Appendix 10

Full Masterplan SW Drainage Strategy

NW Bicester Masterplan

Surface Water Drainage Strategy

Full Site

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A2Dominion

NW Bicester

Surface Water Drainage Strategy

Full Site MasterPlan

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CONTENTS

1 Introduction

1.1 Project Appointment

Hyder Consulting (UK) Limited (HCL) were appointed by A2Dominion to produce a surface water drainage strategy for the NW Bicester Development.

1.2 Project Context

A Drainage Strategy was produced for a small portion of the first phase of the NW Bicester Development, the Exemplar Site, in February 2011. This report sets out the proposed drainage strategy for the remainder of the wider NW Bicester site.

Since the publication of the Exemplar Site Drainage Strategy in February 2011, Planning Policy Statement 25 (PPS25)[1] has been replaced by the National Planning Policy Framework (NPPF)[2] and changes to the guidance used to assess runoff rates from developments has been implemented. This Drainage Strategy is therefore written taking this revised guidance into account.

This Surface Water Drainage Strategy will inform the Flood Risk Assessment (FRA) for the NW Bicester Site in order to meet the requirements of the NPPF which states:

'..the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water runoff, should be incorporated in a flood risk assessment.'

[1] Communities and Local Government (2010) Planning Policy Statement 25 Development and Flood Risk

[2] Communities and Local Government (2012) National Planning Policy Framework

2 Development Context

2.1 Site Description

The site of the proposed NW Bicester Development is on the north west perimeter of Bicester, Oxfordshire and has a total site area of approximately 400ha. The site is bounded by the A4095, B4100 and B4030 and bisected approximately north south by the mainline Birmingham to London Marylebone railway and Bucknell Road.

The existing site is predominantly greenfield in nature, encompassing a number of small farms and associated access. Figure 2-1 shows the site location along with key features referred to in the report. Drawing 7019-UA001881-03 in Appendix B is taken from the Exemplar Site FRA and shows the existing water features on the site in more detail.

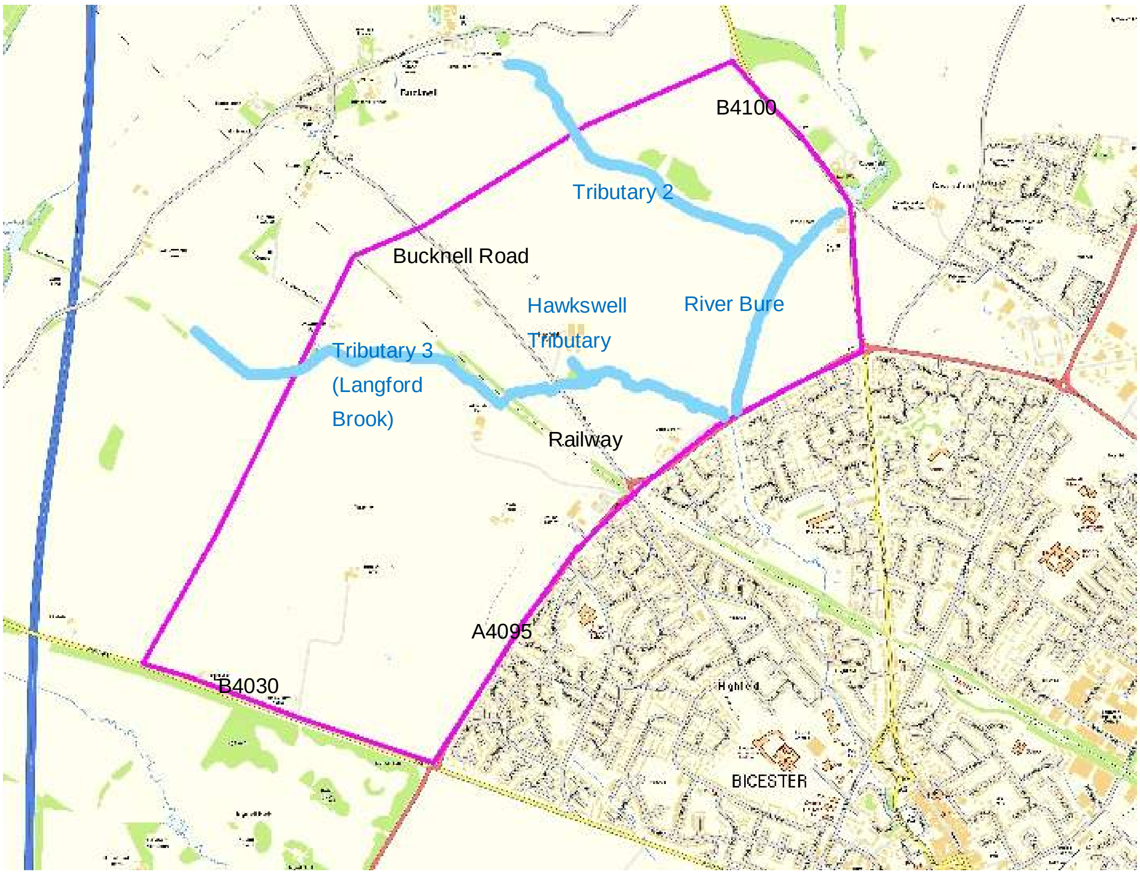

Figure 2-1 Site Location

2.2 Site Topography

The NW Bicester Site slopes predominantly from north west to south east with elevations ranging from around 97mAOD to 80mAOD. A detailed topographic survey of the site has not been completed; elevations are based on LiDAR data supplied by Environment Agency Geomatics in September 2013. The main watercourses on the site drain into the River Bure which leaves the site via a culvert under the A4095, flowing towards Bicester town centre.

2.3 Existing Drainage Features

The proposed development site contains a number of drainage features; the River Bure and its tributaries, the Langford Brook, Hawkswell Farm and unnamed tributary), field drains, ponds and springs. The main drainage features are described below.

The River Bure flows in a southerly direction from Caversfield House to a culvert beneath the A4095. Downstream of this culvert and outside the development site, the river flows in an open channel between Lucerine Avenue and Purslane Drive before flowing beneath the railway line and through Bicester town centre. The River Bure is classed as 'Main River' from Graham Road in the centre of Bicester, upstream of this point, the river is classed as 'Ordinary Watercourse'.

The Langford Brook, an ordinary watercourse, flows in an easterly direction from Crowmarsh Farm and converges with the River Bure at the A4095 culvert. A small unnamed tributary starts downstream of Hawkswell Farm and joins with Langford Brook. This tributary is referred to as the Hawkswell Tributary in this FRA. One other unnamed tributary flows in an easterly direction from Bucknell to converge with the Bure downstream of Home Farm. This tributary is referred to as Tributary 2 in this FRA.

A field drain south of Gowell Farm flows in a southerly direction to a culvert taking it under the A4095 and into the downstream urban area.

There are several ponds within the site boundaries, most notably at Crowmarsh Farm and south of Himley Farm and a spring is shown to present east of Himley Farm. In addition to these prominent water features, it is likely that a number of ditches and other smaller features drain individual fields and feed in to the network.

It is assumed that the existing properties with the site are likely to discharge runoff from roofs and paved areas to ditches or piped networks discharging to the watercourses.

Highways crossing and adjacent the site shed surface water to their grassed verges, from where it infiltrates the ground.

Information obtained from Thames Water indicates that urban areas surrounding the development site are drained by a positive drainage network of surface water pipes and manholes which discharging to nearby watercourses. The urban areas drain away from the proposed development site.

2.4 Ground Conditions

Ground conditions across the entire development site were assessed as part of the Phase 1 work carried out in 2010. A desk study report was produced[3], which drew the following conclusions:

- The majority of the existing fields are surrounded by drainage ditches 0.5m to 0.75m deep; all were dry during the July 2010 site visit
- There is a thin cover of Superficial Deposits across the site

[3] Hyder Consulting (July 2010) NW Bicester Eco-Town - Phase 1 Desk Study, 2501-UA001881-UP33R-01

- Some alluvium is present along stream corridors; this comprises sandy, calcareous clay overlying gravelly clay with limestone clasts and may locally include highly compressible, organic-rich (peaty) layers
- The Solid Geology is dominated by limestones with subordinate mudstone beds
- The site is underlain by:
  - Forest Marble in the floors and sides of the valleys. This may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude between the Cornbrash Formation and the underlying White Limestone Formation. No boreholes drilled into this formation recorded water strikes.
  - Cornbrash Formation across the majority of the site. This is a local aquifer and water strikes have been recorded in shallow boreholes drilled within the site area. The standing water levels are generally between 0.5m and 4.0m below the ground surface
- White Limestone Formation constitutes a major aquifer in the area, which provides some sources of public supply:
  - A 34m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water. Water was struck at 28m and 32m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1m above ground level (about 88m AOD) after the second strike. The yield was over 7 l/s.
  - An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11m below ground level (about 68m AOD) and it yielded 1.7 l/s. Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569

Following the desk study, a targeted, intrusive ground investigation was carried out from the 2nd August to 7th September 2010 and comprised of dynamic sampling, rotary coring and trial pitting including Standard Penetration Tests (SPTs) and permeability testing. Figure 2-2 shows the locations of the investigations carried out. These investigations drew the following conclusions:

- There was insufficient data to determine a groundwater flow direction, however it was considered that it was likely that locally it would be towards the nearest stream and regionally, down-dip towards the south-east
- Excavations for shallow foundations may encounter some groundwater flow in some areas, particularly after heavy rain. Therefore provision for pumping should be allowed for.
- The groundwater strikes within the trial pits generally coincide with the top of the limestone
- Soakaway testing was undertaken in TP7, TP11 and TP12 and TP12A within the limestone rock and indicates limited or no soakage.
- No water strikes were recorded within the Cornbrash formation or superficial deposits during drilling. Follow-up groundwater monitoring recorded groundwater standing at in excess of 3m depth on average.
- Following heavy rain, groundwater was encountered as perched water table above the limestone.

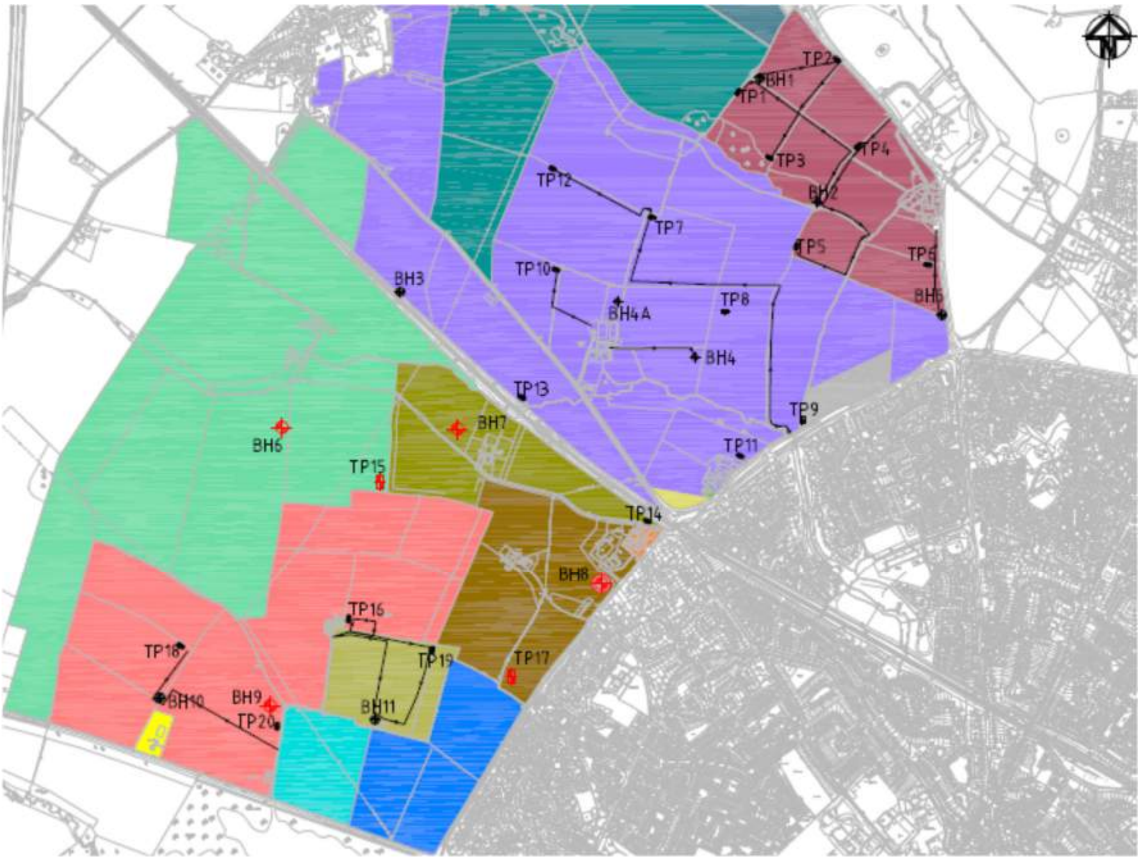

Figure 2-2 Location of Intrusive Site Investigations (taken from Hyder Consulting Report 507-UA001881-UP33R-01: Geotechnical Interpretive Report – Masterplan Site)

2.5 Development Proposals

The proposed NW Bicester Development is comprised of up to 6000 additional residential houses with associated services and infrastructure, governed by a specific Planning Policy Statement on Eco Towns[4], published as a supplement to Planning Policy Statement 1 – Delivering Sustainable Development[5]. The site will be developed sequentially over the next 30 years. The Exemplar Site, a two hectare parcel of the overall site, was granted planning permission in 2012 and construction is expected later this year with anticipated completion in 2017.

A current site MasterPlan is included in Appendix A. Residential development is distributed across the development site with areas of green space located predominantly alongside watercourse corridors. Proposals include for a new primary road access across the Langford Brook (Tributary 3), immediately downstream of the Hawkswell Tributary confluence along with a new foot and cycle crossing of Tributary 2. These proposals are in addition to the crossings associated with the Exemplar Site development.

2.6 Drainage Strategy Principles

To minimise the impact of new development on flood risk, the NPPF requires that the surface water drainage arrangements for any development site are such that the volumes and peak flow

[4] Communities and Local Government (2009) Planning Policy Statement: Eco Towns A Supplement to Planning Policy Statement 1

[5] Communities and Local Government (2005) Planning Policy Statement 1: Delivering Sustainable Development

rates leaving the site post-development are no greater than those under existing conditions. As the NW Bicester site is almost entirely greenfield in its pre development state, this Drainage Strategy is based on the principle of attenuating any additional post development runoff to equivalent greenfield rates.

3 Hydrological Assessment

3.1 Drainage Catchments

For the purposes of the hydrological assessment, the overall site of approximately 400 hectares has been divided into three main drainage catchments (A, B and C), illustrated in Figure 3-1.

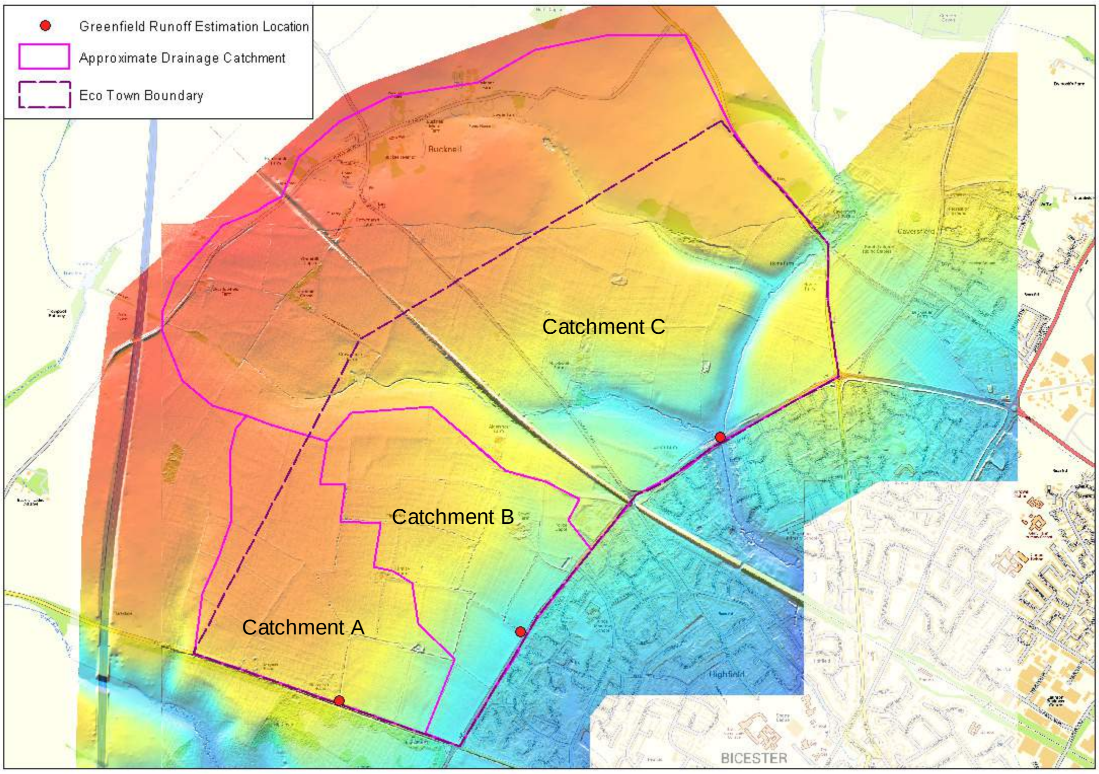

Figure 3-1 Drainage Catchments (Contains Ordnance Survey data © Crown copyright and database right (2013))

The NW Bicester site is located in the catchment of the River Bure, which at the most downstream site of interest drains a catchment area of approximately 16km^2. Catchment descriptors were extracted from the FEH CD ROM (v3) for the areas representing the three main drainage catchments (A, B and C). These descriptors are summarised in Table 3-1.

Drainage Area	SAAR[a]	BFIHOST[b]	SPRHOST[c]	DPSBAR[d]
A	630	0.961	5.5	11.2
B	629	0.959	5.6	12.3
C	639	0.945	6.7	14.2

[a] Standard average annual rainfall (mm) [b] Baseflow Index [c] Standard Percentage Runoff [d] Mean drainage path slope (m/km)

Table 3-1 Catchment Descriptors

The descriptors BFIHOST and SPRHOST are representative of the permeability of catchment soils and geology, with a high BFIHOST and a low SPRHOST value indicating a very permeable catchment.

3.2 Runoff Calculations

Based on the relatively broad scale data sets that inform the FEH, the catchment descriptors values indicate high permeability. Given the difficulties inherent in characterising the hydrological response of permeable catchment, a number of different methodologies were applied to generate comparative estimates of the greenfield runoff rate of the site as a whole. The Exemplar Site is located within drainage subcatchment C; as this site is already benefiting from detailed planning permission and has a separate approved drainage strategy, this area was removed from the runoff calculations.

3.2.1 Greenfield Runoff Rates

Three methods were applied, namely the IH124 method, the FEH Statistical method and estimates based on flows for the River Bure and its tributaries that were supplied by the Environment Agency to inform the NW Bicester Flood Risk Assessment. The results are presented in Table 3-2.

Annual Probability	IH124	FEH Statistical	EA Flows
50% (1 in 2)	2.29	0.26	1.05
20% (1 in 5)	-	0.34	1.27
3.33% (1 in 30)	5.12	0.57	2.45
1% (1 in 100)	7.29	0.84	3.37

Table 3-2 Summary of Greenfield Runoff Rates (l/s/ha)

The methods produce a range of runoff rates, with the FEH Statistical method producing the lowest rates and the IH124 method producing the highest rates. When selecting which rates to take forward, latest best practice guidelines from the Environment Agency (Flood Estimation Guidelines 197_08, June 2012) were considered.

These guidelines state that there is anecdotal evidence that the current regression equation for QMED (from Science Report SC050050), a component of the FEH Statistical method, can under or over-estimate by a long way on some permeable catchments. In addition, the advice is to avoid IH124 for greenfield runoff estimation on small catchments. In order to reduce uncertainty in greenfield runoff estimates use of gauged flow data is strongly recommended, therefore greenfield runoff rates calculated using the Environment Agency flows were adopted.

3.2.2 Storage Volumes

To estimate the volume of rainfall runoff from the three drainage catchments (A, B and C) under greenfield and post development conditions, a rainstorm with a 6 hour duration, in line with CIRIA C609 guidelines, has been simulated using the Revitalised Flood Hydrograph method (ReFH), part of the suite of Flood Estimation Handbook (FEH) techniques.

Design Rainfall can be considered as the rainfall that is predicted to fall at the site during this event, whereas the Net Rainfall refers to the 'effective' rainfall depth, after losses caused by evaporation, soil moisture retention, depression storage etc. are accounted for.

The drainage catchments A, B and C cover approximately 78 ha, 93 ha and 228 ha respectively. The current status of the land is largely undeveloped (greenfield). Development proposals are illustrated on the current version of the Masterplan (Drawing Ref 13016 (sk) 114 M) and the plan was digitised in GIS to calculate the total area in each drainage catchment that in the future will comprise built development. It has been assumed that 60% of the built development area will be covered by impermeable surfaces.

The results of the runoff volume calculations for each drainage catchment as an entirely greenfield area and in the proposed development scenario, are presented in Tables 3-3, 3-4 and 3-5. Three AEP events have been assessed (50%, 20%, 3.33% and 1% plus Climate Change allowance).

Annual Probability Event	Runoff Rate (litres/second/hectare)	
	Greenfield Site	Proposed Development
50%	1.05	3.34
20%	1.27	4.36
3.33%	2.45	7.22
1%+CC	4.05	10.61

Table 3-3 Runoff calculation results for 60% impermeable development – Drainage Catchment A

Annual Probability Event	Runoff Rate (litres/second/hectare)	
	Greenfield Site	Proposed Development
50%	1.05	3.66
20%	1.27	4.78
3.33%	2.45	7.88
1%+CC	4.05	11.53

Table 3-4 Runoff calculation results for 60% impermeable development – Drainage Catchment B

Annual Probability Event	Runoff Rate (litres/second/hectare)	
	Greenfield Site	Proposed Development
50%	1.05	2.41
20%	1.27	3.11
3.33%	2.45	5.30
1%+CC	4.05	7.97

Table 3-5 Runoff calculation results for 60% impermeable development – Drainage Catchment C

The greenfield sites are estimated to have a runoff rate at the 1%+CC AEP of 4.1 l/s/ha. This rate is relatively low and reflects the permeability of the underlying soils and geology.

3.3 Attenuation Storage Requirements

When compared to the existing greenfield scenario, an additional volume of rainfall runoff is estimated to be generated as a result of the proposed development proposals.

Attenuating discharge from the developed site to greenfield rates will require the provision of additional storage within the site to contain surface water volumes that are unable to be disposed of via ground infiltration. The estimated additional volume of rainfall runoff generated during the 1% AEP plus a 20% allowance for climate change, as a result of the development proposals is shown in Table 3-6.

Drainage Catchment	Indicative Storage Volume (m^3)
A	11,576
B	15,636
C	18,837

Table 3-6 Indicative storage volumes required to maintain 1%+CC AEP greenfield runoff rates (m^3)

4 On Site Strategy

4.1 Sustainable Drainage Systems (SuDS)

4.1.1 Techniques

Sustainable Drainage Systems (SuDS) are based on drainage techniques which mimic runoff from the site in its natural state. The aim of a SuDS based system is to manage rainwater on the surface, close to its source with the consequence that water is stored and released slowly thus reducing flood risk and improving water quality.

Examples of SuDS techniques include permeable paving, soakaways, green roofs, swales, detention basins and ponds.

The SuDS strategy for a development should follow the SuDS management or treatment train as shown in Figure 4-1.

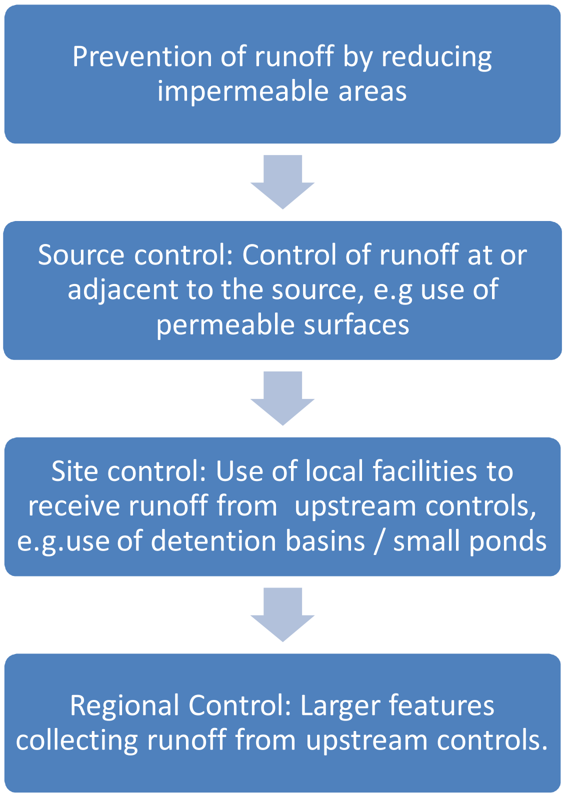

Figure 4-1 SuDS Management Train

4.1.2 Guidance

Schedule 3 of the Flood and Water Management Act 2010 provides for use of SuDS on future developments in England. As part of this, a set of National Standards for SuDS in England have been proposed. Consultation on these standards was carried out between 20th December 2011 and 13th March 2012. A summary of consultation responses was published on 13th August 2012 however, it is not anticipated that the final standards will be published until April 2014 or later this year.

In accordance with the Building Regulations (2000) Part H and the draft National SuDS Standards, surface water runoff from a new development should be disposed of via the following routes, in order of preference:

1 Discharge to the ground

2 Discharge to a surface watercourse / water body

3 Discharge to a surface water sewers

4 Discharge to a combined sewer

4.2 Site Constraints

4.2.1 Geological

The online Environment Agency maps indicate that the bedrock below the NW Bicester site is designated as a Secondary A Aquifer which is described as ‘permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers’. There are no Groundwater Source Protection Zones (SPZ) in the vicinity of the site. Consultation with Cherwell District Council has not identified any private water supply boreholes within the site boundary although four boreholes are located within 1.5km of the site boundary.

A targeted, intrusive ground investigation was carried out from the 2nd August to 7th September 2010 across the entire development site, as described in Section 2.4. The limited amount of soakaway tests carried out during this time indicated little or no soakage.

It has therefore conservatively been assumed for the current masterplan stage that infiltration based drainage is not feasible as the main method of surface water management across the NW Bicester site. Further soakaway testing is recommended during the detailed design stage to confirm the ground infiltration rates and suitability of infiltration SuDS.

The Environment Agency has also advised that the Reserved Matters applications should include further assessment of individual parcels and communal areas to assess if infiltration is possible. Detailed surface water drainage schemes should favour infiltration SuDS wherever feasible although the factors such as depth to groundwater and disposal methods from higher risk areas (such as spine roads, large car parks etc.) should be considered and it should be demonstrated that no negative impact to groundwater quality will result from the proposed surface water management scheme. This may for example require additional pollution prevention measures as part of the SuDS Management Train. The Environment Agency have confirmed that they envisage that the feasibility of infiltration SuDS, the assessment of impacts to water quality and the identification of mitigation measures can be dealt with by condition/through Reserved Matters.

4.2.2 Discharge Locations

Subcatchment A

There are no defined existing surface water discharge outlets within drainage subcatchment A although the general drainage fall is towards the south and south-east corner. Therefore following the hierarchy of disposal routes listed in Section 4.1.2, the preferred route for disposal of surface water within this subcatchment is to the existing minor watercourse and surface water outlet that is further discussed within Subcatchment B below.

Subcatchment B

A small watercourse runs close to the south eastern site boundary within Subcatchment B. This watercourse drains into the surface water sewer system on Howes Lane, opposite Dove Green. The preferred route for disposal of surface water within this subcatchment is therefore via the minor watercourse and surface water sewer system.

Subcatchment C

The River Bure and its tributaries flow through subcatchment C, therefore the preferred disposal route is into these surface watercourses.

4.3 Approach to Defining a Conceptual Strategy

4.3.1 Location of Attenuation Areas and Ponds

The overall aim is to minimise site run-off by integrating water management into the development and the surrounding environment and treating water as a resource. The SuDS Management Train provides the framework for the NW Bicester Drainage Strategy. Therefore the proposed development should first seek to reduce the amount of impermeable surfacing used within the development and secondly, where practical replace traditional hard surfacing with permeable alternatives.

Key pathways for surface water flow through the site were identified using the results from the 1% AEP plus climate change surface water modelling, described within the Flood Risk Assessment report. This enabled a series of site control measures to be identified in the form of attenuation basins and swales distributed throughout the areas highlighted for urban development in a series from the upper to lower subcatchment. Preferentially, attenuation areas were placed in locations where the model results indicate that surface water would pond naturally due to the existing topography as well as keeping the size of the attenuation areas in proportion to the developed area.

In addition, swales were preferentially located in line with corridors of green infrastructure identified on the current site MasterPlan. Where the route of a swale required a road crossing, it has been assumed that an appropriate, clear spanning crossing can be provided unless suitably sized new culvert crossing and an emergency overspill mechanism will be provided through the site detailed design process.

4.3.2 Assessment of Attenuation Volume

In line with guidance set out in the CIRIA SuDS Manual[6], maximum side slopes of 1 in 4 were applied to the detention basins and attenuation ponds. A maximum depth of 0.5m was selected primarily for safety reasons. All strategic attenuation areas should be sized to accommodate the 1% AEP with an allowance for climate change subject to the final contributing catchment size and impermeability.

[6] CIRIA (2007) C697 The SuDS Manual

Swales were assumed not to contribute to the estimated overall storage requirements and were instead designed predominantly for conveyance of surface water flows to, and between attenuation areas. This provides a conservative and robust approach to the proposed drainage strategy for the masterplanning purpose because any additional storage that is available from the swales will reduce the downstream flood risk.

Two types of swales have been proposed for this development primary and secondary. The primary swales have a base width of 1m, a maximum depth of 0.5m, giving an overall top width, and thus a land take corridor, of 5m. The secondary swales have a base width of 0.5m, a maximum depth of 0.25m and an overall top width of 2.5m. In line with the SuDS Manual both the primary and secondary swales have side slopes of 1 in 4.

Sections 4.4 to 4.6 below describe the proposed drainage strategy and attenuation storage available within each key subcatchment. Drawing 0010-UA005241-BMD-07 in Appendix E also shows a preliminary layout of the proposed SuDS features, together with the fluvial flood plain and main existing surface water flow routes. As noted on this drawing, a 20% of the required attenuation storage for each subcatchment will be provided by individual developers using source and site control measures at their individual development plots. This promotes the SuDS management train shown in Figure 4-1 and help reducing flood risk and enhancing water quality.

Therefore, the attenuation volumes presented below exclude the extra storage available at individual plot levels as well as within the proposed swales, which clearly illustrate that the proposed drainage strategy include sufficient attenuation storage.

4.4 Subcatchment A Drainage Strategy

The attenuation volume of 11,576m³ required for Subcatchment A is provided by seven attenuation areas combined with nine lengths of swale which convey water into the areas as well as passing water between as it moves through the catchment.

An 840m length of swale adjacent to the existing B4030 conveys surface water, away from the residential and business areas into an attenuation area and connecting swale network that then finally discharges into the existing outfall within the Subcatchment B.

Five detention areas are to be integrated within the residential areas, with two further areas incorporated into the allocated larger green infrastructure area to the south east.

Table 4-1 summarises the approximate plan areas and attenuation volumes of the attenuation areas shown in Figure 4-2, which indicates that up to 50% extra storage may be available from these features.

Attenuation Area ID	Plan Area (m²)	Volume of Storage Provided (m³)
PA1b	3,964	1,856
PA1b2	5,827	2,721
PA3b	3,409	1,585
PA3b2	8,124	3,870
PA3b3	9,137	4,306
PA4b	3,740	1,707

PA4b2	3,012	1,381
TOTAL		**17,426**

Table 4-1 Subcatchment A Attenuation Areas

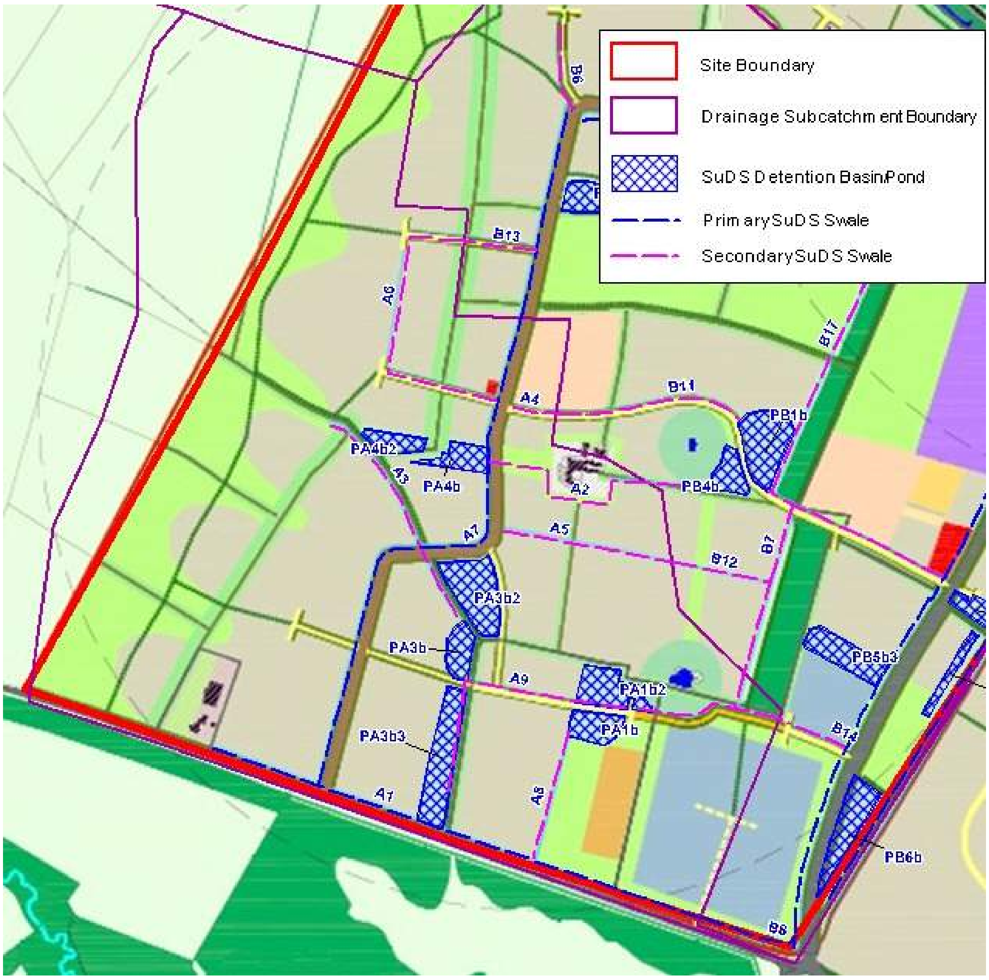

Figure 4-2 Drainage Catchment A SuDS Features

4.5 Subcatchment B Drainage Strategy

The attenuation volume of 15,636m³ required for Subcatchment B is provided by nine attenuation areas linked with swales. There are two key flow routes through Subcatchment B and the attenuation areas and swales follow these flow routes in order to replicate as closely as possible the natural flow pathways.

The existing drainage ditch running parallel to Howes Lane is to be retained and enhanced to convey additional surface water flows south west towards a final attenuation area and existing outlet. This attenuation area will discharge to the surface water sewer system via the existing outfall, shown in Figure 4-3.

Figure 4-3 Existing Outfall under Howes Lane

A significant drainage route currently exists on the parcel of land to be developed as a secondary school and it is proposed that the use of SuDS to convey this water safely and sustainably around and downstream of this area should be integral to the school layout, ensuring that sustainable management of surface water is brought to the fore. Attenuation areas upstream of the school site and intercepting interconnecting swales will also assist in reducing the runoff rates and volumes reaching the school site. A series of interconnected swales convey the water into the final attenuation area described above, and into the surface water sewer system via the existing outfall shown on Figure 4-3 above.

Table 4-2 summarises the plan areas and attenuation volumes of the attenuation areas shown in Figure 4-4 which indicates that up to 20% extra storage may be available from these features.

Attenuation Area ID	Plan Area (m^2)	Volume of Storage Provided (m^3)
PB1b	7,863	3,755
PB2b	4,065	1,915
PB4b	3,187	1,476
PB5b	2,167	916
PB5b2	2,554	1,160
PB5b3	5,709	2,679
PB6b	6,608	3,074
PB7b	5,223	2,465
PB8b	3,926	1,840
TOTAL		**19,280**

Table 4-2 Subcatchment B Attenuation Areas

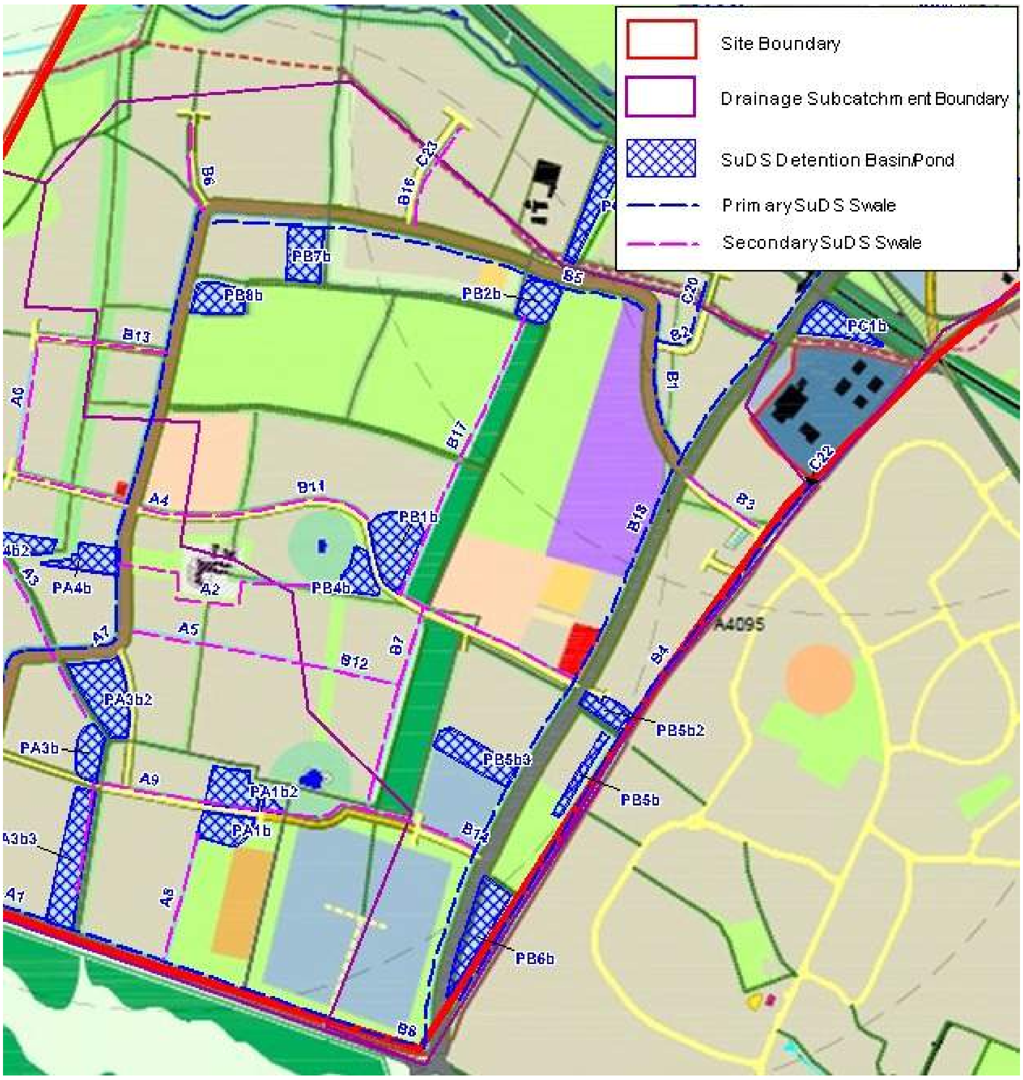

Figure 4-4 Drainage Catchment B SuDS Features

4.6 Subcatchment C Drainage Strategy

The attenuation volume of 18,837m³ required for Subcatchment C is provided by ten attenuation areas. The majority of the subcatchment drains south into Tributary 3 and the Hawkswell Stream with the remainder draining into Tributary 2. Poor quality DTM on the northern portion of this subcatchment has resulted in a poor definition of surface water flow paths consequently making it a little challenging to fully identify locations for attenuation areas and swales.

Two key flow pathways through the Malins residential area / commercial area H3 into Tributary 3 and Hawkswell Stream are served by two individual trains of ponds and swales to be integrated into the urban development areas.

In general, attenuation features have been integrated adjacent to the existing watercourses within suitable downstream locations of this subcatchment.

Table 4-3 summarises the plan areas and attenuation volumes of the attenuation areas shown in Figure 4-5.

Attenuation Area ID	Plan Area (m²)	Volume of Storage Provided (m³)
PC1b	4,326	1,996
PC3b	4,976	2,268
PC4b	2,317	1,059
PC4b2	4,659	2,203
PC5b	4,352	2,043
PC5b2	6,744	3,211
PC6b	3,665	1,713
PC6b2	3,500	1,643
PC7b	4,389	2,053
PC8b	3,325	1,535
TOTAL		**19,723**

Table 4-3 Subcatchment C Attenuation Areas

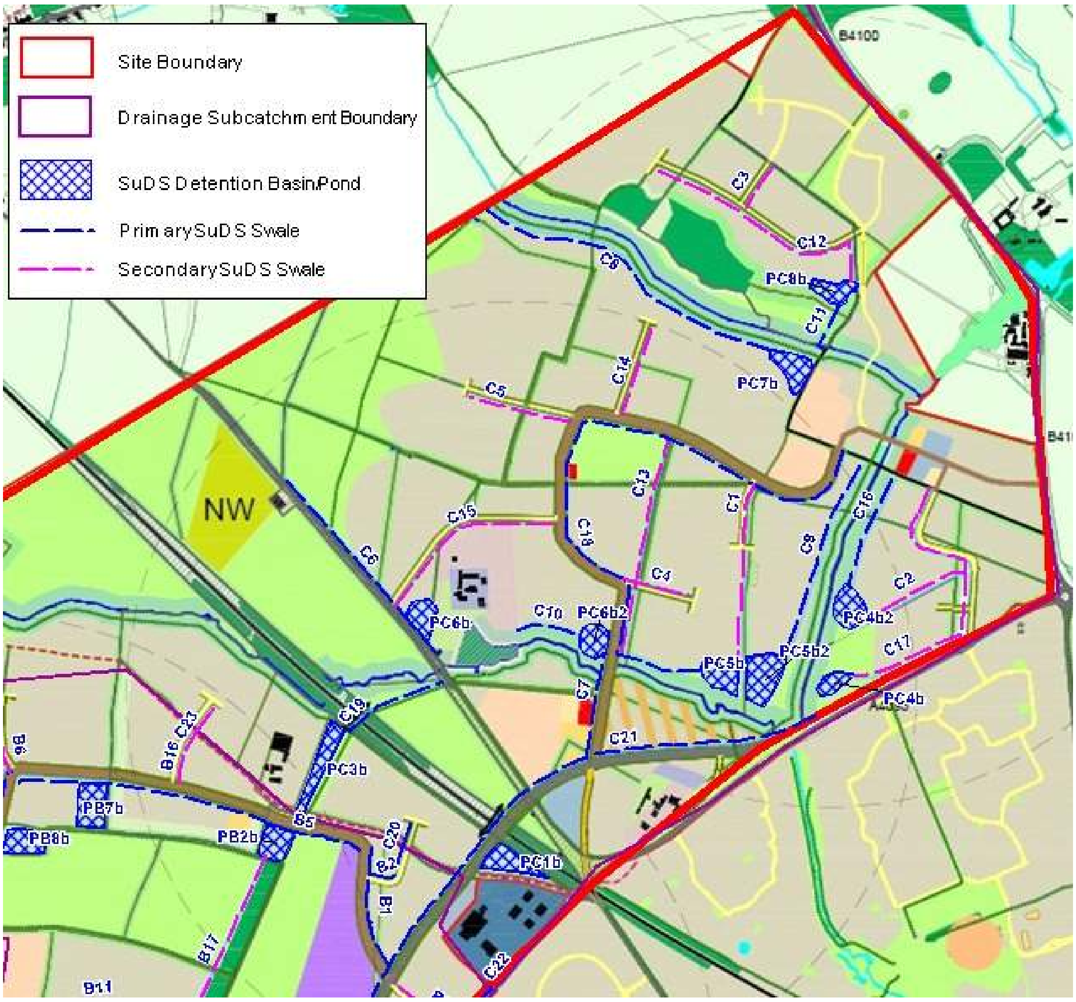

Figure 4-5 Drainage Catchment C SuDS Features

4.7 Water Quality and Ecology

As well as control of runoff rates and volumes, managing storm water above ground using SuDS provides additional water quality and ecology benefits.

Source control measures are also required to prevent discharge to the receiving watercourses from the first 5mm of any rainfall event thus ensuring that the initial flush of pollutants is contained within the SuDS feature. It is generally recommended for residential developments that that there are at least two treatment stages using SuDS prior to discharge into a receiving watercourse. As discussed in sections above the proposed drainage strategy will include a series of source, site and regional control measures involving more the recommended two minimum treatment stages prior to reaching the final outfalls. This will clearly help enhancing the existing water quality and ecology in the receiving watercourses.

The current ecological quality status and predicted ecological quality status in 2015 for the River Bure downstream of Bicester Eco Town are classified as moderate under the Environment Agency River Basin Management Plan.

4.8 Maintenance and Adoption of SuDS

It is essential that sufficient consideration is given to the adoption and maintenance of any SuDS features from the outset, in order to ensure their long-term maintenance and performance. Therefore, the proposed drainage strategy has been developed to enable easy maintenance access and simple operation of the SuDS features according to the current guidance and best practice. The main attenuation areas are incorporated within the green infrastructure. Similarly, the swales are located along the access roads or green infrastructure corridors. All SuDS features will have shallow side slopes and depths to ensure safe operation and easy maintenance in accordance with CIRIA SUDS Manual.

The Flood and Water Management Act 2010 (FWMA) introduces the concept of a SuDS Approving Body (SAB), to be constituted by unitary authorities or county councils (LLFAs). This is likely to be Oxfordshire County Council (OCC) in this instance when the SAB role is formally launched by Defra and therefore further consultation and engagement with OCC is essential prior to detailed design to establish the key requirements for SuDS maintenance and adoption. This should process should start prior to the outline planning application and then continue through to detailed design and site construction.

The role of a local SAB will be to approve local SuDS applications where construction work will have implications for the existing drainage system. They will apply strict standards that will achieve benefits for water quality as well as flood management. The SAB also has a duty to adopt SuDS providing they are constructed in accordance with the approved proposals and the system functions accordingly. As part of the approval process, the SAB can require a non-performance bond to be paid which would be refunded in full once the work was completed to the satisfaction of the approving body. The FWMA also enables SABs to devolve the responsibility of SuDS adoption to other organisations such as land owners or management companies on the condition that all partners are in agreement.

The involvement of SAB will ensure that the proposed ownership responsibilities are suitable and, in particular, that the responsibility for SuDS serving more than one property rests with an organisation that is both durable and accountable.

In December 2011, Defra published draft national standards for the design, operation and maintenance of SuDS which set out the national criteria on which the type of drainage appropriate to any given site or development can be determined. The final publication date of the standards is expected in April 2014 or later this year.

If OCC or SAB are unable to adopt all SuDS features for any reason, a management company or trust should be appointed to undertake long-term maintenance of the system.

It is essential that the key SuDS facilities (e.g. strategic attenuation areas and flow conveyance routes to these) are constructed ahead of the site construction commencement to ensure that flood risk is not increased from a potential flood event during the construction stage. A development phasing plan is currently not available to establish how this should be done. Therefore, it is recommended that a suitable SuDS phasing plan is also prepared along with a maintenance plan during the detailed design stage.

4.9 Designing for Exceedence

It is not economically viable or sustainable to build a drainage system that can accommodate the most extreme events. Consequently, the capacity of the drainage system may be exceeded on rare occasions, with excess water flowing above ground. However, the design of the site layout provides an opportunity to manage this exceedance flow and ensure that indiscriminate flooding of property does not occur.

Therefore, as part of the detailed design of the proposed development, sufficient flood pathways (roads/footpaths/green infrastructure buffer zones) should be identified to ensure that this overland flow is safely routed away from buildings into the proposed SuDS network. The design and construction of the development should also ensure that there are no significant low spots on the site, where unplanned ponding of water could occur and threaten buildings nearby. Additional built in capacity is already provided within the proposed SuDS system but the current volumes should be checked based on the exact development area that is draining into these attenuation facilities and sufficient emergency overflow mechanisms should also be provided through the detailed design process.

As mentioned previously, SuDS network have been located so that they mainly follow the existing key overland rotes based on pre-development ground levels. This will naturally encourage containing the exceedance flows within the proposed SuDS system. However, key existing overland flow routes should also be modelled and reviewed during the detailed design stage once the proposed ground levels and SuDS features are better defined so that the key flow routes are fully intercepted and/or directed to the proposed system without increasing flood risk to the proposed development.

5 Conclusions and Recommendations

The proposed surface water drainage strategy includes a preliminary layout of the proposed SuDS features and available attenuation storage, whilst giving due consideration to the fluvial flood plain and main existing surface water flow routes. The proposed strategic SuDS system will provide significantly more than the required volumes to fully attenuate the runoff for a 1% Annual Exceedance Event plus climate change allowance. A further 20% of the required attenuation storage will be provided by individual developers using source and site control measures at their individual development plots.

Proposed system will also include well in excess of the recommended minimum two treatment stages to address water quality considerations associated with residential developments. Therefore the proposed surface water strategy will help reduce flood risk and enhancing water quality and ecology.

The proposed drainage strategy has been developed to enable easy maintenance access and simple and safe operation of the SuDS features according to the current guidance and best practice. The proposed surface water drainage strategy (including adoption and maintenance responsibilities of SuDS features) should be further consulted by the key parties and implemented to ensure that the post development runoff rates and volumes are no greater than the pre-development rates. It is also recommended that a suitable SuDS phasing plan is prepared along with a maintenance plan during the detailed design stage

Key existing overland flow routes should also be modelled and reviewed during the detailed design stage once the proposed ground levels and SuDS features are better defined so that the key flow routes are fully intercepted and/or directed to the proposed system without increasing flood risk to the proposed development. As part of this process, the exact development area draining into each attenuation facility should be defined so that the corresponding attenuation storage for 1% Annual Exceedance Probability event (with climate change allowance) is provided without causing flood risk to the properties.

Further soakaway testing is recommended during the detailed design stage to confirm the ground infiltration rates and feasibility of infiltration based SuDS measures. The Reserved Matters applications should include further assessment of individual parcels and communal areas to assess if infiltration is possible. Detailed surface water drainage schemes should favour infiltration SuDS wherever feasible although the factors such as depth to groundwater and disposal methods from higher risk areas (such as spine roads, large car parks etc.) should be considered and it should be demonstrated that no negative impact to groundwater quality will result from the proposed surface water management scheme.

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Appendix 11

Full Masterplan Water Cycle Strategy

NW Bicester Masterplan

Water Cycle Study

Detailed Report

north west bicester | a2dominion

THINKING ABOUT TOMORROW

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A2Dominion

NW Bicester Masterplan

Water Cycle Study

Detailed Report

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CONTENTS

GLOSSARY AND KEY TERMS

Acronym	Term
Amm. N	Ammoniacal Nitrogen
AMP	Asset Management Period
AMR	Annual Monitoring Report
AoD	Above Ordnance Datum
ASP	Activated Sludge Process
BAP/ (L)BAP	(Local) Biodiversity Action Plan
BOD	Biochemical Oxygen Demand
BRE	Building Research Establishment (Group)
BREEAM	BRE Environmental Assessment Method
CAMS	Catchment Abstraction Management Strategy
CDC	Cherwell District Council
CSH	Code for Sustainable Homes
Defra	Department for Environment, Food and Rural Affairs
DSR	Distribution Service Reservoir
DWF	Dry Weather Flow
DWI	Drinking Water Inspectorate
EA	Environment Agency
FTFT	Flow to Full Treatment
GEP	Good Ecological Potential
GWR	Greywater recycling
HD	Habitats Directive
HMWB	Heavily Modified Water Body
l/p/d	Litres per Person per Day
MBR	Membrane Bioreactor
NE	Natural England
NWB	North West Bicester
OFWAT	The Water Services Regulation Authority
ORS	Old Red Sandstone
P	Phosphorous
PCC	Per Capita Consumption
PE	Population Equivalent
PPS	Planning Policy Statement
PR09/ 14	Price Review 2009/ 2014
PZ	Planning Zone
RBMP	River Basin Management Plan
RQP	River Quality Planning (Tool)
RSPB	Royal Society for the Protection of Birds
RWH	Rainwater Harvesting
SPS	Sewage Pumping Station
SRP	Soluble Reactive Phosphorus
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
TWUL	Thames Water Utilities Ltd
UKTAG	United Kingdom Technical Advisory Group
WCS	Water Cycle Study
WFD	Water Framework Directive
WRMP	Water Resource Management Plan
WRZ	Water Resource Zone
WwTW	Wastewater Treatment Works

1 INTRODUCTION AND OVERVIEW

Hyder Consulting Limited were appointed by A2Dominion in May 2013 to produce a Detailed Water Cycle Strategy (WCS) for NW Bicester.

The masterplan and related documents set out spatial vision to provide up to 6000 new homes at NW Bicester. The Water Cycle Strategy sets out the analysis, assessment and justification for the approach to the delivery of key water related infrastructure.

1.1 Development context

NW Bicester is being promoted as a site for up to 6000 new homes, after previously being identified as an Eco-town location within the Planning Policy Statement 1 supplement, entitled Eco-Towns A Supplement to Planning Policy Statement 1 (July 2009) (PPS 1 Supplement).

In addition, the development proposal includes non-residential areas comprising commercial floorspace, leisure facilities and social and community facilities.

Planning permission was secured for the Exemplar stage of the development in 2012. The Exemplar stage comprises 393 dwellings. Development of this part of the site is anticipated to commence in 2014.

1.2 The role of this document

This strategy is one of a number of documents prepared on behalf of A2Dominion in support of the masterplan plan. The Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1 (July 2009) requires the preparation and submission of a master plan to demonstrate the eco town standards, as set out in the PPS1 supplement, will be addressed.

The master plan will therefore provide the context for the formulation and preparation of subsequent planning applications. It is open to the Council to adopt the master plan for development control purposes.

The purpose of the WCS is to assess the impact that the proposed development will have on water demand, demonstrate that the development will not result in a deterioration in the status of any surface waters or ground-waters affected by the NW Bicester development, identify the proposed water and wastewater infrastructure improvements required, and set out proposed measures for improving water quality and avoiding surface water flooding from surface water, groundwater and local watercourses.

1.3 Planning policy

NW Bicester (NWB) is identified in the supplement to PPS1 entitled 'The Planning Policy Statement: Eco-Towns A Supplement to Planning Policy Statement 1' (July 2009) as one of four locations for an Eco Town. The principle of the development is supported by Cherwell District Council ('the Council') and the land to the north west of Bicester ('the Site') is identified in the emerging Local Plan as the area within which a development following eco-town principles and the standards in PPS1 Supplement could be developed.

Policy ET 17.5 of the PPS1 Supplement states that the development should aspire towards water neutrality. The current definition of water neutrality accepted by the EA[1] is that:

"For every new development, total water use across the wider area after the development must be equal to or less than total water use across the wider area before the development".

It is anticipated that the current Government will cancel the current PPS Supplement in due course. Notwithstanding, the requirements of the Supplement to PPS1 will be carried over by Cherwell (subject to review and amendments as necessary) into the Local Plan. The Council has already set out its policy position in respect of NWB in the emerging Local Plan and granted planning permission for the Exemplar Phase of NWB for 393 new homes, local facilities and land for a primary school.

1.4 Stakeholders

The development of the Scoping and Outline WCS, and this Detailed WCS, has involved consultation with the following stakeholders:

- Thames Water Utilities (TWU);
- Environment Agency (EA);
- Natural England (NE);
- Cherwell District Council (CDC); and
- Oxfordshire County Council.

1.5 Previous study

Hyder produced a Scoping and Outline WCS in April 2011, for the initial 393 home Exemplar site and 5,000 additional homes, which concluded the following:

1.5.1 Water resources and supply

- The area is considered to be an area of serious water-stress, with the statutory water undertaker for the area – TWUL, predicting supply demand deficits in the area from 2014 onwards, and requiring additional resource development in the future to address this deficit;
- It is expected that no new surface water abstraction would be granted for the development, although existing licences in the area may potentially be upgraded, subject to further investigation;
- The potential of providing an onsite water supply for the development from groundwater sources should be considered further; and
- Water efficiency measures in new properties (and potentially retrofitted in the surrounding area) should be explored further for the development, as should local water reuse, to allow the development to aspire towards water neutrality.

1.5.2 Wastewater collection, treatment and discharge

- The receiving watercourses are at risk of failing Water Framework Directive (WFD) standards due to phosphate and nitrate concentrations, which could potentially be exacerbated by further effluent discharge
- Foul water infrastructure is potentially at capacity and may require improvement – a range of feasible options were identified including:

- Pump foul water from the development to the existing Bicester Wastewater Treatment Works (WwTW) operated by TWUL, which would require upgraded to process/hydraulic capacity;
- Construct a new WwTW on site to locally treat and discharge foul water to the Town Brook (River Bure), or locally to new constructed wetlands (for potential abstraction and reuse);
- Reduce the impact on the new or existing WwTW by the separation of greywater (from showers, baths and wash/ hand basins) in to a separate sewerage system, to be treated on the development for reuse; or
- Incorporate property level greywater recycling (GWR) systems in to the development to reduce the impact on the new or existing WwTW, and provide a local source of non-potable water.

1.5.3 Surface water

- The widespread use of Sustainable Drainage Systems (SuDS) and water harvesting should be explored to provide sustainable storm water management, and create a sustainable resource from rainfall; and
- The use of SuDS would allow the creation of new wildlife spaces incorporating wetlands, ponds and a variety of vegetation, creating valuable open amenity areas whilst enhancing the local water environment.

1.6 Detailed WCS objectives

The objectives of this Detailed WCS can be summarised as follows:

- Investigate the conclusions and recommendations from the above, in light of emerging development plans, updated stakeholder data and industry developments;
- Assess potential solutions to reduce potable water demand and make alternative resources available, which could be used to move the development site towards water neutrality;
- Work closely with the stakeholders and service providers to assess the options for wastewater treatment, and confirm the necessary water quality standards to protect the receiving water environment and comply with legislation;
- Identify possibilities to link the management of surface water drainage with the above solutions, and the amenity and ecological benefits that can be realised from such strategies;
- Assess to what extent the above solutions would be viable and sustainable when considered in conjunction with other development in the Bicester area; and
- Provide transparent and evidence based advice to A2Dominion and CDC; representing the stakeholders' views as to the feasibility, viability and sustainability of the potential water and wastewater solutions available, to support the development masterplan and allow robust decision making through the planning process.

Notably, Hyder are also preparing a Surface Water Drainage Strategy in parallel to this Detailed WCS. For this reason, this Detailed WCS scope only includes flooding and surface water considerations where a potential link exists with water supply, and wastewater collection and treatment. The details of Surface Water Drainage Strategy are presented within Appendix E of the Flood Risk Assessment Report prepared by Hyder for the NW Bicester Development and therefore these details are not repeated here.

1.7 Water infrastructure delivery

1.7.1 Conventional funding

Conventional provision of water supply, and wastewater collection/ treatment infrastructure in the Bicester area is via the statutory water/ wastewater undertaker (TWUL), under the provisions of the Water Industry Act 1991.

TWUL have a duty to supply potable water to customers under Section 52 of the Act, and are hence obliged to connect developments to the network once planning permission has been received. The EA use the provisions of the Act, and their powers under the Water Resources Act 1991 to regulate how much water TWUL can abstract from the environment, by granting abstraction licenses.

In addition, TWUL have a duty to provide and maintain a system of public sewers under Section 94 of the Water Industry Act. The EA use the provisions of the Water Resources Act 1991, and Urban Wastewater Treatment Directive, to control the quality and quantity of effluent discharged from WwTW.

The investment plans of TWUL are based on a five-year cycle, known as Asset Management Periods (AMPs). In general, funding for the maintenance of the existing supply demand balance and the potable water network (including the provision of new strategic infrastructure) comes from investment through the business plan process, whereby the water regulator (Ofwat) sets agreed price increases in customer bills. Ofwat regulate the levels of expenditure of water companies to a level that they see as being affordable by their existing customers.

Similarly, wastewater treatment improvements, maintenance of the existing sewerage network, and the provision of regionally important sewerage schemes, are agreed by Ofwat and funded through customer bills as above.

The current AMP is AMP5 (2010–2015), and TWUL will be currently working to deliver resource development, wastewater treatment improvements and infrastructure maintenance which they identified in their Final Business Plan (agreed by Ofwat) during the Price Review period in 2009 (PR09).

Figure 1-1 illustrates the AMP5 process to 2015, which may dictate the constraints on infrastructure planning and funding, and thereby influence the capacity available for the proposed development in the short term.

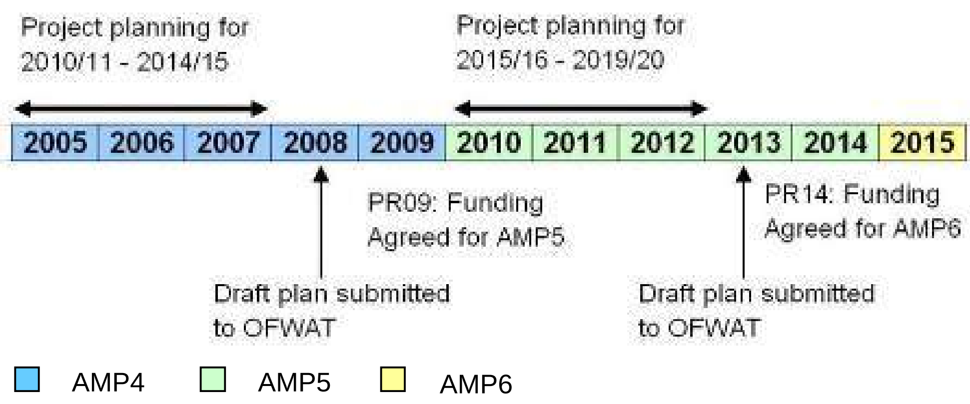

Figure 1-1 Conventional water company planning and funding cycle

Adapted from Rye Meads Water Cycle Strategy Scoping Report; EA, August 2007

TWUL submitted their business plan to Ofwat in December 2013, for the price review in 2014 (PR14), which will detail their planned investment for AMP6.

TWUL have limited powers under the Water Industry Act 1991 to prevent connection of new dwellings ahead of the required infrastructure upgrades, and therefore rely on the planning system (through appropriate planning conditions) to ensure that development does not lead to an unacceptable risk of flooding, or pollution of watercourses.

Where new water supply or sewerage network (pipes, pumping stations or service reservoirs) is required to serve the development site, developers may requisition this infrastructure in accordance with S41 and S98 of the Water Industry Act 1991.

The difference between the costs of infrastructure upgrades (including the provision of any off-site network), and the predicted revenue from the new customers, can be passed onto developers from water companies using Requisitioning Agreements. The amount charged is referred to as the 'relevant deficit', and can be paid over a 12 year period, or one lump sum discounted to a net present value. TWUL also offer, at their discretion, an option of a commercial commuted sum in addition to these two regulatory options.

In addition, TWUL charge every developer a fixed regulated 'infrastructure charge' to contribute towards any improvements required to the existing water supply and sewerage network in to which their new infrastructure will connect.

1.7.2 Inset arrangements

Section 6 of the Water Industry Act 1991 (as amended) allows for new limited companies to be appointed as either water or sewerage undertakers for an area. These inset appointees can be appointed providing one of the following criteria are met:

- The area does not contain any premises that receive services from an appointed water or sewerage company (greenfield sites tend to meet this 'unserved' criterion – however consideration needs to be made for existing connections to the farm buildings across the site;
- A customer uses (or is likely to use) in excess of 50 Ml of water a year and wishes to change their supplier; or
- The existing incumbent appointed undertaker consents to transfer some of its existing area to the new appointee.

Once appointed, an inset water or sewerage company has the same serviceability, quality, data management and financial responsibilities as a statutory water or sewerage undertaker as defined under the Water Industry Act. For Ofwat to grant this appointment, the inset company must demonstrate that they have the ability to carry out and finance the operation.

Additionally, for water supply inset appointments, the Drinking Water Inspectorate (DWI) undertake a competency assessment of the new supplier which appraises their company procedures, and their ability to manage any supply risks in the area.

Since 2007 there have been five new inset appointments granted for either water and sewerage, or sewerage only companies. Four of these appointments met the unserved criterion, whilst the fifth was by incumbent consent. Once an inset company has been successfully appointed a water/ sewerage area, they are then able to apply for a variation of this area (again under the Section 6 of the Water Industry Act). These areas do not have to be geographically linked – which then allows these inset companies to competitively pursue additional development areas across England and Wales.

Section 7 of the Water Industry Act places a duty on Ofwat/Defra to ensure that a water and sewerage undertaker serves all parts of England and Wales, and allows them to vary existing appointment areas to ensure this remains the case. This therefore provides reassurance that a development will not be left unserved if the inset company leaves the market.

Additionally, Sections 23 to 26 of the Water Industry Act prohibit an appointed company being wound up voluntarily, or an administration order being made in relation to the company. If a winding up application is made in relation to an appointed company this cannot be granted – instead the company enters in to a special administration order which allows transfer of any supplied areas to another appointed company as a going concern, hence protecting customers' services.

2 WATER ENVIRONMENT

2.1 Potential impacts

The water environment in and adjacent to areas of development (and in downstream river reaches) has the potential to be detrimentally impacted by the following activities:

- Increased **abstraction of water**, from rivers and the aquifers which support them, to supply the increasing population, potentially leading to:
  - Reduced volumetric flows in rivers, particularly during summer months, which decreases the capability of the watercourse to dilute the pollutants – increasing the risk that aquatic life will be affected, and the risk of non-compliance with statutory water quality targets;
  - Decreased water levels in watercourses – resulting in detriment to bankside habitats or species which depend on these levels; and
  - Decreased water levels and flood frequencies in adjacent sites where the sensitive habitats and protected species are dependent on these factors, such as reedbeds, fens, and ditches through floodplain grazing marshes;
- Increased volumes of urban **surface water run-off** due to an increase in impermeable area in development locations, potentially leading to:
  - Increased conveyance of pollutants including hydrocarbons, detergents and suspended solids in to watercourses (or aquifers via soakaways) – resulting in detrimental impacts to aquatic life and non-compliance with statutory water quality targets; and
  - Increased flood risk to people and property due to deep and/ or fast moving surface water flooding.
- Decreased capacity in the existing **sewerage network** due to the increasing population, leading to:
  - Increased chance of spills from surcharging manholes - resulting in overland flow of raw wastewater, with the final receptor being the watercourse or aquifer, and an increased risk of foul water flooding to people and property; and
  - Increased chance of spills of screened wastewater to receiving watercourses from combined sewer overflows on sewerage networks, and emergency overflows at sewage pumping stations (SPS) – resulting in shock pollutant loads and non-compliance with statutory water quality targets;
- Increased consented discharges of treated **wastewater effluent** from WwTW due to population growth, potentially leading to:
  - Increased suspended solids, which can transfer pollutants and pathogens to river beds as they settle;
  - Increased bio-chemical oxygen demand (BOD) from aerobic biological organisms in the water, resulting in less dissolved oxygen for aquatic life to utilise; and
  - Increased discharges of ammoniacal nitrogen (Amm. N – which is toxic to aquatic organisms) and phosphorus (P) leading to an increase in concentrations of nitrates and phosphates – nutrients which can lead to eutrophication and the excessive growth of algae, again restricting the dissolved oxygen available for other aquatic life, and hampering alternative use of the water, such as recreation or water supply.

2.2 Receiving water environment

The existing watercourse across the north of the site drain south eastwards, pass under the A4095, and continue through the existing town. This watercourse is in part designated a Main River, and is referred to as the Town Brook at Bicester by the EA (and locally referred to as the River Bure).

Immediately downstream of the A4095, the Town Brook passes through the Bure Park Local Nature Reserve (LNR). This 8.4 ha site was declared of local interest by CDC because of the habitats therein, including grass meadow, young broad-leaved woodland, hedges, scrub and the river itself. The latest information from Natural England (NE)[2] suggests the river feeds a small pond which is home to great crested newts.

Immediately south of the town, the Town Brook joins the Langford Brook. The south of the proposed site is drained via an Ordinary Watercourse referred to as the Pingle Brook, which flows in to the Town Brook just upstream of its confluence with the Langford Brook.

The existing Bicester WwTW, operated by TWUL, discharges to the Langford Brook just south of the town.

4.2 km south of the WwTW, the Langford Brook enters the Wendlebury Meads and Mansmoor Closes Site of Special Scientific Interest (SSSI). According to NE[3], this site consists of a rare traditionally managed unimproved neutral meadow draining to the river, incorporating exceptionally diverse flora with over 160 plant species. Short term flooding from the river is described as a frequent occurrence, and the quantity of flooding, and water quality, will in part be responsible for the diversity of the site. The SSSI site was listed as being in favourable condition in February 2014 by NE.

1.1 km after entering the SSSI boundary, the Langford Brook joins the Oxon Ray, which then continues to flow southwards for 1.2 km before reaching the Otmoor reserve. This Royal Society for the Protection of Birds (RSPB) reserve and SSSI incorporates wet meadows and reedbeds which regularly flood, with many species of nationally uncommon plants and animals supported[4]. The SSSI site includes a complex network of drains, weirs and sluices interacting with the Oxon Ray.

Downstream of Otmoor SSSI, the Oxon Ray flows westwards for 3 km before joining the River Cherwell near Islip.

2.3 Water quality in rivers

In addition to the requirement to protect the designated sites above, the stakeholders in the area are required to comply with the European Water Framework Directive (WFD). The EA are the lead authority responsible for compliance with the WFD in England.

The WFD sets out a strategy for protecting and enhancing the quality of groundwater, rivers, lakes, estuaries and coasts. The main objectives of the WFD are to prevent any deterioration in the current ecological status, and bring all water bodies up to ‘good status’ by 2015, or 2027 at the latest. The quality parameters for the assessment of a river have been set by the UK Technical Advisory Group (UK TAG)[5]. A requirement of the WFD is that a no deterioration policy is adopted for the WFD quality parameters, which could have potential implications for future developments.

Extensive data as to the current ecological classification of the Town Brook, Langford Brook and Oxon Ray is published by the EA in the Thames River Basin Management Plan[6] (RBMP).

The Town Brook is classified as being Heavily Modified, as the channels has undergone significant historical morphological changes due to urbanisation. The WFD requirement for Heavily Modified Water Bodies (HMWB) is to reach good ecological potential (GEP), as opposed to 'good status', however the water quality standards required are consistent, regardless of the designation as HMWB.

Under the WFD, supporting elements are assigned a status using the following system:

Physio-chemical Elements	Hydromorphology
High	Supports Good status
Good	
Moderate	Does not support Good status
Poor	
Bad	

Table 2-1 WFD: Surface water bodies - system of classification

These parameters will influence the overall classification of the water bodies – failure to meet Good status for one element will lead to an overall classification of less than Good status. For clarity, the current status of the water bodies (pertinent to this WCS), and the target status for these water bodies, are summarised in Table 2-2 below.

Water Body Reference	Reach Description	Current Ecological Status (or Potential) 2009	Target Ecological Status (or Potential) and Date
Town Brook	Town Brook at Bicester	Moderate	Good – 2027
Langford Brook	Bicester to Ray inc. Gagle Brook	Moderate	Good – 2027
Oxon Ray	Upstream A41 to Cherwell inc. Otmoor	Poor	Good – 2027

Table 2-2 WFD: current status and targets
(no change between 2009 classification and current data on EA website, 2014)

As discussed in Section 2.1, proposed development has the potential to impact primarily on the following supporting elements which form part of the overall ecological status classification:

- Ammonia, via the discharges of Amm. N;
- Dissolved Oxygen, via discharges of BOD (and excessive uptake of oxygen following nutrient enrichment);
- Phosphate, via discharges of P; and
- Quantity and Dynamics of Flow, via abstractions from rivers and aquifers.

Table 2-3 illustrates how the above elements are currently contributing to the overall classification of ecological potential.

Water Body Reference	Reach Description	Ammonia	Dissolved Oxygen	Phosphate	Flow
Town Brook	Town Brook at Bicester	High	Good	Poor	Does not support good
Langford Brook	Bicester to Ray inc. Gagle Brook	High	Good	Poor	Does not support good
Oxon Ray	Upstream A41 to Cherwell inc. Otmoor	High	Moderate	Poor	Does not support good

Table 2-3 WFD: individual components of current ecological status
(based on latest data from EA website, 2014)

The UKTAG guidance suggests that the following concentration standards should be used for the classification of physio-chemical supporting elements in the study area:

Physio-chemical supporting element	High	Good	Moderate	Poor	Bad
BOD mg/l (90%ile)	< 4	< 5	< 6.5	< 9	> 9
Total Ammonia mg/l (90%ile)	< 0.3	< 0.6	< 1.1	< 2.5	> 2.5
Soluble Reactive Phosphorus mg/l (Annual Average)	< 0.05	< 0.12 (0.08)*	< 0.25	< 1	>1

Table 2-4 WFD: concentration standards for physio-chemical elements

Additionally, the EA have advised that whilst the target P concentration to achieve Good status is currently 0.12 mg/l, this will be tightened to 0.08 mg/l post 2015. Additionally, as the Langford Brook is designated as a sensitive area under the Urban Waste Water Treatment Directive, any discharge of treated effluent from in excess of 10,000 population requires tertiary treatment to control concentrations of phosphorous and or nitrates.

Phosphate levels are a concern throughout the majority of England. On-going cooperation is required between water companies, the EA and other parties to overcome this issue at a national and regional level.

Whilst the EA is the 'competent body' tasked with implementing the WFD in England, other stakeholders will have an important part to play. The Programmes of Measures included in the RBMPs contain integrated solutions requiring input and action from Natural England, the water companies, local authorities, existing landowners and developers. To achieve the above P targets, diffuse sources in to rural watercourses (such as the Langford Brook) must also be targeted for reduction.

Whilst the surface water strategy for the proposed development is discussed in separate documents, it is important to emphasis the water quality benefits which can be provided by well-designed and maintained SuDS. The biological and physical processes which occur in wetlands, filter strips and swales have been shown to significantly reduce levels of pollutants and nutrients in run-off, and depending on ground conditions it may be possible for the post-development run-off to improve diffuse pollutant levels against the rural baseline.

* The EA have advised that whilst the target P concentration to achieve Good status is currently 0.12 mg/l, this will be likely tightened to 0.08 mg/l post 2015 (currently subject to consultation).

In order to protect groundwater resources and assist in compliance with the WFD, SuDS drainage across the proposed development will be implemented in accordance with the EA policy; Groundwater protection: Principles and Practice, and site specific contamination risk assessments.

2.4 Water quality modelling

The EA River Quality Planning (RQP) tool (version 2.5) has been used by the EA to inform the water quality aspects of this WCS. The RQP tool uses mass balance Monte Carlo simulations to identify the indicative consent standards that would need to be applied to a new or increased WwTW discharge, and the change in downstream concentrations of physio-chemical elements following a discharge.

The RQP tool was used to calculate the indicative consent standards which would be required to ensure the increased discharges of treated effluent do not cause deterioration in the existing water quality. The physio-chemical standards required to prevent deterioration in current WFD class at the downstream point following the new discharge from a potential on-site WwTW, or an increased discharge from Bicester WwTW, have been calculated. Additionally, the EA have provided results for a more stringent scenario where only 10% deterioration within the current WFD class is permitted. These are discussed further in Section 6.

3 WATER RESOURCES

3.1 Local water resources

The site is located within the Cherwell, Thame and Wye water resources catchment. In this region the most important factor is ensuring that sufficient flow flows towards the River Thames. A review of the most recent EA Catchment Abstraction Management Strategy[7] (CAMS) for the area identified that:

- No new consumptive surface water licences will be granted at low flows;
- Any new consumptive groundwater licences in direct hydraulic continuity with surface water will be subject to a determined flow at Kingston gauging station; and
- Restrictions will be determined case-by-case based on the nature and scale of the proposed abstraction.

In 2013 Hyder undertook a Groundwater Supply: Feasibility Study[8] to appraise the possibility of utilising local groundwater abstractions to supply the development, and hence reduce reliance on the statutory water undertaker.

This study identified the following:

- The Great Oolite aquifer (a moderately productive fracture flow aquifer comprising alternating sequences of limestones and clays) underlies the whole site and is in probable hydraulic connection/partial connection to surface water streams;
- The Great Oolite was used for water supply including for Bicester town in the 1930's. Yields stated in records for the Great Oolite in this area are typically between 0.5 to 11 l/s. There appears to have been a decline of the use of these wells to redundancy or lower licenced or unlicensed abstraction rates. This may indicate that the sustainability of higher yields is problematic;
- Superficial deposits were either thin or absent with bedrock strata encountered close to ground level, meaning that the Great Oolite aquifer is vulnerable to pollution from the surface (e.g. spillages, landfill or diffuse pollution);
- The Old Red Sandstone (ORS) aquifer is deep (in excess of 160 m) below the whole region and little data is currently available, although it is thought to have limited permeability and transmissivity;
- The ORS aquifer is overlain by thick mudstones and is therefore not in hydraulic continuity with the shallower aquifer, hence it may be possible to abstract without directly affecting neighbouring abstractions and surface water flows. However, the water could tend to be more brackish than at shallow depths and there could be elevated mineral content of say iron, manganese and trace metals.

The study concluded that:

- It is unlikely the Great Oolite aquifer would be considered a suitable source for new water supply for the NW Bicester Development. Partial supply may be possible, subject to further assessment of water quality, and an assessment of the likely long term water quality with respect to vulnerability to surface spillages; and
- The ORS aquifer may be considered a more suitable source for new water supply for the NW Bicester Development. However, at least two deep boreholes (perhaps up to 400 m deep) would be required, and it is possible that yields would be lower than expected due to the depth of the aquifer (causing closure of fractures), lower than assumed

groundwater levels, or other restrictions to protect neighbouring resources as determined by EA assessment . Water quality is unknown, but it is likely that some treatment (or blending with a bulk supply from TWUL) will be required before potable use.

If new local abstractions were utilised for potable water supply for the NW Bicester Development, connections to the wider TWUL infrastructure network would be required to provide sufficient resilience for customers, regardless of whether the on-site supply was via TWUL or an inset company.

Providing a proportion of the supply from local abstractions would do little to reduce the extent of any off-site resilience works, as it is likely that the connections would be sized to allow full supply from off-site in case of operational outages, contamination or drought.

Therefore, local abstractions would increase the costs and risks of providing a potable water supply to the NW Bicester Development. Given the planned availability of water resources in the surrounding area (see Section 3.2), and the proximity to existing and planned water supply infrastructure (see Section 4.1), local abstraction is not considered to be a preferable option at this time.

The exception to this would be if additional WwTW effluent discharged to local surface waters was subsequently abstracted to provide a proportion of the supply to the NW Bicester development, as this would mitigate impacts on the surface water and groundwater resource availability, and avoid the requirement for constructing deep boreholes with unknown water quality and yield.

3.2 Regional water resources

TWUL are responsible for maintaining the public water supply across the study area. Every five years, in conjunction with their business plan submission, TWUL are required to set out their strategic requirements for the following 25 years in a Water Resource Management Plan (WRMP).

Following a period of formal consultation in 2013, TWUL have submitted their draft revised WRMP 2015 – 2040[9] for consideration by Defra, with the aim of it being approved for the start of AMP6.

The WRMP sets out the best value demand management and resource development options which TWUL plan to implement, to prevent the supply demand deficits occurring. This strategy includes allowances for predicted development and population changes, and the impacts of climate change.

The development site and Bicester town lie within their Swindon and Oxfordshire (SWOX) Water Resource Zone (WRZ), as shown in Figure 3-2.

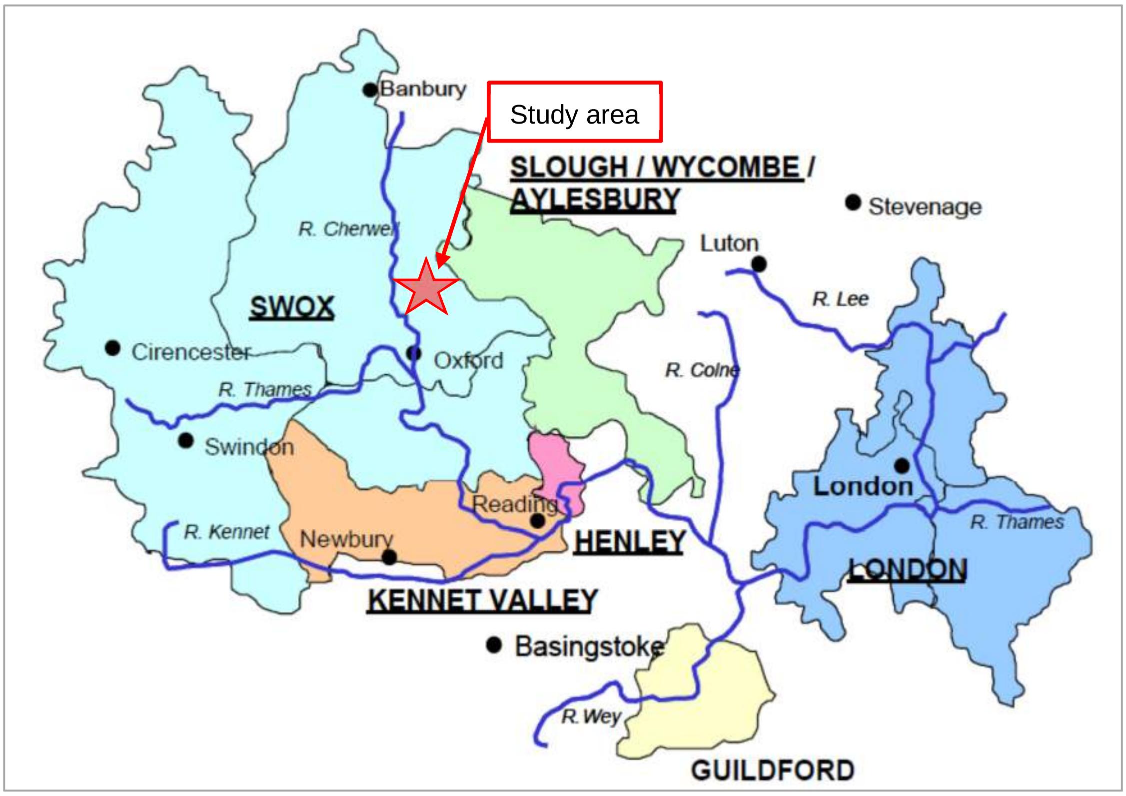

Figure 3-2 TWUL water resource zones

Adapted from TWUL Revised Draft WRMP 2013

The draft revised WRMP suggests that, for the SWOX WRZ:

- Without further investment, a supply demand deficit would develop in a dry year average scenario from 2023/24 rising to 14.6 Ml/d by 2039/40, and in a critical demand period, a deficit from 2019/20 rising to 33 Ml/d by 2039/40;
- The above baseline deficits are driven by population growth, climate change and requirements to reduce some abstractions for environmental reasons (referred to as sustainability reductions);

In order to prevent the above deficits, TWUL are proposing a programme of measures to reduce demand, including:

  - Rolling out metering, to increase meter penetration from 65% of households at the end of AMP6, to 93% of households by the end of AMP10;
  - A campaign promoting water efficiency, to build on the Save Water Swindon campaign launched in 2010 ;
  - Introduction of revised tariffs to encourage customer behavioural change; and
  - A reduction in leakage from customers' supply pipes, made possible due to the increased data and focus on water from the above.

Figure 3-3 shows TWUL's proposed plan for the SWOX WRZ, highlighting how the proposed reduction in demand (distribution input – DI, and target headroom – TH) ensures a surplus is maintained despite planned reductions in available resources (water available for use - WAFU).

The reduction in WAFU shown includes an allowance for the confirmed sustainability reduction requested by the EA at Axford, and likely sustainability reductions at Ogbourne and Childrey Warren.

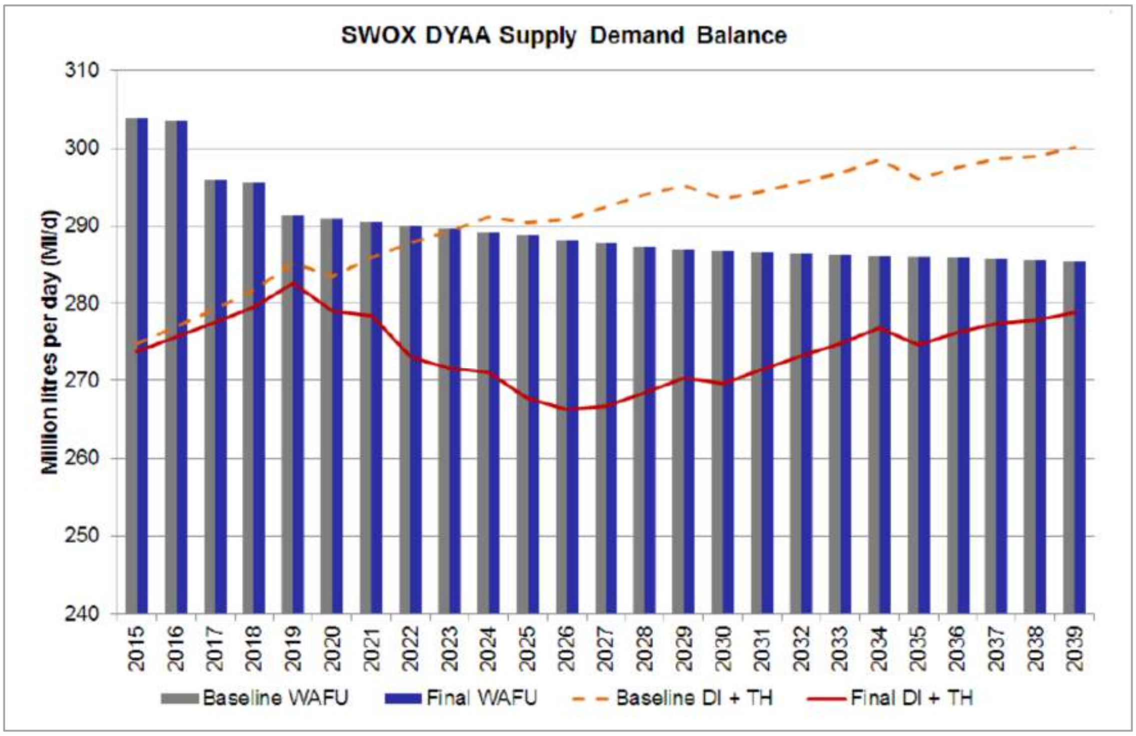

Figure 3-3 SWOX WRZ Dry Year Average Planned Supply and Demand

TWUL Revised Draft WRMP 2013

Notably, the above situation represents an improvement since the Scoping and Outline WCS; which had reported that the TWUL draft WRMP for 2010 to 2035 was predicting deficits occurring from 2014 onwards. This has since been resolved by TWUL implementing groundwater resource development schemes to bolster the resilience of the SWOX WRZ throughout AMP5.

It can therefore be concluded that TWUL have the ability to provide adequate supply of potable water to the proposed development, despite increasing population, and decreasing availability of water resources.

In addition, it should be noted that SWOX WRZ consists of three interconnected Planning Zones (PZ); Swindon, South Oxfordshire and North Oxfordshire, of which Bicester is located in the latter. TWUL advised this study in 2013[10] that the potential deficits in the SWOX WRZ related primarily to development in the Swindon PZ, rather than the North Oxfordshire PZ, which was not predicted to develop a deficit. This further reinforces the conclusion that adequate water resources are available to supply the proposed development.

The projects (either demand management or resource development) required to maintain and increase the WAFU to accommodate growth in the WRZ are funded via existing TWUL customer bills. TWUL will seek to maximise the efficiency of their water supply projects to ensure any necessary increases in customer bills are minimised, as the appropriateness of any increases are strictly monitored by Ofwat through the Price Review process. It must also be noted that supplying the new development (either directly or via an inset company) provides additional revenue for TWUL to utilise for maintaining and increasing WAFU.

However, it must be noted that in order to comply with TWUL's strategy, per capita consumption of potable water in the proposed development must be at least in line with that planned for by TWUL. Any further efficiencies achieved will assist to minimise the increase in demand in the

SWOX WRZ, reducing risks to supply and the environment, and minimising cost increases to TWUL customers.

Therefore, (as discussed in Section 5) this WCS is confirming that the proposed development shall incorporate a water efficiency design standard to limit average per capita consumption (PCC) to 105 litres per person per day (l/p/d) in all new homes. The design standard shall also require that water recycling technologies are used locally to supplement domestic supplies, and hence further reduce the demand of potable water from the SWOX WRZ to 80 l/p/d in all homes.

4 WATER SUPPLY INFRASTRUCTURE

4.1 Existing water supply infrastructure

TWUL supply the SWOX WRZ primarily from abstraction from the River Thames and its tributaries, stored in reservoirs, as shown in Figure 4-4.

Figure 4-4 TWUL water resource schematic
Adapted from TWUL Revised Draft WRMP 2013

Hyder undertook consultation with TWUL in 2013 to ascertain the capacity of the existing water supply infrastructure.

According to TWUL, the majority of the supply for Bicester is sourced from near Oxford. Raw water is abstracted from the River Thames to the west of Oxford, stored and treated at Farmoor, and then transmitted northwards with the assistance of a large pumping station near the A44 to the west of Bicester. Potable water is stored in a Distribution Service Reservoir (DSR) to the north west of Bicester, and the town is then supplied from here via a 450 mm main which runs through the NW Bicester development site along the existing bridleway.

4.2 Proposed water supply infrastructure

TWUL advise that they have recently upgraded the capacity of the pumping station, and the main from the DSR to Bicester. Additionally, TWUL completed the Bicester ring main in 2012, which allows increased resilience in supplying the town, and is designed to cater for the next 40 years of development as assessed by TWUL.

TWUL also advised that the part of the network with the lowest capacity for development is the transfer main from the pumping station to the DSR, however this can be upgraded through the normal funding cycle and hence should not be considered a constraint to the proposed development.

It is estimated that the requisition, design, construction and commissioning of extensions to the strategic water network can take up to three years following the receipt of a developer requisition. However, given the proximity of the development site to the existing 450 mm main, it should be relatively simple and cost effective for TWUL to provide a supply to the development, once requisitioned by either the developer or a potential inset company.

Providing an agreement is reached soon, it is not considered that the provision of this infrastructure would significantly constrain the construction of the development from 2014/15 onwards.

Additionally, TWUL advise a five metre zone from the existing 450 mm main should be protected from development, to avoid the requirement to divert the main, and ensure adequate access is maintained for maintenance and further connections. The current NW Bicester masterplan adheres to this advice, by proposing a green area over the route of the existing bridleway through the development.

5 Potable water demand and supply

This Section further explores the proposed new potable water demand from the development, and the alternative methods to reduce the demand on the existing TWUL network - and hence move the development towards water neutrality to assist in avoiding the above mentioned supply demand deficits.

Reducing potable water demand also allows more water to be retained in the environment, which can have benefits for biodiversity, amenity, and both the flow (additional dilution) and physiochemical elements of the WFD.

5.1 Existing potable water demand

According to the draft revised WRMP, TWUL estimate that the average per capita consumption (PCC) of potable water in the SWOX WRZ in 2011/12 was 156 litres per person per day (l/p/d) for properties without a meter, and 129 l/p/d for metered properties.

TWUL estimate that without any intervention, average PCC would remain relatively stable to 2039/40, as increasing demand would be offset by the increased penetration of meters. However, following the implementation of the demand management measures (see Section 3.1), TWUL estimate that average PCC across the Thames Valley area will reduce to approximately 129 l/p/d by 2039/40.

5.2 Planned potable water demand

Notably in their WRMP forecasts, TWUL have estimated that all new properties achieve an average PCC of 125 l/p/d. This aligns with the Building Regulations Part G requirement that whole building water usage should equate to 125 l/p/d.

In this WCS, it would typically be expected that new development would at least meet the requirements of the Code for Sustainable Homes (CSH) Levels 3/4. This equates to a PCC of 105 l/p/day.

However, the PPS1 Supplement requires that water efficiency equates to 80 l/p/day, in an aspiration to achieve CSH Levels 5/6. This will therefore be the design standard for all new homes in the proposed development. The details of how this may be achieved are discussed further in Section 5.5.

Based on the above policies, it can be concluded that the proposed PCC targets for the development are within the estimates used by TWUL for their WRMP – hence the development will not make it more difficult for TWUL to achieve their demand management strategy and ensure a supply demand surplus is maintained.

5.3 Estimated new potable water demand

The new residential demand of potable water from the NW Bicester development has been calculated using the following equation:

New Demand (Ml/d) = [No. of new homes x occupancy rate x PCC (l/p/d)] / 1,000,000

The occupancy rate of the new dwellings is assumed to remain constant at 2.4, which is consistent with TWUL high level planning estimates for the area.

As discussed in Section 5.2, the PPS1 Supplement requires a PCC rate of 80 l/p/d, hence this is the design standard proposed for this development. For comparison within this WCS, potable water demand has also been calculated using PCC rates of 105 l/p/d and 125 l/p/d. The latter is considered to be the worst case, as it is the minimum requirement in accordance with the Building Regulations, and similar to the current TWUL estimate for new metered properties.

Additionally, this WCS has estimated potable water demand from the proposed non-domestic properties and community infrastructure.

These estimates only relate to the domestic component of use (i.e. employees using kitchen and bathroom facilities), as any significant volume of water required for industrial processes will be subject to separate financial agreements with the water supplier, and cannot be accurately estimated unless the proposed industrial processes are known.

Based on the proposed business classes and plot areas of the masterplan, it is estimated that the NW Bicester development will provide space for approximately:

- 4,600 jobs, including around 2,000 jobs at the proposed business park, with further provision elsewhere within the local area;
- One secondary school; and
- Up to four primary schools.

Additionally, NW Bicester will include care home provision, extra care at home provision, and hotel provision. This WCS has assumed approximate water usage values for these non-residential uses.

The following potable water usage rate of has been assumed, based on the plumbing Engineering Services Design Guide[11].

Facility type	Litres per day	Per unit
School - Nursery and Primary	15	Pupil
School - Secondary and College	20	Pupil
Hotel – average	150	Room
Employment including homeworking, retail, care, factories, warehousing and offices	45	Employee
Care home	135	Bed space
Extra care housing	120	Bedroom

Table 5-5 Potable water demand rates for non-residential development

For the purposes of this WCS, it is assumed that potable water demand from employment/non-residential areas increases proportionately in line with the build out trajectory of the residential units.

Figure 5-5 illustrates the calculated cumulative new potable water demand from the proposed development. Demand from the residential properties is illustrated at each of the three PCC rates, and total demands including the non-residential components are also shown.

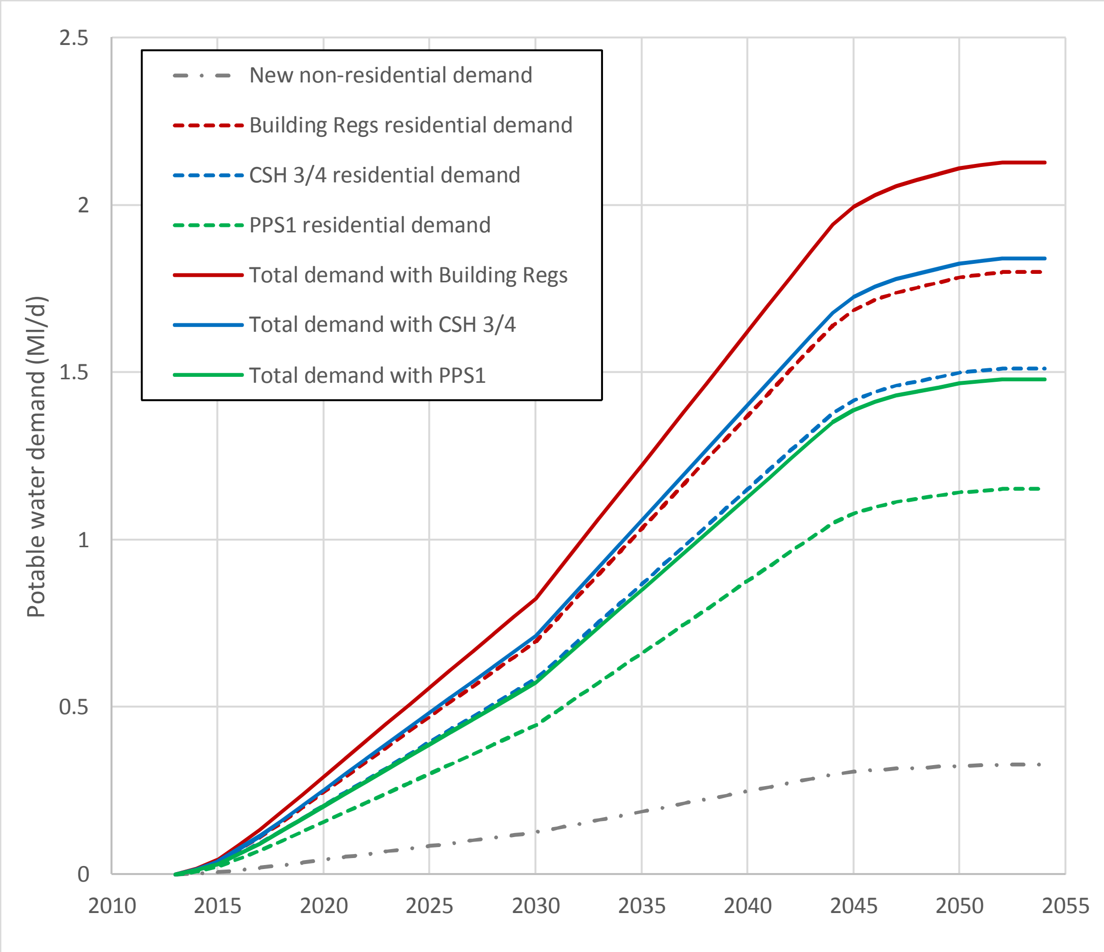

Figure 5-5 New potable water demand for NW Bicester development

The above figure highlights how the proposed policy to achieve a PCC rate of 80 l/p/d for residential properties significantly reduces the increase in net potable water demand, when compared against the Building Regulations PCC rates incorporated in to the TWUL WRMP.

As discussed in Section 3.2, limiting PPC as above allows the proposed development to adhere to and exceed the TWUL strategy for the SWOX WRZ. Whilst the demand in the WRZ will increase, this assist in minimising the scale of the increase and hence the risk to supply, impacts on the water environment and customer bills.

5.4 Water efficiency measures

This Section explores how water efficient fixtures, fittings and behaviours may be utilised to achieve the PCC rates referred to above, and hence assist the development in aspiring towards water neutrality.

5.4.1 Residential water efficiency

To maintain consistency with Part G of the Building Regulations, the Building Research Establishment (BRE) CSH Water Efficiency Calculator Tool[12] was used to appraise the fittings and fixtures options for achieving, or bettering, the PCC rates for CSH Levels 3/4, and the more stringent PPS1 target.

Using the BRE tool, it can be shown that the CSH Level 3/4 PCC target, (105 l/p/d) can realistically be met through the specification and installation of water efficient fixtures, including the following:

- 2.6/ 4.0 l dual flush toilet;
- 9 l/minute shower;
- 150 l bath;
- 6 l/minute taps;
- Conventional dishwasher and washing machine, assumed to use 4.5 and 17.16 l/p/d respectively; and

The above assumes that any water used external to the home (for car washing and garden watering - approximated at 5 l/p/d) is excluded from the total potable water demand. It is assumed that suitable measures will be incorporated in to the development's design to provide this water from a non-potable source, for example garden water butts.

The tool does allow for the specification of higher efficiency fixtures and fittings, however experience from similar WCS projects is that the above levels of efficiency should broadly be considered the limit that occupiers will find acceptable for the foreseeable future. Relying on additional demand reduction measures in the residential dwellings would increase the risk of occupiers replacing the efficient fittings in the future.

5.4.2 Non-residential water efficiency

Similar to the above, the incorporation of water efficient fixtures and fittings in to non-residential properties can significantly assist in moving towards the aspiration of water neutrality.

All new non-residential buildings in the development are aspiring to achieve an excellent rating under the Building Research Establishment Environmental Assessment Method (BREEAM).

BREEAM is an environmental assessment method and rating system which assesses the sustainability of building design, construction and operation, using a range of weighted criteria.[13]

Of these criteria, water efficiency is weighted to represent 6% of the overall rating. In order to achieve a rating of excellent, non-residential properties must achieve an overall rating of at least 70%. Whilst there are numerous routes to achieving this overall score by altering performance against all the criteria, it can be approximated that excellent, in terms of water efficiency, requires a score of 5 out of a possible 6 for this particular criteria.

This requires that the developer show that whole building potable water usage is reduced by at least 55% from the baseline condition. Whilst designs will vary for different building uses, BRE do offer some guidance as to the typical fittings, fixtures and approaches which would be required to achieve this rating.

These include:

- 2.6/ 4.0 l dual flush toilets;
- Dry urinal systems;
- Kitchen and bathroom taps limited to 5 l/minute and 3 l/minute respectively; and
- 3.5 l/minute showers.

Notably, BRE advise that developers should aim to use reclaimed surface water or wastewater to provide at least 75% of the non-potable water demand if they hope to achieve an excellent rating for this criteria.

Depending on the ratio of users to roof areas, and the ownership arrangements of the commercial properties, some non-residential areas will be strong candidates for using local RWH to provide this non-potable supply. However, this may not be practicable in all areas, hence some of these areas may require integration in to any greywater or wastewater effluent recovery systems serving the residential areas.

5.5 Water neutrality

Aspiring to water neutrality is a key theme of the proposed development.

Reducing the magnitude of the new demand from the existing water resources/ potable water infrastructure, and aspiring towards water neutrality, will typically require a mix of the following concepts:

- Increases in water use should be limited by reducing demand with water efficient fixtures, fittings and behaviours (as per Section 5.4);
- Components of water demand in both residential and non-residential properties which do not require potable water standards should be replaced with a suitable non-potable supply; and
- Opportunities to reclaim surface water run-off and wastewater from the new development should be explored, to provide either the non-potable supply described above, or a potable supply to supplement the existing network.

The extent to which water neutrality can be achieved can be measured by comparing the proposed new potable water demands with the baseline new potable water demands which would have resulted if the properties only achieved the PCC rates in line with the Building Regulations, expressed as a percentage.

Based on the calculations in Section 5.3, Table 5-6 illustrates the proportion of water neutrality which may be achieved if residential PCC rates are limited to 105 l/p/d and 80 l/p/d in keeping with the CSH Levels 3/4, and the PPS1 targets respectively.

	Building Regs	CSH 3/4	PPS1
Non-residential demand (Ml/d)	0.33	0.33	0.33
Residential demand (Ml/d)	1.80	1.51	1.15
Total new demand (Ml/d)	2.13	1.84	1.48
Saving vs. Building Regs (Ml/d)	0.00	0.29	0.65
% water neutrality	**0.00%**	**13.53%**	**30.45%**

Table 5-6 Water neutrality comparison

Table 5-7 illustrates the additional gain in terms of water neutrality which would be achieved if the 55% reduction in non-residential water use can be achieved in accordance with BREEAM.

	Building Regs	CSH 3/4	PPS1	PPS1 with 55% reduction in non-residential demand
Non-residential demand (Ml/d)	0.33	0.33	0.33	**0.15**
Residential demand (Mld)	1.80	1.51	1.15	1.15
Total new demand (Ml/d)	2.13	1.84	1.48	1.3
Saving vs. Building Regs (Ml/d)	0.00	0.29	0.65	0.83
% water neutrality	**0.00%**	**13.53%**	**30.45%**	**38.93%**

Table 5-7 Water neutrality comparison (inc. BREEAM excellent for non-residential)

In summary, the policies to limit PCC of potable water to 80 l/p/day in new residential properties, and reduce potable water demand in new non-residential buildings by 55% compared to the traditional baseline, result in the estimated potable water demand for the NW Bicester development reducing from 2.13 Ml/d to 1.3 Ml/d.

This should be considered a significant move towards the aspiration of water neutrality, as the net increase in demand for potable water will be nearly 39% less than if conventional PCC rates were realised.

In order to further close the 'water gap', and move the development further towards the aspiration of water neutrality, it is necessary to consider other changes to the water demand of the area brought about by the development.

As discussed in Section 3.1, it is unlikely that local groundwater or surface water abstractions would be suitable substitutes for supplies via the established TWUL network.

As highlighted in the Groundwater Supply: Feasibility Study, there is an existing licensed groundwater abstraction on site, for supplying drinking water to dairy cattle. If the development were to make the need for this abstraction redundant, then a further 48 m^3/day would be retained within the Great Oolite aquifer. If considered as part of the wider water neutrality calculations, this results in a total water neutrality value in excess of 41%.

Further increases in water neutrality would require the local reclamation of surface water, greywater or treated WwTW effluent to produce a potable supply to supplement or replace any bulk import of potable water from the existing TWUL network. Whilst such a closed loop system is appealing in terms of water neutrality, it includes a number of inherent risks which would likely make it unattractive to TWUL or any inset provider, including:

- Less opportunities to balance climate change and process risks, and resources, across a wider WRZ;
- The requirement to provide of a full scale back-up potable water supply to ensure statutory supply obligations can be met if the WwTW process malfunctions (maintaining drinking water quality in assets which are rarely used is problematic);
- The production of concentrated waste products which require tankering to other facilities for disposal[*];

[*] Alternatively, this effluent could be further dewatered on site to produce sludge for use as an agricultural bio-solid. However, the technologies required to treat this high concentration effluent and produce a high quality bio-solid are only considered to be financially viable on the large scale.

- Emerging technological approach which will make securing funding and gaining Ofwat/ DWI approval problematic; and
- The potential for negative public and investor perception.

Given the above, and ongoing discussions with TWUL and potential inset providers, it is considered likely that any reclamation of surface water, greywater of treated WwTW effluent to achieve the required PCC rates < 80 l/p/day would be limited to the provision of a non-potable supply.

Community wide water efficiency retrofit initiatives may also be promoted by CDC and TWUL across Bicester. Therefore, there is opportunity for A2Dominion contributing to any such future CDC and TWUL potential initiatives if they are forthcoming as it will help further reducing the current water neutrality gap.

Retrofit of existing properties with new water efficient fixtures and fittings can potentially change customer attitudes towards water use, and reduce overall demand, contributing towards the water neutrality of a development.

Strategies from both Waterwise[14] and Anglian Water[15] suggests that, (in homes with a water meter) approximately 30-34 l/property/d typical savings can be expected to be achieved by a water efficiency audit and the subsequent retrofit of basic water efficiency measures, including:

- A variable flush toilet device;
- A reduced flow shower head;
- Reduced flow tap inserts (for the bathroom); and
- A hosepipe gun.

However, in order to maximise customer confidence, cost efficiencies and uptake, it would likely be preferable for TWUL to lead such a scheme. Additionally, Waterwise report that in the Anglian Water region, savings of up to 41.5 l/property/day were achieved when the above measures were applied to unmetered properties in parallel to a meter install.

However, Waterwise estimate that the best case uptake rate of a retrofit scheme would be 20%; requiring a coordinated promotion campaign from TWUL and CDC.

In the absence of detailed demand data for the existing town, an assumption of 65% meter penetration has been assumed in accordance with Section 3.2. Office for National Statistics data[16] from the 2011 census estimated 12,563 dwellings within the town.

With 20% uptake, this would represents a saving of 0.036 Ml/d across all existing unmetered properties, and 0.056 Ml/d across all existing metered properties. This 0.092 Ml/d total saving, if added to the PPS1 saving discussed above, would result in total water neutrality of the development increasing from 41% to approximately 45%.

However, the savings may well be lower if, for example, the existing customers in Bicester have already implemented water efficient fixtures and behaviours. Additional local data from TWUL would be required to further appraise such a scheme, and as discussed above, to make significant gains in water neutrality would require TWUL to lead such a retrofit scheme, to either dramatically increase uptake or extend the scheme in to the wider CDC area.

Additionally, the above makes no allowance for the deterioration in savings from retrofit over time. Notably, the Waterwise best estimate of the half-life of savings achieved by water efficiency retrofit schemes (based on their monitoring of schemes from 2008 – 2011) is 8.4 years; meaning that after this timeframe the savings realised will have reduced by 50%.

Assuming that any retrofit programme were to be rolled out by at the start of the proposed development, the potential water savings would be marginal by the end of the proposed development. It is likely that a mix of active education and promotion by CDC and TWUL, smart metering and smart use of tariffs will be required to maintain any savings realised by retrofit in the long term, which again must be led by TWUL.

Additional opportunities to move further towards the aspiration of water neutrality may become apparent if local water needs for individual development areas can be met with local groundwater abstractions or further water recycling, however the individual merits of such schemes will need appraising as part of the detailed planning phases.

5.6 Non-potable supply options

As discussed in Section 3.2, the proposed development shall include a design standard for water efficiency and water recycling to limit average potable water demand to 80 l/p/d in new homes. For residential properties, at least 25 l/p/d of potable water demand must be replaced with non-potable water, to allow the target of 80 l/p/d to be achieved.

Assuming a dwelling is constructed with water efficient fittings and fixtures, the BRE tool estimates that 12.31 l/p/d is required for toilet flushing, and 15.62 l/p/d for use in washing machines. Therefore, if a non-potable water supply can be provided to supply 100% of these uses (totalling approximately 28 l/p/d), the potable water use of the dwellings will be approximately 77 l/p/d.

For non-residential properties, the proportion of non-potable demand is influence by employment density and building use. For example, office and retail developments have a relatively high non-potable demand, as the majority of their water use may be toilet flushing, whilst health care or hospitality developments require a higher proportion of potable water.

This Section illustrates the risks and opportunities associated with various options to provide a non-potable supply to the NW Bicester Development.

The following options for providing non-potable supply to the dwellings have been appraised by this WCS:

- Rainwater harvesting (RWH) at a property level;
- RWH at a wider neighbourhood level;
- Greywater recycling (GWR) at a property level;
- Greywater recycling at a wider neighbourhood level; and
- Local reclamation of treated wastewater.

The British Standard for RWH systems[17] confirms that potable water standards are not required for toilet flushing or washing machines, as these uses do not involve drinking, food preparation and cooking, dishwashing or personal hygiene.

5.6.1 Property level RWH

As illustrated in Figure 5-6, domestic level RWH would involve the installation of a rainwater tank for each property (preferably at basement level or buried in the garden) to collect filtered rainwater from the roof drainage.

Any additional rainwater would overflow from the RWH system for onwards transmission via the proposed surface water drainage infrastructure.

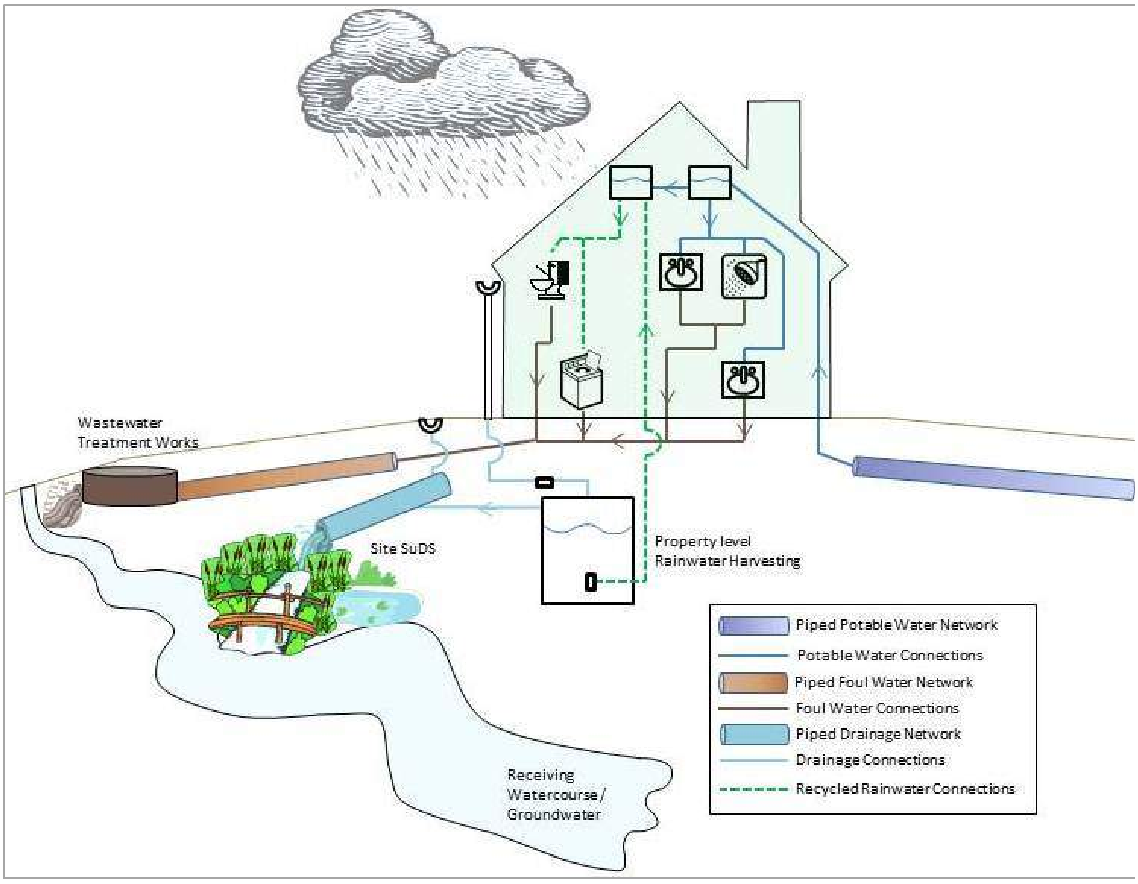

Figure 5-6 Property level RWH schematic

It is anticipated that the filtration would be in two stages; a 'first flush' system on the guttering downpipe to exclude any debris following a dry period, followed by a filter with a maximum particle size of < 1.25 mm prior to the inlet to the tank. BSI 8515:2009 states that such a filter provides suitable quality for toilet flushing and laundry in most residential situations.

This filtered and settled rainwater is then pumped from the tank back in to the house for use in the toilet and washing machine; hence requiring the inlets of these fittings to be connected to internal non-potable plumbing, separate to other potable water plumbing in the house.

The BRE tool calculates that a typical three bedroom house would be able to capture an average of nearly 90 l/day of rainwater from its roof*, equating to a non-potable supply of 30 l/p/d for non-potable use (with an assumed occupancy of 3), or 37 l/p/d (with an assumed occupancy of 2.4).

This suggests that under average conditions (and subject to adequate storage), a domestic level RWH system would be more than capable of supplying the non-potable demand for a house, allowing the 80 l/p/d target to be met.

High level design using the 'intermediate approach' from BSI 8515:2009, assuming an occupancy rate of 2.4, implies a tank size of approximately 1,200 l. The Scoping and Outline

* using BS8515 intermediate approach, with an assumption of 70 m^2 of roof area, a yield coefficient of 80%, a filter with an efficiency of 90% and rainfall of approximately 647 mm/year (Based on 1961-1990 Long Term Average data, DEFRA, 2008. These figures were compiled by the Centre for Ecology and Hydrology, Wallingford using data supplied by the National Climate Information Centre, Met Office).

WCS estimated that a 2,000 l tank would provide a suitable resilience to ensure continuity of non-potable supply during the driest month recorded from 2000 to 2010.

It is however worth noting that under exceptional conditions such as prolonged droughts, RWH systems would not be sufficient. Additional storage, and back up supplies via the potable water networks, may be required, which has implications on cost and drinking water quality (due to infrequent use of this network).

The viability of RWH on individual non-residential developments will vary depending on the building use, and ownership patterns (for example a retail space with a shared RWH system serving a number of owners or tenants, some of whom require varying levels of non-potable supplies, can be problematic in terms of management and maintenance).

5.6.2 Neighbourhood RWH

As illustrated in Figure 5-7, an alternative option for capturing and using local water resources would be the collection of rainwater via a separate drainage network/ SuDS scheme, treatment at a local centre, and then return to the properties via a dedicated non-potable network.

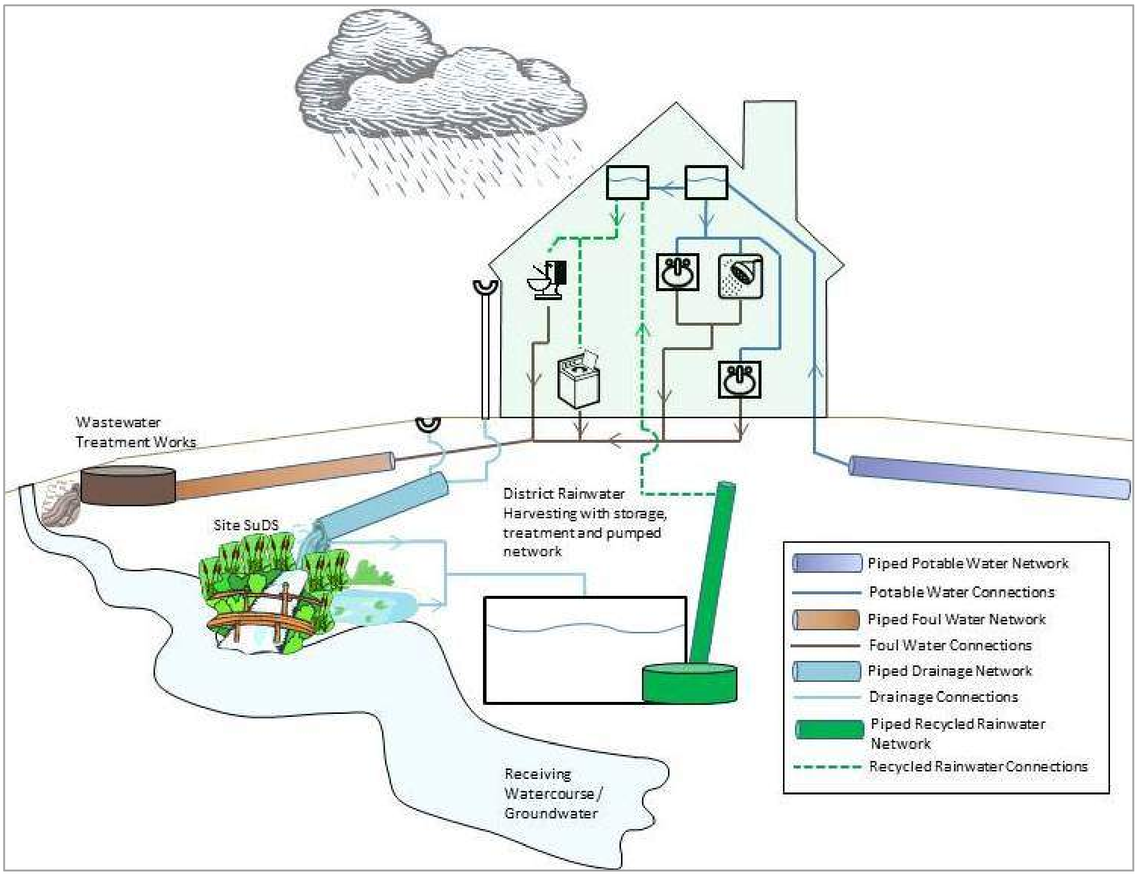

Figure 5-7 Neighbourhood RWH schematic

Centralised treatment and distribution allows better management of technical risks and future process upgrades than domestic level systems, and eradicates the risk that homeowners may let their domestic systems deteriorate until the failsafe connection of potable water replaces any non-potable supply from their RWH.

As discussed in the Section above, there would be a favourable comparison between the potential yield of rainwater from roofs in the area if harvested at the domestic level, and the non-potable demand within the new efficient homes.

The provision of a separate non-potable network and centralised storage and treatment is also appealing for non-residential developments, as management and maintenance issues are simplified for owners/ tenants. Additionally, this offers a resource for non-residential properties to use to further reduce their potable water demand in line with the requirements of BREEAM. For example, a multi-storey densely occupied office building may have difficulty obtaining an excellent BREEAM rating for water as the production of a rainwater/greywater resource would be relatively low, compared to a relatively high non-potable demand for toilet flushing. A centralised network would assist in matching non-residential non-potable demand with supply from elsewhere in the development.

It would be expensive and energy intensive to construct a separate piped drainage network to convey just rainwater from roofs to the non-potable treatment plant. Instead, additional resilience can be provided to the development by utilising run-off from other impermeable areas, providing that water is abstracted far enough along the SuDS treatment train (for example in the downstream wetland areas) to mitigate water quality risks.

Additionally, subject to the details of any environmental permits, it would be possible to maintain a constant flow in to the SuDS/wetland system by discharging treated wastewater effluent here. Providing the non-potable treatment process could treat this sufficiently, this would provide a year round resource in to the non-potable system to ensure that potable water is not required to top up the non-potable system during drought periods.

The logical locations for the non-potable treatment works would be the peripheries of the gravity sub-catchments, allowing the collection of rainwater primarily via gravity, whilst still allowing community level control, treatment and distribution. However, for operational and commercial purposes it is likely that a proliferation of smaller facilities would be avoided by the chosen operator. This would mean that a proportion of the rainwater would have to be pumped to the facility, and then pumped back in to supply via a separate non-potable network.

5.6.3 Property level GWR

The British Standard for greywater systems[18] suggests that the most preferable sources to collect domestic greywater from are showers, baths and wash/ hand basins, and that this water should be considered (once treated) to be suitable for non-potable uses i.e. toilet flushing and washing machines.

As illustrated in Figure 5-8, domestic level GWR would involve the installation of a self-contained storage and treatment unit for each property. This system would collect and treat water drained from showers, baths and wash/ hand basins, and then pump this supply of non-potable water for use in toilets and washing machines.

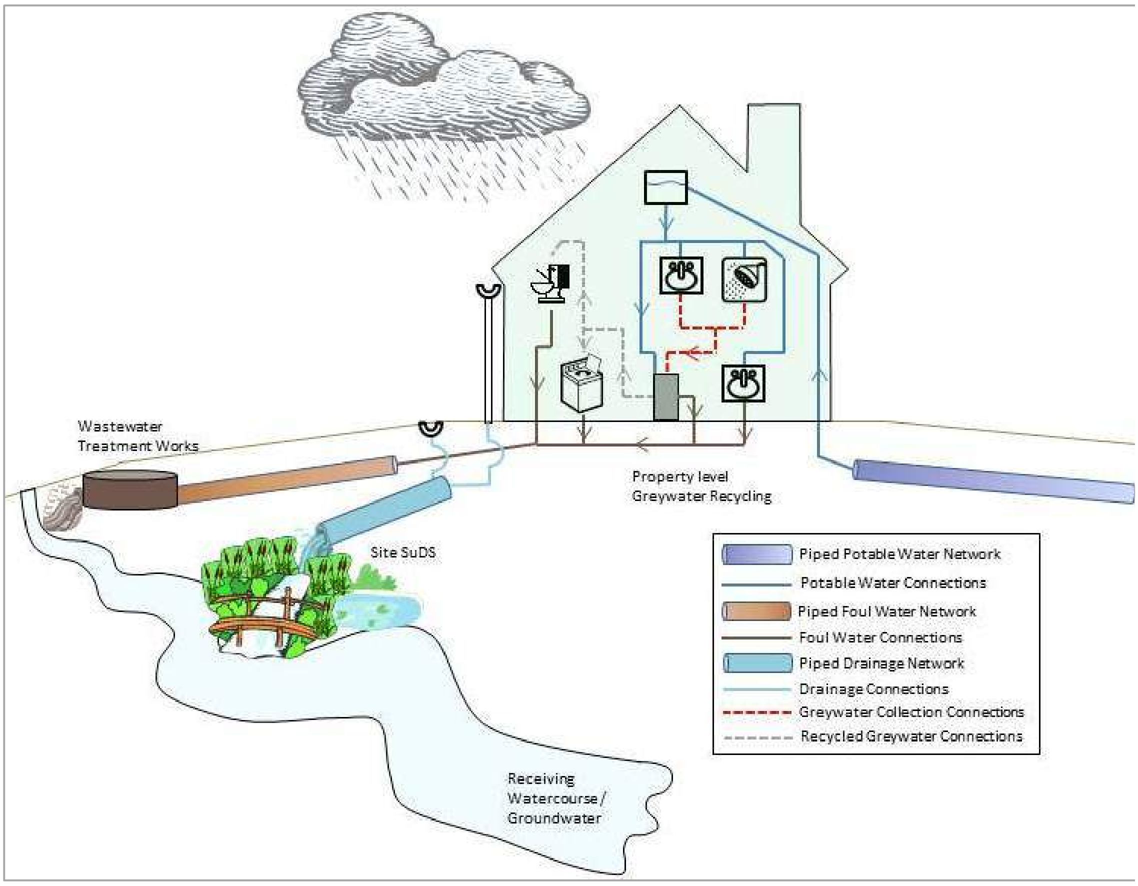

Figure 5-8 Property level GWR schematic

Greywater must be collected separately to wastewater from the toilets or kitchen sinks (high levels of grease and food particles make this unsuitable for local recycling). As with RWH, the GWR must be returned to the toilet and washing machine via non-potable plumbing, separate to other potable water plumbing in the house.

Package systems exist for the domestic markets which utilise a combination of filtration, chemical/ UV disinfection or biological processes to achieve the required treatment. However, assuming that treatment is provided by a small MBR package, the EA advise that the operational energy required for such a system would be more than three times as energy/ carbon intensive as the equivalent property level RWH system[19].

The BRE tool calculates that a typical house built to CSH Level 3/4 water efficiency would provide approximately 67 l/p/d of greywater from these sources. Allowing for a 50% collection and recycling rate would still provide more than the 30 l/p/d non-potable requirement, and hence achieve an overall potable water PCC less than 80 l/p/d.

There would be excess greywater collected compared to the non-potable demand. The higher biological content of greywater as opposed to rainwater means that long term storage should be avoided, to reduce the risk of bacterial growth. It is assumed that a GWR unit would be sized to treat and store a volume of water equivalent to the daily non-potable demand, and a separate header tank would not be used (the unit would store the required volume to allow better control of quality). Therefore, any additional greywater collected would overflow to the conventional wastewater sewers serving the house.

Domestic GWR for non-potable use reduces the volume of wastewater received at the WwTW, by around 30 l/p/d, which theoretically allows more properties to be served within the same hydraulic capacity and volumetric discharge consent. However, the wastewater received by the WwTW will be proportionately stronger, as it will be less diluted. The WwTW process will still have to remove the same mass of pollutants to achieve the consent, so savings in terms of process energy may be negligible. Additionally, it is unlikely that capital savings from reduced sizing of WwTW hydraulic/ process components would be realised, as TWUL (or an inset undertaker) would have to ensure that sufficient capacity existed in case of the GWR units being bypassed in the future.

It should be noted that the treatment used in domestic GWR systems can be susceptible to shock changes in chemical and biological loading from changes in user behaviour. BS8525-1:2010 gives the example of wash basins in the bathroom being used for hair colouring, or disinfection of cotton nappies, as potential problems if treatment processes are not sufficiently robust. It can therefore be concluded that domestic GWR is more onerous than domestic RWH in terms of the behavioural changes demanded from occupiers.

Additionally, the reduced flows entering the sewers due to this option would mean that conventional sewer design standards would have to be reconsidered. To account for the risk of the property level GWR units being abandoned in the future, the sizing of new sewerage pipes would likely have to be based on conventional flows. However, the reduced flows anticipated would mean that steeper gradients would be required to achieve the necessary self-cleansing velocities. Steeper network gradients result in increased construction and operational costs.

5.6.4 Neighbourhood GWR

As discussed above, the BRE tool calculates that, from a home achieving a PCC of 105 l/p/d, approximately 67 l/p/d of greywater would be produced. In this option, this greywater would be transported from homes to a centralised recycling location via an additional sewer network (separate to both the surface water sewers, and the foul water sewers) as illustrated in Figure 5-9.

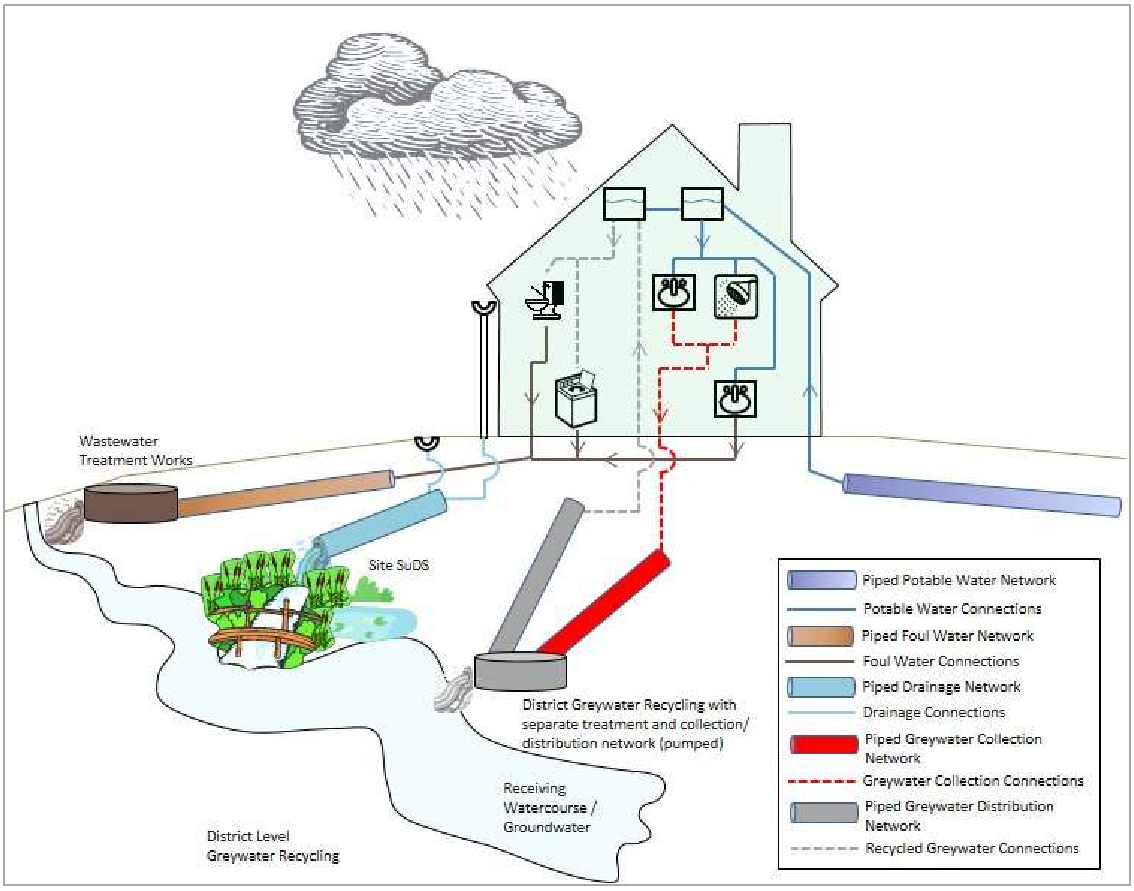

Figure 5-9 Neighbourhood GWR schematic

Similar to neighbourhood RWH, this potential solution offers the benefit of centralised control of treatment and redistribution. This allows for more efficient maintenance and upgrades, and would likely be more favourable for residents and operators as it removes a maintenance burden from individual homes.

Again, similar to neighbourhood RWH, this solution has the potential to allow more of the non-residential developments to achieve a BREEAM excellent rating for water, as their non-potable demands can be met from the centralised network, rather than relying on property level resources.

It should however be noted that this option would be the most intensive in terms of pipework/ infrastructure, as separate collection and distribution systems would be required both within buildings and streets.

As with the above, this option would serve to reduce the DWF received at the WwTW, and would additionally allow foul sewers and WwTW hydraulic components to be reduced in size (albeit that the flows received would now be more concentrated, which may prevent any cost savings in terms of process).

Assuming 90% efficiency in collection, treatment and resupply of greywater equates to a possible non-potable resource of 60 l/p/d. This exceeds the projected non-potable demand in the proposed houses by 100%; hence there would be no requirement for approximately half of the water treated. This excess non-potable water would have to be discharged local to the greywater recycling plant, or could be stored for landscaping purposes, although water quality would have to be monitored and potentially periodically treated to allow irrigation of public areas, both in terms of health and safety, and protection of groundwater and surface water quality.

5.6.5 Local reclamation of treated wastewater

An option for producing a non-potable resource on site would be to divert and treat a proportion of foul water flows from the sewerage network. If the preferred wastewater solution is a traditional sewer system to Bicester WwTW, the required proportion for reclamation could be abstracted from this network prior to it leaving the development site (a process referred to as sewer mining).

An alternative local source for non-potable water would be to reclaim effluent from after the wastewater treatment processes. Due to the stringent wastewater effluent quality standards which would likely be imposed on any WwTW, this effluent could then potentially be transformed in to a reliable non-potable supply via moderate chlorination.

Given the distance to the existing Bicester WwTW, and the potential complications of constructing and operating third party assets in close proximity to existing TWUL site, it is unlikely that this option would be implemented at the existing WwTW site.

Additionally, given the increased operational and water quality risks it is highly unlikely that this technology would be implemented at a property level.

The most viable arrangement would likely be a local reclamation works within the development site (or number of, to maximise use of gravity flows), reclaiming a proportion of the wastewater. If the preferred wastewater solution is an on-site WwTW discharging to local watercourses, it would likely be cost efficient for the reclamation process to be located on the same site, as illustrated in Figure 5-10.

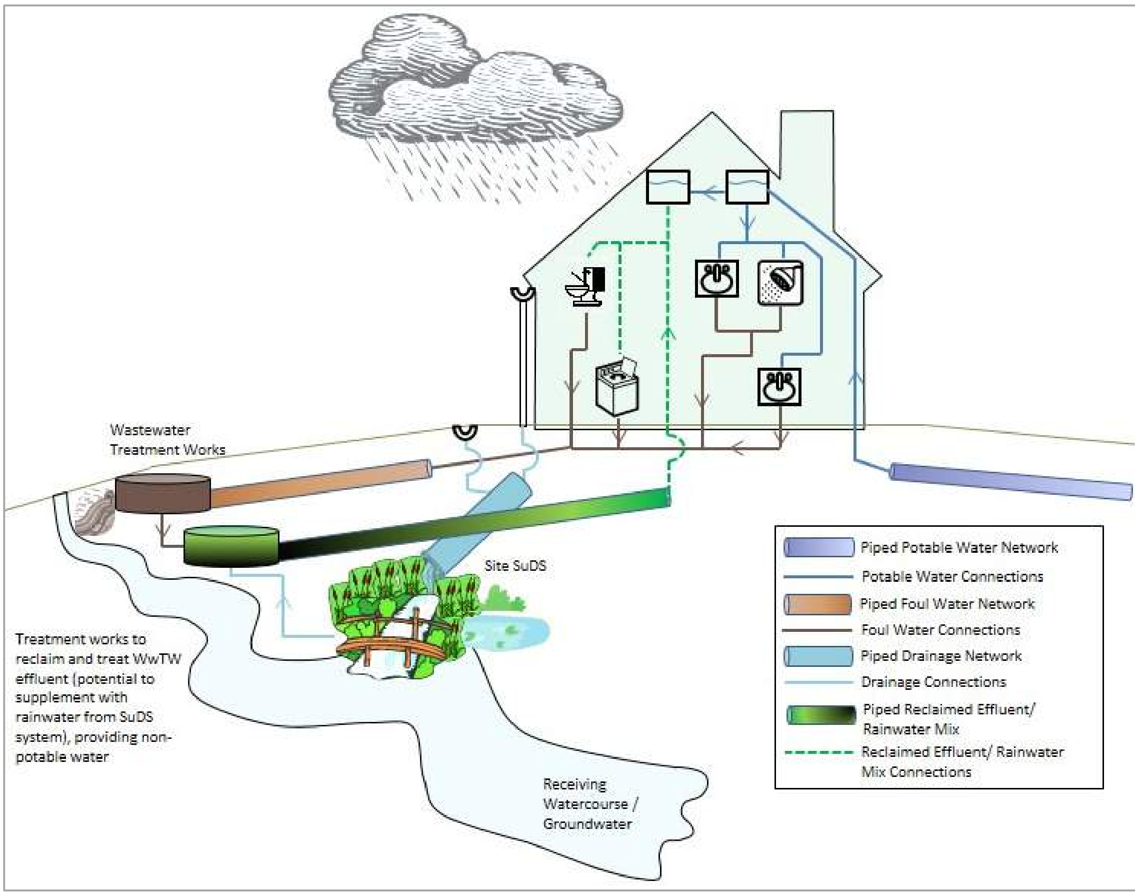

Figure 5-10 Treated wastewater reclamation schematic

Depending on the minimum flows of surface water through the SuDS network required to support any amenity and biodiversity features, it may also be possible to use surface water from the on-site SuDS network to supplement the effluent reclamation. Advantages of this approach are that it assists with dilution and provides some resilience should the WwTW process fail. However, disadvantages are that it may not be available year round, and the potential for upstream contamination of the SuDS network means that the quality of influent to the reclamation process may be variable. Technically feasible treatment processes exist for both approaches, and if this solution were preferred, the strategy would be determined by the operator during detailed process design.

Similar to neighbourhood RWH and GWR, this option has the benefit of providing a centralised non-potable supply which can be managed by a single entity, and provide the opportunity to match non-residential non-potable demand to the available non-potable supplies from across the development, potentially facilitating higher BREEAM ratings for the non-residential developments.

6 SEWERAGE AND WASTEWATER

The following Sections outline the methodologies used to assess the impact of the growth proposals on the existing wastewater treatment and foul water sewerage network in the study area, and determine the likely provision of new wastewater infrastructure.

As illustrated within the Drainage Strategy for the Masterplan, and in keeping with the preferred hierarchy in the Flood and Water Management Act (FWMA), Building Regulations and emerging National Standards for SuDS, it is the firm intention for the development that surface water drainage remain separated from the foul water network.

To aid further discussion of opportunities and constraints, two potential wastewater options were considered for the development:

- **On-site WwTW** – the provision of an on-site WwTW to serve the development, discharging to the Town Brook/ River Bure, allowing for some reclamation of resource should this become the preferred option for sourcing a non-potable supply; or
- **Existing WwTW** – transporting the new DWF from the development site to the existing TWUL Bicester WwTW for treatment and discharge in to the Langford Brook.

6.1 Wastewater capacity: methodology

The potential increase in wastewater generated by the proposed development is therefore calculated in terms of dry weather flow (DWF). DWF is used in the calculations as it assumes the separation of stormwater from foul sewers, and allows for the comparison of the potential flows with the existing volumetric discharge consents at Bicester WwTW.

DWF from the proposed development has been calculated as follows:

$$DWF\ (\mathrm{m^3/d}) = \frac{\underline{Population \times PCC\ (l/p/d) + Infiltration\ Allowance + Trade\ Flows}}{1{,}000}$$

These calculations include the following assumptions:

- Population - increases in residential population are calculated from development trajectories and based on an occupancy rate of between 2.2 and 2.3;
- The trajectory for new residential properties outside of the development, but within the Bicester WwTW catchment, is assumed to match the latest trajectory from the CDC Annual Monitoring Report[20], which totals 4,179 new properties by 2030/31;
- When considering other properties to be built within Bicester, the worst case PCC rates is considered to be 125 l/p/d, minus an allowance of 5 l/p/d for outside usage which does not enter the foul water sewers, similar to the assumptions in the Building Regulations;
- Infiltration allowance - to account for unplanned infiltration of surface water and misconnections to these new sewers in the long term, an additional proportion of unaccounted for flows has been included in the calculations. The value of this (25% of DWF) is in accordance with TWUL estimates used in high level planning for the Region;
- Non-residential DWF - an allowance for the domestic wastewater generated from the proposed 4,400 employees (including home workers and the proposed non-residential development areas) has been calculated, based on 90 l/employee/d, in keeping with the British Water Code of Practice[21];

- Trade flows – the wastewater generated from future industrial processes in new employment areas cannot be accurately estimated, as businesses will have to enter in to a separate financial agreement with the wastewater undertaker on this matter. However, in keeping with Sewers for Adoption[22], an allowance of 0.75 l/s/ha has been made for the proposed 5.8 ha of B2 industrial use;
- Both the non-residential DWF and trade flows are assumed to increase proportionately in line with the residential development build out;
- Non-residential DWF and trade flows from other proposed non-residential or mixed use developments across the CDC area have not been assessed, as this is a matter for CDC and TWUL to consider separate to this WCS;
- Any scenarios involving GWR have assumed that the flows to the foul water sewers reduce proportionately in line with the greywater held back for recycling;

The capacity of WwTW which may serve the development is assessed in three components:

- The volumetric consent (or environmental permit) – the DWF (expressed as m^3/d) which the wastewater undertaker is permitted to discharge to the receiving watercourse, as agreed by the EA under the provisions of the Water Resources Act 1991, and more recently the Environmental Permitting Regulations 2010;
- The process capacity – the ability of the biological and chemical process components to treat the load from the population to the required physio-chemical standards, as stipulated in the consent to discharge/ environmental permit. In the case of the existing WwTW, this was ascertained from discussion with TWUL; and
- The hydraulic capacity – the ability of the physical components in the works to accommodate the wastewater flows, normally expressed in terms of flow to full treatment (FTFT) i.e. the peak wastewater flows which the main process of the WwTW will be designed to handle, excluding any increases due to stormwater (typically stored for later treatment, or screened and discharged separately). Again, this was ascertained from discussions with TWUL.

The sensitivity of the wastewater calculations to varying PCC rates has been assessed in this WCS by considering the following wastewater demand scenarios:

WwTW location	Worst Case PCC l/p/d	Best Case PCC l/p/d	Planned PCC l/p/d
Existing TWUL Bicester WwTW	120 : *Building Regs minus 5 l/p/d*	105 : *CSH 3/4*	105 : *CSH 3/4*
New on-site WwTW	105 : *CSH 3/4*	80 : *PPS1– assumes some greywater reclaimed prior to treatment works*	*105 : PPS1, but assuming that if any wastewater is reclaimed to meet the 80 l/p/d target, this is after treatment*

Table 6-8 DWF PCC scenarios

It should be noted that whilst the above PCC values are used for indicative appraisals in this WCS, the actual flows and discharge quality parameters used to design any treatment processes by the wastewater undertaker (during detailed negotiations with the EA) would allow for elements of risk including shock chemical or biological loadings, unusual weather and climate change, and higher than typical PCC rates.

6.2 Wastewater capacity: DWF results

Based on the calculations in the Section above, Figure 6-11 illustrates the predicted DWF that would be generated from the proposed development site, in terms of trade flows, non-residential DWF and total DWF including the residential development with two separate PCC rates.

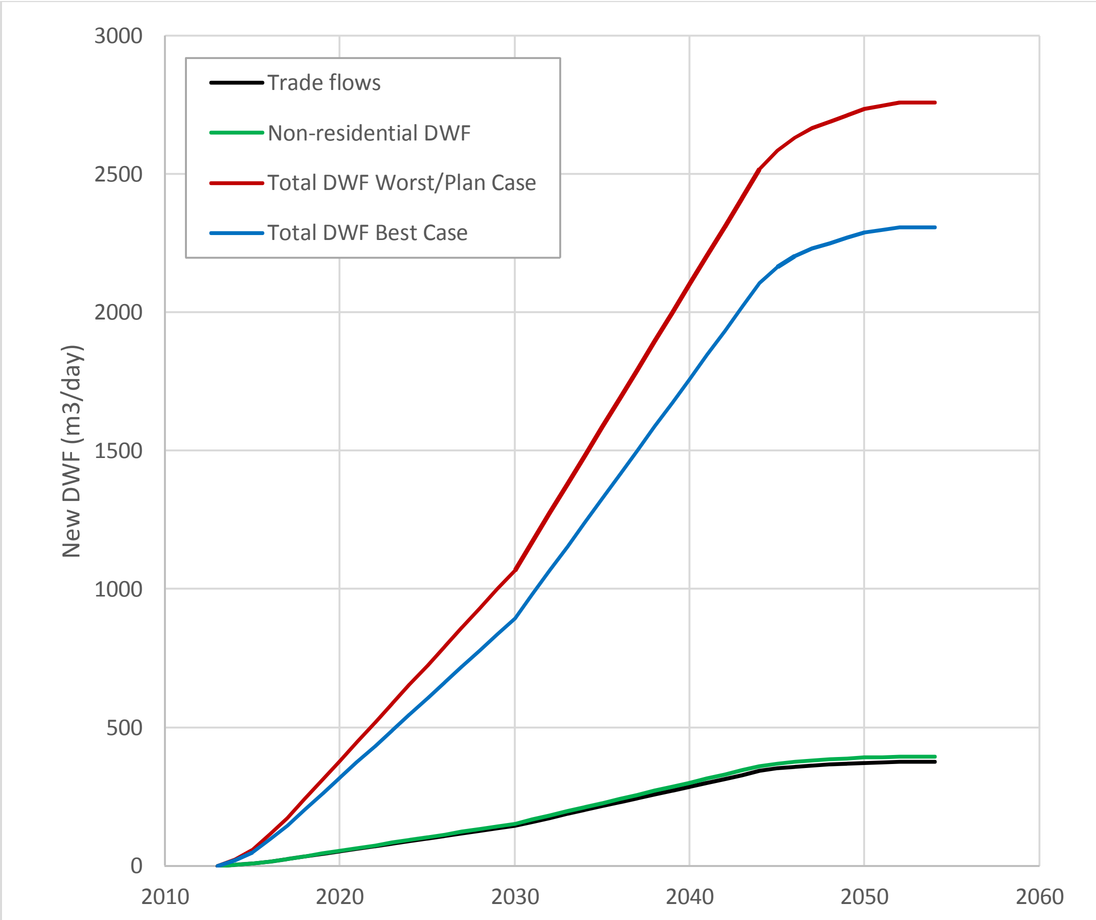

Figure 6-11 New DWF from NW Bicester development site

The calculations suggest, that by the end of the build out period, a DWF of 2,759 m^3/d would be generated (assuming the Worst Case or Plan PCC rates). If GWR were used at a property level to reclaim and treat approximately 25 l/p/d of this wastewater, the DWF would reduce to 2,309 m^3/d.

Figure 6-12 below illustrates the calculation results when considering the DWF from the NW Bicester development in conjunction with the other additional residential development in Bicester. The DWF generated by the end of the build out period is predicted to be 3,626 m^3/d under the Best Case scenario, 4,076 m^3/d under the Plan scenario, and 4,264 m^3/d under the Worst Case scenario.

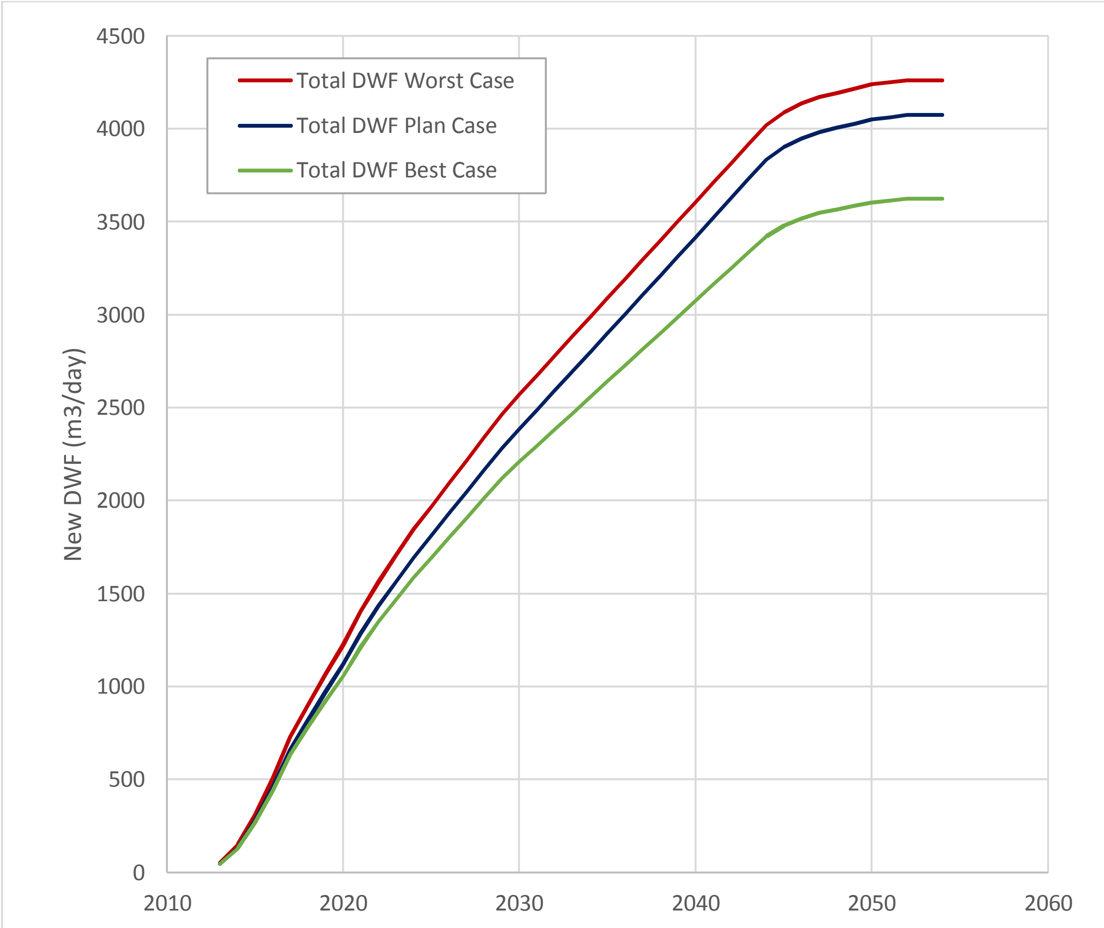

Figure 6-12 New DWF from NW Bicester development site and other Bicester development

6.3 Wastewater capacity: existing WwTW capacity

The current discharge consent/ environmental permit for Bicester WwTW allows for a maximum DWF volumetric consent of 13,427 m^3/d, with the following physio-chemical consent standards:

- Suspended solids – 25 mg/l
- BOD – 10 mg/l
- Ammonia – 2 mg/l
- Phosphate – 2 mg/l

In 2013 TWUL advised that the flows currently being discharged equated to 11,500 m^3/d. When this current headroom of 1,927 m^3/d is considered in conjunction with the DWF increases calculated above, it is predicted that the WwTW would require a new DWF consent to be agreed between 2024 and 2027 (depending on PCC rates realised). Table 6-9 illustrates this in more detail.

DWF PCC Scenario	Date existing consent exceeded	No. of homes in NW Bicester Site at this date	No. of new homes in surrounding catchment at this date
Best Case	2027/28	1,875	3,767
Plan Case	2025/26	1,575	3,459
Worst Case	2024/25	1,425	3,305

Table 6-9 Timeframe in which a new DWF consent will be required at Bicester WwTW

In order to protect the quality of the receiving water environment, the granting of an increased DWF volumetric consent by the EA would likely be accompanied by a tightening in the physio-chemical consent standards required under the provisions of the WFD. The water quality implications of such a solution are discussed further in Section 6.4.

Additionally, in 2013 TWUL advised that the current physical, biological and chemical process capacity at Bicester WwTW would allow for the load from an additional 5,000 to 10,000 PE (population equivalent) to be processed, although that it may be possible to extend this capacity by further optimisation of the processes.

Even discounting any trade flows or non-residential DWF, assuming an occupancy rate of 2.3, this 5,000 or 10,000 PE capacity would be exhausted by 2018/19 or 2023/24 respectively. However, TWUL advise that improvement works to Bicester WwTW are proposed under the AMP6 business plan (as TWUL have been aware of the proposed Bicester growth for some time).

Whilst the TWUL business plan is yet to be approved by Ofwat, it is reassuring to note that TWUL are expecting to undertake a capital project to provide additional capacity prior to 2020/21. Additionally, TWUL advise that there are no land acquisition constraints which may hamper the expansion of the capacity at Bicester WwTW.

6.4 Wastewater capacity: existing WwTW water quality

The following table illustrates current wastewater treatment processes utilised in the industry, the likely quality standards achievable, and key concerns and benefits associated with these types of treatment.

Technology	Achievable Effluent Quality	Typical PE limit	Benefits	Risks
Membrane bioreactor (MBR)	BOD < 5 mg/l[23] Amm. N < 3 mg/l[24] P = technology developing to include EBPR in process to achieve < 1 mg/l, although metal dosing backup required.	No limit, but may be uneconomical beyond 1,750 PE (~ 750 properties).	Modular components allow phased construction. Variant of ASP process which uses filtration rather than secondary settlement, significantly saving on space required. Excellent BOD removal.	Metal dosing for P removal can potentially blind filters. High capital, maintenance and energy costs.
Rotating biological contactor (RBC)	BOD = 8–15 mg/l Amm. N = 3 mg/l P = metal dosing and reedbed required for tertiary treatment towards 2 mg/l.	Assumed to be uneconomical beyond 2,000–5,000PE (~ 875–2,200 properties).	Modular components allow phased construction. High surface area provided for biological reaction – significant space saving over traditional ASP.	Prone to odour issues, requiring additional operational energy to address. Additional disc/ sand filters may be required to reliably reduce P concentrations beyond 2 mg/l.
Submerged aerated filter (SAF)	BOD = 16-25 mg/l Amm. N = 2-10 mg/l (P = metal dosing and reedbed required for tertiary treatment towards 2 mg/l.	RBC normally favoured due to Amm. N and BOD performance. Assumed to be uneconomical beyond 2,000-5,000 PE (~ 875-2,200 properties).	Modular and condensed version of the biological trickling filter process, reducing land take and odour concerns.	Additional filtration or reedbed needed to further reduce Amm. N and BOD.
Small scale ASP (alternating oxi-ditches/ boxes)	BOD = 5-7 mg/l provided good retention times and tertiary reedbed/filtration used Amm. N = 2-5 mg/l P = EBPR to 1 mg/l	Typically used as more economical option to RBC for PE over 2,000 – 3,500.	Well understood technology where on-going design is increasing efficiency and reliability (i.e. fine aeration, or MBBR additions)	Higher land take than the modular options. Some metal dosing required to reliably achieve levels of P beyond 1 mg/l, and reedbeds/ filters required for further BOD/ Amm. N removal.
Sequential batch reactor (SBR)	As above, although condensed size can restrict the retention time provided, and the space available for EBPR.	Theoretically up to any size, although only required where traditional ASP cannot fit.	Condensed version of traditional ASP, where treatment and settlement occur within the unit.	Process known to struggle with varying flows and loads, less flexible than a series of ASP ditches due to design.
Moving bed bioreactor (MBBR)	Beyond current levels of ASP – technology is constantly developing for large scale adoption	Theoretically up to any size – process can be added to ASP if quality constraints require it	Floating plastic media added to ASP process to promote biofilm generation. Other UK wastewater undertakers known to already utilise in +10,000 PE works.	Additional cost of provision and control of the process compared to conventional ASP

Table 6-10 Typical constraints and opportunities for WwTW processes

For the purposes of comparing indicative consent results, the following physio-chemical standards have been assumed to represent current and future best practice:

Colour convention shown is used throughout further Sections of this WCS report	**BOD mg/l** (95%ile)	**Amm. N mg/l** (95%ile)	**SRP mg/l** (Annual Average)
Limits typically considered as reliably economically achievable using conventional technologies*.	**7-8**	**3-5**	**1-2**
Limits that may be currently achieved by enhanced operation of conventional and emerging processes. Although not as reliable as the above, it is assumed that consents such as these will become more common over the study period if water quality constraints are to be met*.	**5-7**	**0.5-3**	**0.5-1**
Limits more stringent than the above, where it is assumed unlikely a water company or process supplier would be able to guarantee such performance in the foreseeable future at a large scale without resorting to energy intensive processes normally reserved for potable water treatment**.	**<5**	**<0.5**	**<0.5**

Table 6-11 Current and future standards assumed to be economically achievable using conventional technology

*The above is based on current and emerging work with a number of UK water companies – however the limits should not be considered definitive, as the industry is currently investing in research and development to explore the processes required to meet WFD requirements.
** If such standards were required, it is likely the water company and the EA would have to agree to set lower targets for the water body under the provision of the WFD, allowing the failure to meet good status for reasons of technical feasibility or disproportionate cost. This would be reviewed every 6 years under the WFD, until such a time that the technology was judged to be sufficiently reliant at a price appropriate for customers. It is likely that further research and pilot schemes during AMP6 will contribute to this body of knowledge.

Based on the proposed increase in DWF calculated in Section 6.2, the indicative consent results from the EA RQP modelling exercise are illustrated below. This is based on the existing DWF of 11,500 m3/d, plus the additional flows from NW Bicester and other development.

Notably, the flows used for the quality calculations also include an additional 25% to account for variances between DWF and average flow, and a further 25% to account for illegal connections and unexpected infiltration in to the sewer network.

Total DWF – scenario and timeframe (m^3/d)	**BOD mg/l** (95%ile)	**Amm. N mg/l** (95%ile)	**SRP mg/l** (Annual Average)
Scenario: worst case flows, deterioration in class limited to 10%			
12,566 – end of AMP6 2019/20	Not possible	**8.7**	**3.99**
13,345 – end of AMP7 2024/25	Not possible	**5.84**	**2.63**
14,488 – end of AMP9 2034/35	**1.76**	Not supplied	**1.9**
15,764 – end of AMP13 2054/55	**2.54**	**3.62**	**1.54**
Scenario: worst case flows, no deterioration from current class			
12,566 – end of AMP6 2019/20	**11.93**	**17.22**	**5.81**
13,345 – end of AMP7 2024/25	**9.44**	**11.03**	**3.81**
14,488 – end of AMP9 2034/35	**8.23**	**8.23**	**2.75**
15,764 – end of AMP13 2054/55	**7.44**	**6.68**	**2.22**
Scenario: worst case flows, raise to good standard			
12,566 – end of AMP6 2019/20	-	-	**0.34**
13,345 – end of AMP7 2024/25	-	-	**0.03**
14,488 – end of AMP9 2034/35	-	-	**0.05**
15,764 – end of AMP13 2054/55	-	-	**0.06**
Scenario: plan flows, deterioration in class limited to 10%			
12,471 – end of AMP6 2019/20	Not possible	**9.58**	**4.3**
13,196 – end of AMP7 2024/25	Not possible	**6.15**	**2.8**
14,300 – end of AMP9 2034/35	**1.55**	**4.6**	**1.98**
15,576 – end of AMP13 2054/55	**2.39**	**3.7**	**1.58**
Scenario: plan flows, no deterioration from current class			
12,471 – end of AMP6 2019/20	**12.58**	**18.66**	**6.27**
13,196 – end of AMP7 2024/25	**9.66**	**11.90**	**4.06**
14,300 – end of AMP9 2034/35	**8.28**	**8.5**	**2.87**
15,576 – end of AMP13 2054/55	**7.54**	**6.80**	**2.27**
Scenario: plan flows, raise to good standard			
12,471 – end of AMP6 2019/20	-	-	**0.36**
13,196 – end of AMP7 2024/25	-	-	**0.03**
14,300 – end of AMP9 2034/35	-	-	**0.05**
15,576 – end of AMP13 2054/55	-	-	**0.06**
Scenario: best case flows, deterioration in class limited to 10%			
12,421 – end of AMP6 2019/20	Not possible	**10.13**	**4.42**
13,090 – end of AMP7 2024/25	Not possible	**6.45**	**2.93**

Total DWF – scenario and timeframe (m^3/d)	**BOD mg/l** (95%ile)	**Amm. N mg/l** (95%ile)	**SRP mg/l** (Annual Average)
14,058 – end of AMP9 2034/35	**1.37**	**4.81**	**2.1**
15,126 – end of AMP13 2054/55	**2.19**	**3.96**	**1.69**
Scenario: best case flows, no deterioration from current class			
12,421 – end of AMP6 2019/20	**12.66**	**19.45**	**6.44**
13,090 – end of AMP7 2024/25	**10.44**	**12.40**	**4.26**
14,058 – end of AMP9 2034/35	**8.92**	**9.01**	**3.04**
15,126 – end of AMP13 2054/55	**7.83**	**7.32**	**2.44**
Scenario: best case flows, raise to good standard			
12,421 – end of AMP6 2019/20	-	-	**0.37**
13,090 – end of AMP7 2024/25	-	-	**0.02**
14,058 – end of AMP9 2034/35	-	-	**0.04**
15,126 – end of AMP13 2054/55	-	-	**0.05**

Table 6-12 Indicative consent results for Bicester WwTW

TWUL and the EA advise that negotiations are on-going regarding the tightening of the existing P consent standard at Bicester WwTW for the next round of improvements under the WFD (post 2015). TWUL have advised this WCS that, should the P consent standard be tightened to less than 0.5 mg/l, they will have to reassess any planned process improvement works for AMP6.

The P consent standards required at the end of the proposed development period are currently considered to be such that a water company or process supplier would be unable to guarantee such performance in the foreseeable future at a large scale without resorting to energy intensive processes normally reserved for potable water treatment, such as membrane bioreactors.

6.5 Wastewater capacity: off-site sewerage network

In 2013 TWUL advised that the existing sewerage network serving Bicester has some design capacity remaining in terms of DWF, but due to the combined nature of some areas of the network, this capacity is not available during wet weather.

TWUL have a network model of the sewers in Bicester, but advise that this will require additional verification and recalibration via the deployment of flow monitors, to enable it to be used accurately to inform any sewer requisition submitted in relation to the NW Bicester development if it involves discharging to the existing sewer network.

In order to consider the extent of new sewerage infrastructure required, this WCS has adopted a precautionary approach, and assumed that a new off-site sewer requisition to serve the NW Bicester Development would require an entirely new link around the south of the town directly to the WwTW. This is considered conservative, as TWUL have advised that there may be some available capacity (subject to modelling) in a new 600 mm sewer recently constructed along Middleton Storey Road to serve the Southwest Bicester development.

Similar to the Surface Water Drainage Strategy, it is assumed that the on-site foul water network would be constructed to encourage flow via gravity to the lowest elevations within the three areas referred to as catchment A, B, and C.

Figure 6-13 illustrates the likely gravity collection points for the new on-site foul water sewerage, and indicative routes for the primary sewer mains. Given the fluid nature of the master planning process, a proportionate area approach has been used to apportion the new residential DWF, non-residential DWF and trade flows across the three catchments. Given the inherent uncertainty regarding exact unit distribution, employment uses, occupancy rates and infiltration rates, this is considered to be an appropriately accurate approach for high level design; particularly as foul sewer and sewage pumping station (SPS) design allows for flows approximate to 3 x DWF.

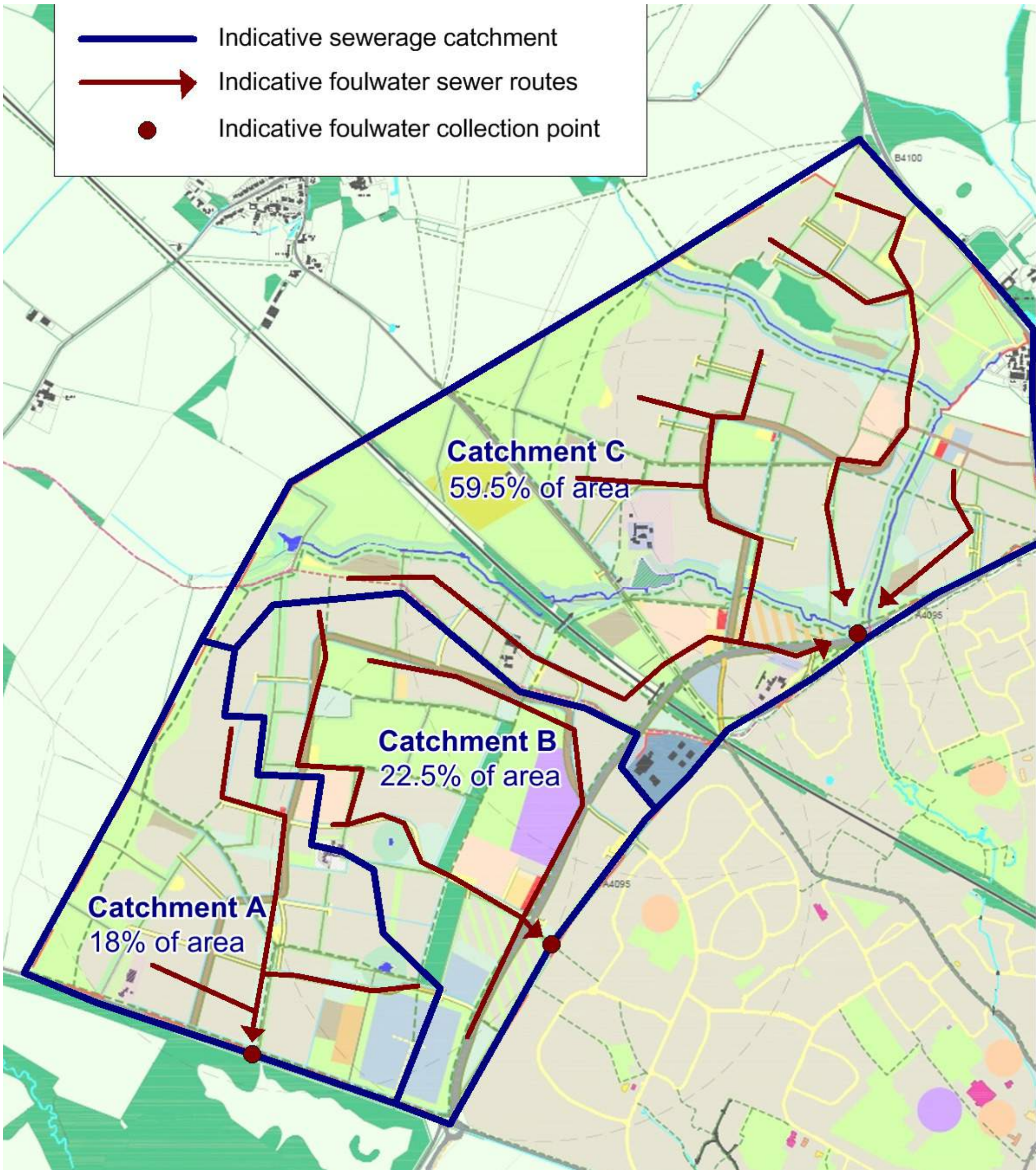

Figure 6-13 Indicative on-site gravity sewerage routes (Contains Ordnance Survey data © Crown copyright and database right (2013))

Whilst there are a number of possible routes to providing the off-site sewerage, for simplicity at this stage it has been assumed that a sewer requisition would have to include new gravity sewers from catchment A and catchment B, to a collection point on the southern corner of the development site. Given the slightly lower elevations, flows from catchment C would require pumping over the watershed to join the network in Catchment B.

From this southern collection point, a new gravity sewer would be required southwards along Middleton Storey Road. However, given the relatively slack gradient available between here and the existing WwTW, it is likely that a new terminal SPS would have to be requisitioned to pump the flows south-eastwards to the WwTW inlet.

Figure 6-14 illustrates the indicative off-site sewerage design undertaken by Hyder.

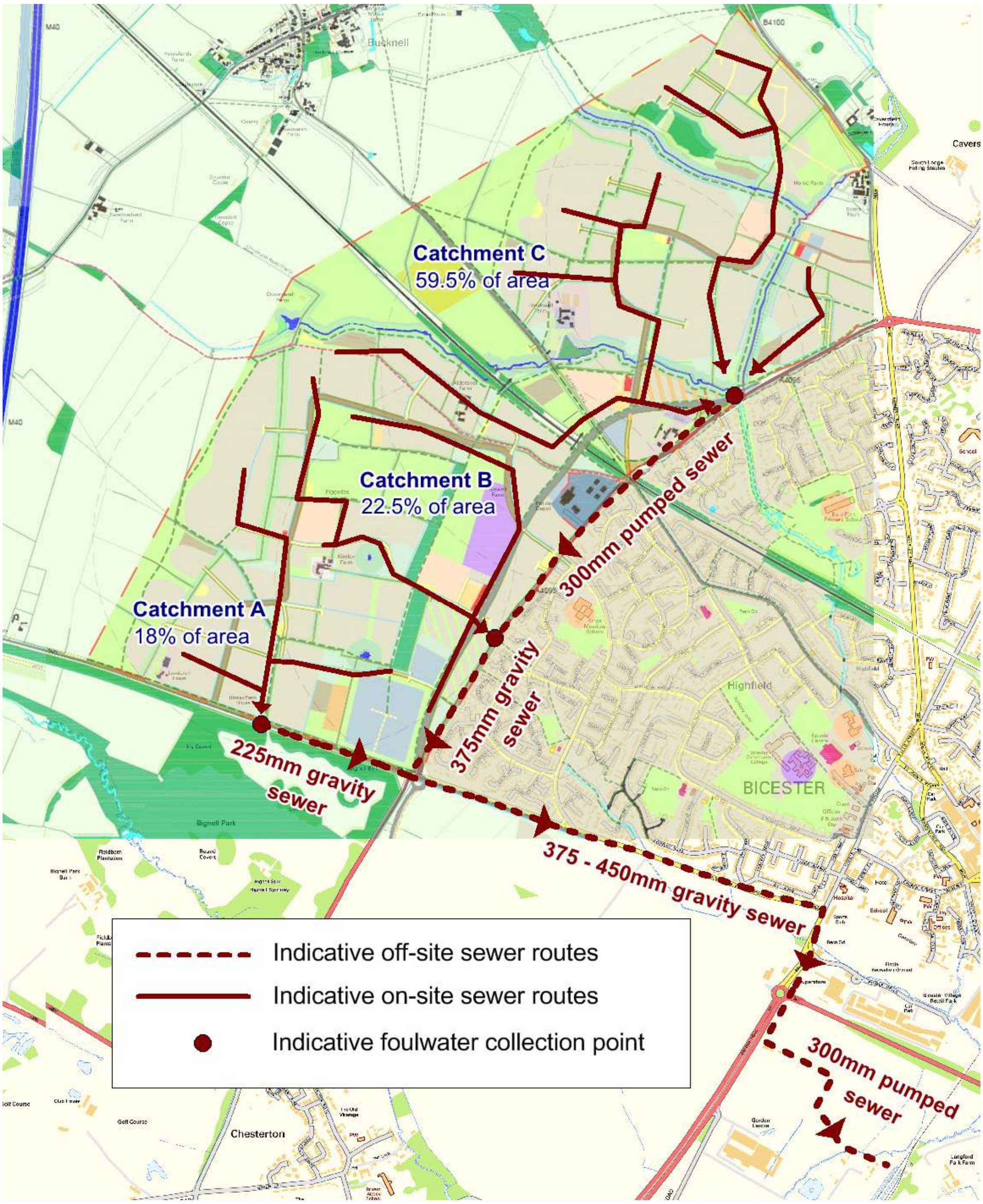

Figure 6-14 Indicative off-site sewerage routes (Contains Ordnance Survey data © Crown copyright and database right (2013))

The final route and configuration of any off-site sewer requisition would be subject to the design of TWUL, following network modelling and verification. However, the above provides a conservative indicative design to assist with cost comparisons.

Using experience gained from working on capital delivery projects for a number of wastewater undertakers, Hyder has estimated that the above off-site sewer connections (and two SPS) would cost approximately £3.5M, including land and planning fees, project management, design and power connections.

Assuming a standard 12 year calculation period for the relevant deficit, it is estimated that the relevant deficit payable by the developer to TWUL would be approximately £3.3M. This is relatively high, as the income generated from the new properties stretches over a much longer timeframe than the 12 year financing arrangement for the capital works. Notably, this calculation makes a number of assumptions regarding income per property, financing costs and inflation, which would need verifying by TWUL through the formal requisition process.

TWUL advise that, as their discretion, a commercial commuted sum arrangement can be used to fund a sewer requisition, rather than the statutory relevant deficit arrangement. This may be more appropriate given the longer timescale of the proposed development.

Additionally, oversized sewer assets can produce operational problems in terms of septicity (requiring additional chemical treatment within the network), and the failure to achieve self-cleansing velocities leading to silting up and potential blockages. Given the long development timeframe, TWUL may design off-site sewer capacity enhancements in phases more appropriate to the development trajectory, and other development and capacity within the wider network. This would alter the estimates of capital costs and relevant deficits.

Hyder have submitted an initial request to TWUL on behalf of A2Dominion to undertake preliminary investigations and prepare a budget estimate of the capital costs/ relevant deficit, to provide additional clarity on the above matters, and provide steer to the next design phase of the development.

It is estimated that the requisition, design and construction of large scale off-site sewers may take up to three years. This may mean that, if this is the preferred option for sewerage, then at least the initial two years of the NW Bicester development will have to rely on an alternative method of connecting to the Bicester sewer network. However, the sewer connection for the entire Exemplar Site (393 new homes) has already been agreed with TWUL and the remaining development is unlikely start until 2018/19. Therefore, there is sufficient timeframe to construct the new large scale off-site sewers to serve the remaining development prior to occupation.

6.6 Wastewater capacity: new on-site WwTW

An alternative to the above would be to collect and treat wastewater on site, and discharge to the Town Brook/ River Bure. An area of over 3 ha has been set aside within the master plan boundary, adjacent to the Town Brook, to facilitate such a solution.

As discussed in Section 5.6, an on-site WwTW offers the opportunity to combine this with a reclamation facility to enable a non-potable supply to be returned to the development, and therefore facilitate the achievement of the required PCC standards.

The water quality implications of such a solution are discussed further in Section 6.7. Given the low dilution available (approximately five times less than at the Langford Brook), and sensitive downstream water environment, the physio-chemical consent standards required are stringent.

Given that the final works will treat a DWF of between 2,309 m^3/d and 2,759 m^3/d, and a residential PE of up to 6,000 dwellings, to relatively high standards, and may be required to be built in modular phasing to better align with development build out, the choice of appropriate treatment technology is limited.

6.7 Wastewater capacity: on-site WwTW water quality

Based on the proposed new DWF to be discharged to the Town Brook, as calculated in Section 6.2, the indicative consent results from the EA RQP modelling exercise are illustrated below:

Total DWF – scenario and timeframe (m^3/d)	**BOD mg/l** (95%ile)	**Amm. N mg/l** (95%ile)	**SRP mg/l** (Annual Average)
Scenario: worst/ plan case flows, deterioration in class limited to 10%			
310 – end of AMP6 2019/20	**3.23**	**1.1**	**0.09**
655 – end of AMP7 2024/25	**2.66**	**0.8**	**0.08**
1,483 – end of AMP9 2034/35	**2.24**	**0.7**	**0.07**
2,759 – end of AMP13 2054/55	**2.03**	**0.6**	**0.07**
Scenario: worst/ plan case flows, no deterioration from current class			
310 – end of AMP6 2019/20	**23.55**	**3.99**	**0.48**
655 – end of AMP7 2024/25	**14.36**	**2.34**	**0.3**
1,483 – end of AMP9 2034/35	**9.66**	**1.76**	**0.21**
2,759 – end of AMP13 2054/55	**7.52**	**1.55**	**0.48**
Scenario: worst/ plan case flows, raise to good standard			
310 – end of AMP6 2019/20	**-**	**-**	**0.17**
655 – end of AMP7 2024/25	**-**	**-**	**0.12**
1,483 – end of AMP9 2034/35	**-**	**-**	**0.10**
2,759 – end of AMP13 2054/55	**-**	**-**	**0.17**
Scenario: best case flows, deterioration in class limited to 10%			
260 – end of AMP6 2019/20	**3.7**	**1.3**	**0.09**
548 – end of AMP7 2024/25	**2.8**	**0.9**	**0.08**
1,241 – end of AMP9 2034/35	**2.3**	**0.7**	**0.08**
2,309 – end of AMP13 2054/55	**2**	**0.6**	**0.07**
Scenario: best case flows, no deterioration from current class			
260 – end of AMP6 2019/20	**27.8**	**4.5**	**0.55**
548 – end of AMP7 2024/25	**16.4**	**2.59**	**0.33**
1,241 – end of AMP9 2034/35	**10.4**	**1.9**	**0.22**
2,309 – end of AMP13 2054/55	**8**	**1.12**	**0.18**
Scenario: best case flows, raise to good standard			
260 – end of AMP6 2019/20	**-**	**-**	**0.18**
548 – end of AMP7 2024/25	**-**	**-**	**0.13**
1,241 – end of AMP9 2034/35	**-**	**-**	**0.10**
2,309 – end of AMP13 2054/55	**-**	**-**	**0.09**

Table 6-13 Indicative consent results for on-site WwTW

Similar to the indicative consent results for Bicester WwTW, the P consent standards required at the end of the proposed development period are currently considered to be such that a water company or process supplier would be unable to guarantee such performance in the foreseeable future at a large scale without resorting to energy intensive processes normally reserved for potable water treatment, such as membrane bioreactors.

As part of this WCS, consultation has been undertaken with TWUL and a number of potential inset wastewater undertakers regarding the above mentioned indicative discharge standards. Whilst the details of these consultations are currently considered to be commercially sensitive, the following points have emerged from these discussions:

- The WwTW process likely to be selected may be a membrane bioreactor works with both an aerated zone and anoxic treatment zone, or a submerged aerated filter;
- This could potentially provide an effluent with Amm.N concentrations less than 0.5 mg/l, and SRP concentrations less than 0.05 mg/l (with appropriate chemical treatment or enhanced biological treatment);
- Tertiary treatment of the effluent via a reedbed/ constructed wetland may not be required – however it should be noted that as sufficient land has been allocated, reedbeds/ wetland may still be incorporated in to any on-site WwTW to provide biodiversity habitats, additional solids and nutrient removal, and a degree of process risk mitigation;
- A proportion of the high quality effluent from such a process could be collected and chlorinated relatively easily on-site to provide the non-potable resource essential for meeting the PCC targets across the development;
- The capital contribution that A2Dominion may need to make towards such a solution would be in the region of £4.5M to £8M, which would likely be more expensive than a conventional off-site sewerage requisition (estimated at £3.3M as discussed in Section 6.5);
- Inset companies believe that this such a works could be operated at a cost which did not result in customer bills any higher than the equivalent TWUL rates; and
- The modular nature of the proposed treatment process would fit easily within the allocated masterplan area, and would allow a phased delivery in line with the development build out.

6.8 Wastewater capacity: on-site sewerage network

Should on-site treatment be the preferred option, it is suggested that gravity sewers are employed to collect the majority of the wastewater, to avoid the need for a multitude of on-site SPS. Similar to Section 6.5, it is suggested that these would terminate at the low points within the three catchments. A new on-site SPS at each of these three locations would then be required to return the wastewater to the on-site WwTW.

Such a solution is illustrated in Figure 6-15. However, there may also be opportunity to gravitate Catchment A and B to a final collection point at the southern corner of the development and then use a single pumping main to the on-site WwTW. This can be investigated during the detailed design stage.

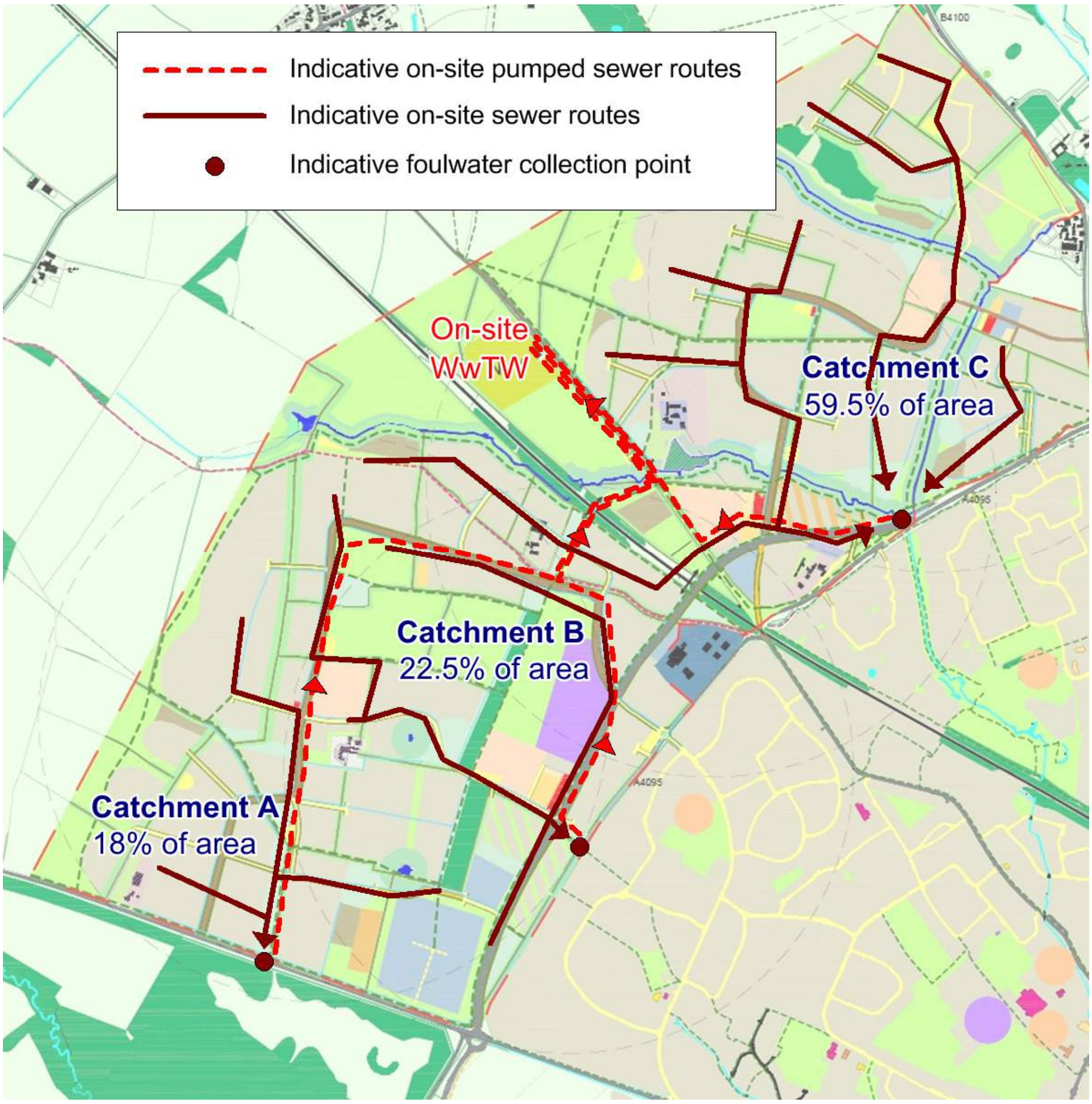

Figure 6-15 Indicative on-site pumped sewerage routes (Contains Ordnance Survey data © Crown copyright and database right (2013))

A sewerage solution such as the above offers the following benefits:

- It is more easily designed and constructed to align with the development build out;
- A more phased delivery avoids the cost/timeframe disparity which may make a traditional off-site requisition unattractive;
- Capital savings can be achieved as the on-site pumped sewers can potentially be constructed at the same time as other utilities across the site; and
- Disruption to the existing town (in terms of construction impacts on traffic), and sewer network works, is minimised.

7 CONCLUSIONS

Following this detailed WCS, the following conclusions can be made regarding the NW Bicester development:

- TWUL are in the process of finalising their 25 year plan to manage the water resources and potable water demand across the wider area, whilst mitigating climate change risks and ensuring best value for their customers. The growth at Bicester has been accounted for within these plans, and the exemplary potable water usage rates proposed for both the residential and non-residential development will mean that the increase in demand is less than that accounted for by TWUL;
- In order to achieve the above mentioned reductions in potable water demand, the proposed development must incorporate best practice water efficiency measures, and provide a reclaimed source of non-potable water to substitute with potable water used for toilet flushing and laundry;
- This non-potable water supply would be most efficiently managed if provided from a centralised location via a separate non-potable network, connected to separate non-potable plumbing in the new buildings;
- In terms of water neutrality, achieving the above mentioned water usage reductions will result in the net increase in potable water demand being limited to between 39%-41% of what it could have possibly been if conventional water usage rates were permitted;
- Whether the potable water supply to the development is provided by the incumbent water undertaker, or via an inset appointee, the existing TWUL network adjacent to the development site is readily capable of supplying this water, with any required upgrades already undertaken or planned through TWUL's standard investment cycle;
- Two viable options exist for the provision of sewerage infrastructure (subject to the finally chosen WwTW solution below) in a timely manner to serve the development – the potential delivery of this infrastructure is well understood, and negotiations with providers are progressing positively;
- The discharge of treated effluent from either an on-site WwTW, or the existing TWUL WwTW at Bicester, will require stringent physio-chemical standards to ensure that the objectives of the WFD are not compromised; and
- These consent standards are beyond those which are currently considered economically achievable using conventional methods – however, consultation with potential inset wastewater undertakers reveals that technical solutions exist, and that they believe the inset market can deliver such solutions at an attractive price which proves viable for both A2Dominion, and the end users.

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