Technical Appendices

Appendix 10.1: RPS Flood Risk Assessment

FLOOD RISK ASSESSMENT

ENERGY FROM WASTE FACILITY IN THE SUTTON COURTENAY RESOURCE RECOVERY PARK

April 2008

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1 Introduction

1.1 Background

RPS Planning and Development (RPS) has been commissioned by Waste Recycling Group Ltd to undertake a flood risk assessment in accordance with PPS25, to determine the impacts on flood risk of the proposed development of an Energy from Waste Facility (EfW) including infrastructure for combined heat and power (CHP), incinerated bottom ash (IBA) Plant with Outside Storage Area, Visitor & Office Accommodation and Air Pollution Control (APC) Disposal Facility within the Sutton Courtenay Resource Recovery Park. Current guidance on development and flood risk (PPS25) identifies several key aims for a development to ensure that it is sustainable in flood risk terms.

It is recognised that developments that are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. Current guidance on development and flood risk identifies several key aims for a development to ensure that it is sustainable in flood risk terms. These aims are as follows:

- the development should not be at a significant risk of flooding and should not be susceptible to damage due to flooding;
- the development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, is threatened;
- normal operation of the development should not be susceptible to disruption as a result of flooding;
- safe access to and from the development should be possible during flood events;
- the development should not increase flood risk elsewhere;
- the development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences;
- the development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk. The responsibility for any operation and maintenance required should be clearly defined;
- future users of the development should be made aware of any flood risk issues relating to the development;

- the development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues;
- the development should not lead to degradation of the environment; and
- the development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change.

The Flood Risk Assessment (FRA) is undertaken with due consideration of these sustainability aims.

The key objectives of the FRA are:

- to assess the flood risk to the proposed development and to demonstrate the feasibility of appropriately designing the development such that any residual flood risk to the development and its users would be acceptable;
- to assess the potential impact of the proposed development on flood risk elsewhere and to demonstrate the feasibility of appropriately designing the development such that the development would not increase flood risk elsewhere; and
- to satisfy the requirements of national planning policy guidance which require FRAs to be submitted in support of planning applications.

1.2 Report Structure

This FRA has the following report structure:

- Section 2 identifies the sources of information that have been consulted during the FRA;
- Section 3 describes the application area including the existing and proposed development;
- Section 4 outlines the flood risk to the existing and proposed development;
- Section 5 details the site drainage and any potential impacts of the proposed development on surface water drainage; and
- Section 6 presents a summary and conclusions.

2 Sources of Information

2.1 Sources of information

General information regarding the site setting and hydrology of the application site has been obtained from OS 1:10 000 Map for the area. The National Grid Reference of the site is 451560 193080, and the nearest post code OX14 4PG.

A location plan is shown on Drawing 1.1 and the proposed site boundary on Drawing 1.2. Drawing 4.1 shows the proposed site layout.

3 Description of the Application Area

3.1 Site Location

The site is located within the Sutton Courtenay waste management facility, situated approximately 13km to the south of Oxford. The site lies immediately to the north of Didcot power station and between the villages of Sutton Courtenay and Appleford each of which lie some 300 metres from the closest approach to the site. Didcot lies some 3.5km to the south of the site and Abingdon some 4.5 km to the north west.

The site is bordered by the B4016 to the north and the Oxford to Reading railway to the east. To the south lies the Didcot Power Station(s). The site is bisected by two private roads, running east-west and north-south.

The site area is relatively flat and surrounded by man-made and natural watercourse and water bodies of varying sizes. The natural watercourses are Mill brook to the west and Moor Ditch to the east. Drainage is generally to the north and northeast, towards the River Thames approximately 1.5km north of the site. The southern edge of the Thames Valley is marked by an Upper Greensand scarp, to the south of the application site.

3.2 Existing and Proposed Development

The site comprises a former sand and gravel quarry which has been variously reclaimed and restored through waste disposal. A processing plant is located in the northern part of the site to serve the Bridge Farm mineral reserves to the north. Active landfill takes place within the south of the site, an area which also houses landfill gas engines and open air composting. There are areas of ancillary land and road ways which serve the development.

4 Flood Risk

4.1 Potential Sources of Flooding – Level 1 Screening Study

All potential sources of flooding must be considered for any proposed development. A summary of the potential sources of flooding and a review of the potential risk posed by each source at the application site is presented in Table 4.1.

Table 4.1 Potential Risk Posed by Flooding Sources

Potential Source	Potential Flood Risk at Application Site?	Data Source
Fluvial flooding	No	**Environment Agency**
Tidal flooding	No	**Environment Agency**
Flooding from rising / high groundwater	No – none reported	**Environment Agency**
Overland flow flooding	No – none reported	**Vale of White Horse District Council**
Flooding from overloaded public sewers	No – none reported	**Thames Water**
Flooding from drainage problems associated with the site	No – none reported	**Environment Agency**

The Sutton Courtenay landfill site lies within the catchment of the River Thames, which lies approximately 1.5km north of the site boundary. Surface water runoff from the site is routed to the River Thames via either Mill Brook to the west or Moor Ditch to the east.

Fluvial and Tidal Flooding

A review of the Environment Agency's flood maps indicates that the site lies within Flood Zone 1 and therefore has a 'low probability', that is less than 1 in 1000 annual probability, of flooding in any one year. A very small part of the area of site designated for the hazardous waste cells falls into Flood Zone 2, and therefore has an annual probability of flooding between 1 in 1000 and 1 in 100. Drawing 10.1 shows the Environment Agency flood map for the area.

The Environment Agency Flood Zones and acceptable development types are explained in Table D1 of PPS25 and summarised in table 4.2 below. According to this, water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table D.2 are appropriate in this zone, while highly vulnerable uses of land are only appropriate subject to the Sequential Test being applied. The Flood Risk Vulnerability Classification in Table D2 of PPS25 'Development and Flood

Risk' shows that the proposed development is landfill and therefore classified as 'more vulnerable' (table 4.4). Therefore a sequential test is not required.

Groundwater Flooding

The Environment Agency does not have any details of groundwater levels in the area. The northern part of the site is above a major aquifer of high vulnerability, and the southern part is above a minor aquifer of high vulnerability.

Other Sources of Flooding

No other potential sources of flooding have been identified in the screening study.

4.2 Historic Flooding

The Environment Agency has confirmed that they have no records of fluvial or tidal flooding at the site, and no records of flooding due to drainage issues at the site. There are no records of anecdotal information of flooding at the site. The British Hydrological Society "Chronology of British Hydrological Event" has no records of flooding in the immediate area. No other historical records of flooding for the site have been recorded.

Table 4.2 Environment Agency Flood Zones and Appropriate Land Use (from PPS25 Table D1)

Flood Zone	Probability	Explanation	Appropriate Land use
Zone 1	Low	Less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)	All development types generally acceptable
Zone 2	Medium	Between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% 0.1%) in any year	Most development type are generally acceptable Exception test may be required
Zone 3	High	A 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year	Some development types not acceptable Exception test may be required

Note: The Flood Zones are the current best information on the extent of the extreme flood from rivers or the sea that would occur without the presence of flood defences, because these can be breached, overtopped and may not be in existence for the lifetime of the development.

Table 4.2, from PPS25, identifies that within Flood Zone 1 all development types are generally acceptable. Table 4.3, also from PPS25, indicates that all types of development are appropriate. The proposed development is classed as 'More Vulnerable' (see Table 4.4 below).

Table 4.3 Flood Risk Vulnerability and Flood Zone 'Compatibility' as identified in Table D3 of PPS25

Flood Risk Vulnerability classification (see Table D2 of PPS25)	**Essential Infrastructure**	**Water Compatible**	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**
Zone 1	Yes	Yes	Yes	Yes	Yes
Zone 2	Yes	Yes	Exception test required	Yes	Yes
Zone 3a	Exception test required	Yes	No	Exception test required	Yes
Zone 3b 'Functional Floodplain'	Exception test required	Yes	No	No	No

Key:
Yes: Development is appropriate,
No: Development should not be permitted

Table 4.4 Flood Risk Vulnerability Classification (from PPS25 Table D2)

More vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • **Landfill and sites used for waste management facilities for hazardous waste.** • Sites used for holiday or short-let caravans and camping,

4.4 Flood Defence Measures

It has been confirmed by the Environment Agency that there are no flood alleviation measures or defences in the area.

5 Site Drainage

5.1 Surface Water Drainage

It is recognised that consideration of flood issues should not be confined to the floodplain. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly flooding downstream. For example, replacing vegetated areas with roofs, roads and other paved areas can increase both the total and the peak flow of surface water runoff from the development site. Changes of land use on previously undeveloped land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage. This section considers the existing drainage system at the application site and potential impacts resulting from the proposed re-development.

5.2 Existing Drainage System

Currently all surface water from the south part of the site is collected in an existing lagoon to the east, by means of overland flow and an engineered ditch running from west to east along the north side of the access road.

5.3 Current Runoff Rate

The development of the site will result in an increase in the amount of impermeable area when compared with the current situation: the south part of the site is currently almost entirely greenfield and will increase to 11.1Ha of impermeable surface, with an estimated 33% of the site made up of buildings and hardstanding, while the hazardous cell area to the north, which is currently 5.7Ha greenfield and 10.4Ha of lake or standing water, will increase to 16.1Ha impermeable for the worst case (ie after the entire area has been capped).

5.4 Runoff Calculations

An assessment of the runoff rates has been undertaken, in order to determine the surface water attenuation requirements for the site. The assessment considers the impact of the site compared to current conditions. Therefore, the surface water attenuation requirement for the developed site can be determined and reviewed against existing arrangements.

In order to quantify any potential change in surface water runoff, the pre-application runoff rate from the site must initially be determined. The rates of runoff have been determined using the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SUDS[1]. The recommended methodology for sites up to 50 hectares in area is the Institute of Hydrology Report 124 method (IoH 124)[2]. Defra/Environment Agency recommends the IoH 124 method in their guidelines for Preliminary Rainfall Runoff Management for Developments[3]. The runoff rates have been calculated using the Micro Drainage WinDes software suite.

This has been compared in Table 5.1 to the rate of surface water runoff from the post application site, also calculated using the IoH124 method. The following parameters have been incorporated into the runoff calculations:

- Catchment Area: 50 ha;
- Standard Average Annual Rainfall (SAAR): 662mm/year;
- Soil: 0.15;
- Impermeable Areas:
    - Greenfield = 0%;
    - Pre-development = approximately 0%;
    - Post-development = approximately 54.4%;
- Region No: 6

The increase in impermeable area has been estimated using site layouts, maps of the site and aerial photographs. Using these values, the allowable runoff has been calculated as 19.0l/s.

PPS25 requires attenuation of the runoff rate following development to the pre-development rate of discharge, to take account of more intense storms in the future. Paragraph F10 of PPS25 Appendix F states that:

"The surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect".

Drainage calculations and criteria, where appropriate, should comply with the 6th edition of Sewers for Adoption. This recommends that the system should be designed not to flood any part of the site in a 1:30 year return period design storm. It also recognises that, during extreme (i.e. an event with a

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[1] Office of the Deputy Prime Minister, National SUDS Working Group, July 2004, Interim Code of Practice for sustainable drainage systems.
[2] Institute of Hydrology (1994) Flood estimation for small catchments. Report no 124.
[3] Defra/Environment Agency (2004) Preliminary Rainfall Runoff Management for Developments, Technical Report W5-074A/TR/1/Revision B.

return period of 100 years) wet weather, the capacity of surface water sewers may be inadequate, so the site layout should be such that internal property flooding does not result.

The Environment Agency require that the rate of runoff which currently discharges from the site should not increase post-development, for any event up to and including the 1 in 100 year storm event.

Thus it is proposed that the runoff from the developed site be restricted to the Greenfield 50% AEP (i.e. 19l/s) for events up to and including the 1 in 100 year return period.

5.5 Sustainable Drainage Options

Current guidance promotes sustainable water management through the use of SUDS. A hierarchy of techniques is identified:

1. **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting).
3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site).
4. **Regional Control** – management of runoff from several sites, typically in a detention pond or wetland.

It is generally accepted that the implementation of SUDS as opposed to conventional drainage systems, provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and wildlife habitat; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The attenuation volume required to restrict runoff from the developed site to the Greenfield runoff rate has been calculated using the industry standard Micro Drainage WinDes software suite. A number of alternative drainage solutions have been considered and are presented within this assessment; it is proposed that the detailed design of the final scheme would be agreed with the Environment Agency prior to the works commencing.

5.6 Attenuation Requirements Assuming no infiltration Losses

The scoping opinion requires that where appropriate infiltration rates should be worked out in accordance with BRE 365. If infiltration methods are likely to be ineffective then discharge may be appropriate. In any case the surface water strategy should clearly show that:

- Peak discharge rates from site will not increase as a result of the proposed development, up to a 1 in 100 year storm with a suitable allowance for climate change;
- Discharge volumes from the site will not increase as a result of the proposed development, up to a 1 in 100 year storm with a suitable allowance for climate change;
- The site will not flood from surface water up to a 1 in 100 year storm with a suitable allowance for climate change, or that any surface water flooding can be safely contained on site up to this event.

The attenuation volume required for the 1 in 100 year (+20% for climate change) storm event assuming no infiltration losses to the ground (e.g. through the use of a lagoon) has been determined.

The following input parameters were assumed in the calculations:

- Impermeable Area: 27.2 hectares;
- Cv (proportion of rainfall forming surface water runoff): assume a factor of 75% for the development in summer, and 84% in winter (weighted average based on proposed land use);
- Infiltration rate through base of infiltration feature: 0m/hour through the base, and 0m/hr through the sides; with 40% porosity.

The attenuation volume required to restrict runoff from the 1 in 100 year storm (+20%) storm event to the 1 in 2 year (50% probability) greenfield runoff rate of 19l/s, has been determined to be approximately 4500 m^3. The system was modelled within WinDes as an infiltration basin of porosity (ratio of voids to total volume) 0.4, and with controlled discharge via an orifice outflow control. The WinDes calculation sheets are included in the Appendices.

5.7 Attenuation lakes

Three of the lagoons proposed will be used for attenuation. It is assumed that only the two adjacent to the IBA and EFW areas respectively will be used to attenuate runoff from the south of the site, while the lagoon to the west of the hazardous waste cells will attenuate runoff from the north of the site. Their surface areas are, respectively, 4500m^2 (IBA lake), 5400 m^2 (EfW lake) and 16000 m^2 (Hazardous waste cell lagoon). The relative areas of hardstanding contributing to the total volume of runoff are 16.1 Ha (capped hazardous waste cells to the north) and 11.1 Ha (IBA and EfW plants to the south). The requirement for attenuation storage will be proportional to the impermeable areas, and is allocated between the north and south sites as shown in the table below. It is proposed that attenuation for runoff from the north site be in the lagoon adjacent to the hazardous waste cell, and that attenuation for runoff from the south site be in the remaining two lagoons.

Table 5.1 Allocation of Attenuation Storage

Site	Impermeable Area ha	Lagoon surface area m^2	Depth increase m	Attenuation Storage Provided m3
North	16.1	16000	0.94	15040
South	11.1	9900	0.94	9306
Total	27.2	25900	-	24346

The attenuation measures proposed include the following:-

- The IBA lagoon to the west of the IBA area is for rainwater and surface run off from the IBA.
- The EfW lagoon east of the EfW plant is for the surface water run-off from roads and any overflow from rainwater collected from the roof of the EfW building. (Rainwater is to be collected from the roof and stored in 200m3 underground tank to be used as process water for the flue gas treatment and top up water for the quench system for IBA. Once the tank is full, excess rainwater will be discharged into this lagoon).
- The IBA and EfW lagoons can also collect contaminated water spillage from the areas of the fly ash collection and chemical loading points
- The lagoon to the west of the Hazardous Waste Cell is designed to accept runoff from this area, once it has been capped and resurfaced, via a pipe under the road. The lagoon itself occupies 1.6ha, and flows into the Thames 1km to the north via a watercourse
- Raw / towns water connection will be required for the boiler and the fire fighting water tank.

6 Conclusions and Recommendations

RPS has been commissioned to undertake a flood risk assessment in accordance with PPS25 to determine the impacts on flood risk of the proposed development of an Energy from Waste Facility (EfW) including infrastructure for combined heat and power (CHP), incinerated bottom ash (IBA) Plant with Outside Storage Area, Visitor & Office Accommodation and Air Pollution Control (APC) Disposal Facility within the Sutton Courtenay Resource Recovery Park.

The overall aim of the study was to ascertain the level of flood risk for the site, and determine suitable mitigation measures to reduce the risk of flooding.

The FRA has demonstrated the following:

- The proposed development site falls almost entirely within Flood Zone 1, and therefore has a low probability of flooding. This has been confirmed with the Environment Agency, and flood outlines for the area have been provided.

- Due to the nature of the proposed development, it is classified as 'more vulnerable' development, and therefore this type of development is appropriate within Flood Zones 1 and 2.

- In addition, the Flood Risk Assessment has considered the potential impact of the proposed development on surface water runoff rates. Appropriate mitigation measures to attenuate runoff to the Greenfield rate have been presented.

- The attenuation volumes required to restrict the runoff to the 1 in 2 year (50% annual probability) Greenfield runoff rate of 19l/s has been determined to be approximately 24300m^3 assuming no infiltration losses. Of this, 15000 m^3 will be stored in the lagoon in the northern part of the site, and 9300 m^3 will be stored in two lakes in the southern part of the site. The three lakes have a combined surface area of 25900m^2, which results in an increase in depth of 0.94m.

- It should be noted that the calculations for attenuation storage are in accordance with Environment Agency guidelines as set out in CIRIA 697 (amongst others), which require the use of the methodology outlined in Institute of Hydrology Report 124 to calculate allowable runoff for sites less than 50 Ha in size.

Therefore this FRA demonstrates that the proposed development would be operated without being at risk from flooding or increasing flood risk elsewhere, and is compliant with the requirements of PPS25. The development should not therefore be objected to on flood risk grounds.

References

CIRIA (2004) Funders report CP/102 Development and Flood Risk – Guidance for the Construction Industry.

CIRIA C522, (2000). Sustainable Urban Drainage Systems – *design manual for England and Wales*

CIRIA C523, (2003). Sustainable urban drainage systems: *best practice manual for England, Scotland, Wales and Northern Ireland.*

CIRIA C609, (2004). Sustainable Drainage Systems

CIRIA C697, (2007). The SUDS Manual

Defra and EA (2004) Preliminary rainfall runoff management for developments. Technical report W5-074A/TR/1 rev B (Draft)

DETR (2001) Planning policy guidance (PPG 25) – development and flood risk.

EA (2006). Rainfall Runoff Management for Developments – Interim National Procedure

Institute of Hydrology (1994) Flood estimation for small catchments. Report no 124.

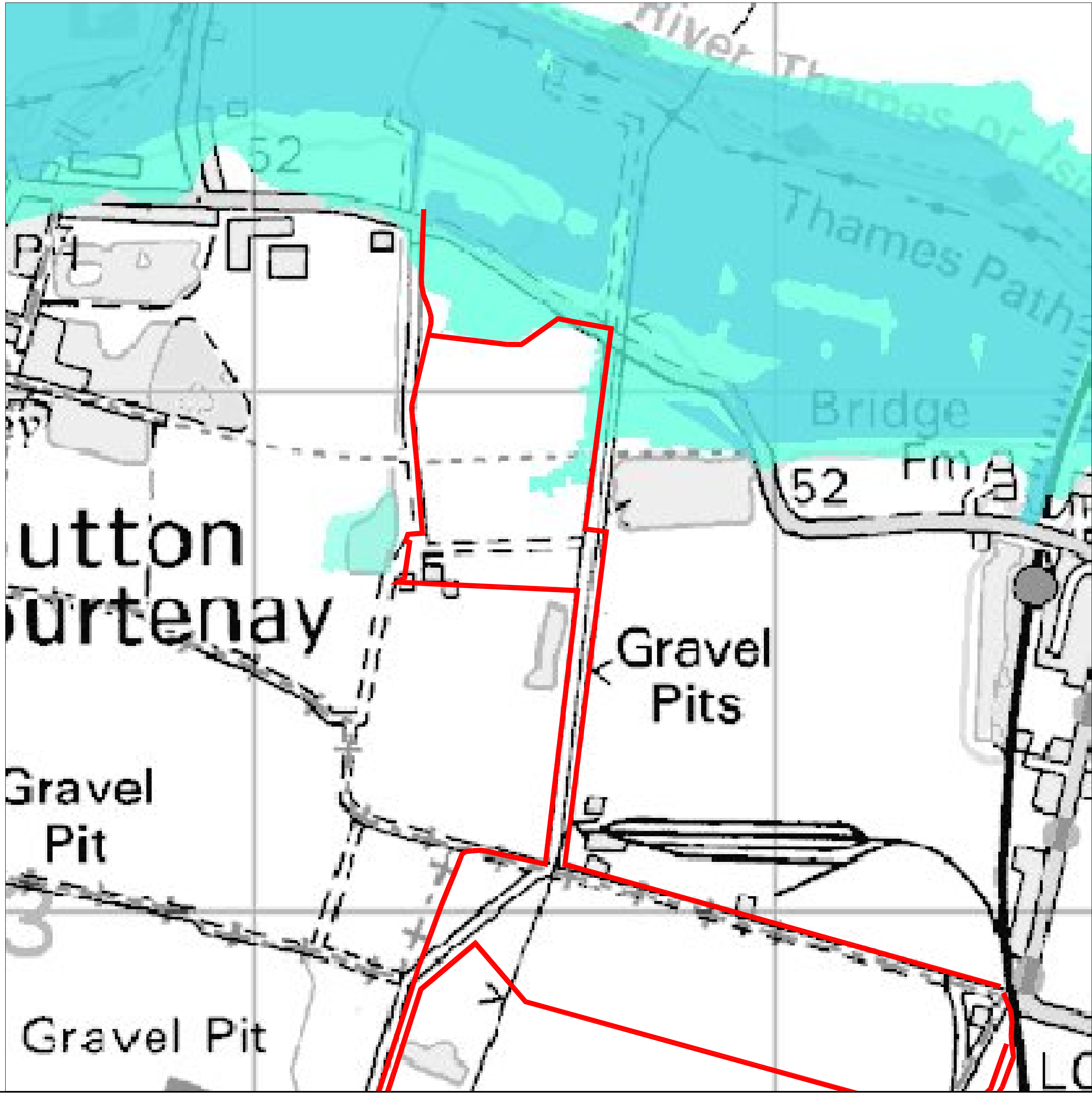
Institute of Hydrology (1999) Flood estimation handbook.

National SUDS working group (2004). Interim code of practice for sustainable drainage systems.

Office of the Deputy Prime Minister, National SUDS Working Group, July 2004, Interim Code of Practice for sustainable drainage systems.

Appendix 1

Drawings



Key

Site Boundary	
Flood Zone 1	
Flood Zone 2	
Flood Zone 3	

RPS
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PROJECT
Sutton Courtenay

TITLE
EA Flood Map

SCALE	DRAWN BY
1:12500 @ A4	MM
DATE	CHECKED
June 08	PM

CAD FILE
T:/Geo-environmental Projects/DLE1101/CAD/Figure 10.1

PROJECT NUMBER	DRAWING NUMBER	REV
DLE1101	Figure 10.1	

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Appendix 2

Calculations

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

Half Drain Time : 22 minutes

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
15 Summer	15.7	1805.6	0.0	1821.2	99.1753	1.1753	0.0	3055.1	O K
30 Summer	18.0	1805.6	0.0	1823.5	99.5317	1.5317	0.0	3982.8	O K
60 Summer	18.1	1805.6	0.0	1823.7	99.5597	1.5597	0.0	4055.2	O K
120 Summer	16.6	1805.6	0.0	1822.2	99.3147	1.3147	0.0	3417.9	O K
180 Summer	14.6	1805.6	0.0	1820.2	99.0253	1.0253	0.0	2666.1	O K
240 Summer	12.4	1805.6	0.0	1817.9	98.7498	0.7498	0.0	1949.0	O K
360 Summer	7.9	1805.6	0.0	1813.5	98.3313	0.3312	0.0	860.6	O K
480 Summer	3.2	1805.6	0.0	1808.7	98.0998	0.0998	0.0	259.1	O K
600 Summer	1.0	1688.2	0.0	1689.2	98.0468	0.0467	0.0	121.7	O K
720 Summer	0.7	1471.5	0.0	1472.2	98.0408	0.0407	0.0	106.6	O K
960 Summer	0.5	1182.6	0.0	1183.1	98.0328	0.0327	0.0	85.2	O K
1440 Summer	0.2	857.6	0.0	857.9	98.0238	0.0237	0.0	62.2	O K
2160 Summer	0.1	622.9	0.0	623.0	98.0173	0.0173	0.0	46.0	O K
2880 Summer	0.1	496.5	0.0	496.6	98.0138	0.0138	0.0	36.7	O K
4320 Summer	0.1	370.1	0.0	370.2	98.0103	0.0103	0.0	26.8	O K
5760 Summer	0.0	279.9	0.0	279.9	98.0078	0.0078	0.0	21.8	O K
7200 Summer	0.0	243.8	0.0	243.8	98.0068	0.0068	0.0	18.7	O K
8640 Summer	0.0	207.6	0.0	207.7	98.0058	0.0058	0.0	16.4	O K
10080 Summer	0.0	189.6	0.0	189.6	98.0053	0.0053	0.0	14.7	O K
15 Winter	16.6	1805.6	0.0	1822.1	99.3062	1.3062	0.0	3396.4	O K
30 Winter	19.0	1805.6	0.0	1824.5	99.6982	1.6982	0.0	4415.3	O K
60 Winter	19.0	1805.6	0.0	1824.6	99.7102	1.7102	0.0	4447.1	O K
120 Winter	16.5	1805.6	0.0	1822.1	99.2977	1.2977	0.0	3374.2	O K
180 Winter	13.2	1805.6	0.0	1818.7	98.8428	0.8428	0.0	2190.6	O K
240 Winter	9.4	1805.6	0.0	1814.9	98.4478	0.4477	0.0	1164.3	O K
360 Winter	1.1	1778.5	0.0	1779.5	98.0493	0.0493	0.0	127.5	O K
480 Winter	0.6	1417.4	0.0	1418.0	98.0393	0.0392	0.0	101.7	O K
600 Winter	0.5	1200.7	0.0	1201.2	98.0333	0.0332	0.0	86.0	O K
720 Winter	0.4	1038.2	0.0	1038.6	98.0288	0.0287	0.0	74.4	O K
960 Winter	0.2	821.5	0.0	821.8	98.0228	0.0227	0.0	59.3	O K
1440 Winter	0.1	604.9	0.0	605.0	98.0168	0.0168	0.0	43.4	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	118.42	32
30 Summer	77.75	41
60 Summer	48.61	58
120 Summer	29.35	92
180 Summer	21.56	124
240 Summer	17.21	154
360 Summer	12.50	212
480 Summer	9.96	264
600 Summer	8.35	316
720 Summer	7.22	376
960 Summer	5.74	494
1440 Summer	4.15	738
2160 Summer	2.99	1088
2880 Summer	2.37	1468
4320 Summer	1.71	2164
5760 Summer	1.35	2848
7200 Summer	1.12	3552
8640 Summer	0.97	4464
10080 Summer	0.85	5000
15 Winter	118.42	32
30 Winter	77.75	42
60 Winter	48.61	62
120 Winter	29.35	96
180 Winter	21.56	130
240 Winter	17.21	158
360 Winter	12.50	196
480 Winter	9.96	252
600 Winter	8.35	314
720 Winter	7.22	374
960 Winter	5.74	506
1440 Winter	4.15	724

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

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
2160 Winter	0.1	442.4	0.0	442.4	98.0123	0.0123	0.0	32.1	O K
2880 Winter	0.0	352.1	0.0	352.1	98.0098	0.0098	0.0	25.7	O K
4320 Winter	0.0	261.8	0.0	261.8	98.0073	0.0073	0.0	19.2	O K
5760 Winter	0.0	207.6	0.0	207.7	98.0058	0.0058	0.0	16.8	O K
7200 Winter	0.0	171.5	0.0	171.5	98.0048	0.0048	0.0	14.3	O K
8640 Winter	0.0	153.5	0.0	153.5	98.0043	0.0043	0.0	12.8	O K
10080 Winter	0.0	135.4	0.0	135.4	98.0038	0.0038	0.0	12.2	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
2160 Winter	2.99	1120
2880 Winter	2.37	1440
4320 Winter	1.71	2256
5760 Winter	1.35	2864
7200 Winter	1.12	3760
8640 Winter	0.97	4376
10080 Winter	0.85	5064

Rainfall Details

Region	ENG+WAL	Cv (Summer)	0.700	Summer Storms	Yes
Return Period (years)	100	Cv (Winter)	0.750	Winter Storms	Yes
M5-60 (mm)	20.000	Shortest Storm (mins)	15	Climate Change %	+20
Ratio-R	0.400	Longest Storm (mins)	10080		

Time / Area Diagram

Total Area (ha) = 27.200

Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)
0	4	1.000	8	12	4.000	16	20	8.000
4	8	2.000	12	16	8.000	20	24	4.200

Infiltration Basin Details

Infil Coef - Base (m/hr)	1.000000	Porosity	0.40
Infil Coef - Sides (m/hr)	0.000000	Invert Level (m)	98.000
Safety Factor	1.0	Ground Level (m)	100.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.00	6500.0	2.40	6500.0	4.80	6500.0	7.20	6500.0	9.60	6500.0
0.40	6500.0	2.80	6500.0	5.20	6500.0	7.60	6500.0	10.00	6500.0
0.80	6500.0	3.20	6500.0	5.60	6500.0	8.00	6500.0		
1.20	6500.0	3.60	6500.0	6.00	6500.0	8.40	6500.0		
1.60	6500.0	4.00	6500.0	6.40	6500.0	8.80	6500.0		
2.00	6500.0	4.40	6500.0	6.80	6500.0	9.20	6500.0		

Orifice Outflow Control

Diameter (m) 0.084 Discharge Coefficient 0.600 Invert Level (m) 98.000

Weir / Flume Overflow Control

Discharge Coef 0.544 Width (m) 10.000 Crest Level (m) 100.000

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

Half Drain Time : 15 minutes

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
15 Summer	16.0	1666.7	0.0	1682.6	98.8623	0.8623	0.0	2068.9	O K
30 Summer	18.2	1666.7	0.0	1684.9	99.1108	1.1108	0.0	2665.3	O K
60 Summer	18.1	1666.7	0.0	1684.7	99.0918	1.0918	0.0	2620.7	O K
120 Summer	15.9	1666.7	0.0	1682.6	98.8598	0.8598	0.0	2063.4	O K
180 Summer	13.3	1666.7	0.0	1679.9	98.6088	0.6088	0.0	1460.7	O K
240 Summer	10.4	1666.7	0.0	1677.0	98.3902	0.3902	0.0	936.7	O K
360 Summer	4.0	1666.7	0.0	1670.7	98.1103	0.1103	0.0	265.1	O K
480 Summer	1.0	1541.7	0.0	1542.6	98.0463	0.0462	0.0	110.9	O K
600 Summer	0.7	1308.3	0.0	1309.0	98.0393	0.0392	0.0	94.2	O K
720 Summer	0.5	1141.7	0.0	1142.2	98.0343	0.0342	0.0	82.2	O K
960 Summer	0.3	925.0	0.0	925.3	98.0278	0.0277	0.0	66.7	O K
1440 Summer	0.2	675.0	0.0	675.2	98.0203	0.0203	0.0	49.1	O K
2160 Summer	0.1	491.7	0.0	491.8	98.0148	0.0148	0.0	35.2	O K
2880 Summer	0.1	408.3	0.0	408.4	98.0123	0.0123	0.0	28.5	O K
4320 Summer	0.0	291.7	0.0	291.7	98.0088	0.0088	0.0	21.6	O K
5760 Summer	0.0	241.7	0.0	241.7	98.0073	0.0073	0.0	18.8	O K
7200 Summer	0.0	208.3	0.0	208.4	98.0063	0.0063	0.0	15.9	O K
8640 Summer	0.0	175.0	0.0	175.0	98.0053	0.0053	0.0	14.0	O K
10080 Summer	0.0	158.3	0.0	158.3	98.0048	0.0048	0.0	13.1	O K
15 Winter	17.0	1666.7	0.0	1683.6	98.9668	0.9668	0.0	2320.8	O K
30 Winter	19.3	1666.7	0.0	1685.9	99.2373	1.2373	0.0	2969.9	O K
60 Winter	18.8	1666.7	0.0	1685.5	99.1803	1.1803	0.0	2833.1	O K
120 Winter	15.2	1666.7	0.0	1681.8	98.7818	0.7818	0.0	1876.0	O K
180 Winter	10.5	1666.7	0.0	1677.1	98.3963	0.3962	0.0	950.7	O K
240 Winter	4.8	1666.7	0.0	1671.4	98.1238	0.1238	0.0	297.6	O K
360 Winter	0.7	1375.0	0.0	1375.7	98.0413	0.0412	0.0	98.4	O K
480 Winter	0.5	1108.3	0.0	1108.8	98.0333	0.0332	0.0	79.2	O K
600 Winter	0.3	925.0	0.0	925.3	98.0278	0.0277	0.0	66.7	O K
720 Winter	0.3	808.3	0.0	808.6	98.0243	0.0242	0.0	58.4	O K
960 Winter	0.2	641.7	0.0	641.8	98.0193	0.0193	0.0	46.4	O K
1440 Winter	0.1	475.0	0.0	475.1	98.0143	0.0143	0.0	34.3	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	91.24	31
30 Summer	59.40	40
60 Summer	36.97	58
120 Summer	22.34	90
180 Summer	16.46	120
240 Summer	13.19	150
360 Summer	9.64	204
480 Summer	7.71	256
600 Summer	6.48	316
720 Summer	5.62	378
960 Summer	4.49	496
1440 Summer	3.27	738
2160 Summer	2.37	1112
2880 Summer	1.89	1440
4320 Summer	1.37	2180
5760 Summer	1.09	2840
7200 Summer	0.91	3656
8640 Summer	0.79	4416
10080 Summer	0.70	4976
15 Winter	91.24	32
30 Winter	59.40	41
60 Winter	36.97	60
120 Winter	22.34	94
180 Winter	16.46	124
240 Winter	13.19	148
360 Winter	9.64	194
480 Winter	7.71	256
600 Winter	6.48	322
720 Winter	5.62	378
960 Winter	4.49	500
1440 Winter	3.27	732

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

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
2160 Winter	0.1	358.3	0.0	358.4	98.0108	0.0108	0.0	25.9	O K
2880 Winter	0.0	275.0	0.0	275.0	98.0083	0.0083	0.0	20.6	O K
4320 Winter	0.0	208.3	0.0	208.4	98.0063	0.0063	0.0	15.3	O K
5760 Winter	0.0	175.0	0.0	175.0	98.0053	0.0053	0.0	13.8	O K
7200 Winter	0.0	141.7	0.0	141.7	98.0043	0.0043	0.0	11.9	O K
8640 Winter	0.0	125.0	0.0	125.0	98.0038	0.0038	0.0	11.4	O K
10080 Winter	0.0	125.0	0.0	125.0	98.0038	0.0038	0.0	9.2	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
2160 Winter	2.37	1100
2880 Winter	1.89	1468
4320 Winter	1.37	2216
5760 Winter	1.09	2800
7200 Winter	0.91	3728
8640 Winter	0.79	4312
10080 Winter	0.70	4680

Rainfall Details

Region	ENG+WAL	Cv (Summer)	0.700	Summer Storms	Yes
Return Period (years)	30	Cv (Winter)	0.750	Winter Storms	Yes
M5-60 (mm)	20.000	Shortest Storm (mins)	15	Climate Change %	+20
Ratio-R	0.400	Longest Storm (mins)	10080		

Time / Area Diagram

Total Area (ha) = 27.200

Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)
0	4	1.000	8	12	4.000	16	20	8.000
4	8	2.000	12	16	8.000	20	24	4.200

Infiltration Basin Details

Infil Coef - Base (m/hr)	1.000000	Porosity	0.40
Infil Coef - Sides (m/hr)	0.000000	Invert Level (m)	98.000
Safety Factor	1.0	Ground Level (m)	100.000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.00	6000.0	2.40	6000.0	4.80	6000.0	7.20	6000.0	9.60	6000.0
0.40	6000.0	2.80	6000.0	5.20	6000.0	7.60	6000.0	10.00	6000.0
0.80	6000.0	3.20	6000.0	5.60	6000.0	8.00	6000.0		
1.20	6000.0	3.60	6000.0	6.00	6000.0	8.40	6000.0		
1.60	6000.0	4.00	6000.0	6.40	6000.0	8.80	6000.0		
2.00	6000.0	4.40	6000.0	6.80	6000.0	9.20	6000.0		

Orifice Outflow Control

Diameter (m) 0.092 Discharge Coefficient 0.600 Invert Level (m) 98.000

Weir / Flume Overflow Control

Discharge Coef 0.544 Width (m) 10.000 Crest Level (m) 100.000