AMBER PLANNING
Flood Risk & Hydrology

Flood Risk Assessment
September 2020
Version 2

Extension of Sand & Gravel Extraction Area
Land at Watlington Quarry
Tottenhill, King's Lynn
Norfolk
PE33 0RG

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EXECUTIVE SUMMARY

Site Area	10.5 (Extension Area) 19.7ha (Entire Site)
Existing / Historic Use	Grade 3 agricultural land
Proposed Use	Extension of existing permitted sand and gravel activities within an 10.5ha plot.
Flood Zone	Flood Zone 1 (Low Risk)
Groundwater Flooding	Low
Infrastructure Failure	Low
Overland Flow - Flooding	Low
Sewer Flooding	Low
Change to Site Surface Finishings (Y/N)	Yes.
Infiltration Potential?	No. Precluded by underlying clay geology.
Attenuation Storage Proposed	Phase 1 - Mineral Extraction: 5,425m^3 Phase 2 – Restored Landform: 4,205m^3
Potential Receptor for Surface Water Discharges	Local watercourses (Greenfield rates).
Climate Change Allowance	Phase 1 - Mineral Extraction: 20% based on a development lifetime <50 years (non-residential). Phase 2 – Restored Landform: 40% based on a development lifetime 100 years (final landform).

1.0 INTRODUCTION

1.1 Background

1.1.1 Amber Planning Ltd. has been appointed to prepare a Flood Risk Assessment (FRA) in support of an application for a 10.5ha extension of existing permitted sand and gravel extraction activities within a wider plot of land at Watlington Quarry, Lynn Road, Tottenhill, King's Lynn, Norfolk, PE33 0RG.

1.1.2 The area falls under the administration of the Borough Council of King's Lynn and West Norfolk, and Norfolk County Council.

1.1.3 Reference to Environment Agency (EA) online Flood Maps indicates the study area to be situated entirely within Flood Zone 1 (Low Risk), Figure 001.

1.1.4 This assessment has been prepared in accordance with the National Planning Policy Framework (NPPF) and its Planning Practice Guidance (PPG). The requirements of the Environment Agency, the Borough Council of King's Lynn and West Norfolk, and Norfolk County Council have also been accounted for within this study.

Figure 001: Environment Agency Indicative Fluvial Flood Map

1.2 Objectives

1.2.1 The objectives of the Flood Risk Assessment are to:

- Review national and local planning policy documents and identify any issues they raise, and which need to be addressed in relation to flooding and hydrology;
- Review readily available information on flooding using data provided by the EA and, where available, the Strategic Flood Risk Assessment (SFRA);
- Evaluate the background hydrology;
- Assess the risks from all sources of flooding, including fluvial;
- Consider the surface water drainage requirement(s); and
- Recommend mitigation and / or management measures required to prevent detrimental impacts to flooding or hydrology at the site or in downstream receptors.

1.2.2 Local development framework documents, as well as strategic policy and technical studies, have been reviewed as part of this study.

1.3 Confidentiality

1.3.1 Amber Planning has prepared this report solely for the use of The Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from Amber Planning; a charge may be levied against such approval.

2.0 SOURCES OF INFORMATION

2.1 General

2.1.1 In preparing this assessment background information has been sought from the following sources:

- Communities and Local Government (2019). National Planning Policy Framework;
- Communities and Local Government (*Living Document*). Planning Practice Guidance;
- UK Government Guidance (2020). Flood Risk Assessments: Climate Change Allowances[1];
- CIRIA (2015). C753: The SUDS Manual V.6;
- Borough Council of King's Lynn and West Norfolk website Planning Policy page[2];
- Norfolk County Council Waste and Minerals Planning Policy Page[3];
- Norfolk County Council (Sept. 2011). Core Strategy Minerals and Waste Development Management Policies DPD;
- Norfolk County Council (Oct. 2013). Minerals Site Specific Allocations DPD;
- Norfolk County Council (Oct. 2013). Waste Site Specific Allocations DPD;
- Norfolk County Council (Dec. 2017). Minerals and Waste Development Framework – Revised Policies Map;
- Norfolk County Council (*Living Document*). Interactive Planning Policy Map;
- Borough Council of King's Lynn and West Norfolk (Nov. 2018). Level 1 Strategic Flood Risk Assessment;
- Borough Council of King's Lynn and West Norfolk (Mar. 2019). Level 2 Strategic Flood Risk Assessment;
- Environment Agency Flood Mapping[4] (Aug. 2019);
- British Geological Survey online mapping[5];
- Centre for Ecology and Hydrology Flood Estimation Handbook (FEH) Web Service, hydrometric data[6]; and
- Topographical Survey (July 2019).

2.2 Planning Context - National Planning Policy

National Planning Policy Framework

2.2.1 The National Planning Policy Framework (NPPF) Section 14: Meeting the Challenge of Climate Change, Flooding and Coastal Change, considers the implications of flooding within the planning process. According to the NPPF:

'A site-specific flood risk assessment is required for:

- *All development within Flood Zones 2 (Medium Risk) and 3 (High Risk);*

In flood zone 1 an assessment should accompany all proposals involving:

- *Sites of 1ha or more;*
- *Land identified by the Environment Agency as having critical drainage problems;*
- *Land identified in a Strategic Flood Risk Assessment as being at increased flood risk in future; or*

[1] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2
[2] https://www.west-norfolk.gov.uk/homepage/19/planning_policy_and_local_plan
[3] https://www.norfolk.gov.uk/what-we-do-and-how-we-work/policy-performance-and-partnerships/policies-and-strategies/minerals-and-waste-planning-policies
[4] http://www.Gov.uk
[5] http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[6] https://fehweb.ceh.ac.uk/GB/map

- *Land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.'*

2.2.2 Paragraph 163 of the NPPF states the following regarding the consideration of flood risk within the planning application process:

'When determining any planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood risk assessment. Development should only be allowed in areas at risk of flooding where, in light of this assessment (and the sequential and exceptions tests, as applicable), it can be demonstrated that:

a) Within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

b) The development is appropriately flood resistant and resilient;

c) It incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

d) Any residual risk can be safely managed; and

e) Safe access and escape routes are included, where appropriate, as part of an agreed emergency plan.'

2.3 Planning Context - Local Planning Policy

Minerals and Waste Development Framework

2.3.1 The Norfolk County Council Minerals and Waste Local Plan Review is being prepared and will consolidate the three currently adopted Minerals and Waste Development Framework documents into one Local Plan, with this document due to be adopted in March 2022. This process will ensure that policies will remain up-to-date and extend the period to the end of 2036. The three current documents include:

- Core Strategy and Minerals and Waste Development Management Policies Development Plan (2010-2026) adopted 2011;
- Site Specific Allocations: Minerals (2013 with amendments adopted 2017); and
- Site Specific Allocations: Waste (2013).

2.3.2 Policies relevant to the consideration of Flood Risk and Drainage are as follows:

- Policy CS13: Climate Change and Renewable Energy Generation
- Policy CS14: Environmental Protection
- Policy DM2: Core River Valleys
- Policy DM3: Groundwater and Surface Water
- Policy DM4: Flood Risk
- Policy DM11: Sustainable Construction and Operations

2.3.3 Review of the interactive Planning Policies Map indicates the site to be located within a mineral safeguarding area for sand and gravel. It is also listed as MIN 206 within the July 2019 Draft Preferred Options (aggregates sites) for the emergent Minerals and Waste Local Plan Review.

Strategic Flood Risk Assessment

2.3.4 The Level 1 and 2 Strategic Flood Risk Assessment (SFRA) reports evaluate the extent and nature of flooding in the district, they also consider the implications for land use planning and sets out the criteria for submitting future planning applications and guiding development control decisions.

2.3.5 These documents have been reviewed as part of this study.

3.0 BACKGROUND AND DATA REVIEW

3.1 Site Setting

Property Address	Land at Watlington Quarry, Lynn Road, Tottenhill, King's Lynn, Norfolk, PE33 0RG.
National Grid Reference	563569, 311731
Area	10.5 (Extension Area) 19.7ha (Entire Site)

Table 001: Site Setting

3.2 Current Layout

3.2.1 The application area comprises an 10.5ha plot of greenfield agricultural land to the south of the existing working area at Watlington Quarry, Figure 002.

Figure 002: Existing Site Layout – Aerial Photograph

3.3 Proposed Development

3.3.1 Planning permission is sought for a 10.5ha extension to existing permitted Sand and Gravel extraction and associated activities on land to the south of the existing Watlington Quarry. Whilst a section of the existing working quarry forms part of the application area, no material alteration to this part of the site is proposed, with the focus of this study on the southern extension (Mineral Extraction and Restoration).

3.3.2 It is proposed to extract a total of approx. 748,000 tonnes of sand and gravel as well as some of the underlying Kimmeridge Clay to supply local flood defence works, lining of lagoons and capping of landfill sites at a potential rate of 90,000 tonnes per annum.

3.3.3 Following extraction it is proposed to restore land to its pre-developed levels with imported inert material (c. 800,000m^3) to return the land to productive agriculture.

3.4 Topographical Survey

3.4.1 Topographical survey data has been provided (Appendix I), which indicates ground levels within the proposed extension area to range between 7.7m AOD and 10m AOD. Lowest levels are seen in the south, while highest levels are seen on the northern boundary of the proposed extraction area, indicating levels to reduce in a southerly direction.

3.4.2 Ground levels within the working quarry present to the north are uneven and likely to have been subject to significant disruption. Surface elevations at the northern access onto Watlington Road are located at 7m AOD increasing in a westerly direction to along Watlington Road to 9m AOD adjacent to the north western boundary of the wider site.

3.5 Surrounding Area

Direction	Description
North	Existing quarry, lakes, Watlington Road and agricultural land beyond.
South	Lakes, Lynn Road, retail park, wooded area and agricultural land beyond.
East	Lynn Road, lakes, Whin Common and agricultural land beyond.
West	Lakes, Watlington Road, Tottenhill Row Common and Long Wood beyond.

Table 002: Site Surrounds

3.5.1 The nearest settlements are Tottenhill, immediately south east; and Watlington 0.45km south west. The nearest towns are King's Lynn, 6.4km north and Downham Market, 7.4km south.

3.6 Hydrogeology

3.6.1 Regional geological mapping indicates the bedrock geology to comprise the Kimmeridge Clay Formation (Mudstone), overlain by superficial glacigenic deposits of the Tottenhill Gravel Member (Gravel).

3.6.2 Whilst the presence of permeable deposits indicates the potential use of infiltration for surface water disposal, it is likely that these will be removed by the proposed mineral extraction activities, exposing the underlying Kimmeridge Clay. The impermeable nature of this underlying geology precludes the use of infiltration as the primary means of surface water disposal.

3.6.3 BGS borehole data is not available within the application area, however, an abundance of boreholes is present to the east of the site, refer to Figure 003. No surface elevations are recorded for the boreholes although groundwater is indicated to be struck variably between 3.2m bgl and 5.5m bgl across a sample selection.

Figure 003: British Geological Survey Borehole Location Map

3.6.4 Mapping data downloaded from Defra's Magic website[7] confirms the site to be located external to Groundwater Source Protection Zones.

3.6.5 Taking account of the underlying clay geology, depth to groundwater and proposed nature of use, the risk posed by this form of flooding is considered to be **Low**, with no further assessment required.

3.7 Hydrology

3.7.1 The application area is situated 450m north and 400m east of Hobb's Drain, which flows in a north westerly direction adjacent to the southern site boundary, before heading north for 1.5km and entering the Polver Drain. The Polver Drain flows in a westerly direction passing within 0.65km of the northern site boundary, before entering the Great Ouse Relief Channel some 2.6km downstream. The Relief Channel flows parallel to the main River Great Ouse for 4.85km with the two watercourses eventually convening upstream of King's Lynn.

3.7.2 The River Nar is situated 1km north of the application site, to the north of the Polver Drain and also flows in a westerly direction for c.1.5km before heading north, flowing parallel to the Great Ouse Relief Channel, eventually convening with the main River Great Ouse at King's Lynn some 6km downstream.

3.7.3 A number of lakes are present in the vicinity of the site, which are assumed to have been formed by historic quarrying activities. The lakes present to the south west, within the wider quarry boundary, discharge via a drainage channel into the Hobb's Drain some 450m south of the site. This channel is culverted beneath Watlington Road.

3.7.4 Catchment descriptor information has been downloaded for the area from the CEH Flood Estimation Handbook web data service (Sept. 2019), which is summarised in Table 003. This indicates a small, essentially rural catchment, with low topographical relief and low to moderate average annual rainfall.

3.7.5 Flows within local watercourses are indicated to be predominated by baseflow (BFIHOST) with more minor contributions from overland flow (SPRHOST) and with a low catchment response to incident rainfall anticipated. The catchment response may be further reduced by the lakes present in this locale; these linked to historic mineral workings.

Catchment Descriptor	Value
AREA	8.20km^2
River Baseflow Index (BFIHOST)	0.804
Standard Percentage Runoff (SPRHOST)	22.87%
Drainage Path Length (DPLBAR)	3.64km
Drainage Path Slope (DPSBAR)	10.10m/km
Flood Attenuation by Rivers and Lakes (FARL)	0.915
Proportion of time soils are wet (PROPWET)	0.230
Standard Annual Average Rainfall (SAAR)	607mm
Urban Extent (URBEXT: 2000)	0.0145

Table 003: FEH Catchment Descriptor Information

3.8 Flood Zone Classification

3.8.1 The site is confirmed to be to be located wholly within Flood Zone 1 (Low Risk).

[7] https://magic.defra.gov.uk/MagicMap.aspx

Flood Defences

3.8.2 The application area is confirmed to be within Flood Zone 1 with no flood defences indicated to be present.

3.9 Flood Risk Vulnerability

	Flood Risk Vulnerability Class'n (PPG Table 2)	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone (PPG Table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	Exception Test Required	✓	✓	✓
	Zone 3a	Exception Test Required	x	Exception Test Required	✓	✓
	Zone 3b (Functional Floodplain)	Exception Test Required	x	x	x	✓

Key:

✓ Development is appropriate x Development should not be permitted

Table 004: PPG Table 3 – Flood Risk Vulnerability and Flood Zone Compatibility

3.9.1 Table 2 of the PPG defines the development as '*Sand and Gravel Working*' and classifies this use as '*Water Compatible*.' Table 3 of the PPG considers all land uses appropriate use within Flood Zone 1.

3.10 NPPF Sequential and Exception Tests

3.10.1 The Sequential Test steers development preferentially towards Flood Zone 1 (Low Risk), considering Flood Zone 2 (Medium Risk) and then Flood Zone 3 (High Risk) only if land cannot be identified as available for development in zones at lower risk from flooding.

3.10.2 The Sequential Test is generally carried out at a strategic level by the Local Planning Authority with input from the Environment Agency, as part of the Local Plan process and should be informed by a Strategic Flood Risk Assessment.

3.10.3 The proposed quarry extension is located within Flood Zone 1 and therefore passes the Sequential Test by default, with no requirement for application of the Exception Test. Nevertheless, element two of the Exception Test is addressed within this FRA.

3.11 Climate Change

Rainfall Allowance

<u>Mineral Extraction</u>

3.11.1 Government Guidance on Climate Change Allowances to Peak Rainfall Intensity (Table 2), requires application of climate change factors of up to 20% (Upper End) to 2069, based on a development lifetime <50 years (non-residential use).

<u>Restored Landform</u>

3.11.2 The restored landform has a default lifetime of 100 years, which requires consideration of climate change factors at between 20% (Central) and 40% (Upper End) to 2115.

3.12 Infrastructure Failure

3.12.1 Flooding from artificial sources occurs when man made infrastructure e.g. flood defences, raised channels or surface water storage features, including reservoirs, becomes overwhelmed leading to breach or failure. The probability of failure is low owing to regular inspection and maintenance regimes. However, in the event of a breach occurring, the consequences can be significant.

3.12.2 Review of the EA National Reservoir Flood Maps (Figure 004) indicates the application area to be unaffected by reservoir flooding and to be remote from raised waterways or flood defence infrastructure, the failure of which could lead to flooding.

3.12.3 The risks posed to the development by infrastructure failure are therefore concluded to be **Low**, with no further investigation required.

Figure 004: Environment Agency Reservoir Flood Map

3.13 Surface Water Flooding

Figure 005: Environment Agency Surface Water Flood Map

3.13.1 Detailed pluvial flood mapping downloaded from the EA website, assesses three main scenarios, Low Risk (0.1%-1% probability of flooding annually), Medium Risk (3.3% - 1%) and High Risk (>3.3%). The findings of this assessment are summarised in Figure 005.

3.13.2 This data indicates the majority of the application area to be at **Very Low** risk of flooding, with no further assessment required.

3.14 Sewers

3.14.1 The application area is considered to be remote from public surface water sewers, with no further assessment proposed.

4.0 FLOOD RISK ASSESSMENT

4.1 Flood Risk Screening Opinion

4.1.1 In accordance with the NPPF Section 14 it is necessary to consider all forms of flood risk. A flood risk scoping exercise has therefore been completed for the site, the results of which are outlined in Table 005.

Nature of Flood Risk	Flood Risk to Site?
Groundwater	No. Groundwater is located at depth. Underlying Clay geology further reduces risk.
Tidal	No. Plot is situated inland.
Fluvial	No. Flood Zone 1 (Low Risk).
Infrastructure Failure (Reservoirs, Canals and Other Artificial Sources)	No. The property is remote to infrastructure (flood defences / reservoirs / raised waterways), the failure of which could lead to flooding.
Overland Flow (surface water from off-site sources)	No. EA Flood Maps indicate a **Very Low** risk from surface water flooding.
Sewers	No. The flood risk from sewerage infrastructure is considered to be low with no further assessment required.
Surface Water Drainage (on-site)	Yes. An uplift in the surface water runoff coefficient will arise from development proposals. Full surface water management is proposed in line with best practice for new development.

Table 005: Flood Risk Screening Opinion

4.2 Summary of Flood Risk

4.2.1 In accordance with the requirements of the NPPF all potential flood risks posed to / by the development have been assessed and concluded to be **Low**, with no requirement for flood mitigation and/or management.

4.2.2 The proposals are therefore considered appropriate within the context of the Local Planning Policy documents and paragraph 163 of the NPPF:

- *Is the site at risk of flooding?*

If yes and following the Sequential Test:

- *Has the most vulnerable development been located in areas of lowest flood risk?*
- *Is development appropriately flood resilient and resistant?*
- *Can any residual risk be safely managed (including safe access / escape routes)?*
- *Has priority been given to the use of SUDS?*

4.2.3 Potential impacts to flood risk arising from surface water generated within the development are addressed in Section 5.0.

5.0 SURFACE WATER

5.1 Introduction

5.1.1 An application is to be submitted for an 10.5ha extension of existing Sand and Gravel extraction activities on land to the south of the existing Watlington Quarry, Lynn Road, Tottenhill, King's Lynn, Norfolk, PE33 0RG.

5.1.2 The site currently drains via infiltration into the underlying soils with excess runoff discharged to the surrounding lakes and local watercourses via overland flow.

5.1.3 The NPPF and its PPG require that existing runoff rates be maintained, taking account of climate change and that, wherever possible, a degree of betterment is provided.

5.1.4 An increase in the runoff coefficient will arise from development proposals which, without mitigation, would have a consequent detrimental impact on the rate and volume of surface water runoff generated. This would be further compounded by climate change impacts over time.

5.1.5 In accordance with the NPPF new development must incorporate flood attenuation measures sized to accommodate flows from impervious areas for return period pluvial flood events up to and including 100 years, taking account of climate change and with discharges restricted to greenfield rates. This is discussed in greater detail below.

5.1.6 The use of Sustainable Drainage Systems (SuDS) has been considered wherever possible.

5.2 Land Use

Surface Finishing	Runoff Coefficient	Pre-Developed (ha)	Working Quarry (ha)	Restored Landform (ha)
Agricultural Land (Greenfield)	0.35	10.50	0.00	0.00
Exposed Clay	0.85	0.00	10.50	0.00
Restored Landform (Clay soils at pre-developed ground levels). Final use Agricultural.	0.45	0.00	0.00	10.67
Species Rich Grassland	0.30	0.00	0.00	5.98
Reed Beds (restored silt lagoons)	0.20	0.00	0.00	1.73
TOTAL		**10.50**	**10.50**	**18.38**
Runoff Coefficient		**0.35**	**0.85**	**0.38**

Table 006: Summary of Land Use

5.3 SuDS Options for Surface Water Disposal

5.3.1 Desk based investigation indicates the presence of underlying clay bedrock geology, overlain by Sand and Gravel deposits. The proposed extraction of the overlying sand and gravel deposits and exposure of the underlying (impermeable) Clay precludes the use of infiltration as the primary means of surface water disposal.

5.3.2 The lakes present within the wider quarry currently discharge south via a drainage channel into the Hobb's Drain. It is therefore proposed to continue to release all clean runoff to local watercourses, following upstream water quality treatment, attenuation and discharge control. This will be supplemented by SuDS measures interspersed throughout the site, wherever possible. This is in accordance with the SuDS hierarchy as outlined within Section 3.2.3 of the SuDS Manual, and summarised below:

SuDS Discharge Hierarchy:

- Infiltration. No: Precluded by impervious underlying geology.
- Discharge to surface waters. Yes – an ordinary watercourse is present within the site into which a gravitational connection could be established. **Preferred Option**.
- Discharge to surface water sewer. No – none present.
- Discharge to combined sewer (last resort). No – none present.

5.4 Greenfield Runoff Rates

5.4.1 Greenfield runoff rates have been estimated using the WinDes Micro drainage ICPSUDS function, with input data from the Flood Estimation Handbook web service and based on linear interpolation from a 50ha catchment, in accordance with SUDS Manual guidance. Table 007 summarises the results of this analysis. Full copies of these calculations are located at Appendix II: *Workings*.

Return Period (yrs.)	Runoff Rate (l/s/ha)	Runoff Rate (l/s)* Working Quarry	Runoff Rate (l/s)** Restored Landform
Q_{BAR}	2.222	23.420	40.840
30	5.306	55.925	97.524
100	7.812	82.338	143.585

Table 007: Greenfield Runoff Rates

* Site area = 10.5ha

** Site area = 18.38ha

5.5 Attenuation and Discharge

5.5.1 The WinDes Micro Drainage software package has been used to estimate the surface water attenuation requirements. Storm scenarios were run for both winter and summer profiles, for a range of durations (15-10,080 minutes), taking account of land use data, allowable discharge rates and climate change, respectively. Copies of these calculations are contained within Appendix II and are summarised below.

5.5.2 The WinDes Micro Drainage package assumes all land surface to be impermeable. Therefore, where the runoff coefficient differs (e.g. gravel / stone chipping) the total contributing area has been multiplied by the runoff coefficient to establish '*Effective Impermeable Areas*' for assessment of **8.96ha** (Mineral Extraction) and **6.94ha** (Restored Landform). Impermeable surfaces (where present) are accounted for at 100%.

5.5.3 The above assumption is extremely conservative since the site would be subject to progressive restoration. The probability of all topsoil being stripped and each of the mineral voids remaining open at the same time is therefore exceptionally low.

Results

Return Period Rainfall Event (Yrs.)	Storage Requirement (m^3) Working Quarry	Storage Requirement (m^3) Restored Landform
$Q_{BAR\ Urban}$	2,200	1,660
30	4,140	3,130
100	5,425	4,205

Table 008: Surface Water Attenuation Requirements

5.6 Drainage Layout

Phase 1: Mineral Extraction

5.6.1 A maximum rainwater storage requirement of 5,425m^3 has been estimated. This will be provided within the base of the quarry voids, which will total up to 10.5ha in area once all mineral extraction has been completed. For the purpose of this assessment it has been assumed that a 0.46ha pond area is available for flood attenuation, (conservative).

5.6.2 It is demonstrated that the attenuation facility would accommodate runoff for return period rainfall events up to and including the 100 year storm without surcharge and accounting for climate change at 20%.

5.6.3 The following design considerations have been assumed:

- Depth: 1.48m
- Area: 0.46ha (4,600m^2)
- Max. Water Level: 1.179m
- Volume (Max. Water Level): 5,425m^3
- Freeboard: 300mm

5.6.4 Owing to the depth of the sand and gravel pits a dual pumped outfall arrangement is proposed with a single pump running under standard flow conditions and with a secondary pump to allow discharge at higher rates under extreme flood conditions. Both will be specified to discharge at existing greenfield rates.

5.6.5 The use of a dual pumped outfall arrangement will allow for a degree of redundancy and reduce the likelihood of surcharge arising from pump failure. It is recommended that use of the pumps be alternated daily to ensure both remain in good working order.

5.6.6 The pumped discharge will pass via a second pond designed to accept pumped inflows upstream of the discharge point to the drainage channel. This will enable the settlement of remaining silts and fines ahead of discharge to local watercourses and prevent scour at the outfall.

5.6.7 A dual gravity fed outfall arrangement is proposed from this second pond, with a low level outfall to maintain low flows within local watercourses under standard flow conditions, and a high level offtake to allow discharge at higher rates under extreme flood conditions. Discharge from both outfalls will be controlled by a restricted orifice fitted with a flow control slot and / or flap valve to ensure greenfield runoff rates are maintained and to reduce the likelihood of blockage leading to surcharge.

Phase 2: Restored Landform

5.6.8 A maximum rainwater storage requirement of 4,205m^3 has been estimated. This will be provided by an detention pond situated on the southern boundary and sized to accommodate runoff for return period rainfall events up to and including the 100 year storm, accounting for climate change at 40% and without surcharge.

5.6.9 The following design considerations have been assumed:

- Depth: 1.10m
- Length (Top of Bank): 101.6m
- Width (Top of Bank): 61.6m
- Length (Base): 95m
- Width (Base): 55m
- Bank Slope: 1:3
- Max. Water Level: 0.753m
- Volume (Max. Water Level): 4,205m^3
- Freeboard: >300mm

5.6.10 The pond will be situated at the topographically lowest point within the site to permit the discharge of runoff into the storage area via gravity.

5.6.11 A dual gravity fed outfall arrangement is proposed from the detention pond, with a low level outfall to maintain low flows within local watercourses under standard flow conditions, and a high level offtake to allow discharge at higher rates under extreme flood conditions. Discharge from both outfalls will be controlled by a restricted orifice fitted with a flow control slot and / or flap valve to ensure greenfield runoff rates are maintained and to reduce the likelihood of blockage leading to surcharge.

5.7 Network Capacity

Phase 1: Mineral Extraction

5.7.1 The sand and gravel pits will be contoured to convey runoff to perimeter swales via overland flow, which will discharge into a detention pond downstream. The swales will be sized to convey runoff for return period rainfall events up to and including the 100 year storm, including climate change and without surcharge.

5.7.2 The mineral voids will largely drain themselves, with incident rainfall stored within the base of the void(s). Nevertheless calculations have been prepared to inform the capacity required within the attenuation area(s) to accommodate rainfall events up to and including the 100 year storm, accounting for climate change at 20% and without surcharge.

5.7.3 The detention facility is designed to be dry under normal conditions becoming operational only following periods intense rainfall or storm activity. The design incorporates a 300mm additional freeboard above the maximum water level to account for seasonal variations in rainfall, successive storms and losses in storage associated with siltation.

5.7.4 Groundwater is indicated to be present at depth and it is anticipated that the attenuation facility will not suffer impacts to efficiency arising from elevated or perched water tables.

Phase 2: Restored Landform

5.7.5 The restored landform will be contoured to convey runoff to perimeter swales via overland flow, which will discharge into a detention pond downstream.

5.7.6 The attenuation facility is designed to be dry under normal conditions becoming operational only following periods intense rainfall or storm activity. Capacity is present to accommodate rainfall events up to and including the 100 year storm, accounting for climate change at 40% and without surcharge. The outer banks of the pond will be elevated (>300mm) relative to the inboard banks to retain surcharged runoff within on-site areas and to redirect it back into the surface water management systems.

5.7.7 The perimeter swales have been sized to accommodate runoff for return period rainfall events up to and including the 100 year storm, including climate change and without surcharge. The outer bank of the swales will be elevated (>300mm) relative to the inboard bank to contain runoff within the site and to direct water towards the attenuation facility via overland flowpaths. An emergency spill unit will be located on the swale headwall at the pond inlet to encourage overland flows to enter the pond via exceedance routes, and to direct runoff back into the main site in the event of surcharge of either the detention pond or upstream drainage network.

5.7.8 A 300mm freeboard will be provided above the maximum water level to account for seasonal variations in rainfall, successive storms and losses in storage associated with siltation.

5.7.9 Groundwater is indicated to be present at depth and it is anticipated that the attenuation facility will not suffer impacts to efficiency arising from elevated or perched water tables. Where groundwater is encountered during construction a clay liner should be incorporated to prevent its ingress.

5.8 Water Quality

5.8.1 The surface water drainage system incorporates a number of SuDS elements which have been designed in accordance with the SuDS Manual (CIRIA report no. C753). These are specified to provide on-site water quality treatment, taking account of the Pollution Hazard and Mitigation Indices outlined within Tables 26.2 and 26.3 of the SuDS Manual, respectively; with these summarised in Tables 009 and 010 of this report.

5.8.2 Review of the SuDS Manual Table 26.2 indicates there to be no hazard classification which applies specifically to the nature of development proposed. However, as the Mineral Extraction phase is industrial in nature a High Hazard has been assumed. A Very Low hazard has been assumed for the Restored Landform, based on its return to agricultural land, species rich grassland and wetland areas.

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Working Quarry Sites with heavy pollution (e.g. waste sites).	High	0.8	0.8	0.9
Restored Landform No applicable Hazard Index. Assessed as Very Low	Very Low	0.2	0.2	0.05

Table 009: Excerpt from CIRIA 753 Table 26.2 Pollution Hazard Indices for Different Land Use Classifications

		SuDS Mitigation Indices		
SuDS Component	**Development Phase Served**	**Total Suspended Solids (TSS)**	**Metals**	**Hydrocarbons**
Swale	▪ Mineral Extraction ▪ Restored Landform	0.5	0.6	0.6
Settlement Pond (detention area)	▪ Mineral Extraction	0.5	0.5	0.6
Detention Pond	▪ Mineral Extraction ▪ Restored Landform	0.5	0.5	0.6
Adjusted SuDS Mitigation Index[1]	**Mineral Extraction**	**1.00**	**1.10**	**1.20**
Adjusted SuDS Mitigation Index[1]	**Restored Landform**	**0.75**	**0.85**	**0.90**

[1] Applies where the Mitigation Index of individual SuDS component is insufficient to treat runoff in isolation and where 2 SuDS components (or more) are required in series

Table 010: Excerpt from CIRIA 753 Table 26.3 SuDS Mitigation Indices for Discharges to Surface Waters

Pollution Hazard – Phase 1: Mineral Extraction

5.8.3 Review of the above data indicates the Mitigation Index for each of the SuDS Components to be below the identified Pollution Hazard Index for each of the potential contaminants which may be present within runoff generated by the mineral extraction works.

5.8.4 The guidance notes within CIRIA 753, P.568 state that where the Mitigation Index of an individual SuDS component is insufficient to perform water treatment in isolation, two (or more) SuDS components will be required in series, where:

Total SuDS Mitigation Index = Mitigation Index$_1$ + 0.5 (Mitigation Index$_2$)

5.8.5 A factor of 0.5 is used to account for the reduced performance of secondary or tertiary components associated with already reduced inflow concentrations. For example, the adjustment for TSS would be calculated as follows:

Total SuDS Mitigation Index (TSS) = 0.5 + (0.5 * 0.5) + (0.5 x 0.5) = 1.0

5.8.6 The adjusted SuDS Mitigation Indices are presented in the bottom two rows of Table 010. Based on this adjusted data it is concluded that the proposed SuDS Mitigation measures outlined above and expanded on below, are sufficient to mitigate potential contaminants present within the runoff from the proposed mineral workings, with no further treatment measures required.

5.8.7 Nevertheless, where it is felt necessary an oil interceptor can be provided upstream of the surface water storage area to remove silts, suspended solids and hydrocarbons from runoff and to ensure that no detrimental impacts to water quality arise from development proposals.

Pollution Hazard – Phase 2: Restored Landform

5.8.8 Review of the above data indicates the identified Pollution Hazard Indices for all identified contaminants to be lower than the Mitigation Indices for at least one of the individual SuDS components, refer to Tables 009 & 010. It is therefore concluded that the proposed SuDS Mitigation measures outlined in Table 010 and expanded on below, are sufficient to mitigate potential contaminants present within site generated runoff.

Water Quality Treatment – Phase 1: Mineral Extraction

5.8.9 It is proposed to provide on-site water quality treatment to ensure only clean water is discharged, using one, or a combination of, the following water quality treatment, designed in accordance with the requirements of the SuDS Manual section 4 (Table 4.3) and Section 26 (Tables 26.2 and 26.3):

- Runoff will pass to the surface water storage area via perimeter swales. These will include step dams and flow expansion points to reduce flows and encourage silt / sediment deposition upstream of the outfall to the attenuation facility, particularly where elevated topographical relief is encountered;
- Attenuated runoff to be discharged into settlement ponds to remove residual silts and sediments upstream of the discharge point and prevent scour of the watercourse channel / banks downstream; and
- Where required, runoff will pass via a silt buster upstream of the discharge pumps; this to reduce the likelihood of pump blockage / failure;
- Reed planting is proposed within the settlement pond to further slow flows, encourage sedimentation / retention and aid water polishing.

5.8.10 The inclusion of the above measures will encourage the settlement and retention of sediments, preventing blockage of the inlets / outfall and the discharge of sediment laden water to local watercourses, reducing potential scour and ensuring that only clean water is discharged.

5.8.11 The underlying clay bedrock geology will prevent the opening of contaminant pathways between surface and groundwater and ensure that the detention facility will not suffer impacts to efficiency arising from groundwater ingress.

Water Quality Treatment – Phase 2: Restored Landform

5.8.12 The restored landform will drain via perimeter swales to an detention pond / detention facility, with reed beds present which will aid the settlement of silts and sediments. Given the limited potential contaminant sources present no further water quality mitigation measures are proposed.

5.9 Health and Safety

Phase 1: Mineral Extraction

5.9.1 All surface water storage areas are designed to be dry under normal conditions becoming wet only during periods of elevated rainfall and / or flooding.

5.9.2 The surface water storage area should be bunded and / or fenced to prevent accidental fall in and to reduce vehicle access / turning in close proximity.

5.9.3 Life buoys and other emergency lifesaving equipment and signage should be situated at regular intervals along the edge of the surface water storage area to reduce risks to site users in the event of flooding.

5.9.4 The area will not be publicly accessible and will service a working quarry, which would have site specific Health and Safety policies for working near water.

5.9.5 The full Health and Safety requirements should be established using a dedicated and appropriately qualified Health and Safety consultant, with specific regard to the potential hazards associated with on-site water bodies and in accordance with relevant Health and Safety guidance. All Health and Safety documentation should be fully ratified with the Lead Local Flood Authority.

Phase 2: Restored Landform

5.9.6 All surface water storage areas are designed to be dry under normal conditions becoming wet only during periods of elevated rainfall and / or flooding.

5.9.7 The outer banks of all swales and surface water attenuation facilities have been designed at 1:3 to allow safe crawl-out in the event of accidental fall in. Whilst the area will not be publicly accessible and will service an agricultural setting, in accordance with Chapter 36 of the SuDS Manual (CIRIA Report 753), the following design features should be incorporated within the final design of the detention pond:

- Max. bank slopes designed at 1:3 to permit safe crawl-out in the event of accidental fall in
- Dry / level benching (min. width 1.5m) provided above the max. lake water level
- Wet bench just below the standard water level c.1.5m wide
- Wet bench min. 1.5m wide located at 0.6m water depth
- Max. bank gradient 1:2.5 below 0.6m water depth to a max. depth of 1.5m
- Wet bench min. 1.5m wide to be situated at the 1.5m water depth, before the lake deepens further.

5.10 Management and Maintenance Responsibility

5.10.1 **Mick George Ltd.** will be responsible for ensuring the ongoing management and maintenance of the surface water management systems serving the quarry, either directly or via an appointed contractor.

Inspection and Maintenance Schedule

5.10.2 A programme of inspection and maintenance of the surface water management systems will be executed by the site facilities manager, or appointed drainage contractor. This should be undertaken in accordance with the schedule outlined below and following significant rainfall events and / or storm activity.

5.10.3 A photographic record of inspections should be undertaken to pick up long term changes that may not be apparent within a single inspection. Inspections should comply with all relevant Health and Safety legislation.

5.10.4 This management and maintenance schedule applies for the lifetime of the development.

Notes

5.10.5 All waste arisings should be collected by an approved contractor and should be subject to appropriate treatment and disposal. The site facilities manager should be contacted where pollution or blockage are identified.

Element	Frequency	Notes
Silt Traps / Silt Busters	**Mineral Extraction:** Weekly / following storm activity **Restored Landform:** NA	▪ Visual inspection, removal of accumulated silt.
Detention Areas / Swales	**Mineral Extraction:** Monthly **Restored Landform:** Quarterly	▪ Visual inspection for accumulated silt. Where significant siltation is seen, remedial works should be undertaken. ▪ Visual inspection / removal of accumulated, debris, blockage.
Reed Beds	Twice Annually (Mar. / Sept.)	▪ Regular cutting (annually following peak growth seasons) will be key to ensuring the longevity of the reed beds and preventing excessive die back. ▪ Where die back is seen replanting should be undertaken. A borrow area may be necessary elsewhere within the site (zones subject to more regular wetting, e.g. near to watercourses), where reeds can be grown and transplanted to the detention facilities area(s).
Vegetation	Quarterly (ensure cutting / strimming is undertaken at least twice during peak growing seasons e.g. Mar. / Sept.)	▪ Regular grass cutting and maintenance of shrubs / trees will be key in reducing the presence of debris which could block the drainage network or cause eutrophication of water bodies. ▪ Grass should be cut quarterly, with focus on the growing season (Mar. – Oct.) and leaves / debris cleared from landscaped areas. ▪ During the winter shrubs and trees should be pruned to reduce accumulated vegetation within the site / lagoons. ▪ All mowings / cuttings to be removed from vicinity of pond / swales to prevent eutrophication.
Inlets / Outfalls	**Mineral Extraction:** Weekly / following storm activity **Restored Landform:** Quarterly / following storm activity	▪ Visual inspection for accumulated debris or blockage, at both upstream and downstream faces. ▪ Check every orifice / inlet / outlet / structure for blockage or siltation, pour water into each to verify through flow. ▪ Remove any debris and rod where required.
Pumps	**Mineral Extraction:** Daily In accordance with manufacturers' specification. **Restored Landform:** NA	▪ Check pumps are working and no blockage or debris are present at the inlets / outlets. ▪ Regular servicing will be critical to the continued efficiency of the pumps serving the site.
Petrol Interceptors (Where required)	**Mineral Extraction:** In accordance with manufacturer's specification(s) **Restored Landform:** NA	▪ In accordance with manufacturers' specification(s)

Table 011: Drainage Inspection and Maintenance Schedule

6.0 CONCLUSIONS

6.1 Proposals include an 10.5ha extension of existing Sand and Gravel extraction activities on land to the south of Watlington Quarry, Lynn Road, Tottenhill, King's Lynn, Norfolk, PE33 0RG. The proposals are linked to an existing and established business use.

6.2 This Flood Risk Assessment has been completed in accordance with the guidance set out in the NPPF, Section 14, and its accompanying PPG, for '*Water Compatible*' development within Flood Zone 1. The requirements of Local Planning Policy, including the SFRA, have been accounted for within this assessment.

6.3 A scoping exercise has been completed which considers all potential flood risks, each of which have been fully assessed as part of this study and concluded to be low, taking account of the development lifetime and climate change predictions.

6.4 The surface water attenuation requirements have been assessed for both development phases using the WinDes Micro Drainage software package for return period rainfall events up to and including 100 years, taking account of allowable discharge rates, proposed changes in land use and climate change consideration.

6.5 It is anticipated that the provision of a formal surface water management system, which incorporates on-site attenuation, controlled discharge at Greenfield rates and water quality treatment, will ensure that potential detrimental impacts on flood risk and water quality are suitably mitigated throughout the anticipated development lifetime, in accordance with the National Planning Policy Framework and its accompanying Planning Practice Guidance.

6.6 All drainage networks have been designed to account for industry best practice with regards system capacity, with freeboard provided to allow for successive rainfall events, fluctuations in flow and flood levels, climate change sensitivity and losses in efficiency associated with siltation. Residual risks associated with pump failure (operational phase) have been suitably mitigated.

6.7 Mick George Ltd. will be responsible for the ongoing management and maintenance of the surface water management systems, throughout both development phases, taking account of their respective lifetimes.

6.8 The mitigation solutions noted within this report are subject to agreement with the Environment Agency, Borough Council of King's Lynn and West Norfolk, and Norfolk County Council in their respective capacities within the Lead Local Flood Authority and as part of the application process.

6.9 It is duly presented that the proposed quarry extension is appropriate within the context of the NPPF and Local Planning Policy.

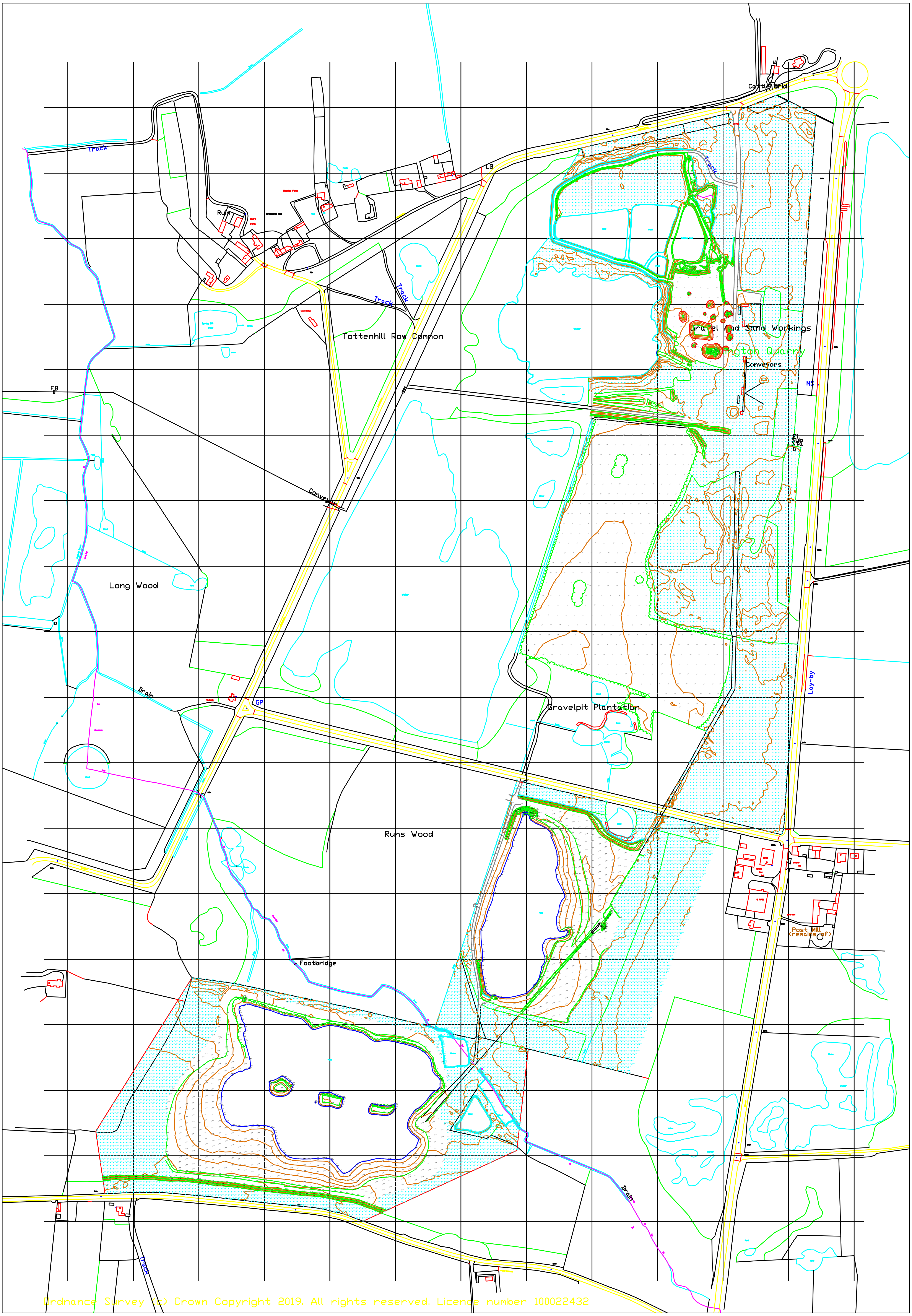
7.0 CLOSURE

7.1 This report has been prepared by Amber Planning Ltd. with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with The Client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

7.2 Reliance has been placed on factual and anecdotal data obtained from the sources identified. Amber Planning Ltd. cannot be held responsible for the scope of work, or any omissions, misrepresentation, errors or inaccuracies within the supplied information. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part in the event of delay between the writing of the report and its consideration by The Client, with particular regard to submission of a planning application.

7.3 This report is for the exclusive use of The Client; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from Amber Planning.

7.4 Amber Planning disclaims any responsibility to The Client and others in respect of any matters outside the agreed scope of the work.



Track
LB
Ruin
Cattle Grid
Track
Track
Track
Tottenhill Row Common
Gravel and Sand Workings
Conveyors
MS
FB
Conveyor
Long Wood
Drain
GP
Gravelpit Plantation
Lay-by
Runs Wood
Post Mill (remains of)
Footbridge
Drain
Track

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.350
Area (ha)	50.000	Urban	0.015
SAAR (mm)	607	Region Number	Region 5

Results	**l/s**
QBAR Rural	107.8
QBAR Urban	111.1
Q100 years	390.6
Q1 year	96.7
Q30 years	265.3
Q100 years	390.6

Summary of Results for 2 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.166	0.166	10.7	0.0	10.7	765.3	O K
30 min Summer	0.202	0.202	13.4	0.0	13.4	927.0	O K
60 min Summer	0.243	0.243	15.3	0.0	15.3	1117.9	O K
120 min Summer	0.290	0.290	17.2	0.0	17.2	1335.5	O K
180 min Summer	0.320	0.320	18.3	0.0	18.3	1470.2	O K
240 min Summer	0.340	0.340	19.0	0.0	19.0	1565.4	O K
360 min Summer	0.368	0.368	20.0	0.0	20.0	1691.6	O K
480 min Summer	0.384	0.384	20.5	0.0	20.5	1768.4	O K
600 min Summer	0.395	0.395	20.9	0.0	20.9	1815.5	O K
720 min Summer	0.402	0.402	21.1	0.0	21.1	1850.7	O K
960 min Summer	0.414	0.414	21.5	0.0	21.5	1906.4	O K
1440 min Summer	0.429	0.429	21.9	0.0	21.9	1971.9	O K
2160 min Summer	0.435	0.435	22.1	0.0	22.1	2002.1	O K
2880 min Summer	0.433	0.433	22.0	0.0	22.0	1990.7	O K
4320 min Summer	0.402	0.402	21.1	0.0	21.1	1850.7	O K
5760 min Summer	0.372	0.372	20.1	0.0	20.1	1711.9	O K
7200 min Summer	0.345	0.345	19.2	0.0	19.2	1586.3	O K
8640 min Summer	0.321	0.321	18.4	0.0	18.4	1475.1	O K
10080 min Summer	0.299	0.299	17.6	0.0	17.6	1377.5	O K
15 min Winter	0.186	0.186	12.5	0.0	12.5	856.7	O K
30 min Winter	0.226	0.226	14.5	0.0	14.5	1038.7	O K
60 min Winter	0.273	0.273	16.5	0.0	16.5	1253.7	O K
120 min Winter	0.326	0.326	18.6	0.0	18.6	1499.6	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	46.121	0.0	34
30 min Summer	28.124	0.0	48
60 min Summer	17.150	0.0	78
120 min Summer	10.457	0.0	134
180 min Summer	7.830	0.0	192
240 min Summer	6.377	0.0	250
360 min Summer	4.775	0.0	366
480 min Summer	3.888	0.0	482
600 min Summer	3.316	0.0	590
720 min Summer	2.911	0.0	634
960 min Summer	2.372	0.0	760
1440 min Summer	1.778	0.0	1018
2160 min Summer	1.332	0.0	1432
2880 min Summer	1.086	0.0	1844
4320 min Summer	0.788	0.0	2644
5760 min Summer	0.628	0.0	3416
7200 min Summer	0.527	0.0	4192
8640 min Summer	0.456	0.0	4936
10080 min Summer	0.404	0.0	5664
15 min Winter	46.121	0.0	34
30 min Winter	28.124	0.0	48
60 min Winter	17.150	0.0	76
120 min Winter	10.457	0.0	132

Summary of Results for 2 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.359	0.359	19.7	0.0	19.7	1652.7	O K
240 min Winter	0.383	0.383	20.5	0.0	20.5	1761.8	O K
360 min Winter	0.415	0.415	21.5	0.0	21.5	1908.0	O K
480 min Winter	0.435	0.435	22.1	0.0	22.1	1999.3	O K
600 min Winter	0.447	0.447	22.5	0.0	22.5	2058.4	O K
720 min Winter	0.456	0.456	22.7	0.0	22.7	2096.6	O K
960 min Winter	0.466	0.466	23.0	0.0	23.0	2141.5	O K
1440 min Winter	0.477	0.477	23.3	0.0	23.3	2196.5	O K
2160 min Winter	0.476	0.476	23.3	0.0	23.3	2191.6	O K
2880 min Winter	0.465	0.465	23.0	0.0	23.0	2139.5	O K
4320 min Winter	0.417	0.417	21.5	0.0	21.5	1916.9	O K
5760 min Winter	0.373	0.373	20.1	0.0	20.1	1714.2	O K
7200 min Winter	0.335	0.335	18.9	0.0	18.9	1539.4	O K
8640 min Winter	0.302	0.302	17.7	0.0	17.7	1391.3	O K
10080 min Winter	0.275	0.275	16.6	0.0	16.6	1266.2	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	7.830	0.0	190
240 min Winter	6.377	0.0	246
360 min Winter	4.775	0.0	360
480 min Winter	3.888	0.0	472
600 min Winter	3.316	0.0	582
720 min Winter	2.911	0.0	688
960 min Winter	2.372	0.0	790
1440 min Winter	1.778	0.0	1090
2160 min Winter	1.332	0.0	1548
2880 min Winter	1.086	0.0	1992
4320 min Winter	0.788	0.0	2824
5760 min Winter	0.628	0.0	3640
7200 min Winter	0.527	0.0	4408
8640 min Winter	0.456	0.0	5192
10080 min Winter	0.404	0.0	5944

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	2	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+20
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 8.959

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	1.792	4-8	1.792	8-12	1.792	12-16	1.792	16-20	1.791

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4600.0	1.625	4600.0

Orifice Outflow Control

Diameter (m) 0.132 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice Overflow Control

Diameter (m) 0.182 Discharge Coefficient 0.600 Invert Level (m) 0.682

Summary of Results for 30 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.424	0.424	21.8	0.0	21.8	1948.5	O K
30 min Summer	0.492	0.492	23.7	0.0	23.7	2263.2	O K
60 min Summer	0.569	0.569	25.8	0.0	25.8	2617.8	O K
120 min Summer	0.653	0.653	27.9	0.0	27.9	3004.1	O K
180 min Summer	0.703	0.703	29.0	0.3	29.4	3235.1	O K
240 min Summer	0.737	0.737	29.8	1.9	31.7	3392.0	O K
360 min Summer	0.778	0.778	30.7	5.9	36.6	3580.6	O K
480 min Summer	0.798	0.798	31.1	8.4	39.5	3671.3	O K
600 min Summer	0.806	0.806	31.3	9.2	40.5	3708.9	O K
720 min Summer	0.810	0.810	31.4	9.6	41.0	3726.5	O K
960 min Summer	0.817	0.817	31.5	10.4	41.9	3758.7	O K
1440 min Summer	0.823	0.823	31.6	11.0	42.7	3786.4	O K
2160 min Summer	0.818	0.818	31.5	10.4	42.0	3762.4	O K
2880 min Summer	0.805	0.805	31.3	9.1	40.3	3701.9	O K
4320 min Summer	0.750	0.750	30.1	3.0	33.0	3451.4	O K
5760 min Summer	0.693	0.693	28.8	0.1	28.9	3189.0	O K
7200 min Summer	0.637	0.637	27.5	0.0	27.5	2929.7	O K
8640 min Summer	0.587	0.587	26.3	0.0	26.3	2701.6	O K
10080 min Summer	0.544	0.544	25.2	0.0	25.2	2502.5	O K
15 min Winter	0.475	0.475	23.3	0.0	23.3	2183.5	O K
30 min Winter	0.551	0.551	25.3	0.0	25.3	2536.8	O K
60 min Winter	0.638	0.638	27.5	0.0	27.5	2935.4	O K
120 min Winter	0.733	0.733	29.7	1.7	31.4	3370.8	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	117.429	0.0	34
30 min Summer	68.471	0.0	49
60 min Summer	39.924	0.0	78
120 min Summer	23.279	0.0	136
180 min Summer	16.980	0.7	194
240 min Summer	13.574	9.5	252
360 min Summer	9.901	50.7	368
480 min Summer	7.915	103.1	484
600 min Summer	6.653	150.4	600
720 min Summer	5.773	190.7	642
960 min Summer	4.618	252.2	758
1440 min Summer	3.371	310.1	1012
2160 min Summer	2.461	301.1	1424
2880 min Summer	1.968	255.2	1840
4320 min Summer	1.392	72.6	2692
5760 min Summer	1.089	1.0	3528
7200 min Summer	0.900	0.0	4328
8640 min Summer	0.770	0.0	5104
10080 min Summer	0.675	0.0	5856
15 min Winter	117.429	0.0	34
30 min Winter	68.471	0.0	48
60 min Winter	39.924	0.0	76
120 min Winter	23.279	6.1	134

Summary of Results for 30 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.788	0.788	30.9	7.3	38.2	3623.2	O K
240 min Winter	0.823	0.823	31.6	11.0	42.7	3787.8	O K
360 min Winter	0.865	0.865	32.5	16.8	49.4	3977.6	O K
480 min Winter	0.884	0.884	32.9	19.7	52.6	4064.5	O K
600 min Winter	0.891	0.891	33.0	20.7	53.8	4098.3	O K
720 min Winter	0.893	0.893	33.1	21.0	54.1	4106.3	O K
960 min Winter	0.901	0.901	33.2	22.2	55.4	4142.3	O K
1440 min Winter	0.900	0.900	33.2	22.1	55.3	4137.8	O K
2160 min Winter	0.881	0.881	32.8	19.2	52.1	4051.0	O K
2880 min Winter	0.856	0.856	32.3	15.6	47.9	3938.8	O K
4320 min Winter	0.787	0.787	30.9	7.1	38.0	3618.5	O K
5760 min Winter	0.720	0.720	29.4	0.9	30.4	3312.7	O K
7200 min Winter	0.645	0.645	27.7	0.0	27.7	2968.5	O K
8640 min Winter	0.579	0.579	26.1	0.0	26.1	2665.0	O K
10080 min Winter	0.523	0.523	24.6	0.0	24.6	2405.2	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	16.980	47.2	190
240 min Winter	13.574	104.8	246
360 min Winter	9.901	217.7	358
480 min Winter	7.915	315.1	468
600 min Winter	6.653	395.2	572
720 min Winter	5.773	460.6	610
960 min Winter	4.618	558.2	742
1440 min Winter	3.371	655.6	1046
2160 min Winter	2.461	657.1	1496
2880 min Winter	1.968	568.4	1936
4320 min Winter	1.392	239.4	2824
5760 min Winter	1.089	24.9	3752
7200 min Winter	0.900	0.0	4608
8640 min Winter	0.770	0.0	5368
10080 min Winter	0.675	0.0	6160

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	30	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+20
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 8.959

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	1.792	4-8	1.792	8-12	1.792	12-16	1.792	16-20	1.791

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4600.0	1.625	4600.0

Orifice Outflow Control

Diameter (m) 0.132 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice Overflow Control

Diameter (m) 0.182 Discharge Coefficient 0.600 Invert Level (m) 0.682

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.647	0.647	27.7	0.0	27.7	2976.5	O K
30 min Summer	0.737	0.737	29.8	1.9	31.7	3389.3	O K
60 min Summer	0.833	0.833	31.9	12.3	44.2	3833.4	O K
120 min Summer	0.930	0.930	33.8	26.6	60.4	4276.0	O K
180 min Summer	0.980	0.980	34.8	31.4	66.2	4507.7	O K
240 min Summer	1.010	1.010	35.3	33.7	69.0	4647.0	O K
360 min Summer	1.039	1.039	35.9	35.7	71.6	4781.7	O K
480 min Summer	1.047	1.047	36.0	36.2	72.2	4815.0	O K
600 min Summer	1.051	1.051	36.1	36.4	72.5	4832.8	O K
720 min Summer	1.053	1.053	36.1	36.6	72.7	4845.7	O K
960 min Summer	1.056	1.056	36.2	36.8	73.0	4858.6	O K
1440 min Summer	1.049	1.049	36.1	36.3	72.4	4827.0	O K
2160 min Summer	1.024	1.024	35.6	34.6	70.2	4708.4	O K
2880 min Summer	0.992	0.992	35.0	32.4	67.4	4563.8	O K
4320 min Summer	0.914	0.914	33.5	24.2	57.7	4202.3	O K
5760 min Summer	0.856	0.856	32.3	15.6	47.9	3938.3	O K
7200 min Summer	0.807	0.807	31.3	9.3	40.6	3712.6	O K
8640 min Summer	0.764	0.764	30.4	4.1	34.5	3516.6	O K
10080 min Summer	0.720	0.720	29.4	0.9	30.3	3309.9	O K
15 min Winter	0.725	0.725	29.5	1.2	30.8	3335.3	O K
30 min Winter	0.825	0.825	31.7	11.2	42.8	3793.0	O K
60 min Winter	0.931	0.931	33.8	26.7	60.6	4282.2	O K
120 min Winter	1.039	1.039	35.9	35.6	71.5	4777.6	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	179.122	0.0	35
30 min Summer	102.352	6.4	49
60 min Summer	58.485	96.8	78
120 min Summer	33.419	306.1	134
180 min Summer	24.089	470.5	192
240 min Summer	19.096	597.5	248
360 min Summer	13.765	787.5	364
480 min Summer	10.912	927.3	456
600 min Summer	9.113	1036.7	508
720 min Summer	7.865	1125.1	566
960 min Summer	6.239	1261.2	692
1440 min Summer	4.500	1419.7	964
2160 min Summer	3.247	1467.0	1372
2880 min Summer	2.575	1391.0	1772
4320 min Summer	1.800	997.5	2568
5760 min Summer	1.396	659.1	3400
7200 min Summer	1.146	383.0	4200
8640 min Summer	0.976	157.2	5032
10080 min Summer	0.851	26.4	5864
15 min Winter	179.122	3.1	34
30 min Winter	102.352	79.3	48
60 min Winter	58.485	280.9	76
120 min Winter	33.419	574.6	132

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	1.097	1.097	36.9	39.3	76.3	5045.1	O K
240 min Winter	1.132	1.132	37.6	41.4	79.0	5208.6	O K
360 min Winter	1.168	1.168	38.2	43.5	81.7	5373.6	O K
480 min Winter	1.179	1.179	38.4	44.1	82.4	5424.4	O K
600 min Winter	1.178	1.178	38.4	44.0	82.4	5419.3	O K
720 min Winter	1.179	1.179	38.4	44.0	82.4	5422.4	O K
960 min Winter	1.176	1.176	38.3	43.9	82.2	5411.1	O K
1440 min Winter	1.152	1.152	37.9	42.6	80.4	5297.6	O K
2160 min Winter	1.099	1.099	37.0	39.5	76.4	5053.3	O K
2880 min Winter	1.045	1.045	36.0	36.0	72.0	4806.9	O K
4320 min Winter	0.937	0.937	33.9	27.6	61.6	4308.6	O K
5760 min Winter	0.869	0.869	32.6	17.5	50.1	3997.8	O K
7200 min Winter	0.814	0.814	31.4	10.0	41.5	3742.5	O K
8640 min Winter	0.764	0.764	30.4	4.1	34.5	3516.4	O K
10080 min Winter	0.708	0.708	29.1	0.5	29.6	3258.2	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	24.089	772.7	188
240 min Winter	19.096	923.2	244
360 min Winter	13.765	1146.8	356
480 min Winter	10.912	1311.0	462
600 min Winter	9.113	1439.5	556
720 min Winter	7.865	1543.7	578
960 min Winter	6.239	1705.4	730
1440 min Winter	4.500	1907.1	1030
2160 min Winter	3.247	2022.6	1464
2880 min Winter	2.575	1972.0	1884
4320 min Winter	1.800	1462.7	2688
5760 min Winter	1.396	972.7	3528
7200 min Winter	1.146	551.6	4400
8640 min Winter	0.976	204.6	5288
10080 min Winter	0.851	15.2	6256

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	100	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+20
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 8.959

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.792	4-8	1.792	8-12	1.792	12-16	1.792	16-20	1.791

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4600.0	1.625	4600.0

Orifice Outflow Control

Diameter (m) 0.132 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice Overflow Control

Diameter (m) 0.182 Discharge Coefficient 0.600 Invert Level (m) 0.682

Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.131	0.131	11.4	0.0	11.4	690.9	O K
30 min Summer	0.158	0.158	14.8	0.0	14.8	835.5	O K
60 min Summer	0.189	0.189	19.9	0.0	19.9	1001.7	O K
120 min Summer	0.221	0.221	25.7	0.0	25.7	1179.0	O K
180 min Summer	0.239	0.239	28.9	0.0	28.9	1276.5	O K
240 min Summer	0.250	0.250	30.8	0.0	30.8	1335.4	O K
360 min Summer	0.262	0.262	33.0	0.0	33.0	1399.1	O K
480 min Summer	0.270	0.270	34.5	0.0	34.5	1444.0	O K
600 min Summer	0.276	0.276	35.6	0.0	35.6	1477.7	O K
720 min Summer	0.280	0.280	36.4	0.0	36.4	1502.0	O K
960 min Summer	0.286	0.286	37.4	0.0	37.4	1531.6	O K
1440 min Summer	0.288	0.288	37.9	0.0	37.9	1545.0	O K
2160 min Summer	0.283	0.283	37.0	0.0	37.0	1516.4	O K
2880 min Summer	0.274	0.274	35.3	0.0	35.3	1469.2	O K
4320 min Summer	0.250	0.250	30.9	0.0	30.9	1337.1	O K
5760 min Summer	0.231	0.231	27.5	0.0	27.5	1232.9	O K
7200 min Summer	0.216	0.216	24.7	0.0	24.7	1149.7	O K
8640 min Summer	0.203	0.203	22.4	0.0	22.4	1082.2	O K
10080 min Summer	0.193	0.193	20.6	0.0	20.6	1024.7	O K
15 min Winter	0.146	0.146	13.4	0.0	13.4	773.2	O K
30 min Winter	0.176	0.176	17.7	0.0	17.7	934.9	O K
60 min Winter	0.210	0.210	23.7	0.0	23.7	1120.4	O K
120 min Winter	0.247	0.247	30.3	0.0	30.3	1319.1	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	53.808	0.0	34
30 min Summer	32.811	0.0	48
60 min Summer	20.008	0.0	76
120 min Summer	12.200	0.0	132
180 min Summer	9.135	0.0	188
240 min Summer	7.440	0.0	244
360 min Summer	5.570	0.0	314
480 min Summer	4.537	0.0	372
600 min Summer	3.869	0.0	434
720 min Summer	3.397	0.0	502
960 min Summer	2.768	0.0	636
1440 min Summer	2.074	0.0	908
2160 min Summer	1.554	0.0	1304
2880 min Summer	1.267	0.0	1684
4320 min Summer	0.920	0.0	2436
5760 min Summer	0.733	0.0	3184
7200 min Summer	0.614	0.0	3904
8640 min Summer	0.532	0.0	4672
10080 min Summer	0.471	0.0	5368
15 min Winter	53.808	0.0	34
30 min Winter	32.811	0.0	48
60 min Winter	20.008	0.0	74
120 min Winter	12.200	0.0	130

Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.267	0.267	34.0	0.0	34.0	1428.9	O K
240 min Winter	0.279	0.279	36.2	0.0	36.2	1495.6	O K
360 min Winter	0.291	0.291	38.4	0.0	38.4	1562.3	O K
480 min Winter	0.299	0.299	39.6	0.0	39.6	1606.2	O K
600 min Winter	0.305	0.305	40.1	0.0	40.1	1635.8	O K
720 min Winter	0.308	0.308	40.4	0.0	40.4	1652.5	O K
960 min Winter	0.309	0.309	40.6	0.0	40.6	1661.9	O K
1440 min Winter	0.304	0.304	40.0	0.0	40.0	1631.3	O K
2160 min Winter	0.289	0.289	38.0	0.0	38.0	1549.3	O K
2880 min Winter	0.274	0.274	35.2	0.0	35.2	1465.0	O K
4320 min Winter	0.241	0.241	29.3	0.0	29.3	1288.8	O K
5760 min Winter	0.218	0.218	25.1	0.0	25.1	1161.5	O K
7200 min Winter	0.200	0.200	21.9	0.0	21.9	1065.5	O K
8640 min Winter	0.186	0.186	19.5	0.0	19.5	990.0	O K
10080 min Winter	0.175	0.175	17.5	0.0	17.5	929.2	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	9.135	0.0	184
240 min Winter	7.440	0.0	238
360 min Winter	5.570	0.0	338
480 min Winter	4.537	0.0	382
600 min Winter	3.869	0.0	458
720 min Winter	3.397	0.0	534
960 min Winter	2.768	0.0	684
1440 min Winter	2.074	0.0	968
2160 min Winter	1.554	0.0	1376
2880 min Winter	1.267	0.0	1768
4320 min Winter	0.920	0.0	2552
5760 min Winter	0.733	0.0	3296
7200 min Winter	0.614	0.0	4040
8640 min Winter	0.532	0.0	4768
10080 min Winter	0.471	0.0	5552

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	2	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+40
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 6.941

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	1.388	4-8	1.388	8-12	1.388	12-16	1.388	16-20	1.389

Model Details

Storage is Online Cover Level (m) 1.100

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	5225.0	1.100	6260.0

Orifice Outflow Control

Diameter (m) 0.207 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice Overflow Control

Diameter (m) 0.250 Discharge Coefficient 0.600 Invert Level (m) 0.328

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.324	0.324	42.0	0.0	42.0	1744.0	O K
30 min Summer	0.373	0.373	46.4	1.6	48.0	2014.1	O K
60 min Summer	0.424	0.424	50.7	6.9	57.5	2302.0	O K
120 min Summer	0.472	0.472	54.3	15.8	70.1	2572.8	O K
180 min Summer	0.493	0.493	55.8	19.5	75.3	2692.6	O K
240 min Summer	0.503	0.503	56.5	21.1	77.6	2744.7	O K
360 min Summer	0.512	0.512	57.1	22.6	79.8	2796.0	O K
480 min Summer	0.517	0.517	57.5	23.5	81.1	2828.8	O K
600 min Summer	0.520	0.520	57.7	24.0	81.8	2845.5	O K
720 min Summer	0.521	0.521	57.8	24.1	81.9	2849.7	O K
960 min Summer	0.519	0.519	57.6	23.8	81.4	2835.7	O K
1440 min Summer	0.505	0.505	56.7	21.5	78.2	2760.7	O K
2160 min Summer	0.480	0.480	54.9	17.3	72.2	2618.0	O K
2880 min Summer	0.457	0.457	53.2	12.4	65.5	2484.1	O K
4320 min Summer	0.403	0.403	48.9	4.1	53.1	2180.8	O K
5760 min Summer	0.359	0.359	45.2	0.8	46.0	1934.8	O K
7200 min Summer	0.322	0.322	41.8	0.0	41.8	1733.4	O K
8640 min Summer	0.295	0.295	39.1	0.0	39.1	1581.3	O K
10080 min Summer	0.276	0.276	35.6	0.0	35.6	1476.7	O K
15 min Winter	0.362	0.362	45.5	0.9	46.4	1953.2	O K
30 min Winter	0.416	0.416	50.0	5.8	55.9	2255.7	O K
60 min Winter	0.473	0.473	54.3	15.9	70.3	2575.5	O K
120 min Winter	0.526	0.526	58.1	25.0	83.1	2876.3	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	137.001	0.0	34
30 min Summer	79.883	4.0	48
60 min Summer	46.579	32.4	76
120 min Summer	27.159	106.6	130
180 min Summer	19.810	173.1	184
240 min Summer	15.836	226.5	240
360 min Summer	11.551	306.5	292
480 min Summer	9.234	362.0	354
600 min Summer	7.762	400.5	420
720 min Summer	6.735	425.2	490
960 min Summer	5.387	447.4	624
1440 min Summer	3.933	431.5	894
2160 min Summer	2.871	361.9	1292
2880 min Summer	2.296	275.1	1680
4320 min Summer	1.624	96.6	2464
5760 min Summer	1.270	15.1	3192
7200 min Summer	1.050	0.0	3912
8640 min Summer	0.898	0.0	4608
10080 min Summer	0.788	0.0	5352
15 min Winter	137.001	1.7	34
30 min Winter	79.883	22.8	47
60 min Winter	46.579	89.6	74
120 min Winter	27.159	210.7	128

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.549	0.549	59.7	30.3	90.0	3010.6	O K
240 min Winter	0.559	0.559	60.4	32.6	93.0	3068.3	O K
360 min Winter	0.566	0.566	60.8	34.1	94.9	3106.9	O K
480 min Winter	0.569	0.569	61.0	34.9	96.0	3127.0	O K
600 min Winter	0.568	0.568	61.0	34.7	95.7	3121.9	O K
720 min Winter	0.565	0.565	60.7	33.9	94.6	3101.8	O K
960 min Winter	0.554	0.554	60.0	31.5	91.5	3040.3	O K
1440 min Winter	0.527	0.527	58.2	25.3	83.5	2886.9	O K
2160 min Winter	0.487	0.487	55.4	18.5	73.9	2658.1	O K
2880 min Winter	0.454	0.454	53.0	11.8	64.8	2471.2	O K
4320 min Winter	0.386	0.386	47.6	2.6	50.2	2089.1	O K
5760 min Winter	0.330	0.330	42.5	0.0	42.6	1775.1	O K
7200 min Winter	0.290	0.290	38.1	0.0	38.1	1553.7	O K
8640 min Winter	0.265	0.265	33.6	0.0	33.6	1414.9	O K
10080 min Winter	0.245	0.245	29.9	0.0	29.9	1306.8	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	19.810	302.5	182
240 min Winter	15.836	375.3	234
360 min Winter	11.551	481.6	294
480 min Winter	9.234	553.0	368
600 min Winter	7.762	600.8	444
720 min Winter	6.735	632.3	520
960 min Winter	5.387	661.1	666
1440 min Winter	3.933	625.8	952
2160 min Winter	2.871	496.9	1356
2880 min Winter	2.296	342.5	1764
4320 min Winter	1.624	74.0	2564
5760 min Winter	1.270	0.1	3336
7200 min Winter	1.050	0.0	3984
8640 min Winter	0.898	0.0	4752
10080 min Winter	0.788	0.0	5456

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	30	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+40
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 6.941

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	1.388	4-8	1.388	8-12	1.388	12-16	1.388	16-20	1.389

Model Details

Storage is Online Cover Level (m) 1.100

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	5225.0	1.100	6260.0

Orifice Outflow Control

Diameter (m) 0.207 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice Overflow Control

Diameter (m) 0.250 Discharge Coefficient 0.600 Invert Level (m) 0.328

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.486	0.486	55.3	18.3	73.6	2652.9	O K
30 min Summer	0.546	0.546	59.5	29.6	89.2	2994.2	O K
60 min Summer	0.605	0.605	63.4	43.6	106.9	3335.8	O K
120 min Summer	0.655	0.655	66.4	55.5	121.9	3621.3	O K
180 min Summer	0.671	0.671	67.4	59.4	126.8	3717.1	O K
240 min Summer	0.675	0.675	67.6	60.4	128.0	3740.9	O K
360 min Summer	0.680	0.680	67.9	61.6	129.5	3769.9	O K
480 min Summer	0.681	0.681	68.0	61.9	129.9	3777.3	O K
600 min Summer	0.679	0.679	67.9	61.5	129.3	3766.1	O K
720 min Summer	0.675	0.675	67.6	60.5	128.1	3742.6	O K
960 min Summer	0.664	0.664	67.0	57.8	124.8	3677.1	O K
1440 min Summer	0.636	0.636	65.3	51.0	116.3	3514.8	O K
2160 min Summer	0.595	0.595	62.7	41.2	103.9	3275.6	O K
2880 min Summer	0.559	0.559	60.4	32.6	93.0	3069.5	O K
4320 min Summer	0.490	0.490	55.6	18.9	74.5	2672.2	O K
5760 min Summer	0.441	0.441	52.0	9.1	61.1	2398.0	O K
7200 min Summer	0.400	0.400	48.7	3.9	52.6	2166.2	O K
8640 min Summer	0.365	0.365	45.7	1.0	46.8	1969.4	O K
10080 min Summer	0.334	0.334	42.9	0.0	43.0	1795.2	O K
15 min Winter	0.542	0.542	59.2	28.6	87.8	2968.3	O K
30 min Winter	0.608	0.608	63.5	44.2	107.7	3348.3	O K
60 min Winter	0.673	0.673	67.5	59.9	127.4	3729.2	O K
120 min Winter	0.728	0.728	70.7	68.4	139.1	4055.4	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	208.976	98.4	34
30 min Summer	119.411	214.2	47
60 min Summer	68.232	382.3	74
120 min Summer	38.989	599.8	128
180 min Summer	28.104	745.1	182
240 min Summer	22.278	853.0	216
360 min Summer	16.059	1005.0	276
480 min Summer	12.730	1106.0	342
600 min Summer	10.631	1175.0	410
720 min Summer	9.176	1221.0	478
960 min Summer	7.278	1268.3	614
1440 min Summer	5.251	1248.5	880
2160 min Summer	3.788	1107.0	1272
2880 min Summer	3.004	953.1	1656
4320 min Summer	2.100	583.3	2424
5760 min Summer	1.629	294.2	3184
7200 min Summer	1.337	117.9	3960
8640 min Summer	1.138	27.1	4680
10080 min Summer	0.993	0.5	5440
15 min Winter	208.976	195.2	33
30 min Winter	119.411	359.7	47
60 min Winter	68.232	580.0	72
120 min Winter	38.989	844.7	126

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.748	0.748	71.8	70.9	142.7	4174.0	O K
240 min Winter	0.753	0.753	72.1	71.5	143.6	4201.3	O K
360 min Winter	0.753	0.753	72.1	71.5	143.6	4202.8	O K
480 min Winter	0.749	0.749	71.8	70.9	142.8	4177.2	O K
600 min Winter	0.740	0.740	71.4	69.9	141.3	4124.8	O K
720 min Winter	0.729	0.729	70.7	68.5	139.2	4058.1	O K
960 min Winter	0.704	0.704	69.3	65.3	134.6	3911.4	O K
1440 min Winter	0.657	0.657	66.5	56.0	122.5	3633.3	O K
2160 min Winter	0.598	0.598	62.9	41.8	104.6	3290.4	O K
2880 min Winter	0.551	0.551	59.8	30.7	90.5	3021.8	O K
4320 min Winter	0.470	0.470	54.2	15.4	69.5	2559.8	O K
5760 min Winter	0.413	0.413	49.7	5.4	55.1	2237.4	O K
7200 min Winter	0.363	0.363	45.5	1.0	46.5	1956.5	O K
8640 min Winter	0.318	0.318	41.4	0.0	41.4	1710.9	O K
10080 min Winter	0.288	0.288	37.8	0.0	37.8	1543.6	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	28.104	1013.1	180
240 min Winter	22.278	1136.8	232
360 min Winter	16.059	1312.7	288
480 min Winter	12.730	1434.1	364
600 min Winter	10.631	1521.4	438
720 min Winter	9.176	1581.8	512
960 min Winter	7.278	1647.5	654
1440 min Winter	5.251	1627.2	930
2160 min Winter	3.788	1420.4	1332
2880 min Winter	3.004	1174.7	1732
4320 min Winter	2.100	616.6	2512
5760 min Winter	1.629	221.3	3296
7200 min Winter	1.337	32.6	4104
8640 min Winter	1.138	0.0	4776
10080 min Winter	0.993	0.0	5456

Rainfall Details

Rainfall Model	FEH	D3 (1km)	0.227	Cv (Winter)	0.840
Return Period (years)	100	E (1km)	0.314	Shortest Storm (mins)	15
Site Location		F (1km)	2.442	Longest Storm (mins)	10080
C (1km)	-0.024	Summer Storms	Yes	Climate Change %	+40
D1 (1km)	0.303	Winter Storms	Yes		
D2 (1km)	0.305	Cv (Summer)	0.750		

Time / Area Diagram

Total Area (ha) 6.941

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	1.388	4-8	1.388	8-12	1.388	12-16	1.388	16-20	1.389

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