APPENDIX ES4.1

SURFACE WATER MANAGEMENT SCHEME

SCHEME FOR THE MANAGEMENT OF SURFACE WATER AT COOKS HOLE QUARRY AND THORNHAUGH LANDFILL SITE

Report reference: AU/CH/SPS/1774/01/SWMS/FV
February 2024

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Cooks Hole

1.1 In July 2011 a scheme for the management of surface water and groundwater at Cooks Hole was submitted to the Local Planning Authority under conditions 9 and 10 of planning permission reference 03/01171/RMP-ROMPP and Conditions 10 and 11 of planning permission reference 10/01440/MMFUL (Appendix 1.1). As mineral extraction operations have now ceased in Cooks Hole it is no longer necessary to manage groundwater.

Thornhaugh

1.2 The current surface water management plan for Thornhaugh was prepared in 2006 (Appendix 1.2). The scheme includes the design of the post-restoration surface water management system comprising the installation of surface water management ditches and an attenuation lagoon which is designed to provide storage capacity for surface water runoff as a result of up to a 1 in 100 year rainfall event. The scheme also provides details of the monitoring and maintenance of the surface water management system.

Surface water management

1.3 This scheme has been prepared based on the principles set out in the existing approved surface water management schemes. It sets out the controls that will be in place for the management of surface water during the operational and restoration stages of the sites together with the maintenance and management protocols for the surface water management system.

2. Operational surface water management

Cooks Hole

2.1 During the placement of restoration materials in Cooks Hole temporary surface water attenuation and settlement basins will be constructed as necessary down slope of working areas to minimise the potential for the discharge of silt laden runoff to the Thornhaugh Brook. During the operational period the temporary attenuation basins constructed as the operations progress will collect surface water runoff at the site as is the case currently therefore the volume and quality of water discharging from the temporary basins into Thornhaugh Brook will be controlled.

2.2 Ditches will be excavated near stockpiles as necessary to capture surface water runoff and encourage the settlement of suspended solids in order to minimise the risk of the discharge of silt laden runoff to Thornhaugh Brook and the surface water drainage ditch adjacent to the eastern boundary of Cooks Hole.

2.3 A daily watching brief will be maintained during the placement of materials in proximity to Thornhaugh Brook or the surface water drainage ditch adjacent to the eastern boundary of Cooks Hole to monitor the potential for silt laden run off reaching the surface water system. If silt laden or otherwise contaminated runoff is observed to be migrating towards Thornhaugh Brook or the surface water drainage ditch adjacent to the eastern boundary of Cooks Hole any such water will be impounded immediately and will not be released until the operators are satisfied that any suspended sediment which may pose a risk to water quality in the Thornhaugh Brook has settled.

Thornhaugh

2.4 Operational surface water management at Thornhaugh is regulated by the Environment Agency through Environmental Permit reference EPR/RP3133PP/V006 including the monitoring requirements. There is an established surface water management system at Thornhaugh which is shown on Figure SWMS 1 which comprises a perimeter surface water management ditch and an attenuation pond. All leachate and surface water which may be contaminated by waste is contained within the engineered landfill structures and managed as leachate as specified in the Environmental Permit and associated management procedures. The management of leachate and any potentially contaminated surface water at Thornhaugh will continue to be the subject of the site Environmental Permit.

2.5 During the operational period of the sites including during the placement of restoration materials, Augean will maintain and manage the drainage system in the areas of the site where the operations are being carried out and which may affect the surface water drainage and management system. The details of the maintenance and management of the surface water drainage system are set out in Section 4 of this scheme.

3. Surface water management following restoration

3.1 The layout of the surface water management system following restoration of the sites is presented on Figure SWMS 1. The design principles for the surface water management system are summarised below:

- A number of surface water attenuation basins or detention basins will be constructed in the restored areas of the site.
- Shallow ditches will direct runoff to the basins and ditches will convey water between the basins where necessary and to the point of discharge from the site where the discharge is not directly from the basins.
- The rate at which water can leave each attenuation or detention basin will be controlled using a suitable flow restriction device so that during extreme rainfall events a proportion of runoff will be held back to attenuate the runoff peak flow which discharges to the watercourse.
- The rate at which water will leave the surface water management system will be constrained to a rate equivalent to the greenfield runoff rate consistent with the requirements of the National Planning Policy Framework and associated Planning Practice Guidance on Flood Risk and Coastal Change so the risk of flooding downstream is minimised.
- The design rainfall event assumed for the purpose of the calculations presented in this scheme is a 1 in 100 year rainfall event plus a 40% allowance for climate change consistent with the upper end allowance for the 2070s presented on the Climate Change Allowances for Peak Rainfall in England map on the Gov.uk website[1].

Cooks Hole

3.2 Surface water attenuation will be provided by a series of detention basins which are shown on Figure SWMS 1 which will be installed as the restoration operations progress. The proposed landform profile in Cooks Hole has been divided into 7

[1] DEFRA (2024) Climate Change Allowances https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall?mgmtcatid=3059

catchment areas based on the proposed restoration contours. Surface water drainage ditches will drain the runoff from the restored land to basins at the low point in each catchment as shown on Figure SWMS 1. The point of discharge from each detention basin is shown on Figure SWMS 1.

3.3 The catchment areas, proposed storage capacities and proposed maximum discharge rates in respect of the individual detention basins are summarised in Table 1. The calculated greenfield run off rates in respect of each individual detention basin catchment area as well as of the entire catchment area the subject of the proposed surface water management system are presented at Appendix 3.1. The surface water run-off attenuation calculations in respect of the individual detention basin catchment areas together with justification of the parameters used are presented at Appendix 3.2.

3.4 The rate at which water will leave the basins will be controlled so that during extreme rainfall events a significant proportion of runoff will be retained to attenuate the runoff peak flow which discharges to the watercourse. The surface water attenuation function will be accomplished primarily by allowing water to accumulate in the basin areas temporarily during storm events and releasing the water from the basin areas at a controlled rate following the storm event. The design of the surface water management scheme includes the necessary provisions to take into account climate change in particular the predicted increase in frequency and intensity of rainfall storm events. Consistent with guidance, the design rainfall event used to calculate the capacities of the attenuation features comprises the 1 in 100 year rainfall event plus a 40% allowance for climate change.

3.5 Suitable outlets for the discharge of water from the surface water management system will be created so that water can drain passively by gravity and at a controlled rate to the Thornhaugh Brook and the surface water drainage ditch adjacent to the eastern boundary of the sites.

3.6 Consistent with the SuDS Manual the sides of the detention basins will comprise a maximum slope angle of 1 vertical in 3 horizontal. The bases of the detention basins will be generally flat.

3.7 Suitable flow restriction devices will be fitted to the outflow points for each detention basin to restrict the discharge from each basin to the calculated greenfield runoff rates as summarised in Table 1 below.

Table 1

Capacities of the surface water detention basins constructed as part of the proposed surface water management system at the site following restoration

Attenuation basin number	Catchment area (ha)	Storage capacity of basin (m^3)	Greenfield discharge rate (m^3/day)	Maximum storage volume required (m^3)
1	19.94	8523	1543	6020
2	9.02	6256	698	2725
3	4.36	2576	337	1315
4	0.95	5040	73	285
5	5.56	2202	430	1678
6	3.47	1363	269	1049
7	6.97	2287	539	2106
Total	**50.27**	**28247**	**3889**	**15178**

3.8 The drainage channels and pipes shown on Figure SWMS 1 will have sufficient capacity to convey the runoff rate generated during the 1 in 100 year six hour rainfall event plus a 40% allowance for climate change within their respective catchment areas. There is sufficient capacity within each individual detention basin to restrict the discharge of surface water runoff during the 1 in 100 year rainfall event plus a 40% allowance for climate change to the greenfield runoff rate hence the proposed development will not increase flood risk in the catchment of the River Nene including in the catchment of the Thornhaugh Brook and White Water Brook.

Thornhaugh

3.9 Surface water runoff at Thornhaugh will continue to drain to the perimeter of the site into the surface water management ditch where it is conveyed into the existing attenuation pond in the north eastern corner of Thornhaugh and subsequently discharged via a flow restriction device to the surface water drainage ditch adjacent to the eastern boundaries of Cooks Hole. The existing attenuation pond has been designed and approved based on the same principles as those used for the design of the surface water management system for Cooks Hole. As shown on Figure SWMS 1 a small area of the Thornhaugh restoration landform which currently drains to the attenuation pond at Thornhaugh will, as part of the proposed development, drain to the proposed surface water management system within the Cooks Hole site. No other changes are proposed to the general arrangement of the existing surface water drainage system in Thornhaugh. The proposed development will not result in an increase in the rates or volumes of surface water discharging to the existing attenuation pond when compared with the consented scheme and will remove a small area of the catchment from the consented surface water management system at Thornhaugh. The proposed development will therefore result in a betterment in comparison with the baseline situation with respect to flood risk at Thornhaugh and with respect to flood risk elsewhere.

Conclusion

3.10 Based on the overall surface water management system design, the proposed development will not result in an increase in flood risk in the catchment of the River Nene including in the catchment of the Thornhaugh Brook and White Water Brook.

4. The maintenance and management of the surface water drainage system

4.1 During the operational period of the sites including the placement of restoration materials, Augean will maintain and manage the drainage system in the areas of the site where the operations are being carried out and may affect the quality of the water in the drainage system. Maintenance and management of the surface water drainage and management system will continue following the completion of the restoration of the site.

4.2 The principles on which maintenance and management of the surface water management system will be based are set out below:

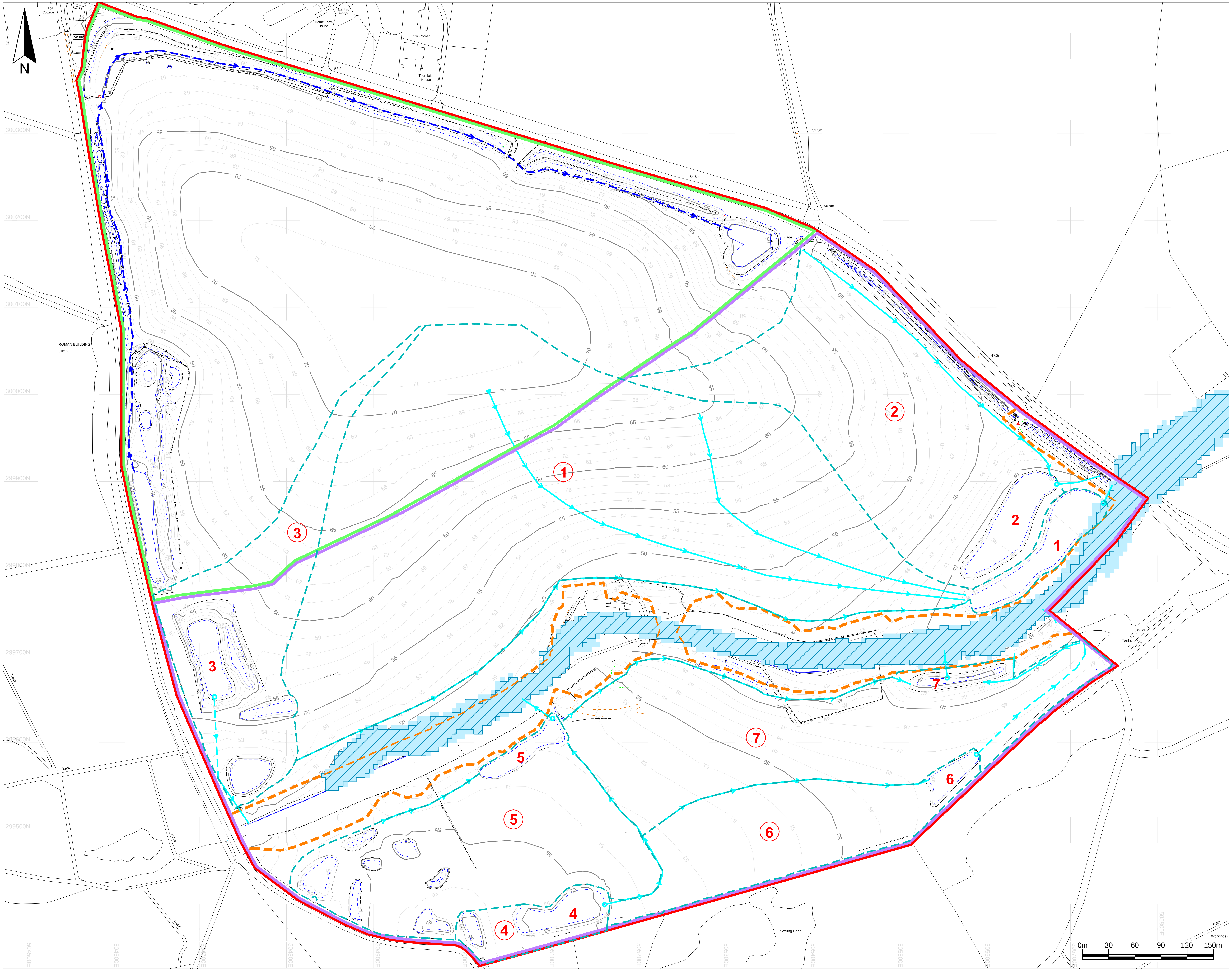
- Regular inspections of the surface water drainage system will be undertaken. The purpose of the inspections will be to confirm the adequate performance of the drainage system, to identify operational problems and to facilitate planning of maintenance actions as necessary.
- Insofar as it is practicable inspections of the surface water drainage system will be carried out in a range of weather conditions including during rainfall events.
- Maintenance actions will be planned and implemented as necessary to facilitate the proper functioning of the drainage system.
- The planning and implementation of maintenance actions will take into account the protection of habitats and ecosystems as necessary.

4.3 Specific maintenance and management actions are likely to include but may not be limited to:

- Removal of litter and debris from attenuation basins and ditches at the site as necessary.
- Sediment management such as the removal of accumulated sediment in attenuation basins and the ditches as necessary.
- Inspection and remedial maintenance of the flow control structures at the outlet of attenuation basins as necessary.

- Grass cutting and other vegetation management such as pruning as necessary.
- Control of weeds and invasive plants as necessary.
- Repairing damage to ditches caused by erosion or other processes.

FIGURE



Key / Notes

- Application boundary
- Boundary of Cooks Hole Quarry
- Boundary of Thornhaugh Landfill Site
- Contours (mAOD)
- Change of surface
- Top of bank
- Bottom of bank
- Ditch invert
- Verge
- Fenceline
- Building/Road
- Track
- Overhead power line
- Survey station
- 20m standoff from existing tree groups
- Drain
- Basin out flow via flow restriction device
- Detention basin
- Detention basin catchment area
- Underground drainage pipe
- Area draining to consented surface water management system at Thornhaugh Landfill Site
- Flood zone 2
- Flood zone 3

This drawing may not include all of the features listed in the above key

Rev	Status	Drn	App	Chk	Date
	Final	KR	CJG	LH	07/02/24

Site
Cooks Hole Quarry and Thornhaugh Landfill Site

Client
Augean

Title
Current and proposed surface water management infrastructure

Figure SWMP 1

Scale
1:3,000@A2

Drawing Ref
AU/CH/02-24/24179

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APPENDIX 1.1

SURFACE WATER AND GROUNDWATER MANAGEMENT SCHEME FOR COOKS HOLE DATED 2011

Schemes for the management of surface water and groundwater required under conditions 9 and 10 of Permission reference 03/01171/RMP-ROMPP conditions 10 and 11 of Permission ref. 10/01440/MMFUL-Extension

Surface water

1. *No operations under this permission shall be begun before a scheme for the mitigation of impacts on surface waters has been submitted to and approved by the Mineral Planning Authority. The scheme shall be limited to the mitigation measures proposed in the Hydrogeological and Hydrological Impact assessment included at Appendix F of the Environmental Statement. The development shall be carried out in accordance with the approved scheme.*

2. *Reason: In order to maintain the present hydrological conditions in order to preserve the quality of water, flow of water and the natural environment that depends on such hydrology in accordance with policies CS 21 and CS 22 of the adopted Peterborough Core Strategy, emerging policies 35 and 39 of the Minerals and Waste Core Strategy DPD and PPS9, 23 and 25.*

Groundwater

3. *The winning and working of minerals hereby approved shall not take place below the water table until a scheme for the mitigation of impacts on ground waters has been submitted to and approved by the Mineral Planning Authority. The scheme shall be limited to the mitigation measures proposed in the Hydrogeological and Hydrological Impact assessment included at Appendix F of the Environmental Statement. The development shall be carried out in accordance with the approved scheme.*

4. *Reason: In order to maintain the present hydrological conditions in order to preserve the quality of water, flow of water and the natural environment that depends on such hydrology in accordance with policies CS 21 and CS 22 of the adopted Peterborough Core Strategy, emerging policies 35 and 39 of the Minerals and Waste Core Strategy DPD and PPS9, 23 and 25.*

Hydrology and hydrogeology

5. A full description of the hydrology and hydrogeology of the site is provided in Appendix F of the Environmental Statement. The particular details pertinent to the preparation of this scheme are:

- The site is a valley feature of approximately 50ha;
- The Thornhaugh Beck crosses the site from west to east;
- The Thornhaugh Beck is dry from the western boundary to midway across the site where spring arise by Cook's Hole farmhouse;
- The geology of the site comprises limestone overlying sands with ironstone overlying grey mudstone and clay.
- In the western half of the site is a restored ironstone working into which the overlying limestone was backcast;
- Groundwater is present in the sand and the limestone and flows generally to the east and towards the Beck with which it is in continuity.
- Incident rainfall either infiltrates the ground to the groundwater or water flows across the site to the Beck;

Scheme of mineral working

6. The scheme of working is described in detail in the Environmental Statement. The key elements of the working scheme pertinent to hydrological and hydrogeological impact are:

- The site will be progressively extracted and restored in a series of phases with a maximum area per phase of approximately 8ha.

- There will be a minimum standoff of 20m from the beck hence the drainage in the workings will not be in direct continuity with the beck
- Incident rainfall to the workings will drain across or through the floor of the workings and infiltrate to the beck through the 20m standoff of in-situ limestone and sands;
- The depth of extraction below the groundwater table is 1 to 4m in the north of the beck and a maximum of 2m to the south of the beck .
- Where excavations are below the groundwater table groundwater entering the workings will drain across the quarry floor and infiltrate to the Beck through the 20m standoff of in-situ limestone and sands. It may be necessary to pump water from one area to another within the workings to maintain dry working;
- It is considered that it will be unnecessary to pump surface water or groundwater from the workings to the Beck. In the event that it is necessary an application to the Environment Agency for a Discharge Permit will be made.
- The extracted areas will be progressively backfilled with quarry fines and sand hence providing a permeable medium in which groundwater levels will re-establish.
- Each phase will be progressively restored and grassland re-established;
- The final landform will be at low level with steeper slopes at the southern and northern boundaries of the site and shallower slopes in the centre of the site compared with the original landform. The average slopes across the site from the northern and southern boundaries to the Beck will be the same as the original landform.

Potential hydrological impacts

7. Based on the proposed working scheme surface water and groundwater flows will be maintained to the Beck. The excavation will not result in an increase in flood risk. Consideration has been given to whether the newly restored surface could give rise to increased surface water run-off by reference to the National Coal Board - Mining Department ,1982; Technical Management of Water in the Coal Mining Industry. It is stated at Page 54 that when the site has been restored the run-off coefficient will be similar to normal agricultural land. This is likely due to the freshly cultivated land being relatively porous.

8. Based on the above description of the development the potential impacts that must be controlled are:

- Impact on water quality due to the use of mobile and fixed plant and storage of fuels and chemicals;
- Impact on water quality due to the generation of suspended solids (Note that the main activities which could result in suspended solids are confined within the quarry workings);
- Impact of draw down of groundwater beyond the site with particular reference to the Bedford Purlieus SSSI at the north west boundary.

9. The control of mineral extraction operations to ensure that surface water and groundwater quality and flow are not adversely affected by the proposed development are set out below.

Protection of surface and groundwater quality

10. The potential for impacts on the quality of surface and groundwater water will be controlled by the adoption of the following mitigation measures:

11. Operations will be carried out in accordance with guidance contained within the Environment Agency Pollution Prevention Guidelines (PPG), including:

General Guide to the Prevention of Pollution: PPG1;

Above Ground Oil Storage tanks: PPG2;

Works in, Near or Liable to Affect Watercourse: PPG5;

Working at Construction and Demolition Sites: PPG6;

Storage and Disposal of Used Oil: PPG8;

High Pressure Water and Steam Cleaners: PPG13;

Control of Spillages and Fire Fighting Runoff: PPG18;

Pollution Incident Response Planning: PPG21; and

Storage and Handling of Drums and Intermediate Bulk Containers: PPG26;

12. The potential for impacts to occur as a result of generation of suspended solids will be minimised by the following measures:

- Where possible, storage compounds (for the temporary stockpiling of excavated soils) would be located away from the Thornhaugh Beck.
- There would be no pumping (e.g. of displaced ground or surface water) to controlled waters without a Discharge Consent obtained from the Environment Agency;
- If pumping is necessary operations would be carried out on a "permit to pump" basis, and all pumps would have a tag indicating this authorisation;
- The site will be worked in a phased manner in which areas of bare soil would be kept to a minimum;
- All haul roads will be kept clean and tidy in order to prevent the build-up of oil and dirt that could be washed into a watercourse or drain during heavy rainfall; and
- The use of water sprays for reducing dust or washing construction areas will be carefully regulated in order to avoid mobilising substantial quantities of silt (etc.).
- Grips will be made perpendicular to the fall across the restored surface of the site to slow run off from the restored surface while vegetation establishes

13 The potential for impacts to occur as a result of contamination of water by oil or other liquids would be minimised by the following measures:

- Storage compounds for fuels, oils or other liquid chemicals would be located away from surface water. They would have an impermeable base and impermeable bunds with a capacity of 110%;
- Small plant such as pumps would be equipped with drip trays;
- Drums and barrels will be stored in a designated, bund-shielded safe area within the site compound and;

- All drums and barrels will be properly labelled.

14 The potential for impacts to occur as a result of contamination from accidental spillages will be minimised by the following measures:

- Spill kits will be located on sites near to watercourses and within the works compounds, and staff would be trained in the usage of spill kits.
- Although the potential impact on groundwater quality as a result of dewatering activities (see below) is expected to be insignificant, the maximum acceptable water turbidity as well as a water quality monitoring programme will be agreed with the EA.
- In order to prevent water pollution resulting from worker-generated sewage effluents, foul sewage would be managed either by removal from site by road tanker or a suitable effluent treatment unit, installed to a specification agreed in consultation with the Environment Agency; and

Groundwater management

15 It is anticipated that groundwater entering the workings will drain across the floor but it may be necessary to actively pump water to maintain dry workings. If pumping is necessary localised dewatering will take place of each phase by pump from a sump in each phase. Pumped water will be recharged either within the working phase or the adjacent phase. The water thus reintroduced will maintain groundwater flow and flow in Cook's Hole spring and Thornhaugh Beck during operations. Water quality in the beck will be maintained by natural filtration however, it may be necessary to periodically de-silt the recharge areas to maintain infiltration capacity.

16 The impacts on groundwater flow and consequent impacts on surface water flow will be mitigated by a programme of monitoring, remedial action if necessary and reporting.

<u>Monitoring</u>

17 Groundwater levels will be monitored at existing groundwater monitoring boreholes located on the periphery of Cook's Hole site. Flow in Cook's Hole Spring will also be monitored. The readings will be taken monthly.

18 As past groundwater monitoring has established that the groundwater table at the site is not subject to significant seasonal variation, the monitoring results for the 12 month period preceding the commencement of site operations will be used to provide a baseline information, against which the effects (if any) of working below the water table will be assessed.

19 Remedial action will be taken if the results of the monitoring (relative to the baseline data) indicate that either:

- groundwater levels are reduced by 1 metre or more, or
- there is a significant reduction in spring flow (75% or more).

Remedial action

20 In the event that a change in water levels occurs in excess of the trigger limits, the methods to be used to restore the hydraulic regime will vary depending on the extent of any derogation.

21 If an adverse impact occurs in terms of the groundwater level, the method to be used to restore the hydraulic regime will be to:

- suspend any further dewatering and
- Institute a review of the groundwater information.
- Groundwater control will only be resumed either when:
    - o groundwater levels have recovered, or
    - o it is accepted by the MPA that the results of the review demonstrate that significant harm is unlikely to result.

Reporting

22 The results of monitoring and the details of any remedial action taken during the preceding 12 months will be provided to the MPA on request.

APPENDIX 1.2

THORNHAUGH LANDFILL SURFACE WATER MANAGEMENT PLAN DATED 2006

Augean plc

Thornhaugh Landfill Site
Surface Water Management Plan

February 2006

Augean plc

Thornhaugh Landfill Site Surface Water Management Plan

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February 2006

CONTENTS

1.0 INTRODUCTION

1.1 Egniol Limited was commissioned by Augean plc, to prepare a Surface Water Management (SWM) design and associated Management Plan for the Thornhaugh Landfill Site, nr Peterborough which is operated by Augean plc (Appendix A).

1.2 The purpose of the assessment is to determine whether the site restoration proposals and surface water management design pose an unacceptable risk to surface and groundwater and whether proposed mitigation measures are sufficiently robust to reduce/control those risks to an acceptable level.

1.3 The site is an active landfill site. At present there is no formal surface water management scheme in operation. This report outlines the proposals for a surface water management scheme, which will be implemented in line with the phasing of the landfilling.

1.4 The scheme intercepts surface water run-off and provides attenuation using a lagoon to prevent flooding to the surrounding land for up to a 1 in 50 year event. Additionally the lagoon provides an opportunity for monitoring the water quality and the closure of the system should contamination occur, allowing proper disposal of the contaminated waters.

1.5 Proposed discharge rates of run-off from the site to a receiving watercourse are expressed in terms of "Greenfield" rates. Calculations for the performance of the ditches and attenuation lagoons have been produced using the Flood Studies Report (FSR) and MicroDrainage software.

1.6 Particle settling velocities have been calculated to illustrate the efficiency of the lagoon (Appendix B).

1.7 Subsurface flow, if any, has been ignored since this assessment deals purely with surface water run-off.

1.8 The proposed landfill comprises cell filling phases 1A/B, 2, 3, 5, 6A/B and 7A/B (Appendix C). Reprofiling has been carried out to reduce levels in cell 3. Under the SWM plan, a network of collector ditches has been incorporated into the reprofiled batters to prevent off site run-off. The ditches issue into an attenuation lagoon, which although designed for a 1 in 50 year event will provide storage up to a 1 in 100 year event. The lagoon also provides the means for monitoring for compliance with the discharge parameters stated in the Pollution Prevention and Control[1] (PPC) permit. The run-off will discharge from the lagoon into Thornhaugh Beck to the east of the site which confluences with the River Nene some 0.65km downstream.

1.9 Cells 4B and 4C are currently subject to a planning application for mineral extraction, therefore surface water management of this area will not be required until the extraction and filling has taken place. The lagoon however has been sized so as to incorporate this area at a later date.

1.10 Cell 4A contains recently constructed lined lagoons which are colonised by Great Crested Newts. This scheme does not alter or interfere with these lagoons. No surface water run-off will enter these ponds for events, up to the required 1 in 50 year event. The system has been tested for sensitivity to greater rainfall events, this shows that the designed lagoon and ditch system also provides protection for up to a 1 in 100 year event.

2.0 PRESENT SITUATION

2.1 At present there is no active surface water management scheme on site.

2.2 The run-off from the northern catchment flows towards the A47 which has a ditch alongside it which accepts road run-off. At present run-off from the landfill site can settle on the bund crest and during large rainfall events there is a possibility that it may enter the highway drainage ditch before it reaches the road. The Environment Agency (EA) has highlighted concerns from local residents that the ditch may fill in times of storm and may flood their properties.

2.3 The land to the south of the site is owned by Augean and is open pasture, there are also newt ponds to the west which are in Augean land ownership. Also to the west is woodland not in Augean land ownership.

2.4 The area which contains the Great Crested Newt ponds will not be altered and the surface water ditches will protect these ponds for up to the designed 1 in 50 year event. The system has also been tested for greater rainfall events and it was found that the ditches will also provide protection for an event up to 1 in 100 years.

3.0 SOURCES OF POLLUTION

3.1 Potential sources of pollution have been identified and their effect in terms of pathways and receptors are discussed in Section 4.0 of this report. These potential sources are:

- From waste decomposition within the restored landfill.
- From the contamination of run-off which comes into contact with waste during filling of the cells.
- Contaminants (oil/fuel) from vehicles which may get deposited in the weighbridge and site engineering/development offices area and car park.
- Waste which may fall from vehicles as they cross the site to the active cell.
- From materials placed in the quarantine area, which is currently unsurfaced with no positive drainage system.
- Contaminated run-off entering the A47 drainage ditch and overflowing into the properties.
- Contaminated run-off which could enter:
  - The lagoon and therefore Thornhaugh Beck.
  - The newt ponds via overflowing ditches.
  - The groundwater via overflowing ditches.

4.0 PATHWAYS AND RECEPTORS

4.1 This section of the report asses the pathways and receptors of the potential sources of pollution highlighted in section 3.0.

- Rainfall will not be able to enter the restored landfill due to the engineered liner within the capping layer. Should any rainfall enter the cell due to a puncture for example, then the lower liner will prevent it from entering the groundwater. Leachate will be formed and treated accordingly. Rainfall which enters the restoration soils will be directed to the ditches by the drainage layer in the capping geo-membrane.

- Rainfall during the filling process will not create run-off as the waste is 100% permeable, any water entering the cell will be collected in the leachate system and dealt with accordingly.

- Contaminants on the hardstanding weighbridge and site engineering/development offices area and car park enter the existing surface water drainage system. The surface water run-off from this area is designed to be captured within the on-site drainage system

- Any solid waste which falls from the vehicles on site will be removed and dealt with. The site does not accept liquid waste.

- Contamination of run-off within the quarantine area can access groundwater. This is the subject of an improvement notice and there are proposals to convert this to a hard standing area with a separate sealed drainage system and sump.

- The installation of the northern perimeter bund with remove the pathway for potentially contaminated run-off to enter the highway drainage and flood properties.

- To avoid any contaminated run-off from entering:
  - The lagoon and therefore the Thornhaugh Beck;

    A penstock has been supplied at the lagoon outfall so that if the water, which is analysed under the Environmental Monitoring Plan, is found to be out of the specified parameters the lagoon can be closed and contaminated run-off tankered off for treatment.

  - The newt ponds via overflowing ditches;

    The system's sensitivity has been tested and the ditches were found to protect the newt ponds for up to a 1 in 100 year event. Should a larger event happen concurrent with a contamination issue then the potential for the ponds to be contaminated would be minimal due to dilution.

  - The groundwater via overflowing ditches;

    As with the newt ponds should an event larger than 1 in 100 years occur concurrent with a contamination issue then the potential for the ponds to be contaminated would be minimal due to dilution.

5.0 PROPOSED SURFACE WATER MANAGEMENT

5.1 The proposed SWM system, lagoon and outfall details are shown on drawings 1622.SWM.02, 03, 04 and 05 (Appendix D). The restored site slopes have been configured into north and south catchment areas.

5.2 The SWM system is designed to be installed progressively as the cells are restored. Surface water cut off grips are provided in the restoration soils to guide the run-off to the main perimeter ditches which feed the lagoon. The grips are provided to reduce erosion of the restoration soils prior to the establishment of vegetation. Once the vegetation has established the grips can be removed or filled.

Northern Site Catchment

5.3 The northern catchment is serviced by three grips in the restoration soils which direct the run-off to the perimeter ditch. These are designed to reduce erosion of the restoration soils.

Southern Site Catchment

5.4 The southern catchment is similar to the north, here there are two grips which lead to the perimeter ditch. Drainage of cells 4B and 4C have been omitted at this point as the area is still subject to planning; however the lagoon is sized to take this flow should it be required at a later date.

Principles of the Surface Water Management Design

5.5 The EA have stipulated that the surface water management system attenuates the run-off from a 1 in 50 year rainfall event (Appendix E), passing forward the Greenfield rate and attenuating the remainder on site. In addition, measures are required to improve the quality of the final effluent by encouraging the settlement of suspended solids.

5.6 The surface water run-off is attenuated on site and discharged to the receiving watercourse at the agreed maximum discharge rate of 5.14l/s (Appendix F). There is a ditch along the northern boundary which is utilised for highway drainage; this is not being used in this scheme. The proposed SWM scheme will be independent of this ditch which will be designed to prevent water surface water from leaving the site apart from at the approved discharge point.

5.7 A surface water monitoring point is provided at the lagoon outfall prior to the water being discharged to the beck. The discharge will be monitored in accordance with the Monitoring and Action Plan. A penstock is located at the lagoon outfall to allow the system to be isolated in the event of contamination.

Technical aspects of the Surface Water Management Design

5.8 Calculations for the performance of the ditches and attenuation lagoon have been produced using the Wallingford Procedure in the MicroDrainage software. Simulations of a range of design storms with a return period of up to 1 in 100-year, to test the sensitivity of the 1 in 50 year design, were modelled. These produced results for critical storm lengths (Appendix G).

5.9 As an integral part of the strategy, a hydrological study has been completed using the FSR and the Wallingford Procedure. This is used along with computer aided design techniques to predict the run-off from the site for a storm event with a return period of 1 in 50-years (2.0% annual probability). Calculations to predict the Greenfield run-off rates and the percentage run-off (PR), identified the proportion of rainfall which constitutes surface flows.

5.10 The 1 in 1 year Greenfield Run-off was calculated to be 5.14l/s (0.39l/s/ha) for the area draining into the proposed surface water scheme (Appendix H). The run-off rate was determined using the FSR. The lagoon will discharge at a rate no greater than this for events up to a 1 in 50 year return period as agreed with the EA.

5.11 The ditches have been sized for a 1 in 10-year (10% annual probability) design storm. Other variables used in the model were:

- Region: England and Wales
- M 5:60: 19.800
- Ratio r: 0.400

5.12 Although the design is for a 1 in 50 year event, no out of bank flow is expected from the ditches or lagoon for up to the 1 in 100 year event.

5.13 Approximately 1250m^3 of flood attenuation (top water level of 53.552m AOD) is required (to allow for the Greenfield discharge rate in the 1 in 50-year rainfall event). The lagoon will attenuate this additional run-off and provide the settlement of suspended solids.

5.14 The lagoon has a bottom water level of 52.500m AOD and a base level of 52.000m AOD. The banks of the lagoon area have a level of 55.000m AOD, thus providing a total storage volume in excess of 2600m^3. This additional volume will provide freeboard and a volume to allow for the reduction caused by settling of suspended solids. Extra volume had also been provided to allow for the effects of climate change over the lifetime of the site.

5.15 Discharge from the lagoon is limited to the Greenfield rate and this is achieved using an orifice structure with a diameter of 0.050m. The outfall pipe has a 225mm diameter with an upstream invert of 52.500m AOD.

5.16 Settlement of suspended solids is also a function of the lagoon and the geometry has been configured to dissipate energy from incoming turbulent flow during storm events. The lagoon has at least 0.5m of water below the bottom water level which will provide inertia to reduce inlet velocity. A sump has been incorporated into the base of the lagoon to collect suspended solids and aid removal.

5.17 The storage lagoon will also provide an opportunity for intercepting potentially contaminated flows. The design of the lagoon incorporates a penstock control which will enable any contaminated waters to be contained and tankered off site.

5.18 The lagoon and perimeter ditches will either be lined with 600mm of clay or a geomembrane liner to prevent contamination of the groundwater. This is overlain by Erosamat which will then be dressed in topsoil and seeded. When established, the grass will provide further natural filtration.

5.19 The lagoon will have side slopes of a maximum of 1 in 3 to permit egress in the event of someone falling in. The lagoon will be fenced with a gated access and have signs indicating the presence of deep water.

5.20 The lagoon shape may be modified on site within reason to ensure it fits in with the surrounding area and promote ecological growth. However this must not affect the hydraulic workings of the lagoon.

5.21 Surface water ditches will be excavated into the restoration soils to direct run-off into the main perimeter cut-off ditch. The ditch section profile is indicated on drawing 1622.SWM.03 in Appendix D and is integrated with the capping materials.

5.22 The construction of surface water management infrastructure will be subject to Construction Quality Assurance (CQA) supervision to ensure that the works are built in accordance with the drawings and specification.

5.23 The outfall from the lagoon is initially via a pipe then a ditch which runs down the field boundary to Thornhaugh Beck. A small section of the outfall is piped where the outfall crosses under a road/track (see 1622.SWM.05, Appendix D). An alternative piped outfall has been considered and drawing 1622.SWM.03 shows details of the pipe alternative as well as the pipe bedding and road crossing details.

6.0 MONITORING AND MAINTENANCE

6.1 It will be necessary to initially closely monitor the accumulation of sediments within the lagoon. This may be high until the restoration soil grasses establish. Rates of accumulation of sediment will also depend on rainfall and season. A sump is provided in the base of the lagoon to collect solids and aid removal.

6.2 The permitted limit on suspended solids has been set at 40mg/l. The calculations to determine the particle settling velocity show that both 20µm and 60µm particles settle in 1/292 and 1/545 of the lagoon length.

6.3 Testing of contaminated water in the lagoon will be undertaken in accordance with the Monitoring and Action Plan. Records of sampling data shall be available for scrutiny by the EA at all reasonable times to offer assurance that compliance to agreed discharge criteria is being adhered to. Should this not be the case, the water will be tankered off-site for disposal at a licensed treatment facility.

6.4 The PPC permit for the site has stipulated an emission limit for ammoniacal nitrogen level of <1.0mg/l. This level of ammoniacal nitrogen is not expected from the surface water discharge. However, should the ammoniacal nitrogen levels in the surface water discharge begin to increase, reed planting can be incorporated into the lagoon to provide nutrient removal. The banks of the lagoon will be set at no more than 1 in 3 allowing margins to be established for reed planting.

6.5 As the landform settles, ditches may need to be realigned to maintain gradient.

7.0 CONCLUSIONS

7.1 The design of the SWM system ensures that under normal operating conditions site run-off will be isolated from the surrounding area. This reduces the possibility of pollution or flooding event from the site to the surrounding areas.

7.2 The results of the Microdrainage model illustrate that the SWM design is valid for the 1 in 50-year event (and 1 in 100 year event) and that it effectively retains flow within the ditch network, culvert and attenuation / settlement lagoon.

7.3 The lagoon has been sized for the 1 in 50-year rainfall event (however, no flooding is expected from the lagoon during the 1 in 100-year rainfall event) and provides flooding and contamination protection for the receiving watercourse. The lagoon is the last opportunity before the receiving watercourse for intercepting potentially contaminated flows.

7.4 The efficiency of the removal of suspended solids is dependant on the lagoon design. Its geometry has been configured to aid the dissipation of energy from incoming turbulent flow during storm events allowing the suspended solids to settle. A sump is provided in the base of the lagoon to collect suspended solids and aid removal.

7.5 The drainage ditches and lagoon will be lined with either a clay or geomembrane liner. This will allow run-off to reach the lagoon without the potential to contaminate the groundwater. Once the run-off reaches the lagoon it can be sampled before discharge.

7.6 The ditches have been designed so that no out of bank flow will occur for the 1 in 50-year event. When the ditches and lagoon are modelled together it is shown that the system provides protection for up to a 1 in 100 year event.

7.7 Discharge from the site is limited to the agreed 1 in 1-year Greenfield rate of 5.14l/s.

7.8 Testing of water discharged from the water lagoon will be undertaken in accordance with the Monitoring and Action Plan. Records of sampling data shall be available to the EA at all reasonable times to offer assurance that compliance to agreed discharge criteria is being adhered to.

REFERENCES

1: PPC permit – Thornhaugh Landfill Site, dated 09 November 05.
Permit no. RP 31333PP

Appendix A

Site Location Plan

DWG NO.1622.LP.01

Augean plc	THORNHAUGH LANDFILL SITE	SITE LOCATION PLAN	Egniol Limited Amber Mill, Oakerthorpe, Alfreton, Derbyshire, DE55 7LL Tel: 01773 520200 Fax: 01773 835439 Website: www.egniol.co.uk

DRAWN BY	CHECKED BY	APPROVED BY	DATE	SCALE @ A4	ISSUING OFFICE	DRAWING NUMBER	ISSUE	REVISION
EW	AK	AK	01.02.2005	1:50,000	ALFRETON	1622.LP.01	D	-

CAD FILE REF: 1622.LP.01.DWG

Appendix B

Calculations to Determine Particle Settling Velocities

DETERMINING PARTICLE SETTLING VELOCITIES

Assess terminal velocity of settlement of fluvial deposits in balancing lagoon using "Design of Flood Storage Reservoirs" by CIRIA.

From para 6.5.1

The settlement velocity of a sphere of given diameter, d, is derived from the drag force, Cd and Reynolds Number, Re, expressed in two dimensional groups:-

$$\frac{Cd}{Re} = \frac{4}{3} \frac{((\rho_p - \rho)\, g\mu)}{\rho^2 - \upsilon_s^{\,2}} \qquad \text{Equation 6.2}$$

$$Cd.\ Re^2 = \frac{4}{3} \frac{(\rho(\rho_p - \rho)\, gd^2)}{\mu^2} \qquad \text{Equation 6.3}$$

Where g = gravitational acceleration $9.81 m/s^2$

μ= absolute viscosity of the fluid (Ns/m^2)

ρ_p = particle density (kg/m^3)

ρ = fluid density (kg/m^3)

Assume the particle size will arise from use of the granular restoration soils. Also check the efficiency of the designed lagoons to cater for clay content if the restoration soils are taken from soil arising from waste inputs.

So for restoration soils:-

µ metres	% Passing
20	65
60	100

Where < 2 µm is clay
2 -6 µm is fine silt
6 -20 µm is medium size silt
20 – 60 µm is coarse silt
60 – 200 µm fine sand

Determine the particle settling velocity for 20µm particles settling in water at 20^0 C. Assume a specific gravity of 2.4.

Check υ_s for 20µm size particles;-

$$Cd.\ Re^2 = \frac{4}{3}\left(\frac{\rho(\rho_p - \rho)\,gd^2}{\mu^2}\right) \qquad \text{Equation 6.3}$$

$= 0.076$

From Fig 6.7 Re = 0.04

As Reynolds Number is < 1, Stokes Law is valid and settlement is in the laminar range.

So from $Cd.\ Re^2 = 0.076$

Cd = 47.5

And υ_s = 2.6mm/s (20µm particle)

Similarly, υ_s for 60µm gives Re = 0.23 (laminar) and Cd = 38.94

and υ_s = 4.98mm/s (60µm particle)

Determine the trap efficiency of the lagoon

From Design of Flood Storage Reservoirs Para 6.5.3

$$\text{Trap efficiency} = \eta = \frac{\upsilon_s\, t_R}{d_l}$$

where υ_s = Settling velocity
t_R = Mean hydraulic residence time
d_l = Flowing layer mean depth of flood basin

Check η for 20µm and 60µm particles

Total Volume at 1 in 50 year level = 1250m^2
Use half of lagoon for settlement therefore volume = 625m^2

Depth of lagoon for a 1 in 50 year event = TWL – BWL = 53.61 – 52.50 = 1.11m

$$\text{Mean hydraulic residence time } t_R = \frac{Vol}{Q}$$

Where Q = steady state inflow / outflow. This is not feasible for attenuation lagoons where inflow / outflow ratios will change, so use outflow rate.

So $t_R = \frac{625}{5.14 \times 10^{-3}}$ = 121,595s = 2027 hours

Mean through flow velocity $V = \frac{L}{t_R} = \frac{43.5}{121{,}595}$

$= 3.58 \times 10^{-4}$ m/s

for 20µm particles, where $\upsilon_s = 2.66$mm/s

$$\eta = \frac{\upsilon s \times t_R}{d_1} = \frac{2.66 \times 10^{-3} \times 121{,}595}{1.11}$$

$\eta = 291$ Satisfactory

Therefore all of the remaining 20µm particles would be trapped in 1/291 the length of the lagoons.

for 60µm particles, where $\upsilon_s = 4.98$mm/s

$$\eta = \frac{\upsilon s \times t_R}{d_1} = \frac{4.98 \times 10^{-3} \times 121{,}595}{1.11}$$

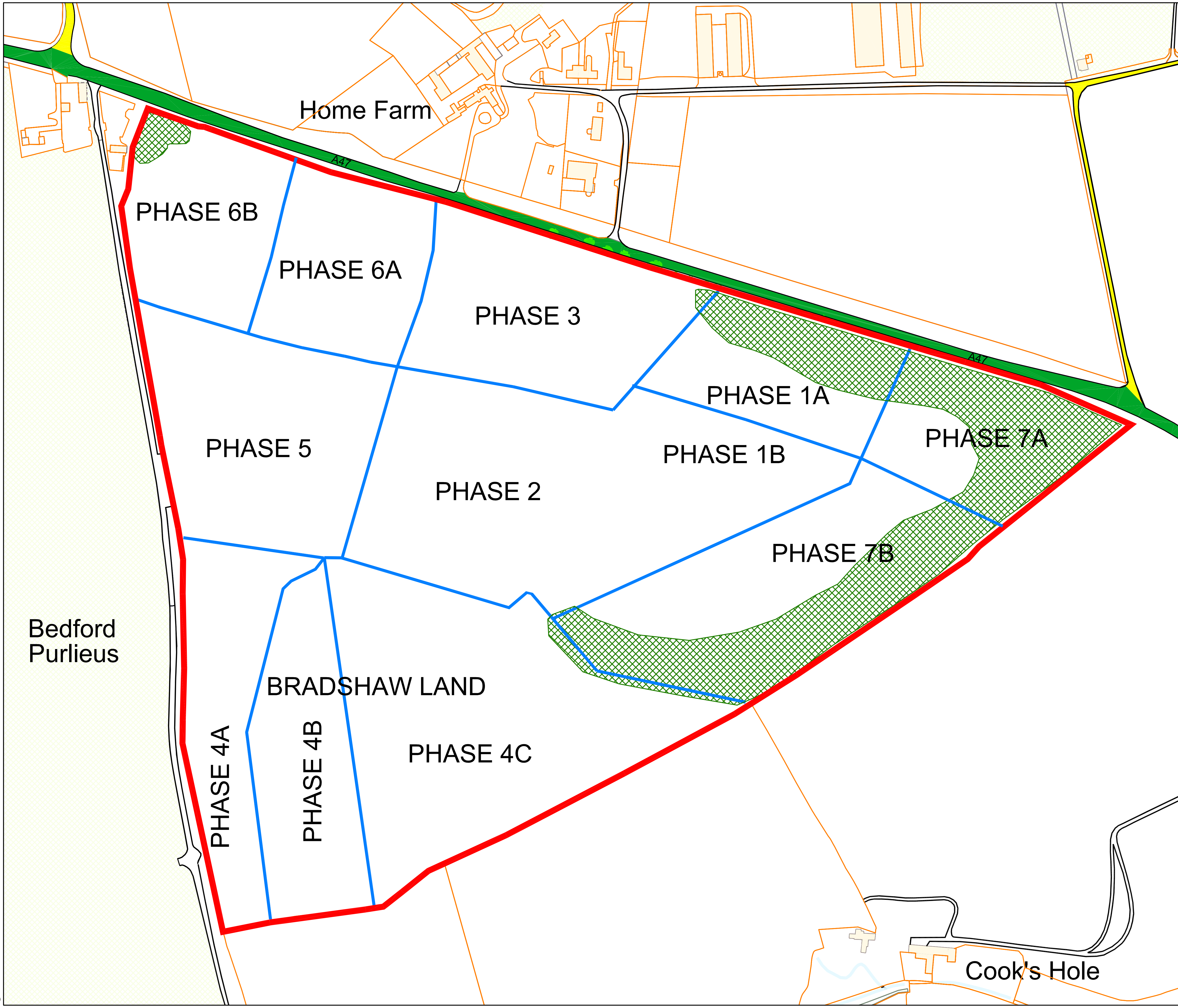
$\eta = 545$ Satisfactory

Therefore all of the remaining 60µm particles would be trapped in 1/545 the length of the lagoons. The Erosamat lining and grass within the outfall ditches would entrap fluvial fine silts also.

Appendix C

Site Filling Phasing Plan

DWG NO.1622.SWM.06



NOTES

- Thornhaugh Quarry
- Landfill Phase Boundaries

Augean SOUTH LTD

THORNHAUGH LANDFILL SURFACE WATER MANAGEMENT

SITE PHASING PLAN

DRAWN BY AK	DATE 26.01.2006
CHECKED BY CW	SCALE @ A3 3000
APPROVED BY CP	ISSUING OFFICE PEOVER

DRAWING NUMBER	ISSUE	REVISION
1622.SWM-06	Fn	A

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CAD FILE REF: XX.DWG

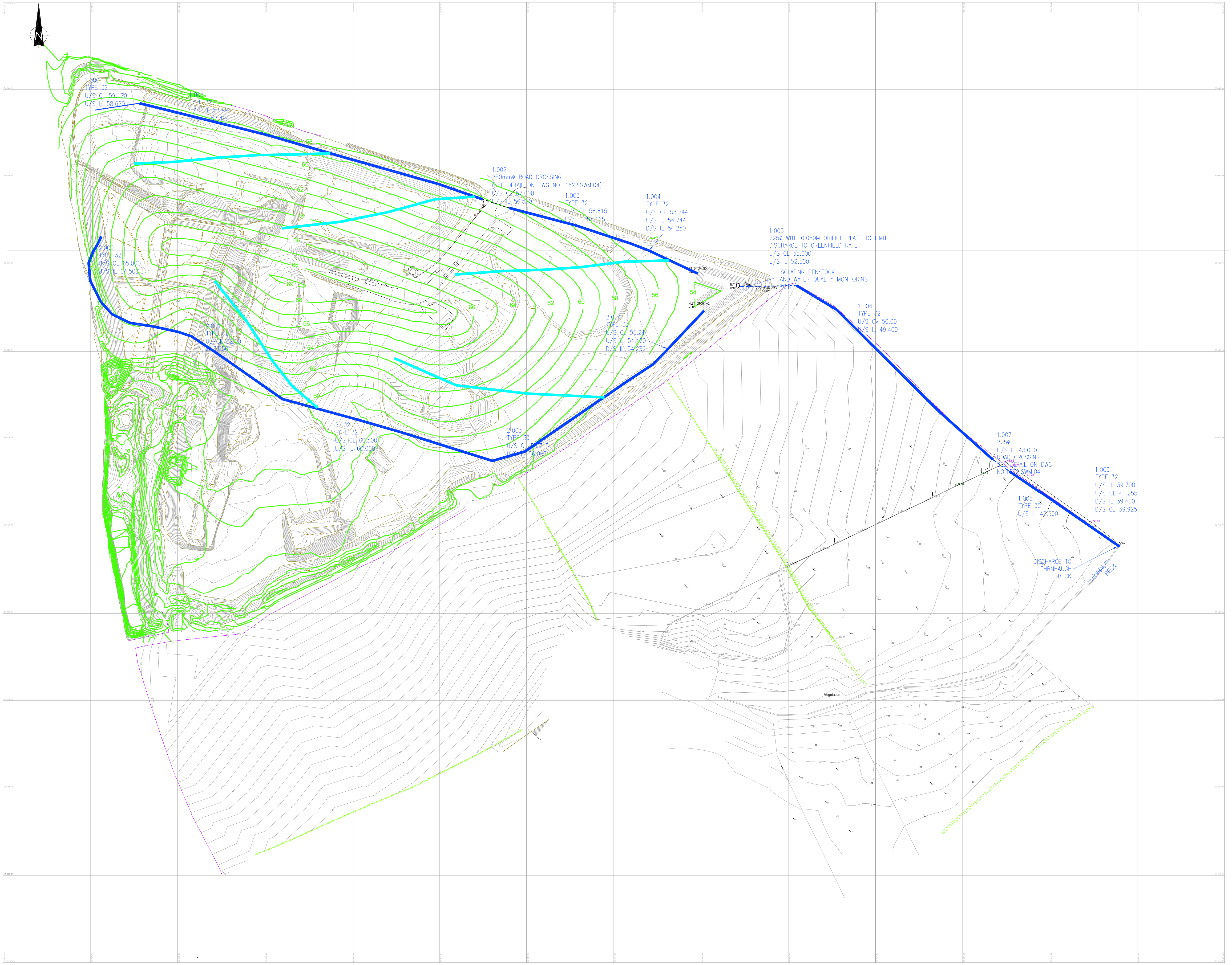
Appendix D

Surface Water Management Scheme Layout
DWG NO.1622.SWM.02

Ditch, Outfall and Lagoon Details
DWG NO.1622.SWM.03

Outfall Details
DWG NO.1622.SWM.04

Outfall Long Section
DWG NO.1622.SWM.05



NOTES

SURFACE WATER DITCH

SURFACE WATER PIPEWORK

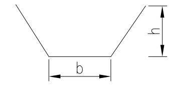
SURFACE WATER GRIPS

RESTORATION CONTOURS

EXISTING CONTOURS

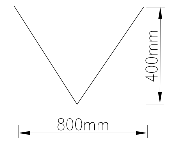
ALL BEDDING DETAIL TO BE CLASS S UNLESS OTHERWISE STATED

DITCH SECTIONS



DITCH DIMENSIONS			
DITCH TYPE	b(m)	h(m)	SIDE SLOPE
32	0.300	0.495	1:1.5
33	0.375	0.619	1:1.5

SURFACE WATER GRIP DETAIL



REV	MODIFICATIONS	BY	CH	AP	DATE
B	DWG INCLUDED CUT-OFF DITCHES	AK	CW	CP	03.02.06
A	ORIGINAL DRAWING	AK	CW	CP	05.01.06

Augean SOUTH LTD

THORNHAUGH LANDFILL SURFACE WATER MANAGEMENT

SURFACE WATER SCHEME LAYOUT

DRAWN BY: AK	DATE: 03.02.2006
CHECKED BY: CW	SCALE @ A1: 1:2000
APPROVED BY: CP	ISSUING OFFICE: PEOVER

DRAWING NUMBER	ISSUE	REVISION
1622.SWM.02	FN	B

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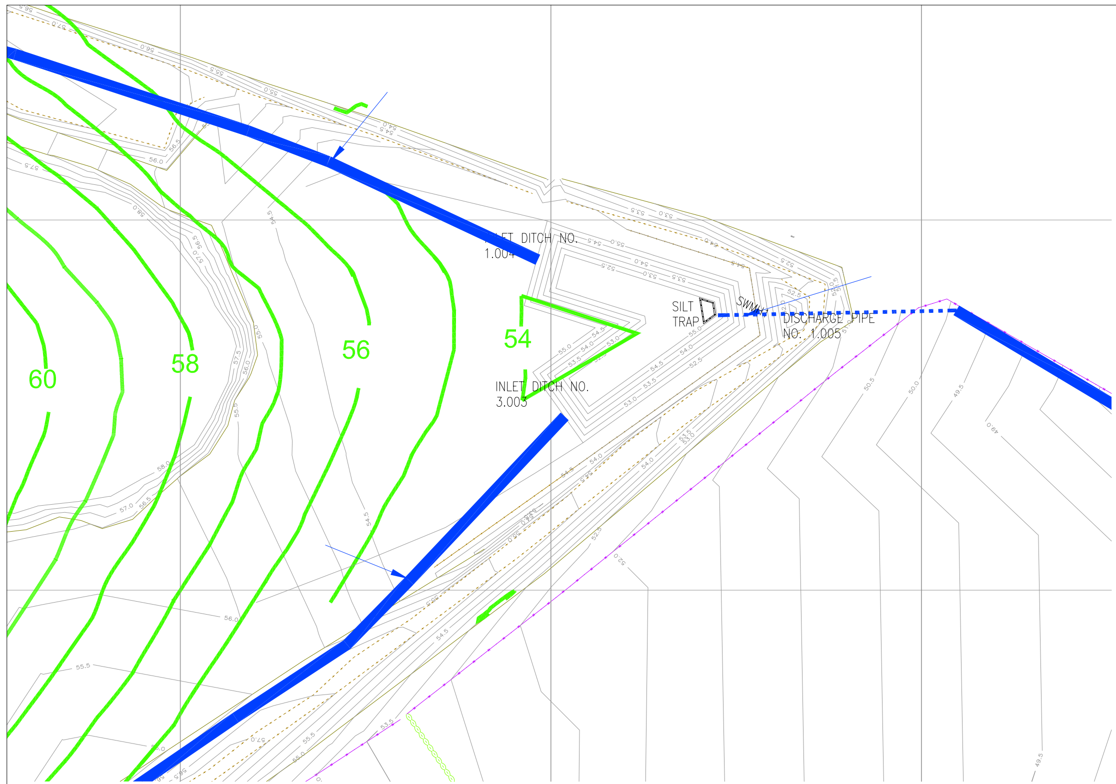
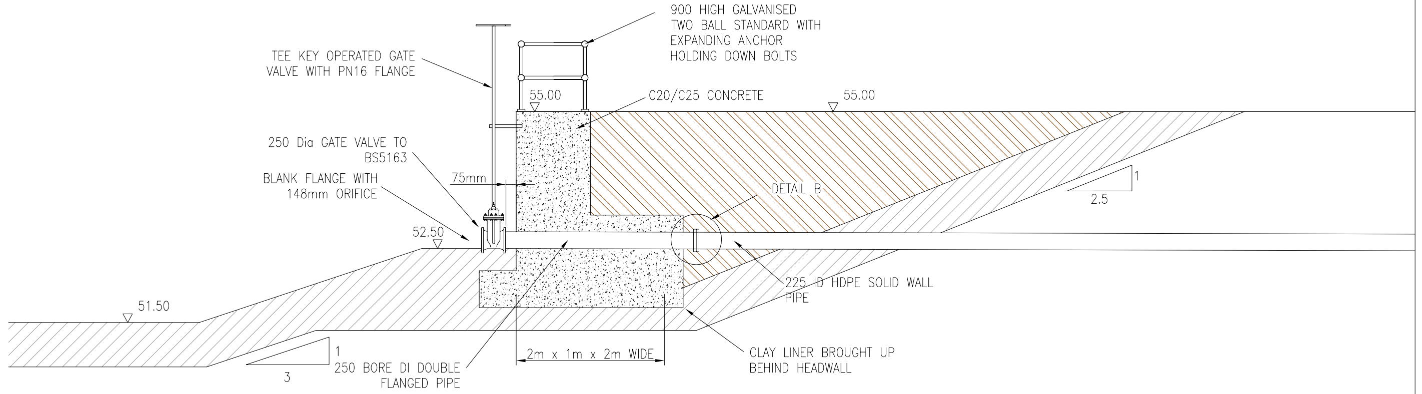
CAD FILE REF:1622.SWM.02.DWG



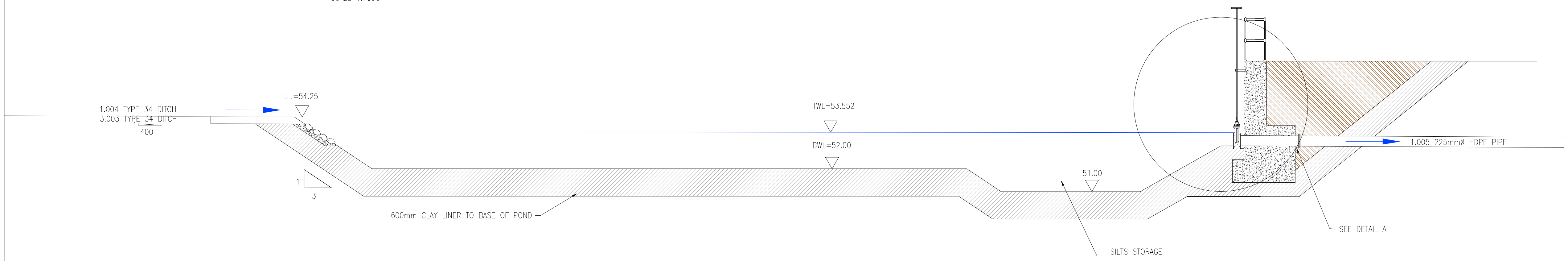
LAYOUT SHOWING PROPOSED SURFACE WATER POND

SCALE 1:1000



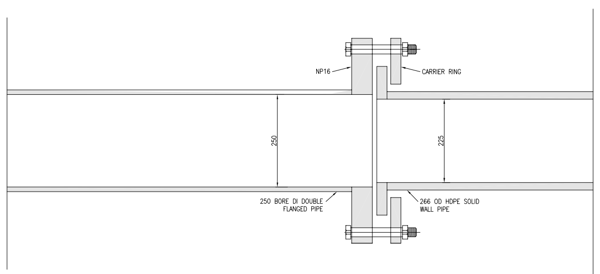
SECTION THROUGH LAGOON OUTFALL DETAIL A

SCALE 1:50



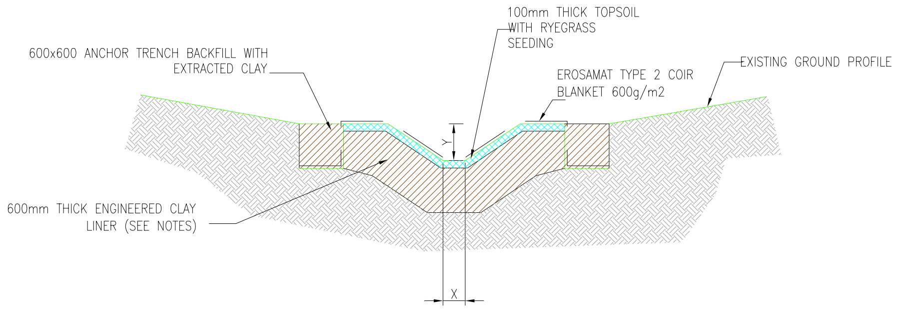
CROSS SECTION A–A' THROUGH PROPOSED LAGOON

SCALE 1:100



PIPE FIXING "DETAIL B"

SCALE 1:5



TYPICAL DITCH DETAIL

(FOR X AND Y DIMENSIONS SEE NOTES)

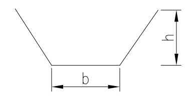
1:50

NOTES

1. SPECIFICATION TO BE "CIVIL ENGINEERING SPECIFICATION FOR THE WATER INDUSTRY, 5th EDITION" UNLESS DETAILED OTHERWISE

2. DRAWING SHOWS A CLAY LINER HOWEVER A GEOMEMBRANE MAY ALSO BE USED

DITCH SECTIONS



DITCH DIMENSIONS

DITCH TYPE	b(m)	h(m)	SIDE SLOPE
32	0.300	0.495	1:1.5
33	0.375	0.619	1:1.5

B	CHANGE OUTFALL PIPE TO DITCH	CP	CP	CP	06.02.06
A	ORIGINAL PROPOSAL	AK	CW	CP	25.01.06

Augean SOUTH LTD

THORNHAUGH LANDFILL SURFACE WATER MANAGEMENT

DITCH, OUTFALL AND LAGOON DETAIL

DRAWN BY: AK	DATE: 25.01.06
CHECKED BY: CW	SCALE @ A1: AS SHOWN
APPROVED BY: CP	ISSUING OFFICE: PEOVER

DRAWING NUMBER	ISSUE	REVISION
1622.SWM.03	Fn	B

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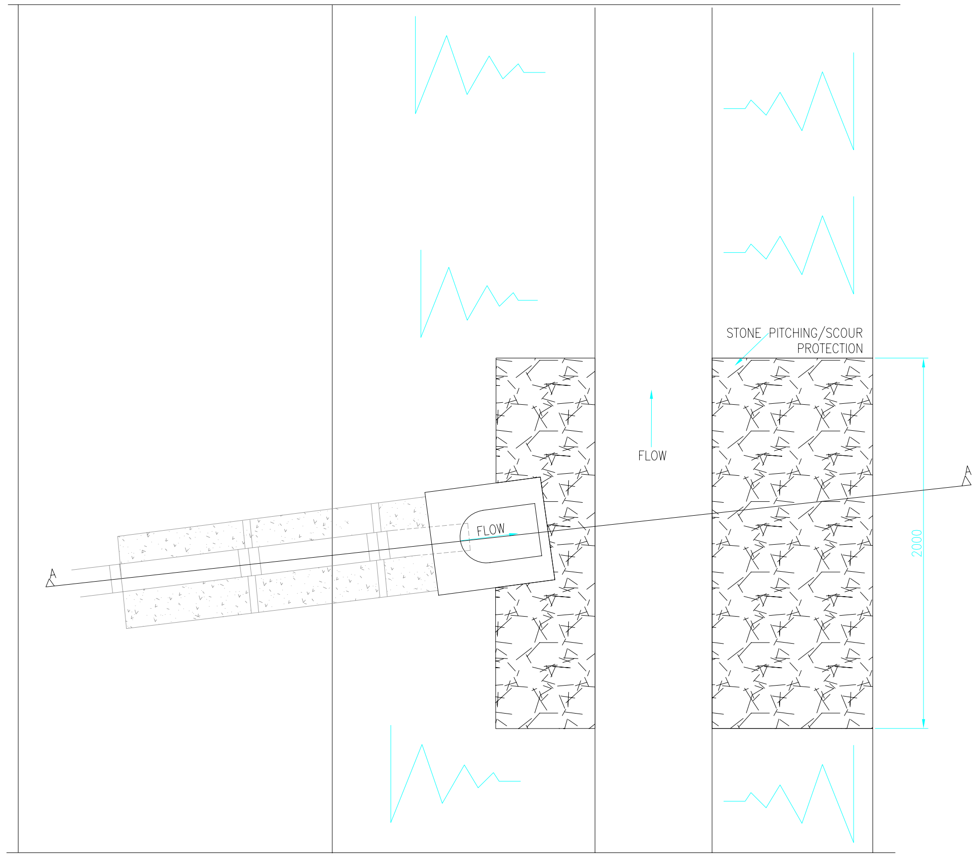
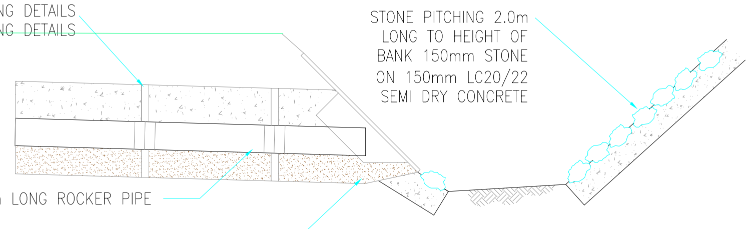
CAD FILE REF: 1622.SWM.03

NOTES
1. FOR BEDDING TYPE LOCATIONS SEE DWG NO 1622.SWM.02



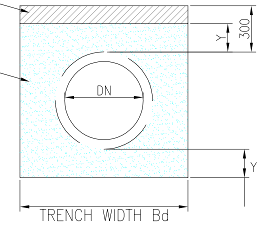
OUTFALL DETAIL TO WATERCOURSE

SCALE 1:20



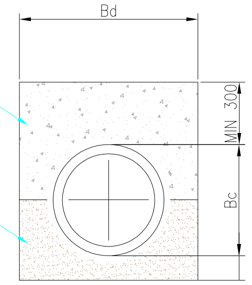
CROSS SECTION A–A

1:20



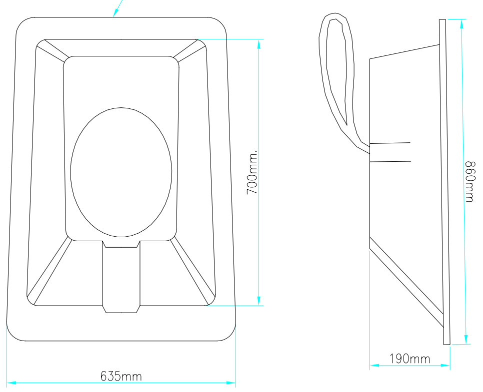
CLASS S BEDDING DETAIL

SCALE 1:25



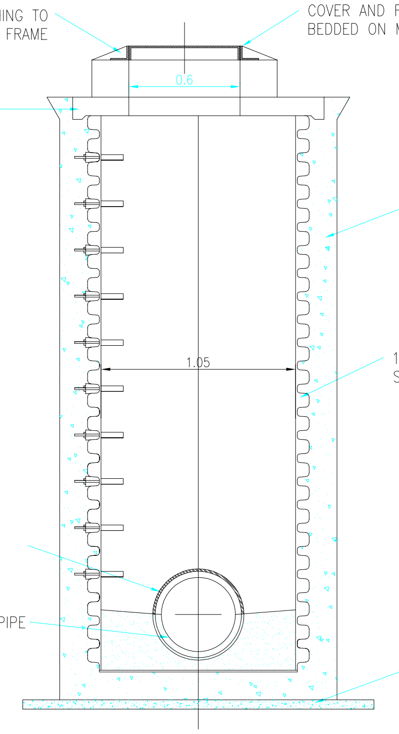
CONCRETE SURROUND DETAIL

SCALE 1:25



OUTFALL TO WATERCOURSE DETAIL

SCALE 1:10



SECTION THROUGH POLYPIPE RIGIDRAIN CHAMBER (ø1.05m)

SCALE 1:20

REV	MODIFICATIONS	BY	CH	AP	DATE

Augean SOUTH LTD

THORNHAUGH LANDFILL SURFACE WATER MANAGEMENT

ROAD CROSSING AND OUTFALL DETAIL

DRAWN BY: CW	DATE: 12.01.2006
CHECKED BY: CP	SCALE @ A1: AS SHOWN
APPROVED BY: CP	ISSUING OFFICE: PEOVER

DRAWING NUMBER	ISSUE	REVISION
1622.SWM.04	FN	A

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CAD FILE REF: 1622.SWM.04.DWG

Appendix E

E-mail from EAregarding 1 in 50 year Event

Appendix F

E-mail from EA regarding Greenfield Discharge Rate

Appendix G

Microdrainage Outputs

Global Variables

Region	FSR - England & Wales
Return Period (yrs)	1
M5-60 (mm)	19.800
Ratio R	0.400
Volumetric Runoff Coef	0.750
Profile Type	Summer
PIMP (%)	100
Areal Reduction Factor	1.000
Storm Duration (mins)	15
Hot Start (mins)	0
Manhole Headloss Coefficient	0.150
MADD Factor * 10m³/ha Storage	4.000
Foul Sewage/Hectare (l/s)	0.00
Additional Flow - % of Total Flow	0
Number of Input Hydrographs	0
Number of Time/Area Diagrams	0
Number of Bifurcations	0
Number of Overflows	0
Number of Off-Line Controls	0
Number of On-Line Controls	2

Freely Discharging Outfalls

Outfall Pipe Number	Outfall MH/No	C.Level (m)	I.Level (m)	D,L (mm)	B (mm)
1.009		39.925	39.400	1200	0

On-Line Controls (Orifice)

US/PN	Volume (m^3)	Ctrl MH Name	Invert (m)	Dia (m)	Coef of Contraction
1.004	6.687	16	52.500	0.050	0.600
2.004	43.183	16	52.500	0.050	0.600

Storage Pond at pipe 1.005 USMH 16

Storage Pond Invert Level (m) 52.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.0	691.0	2.4	1985.0	4.8	1985.0	7.2	1985.0	9.6	1985.0
0.4	923.0	2.8	1985.0	5.2	1985.0	7.6	1985.0	10.0	1985.0
0.8	1169.0	3.2	1985.0	5.6	1985.0	8.0	1985.0		
1.2	1429.0	3.6	1985.0	6.0	1985.0	8.4	1985.0		
1.6	1701.0	4.0	1985.0	6.4	1985.0	8.8	1985.0		
2.0	1985.0	4.4	1985.0	6.8	1985.0	9.2	1985.0		

Network Details

* - Indicates pipe has been modified outside of WinDes's Storm/Foul & Schedules

PN	Length (m)	Fall (m)	Slope (1:x)	Area (ha)	T.E. (mins)	Rain Pro	k (mm)	Hyd Sect	Dia (mm)
1.000	51.31	1.126	45.6	0.169	27.50	1	300.000	\/	32
1.001	408.65	0.994	411.1	0.551	0.00	1	300.000	\/	32
1.002	32.26	0.385	83.8	0.000	0.00	1	0.600	o	250
1.003	166.70	1.371	121.6	0.036	0.00	1	300.000	\/	32
1.004	15.96	0.494	32.3	0.310	0.00	1	300.000	\/	32
2.000	194.00	3.000	64.7	0.159	18.90	1	300.000	\/	32
2.001	124.00	1.500	82.7	0.176	0.00	1	300.000	\/	32
2.002	293.30	3.935	74.5	0.547	0.00	1	300.000	\/	32
2.003	132.63	1.595	83.2	0.315	0.00	1	300.000	\/	33
2.004	55.62	0.220	252.8	0.000	0.00	1	300.000	\/	33
1.005	63.59	3.100	20.5	0.000	0.00	1	0.600	o	225
1.006	305.00	6.400	47.7	0.000	0.00	1	300.000	\/	32
1.007	25.00	0.500	50.0	0.000	0.00	1	0.600	o	225
1.008	107.00	2.800	38.2	0.000	0.00	1	300.000	\/	32
1.009	88.00	0.300	293.3	0.000	0.00	1	0.600	o	225

PN	USMH No.	US/CL (m)	US/IL (m)	US/Dep (m)	DS/CL (m)	DS/IL (m)	DS/Dep (m)	Ctrl No.	US/MH (mm)
1.000	1	59.120	58.620	0.005	57.994	57.494	0.005		3000
1.001	2	57.994	57.494	0.005	57.000	56.500	0.005		3000
1.002	3	57.000	56.500	0.250	56.615	56.115	0.250		3000
1.003	4	56.615	56.115	0.005	55.244	54.744	0.005		3000
1.004	5	55.244	54.744	0.005	55.000	54.250	0.255		3000
2.000	6	65.000	64.500	0.005	62.000	61.500	0.005		1220
2.001	7	62.000	61.500	0.005	60.500	60.000	0.005		1220
2.002	9	60.500	60.000	0.005	56.715	56.065	0.155		1220
2.003	10	56.715	56.065	0.031	55.244	54.470	0.155		1220
2.004	11	55.244	54.470	0.155	55.000	54.250	0.131		1220
1.005	16	55.000	52.500	2.275	50.000	49.400	0.375	1	3000
1.006	17	50.000	49.400	0.105	44.500	43.000	1.005		1800
1.007	18	44.500	43.000	1.275	43.250	42.500	0.525		1200
1.008	19	43.250	42.500	0.255	40.255	39.700	0.060		1200
1.009	20	40.255	39.700	0.330	39.925	39.400	0.300		1200

The following hydraulic sections have been used in this network

NOTE: Diameters less than 66 refer to section numbers of hydraulic conduits. These conduits are marked by the symbols:- [] box culvert, \/ open channel, oo dual pipe, ooo triple pipe, O egg.

Section Number	Conduit Type	Major Dimn. (mm)	Minor Dimn. (mm)	Side Slope (Deg)	Corner Splay (mm)	4*Hyd Radius (m)	XSect Area (m²)
32	\/	300	495	34		0.990	0.516
33	\/	375	619	34		1.238	0.807

PIPELINE SCHEDULES

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH No.	C.Level (m)	I.Level (m)	Depth (m)	MH DIAM., L*W (mm)
1.000	\/	32	1	59.120	58.620	0.005	3000
1.001	\/	32	2	57.994	57.494	0.005	3000
1.002	o	250	3	57.000	56.500	0.250	3000
1.003	\/	32	4	56.615	56.115	0.005	3000
1.004	\/	32	5	55.244	54.744	0.005	3000
2.000	\/	32	6	65.000	64.500	0.005	1220
2.001	\/	32	7	62.000	61.500	0.005	1220
2.002	\/	32	9	60.500	60.000	0.005	1220
2.003	\/	33	10	56.715	56.065	0.031	1220
2.004	\/	33	11	55.244	54.470	0.155	1220
1.005	o	225	16	55.000	52.500	2.275	3000
1.006	\/	32	17	50.000	49.400	0.105	1800
1.007	o	225	18	44.500	43.000	1.275	1200
1.008	\/	32	19	43.250	42.500	0.255	1200
1.009	o	225	20	40.255	39.700	0.330	1200

Downstream Manhole

PN	Length (m)	Slope (1:x)	MH No.	C.Level (m)	I.Level (m)	Depth (m)	MH DIAM., L*W (mm)
1.000	51.31	45.6	2	57.994	57.494	0.005	3000
1.001	408.65	411.1	3	57.000	56.500	0.005	3000
1.002	32.26	83.8	4	56.615	56.115	0.250	3000
1.003	166.70	121.6	5	55.244	54.744	0.005	3000
1.004	15.96	32.3	16	55.000	54.250	0.255	3000
2.000	194.00	64.7	7	62.000	61.500	0.005	1220
2.001	124.00	82.7	9	60.500	60.000	0.005	1220
2.002	293.30	74.5	10	56.715	56.065	0.155	1220
2.003	132.63	83.2	11	55.244	54.470	0.155	1220
2.004	55.62	252.8	16	55.000	54.250	0.131	3000
1.005	63.59	20.5	17	50.000	49.400	0.375	1800
1.006	305.00	47.7	18	44.500	43.000	1.005	1200
1.007	25.00	50.0	19	43.250	42.500	0.525	1200
1.008	107.00	38.2	20	40.255	39.700	0.060	1200
1.009	88.00	293.3		39.925	39.400	0.300	1200

MANHOLE SCHEDULES

M/Hole Number	Cover Level (m)	M/Hole Depth (m)	M/Hole Diam.,L*W (mm)	PN	Pipes Out IL.(m)	D (mm)	PN	Pipes In IL.(m)	D (mm)
1	59.120	0.500	3000	1.000	58.620	32			
2	57.994	0.500	3000	1.001	57.494	32	1.000	57.494	32
3	57.000	0.500	3000	1.002	56.500	250	1.001	56.500	32
4	56.615	0.500	3000	1.003	56.115	32	1.002	56.115	250
5	55.244	0.500	3000	1.004	54.744	32	1.003	54.744	32
6	65.000	0.500	1220	2.000	64.500	32			
7	62.000	0.500	1220	2.001	61.500	32	2.000	61.500	32
9	60.500	0.500	1220	2.002	60.000	32	2.001	60.000	32
10	56.715	0.650	1220	2.003	56.065	33	2.002	56.065	32
11	55.244	0.774	1220	2.004	54.470	33	2.003	54.470	33
16	55.000	2.500	3000	1.005	52.500	225	1.004	54.250	32
							2.004	54.250	33
17	50.000	0.600	1800	1.006	49.400	32	1.005	49.400	225
18	44.500	1.500	1200	1.007	43.000	225	1.006	43.000	32
19	43.250	0.750	1200	1.008	42.500	32	1.007	42.500	225
20	40.255	0.555	1200	1.009	39.700	225	1.008	39.700	32
	39.925	0.525	1200		OUTFALL		1.009	39.400	225

Summary Wizard of "CRITICAL"(Rank 1)
Results for Design Storms

Margin for Flood Risk warning (mm) 200 Inertia Status OFF
DVD Status OFF

PN	Storm	Return Period	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act	Lvl Ex.
1.000	15 Summer	1	1					
1.001	15 Winter	1	1					
1.002	30 Winter	1	1					
1.003	30 Winter	1	1					
1.004	60 Winter	1	1					
2.000	15 Summer	1	1					
2.001	15 Winter	1	1					
2.002	15 Winter	1	1					
2.003	30 Winter	1	1					
2.004	30 Winter	1	1					
1.005	1440 Winter	1	1	1/60 Summer				
1.006	1440 Winter	1	1					
1.007	960 Winter	1	1					
1.008	480 Winter	1	1					
1.009	1440 Winter	1	1					

PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	58.716	-0.399	0.000	0.02	0	16	O K
1.001	57.758	-0.231	0.000	0.17	0	41	O K
1.002	56.628	-0.122	0.000	0.52	0	38	O K
1.003	56.289	-0.321	0.000	0.08	0	36	O K
1.004	54.879	-0.360	0.000	0.05	0	41	O K
2.000	64.585	-0.410	0.000	0.02	0	10	O K
2.001	61.625	-0.370	0.000	0.04	0	21	O K
2.002	60.208	-0.287	0.000	0.10	0	56	O K
2.003	56.267	-0.417	0.000	0.07	0	73	O K
2.004	54.721	-0.368	0.000	0.12	0	73	O K
1.005	52.992	0.267	0.000	0.03	0	4	SURCH'ED
1.006	49.453	-0.442	0.000	0.00	0	4	O K
1.007	43.032	-0.193	0.000	0.05	0	4	O K
1.008	42.551	-0.444	0.000	0.00	0	3	O K
1.009	39.752	-0.173	0.000	0.12	0	4	O K

Summary Wizard of "CRITICAL"(Rank 1)
Results for Design Storms

Margin for Flood Risk warning (mm) 200 Inertia Status OFF
DVD Status OFF

PN	Storm	Return Period	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act	Lvl Ex.
1.000	15 Summer	10	1					
1.001	15 Winter	10	1					
1.002	15 Winter	10	1					
1.003	15 Winter	10	1					
1.004	15 Summer	10	1					
2.000	15 Summer	10	1					
2.001	15 Winter	10	1					
2.002	15 Winter	10	1					
2.003	30 Winter	10	1					
2.004	30 Winter	10	1					
1.005	1440 Winter	10	1	10/15 Summer				
1.006	1440 Winter	10	1					
1.007	960 Winter	10	1					
1.008	960 Winter	10	1					
1.009	960 Winter	10	1					

PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	58.758	-0.357	0.000	0.04	0	33	O K
1.001	57.859	-0.130	0.000	0.35	0	86	FLD RISK
1.002	56.714	-0.036	0.000	0.98	0	72	O K
1.003	56.345	-0.265	0.000	0.15	0	66	O K
1.004	54.934	-0.305	0.000	0.10	0	88	O K
2.000	64.618	-0.377	0.000	0.03	0	19	O K
2.001	61.687	-0.308	0.000	0.09	0	47	O K
2.002	60.291	-0.204	0.000	0.20	0	114	O K
2.003	56.336	-0.348	0.000	0.14	0	146	O K
2.004	54.812	-0.277	0.000	0.25	0	145	O K
1.005	53.252	0.567	0.000	0.04	0	5	SURCH'ED
1.006	49.457	-0.438	0.000	0.01	0	5	O K
1.007	43.037	-0.188	0.000	0.06	0	5	O K
1.008	42.555	-0.440	0.000	0.01	0	5	O K
1.009	39.758	-0.167	0.000	0.15	0	5	O K

Summary Wizard of "CRITICAL"(Rank 1)
Results for Design Storms

Margin for Flood Risk warning (mm) 200 Inertia Status OFF
DVD Status OFF

PN	Storm	Return Period	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act	Lvl Ex.
1.000	15 Summer	50	1					
1.001	15 Winter	50	1					
1.002	30 Winter	50	1	50/15 Summer				
1.003	30 Winter	50	1					
1.004	15 Winter	50	1					
2.000	15 Summer	50	1					
2.001	15 Winter	50	1					
2.002	15 Winter	50	1					
2.003	30 Winter	50	1					
2.004	30 Winter	50	1					
1.005	1440 Winter	50	1	50/15 Summer				
1.006	480 Winter	50	1					
1.007	960 Winter	50	1					
1.008	480 Winter	50	1					
1.009	1440 Winter	50	1					

PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	58.785	-0.330	0.000	0.07	0	47	O K
1.001	57.922	-0.067	0.000	0.51	0	123	FLD RISK
1.002	56.858	0.108	0.000	1.13	0	83	FLD RISK
1.003	56.363	-0.247	0.000	0.18	0	83	O K
1.004	54.968	-0.271	0.000	0.15	0	127	O K
2.000	64.643	-0.352	0.000	0.04	0	27	O K
2.001	61.720	-0.275	0.000	0.12	0	68	O K
2.002	60.341	-0.154	0.000	0.29	0	166	FLD RISK
2.003	56.389	-0.295	0.000	0.21	0	213	O K
2.004	54.873	-0.216	0.000	0.36	0	213	O K
1.005	53.552	0.827	0.000	0.05	0	5	SURCH'ED
1.006	49.459	-0.436	0.000	0.01	0	5	O K
1.007	43.040	-0.185	0.000	0.07	0	5	O K
1.008	42.557	-0.438	0.000	0.01	0	5	O K
1.009	39.764	-0.161	0.000	0.18	0	5	O K

Summary Wizard of "CRITICAL"(Rank 1)
Results for Design Storms

Margin for Flood Risk warning (mm) 200 Inertia Status OFF
DVD Status OFF

PN	Storm	Return Period	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act	Lvl Ex.
1.000	15 Summer	100	1					
1.001	15 Winter	100	1					
1.002	30 Winter	100	1	100/15 Summer				
1.003	30 Winter	100	1					
1.004	15 Winter	100	1					
2.000	15 Summer	100	1					
2.001	15 Winter	100	1					
2.002	15 Winter	100	1					
2.003	30 Winter	100	1					
2.004	30 Winter	100	1					
1.005	1440 Winter	100	1	100/15 Summer				
1.006	1440 Winter	100	1					
1.007	480 Winter	100	1					
1.008	1440 Winter	100	1					
1.009	1440 Winter	100	1					

PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m^3)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	58.796	-0.319	0.000	0.08	0	56	O K
1.001	57.955	-0.034	0.000	0.59	0	143	FLD RISK
1.002	56.934	0.184	0.000	1.21	0	89	FLD RISK
1.003	56.369	-0.241	0.000	0.20	0	88	O K
1.004	54.985	-0.254	0.000	0.17	0	148	O K
2.000	64.655	-0.340	0.000	0.05	0	32	O K
2.001	61.737	-0.258	0.000	0.15	0	79	O K
2.002	60.364	-0.131	0.000	0.34	0	194	FLD RISK
2.003	56.410	-0.274	0.000	0.24	0	250	O K
2.004	54.904	-0.185	0.000	0.43	0	250	O K
1.005	53.683	0.958	0.000	0.05	0	6	SURCH'ED
1.006	49.461	-0.434	0.000	0.01	0	6	O K
1.007	43.041	-0.184	0.000	0.08	0	5	O K
1.008	42.559	-0.436	0.000	0.01	0	6	O K
1.009	39.766	-0.159	0.000	0.19	0	6	O K

Appendix H

Calculation of Greenfield Run-off and Percentage Run-off

ESTIMATION OF GREENFIELD RUN OFF FROM SITE

Determine Q (mean annual flood) using FSR for each catchment

From FSR Supplementary Report No 6,

$Q = 0.00066 \times AREA^{0.92} \times SAAR^{1.22} \times SOIL^2$

Total contributing AREA = 13.1 ha = 0.131 km^2

Thornhaugh National Grid Ref – 5050000E 300100N

From Fig II 3.1 (S) » SAAR = 560mm

From Fig I 4.18 (S) » S_1 = 100%

$$SOIL = \frac{0.15S_1 + 0.3S_2 + 0.45\,S_3 + 0.45\,S_4 + 0.5\,S_5}{S_1 + S_2 + S_3 + S_4 + S_5}$$

SOIL = 0.15

Therefore $Q = 0.00066 \times 0.131^{0.92} \times 560^{1.22} \times 0.15^2$

Q = 5.14 l/s = 0.39l/s/ha

PERCENTAGE RUN OFF CALCULATIONS

Calculate the predicted percentage run off for the restored site

From "Design of Flood Storage Reservoirs" (CIRIA)

$PR_{RURAL} = SPR + DPR_{CWI} + DPR_{RAIN}$

Where $SPR = 10\ S_1 + 30\ S_2 + 37S_3 + 47\ S_4 + 53\ S_5$

Restoration soils will be approximately 800mm deep over HDPE membrane or engineered clay cap.

T 4.5 (FSR Vol. 1)

Drainage Group = 1 (Rarely waterlogged within 60cm)
Depth to impermeable layer > 80cm
Permeability Group above Imp layer = Medium
Slope > 8^0

Therefore Soil Class = 2 so S2 = 100%

SPR = 30 x 1 = 30

$DPR_{CWI} = 0.25\ (CWI – 125)$

Thornhaugh Grid Ref 505000E 300100N

From FSR Fig II 3.1 (S) SAAR = 560mm
FSR Fig I 6.62 CWI = 78

Therefore $DPR_{CWI} = 0.25\ (78 – 125) = -11.75$

$DPR_{CWI} = - 11.75$

$DPR_{RAIN} = 0.45\ (P – 40)^{0.7}$

Where P = Rainfall (in mm) for the design event

For Thornhaugh M5 - 60 = 19.8mm
R = 0.40

Critical Duration = Time of Entry + Time of Flow

Maximum length of ditch to outfall = 660m
Assume flow velocity in ditch of 0.4m/s
Assume overland flow velocity of 0.1m/s

$$Te = \frac{\text{Distance from catchment boundary to furthest ditch}}{\text{Overland flow velocity}}$$

$$= \frac{190m}{0.1 \times 60}$$

$$Te = 31.7mins$$

Tc = Te + Tf

$$\text{So } Tc = 31.7 + \frac{660}{0.4 \times 60} = 59 \text{ mins}$$

Critical Duration = 59 mins

Z1 = 1.00 (Figure A3b – Wallingford Procedure)

Therefore
M5 – 59 1.00 x 19.8 = 19.8mm

Z2 = 2.03(Table A1 – Wallingford Procedure)

Therefore
M100 – 59 = 40.2mm/hr

The areal reduction factor has not considered as the small catchment makes any reduction insignificant.

So $DPR_{RAIN} = 0.45 (P - 40)^{0.7}$

For Tc = 50mins, $DPR_{RAIN} = 0.45 (40.2 - 40)^{0.7}$

$DPR_{RAIN} = 0.15$

$PR_{RURAL} = SPR + DPR_{CWI} + DPR_{RAIN}$

Therefore $PR_{60} = 30 + (-11.75) + 0.15$

$PR_{60} = 18.4\%$

Percentage Runoff for the restored site = 18.4%

APPENDIX 3.1

GREENFIELD RUNOFF CALCULATIONS

hrwallingford

Catchment 1

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	3022247618
Date:	Dec 19 2023 12:12

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha):	19.9384686000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

	Default	Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		5.02
1 in 1 year (l/s):		4.36
1 in 30 years (l/s):		12.29
1 in 100 year (l/s):		17.86
1 in 200 years (l/s):		21.12

hrwallingford

Catchment 2

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	2049405995
Date:	Dec 19 2023 12:12

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 9.0232442000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

Default Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		2.27
1 in 1 year (l/s):		1.97
1 in 30 years (l/s):		5.56
1 in 100 year (l/s):		8.08
1 in 200 years (l/s):		9.56

hr wallingford

Catchment 3

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	244343672
Date:	Dec 19 2023 12:12

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 4.3547925000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

	Default	Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		1.1
1 in 1 year (l/s):		0.95
1 in 30 years (l/s):		2.68
1 in 100 year (l/s):		3.9
1 in 200 years (l/s):		4.61

hr wallingford

Catchment 4

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	3250345747
Date:	Dec 19 2023 12:13

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha):	0.9454174000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

Default Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		0.24
1 in 1 year (l/s):		0.21
1 in 30 years (l/s):		0.58
1 in 100 year (l/s):		0.85
1 in 200 years (l/s):		1

hr wallingford

Catchment 5

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	299296419
Date:	Dec 19 2023 12:13

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha):	5.5577717000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

	Default	Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		1.4
1 in 1 year (l/s):		1.22
1 in 30 years (l/s):		3.43
1 in 100 year (l/s):		4.98
1 in 200 years (l/s):		5.89

hr wallingford

Catchment 6

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance “Rainfall runoff management for developments”, SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	1411314383
Date:	Dec 19 2023 12:14

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 3.4728602000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

Default Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		0.87
1 in 1 year (l/s):		0.76
1 in 30 years (l/s):		2.14
1 in 100 year (l/s):		3.11
1 in 200 years (l/s):		3.68

hr wallingford

Catchment 7

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

Site Details

Latitude:	52.58665° N
Longitude:	0.44932° W
Reference:	3892809414
Date:	Dec 19 2023 12:14

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 6.9725270000

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

Default Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		1.75
1 in 1 year (l/s):		1.53
1 in 30 years (l/s):		4.3
1 in 100 year (l/s):		6.24
1 in 200 years (l/s):		7.39

hr wallingford

Area draining to Cooks Hole surface water management system

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Chris Greenwood
Site name:	Cooks Hole
Site location:	Thornhaugh

Site Details

Latitude:	52.58648° N
Longitude:	0.44929° W
Reference:	3484219859
Date:	Dec 19 2023 12:10

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 57.6

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.933
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.12

Hydrological characteristics

	Default	Edited

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible.

SAAR (mm):	561	561
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):		14.19
1 in 1 year (l/s):		12.34
1 in 30 years (l/s):		34.76
1 in 100 year (l/s):		50.51
1 in 200 years (l/s):		59.74

APPENDIX 3.2

SURFACE WATER ATTENUATION CALCULATIONS

Table A.ES.11.C.1

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the proposed Cooks Hole and Thornhaugh surface water management system using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	58	ha	Area draining to the proposed surface water management system shown on drawing reference AU/CH/12-23/24084
Net discharge rate	4364	m^3/day	The 1 in 100yr greenfield runoff rate of 50.51 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	6014.78	45.46	5969
0.5	33.62	94.14	7862.24	90.92	7771
0.75	38.52	71.90	9008.13	136.38	8872
1	42.02	58.83	9826.63	181.84	9645
1.5	47.35	44.19	11073.08	272.75	10800
2	51.43	36.00	12027.21	363.67	11664
3	57.7	26.93	13493.49	545.51	12948
4	62.44	21.85	14601.97	727.34	13875
5	66.22	18.54	15485.94	909.18	14577
6	69.37	16.19	16222.59	1091.02	15132
7	72.08	14.42	16856.34	1272.85	15583
8	74.43	13.03	17405.90	1454.69	15951
9	76.52	11.90	17894.66	1636.52	16258
10	78.38	10.97	18329.63	1818.36	16511
15	85.43	7.97	19978.32	2727.54	17251
20	90.25	6.32	21105.50	3636.72	17469
20.25	90.45	6.25	21152.28	3682.18	17470
20.5	90.65	6.19	21199.05	3727.64	17471
20.75	90.85	6.13	21245.82	3773.10	17473
21	91.05	6.07	21292.59	3818.56	17474
21.25	91.24	6.01	21337.02	3864.02	17473
21.5	91.43	5.95	21381.45	3909.47	17472
21.75	91.61	5.90	21423.55	3954.93	17469
22	91.8	5.84	21467.98	4000.39	17468
22.25	91.98	5.79	21510.07	4045.85	17464
22.5	92.16	5.73	21552.17	4091.31	17461
22.75	92.33	5.68	21591.92	4136.77	17455
23	92.51	5.63	21634.02	4182.23	17452
23.25	92.68	5.58	21673.77	4227.69	17446
23.5	92.85	5.53	21713.53	4273.15	17440
23.75	93.02	5.48	21753.29	4318.61	17435
24	93.18	5.44	21790.70	4364.06	17427
24.25	93.34	5.39	21828.12	4409.52	17419
24.5	93.49	5.34	21863.20	4454.98	17408
24.75	93.64	5.30	21898.28	4500.44	17398
25	93.79	5.25	21933.35	4545.90	17387
30	96.46	4.50	22557.75	5455.08	17103
40	100.61	3.52	23528.25	7273.44	16255
50	103.85	2.91	24285.95	9091.80	15194
60	106.54	2.49	24915.02	10910.16	14005
70	108.99	2.18	25487.97	12728.52	12759
80	111.28	1.95	26023.50	14546.88	11477
90	113.47	1.77	26535.64	16365.24	10170
96	114.75	1.67	26834.98	17456.26	9379

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.
Reference 2. https://fehweb.ceh.ac.uk/
Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Denotes parameters which are determined based on the restoration scheme, rainfall data or other constraints on discharge or water levels
Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.2

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 1 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	20	ha	Area of Catchment 1 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	1543	m^3/day	The 1 in 100yr greenfield runoff rate of 17.86 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	2082.04	16.07	2066
0.5	33.62	94.14	2721.55	32.15	2689
0.75	38.52	71.90	3118.20	48.22	3070
1	42.02	58.83	3401.53	64.30	3337
1.5	47.35	44.19	3832.99	96.44	3737
2	51.43	36.00	4163.27	128.59	4035
3	57.7	26.93	4670.83	192.89	4478
4	62.44	21.85	5054.53	257.18	4797
5	66.22	18.54	5360.52	321.48	5039
6	69.37	16.19	5615.51	385.78	5230
7	72.08	14.42	5834.89	450.07	5385
8	74.43	13.03	6025.12	514.37	5511
9	76.52	11.90	6194.31	578.66	5616
10	78.38	10.97	6344.88	642.96	5702
15	85.43	7.97	6915.57	964.44	5951
20	90.25	6.32	7305.75	1285.92	6020
20.25	90.45	6.25	7321.94	1301.99	6020
20.5	90.65	6.19	7338.13	1318.07	6020
20.75	90.85	6.13	7354.32	1334.14	6020
21	91.05	6.07	7370.51	1350.22	6020
21.25	91.24	6.01	7385.89	1366.29	6020
21.5	91.43	5.95	7401.28	1382.36	6019
21.75	91.61	5.90	7415.85	1398.44	6017
22	91.8	5.84	7431.23	1414.51	6017
22.25	91.98	5.79	7445.80	1430.59	6015
22.5	92.16	5.73	7460.37	1446.66	6014
22.75	92.33	5.68	7474.13	1462.73	6011
23	92.51	5.63	7488.70	1478.81	6010
23.25	92.68	5.58	7502.46	1494.88	6008
23.5	92.85	5.53	7516.22	1510.96	6005
23.75	93.02	5.48	7529.99	1527.03	6003
24	93.18	5.44	7542.94	1543.10	6000
24.25	93.34	5.39	7555.89	1559.18	5997
24.5	93.49	5.34	7568.03	1575.25	5993
24.75	93.64	5.30	7580.18	1591.33	5989
25	93.79	5.25	7592.32	1607.40	5985
30	96.46	4.50	7808.45	1928.88	5880
40	100.61	3.52	8144.40	2571.84	5573
50	103.85	2.91	8406.68	3214.80	5192
60	106.54	2.49	8624.43	3857.76	4767
70	108.99	2.18	8822.76	4500.72	4322
80	111.28	1.95	9008.14	5143.68	3864
90	113.47	1.77	9185.42	5786.64	3399
96	114.75	1.67	9289.03	6172.42	3117

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.
Reference 2. https://fehweb.ceh.ac.uk/
Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Denotes parameters which are determined based on the restoration scheme, rainfall data or other constraints on discharge or water levels

Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.3

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 2 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	9	ha	Area of Catchment 2 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	698	m^3/day	The 1 in 100yr greenfield runoff rate of 8.08 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	942.24	7.27	935
0.5	33.62	94.14	1231.65	14.54	1217
0.75	38.52	71.90	1411.16	21.82	1389
1	42.02	58.83	1539.38	29.09	1510
1.5	47.35	44.19	1734.64	43.63	1691
2	51.43	36.00	1884.11	58.18	1826
3	57.7	26.93	2113.80	87.26	2027
4	62.44	21.85	2287.45	116.35	2171
5	66.22	18.54	2425.93	145.44	2280
6	69.37	16.19	2541.33	174.53	2367
7	72.08	14.42	2640.61	203.62	2437
8	74.43	13.03	2726.70	232.70	2494
9	76.52	11.90	2803.26	261.79	2541
10	78.38	10.97	2871.40	290.88	2581
15	85.43	7.97	3129.67	436.32	2693
20	90.25	6.32	3306.25	581.76	2724
20.25	90.45	6.25	3313.58	589.03	2725
20.5	90.65	6.19	3320.91	596.30	2725
20.75	90.85	6.13	3328.23	603.58	2725
21	91.05	6.07	3335.56	610.85	2725
21.25	91.24	6.01	3342.52	618.12	2724
21.5	91.43	5.95	3349.48	625.39	2724
21.75	91.61	5.90	3356.07	632.66	2723
22	91.8	5.84	3363.04	639.94	2723
22.25	91.98	5.79	3369.63	647.21	2722
22.5	92.16	5.73	3376.22	654.48	2722
22.75	92.33	5.68	3382.45	661.75	2721
23	92.51	5.63	3389.05	669.02	2720
23.25	92.68	5.58	3395.27	676.30	2719
23.5	92.85	5.53	3401.50	683.57	2718
23.75	93.02	5.48	3407.73	690.84	2717
24	93.18	5.44	3413.59	698.11	2715
24.25	93.34	5.39	3419.45	705.38	2714
24.5	93.49	5.34	3424.95	712.66	2712
24.75	93.64	5.30	3430.44	719.93	2711
25	93.79	5.25	3435.94	727.20	2709
30	96.46	4.50	3533.75	872.64	2661
40	100.61	3.52	3685.78	1163.52	2522
50	103.85	2.91	3804.48	1454.40	2350
60	106.54	2.49	3903.03	1745.28	2158
70	108.99	2.18	3992.78	2036.16	1957
80	111.28	1.95	4076.67	2327.04	1750
90	113.47	1.77	4156.90	2617.92	1539
96	114.75	1.67	4203.79	2792.45	1411

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.

Reference 2. https://fehweb.ceh.ac.uk/

Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Denotes parameters which are determined based on the restoration scheme, rainfall data or other constraints on discharge or water levels

Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.4

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 3 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	4	ha	Area of Catchment 3 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	337	m^3/day	The 1 in 100yr greenfield runoff rate of 3.90 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	454.74	3.51	451
0.5	33.62	94.14	594.42	7.02	587
0.75	38.52	71.90	681.05	10.53	671
1	42.02	58.83	742.93	14.04	729
1.5	47.35	44.19	837.17	21.06	816
2	51.43	36.00	909.31	28.08	881
3	57.7	26.93	1020.16	42.12	978
4	62.44	21.85	1103.97	56.16	1048
5	66.22	18.54	1170.80	70.20	1101
6	69.37	16.19	1226.49	84.24	1142
7	72.08	14.42	1274.41	98.28	1176
8	74.43	13.03	1315.96	112.32	1204
9	76.52	11.90	1352.91	126.36	1227
10	78.38	10.97	1385.79	140.40	1245
15	85.43	7.97	1510.44	210.60	1300
20	90.25	6.32	1595.66	280.80	1315
20.25	90.45	6.25	1599.20	284.31	1315
20.5	90.65	6.19	1602.73	287.82	1315
20.75	90.85	6.13	1606.27	291.33	1315
21	91.05	6.07	1609.81	294.84	1315
21.25	91.24	6.01	1613.16	298.35	1315
21.5	91.43	5.95	1616.52	301.86	1315
21.75	91.61	5.90	1619.71	305.37	1314
22	91.8	5.84	1623.07	308.88	1314
22.25	91.98	5.79	1626.25	312.39	1314
22.5	92.16	5.73	1629.43	315.90	1314
22.75	92.33	5.68	1632.44	319.41	1313
23	92.51	5.63	1635.62	322.92	1313
23.25	92.68	5.58	1638.62	326.43	1312
23.5	92.85	5.53	1641.63	329.94	1312
23.75	93.02	5.48	1644.64	333.45	1311
24	93.18	5.44	1647.47	336.96	1311
24.25	93.34	5.39	1650.29	340.47	1310
24.5	93.49	5.34	1652.95	343.98	1309
24.75	93.64	5.30	1655.60	347.49	1308
25	93.79	5.25	1658.25	351.00	1307
30	96.46	4.50	1705.46	421.20	1284
40	100.61	3.52	1778.83	561.60	1217
50	103.85	2.91	1836.12	702.00	1134
60	106.54	2.49	1883.68	842.40	1041
70	108.99	2.18	1926.99	982.80	944
80	111.28	1.95	1967.48	1123.20	844
90	113.47	1.77	2006.20	1263.60	743
96	114.75	1.67	2028.83	1347.84	681

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.

Reference 2. https://fehweb.ceh.ac.uk/

Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Denotes parameters which are determined based on the restoration scheme, rainfall data or other constraints on discharge or water levels

Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.5

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 4 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	1	ha	Area of Catchment 4 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	73	m^3/day	The 1 in 100yr greenfield runoff rate of 0.85 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	98.72	0.77	98
0.5	33.62	94.14	129.05	1.53	128
0.75	38.52	71.90	147.85	2.30	146
1	42.02	58.83	161.29	3.06	158
1.5	47.35	44.19	181.75	4.59	177
2	51.43	36.00	197.41	6.12	191
3	57.7	26.93	221.48	9.18	212
4	62.44	21.85	239.67	12.24	227
5	66.22	18.54	254.18	15.30	239
6	69.37	16.19	266.27	18.36	248
7	72.08	14.42	276.67	21.42	255
8	74.43	13.03	285.69	24.48	261
9	76.52	11.90	293.71	27.54	266
10	78.38	10.97	300.85	30.60	270
15	85.43	7.97	327.91	45.90	282
20	90.25	6.32	346.42	61.20	285
20.25	90.45	6.25	347.18	61.97	285
20.5	90.65	6.19	347.95	62.73	285
20.75	90.85	6.13	348.72	63.50	285
21	91.05	6.07	349.49	64.26	285
21.25	91.24	6.01	350.22	65.03	285
21.5	91.43	5.95	350.94	65.79	285
21.75	91.61	5.90	351.64	66.56	285
22	91.8	5.84	352.36	67.32	285
22.25	91.98	5.79	353.06	68.09	285
22.5	92.16	5.73	353.75	68.85	285
22.75	92.33	5.68	354.40	69.62	285
23	92.51	5.63	355.09	70.38	285
23.25	92.68	5.58	355.74	71.15	285
23.5	92.85	5.53	356.39	71.91	284
23.75	93.02	5.48	357.05	72.68	284
24	93.18	5.44	357.66	73.44	284
24.25	93.34	5.39	358.28	74.21	284
24.5	93.49	5.34	358.85	74.97	284
24.75	93.64	5.30	359.43	75.74	284
25	93.79	5.25	360.00	76.50	284
30	96.46	4.50	370.25	91.80	278
40	100.61	3.52	386.18	122.40	264
50	103.85	2.91	398.62	153.00	246
60	106.54	2.49	408.94	183.60	225
70	108.99	2.18	418.35	214.20	204
80	111.28	1.95	427.14	244.80	182
90	113.47	1.77	435.54	275.40	160
96	114.75	1.67	440.46	293.76	147

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.
Reference 2. https://fehweb.ceh.ac.uk/
Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.6

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 5 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	6	ha	Area of Catchment 5 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	357	m^3/day	The 1 in 100yr greenfield runoff rate of 4.98 l/s calculated using the HR Wallingford greenfield runoff estimation tool adjusted to allow for the inflow of 0.85l/s from Basin 4
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	580.36	3.72	577
0.5	33.62	94.14	758.62	7.43	751
0.75	38.52	71.90	869.19	11.15	858
1	42.02	58.83	948.16	14.87	933
1.5	47.35	44.19	1068.43	22.30	1046
2	51.43	36.00	1160.49	29.74	1131
3	57.7	26.93	1301.97	44.60	1257
4	62.44	21.85	1408.93	59.47	1349
5	66.22	18.54	1494.22	74.34	1420
6	69.37	16.19	1565.30	89.21	1476
7	72.08	14.42	1626.45	104.08	1522
8	74.43	13.03	1679.48	118.94	1561
9	76.52	11.90	1726.64	133.81	1593
10	78.38	10.97	1768.61	148.68	1620
15	85.43	7.97	1927.69	223.02	1705
20	90.25	6.32	2036.45	297.36	1739
20.25	90.45	6.25	2040.96	301.08	1740
20.5	90.65	6.19	2045.48	304.79	1741
20.75	90.85	6.13	2049.99	308.51	1741
21	91.05	6.07	2054.50	312.23	1742
21.25	91.24	6.01	2058.79	315.95	1743
21.5	91.43	5.95	2063.08	319.66	1743
21.75	91.61	5.90	2067.14	323.38	1744
22	91.8	5.84	2071.43	327.10	1744
22.25	91.98	5.79	2075.49	330.81	1745
22.5	92.16	5.73	2079.55	334.53	1745
22.75	92.33	5.68	2083.39	338.25	1745
23	92.51	5.63	2087.45	341.96	1745
23.25	92.68	5.58	2091.28	345.68	1746
23.5	92.85	5.53	2095.12	349.40	1746
23.75	93.02	5.48	2098.95	353.12	1746
24	93.18	5.44	2102.57	356.83	1746
24.25	93.34	5.39	2106.18	360.55	1746
24.5	93.49	5.34	2109.56	364.27	1745
24.75	93.64	5.30	2112.94	367.98	1745
25	93.79	5.25	2116.33	371.70	1745
30	96.46	4.50	2176.58	446.04	1731
40	100.61	3.52	2270.22	594.72	1675
50	103.85	2.91	2343.33	743.40	1600
60	106.54	2.49	2404.03	892.08	1512
70	108.99	2.18	2459.31	1040.76	1419
80	111.28	1.95	2510.98	1189.44	1322
90	113.47	1.77	2560.40	1338.12	1222
96	114.75	1.67	2589.28	1427.33	1162

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.
Reference 2. https://fehweb.ceh.ac.uk/
Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.7

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 6 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	3	ha	Area of Catchment 6 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	269	m^3/day	The 1 in 100yr greenfield runoff rate of 3.11 l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	362.65	2.80	360
0.5	33.62	94.14	474.04	5.60	468
0.75	38.52	71.90	543.12	8.40	535
1	42.02	58.83	592.47	11.20	581
1.5	47.35	44.19	667.63	16.79	651
2	51.43	36.00	725.15	22.39	703
3	57.7	26.93	813.56	33.59	780
4	62.44	21.85	880.39	44.78	836
5	66.22	18.54	933.69	55.98	878
6	69.37	16.19	978.10	67.18	911
7	72.08	14.42	1016.31	78.37	938
8	74.43	13.03	1049.45	89.57	960
9	76.52	11.90	1078.92	100.76	978
10	78.38	10.97	1105.14	111.96	993
15	85.43	7.97	1204.55	167.94	1037
20	90.25	6.32	1272.51	223.92	1049
20.25	90.45	6.25	1275.33	226.72	1049
20.5	90.65	6.19	1278.15	229.52	1049
20.75	90.85	6.13	1280.97	232.32	1049
21	91.05	6.07	1283.79	235.12	1049
21.25	91.24	6.01	1286.47	237.92	1049
21.5	91.43	5.95	1289.15	240.71	1048
21.75	91.61	5.90	1291.68	243.51	1048
22	91.8	5.84	1294.36	246.31	1048
22.25	91.98	5.79	1296.90	249.11	1048
22.5	92.16	5.73	1299.44	251.91	1048
22.75	92.33	5.68	1301.84	254.71	1047
23	92.51	5.63	1304.37	257.51	1047
23.25	92.68	5.58	1306.77	260.31	1046
23.5	92.85	5.53	1309.17	263.11	1046
23.75	93.02	5.48	1311.56	265.91	1046
24	93.18	5.44	1313.82	268.70	1045
24.25	93.34	5.39	1316.08	271.50	1045
24.5	93.49	5.34	1318.19	274.30	1044
24.75	93.64	5.30	1320.31	277.10	1043
25	93.79	5.25	1322.42	279.90	1043
30	96.46	4.50	1360.07	335.88	1024
40	100.61	3.52	1418.58	447.84	971
50	103.85	2.91	1464.27	559.80	904
60	106.54	2.49	1502.19	671.76	830
70	108.99	2.18	1536.74	783.72	753
80	111.28	1.95	1569.03	895.68	673
90	113.47	1.77	1599.91	1007.64	592
96	114.75	1.67	1617.95	1074.82	543

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.
Reference 2. https://fehweb.ceh.ac.uk/
Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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Denotes parameters which are calculated based on other parameters

Table A.ES.11.C.8

Calculation of attentuation storage during a 1 in 100 year storm event plus an allowance for climate change for the Detention Basin 7 catchment using the Rational Method (reference 1)

Parameter	Value	Units	Reference
Catchment area	7	ha	Area of Catchment 7 shown on drawing reference AU/CH/12-23/24084
Net discharge rate	539	m^3/day	The 1 in 100yr greenfield runoff rate of 6.24l/s calculated using the HR Wallingford greenfield runoff estimation tool.
Runoff coefficient	0.29	unitless	The runoff coefficent has been calculated using the nomogram presented on Figure 3 of Reference 1. In deriving the runoff coefficient a dominant vegetation type of cultivated land or short grass has been assumed and dominant soil type of gravelly sand has been assumed. The catchment slope of 1 vertical in 9.5 horizontal is derived from the proposed topography shown on drawing reference AU/CH/12-23/24084.
Climate change factor	40%	unitless	The recommended precautionary upper end increase in rainfall intensity to allow for climate change beyond 2100 from Reference [3]

Storm Duration (hr)	Rainfall for the site derived from Reference [2] (mm)	Rainfall Intensity corrected for climate change (mm/hr)	Volume of rainfall run off in time period (m^3)	Outflow in time period (m^3)	Storage necessary in time period (m^3)
0.25	25.72	144.03	728.09	5.62	722
0.5	33.62	94.14	951.73	11.23	940
0.75	38.52	71.90	1090.44	16.85	1074
1	42.02	58.83	1189.52	22.46	1167
1.5	47.35	44.19	1340.41	33.70	1307
2	51.43	36.00	1455.90	44.93	1411
3	57.7	26.93	1633.40	67.39	1566
4	62.44	21.85	1767.58	89.86	1678
5	66.22	18.54	1874.59	112.32	1762
6	69.37	16.19	1963.76	134.78	1829
7	72.08	14.42	2040.47	157.25	1883
8	74.43	13.03	2107.00	179.71	1927
9	76.52	11.90	2166.16	202.18	1964
10	78.38	10.97	2218.82	224.64	1994
15	85.43	7.97	2418.39	336.96	2081
20	90.25	6.32	2554.84	449.28	2106
20.25	90.45	6.25	2560.50	454.90	2106
20.5	90.65	6.19	2566.16	460.51	2106
20.75	90.85	6.13	2571.82	466.13	2106
21	91.05	6.07	2577.49	471.74	2106
21.25	91.24	6.01	2582.86	477.36	2106
21.5	91.43	5.95	2588.24	482.98	2105
21.75	91.61	5.90	2593.34	488.59	2105
22	91.8	5.84	2598.72	494.21	2105
22.25	91.98	5.79	2603.81	499.82	2104
22.5	92.16	5.73	2608.91	505.44	2103
22.75	92.33	5.68	2613.72	511.06	2103
23	92.51	5.63	2618.82	516.67	2102
23.25	92.68	5.58	2623.63	522.29	2101
23.5	92.85	5.53	2628.44	527.90	2101
23.75	93.02	5.48	2633.25	533.52	2100
24	93.18	5.44	2637.78	539.14	2099
24.25	93.34	5.39	2642.31	544.75	2098
24.5	93.49	5.34	2646.56	550.37	2096
24.75	93.64	5.30	2650.80	555.98	2095
25	93.79	5.25	2655.05	561.60	2093
30	96.46	4.50	2730.63	673.92	2057
40	100.61	3.52	2848.11	898.56	1950
50	103.85	2.91	2939.83	1123.20	1817
60	106.54	2.49	3015.98	1347.84	1668
70	108.99	2.18	3085.34	1572.48	1513
80	111.28	1.95	3150.17	1797.12	1353
90	113.47	1.77	3212.16	2021.76	1190
96	114.75	1.67	3248.40	2156.54	1092

References

Reference 1. National Coal Board, 1982. Technical Management of Water in the Coal Mining Industry.

Reference 2. https://fehweb.ceh.ac.uk/

Reference 3. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Denotes parameters which are determined based on the restoration scheme, rainfall data or other constraints on discharge or water levels

Denotes parameters which are calculated based on other parameters