Mansfield Digestors and Sludge Tank
IED Containment Assessment – Proposed Options Report

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Severn Trent Water

Severn Trent IED containment Studies
20 April 2023

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1.0	20/112/21	Draft	RW	SG	SG	RB
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Executive summary

Mansfield Sewage Treatment Works is located one mile to the northeast of the centre of Mansfield. The River Maun lies to the east of the site and an industrial park lies to the west side. These features act as boundaries to the site. Figure i shows an aerial view of the site in context to nearby surroundings. An initial site visit to Mansfield Sewage Treatment Works was conducted for the purpose of site assessment and data collection.

Figure i Aerial view of Mansfield Sewage Treatment Works

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

- Risk Report has identified that class 2 containment is required
- The required containment is 2215m^3 and is 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 preferred technical solution is option 2, to utilise the redundant balance tank to store 90% of the spill volume, and the remaining 10% to be contained within the sludge area. (See figure ii overleaf). This solution provides an efficient containment solution. The old cake pad is not used and can be used for future developments on site. The position of bunds / walls will be determined by detailed design ensuring storage footprint is not compromised and the bund walls compliment site operations and other considerations (i.e. services)

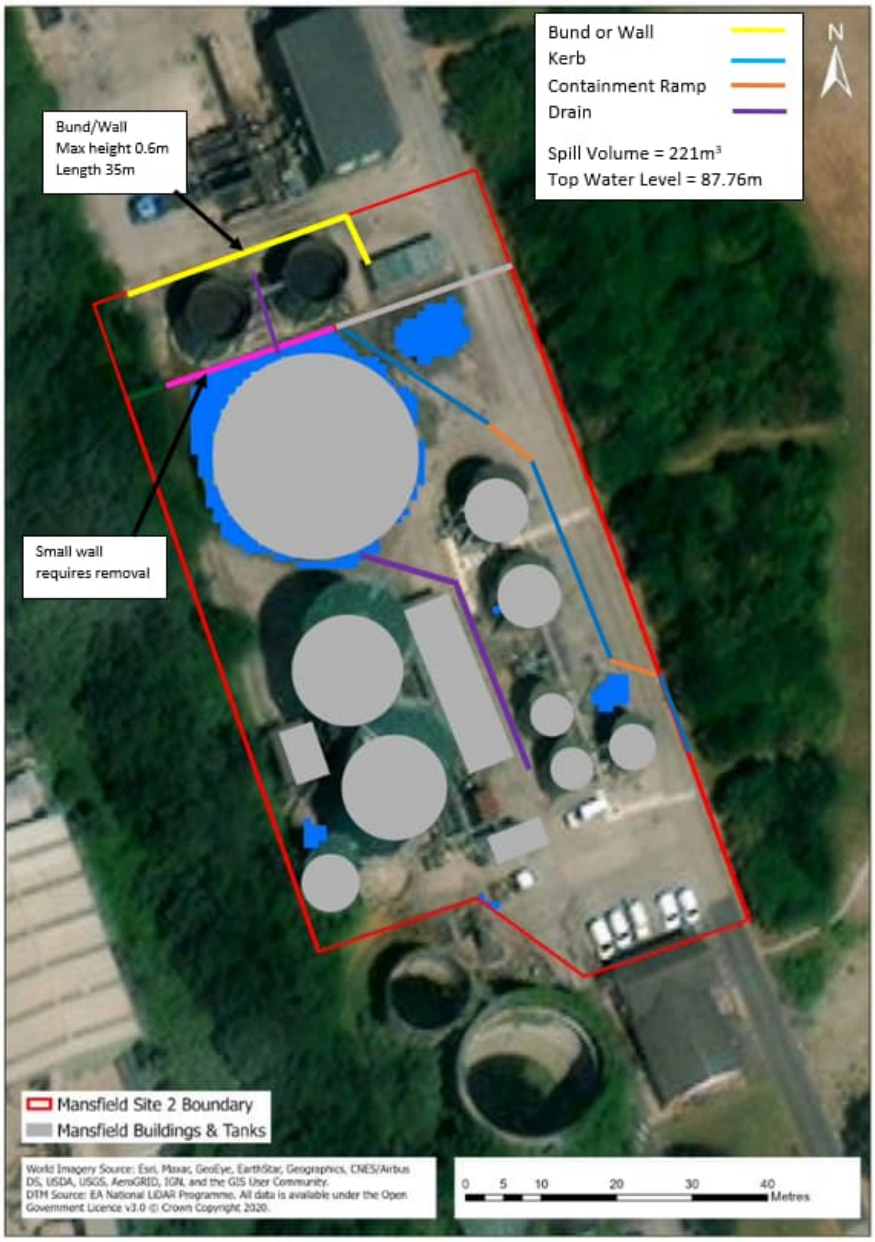

Figure ii – Plan showing recommended technical solution

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 Mansfield 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 'Mansfield Digesters and Sludge Tanks, IED Containment Assessment-Risk Report, revision 1.1' 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 Worksop.

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 Worksop 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 Worksop 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.

Contents

Appendices

1. Proposed Containment at Mansfield

1.1 CIRIA C736

This containment option report has been prepared using CIRIA C736 as the basis of design and guidelines. Where a deviation from C736 has been recommended it is highlighted in the text.

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

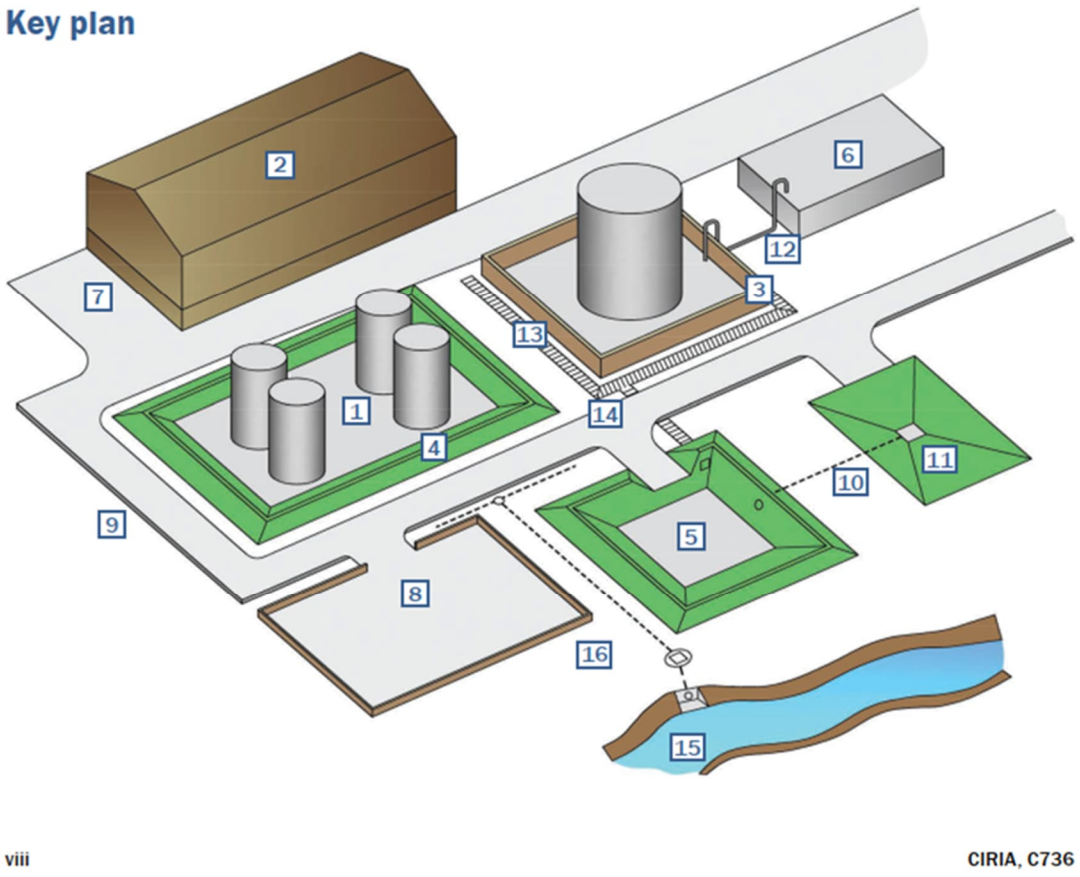

Figure 1.1 Diagram of primary, secondary, and tertiary containment examples

-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 provide the necessary degree of environmental protection. The overriding concern is not the terminology but the robustness and reliability of the system which depends on 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 Mansfield STW

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk Mansfield 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)

The detailed ADBA risk assessment tool is attached in Appendix A.

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 Mansfield 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 Mansfield STW is 64.5 mm. It should be noted that the rainfall depths for Mansfield 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 Option 1 a catchment of 8592m^2 area for the sludge area with 64.5mm rainwater depth, the total design containment volume comprises of 1898m^3 from catastrophic tank failure, and 554m^3 from rainfall. This gives a total volume of 2452m^3. The containment volume is credible spill, which is greater than both 25% (1323m^3) of the volume of all sludge assets in this area and 110% (2088m^3) of the largest tank in this area.

For Option 2 a catchment of 4915m^2 area for the sludge area with 64.5mm rainwater depth, the total design containment volume comprises of 1898m^3 from catastrophic tank failure, and 317m^3 from rainfall. This gives a total volume of 2215m^3. The containment volume is credible spill, which is greater than both 25% (1323m^3) of the volume of all sludge assets in this area and 110% (2088m^3) of the largest tank in this area. This option utilises a redundant balance tank, which will store 90% of this spill volume. The remaining 10% (221m^3) of the spill volume will require additional secondary containment within the area.

3. Remote Secondary Containment

3.1 The Containment Area

3.1.1 Sludge Area Topography

The Topography of the Sludge Area shown in figure 3.1 generally slopes from South to North and from a slight gradient from West to East. The lowest point of the site is the old cake pad, where the spill volume would naturally collect.

Figure 3.1 Contouring map of Mansfield Sludge Area

3.1.2 Containment Option 1

To provide sufficient secondary containment for the Sludge Area, a total containment volume of 2,452m^3 needs to be provided. LiDAR spill modelling predicted the top water level (TWL) when 2,452m^3 is contained in this area to be at 87.29m AOD. Figure 3.2 shows the physical works necessary to the Sludge Area to enable the effective secure remote secondary containment of the spill.

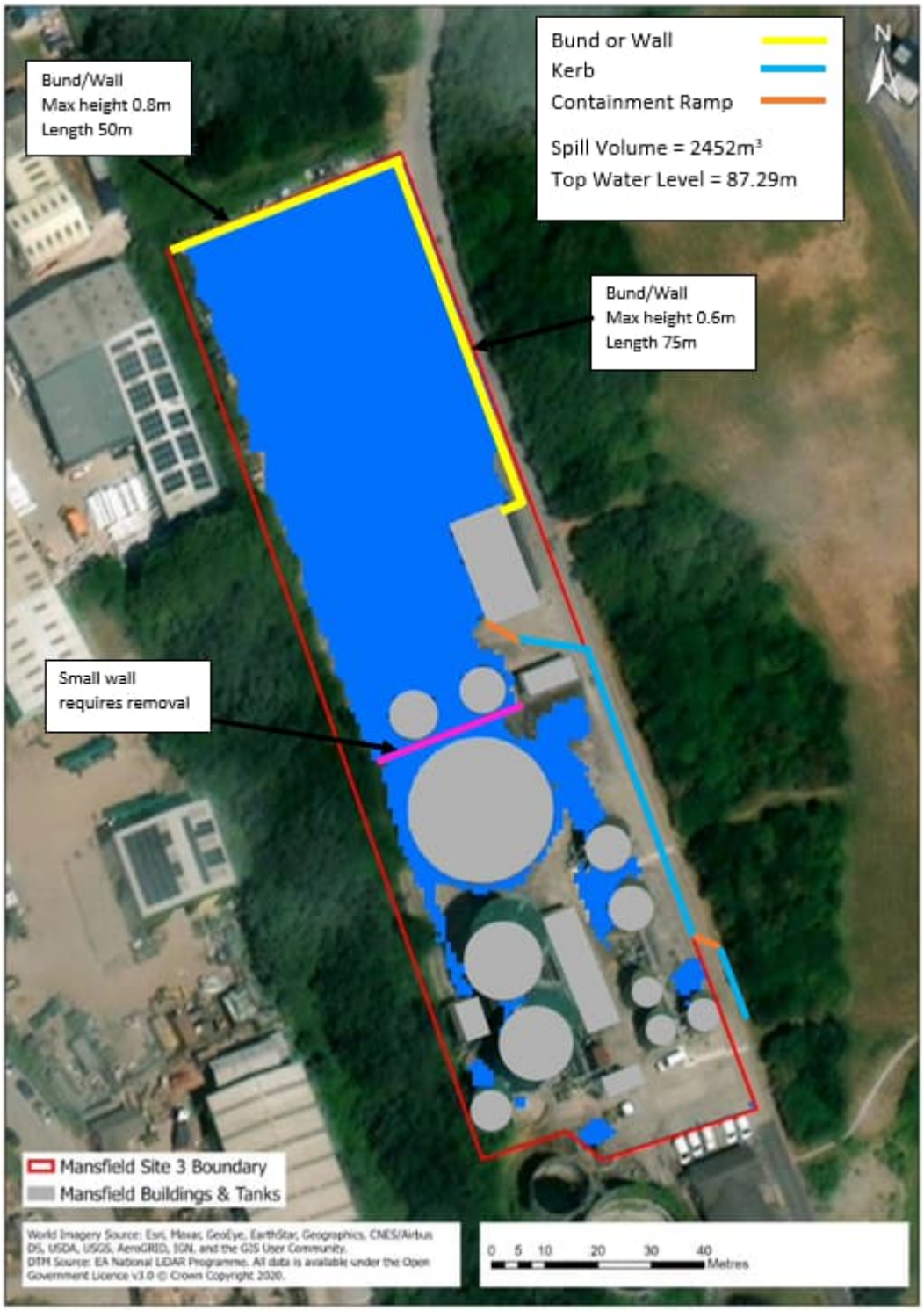

Figure 3.2 Recommended site modifications to provide secondary containment for Sludge Area (Option 1)

A small wall lies between the balance tank and post-digestion tanks in the sludge area. This must be removed to allow flow of the spill into the cake pad area. Kerbing and containment ramps have been provided along the road to guide flows into the cake pad area.

3.1.3 Containment Option 2

Containment option 2 utilises the balance tank at the centre of the sludge area to collect sludge in the event of catastrophic tank failure. In this scenario 90% of the sludge spill will be stored in the balance tank, and the remaining 10% of the design containment volume requires containing within the sludge area. LiDAR spill modelling predicted the top water level (TWL) is 86.76m AOD, when 221m^3 is contained in this area. Figure 3.3 overleaf shows the works necessary to provide secondary containment.

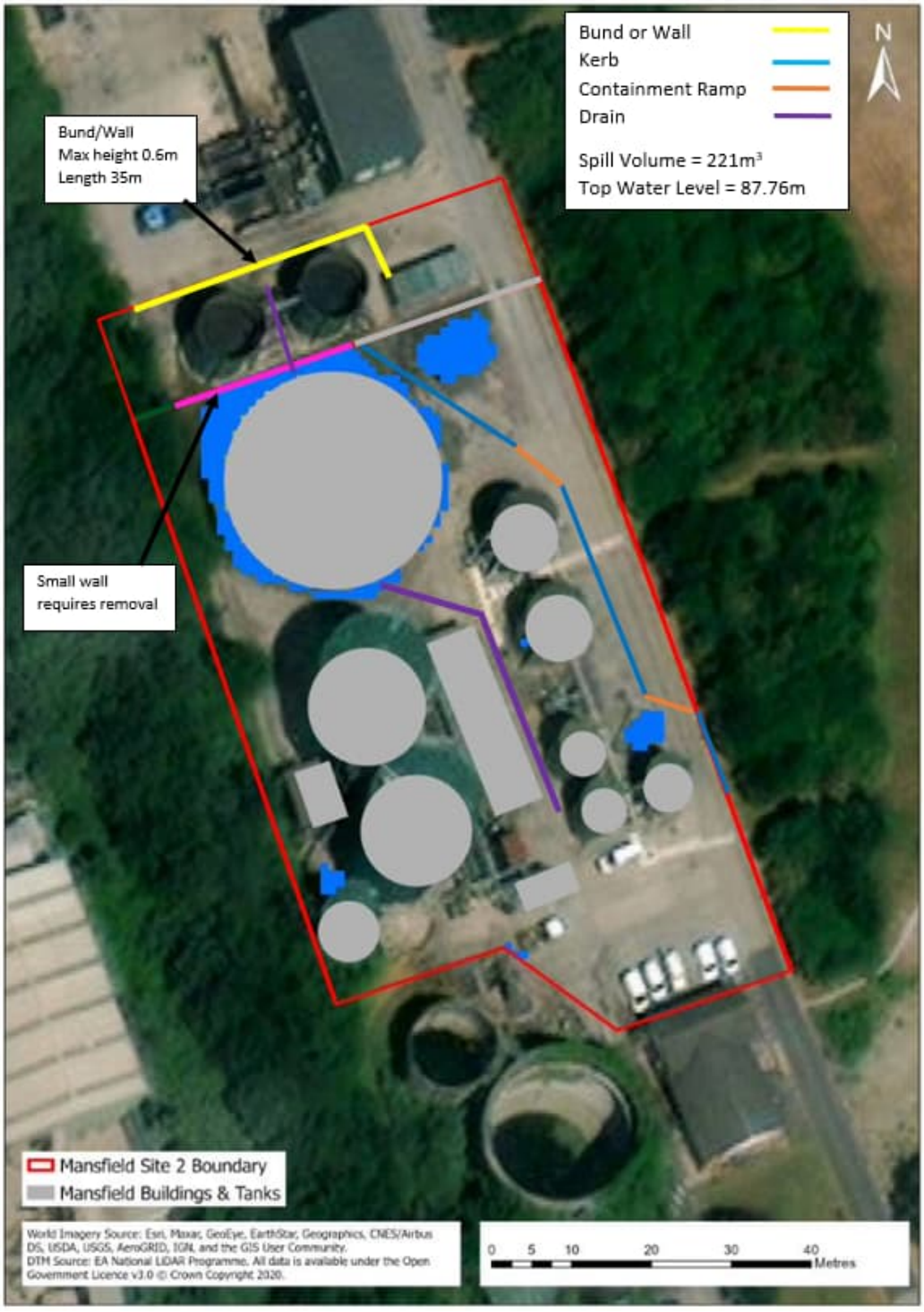

Figure 3.3 Recommended site modifications to provide secondary containment for Sludge Area (Option 2)

The small wall between the balancing tanks and the post digestion tanks needs to be removed. A wall or bund is needed to the north of the post digestion tanks. Kerbing and containment ramps have been provided along the road to guide the sludge spill to the containment area.

To transfer the spill volumes to the balance tank, drainage arrangements must be made to collect the volume, with the installation of potentially new pipework to transfer the sludge into the tank. It is understood that pipework exists between the derelict digesters and the balance tank, however, confirmation on existing connection between the new digesters and the balance tank is required. The opportunity to use these lines needs further investigation. Alternatively, new pipework from the drains to the balance tank must be installed for this scenario.

The drainage points shown in Figure 3.3 were positioned based on analysis of contours in the area. Figure 3.4 and 3.5 captures this analysis, showing points of high elevation (circled in pink) that will prevent flow to the south of the site, and low points in (circled in blue) where the spill is expected to collect. The drains were placed in the low points identified.

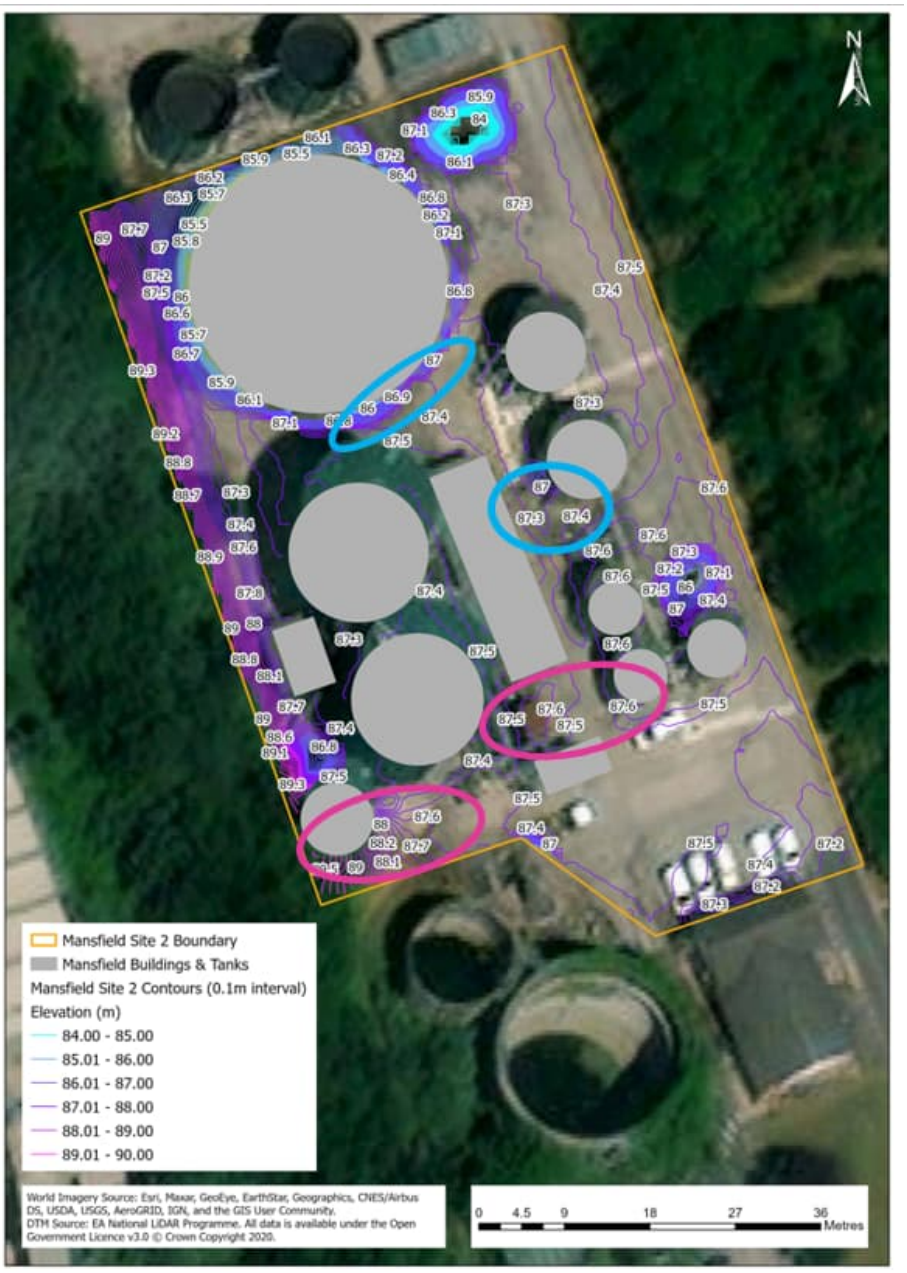

Figure 3.4 10cm contour of sludge area with high and low points identified

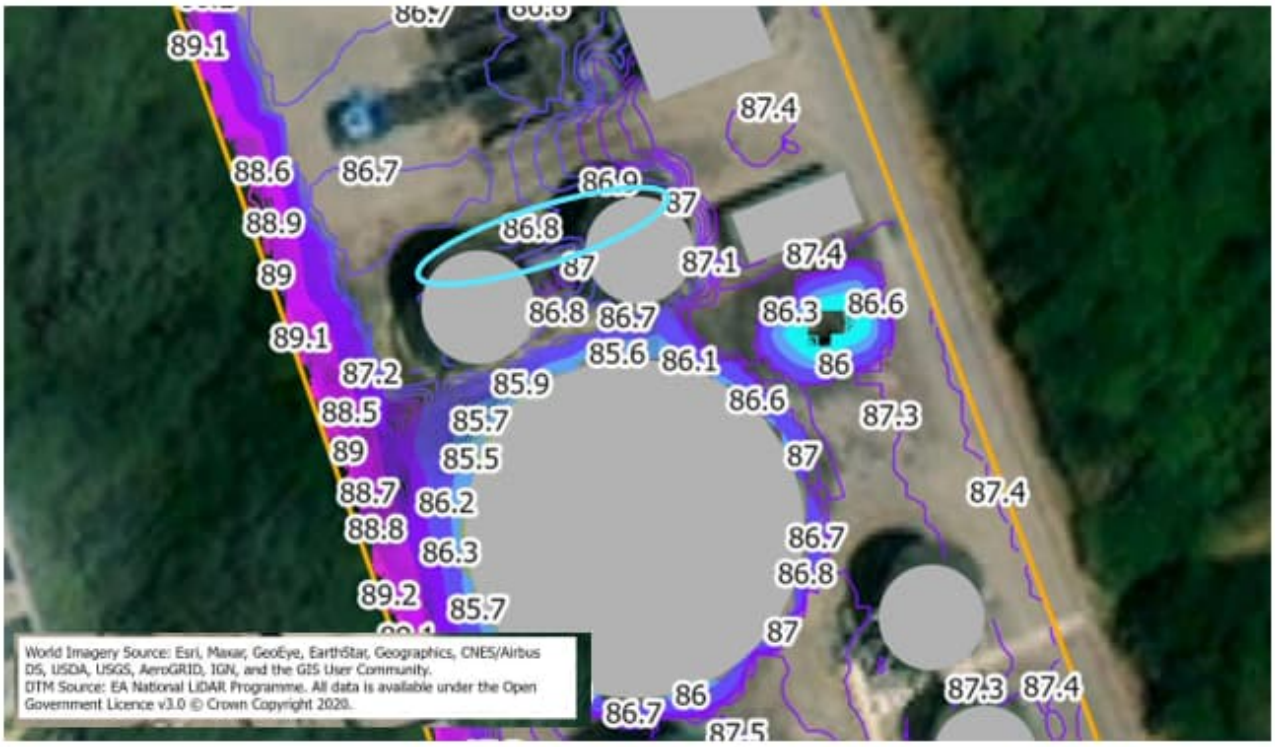

Figure 3.5 10cm contour of sludge area with high and low points identified

3.1.4 The Transfer System

Due to the topography of the site, the transfer of liquid from the digestors to the remote secondary containment occurs under gravity and no transfer system is required.

3.1.5 Remote Secondary Containment Summary

A summary of the containment solutions for the sludge area are listed in the table below.

Table 3.1 Summary of containment for option 1

	Impermeable Lining / m2	Wall/ barriers	Ramps	Other (Isolation Valves / Building Protection / Local Infill)
Transfer System	None	2 Sections of wall/bund: Max height 0.8m length 50m Max height 0.6m length 75m 100m of kerbing - to be raised 400mm above road level to direct and contain spillages	15m 200mm high - in 2 sections	Remove wall between balance tank and post-digestion tanks Isolation of drainage system to prevent it heading to head of works

Table 3.2 Summary of containment for option 2

	Impermeable Lining / m2	Wall/ barriers	Ramps	Other (Isolation Valves / Building Protection / Local Infill)
Transfer System	None	1 Sections of wall/bund: Max height 1.2m length 35m 100m of kerbing - to be raised 400mm above road level to direct and contain spillages	15m 200mm high - in 2 sections	Remove wall between balance tank and post-digestion tanks 2 sections of drainage line into balance tank Isolation of drainage system to prevent it heading to head of works

4. Site Drainage

Site drainage assessments are based on Mansfield Bath Lane STW Treatment Works Layout Plan Drawing Number DT7173/ Mansfield STW/001.

4.1 Foul, Process and Effluent Drainage

The sewage work plan for Mansfield shows that drainage pipes within the containment areas, indicated by red lines go to the head of the works shown in figures 4.1 and 4.2. In the event of sludge entering the head of the works, the shock load could adversely impact the sewage works treatment process. Therefore, in the event of a catastrophic loss of containment this line should be isolated.

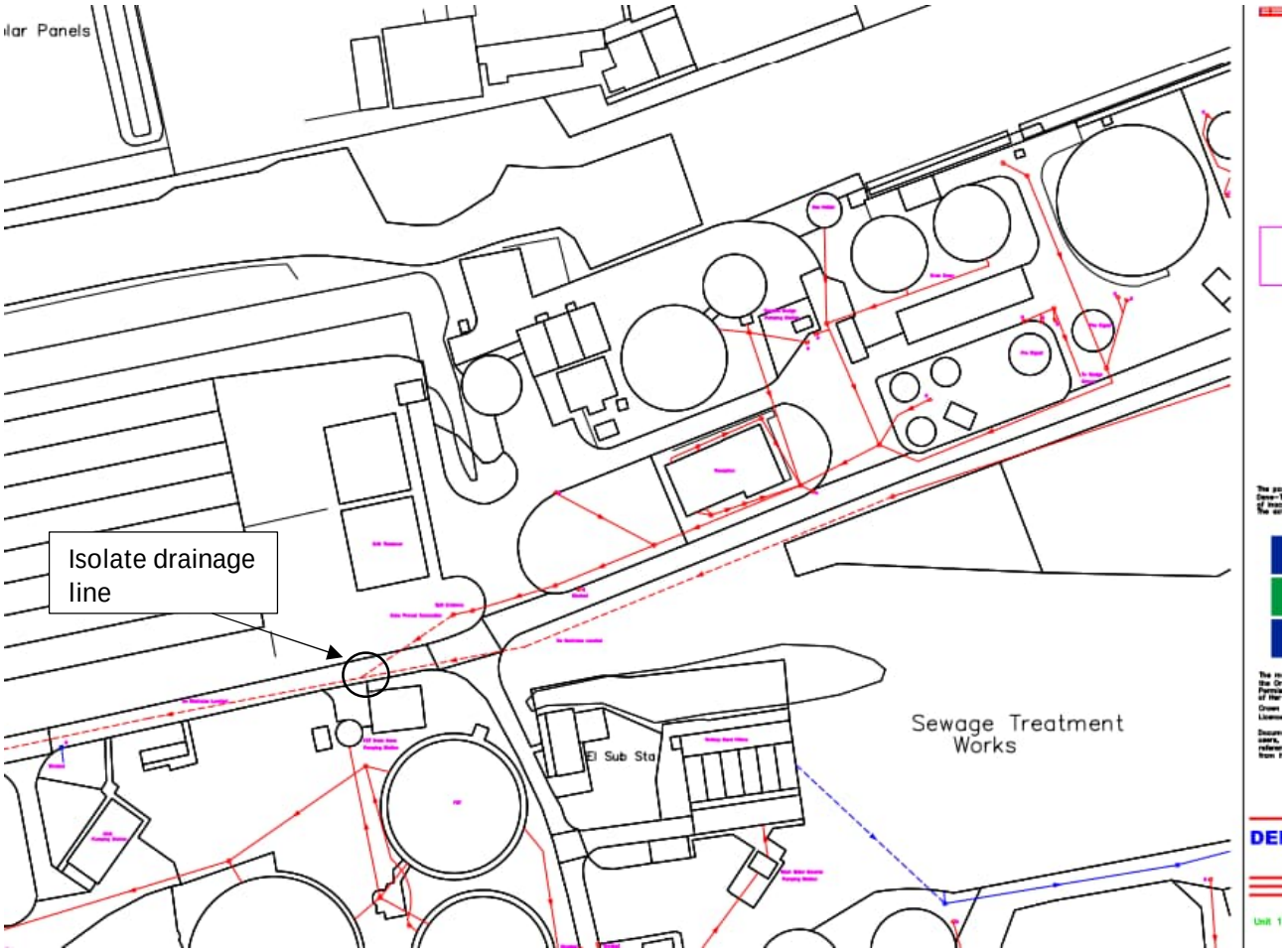

Figure 4.1 Mansfield STW Drainage layout Drawing number DT7177/Mansfield STW/003

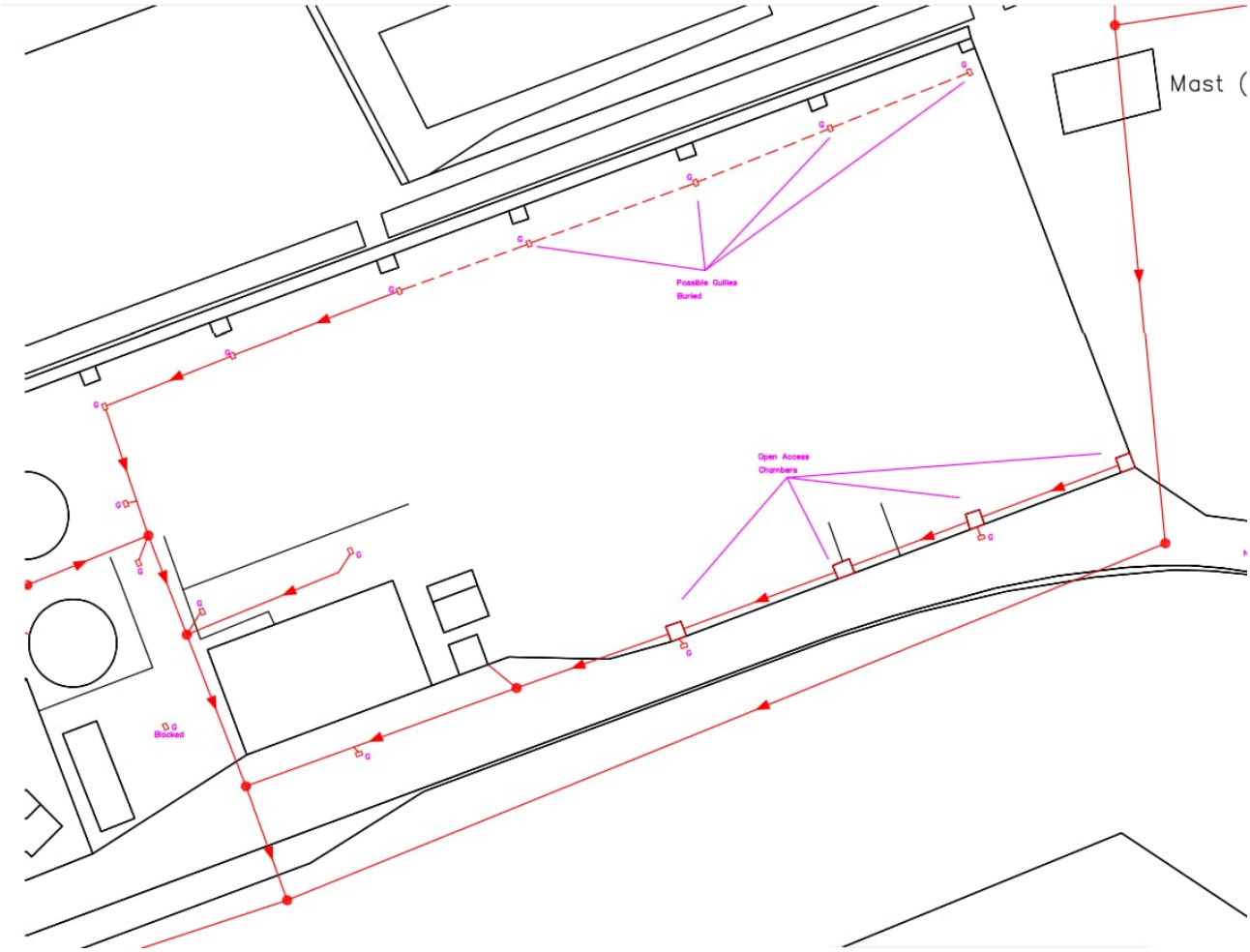

Figure 4.2 Mansfield STW Drainage layout Drawing number DT7177/Mansfield STW/004

4.2 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.
- 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. However, it should be noted that in this report jetting has been assessed at high level and it is recommended that prior to design any containment equipment, a detailed assessment is required to be completed, given that all distances in this report are made on estimates taken from Bing maps.

5.2 Flooding

According to the UK Government's Flood Map for Planning, Mansfield STW is not within any potential flooding zone (Flood Zone 1) as shown in Figure 5.1. The Flood Zone definitions listed in Table 4.1 provide additional detail of the areas of concern, which in the case of Mansfield 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 5.1 Flood Risk Map

6. Conclusions

This section summarises the findings of the containment assessment at sludge and bioresources areas, located at Mansfield sewage treatment work.

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

The assessment focuses on site-specific risks and outlines the options available for providing remote secondary containment of a catastrophic tank or digestor failure. Two options have been developed for the containment of spills within the sludge area.

Option 1 uses walls / kerbing and ramps to guide flows into the cake pad area. The cake pad is utilised to store the spill volumes. The cake pad requires 50m of 0.8m high wall or bunds and 75m of 0.6m high wall or bund, to provide an effective storage volume.

Option 2 utilises a redundant balance tank to provide storage for the spill volume. The balance tank will store 90% of the spill volume. The remaining 10% will be stored in the sludge area. To provide containment for the remaining spill 35m of 0.6m high wall or bund is required to the North of the post digestion tanks. Two drainage lines will be required to transfer flow from the containment area into the balance tank. Kerbing and ramps will be provided to guide flows to the balance tank area.

The preferred technical solution is option 2. The utilisation of the balance tank provides a more efficient solution. The height and length of walls, kerbing and ramps is smaller, and option 2 requires a smaller footprint of the site. The solution also has the benefit of not using the old cake pad, which means it can be used for future site developments.

The effect of jetting and surge flows were also assessed and found to pose no risk.

Finally, assessment of the risk of flooding at Mansfield STW based on the UK Government's Flood Risk for Planning, showed that the Bioresources area is in Flood Zone 1. This means that the likelihood of the sludge area flooding is very low at less than 1 in 1000 annual probability.

Appendix A. ADBA Site Hazard Risk Assessment for Mansfield STW

Site Name	Mansfield STW Containment Classification Assessment					
Revision	Date	Description	Author	Checked	Reviewed	Approved
1.0	31/01/2022	Draft	B. Brown			
1.1	20/04/2023	Final Draft	H. Rani	W. Liu	C.Sfynia	K.Chiu

Material	Physical properties	Quantity	units	Storage	Flammability	Corrosive	Ecotoxicity (based on LD and quantity)	Environmental hazard rating	Justification
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	Two Digesters, Three Thickening Tanks, Two Predigestion Blending Tanks and Two Post - Digestion Storage Tanks with total capacity of 5290m3.
Additives and site chemicals									
Ferric Chloride	Liquid	1	IVC	IVC	Not flammable	No	Low	L	Not present
Glycol	Liquid	1	IVC	IVC	Not flammable	No	Low	L	Not Present
Cleaning products	Liquid	1	IVC	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	Section not relevant
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" threfore the overall rating is low
							Sources Overall Hazard Rating	H	Justification: Digesters, thickening tanks, predigestion blending tanks and post digestion storage 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 River Maun within 4 minutes.
If any of the site inventory has a runoff time of a few hours....								L	Not Applicable
If any of the site inventory has a runoff time of a few days...								L	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 the site is raised above River Maun.
Chalk								L	According to the British Geological Survey the site is not in the chalk aquifer zone
Fractured chalk								L	Not applicable
Principal Aquifer								H	Principal Aquifer is present at the site
Groundwater protection zone 1								H	Groundwater Vulnerability is High according to Ground Water Vulnerability Map.
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: it is unclear where site drainage goes to Mansfield Bath Lane STW Treatment Works Layout Plan Drawing Number DT7173/ Mansfield STW/001. Assume high risk in lack of information.
Climatic conditions									
Annual rainfall < 1000 mm								M	Annual rainfall within 715.57 mm - 809.89 mm
Annual rainfall > 1000 mm								L	Not Applicable
Snow accumulation is possible								M	Yes
Fire Fighting Water									
Inflammable materials normally present on site in large quantities?								L	Not Present
Location									
Site is in a flood plain								M	The Mansfield STW site is in Flood Zone 2 whereas the IED permitted area is in Flood Zone 1.
Site is at bottom of a hill								H	The site inclines from West to East, towards the river
Site is connected to a sewage treatment works								H	Area IED permitted is connected to sewage treatment works
							Site Considerations Overall Rating	H	Justification: IED permitted area is connected to sewage treatment works.
							Pathway Overall Hazard Rating	H	Justification: The site inclines from West to East, towards the river

Receptors	Within	units						Environmental hazard rating	Notes
Watercourses and bodies									
Rivers above potable water supplies	100	m						H	The River Maun is within 30m from the east side of the IED permit Area.
Aquifers used for public supply	150	m						H	Principal Aquifer is present at the site
High quality waters	1000	m						L	Not found
Agricultural abstraction points	50	m						L	No Agricultural abstraction identified via desktop analysis
High value ecosystems	1000	m						H	SSSI and LNR sites are near the IED permitted area
Recreational waters	50	m						L	Not applicable
Small treatment works	50	m						H	A B Waste disposal is within 50m from the Sewage Treatment site
None of the above								L	Not applicable
							Water Overall Rating	H	Justification: The River Maun is within 30m
Habitation									
Dwelling	250	m						H	Housing is within 240m from the site
Workplace	250	m						H	Workplace is within 170m of the IED site. Secondary School The Brunts Academy is within 260m.
None of the above								L	Not applicable
							Habitation Overall Rating	H	Justification: There is an industrial estate on the west boundary of the site
Other									
SSSI/SPA/SAC	1000	m						H	Ravensdale LNR east 60m; Maun Valley Park LNR east 560m; Oak Tree Heath LNR South-East 3300m; Quarry Lane LNR South 2800m; Oakham LNR South 3500m ; The Hermitage LNR South 4000m; Pleasley Vale LNR North- East 3330m ; Pleasley Vale Railway SSSI North-East 4150m.
RAMSAR Site	1000	m						L	Not present
None of the above								L	Not applicable
							Other Overall Rating	H	Justification: SSSI and LNR sites are present nearby the site.
							Receptors Overall Hazard Rating	H	Justification: SSSI and LNR sites are present nearby the site.

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
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. Mansfield STW Site Surfacing Plan