Proposed Restoration of Barrington Quarry

Flood Risk Assessment and

Surface Water Management Strategy

Final Report Version 3

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Contract

This report describes work commissioned by Chris Pointer, on behalf of CEMEX Materials Limited, by an email dated 14 April 2016. CEMEX's representatives for the contract were Chris Pointer and Shaun Denny. David Stark and Jonathan Summersgill of JBA Consulting carried out this work.

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Purpose

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Executive Summary

Introduction

CEMEX Materials Limited now propose to submit an application for a comprehensive 15-year quarry restoration scheme (which will overlay and modify the current partial restoration scheme). Preliminary discussions have been held with CCC, acting in their role as LLFA.

A housing scheme is planned on the adjacent site of the former cement works. The housing scheme is separate from the quarry restoration scheme but the cumulative drainage impact has been considered within this report.

Flood risk

The site is in Flood Zone 1 (low probability) remote from the River Cam and the associated Flood Zone 2 (medium probability) and Flood Zone 3 (high probability). The site is therefore at low risk of river flooding and the planning application passes the NPPF Sequential Test.

The EA's Surface Water Flood Map shows ponding of water in the existing quarry voids, North Pit and Gault Pit. The map shows a surface water flowpath heading southwards along the railway cutting towards Haslingfield Road. These potential overland flows will be intercepted by the proposed surface water management scheme and directed into North Pit for attenuation and controlled release to the adjacent watercourse and the River Cam.

Existing drainage arrangements

The existing drainage system at Barrington Quarry comprises:

- An original drainage system consisting of several pumps.
- Drainage works currently being constructed pursuant to Condition 57 of planning consent S/01080/10/CW for partial restoration of the northwestern part of the quarry.

The design philosophy of the Condition 57 drainage scheme for North Pit is as follows:

- The existing small manually operated electric pump is to be retained (continuing to discharge to the adjacent watercourse **at a maximum rate of 12 l/s**). The pumping rate will be reduced to **6.5l/s** if the housing scheme proceeds.
- In storm conditions runoff will continue to be stored in North Pit.
- An overflow weir and spillway **are** being provided to cater for any excess runoff in an extreme event. The spillway will discharge to the adjacent watercourse.
- The crest of the overflow weir is to be set at **27.8mAOD**, which is below the existing ground level at the toe of the perimeter embankment (so that North Pit does not come within the scope of the Reservoirs Act).
- The downstream former swimming pool has been refurbished (so that it may continue to function as a sediment trap and provide some attenuation of flow).

Proposed drainage strategy for the 15-year restoration scheme

- North Pit is to be left in place for surface water management (attenuation of flows) and sediment settlement.
- The surface water attenuation arrangements are designed for the **100-year event + 30%** increase in rainfall intensity to allow for future climate change.
- The Condition 57 drainage scheme (retained **12l/s** pump in North Pit, overflow weir and spillway, and refurbished swimming pool) will remain in operation.
- The pumping rate from North Pit to the village watercourse will be reduced from **12l/s** to **6.5l/s** if the housing scheme proceeds.
- The majority of the surface water runoff in storm conditions will be directed to the River Cam, initially via an existing **200mm** pipe, and ultimately via a substantial new **500mm** outfall pipe. Both pipes are routed alongside the private quarry railway line. Thus the majority of the surface water runoff in storm conditions will be diverted away from the village watercourse to the River Cam, significantly reducing the potential flood risk to the village of Barrington.

Summary of North Pit attenuation storage arrangements

- Design standard: **100-year event + 30%** increase in rainfall intensity to allow for future climate change.
- Crest level of overflow weir: **27.8mAOD**.
- Invert level of outlet: **26.3mAOD**.
- Attenuation storage depth: **1.5m**.
- Surface area of North Pit: **34,534m^2**.
- Attenuation storage volume available: **51,801m^3**.
- The discharge from North Pit may be initially controlled by a **120mm** throttle pipe and ultimately by a **498mm** Hydrobrake (vortex flow control device).

Site of Special Scientific Interest quarry void

A residual feature of the proposed restoration scheme, which is no different from the current situation, is the need to keep the area of the geological SSSI quarry void dry in perpetuity. Long-term pumping will therefore continue to dewater the base of this residual quarry void.

Telemetry

It is proposed to install telemetry:

- To monitor water levels in North Pit and the retained SSSI quarry void in the future when the quarry restoration scheme has been completed and the site is no longer staffed.
- To stop pumping from the SSSI quarry void to North Pit when the water level in North Pit reaches the outlet level of **26.3mAOD**.

Summary of MicroDrainage design output

The proposed arrangements for attenuating surface water runoff in North Pit have been designed using MicroDrainage (an industry-standard software package). A summary and detailed MicroDrainage output are presented in this report. The MicroDrainage design output demonstrates that the proposed drainage arrangements will operate satisfactorily:

- The maximum water level in North Pit is **27.367mAOD** in the **100-year plus 30%** climate change scenarios (**0.433m** below the crest of the overflow weir). Therefore the overflow weir will not operate in the **100-year plus 30%** climate change scenarios.
- The maximum total discharge to the River Cam is **225l/s** in the **100-year plus 30%** climate change scenarios (within the permitted greenfield rate of **288l/s**).

Cumulative impact with the housing scheme

Cumulative impact only needs to be considered when the Barrington 15 restoration scheme and the housing development co-exist, at which point the restoration scheme will be discharging at a maximum rate of **6.5l/s** to the village watercourse, which accords with the emerging drainage strategy for the housing scheme and results in no cumulative impact.

Reservoirs Act assessment

An independent panel engineer was engaged to assess whether North Pit comes within the scope of the Reservoirs Act:

- The panel engineer advised that North Pit does not come within the scope of the Reservoirs Act, providing that the overflow weir is set below the level of the surrounding ground (which is approximately **28.0mAOD**).
- The overflow weir is to be set at **27.8mAOD** thus complying with the panel engineer's advice.

The potential wave height in North Pit has been estimated to be **0.21m** (well below the available freeboard of **1.0m**). As such there is considered to be little or no risk of waves overtopping the embankment.

Conclusions

It is concluded that the development proposed will not increase the likelihood of downstream flooding occurring. The majority of the surface water runoff in storm conditions will be diverted away from the village watercourse to the River Cam, significantly reducing the potential flood risk to the village of Barrington.

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Abbreviations

CCC	Cambridgeshire County Council
CCTV	Closed circuit television
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
SPRHOST	Standard Percentage Runoff (Hydrology of Soil Types)
SSSI	Site of Special Scientific Interest

1 Introduction

1.1 Current partial quarry restoration scheme

The northwestern part of Barrington Quarry is currently being restored in accordance with planning consent S/01080/10/CW dated 5 August 2011.

An associated surface water drainage scheme is currently being constructed pursuant to Condition 57 of that consent. A revised surface water drainage scheme was approved by Cambridgeshire County Council (CCC) on 5 December 2016 (Appendix F.4).

1.2 Proposed 15-year quarry restoration scheme

CEMEX Materials Limited now propose to submit an outline application for a comprehensive 15-year quarry restoration scheme (which will overlay and modify the current partial restoration scheme).

Planning permission is sought to continue to restore Barrington Quarry through the importation by rail of inert restoration material, creating a chalk downland landscape and deciduous woodland whilst retaining a section of quarry face as representative of the site's geological SSSI status. To achieve this it is proposed to import **8.5 million m^3** of restoration material over 15 years. The restoration of the quarry is proposed to take place in four main stages, with a preparatory or initial development stage and a final restoration stage (an additional two years). The restored site will then be subject to five years aftercare. '

1.3 Proposed housing scheme

A proposed housing scheme is planned on the adjacent site of the former cement works. The housing scheme is separate from the quarry restoration scheme but the cumulative drainage impact has been considered within this report (see Section 4.12).

1.4 Scheme drawings

A site location plan is included in Appendix A.

A catchment areas and concept drainage plan is included in Appendix B.

1.5 Preliminary discussions with Cambridgeshire County Council

Preliminary discussions have been held with CCC, acting in their role as Lead Local Flood Authority (LLFA).

1.6 Purpose of this report

This Flood Risk Assessment (FRA) and Surface Water Management Strategy Report have been prepared to accompany the outline application for the 15-year quarry restoration scheme.

2 Flood risk

2.1 Environment Agency Flood Map for Planning

The EA's Flood Map for Planning shows land at risk of flooding from rivers and the sea (copy in Appendix C). The site is in Flood Zone 1 (low probability) far away from the River Cam and the associated Flood Zone 2 (medium probability) and Flood Zone 3 (high probability). The site is therefore at low risk of river flooding and the outline planning application passes the National Planning Policy Framework (NPPF) Sequential Test.

2.2 Environment Agency Surface Water Flood Map

The EA's Surface Water Flood Map shows land at risk of flooding from surface water (copy in Appendix D).

The map shows ponding of water in the existing quarry voids, North Pit and Gault Pit.

The map shows a surface water flowpath heading southwards along the railway cutting towards Haslingfield Road. These potential overland flows will be intercepted by the proposed surface water management scheme and directed into North Pit for attenuation and controlled release to the adjacent watercourse and the River Cam.

3 Existing drainage arrangements

3.1 Introduction

The existing drainage system at Barrington Quarry comprises:

- An original drainage system consisting of several pumps (see Appendix E).
- Drainage works currently being constructed pursuant to Condition 57 of planning consent S/01080/10/CW dated 5 August 2011 for partial restoration of the northwestern part of the quarry (the Condition 57 scheme). See Appendix F.

Some photos of North Pit and the swimming pool refurbishment are included in Appendix F.5.

3.2 Original drainage system

The original drainage system is shown in Appendix E and has the following characteristics:

- Surface water runoff from the quarry and partial restoration scheme is attenuated in North Pit and pumped intermittently at a very low discharge rate (**12l/s**) to the adjacent watercourse.
- Surface water runoff from the former cement works drains to North Pit, Gault Pit and watercourses near Haslingfield Road. These drainage arrangements are not relevant to the 15-year quarry restoration scheme (except for the Palletiser Yard Pumping Station, marked PS1, which discharges to North Pit). The Palletiser Yard Pumping Station has been taken into account in the drainage strategy for the 15-year quarry restoration scheme.

The existing drainage system includes four pumping stations:

- A small manually operated pump which discharges from North Pit to the adjacent watercourse.
- A small manually operated pump which discharges from the SSSI quarry void in the northeastern part of the site to North Pit.
- A small manually operated pump which discharges from Gault Pit to the adjacent watercourse.
- A pumping station in the yard in the southeast part of the site (known as the "Palletiser yard sump"). This pumping station includes two separate pumps: a leachate pump (pumping to the leachate holding tank) and a surface water pump (pumping to North Pit).

3.3 Condition 57 drainage scheme for North Pit

The design philosophy of the Condition 57 drainage scheme for North Pit (Appendix F, currently being constructed) is as follows:

- The existing small manually operated electric pump is to be retained (continuing to discharge **12l/s** to the adjacent watercourse).
- In storm conditions runoff will continue to be stored in North Pit.
- An overflow weir and spillway are being provided to cater for any excess runoff in an extreme event. The spillway will discharge to the adjacent watercourse.
- The crest of the overflow weir is to be set at **27.8mAOD**, which is below the existing ground level at the toe of the perimeter embankment (so that North Pit does not come within the scope of the Reservoirs Act).
- The downstream watercourse was apparently diverted many years ago to feed a swimming pool. The swimming pool is no longer in use and it has become dilapidated. However, it does provide a sediment trap and perhaps very limited attenuation of flows (although it was never designed for these purposes). The Condition 57 drainage scheme includes the refurbishment of the swimming pool (so that it may continue to function as a sediment trap and provide some attenuation of flow). A drawing of the proposed refurbishment works is included in Appendix F.2. An as-built survey of the refurbished swimming pool is in Appendix F.3. Photos of the refurbishment works are in Appendix F.5. Applications have been submitted to and approved by CCC for Ordinary Watercourse Consent for the temporary and permanent works at the swimming pool.

4 Proposed drainage arrangements

4.1 Introduction

North Pit is to be left in place for surface water management (attenuation of flows) and settlement of any sediment. The surface water attenuation arrangements are designed for the **100-year event + 30%** increase in rainfall intensity to allow for future climate change. See Appendix B for the concept drainage plan which considers the following:

- The Condition 57 drainage scheme (retained **12l/s** pump in North Pit, overflow weir and spillway, and refurbished swimming pool) will remain in operation.
- The pumping rate from North Pit to the village watercourse will be reduced from **12l/s** to **6.5l/s** if the housing scheme proceeds.
- The catchment area of North Pit will increase from **31.8ha** to **38.3ha**, and there will be an associated increase in surface water inflows.
- The majority of the surface water runoff in storm conditions will be directed to the River Cam, initially via an existing **200mm** pipe, and ultimately via a substantial new **500mm** outfall pipe. Both pipes are routed alongside the private quarry railway line. Thus the majority of the surface water runoff in storm conditions will be diverted away from the village watercourse to the River Cam, significantly reducing the potential flood risk to the village of Barrington. See drawings in Appendix G.2 and Appendix G.3.

4.2 Catchment area of North Pit

A summary of the details of the catchment area of North Pit is as follows (see concept drainage plan in Appendix B):

- Surface water runoff from a substantial part of the restored quarry will drain into North Pit via a network of ditches (Catchment Areas 3, 4 and 6).
- The large SSSI quarry void (Catchment Area 2) will be retained, and the adjacent northwest part of the site (Catchment Area 1) will drain into that void. The **12l/s** pump in the void will switch off when the water level in North Pit rises to **26.3mAOD**. Thus Catchment Areas 1 and 2 will not discharge to North Pit in a storm scenario.
- There will be a valley feature in the western part of the site (Catchment Area 5). Runoff from this catchment would naturally tend to overflow westwards across the site boundary into the adjoining land. The topography prevents runoff from this catchment being directed easily by gravity into North Pit. The underlying chalk strata will be exposed in this area to form an infiltration basin for surface water disposal. Thus Catchment Area 5 will not discharge to North Pit.
- The Palletiser Yard Pumping Station will initially continue to discharge to North Pit (**5.7l/s**). This pumping station drains part of the restoration site. If the housing scheme is built, that development will absorb the **5.7l/s** discharge from the Palletiser Yard Pumping Station (i.e. that discharge will be diverted from North Pit to the housing scheme). At that point the discharge from North Pit to the village watercourse can be reduced from **12l/s** to **6.5l/s** to accord with the emerging drainage strategy for the housing scheme (Appendix K), and result in no cumulative impact. See Section 4.12 for further details of cumulative impact.
- The retained **12l/s** pump in North Pit will maintain some flow to the adjacent watercourse for ecological and amenity purposes, particularly during dry weather. However, no reliance will be placed on this pump in storm conditions (the calculations assume that it will not operate in storm conditions).

4.3 North Pit attenuation arrangements

Details include:

- The ground water level has been monitored for many years in a borehole near to North Pit (see records in Appendix G.1). These records represent the water level in North Pit which is considered to be in hydraulic continuity with groundwater. The peak groundwater level of **28.65mAOD** was reached on 13 June 2012 during a period of exceptionally high rainfall. North Pit has never overtopped and the current pumping regime (maximum of **12l/s**) has proved to be sufficient to control the water level in North Pit. Historically the water level is generally below **26.0mAOD**.
- The proposals include an outlet invert level of **26.3mAOD** at North Pit, and it is assumed that the water level will be at or below this level at the start of a storm. The **12l/s** pump in North Pit will continue to operate in dry weather, thus tending to reduce the water level below **26.3mAOD** after stored water has discharged from North Pit after a storm. The historical record shows that the water level in North Pit may be below **26.3mAOD** at the start of a storm. Thus significant extra storage capacity may be available at the start of a storm, although no reliance has been placed on this possibility in the design.
- Summary of North Pit attenuation storage arrangements:
    - Design standard: **100-year event + 30%** increase in rainfall intensity to allow for future climate change.
    - Crest level of overflow weir: **27.8mAOD**.
    - Invert level of outlet: **26.3mAOD**.
    - Attenuation storage depth: **1.5m**.
    - Surface area of North Pit: **34,534m^2**.
    - Attenuation storage volume available: **51,801m^3**.
- The discharge from North Pit may be initially controlled by a **120mm** throttle pipe and ultimately by a **498mm** Hydrobrake (vortex flow control device).

4.4 Outfall to River Cam

Details include:

- There is an old **200mm** water abstraction pipe from the River Cam (routed alongside the railway) which may be used as a temporary outfall subject to closed circuit television (CCTV) survey and further assessment (investigations currently ongoing at the time of writing this report). The assessment to date indicates that the pipe is in good condition and that it extends from the River Cam to within approximately 300m of North Pit.
- The proposed **500mm** River Cam outfall pipe will generally have the standard ground cover of **1,200mm** as it passes through the former cement works and future residential development.
- The River Cam outfall pipe will have the standard cover of **1,200mm** as it passes under Haslingfield Road and Glebe Road (near the level crossings).
- The River Cam outfall pipe will have to be slung alongside or within the bridge deck at the railway underbridge.
- Elsewhere alongside the railway, the pipe could have a reduced cover of **600mm** (for economy and to avoid undermining the railway).
- The new outfall pipe to the River Cam is only required when the catchment area of North Pit (**ultimately 38.25ha**) exceeds the catchment area of the Condition 57 scheme (**31.76ha**). In order to meet this objective, it is anticipated that the pipeworks will be commissioned in the first half of the infilling operation, before completion of Phase 2. It would also be beneficial to install the pipework prior to completion of the adjacent housing scheme (to avoid disruption during pipe-laying operations).

4.5 Permitted discharge

The EA has verbally advised that direct discharges to the River Cam should be restricted to a nominal greenfield rate of **4l/s/ha** (telephone call from Chris Pointer of Cemex to Jeremy Hay at the EA's Brampton Office on 5 April 2016).

4.6 Site of Special Scientific Interest quarry void

A residual feature of the proposed restoration scheme, as the current situation, is the need to keep the area of the geological SSSI quarry void dry in perpetuity. Long-term pumping will therefore continue to dewater the base of this residual quarry void. The existing small submersible electric pump has proven to be adequate to deal with the existing situation. Pumping rates have been monitored and the maximum discharge rate is **12l/s**. It is therefore proposed to maintain this arrangement.

4.7 Telemetry

It is proposed to install telemetry to:

- monitor water levels in North Pit and the retained SSSI quarry void in the future when the quarry restoration scheme has been completed and the site is no longer staffed.
- stop pumping from the SSSI quarry void to North Pit when the water level in North Pit reaches the outlet level of **26.3mAOD**.

4.8 Flow monitoring

The table below and drawing TL3950_CAW_D_250711_A_3 (Appendix G.4) show the locations of electromagnetic flow meters installed at the site. The meters record flow at 15 minute intervals and the data can be accessed remotely using telemetry. There is also a tipping bucket rain gauge located between Gault Pit and North Pit.

Locations of flow meters:

Meter Ref	National Grid Ref.	Location
FM01	539668 250260	Receiving drain for North Pit discharge
FM02	539461 251398	Quarry dewatering (SSSI)
FM03	539131 250841	North Pit dewatering
FM04	539580 250257	Western catchment (rural)
FM05	539668 250077	Final discharge (Haslingfield Road culvert)
FM06	539669 250834	Palletiser Yard

4.9 MicroDrainage design output

The proposed arrangements for attenuating surface water runoff in North Pit have been designed using MicroDrainage (an industry-standard software package). A summary of the MicroDrainage output is presented in Appendix H comprising:

- Calculations for the **100-year plus 30%** climate change event.
- Catchment areas.
- Pipe capacities.

Detailed MicroDrainage output for **100-year plus 30%** climate change scenarios is included in Appendix I.

4.10 Summary of MicroDrainage design output

The MicroDrainage design output demonstrates that the proposed drainage arrangements will operate satisfactorily:

- The maximum water level in North Pit is **27.367mAOD** in the **100-year plus 30%** climate change scenarios (**0.433m** below the crest of the overflow weir). Therefore the overflow weir will not operate in the 100-year plus 30% climate change scenarios.
- The maximum total discharge to the River Cam is **225l/s** in the **100-year plus 30%** climate change scenarios (within the permitted greenfield rate of **288l/s**).

4.11 Ground permeability

The catchment of North Pit is not natural (it will consist of a mixture of surfaces as the phased filling operation proceeds and the final surface is covered with **0.4m** of chalk and **0.1m** of soil to create a chalk downland habitat or **0.5m** of soil in areas proposed for deciduous woodland).

The Standard Percentage Runoff (SPRHOST) value of **0.242** in the Flood Estimation Handbook (FEH) is considered too low to represent the restored quarry (which may contain clay under the chalk capping).

A "runoff coefficient" of **0.8** has been assumed: this is conservative but is consistent with the approach taken in the design of the current partial quarry restoration (approved Condition 57 drainage scheme).

Infiltration testing of the proposed infiltration basin in Catchment 5 and the proposed soil mixture in a test area may be undertaken in due course to more accurately assess the permeability of the ground and the value of the runoff coefficient.

4.12 Cumulative impact with the housing scheme

The cumulative impact of the Barrington 15 restoration scheme and the proposed residential development on the site of the former cement works has been assessed as follows:

- In the existing situation the pump in North Pit discharges a maximum of **12l/s** to the village watercourse.
- The revised (and approved) Condition 57 Drainage Scheme (submitted to CCC in November 2016) includes retention of the existing pumping arrangement at **12l/s** to the village watercourse (this will maintain the status quo as regards flows in the village watercourse).
- The emerging drainage strategy for the housing scheme assumes a maximum discharge from the quarry restoration scheme of **6.5l/s** from North Pit to the village watercourse (in line with the original Condition 57 drainage scheme). See the Campbell Reith Hill Combined Drainage Report of March 2016 (Appendix K) which has been presented to Barrington Parish Council.
- In the event that the housing scheme is built that development will absorb the **5.7l/s** discharge from the Palletiser Yard Pumping Station (i.e. that discharge will be diverted from North Pit to the housing scheme). At that point the discharge from North Pit to the village watercourse can be reduced to **6.5l/s**.
- In summary, the cumulative impact only needs to be considered when the Barrington 15 restoration scheme and the housing development co-exist, at which point the restoration scheme will only be discharging **6.5l/s** to the village watercourse, which accords with the assumptions of the emerging drainage strategy for the housing scheme and results in no cumulative impact.

5 Reservoirs Act assessment

5.1 Introduction

An independent panel engineer was engaged to assess whether North Pit comes within the scope of the Reservoirs Act (see Appendix J.1 for a copy of his report).

The panel engineer's report refers to preliminary drawings of the proposed drainage arrangements for North Pit. Those preliminary drawings included a proposed gravity outlet to the adjacent village watercourse (outlet invert level **26.8mAOD**, **76mm** orifice). That preliminary drainage scheme has now been abandoned, and a larger outlet set at a lower level (**26.3mAOD**) is now proposed (to discharge direct to the River Cam) all as described in this report. However, the findings of the panel engineer's report are still valid.

5.2 Key points

The panel engineer advised that North Pit does not come within the scope of the Reservoirs Act, providing that the overflow weir is set below the level of the surrounding ground (which is approximately **28.0mAOD**).

The overflow weir is to be set at **27.8mAOD** thus complying with the panel engineer's advice.

5.3 Wave height

The potential wave height in North Pit has been estimated to be **0.21m,** well below the available freeboard of **1.0m** provided by the perimeter embankment:

Level of embankment crest: **28.8mAOD**.

Subtract level of crest of proposed overflow weir: -**27.8mAOD** (the maximum water level in North Pit).

Freeboard available: **1.0m**.

So there is little or no risk of waves overtopping the embankment.

See wave height calculation in Appendix J.2.

6 Conclusions

6.1 Flood Risk

The site is in Flood Zone 1 (low probability) and is therefore at low risk of river flooding and the planning application passes the NPPF Sequential Test.

The EA's Surface Water Flood Map shows potential overland flows which will be intercepted by the proposed surface water management scheme and directed into North Pit for attenuation and controlled release to the adjacent watercourse and the River Cam.

6.2 Existing drainage arrangements

The original drainage system at Barrington Quarry comprises attenuation of surface water runoff in North Pit with an existing small manually operated electric pump discharging to the adjacent village watercourse at a maximum rate of **12 l/s**.

The drainage works currently being constructed pursuant to Condition 57 of planning consent S/01080/10/CW (for partial restoration of the northwestern part of the quarry) retain the existing pumping arrangement and include an overflow weir and spillway to cater for any excess runoff in an extreme event, and refurbishment of the downstream former swimming pool.

6.3 Proposed drainage strategy for the 15-year restoration scheme

- North Pit is to be left in place for attenuation of flows.
- The Condition 57 drainage scheme (retained **12l/s** pump in North Pit, overflow weir and spillway, and refurbished swimming pool) will remain in operation.
- The pumping rate from North Pit to the village watercourse will be reduced from **12l/s** to **6.5l/s** if the housing scheme proceeds.
- The majority of the surface water runoff in storm conditions will be directed to the River Cam, initially via an existing **200mm** pipe, and ultimately via a substantial new **500mm** outfall pipe. Both pipes are routed alongside the private quarry railway line. Thus the majority of the surface water runoff in storm conditions will be diverted away from the village watercourse to the River Cam, significantly reducing the potential flood risk to the village of Barrington.
- The MicroDrainage design output demonstrates that the proposed drainage arrangements will operate satisfactorily in the **100-year plus 30% climate change** event, with no water overflowing from North Pit.
- The maximum total discharge to the River Cam is **225l/s** in the **100-year plus 30%** climate change scenarios (within the permitted greenfield rate of **288l/s**).
- If both the Barrington 15 restoration scheme and the housing development proceed, the discharge from the North Pit to the village watercourse will be reduced from **12l/s** to **6.5l/s**, which results in no cumulative impact.

6.4 Reservoirs' Act assessment

The independent panel engineer advised that North Pit does not come within the scope of the Reservoirs Act, and there is little or no risk of waves overtopping the embankment.

6.5 Summary

It is concluded that the development proposed will not increase the likelihood of downstream flooding occurring. The majority of the surface water runoff in storm conditions will be diverted away from the village watercourse to the River Cam, significantly reducing the potential flood risk to the village of Barrington.

Appendices

A Site location plan

Drg. No. 16_CO18_BARR_001: Site Location Plan.

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HELPING TO BUILD A GREATER BRITAIN

Haslingfield

Barrington

North

Barrington Quarry *Proposed Restoration Scheme*

Site Location Plan

16_C018_BARR_001

Shaun Denny_CAW

November 2016

1 : 10 000 @ A3

Ordnance Survey Reference - TL 3950

Survey Reference - None

0 200 400 600

Legend

Company Controlled Land

Application Area

Department of National Reserves & Development
CEMEX UK Operations Limited
Wolverhampton Road, Oldbury,
Warley, West Midlands. B69 4RJ.

B Catchment areas and concept drainage plan

Drg. No. 16_C018_BARR_025 dated 19 December 2016.

Drainage gulley to prevent off-site run-off; directing it to the quarry void

Drainage Gulleys are mainly set along proposed field boundaries (dwg. ref. 1610_002.001_BARRIT15)

Surface run-off into quarry void
Water captured in base (sump) and pumped off site via infiltration ponds and North Pit

2.

3.

5.

4.

6.

Drainage gulley to prevent surface water leaving the site; directing it to the infiltration pond

Drainage gulley to be formed around railway 'valley' to passively direct surface water to North Pit

Wetland and shallow ponds to hold surface runoff prior to infiltration or discharge into North Pit

Infiltration basin
(formed into the chalk bench)
(total area c.11,063sq.m)

Low level embankment to be built to direct surface runoff into North Pit

'Palletiser Yard' Pump

North Pit
To be utilised as surface water storage

Proposed emergency overflow weir and spillway

Condition 57 pump and rising main

Catchment 6 south of embankment directed into North Pit via ditches and pipes

Pumped site drainage to North Pit (schematic)

Overflow weir with direct discharge (along pipe) to River Cam

Safe overland flowpath to watercourse

Piped (underground) discharge to the River Cam

Watercourse to site discharge point

Outfall to River Cam

Gault Pit

OSBM

Legend and Notes:

- Catchment Area 1 (Plan Area: 7.79 Hectares)
- Catchment Area 2 (Plan Area: 20.3 Hectares)
- Catchment Area 3 (Plan Area: 20.4 Hectares)
- Catchment Area 4 (Plan Area: 12.8 Hectares)
- Catchment Area 5 (Plan Area: 5.7 Hectares)
- Catchment Area 6 (Plan Area: 4.9 Hectares)
- Major Drainage Gulley (c.4,900 linear metres) Main purpose - transfer of surface water
- Minor Swale / Grip (c.5,600m linear metres) Main purpose - directing run-off to drainage gulleys and attenuation
- Drainage Pipe (indicative route only)
- Infiltration Pond
- Palletiser Yard Catchment (Area 7) (Plan area: 5.6 Hectares)

Models		
	Drawn from	1611-S238 BARRINGTON FINAL RESTORATION DRAINAGE PLAN_V6
	Overlay 1	none
	Overlay 2	none
	Overlay 3	none
	Overlay 4	none

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UK National Reserves Department
CEMEX UK Operations Limited
Wolverhampton Road, Oldbury
Warley, West Midlands.
B69 4RJ
Telephone 0121 569 7464
Facsimile 0121 544 7447

Drawn By: Steven Hopkins	Company: CEMEX UK Materials Limited
Date: 19th Dec 2016	Site: Barrrington Quarry
Scale: 1:2500	Project: Proposed Restoration Scheme
Checked By:	Title: Concept surface water drainage scheme
OS Ref.	Drawing No.: 16_C018_BARR_025

C Environment Agency Flood Map for Planning

Drg. No. 2015s3432-31.

Map legend

Click on the map to see what Flood Zone (National Planning Policy Guidance definitions) the proposed development is in.

- Flood Map for Planning (Rivers and Sea)
  - Flood Zone 3
  - Flood Zone 2
  - Flood defences (Not all may be shown*)
  - Areas benefiting from flood defences (Not all may be shown*)
- Main River Line
  - Main River Line
- Other national environmental organisations
  - Natural Resources Wales Area of responsibility
  - Scottish Environment Protection Agency Area of responsibility

Barrington, Cambridgeshire at scale 1:20,000

Other maps · Data search · Text only version

Legend

Site boundary

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved
			J. Summersgill			

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for

Cemex UK Operations Ltd

Barrington Quarry 15 Year Scheme
Environment Agency Flood Map For Planning

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	Rev.:	Sheet No.:	Status:
2015s3432-31		1 of 1	

D Environment Agency Surface Water Flood Map

Drg. No. 2015s3432-32.

Map legend

- [x] Risk of Flooding from Surface Water
  - High
  - Medium
  - Low
  - Very Low
- [x] Other national environmental organisations
  - Natural Resources Wales Area of responsibility
  - Scottish Environment Protection Agency Area of responsibility

Map of X: 539,444; Y: 250,574 at scale 1:15,000

Data search

Legend

Site boundary

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved

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Cemex UK Operations Ltd

Barrington Quarry 15 Year Scheme
Environment Agency Surface Water Flood Map

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Digital File Name:

Drawing Number:	Rev.:	Sheet No.:	Status:
2015s3432-32		1 of 1	

E Existing surface water drainage arrangements

Drg. No. 2015s3432-5: Existing Surface Water Drainage Arrangements.

This drawing shows the existing drainage arrangements in 2016 whilst the partial quarry restoration scheme is in progress.

Notes:

1. Existing drainage arrangements deduced from:
Campbell Reith Drg. No. 11104/C300/SI: Existing Drainage Layout.
MK Surveys Drg. No. 1934-2 (Sheets 1-8): Topographical and Utility Survey.

2. This drawing is diagrammatic.

North

Watershed

SSSI Quarry Void

PS4

Lime Quarry

PS3

North Pit

PS1

PS2

Gault Pit

Cement Works

Head of watercourse

Former swimming pool acting as settlement lagoon

Watercourse ultimately connects to River Cam

825mm culvert under Hasingfield Road

Surface Water Pumping Stations

- PS1 Serves northern part of cement works. Discharges to North Pit.
- PS2 Small manually operated electric pump (occasional operation).
- PS3 Small manually operated electric pump (occasional operation).
- PS4 Small manually operated electric pump (occasional operation).

Legend

- Culverted watercourse
- Open watercourse or ditch
- Discharge point of drainage catchment or pumping station
- Pond
- Approximate Site Boundary

Surface Water Drainage Catchment Areas (Cement Works)

- Pumped to North Pit
- Discharges to Gault Pit
- Discharges to Gault Pit
- Discharges to ditch alongside Haslingfield Road
- Discharges to various watercourses

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Drg. No. 2015s3432-5

Existing Surface Water Drainage Arrangements Barrington Quarry

Prepared by: S Marshfield
Approved by: DC Stark
Date: 16 February 2016

JBA consulting

Not to Scale

F Condition 57 proposed drainage works

The drawings in this Appendix relate to the outfall works at North Pit that are being constructed as part of the Condition 57 scheme (including details of the refurbishment of the settlement lagoon/swimming pool on the downstream watercourse).

F.1 Proposed surface water drainage works - location plan

Drg. No. 2015s3442-6B: Proposed Surface Water Drainage Works - Restoration of Part of Barrington Quarry.

This drawing shows the drainage works currently being constructed pursuant to Condition 57 of planning consent S/01080/10/CW dated 5 August 2011 for partial restoration of the northwestern part of the quarry.

Notes:

1. This drawing is diagrammatic.

North

Watershed

SSSI Quarry Void

Lime Quarry

Retain existing 12l/s pump and discharge main

North Pit

Proposed emergency overflow weir and spillway

Mound

Mound

Create safe overland flowpath to watercourse

Cement Works

Gault Pit

Refurbish settlement lagoon

Revision B, 30-11-2016

Piped outlet from North Pit deleted.
Existing pump retained at North Pit.

Revision A, 14-06-2016

North Pit spillway rerouted to watercourse.
Gault Pit spillway omitted.
Proposed regrading of watercourse omitted.
Discharge pipe diameter changed to 300mm.
North Pit outlet changed to 76mm orifice.

Legend

- Existing open watercourse or ditch
- Existing culverted watercourse
- Proposed Watercourse
- Approximate boundary of quarry restoration area (Planning Permission S/0180/10/CW)
- Pond
- Approximate Site Boundary

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Drg. No. 2015s3432-6B

Proposed Surface Water Drainage Works
Restoration of Part of Barrington Quarry

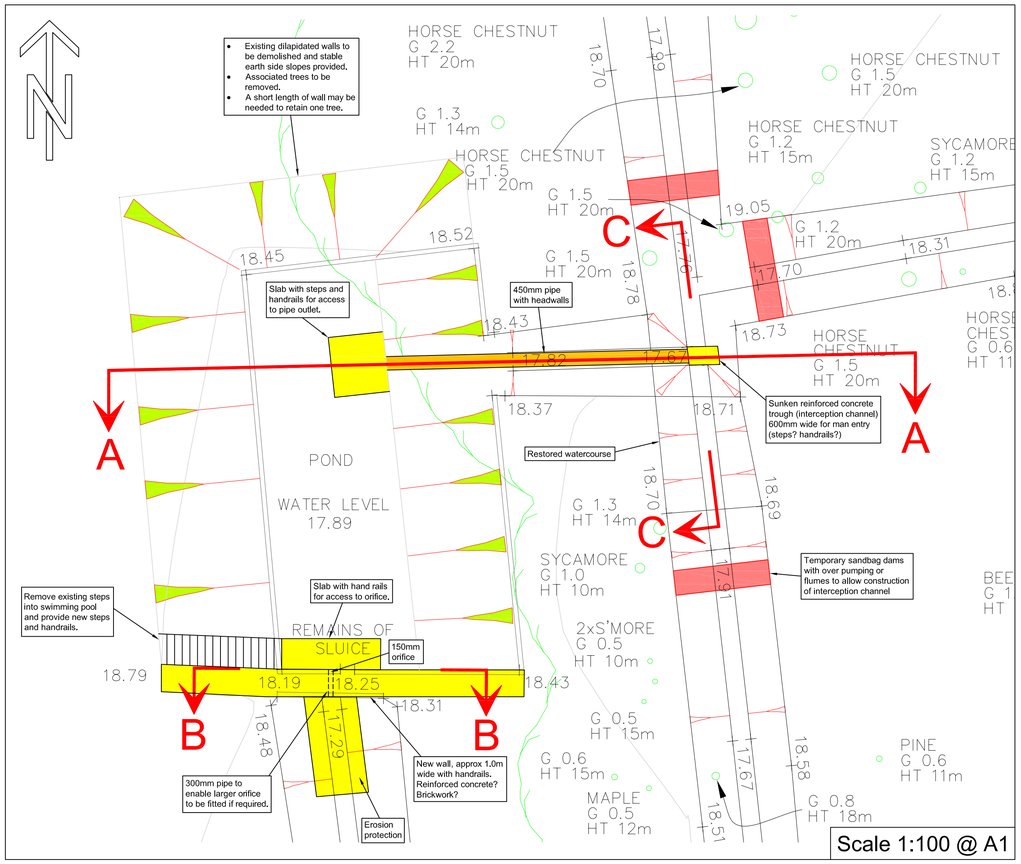
Prepared by: S Marshfield / J Summersgill
Approved by: DC Stark
Date: 30 November 2016

JBA consulting

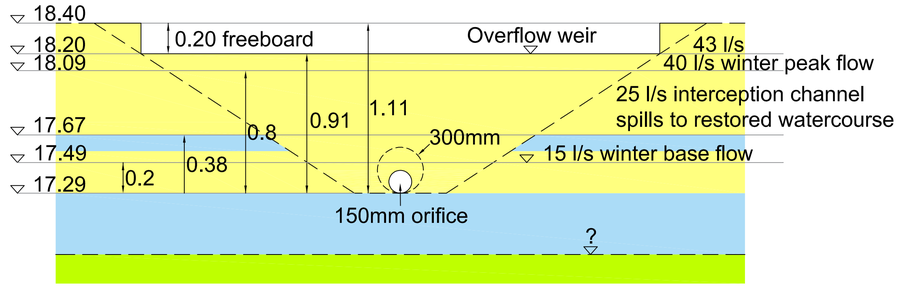
Not to Scale

F.2 Proposed refurbishment of swimming pool

Drg. No. 2015s3432-18.

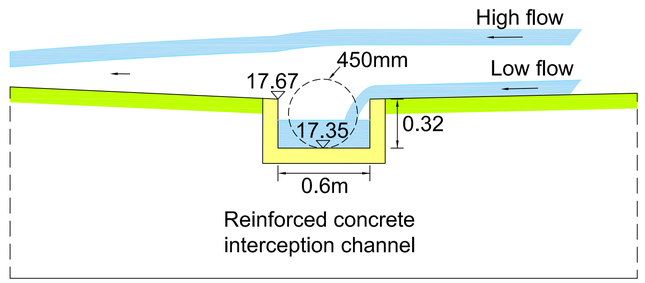


Operation of flow control structure (1:20 @ A1)
(Showing discharges through orifice for various water levels)
Section B-B

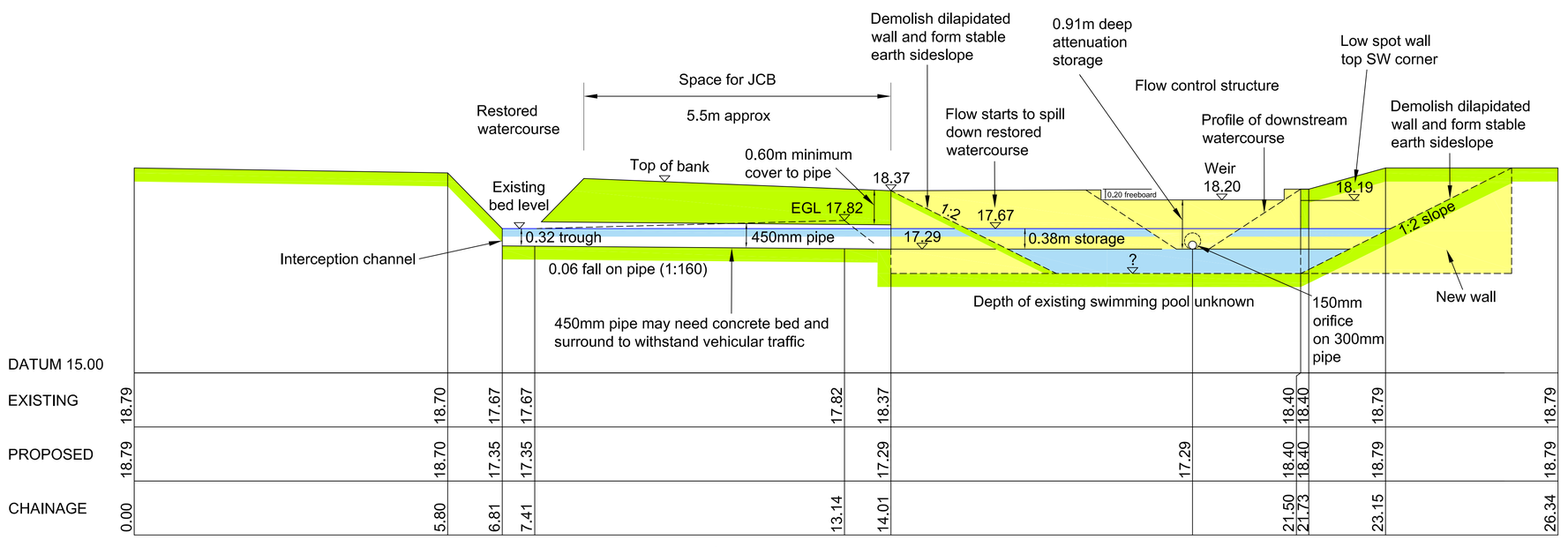


Depth of existing swimming pool unknown

Section C-C (1:20 @ A1)



Cross section A-A is drawn looking south along the swimming pool and includes the elevation view of the flow control structure in Section B-B.



Cross section A-A
Scale 1:50 @ A1

Key

EGL = Existing ground level
SW = Southwest

General Notes

1. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
2. Do not scale from this drawing. All dimensions must be checked/verified on site.
3. This drawing is to be read in conjunction with (TO BE COMPLETED WITH RELEVANT INFORMATION!).
4. Any discrepancies noted on site are to be reported to the Engineer immediately.
5. All works in watercourses will be carried out with care to minimise the risk of pollution adhering to Pollution Prevention Guidelines.
6. All works affecting flood defences, main watercourses and/or ordinary watercourses will be subject to Consent for Permanent and Temporary Works under the Land Drainage Act 1991.
7. The locations of any known services shown on drawing are approximate and for guidance only. The Contractor will confirm the location of any services prior to the commencement of any works.
8. The electronic model of this drawing is not to be used for setting out.

Design philosophy

1. The swimming pool is to be retained and refurbished to continue to act as an informal settlement lagoon.
2. There is a risk that, in a high flow scenario, accumulated sediment will be scoured out and flushed into the downstream watercourse. Precautions need to be taken to avoid this scenario, as described below.
3. Cambridge County Council would also like the swimming pool to continue to perform an informal flood attenuation function. This objective will be achieved as described below.
4. The inlet channel to the swimming pool will be culverted using a 450mm pipe. This will allow vehicular and pedestrian access around the perimeter of the swimming pool for the refurbishment works and for future maintenance. The 450mm pipe will have a flow capacity well in excess of the 150mm flow control orifice. Thus the 450mm pipe will convey sufficient flow into the swimming pool for the 150mm flow control to operate satisfactorily.
5. Low flows will drop into the interception channel, pass through the 450mm culvert into the swimming pool, and exit via the small orifice in the Flow Control Structure.
6. As flows increase, the orifice will act as a throttle and the water level in the pool will increase until it reaches 17.67mAOD and the interception channel is full (thus providing some attenuation of flows). At this point the interception channel will start to spill into the restored watercourse.
7. As flows increase further, the water level will continue to rise in the restored channel and the swimming pool (thus providing further attenuation of flows). The majority of the excess flow will now be routed down the restored channel (thus reducing the flow through the swimming pool and reducing the risk of sediment being remobilised).
8. In extreme storms the full cross-sectional area of the restored channel will be available to convey flows (plus whatever passes through the swimming pool).
9. Eventually the swimming pool will overtop the weir in the Flow Control Structure (18.20mAOD).
10. The swimming pool needs to be isolated in the future when it is desilted, etc. This can be done by placing a stoplog (or sandbags) on the inlet to the 450mm culvert. A small sandbag dam might also be needed just downstream of the Flow Control Structure (to prevent water backing-up into the swimming pool from the downstream watercourse. A machine (e.g. an excavator with a ditching bucket) will work from the top of the bank and remove the sediment from the swimming pool.

Hydraulic Operation of Flow Control Structure

1. The flow in the watercourse was monitored from December 2015 to June 2016 (Flow Meter FM05):
   a. Base flow in winter: 15l/s.
   b. Peak flow in winter: 40l/s.
   c. Base flow in summer: 2l/s.
   d. Peak flow in summer: 15l/s.
2. Winter base flow of 15l/s passes through swimming pool with small rise in water level and small mobilisation of attenuation storage.
3. When water level reaches 17.67mAOD, interception channel starts to spill down restored watercourse. Depth of storage in swimming pool is 0.38m. Discharge via 150mm orifice is 25l/s.
4. When water reaches weir crest level of 18.20 it overflows. Discharge via 150mm orifice is 43l/s (winter peak).
5. In reality the watercourse immediately downstream of the flow control structure may be partly full of water (which will reduce the discharge through the orifice).
6. When weir is overtopping, full temporary attenuation will be mobilised, Volume = Length x Width x Depth (0.91) = 93m³.
7. Discharges calculated using simple orifice equation.
8. The 450mm inlet pipe can convey flows of around 50l/s with a velocity of 0.3m/s and a headloss of less than 10mm (inlet loss, outlet loss and friction loss). So water level in swimming pool will be approx. 10mm lower than in restored watercourse channel.
9. Estimated flood flow in watercourse is 443 l/s (100 years + climate change, Campbell Reith report to Parish Council May 2016).

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved

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for

Cemex UK Operations Ltd

Barrington Quarry
Refurbishment of swimming pool

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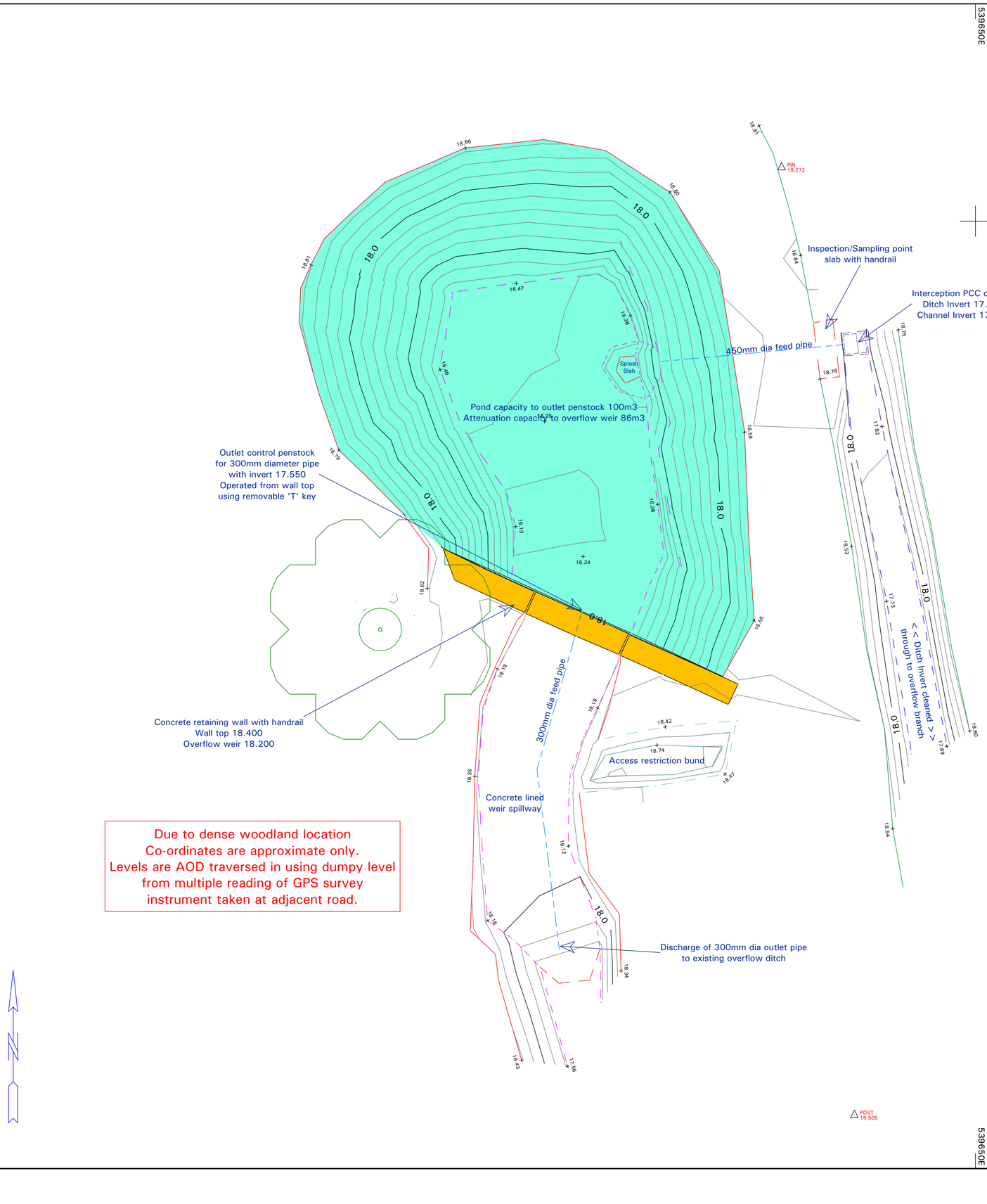
Digital File Name:

Drawing Number:	Rev.:	Sheet No.:	Status:
2015s3432-18		1 of 1	Draft

F.3 As-built survey of refurbished swimming pool

Drg. No. C16062/C/001



Notes.

Draft	Date	08/12/16	Init	LDS
Issued for Approval	Date	08/12/16	Init	LDS
Issued for Construction	Date		Init	

Rev	Date	Amendment

Scheme

Refurbishment of Swimming Pool

Client

CEMEX UK

Drawing title

As Built Settlement Lagoon
Barrington Quarry

Scale	Drawing Number	Rev.
1:100	C16062/C/001	

Cad file	Drawn	Checked	Approved
11314A2	LDS	LDS	
	Date 08/12/16	Date 08/12/16	Date

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Caenby Hall
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Lincolnshire
LN8 2BU
Tel: 01673 878444
Fax: 01673 878644

F.4 Approval of revised Condition 57 drainage scheme

Letter dated 5 December 2016 from Cambridgeshire County Council.

My ref: S/01080/10/CW
Your ref:

Date: 5 December 2016

Contact: Helen Wass
Direct dial: 01223 715522
E Mail: helen.wass@cambridgeshire.gov.uk

Cambridgeshire County Council

Economy, Transport & Environment

Executive Director – Graham Hughes

Box SH1315
Shire Hall
Castle Hill
Cambridge
CB3 0AP

Shaun Denny
Cemex UK Materials Ltd

By email only to
Shaun.denny@cemex.com

Dear Mr Denny

Barrington Quarry, Haslingfield Road, Barrington, CB22 7RQ

Planning permission S/01080/10/CW – Importation by rail of suitable restoration material to partially infill existing quarry void etc

Condition 57 – Surface water drainage scheme

I refer to your letter dated 20 October 2016 together with a revised surface water drainage scheme (which were received on 10 November 2016).

I have consulted the Environment Agency, the County Council's Flood and Water Team and Barrington Parish Council who raise no objections. We note that the maximum rate of pumping from North Pit will not increase and will remain at 12 litres/second. The report indicates the pit has sufficient capacity to accommodate flows arising from a 1 in 100 (1%) annual probability storm and sensitivity testing indicates there is sufficient storage capacity in North Pit to contain a 1 in 200 (0.5%) annual probability storm.

I am pleased to give the waste planning authority's approval of the revised surface water drainage scheme:

Submission of details for approval pursuant to condition 57 – Revised Surface Water Drainage Scheme (October 2016)

which supersedes the June 2013 version approved on 30 August 2013.

Yours sincerely

SC Pledger.

Sass Pledger
Head of Growth & Economy

F.5 Photos of North Pit and the swimming pool refurbishment

Photo Report for Barrington Quarry

View of North Pit, looking south from near the outfall pump. Photo taken 22 March 2016.

View of North Pit, looking east along the southern perimeter of North Pit, showing the existing low perimeter embankment near the location of the proposed overflow weir and spillway. Photo taken 22 March 2016.

View of dilapidated former swimming pool. Photo taken 22 March 2016.

View of swimming pool showing the completed refurbishment works prior to erection of perimeter fencing. Photo taken 5 December 2016.

G Proposed drainage arrangements

G.1 Groundwater levels in borehole 13

Figure 3 from Revised Condition 57 Surface Water Drainage Scheme (October 2016).

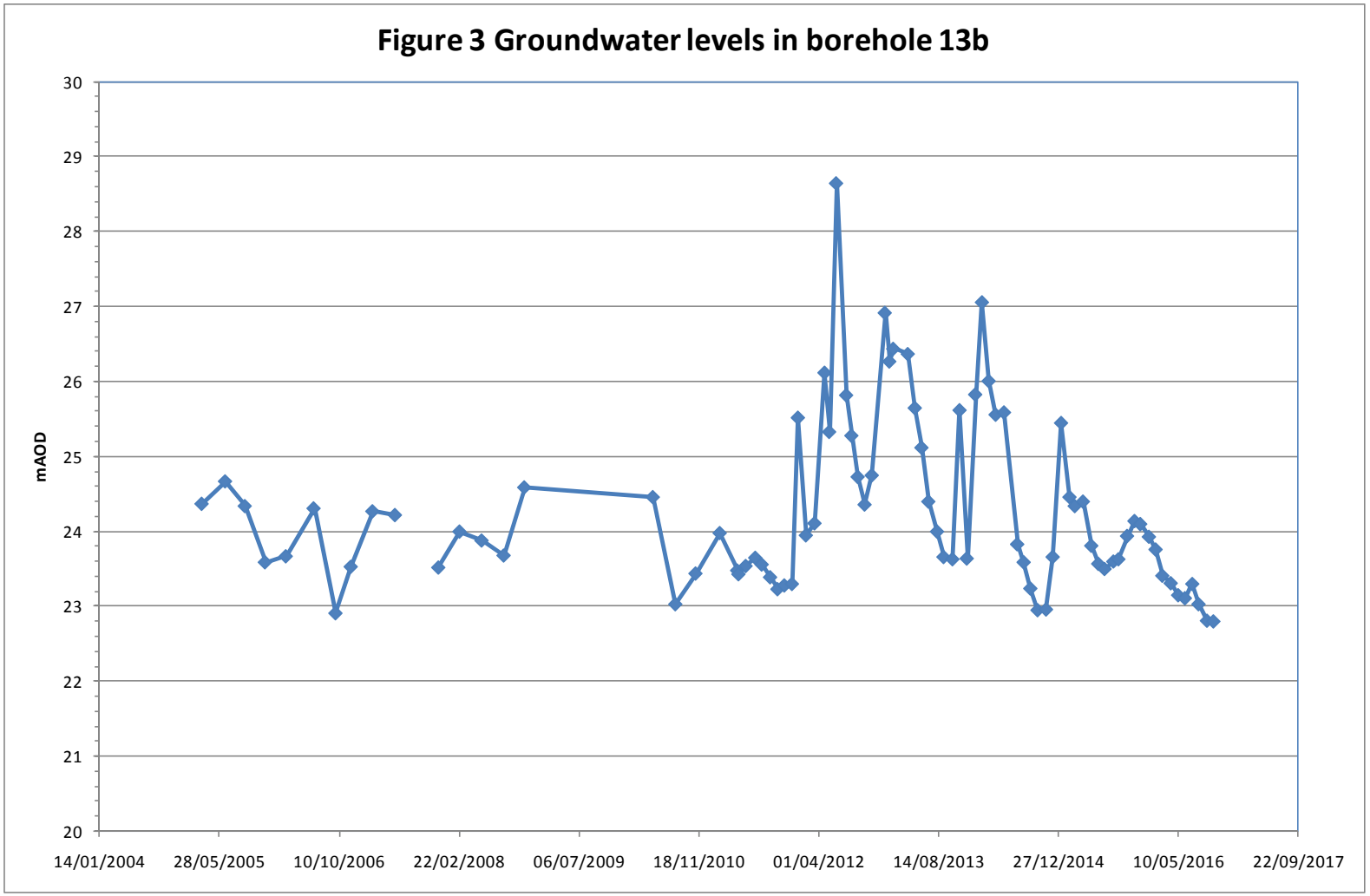
Figure 3 Groundwater levels in borehole 13b
mAOD
30
29
28
27
26
25
24
23
22
21
20
14/01/2004
28/05/2005
10/10/2006
22/02/2008
06/07/2009
18/11/2010
01/04/2012
14/08/2013
27/12/2014
10/05/2016
22/09/2017

G.2 Proposed outfall pipe to the River Cam - plan

Drg. No. 2015s3432-20B: Proposed Outfall Pipe to River Cam - Plan.

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Spillway to be constructed as part of Condition 57 Drainage Scheme (Consent S / 01080 / 10 / CW) for initial restoration of the western part of the quarry.

North Pit

Route and levels of 500mm outfall pipe to be compatible with railway and layout of future residential development and associated drainage systems on the site of the former cement works.

Haslingfield Road Level Crossing

Railway underbridge

Glebe Road Level Crossing

River Cam

Gault Pit

Cement Works

Barrington

Legend

- Proposed outfall pipe
- Watercourse
- Culvert

Permissible discharge to River Cam

Gross catchment area: 72.1ha
Environment Agency permitted discharge rate: 4 l/s/ha
Permitted discharge rate: 72.1ha x 4 l/s/ha = 288 l/s

Average gradient of land along route of outfall pipe

Ground level 29.00mAOD at chainage 63m
Ground level 16.28mAOD at chainage 1516m
Fall 12.72m in 1,453m (1 in 114)

Design philosophy

1. A spillway is to be constructed as part of the Condition 57 Drainage Scheme for the initial restoration of the western part of the quarry.
2. The existing pump in North Pit will continue to discharge to the adjacent watercourse at a maximum rate of 12l/s, in order to minimise flood risks downstream in Barrington.
3. The pump will maintain a flow of water in that watercourse during dry weather.
4. The proposed outfall pipe to the River Cam will reduce flood risks to Barrington during extreme events.
5. The River Cam outfall pipe will generally have the standard cover of 1,200mm below ground level as it passes through the former cement works and future residential development.
6. The River Cam outfall pipe will have the standard cover of 1,200mm below ground level as it passes under Haslingfield Road and Glebe Road (near the level crossings).
7. The River Cam outfall pipe will have to be slung alongside or within the bridge deck at the railway underbridge.
8. Elsewhere along the railway, the pipe could have a reduced cover of 600mm (for economy and to avoid undermining the railway).

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved
B	Note amended relating to outfall pipe through former cement works	06/12/16	GH	DCS	DCS	DCS
A	Inset catchment plan deleted. Condition 57 outfall pipe deleted.	02/12/16	GH	DCS	DCS	DCS

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Barrington Quarry 15 Year Scheme
Proposed Outfall Pipe to River Cam - Plan

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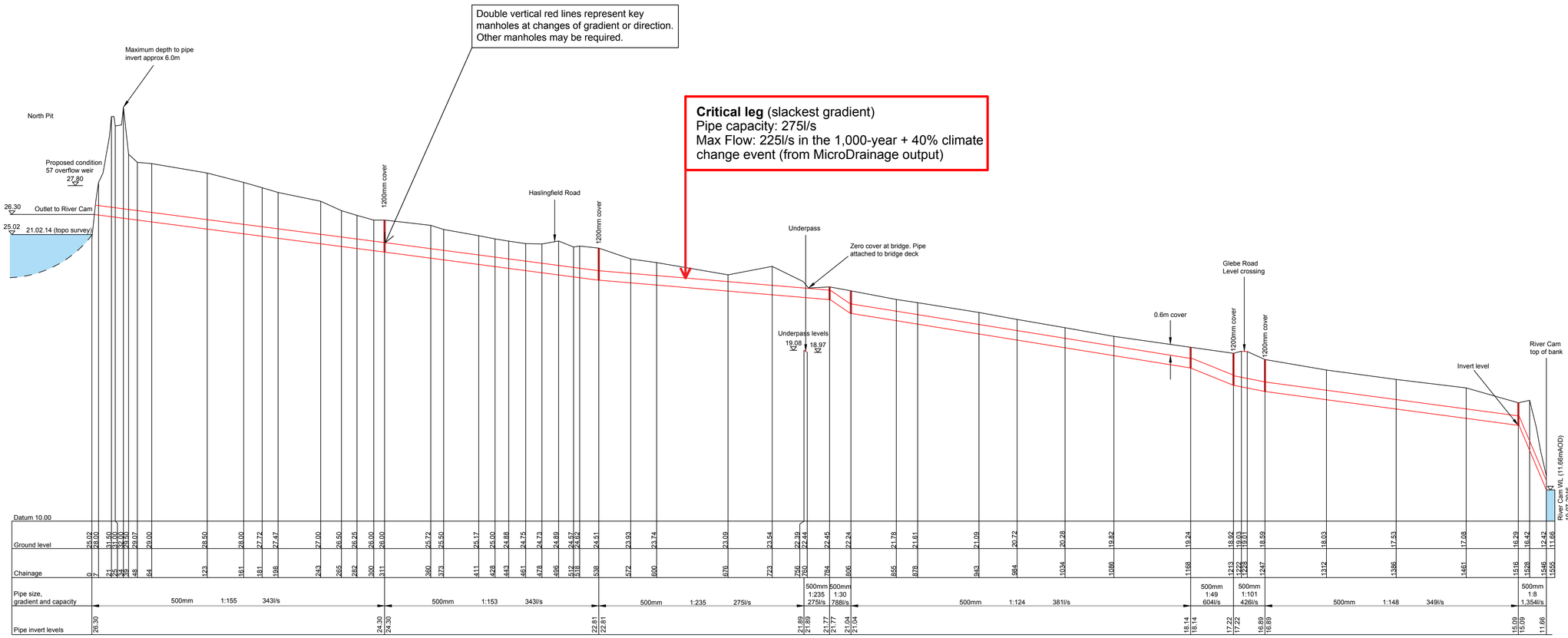
	Checked: D. Stark	21/07/16
	Approved: D. Stark	21/07/16

Digital File Name: 2015s3432-20.dwg

Drawing Number:	Rev.:	Sheet No.:	Status:
2015s3432-20	B	1 of 1	Draft

G.3 Proposed outfall pipe to the River Cam - long section

Drg. No. 2015s3432-21B: Proposed Outfall Pipe to River Cam - Long Section.



Long section of proposed outfall pipe
1:2500H
1:125V

Notes

WL = Water level

1. Manholes will be required at every change in pipe gradient and pipe size, and at maximum intervals of 100m.

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved
B	Note about critical leg amended Note about manhole added	06/12/16	GH	DCS	DCS	DCS
A	North Pit outlet level reduced to 26.3mAOD. Pipe redesigned to be 500mm throughout.	02/12/16	GH	DCS	DCS	DCS

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for

Cemex UK Operations Ltd

Barrington Quarry 15 Year Scheme
Proposed Outfall Pipe to River Cam - Long Section

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Scale:		
As shown @ A1	Drawn:	J. Summersgill 21/07/16
	Designed:	D. Stark 21/07/16
	Checked:	D. Stark 21/07/16
	Approved:	D. Stark 21/07/16

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Drawing Number:	Rev.:	Sheet No.:	Status:
2015s3432-21	B	1 of 1	Draft

G.4 Locations of flow monitors

Drawing Number TL3950_CAW_D_250711_A_3.

The start of Section A-A (not visible) is from houses on the southern edge of Harlton, to the north

Proposed drainage ditch

PROPOSED RESTORED AREA

GAULT CLAY EXCAVATED AREA

Proposed drainage ditch leading down into lower, previously worked levels of the quarry to the east

FM02

Existing drainage ditch

Electrical Submersible Pump For Dewatering Quarry

EXISTING RESTORED AREA

Palletiser Yard Surface Water Catchment Area

Pump (12 l/s)

FM03

North Pit

FM06

Pumped Discharge

Palletiser Yard Pump (5.7 l/s)

Overflow Weir

Spillway

Drain

B

BM 19.63m

B'

Pumped Lake Discharge to River Rhee

Pond

Proposed Settlement Lagoon

Drainage Ditch

Gault Pit

C

A'

A

S15 Sampling and discharge point

Sluice

C'

Drainage Ditch

Proposed Settlement Lagoon

FM01

FM04

B

B'

C'

Culvert Under Road FM05

PLANNING APPLICATION BOUNDARY (See P4/1741/2 for full boundary)

EXISTING WOODLAND/HEDGEROWS

PROPOSED WOODLAND/HEDGEROWS

EXISTING DRAINAGE DITCH & DIRECTION OF SURFACE WATER FLOW

A — A' LINE OF CROSS SECTION

C — C' LINE OF LONGITUDINAL SECTION

FM01 FLOW METER

CULVERTED DRAIN

DRAINAGE DITCH & PROPOSED DIRECTION OF SURFACE WATER FLOW

EXISTING PUMPED DISCHARGE TO RIVER RHEE

ESTIMATED SURFACE WATER CATCHMENT AREAS

DRAINING TO NORTH PIT

DRAINING TO QUARRY

DRAINING TO PALLETISER YARD

Revisions			
6			
5			
4			
3	Plan Amended		
2	Plan Amended	June 2013	CMP/caw
1	Plan Amended	Nov 2011	CMP/caw

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Drawn By: cmp/caw	Company: CEMEX UK Materials Limited
Date: July 2011	Site: Barrington Quarry
Scale(s): 1 : 5 000 @ A3	Project: Importation of Material for Restoration
Checked/Model(s):	Title: Surface Water Management Plan
Site Reference: TL3950	Drawing Number: TL3950_CAW_D_250711_A_3

H MicroDrainage modelling - summary of output

H.1 100-year plus 30% climate change scenarios

Scenario	North Pit catchment area (ha)	Total catchment area (ha)	Greenfield runoff @ 4l/s/ha (l/s)	Total additional flow (l/s)[a]	Additional flow duration (min)	Control outflow type	Hydro-Brake® Optimum sump (Y/N)	Control outflow ID (mm)	Control outflow invert (mAOD)	Design head to crest of overflow weir (m)	Pump intake level (mAOD)	Pump discharge (l/s)	Control outflow destination	Control outflow peak discharge (l/s)	Max WL in North Pit (mAOD)	Critical storm (min)	Overflow discharge (l/s)	Pipe diameter (mm)	Pipe length (m)	Total discharge (l/s)
Condition 57	31.8	66.0	264	5.7	10,080	Pump					26.0	12	Barrington watercourse	12	26.971	> 10,080	0			12.0
Barr-15 last year operational	38.3	77.7	311	5.7	10,080	Pipe		120	26.3				R Cam via existing 200mm ID pipe	30.0	27.356	8,640	0	203	1,000	30.0
Barr-15 last year operational	38.3	72.1	288	0[b]		Hydro-Brake® Optimum	Y	201	26.3	1.5			R Cam via existing 200mm ID pipe	25.9	27.300	7,200	0	203	1,000	25.9
Barr-15 last year operational	38.3	77.7	311	5.7	10,080	Hydro-Brake® Optimum	Y	201	26.3	1.5			R Cam via existing 200mm ID pipe	25.9	27.367	8,640	0	203	1,000	25.9
Barr-15 restored	38.3	72.1	288	0[b]		Hydro-Brake® Optimum	Y	498	26.3	1.5			R Cam via proposed 500mm ID pipe	225	27.011	720	0	500	1,500	225.0
Barr-15 restored	38.3	77.7	311	5.7	10,080	Hydro-Brake® Optimum	Y	498	26.3	1.5			R Cam via proposed 500mm ID pipe	225	27.018	720	0	500	1,500	225.0

Common parameters

Return period storm	1 in 100
Climate change addition	30%
Run-off coefficient	0.8
North Pit area (m2)	34,534
North Pit embankment crest (mAOD)	28.8
Embankment toe (mAOD)	28.0
Control overflow type	Weir
Overflow weir width (m)	2.5
Overflow weir invert (mAOD)	27.8
Hydro-Brake® Optimum objective	Minimise blockage risk

[a]12l/s discharge from SSSI to North Pit switched off when water level in North Pit rises to 26.3 mAOD.

[b]5.7 l/s from Palletiser Yard pumped to housing development drainage system.

Assume Condition 57 pump in North Pit (12l/s) does not operate in an extreme event.

H.2 Catchment areas

Catchment No.	Catchment description	m2	ha
1	NW corner	77,799	7.8
2	SSSI	203,267	20.3
3	Railway valley	204,797	20.5
4	N Pit	128,239	12.8
5	W catchment / infiltration pond	57,251	5.7
6	E of N Pit	49,508	5.0
7	Palletiser yard catchment (goes to housing development drainage)	55,905	5.6
	Total (excluding catchment 7)	720,861	72.1
	Catchments 3, 4 & 6.	382,544	38.3
	Infiltration pond (included in 5)	11,063	1.1

H.3 Outfall pipe capacities

Barr-15 last year operational

Parameter	Value	Units
Pipe material: Steel		
Pipe diameter	200	mm
Pipe length	1,500	m
Upstream invert level	26.30	mAOD
Upstream water level	27.30	mAOD
Downstream invert level	16.30	mAOD
Downstream water level	16.50	mAOD
Head loss	11	m
Hydraulic gradient	0.72%	
Minimum self-cleaning velocity	0.6	m/s
Allowable discharge	315	l/s
Hazen & Williams		
Roughness coefficient	110	
Velocity	0.99	m/s
Flow	31	l/s
Colebrook White		
Roughness value	0.6	mm
Velocity	1.02	m/s
Flow	32	l/s

Barr-15 last restored

Parameter	Value	Units
Pipe material: Steel		
Pipe diameter	500	mm
Pipe length	1,500	m
Upstream invert level	26.30	mAOD
Upstream water level	27.01	mAOD
Downstream invert level	16.30	mAOD
Downstream water level	16.80	mAOD
Head loss	10	m
Hydraulic gradient	0.68%	
Minimum self-cleaning velocity	0.6	m/s
Allowable discharge	315	l/s
Hazen & Williams		
Roughness coefficient	110	
Velocity	1.70	m/s
Flow	334	l/s
Colebrook White		
Roughness value	0.6	mm
Velocity	1.79	m/s
Flow	351	l/s

I MicroDrainage modelling - 100-year scenarios

All scenarios include a **30%** increase in rainfall intensity to allow for climate change.

Scenarios are listed in the same order as they appear on the MicroDrainage Summary of the **100-year** scenarios in Appendix H.1.

I.1 Condition 57 - pump - Palletiser Pump

Discharges to village watercourse.

Summary of Results for 100 year Return Period (+30%)

Outflow is too low. Design is unsatisfactory.

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	26.366	0.366	12.0	0.0	12.0	12625.5	O K
30 min Summer	26.412	0.412	12.0	0.0	12.0	14239.3	O K
60 min Summer	26.465	0.465	12.0	0.0	12.0	16056.4	O K
120 min Summer	26.524	0.524	12.0	0.0	12.0	18099.8	O K
180 min Summer	26.562	0.562	12.0	0.0	12.0	19408.8	O K
240 min Summer	26.590	0.590	12.0	0.0	12.0	20391.1	O K
360 min Summer	26.633	0.633	12.0	0.0	12.0	21853.6	O K
480 min Summer	26.664	0.664	12.0	0.0	12.0	22947.3	O K
600 min Summer	26.690	0.690	12.0	0.0	12.0	23827.6	O K
720 min Summer	26.711	0.711	12.0	0.0	12.0	24567.4	O K
960 min Summer	26.738	0.738	12.0	0.0	12.0	25481.8	O K
1440 min Summer	26.776	0.776	12.0	0.0	12.0	26796.4	O K
2160 min Summer	26.814	0.814	12.0	0.0	12.0	28122.3	O K
2880 min Summer	26.841	0.841	12.0	0.0	12.0	29053.3	O K
4320 min Summer	26.887	0.887	12.0	0.0	12.0	30619.1	O K
5760 min Summer	26.917	0.917	12.0	0.0	12.0	31679.5	O K
7200 min Summer	26.940	0.940	12.0	0.0	12.0	32448.8	O K
8640 min Summer	26.956	0.956	12.0	0.0	12.0	33026.3	O K
10080 min Summer	26.969	0.969	12.0	0.0	12.0	33465.0	O K
15 min Winter	26.366	0.366	12.0	0.0	12.0	12625.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	1033.0	0.0	19
30 min Summer	112.134	0.0	1030.3	0.0	34
60 min Summer	63.245	0.0	2062.6	0.0	64
120 min Summer	35.671	0.0	2053.7	0.0	124
180 min Summer	25.517	0.0	2045.5	0.0	184
240 min Summer	20.119	0.0	2037.6	0.0	244
360 min Summer	14.392	0.0	2022.7	0.0	364
480 min Summer	11.347	0.0	2008.5	0.0	484
600 min Summer	9.437	0.0	1994.8	0.0	604
720 min Summer	8.117	0.0	1981.6	0.0	724
960 min Summer	6.329	0.0	1955.0	0.0	964
1440 min Summer	4.456	0.0	1904.3	0.0	1444
2160 min Summer	3.138	0.0	3906.6	0.0	2164
2880 min Summer	2.446	0.0	3838.2	0.0	2884
4320 min Summer	1.739	0.0	3712.2	0.0	4324
5760 min Summer	1.365	0.0	7741.1	0.0	5768
7200 min Summer	1.132	0.0	7628.8	0.0	7208
8640 min Summer	0.971	0.0	7520.6	0.0	8648
10080 min Summer	0.853	0.0	7416.4	0.0	10088
15 min Winter	198.815	0.0	1033.1	0.0	19

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Summary of Results for 100 year Return Period (+30%)

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
30 min Winter	26.412	0.412	12.0	0.0	12.0	14239.2	O K
60 min Winter	26.465	0.465	12.0	0.0	12.0	16056.1	O K
120 min Winter	26.524	0.524	12.0	0.0	12.0	18099.5	O K
180 min Winter	26.562	0.562	12.0	0.0	12.0	19408.4	O K
240 min Winter	26.590	0.590	12.0	0.0	12.0	20390.9	O K
360 min Winter	26.633	0.633	12.0	0.0	12.0	21853.5	O K
480 min Winter	26.664	0.664	12.0	0.0	12.0	22947.5	O K
600 min Winter	26.690	0.690	12.0	0.0	12.0	23828.4	O K
720 min Winter	26.711	0.711	12.0	0.0	12.0	24568.7	O K
960 min Winter	26.738	0.738	12.0	0.0	12.0	25484.0	O K
1440 min Winter	26.776	0.776	12.0	0.0	12.0	26800.4	O K
2160 min Winter	26.815	0.815	12.0	0.0	12.0	28129.3	O K
2880 min Winter	26.842	0.842	12.0	0.0	12.0	29064.3	O K
4320 min Winter	26.887	0.887	12.0	0.0	12.0	30640.6	O K
5760 min Winter	26.918	0.918	12.0	0.0	12.0	31712.2	O K
7200 min Winter	26.941	0.941	12.0	0.0	12.0	32492.3	O K
8640 min Winter	26.958	0.958	12.0	0.0	12.0	33080.5	O K
10080 min Winter	26.971	0.971	12.0	0.0	12.0	33531.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
30 min Winter	112.134	0.0	1030.5	0.0	34
60 min Winter	63.245	0.0	2062.9	0.0	64
120 min Winter	35.671	0.0	2054.1	0.0	124
180 min Winter	25.517	0.0	2045.8	0.0	184
240 min Winter	20.119	0.0	2037.9	0.0	244
360 min Winter	14.392	0.0	2022.8	0.0	364
480 min Winter	11.347	0.0	2008.2	0.0	484
600 min Winter	9.437	0.0	1994.1	0.0	602
720 min Winter	8.117	0.0	1980.5	0.0	722
960 min Winter	6.329	0.0	1953.2	0.0	962
1440 min Winter	4.456	0.0	1900.7	0.0	1442
2160 min Winter	3.138	0.0	3900.2	0.0	2160
2880 min Winter	2.446	0.0	3829.0	0.0	2856
4320 min Winter	1.739	0.0	3696.8	0.0	4280
5760 min Winter	1.365	0.0	7719.7	0.0	5712
7200 min Winter	1.132	0.0	7601.8	0.0	7136
8640 min Winter	0.971	0.0	7488.1	0.0	8552
10080 min Winter	0.853	0.0	7378.7	0.0	9976

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 31.760

Time (mins) From:	To:	Area (ha)
0	4	31.760

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Pump Outflow Control

Invert Level (m) 26.000

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	12.0000	0.900	12.0000	1.700	12.0000	2.500	12.0000
0.200	12.0000	1.000	12.0000	1.800	12.0000	2.600	12.0000
0.300	12.0000	1.100	12.0000	1.900	12.0000	2.700	12.0000
0.400	12.0000	1.200	12.0000	2.000	12.0000	2.800	12.0000
0.500	12.0000	1.300	12.0000	2.100	12.0000	2.900	12.0000
0.600	12.0000	1.400	12.0000	2.200	12.0000	3.000	12.0000
0.700	12.0000	1.500	12.0000	2.300	12.0000		
0.800	12.0000	1.600	12.0000	2.400	12.0000		

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 27.800

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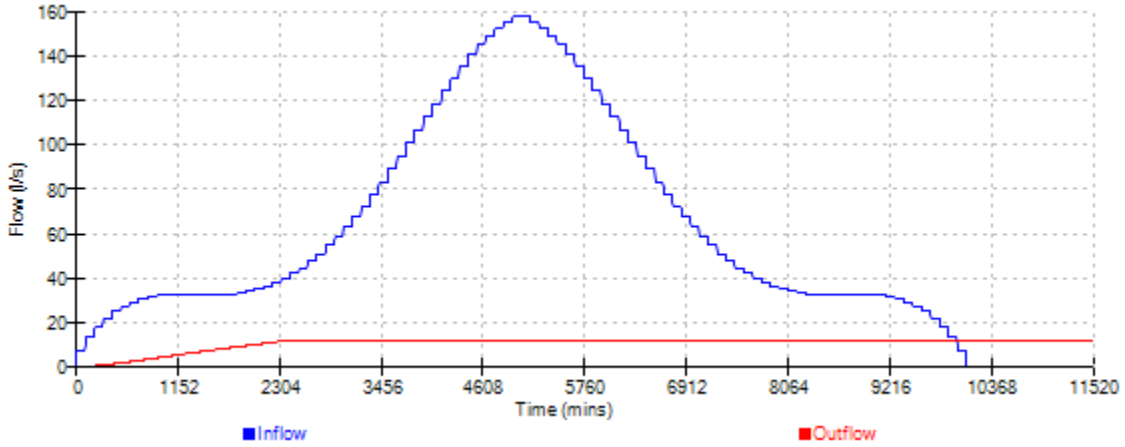
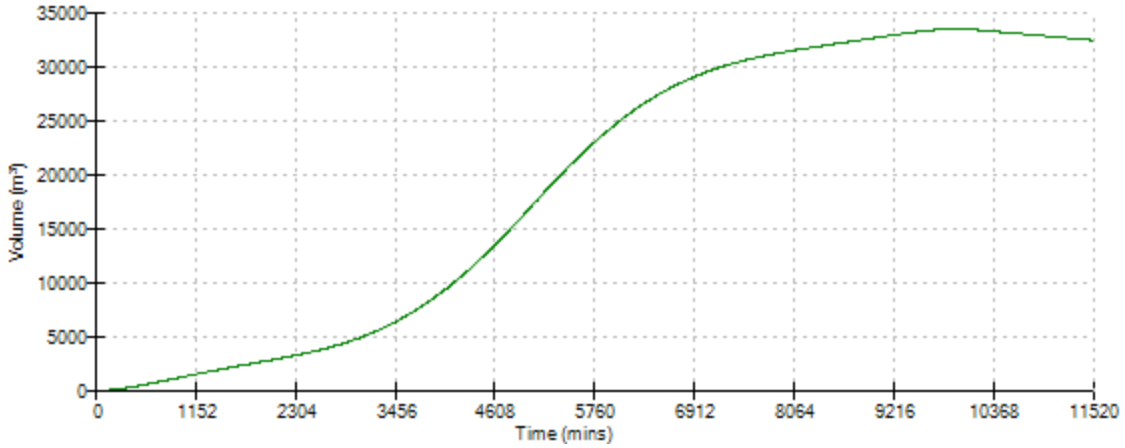
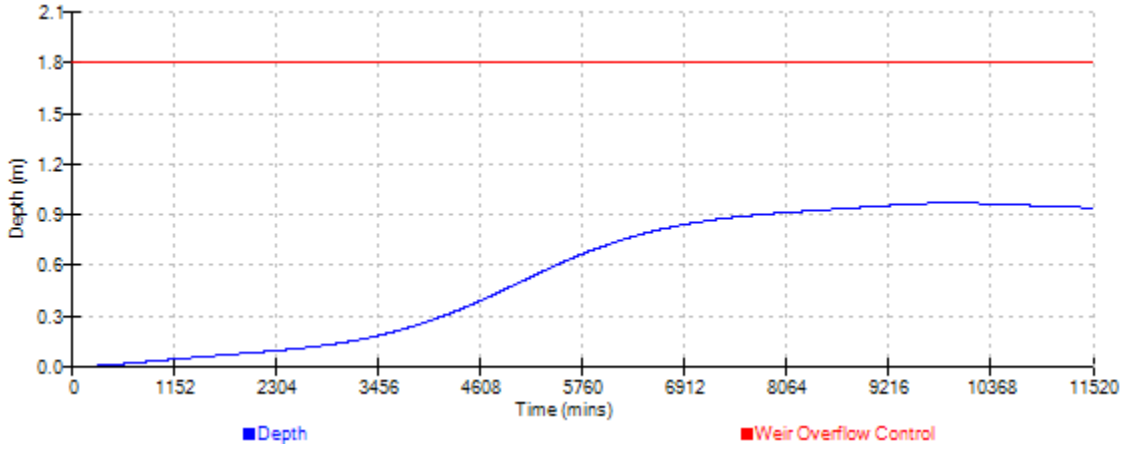
Event: 10080 min Winter







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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
1	5.7	50	5.7	99	5.7	148	5.7	197	5.7	246	5.7
2	5.7	51	5.7	100	5.7	149	5.7	198	5.7	247	5.7
3	5.7	52	5.7	101	5.7	150	5.7	199	5.7	248	5.7
4	5.7	53	5.7	102	5.7	151	5.7	200	5.7	249	5.7
5	5.7	54	5.7	103	5.7	152	5.7	201	5.7	250	5.7
6	5.7	55	5.7	104	5.7	153	5.7	202	5.7	251	5.7
7	5.7	56	5.7	105	5.7	154	5.7	203	5.7	252	5.7
8	5.7	57	5.7	106	5.7	155	5.7	204	5.7	253	5.7
9	5.7	58	5.7	107	5.7	156	5.7	205	5.7	254	5.7
10	5.7	59	5.7	108	5.7	157	5.7	206	5.7	255	5.7
11	5.7	60	5.7	109	5.7	158	5.7	207	5.7	256	5.7
12	5.7	61	5.7	110	5.7	159	5.7	208	5.7	257	5.7
13	5.7	62	5.7	111	5.7	160	5.7	209	5.7	258	5.7
14	5.7	63	5.7	112	5.7	161	5.7	210	5.7	259	5.7
15	5.7	64	5.7	113	5.7	162	5.7	211	5.7	260	5.7
16	5.7	65	5.7	114	5.7	163	5.7	212	5.7	261	5.7
17	5.7	66	5.7	115	5.7	164	5.7	213	5.7	262	5.7
18	5.7	67	5.7	116	5.7	165	5.7	214	5.7	263	5.7
19	5.7	68	5.7	117	5.7	166	5.7	215	5.7	264	5.7
20	5.7	69	5.7	118	5.7	167	5.7	216	5.7	265	5.7
21	5.7	70	5.7	119	5.7	168	5.7	217	5.7	266	5.7
22	5.7	71	5.7	120	5.7	169	5.7	218	5.7	267	5.7
23	5.7	72	5.7	121	5.7	170	5.7	219	5.7	268	5.7
24	5.7	73	5.7	122	5.7	171	5.7	220	5.7	269	5.7
25	5.7	74	5.7	123	5.7	172	5.7	221	5.7	270	5.7
26	5.7	75	5.7	124	5.7	173	5.7	222	5.7	271	5.7
27	5.7	76	5.7	125	5.7	174	5.7	223	5.7	272	5.7
28	5.7	77	5.7	126	5.7	175	5.7	224	5.7	273	5.7
29	5.7	78	5.7	127	5.7	176	5.7	225	5.7	274	5.7
30	5.7	79	5.7	128	5.7	177	5.7	226	5.7	275	5.7
31	5.7	80	5.7	129	5.7	178	5.7	227	5.7	276	5.7
32	5.7	81	5.7	130	5.7	179	5.7	228	5.7	277	5.7
33	5.7	82	5.7	131	5.7	180	5.7	229	5.7	278	5.7
34	5.7	83	5.7	132	5.7	181	5.7	230	5.7	279	5.7
35	5.7	84	5.7	133	5.7	182	5.7	231	5.7	280	5.7
36	5.7	85	5.7	134	5.7	183	5.7	232	5.7	281	5.7
37	5.7	86	5.7	135	5.7	184	5.7	233	5.7	282	5.7
38	5.7	87	5.7	136	5.7	185	5.7	234	5.7	283	5.7
39	5.7	88	5.7	137	5.7	186	5.7	235	5.7	284	5.7
40	5.7	89	5.7	138	5.7	187	5.7	236	5.7	285	5.7
41	5.7	90	5.7	139	5.7	188	5.7	237	5.7	286	5.7
42	5.7	91	5.7	140	5.7	189	5.7	238	5.7	287	5.7
43	5.7	92	5.7	141	5.7	190	5.7	239	5.7	288	5.7
44	5.7	93	5.7	142	5.7	191	5.7	240	5.7	289	5.7
45	5.7	94	5.7	143	5.7	192	5.7	241	5.7	290	5.7
46	5.7	95	5.7	144	5.7	193	5.7	242	5.7	291	5.7
47	5.7	96	5.7	145	5.7	194	5.7	243	5.7	292	5.7
48	5.7	97	5.7	146	5.7	195	5.7	244	5.7	293	5.7
49	5.7	98	5.7	147	5.7	196	5.7	245	5.7	294	5.7

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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
9997	5.7	10011	5.7	10025	5.7	10039	5.7	10053	5.7	10067	5.7
9998	5.7	10012	5.7	10026	5.7	10040	5.7	10054	5.7	10068	5.7
9999	5.7	10013	5.7	10027	5.7	10041	5.7	10055	5.7	10069	5.7
10000	5.7	10014	5.7	10028	5.7	10042	5.7	10056	5.7	10070	5.7
10001	5.7	10015	5.7	10029	5.7	10043	5.7	10057	5.7	10071	5.7
10002	5.7	10016	5.7	10030	5.7	10044	5.7	10058	5.7	10072	5.7
10003	5.7	10017	5.7	10031	5.7	10045	5.7	10059	5.7	10073	5.7
10004	5.7	10018	5.7	10032	5.7	10046	5.7	10060	5.7	10074	5.7
10005	5.7	10019	5.7	10033	5.7	10047	5.7	10061	5.7	10075	5.7
10006	5.7	10020	5.7	10034	5.7	10048	5.7	10062	5.7	10076	5.7
10007	5.7	10021	5.7	10035	5.7	10049	5.7	10063	5.7	10077	5.7
10008	5.7	10022	5.7	10036	5.7	10050	5.7	10064	5.7	10078	5.7
10009	5.7	10023	5.7	10037	5.7	10051	5.7	10065	5.7	10079	5.7
10010	5.7	10024	5.7	10038	5.7	10052	5.7	10066	5.7	10080	5.7

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I.2 Barrington 15 - last year operational - 120mm throttle pipe - Palletiser Pump

Discharges to River Cam via existing 200mm pipe.

This scenario has been modelled as a worst case scenario. In practice, the 500mm pipe to the River Cam is likely to be installed well before the last year of operation.

CEMEX House
Church Lane
Bromsgrove B61 8RA

Date 01/12/2016 10:41 | Designed by CM Pointer, CEMEX
File Barrington-15 100 yrs+3... | Checked by D Stark, JBA Cons...
Micro Drainage | Source Control 2016.1

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	26.741	0.441	18.5	0.0	18.5	15224.4	O K
30 min Summer	26.797	0.497	19.9	0.0	19.9	17168.9	O K
60 min Summer	26.860	0.560	21.3	0.0	21.3	19355.9	O K
120 min Summer	26.932	0.632	22.7	0.0	22.7	21809.0	O K
180 min Summer	26.977	0.677	23.6	0.0	23.6	23374.4	O K
240 min Summer	27.011	0.711	24.2	0.0	24.2	24544.5	O K
360 min Summer	27.061	0.761	25.2	0.0	25.2	26275.8	O K
480 min Summer	27.098	0.798	25.8	0.0	25.8	27559.2	O K
600 min Summer	27.128	0.828	26.3	0.0	26.3	28583.0	O K
720 min Summer	27.152	0.852	26.8	0.0	26.8	29435.3	O K
960 min Summer	27.182	0.882	27.2	0.0	27.2	30458.6	O K
1440 min Summer	27.223	0.923	27.9	0.0	27.9	31874.7	O K
2160 min Summer	27.261	0.961	28.5	0.0	28.5	33203.3	O K
2880 min Summer	27.286	0.986	28.9	0.0	28.9	34042.2	O K
4320 min Summer	27.323	1.023	29.5	0.0	29.5	35317.2	O K
5760 min Summer	27.341	1.041	29.8	0.0	29.8	35958.8	O K
7200 min Summer	27.349	1.049	29.9	0.0	29.9	36237.9	O K
8640 min Summer	27.351	1.051	29.9	0.0	29.9	36279.3	O K
10080 min Summer	27.347	1.047	29.9	0.0	29.9	36162.6	O K
15 min Winter	26.741	0.441	18.5	0.0	18.5	15224.4	O K
30 min Winter	26.797	0.497	19.9	0.0	19.9	17168.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	1560.4	0.0	19
30 min Summer	112.134	0.0	1665.5	0.0	34
60 min Summer	63.245	0.0	3502.5	0.0	64
120 min Summer	35.671	0.0	3718.0	0.0	124
180 min Summer	25.517	0.0	3834.3	0.0	184
240 min Summer	20.119	0.0	3908.0	0.0	244
360 min Summer	14.392	0.0	3991.6	0.0	364
480 min Summer	11.347	0.0	4029.1	0.0	484
600 min Summer	9.437	0.0	4040.1	0.0	604
720 min Summer	8.117	0.0	4033.8	0.0	724
960 min Summer	6.329	0.0	3962.0	0.0	964
1440 min Summer	4.456	0.0	3755.5	0.0	1444
2160 min Summer	3.138	0.0	8063.4	0.0	2164
2880 min Summer	2.446	0.0	7758.7	0.0	2884
4320 min Summer	1.739	0.0	7036.0	0.0	4320
5760 min Summer	1.365	0.0	15826.2	0.0	5760
7200 min Summer	1.132	0.0	15221.2	0.0	7200
8640 min Summer	0.971	0.0	14511.5	0.0	8640
10080 min Summer	0.853	0.0	13719.7	0.0	9784
15 min Winter	198.815	0.0	1560.5	0.0	19
30 min Winter	112.134	0.0	1665.8	0.0	34

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Summary of Results for 100 year Return Period (+30%)

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
60 min Winter	26.860	0.560	21.3	0.0	21.3	19355.4	O K
120 min Winter	26.931	0.631	22.7	0.0	22.7	21808.0	O K
180 min Winter	26.977	0.677	23.6	0.0	23.6	23372.8	O K
240 min Winter	27.011	0.711	24.2	0.0	24.2	24542.9	O K
360 min Winter	27.061	0.761	25.2	0.0	25.2	26273.7	O K
480 min Winter	27.098	0.798	25.8	0.0	25.8	27556.5	O K
600 min Winter	27.128	0.828	26.3	0.0	26.3	28579.6	O K
720 min Winter	27.152	0.852	26.8	0.0	26.8	29431.5	O K
960 min Winter	27.182	0.882	27.2	0.0	27.2	30454.8	O K
1440 min Winter	27.223	0.923	27.9	0.0	27.9	31873.4	O K
2160 min Winter	27.262	0.962	28.5	0.0	28.5	33206.5	O K
2880 min Winter	27.286	0.986	28.9	0.0	28.9	34051.9	O K
4320 min Winter	27.324	1.024	29.5	0.0	29.5	35352.5	O K
5760 min Winter	27.343	1.043	29.8	0.0	29.8	36028.6	O K
7200 min Winter	27.353	1.053	29.9	0.0	29.9	36358.4	O K
8640 min Winter	27.356	1.056	30.0	0.0	30.0	36461.6	O K
10080 min Winter	27.354	1.054	30.0	0.0	30.0	36412.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	63.245	0.0	3502.9	0.0	64
120 min Winter	35.671	0.0	3718.9	0.0	124
180 min Winter	25.517	0.0	3835.7	0.0	184
240 min Winter	20.119	0.0	3910.0	0.0	242
360 min Winter	14.392	0.0	3994.5	0.0	362
480 min Winter	11.347	0.0	4032.9	0.0	482
600 min Winter	9.437	0.0	4044.9	0.0	600
720 min Winter	8.117	0.0	4039.5	0.0	720
960 min Winter	6.329	0.0	3969.5	0.0	954
1440 min Winter	4.456	0.0	3766.4	0.0	1428
2160 min Winter	3.138	0.0	8077.9	0.0	2140
2880 min Winter	2.446	0.0	7777.7	0.0	2852
4320 min Winter	1.739	0.0	7063.3	0.0	4236
5760 min Winter	1.365	0.0	15856.0	0.0	5600
7200 min Winter	1.132	0.0	15257.8	0.0	6984
8640 min Winter	0.971	0.0	14554.7	0.0	8296
10080 min Winter	0.853	0.0	13769.4	0.0	9584

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 38.300

Time (mins) From:	To:	Area (ha)
0	4	38.300

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Pipe Outflow Control

Diameter (m)	0.120	Entry Loss Coefficient	0.500
Slope (1:X)	20.0	Coefficient of Contraction	0.600
Length (m)	2.000	Upstream Invert Level (m)	26.300
Roughness k (mm)	0.600		

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.500 Invert Level (m) 27.800

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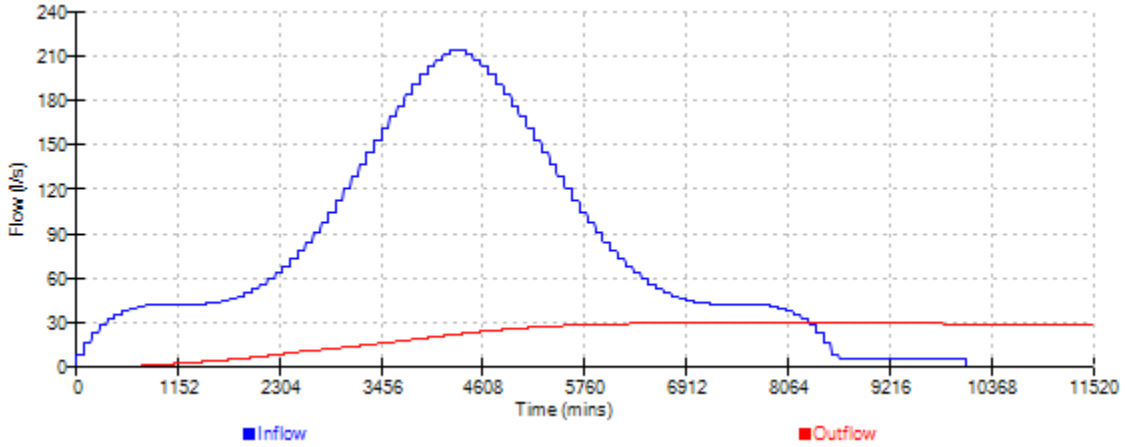
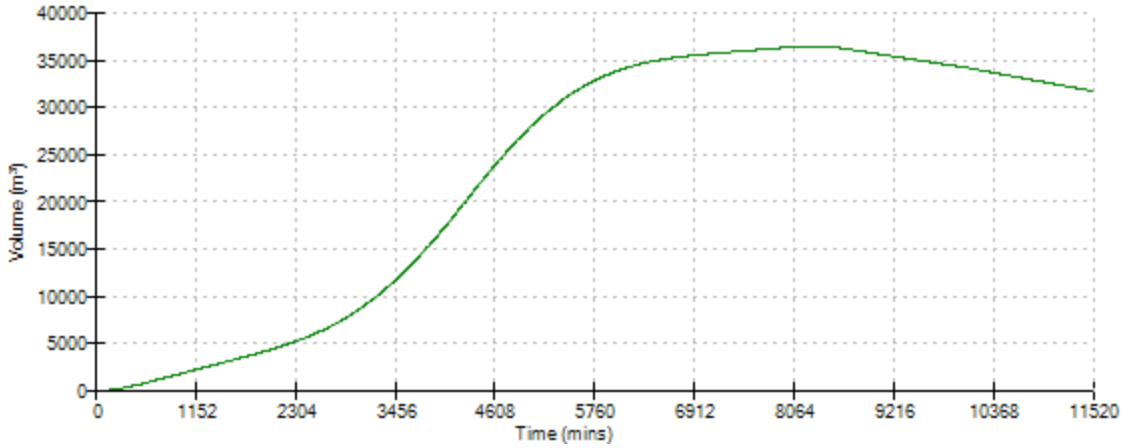
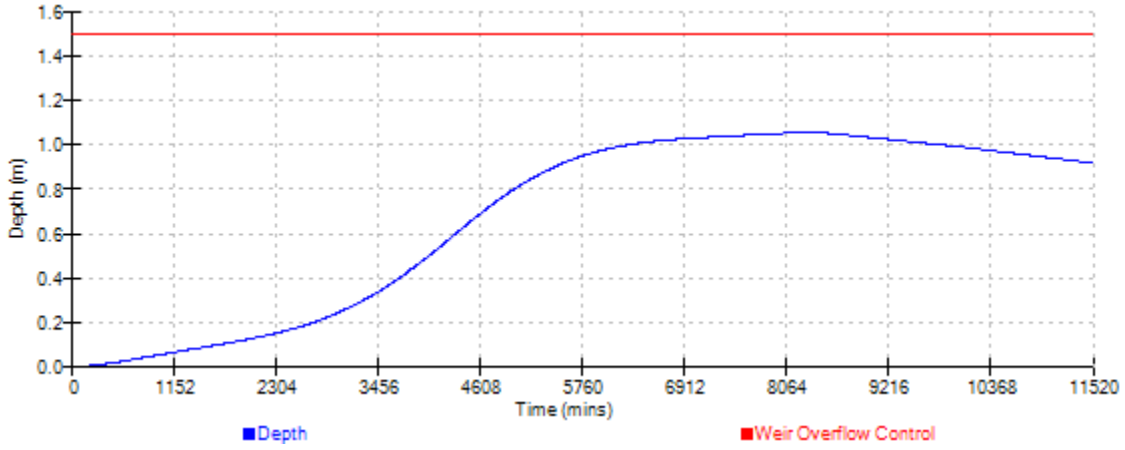
Event: 8640 min Winter







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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
1	5.7	50	5.7	99	5.7	148	5.7	197	5.7	246	5.7
2	5.7	51	5.7	100	5.7	149	5.7	198	5.7	247	5.7
3	5.7	52	5.7	101	5.7	150	5.7	199	5.7	248	5.7
4	5.7	53	5.7	102	5.7	151	5.7	200	5.7	249	5.7
5	5.7	54	5.7	103	5.7	152	5.7	201	5.7	250	5.7
6	5.7	55	5.7	104	5.7	153	5.7	202	5.7	251	5.7
7	5.7	56	5.7	105	5.7	154	5.7	203	5.7	252	5.7
8	5.7	57	5.7	106	5.7	155	5.7	204	5.7	253	5.7
9	5.7	58	5.7	107	5.7	156	5.7	205	5.7	254	5.7
10	5.7	59	5.7	108	5.7	157	5.7	206	5.7	255	5.7
11	5.7	60	5.7	109	5.7	158	5.7	207	5.7	256	5.7
12	5.7	61	5.7	110	5.7	159	5.7	208	5.7	257	5.7
13	5.7	62	5.7	111	5.7	160	5.7	209	5.7	258	5.7
14	5.7	63	5.7	112	5.7	161	5.7	210	5.7	259	5.7
15	5.7	64	5.7	113	5.7	162	5.7	211	5.7	260	5.7
16	5.7	65	5.7	114	5.7	163	5.7	212	5.7	261	5.7
17	5.7	66	5.7	115	5.7	164	5.7	213	5.7	262	5.7
18	5.7	67	5.7	116	5.7	165	5.7	214	5.7	263	5.7
19	5.7	68	5.7	117	5.7	166	5.7	215	5.7	264	5.7
20	5.7	69	5.7	118	5.7	167	5.7	216	5.7	265	5.7
21	5.7	70	5.7	119	5.7	168	5.7	217	5.7	266	5.7
22	5.7	71	5.7	120	5.7	169	5.7	218	5.7	267	5.7
23	5.7	72	5.7	121	5.7	170	5.7	219	5.7	268	5.7
24	5.7	73	5.7	122	5.7	171	5.7	220	5.7	269	5.7
25	5.7	74	5.7	123	5.7	172	5.7	221	5.7	270	5.7
26	5.7	75	5.7	124	5.7	173	5.7	222	5.7	271	5.7
27	5.7	76	5.7	125	5.7	174	5.7	223	5.7	272	5.7
28	5.7	77	5.7	126	5.7	175	5.7	224	5.7	273	5.7
29	5.7	78	5.7	127	5.7	176	5.7	225	5.7	274	5.7
30	5.7	79	5.7	128	5.7	177	5.7	226	5.7	275	5.7
31	5.7	80	5.7	129	5.7	178	5.7	227	5.7	276	5.7
32	5.7	81	5.7	130	5.7	179	5.7	228	5.7	277	5.7
33	5.7	82	5.7	131	5.7	180	5.7	229	5.7	278	5.7
34	5.7	83	5.7	132	5.7	181	5.7	230	5.7	279	5.7
35	5.7	84	5.7	133	5.7	182	5.7	231	5.7	280	5.7
36	5.7	85	5.7	134	5.7	183	5.7	232	5.7	281	5.7
37	5.7	86	5.7	135	5.7	184	5.7	233	5.7	282	5.7
38	5.7	87	5.7	136	5.7	185	5.7	234	5.7	283	5.7
39	5.7	88	5.7	137	5.7	186	5.7	235	5.7	284	5.7
40	5.7	89	5.7	138	5.7	187	5.7	236	5.7	285	5.7
41	5.7	90	5.7	139	5.7	188	5.7	237	5.7	286	5.7
42	5.7	91	5.7	140	5.7	189	5.7	238	5.7	287	5.7
43	5.7	92	5.7	141	5.7	190	5.7	239	5.7	288	5.7
44	5.7	93	5.7	142	5.7	191	5.7	240	5.7	289	5.7
45	5.7	94	5.7	143	5.7	192	5.7	241	5.7	290	5.7
46	5.7	95	5.7	144	5.7	193	5.7	242	5.7	291	5.7
47	5.7	96	5.7	145	5.7	194	5.7	243	5.7	292	5.7
48	5.7	97	5.7	146	5.7	195	5.7	244	5.7	293	5.7
49	5.7	98	5.7	147	5.7	196	5.7	245	5.7	294	5.7

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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
9997	5.7	10011	5.7	10025	5.7	10039	5.7	10053	5.7	10067	5.7
9998	5.7	10012	5.7	10026	5.7	10040	5.7	10054	5.7	10068	5.7
9999	5.7	10013	5.7	10027	5.7	10041	5.7	10055	5.7	10069	5.7
10000	5.7	10014	5.7	10028	5.7	10042	5.7	10056	5.7	10070	5.7
10001	5.7	10015	5.7	10029	5.7	10043	5.7	10057	5.7	10071	5.7
10002	5.7	10016	5.7	10030	5.7	10044	5.7	10058	5.7	10072	5.7
10003	5.7	10017	5.7	10031	5.7	10045	5.7	10059	5.7	10073	5.7
10004	5.7	10018	5.7	10032	5.7	10046	5.7	10060	5.7	10074	5.7
10005	5.7	10019	5.7	10033	5.7	10047	5.7	10061	5.7	10075	5.7
10006	5.7	10020	5.7	10034	5.7	10048	5.7	10062	5.7	10076	5.7
10007	5.7	10021	5.7	10035	5.7	10049	5.7	10063	5.7	10077	5.7
10008	5.7	10022	5.7	10036	5.7	10050	5.7	10064	5.7	10078	5.7
10009	5.7	10023	5.7	10037	5.7	10051	5.7	10065	5.7	10079	5.7
10010	5.7	10024	5.7	10038	5.7	10052	5.7	10066	5.7	10080	5.7

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I.3 Barrington 15 - last year operational - 201mm HydroBrake

Discharges to River Cam via existing 200mm pipe.

CEMEX House
Church Lane
Bromsgrove B61 8RA

Date 29/11/2016 10:17 | Designed by cmpointer
File Barrington-15 100 yrs+3... | Checked by
Micro Drainage | Source Control 2016.1

Summary of Results for 100 year Return Period (+30%)

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	26.740	0.440	25.9	0.0	25.9	15212.2	O K
30 min Summer	26.797	0.497	25.9	0.0	25.9	17147.9	O K
60 min Summer	26.859	0.559	25.9	0.0	25.9	19318.7	O K
120 min Summer	26.930	0.630	25.9	0.0	25.9	21741.5	O K
180 min Summer	26.974	0.674	25.9	0.0	25.9	23279.0	O K
240 min Summer	27.007	0.707	25.9	0.0	25.9	24422.9	O K
360 min Summer	27.056	0.756	25.9	0.0	25.9	26106.0	O K
480 min Summer	27.092	0.792	25.9	0.0	25.9	27346.0	O K
600 min Summer	27.120	0.820	25.9	0.0	25.9	28330.5	O K
720 min Summer	27.144	0.844	25.9	0.0	25.9	29147.3	O K
960 min Summer	27.172	0.872	25.9	0.0	25.9	30100.8	O K
1440 min Summer	27.209	0.909	25.9	0.0	25.9	31388.4	O K
2160 min Summer	27.242	0.942	25.9	0.0	25.9	32533.8	O K
2880 min Summer	27.261	0.961	25.9	0.0	25.9	33197.9	O K
4320 min Summer	27.289	0.989	25.9	0.0	25.9	34157.8	O K
5760 min Summer	27.299	0.999	25.9	0.0	25.9	34508.5	O K
7200 min Summer	27.300	1.000	25.9	0.0	25.9	34519.3	O K
8640 min Summer	27.294	0.994	25.9	0.0	25.9	34311.4	O K
10080 min Summer	27.283	0.983	25.9	0.0	25.9	33954.3	O K
15 min Winter	26.740	0.440	25.9	0.0	25.9	15212.0	O K
30 min Winter	26.797	0.497	25.9	0.0	25.9	17147.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	2211.2	0.0	19
30 min Summer	112.134	0.0	2175.9	0.0	34
60 min Summer	63.245	0.0	4316.8	0.0	64
120 min Summer	35.671	0.0	4193.1	0.0	124
180 min Summer	25.517	0.0	4099.7	0.0	184
240 min Summer	20.119	0.0	4020.1	0.0	244
360 min Summer	14.392	0.0	3880.2	0.0	364
480 min Summer	11.347	0.0	3752.6	0.0	484
600 min Summer	9.437	0.0	3631.7	0.0	604
720 min Summer	8.117	0.0	3516.1	0.0	724
960 min Summer	6.329	0.0	3337.3	0.0	964
1440 min Summer	4.456	0.0	3124.4	0.0	1444
2160 min Summer	3.138	0.0	6523.7	0.0	2164
2880 min Summer	2.446	0.0	6315.8	0.0	2884
4320 min Summer	1.739	0.0	6024.5	0.0	4324
5760 min Summer	1.365	0.0	12862.9	0.0	5760
7200 min Summer	1.132	0.0	12446.2	0.0	7200
8640 min Summer	0.971	0.0	12112.9	0.0	8640
10080 min Summer	0.853	0.0	11750.9	0.0	10080
15 min Winter	198.815	0.0	2211.4	0.0	19
30 min Winter	112.134	0.0	2176.6	0.0	34

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Summary of Results for 100 year Return Period (+30%)

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
60 min Winter	26.859	0.559	25.9	0.0	25.9	19317.1	O K
120 min Winter	26.929	0.629	25.9	0.0	25.9	21738.1	O K
180 min Winter	26.974	0.674	25.9	0.0	25.9	23273.9	O K
240 min Winter	27.007	0.707	25.9	0.0	25.9	24417.1	O K
360 min Winter	27.056	0.756	25.9	0.0	25.9	26097.4	O K
480 min Winter	27.092	0.792	25.9	0.0	25.9	27334.5	O K
600 min Winter	27.120	0.820	25.9	0.0	25.9	28316.4	O K
720 min Winter	27.144	0.844	25.9	0.0	25.9	29130.5	O K
960 min Winter	27.171	0.871	25.9	0.0	25.9	30079.0	O K
1440 min Winter	27.208	0.908	25.9	0.0	25.9	31357.6	O K
2160 min Winter	27.241	0.941	25.9	0.0	25.9	32491.4	O K
2880 min Winter	27.260	0.960	25.9	0.0	25.9	33145.7	O K
4320 min Winter	27.287	0.987	25.9	0.0	25.9	34094.4	O K
5760 min Winter	27.297	0.997	25.9	0.0	25.9	34446.3	O K
7200 min Winter	27.298	0.998	25.9	0.0	25.9	34461.1	O K
8640 min Winter	27.292	0.992	25.9	0.0	25.9	34263.9	O K
10080 min Winter	27.282	0.982	25.9	0.0	25.9	33922.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	63.245	0.0	4318.4	0.0	64
120 min Winter	35.671	0.0	4196.6	0.0	124
180 min Winter	25.517	0.0	4105.1	0.0	182
240 min Winter	20.119	0.0	4027.3	0.0	242
360 min Winter	14.392	0.0	3890.8	0.0	362
480 min Winter	11.347	0.0	3766.6	0.0	482
600 min Winter	9.437	0.0	3649.1	0.0	600
720 min Winter	8.117	0.0	3536.7	0.0	720
960 min Winter	6.329	0.0	3364.7	0.0	956
1440 min Winter	4.456	0.0	3163.4	0.0	1428
2160 min Winter	3.138	0.0	6585.0	0.0	2140
2880 min Winter	2.446	0.0	6392.0	0.0	2852
4320 min Winter	1.739	0.0	6135.3	0.0	4240
5760 min Winter	1.365	0.0	13016.1	0.0	5648
7200 min Winter	1.132	0.0	12625.7	0.0	6992
8640 min Winter	0.971	0.0	12323.0	0.0	8384
10080 min Winter	0.853	0.0	12007.3	0.0	9680

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 38.300

Time (mins) From:	To:	Area (ha)
0	4	38.300

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SCL-0201-2600-1500-2600
Design Head (m)	1.500
Design Flow (l/s)	26.0
Flush-Flo™	Calculated
Objective	Minimise blockage risk
Application	Surface
Sump Available	Yes
Diameter (mm)	201
Invert Level (m)	26.300
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	25.9
Flush-Flo™	0.343	25.9
Kick-Flo®	0.869	20.0
Mean Flow over Head Range	-	21.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.6	1.000	21.4	2.400	32.4	5.500	48.3
0.200	20.9	1.200	23.3	2.600	33.7	6.000	50.4
0.300	25.8	1.400	25.1	3.000	36.1	6.500	52.4
0.400	25.8	1.600	26.7	3.500	38.9	7.000	54.3
0.500	25.2	1.800	28.3	4.000	41.5	7.500	56.2
0.600	24.4	2.000	29.7	4.500	43.9	8.000	57.9
0.800	21.9	2.200	31.1	5.000	46.2	8.500	59.7

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Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
9.000	61.4	9.500	63.0				

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.500 Invert Level (m) 27.800

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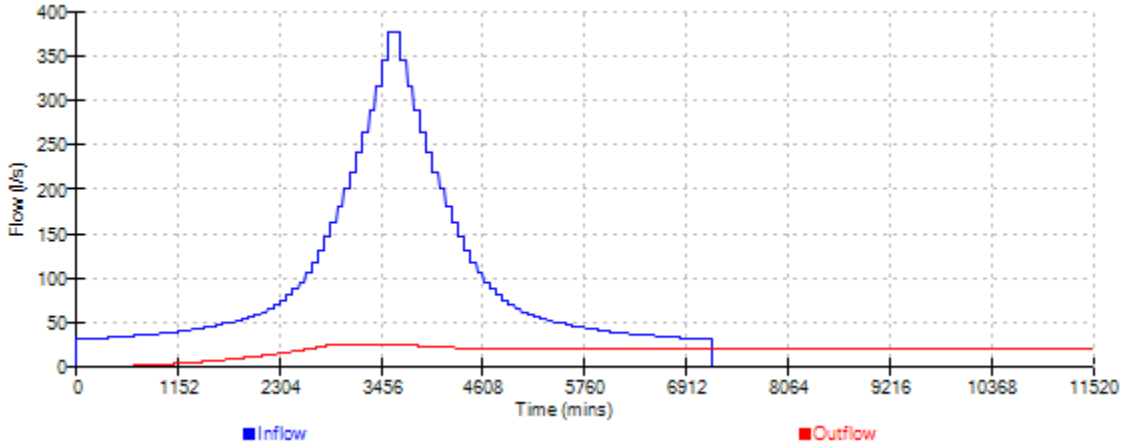
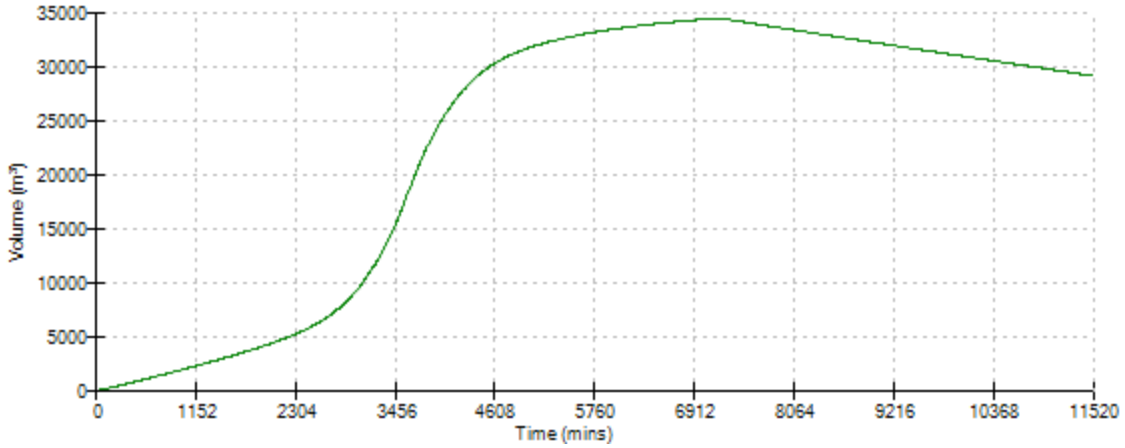
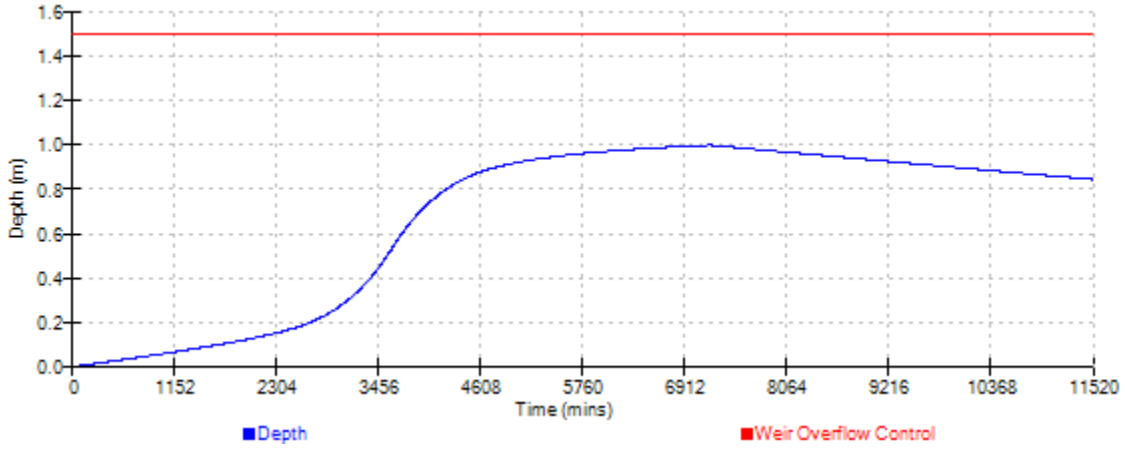
Event: 7200 min Summer







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I.4 Barrington 15 - last year operational - 201mm HydroBrake - Palletiser Pump

Discharges to River Cam via existing 200mm pipe.

CEMEX House
Church Lane
Bromsgrove B61 8RA

Date 29/11/2016 11:18 | Designed by cmpointer
File Barrington-15 100 yrs+3... | Checked by
Micro Drainage | Source Control 2016.1

Summary of Results for 100 year Return Period (+30%)

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	26.741	0.441	25.9	0.0	25.9	15218.5	O K
30 min Summer	26.797	0.497	25.9	0.0	25.9	17159.3	O K
60 min Summer	26.860	0.560	25.9	0.0	25.9	19340.2	O K
120 min Summer	26.931	0.631	25.9	0.0	25.9	21783.5	O K
180 min Summer	26.976	0.676	25.9	0.0	25.9	23341.4	O K
240 min Summer	27.010	0.710	25.9	0.0	25.9	24505.7	O K
360 min Summer	27.060	0.760	25.9	0.0	25.9	26229.6	O K
480 min Summer	27.097	0.797	25.9	0.0	25.9	27510.4	O K
600 min Summer	27.126	0.826	25.9	0.0	25.9	28535.8	O K
720 min Summer	27.151	0.851	25.9	0.0	25.9	29393.5	O K
960 min Summer	27.181	0.881	25.9	0.0	25.9	30428.5	O K
1440 min Summer	27.223	0.923	25.9	0.0	25.9	31873.9	O K
2160 min Summer	27.263	0.963	25.9	0.0	25.9	33249.8	O K
2880 min Summer	27.289	0.989	25.9	0.0	25.9	34138.2	O K
4320 min Summer	27.329	1.029	25.9	0.0	25.9	35528.1	O K
5760 min Summer	27.351	1.051	25.9	0.0	25.9	36287.6	O K
7200 min Summer	27.362	1.062	25.9	0.0	25.9	36688.0	O K
8640 min Summer	27.367	1.067	25.9	0.0	25.9	36853.4	O K
10080 min Summer	27.367	1.067	25.9	0.0	25.9	36853.1	O K
15 min Winter	26.741	0.441	25.9	0.0	25.9	15218.3	O K
30 min Winter	26.797	0.497	25.9	0.0	25.9	17158.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	2208.7	0.0	19
30 min Summer	112.134	0.0	2172.1	0.0	34
60 min Summer	63.245	0.0	4299.7	0.0	64
120 min Summer	35.671	0.0	4173.4	0.0	124
180 min Summer	25.517	0.0	4078.5	0.0	184
240 min Summer	20.119	0.0	3997.0	0.0	244
360 min Summer	14.392	0.0	3851.6	0.0	364
480 min Summer	11.347	0.0	3717.0	0.0	484
600 min Summer	9.437	0.0	3588.3	0.0	604
720 min Summer	8.117	0.0	3464.5	0.0	724
960 min Summer	6.329	0.0	3283.0	0.0	964
1440 min Summer	4.456	0.0	3146.3	0.0	1444
2160 min Summer	3.138	0.0	6528.1	0.0	2164
2880 min Summer	2.446	0.0	6429.9	0.0	2884
4320 min Summer	1.739	0.0	6173.1	0.0	4324
5760 min Summer	1.365	0.0	13128.8	0.0	5768
7200 min Summer	1.132	0.0	12927.3	0.0	7200
8640 min Summer	0.971	0.0	12669.9	0.0	8640
10080 min Summer	0.853	0.0	12370.9	0.0	10080
15 min Winter	198.815	0.0	2208.9	0.0	19
30 min Winter	112.134	0.0	2172.7	0.0	34

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Summary of Results for 100 year Return Period (+30%)

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
60 min Winter	26.860	0.560	25.9	0.0	25.9	19338.6	O K
120 min Winter	26.931	0.631	25.9	0.0	25.9	21780.1	O K
180 min Winter	26.976	0.676	25.9	0.0	25.9	23336.3	O K
240 min Winter	27.009	0.709	25.9	0.0	25.9	24499.3	O K
360 min Winter	27.059	0.759	25.9	0.0	25.9	26220.5	O K
480 min Winter	27.096	0.796	25.9	0.0	25.9	27498.5	O K
600 min Winter	27.126	0.826	25.9	0.0	25.9	28521.0	O K
720 min Winter	27.151	0.851	25.9	0.0	25.9	29375.9	O K
960 min Winter	27.180	0.880	25.9	0.0	25.9	30405.0	O K
1440 min Winter	27.222	0.922	25.9	0.0	25.9	31839.7	O K
2160 min Winter	27.261	0.961	25.9	0.0	25.9	33203.2	O K
2880 min Winter	27.287	0.987	25.9	0.0	25.9	34082.6	O K
4320 min Winter	27.327	1.027	25.9	0.0	25.9	35462.7	O K
5760 min Winter	27.349	1.049	25.9	0.0	25.9	36221.8	O K
7200 min Winter	27.361	1.061	25.9	0.0	25.9	36629.4	O K
8640 min Winter	27.366	1.066	25.9	0.0	25.9	36801.9	O K
10080 min Winter	27.366	1.066	25.9	0.0	25.9	36815.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	63.245	0.0	4301.3	0.0	64
120 min Winter	35.671	0.0	4177.0	0.0	124
180 min Winter	25.517	0.0	4083.8	0.0	184
240 min Winter	20.119	0.0	4004.1	0.0	242
360 min Winter	14.392	0.0	3862.2	0.0	362
480 min Winter	11.347	0.0	3730.9	0.0	482
600 min Winter	9.437	0.0	3605.5	0.0	602
720 min Winter	8.117	0.0	3485.1	0.0	722
960 min Winter	6.329	0.0	3309.6	0.0	960
1440 min Winter	4.456	0.0	3183.0	0.0	1430
2160 min Winter	3.138	0.0	6580.3	0.0	2144
2880 min Winter	2.446	0.0	6497.5	0.0	2852
4320 min Winter	1.739	0.0	6266.3	0.0	4276
5760 min Winter	1.365	0.0	13233.7	0.0	5656
7200 min Winter	1.132	0.0	13052.2	0.0	7056
8640 min Winter	0.971	0.0	12816.3	0.0	8464
10080 min Winter	0.853	0.0	12539.9	0.0	9784

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 38.300

Time (mins) From:	To:	Area (ha)
0	4	38.300

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SCL-0201-2600-1500-2600
Design Head (m)	1.500
Design Flow (l/s)	26.0
Flush-Flo™	Calculated
Objective	Minimise blockage risk
Application	Surface
Sump Available	Yes
Diameter (mm)	201
Invert Level (m)	26.300
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	25.9
Flush-Flo™	0.343	25.9
Kick-Flo®	0.869	20.0
Mean Flow over Head Range	-	21.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.6	1.000	21.4	2.400	32.4	5.500	48.3
0.200	20.9	1.200	23.3	2.600	33.7	6.000	50.4
0.300	25.8	1.400	25.1	3.000	36.1	6.500	52.4
0.400	25.8	1.600	26.7	3.500	38.9	7.000	54.3
0.500	25.2	1.800	28.3	4.000	41.5	7.500	56.2
0.600	24.4	2.000	29.7	4.500	43.9	8.000	57.9
0.800	21.9	2.200	31.1	5.000	46.2	8.500	59.7

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Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
9.000	61.4	9.500	63.0				

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.500 Invert Level (m) 27.800

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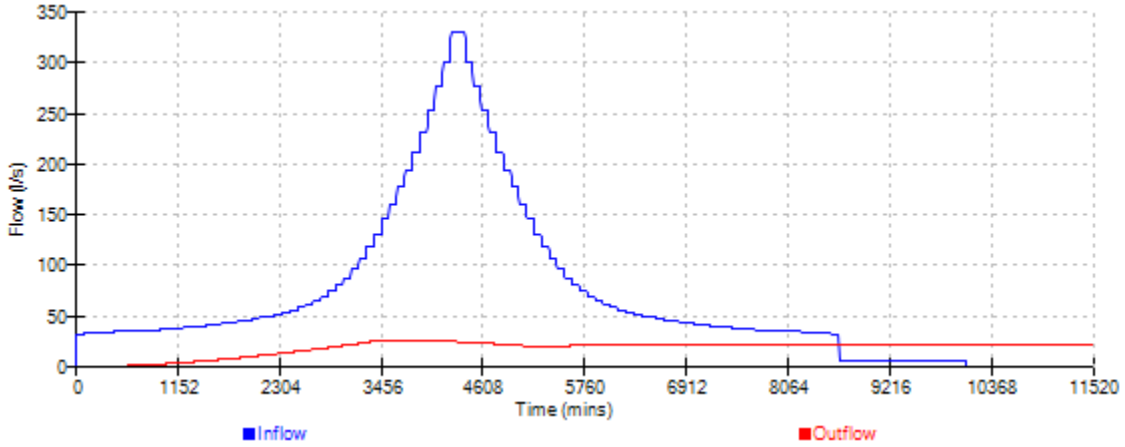
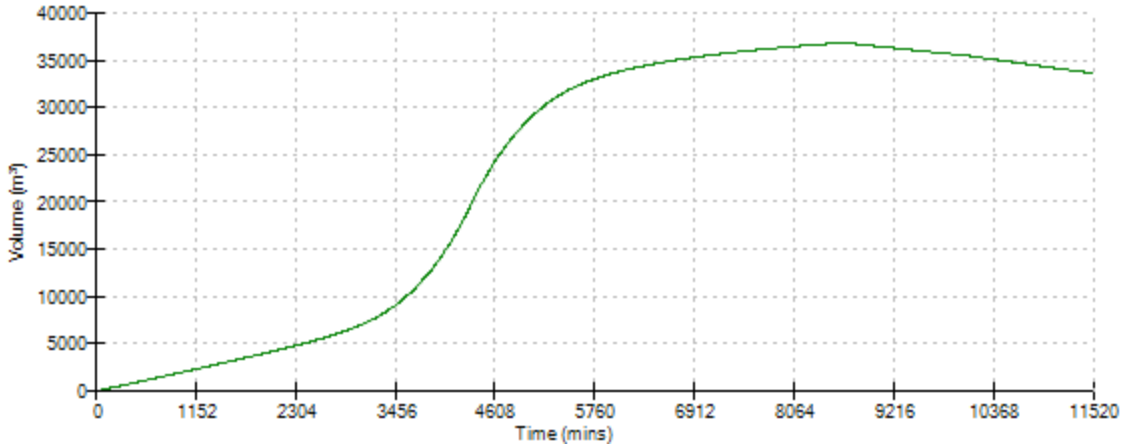
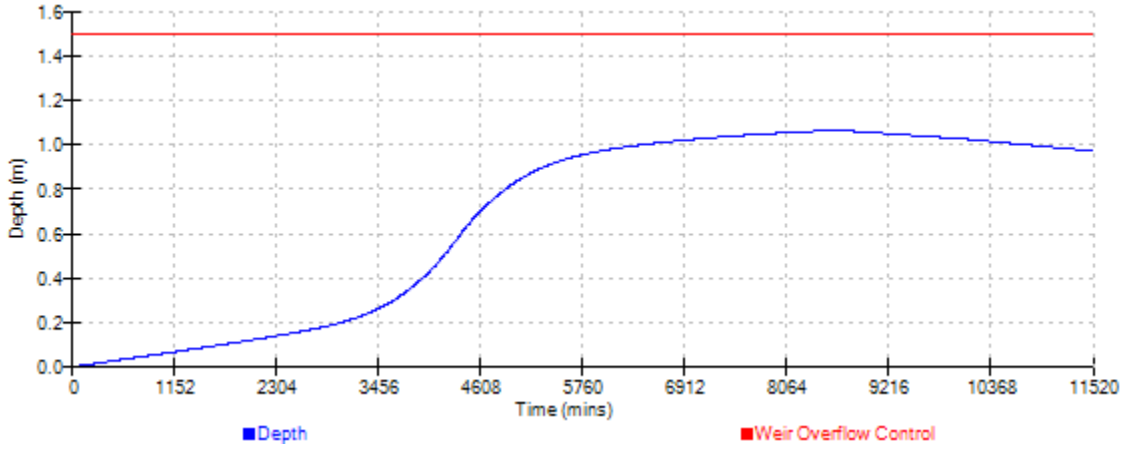
Event: 8640 min Summer







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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
1	5.7	50	5.7	99	5.7	148	5.7	197	5.7	246	5.7
2	5.7	51	5.7	100	5.7	149	5.7	198	5.7	247	5.7
3	5.7	52	5.7	101	5.7	150	5.7	199	5.7	248	5.7
4	5.7	53	5.7	102	5.7	151	5.7	200	5.7	249	5.7
5	5.7	54	5.7	103	5.7	152	5.7	201	5.7	250	5.7
6	5.7	55	5.7	104	5.7	153	5.7	202	5.7	251	5.7
7	5.7	56	5.7	105	5.7	154	5.7	203	5.7	252	5.7
8	5.7	57	5.7	106	5.7	155	5.7	204	5.7	253	5.7
9	5.7	58	5.7	107	5.7	156	5.7	205	5.7	254	5.7
10	5.7	59	5.7	108	5.7	157	5.7	206	5.7	255	5.7
11	5.7	60	5.7	109	5.7	158	5.7	207	5.7	256	5.7
12	5.7	61	5.7	110	5.7	159	5.7	208	5.7	257	5.7
13	5.7	62	5.7	111	5.7	160	5.7	209	5.7	258	5.7
14	5.7	63	5.7	112	5.7	161	5.7	210	5.7	259	5.7
15	5.7	64	5.7	113	5.7	162	5.7	211	5.7	260	5.7
16	5.7	65	5.7	114	5.7	163	5.7	212	5.7	261	5.7
17	5.7	66	5.7	115	5.7	164	5.7	213	5.7	262	5.7
18	5.7	67	5.7	116	5.7	165	5.7	214	5.7	263	5.7
19	5.7	68	5.7	117	5.7	166	5.7	215	5.7	264	5.7
20	5.7	69	5.7	118	5.7	167	5.7	216	5.7	265	5.7
21	5.7	70	5.7	119	5.7	168	5.7	217	5.7	266	5.7
22	5.7	71	5.7	120	5.7	169	5.7	218	5.7	267	5.7
23	5.7	72	5.7	121	5.7	170	5.7	219	5.7	268	5.7
24	5.7	73	5.7	122	5.7	171	5.7	220	5.7	269	5.7
25	5.7	74	5.7	123	5.7	172	5.7	221	5.7	270	5.7
26	5.7	75	5.7	124	5.7	173	5.7	222	5.7	271	5.7
27	5.7	76	5.7	125	5.7	174	5.7	223	5.7	272	5.7
28	5.7	77	5.7	126	5.7	175	5.7	224	5.7	273	5.7
29	5.7	78	5.7	127	5.7	176	5.7	225	5.7	274	5.7
30	5.7	79	5.7	128	5.7	177	5.7	226	5.7	275	5.7
31	5.7	80	5.7	129	5.7	178	5.7	227	5.7	276	5.7
32	5.7	81	5.7	130	5.7	179	5.7	228	5.7	277	5.7
33	5.7	82	5.7	131	5.7	180	5.7	229	5.7	278	5.7
34	5.7	83	5.7	132	5.7	181	5.7	230	5.7	279	5.7
35	5.7	84	5.7	133	5.7	182	5.7	231	5.7	280	5.7
36	5.7	85	5.7	134	5.7	183	5.7	232	5.7	281	5.7
37	5.7	86	5.7	135	5.7	184	5.7	233	5.7	282	5.7
38	5.7	87	5.7	136	5.7	185	5.7	234	5.7	283	5.7
39	5.7	88	5.7	137	5.7	186	5.7	235	5.7	284	5.7
40	5.7	89	5.7	138	5.7	187	5.7	236	5.7	285	5.7
41	5.7	90	5.7	139	5.7	188	5.7	237	5.7	286	5.7
42	5.7	91	5.7	140	5.7	189	5.7	238	5.7	287	5.7
43	5.7	92	5.7	141	5.7	190	5.7	239	5.7	288	5.7
44	5.7	93	5.7	142	5.7	191	5.7	240	5.7	289	5.7
45	5.7	94	5.7	143	5.7	192	5.7	241	5.7	290	5.7
46	5.7	95	5.7	144	5.7	193	5.7	242	5.7	291	5.7
47	5.7	96	5.7	145	5.7	194	5.7	243	5.7	292	5.7
48	5.7	97	5.7	146	5.7	195	5.7	244	5.7	293	5.7
49	5.7	98	5.7	147	5.7	196	5.7	245	5.7	294	5.7

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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
9997	5.7	10011	5.7	10025	5.7	10039	5.7	10053	5.7	10067	5.7
9998	5.7	10012	5.7	10026	5.7	10040	5.7	10054	5.7	10068	5.7
9999	5.7	10013	5.7	10027	5.7	10041	5.7	10055	5.7	10069	5.7
10000	5.7	10014	5.7	10028	5.7	10042	5.7	10056	5.7	10070	5.7
10001	5.7	10015	5.7	10029	5.7	10043	5.7	10057	5.7	10071	5.7
10002	5.7	10016	5.7	10030	5.7	10044	5.7	10058	5.7	10072	5.7
10003	5.7	10017	5.7	10031	5.7	10045	5.7	10059	5.7	10073	5.7
10004	5.7	10018	5.7	10032	5.7	10046	5.7	10060	5.7	10074	5.7
10005	5.7	10019	5.7	10033	5.7	10047	5.7	10061	5.7	10075	5.7
10006	5.7	10020	5.7	10034	5.7	10048	5.7	10062	5.7	10076	5.7
10007	5.7	10021	5.7	10035	5.7	10049	5.7	10063	5.7	10077	5.7
10008	5.7	10022	5.7	10036	5.7	10050	5.7	10064	5.7	10078	5.7
10009	5.7	10023	5.7	10037	5.7	10051	5.7	10065	5.7	10079	5.7
10010	5.7	10024	5.7	10038	5.7	10052	5.7	10066	5.7	10080	5.7

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I.5 Barrington 15 - restored - 498mm HydroBrake

Discharges to River Cam via proposed 500mm pipe.

CEMEX House
Church Lane
Bromsgrove B61 8RA

Date 29/11/2016 11:28 | Designed by cmpointer
File Barrington-15 100 yrs+3... | Checked by
Micro Drainage | Source Control 2016.1

Summary of Results for 100 year Return Period (+30%)

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	26.738	0.438	179.4	0.0	179.4	15138.3	O K
30 min Summer	26.792	0.492	203.4	0.0	203.4	16990.5	O K
60 min Summer	26.849	0.549	224.5	0.0	224.5	18975.2	O K
120 min Summer	26.908	0.608	225.0	0.0	225.0	21013.0	O K
180 min Summer	26.942	0.642	225.0	0.0	225.0	22168.4	O K
240 min Summer	26.964	0.664	225.0	0.0	225.0	22925.3	O K
360 min Summer	26.990	0.690	225.0	0.0	225.0	23821.9	O K
480 min Summer	27.003	0.703	225.0	0.0	225.0	24264.4	O K
600 min Summer	27.008	0.708	225.0	0.0	225.0	24447.0	O K
720 min Summer	27.008	0.708	225.0	0.0	225.0	24454.9	O K
960 min Summer	26.996	0.696	225.0	0.0	225.0	24050.4	O K
1440 min Summer	26.978	0.678	225.0	0.0	225.0	23403.9	O K
2160 min Summer	26.950	0.650	225.0	0.0	225.0	22436.9	O K
2880 min Summer	26.921	0.621	225.0	0.0	225.0	21433.1	O K
4320 min Summer	26.871	0.571	224.8	0.0	224.8	19708.9	O K
5760 min Summer	26.829	0.529	218.4	0.0	218.4	18255.5	O K
7200 min Summer	26.795	0.495	204.6	0.0	204.6	17080.1	O K
8640 min Summer	26.766	0.466	192.1	0.0	192.1	16077.7	O K
10080 min Summer	26.741	0.441	180.6	0.0	180.6	15224.1	O K
15 min Winter	26.738	0.438	179.4	0.0	179.4	15138.7	O K
30 min Winter	26.792	0.492	203.6	0.0	203.6	16993.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	8504.6	0.0	19
30 min Summer	112.134	0.0	9903.3	0.0	34
60 min Summer	63.245	0.0	14842.2	0.0	64
120 min Summer	35.671	0.0	17008.7	0.0	124
180 min Summer	25.517	0.0	18363.3	0.0	182
240 min Summer	20.119	0.0	19356.6	0.0	242
360 min Summer	14.392	0.0	20784.3	0.0	362
480 min Summer	11.347	0.0	21797.5	0.0	482
600 min Summer	9.437	0.0	22564.8	0.0	600
720 min Summer	8.117	0.0	23165.5	0.0	716
960 min Summer	6.329	0.0	23755.8	0.0	808
1440 min Summer	4.456	0.0	24208.7	0.0	1040
2160 min Summer	3.138	0.0	31024.2	0.0	1432
2880 min Summer	2.446	0.0	31961.1	0.0	1844
4320 min Summer	1.739	0.0	32976.8	0.0	2632
5760 min Summer	1.365	0.0	38230.6	0.0	3392
7200 min Summer	1.132	0.0	39337.3	0.0	4112
8640 min Summer	0.971	0.0	40050.0	0.0	4848
10080 min Summer	0.853	0.0	40287.4	0.0	5640
15 min Winter	198.815	0.0	8504.5	0.0	19
30 min Winter	112.134	0.0	9903.0	0.0	33

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Summary of Results for 100 year Return Period (+30%)

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
60 min Winter	26.850	0.550	224.5	0.0	224.5	18981.4	O K
120 min Winter	26.909	0.609	225.0	0.0	225.0	21035.5	O K
180 min Winter	26.943	0.643	225.0	0.0	225.0	22197.1	O K
240 min Winter	26.965	0.665	225.0	0.0	225.0	22955.6	O K
360 min Winter	26.991	0.691	225.0	0.0	225.0	23861.9	O K
480 min Winter	27.004	0.704	225.0	0.0	225.0	24321.9	O K
600 min Winter	27.010	0.710	225.0	0.0	225.0	24527.3	O K
720 min Winter	27.011	0.711	225.0	0.0	225.0	24569.6	O K
960 min Winter	26.996	0.696	225.0	0.0	225.0	24036.9	O K
1440 min Winter	26.970	0.670	225.0	0.0	225.0	23124.5	O K
2160 min Winter	26.928	0.628	225.0	0.0	225.0	21701.4	O K
2880 min Winter	26.887	0.587	224.9	0.0	224.9	20264.2	O K
4320 min Winter	26.824	0.524	216.4	0.0	216.4	18084.7	O K
5760 min Winter	26.776	0.476	196.5	0.0	196.5	16425.7	O K
7200 min Winter	26.737	0.437	178.9	0.0	178.9	15103.3	O K
8640 min Winter	26.707	0.407	163.7	0.0	163.7	14043.3	O K
10080 min Winter	26.682	0.382	150.1	0.0	150.1	13188.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	63.245	0.0	14842.0	0.0	62
120 min Winter	35.671	0.0	17008.5	0.0	122
180 min Winter	25.517	0.0	18363.4	0.0	180
240 min Winter	20.119	0.0	19357.6	0.0	238
360 min Winter	14.392	0.0	20787.9	0.0	354
480 min Winter	11.347	0.0	21804.5	0.0	468
600 min Winter	9.437	0.0	22576.5	0.0	580
720 min Winter	8.117	0.0	23182.6	0.0	688
960 min Winter	6.329	0.0	23784.4	0.0	888
1440 min Winter	4.456	0.0	24268.2	0.0	1096
2160 min Winter	3.138	0.0	31041.0	0.0	1536
2880 min Winter	2.446	0.0	31985.6	0.0	1960
4320 min Winter	1.739	0.0	32995.3	0.0	2764
5760 min Winter	1.365	0.0	38232.5	0.0	3520
7200 min Winter	1.132	0.0	39341.3	0.0	4320
8640 min Winter	0.971	0.0	40060.0	0.0	5024
10080 min Winter	0.853	0.0	40313.6	0.0	5840

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 38.300

Time (mins) From:	To:	Area (ha)
0	4	38.300

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SCL-0498-2250-1500-2250
Design Head (m)	1.500
Design Flow (l/s)	225.0
Flush-Flo™	Calculated
Objective	Minimise blockage risk
Application	Surface
Sump Available	Yes
Diameter (mm)	498
Invert Level (m)	26.300
Minimum Outlet Pipe Diameter (mm)	Site Specific Design (Contact Hydro International)
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	224.9
Flush-Flo™	0.603	225.0
Kick-Flo®	1.097	193.1
Mean Flow over Head Range	-	170.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	13.8	1.000	204.5	2.400	282.9	5.500	424.9
0.200	50.9	1.200	201.7	2.600	294.2	6.000	443.5
0.300	103.3	1.400	217.4	3.000	315.6	6.500	461.3
0.400	160.1	1.600	232.1	3.500	340.3	7.000	478.4
0.500	206.8	1.800	245.8	4.000	363.4	7.500	494.9
0.600	225.0	2.000	258.8	4.500	385.0	8.000	510.9
0.800	219.3	2.200	271.1	5.000	405.5	8.500	526.3

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Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
9.000	541.4	9.500	556.0				

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.500 Invert Level (m) 27.800

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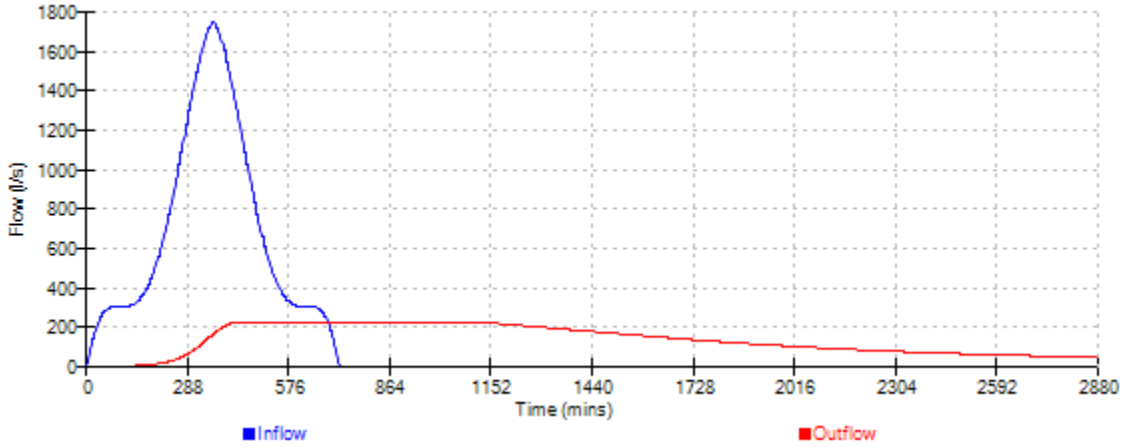
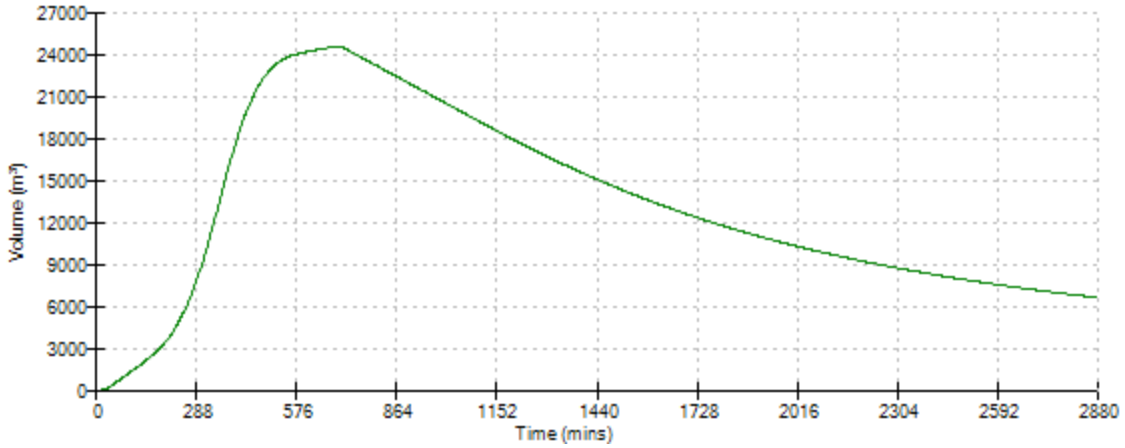
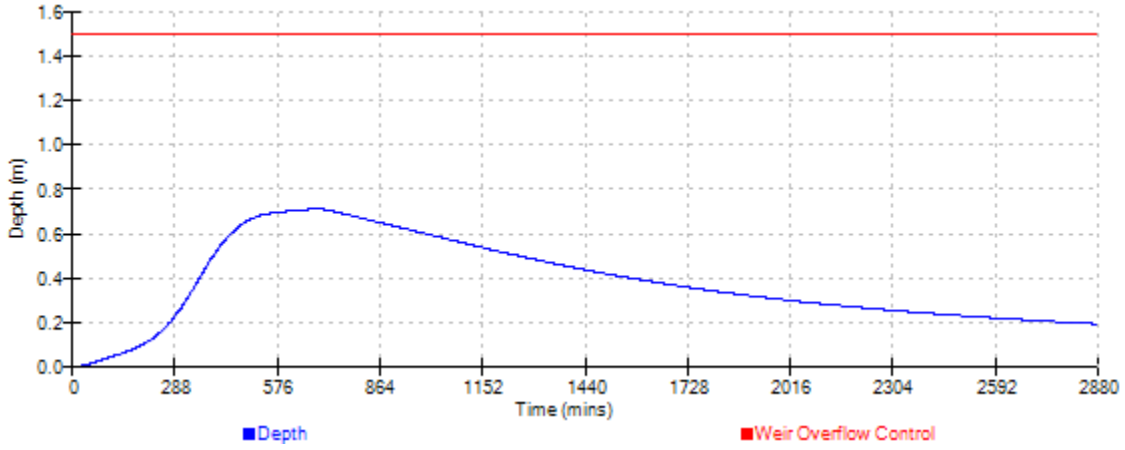
Event: 720 min Winter







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I.6 Barrington 15 - restored - 498mm HydroBrake - Palletiser Pump

Discharges to River Cam via proposed 500mm pipe.

CEMEX House
Church Lane
Bromsgrove B61 8RA

Date 29/11/2016 11:34 | Designed by cmpointer
File Barrington-15 100 yrs+3... | Checked by
Micro Drainage | Source Control 2016.1

Summary of Results for 100 year Return Period (+30%)

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	26.739	0.439	179.6	0.0	179.6	15144.5	O K
30 min Summer	26.792	0.492	203.6	0.0	203.6	17001.8	O K
60 min Summer	26.850	0.550	224.5	0.0	224.5	18996.3	O K
120 min Summer	26.910	0.610	225.0	0.0	225.0	21054.2	O K
180 min Summer	26.944	0.644	225.0	0.0	225.0	22228.9	O K
240 min Summer	26.966	0.666	225.0	0.0	225.0	23005.6	O K
360 min Summer	26.993	0.693	225.0	0.0	225.0	23941.1	O K
480 min Summer	27.007	0.707	225.0	0.0	225.0	24422.2	O K
600 min Summer	27.014	0.714	225.0	0.0	225.0	24641.8	O K
720 min Summer	27.015	0.715	225.0	0.0	225.0	24686.8	O K
960 min Summer	27.004	0.704	225.0	0.0	225.0	24302.9	O K
1440 min Summer	26.986	0.686	225.0	0.0	225.0	23703.6	O K
2160 min Summer	26.960	0.660	225.0	0.0	225.0	22808.7	O K
2880 min Summer	26.933	0.633	225.0	0.0	225.0	21855.4	O K
4320 min Summer	26.884	0.584	224.9	0.0	224.9	20182.8	O K
5760 min Summer	26.841	0.541	223.3	0.0	223.3	18683.5	O K
7200 min Summer	26.807	0.507	209.8	0.0	209.8	17508.8	O K
8640 min Summer	26.778	0.478	197.4	0.0	197.4	16502.7	O K
10080 min Summer	26.753	0.453	186.2	0.0	186.2	15639.7	O K
15 min Winter	26.739	0.439	179.6	0.0	179.6	15145.0	O K
30 min Winter	26.792	0.492	203.6	0.0	203.6	17004.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	198.815	0.0	8719.7	0.0	19
30 min Summer	112.134	0.0	10122.8	0.0	34
60 min Summer	63.245	0.0	15418.5	0.0	64
120 min Summer	35.671	0.0	17596.8	0.0	124
180 min Summer	25.517	0.0	18958.1	0.0	182
240 min Summer	20.119	0.0	19955.9	0.0	242
360 min Summer	14.392	0.0	21388.5	0.0	362
480 min Summer	11.347	0.0	22402.8	0.0	482
600 min Summer	9.437	0.0	23169.9	0.0	600
720 min Summer	8.117	0.0	23767.5	0.0	720
960 min Summer	6.329	0.0	24349.3	0.0	818
1440 min Summer	4.456	0.0	24772.8	0.0	1052
2160 min Summer	3.138	0.0	32470.6	0.0	1448
2880 min Summer	2.446	0.0	33440.5	0.0	1844
4320 min Summer	1.739	0.0	34522.4	0.0	2636
5760 min Summer	1.365	0.0	41261.0	0.0	3392
7200 min Summer	1.132	0.0	42449.9	0.0	4112
8640 min Summer	0.971	0.0	43244.1	0.0	4848
10080 min Summer	0.853	0.0	43550.5	0.0	5640
15 min Winter	198.815	0.0	8719.6	0.0	19
30 min Winter	112.134	0.0	10122.6	0.0	33

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Summary of Results for 100 year Return Period (+30%)

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
60 min Winter	26.850	0.550	224.5	0.0	224.5	19002.0	O K
120 min Winter	26.910	0.610	225.0	0.0	225.0	21075.9	O K
180 min Winter	26.944	0.644	225.0	0.0	225.0	22256.8	O K
240 min Winter	26.967	0.667	225.0	0.0	225.0	23034.1	O K
360 min Winter	26.994	0.694	225.0	0.0	225.0	23977.5	O K
480 min Winter	27.009	0.709	225.0	0.0	225.0	24473.5	O K
600 min Winter	27.016	0.716	225.0	0.0	225.0	24713.5	O K
720 min Winter	27.018	0.718	225.0	0.0	225.0	24788.9	O K
960 min Winter	27.004	0.704	225.0	0.0	225.0	24313.3	O K
1440 min Winter	26.979	0.679	225.0	0.0	225.0	23434.2	O K
2160 min Winter	26.940	0.640	225.0	0.0	225.0	22085.7	O K
2880 min Winter	26.899	0.599	225.0	0.0	225.0	20691.0	O K
4320 min Winter	26.835	0.535	221.0	0.0	221.0	18486.0	O K
5760 min Winter	26.787	0.487	201.5	0.0	201.5	16833.0	O K
7200 min Winter	26.749	0.449	184.4	0.0	184.4	15503.9	O K
8640 min Winter	26.718	0.418	169.3	0.0	169.3	14431.4	O K
10080 min Winter	26.693	0.393	156.2	0.0	156.2	13562.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	63.245	0.0	15418.4	0.0	62
120 min Winter	35.671	0.0	17596.6	0.0	122
180 min Winter	25.517	0.0	18958.4	0.0	180
240 min Winter	20.119	0.0	19956.7	0.0	238
360 min Winter	14.392	0.0	21392.1	0.0	354
480 min Winter	11.347	0.0	22410.5	0.0	468
600 min Winter	9.437	0.0	23181.5	0.0	582
720 min Winter	8.117	0.0	23785.4	0.0	692
960 min Winter	6.329	0.0	24380.0	0.0	894
1440 min Winter	4.456	0.0	24837.4	0.0	1098
2160 min Winter	3.138	0.0	32487.3	0.0	1540
2880 min Winter	2.446	0.0	33466.4	0.0	1964
4320 min Winter	1.739	0.0	34554.4	0.0	2764
5760 min Winter	1.365	0.0	41262.4	0.0	3528
7200 min Winter	1.132	0.0	42453.8	0.0	4320
8640 min Winter	0.971	0.0	43254.4	0.0	5024
10080 min Winter	0.853	0.0	43579.9	0.0	5760

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	539100 249400 TL 39100 49400
C (1km)	-0.027
D1 (1km)	0.298
D2 (1km)	0.259
D3 (1km)	0.283
E (1km)	0.316
F (1km)	2.431
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.800
Cv (Winter)	0.800
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 38.300

Time (mins) From:	To:	Area (ha)
0	4	38.300

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Model Details

Storage is Online Cover Level (m) 28.800

Tank or Pond Structure

Invert Level (m) 26.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	34534.0	1.400	34534.0	2.800	34534.0	4.200	34534.0
0.200	34534.0	1.600	34534.0	3.000	34534.0	4.400	34534.0
0.400	34534.0	1.800	34534.0	3.200	34534.0	4.600	34534.0
0.600	34534.0	2.000	34534.0	3.400	34534.0	4.800	34534.0
0.800	34534.0	2.200	34534.0	3.600	34534.0	5.000	34534.0
1.000	34534.0	2.400	34534.0	3.800	34534.0		
1.200	34534.0	2.600	34534.0	4.000	34534.0		

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SCL-0498-2250-1500-2250
Design Head (m)	1.500
Design Flow (l/s)	225.0
Flush-Flo™	Calculated
Objective	Minimise blockage risk
Application	Surface
Sump Available	Yes
Diameter (mm)	498
Invert Level (m)	26.300
Minimum Outlet Pipe Diameter (mm)	Site Specific Design (Contact Hydro International)
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	224.9
Flush-Flo™	0.603	225.0
Kick-Flo®	1.097	193.1
Mean Flow over Head Range	-	170.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	13.8	1.000	204.5	2.400	282.9	5.500	424.9
0.200	50.9	1.200	201.7	2.600	294.2	6.000	443.5
0.300	103.3	1.400	217.4	3.000	315.6	6.500	461.3
0.400	160.1	1.600	232.1	3.500	340.3	7.000	478.4
0.500	206.8	1.800	245.8	4.000	363.4	7.500	494.9
0.600	225.0	2.000	258.8	4.500	385.0	8.000	510.9
0.800	219.3	2.200	271.1	5.000	405.5	8.500	526.3

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Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
9.000	541.4	9.500	556.0				

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.500 Invert Level (m) 27.800

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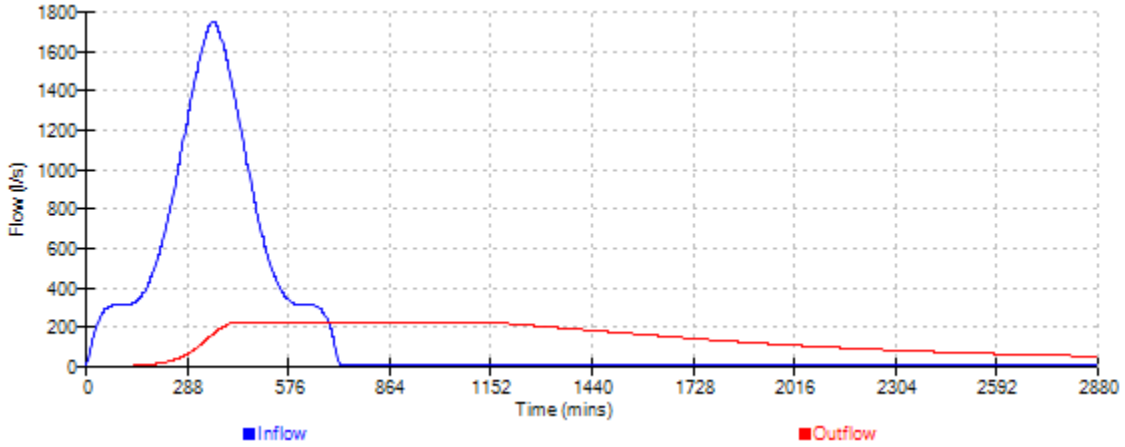
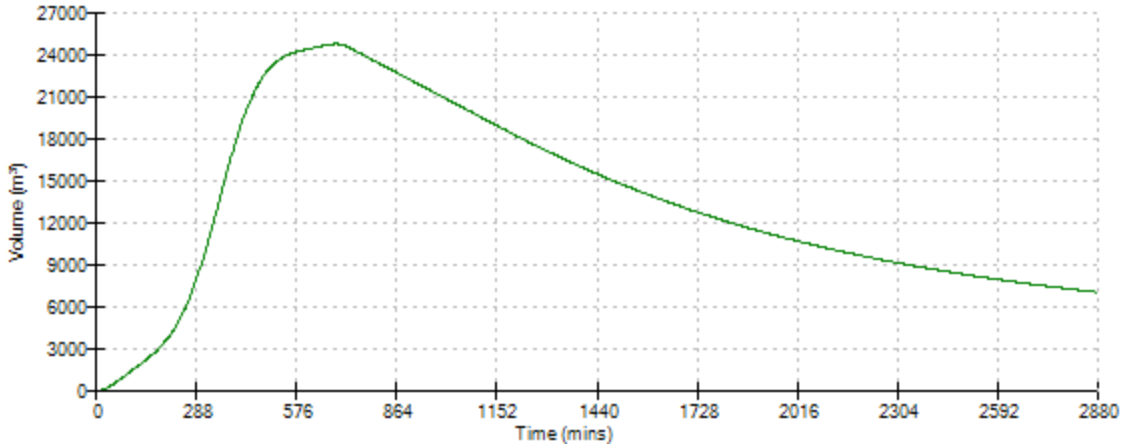
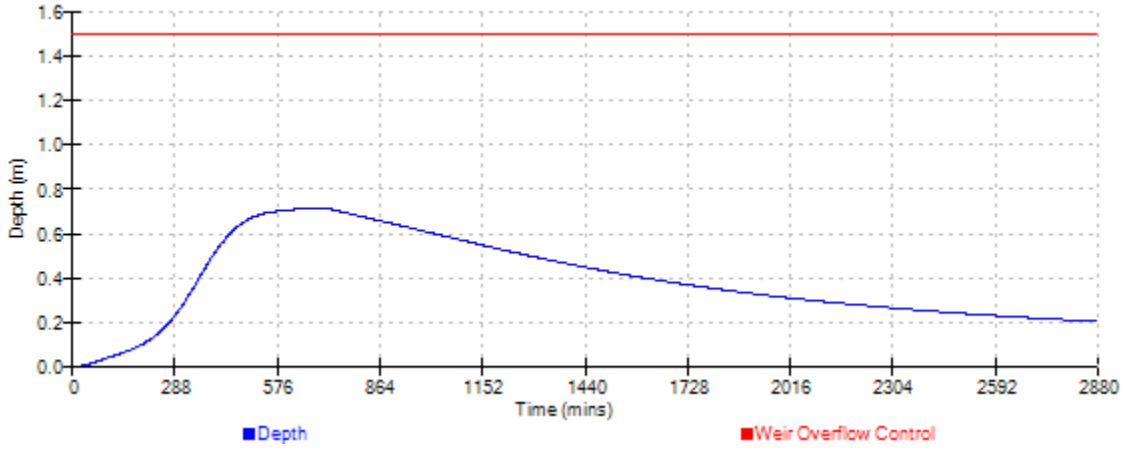
Event: 720 min Winter







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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
1	5.7	50	5.7	99	5.7	148	5.7	197	5.7	246	5.7
2	5.7	51	5.7	100	5.7	149	5.7	198	5.7	247	5.7
3	5.7	52	5.7	101	5.7	150	5.7	199	5.7	248	5.7
4	5.7	53	5.7	102	5.7	151	5.7	200	5.7	249	5.7
5	5.7	54	5.7	103	5.7	152	5.7	201	5.7	250	5.7
6	5.7	55	5.7	104	5.7	153	5.7	202	5.7	251	5.7
7	5.7	56	5.7	105	5.7	154	5.7	203	5.7	252	5.7
8	5.7	57	5.7	106	5.7	155	5.7	204	5.7	253	5.7
9	5.7	58	5.7	107	5.7	156	5.7	205	5.7	254	5.7
10	5.7	59	5.7	108	5.7	157	5.7	206	5.7	255	5.7
11	5.7	60	5.7	109	5.7	158	5.7	207	5.7	256	5.7
12	5.7	61	5.7	110	5.7	159	5.7	208	5.7	257	5.7
13	5.7	62	5.7	111	5.7	160	5.7	209	5.7	258	5.7
14	5.7	63	5.7	112	5.7	161	5.7	210	5.7	259	5.7
15	5.7	64	5.7	113	5.7	162	5.7	211	5.7	260	5.7
16	5.7	65	5.7	114	5.7	163	5.7	212	5.7	261	5.7
17	5.7	66	5.7	115	5.7	164	5.7	213	5.7	262	5.7
18	5.7	67	5.7	116	5.7	165	5.7	214	5.7	263	5.7
19	5.7	68	5.7	117	5.7	166	5.7	215	5.7	264	5.7
20	5.7	69	5.7	118	5.7	167	5.7	216	5.7	265	5.7
21	5.7	70	5.7	119	5.7	168	5.7	217	5.7	266	5.7
22	5.7	71	5.7	120	5.7	169	5.7	218	5.7	267	5.7
23	5.7	72	5.7	121	5.7	170	5.7	219	5.7	268	5.7
24	5.7	73	5.7	122	5.7	171	5.7	220	5.7	269	5.7
25	5.7	74	5.7	123	5.7	172	5.7	221	5.7	270	5.7
26	5.7	75	5.7	124	5.7	173	5.7	222	5.7	271	5.7
27	5.7	76	5.7	125	5.7	174	5.7	223	5.7	272	5.7
28	5.7	77	5.7	126	5.7	175	5.7	224	5.7	273	5.7
29	5.7	78	5.7	127	5.7	176	5.7	225	5.7	274	5.7
30	5.7	79	5.7	128	5.7	177	5.7	226	5.7	275	5.7
31	5.7	80	5.7	129	5.7	178	5.7	227	5.7	276	5.7
32	5.7	81	5.7	130	5.7	179	5.7	228	5.7	277	5.7
33	5.7	82	5.7	131	5.7	180	5.7	229	5.7	278	5.7
34	5.7	83	5.7	132	5.7	181	5.7	230	5.7	279	5.7
35	5.7	84	5.7	133	5.7	182	5.7	231	5.7	280	5.7
36	5.7	85	5.7	134	5.7	183	5.7	232	5.7	281	5.7
37	5.7	86	5.7	135	5.7	184	5.7	233	5.7	282	5.7
38	5.7	87	5.7	136	5.7	185	5.7	234	5.7	283	5.7
39	5.7	88	5.7	137	5.7	186	5.7	235	5.7	284	5.7
40	5.7	89	5.7	138	5.7	187	5.7	236	5.7	285	5.7
41	5.7	90	5.7	139	5.7	188	5.7	237	5.7	286	5.7
42	5.7	91	5.7	140	5.7	189	5.7	238	5.7	287	5.7
43	5.7	92	5.7	141	5.7	190	5.7	239	5.7	288	5.7
44	5.7	93	5.7	142	5.7	191	5.7	240	5.7	289	5.7
45	5.7	94	5.7	143	5.7	192	5.7	241	5.7	290	5.7
46	5.7	95	5.7	144	5.7	193	5.7	242	5.7	291	5.7
47	5.7	96	5.7	145	5.7	194	5.7	243	5.7	292	5.7
48	5.7	97	5.7	146	5.7	195	5.7	244	5.7	293	5.7
49	5.7	98	5.7	147	5.7	196	5.7	245	5.7	294	5.7

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Additional Hydrograph #1

Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)	Time (mins)	Flow (l/s)
9997	5.7	10011	5.7	10025	5.7	10039	5.7	10053	5.7	10067	5.7
9998	5.7	10012	5.7	10026	5.7	10040	5.7	10054	5.7	10068	5.7
9999	5.7	10013	5.7	10027	5.7	10041	5.7	10055	5.7	10069	5.7
10000	5.7	10014	5.7	10028	5.7	10042	5.7	10056	5.7	10070	5.7
10001	5.7	10015	5.7	10029	5.7	10043	5.7	10057	5.7	10071	5.7
10002	5.7	10016	5.7	10030	5.7	10044	5.7	10058	5.7	10072	5.7
10003	5.7	10017	5.7	10031	5.7	10045	5.7	10059	5.7	10073	5.7
10004	5.7	10018	5.7	10032	5.7	10046	5.7	10060	5.7	10074	5.7
10005	5.7	10019	5.7	10033	5.7	10047	5.7	10061	5.7	10075	5.7
10006	5.7	10020	5.7	10034	5.7	10048	5.7	10062	5.7	10076	5.7
10007	5.7	10021	5.7	10035	5.7	10049	5.7	10063	5.7	10077	5.7
10008	5.7	10022	5.7	10036	5.7	10050	5.7	10064	5.7	10078	5.7
10009	5.7	10023	5.7	10037	5.7	10051	5.7	10065	5.7	10079	5.7
10010	5.7	10024	5.7	10038	5.7	10052	5.7	10066	5.7	10080	5.7

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J Reservoir aspects

J.1 Report by Martin Airey (All Reservoirs Panel Engineer) 21 May 2016

Barrington Quarry

Revised Surface Water Drainage Scheme: North Pit and Gault Pit

Design of Proposed Works in the context of the Reservoirs Act 1975

1. Current Situation at the Site

The Barrington Quarry site is situated approximately 10km to the south-west of Cambridge and is located alongside the Chapel Hill road that connects the villages of Barrington and Haslingfield. The quarry used to be used for the extraction of limestone that was used in the manufacture of cement and there was a cement works also contained within the site area. Both the quarry and the cement works are no longer used for their original purpose. The excavation that was the quarry is now being used for landfill purposes, whilst the buildings and infrastructure of the cement works are derelict and abandoned. It is understood that cement production at this site was stopped more than 10 years ago.

There are three parts to the site area. These are:-

- The Quarry Excavation area to the north part of the site
- The old buildings and facilities of the cement works that are towards the eastern side
- A surface water drainage system incorporating two settling ponds located to the western side

It is the two settling ponds which are referred to as the North Pit and the Gault Pit that are the subject of this report. The ponds used to be used as settling lagoons during quarrying operations. They are still in use today and play an important role in maintaining the drainage of the site. In particular surface water drainage from the quarry to the north and from the northern part of the cement works is pumped into the North Pit, before being pumped out of the pit into a local drainage ditch. This then carries the water away from the site so as to drain to the watercourse of the River Cam. In addition, there are areas on the western side of the cement works that drain into the Gault Pit from where excess water can also be pumped to the outfall drainage ditch. The base of the quarry excavation is currently lower than the surrounding ground and in order to keep the area dewatered for the landfill to be carried out, it is necessary to operate this pumped drainage system.

The two pits are essentially large excavated basins that as part of the drainage system contain water. The basins were excavated many years ago and are surrounded by higher natural ground. At the present time the water that is retained in both basins is held well below the level of the surrounding natural ground. As a consequence the pits provide only ‘below ground’ storage and do not come under

the ambit of the Reservoirs Act. The existing surface water drainage arrangements at the site are shown on the JBA Drawing No 2015s3432-5.

2. Proposed Modifications to the Drainage System

As part of the proposed restoration of the site there will be a need to carry out modifications to the drainage system. Plans are currently being considered to carry out further phases of landfilling to the quarry area. Eventually this will mean that the ground profile, which is currently a deep excavation, will be returned to its pre-quarry, natural state that was essentially a hillside sloping downwards from north to south. Under these circumstances there will still be a need to provide surface water drainage to cater for the run-off from the quarry area. This will be largely the natural run-off from the hillside into the North Pit so there will be less reliance on pumping, albeit that a part of the quarry void which is designated as an SSSI will remain, such that there will still be a requirement for some pumping. The proposed surface water drainage works that would be incorporated as part of the restoration scheme are shown on Drawing No 2015s3432-6.

Both the North Pit and the Gault Pit will be retained as open bodies of water within the modified system. There are proposals that are currently under consideration to raise the water level within the North Pit to facilitate the surface water drainage. In addition, there is the possibility that under extreme flood conditions excess water would spill from North Pit into the Gault Pit. The possible increase in water levels within each of the pits has raised the question as to whether it will be necessary to consider either of the pits as reservoirs under the Reservoirs Act.

To provide advice on this topic I was appointed by JBA Consulting who is working for Cemex Ltd (the owners of the site) in connection with the overall surface water drainage requirements. I visited the site on 3rd May 2016 and during that visit I was accompanied by Mr Chris Pointer who is Senior Hydrogeologist with Cemex UK Operations Ltd. Prior to the visit I was provided with various documents these included:-

- Drawing No 2015s3432-5 Existing Surface Water Drainage Arrangements
- Drawing No 2015s3432-6 Proposed Surface Water Drainage Works
- Letter from JBA to Cemex - Reference 2015s3432-B-L001-1 dated 31st March 2016
- Various cross sections taken through the pits and the surrounding ground

During the site visit I was also given A0 copies of the topographical survey of the site. This survey was prepared by MK Surveys in March 2014 and the drawings in question (Sheets 3, 5 and 7) covered the western parts of the site incorporating both the North Pit and the Gault Pit. It is noted however that this survey was a ground survey only and captured all details of the above ground features. It did not

include a bathymetric survey of the pits to determine the 'below water' profile. From my discussions with Mr Pointer it is understood that bathymetric surveys of both basins will be carried out in due course in order to establish the volumes of water that are retained in the pits at any particular level. This information was not available at the time of the site visit.

Under the terms of the Reservoirs Act a reservoir is defined as:-

> '*A large raised lake or other area capable of storing water which was created or enlarged by artificial means*.'

It is also stated that it shall be considered as 'raised' if:-

> 'I*t is capable of holding water above the natural level of any part of the surrounding land.*'

At the present time the threshold value for the definition of a large raised reservoir is more than 25,000m^3 stored above natural ground. However new legislation will bring this threshold value down to 10,000m^3. This change has not yet been implemented but it is likely that it will come into effect in 2017 and it may be relevant in the context of the North Pit and Gault Pit proposals.

3. North Pit

It is understood that the current normal operating level of the North Pit is approximately 26.0m AOD. However to facilitate the surface water drainage under gravity, the proposals are to raise the water level in the basin by around 1m. A higher water level in the basin will ensure that the water can drain away to the outfall ditch and will minimise the need to deepen the ditch. It is proposed that there will be a buried pipe connection from the pit to the ditch. This will run through the stretch of ground that separates the pit from the ditch at the south-west corner of the basin. The pipe will be designed to operate with a discharge of 12 litres/sec. It is understood that this is the current permitted discharge that can be released to the downstream watercourse and that this limit will be retained with the modified system.

For flood discharges in excess of this discharge the excess water would be temporarily retained in the North Pit. A temporary flood storage volume equivalent to the 1 in 200 year flood (including climate change) would be accommodated above the normal water level and the overflow spill level would be determined accordingly, such that any flood discharge in excess of this would spill out of the pit. A spillway arrangement is therefore proposed at the North Pit which would connect to a channel that would lead down to the Gault Pit. The current proposal is for the overflow weir of this spillway to be set at a level of 27.8m AOD. To understand the implications in terms of the Reservoirs Act it is necessary to compare this proposed water level with the levels of the surrounding ground.

From the Topographical Sheet No 3 it can be seen that the majority of the ground that surrounds the North Pit is at an elevation that is greater than 30m AOD. As noted above the pit is essentially a large excavated basin and this situation was confirmed at the site visit (see Photograph A1). During the site visit the water level in the pit was approximately 23m AOD; in other words well below the higher levels that are now being considered, but nonetheless the 'below ground' nature of the storage is clearly visible. The lowest section of the surrounding perimeter is located at southern corner and is shown in Photograph A2. At this point there is a short and very low 'man made' embankment that closes off the corner of the basin. Examination of the survey data indicates that this embankment extends for about 50m and has a height of approximately 1m. The crest of this embankment has a level of approximately 29.0m AOD and the ground at the toe is at approximately 28.0m AOD. Beyond the toe the ground slopes gently down towards the south-west until it meets the outfall drainage ditch which is some 100m from the embankment. The natural ground at the top of the ditch is at a level of 26.5m AOD whilst the invert of the ditch is at approximately 25.5m AOD. The crucial factor in determining the depth and hence the volume of water retained in the pit is assessing which part of the terrain should be regarded as the 'surrounding' natural ground.

In this case it is my opinion that the toe of the embankment defines the boundary between the 'man made' embankment and the natural ground. As noted above this has a lowest level of around 28.0m AOD. The ground beyond this point has over the years probably been in-filled to the profile that exists today. It has undoubtedly been in existence for many years such that it is reasonable to consider it as the natural terrain. This area can be seen in Photograph A3 which is a view from the toe of the embankment looking down the slope towards the ditch. Furthermore there is a significant distance between the embankment and the drainage ditch such that a potential breach failure that would allow water to escape down to the level of the ditch is almost inconceivable. In my view, taking the invert of the ditch as the lowest surrounding ground would be unrealistic and over conservative.

Taking the lowest natural ground level as 28.0m AOD it is possible to compare this level with the water levels that will occur in the pit when the new drainage regime is implemented. Under normal, non-flood conditions the water level would be equal to that of the pipe outlet and it is understood that it would be approximately 27.0m AOD (say 1m higher the present maximum level) with an outflow through the pipe of 12 litres/sec. This outflow would balance the modest incoming flow from natural run-off and/or a small amount of pumping. This normal water level is below the toe of the embankment and thus it is concluded that water would not be retained above the lowest natural ground. As a consequence the water held in the pit need not be considered as a Large Raised Reservoir under the Reservoirs Act.

It is recognised that with a small pipe outlet there is the potential for it to become blocked. I would recommend therefore that this pipe should be of sufficient size to reduce the risk of blockage and that

regular maintenance and surveillance is introduced into the operating regime to ensure that floating debris that might cause a blockage is removed. If the pipe was to become totally blocked such that there was no flow through the pipe, the water level would potentially rise within the pit to the level that is equal to that of the overflow weir (27.8m AOD). This level is still lower than the lowest natural ground and thus even under these circumstances the flooded pit would not constitute a reservoir.

Under extreme flood conditions with flood flows greater than the 1 in 200 year event (plus climate change effects), the spillway would operate and the water level would rise higher than the fixed weir level of 27.8m AOD. However in this context it is emphasised that to constitute a reservoir, the volume of water retained above the lowest natural ground shall be the volume that is exclusive of any flood storage; be it either 25,000m^3 with the current legislation or 10,000m^3 as proposed with the legislative changes. In other words any additional, temporary flood storage above 27.8m AOD that might arise under a rare flood scenario need not be considered, and the conclusions presented above are confirmed.

4. Gault Pit

The Gault Pit is situated to the south of the North Pit and is at a slightly lower elevation. It is understood that the normal operating level for this pond is 21.68m AOD; under normal circumstances it does not receive drainage water from the quarry and is not subject to significant water level variations. With the new drainage proposals the Gault Pit will be used as the receiving pond for any excess water that spills out of the North Pit. This will only occur in flood events that have a return period of greater than 1 in 200 years. The current design indicates that under the most extreme conditions the water level in the pit could rise to 22.40m AOD. At this level there would be a fixed overflow weir whereby the excess water would be released in a gradual and controlled manner via an open channel that would connect to the adjacent drainage ditch.

From the site visit and from the topographical information it was necessary therefore to determine whether water would, under this new regime, be retained to a level that would constitute the creation of a reservoir. As can be seen from Photograph A4 the Gault Pit basin is also a large excavated hole that is surrounded by natural ground that stands several metres higher than the water surface. The topographical survey indicated there is no man made structure that forms any part of the perimeter of the basin. The lowest part of the perimeter is located at the southern end and it is at this point where the drainage ditch outlet is closest to the open water surface of the pit. There is a swathe of natural ground that separates the basin from the ditch and this ground is shown in Photographs A5 and A6. The survey data indicates that the ground levels in this area are in the region of 22.5 to 22.8m AOD. In other words the flood water would be retained at a level that is below the lowest natural ground and there would be no uncontrolled escape of water from the pit. Under very extreme flood events it is anticipated that there would be the need to evacuate some excess water from the Gault Pit and for this

reason there is the provision for a spillway overflow. It recognised that there is very little freeboard margin, but given that these conditions would only occur under an extreme flood situation, it is considered to be acceptable. Taking these points into account it is my opinion that the water will not be retained at a level that is higher than the surrounding natural ground, and as a consequence the Gault Pit need not be considered as a Large Raised Reservoir under the ambit of the Reservoirs Act.

The estimated invert level of the drainage ditch is approximately 22.0m AOD. At the closet point the drainage ditch is around 20m from the open water surface of the pit. This could potentially create a hydraulic gradient through this barrier of natural ground of 1 in 50. This is a relatively shallow gradient and whilst the in-situ properties of the ground are unknown, it is highly unlikely that this would be sufficient to cause erosion and failure. Once again it is emphasised that these extreme conditions would be a very rare occurrence and would only exist over a short period if the North Pit was required to spill.

5. Conclusions

I have examined the information that was provided to me and I have visited the site to inspect at first hand the situation at the two ponds. I have also discussed the proposed drainage arrangements with representatives of Cemex Ltd and JBA and taking all of this into account, I make the following conclusions:-

North Pit

I conclude that if the revised operational arrangement for North Pit involves a fixed overflow level of 27.8m AOD then the water will not be retained above the lowest natural ground level of 28.0m AOD which occurs at the outer toe of the man-made embankment. The bed of the receiving watercourse (drainage ditch) is sufficiently remote from the toe of the embankment such that it need not be considered to be surrounding ground. **As a result the pit need not be considered as a Large Raised Reservoir.**

As the flood level is deemed to be lower than natural ground, then the conclusion applies equally to the current situation where a reservoir is greater than 25,000m^3 and also to possible future limit where reservoir volume could be reduced to 10,000m^3. If however the final designs for the drainage system required a spill level of greater than 28m AOD, then it would be necessary to re-visit this decision.

Gault Pit

I conclude that there is no ‘man made’ element of the surrounding ground that would constitute the creation of a reservoir. Even under very extreme flood conditions the water would be retained within an excavated hole that is wholly below natural ground, albeit that an overflow channel will be

provided to carry any excess flow to the nearby drainage ditch. This adjacent watercourse is closer than is the case for the North Pit, but even so the hydraulic gradient between the predicted flood level and the invert of the ditch is sufficiently low such that a breach failure is highly unlikely. **Based on these findings I conclude that there is no requirement to consider the Gault Pit as a reservoir.**

Although the two ponds need not be considered as reservoirs, the owners will still have a duty of care to ensure that the improved drainage works are designed and implemented in a proper manner. In particular the modifications will need to be designed so that the regulated outflow from the North Pit does not exceed the permitted value of 12 litres/sec. It is understood that under higher discharge conditions there is the potential for localised flooding as the watercourse passes through the village of Barrington en route to the River Cam. In addition there are outline proposals for the redevelopment of the cement works with new housing. The surface water drainage system for the new housing area to the east will also need to be designed so as to be compatible with the modified surface water drainage arrangements from the proposed landfill area to the north.

Design Standard

There were two parts specified for this assignment. Firstly to give an opinion as to whether the two pits should be considered as reservoirs, and secondly, if they were to be reservoirs under the Act, then to provide recommendations on the Design Flood Category that should be applied. As I have concluded that the pits need not be considered as reservoirs, there is no requirement that the design standards that are usually used for reservoirs, as presented in the ICE guideline document 'Floods and Reservoir Safety – 4th Edition, 2015', need be applied. Nonetheless for completeness it is worth looking at these guidelines in the context of the current design proposals.

The reservoir flood protection standards are based upon the potential effect of a dam breach on the downstream valley. There are four categories (A to D) where A is the most onerous and D is the least onerous. It is difficult without some estimate of flood inundation extent for the downstream valley to be precise about the category that should be used. However, from a preliminary review of the downstream conditions it would my opinion that the second tier category (Category B) would need to be considered if either of the two pits were reservoirs. The potential effect of a dam breach for a Category B reservoir is described as:-

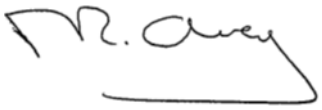
- *'Where a breach could endanger lives not in a community'* OR
- *'Could result in extensive damage'*

This is an onerous design standard, but given the proximity of the village of Barrington as well as the potential for the new housing development it would be appropriate. For a Category B reservoir the

recommended Design Flood Conditions which should be used for the sizing of the spillway and the provision of freeboard would normally be the 1 in 1000 year flood. However, it is emphasised that these standards are applicable only to reservoirs where a breach of a retaining structure (dam) can occur. They are far more onerous than the standards that are used to protect against normal fluvial flooding in that a failure of the dam structure would cause a sudden escape of water comprising not only the flood volume, but the additional volume that was stored in the reservoir and which would be released as a result of the dam failure.

However it must be remembered that this design flood standard would only apply if the two pits were being considered as reservoirs and there was a conceivable breach mechanism where failure could occur. As this is not the case, then I believe it is far more appropriate and realistic to revert to design standards that would normally be used to protect people and properties from fluvial flooding of natural river channels. These standards would normally be used to provide protection against floods with a return period of up to 100 years. In this case it is understood that the design has been based upon the 1 in 200 year flood (with an additional allowance to accommodate the increase in volume and/or peak discharge that might arise from climate change effects). This is considered to be satisfactory and is probably a higher standard than would be used for simple fluvial flood protection. It should also be noted that the existence of the two pits will provide a considerable amount of flood attenuation, such that the discharges to be released to the downstream watercourse will be regulated and restricted. It is undoubtedly true that these discharges will be significantly lower than those that would occur naturally if the two pits did not exist.

Signature of Engineer



Dated: 21st May 2016

Working on behalf of JBA Consulting
All Reservoirs Panel Engineer qualified under the Reservoirs Act 1975
Current Appointment expires on 17th December 2017

APPENDIX A

PHOTOGRAPHS OF THE NORTH PIT AND THE GAULT PIT

(taken on 3rd May 2016)

PHOTOGRAPH A1:

General View of the North Pit looking towards the south-east

PHOTOGRAPH A2:

Embankment at the southern corner of the North Pit

PHOTOGRAPH A3:

Ground to the downstream side of the embankment – looking towards the outfall drainage channel

PHOTOGRAPH A4:

View of Gault Pit from the southern end – looking to the north

PHOTOGRAPH A5:

Barrier of natural ground between the Gault Pit and the drainage ditch – looking towards the ditch

PHOTOGRAPH A6:

Natural ground barrier looking back towards the Gault Pit

J.2 Wave height calculation

Dated 29 July 2016.

2015s3432 - Barrington Quarry - North Pit

Calculation Cover Sheet

Wave Overtopping Discharge Calculation for North Pit, Barrington Quarry

Ref.	Title	Originated		Rev.	Checked		Approved		
C001		JSC	29-Jul-16						

Aim

To determine the overtopping discharge over the crest of Cotting Burn Dam for the Probable Maximum Flood in compliance with Floods and Reservoir Safety, Fourth Edition, ICE, 2015 (F&RS, 4th ed).

Outcome

Comment	Overall Result
Predicted overtopping discharge of 0.001 l/s/m (for wind direction 235°) is less than the allowable 0.1 l/s/m (as per F&RS, 4th ed).	**OK**

Background

Wave overtopping discharges can lead to the erosion of the dam crest, downstream face or abutments, and may cause a safety hazard to people or property close to the dam structure. These hazards can be important even if wave overtopping occurs from only a few per cent of the waves. In compliance with F&RS, 4th ed, it is therefore necessary to assess the overtopping discharge.

Methodology

Wave overtopping discharge assessment in compliance with F&RS, 4th ed Chapters 5 and 6.

Key Assumptions

KA1 Safety check flood conditions are taken as PMF (for a Category A dam as per Table 2.1 on page 5 of F&RS, 4th ed).

References

R1 Floods and Reservoir Safety, Fourth Edition, Institution of Civil Engineers, 2015.

R2 Topographic survey plan

2015s3432 - Barrington Quarry - North Pit **30-Jun-16**

Spreadsheet for Calculating Overtopping Discharge

	Yellow Cells are Input Cells
	White Cells are Calculation Cells

Parameter	Symbol	Input Data	Unit	Comments
Fetch	F	230	m	
Wind Direction		145	° (North=0° & clockwise)	
Altitude		26	mAOD	
	U_{50}	23	m/s	
Return period adjustment	f_T	1.18		
Altitude adjustment	f_A	1.03		
Over-water adjustment	f_W	1		
Duration adjustment	F_D	1.05		
Direction adjustment	f_N	0.8		
Design wind speed	U	23.4	m/s	
Significant wave height	H_s	**0.20**	m	
Peak wave period	T_p	1.28	s	
Mean wave period	T_{m-1}	1.17	s	
Deep water wave length	$L_{m-1,0}$	2.1		
U/S slope angle		2		x where slope = 1v:xh
Wave wall / Upper slope angle		27		90 = vertical (input to D27)
Wave breaking parameter	$\xi_{m-1,0}$	1.62		
Influence factor for berm	γ_b	1		1 for no berm
Roughness factor	γf	1		Concrete slabs 1, Fitted blocks 0.9, Riprap 0.6
Influence factor for wave obliquity	γ_β	1		1 for waves normal to face
Influence factor for small wall	γ_v	1		0.648 for vertical wall, 1 for no wall.
Freeboard (m)	R_c	0.80		
Overtopping discharge (l/s/m)	**q**	**0.000**		**OK (< 0.1 l/s/m)**

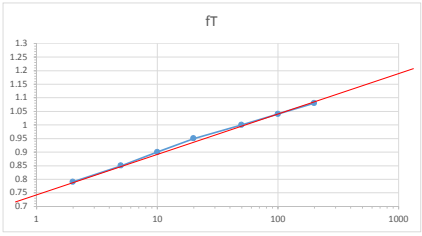
2015s3432 - Barrington Quarry - North Pit **30-Jun-16**

Spreadsheet for Calculating Overtopping Discharge

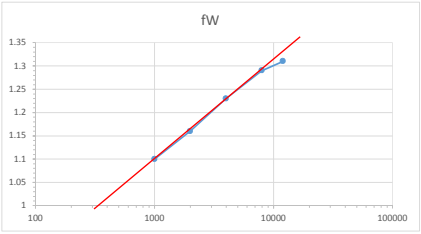
	Yellow Cells are Input Cells
	White Cells are Calculation Cells

Parameter	Symbol	Input Data	Unit	Comments
Fetch	F	165	m	
Wind Direction		235	° (North=0° & clockwise)	
Altitude		26	mAOD	
	U_{50}	23	m/s	
Return period adjustment	f_T	1.18		
Altitude adjustment	f_A	1.03		
Over-water adjustment	f_W	1		
Duration adjustment	F_D	1.05		
Direction adjustment	f_N	1		
Design wind speed	U	29.2	m/s	
Significant wave height	H_s	**0.21**	m	
Peak wave period	T_p	1.27	s	
Mean wave period	T_{m-1}	1.16	s	
Deep water wave length	$L_{m-1,0}$	2.1		
U/S slope angle		2		x where slope = 1v:xh
Wave wall / Upper slope angle		27		90 = vertical (input to D27)
Wave breaking parameter	$\xi_{m-1,0}$	1.56		
Influence factor for berm	γ_b	1		1 for no berm
Roughness factor	γf	1		Concrete slabs 1, Fitted blocks 0.9, Riprap 0.6
Influence factor for wave obliquity	γ_β	1		1 for waves normal to face
Influence factor for small wall	γ_v	1		0.648 for vertical wall, 1 for no wall.
Freeboard (m)	R_c	0.80		
Overtopping discharge (l/s/m)	**q**	**0.001**		**OK (< 0.1 l/s/m)**

RtnPeriod, yrs	2	5	10	20	50	100	200
f_T	0.79	0.85	0.9	0.95	1	1.04	1.08



Fetch, m	1000	2000	4000	8000	12000
f_W	1.1	1.16	1.23	1.29	1.31



K Campbell Reith Hill Combined Drainage Report

Combined Drainage Summary Report dated March 2016 prepared by Campbell Reith Hill LLP (presented to Barrington Parish Council).

Confidential

CEMEX Quarry, Barrington

Combined Drainage Summary

Project Number:

11104

March 2016

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F2	March 2016	Issued for Information	CCTjt11104-150316-DS F2.doc	CCT	SA	SA

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Project Number	11104
Project Name	CEMEX Quarry, Barrington

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1.0 INTRODUCTION

1.1. CampbellReith (CR) have been commissioned by Macegreen Consulting (MC) on the behalf of CEMEX UK Material Limited (CEMEX) to prepare a Combined Drainage Summary Report for decommissioned CEMEX site in Barrington, Cambridgeshire, using the FRA and Addendum used for the residential development planning application (CR FRA Report, September 2014 and FRA Addendum, January 2015) and the drainage report by CEMEX for the quarry site planning application (CEMEX Condition 57 Surface Water Drainage Report, June 2013).

1.2. The purpose of this report is to summarise the joint impact of the two granted applications on the culverted outfall that runs under Haslingfield Road.

1.3. This report looks at the site drainage proposals of the two planning applications submitted:

Application (A) – The Proposed Residential Development

CR developed the initial site drainage strategy for the proposed residential development (from this point forward referred to as ('Application Site A') as part of the scope of works and the proposed site drainage strategy is outlined within the submitted Flood Risk Assessment (FRA) report (by CR September 2014) and subsequent additional submitted information and amendments in the FRA Addendum (by CR January 2015).

Outline planning permissions were granted for Application Site A with the planning reference S/2365/14/OL based on the above drainage strategy.

Application (B) – Legacy CEMEX Barrington Quarry

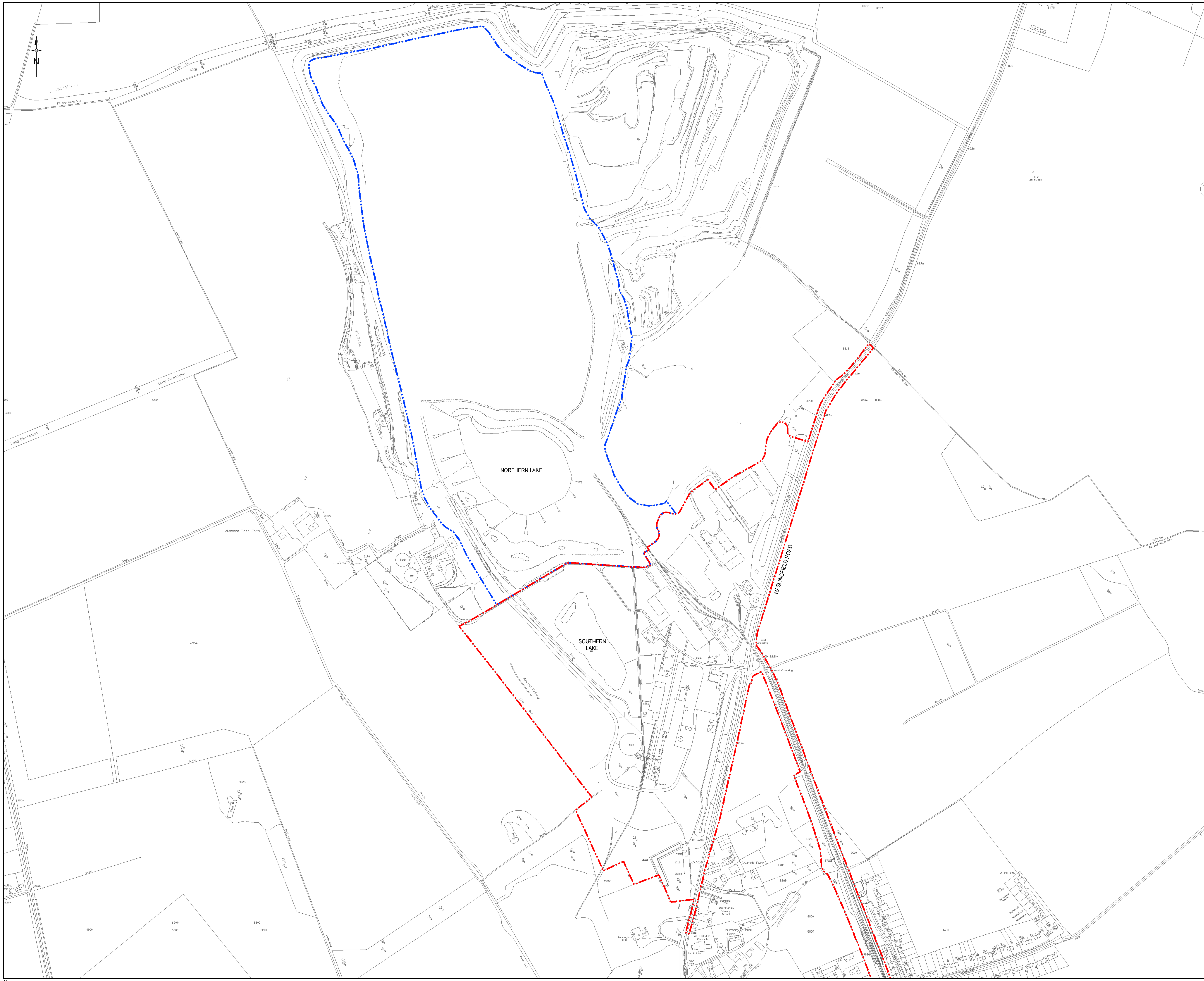
CEMEX also developed a separate proposed site drainage plan for the legacy CEMEX Barrington Quarry (from this point forward referred to as 'Application Site B') as part of the information submitted for the planning application for the continuance of the restoration works to the quarry. A revised surface water drainage scheme, Condition 57 Surface Water Drainage Report was prepared and submitted for approval by CEMEX in June 2013.

Full planning permission was granted for the proposals on Application Site B with the planning reference S/01080/10/CW.

2.0 SITE LOCATION

2.1. The site is situated in the village of Barrington which is situated about six miles south of the city of Cambridge. The site accessed off Haslingfield Road which is situated south of the site boundary and another access point is available from Chapel Hill which is towards the north-east of the site boundary. The site is centred on approximate co-ordinates E:539630, N:250669 and with a postcode reference CB22 7RQ.

Figure 1: Site Location Plan



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5 10m extent outside of site boundary is shown as indicative only and is not to scale.

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7 DRAWING STATUS

S :- SCHEME — Outline/Scheme drawings for proposals, budgets etc.

D :- DESIGN DEVELOPMENT — Evolving final design drawings for approvals, tenders, billing etc.

C :- CONSTRUCTION — Fully developed drawings issued under instruction for construction.

ONLY STATUS C DRAWINGS TO BE USED FOR CONSTRUCTION.

8. GULLIES, CHANNEL DRAINS, ETC. NOT SHOWN FOR CLARITY, REFER TO TOPOGRAPHICAL SURVEY FOR FURTHER DETAILS.

9. TOPOGRAPHICAL SURVEY PROVIDED BY MKSURVEYS IN MARCH 2014.

LEGEND

APPLICATION SITE BOUNDARY A

APPLICATION SITE BOUNDARY B

Status/Rev	Description	Date	By
S1	ISSUED FOR INFORMATION	16.02.16	TH

CampbellReith
consulting engineers

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REDHILL 01737 784 500 · BIRMINGHAM 01675 467 484
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www.campbellreith.com

Job Title: CEMEX QUARY, BARRINGTON

Client: CEMEX

SITE PLAN

drawn	date	scale	C1 checked	CAD filename
TH	FEB'16	NTS		11104-FIGURE 1

Job No.	Drg No.	Status/Revision
11104	FIGURE 1	S1

A1

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2.2. Application Site A is situated in the southern part which is approximately 34.27Ha and is the area of the former CEMEX cement works factory that was decommissioned and remained redundant and is now the proposed site location for the planned residential development.

2.3. Application B is situated in the northern part and is approximately 31.76Ha. This is the legacy CEMEX Barrington Quarry site that is in the process of being restored to provide a combination of agricultural land and nature conservation after-uses.

2.4. The two combined application site area is approximately 66.03Ha in area and is split into two distinct sites as stated above.

3.0 SITE DRAINAGE ASSESSMENT

Application (A) – The Proposed Residential Development

3.1. Existing Site Drainage

The total site area of Application A is 34.27Ha, with 27.4Ha being undeveloped (greenfield) land and 6.87Ha being previously developed (brownfield) land. A small portion of Site A (approximately 0.343Ha), discharges directly into ditches that are situated west of Haslingfield Road and eventually flows downstream towards the final outfall. Run-off from the watercourse that runs parallel to Haslingfield Road also discharges to the localised ditches situated west of the carriageway.

Another part of the development (approximately 1.031Ha) of Site A discharges into local ditches that is connected just before the 900mm dia. culverted waterway (from this point forward referred to as 'Outfall 1'). The remaining majority of Site A (approximately 5.496 Ha) all drain towards the Southern Lake (also known as Gault Pit) before being discharged to the local ditches that then finally connect into Outfall 1. An area approximately 15ha west of Application A currently drains through the site via a localised ditch/watercourse that crosses Application A site and connects to the final outfall. This information has been taken from topographical survey prepared by MK Survey in March 2014. An outline Existing Drainage Layout Plan (Drg. 11104 C300-S1) was submitted with the FRA which shows the existing site drainage conditions.

From the statement above, it has been calculated that approximately 101 l/sec. discharges from the ditch west of Haslingfield Road that flows towards the final outfall and approximately 479 l/sec. discharges into ditches just upstream of Outfall 1. A calculated Greenfield discharge rate of approximately 70 l/sec. is the run-off rate from the ditch/watercourse west of Application A.

The discharge from the South Lake is via a pumped system and is currently being investigated; however it is envisaged that the existing discharge rates is in the region of 85 l/sec. via a pumped rising main.

By combining the above the total existing peak flow into 900mm dia. Outfall 1 from Application Site A area is calculated at 665 l/sec. Outfall 1 then flows downstream towards an existing 825mm dia. culverted watercourse (from this point forward referred to as 'Output 2') that runs under Haslingfield Road before leaving/exiting the site.

3.2. Proposed Site Drainage (As shown in approved Application A)

The proposed site drainage for Application Site A is to maintain existing conditions where possible and to continue to drain into existing Outfall 1 in a controlled manner. All of the proposed surface water run-off from Application Site A will be managed further upstream before discharging to Outfall 1 by using SUDs as required by the Local Planning Authority (LPA)/Environment Agency (EA). The final proposed discharge rates from Application Site A were calculated as approximately 75 l/sec. (for the 1 in 100 year including 30% allowance for climate change). This final discharge rate is based on Greenfield run-off rates with 2,500m^3 storage as stated within the FRA Addendum that has been approved by the LPA.

The Southern Lake (Gault Pit) although is situated within the site boundary of the proposed residential development is not included in the proposed drainage scheme for Application Site A and is kept separate from the proposed surface water networks.

The proposed drainage conditions of the Southern Lake will continue to discharge to their existing outfalls which flow towards the local ditches that in turn flow downstream to Outfall 1. The Southern Lake will maintain its existing conditions, and there will be no run-offs from Application Site A being routed to the Lake for reasons as stated within the submitted FRA in Section 6.3.3 "Due to potential risk of contamination and to avoid the use of pumping stations where possible, the existing North and South Lakes will not be directly used as part of the proposed drainage scheme".

The existing excess discharge from the Southern Lake when it reaches above its peak level is currently being investigated and as stated previously it is anticipated that the final discharge rate falls within the region of 85 l/sec. This discharge rate will remain unchanged as the Southern Lake is to be kept separate from the proposed Application Site A drainage network.

Application (B) – CEMEX Revised Surface Water Drainage Scheme Report

3.3. Existing Site Drainage

The pre-development site drainage for Application Site B currently drains to the Northern Lake and then discharges via a pumped system into the local ditches that flow downstream to Outfall 1. The existing discharge rate from the pumped system at the Northern Lake is approximately 12 l/sec., this is based on the information supplied within the Revised Surface Water Drainage Scheme report by CEMEX (2013).

There are existing leachate wells, holding tanks and pumps that are operational within Application Site B that will be retained. Leachate is still being removed from the site with an average of 2 tankers per day and is proposed to continue.

3.4. Proposed Site Drainage

The proposed site drainage for Application Site B is to remain draining into the Northern Lake, however the discharge from the lake that flows into the local ditches will be in a controlled manner by restricting the final discharge from the lake to a final discharge rate of approximately 6.5 l/sec. (for the 1 in 100 year including 30% allowance for climate change). The proposed discharge rate offers approximately 54% betterment from the existing conditions.

Combined Proposed Site Drainage

3.5. An outline plan of the two separate application site drainage proposals have been combined in order to assess the overall impact of the sites drainage on the joint discharge point, Outfall 1 and subsequently the impact on the final discharge point, Outfall 2. Combining both Application A and Application B post development 1 in 100 year peak discharge rates gives a total discharge rate of approximately 338 l/sec.

The existing joint outfall (Outfall 1) as mentioned above in previous sections is a 900mm dia culvert. These structures have an approximate capacity of up to 880 l/sec depending on the steepness of the laid culvert. The a 900mm dia. culvert has been laid with a hydraulic gradient at of approximately 1 in 515 and achieving a velocity of 0.7 m/sec. is considered to have an approximate capacity of 874 l/sec.

The existing outfall (Outfall 2) also mentioned in sections above is a 825mm dia culvert. These structures have an approximate capacity of up to 706 l/sec depending on their gradients. The 825mm dia. culvert laid with a hydraulic gradient of 1 in 510 and achieving a velocity of 0.7m/sec. is considered to have an approximate capacity of 699 l/sec.

From Figure 2, the combined site drainage model for the existing conditions shows that the existing combined site discharge rates are in excess of the carrying capacity of the final discharge point, Outfall 2.

Figure 3, the combined site drainage model, shows that the total proposed offsite discharge from Application Site A and Application Site B to be approximately 338 l/sec.

Based on the existing capacity of Outfall 1 (874 l/sec.) and Outfall 2 (699 l/sec.), the two outfalls have been demonstrated to have adequate capacity for the combined post development peak 1: 100 year discharge rate of 338 l/sec.

Figure 2: Combined Existing Drainage Plan (Application Site A and Application Site B)

N

EXISTING DISCHARGE FROM APPLICATION SITE B @ 12 l/sec.

NORTHERN LAKE

SOUTHERN LAKE

EXISTING DISCHARGE RATE @ 85 l/sec. (TO BE CONFIRMED BY FURTHER SITE INVESTIGATIONS/SURVEY)

EXISTING DISCHARGE FROM APPLICATION SITE A @ 479 l/sec.

EXISTING GREENFIELD DISCHARGE FROM AREAS WEST OF APPLICATION SITE A @ 70 l/sec.

EXISTING DISCHARGE RATE @ 101 l/sec.

JOINT OUTFALL (1) Q=576 l/sec. TOTAL EXISTING DISCHARGE

OUTFALL (2) Q=747 l/sec. TOTAL EXISTING DISCHARGE

HASLINGFIELD ROAD

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LEGEND
- APPLICATION SITE BOUNDARY A
- APPLICATION SITE BOUNDARY B

Status/Rev	Description	Date	By
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Client: CEMEX

EXISTING COMBINED SURFACE WATER STRATEGY

drawn	date	scale	C1 checked	CAD filename
TH	SEP'14	NTS		11104-FIGURE 2

Job No.	Drg No.	Status/Revision
11104	FIGURE 2	S1

A1

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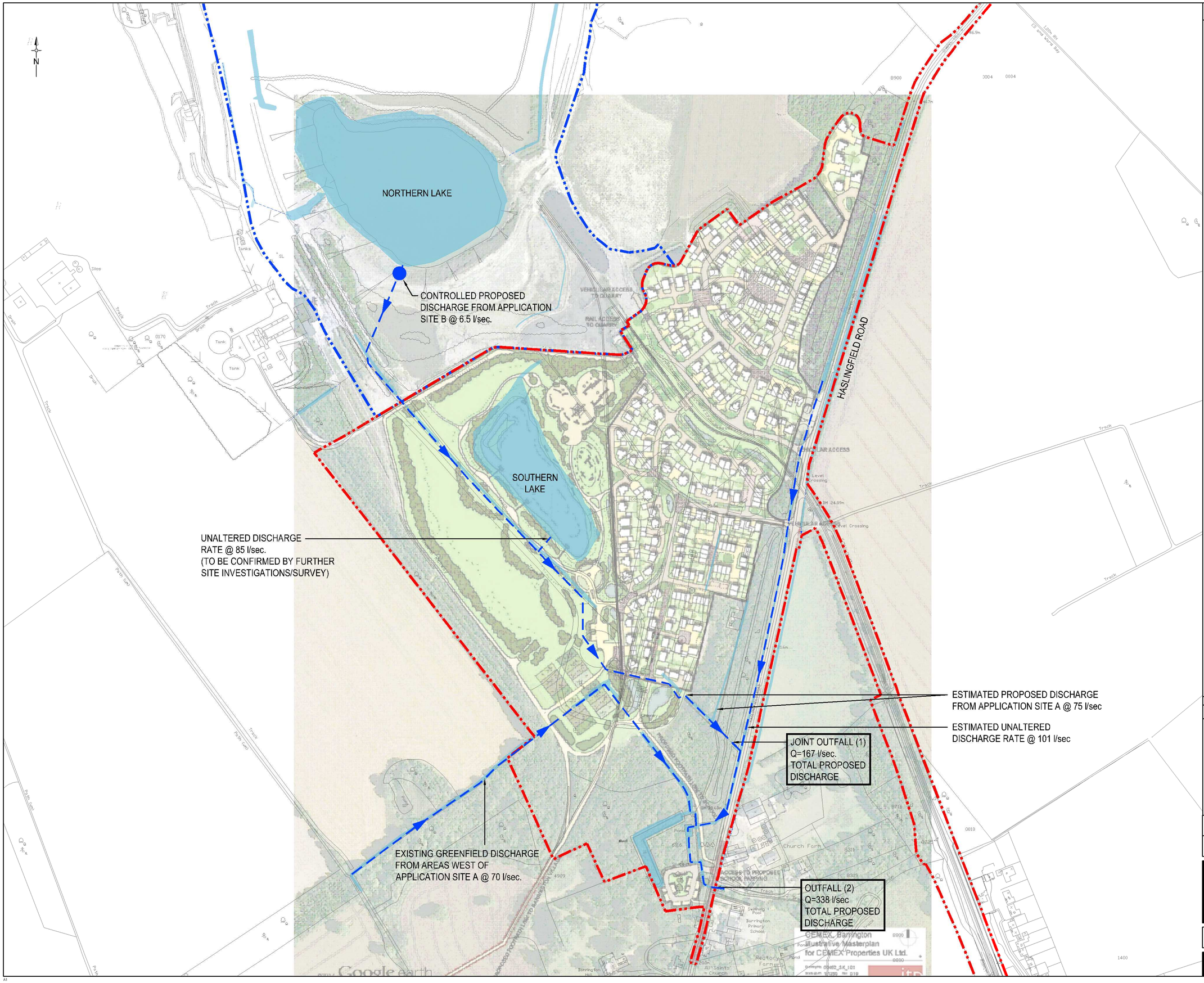
Figure 3: Combined Proposed Drainage Plan (Application Site A and Application Site B)



notes

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LEGEND

- APPLICATION SITE BOUNDARY A
- APPLICATION SITE BOUNDARY B

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PROPOSED COMBINED SURFACE WATER STRATEGY

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TH	FEB'16	NTS		11104-FIGURE 3

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11104	FIGURE 3	S1

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Table 1. Surface water discharge summary table

Application Site	Existing Flow Rates to Outfall 2 (l/sec.)	Proposed Flow Rates to Outfall 2 (l/sec.)
A	665	261
B	12	6.5
Greenfield run-off from localised ditches/watercourse	70	70
Combined Site (Total)	**747**	**338**

The proposed discharge rates from each application site area are much lower than the existing conditions and an excess of 50% betterment on the surface water discharge of the final outfall (Outfall 2) is achieved by the combined proposal drainage schemes.

It is envisaged that the balancing pond prior to Outfall 2 provides an additional throttle to the final offsite flow rates, this is currently being investigated.

Additional investigations and flow monitoring has been requested to monitor all the existing outfalls in order to enable to quantify the existing run-off rates from the combined sites. The assessment and analysis of the flow monitoring data collected (over a minimum period of three months) will be available in early summer 2016.

4.0 TEMPORARY WORKS

4.1. Recent Flooding Incidents

In July 2015, it was recorded that over-land flooding occurred in the area and including the local town situated further south of where the site is located. Floodwaters flowed downstream towards the village after flowing past Chapel Hill, Haslingfield Road and parts of the decommissioned CEMEX site (Application Site A).

The flooding was investigated by CEMEX and also by the Environment Agency (EA). This investigation concluded that the flooding that occurred was due to a severe flood event as a result of heavy rainfalls. The flooding of the town downstream occurred due to:

- Surface water run-off north-east of Application A flowing through the site;
- Extreme storms/heavy rainfalls;
- Crushed drains along Haslingfield Road near the railway line and site entrance, silted up pipes/block drains and waterways.

Also parts of the local town downstream of the CEMEX development catchment area is situated in Flood Zone 2 area, these areas are susceptible to flooding from the local rivers in the area and extreme storm events.

Since the incident, CEMEX have unblocked, re-laid crushed pipes, cleaned the watercourse and cleared the majority of the drainage networks within their site in order to avoid further flooding incidents.

4.2. Interim Site Drainage Proposals

Application Site A is redundant site and some of the drainage/drains will not be working as effectively as when it was a live site. Between now and when the proposed drainage scheme for Application site is completed, to reduce the risk of uncontrolled discharge flows from the existing Application Site A an interim drainage strategy is being considered. The interim drainage proposals being considered are:

- Cleaning out /unblocking existing drains replacing pipe work as necessary;
- Maintaining watercourse by de-silting and clearing watercourse;
- Bund/Attenuation – introducing a bund around the perimeter of the CEMEX site with Chapel Hill and Haslingfield Road; and
- Modelling – 3D ground modelling of the existing Application A site, to determine the existing flow patterns.

5.0 CONCLUSIONS

- This report has given a brief overview of the two separate approved planning applications site drainage conditions.
- The existing and proposed drainage conditions have been outlined for each planning application site.
- A combined scheme was analysed to show that both of the approved drainage scheme were viable and there are no adverse impact on the existing outfalls.
- It is estimated that the final discharge from the legacy CEMEX Barrington Quarry Site (Application B) will 6.5 l/sec. and the final discharge from the proposed residential development (Application A) will be a total approximately 160 l/sec. which is the sum of 75 l/sec. from the proposed residential development surface water run-off and approximately 85 l/sec. for the Southern Lake discharge. A flow of approximately 101 l/sec. is maintained from the existing ditch west of Haslingfield Road and a flow of 70 l/sec is maintained from the existing ditch/watercourse west of Application A site.
- The total combined site discharge of Application Site A and Application Site B will be circa 338 l/sec. (this is subject to further investigations and flow monitoring within the site).
- It is anticipated that the existing joint Outfall 1 has the capacity to accommodate up to 874 l/sec. and the existing final Outfall 2 has the capacity to accommodate up to 699 l/sec. The proposed flow rate from the combined sites is calculated as 338 l/sec., this flow rate is within the capacity of both existing outfalls.
- It has been proven that both submitted and approved site drainage schemes particularly the surface water management are acceptable and are not going to increase flood risk within the site or its immediate vicinities.
- Therefore the drainage proposals as they stand are acceptable and no additional works are believed to be required, all of which is subject to further site investigations and detail design.

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