CONCEPTUAL DRAINAGE STRATEGY

Thurrock Flexible Generation Plant

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Conceptual Drainage Strategy
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1 INTRODUCTION

1.1 RPS has been commissioned by Statera Energy to produce a Conceptual Drainage Strategy in support of a Development Consent Order (DCO) application for a proposed Flexible Generation Plant (FGP) in Thurrock Essex.

1.2 The proposed development site, approximately 20ha in size, comprises a new gas fired power and battery storage facility together with gas connection compound and other associated plant infrastructure:

- Gas engines, air pollutant control and cooling
- Gas connection compound
- Substation
- Battery Storage
- Carbon capture Ready Area
- Access Track and Soft Landscaping

1.3 The site will be fully secured against access by the general public and will in general not be manned.

1.4 The purpose of the Conceptual Drainage Strategy is to outline the design principles for surface water drainage to be adopted for the development of the site. This report has been produced in conjunction with an RPS Flood Risk Assessment contained within Volume 6, Appendix 15.1: Flood Risk Assessment of the Environmental Statement (application document A6).

1.5 The contents of this report are to be read in conjunction with all supporting drawings and/or documents referenced herein, appended to this report or submitted in support of the DCO application for this development.

Site Description

1.6 The site is located in Thurrock, Essex and consists of approximately 20ha agricultural land, which is split into two distinct fields, north and south, by a land drainage ditch, see RPS drawing 019512-RPS-SI-XX-DR-D-0300.

1.7 The Site is bound by agricultural land to the east and west, with an existing National Grid substation on the southern boundary. The River Thames is situated approximately 1km south of the Existing substation. Vehicular access to the site is via an existing access track to the north east which connects to Station Road.

1.8 More information regarding the site location and description can been found in Volume 2: Project description of the Environmental Statement (application document A6).

1.9 A topographical survey carried out by Survey Solutions dated 28/02/2018, confirmed an average site level of approximately 1.5m AOD. The survey indicates the north field to have a gentle slope from the northwest to the southwest, c.1.4m AOD to c.1.23m AOD and the south field to fall from west to east. c.1.55m AOD to c.1.3mAOD. Some localised raised areas up to 1.8mAOD are also identified in the survey.

1.10 The site and its immediate surroundings are farmland, therefore surface water drainage provisions which currently exist are limited to local field drains / open ditches and/or minor watercourses laid to the perimeter of existing fields.

Ground Conditions

1.11 A Phase 2 site investigation was carried out by TerraConsult Ltd to provide information on the condition of the site prior to application for an Environmental Permit. This report contained a summary of the following encountered ground conditions;

- Topsoil
- Made Ground
- Alluvium
- Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation

More information regarding the location and depths of the encountered ground conditions can be found in the TerraConsult Ltd. Phase 2 Site Investigation Report, Report No 4593/R01 Issue 1.

2 PROPOSED SURFACE WATER DRAINAGE

2.1 The proposed new surface water drainage system will be designed using current MicroDrainage Design software by Innovyze, to take account of planning guidance, Lead Local Flood Authorities (LLFA) and Environment Agency (EA) guidance to prevent uncontrolled flooding of the site and surrounding areas.

2.2 Due to the nature of the DCO application, the final site layout will be determined within the limits of deviation. At this stage, the drainage strategy for the site has been carefully devised achieve a strategy which adequately manages water quality, water quantity and promotes biodiversity whilst accommodating design flexibility that the DCO and limits of deviation allow. This strategy will be refined at detailed design stage.

In the absence of a finalised site plan, proposals to manage water quality, water quantity and promote biodiversity have been developed conceptually at this stage using an indicative areas plan. The Indicative Drainage Areas plan has been included in Appendix A.

2.3 Surface water runoff from the proposed development areas will be managed as follows;

- Permeable surfaces
  - Landscaping – any grassed landscaped areas will drain directly to one of the onsite attenuation basins or any of the series of ditches on the site.
  - Unbound site access roads – access roads will be constructed of unbound materials and will therefore generate similar runoff volumes to the naturally occurring clay subgrade. Runoff from these areas will drain as existing to either the attenuation basins, ditches or filter drains.
- Semi-permeable surfaces
  - Gravelled compound areas – Runoff will percolate into the gravel which will be laid to falls to a network of filter drains. A perforated pipe will then carry generated flows to the attenuation basin. The exact arrangement of smaller plant and battery units in these areas is currently unknown. This area has been conservatively assumed to be 50% impermeable surfacing.
  - Carbon capture – The areas allocated for carbon capture have been bound by a series of land drainage ditches to intercept overland flows. These ditches will then convey runoff towards the attenuation basins. The exact makeup of these areas is currently unknown and therefore this area has been conservatively assumed to be 50% impermeable surfacing.

- Impermeable surfaces
  - Plant areas – It is envisaged that gas reciprocating engines will be located on concrete slabs. The slabs will be laid to crossfalls which direct surface water to a channel/ slot drain. After passing through a proprietary interceptor, surface water will then be directed towards the attenuation basins. Penstocks will also be provided at these locations to allow for containment of spillages.

2.4 The areas mentioned above have been set out in an Indicative Areas plan included in Appendix A. Based on this plan, a total impermeable area of 63,500m² has been estimated which equates to approximately 32% of the total site area. These figures have been using to calculated site specific runoff coefficients (Cv) of 0.729 Summer and 0.851 Winter for use in the drainage design. Calculations included in Appendix B.

2.5 For conceptual design purposes the following levels have been assumed;

Table 1: Conceptual Design Levels

Conceptual Design levels	
Existing site levels	Average approximately 1.5mAOD
Attenuation Basin cover level	1.75mAOD
Attenuation Basin invert level	0.75mAOD
Outfall to perimeter ditch level	0.5mAOD
Zone A areas including the gas fired facility, battery storage and customer substation	2.0mAOD

Levels to be reviewed during detailed design

2.6 The proposed level for the gravel compounds and plant areas is set c.840mm below the design flood level for the development. Flood resistant / resilient measures will therefore be incorporated to protect the proposed infrastructure up to this level. Measures may include flood resilient construction and localised bunding. Further details on flood risk and resilience is included in the RPS Flood Risk Assessment contained within Volume 6, Appendix 15.1: Flood Risk Assessment of the Environmental Statement.

Surface Water Quantity

2.7 Greenfield runoff rates for the site have been calculated for the site using IH124 Methodology within MicroDrainage software and have been included in Appendix B.

2.8 Surface water discharge from the site will be controlled to the equivalent greenfield 1 in 1 year event for all return periods up to and including the critical 1 in 100 year +40%cc event through the use of a flow control device. The site 1 in 1 year greenfield rate has been calculated as 56.4l/s.

2.9 Surface water runoff will be collected as per the methods above and discharged into one of the two on-site surface water attenuation basins, designed in accordance with The SuDS Manual, CIRIA Report C753, 2015. The attenuation basins will provide attenuation of flows and assist with removal of sediments from rainwater runoff. The downstream outlet of the attenuation basin will include a sump / catch pit for removal of silt and debris. Each attenuation basin will provide adequate storage for all storm events up to and including the 1:100 year return period with an additional 40% for future climate change.

2.10 As per the Indicative areas plan, a proportion of the landscaping areas will drain as per existing arrangements to the perimeter ditches. The runoff from the remainder of the site has been divided between two sub-catchments 1 and 2 which drain to attenuation basins 1 and 2, see RPS drawing 019512-RPS-SI-XX-DR-D-0300. The 56.4l/s discharge rate will therefore be divided proportionally between the attenuation basins to two separate outfalls. The proposed discharge rates from Attenuation basins 1 and 2 are 41.7l/s and 14.7l/s respectively.

2.11 Initial attenuation volume estimates indicated that volumes in the region of 20,100m³ would be required to achieve adequate storage to restricted to the greenfield runoff rates. This figure has also been dived proportionally between the two site catchments so that Attenuation basin 1 and Attenuation basin 2 each provide approximately 17,000m³ and 4,500m³ attenuation volume respectively.

2.12 Preliminary calculations have been undertaken using MicroDrainage Software and included as Appendix B. These calculations demonstrate that both Attenuation basins 1 and 2 have adequate capacity to attenuate flows from all storms up to and including the 1 in 100 year storm including a 40% allowance for climate change.

2.13 The outfalls to the perimeter drainage ditches will be fitted with non-return valves to prevent the ingress of water should the water level in the ditch rise. Due to the distance from the Thames it is not considered likely that the outfall would be submerged for long periods due to tidal influences. In the event that an excessively high tide prevents an outfall from the site for a prolonged period, the site will be allowed to flood as it would in its undeveloped state. Any flooding which occurs due to a submerged outfall is not likely to cause significant disruption as this will be lower than the 2.84mAOD flood resilience level determined by the FRA for the tidal breach scenario.

2.14 The proposed surface water drainage layout is shown on RPS drawing 019512-RPS-SI-XX-DR-D-0300 - Indicative Drainage Layout, which is included in Appendix A.

Surface Water Quality

2.15 Proposed run-off quality control for the Thurrock FGP Site will include a combination of proprietary pollution interceptors, filter drains, open channels and attenuation basins arranged in a format relative to the pollution hazard level of the different site areas. A general arrangement of these elements has been included as RPS drawing 019512-RPS-SI-XX-DR-D-0300. The exact location and combination of features will be determined in the final Drainage Strategy during detailed design, prior to construction.

2.16 A water quality risk assessment has been carried out using the SuDS hazard mitigation indices in accordance with Chapter 26, of The SuDS Manual, CIRIA Report C753, 2015. Under this method of assessment, the worst case area of the development is considered to be the concrete slab, plant areas. Considering the low expected traffic volumes and appropriate containment of any hazardous substances, the residual pollution hazard level is considered to be medium hazard levels similar to that of a commercial yard.

2.17 A combination of proprietary interceptor units, filter drains and attenuation basins will be the minimum level of water quality control provided to the plant slab areas. The following table demonstrates that the SuDS Mitigation indices provided by the features exceed that of the associated pollution hazard index.

Table 2: Medium Hazard - Pollution Mitigation

	Hazard Level	Total Suspended Solids (TSS)	Metals	Hydro-carbons
Pollution Hazard Indices	Medium	0.8	0.8	0.9
Proposed SuDS mitigation I_1 Bypass interceptor unit	-	0.6	0.5	0.6
Proposed SuDS mitigation I_2 Filter Drain		0.4	0.4	0.5
Proposed SuDS mitigation I_3 Attenuation basin		0.5	0.5	0.5
Total SuDS Mitigation (I_1+0.5xI_2…)		**1.05**	**0.95**	**1.1**

2.18 Any areas at risk of spillages or proposed for storage of hazardous chemicals will be subject to specific appropriate containment measures, regulated though the environmental permit. These additional containment measures will ensure there is no risk of pollution to the surface water drainage system.

SuDS Biodiversity and Amenity

2.19 The proposed site layout will require infilling of existing land drainage ditches, see RPS drawing 019512-RPS-SI-XX-DR-D-0300. This has been recognised as a potential loss of habitat in an area known to accommodate protected species such as water voles. Working closely with the ecology team, SuDS techniques have been incorporated into the proposed drainage strategy to harness the multiple benefits of SuDS including habitat compensation.

2.20 The proposed drainage strategy includes several open ditches to replace those lost through the development proposals. These ditches will be designed with integral weir boards to help retain flows and provide a permanent wetted bench for habitat enhancement. Ditches will be constructed with side slopes as steep as ground conditions will allow, preferably 1:1 slopes with a minimum 2m vegetated strip to provide optimum habitat for native species.

2.21 In addition to the new ditches, the attenuation basins will look provide a continuation of this permanent wetted bench. After vegetation begins to establish, the proposed attenuation basins will resemble Figure 2-1 below. The area above the permanent water level will be utilised as surface water attenuation and will therefore be encouraged to flood during high rainfall events. The reciprocal effect of this will encourage the formation of a marsh like environment similar to that of the surrounding area under tidal influence.

2.22 Proposed ditches and attenuation Basins have, where possible, been linked to perimeter ditches through parallel sections to provide a continuation of habitat throughout the site.

Figure 2-1 Detention Basin with low flow channel

3 SURFACE WATER DESIGN PARAMETERS

3.1 The new surface water drainage system will be designed using current analysis software, MicroDrainage, ensuring planning guidelines are satisfied to prevent uncontrolled flooding of the Thurrock FGP Site and surrounding areas.

3.2 At this stage, preliminary calculations have demonstrated the proposed attenuation basins to provide adequate storage to contain all runoff from the 1 in 100 year rainfall event including 40% allowance for climate change.

3.3 During detailed design, the network of ditches, filter drains and piped network shown indicatively in drawing 019512-RPS-SI-XX-DR-D-0300 will be designed to the parameters, return periods and storm durations included below.

3.4 The drainage network will ensure that no flooding occurs in any area of the site for events up to the 1 in 30 year return period storms. For storms in excess of 1 in 30 year events, controlled temporary overland flooding is permitted with flood depths restricted accordingly to consider Health & Safety using Environment Agency's R&D Technical Report FD2320/TR2, Table 13.1 "Danger to people for different combinations of depth and velocity". Any overland flow will be routed to the onsite attenuation basins. No flooding detrimental to buildings will occur during any storm event as a result of surface water runoff.

Design Parameters

- Rainfall: FEH Data; FEH CD-R version 3 – Grid Ref E 566350, N 176250.
- Design Return Period: 2, 30 and 100 (+40% climate change) years.
- Climate change: rainfall profiles increased by 40% for 100 year return period
- Volumetric Runoff coefficient: 0.729 Summer, 0.851 Winter
- Global time of entry: 60mins for filter drain and gravel areas, 10 mins for plant slab
- Infiltration: Ignore for peak flow design
- Backdrops: Allow in design; maximum depth of 1.5m
- Velocity: 0.75 m/s for self-cleansing (private drainage)

Storm Return Periods and Durations

- 2 year return period – 15mins to 1440mins storm duration
- 30 year return period – 15mins to 1440mins storm duration
- 100 year return period (+40% climate change) – 15mins to 1440mins storm duration

4 PROPOSED FOUL WATER DRAINAGE

4.1 The proposed Thurrock FGP will be operated remotely however it is envisaged that staff welfare facilities will be provided. The proposed development will not have a sewer connection. Foul drainage from staff welfare facilities on site will be either to a packaged biological foul treatment plant with discharge to the surface water system or to a storage tank for off-site disposal via road tanker. Any provisions for managing foul flows locally within the site will be designed and specified in accordance with BS EN 12566.

5 CONSTRUCTION STAGE DRAINAGE

5.1 During construction of the development, the building contractor will be responsible for management and disposal of rainwater runoff generated from the site in its temporary condition.

5.2 The contractor will implement methods to manage drainage during construction in accordance with the Code of Construction Practice (application document A8.6). These methods will address pollution management and control in relation to site plant and vehicles, raw materials storage and waste generation, to ensure that all surface water runoff generated in the temporary condition will be free of contamination.

5.3 The site will be subject to topsoil strip and bulk earthworks to prepare the site to the correct level for development. The contractor will provide temporary drainage measures as illustrated within Section 6 of Ciria C532 'Control of Pollution from Construction Sites', to contain runoff within the development site boundary, ensuring that these measures are sized appropriately, and that means to remove excess surface water are available for use at all times.

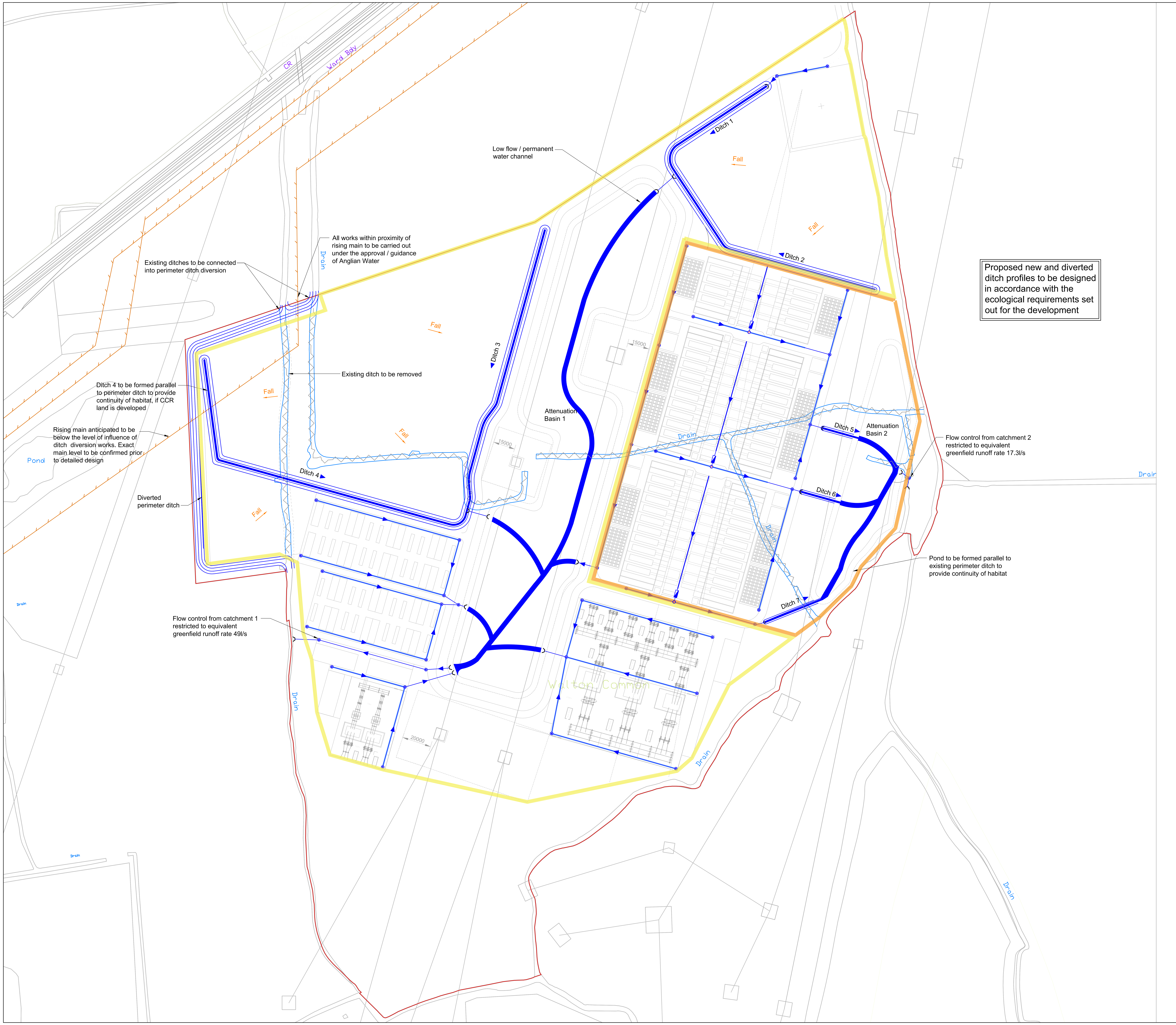
6 MAINTENANCE

6.1 The maintenance for all plot specific drainage infrastructure will be the responsibility of the owner of the proposed development. Details of the maintenance activities for the constructed drainage infrastructure will be passed to the end user as part of an Operation and Maintenance Manual post completion. Typical maintenance activities may include;

Table 3: Typical Maintenance Activities

Element	Access Method	Method of Maintenance	Frequency Required
Roof Gutters	Scaffolding / Cherry pickers to be used where required.	General cleaning of gutters. Jet cleaning where required.	Periodic inspection of gutters to ensure rainwater outlets do not become blocked. Periodic renewal of gutter coatings to prevent corrosion.
Oil / Petrol Separators	In accordance with H&S regulations and confined spaces requirements.	Refer to manufacturer's guidance.	Bi-annual inspection and emptying.
Slot Drains / Kerb Drainage	In accordance with H&S regulations.	Monitor to ensure no blockages develop. Jet cleaning where required.	Bi-annual jet cleaning of channel drains.
Silt-traps and Gullies	In accordance with H&S regulations.	Monitor to ensure no blockages develop.	Bi-annual inspection and emptying of all silt traps and gullies.
Penstock Valves/ Non-Return Flap Valves	In accordance with health and safety regulations and confined spaces requirements.	Monitored to ensure no blockages develop in accordance with the manufacturers recommendations.	Bi-annual inspection or in accordance with the manufacturers recommendations, whichever occurs sooner.
Surface Water Ponds and Swales	In accordance with H&S regulations	General cleaning and monitoring to ensure no blockage. Remove litter and debris. Cut grass and manage vegetation. Inspect inlets and outlets	Bi-annual inspection, cleaning and removal of silt and/or debris
Pumps	In accordance with health and safety regulations and confined spaces requirements.	Monitored via visual and audible alarms in development gatehouse to ensure no blockages develop in accordance with the manufacturer's recommendations.	Bi-annual inspection or in accordance with the manufacturers recommendations, whichever occurs sooner.
Headwall	In accordance with health and safety regulations.	Monitored to ensure no blockages develop.	Bi-annual inspection and clearance of any debris

Appendix A – RPS Drawings



Notes

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3. This drawing should be read in conjunction with all other relevant drawings and specifications.

Drainage Key

- Surface water drain
- Surface water filter drain (perforated pipe and gravel trench)
- Proposed ditch - min. 600mm depth (engineered to permanently hold water)
- Ditch infill
- Interceptor unit
- Penstock Isolation Valve
- Foul Rising Main (Anglian Water)
- Indicative fall
- Catchment 1
- Catchment 2

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Projection: BNG

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25m SCALE 1:1250

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P01	24/10/19	First Issue
P02	16/12/19	Notes updated as per internal review comments
P03	17/02/20	Notes updated as per internal review comments

APFP Regulations Reference: 5(2)(o)
Application Document Number: A2.10

Thurrock Flexible Generation Plant

Indicative Drainage Layout

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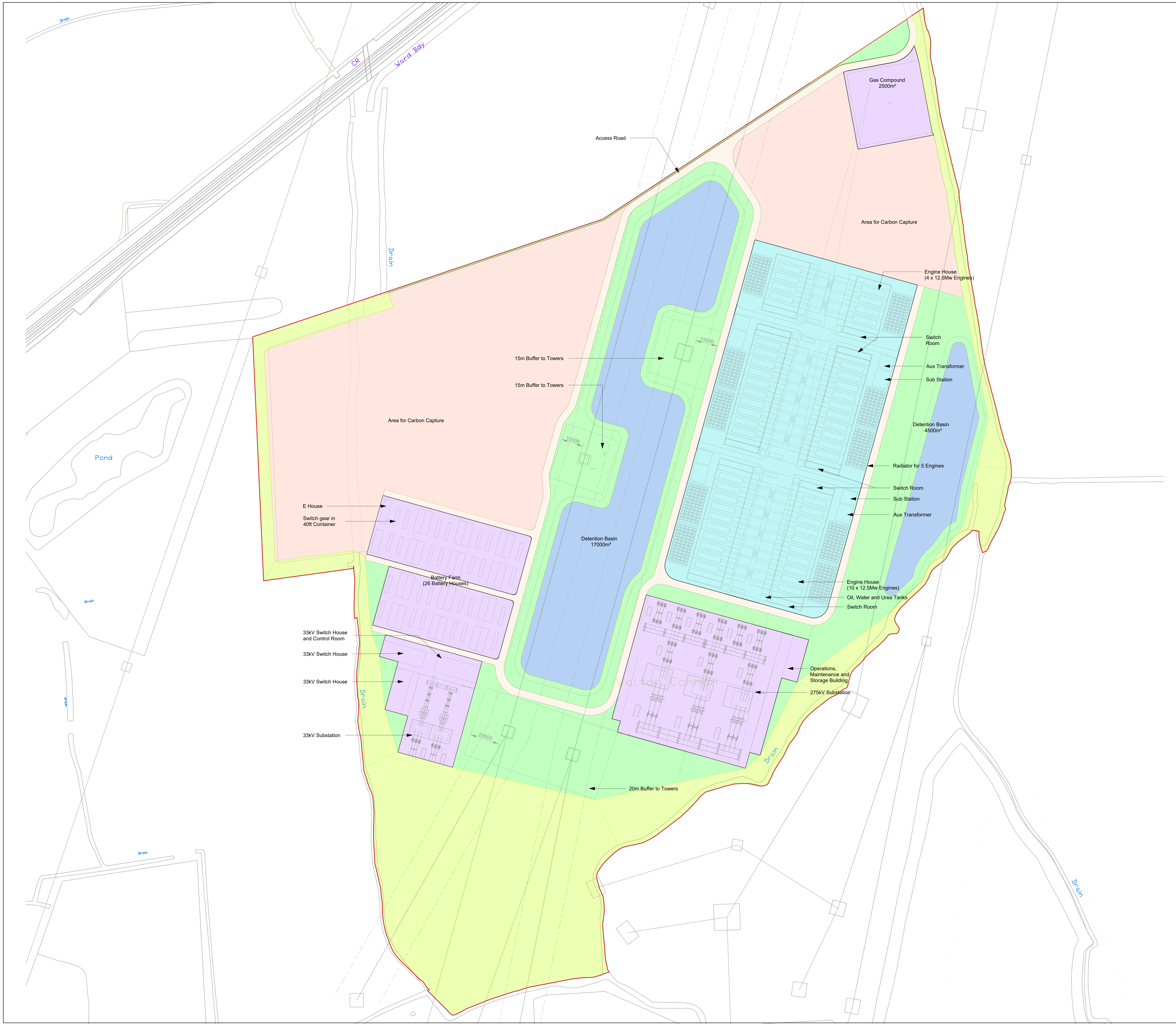
THURROCK POWER



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Surface Water Catchments Key

Permeable Areas

- Landscaping & ponds
- Stone Access Track
- Landscaping (to drain as existing)

Semi-permeable Areas
(assumed to be 50% impermeable surfaces for runoff coefficient calculations)

- Gravel compound areas
- Carbon Capture

Impermeable Areas

- Plant areas (Concrete slab assumed)

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Thurrock Flexible Generation Plant

Indicative Drainage Areas

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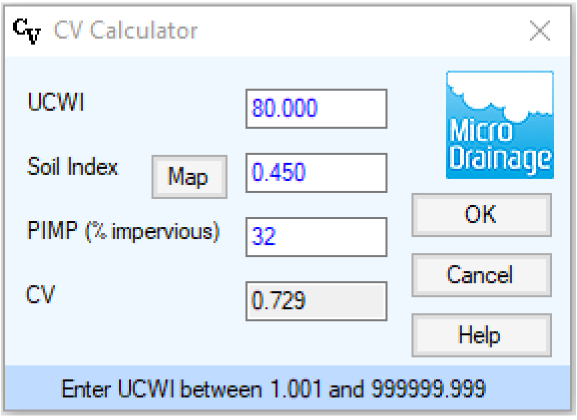
THURROCK POWER

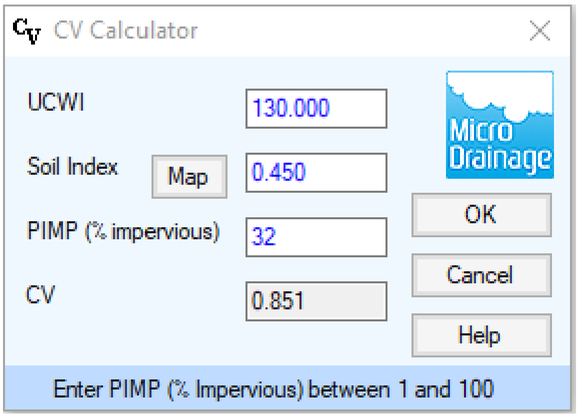
Appendix B – RPS Calculations

B.1 Runoff Coefficient Calculations

Summer CV Calculation



Winter CV Calculation



B.2 Greenfield Runoff Rate Calculation

ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	Soil	0.450
Area (ha)	20.010	Urban	0.000
SAAR (mm)	550	Region Number	Region 6

Results	**l/s**
QBAR Rural	66.3
QBAR Urban	66.3
Q1 year	56.4
Q1 year	56.4
Q30 years	150.2
Q100 years	211.5

B.3 Attenuation Basin Calculations

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	1.079	0.329	41.2	5819.5	O K
30 min Summer	1.111	0.361	41.5	6401.1	O K
60 min Summer	1.145	0.395	41.6	7023.6	O K
120 min Summer	1.180	0.430	41.7	7672.1	O K
180 min Summer	1.200	0.450	41.7	8049.1	O K
240 min Summer	1.214	0.464	41.7	8306.5	O K
360 min Summer	1.231	0.481	41.7	8640.5	O K
480 min Summer	1.242	0.492	41.7	8842.4	O K
600 min Summer	1.249	0.499	41.7	8968.8	O K
720 min Summer	1.253	0.503	41.7	9045.4	O K
960 min Summer	1.280	0.530	41.7	9566.5	O K
1440 min Summer	1.314	0.564	41.7	10205.5	O K
2160 min Summer	1.338	0.588	41.7	10668.8	O K
2880 min Summer	1.353	0.603	41.7	10946.4	O K
4320 min Summer	1.316	0.566	41.7	10242.4	O K
5760 min Summer	1.282	0.532	41.7	9588.2	O K
7200 min Summer	1.249	0.499	41.7	8968.0	O K
8640 min Summer	1.218	0.468	41.7	8380.6	O K
10080 min Summer	1.189	0.439	41.7	7836.2	O K
15 min Winter	1.132	0.382	41.6	6796.5	O K
30 min Winter	1.169	0.419	41.7	7479.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	263.696	0.0	2906.0	27
30 min Summer	145.425	0.0	3153.8	42
60 min Summer	80.200	0.0	5057.5	72
120 min Summer	44.229	0.0	5539.9	130
180 min Summer	31.226	0.0	5807.1	190
240 min Summer	24.392	0.0	5980.4	250
360 min Summer	17.221	0.0	6182.2	368
480 min Summer	13.452	0.0	6275.8	488
600 min Summer	11.106	0.0	6304.3	606
720 min Summer	9.497	0.0	6287.3	726
960 min Summer	7.754	0.0	6197.4	964
1440 min Summer	5.827	0.0	5781.3	1442
2160 min Summer	4.379	0.0	11347.6	1928
2880 min Summer	3.576	0.0	11514.2	2304
4320 min Summer	2.499	0.0	10444.6	3028
5760 min Summer	1.938	0.0	15508.3	3808
7200 min Summer	1.591	0.0	15788.1	4616
8640 min Summer	1.355	0.0	15940.5	5368
10080 min Summer	1.182	0.0	15902.7	6160
15 min Winter	263.696	0.0	3296.1	27
30 min Winter	145.425	0.0	3453.7	41

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	1.209	0.459	41.7	8211.7	O K
120 min Winter	1.249	0.499	41.7	8979.2	O K
180 min Winter	1.273	0.523	41.7	9430.2	O K
240 min Winter	1.290	0.540	41.7	9742.2	O K
360 min Winter	1.311	0.561	41.7	10154.4	O K
480 min Winter	1.325	0.575	41.7	10413.2	O K
600 min Winter	1.334	0.584	41.7	10583.9	O K
720 min Winter	1.340	0.590	41.7	10697.0	O K
960 min Winter	1.374	0.624	41.7	11357.8	O K
1440 min Winter	1.418	0.668	41.7	12220.6	O K
2160 min Winter	1.454	0.704	41.7	12912.4	O K
2880 min Winter	1.470	0.720	41.7	13222.5	O K
4320 min Winter	1.414	0.664	41.7	12142.0	O K
5760 min Winter	1.365	0.615	41.7	11181.0	O K
7200 min Winter	1.316	0.566	41.7	10239.5	O K
8640 min Winter	1.269	0.519	41.7	9343.4	O K
10080 min Winter	1.224	0.474	41.7	8506.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	80.200	0.0	5855.7	70
120 min Winter	44.229	0.0	6310.3	128
180 min Winter	31.226	0.0	6526.5	188
240 min Winter	24.392	0.0	6639.2	246
360 min Winter	17.221	0.0	6708.2	362
480 min Winter	13.452	0.0	6668.3	480
600 min Winter	11.106	0.0	6576.8	596
720 min Winter	9.497	0.0	6477.1	714
960 min Winter	7.754	0.0	6267.3	944
1440 min Winter	5.827	0.0	5830.6	1404
2160 min Winter	4.379	0.0	12286.6	2076
2880 min Winter	3.576	0.0	11777.5	2716
4320 min Winter	2.499	0.0	10736.0	3332
5760 min Winter	1.938	0.0	18066.8	4216
7200 min Winter	1.591	0.0	18368.7	5056
8640 min Winter	1.355	0.0	18515.8	5888
10080 min Winter	1.182	0.0	18477.3	6664

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 566350 176250 TQ 66350 76250
C (1km)	-0.026
D1 (1km)	0.261
D2 (1km)	0.415
D3 (1km)	0.236
E (1km)	0.320
F (1km)	2.576
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.729
Cv (Winter)	0.851
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 12.180

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	4.060	4	8	4.060	8	12	4.060

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.750

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	17097.0	1.000	20740.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0273-4170-1000-4170
Design Head (m)	1.000
Design Flow (l/s)	41.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	273
Invert Level (m)	0.750
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	41.7
Flush-Flo™	0.421	41.7
Kick-Flo®	0.770	36.8
Mean Flow over Head Range	-	33.9

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.6	1.200	45.5	3.000	70.9	7.000	107.1
0.200	28.1	1.400	49.0	3.500	76.4	7.500	110.7
0.300	40.8	1.600	52.3	4.000	81.5	8.000	114.3
0.400	41.7	1.800	55.3	4.500	86.3	8.500	117.7
0.500	41.4	2.000	58.2	5.000	90.9	9.000	121.1
0.600	40.5	2.200	61.0	5.500	95.2	9.500	124.3
0.800	37.5	2.400	63.6	6.000	99.3		
1.000	41.7	2.600	66.1	6.500	103.3		

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	1.166	0.416	14.7	1989.2	O K
30 min Summer	1.205	0.455	14.7	2187.6	O K
60 min Summer	1.246	0.496	14.7	2398.6	O K
120 min Summer	1.287	0.537	14.7	2615.9	O K
180 min Summer	1.310	0.560	14.7	2740.1	O K
240 min Summer	1.326	0.576	14.7	2823.5	O K
360 min Summer	1.346	0.596	14.7	2928.4	O K
480 min Summer	1.357	0.607	14.7	2988.4	O K
600 min Summer	1.363	0.613	14.7	3022.7	O K
720 min Summer	1.366	0.616	14.7	3040.0	O K
960 min Summer	1.396	0.646	14.7	3204.4	O K
1440 min Summer	1.432	0.682	14.7	3402.0	O K
2160 min Summer	1.455	0.705	14.7	3526.5	O K
2880 min Summer	1.462	0.712	14.7	3567.8	O K
4320 min Summer	1.398	0.648	14.7	3213.4	O K
5760 min Summer	1.343	0.593	14.7	2914.9	O K
7200 min Summer	1.293	0.543	14.7	2648.7	O K
8640 min Summer	1.247	0.497	14.7	2406.1	O K
10080 min Summer	1.205	0.455	14.7	2186.2	O K
15 min Winter	1.231	0.481	14.7	2324.2	O K
30 min Winter	1.276	0.526	14.7	2557.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	263.696	0.0	1240.2	27
30 min Summer	145.425	0.0	1245.6	42
60 min Summer	80.200	0.0	2089.7	72
120 min Summer	44.229	0.0	2250.9	130
180 min Summer	31.226	0.0	2326.7	190
240 min Summer	24.392	0.0	2363.3	250
360 min Summer	17.221	0.0	2374.6	368
480 min Summer	13.452	0.0	2347.2	488
600 min Summer	11.106	0.0	2313.8	606
720 min Summer	9.497	0.0	2279.7	726
960 min Summer	7.754	0.0	2197.9	964
1440 min Summer	5.827	0.0	2038.9	1442
2160 min Summer	4.379	0.0	4236.4	2100
2880 min Summer	3.576	0.0	4126.9	2424
4320 min Summer	2.499	0.0	3840.4	3072
5760 min Summer	1.938	0.0	5553.7	3816
7200 min Summer	1.591	0.0	5685.7	4616
8640 min Summer	1.355	0.0	5786.0	5368
10080 min Summer	1.182	0.0	5843.4	6152
15 min Winter	263.696	0.0	1251.3	27
30 min Winter	145.425	0.0	1241.4	41

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	1.323	0.573	14.7	2805.7	O K
120 min Winter	1.371	0.621	14.7	3064.0	O K
180 min Winter	1.398	0.648	14.7	3214.4	O K
240 min Winter	1.417	0.667	14.7	3317.3	O K
360 min Winter	1.441	0.691	14.7	3451.6	O K
480 min Winter	1.456	0.706	14.7	3533.9	O K
600 min Winter	1.466	0.716	14.7	3586.0	O K
720 min Winter	1.471	0.721	14.7	3618.3	O K
960 min Winter	1.509	0.759	14.7	3831.3	O K
1440 min Winter	1.555	0.805	14.7	4091.0	O K
2160 min Winter	1.586	0.836	14.7	4268.8	O K
2880 min Winter	1.594	0.844	14.7	4318.2	O K
4320 min Winter	1.521	0.771	14.7	3897.6	O K
5760 min Winter	1.450	0.700	14.7	3499.5	O K
7200 min Winter	1.374	0.624	14.7	3084.2	O K
8640 min Winter	1.305	0.555	14.7	2711.6	O K
10080 min Winter	1.241	0.491	14.7	2373.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	80.200	0.0	2343.6	70
120 min Winter	44.229	0.0	2427.7	128
180 min Winter	31.226	0.0	2418.9	188
240 min Winter	24.392	0.0	2394.8	246
360 min Winter	17.221	0.0	2343.9	364
480 min Winter	13.452	0.0	2295.7	480
600 min Winter	11.106	0.0	2253.0	598
720 min Winter	9.497	0.0	2214.6	714
960 min Winter	7.754	0.0	2125.8	946
1440 min Winter	5.827	0.0	2008.6	1404
2160 min Winter	4.379	0.0	4334.4	2076
2880 min Winter	3.576	0.0	4171.8	2712
4320 min Winter	2.499	0.0	3832.0	3372
5760 min Winter	1.938	0.0	6468.1	4280
7200 min Winter	1.591	0.0	6620.9	5112
8640 min Winter	1.355	0.0	6732.3	5888
10080 min Winter	1.182	0.0	6801.1	6664

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 566350 176250 TQ 66350 76250
C (1km)	-0.026
D1 (1km)	0.261
D2 (1km)	0.415
D3 (1km)	0.236
E (1km)	0.320
F (1km)	2.576
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.729
Cv (Winter)	0.851
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 4.170

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	1.390	4	8	1.390	8	12	1.390

Model Details

Storage is Online Cover Level (m) 1.750

Tank or Pond Structure

Invert Level (m) 0.750

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	4468.0	1.000	6050.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0173-1470-1000-1470
Design Head (m)	1.000
Design Flow (l/s)	14.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	173
Invert Level (m)	0.750
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.000	14.7
Flush-Flo™	0.322	14.7
Kick-Flo®	0.702	12.4
Mean Flow over Head Range	-	12.5

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

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	6.1	1.200	16.0	3.000	24.8	7.000	37.3
0.200	14.2	1.400	17.2	3.500	26.7	7.500	38.6
0.300	14.7	1.600	18.4	4.000	28.5	8.000	39.8
0.400	14.6	1.800	19.4	4.500	30.2	8.500	41.0
0.500	14.3	2.000	20.4	5.000	31.7	9.000	42.2
0.600	13.8	2.200	21.4	5.500	33.2	9.500	43.3
0.800	13.2	2.400	22.3	6.000	34.6		
1.000	14.7	2.600	23.2	6.500	36.0		