Hayden STW Digesters and Sludge Tanks

IED Containment Assessment – Risk Identification Report

July 2023

Severn Trent Water Limited

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Contents

i. Background

Following initial audits by the Environment Agency (EA) in 2019 that examined the primary, secondary, and tertiary containment provisions for Severn Trent'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 Severn Trent's sites. Catastrophic tank failure may impact nearby receptors and the operation of adjacent sewage treatment activities"*. Jacobs was appointed to assess site risks and outline the options available for providing remote secondary containment of a catastrophic tank or digester failure across multiple Severn Trent sites. This report details the site-specific risks at Hayden Sewage Treatment Works (STW), the illustration of the uncontained spill event and the containment classification.

Hayden STW is located 2.5 miles west of the centre of Cheltenham, the Hatherley Brook watercourse lies to the south and M5 lies to the west of the site. The boundary of the site has fields on the north and east sides and housing on the east side. Figure i i shows an aerial view of the site in the context of its nearby surroundings. Figure ¡ shows an aerial view of the site in the context of its nearby surroundings. An initial visit to Hayden Sewage Treatment Works occurred for the purpose of site assessment and data collection.

Figure i i Satellite view of Hayden Sewage Treatment Works

This document precedes 'Hayden STW Digesters and Sludge Tanks, IED Containment Assessment- Option and Recommendations Report, revision 1.1' and informs the containment classification required. This report outlines the options to contain a spill from the tanks within the IED permit boundary.

Chapter 1 outlines the site-specific risks at Hayden STW for sludge holding and digestion assets and discusses the CIRIA/ ADBA containment classification assessment.

Chapter 2 describes the site contouring, derivation of overland flow paths and any significant sludge holding tanks.

Chapter 3 analyses the spill mapping for the Digester Area that was achieved using ArcGIS and ArcPy coding of LiDAR data and digital topographic imagery.

Chapter 4 discusses the risks to the site from external flooding.

Chapter 5 discusses the potential options for sludge containment.

Chapter 6 presents the main conclusions of this assessment.

Appendix A presents the ADBA site hazard risk assessment completed for this site.

1. Site specific risks at Hayden STW

To model the event of a credible and catastrophic tank failure resulting in loss of containment of sludge at Hayden STW, the assets on site must be evaluated to identify the most hazardous failure events.

The principal sludge holding and digestion tanks at Hayden STW is as detailed below:

- 2 digesters of concrete with a capacity of 2,989m^3 and 3,040m^3;
- 5 Pathogen Kill Tanks (PKTs) in steel construction each with 860m^3 capacity;
- 1 Imported sludge tank in steel construction with 51m^3 capacity;
- 2 sludge storage tanks in concrete construction of 2,500m^3 and 2,800m^3 capacity;
- 2 Centrate balancing tanks in steel construction with 500m^3 capacity;
- 1 Primary Continuous Thickener Tank and 2 Digester Feed Tanks of concrete construction with 2,071m^3 capacity; (labelled as Primary Sludge Thickening Tanks on the site photo);
- Centrifuge Buffer Tank in steel construction with 72m^3 capacity.

Site tank inventory

Tank Purpose	Number	Operational Volume (each) (m^3)	Construction	Tank Covering
Primary Continuous Thickener Tank	1	2,071m^3	Concrete	Open
Digester Feed Tanks	2	2,071m^3	Concrete	Open
Imported Sludge Tank	1	51m^3	Concrete	Open
Centrifuge Buffer Tank	1	72m^3	Steel	Open
Sludge Import Tanks	2	2,500m^3 2,800m^3	Concrete	Open
Primary Digester Tanks	2	2,989m^3 3,040m^3	Concrete	Enclosed
Pathogen Kill Tanks (PKTs)	5	860m^3	Steel	Open
Centrate Balancing Tanks	2	500m^3	Steel	Open

For clarity, in each case the capacities given above are the total tank capacity, i.e., the maximum volume that a particular tank could hold. In practice the operational volumes are less due to freeboard and headspace, but the maximum volume is used to represent worst case scenario.

The plan in
Figure **1.1** below indicates the boundary of the permitted IED area and the assets contained within.

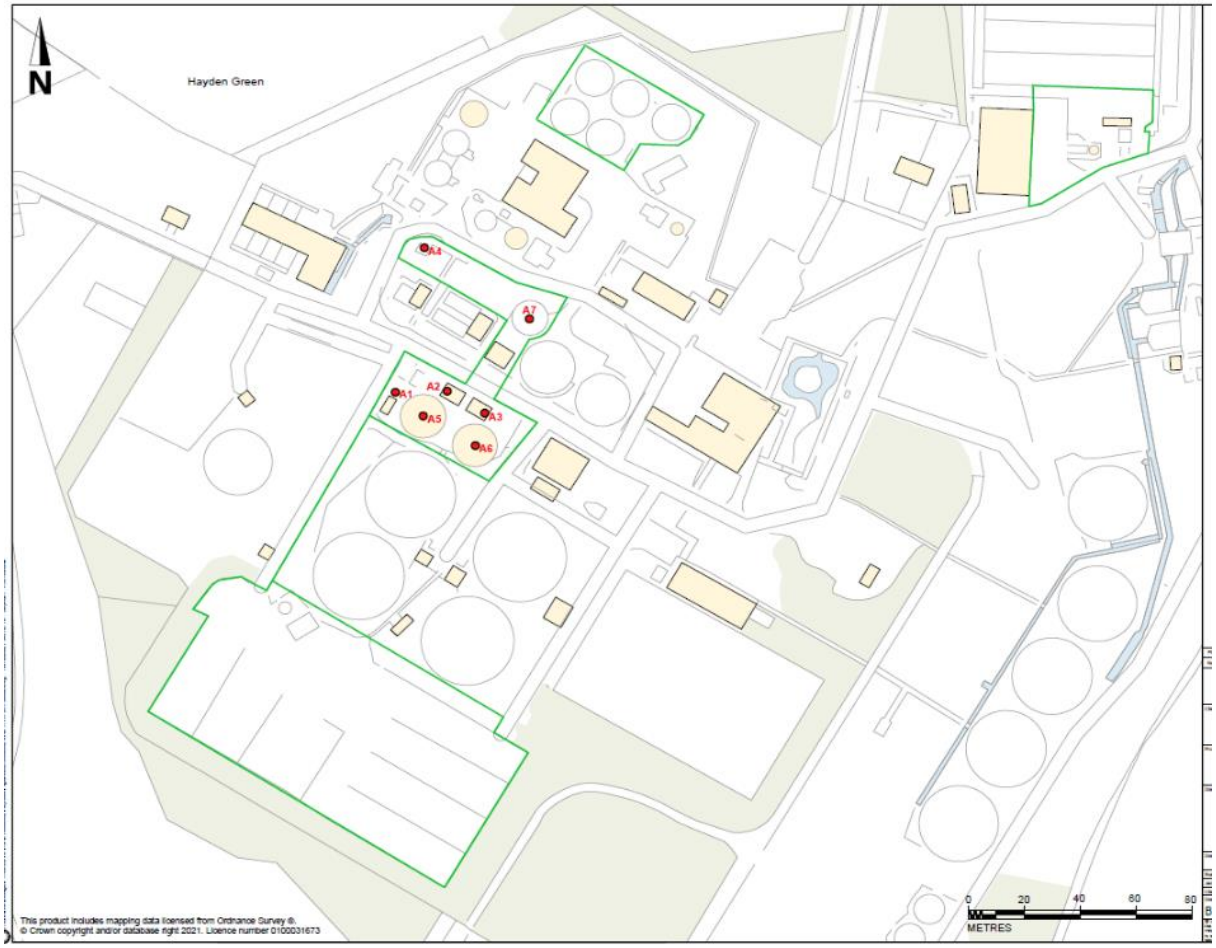

Figure 1.1 Boundary of the permitted IED area and the assets contained in Hayden STW

The site-specific risk factors that were identified at Hayden STW are as follows:

- The total digester volume onsite and the number of large tanks and their individual tank capacities.
- Groundwater vulnerability is ranked as "High", information retrieved from Ground Water Vulnerability Map.
- The Hatherley Brook is situated to the south boundary of the site which then later discharges to the Broadboard Brook which then discharges into River Severn. The distance between the IED permitted area and Hatherley Brook is within 500m in the south direction of the site.
- Proximity to M5– the site is within 970m of this road.
- There are residentials dwellings within 150m of the site to the west, a hotel The Firs, Cheltenham Spa is located 265m to the west side of the site and the rest are fields around the site.

- Griffiths Avenue is a Local Nature Reserve area which is located 2250m to the east of the site.

1.1. Containment Classification Assessment

CIRIA C736 states how the site hazard rating and, the site risk and classification are to be calculated. The ADBA risk assessment tool was used and is attached in Appendix 1. A summary of the hazard risks for Hayden STW are as follows:

Source – There is a source that has been identified:

1. Domestic and trade effluent Wastewater sludges, both in a raw, semi treated and treated state.

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

Pathway – There are four 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 cross the site boundary within 4 minutes of a spill.
2. The Groundwater Vulnerability is classified as High with soluble rock risk according to Ground Water Vulnerability Map.
3. There are a number of areas where a sludge spill could pass over permeable ground.
4. The site inclines from East to West, towards residential area.

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

Receptor – There are two receptors that have been identified:

1. Residential area is within 150m of the site.
2. There is The Firs, Cheltenham Spa to the west of the STW on Hayden Lane.

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

Likelihood

A review was completed with Severn Trent Bioresources staff and the likelihood for mitigated and unmitigated risks were calculated. The probabilities outlined in CIRIA C736 section 2.5, table 2.3 were used. Scoring was completed on the basis of a loss of containment which was not necessarily a total loss through a catastrophic failure but could in fact be a partial loss through a leak of minor spillage.

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 also.

Following the implementation of post-mitigation measures the risk was scored as **Low.**

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

Based on the information above the overall site risk rating was calculated to be high which means that 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)

2. Flow Paths

2.1. Site Characterisation

To understand the topography of the site, open-source LiDAR (Light detection and ranging) imaging data from the Environment Agency (EA) National LiDAR Programme, was utilised. This dataset was captured aerially and used to accurately measure the terrain or objects on the surface using a series of laser pulses on 1m pulse laser beam intervals and 1km grid tiles across the whole site. ArcGIS 10.8.1 modelling software was used to analyse LiDAR Digital Surface Model (DSM)/Digital Terrain Model (DTM) and formulate coloured hill shading and contour models. There are several products available as part of this programme, this project has utilised the DSM (Digital Surface Model) and DTM (Digital Terrain Model) alongside aerial imagery. The DSM was used with aerial imagery to locate any buildings or tanks within the site so these could be removed from the process. The 1m resolution DTM uses the last return of the LiDAR pulse, classified as the ground, and as part of the EA National Programme has been manually filtered to improve accuracy of the ground model.

The DTM was observed for the entire site as shown in Figure 2.1 . DTM model for Hayden STW shows that the site gradually slopes from east to west. Higher elevation is to the upper east of the site, reaching 40.68 m. The central area is relatively around 27.5m high with some lower area to the west side reaching 24.30m.

Figure 2.2 shows the site annotated with principal sludge holding and digestion tanks, significant buildings and the IED area.

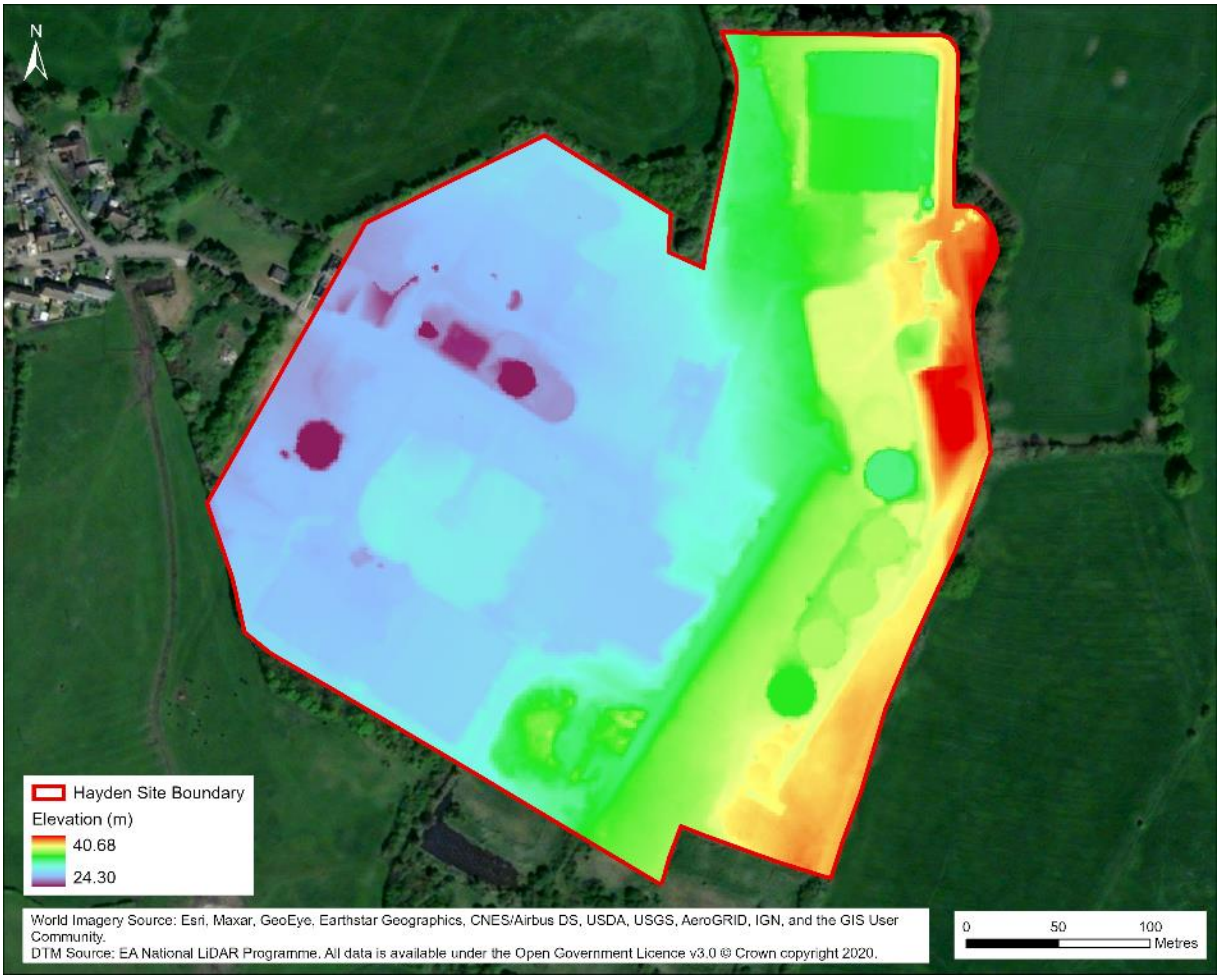

Figure 2.1 DEM/DTM imagery of Hayden Sewage Treatment Works Site

Figure 2.2 Labelled image of Hayden Sewage Treatment Works

2.2. Uncontained spill mapping and flow paths

In order to demonstrate the location of the flow paths and the area sludge is deposited to following the catastrophic failure of sludge tank(s) onsite, uncontained flood mapping has been completed utilising Flood modeller software.

This modelling has been completed using a spill volume of 5543m^3, which is 25% of all above ground sludge assets in the containment area. This value is larger than 110% of the largest sludge asset volume onsite.

Figure 2.3 below indicate the pathways, depths and velocities of sludge applicable to Hayden STW.

Modelling limitations

The software models the spill using a single density, a modelling tool is not available that can model all the variables associated with sludge storage and sludge spill i.e. Sludge density in the tank will vary from day to day, sludge density will be different at different levels in the tank and again different every day, it is likely that solids separation will occur in the area closest to the spill, but again this is variable depending upon the velocity of the liquid and the variability of the surface the sludge is travelling over.

Hydraulic modelling has been used to assess the uncontained spill following a catastrophic failure of the largest digester tank within the site. The 2D model generated uses the TUFLOW software package (Version 2020-10-AC), which can be used for simulating depth-averaged, one and two-dimensional free-surface flows exhibited with floods and tides. TUFLOW's implicit 2D solver, solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow using a 2nd order semi-implicit matrix over a regular grid of square elements. Furthermore, it includes the viscosity or sub-grid scale turbulence term that other mainstream software omit.

The DTM used in the model was of 1m resolution and the footprints of buildings and tanks were omitted from the model. The dimensions of the tank were used to calculate a constant flow of liquid in all directions from the circumference until it was emptied. Areas with different roughness coefficients were delineated using aerial imagery e.g., liquid would flow more easily over roads and paths as opposed to vegetated ground. The model outputs are 2m resolution with a timestep of one second. The model was run until the liquid front was no longer moving. Default parameters were used in the simulation and the model was stable with a mass balance error below the acceptable 1%.

Figure 2.3 Uncontrolled spill of Hayden Sewage Treatment Works (Depth profile)

2.3. Assets impacted by the spill

In the event of a spill event on site at Hayden Sewage Treatment Works, the assets that will be impacted are two digesters, sludge storage tank, cake pad and other significant buildings and assets at the Hayden Sewage Treatment site, for more details please refer to Figure 2.3.

The sludge spill mapping of an uncontained event in Hayden STW (Figure 2.3) showed that a potential sludge spill from a digester tank will not be contained within the site and therefore passive containment needs to be implemented to safeguard the nearby receptors. According to the model, the spill will leave the site boundary (in the west site boundary) in approximately 4 minutes following failure of the tanks.

The spillage would run to the west boundary and spread into the site and contaminate the nearby housings to the west of the site, the Fir, Cheltenham Spa hotel and Hayden Lane to the west of the site for about 485m.

3. Spill through Jetting

3.1. Jetting and surge flows

In addition to analysis of spill maps for the areas, jetting effects should also be considered to understand flow paths for a potential spill. Jetting is the phenomenon whereby the failure of a tank through rupture or corrosion results in the escape of a jet of liquid with sufficient force causing projection out of the tank.

In the instance that tanks lie near the boundary of the containment areas discussed in the chapter, jetting may have implications on where spills accumulate. The surrounding area of the tanks, where the spill could accumulate is the impermeable area, if the sludge assembles outside the bund the sludge will penetrate the permeable area. Both the digesters and containment tanks lie near the area boundaries.

Figure 3.1 below details the method for determining the necessary height and distance of a bund wall from a given tank to prevent jetting.

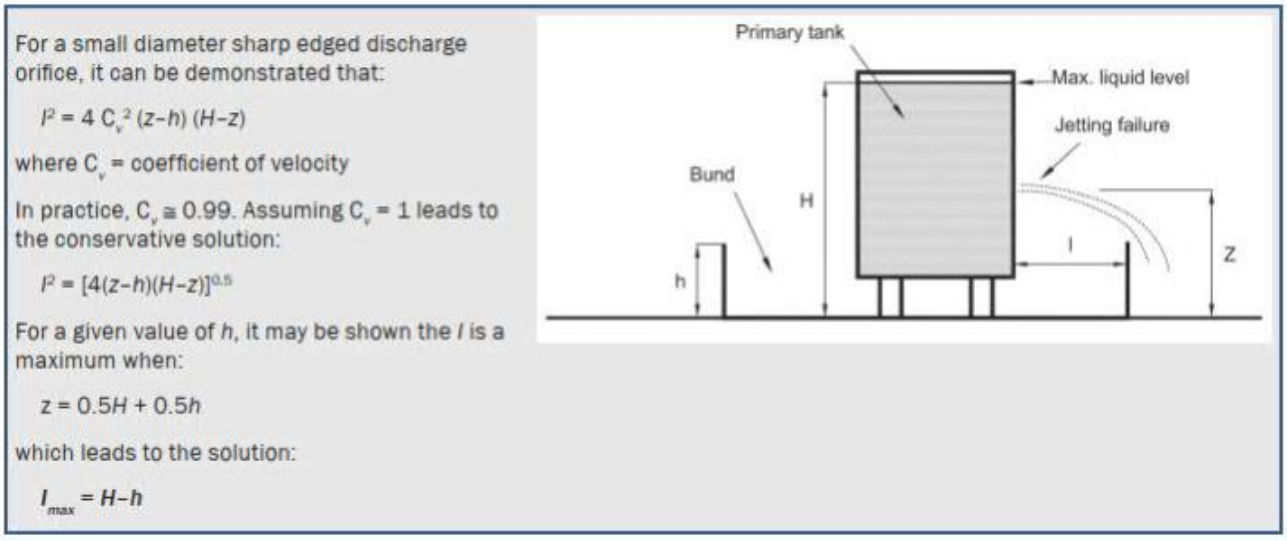

Figure 3.1 Extract for tank jetting consideration, *CIRIA guidance document C736 (Containment systems for the prevention of pollution – Secondary, tertiary, and other measures for industrial and commercial premises, 2014)*

3.2. Surge Flows

Surge effects of a catastrophic failure of the primary storage vessel will be considered in the design of the containment solution. This will consider the distance of the tanks from the bund walls and also the profile of the bund structure.

The surge allowance requirements (in the absence of detailed analysis) for different type of bund/containment structure are detailed in Table 4.7 of CIRIA C736.

- In situ reinforced concrete and blockwork bunds – 250mm surge allowance.
- Secondary containment tanks – 250mm surge allowance.
- Earthwork bunds – 750mm surge allowance.

4. Flooding

According to the UK Government's Flood Map for Planning, Hayden STW is not within any potential flooding zone (Flood Zone 1) as shown in Figure 4.1. The Flood Zone definitions listed in Table 4.1 provide additional detail of the areas of concern, which in the case of Hayden STW, have less than 1 in 1000 annual probability of river flooding. Given that the probability of flooding in the area is low, further mitigation measures are not required. Additionally, in the Flood Risk Vulnerability Classification, sewage works are classified as 'less vulnerable,' if adequate measures to control pollution and manage sewage during flooding events are in place.

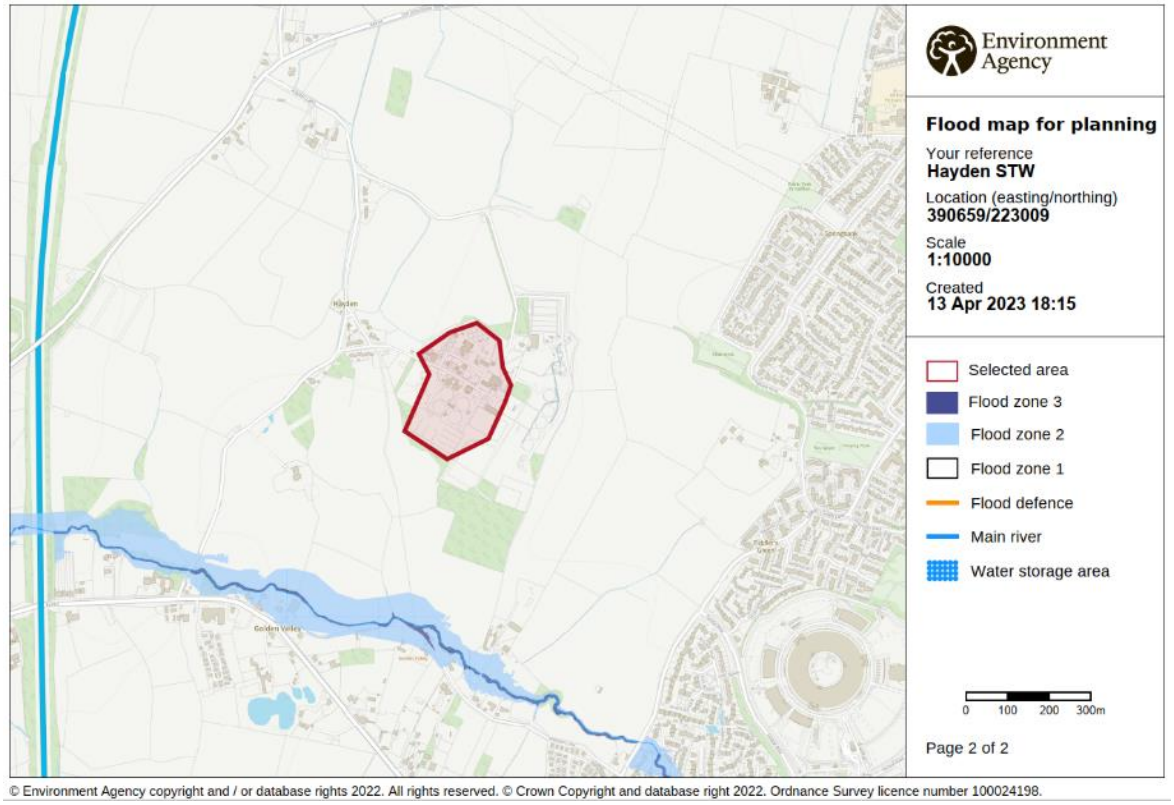

Figure 4.1 Extent of Fluvial flooding due to extreme weather events

Table 4.1 Flood Zone Definitions from GOV.UK Flood Map for Planning

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)

5. Potential Options

There are several options which need to be considered as part of the optioneering to deliver containment at the Sludge Treatment Centre. This optioneering has not yet been carried out and hence some of the proposed options may not be appropriate for the site on a cost, engineering, space or practicality basis.

Some of these options are applicable across a number of sites, while others are site and location specific. It is possible that more than option may be appropriate at a single site, on an asset specific basis, rather than using a single concept at the site.

If any of the incoming power supply and combustion assets are impacted by a potential spill which would impact on their ability to function, Severn Trent will seek to either re-locate or protect them with a specific containment solution.

The high-level containment options are tabulated below, followed by an overview of some of the options, with regards to their practicality at the specific site. Some options may not relate to specific tanks but involve the movement of other assets such as pumps, pipework or the biogas systems to minimise the risk of damage to these in the event of a spill. This may involve relocating assets or raising them above their current level, which may alter available volumes close to tanks impacting upon bunding requirements with regards to location and height.

Table 5.1 Potential Option of containment

High Level Option	Details	Scope	Applicability
Replacement of tanks	Existing tanks replaced by assets which are double skinned or integrally bunded.	May apply to all tanks or a subset of tanks	Will depend upon the assessed current asset lifespan. Integral bunding practicality may be influenced by tank volume
Resizing of tanks	Resizing of existing tanks to reduce either the overall number of tanks, or potential volume in a containment failure scenario	May apply to all tanks or a subset of tanks	Will depend upon the assessed current asset lifespan. May increase overall number of tanks on site. May reduce site resilience due to reduced storage volumes
Installation of tank farm bunding	Bunding of tanks on either an individual basis or for a group of closely spaced tanks	May apply to all tanks or a subset of all tanks	May be used on all tanks, however, likely to involve changes to existing pipe runs and pumping requirements, to reduce the requirement for bund penetrations by pipes. May impact on access to individual tanks For some assets, may lead to potential

High Level Option	Details	Scope	Applicability
			confined space or DSEAR concerns
Use of Tertiary containment	Remote bunding of tanks, which may include use of existing assets to capture spillages, such as roadways or open space	May apply to all tanks or a subset of all tanks	Likely to be applicable to all sites. However, may lead to increased requirement for impermeable surfacing to reduce infiltration in designated spill containment areas. Will depend on existing site infrastructure and may lead to land sterilisation issues
Installation of increased diameter drains and wet wells	Installation of increased diameter drainage locally to capture more of a spillage, linked to wet wells to hold spillages, prior to return to works inlet	May be possible for some tanks but will depending on existing drainage infrastructure.	May be applicable for single or multiple tanks, but the larger the covered area, the greater the potential volume needed to account for rainwater May be limited in use due to ground conditions and subsurface asset locations May have carbon related impacts due to increase in pumping requirements
Construction of sumps	Construction of engineered, sealed, sumps, to increase storage capacity locally in the event of a loss of containment	May be possible for some tanks, but likely to only have potential for a limited storage volume	Likely to be applicable mainly for smaller tanks May be limited in use due to ground conditions and subsurface asset locations May create confined spaces or raise DSEAR concerns.
Tank construction	Change to asset standards to reduce the potential risk of tank failure	May apply to tanks if they are being replaced	Will not remove need for containment, but may alter the failure mode, impacting on the speed of a spillage occurring and volume involved. Potential carbon related impacts

High Level Option	Details	Scope	Applicability
Process changes	Changes to process technology and techniques to reduce the requirement for post digestion storage duration to achieve the required pathogen kill level	Applicable to sites without advanced digestion techniques	May reduce to the overall volume of sludge stored reducing containment requirements. However, may increase dewatering requirements and associated storage volumes May have wider impact on works, such as changes to gas yield or requirement for liquor treatment
Movement or raising of ancillary assets	Movement of assets such as pumps, pipework and the biogas system in order to raise it above the potential spill level local to those assets.	All assets which may be impacted by a sludge spillage within the spill mapped area	Applicable to all assets which may be impacted by a loss of containment. May involve raising levels locally through installation of plinths or similar, altering the existing spill mapping. May have carbon related impacts due to increase in pumping requirements
Site closure	Closure of sludge assets, with transfer of sludge to alterative treatment location	Would apply to all permitted assets. Likely to only be applicable at treatment centres with lower throughputs	Will depend upon the assessed current asset lifespan. Requires sufficient capacity at alternative treatment location Potential for carbon impact due to transfer of sludge

6. Conclusions

This section summarises the findings of the site assessment at Hayden STW for event of a credible failure of a sludge holding tank.

Sludge spill mapping was undertaken for an event of an uncontained sludge spill which showed that the spill does not self-contain within the site. According to the model the spill would run into Hayden Lane and enter the residential area to the west but not contaminate a watercourse.

A hazard risk assessment was carried out for the site. A site hazard rating was calculated to be high, with the likelihood of a spillage being classed as low. Based on these risks an overall site risk rating was determined to be medium, meaning that class 2 containment is required.

In addition to analysis of spill maps for the areas, jetting effects should also be considered to understand flow paths for a potential spill. In the instance that tanks lie near the boundary of the containment areas, jetting may have implications on where spills accumulate.

The site is in Flood Zone 1 according to the UK Government's Flood Map for Planning and therefore additional measures for flooding are not required.

Digital terrain models generated show the topography of the site and identify low point where sludge spills would collect on site, or flow to the west side of the site. The Digester, Pathogen kill tanks and Centrate Balancing tanks were subsequently identified as areas of interest to perform spill mapping. The uncontained sludge spill modelling shows that a potential digester failure spill will leave the site boundaries within 4 minutes and impact on the adjacent housing and workplaces.

In the instance of a credible failure scenario at Hayden STW, the provision of a secondary containment system should be considered to prevent sludge from spreading into the adjacent residential area and to prevent sludge possibly entering the ground water.

Appendix A. ADBA Site Hazard Risk assessment for Hayden STW

Material	Physical properties	Quantity	Units	Storage	Flammability	Corrosive	Ecotoxicity (based on LD and quantity)	Environmental hazard rating	Justification
Feedstock Process									
Digestate (fermenter)	Liquid	< 1000	m3	Covered Tank or lagoon				H	Based on latest aquatic toxicity results from REA
	Liquid	1000 < X < 5000	m3	Covered Tank or lagoon				H	Based on latest aquatic toxicity results from REA
Separated digestate solids	Cake			Concrete pad				M	Largely immobile therefore presents only a medium risk.
Separated digestate liquid	Liquid			Covered tank				H	Present at this site.
							Process Overall Rating	H	Justification: Two digesters; Five Pathogen Kill Tanks; Two Sludge Storage Tanks; Two Centrate Balancing Tanks and three Primary sludge thickening tanks with a total capacity of 22842 m3.
Additives and site chemicals									
Ferric Chloride	Liquid	1	IBC	IBC	Not flammable	No	Medium	M	
Glycol	Liquid	1	IBC	IBC	Not flammable	No	Low	L	Not present
Cleaning products	Liquid	1	IBC	Consumables container	Not flammable	No	Low	L	Not present
Lab consumables	Liquid	20	litres	Consumables container	Not flammable	No	Low	L	Not present
							Chemicals Overall Rating	M	Polyelectrolyte chemicals for sludge thickening.
Fire fighting agents and cooling water spillages									
Fire Fighting Agents harmful in their own right or contaminated by inventory	Liquid	>25	m3	NA	Not flammable	No	Low	L	Not present
Fire fighting and cooling water contaminated by inventory	Liquid	>25	m3	NA	Not flammable	No	Low	L	Not present
							Spillages Overall Rating	L	All the hazards are "Low" therefore the overall rating is low
							Sources Overall Hazard Rating	H	Justification: Digesters; Pathogen Kill Tanks; Sludge Storage Tanks; Centrate Balancing Tanks and Primary sludge thickening tanks are present at this site.

Pathway - the route from primary containment to receptor		Environmental hazard rating	Notes
Site layout and drainage			
If any of the site inventory has a runoff time of a few minutes…		H	Sludge would reach head of works within 4 minutes.
If any of the site inventory has a runoff time of a few hours….		H	Not applicable
If any of the site inventory has a runoff time of a few days…		M	Not applicable
If any of the site inventory has a runoff time of a few weeks…		L	Not applicable
Topography, geology and hydrology			
Site is raised above a nearby receptor		H	Site slopes from East to West, therefore raised above the near housing area.
Chalk		H	According to the British Geological Survey, the site is not in the chalk aquifer area.
Fractured chalk		H	Not applicable
Principal Aquifer		H	Aquifer present are secondary type (undifferentiated).
Groundwater protection zone 1		H	According to Ground Water Vulnerability Map, Groundwater Vulnerability is high risk with soluble rock.
None apply		L	Not applicable
Mitigation - do these apply?			
If a secondary containment system is present…		L	Not present at the moment
If the rain water drainage system in the secondary containment fails safe…		L	Not applicable
	Path & Mitigation Overall Rating	H	Justification: Sludge would reach the head of work within 4 minutes. The site is raised above nearby receptors. The Groundwater Vulnerability is rated as High for this location.
Climatic conditions			
Annual rainfall < 1000 mm		L	Annual Rainfall within 809.9 mm - 867.2mm
Annual rainfall > 1000 mm		M	Not applicable
Snow accumulation is possible		M	Yes
Fire Fighting Water			
Inflammable materials normally present on site in large quantities?		M	Not applicable.
Location			
Site is in a flood plain		H	Flooding from River is at low risk; Flooding from Surface water is medium- high risk
Site is at bottom of a hill		M	The site inclines from East to West, towards the residential area.
Site is connected to a sewage treatment works		M	IED permitted is connected to sewage treatment works.
	Site Considerations Overall Rating	M	Justification: IED permitted is connected to sewage treatment works.
	Pathway Overall Hazard Rating	**H**	Justification: Runoff time to the head of the work is less than a few minutes. The site is a sewage treatment work.

Receptors	Within	units						Environmental hazard rating	Notes
Watercourses and bodies									
Rivers above potable water supplies	100	m						H	River Severn is 6.49 km away from the site to the west, and Hatherley Brook is within 500m from the IED permitted area to the south.
Aquifers used for public supply	150	m						H	Aquifer present are secondary type (undifferentiated).
High quality waters	1000	m						H	Not applicable
Agricultural abstraction points	50	m						M	No Agricultural abstraction identified via desktop analysis
High value ecosystems	1000	m						M	Local Nature Reserve is to the east of the site but more than 1000 m away.
Recreational waters	50	m						M	Not applicable
Small treatment works	50	m						M	Not applicable
None of the above								L	Not applicable
							Water Overall Rating	L	Justification: The site is far from these Watercourses and bodies receptors.
Habitation									
Dwelling	Within 250	m						H	Housing is within 150m of the Sewage Treatment works.
Dwelling	251-500	m						M	Not applicable
Workplace	Within 250	m						M	The Firs, Cheltenham Spa is within 265m to the west of the site.
None of the above								L	Not applicable
							Habitation Overall Rating	H	Justification: housing is within 150m from the Sewage Treatment work.
Other									
SSSI/SPA/SAC	1000	m						M	Not found
RAMSAR Site	1000	m						M	Not found
None of the above								L	Griffiths Avenue is a LNR site 2250m to the site's east side.
							Other Overall Rating	L	Justification: There is a LNR site nearby that is not considered in this ADBA.
							Receptors Overall Hazard Rating	**H**	Justification: Housing is within 250m from the Sewage Treatment works.

Calculated hazard ratings:

Source	Pathway	Receptor	**Site Hazard Rating**
H	H	H	**High**

Possible Combination			Site Hazard Rating
L	L	L	Low
M	M	L	Low
H	L	L	Low
M	M	M	Medium
H	M	L	Medium
H	H	L	Medium
H	M	M	High
H	H	M	High
H	H	H	High

Risk #	Description of Risk	UNMITIGATED LIKELIHOOD	Mitigation applied	MITIGATED LIKELIHOOD	Low	Site Overall Likelihood
1	Operational failures, such as failure of plant, or human failure by operators	H	Annual HAZOPs and operator training	L		
2	Shortfalls in design – lack of alarms and fail-safe devices	M	Pre-construction HAZOP identified measures - see P&IDs	L		
3	Structural failure – materials, components, detailing, corrosion or when exposed to heat and flame	M	Inspection of vessels, asset management	L		
4	Abuse – inappropriate change of use or other misuse	L		L		
5	Impact, eg from a vehicle	L	Armco barriers and concrete bollards installed	L		
6	Vandalism, terrorism, force majeure etc	L		L		
7	Fire or explosion	L		L		
8	Geological factors -subsidence etc	L		L		
9	Ageing or deteriorating assets/sub-components.	M	Inspection of vessels, asset management	L		
10	Lightning strike	L		L		

Site Hazard Rating	Likelihood	Overall Site Risk Rating	Indicated Class of Secondary Containment Required
High	Low	**Medium**	**Class 2**