Patterson Reeves & Partners
Consulting Civil & Structural Engineers – Building Consultants

Westleigh House, 83-85 Leigh Road,
Eastleigh, Hampshire, SO50 9DQ

Tel: 02380 488 488
www.Structural-Engineers.co.uk

DRAINAGE CALCULATIONS

EYE 400kV SUBSTATION

Engineer: Patterson Reeves & Partners Ltd
Client: Siemens Energy Ltd
Date: October 2023
Internal Ref: J5656 / DC02
Client Ref: D069-SEL-V00-400-CA-C-0005
Revision: 02 – For Construction

Designing For Your Needs

Calculation Issue/Revision Log

Revision / Issue	Date	Comment	By	Checked
P01	July 2023	First Issue	MDP	PJR
01	September 2023	For Comment	MDP	PJR
02	October 2023	For Construction	MDP	PJR

Contents

1.0 Drainage Design Philosophy

Green field site area lost to new development = 9,006m².

As a minimum the surface water drainage system shall fully manage surface water flows resulting from the developed site up to the 1 in 100 year peak rainfall event plus a minimum of 45% for the impacts of climate change.

Analysis identifies the flows from the green field site i.e. the area inside the substation security fence line is 2.3 l/s during a 1 in 1year return period storm. This rises up to 9.4 l/s during a 1 in 100 years event.

Following completion of the development, the proposal is to limit the maximum flow to downstream watercourses to 2.3 l/s by means of a hydrobrake. This is significantly less than the existing greenfield runoff rate which as stated above is 9.4 l/s during a 1 in 100 year return period storm. Calculations demonstrates that in order to achieve this we will need to provide an attenuation volume of 292m³ during a 1 in 100 year return period storm with an allowance for climate change.

It should be noted that historically substation platforms for electrical substations were made-up of 300mm of compacted Type 1 MOT stone with a layer of 75mm single sized stone chippings on top. The former layer off stone was largely impervious and thus rainfall would not penetrate below the chipping layer. More recently it has become common practise to replace the Type 1 stone layer with an unbound stone e.g. Type 3. This has far fewer fines and will easily absorb rainfall. This will allow paved areas to drain directly into the platform. The platform will effectively have the capacity to absorb over 1000m³ of rainfall. Although filter drains are provided around the perimeter of the substation it will take some time for rainfall to pass through the stone layer before it reaches the drainage routes. Run off from building roofs will be directed into the filter drains. The calculations have assumed that the flow will pass quickly into the detention basin however in reality this will be considerably slowed as flows will be absorbed to some degree into the stone platform.

In addition to this it is a requirement of the environment agency (EA) to follow the principals set out in the suds manual in providing levels of treatment to surface water flows, whilst at the same time providing a natural and stable habitat for plants and wildlife. Flows from the site are initially given some filtration whereby flows pass through a geotextile membrane prior to passing into a perforated land drainage system. This will remove silts and other suspended contaminates. Flows from bunds, where oils may be present, are firstly protected by intelligent pumping systems which will detect the presence of oil and if so cease operation. In addition flows from these locations will pass through an oil separator, before passing downstream.

The outgoing invert level from the pond will be set such that there will always be a minimum depth of 300mm of water in the pond. This will ensure a suitable environment for wildlife and plants. As flows pass through the wetland pond they will get further treatment with the interaction of carefully selected plants which will assist in removing dissolved contaminates etc. The area of the pond will be 290m^2 and so during the most intense storm the water level in the pond will rise by 1.0m this level will return back to normal in 35 hours.

The above proposal is a recognised standard way of achieving the principals of the SUDS manual.

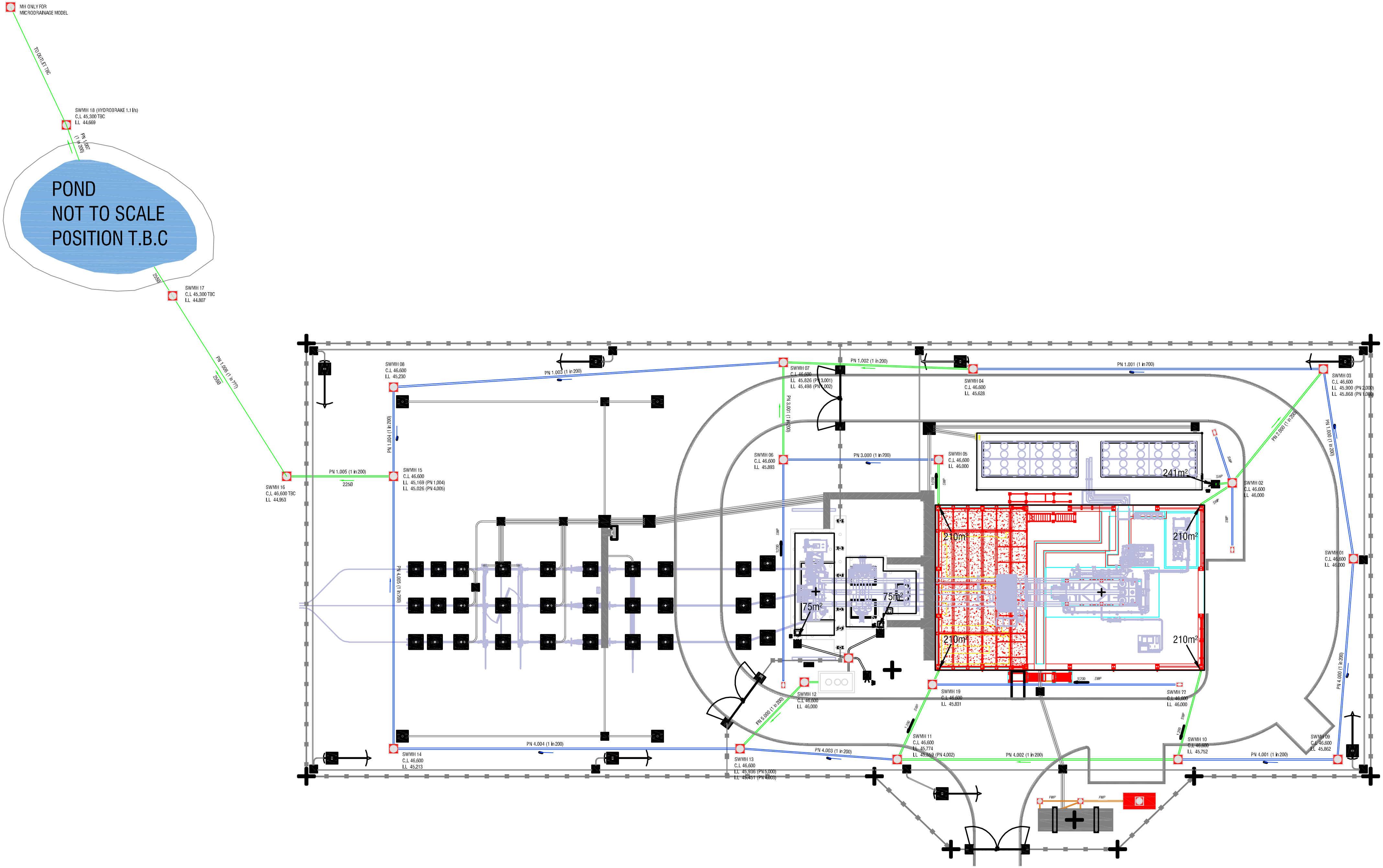
2.0 Potential Oily Water

All oil containing plant is located within bunded areas and drainage of these areas is strictly through bund water control units.

3.0 Foul Water

All foul water shall be gravity drained to a 9,000 litre cess pit which will have a high level alarm and will require manual emptying.

4.0 Site Drainage Layout with Pipe number and Areas



Patterson Reeves		Page 1
85 Leigh Road Eastleigh SO50 9DQ		Micro Drainage
Date 10/05/2023 13:57 File EYE - Drainage.MDX	Designed by MarkP Checked by	
Innovyze	Network 2020.1.3	

Existing Network Details for Existing

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type
1.000	26.352	0.132	199.6	0.000	5.00	0.0	0.600	o	375	Pipe/Conduit
2.000	20.006	0.100	200.1	0.045	5.00	0.0	0.600	o	150	Pipe/Conduit
1.001	48.057	0.240	200.2	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
1.002	26.046	0.130	200.4	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit
3.000	21.308	0.107	199.1	0.021	5.00	0.0	0.600	o	375	Pipe/Conduit
3.001	13.343	0.067	199.1	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit
1.003	53.574	0.268	199.9	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
1.004	12.233	0.061	200.5	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
4.000	27.632	0.138	200.2	0.000	5.00	0.0	0.600	o	375	Pipe/Conduit
4.001	21.932	0.110	199.4	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
4.002	38.522	0.193	199.6	0.021	5.00	0.0	0.600	o	150	Pipe/Conduit
4.003	21.612	0.108	200.1	0.021	5.00	0.0	0.600	o	375	Pipe/Conduit
5.000	12.706	0.064	198.5	0.015	5.00	0.0	0.600	o	150	Pipe/Conduit
4.004	47.537	0.238	199.7	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
4.005	37.385	0.187	199.9	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit

Network Results Table

PN	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Vel (m/s)	Cap (l/s)
1.000	46.000	0.000	0.0	1.28	141.2
2.000	46.000	0.045	0.0	0.71	12.5
1.001	45.868	0.045	0.0	1.28	141.0
1.002	45.628	0.045	0.0	0.71	12.5
3.000	46.000	0.021	0.0	1.28	141.4
3.001	45.893	0.021	0.0	0.71	12.5
1.003	45.498	0.066	0.0	1.28	141.1
1.004	45.230	0.066	0.0	1.28	140.9
4.000	46.000	0.000	0.0	1.28	141.0
4.001	45.862	0.000	0.0	1.28	141.3
4.002	45.752	0.021	0.0	0.71	12.5
4.003	45.559	0.042	0.0	1.28	141.1
5.000	46.000	0.015	0.0	0.71	12.5
4.004	45.451	0.057	0.0	1.28	141.2
4.005	45.213	0.057	0.0	1.28	141.1

Existing Network Details for Existing

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type
1.005	14.666	0.073	200.9	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
1.006	29.284	0.146	200.6	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
1.007	27.615	0.138	200.1	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit
1.008	17.890	0.090	198.8	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit

Network Results Table

PN	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Vel (m/s)	Cap (l/s)
1.005	45.026	0.123	0.0	1.27	140.8
1.006	44.953	0.123	0.0	1.28	140.9
1.007	44.807	0.123	0.0	1.28	141.1
1.008	44.669	0.123	0.0	0.71	12.5

Free Flowing Outfall Details for Existing

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.008		45.300	44.579	0.000	150	0

Simulation Criteria for Existing

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	1
Number of Online Controls	1	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Storm Duration (mins)	30
Ratio R	0.449		

Online Controls for Existing

Hydro-Brake® Optimum Manhole: SWMH 18, DS/PN: 1.008, Volume (m³): 3.4

Unit Reference	MD-SHE-0054-1100-0631-1100
Design Head (m)	0.631
Design Flow (l/s)	1.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	54
Invert Level (m)	44.669
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.631	1.1
Flush-Flo™	0.194	1.1
Kick-Flo®	0.407	0.9
Mean Flow over Head Range	-	1.0

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	1.0	1.200	1.5	3.000	2.2	7.000	3.3
0.200	1.1	1.400	1.6	3.500	2.4	7.500	3.4
0.300	1.1	1.600	1.7	4.000	2.5	8.000	3.5
0.400	0.9	1.800	1.8	4.500	2.7	8.500	3.6
0.500	1.0	2.000	1.8	5.000	2.8	9.000	3.7
0.600	1.1	2.200	1.9	5.500	2.9	9.500	3.9
0.800	1.2	2.400	2.0	6.000	3.1		
1.000	1.4	2.600	2.1	6.500	3.2		

Patterson Reeves		Page 4
85 Leigh Road Eastleigh SO50 9DQ		
Date 10/05/2023 13:57 File EYE - Drainage.MDX	Designed by MarkP Checked by	
Innovyze	Network 2020.1.3	

Storage Structures for Existing

Tank or Pond Manhole: SWMH 18, DS/PN: 1.008

Invert Level (m) 44.669

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	92.3	1.300	92.3

Summary of Critical Results by Maximum Level (Rank 1) for Existing

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Storage Structures 1
Number of Online Controls 1 Number of Time/Area Diagrams 0
Number of Offline Controls 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.449
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 20.000 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440, 2880
Return Period(s) (years) 100
Climate Change (%) 45

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.
1.000	SWMH 01	15 Winter	100	+45%				
2.000	SWMH 02	15 Winter	100	+45%	100/15 Winter	100/15 Winter		
1.001	SWMH 03	15 Winter	100	+45%				
1.002	SWMH 04	15 Winter	100	+45%	100/15 Winter			
3.000	SWMH 05	15 Winter	100	+45%				
3.001	SWMH 06	15 Winter	100	+45%	100/15 Winter			
1.003	SWMH 07	15 Winter	100	+45%				
1.004	SWMH 08	15 Winter	100	+45%				
4.000	SWMH 01	15 Winter	100	+45%				
4.001	SWMH 09	15 Winter	100	+45%				
4.002	SWMH 10	15 Winter	100	+45%				
4.003	SWMH 11	15 Winter	100	+45%				
5.000	SWMH 12	15 Winter	100	+45%				
4.004	SWMH 13	15 Winter	100	+45%				
4.005	SWMH 14	15 Winter	100	+45%				
1.005	SWMH 15	240 Winter	100	+45%				
1.006	SWMH 16	360 Winter	100	+45%				
1.007	SWMH 17	360 Winter	100	+45%	100/60 Winter			
1.008	SWMH 18	360 Winter	100	+45%	100/15 Winter			

Patterson Reeves		Page 6
85 Leigh Road Eastleigh SO50 9DQ		
Date 10/05/2023 13:57 File EYE - Drainage.MDX	Designed by MarkP Checked by	
Innovyze	Network 2020.1.3	

Summary of Critical Results by Maximum Level (Rank 1) for Existing

PN	US/MH Name	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
1.000	SWMH 01	46.000	-0.375	0.000	0.00			0.0	OK
2.000	SWMH 02	46.600	0.450	0.030	2.33			27.4	FLOOD
1.001	SWMH 03	45.992	-0.251	0.000	0.20			26.6	OK
1.002	SWMH 04	45.963	0.185	0.000	1.57			18.7	SURCHARGED
3.000	SWMH 05	46.093	-0.282	0.000	0.12			13.8	OK
3.001	SWMH 06	46.049	0.006	0.000	1.10			12.6	SURCHARGED
1.003	SWMH 07	45.617	-0.256	0.000	0.22			28.8	OK
1.004	SWMH 08	45.362	-0.243	0.000	0.27			28.8	OK
4.000	SWMH 01	46.000	-0.375	0.000	0.00			0.0	OK
4.001	SWMH 09	45.881	-0.356	0.000	0.00			0.3	OK
4.002	SWMH 10	45.899	-0.003	0.000	1.00			12.1	OK
4.003	SWMH 11	45.677	-0.257	0.000	0.21			25.5	OK
5.000	SWMH 12	46.110	-0.040	0.000	0.87			9.9	OK
4.004	SWMH 13	45.583	-0.243	0.000	0.27			34.6	OK
4.005	SWMH 14	45.345	-0.243	0.000	0.27			33.9	OK
1.005	SWMH 15	45.301	-0.100	0.000	0.13			14.4	OK
1.006	SWMH 16	45.300	-0.028	0.000	0.08			10.3	OK
1.007	SWMH 17	45.299	0.117	0.000	0.08			9.5	FLOOD RISK
1.008	SWMH 18	45.298	0.479	0.000	0.09			1.1	FLOOD RISK

PN	US/MH Name	Level Exceeded
1.000	SWMH 01	
2.000	SWMH 02	1
1.001	SWMH 03	
1.002	SWMH 04	
3.000	SWMH 05	
3.001	SWMH 06	
1.003	SWMH 07	
1.004	SWMH 08	
4.000	SWMH 01	
4.001	SWMH 09	
4.002	SWMH 10	
4.003	SWMH 11	
5.000	SWMH 12	
4.004	SWMH 13	
4.005	SWMH 14	
1.005	SWMH 15	
1.006	SWMH 16	
1.007	SWMH 17	
1.008	SWMH 18	

6.0 Summary of Results

Several storm durations were modelled from 15 minutes to 2 days duration. The total required volume for the SUDS attenuation Basin for a 1 in 100 Year Return Period Storm + 45% Climate Change so that flooding does not occur in any part of the site is 292m^3.

It is proposed that flows leaving the developed site would be best attenuated in a wetland pond. This will be constructed to the north west of the substation. Flows from the wetland pond will be limited to 2.3 l/s by means of a hydrobrake and will discharge to a nearby watercourse.

The outgoing invert level from the pond will be set such that there will always be a minimum depth of 300mm of water in the pond. This will ensure a suitable environment for wildlife and plants. As flows pass through the wetland pond, they will get further treatment with the interaction of carefully selected plants which will assist in removing dissolved contaminates etc. The area of the pond will be 292m^2 and so during the most intense storm the water level in the pond will rise by 1000mm. This level will return back to normal in 35 hours.

All oil containing plant is located within bunded areas. Flows from bunds, where oils may be present, are firstly protected by intelligent pumping systems which will detect the presence of oil and if so, cease operation. In addition, flows from these locations will pass through an oil separator, before passing downstream.

All foul water shall be gravity drained to a 9,000 Litre cess pit which will have a high-level alarm and will require manual emptying.