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excellence through innovation

Plymouth Drainage Study

February 2016

R00849/VDK/Y001

Submitted by Pell Frischmann

REVISION RECORD **Report Ref:** P:\DATA\PROJINFO\E00849 K6 Y1 SCOPING\VDK PLYMOUTH DRAINAGE STRATEGY\18 ENGINEERING\12 REPORT\DRAINAGE STRATEGY REPORT\TECHNICAL REPORT\160202 PLYMOUTH OVERARCHING DRAINAGE STUDY.DOC

Rev	Description	Date	Originator	Checked	Approved
A	Draft for comments by partnership	July 2015	RS	DT	DT
B	Finalised report incorporating partnership comments	February 2016	DM/RS	TC	RS

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SOUTH WEST WATER

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1. INTRODUCTION

As part of the Plymouth Integrated Urban Drainage Modelling (IUDM) Study, a need has been identified to develop an overarching drainage study for Plymouth by the Partnership formed of:

- South West Water (SWW)
- Plymouth City Council (PCC)
- Environment Agency (EA)

The population in Plymouth is expected to grow from approximately 260,000 at present to a projected 300,000 in 2031. To support this growth, approximately 23,000 new homes and 58 Ha of employment land will be required either through redevelopment and regeneration of existing areas or development of greenfield sites over the next 15 years.

The study looks to span SWW investment cycles and PCC spatial planning cycles to guide the transition of the city away from traditional combined drainage systems towards a more separate and sustainable drainage system, where feasible. This will guide spatial planning and investment in drainage infrastructure across the city. Map 1 (Appendix A) illustrates the PCC administrative area.

1.1 AIM & OBJECTIVES

The overall aim of the study is to provide an overarching approach to delivering drainage for Plymouth. In order to deliver this aim, the following objectives have been identified:

- Identify blue/green corridors to create or supplement the existing surface water drainage system and estimate the level of capacity required. Where this is not possible, identification of new strategic surface water sewers may be the most appropriate option;
- Identify green open space that could be allocated for Regional SuDS and attenuation taking account of existing and proposed development and local topography;
- Identify the suitability of green open space for different SuDS techniques based on British Geological Survey mapping and available information on infiltration testing provided by the EA;
- Identify high level volumes of attenuation that could be located within green open space based on local topography, the need to maintain areas for amenity/recreation, infiltration rates and historical contamination. This will include an allowance for climate change based on a 100 year development lifetime.

These will help move Plymouth towards a sustainable, resilient drainage system that provides wider benefits including a reduction in flood risk from multiple sources, reduced frequency and volume of Combined Sewer Overflow (CSO) discharges that maintains and improves water quality (to both watercourses and tidal waters), reduction in pumping and treatment of surface water including the associated reduction in energy costs, and social, health and wellbeing benefits including education through multiple uses of green open space.

1.2 PARTNERSHIP RESPONSIBILITIES

The following section provides a brief overview of the main roles and responsibilities of the Partnership.

1.2.1 Environment Agency

The Environment Agency has a broad range of responsibilities including:

- managing the risk of flooding from main rivers, reservoirs, estuaries and the sea;
- regulating major industry and waste;
- treatment of contaminated land;
- water quality and resources;
- fisheries;
- inland river, estuary and harbour navigation; and
- conservation and ecology.

With regard to flood risk, the Environment Agency are a statuatory consultee within the planning process for proposed developments that fall within the criteria specified in the National Planning Policy Framework.

1.2.2 Plymouth City Council

PCC is a unitary authority and has a range of responsibilities including:

- Strategic Planning (including minerals and waste)
- Highways (including associated drainage infrastructure)
- Environmental Protection (including control of noise, pollution including the pollution permitting process, statutory nuisance, contaminated land and waste)
- Lead Local Flood Authority (managing flood risk from ordinary watercourses, surface water and groundwater)

PCC are currently developing their Local Plan that is due to replace the existing Core Strategy. This takes into account multiple factors with regard to existing and future development including drainage and flood risk. PCC are responsible for determining planning applications within their administrative area and are a statutory consultee for developments that have surface water implications.

1.2.3 South West Water

SWW is the regulated water company that provides water supply and sewerage services for the PCC administrative area. Map 3 (Appendix A) illustrates the extensive network of surface water, foul and combined sewers across the study area that fall under SWW responsibilities. In addition, SWW assets include treatment works, pumping stations, storm tanks and CSOs that are used to manage clean water supply and wastewater drainage.

The design requirements for new sewers that will become part of the public sewer network are specified within ‘Sewers for Adoption’ and typically provide protection for a 1 in 30 year return period storm (3.3% annual exceedance probability) event.

However, existing sewers may not be to a similar standard due to deterioration with age and therefore assessment of sewer capacity is typically undertaken where new development is proposed to manage future changes and identify potential capacity issues.

1.3 CURRENT PLANNING POLICY AND GUIDANCE

The following provides a brief overview of current policy and guidance that are considered to be the main drivers for the study. This includes policy at a national and local level, including the emerging Plymouth Plan and their relationship with associated guidance.

1.3.1 National Planning Policy Framework (Policy)

The National Planning Policy Framework (NPPF) provides the current planning policy for future development. The NPPF recognises that flood risk is a key factor in the decision making process when allocating new development and promotes a sequential approach for locating new development.

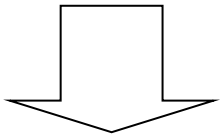
The NPPF recognises that new development could potentially increase flood risk to others, in particular, from surface water flooding due to changes in site characteristics.

1.3.2 Plymouth City Council Core Strategy / Plymouth Local Plan (Policy)

The PCC Core Strategy was adopted in 2007 and has overarching strategic objectives that are achieved through specific policies. These are the current planning policies at the local level and reflect previous national planning policy whilst considering local requirements.

PCC are currently developing their Local Plan in line with NPPF, this builds on the existing Core Strategy and takes account of development and infrastructure that has been progressed since 2007. Figure 1.1 illustrates the current and proposed strategic objectives and relevant policies that have the main influence on spatial planning for drainage and flood risk.

Current	**Core Strategy – Adopted 2007**
	Strategic Objectives
	• SO2: Delivery of the City Vision • SO11: Delivering a Sustainable Environment
	Policies
	• CS21: Flood Risk • CS24: Mineral Development • CS34: Planning Application Considerations



Proposed	**Local Plan – In consultation**
	Strategic Objectives
	• SO8: Delivering an effective spatial strategy for Plymouth
	Policies
	• Policy 3: Delivering a green city • Policy 27: Delivering Plymouth's natural network • Policy 29: Dealing with flood risk • Policy 33: Safeguarding environmental quality, function and amenity • Policy 49: Delivering Plymouth's infrastructure priorities

Figure 1.1: Existing and proposed PCC Strategic Objectives and Policies relevant to drainage and flood risk.

The transition to the Local Plan provides opportunities to identify strategic requirements for future management of surface water and integrate, where feasible, with other drivers such as future development, green infrastructure (parks, open spaces etc) to provide multiple benefits.

1.3.3 Local Flood Risk Management Strategy (Guidance)

PCC have responsibilities under the Flood and Water Management Act (F&WMA, 2010) to manage flood risk from:

a) surface runoff,
b) groundwater, and
c) ordinary watercourses.

As part of these responsibilities, PCC have developed a Local Flood Risk Management Strategy (LFRMS) that has identified the key drivers, undertaken a risk assessment, developed a partnership with key stakeholders (SWW and EA), developed a strategy that includes prioritisation of flood risk catchments based on a range of factors and how local strategies will be implemented. This study aims to build on the LFRMS and aid implementation through partnership working.

1.3.4 Plymouth Critical Drainage Area (Guidance)

The EA have identified that within Plymouth, many catchments are small, steep and heavily urbanised making them prone to 'flash' flooding during heavy rainfall events. Alongside this, the reliance on combined drainage systems and tides restricting discharge of surface water from low lying land create critical drainage problems.

A large proportion of PCC's administrative area is classified as a 'Critical Drainage Area' (CDA) (see Map 2, Appendix A). All new development is required to manage and reduce current runoff rates including sites that are previously developed. The surface water drainage hierarchy should be followed:

- Infiltration (as far as is practicable)
- Discharge to a watercourse (attenuated) or tidal waters (unattenuated)
- Discharge to a surface water sewer
- Discharge to combined sewer

All off site surface water discharge from development should mimic greenfield performance up to a maximum 1 in 10 year discharge rate. On site, all surface water should be safely managed up to the 1 in 100 inclusive of climate change conditions. This will require additional water storage areas to be created, thereby contributing to a reduction in flooding downstream.

1.4 DATA

In order to fulfil the aims of the Plymouth Drainage Strategy, this has built on existing information from a range of studies and additional spatial data provided by the Partnership (see Table 1.1).

Table 1.1: Sources of data

Data Source	Data Description
PCC	• Level 1 and Level 2 Strategic Flood Risk Assessments • Preliminary Flood Risk Assessment • Surface Water Management Plan • Local Flood Risk Management Strategy • Contaminated Land GIS Layer • Green Open Space GIS Layer • Draft Plymouth Plan • Core Strategy
EA	• Catchment Flood Management Plan • Known Infiltration Locations • Initial Strategic Sewer considerations • Critical Drainage Area information
SWW	• Sewer mapping (surface water, foul and combined + pipe dimensions) • LiDAR data • Flood Zones • Updated Flood Map for Surface Water (30 year, 100 year and 1000 year return periods)

In addition, liaison with PCC, SWW and the Environment Agency has been undertaken to utilise existing knowledge and ideas to contribute towards the formation of the overarching drainage study.

2. STUDY AREA

The study area covers the PCC administrative area (~80 km^2) and includes a mixture of urban, semi-rural and rural areas. Within the urban areas, this includes significant areas of housing, commercial and retail development alongside associated transport and green infrastructure.

The topography across the study area ranges from sea level to a maximum of height of ~155 mAOD and influences the potential sources of flood risk. Plymouth has a large frontage that is influenced by tidal and fluvial sources associated with the River Tamar, Plymouth Sound and River Plym. Map 1 (Appendix A) provides a general overview of the study area.

In addition to flood risk from tidal and fluvial sources, there is an existing risk from surface water sources including sewer exceedance causing overland flow and ponding in low lying areas. There is a potential for future development to exacerbate this risk through increased impermeable areas and increased surface water flooding combined with the effects of climate change if not managed appropriately at the planning stage.

Reliance on the existing sewer network to dispose of surface water is potentially constrained. In particular, where existing development is served predominantly by combined sewers, the ability for these systems to accept additional flows from new development is constrained. SWW are required to effectively drain to a 1 in 30 year standard and therefore have to provide this capacity, contributions towards delivering this infrastructure is collected from developers through the requisition route. Lack of capacity within the combined system also raises issues with water quality due to increased CSO spills[1].

2.1 DRAINAGE CATCHMENTS & CONSTRAINTS

Due to the topography of the study area, drainage catchments (both topographic and sewer) can be further defined to allow generalised approaches to be adopted based on the catchment characteristics.

Following a review of the LFRMS, it is noted that PCC have identified 15 catchments for the purpose of developing localised strategies taking a prioritised, risk based approach. These catchments range from 0.2 km^2 to 12 km^2 in area and include:

- Plympton Tory Brook
- Dockyard
- Pomphlett
- Marsh Mills
- Plympton Longbrook
- Sutton & Laira
- Plym Valley
- Millbay & City Centre
- Stonehouse
- Hamoaze
- Tamerton Lake
- Crownhill
- Royal William Yard
- Plympton Woodford
- Saltram

[1] These are currently being investigated within the Plymouth IUDM project alongside the Plymouth Bathing Waters Project to identify appropriate actions to reduce CSO spills in line with the National Environment Programme outcome measures.

These catchments were determined as part of the LFRMS and are based on existing Main River and Ordinary Watercourse catchments within the city boundary with additional refinement by PCC through the use of a 'rolling ball' modelling technique to identify overland surface water flow routes. Additional information for each catchment was utilised (see Section 5.3 of the LFRMS) to aid in prioritisation. Map 1 (Appendix A) provides an overview of the catchment boundaries and location.

In order to aid consistency with the PCC LFRMS and future spatial planning approach, further refinement of catchment boundaries is not considered necessary based on the available information.

2.1.1 Existing Sewer Network

Map 3 (Appendix A) provides an overview of the SWW sewer network across the study area. Based on the catchments identified by PCC, these can be further separated into sewer catchment types with where existing development is predominantly served by either predominantly combined sewers, separate foul and surface sewers or a mixture of the combined and separate systems (see Map 4, Appendix A). An analysis was undertaken of the total pipe length for each sewer type within the 15 individual catchments, this is illustrated in Table 2.1

Table 2.1: PCC catchments separated into predominant sewer type serving existing development.

	Catchment	% Foul	% Combined	% Surface
Predominantly Combined System	Millbay & City Centre	4	82	14
	Sutton & Laira	3	81	16
	Stonehouse Creek	9	67	24
	Dockyard	11	66	23
	Marsh Mills	16	56	28
Intermediate mix of combined and separate systems	Royal William Yard	25	34	41
	Pomphlett Lake	29	24	47
	Plympton Woodford	37	18	45
	Plympton Long Brook	37	17	46
Predominantly Separate System	Hamoaze	47	10	43
	Tamerton Lake	41	8	51
	Crownhill	45	5	50
	Plym Valley	43	5	52
	Plympton Tory Brook	46	4	50
	Saltram	0	0	100

2.1.2 Existing Surface Water, Fluvial and Tidal Flood Risk

It is important to understand the interaction of surface water with fluvial and tidal sources, this will aid in identifying potential capacity issues in the future. In fluvial corridors, the surface water sewer network may discharge to a watercourse and in areas adjacent to tidally influenced waters, surface water may discharge directly into estuaries or the sea. Depending on river and sea levels, these can cause 'locking' of discharge points where there is lack of sufficient head within the sewer

system to discharge water causing it to back up and potentially causing surface water flooding due to insufficient capacity.

The EA updated flood map for surface water allows identification of potential risk from surface water flooding where:

Chance	Annual Probability
High	> 1 in 30 (3.3%)
Medium	Between 1 in 30 (3.3%) and 1 in 100 (1%)
Low	Between 1 in 100 (1%) and 1 in 1000 (0.1%)
Very Low	< 1 in 1000 (0.1%)

For fluvial and tidal flooding, the EA separate indicative flood extents into three zones. These are

Fluvial

Flood Zone	Annual Probability
Flood Zone 3	> 1 in 100 (1%)
Flood Zone 2	Between 1 in 100 (1%) and 1 in 1000 (0.1%)
Flood Zone 1	< 1 in 1000 (0.1%)

Tidal

Flood Zone	Annual Probability
Flood Zone 3	> 1 in 200 (0.5%)
Flood Zone 2	Between 1 in 200 (0.5%) and 1 in 1000 (0.1%)
Flood Zone 1	< 1 in 1000 (0.1%)

Utilising these maps (see Map 5 & 6, Appendix A), potential constraints within the identified surface water corridors can be identified. These help to identify where potential capacity issues with receiving watercourses exist and reinforces the need for future development to follow the guidance provided for Critical Drainage Areas (see Section 1.3.4).

PCC maintains an Ordinary Watercourse Asset Register that records details of the asset location, type and function of the asset, outline dimensions, condition, owner, level of flood risk, designation, date of survey and a photograph of the asset. The Asset Register has been designed to be 'live' and therefore can be amended as required e.g. works are undertaken to improve asset performance. Through documenting these assets, PCC have identified 'flood critical culverts' that should they become blocked or restricted may result in property or infrastructure flooding. These are summarised in Table 2.2 and it should be noted that these only relate to ordinary watercourses, therefore a number of catchments do not have culvert location details.

Table 2.2: Culverts likely to cause flooding due to capacity issues.

Catchment	Culvert Location + notes
Marsh Mills	Finch Close – End of Finch Close
Pomphlett Lake	Haye Road – Adjacent to St George Playing Field Southgate Avenue – Between 7 & 11 Southgate Avenue Goosewell Land – Rear of 63 Goosewell Lane (Convenience Store) Southwell Close – Rear of 22 Southgate Close Furland Close – Opposite 2 Furland Close Wellhay Close – Rear of 6 Wellhay Close
Plympton Long Brook	Linketty Lane – Adjacent to 22 Linketty Lane Market Road – Opposite Hele Arms Public House Dark St Lane – Junction of Dark St Lane and Redvers Grove Longbrook St – Adjacent to Brook Inn Public House
Hamoaze	Mowhay Road – Adjacent to Mowhay Road off St Budeaux Bypass Ham Brook – Access by Mowhay Road/Ham Lane Kitto Centre – Junction of Honicknowle Lane and St Pancras Avenue Shakespear Road – Opposite 401 Honicknowle Lane St Peters Road – Opposite 67 St Peters Road (T&L Stores)
Tamerton Lake	Frontfield Road – Adjacent to 20 Southway Drive Tamerton Foliot Road – Opposite Borrowdale Close Millford Lane – Rear of Cross Wind
Crownhill	John Bull Close – adjacent to the road at first carp park on left Novorossick Road – Junction of Forder Valley Road and Novorossisk Road Leigham Mill Cottages – Junction of Forder Valley Road and Willburt Road Pendennis Close – Junction of Pendennis Close & Beaumaris Close Harlech Close – Access opposite 154 Beaumaris Close Reddington Close – Access opposite 72 Reddington Close Frogmore Avenue – In playing field off Frogmore Avenue.
Plympton Tory Brook	Borringdon Road – Rear of 7 Coles Cottages Lower Stoggy Land – Opposite 10 Kay Close Stoggy Lane – Adjacent to 65 High Glen Road
Saltram	The Ride – Adjacent to Gypsy and Travellers Site

2.1.3 Geology

At the strategic level, Table 2.3 provides a broad overview of the underlying bedrock geology based on the British Geological Survey 'Geology of Britain Viewer' at a 1:625,000 scale. In general, infiltration across Plymouth is variable with a number of areas identified by the Environment Agency as having good potential. These are based on planning applications where infiltration testing has previously been undertaken and includes Efford and an area around Derriford and the former Plymouth Airport. However, it should also be noted that these maybe constrained depending on superficial deposits and/or potential underlying contaminated land.

Table 2.3: Broad scale overview of bedrock geology in each sub-catchment

Catchments	Underlying Bedrock
Dockyard, Marsh Mills, Sutton & Laira, Plym Valley, Millbay & City Centre, Stonehouse, Hamoaze, Tamerton Lake, Crownhill, Plympton Woodford, Saltram.	Upper Devonian Rocks (undifferentiated) - Mudstone, Siltstone And Sandstone. Sedimentary Bedrock formed approximately 359 to 385 million years ago in the Devonian Period. Local environment previously dominated by lakes and lagoons.
Plympton Tory Brook, Pomphlett Lake.	Middle Devonian (undifferentiated) - Mudstone, Siltstone And Sandstone. Sedimentary Bedrock formed approximately 385 to 398 million years ago in the Devonian Period. Local environment previously dominated by rivers and alluvial fans.
Dockyard, Pomphlett Lake, Sutton & Laira, Millbay & City Centre, Royal William Yard, Slatram.	Devonian Rocks (undifferentiated) - Limestone, Mudstone And Calcareous Mudstone. Sedimentary Bedrock formed approximately 359 to 416 million years ago in the Devonian Period. Local environment previously dominated by shallow carbonate seas.
Crownhill, Hamoaze, Stonehouse, Pomphlett Lake, Plympton Long Brook, Marsh Mills.	Unnamed Extrusive Rocks, Devonian - Mafic Lava And Mafic Tuff. Igneous Bedrock formed approximately 359 to 416 million years ago in the Devonian Period. Local environment previously dominated by eruptions of silica-poor magma.
Pomphlett Lake.	Lower Devonian Rocks (undifferentiated) - Sandstone And Conglomerate, Interbedded. Sedimentary Bedrock formed approximately 398 to 416 million years ago in the Devonian Period. Local environment previously dominated by rivers and alluvial fans.

2.1.4 Contaminated Land

Historic land use, land reclamation and disposal of waste material can be a potential constraint when considering surface water management in areas of contaminated land. Depending on the type of contamination, the use of infiltration can be inhibited due to the potential spread of pollutants into the underlying groundwater and ultimately their discharge into the environment.

Across Plymouth, there is a contaminated land legacy with large areas of reclaimed land predominantly in coastal areas that were developed to provide facilities associated with either the Royal Navy or other marine businesses. These areas included associated industrial uses such as chemical works, gas works, oil storage and therefore historical contamination is likely within these locations. In addition, there are areas across Plymouth where significant amounts of fill is noted within the base of valleys. A good example of this is the infilling of Stonehouse Creek in the 1960s; previously this area had an open channel discharging into the tidally influenced creek whereas the watercourse is now wholly culverted and the infilled area used for recreation. In some areas, this is inert material and therefore considered to be a 'low' risk of contamination. However, in other areas, 'medium' to 'high' risks remain associated with heavy metals and PAHs.

Remediation and/or disposal of contaminated material provide constraints to re-use of previously developed land. Where contaminated material is not considered to be 'high' risk, there is an emphasis on leaving contamination within the land and consider more creative solutions in managing potential risk. This provides longer term sustainable benefits through the release of land for development.

2.1.5 Other Constraints

Other constraints need to be considered on a case by case basis and in liaison with other functions within the partnership groups. These constraints include but are not limited to:

- Other strategic infrastructure (highways, railways, water mains, gas, electricity, telecommunications).
- Other strategic drivers (e.g. Bathing Water Directive requirements for solutions within the short term vs longer term sustainable solutions to manage CSO spills).
- Listed buildings and structures (e.g. Quay Walls may be listed and therefore creation of surface water outfalls may not be in keeping with the listed status).
- Funding sources – both availability and timing alongside integration with future development.

3. PROPOSED DRAINAGE APPROACH

3.1 DRAINAGE CATCHMENTS

Due to the nature of development across the Plymouth administrative area, each catchment as defined within the Plymouth LFRMS (see Section 2.1) has been assessed with regard to:

- Catchment overview
- Areas of potential blue/green space
- Infiltration potential
- Existing sewer system
- Relevant city wide policies
- Sub catchment specific water drainage policies

Catchment overviews are provided within Appendix B and are accompanied with mapping that illustrates green open space and existing or potential strategic surface water corridors for management of runoff. These corridors may utilise existing surface water sewer networks that discharge into local watercourses or tidal waters and/or provide indicative locations for a new strategic surface water sewer to aid separation and reliance on the combined sewer network.

3.2 GREENFIELD RUNOFF ESTIMATION

To provide consistent, easily replicable estimates at a strategic scale, greenfield rates have been estimated utilising the UK SuDS Tools Website (http://www.uksuds.com/index.htm). The IH124 method for greenfield runoff estimates has been used, this is recommended in the Environment Agency 'Rainfall runoff management for developments'. In addition, based on the CDA guidance for Plymouth provided by the Environment Agency, all off-site discharges from developments should mimic greenfield performance up to a maximum 1 in 10 year discharge rate.

The following variables were used:

- Catchment area = 50 ha
- SAAR (Standard Average Annual Rainfall) = 1125 mm
- Soil Class = 2 (equates to a soil index value of 0.3)
- Urban Area = 0 (set to zero because calculating greenfield rate)
- Hydrological Region = 8 (South West)

Table 3.1: Greenfield runoff rates for a range of return periods for a catchment area of 50 ha.

Return Period	Growth Curve Factor	Greenfield Runoff Rates (l/s)*
QBar	1	159
1 in 1	0.78	124
1 in 10	1.49	237
1 in 30	1.95	310
1 in 100	2.43	386

* These have been rounded to nearest whole value

In order to provide an indication of greenfield runoff rates per hectare, these have been scaled and provide the following:

Table 3.2: Greenfield runoff rates per hectare for a range of return periods.

Return Period	Greenfield Runoff Rates per Hectare (l/s/ha)*
QBar	3.2
1 in 1	2.5
1 in 10	4.7
1 in 30	6.2
1 in 100	7.7

* These have been rounded to 1 decimal place

3.3 INDICATIVE ATTENUATION VOLUMES

The location and timing of future development is ongoing within the spatial planning process. In locations where infiltration is not considered feasible, attenuated surface water flows will require provision for on-site storage volumes either above or below ground prior to discharge into receiving waters. To provide consistent, easily replicable estimates at a strategic scale, storage volumes have been estimated using the UK SuDS Tools (http://www.uksuds.com/index.htm). A conservative estimate of the impermeable area that will be positively drained has been set at 80% to account for areas of potential green open space.

The 'Surface Water Storage Requirements for Sites' Tool provides estimates for the 4 elements of surface water storage, these are:

Interception Storage

This is the volume of runoff which must be prevented from leaving the site for up to the first 5mm of a rainfall event.

Attenuation Storage

This aims to limit the rate of runoff into the receiving water to similar rates of discharge to that which took place before the site was developed (i.e. greenfield runoff rate). This can be provided at one or several locations using a variety of SuDS or other storage techniques.

Long Term Storage

This is similar to attenuation storage, but aims to specifically address the additional volume of runoff caused by the development. This is either infiltrated into the ground or, if this is not possible due to soil conditions, attenuated and discharge as very low rates of flow to the receiving watercourse so as to minimise the risk of exacerbating river flooding.

Treatment Storage

This aims to ensure the water quality of the storm water is sufficiently improved to minimise its impact on the flora and fauna in the receiving water. This is normally provided as the dry period volume of one or more ponds.

Table 3.3: Indicative storage volumes for a range of site areas

Site Area (Ha)	Assumed Impermeable	Interception Storage	Attenuation Storage	Long Term Storage	Treatment Storage	Total Storage*
0.1	0.08	3.2	59.8	20.8	9.6	83.8
0.2	0.16	6.4	119.6	41.5	19.2	167.5
0.3	0.24	9.6	179.4	62.2	28.8	251.2
0.4	0.32	12.8	239.2	83.0	38.4	335.0
0.5	0.40	16.0	299.0	103.7	48.0	418.7
0.6	0.48	19.2	358.8	124.4	57.6	502.4
0.7	0.56	22.4	418.6	145.2	67.2	586.2
0.8	0.64	25.6	478.4	165.9	76.8	669.9
0.9	0.72	28.8	538.2	186.7	86.4	753.7
1.0	0.80	32.0	598.0	207.4	96.0	837.4
1.5	1.20	48.0	897.0	311.1	144	1256.1
2.0	1.60	64.0	1196.1	414.8	192	1674.9

*Total storage is the sum of the interception, attenuation and long term storage only and does not include treatment storage.

It should be noted that these are indicative only and therefore should not be used as a basis for justifying decisions on a site by site basis but provide a conservative estimate of potential storage required for future development. A number of assumptions are integral to the tool including:

- No account is taken of head-discharge characteristics of outfalls;
- A number of safety factors are built into the tool that aim to ensure that storage volumes are not under sized and the tool will provide an estimate of volume which is within 20% of that typically determined by detailed design;
- The performance and integration of different SuDS units (e.g. green/brown roofs, rainwater harvesting, areas utilising infiltration) all with their own runoff and storage characteristics will affect the actual performance of the drainage system for any site.

Further to the above, no account has been undertaken for the potential for tide locking of outfalls and the capacity of the receiving system. These will need to be understood on a site by site basis.

3.3.1 SuDS Options

Depending on the site location, underlying ground conditions, available open space and type of development, a range of options may be considered to manage surface water utilising SuDS. A significant amount of information is available on SuDS; Susdrain (www.susdrain.org) provides a comprehensive range of resources, case studies and implementation of SuDS, including the benefits of different components. Table 3.4 provides an overview of the benefits provided by the range of SuDS that could be implemented on sites and hyperlinks to these components that include schematics / photos illustrating typical features.

Table 3.4: Benefits of SuDS components

	Type of Benefit						
SuDS components	Manage Local Flood Risk	Manage Water Quality	Enhance Biodiversity	Provide Amenity / Community Opportunities	Provides Educational Opportunities	Multifunctional	Adaptable
Green Roofs	✓	✓	✓	✓	✓	✓	
Rainwater Harvesting	✓				✓	✓	
Permeable Pavements	✓	✓	✓			✓	
Other Permeable Surfaces	✓	✓	✓			✓	
Swales		✓	✓	✓	✓		
Canals, Rills and other channels		✓		✓	✓		
Filter Strips		✓					
Filter Trench		✓		✓		✓	
Bioretention Area	✓	✓	✓	✓	✓	✓	
Soakaways	✓	✓					
Infiltration Trenches	✓	✓					
Infiltration Basins	✓		✓	✓		✓	✓
Rain Gardens	✓		✓	✓	✓	✓	
Detention Basins	✓	✓	✓	✓	✓	✓	
Retention Ponds	✓	✓	✓	✓	✓		
Geocellular Drainage	✓						
Wetlands	✓	✓	✓	✓	✓	✓	✓

In addition to the information provided on the delivery of SuDS, Susdrain provides information on the retrofitting of SuDS including within the urban environment that may provide further betterment to the management of surface water drainage across Plymouth.

3.4 SURFACE WATER SEPARATION

Where opportunities exist, surface water separation should be undertaken prior to discharge into the combined sewer. A collective approach is required between PCC, SWW and the EA to avoid potential missed opportunities to provide Betterment. Figure 3.1 illustrates an example where separate foul and surface water sewer systems were implemented within the site at Tamar Wharf. However, these separate systems then discharge into the combined system, therefore significantly reducing the wider benefits to the sewer network. In addition, an opportunity to discharge surface water to tidal waters has been missed, again, reducing potential capacity and operational benefits to the wider sewer network.

Figure 3.1: Example of missed opportunity to discharge surface water to tidal waters as opposed to combined sewer system.

Integrated Urban Drainage Modelling (IUDM) studies are currently being undertaken for a number of sewerage catchments within the Plymouth administrative area. As part of this work, a high level analysis has been undertaken to identify locations where potential opportunities for surface water separation can be undertaken. This could include the provision of new strategic sewers to reduce capacity issues within the combined system. Where feasible, this approach can provide a range of benefits including:

- Reduced reliance of combined sewer network for disposal and treatment of surface water;
- Strategic surface water sewers that allow future development to connect into at restricted rates. This potentially enables future development through providing a viable means to discharge surface water;
- Potential reduction in volume and number of CSO operations.

The implementation of surface water separation and/or new strategic sewers is, in part, dependant on the location and timing of future development alongside associated funding. In some locations, quick wins can be identified, however the implementation of strategic surface water sewers will require consideration of wider opportunities and constraints.

4. FUNDING SOURCES

One of the key elements of managing existing and future drainage requirements within Plymouth is adequate funding. Inadequate funding can lead to constraints on progress and without funding schemes are unlikely to be progressed. Consideration of how funding is achieved must be given to deliver schemes now and in the future.

Funding can be sourced in various ways and the following section provides a brief overview of these. Understanding the timing and resources required to bid for available sources of funding is key to maximising the potential for securing funds from a range of sources.

4.1 FLOOD DEFENCE GRANT in AID (FDGiA)

This is Government funding provided through Defra and administered and managed by the EA via an approval process from the Regional Flood and Coastal Committees (RFCC). Historically, this has been the main source of funding for flood risk management and coastal defence schemes.

Application for funding through FDGiA has to meet strict criteria, in particular, to demonstrate that the whole life benefits exceed the whole life costs of the scheme. Projects need a strong partnership base and should investigate all possible benefits to obtain contributions from other funding sources as well. This includes ensuring that outcomes of the scheme do not just focus on the capital cost of delivery but provide wider social benefits (i.e. health, education and deprivation).

4.2 LOCAL LEVY

This is made up of contributions by Local Authorities and is used to support flood risk management projects that do not attract FDGiA funding. The Local Levy allows locally important projects to be undertaken and are more likely to attract funding where schemes can demonstrate outcomes that will aid regional priorities.

4.3 LOCAL AUTHORITY FUNDING

In addition to funding specifically available to PCC in their role as LLFA, the Council also has its own funding for capital projects and revenue programmes that may be used for flood risk management purposes. An ongoing programme of flood alleviation and drainage schemes is currently coordinated by the council.

Schemes can potentially deliver benefits across a range of the Councils responsibilities (e.g. Highways, Parks & Gardens, Regeneration). A combination of revenue, capital and additional funding can aid in the delivery of schemes that provide multiple benefits. For example, the use of SuDS can provide a wide range of benefits including the management of surface water quantity and quality, potential for groundwater recharge (through infiltration) and amenity benefits where the periphery of infiltration basins are planted to encourage insects and wildlife. These can be used for educational purposes to illustrate the integration of such features with the wider environment, therefore providing social and environmental benefits as well as a reduction in flooding (economic benefit).

The use of planning obligations and the Community Infrastructure Levy (CIL) may provide a source of funding for drainage improvements through the accrual of funds, although this cannot specifically be allocated for flooding.

4.4 LOCAL ENTERPRISE PARTNERSHIP FUNDING

Local Enterprise Partnerships (LEP) are voluntary partnerships between local authorities and businesses to help determine local economic priorities and lead economic growth and job creation within the local area. Plymouth lies within the 'Heart of the South West' LEP that was formed under the leadership of the private sector supported by the local authorities from Devon, Plymouth, Somerset and Torbay.

LEPs produce Strategic Economic Plans that focus on key priority areas. Growth Deals then provide funds to LEPs for projects that benefit the local area and economy that brings together funding from local, national and private sources.

Plymouth will benefit from Growth Deal funding for a number of projects including the enhancement of existing or provision of new infrastructure including transport improvements along the Plymouth Northern Corridor, A38 Deep Lane Sherford Access, Plymouth Eastern Corridor (potential), South Yard and a new link road between the A38 Parkway and Derriford/Seaford Barracks. The potential for securing surface water drainage improvements associated with these may be explored to maximise potential benefits through integrated thinking.

4.5 PRIVATE FUNDING

Where a private individual or company would benefit from a proposed measure, there is potential for private funding of the scheme. Their funding contribution would probably have to demonstrate a clear commercial benefit to themselves. Alternatively, sponsorship could be offered where there is a good business case and may be an effective method of securing financial support.

Whilst private sector partnerships and initiatives could be formed to promote specific schemes, these are unlikely to be viable due to potential high start-up costs, investors looking for a return on their investment and the ongoing management responsibilities of schemes.

As per section 4.4, Local Enterprise Partnerships alongside developer contributions and other funding associated with development has potential to provide funding for schemes. In particular, where significant development is proposed, contribution to upfront strategic infrastructure that enables future development is considered sustainable in the long term.

4.6 CHARITABLE TRUSTS & NON GOVERNMENT ORGANISATIONS

For relatively small local schemes, grants from charitable trusts and non-government organisations may provide a potential source of funding. These include trusts that support wildlife, communities, education, poverty (i.e. social and environmental causes) where a scheme may provide benefits to these causes.

Applications may be made to support new schemes where they may provide wider benefits.

4.7 COMMUNITY FUNDRAISING

This source of funding provides opportunities for community engagement although can be time consuming with small amounts raised. However, there are opportunities to apply for additional funding (e.g. matched funding where the amount raised by the community will be matched by another funder). This approach is typically used to raise funds for specific schemes.

4.8 OTHER SOURCES OF FUNDING

There are a range of other funding sources including public appeals, Lottery, European Union and Defra grants/pilot schemes. These have specific criteria for qualification and need to be taken into account when applying for funds for a scheme. An assessment of the likelihood of success in gaining funding and ensuring there are sufficient resources to prepare the bid should be taken into account before entering the process.

4.9 NON-FINANCIAL CONTRIBUTIONS

In some instances, contribution maybe made in other ways such as providing land, material or labour free of charge. This is an effective way of delivering a scheme with minimal cost and maybe beneficial where landowners wish to see schemes implemented.

5. SUMMARY AND RECOMMENDATIONS

This study has utilised available information provided by SWW, PCC and the EA to provide an overarching appreciation of existing drainage infrastructure and assets (including natural watercourses). To better understand existing drainage issues and constraints, the wider Plymouth area has been assessed at local catchment scale with 15 individual catchments identified in line with the LFRMS.

This has provided a high level overview of each catchment including areas of potential blue/green space, infiltration potential (including contaminated land), the existing sewer system and relevant city wide policies. In addition, indicative strategic surface water corridors have been identified that are either existing such as ordinary watercourses that currently convey surface water, or locations where a potential solution such as strategic surface water sewer could be implemented to manage existing and future surface water flows.

In order for Plymouth to sustainably manage and increase its resilience to surface water flooding over the next 50 years, continued collaborative working is required to deliver solutions that both provide short term gains and longer term benefits to health and wellbeing of residents alongside the surrounding environment.

The drainage principles provided for each catchment should be a consideration within future planning decisions. Where future development identifies that connection is required to the existing sewer system (whether it be surface or combined), it should be demonstrated that preferred options within the drainage hierarchy are not achievable (i.e. infiltration, discharge to tidal waters) prior to permitting discharge to the sewer system.

The overarching drainage study is considered to be a live document and will be updated accordingly. This maybe a result of:

- Confirmation of timescales and location of future development that allows greater certainty for the implementation of preferred approaches within each catchment;
- Identification of infrastructure upgrades (e.g. highways, sewers or flood defences) where collaborative inputs may provide multiple benefits (e.g. water quality, environment and flooding);
- Securing of funding sources where management of surface water flooding may be integrated into wider environment or public realm (e.g. Central Park Masterplan, City Centre regeneration);
- Significant flood events that may affect the prioritisation of flood alleviation schemes.

In addition, continued collaborative working and communication is required to monitor the progress of the IUD Studies and Bathing Waters Study that are being undertaken concurrently. These projects have separate drivers (National Environment Programme) and may influence short term decisions for implementation of schemes that do not always align with longer term strategic management of surface water.

6. LIMITATIONS AND UNCERTAINTIES

This report has been prepared by Pell Frischmann with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client.

The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true representative data with respect to site conditions. The information reported herein is based on the interpretation of data collected during a desk based assessment of flood risk including information held by third parties for which we cannot be held responsible. Should additional information become available that may influence the opinions expressed in this report, Pell Frischmann reserves the right to review such information and, if warranted, to alter the opinions accordingly.

The evaluation and conclusions do not preclude the existence of other site conditions which could not reasonably have been revealed at the time of writing. This report should be used for information purposes only and should not be construed as a comprehensive characterisation of all site conditions. In addition, this report has been prepared solely for the use of the client, and may not be relied upon by other parties without written consent from Pell Frischmann.

Pell Frischmann disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of work.

APPENDIX A

OVERARCHING MAPS

APPENDIX B

CATCHMENT OVERVIEWS