Monkmoor Digesters and Sludge Tank IED Containment Assessment - Proposed Options Report

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Severn Trent Water

Severn Trent IED Containment Studies
14 July 2023

Monkmoor Digesters and Sludge Tank IED Containment Assessment - Proposed Options Report

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Executive summary

Monkmoor sewage treatment works is to the northeast of Shrewsbury. The River Severn lies on the north, east and south sides of the site and the A49 lies on the east side. The boundary of the site has fields on the north and east sides and housing on the south and west sides. Figure i shows an aerial view of the site in the context of its nearby surroundings. An initial visit to Monkmoor Sewage Treatment Works occurred for the purpose of site assessment and data collection.

Figure i Satellite view of Monkmoor Sewage Treatment Works

The secondary containment solution has been based on the following design parameters:

- Risk Report has identified that class 2 containment is required
- The required containment for the pathogen kill tanks (PKT) area is 2065m^3 and is the point of spill plus rainfall ('credible spill').
- The required containment for the digester area is 1808m^3 and is the point of spill plus rainfall ('credible spill').
- The containment recovery period is 48 hours, a 3 day 1 in 10-year event has been used for rainfall

The solution for the Digester area uses bund walls, kerbing and ramps to guide the flow to the secondary containment area, which is a storage area. This has been selected as the preferred technical solution as there is less impact on day-to-day site operations, due to the practical height of the ramps. (See figure ii overleaf).

The preferred technical solutions for the PKT area is to use kerbs, bund walls and ramps to guide and contain flows. The position of walls/bunds will be finalised during detailed design, ensuring storage footprint is not

compromised and the bund walls compliant to site operations and other considerations (i.e. services). (Figure iii)

Figure ii – Plan showing recommended solution (Digesters - Area 1)

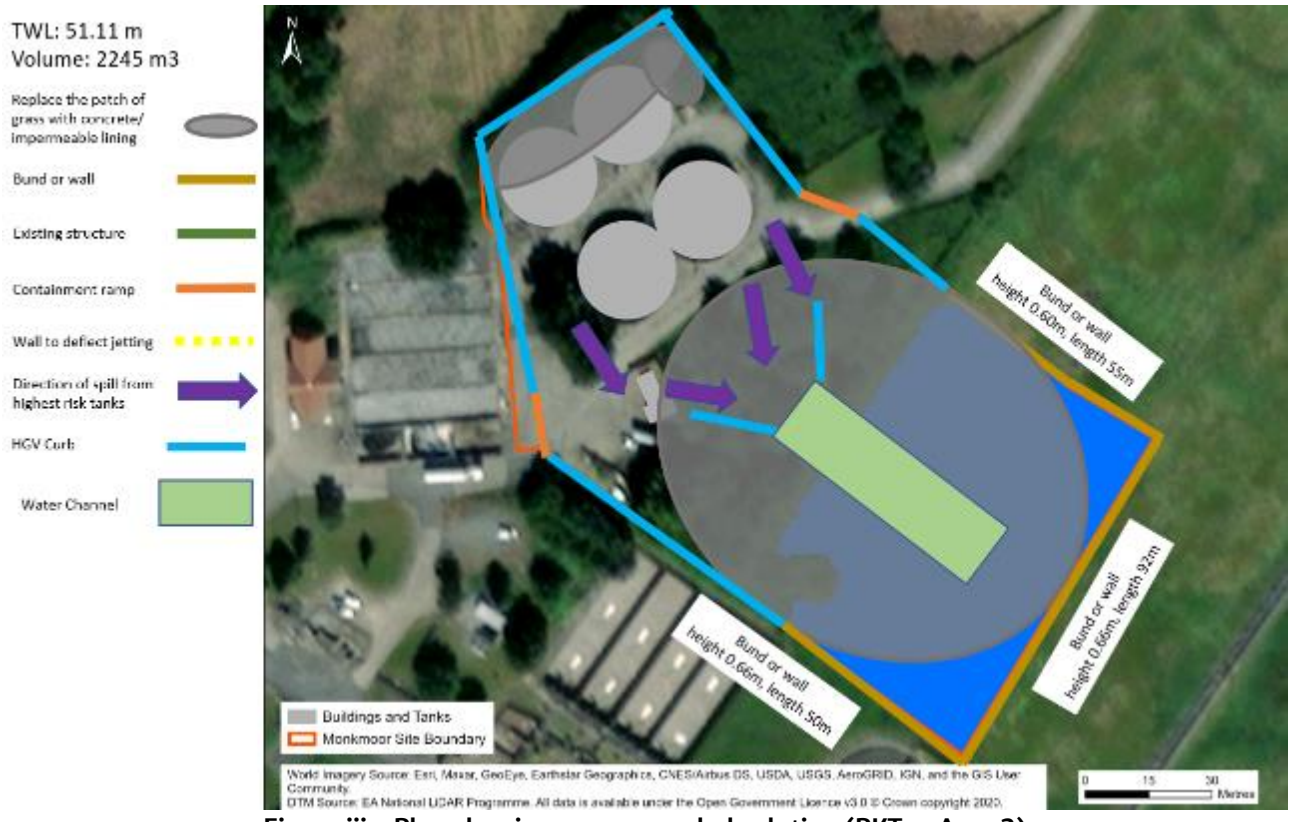

Figure iii – Plan showing recommended solution (PKTs - Area 2)

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 were 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. Based on CIRIA C736 and ADBA risk assessment tools this containment report addresses the site-specific risks at Monkmoor Sewage Treatment Works (STW) and outlines the options available for providing remote secondary containment in the event of a catastrophic tank or digester failure.

This document follows 'Monkmoor Digesters and Sludge Tanks, IED Containment Assessment-Risk Report, revision 2.0' which outlines the impact of an uncontained spill and the risk assessment completed and contains a complete tank list inventory for the IED permit area.

Chapter 1 provides an overview of the differing options for containment as outlined in CIRIA guidance document C736 (Containment systems for the prevention of pollution – Secondary, tertiary, and other measures for industrial and commercial premises, 2014) and the importance of this work at Monkmoor.

Chapter 2 details the loss of stock and rainfall components to identify the containment volume required

Chapter 3 details the recommended options to provide remote secondary containment considering containment and transfer areas for each area investigated and discusses the optimal option at the Monkmoor site.

Chapter 4 evaluates the surface water site drainage. Automated isolation valves linked to level indicators in the tanks are discussed to prevent shock loadings from being returned to the head of the works or sludge discharging into the river in the event of sludge tank failure.

Chapter 5 addresses the site-specific risks identified in Monkmoor IED Containment Assessment- Risk Identification Report, namely jetting and fluvial flooding.

Chapter 6 presents the main conclusions of the containment assessment.

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

Appendix B presents the Site Surfacing Plan for this site.

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1. Proposed Containment at Monkmoor

1.1 CIRIA C736

CIRIA guidance document C736 (*Containment systems for the prevention of pollution – Secondary, tertiary and other measures for industrial and commercial premises, 2014*) describes various options for containment of spillages from a credible failure scenario. It makes reference to a key plan, reproduced below:

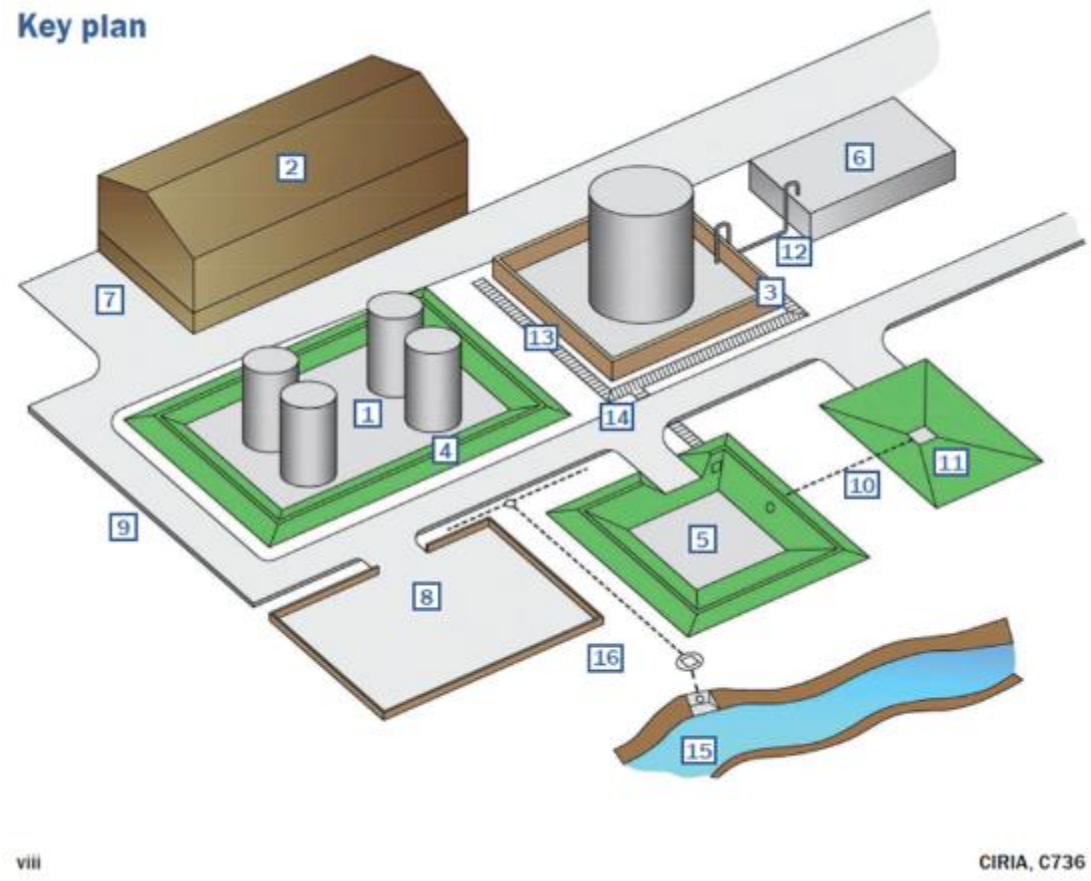

Figure 1.1 - Diagram of primary, secondary, and tertiary containment examples

-**Primary containment** is provided by the actual tank or vessel [1]

-**Secondary containment** is provided by a bund immediately surrounding the primary vessel e.g. [3] and [4], or by a lagoon [5] or tank [6]. If containment is provided away from the primary vessels this is known as **remote containment** and may be considered as either **remote secondary** or **tertiary containment**.

-**Tertiary containment** can be provided by a number of means including lagoons [5], or impermeable areas such car parks [8]. Roadways with high kerbing of sufficient height [9] can also form part of a tertiary containment system, or the **transfer system** to the remote containment.

-The distinction between remote *secondary* and *tertiary* containment is not always clear but, if properly designed, a combined system can be provided that is capable of providing the necessary degree of environmental protection.

The overriding concern is not the terminology but the robustness and reliability of the system which depends on a number of factors such as:

- Its complexity – the more there is to go wrong, the greater the risk. Passive systems relying solely on gravity are more reliable than pumped.
- Whether manual intervention is relied on to make the system work or whether the system can be automated to include fail-safes and interlocks.
- The ease of maintenance and monitoring of the system's integrity, and repair of any defects.

During and after an incident any rainfall runoff from the remote secondary storage areas, from the spillage catchment areas and from the transfer systems must also be prevented from reaching any outfall(s) to surface water by closure of control valve(s).

1.2 Site specific risks at Monkmoor STW

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

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

1.3 Objectives of remote secondary containment

The objectives of the remote secondary containment measures proposed in this report are to safely contain spillages from credible failure scenarios and prevent them from:

- escaping off site
- entering surface waters
- percolating into groundwater
- being pumped back to the inlet of the sewage works in an uncontrolled manner.

The remote secondary containment will be provided by maximising the use of existing impermeable surfaced areas to provide a fail-safe passive system that relies on gravity rather than pumps. A means of leak detection that will automatically trigger isolation valves at key locations in the drainage system is also proposed.

2. Loss of Stock from Failure Scenario

In the Schedule 5 Notice dated Nov 2022, the EA has provided guidance on the failure scenarios to be modelled to assess the impact of catastrophic failure of sludge asset(s) within the IED permit boundary. The guidance stated, 'assessment of the impact of spill volumes using 110% of the largest tank or 25% of all tanks within a bunded area (whichever is greater)'. Contained spill volumes for containment areas have therefore been selected as the greater of 110% of the largest tank or 25% of all tanks within a bunded area or a credible spill volume (largest tank volume plus rainfall).

It was also later clarified with the EA that the total volume of sludge assets to be considered includes only above ground volumes of the assets.

2.1 Design allowance for rainfall

In addition to the maximum volume arising from a credible failure scenario, extra allowance for rainfall that may accumulate within the contained area before and after an incident has been made. The CIRIA guidance recommends that the containment volume should include an allowance for the total rainfall accumulated in response to a 1 in 10-year return period events for the 24 hours preceding an incident and for an eight-day period following an incident, *or other time periods as dictated by a site-specific assessment*. Given that Worksop STW is a large, manned wastewater works with ready access to pumps and tankers, and with a (controlled) disposal route via the wastewater treatment system being available, it is considered unlikely that even a catastrophic spillage would take more than 48 hours to be pumped and drained away, therefore a 3-day event period has been selected. The average 72 hours rainfall depths for a 1 in 10-year storm for Monkmoor STW is 59 mm. It should be noted that the rainfall depths for Monkmoor STW have been estimated using the depth-duration-frequency rainfall model contained on the *Flood Estimation Handbook* (FEH 13), which provides location specific rainfall totals for given durations and return periods.

2.2 Total Design Containment Volume

For the Containment Digester area – Area 1, a 12,443 m^2 catchment with 59 mm rainwater depth, the total design containment volume comprises 1,402 m^3 from catastrophic tank failure, and 736 m^3 from the rainfall event, giving a total volume of 2,138 m^3. The containment volume is a credible spill, which is greater than both 25% (1189m^3) of the volume of all sludge assets in this area and 110% (1542m^3) of the largest tank in this area.

For the Pathogen Kill Tank area – Area 2, a 7526 m^2 catchment area with 59 mm rainwater depth, the total design containment volume comprises 1800 m^3 from catastrophic tank failure, and 445 m^3 from the rainfall event, giving a total volume of 2,245 m^3. The containment volume is a credible spill, which is greater than both 25% (1800m^3) of the volume of all sludge assets in this area and 110% (1980m^3) of the largest tank in this area.

3. Remote Secondary Containment

3.1 The Containment Area

3.1.1 Topography

Figure 3.1 shows the topography of area 1 containing the sludge assets at Monkmoor. The highest ground is shown with the pink contours to the north-west of the site. The lowest elevations are shown with the blue contours to the south-east of the site. The site slopes from north-west to south-east.

Figure 3.1 – DTM of the sludge assets showing contours at 10cm intervals (area 1)

Figure 3.12 shows the topography of the PKT area at Monkmoor. The highest ground is shown with the pink contours to the north-west of the site. The lowest elevations are shown with the blue contours to the south-east of the site. The site slopes from north-west to south-east.

Figure 2.2 – DTM of the PKTs showing contours at 10cm intervals

Figure 3.3 - Labelled site plan at Monkmoor STW

3.1.2 Containment Solution

3.1.2.1 Containment: Digesters - Area 1

To provide sufficient secondary containment for the Digester Area, the total design containment volume of 2,138m^3 needs to be securely contained. LiDAR spill modelling calculated the top water level (TWL) when 2,138m^3 is contained in this area to be at 50.80 mAOD. Figure 3.4 shows the works necessary to convert the digester Area into a secure remote secondary containment facility. The works consists of impermeable linings on the grass areas within the containment area, bund/wall structures on the south-east east sides of the containment area, HGV curbs as well as cutting into the grassed area in the south-east of the area and levelling the area to 50.2m AOD to increase the area that can be used for storage. Three containment ramps will be required. There is approximately 5,900m^2 of grassed area that require the installation of impermeable area.

Figure 3.4 - recommended modifications to provide secondary containment for Area 1

The position of bund walls will be finalised during detailed design ensuring the storage footprint is not compromised, and bund walls are compliant with site operations and other considerations (e.g. services)

3.1.2.2 Containment: Pathogen Kill Tanks - Area 2

To provide sufficient secondary containment for the pathogen kill tank area, the total design containment volume of 2,245 m^3 needs to be securely contained. LiDAR spill modelling predicted the top water level (TWL) when 2,245 m^3 is contained in this area to be at 51.11m AOD. Figure 3.5 shows the works necessary to convert the sludge asset area into a secure remote secondary containment facility. Installation of kerbing, containment ramps and construction of bund/wall structures create a secondary containment area. A channel will also be created to guide flows into the containment area.

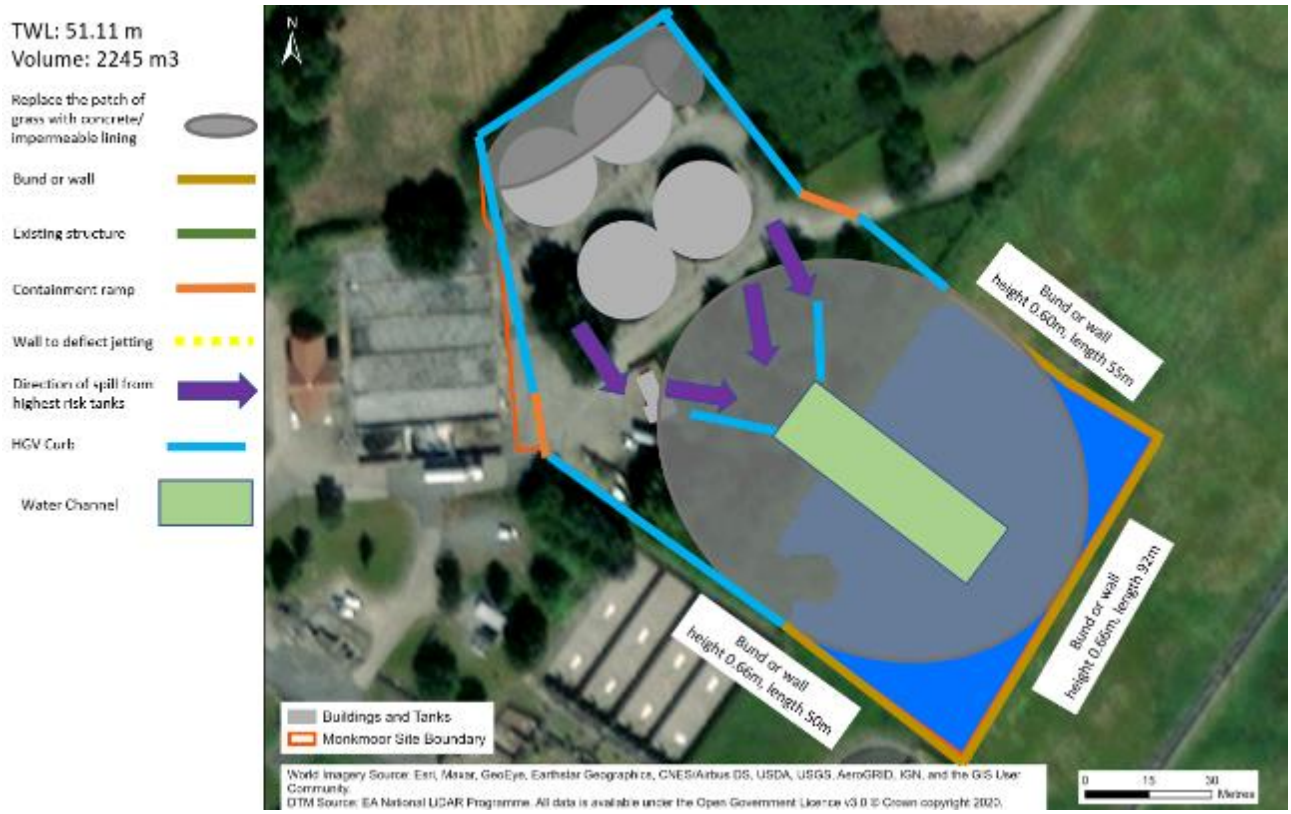

Figure 3.5 – recommended modifications to provide remote secondary containment for area 2

The position of bund walls will be finalised during detailed design ensuring the storage footprint is not compromised, and bund walls are compliant with site operations and other considerations (e.g. services)

3.2 The Transfer System

Due to the topography of the site the transfer of liquid to the remote secondary containment occurs under gravity.

The site surfacing plan for Monkmoor STW, shown in Appendix B, details the current impermeable and permeable surfacing in the containment areas. The grass areas around the transfer system and tanks should be lined for the eventuality of sludge collecting on them, either through jetting from the tanks or pipework, or spillages over kerbing.

3.3 Remote Secondary Containment Summary

A summary of the recommended containment for Monkmoor STW are listed below.

Table 3.2 - Summary of Recommended Site Modifications (Area 1)

	Impermeable Lining /m2	Walls/ Barriers	Ramps	Other (Isolation Valves/Building Protection/ local infill)
Containment Area 1 (Digesters)	Approximately 5900m^2 require impermeable lining	5 sections: • Max height 0.8m length 85m • Max Height 0.80m length 50m • Max height 0.64m length 14m • Max height 0.87m length 54m • Max height 0.58m length 54m Kerbing to be raised to 400 mm above road level to direct and contain spillages and protect buildings.	1 Containment Ramp Max Height 0.33m Length 8m Two flow guiding containment ramps at nominal height of 0.1m	

Table 3.3 - Summary of Recommended Site Modifications (Area 2)

	Impermeable Lining /m2	Walls/ Barriers	Ramps	Other (Isolation Valves/Building Protection/ local infill)
Containment Area 2 (PKT)	Approximately 9,780m^2 require impermeable lining	3 sections: • Max height 0.66 Length 50m • Max height 0.66m Length 92m • Max height 0.60m Length 55m Kerbing to be raised to 400 mm above road level to direct and contain spillages and protect buildings.	Two flow guiding containment ramps at nominal height of 0.1m	Water Channel to direct flow to containment area

4. Site Drainage

Site drainage assessments are based on Monkmoor Sewage Treatment Works Layout Plan Drawing Number R793/001.

4.1 Foul Process and Effluent Drainage

The Monkmoor Sewage Treatment Works Layout Plan shows all foul/ combined/ process/ treated effluent drainage pipes, indicated by red lines, either go to the head of the works shown in Figure 4.1, or into the treated effluent manhole T57 which discharges into the River Severn as shown in Figure 4.2 overleaf. In the event of sludge entering the head of the works, the shock load could adversely impact the sewage works treatment processes. The release of untreated effluent and sludge into the River Severn would be hazardous to the environment and in breach of the EA regulations. However, there are no foul manholes within the containment storage area for both areas. For this reason, in the event of catastrophic loss of containment, these lines do not need to be isolated.

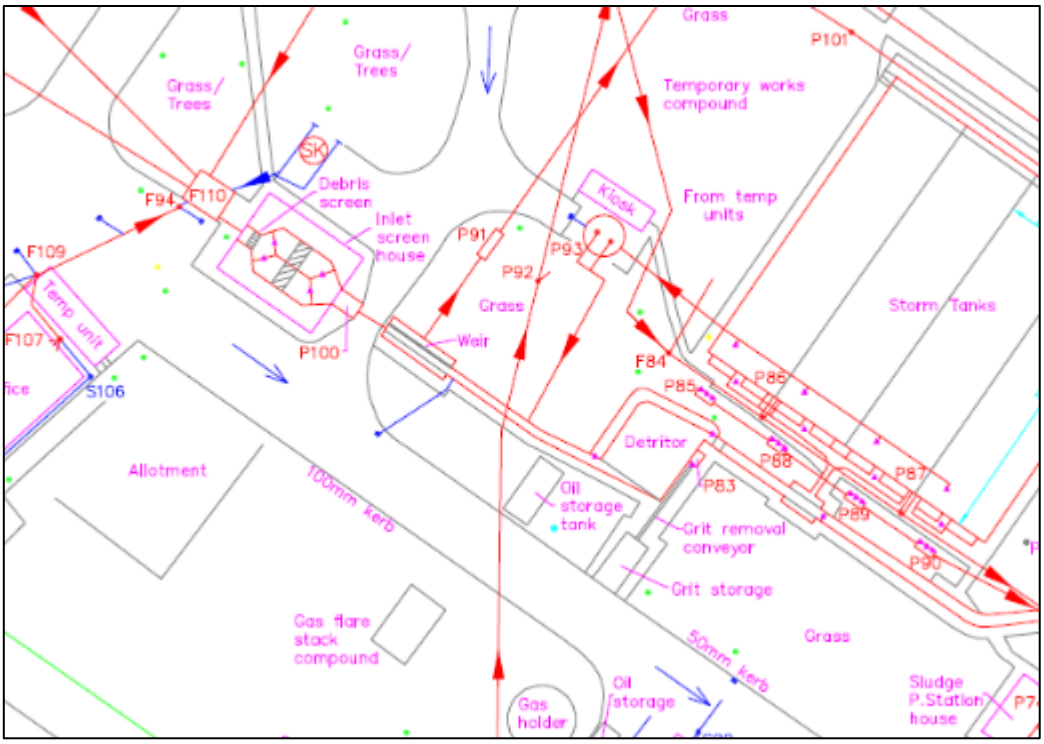

Figure 4.1 - Drainage line to head of works

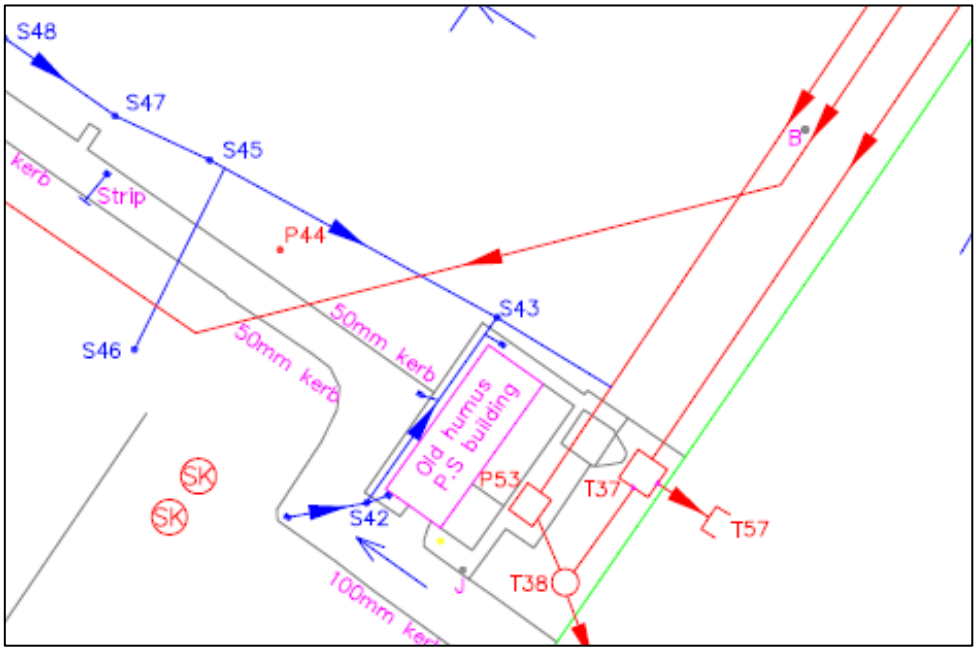

Figure 4.2 - Drainage line to the Treated Effluent manhole T57

4.2 Surface Water Drainage

Surface water drainage at Monkmoor layout plan is represented by blue lines. These lines drain to the treated effluent pipelines which finally drain to the outfall located on the south-east of the site. For the loss of containment events explored in this report, any of the surface water manholes within the containment areas (circled in Figures 4.3) could potentially send sludge into the treated effluent drainage. These lines should therefore be isolated in the event of a catastrophic loss of containment. To minimise the number of isolation valves installed, the connectivity of the surface water drainage system should be further investigated with the aim of identifying a common pipe that all manholes in the transfer and containment areas drain to, prior to discharge into the treated effluent pipeline. This would then be the only line that requires an automated isolation valve. If no common pipe exists, the elevations of all manholes should be determined and those below the relevant top water levels, should be fitted with an automated isolation valve.

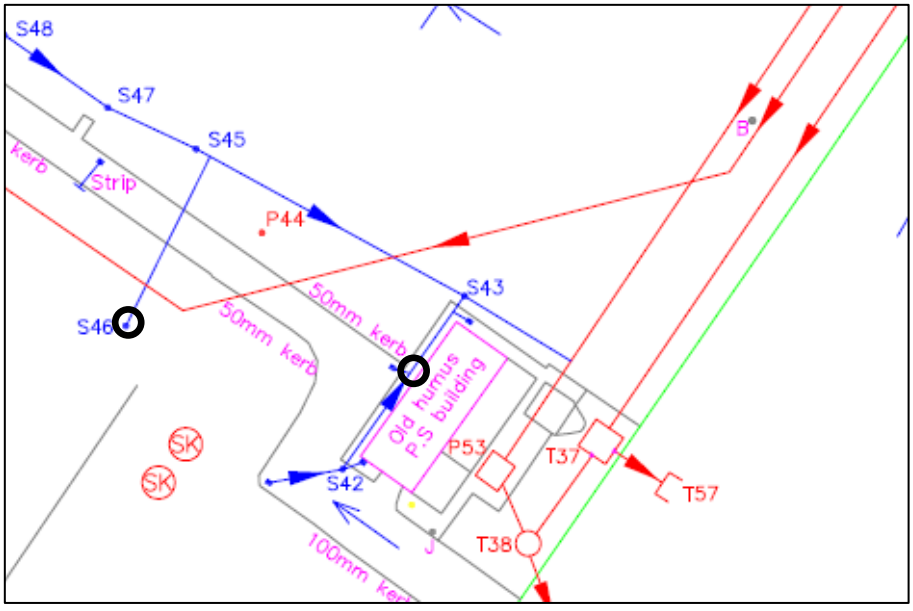

Figure 4.3 - Digester Area surface water manholes to be isolated

4.3 Automatic Isolation Valves

For the catastrophic loss of containment scenarios for sludge area discussed, such a loss could be automatically detected by the level sensors in the tanks. A catastrophic failure would be identified by the rate of change in tank level being larger than expected at normal operation. The signal from the sensors would be used to automatically prevent any adverse impact on sewage treatment.

In the event of a catastrophic sludge spill, flows entering the head of works via the drainage pipes could adversely impact the sewage works treatment process. Therefore, in the event of a catastrophic loss of containment, the drainage lines within the containment area should be isolated.

It is recommended that float operated isolation valves are installed on all outgoing drainage lines from the containment area. These valves will remain normally open but will close when high levels in the existing drainage system are encountered. This drainage configuration will have the following impacts:

- In heavy or intense rain events these drainage isolation valves may be triggered, and operators onsite will need to manually operate these valves to release flows into the existing drainage network
- In minor or slow flow tank spills, the sludge spill will flow into the exiting drainage network (and into the head of the works) unless operators intervene to isolate the drainage networks. Due to the flow to full treatment at Monkmoor being large, minor spill flows will not adversely impact the process.
- In most locations, to accommodate the new isolation valves, new manholes need to be constructed over the existing drainage lines.

5. Mitigation of Site-Specific Risks

5.1 Jetting and Surge Flows

No additional walls should be required to be constructed around any of the vessels with the containment parameters detailed in this report, as all tanks included in this assessment are sufficiently far away from the containment boundary for jetting to be of concern.

5.2 Flooding

According to the UK Governments Flood Map for Planning, Monkmoor STW is not within any potential flooding zone as shown in **Error! Reference source not found.** therefore no modifications need to be made to M onkmoor STW to accommodate risk.

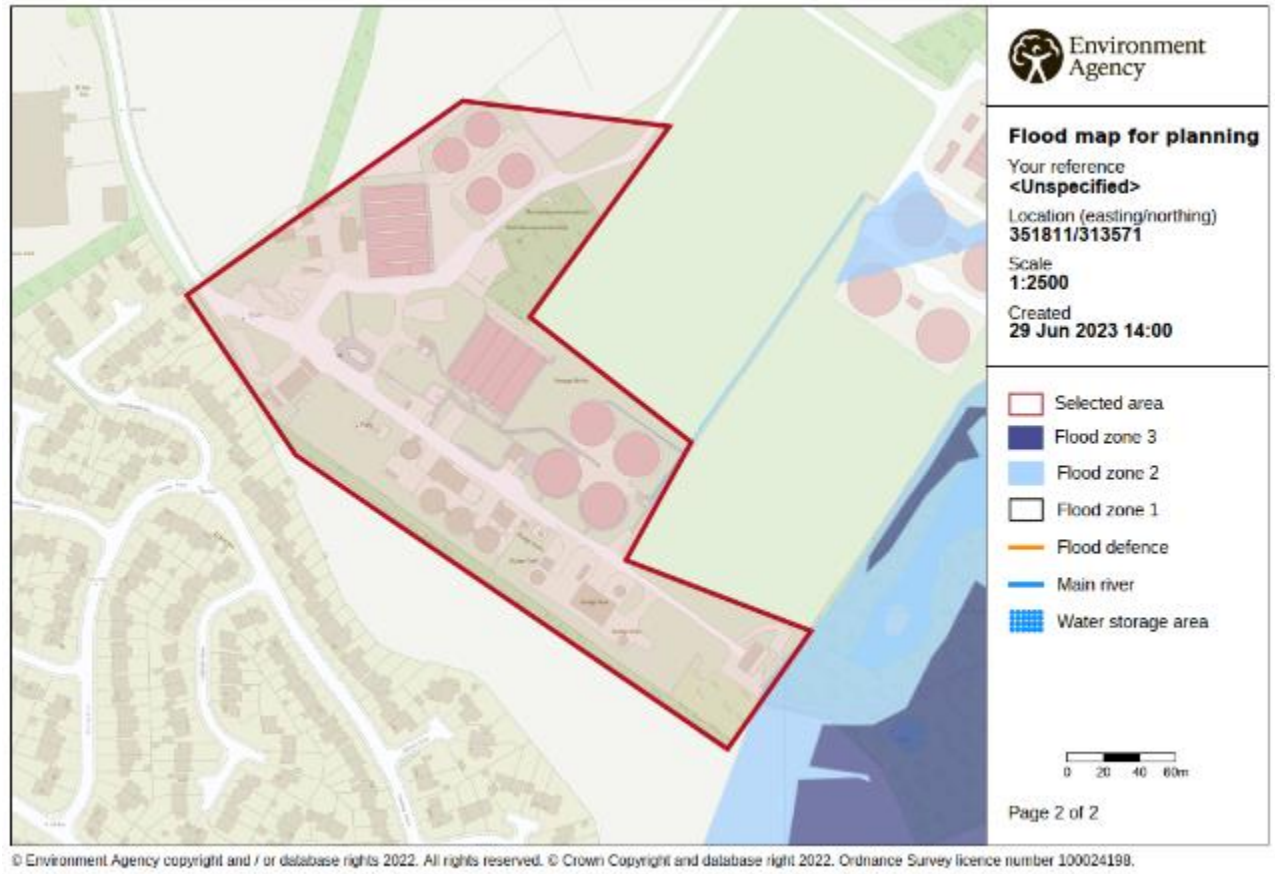

Figure 5.1 - UK Government's Flood Map for Planning

6. Conclusions

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

In the Risk Identification Report for Monkmoor STW a containment classification report was carried out. An overall site risk rating of medium was determined meaning that class 2 containment is needed. The detailed requirements for class 2 containment have been outlined in the Risk Identification Report in section 1.1.

The assessment focusses on site -specific risks and outlines the options available for providing remote secondary containment of a catastrophic tank or digester failure. A technical option has been developed for the containment of spills within the two sludge areas.

The digester area uses walls/bunds, ramps and kerbs to guide flows into a storage area to store the spills. Walls /Bunds and ramps are required to contain the flows at certain points of the boundary. This solution has been developed so that the impact of the site operations is not affected.

The PKT area uses walls/bunds and ramps to store the spills. Walls /Bunds and ramps are required to contain the flows within the boundary. This solution has been developed so that the impact of the site operations is not affected.

The effect of Jetting and surge flows were also assessed and found to pose no issues in the containment areas.

Appendix A. ADBA Site Hazard Risk Assessment for Monkmoor 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	
							Process Overall Rating	H	Justification: Three Digesters; Four Pathogen Kill Tanks; One Pre-digestion Blending Tank; One SAS belt feed tank; One Crude Belt Feed Tank; One Import sludge tank with total capacity 12336
Additives and site chemicals									
Ferric Chloride	Liquid	1	IBC	IBC	Not flammable	No	Medium	M	Not present
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	L	
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, Pre-digestion Blending Tank, SAS belt feed tank, Crude Belt Feed Tank, Import sludge tank are present on 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 of work within 1 minute.
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 West to East therefore is raised above River Severn.
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 of Secondary A type is present in this location.
Groundwater protection zone 1		H	Groundwater Vulnerability is Medium- High risk with soluble rock according to Ground Water Vulnerability Map.
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 head of of work within a minute.
Climatic conditions			
Annual rainfall < 1000 mm		L	Annual Rainfall within 684.98 mm - 809.9 mm
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	IED permitted area is in Flood Zone 1.
Site is at bottom of a hill		M	The site inclines from West to East, towards River Severn.
Site is connected to a sewage treatment works		M	IED permitted is connected to sewage treatment works.
	Site Considerations Overall Rating	M	Justification : The site inclines from West to East, towards River Severn.
	Pathway Overall Hazard Rating	H	Justification: Runoff time to the head of the work in 1 minute.

Receptors	Within	units						Environmental hazard rating	Notes
Watercourses and bodies									
Rivers above potable water supplies	100	m						H	RIver Severn is within 200m from the IED permitted Zone.
Aquifers used for public supply	150	m						M	Aquifer of Secondary type A is present at this location.
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	Site of Special Scientific Interest and Local Nature Reserves are 2000m away from this STW.
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 not near these.
Habitation									
Dwelling	Within 250	m						H	Housing is wtihin 150m from the Sewage Treatment works.
Dwelling	251-500	m						M	Not applicable
Workplace	Within 250	m						M	Shrewsbury Business units are within 160m from 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	Old River Bed SSSI 2050m; Hencott Pool SSSI 2610m;
RAMSAR Site	1000	m						M	Midland Meres & Mosses Phase 2 RAMSAR 4170m;
None of the above								L	Rea Brock Valley LNR 2200m;
							Other Overall Rating	L	Justification: SSSI and LNR sites are located up to 2.2 km from the STW.
							Receptors Overall Hazard Rating	**H**	Justification: Housing is wtihin 150m 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**

Appendix B. Monkmoor STW Site Surfacing Plan