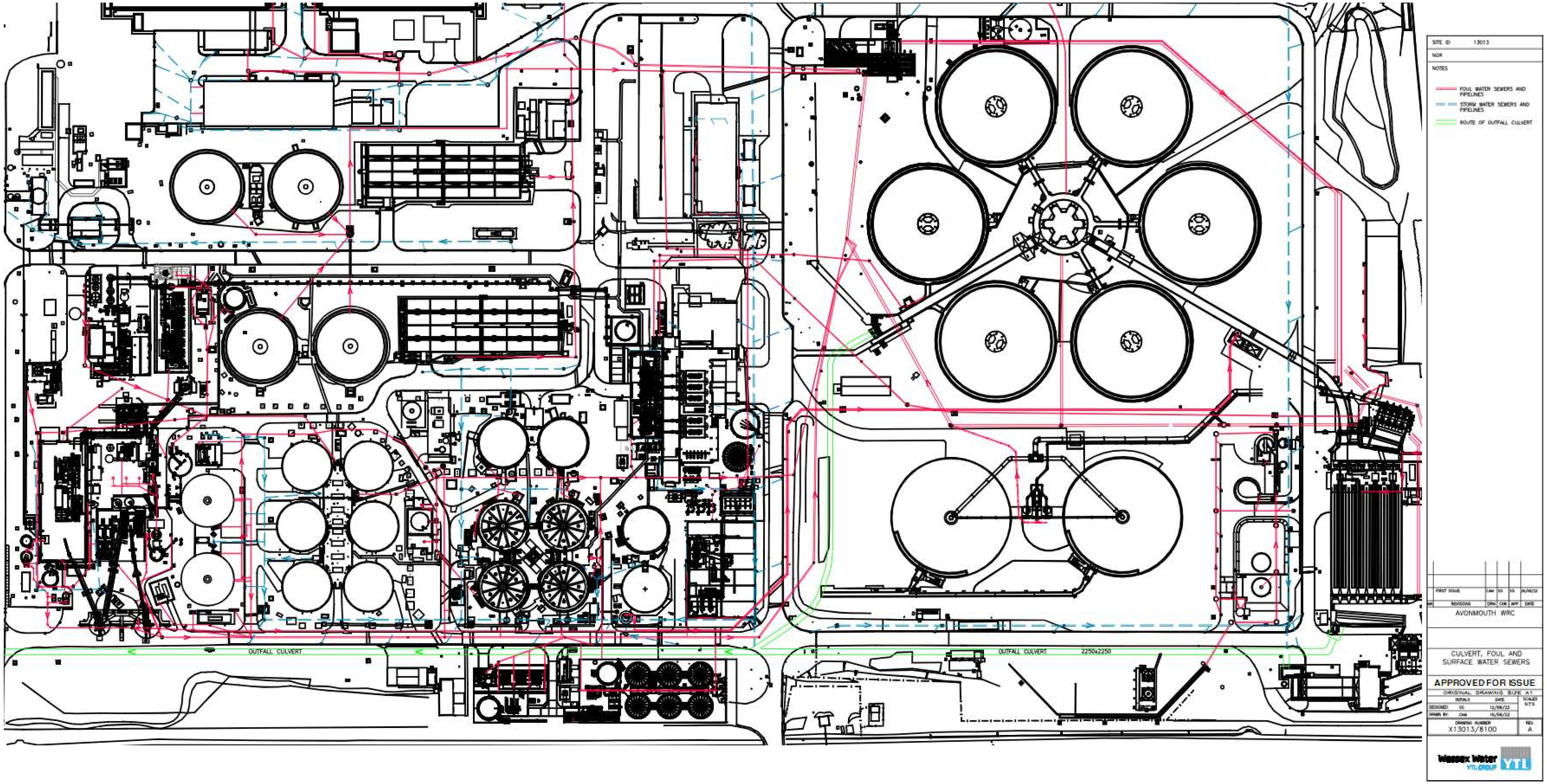


**Figure 5.3 – Below Ground Site Drainage Arrangements at the Avonmouth Site**

## 6. Environmental Setting

### 6.1 Geology

The geology at the Site may be summarised as follows:

- Made Ground is encountered in the majority of locations and is described as firm to stiff, brown silty clay, with some fine to coarse subangular gravel. Where identified, the Made Ground is present at a thickness of between 0.4 m to 4.2 m across the Site but is generally 1 m to 2 m thick.
- Superficial deposits are recorded either underlying the Made Ground, where present, or directly beneath the topsoil. The Tidal Flat Deposits are comprised of interbedded layers of clay and silt at a confirmed thickness of between 13.7 m and 20.3 m across the Site. This ranges from firm grey-brown mottled orange slightly sandy slightly gravelly clay to very soft to soft, brown-blue-grey slightly sandy silt and clay. Intermittent thin layers of peat were recorded in numerous boreholes at thicknesses of approximately 0.15 m.
- The Mercia Mudstone Group transitions through a weathered zone between the Tidal Flat Deposits and into the mudstone / siltstone. However, the zone is not well defined. The weathered zone is generally described as very stiff red-brown silty clay with gravel sized lithorelicts. This then transitions downwards into very weak thinly laminated reddish-brown mudstone and strong, red-brown occasionally grey-green mottled thinly bedded siltstone.

### 6.2 Hydrology

The site is approximately 1.8km north-east of the River Severn / Severn Estuary which flows south-westwards into the Bristol Channel. The River Avon lies approximately 2.5km to the south-west of the site which flows to the north-west into the Severn Estuary.

Two drains lie along the south-western boundary of the Site, which are separated by the monument ‘Mere Bank’ which is an historic linear flood defence. The most north-eastern of these two drains is named ‘Mere Bank Rhine’ and the other is not named.

A drain (the eastern drain) runs parallel to the eastern boundary of the site approximately 40m to the south-east of the site. The drain was not visible during the site visit. However, it was noted that a small watercourse is present immediately along the eastern boundary. All these drains are interconnected across the adjacent fields.

Another drain (the northern drain) is present along the northern boundary of the WRC and within the Site in the northern area next to Katherine Farm. The topography of the land in the centre of the site falls towards this drain.

Three surface water bodies (the western lagoons) lie approximately 40m to the north-west of the Site on Wessex Water owned land. The northern two lagoons are nature reserves and used for fishing. It is understood from the site staff that all three lagoons are lined. The lagoons lie at a similar elevation as the food waste assets within the west of the Site.

There were further historic lagoons in the northeast corner of the site. These were dewatered and are understood to have become compost heaps. However, the northern-most lagoon has been left to refill naturally (with rainfall). Site staff do not think this lagoon is lined.

Surface water in the area is expected to generally drain to the north-west towards the Severn Estuary from the higher ground to the south-east. However, local to the Site, surface water is expected to drain towards the southwest and Mere Bank Rhine and then onwards to the Severn Estuary. The majority of the surface water within the Site will be captured by the engineered surface drainage system.

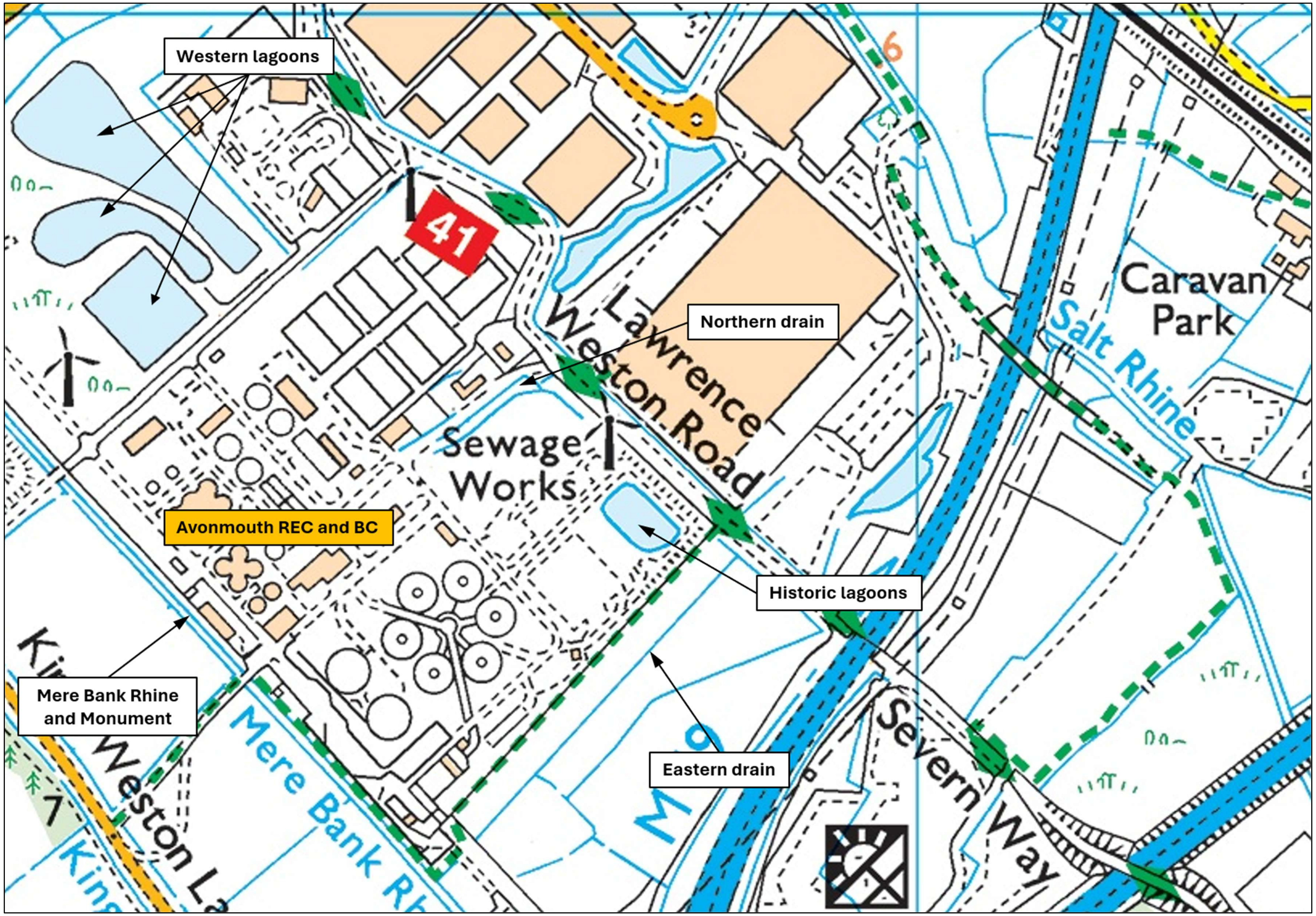


Figure 6.1 – Surface Water Features in relation to Avonmouth REC

### 6.3 Hydrogeology

The superficial deposits present at and within the vicinity of the Site are classified as unproductive aquifers. The Mercia Mudstone bedrock beneath the Site is classified as a Secondary B aquifer.

Rainfall, or liquors, entering the ground is likely to migrate downwards within the Made Ground deposits and Tidal Flat Deposits until it reaches the upper surface of the Mercia Mudstone Group present beneath the Site.

This liquor may mix and be diluted within the limited perched groundwater that may be present locally within the Made Ground and Tidal Flat Deposits. Alternatively, local conditions may allow liquors to continue to migrate downwards and mix and be diluted by groundwater present within the Mercia Mudstone Group. From here, it may be transported laterally according to the local hydraulic gradient. However, groundwater flows are expected to be limited due to the low permeability nature of these units.

## 7. Receptors

Key receptors and the risks posed from emissions to surface water and groundwater based on the information in Section 6 include:

- Shallow Aquifer – Made ground / Tidal Flat Deposits
- Deep Aquifer – Mercia Mudstone Secondary B aquifer
- Severn Estuary (SSSI, SPA, SAC, and Ramsar)
- Surface Waters – The Mere Bank Rhine including the Mere Bank Monument (Scheduled Monument).
- Surface Waters – other drains surrounding the site.
- Western Lagoons (Local Nature Reserve) to the North-east of the Site.
- Lawrence Weston Moor Nature Reserve.
- Avonmouth WRC.

The most sensitive receptors that may be impacted by a loss of containment at Avonmouth REC are the Severn Estuary, due to its nationally significant environmental designations, and the Mere Bank Monument due to its heritage value.

The above factors are all considered in the CIRIA C736 ERAs to determine a site hazard rating.

# 8. Environmental Risk Assessments

An environmental risk assessment (ERA) has been prepared for the assets holding food waste inventory within the REC to determine the class of secondary containment required. The ERA adopts the source-pathway-receptor linkage principle outlined in the CIRIA C736 and is based on the information presented within Sections 4 to 7 of this report.

**Figure 8.1 Aerial view of Avonmouth Site**

To support the ERA further, a general overview of the inspected assets (summarised in Table 8.1 below) and the immediate surrounding area is presented in this section.

All tank assets are subject to daily visual operator inspection in line with asset management procedures. All tanks include connecting pipework at both high and low levels and feature a high-level overflow that discharges into the local drainage system or to downstream processes. They also include level indication via pressure transducers, ultrasonic instruments, or radar instruments, linked to associated alarms to alert operators of abnormal conditions. The site is manned at all times.

Spill model outputs are included to demonstrate the typical overland and below ground flow paths following a catastrophic failure of inventory from primary containment assets. These outputs also indicate the receptors that are currently at risk.

**Table 8.1 Asset Overview**

| Tank Ref | Asset Name | Above ground Volume (m3) | Brim full capacity (m3) | Height (m) | Material | Year built |
|---|---|---|---|---|---|---|
| **40** | Hydrolysis Buffer Tank | 808 | 808 | 11.1 | SS | 2025 |
| **41** | Post Digestion Storage Tank | 863 | 863 | 10.5 | EFS | 2012 |
| **Q** | Digester Nr. 1 and Nr.3 (each) | 2332 | 2769 | 8.8 | RC | 1963 |

*RC – Reinforced Concrete, EFS – Epoxy Fused Steel, SS – Stainless Steel*

### 8.1 Digester Nr. 1 and Nr. 3

Digesters Nr. 1 and Nr. 3 are located on the southern side of the site, across the road from the bioresources centre (BC) APD tanks and adjacent to the gas holders. Both tanks treat food waste and are run as a separate process from the BC sludge treatment process.

The tanks are reinforced concrete cylindrical structures with a concrete roof and floor slab constructed in 1963. They have a perimeter walkway and a sloping roof. The total volume of each tank is 2769m$^3$ of which 2332m$^3$ is above-ground volume The height of the walls is approximately 8.8m. Connecting pipework is at both high and low levels. The tanks each feature a high-level overflow that discharges into the local drainage system, level indication via pressure transducers and associated high level alarms. They are subject to daily operator inspections.

**Figure 8.1.1 Digester Nr. 1**

**Figure 8.1.2 Digester Nr. 3**

The surrounding ground consists of concrete pavement, roads, and permeable (gravelled) areas.

The spill modelling output for Digesters Nr.1 and Nr. 3 in Figures 8.1.3 and 8.1.4 demonstrates that a catastrophic failure could lead to contamination of groundwater via the permeable gravel near the tank and grass areas near the water course. More critically, the spill is also shown in the model to reach the Mere Bank Rhine.

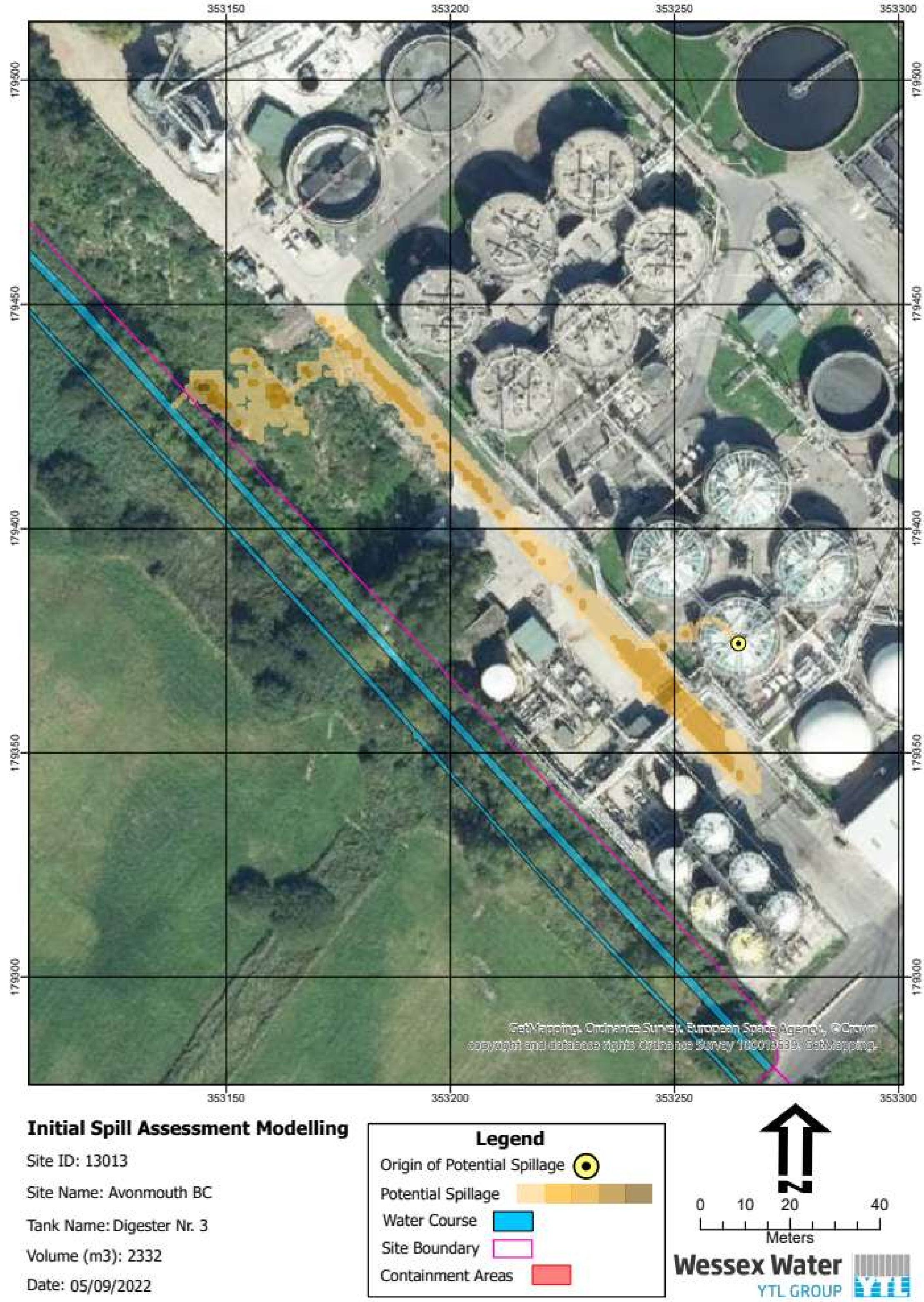


**Figure 8.1.3 Spill assessment model for Digester Nr. 3**

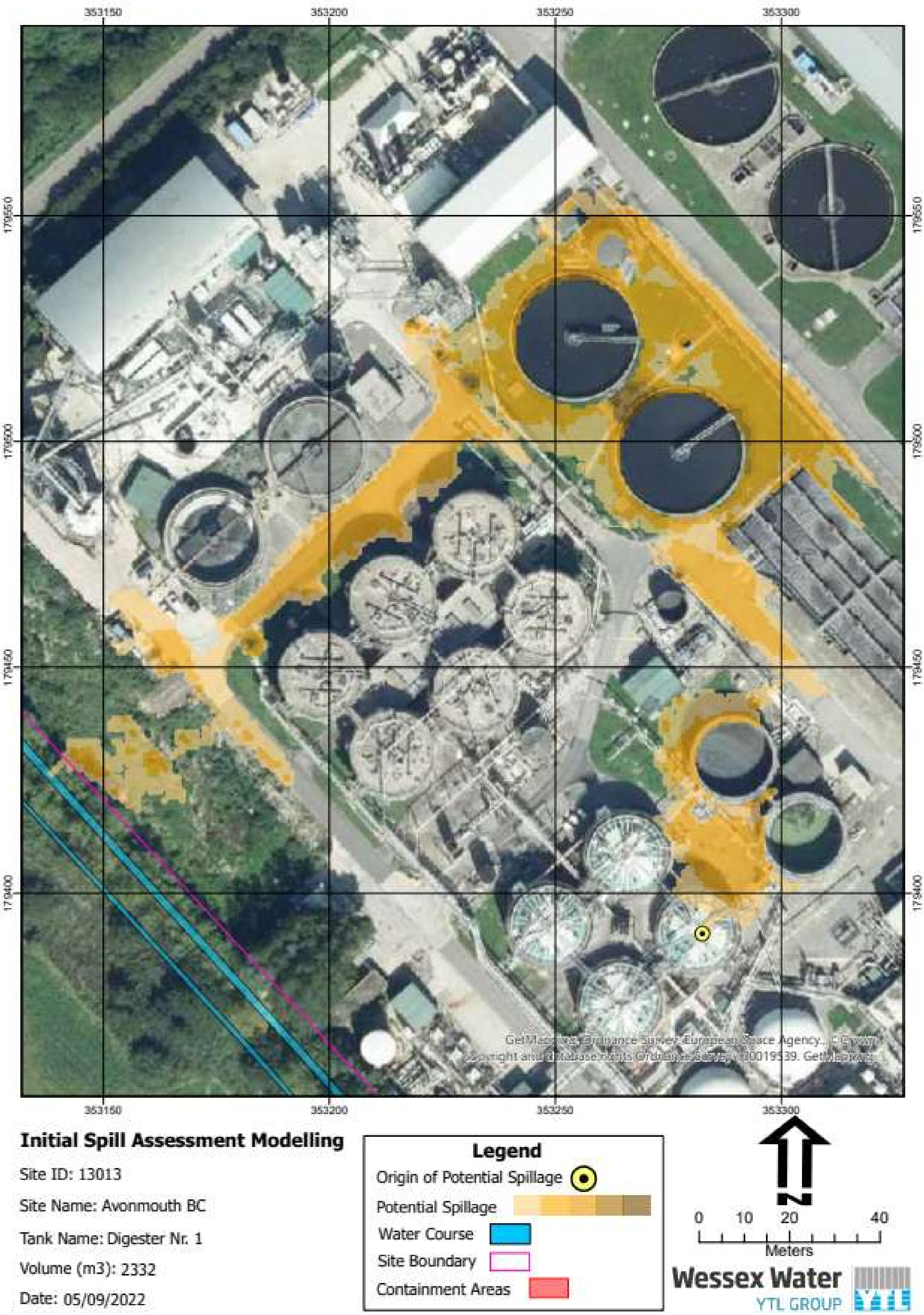


**Figure 8.1.4 Spill assessment model for Digester Nr. 1**

## 8.2 Post Digestion Storage Tank

The Post Digestion Storage Tank is located across from the WRC storm tanks and adjacent to the gas holders and is fed from the food waste digesters.

It is a non-covered, above-ground, epoxy fused steel structure installed in 2010. The tank was previously inspected December 2021, by Hayes, and was found to be structurally sound. Reinspection was recommended before December 2026. The total volume of the tank is 863m$^3$. The height of the walls is approximately 10.5m. Connecting pipework is at both high and low level. The tank features a high-level overflow that discharges into the local drainage system, and level indication via pressure transducers and associated high level alarms. It is subject to daily operator inspections.

**Figure 8.2.1 Post Digestion Tank**

The surrounding ground around the tank consists of a reinforced concrete bund floor and wall to contain moderate and potentially larger spills. The concrete is visually in good condition.

The spill modelling output for the Post Digestion Storage Tank in Figure 8.2.2 demonstrates that a catastrophic failure (total loss of volume) could lead to contamination of groundwater via the permeable grass areas opposite the tank. More critically, the spill is shown to reach the Mere bank Rhine. The spill model also confirms the benefit of the existing immediate containment area.

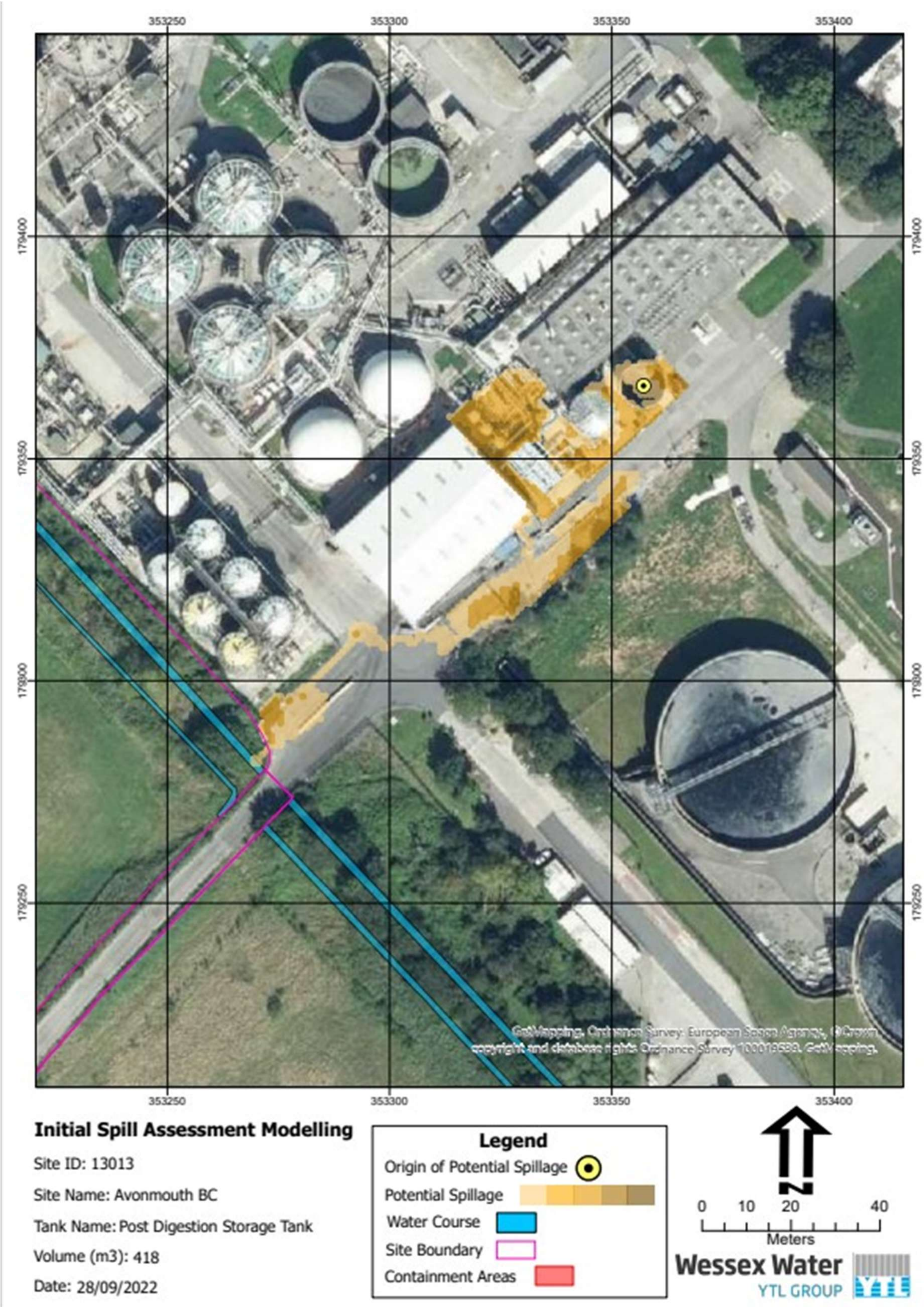


**Figure 8.2.2 Spill Assessment model for Post Digestion Storage Tank**

## 8.3 Hydrolysis Buffer Tank

The Hydrolysis Buffer Tank is located across from the storm tanks and adjacent to the gas holders and the Post Digestion Storage Tank.

Following replacement in summer 2025, the tank is now an above ground stainless steel structure. Prior to this, it was an epoxy fused steel structure. The contained volume is 808m3.

Connecting pipework is at both high and low level. The tank features a high-level overflow that discharges into the local drainage system, level indication via pressure transducers, and associated high level alarms. The tank is subject to daily operator inspections.


**Figure 8.3.1 Hydrolysis Buffer Tank**

The surrounding ground around the tank consists of a reinforced concrete bund floor and wall to contain moderate and potentially larger spills. The concrete is in visually good condition.

No existing site spill model has been carried out for the Hydrolysis Buffer Tank as it is in proximity to the Post Digestion Storage Tank that is modelled in Figure 8.2.2 above. A catastrophic spill event from the Hydrolysis Buffer Tank would follow the same overland route as a spill from the Post Digestion Storage Tank.

### 8.4 Source – Pathway – Receptor ERA Summary

The ERA has been developed considering the REC as whole. The ERA acknowledges specific and higher risk assets where appropriate.

The main sources, credible pathways and the most severe receptors are highlighted to determine the overall and the most severe source-pathway-receptor linkage. This Risk Assessment includes the source (Table 8.2), and Pathway – Receptor linkage including the risk rating of all three linkages (Table 8.3).

**Table 8.2: Source Summary**

| Source | Contents | Flammability | Corrosive | Hazard rating |
|---|---|---|---|---|
| **Hydrolysis Buffer Tank** | Food waste (10 - 12% DS typical) | Not Flammable | Slightly | H |
| **Mesophilic Anaerobic (Food Waste) Digesters** | Partially digested food waste (3 - 4% DS typical) | Not Flammable | Slightly | H |
| **Post Digestion Storage Tank** | Fully digested food waste (3 - 4% DS typical) | Not Flammable | Slightly | M |
| **Rainwater run-off** | Surface water | Not Flammable | No | L |

**Table 8.3: Pathway and Receptor Summary**

| Pathway to receptor | Time of concentration / duration of source outside containment | Transport Potential rating | Receptor | Damage Potential Rating | S-P-R Hazard Combinations Existing | Site Hazard Rating Existing | S-P-R Hazard Combinations with Solutions | Site Hazard Rating with Solutions |
|---|---|---|---|---|---|---|---|---|
| **Infiltration of Inventory into Ground and the Shallow Aquifer in the Made ground / Tidal Flat Deposits**<br><br>The EFS and SS tanks benefit from having a drainage bund around them, which will effectively contain larger spill events associated with most credible modes of failure. The in-situ RC mesophilic anaerobic digesters (MADs) benefit from some secondary containment provided by the central buildings which contains connecting pipework. This building will help to provide containment for moderate scale escapes of inventory from the most vulnerable positions (pipework). There are existing permeable areas of ground around the remaining perimeter of the digesters. In all cases any catastrophic failure and complete loss of containment would lead to a significant volume discharged to permeable ground.<br><br>Volumes lost from primary containment will continue to migrate according to the site topography, which is demonstrated on the existing spill model outputs. However, a proportion will percolate into the ground and quickly into the shallow aquifer typically present 1.5 to 2 metres below ground level. From here there is limited potential for gradual, onward lateral movement towards other pathways and receptors.<br><br>There will be adsorption of contaminants in the ground as the spill migrates and spreads outward, so the magnitude of the hazard will reduce exponentially with distance through the ground.<br><br>**Solution Recommendation:** Replace any permeable areas around the perimeter of the tanks with impermeable surfacing to change the pathway hazard rating to Low. | Minutes | M to L | **Groundwater - Shallow Aquifer - Made ground/Tidal Flat Deposits**<br><br>The superficial deposits present at and within the vicinity of the site are classified as unproductive aquifers. The aquifer may be contaminated by percolation of food waste solids or liquors through the made ground which is typically 1-2m deep.<br><br>The consequence of contamination of aquifer itself is considered to be low given its insignificance for water supply and unproductive designation. | L | HML | L | HLL | L |

| Pathway to receptor | Time of concentration / duration of source outside containment | Transport Potential rating | Receptor | Damage Potential Rating | S-P-R Hazard Combinations Existing | Site Hazard Rating Existing | S-P-R Hazard Combinations with Solutions | Site Hazard Rating with Solutions |
|---|---|---|---|---|---|---|---|---|
| **Vertical Migration into the Mercia Mudstone bedrock group Secondary B Aquifer**<br><br>There is effectively no risk that contaminants within the shallow aquifer could subsequently migrate vertically down to the deep aquifer. Any vertical movement will lead to scribing of any contaminants. The tidal flat deposits above this aquifer range from approximately 15 to 20m deep across the site and predominantly consist of clay and silts with very low permeability. | N/A | (V)L | **Groundwater - Mercia Mudstone bedrock group Secondary B Aquifer**<br><br>The aquifer consists of predominantly lower permeability layers such as fissures, thin permeable horizons and weathering which may store/yield limited amounts of groundwater due to these localised features. There are no localised groundwater abstractions - the nearest is located 1.2km away for dust suppression and there are no source protection zones within 5km of the site.<br><br>The consequence of contamination is considered to be Medium given its WFD designation. However, its storage of limited amounts of groundwater, general low permeability, and distance from abstractions and source protection zones is important to note. | M | H(V)LM | L | H(V)LM | L |
| **Drainage Pathway to the Water Recycling Centre (WRC)**<br><br>An engineered drainage system serves the main REC containment areas and roadways. This drains surface run-off and process washdown to a local REC drainage pump station which in turn pumps into the wider network feeding the internal pumping station (IPS) at a central location within the site. The IPS returns flows upstream of primary treatment. Catastrophic loss of containment would lead to food waste overwhelming this drainage system, which is designed for management of rainfall run-off and some operational and process activities only.<br><br>Following catastrophic failure of the digesters, a proportion of food waste would still rapidly find its way to the local pump station and directly to the wider drainage network. For the EFS and SS tanks, a large proportion of the escaped volume would be contained and conveyed to the local pump station. The pump stations means there are control points that can be managed by operators and would limit flows back to the treatment process in accordance with the maximum pumping rate. This reduces the pathway risk from high to moderate. | Minutes to Hours | M | **Water Recycling Centre (WRC) Upstream of Primary Settlement Treatment and Final Effluent Discharge**<br><br>Avonmouth WRC may be impacted via REC inventory spills through the underground engineered drainage network and internal pumping station, which pumps upstream of the primary settlement tanks. The size of the works (treating up to 3.2 cumecs) is significant in relation to the volume of any spill. This means there will be a high degree of treatment resilience to the spill event.<br><br>The consequence of contamination of the WRC and subsequent pollution event at the final effluent discharge point is therefore low. | L | HML | L | HML | L |

| Pathway to receptor | Time of concentration / duration of source outside containment | Transport Potential rating | Receptor | Damage Potential Rating | S-P-R Hazard Combinations Existing | Site Hazard Rating Existing | S-P-R Hazard Combinations with Solutions | Site Hazard Rating with Solutions |
|---|---|---|---|---|---|---|---|---|
| **Overland and Below Ground Pathways to Local Surface Waters - The Mere Bank Rhine including the Mere Bank Scheduled Monument.**<br><br>The closest surface water body to the REC is the Mere Bank Rhine and the existing catastrophic spill model outputs from the various tanks on site indicates food waste eventually reaching it via overland routes as the immediate local topography tends to from Northeast to Southwest.<br><br>Spills / discharges from the primary containment that have infiltrated into the shallow aquifer have the potential to reach the Mere Bank Rhine, but this pathway is far less significant when considering a catastrophic failure event.<br><br>**Solution Recommendation:** Construct a wall to prevent overland migration to the Mere Bank Rhine. | Minutes to hours | H to L | **Surface Waters - The Mere Bank Rhine including the Mere Bank Scheduled Monument.**<br><br>This surface water body, and connecting surface water ditches, could be contaminated by loss of inventory from the REC. The Mere Bank Monument has a local designation and value from a heritage perspective.<br><br>The Mere Bank Monument structure itself would be resilient to contamination by food waste and given the lack of environmental designation along the immediate network of connecting surface waters, the sensitivity is considered to be low overall. | L | HHL | M | HLL | L |
| **Onward surface water flows via the Rhine network towards the Severn Estuary.**<br><br>Any contaminants that reach the Mere Bank Rhine will continue to flow along a series of drainage networks. A significant proportion of this food waste would settle, or be retarded, diluted and dispersed along the circa 2km route. The pathway hazard is therefore considered to be low.<br><br>**Solution Recommendation:** Construct a wall to prevent overland migration to the Mere Bank Rhine (same solution as previous row). | Hours | L | **Surface Waters - Severn Estuary SSSI, SPA, SAC and Ramsar site.**<br><br>The receptor is situated approximately 1.6km away from the site but there could be a potential for some contamination from a significant spill event at the REC due to hydraulic connectivity with the large network of Rhines draining the area.<br><br>This is a high hazard receptor due to its multiple national designations. However, its sheer scale in relation to relatively negligible volume of contaminants potentially reaching it from a catastrophic spill event is important to note. | H | HLH | M | HLH | L |

| Pathway to receptor | Time of concentration / duration of source outside containment | Transport Potential rating | Receptor | Damage Potential Rating | S-P-R Hazard Combinations Existing | Site Hazard Rating Existing | S-P-R Hazard Combinations with Solutions | Site Hazard Rating with Solutions |
|---|---|---|---|---|---|---|---|---|
| **Overland Pathways to Local Surface Waters - Square Lagoon and then onto the Lagoon Local Nature Reserves.**<br><br>Overland spill modelling indicates there is no risk of direct contamination of this surface water from overland flows from the REC. | N/A | (V)L | **Lagoon Local Nature Reserves**<br><br>Two of the three lagoons to the West of the site are nature reserves and are used for fishing. They are assumed to be hydraulically connected to the lagoon used to serve a local power station.<br><br>Given the local environmental designations of the two lagoons, their sensitivity to contamination is considered to be moderate. | M | H(V)LM | L | H(V)LM | L |
| **Onward surface water flows via the Rhine network towards the Lawrence Weston Moor Nature Reserve.**<br><br>The nature reserve is only 700m away from the REC. However, it is situated in the opposite direction to the prevailing surface water direction of flow adjacent to the REC. Therefore, there is effectively no risk of contaminants reaching the reserve. | N/A | (V)L | **Lawrence Weston Moor Nature Reserve**.<br><br>This is a local designated site approximately 700m away from the REC. It consists of an extensive network of wet meadows and reedbeds. Given its local designation and likely ecological distinctiveness, it's sensitivity is considered to be moderate. | M | H(V)LM | L | H(V)LM | L |

Overall Site Hazard Rating for the site is **MEDIUM.**

## 8.5 Frequency of Loss of Containment

As part of the Environmental Risk Assessment, a frequency of Loss of Containment assessment has been completed for all of the food waste primary containment tanks. This considers likely causes and probability of partial loss of containment and potential causes and probability of catastrophic loss of containment.

The assessment is based on standard failure mode risk assessments developed for the types of tank material – Glass Fused Steel, Stainless Steel, or Reinforced Concrete – combined with the operational purpose of the tank. These risk assessments were referred to alongside the individual asset specific features such as condition of the tank, surroundings, and pipework penetrations.

Risk ratings for potential failure modes are assigned based on CIRIA C736 methodology, where:

- low risk means a probability of less than 1 in 1 million years,
- medium / moderate risk means a probability between 1 in 100 and 1 in 1million years,
- high risk means a probability greater than 1 in 100 years.

The output is summarised in Table 8.4 and broadly indicates that the frequency of loss of containment is likely to fall within the medium / moderate frequency category, with marginal or partial loss of scenarios having a probability of occurrence closer to 1 in 100. Catastrophic scenarios identified have significantly lower probabilities of occurrence.

The Overall Site Risk Rating for the site based on the assessment is considered to be **MEDIUM**.

**Table 8.4: Frequency of Loss of Containment Summary**

| Asset Name | Material | Condition | Catastrophic Loss of Containment Frequency Risk | Probability | Comments |
|---|---|---|---|---|---|
| Hydrolysis Buffer Tank | SS | Good | M | Between 1% (1 in 100) and 0.001% (1 in 1 million) | The epoxy fused steel superstructure has recently (2025) been replaced in stainless steel. The tank is regularly inspected and maintained as required.<br>High level overflow physical safeguards are in place. Control inhibits, pressure and level indication in place.<br>Tank is offset from main vehicle routes.<br>Existing containment bund able to contain relatively large spills. |
| Post Digestion Storage Tank | EFS | Average | M | | The tank was constructed in 2012 and is regularly inspected and maintained as required.<br>High level overflow physical safeguards are in place. Control inhibits, pressure and level indication in place.<br>Tank is offset from main vehicle routes.<br>Existing containment bund able to contain relatively large spills. |
| Mesophilic Anaerobic (Food Waste) Digesters | Reinforced concrete | Average | M | | These tanks are of RC construction and were built circa 60 years ago.<br>Relatively complex operation to digest food waste so operational failure modes such as foaming and subsequent overtopping, become credible scenarios if operating parameters are not maintained, and other protection safeguards fail.<br>Presence of biogas means explosion and short-lived flame in the tank headspace, could occur in extreme instances when multiple safeguards fail.<br>Anti-foaming dosing in place and radar instrumentation in place to inhibit feed on detection of high-high level cause by foam.<br>Material very resilient to corrosion.<br>High level overflow physical safeguards are in place. Control inhibits, pressure and level indication in place.<br>Tanks are offset from vehicle routes and construction and would be more resilient to vehicle impact than metal tanks.<br>Low level pipework is contained within the buildings between these tanks, which provides partial secondary containment.<br>Partial loss of containment possible due to operator error with low level pipework, which would be quickly rectified.<br>Partial loss of containment by overtopping possible if site is not operated within defined parameters and other controls fail.<br>Catastrophic failure of the tanks is extremely unlikely due to the robust construction. |

**Overall Loss of Containment Risk Rating for the Site is MEDIUM**

**Table 8.5: Overall Rating and Containment Class**

| Description | Hazard Rating Before Recommendations | Comments | Rating After Recommendations |
|---|---|---|---|
| Worst Case REC site wide Source-Pathway-Receptor hazard rating | HHL = M<br>&<br>HLH = M | Source hazard is **H** due to large inventory volumes, and high COD content.<br>Worst case pathway potential is overland sludge flows into the Mere Bank Rhine from local food waste tanks. However, the Rhine has no environmental designation, so the receptor damage potential is Low.<br>The worst-case receptor is the Severn Estuary<br>Receptor hazard is **H**, principally due to the environmental designations. | H(V)LH= L |
| Catastrophic loss of containment risk rating | M | Based on Table 2.3 in CIRIA C736, M risk equates to: 1 in 100 years < significant spill event probability < 1 in 1 million years. | M |
| Overall Site Rating | M | Based on Box 2.2 in CIRIA C736. This demonstrates that action is required, and this will consist of new secondary containment equivalent to a Class 2 standard. | M |

# 9. Solutions

The solution approach for the REC area is presented in this section. This includes a plan of the scope of works needed to achieve a secondary containment solution equivalent to BAT, and spill modelling outputs to demonstrate the effectiveness of the proposed solution following any failure of the primary containment assets. For each area, the preferred option is presented first. Options that have been considered, but are not preferred, are also discussed.

As explained within Section 2.4, a chartered structural engineer will be consulted throughout the detailed design of the selected solution and will complete a full review of the proposals. Inspection and maintenance plans, as specified by a structural engineer will be developed in addition and will be incorporated into Wessex Water's asset management systems. It is anticipated that monthly checks by trained operators will be routinely carried out and any signs of deterioration will be flagged to a chartered structural engineer for review. A chartered structural engineer will also be requested to carry out an independent review on a suggested two-yearly basis to verify the integrity of the containment assets.

The solutions being proposed can adopt any of the following two principal approaches as outlined within Section 2.4. These being:

1) Fully compliant Secondary Containment solution in accordance with CIRIA C736.
2) A solution that prevents food waste from leaving the site following a Catastrophic Failure.

## 9.1 Preferred solution Adopting Approach 2

This solution utilises a wide area of the site and consists of constructing a relatively shallow containment perimeter walls and replacing large areas of permeable ground with impermeable surfaces. It exploits the favourable topography around the south border of the REC to contain any spilled food waste from a catastrophic failure of any of the RC Digesters and other EFS / SS food waste assets.

The bund is designed to maintain access from all existing roads. It also minimises the impact to day-to-day inspection, operation, and maintenance of the site personnel by maintaining the existing vehicle and personnel access routes. This is particularly important as the whole Renewable Energy Centre will be located within the bund.

The solution is presented in Figure 9.1.1.

### Volume of containment

Spill modelling outputs for individual REC primary containment assets are presented in figures 9.1.2 to 9.1.5 and allow for 110% of the contained volume above ground level.

In accordance with the requirements of CIRIA C736, Figure 9.1.6 presents the spill modelling output allowing for 25% of the total above ground volume of both REC and bioresources centre (BC) assets. This is the worst case scenario and is required because of the close proximity of all of these assets.

### Perimeter Walls

Perimeter walls will be constructed from reinforced concrete and will meet a minimum requirement of tightness class 1 to BS EN 1992-3:2006. The strip footing will be integrally tied to the wall and a water stop shall be installed at any required cold joints. The foundation and structural design will consider local ground conditions to manage differential settlement risks along the wall's alignment.

Wall heights vary depending upon ground topography and are expected to be broadly as shown by Figure 9.1.1.

At certain points, vehicles will need to enter the bunded area from road access points, shown by the green shaded areas in Figure 9.1.1. The roads will be graded up to achieve the required containment heights at the access points. From here they will grade back down to the existing road level within the bunded area. Gradients will be designed to ensure that vehicles can safely negotiate the ramps.

### New Impermeable Surfaces

The proposal is to replace permeable surfaces with tarmac in lightly trafficked areas. Tarmac is recognised as an appropriate technology for chemical containment and has the following advantages over reinforced concrete:

- Relative ease of construction in impermeable areas around existing assets.
- Lower cost and embodied carbon.
- Simpler to inspect and maintain.
- No joint details.

Where new reinforced concrete is required, it will meet a minimum requirement of tightness class 1 to BS EN 1992-3:2006. Joint detailing shall comply with Section 7.2.4 in CIRIA C736.

Figure 9.1.7 shows the existing and proposed impermeable areas within the proposed containment bund.

### Existing Impermeable Surfaces

Existing impermeable surfaces will be retained where possible unless the condition is so poor that it becomes simpler to demolish and replace them. Retained concrete may not comply with the requirements set out in CIRIA C736 as Wessex Water design standards do not specify the requirement for water stops at construction joints in reinforced concrete roads or footpaths. Existing joints will therefore be inspected and reinstated with an appropriate surface poly-urethane sealant. These joints will be inspected regularly and proactively repaired to ensure they remain in good condition.

Additional proprietary waterproofing epoxy products from specialists will also be considered at detailed design to improve the robustness at concrete joints and joints across existing kerb alignments transitioning between concrete and other surfaces. Detailed design material specifications will be developed in close consultation with suppliers offering these types of products.

### Vehicle Impact Protection

This shall be provided where there is a credible risk of vehicles damaging existing tanks and will normally consist of bollards or Armco barriers.

## Drainage

Existing below ground drainage conveying surface run-off will be utilised as part of the containment solution. An area outside the bund may be utilised for an attenuation tank to store rainfall run-off water from the containment bund impermeable surfaces. Flows from the attenuation tank will discharge to the Internal PS.

In the event of the catastrophic failure of an asset, the contents along with the run-off surface water will be transferred to these attenuation tanks. Depending on the volume and origin of the escaped food waste, lost inventory will either be tankered away or returned to the Internal PS at a controlled rate ensuring that the WRC is not overwhelmed by the returns.

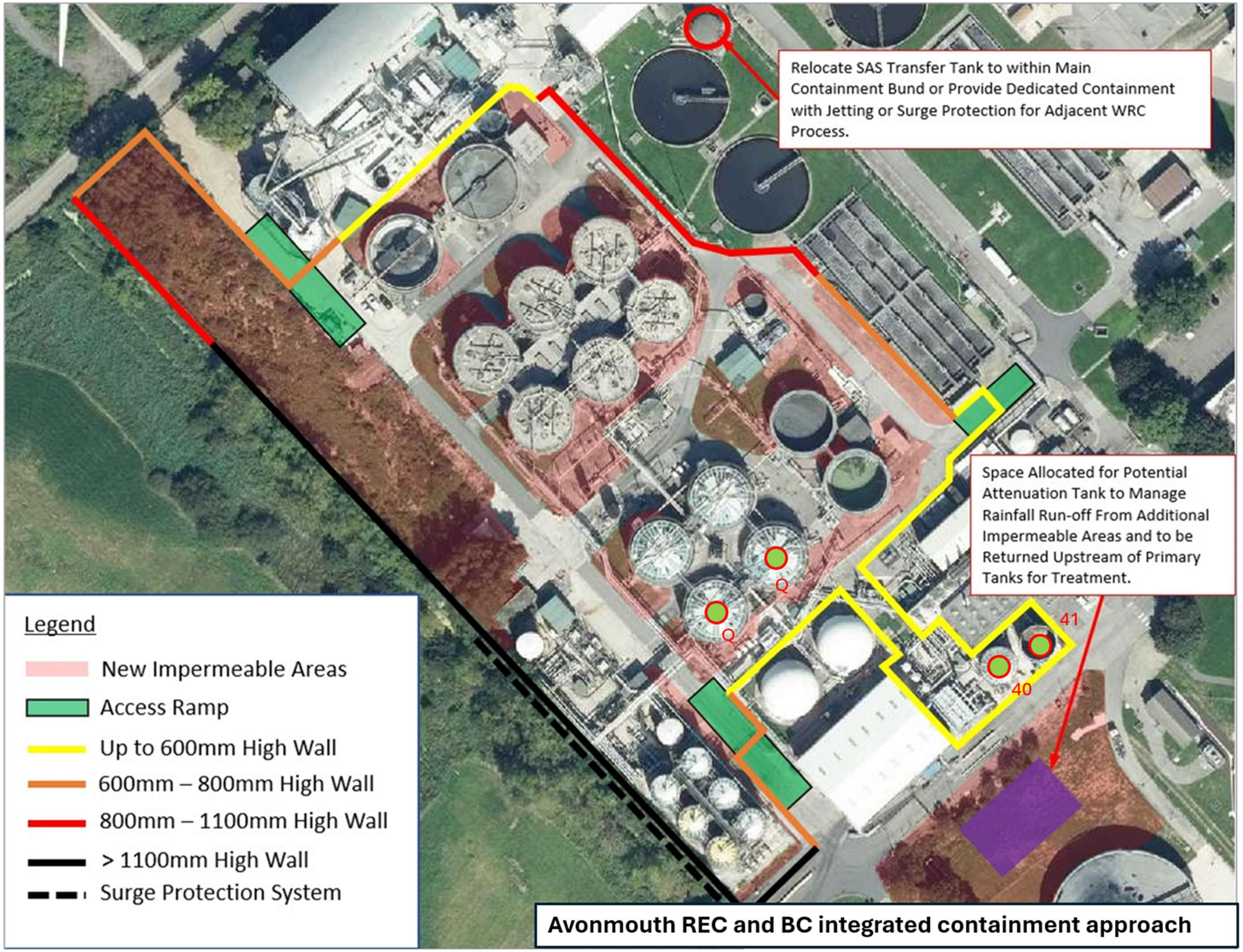


**Figure 9.1.1 REC (and BC) Proposed Secondary Containment Solution**

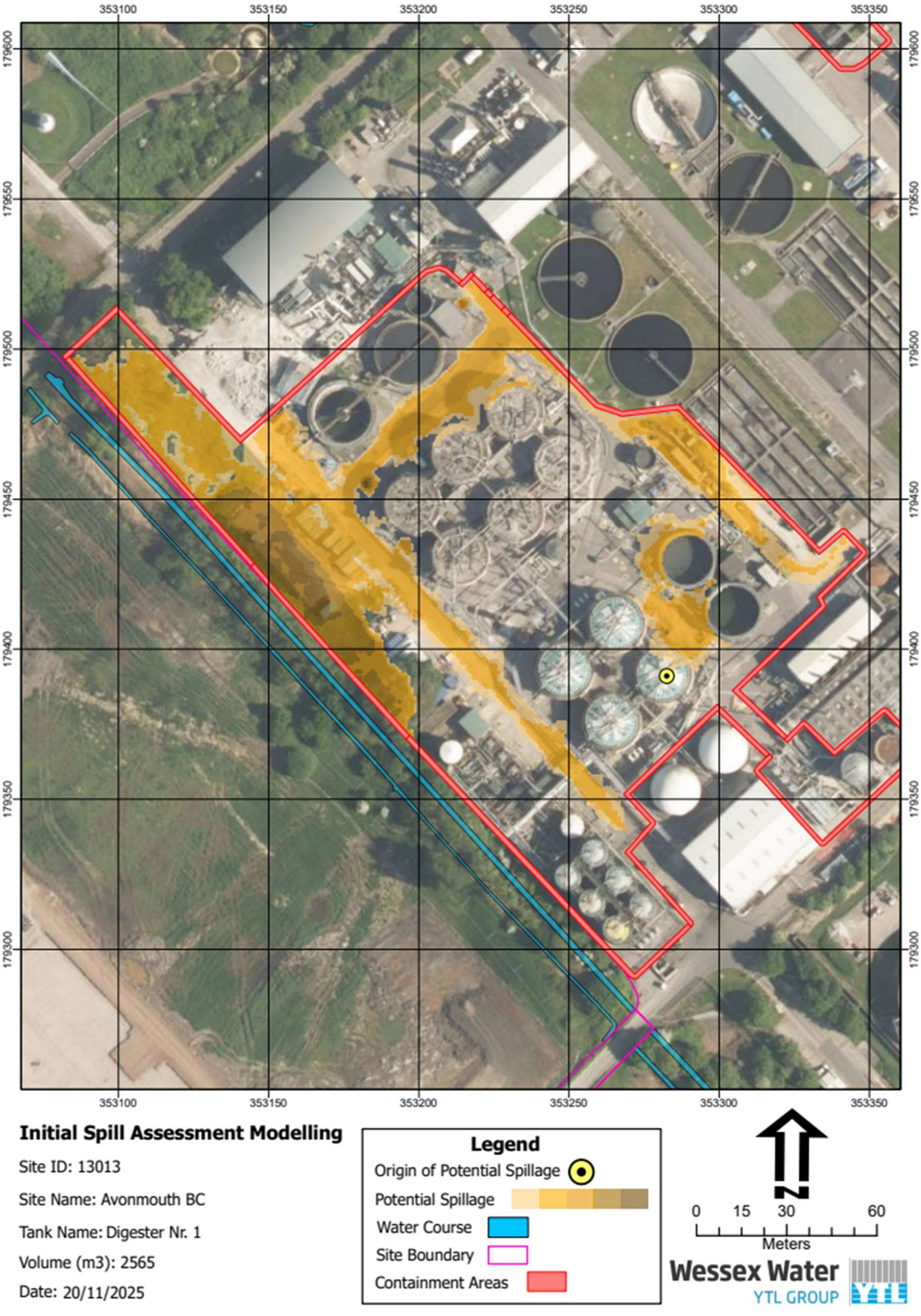


**Figure 9.1.2 Digester Nr.1 Spill model with proposed Secondary Containment solution**

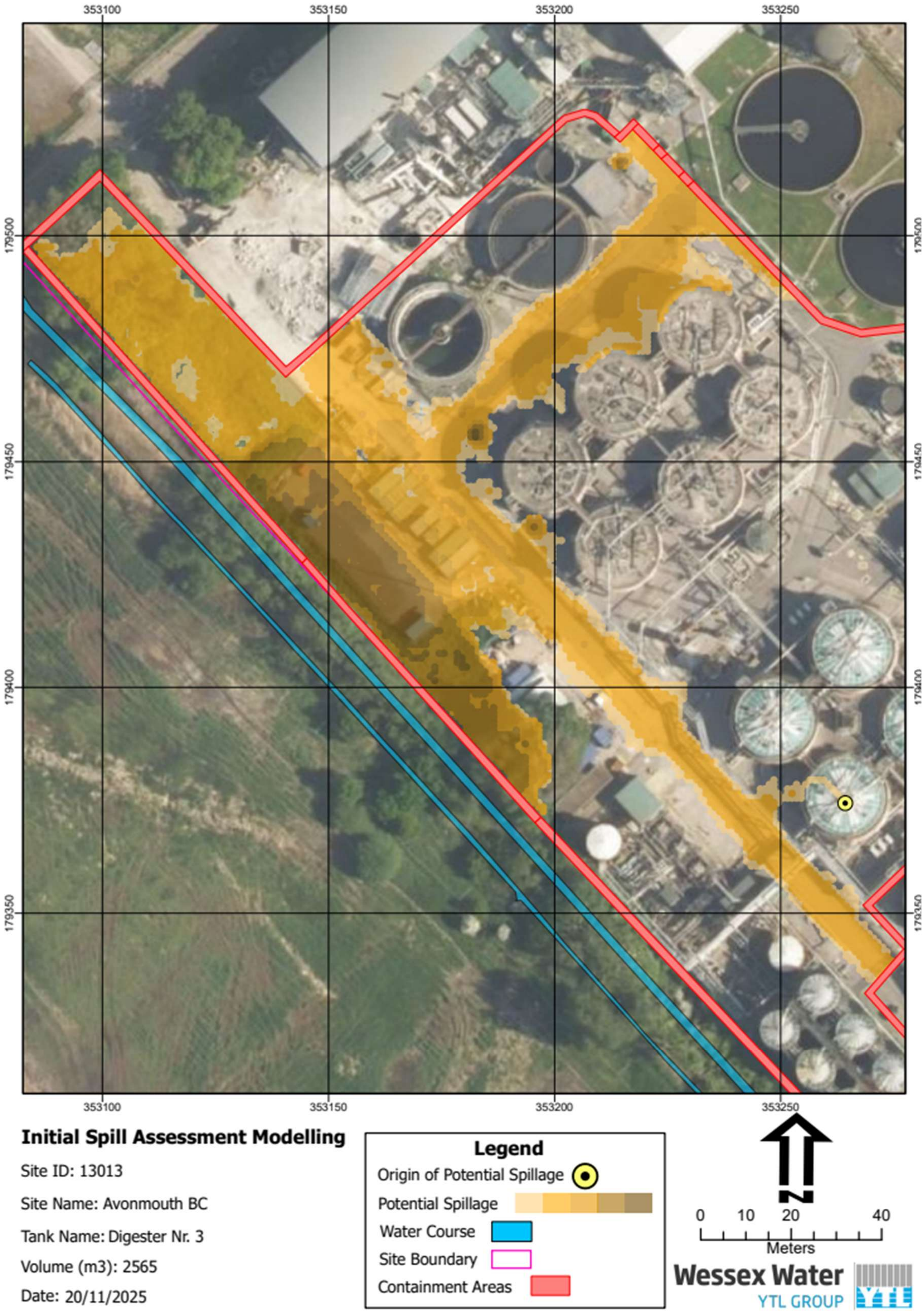


**Figure 9.1.3 Digester Nr.3 Spill model with proposed Secondary Containment solution**

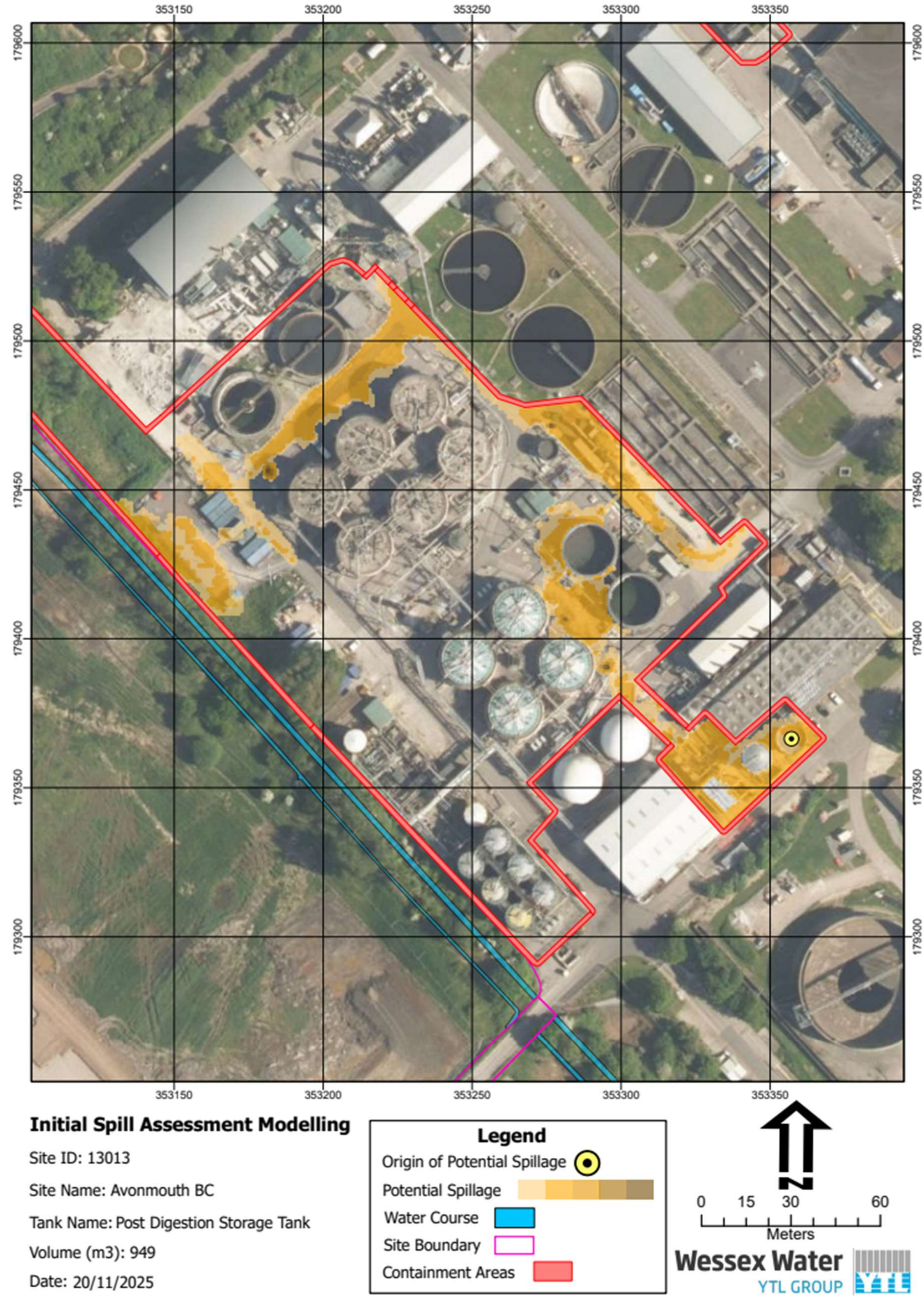


**Figure 9.1.4 Post Digestion Storage Tank Spill model with proposed Secondary containment Solution**

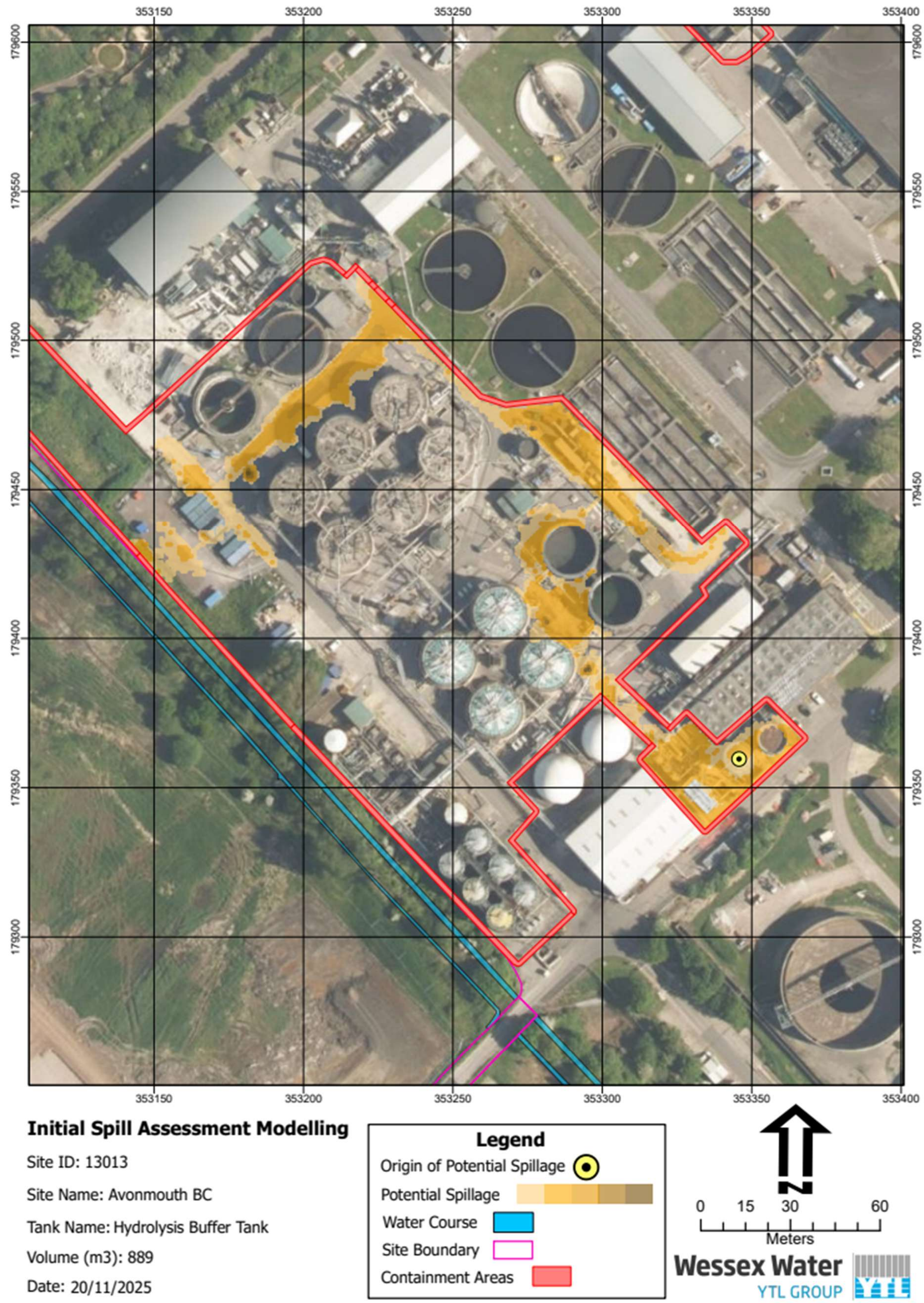


**Figure 9.1.5 Hydrolysis Buffer Tank Spill model with proposed Secondary containment Solution**

Figure 9.1.6 illustrates the proposed containment solution with a spill volume equivalent to 25% of the above ground storage volume of all assets – both associated with the REC and the Avonmouth Bioresources Centre BC as set out in the table below. As noted in section 2.4, the proposed containment solution will be common to both installations.

**Table 9.1: Assets in Main BC Containment Area and Volume to be Contained Summary**

| Asset name | Ref | Above Ground Volume Per Tank (m3) | Number Of Tanks | Above Ground Vol Per Asset Type (m3) |
|---|---|---|---|---|
| SAS Transfer Tank* and ** | **BC** | 719 | 1 | 719 |
| Avonmouth Consolidation Tanks** | **BC** | 1227 | 2 | 2454 |
| Bellmer Feed Tank** | **BC** | 341 | 1 | 341 |
| Thickened Sludge Bellmer tank** | **BC** | 313 | 1 | 313 |
| APD GBTs 1, 2 and 3 Feed Tank** | **BC** | 483 | 1 | 483 |
| APD Feed Tank** | **BC** | 434 | 1 | 434 |
| Acid Phase Digestion (APD)** | **BC** | 813 | 6 | 4,878 |
| Mesophilic Anaerobic Digesters (MAD)** | **BC** | 2728 | 6 | 16,368 |
| Mesophilic Anaerobic Digesters (MAD)** | **BC, Q and Q** | 2332 | 4 | 9,328 |
| Secondary Sludge Storage Tanks (SSST)** | **BC** | 1840 | 2 | 3,680 |
| Centrifuge Feed Sludge Tank** | **BC** | 552 | 1 | 552 |
| Raw Break Tank** | **BC** | 61 | 1 | 61 |
| Hydrolysis Buffer Tank | **40** | 808 | 1 | 808 |
| Post Digestion Storage Tank | **41** | 863 | 1 | 863 |

| | |
|---|---|
| **Sum of Above Ground Asset Volumes** | 41,282m$^3$ |
| **x0.25** | **10,321m$^3$** |

**Assuming the BC SAS Transfer Tank is relocated inside the proposed containment area*

*** Bioresources Centre (BC) tanks which are also situated within the proposed containment area*

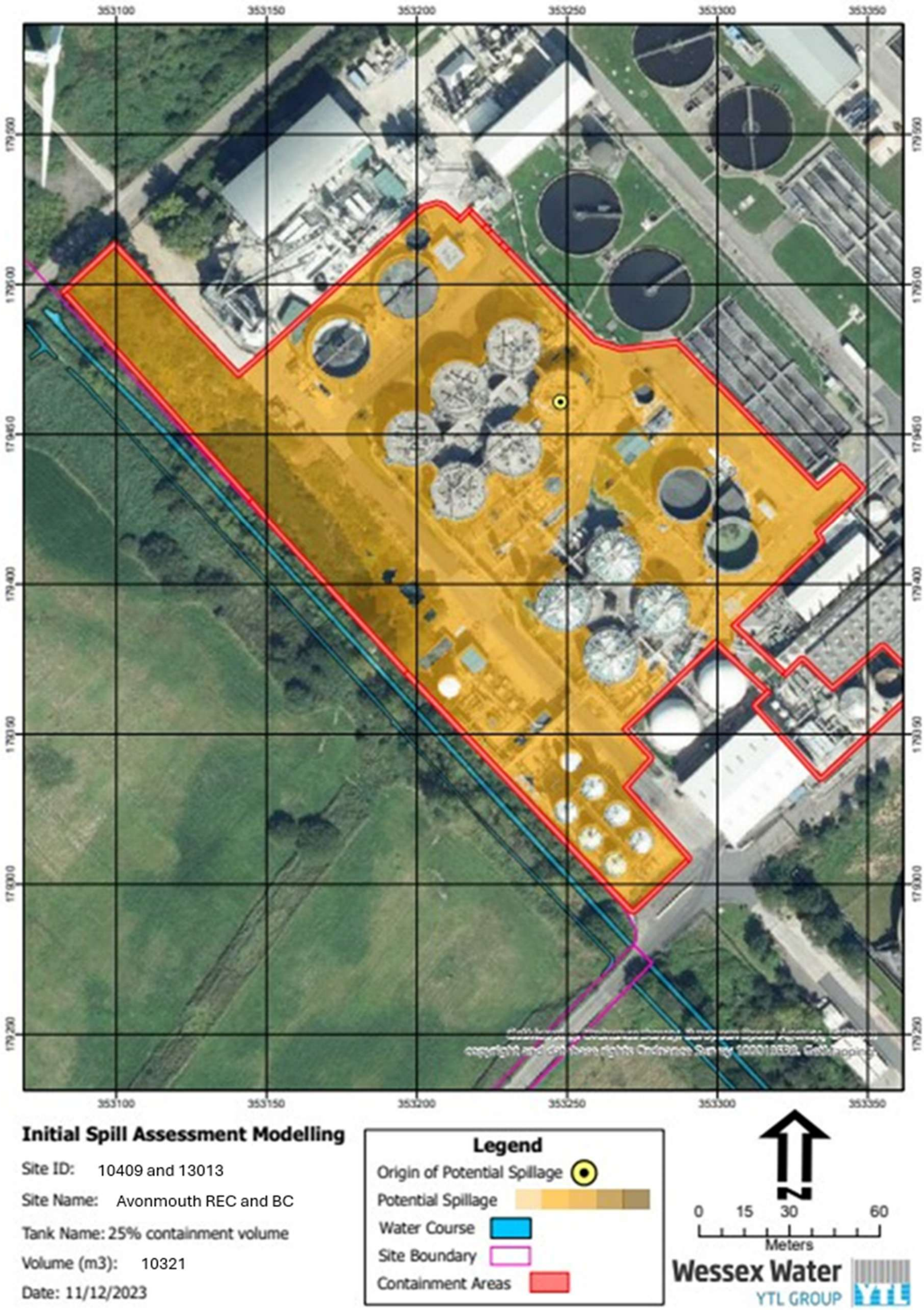


**Figure 9.1.6 Secondary containment proposal for both REC and BC assets**

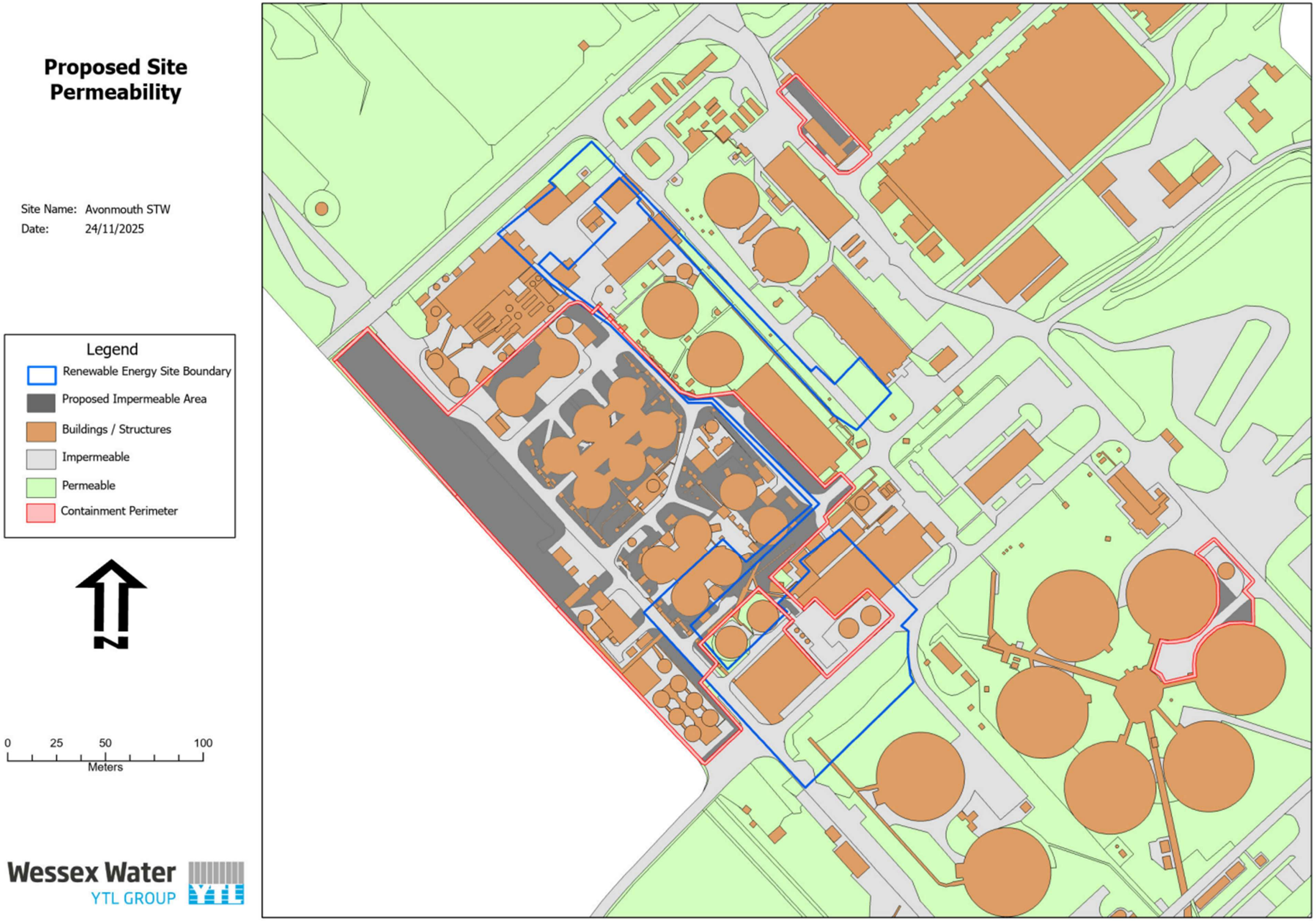


**Figure 9.1.7 Proposed Avonmouth REC Permeability Plan**

## 9.2 CIRIA C736 compliant Secondary Containment solutions Considered (Adopting Approach 1)

CIRIA C736 compliant secondary containment solutions were considered for all areas. This would be achieved by constructing new purpose-built water retaining, reinforced concrete structures locally around individual tanks or one purpose tanks (e.g. Digesters Nr.1 and Nr.3). The containment structure would be detailed to meet the minimum expectations outlined in Chapter 7 of CIRIA C736. For example, the specification of water bars where construction joints cannot be avoided. The approach would retain the spill local to the tank, to minimise impact on adjacent processes outside of the bund and to simplify the emergency response.

The following wall heights were calculated to allow the bund to contain either 110% of the maximum volume of primary inventory from a single tank, or 25% of combined primary inventory volume within the bund. The higher value of the loss of containment volume was used to determine the height of the bund.

- Digester Nr. 1 and Nr. 3 – 1.55m
- Hydrolysis Buffer Tank and Post Digestion Storage Tank – 2m.

Heights include an allowance to manage potential rainwater volumes before, during, and after the catastrophic failure of one of the tanks, equivalent to expected rainfall during 1 in 10-year probability storm event. It also includes a 250mm allowance to account for surge transients.

**Solution Challenges**

The challenge with this approach is linked the height of the bund walls required. Section 6.3.1 in CIRIA C736 acknowledges the challenges that are introduced when walls exceed 1.5m in height. The reality is that the volumes to be contained, coupled with the existing operational and physical constraints around the assets, makes it impracticable to implement these types of solutions in most cases. The containment structures themselves will be detrimental to the operation, inspection, and maintenance requirements in these areas.

Taking the Hydrolysis Buffer and Post Digestion Storage tanks as an example, installation of a 2m high bund wall would result in:

- Creation of a restricted access area making it harder for someone to be safely removed from the area following incapacitation.
- Compromised access to the digester feed pumps, gas lift compressors.
- Severely compromised access to the tanks including tank cleans, pro-active repairs, tank replacement.
- Damage of existing assets within the bund following catastrophic failure or an substantial credible failure of one of the assets.
- Increased health and safety risks in carrying out day to day activities.

Adopting this type of approach for these tanks is not appropriate given the scope of existing operational and maintenance activities in this part of the REC. Operator preference is for a wider containment solution that prevents food waste from leaving site following catastrophic failure while minimising detriment to the day-to-day operation of the REC.

## 9.3 Standard Precautionary and "Soft" Solutions

The following measures will be implemented as part of a detailed design solution.

### Drainage and Services

- Impermeable surfacing and drainage to be provided beneath pipework that falls outside of the specified bund perimeters. Jetting effects to be considered for each pipe run.
- All existing site surface water drainage and newly installed surface drainage is reviewed to demonstrate adequate capacity for rainfall and spill events.
- Surface water drainage systems capacity to be established to demonstrate that lost inventory is not surcharging manholes or gullies outside of the bund perimeter.

### REC Control and Telemetry Systems

- Process scientist to HAZOP the existing site processes and operation against current industry best safeguarding practices and propose proportionate improvement recommendations where required.
- Security expert to review current unauthorised access deterrence provisions against current industry best practice and propose proportionate improvement recommendations.
- Ultrasonic level sensors in tanks to be alarmed and to be visible remotely in the event of a rapid and unanticipated drop in level within a given tank e.g. tank level dropping, feed pump and draw off pump not running.
- Rising mains to be installed with pressure indication and inhibits if they do not already have them.

### Structural Performance

- Consider early warning tank shell or reinforcement corrosion systems for tanks where this may not be obvious during an external physical inspection.
- Carry out condition assessment of existing hardstanding areas and, where required, propose remedial work to ensure an appropriate containment for the short period of time associated with an improbable spill event – Refer to Table 9.4.1 below.
- Propose locations for vehicle impact protection to avoid any risk of collision with primary containment assets.
- Commit to minimum 2 yearly external structural inspections of concrete, steel assets and pipework and an appropriate frequency of yearly internal inspections by a chartered structural engineer or competent independent consultant for steel tanks.
- Secondary containment structures to be identified as assets on Wessex Water's asset register.
- Development of an operation and maintenance manual for the secondary containment structure by a chartered structural engineer.

**Table 9.3.1 Example Inspection Plan for Existing Concrete Paving**

| Asset | Sub Asset | Theoretical Design Life | Inspection and Report By | Documentation | Typical Visual Observation & In Situ Testing | Method | Inspection Frequency (TBA) |
|---|---|---|---|---|---|---|---|
| Existing concrete pavement including Access Roads, and Footpaths and operational working areas. | Concrete Segments | 40 years | **Originator**: Structural Engineer +2 years' experience. **Checker:** Chartered Civil or Structural Engineer. **Approver:** TBA | Inspection Report to Include: As Built Drawing or Standard Detail. Estimated Construction Date. Applicable Design Code. Observation Condition Assessments. Testing Condition Assessments. | Cracks > 0.3mm | Observation Crack Width Gauge | 2 Yearly |
| | | | | | Cracks < 0.3mm | Observation Crack Width Gauge | 2 Yearly |
| | | | | | Differential Settlement / Subsidence across segment or between Adjacent Segments | Observation Dumpy Level | 2 Yearly |
| | | | | | Surface condition - Damp patches, Spalling, Biodegradation. | Observation Dumpy Level | 2 Yearly |
| | | | | | Reinforcement | Ferroscan | First Inspection |

## 9.4 Groundwater Monitoring

The following monitoring well requirements are proposed to help pro-actively identify below ground leaks originating from partially buried assets – Digesters Nr.1 & Nr.3:

- 24 x 6m deep dynamic window sampler boreholes. Installed with 50mm screened standpipes to the base, typical response zone from 1 – 6m deep with gravel (non-calcareous) surround.
- Samples would be taken from soil (72 No.) and groundwater (24 No.) contamination during the investigation to provide a baseline. During the sample collection PID meters testing would be completed along with headspace analysis.
- Following the borehole completion a competent engineer would return to all boreholes, micro-purge and take samples (within 24hours to lab) and testing would include groundwater suite F x 24 samples - ICE Specification for Ground investigation testing suite – With addition of E.coli and Faecal Coliforms
- Monitoring / Sampling Frequency would be monthly for year 1. Twice a year from then on

Preliminary monitoring borehole locations are indicated in Figure 9.5.1, but exact details are to be assessed and confirmed following further investigation.


**Figure 9.4.1 Preliminary Monitoring Borehole Location Plan**