APPENDIX TWELVE – WATERBEACH WATER CYCLE STUDY



Denny St Francis Water Cycle Study

Detailed Report

December 2014

RLW Estates Ltd

Mott MacDonald

Denny St Francis Water Cycle Study

Detailed Report

December 2014

RLW Estates Ltd

The Warehouse
33 Bridge Street
Cambridge
CB2 1UW

Mott MacDonald, Demeter House, Station Road, Cambridge CB1 2RS, United Kingdom
T +44 (0)1223 463500 F +44 (0)1223 461007 W www.mottmac.com

Mott MacDonald

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description	Standard
A	06/06/2014	L Peaver P Satchell E Fowler S Watson F Marron	A Rawlings P Selby R Gamble S Watson	A Rawlings	Draft for client review	
B	30/06/2014	L Peaver	A Rawlings	A Rawlings	Final draft for stakeholder review	
C	03/10/2014	L Peaver P Satchell	A Rawlings	J Pavey	Final issue	
D	02/12/2014	L Peaver	A Rawlings	J Pavey	Final issue incorporating EA comments (see Appendix I)	

Contents

Executive Summary

Denny St Francis has been identified as a strategic development site in South Cambridgeshire District Council's Proposed Submission Local Plan. The development would be situated to the north of the existing settlement at Waterbeach, encompassing the existing brownfield site of the former Ministry of Defence site, Waterbeach Barracks.

A Water Cycle Study was commissioned in order to:

- Engage key stakeholders in identifying options and constraints for local water management issues associated with the proposed development; and
- Deliver an integrated approach to water management issues associated with the proposed development.

The study has comprised two stages – a Scoping Phase (reported in February 2014) and a Detailed Phase (this report), with the key output being recommended Water Cycle Strategy for water at Denny St Francis.

A stakeholder group comprising Anglian Water Service Ltd, Cambridgeshire County Council, Cambridge Water, the Environment Agency, South Cambridgeshire District Council and Waterbeach Level Internal Drainage Board have been engaged through all stages of the development of this Water Cycle Strategy. These stakeholders attended a series of three workshops, at which the environmental context was conceptualised, opportunities and constraints for water discussed, assessment methodologies agreed and the main findings of the study reported. In addition, a series of telephone interviews were conducted with representatives of these organisations, plus English Heritage and Natural England.

The recommended Water Cycle Strategy incorporates opportunities for a cross-discipline approach to water, whereby all aspects of the water cycle are considered in a holistic, sustainable way. The Strategy is based on analysis of available data, understanding of the opportunities and constraints, and a sustainability assessment of the proposed options for each topic.

The Sustainability Assessment of the proposed options assessed the key principles of social, economic and environmental sustainability, to ensure that the development proposal does not conflict with environmental needs.

The Strategy covers five main themes: 'Water resources, supply and efficiency', 'Flood risk management', 'Surface water management', 'Used water management' and 'Ecology and biodiversity'.

The key recommendations include:

Water resources, supply and efficiency

WR 1: All properties should be installed with a smart water meter

WR 2: Water efficient components should be installed in all homes and businesses at the construction stage

WR 3: Active education of residents in water efficiency

WR 4: A connection to Cambridge Water Company would provide the most practical and deliverable source of potable water

WR 5: Installation of non-potable rainwater supply systems in all dwellings and appropriate other buildings

Flood risk management

FRM 1: On-site flood mitigation measures would be the most sustainable form of flood protection at Denny St Francis

FRM 2: The Denny St Francis development should be designed so as not to rely on the protection of existing flood defences

FRM 3: The raised on-site embankments should be retained

FRM 4: A Level 3 Flood Risk Assessment will need to be undertaken

FRM 5: Off-site associated development should be flood resilient

Surface water management

SWM 1: The surface water management strategy should be based on Sustainable Drainage Systems

SWM 2: Biodiversity and amenity considerations should be included in the drainage design

SWM 3: The potential to incorporate a retention pond to support the local Internal Drainage Board network should be promoted

Used water management

UWM 1: A new Water Recycling Centre at Denny St Francis would be the most sustainable option for used water treatment

UWM 2: Waterbeach Water Recycling Centre should be decommissioned and used water transferred to the new Denny St Francis Water Recycling Centre.

UWM 3: The location of a new Water Recycling Centre should continue to be explored

UWM 4: Green treatment technologies should be adopted where possible

Ecology and biodiversity

ECO 1: Opportunities for the Denny St Francis ecological mitigation programme to link with wider strategies should be advanced

ECO 2: Ecological opportunities should be maximised within the design and development of amenity features on the site

ECO 3: Water should underpin the Denny St Francis landscape structure

ECO 4: Development should be sensitive to the existing habitats and species of Denny St Francis

1 Introduction

1.1 Background

Mott MacDonald has been commissioned to undertake a Water Cycle Study (WCS) for the proposed development at Denny St Francis, Waterbeach.

Denny St Francis has been identified as a strategic development site in South Cambridgeshire District Council's (SCDC) Proposed Submission Local Plan (South Cambridgeshire District Council, July 2013). The development would be situated to the north of the existing settlement at Waterbeach, encompassing the existing brownfield site of the former Ministry of Defence (MOD) site, Waterbeach Barracks.

The aims of the study are to:

- Engage key stakeholders in identifying options and constraints for local water management issues associated with the proposed development; and
- Deliver an integrated approach to water management issues associated with the proposed development.

The WCS has comprised two stages; a Scoping Study followed by a Detailed Study[1]. There have been two reporting deliverables for this WCS, one for each stage, which consolidate and appraise the issues raised throughout the investigation and stakeholder engagement process.

This report forms the draft output of the detailed stage of the project.

1.2 Introduction to Water Cycle Studies

A Water Cycle Study is a holistic, evidence-based review of all aspects of the water cycle relevant to the proposed development. It seeks to ascertain site-specific sustainability issues and constraints that should be considered in future development proposals.

A WCS will help secure a more sustainable approach to water management by:

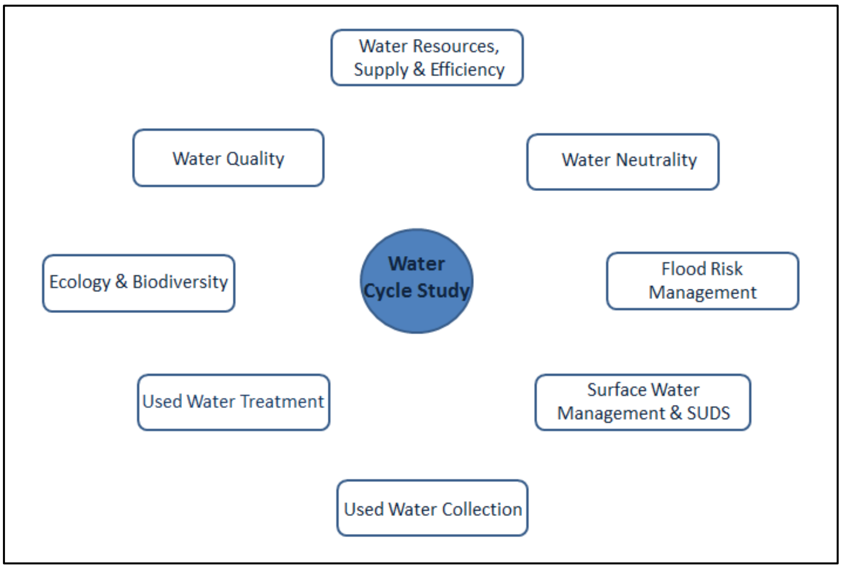
- Bringing together all partners and stakeholders' existing knowledge, understanding and skills;

[1] The detailed stage of a water cycle study is often undertaken in two distinct parts: outline (Phase 1) and detailed (Phase 2). The Denny St Francis Detailed Study combined these in a single study as befitting the scale of the proposed development.

- Bringing together all water and planning evidence under a single framework;
- Understanding the environmental and physical constraints to the proposed development;
- Incorporating green infrastructure planning to identify opportunities for more sustainable planning; and
- Identifying water cycle planning policies and a water cycle strategy to help all partners plan for a sustainable future water environment (Environment Agency, 2009).

National guidance on completing water cycle studies was published by the Environment Agency (EA) in 2009 to provide Local Planning Authorities (LPAs) with support in commissioning their own WCS assessments. This guidance sets out best practice and key objectives for each stage of the WCS, and emphasises the importance of stakeholder engagement in the adoption of the final strategy. The main areas of study focus are presented in Figure 1.1.

Figure 1.1: Water Cycle Study topics



Source: (Environment Agency, 2009)

Further to the national guidance, Anglian Water and the Environment Agency produced their own ‘framework’ of position statements and guidance at the local level. The document states that the fundamental basis for any engagement in water cycle studies from an Environment Agency-Anglian Water Services perspective is to support and actively encourage strategies and behaviours that demonstrate commitment to the long-term viability of the provision of water and used water services and the protection of the water environment (Anglian Water Services Ltd & Environment Agency, 2010).

1.3 Introduction to Denny St Francis

The Proposed Submission of the South Cambridgeshire Local Plan was published by SCDC in July 2013, to cover the planning period 2011 to 2031 (South Cambridgeshire District Council, July 2013). The Local Plan identifies Denny St Francis (known as Waterbeach New Town in the Local Plan document) as one of four major strategic sites for development in South Cambridgeshire.

Policy SS/5

Waterbeach New Town will "deliver an example of excellence in sustainable development"

(South Cambridgeshire District Council, July 2013)

Policy SS/5 states that Waterbeach New Town will "*deliver an example of excellence in sustainable development*" and will comprise:

- A mixed use development incorporating 8,000 – 9,000 dwellings. Details of the dwelling capacity and other uses will be established through an Area Action Plan (AAP).
- A start to housing delivery in 2026 and the delivery of 1,400 dwellings by 2031 (unless agreed otherwise by the Local Planning Authority).
- A firm commitment to the remainder of the development.
- The potential to review the start date of development through a review of the Local Plan if housing needs prove that capacity is required earlier.

The Local Plan proposes the preparation of a new AAP, to have the status of a Development Plan, which would guide the development. The AAP is intended to establish the details of the scheme prior to submission of a planning application. It would determine the final number of dwellings and highlight opportunities to exceed Local Plan sustainability standards, including the management of surface water drainage measures. South Cambridgeshire District Council has included a Denny St Francis AAP in its 2014-2020 Local Development Scheme, which states that work on the AAP will commence in winter 2017, with adoption in spring 2020 (South Cambridgeshire District Council, February 2014).

Table 1.1 highlights the current status and future stages of the local planning process.

Table 1.1: South Cambridgeshire planning schedule

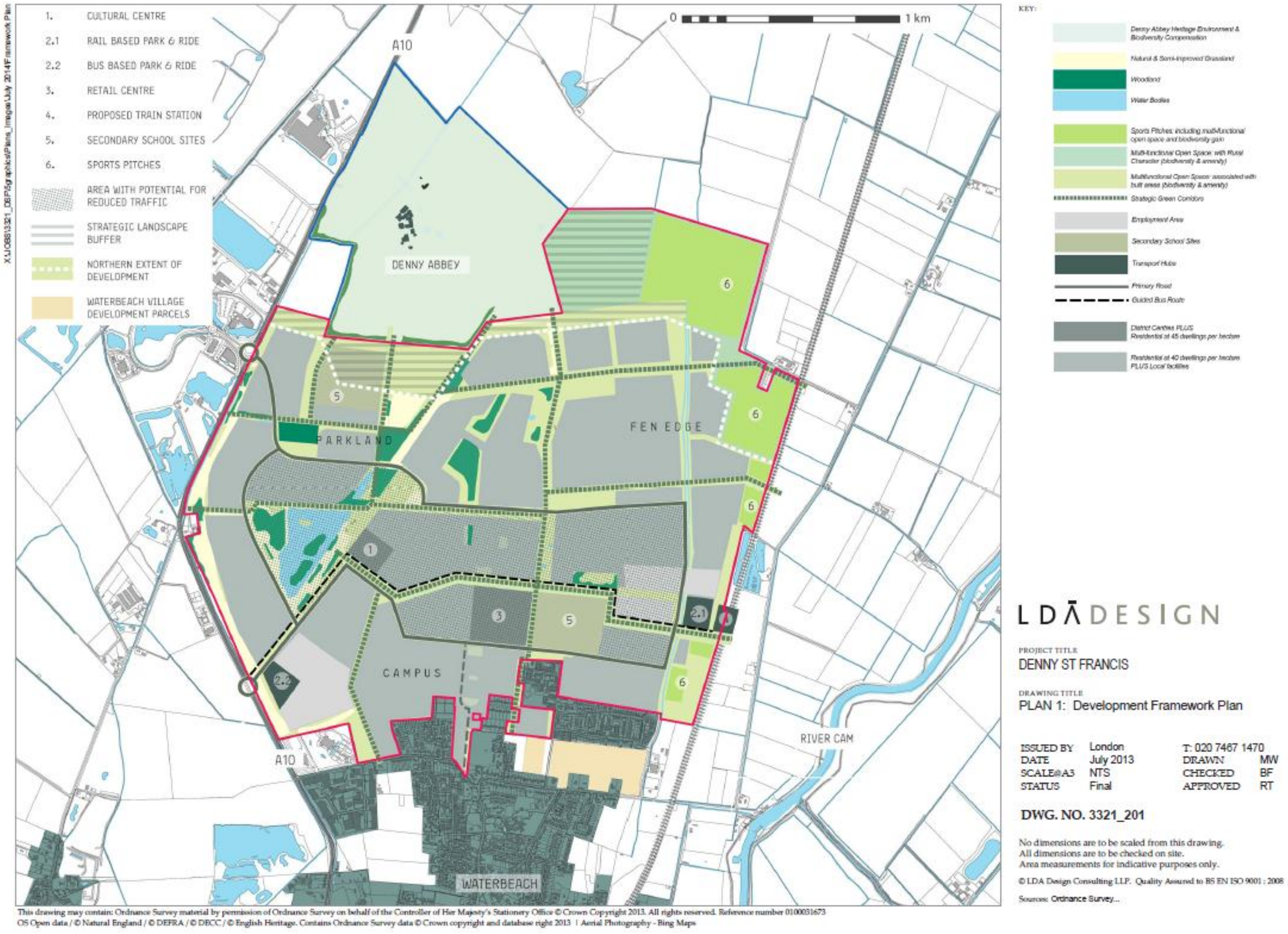
Planning document	Date
South Cambs. Local Plan Public Consultations: Issues and Options	Jul – Sep 2012 Jan – Feb 2013
South Cambs. Proposed Submission Local Plan Public Consultations	Jul – Oct 2013
Submission of Local Plan to Secretary of State	Spring 2014
Public Examination of Local Plan by Planning Inspector	Autumn/Winter 2014
Receipt of Inspectors Report and adoption of the Local Plan	Spring/Summer 2015
Compilation of the Waterbeach New Town Area Action Plan	Winter 2017
Adoption of the Waterbeach New Town Area Action Plan	Spring 2020

Source: Boyer Planning.

The Denny St Francis promoter, RLW Estates Ltd., submitted their responses to the 2012 consultation jointly with the Defence Infrastructure Organisation (DIO) which supported the principle of the allocation but addressed a number of detailed points. These include a revised capacity assessment showing that the site could accommodate between 9,000 and 10,000 dwellings, and a request for greater flexibility regarding the start date of the development (RLW Estates Ltd. & Defence Infrastructure Organisation, October 2013).

The current framework plan of the proposed development is shown in the below figure. Water is a key aspect of the Denny St Francis masterplan and would be used to help define the character and landscape of the development.

Figure 1.2: Denny St Francis Development Framework Plan



Source: LDA Design. 3321_201, August 2014.

1.4 Objectives of the Detailed Study

The main objectives of a combined outline and detailed WCS report are to:

- Identify environmental risks and constraints;
- Identify if environmental resources can cope with further development;
- Identify if the development would overload the existing infrastructure;
- Identify if major new systems are needed to allow development;
- Help pinpoint if there is water cycle capacity for new development without needing to build major new infrastructure;
- Provide the evidence base for the local planning authority's Core Strategy;
- Complete any detailed assessments identified in the outline study;
- Establish minimum design standards to be applied to new developments to ensure a sustainable and integrated water cycle;
- Carry out a sustainability analysis of development options and water cycle infrastructure;
- Provide a detailed framework for the sustainable provision of infrastructure including a timeline of requirements (the water cycle strategy);
- Help ensure that water cycle infrastructure will be funded and implemented in a timely manner;
- Inform supplementary planning guidance; and
- Provide the basis for a financial mechanism for developer contributions, or a 'reasonable prospect' of infrastructure provision to link planning conditions.

1.5 Stakeholder engagement

Stakeholder engagement during the Scoping Study involved the establishment of a stakeholder steering group and a series of telephone interviews to capture and collate existing information on water issues and constraints affecting the study area.

The following stakeholders were approached as part of the scoping stage:

- Anglian Water
- Cambridge Water
- Cambridgeshire County Council
- English Heritage (declined)

- Environment Agency
- Natural England
- South Cambridgeshire District Council
- Waterbeach Level Internal Drainage Board
- Waterbeach Parish Council (declined)

English Heritage declined to be involved at this stage, feeling that the Cambridgeshire County Council would adequately cover their concerns. Waterbeach Parish Council also declined. Consequentially, seven stakeholder organisations have contributed to the Denny St Francis WCS.

1.5.1 Stakeholder interviews

Stakeholder interviews were conducted during December 2013 and January 2014, at which the stakeholders were offered the opportunity to comment on all seven key aspects of the WCS presented in Figure 1.1.

A series of interview questions were developed and put to all organisations in order to build an understanding of the issues, constraints and opportunities that each organisation considered important for Denny St Francis. These findings helped to build the initial conceptualisation of the key aspects of the Water Cycle Study that was reported in the Denny St Francis Water Cycle Study Scoping Report (RLW Estates Ltd., February 2014).

1.5.2 Stakeholder workshops

A series of three workshops were subsequently held. The first workshop helped to build the Scoping Report, with the second and third workshops directing the Detailed Study.

Workshop 1 – 13th February 2014
1. Refine and confirm WCS opportunities and constraints
2. Agree the proposed approach for the detailed study

Workshop 2 – 7th April 2014
1. Refine and agree Detailed Study methods and objectives
2. To provide guidance for the Detailed Study

Workshop 3 – 8th May 2014
1. To agree the conclusions of the Detailed Study
2. To review the sustainability assessment
3. To highlight any outstanding issues to be addressed

Representatives of Anglian Water Services Ltd, Cambridge Water, Cambridgeshire County Council, the Environment Agency, South Cambridgeshire District Council and the Waterbeach Internal Drainage Board attended these meetings.

Details of the attendees and a summary of the discussions from each of the workshops can be found in Appendix A.

1.5.3 Stakeholder comments

The stakeholders were invited to comment on the draft Detailed Report (Revision B) in July 2014. The comments received were reviewed and incorporated into Revision C of the Detailed Report.

All stakeholders subsequently provided letters to Mott MacDonald, formally acknowledging their involvement in the stakeholder engagement group, attendance at the stakeholder workshops and their review of Revision B of the Detailed Report.

Additional comments on Revision C were received from the Environment Agency in their letter of the 29th October 2014 (reproduced in Appendix I). Revision C of the Detailed Report has consequently been reissued with reference to these comments, as Revision D – this report.

1.6 Structure of this report

Section 2 of this report provides an overview of the findings of the Denny St Francis Water Cycle Study Scoping Report, including the recommendations agreed by all stakeholders for the Detailed Study.

The Development Scenarios against which water and used water options are assessed are detailed in Section 3, followed by an overview of the sustainability assessment methodology being adopted for this study in Section 4.

The analysis and results from the Detailed Study assessments are reported in the subsequent individual chapters:

- Water resources, supply and efficiency (Section 5)
- Flood risk management (Section 6)
- Surface water management (Section 7)
- Used water treatment and water quality (Section 8); and
- Ecology and biodiversity (Section 9).

The proposed Water Cycle Strategy for Denny St Francis is reported in Section 10.

Supporting technical reports can be found in the Appendix.

2 Review of Scoping Study Findings

2.1 The Scoping Study

A Water Cycle Study Scoping Study is a report providing a summary of the available information relating to the water environment within the study area. This was published by Mott MacDonald in February 2014 (RLW Estates Ltd., February 2014). The key findings and recommendations are summarised below.

2.2 Key findings of the Scoping Study

2.2.1 Water resources

There are significant licencing constraints to raw water abstraction at (or in close proximity) to Denny St Francis. On the River Cam, new licences would be restricted and only available above Q30[2] (high) flows. In addition, no further consumptive groundwater licences are available.

An initial assessment has shown that water neutrality is unlikely to be achievable at Denny St Francis due to the constraint of rainfall quantity. The review, however, was based on limited data and information.

Although the study identified that Cambridge Water assessments predict that the Denny St Francis development can be reliably supplied from their sources, there are some residual risks. Future sustainability reductions as a result of the Water Framework Directive are unknown. In addition, licence renewals may limit deployable output.

These uncertainties have potential to impact on the security of a supply from Cambridge Water. However, current information indicates the risk to security of supply is small during the current water company planning period.

2.2.2 Flood risk and surface water management

Existing assessments have shown the Denny St Francis site to be within Flood Zone 1, with the exception of the south-western corner of the site which is shown to be within Flood Zone 2. The National Planning Policy Framework Technical Guidance defines Flood Zone 1 as land assessed as having a less than 1 in 1,000 annual probability of

[2] Q30 is a statistical hydrological measure of river discharge. It equates to the flow equalled or exceeded for 30% of the specified term. It is therefore a high flow parameter.

river or sea flooding (<0.1%) in any year. Flood Zone 2 is defined in the same document as land assessed as having between a 1 in 100 and a 1 in 1,000 annual probability of river flooding (1% - 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% - 0.1%) in any year (Department for Communities and Local Government , 2012).

Previous flood modelling of the River Cam concluded that the site is not at risk from fluvial flooding under the 1 in 1,000 year plus climate change scenario.

Whilst the available published flood defence breach assessments did not find there to be any risk to Denny St Francis, it was acknowledged that the assessments may not have considered the worst-case breach locations for the development and, as such, may have underestimated the impact of defence failures.

Drainage at the site is currently managed by the Waterbeach Level IDB. Discussions with representatives of the IDB confirmed that their existing system does not have the capacity for any additional runoff.

2.2.3 Used water and water quality

The local Water Recycling Centre (WRC) of Waterbeach would not be able to support the proposed development at Denny St Francis without a major upgrade.

Anglian Water has confirmed that the expansions planned for Cambridge WRC to meet developments in the Cambridge area do not include an allowance for Denny St Francis. The options for used water treatment include the construction and development of a new works at, or near, the development.

The River Cam is classified as having Moderate Ecological Potential in the 2009 River Basin Management Plan, with the objective of meeting Good Ecological Potential by 2027. Stringent water quality discharge conditions would likely be required for any new discharge consent.

No groundwater quality concerns were found by the Scoping Study, other than those relating to the presence of contaminated land on the site of the old barracks.

2.2.4 Ecology and biodiversity

There are no designated sites within the footprint of the proposed development. Areas of priority habitat are present, categorised for deciduous woodland, but no water-dependent habitats are listed.

Historic ecological surveys have found Great Crested Newts and Water Voles on the Waterbeach Barracks site; both of which are UK BAP (Biodiversity Action Plan) priority aquatic species and would require careful ecological mitigation.

The Cambridgeshire Green Infrastructure Strategy identified a ‘Strategic Network’ of green infrastructure routes, including the River Cam corridor (Cambridgeshire Horizons, 2011). In addition, the site is in close proximity to land identified by the Wicken Fen Vision (National Trust, 2009). There could be opportunities at Denny St Francis to link with these strategies and their networks of green infrastructure.

2.3 Key recommendations of the Scoping Study

The review of the existing situation and available information highlighted the need for further review into the following areas during the Detailed Study. These recommendations have been taken forward into the Detailed Study and assessed against the environmental objectives which will be developed for the study area.

Table 2.1: Recommendations for the Detailed Study

Component	Recommendations for the Detailed Study
Water Resources	• The current CAMS statuses for surface and groundwater resources in the Ely Ouse and Cam, Rhee and Granta sub-catchments should be confirmed with the Environment Agency. • Review of the current National Environment Programme sustainability reductions table in order to understand future WFD implications and ascertain any need for a revised supply-demand balance for Denny St Francis. • Consideration of off-site ecological impacts from potential raw water abstractions. • Review of the reduced total forecast demand for Cambridge Water if Denny St Francis achieves CfSH level 3/4 or 5/6. • Discussion with Cambridge Water regarding the potential for long-term collaboration in working towards CfSH level 3/4 or 5/6. • It should be determined whether a reassessment of the existing water neutrality calculations is worthwhile and, if so, what additional data would be required. • Licensing implications should be discussed with the Environment Agency.

Component	Recommendations for the Detailed Study
Flood Risk & Surface Water Management	• Proposals for further River Cam breach flooding assessments should be developed as a part of the Detailed Study, through the review of the existing Environment Agency modelling work. • Develop the scope for a Level 3 Flood Risk Assessment, if deemed necessary. • Confirmation from the Waterbeach IDB regarding the capacity of their assets. • Provide the IDB with an indication of potential changes to the quantity and quality of surface water as a result of the development. • Review of runoff rates from the development. • Assessment of the potential for SUDS for managing surface water at the site given the local geology and hydrogeology. Existing reports should be reviewed by stakeholder experts. • Develop the scope for a programme of groundwater level monitoring, infiltration tests and geotechnical investigations, if required. • Confirm the suitability of a target site drainage discharge rate of 1.1 l/s/ha and discuss the suitability of drainage methods previously proposed, in light of newer information and recent stakeholder discussions. • Agreement of the storm scenarios assessed. • Provide guidance on a suitable drainage maintenance regime. • Development of best practice for incorporating biodiversity requirements into SUDS design and management, building upon stakeholder liaison and experience. • Further discussion with stakeholders regarding the funding, management and maintenance of any SUDS programme. • Consideration of a site drainage strategy including used water and SUDS. • The risk of pluvial flooding on the site should be considered in the Detailed Study.
Used Water & Water Quality	• Determine whether water quality infrastructure can be funded and built to meet demand from the proposed development. • Estimate the increase in used water discharge to the environment under all development scenarios. • Quantify the water quality of this effluent and assess whether increases in the volume and concentration of used water discharges would prevent compliance with water quality objectives through examination of key current raw water quality parameters. • Review previous cost estimates of a new WRC at Waterbeach. • Further discuss discharge consent requirements with EA and AWS. • Review potential used water drainage routes, with reference to the existing topography.
Ecology & Biodiversity	• A review of existing ecology data should be undertaken, with particular reference to protected species. • Further clarification of the local wildlife trust's interest in designating the Waterbeach Barracks site as a County Wildlife Site. • Consideration of the potential links between Denny St Francis and the Cambridgeshire Green Infrastructure Strategy and Wicken Fen Vision. • Opportunities for multi-benefit open spaces and drainage systems should be

Component	Recommendations for the Detailed Study
	promoted. • Screening of designated sites in proximity of the Denny St Francis site footprint to determine any potential secondary impacts of the proposed development. • Review the validity of the mitigation options suggested by the existing Phase 1 ecology report.

3 Development Scenarios

3.1 Introduction

In conjunction with the stakeholder group, development scenarios were formulated, against which to review and assess options for water demand and used water management at Denny St Francis.

Assumptions were made regarding:

- Development construction,
- Property occupancy rates,
- Water demand rates; and
- Used water contribution rates

Lower (L) and upper (U) scenarios were selected, based on 8,000 and 10,000 domestic dwellings respectively.

Details of these assumptions plus the calculation steps can be found in Appendix B.

3.2 Water development scenarios

Four water demand scenarios were assessed, based on varying domestic consumption rates, ranging from Cambridge Water's 2014 Water Resources Management Plan (WRMP) base year assumption of 131 l/h/d for metered existing homes (Cambridge Water, May 2014), to a more aspirational consumption rate of 80 l/h/d, depicted as Level 5/6 in the UK Government's Code for Sustainable Homes (Department for Communities and Local Government, December 2006):

1. Baseline: WRMP metered existing homes – 131 l/h/d
2. Building Regulations 2010: New dwellings – 125 l/h/d
3. Code for Sustainable Homes: Level 3/4 – 105 l/h/d
4. Code for Sustainable Homes: Level 5/6 – 80 l/h/d

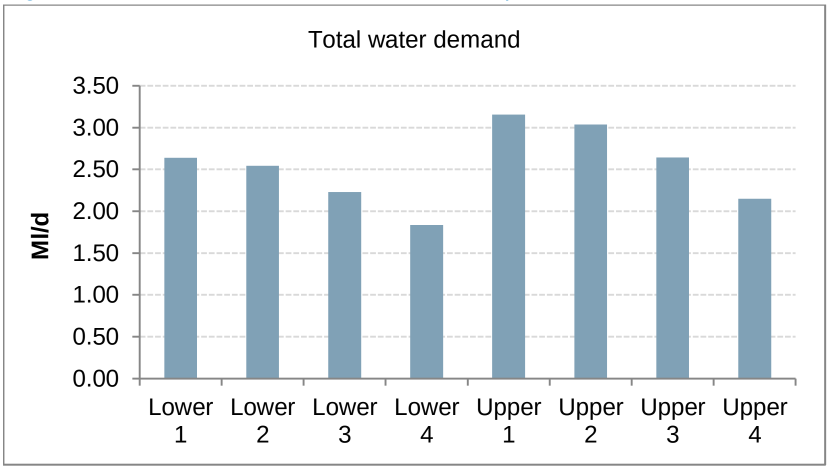
Non-domestic water demand was calculated following The Plumbing Engineering Services Design Guide (Institute of Plumbing, 2002), which is a widely used industry standard for estimating water demand for a range of building uses. Further details of the calculations are given in Appendix B.

Total water demand at Denny St Francis was estimated to range from **1.84 Ml/d to 3.16 Ml/d** at the end of construction in 2047.

Table 3.1: Total water demand under development scenarios

Water scenario	2047
Lower 1 (L1)	2.64 Ml/d
Lower 2 (L2)	2.54 Ml/d
Lower 3 (L3)	2.23 Ml/d
Lower 4 (L4)	1.84 Ml/d
Upper 1 (U1)	3.16 Ml/d
Upper 2 (U2)	3.04 Ml/d
Upper 3 (U3)	2.64 Ml/d
Upper 4 (U4)	2.15 Ml/d

Figure 3.1: Total water demand under development scenarios



Source: Mott MacDonald

3.3 Used water development scenarios

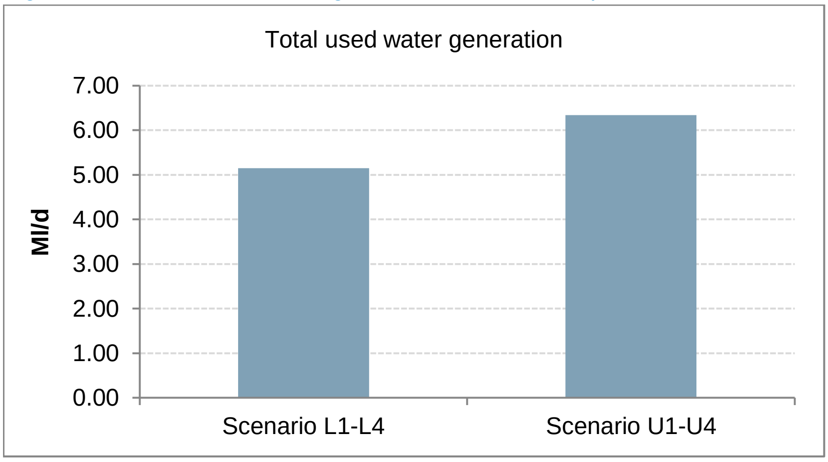
Figures for used water from both the lower and upper development scenario have been calculated for Denny St Francis in order to assist in the assessment of used water management options for the proposed development. These have followed standard industry practices and were based on a set contribution rate from both domestic and non-domestic properties under both the upper and lower development size scenario. Further information is given in Appendix B.

The average total used water from Denny St Francis requiring treatment can be estimated to range from **5.2 Ml/d to 6.4 Ml/d** at the end of construction for the purposes of planning and analysis[3].

Table 3.2: Average total used water generation under development scenarios

Used water scenario	2047
Lower	5.15 Ml/d
Upper	6.34 Ml/d

Figure 3.2: Total used water generation under development scenarios



Source: Mott MacDonald

[3] It is acknowledged that the figures for wastewater are considerably higher than those for water. Water Recycling Centre (WRC) loading calculations have to consider peak demands rather than daily averages. In addition, wastewater contribution is calculated based on a high assumed daily per capita consumption, as per standard planning methodologies. See Appendix B for more details, in particular Section B.4.

4 Approach to Sustainability Assessment

4.1 Introduction

Sustainability is at the heart of both the National Planning Policy Framework (NPPF) (Department for Communities and Local Government, 2012) and the South Cambridgeshire District Council Local Plan.

A key component of a Water Cycle Study Detailed Study is the assessment of preferred strategy options against relevant sustainability criteria (Environment Agency, 2009). As such, a WCS sustainability assessment methodology must be developed and used to review the preferred options for water at Denny St Francis.

4.2 Water Cycle Study guidance

As detailed in the guidance, a Water Cycle Study can help define the preferred development areas to ensure that development does not conflict with environmental needs. There may be occasions where site allocations have been agreed, or where proposed development may have an impact on the environment and require mitigation. A Water Cycle Study should seek to resolve such conflicts by ensuring that the water cycle infrastructure options are as sustainable as possible.

A WCS sustainability assessment should consist of the following stages:

- Defining ‘sustainability objectives’: against which the different development and infrastructure options will be assessed;
- Developing scenarios: developing a number of development scenarios and options to be tested by the study;
- Comparing options: testing options and option appraisal using economic, social, technical and environmental criteria and resolution of conflicting interests; and
- Selecting options: identifying a preferred option and selecting the preferred strategy to be promoted (Environment Agency, 2009).

4.3 The ‘Principles of Sustainability’

The concept of sustainability can be broken into three broad aspects: environmental, social and economic.

4.3.1 Environmental

Environmental sustainability is a broad topic, comprising a number of aspects including ecology, natural resources and climate change.

The resources of the planet cannot be depleted indefinitely, resulting in sustainability becoming an increasingly important topic. Environmental sustainability could be achieved through the limitation and mitigation of the impact of human activity and consumption on resources. Aspects to consider for environmental sustainability include:

- Water;
- Energy
- Ecology;
- Resources;
- Waste;
- Land use; and
- Climate change.

4.3.2 Social

Together with environmental factors, social impacts are also important considerations to be reviewed in conjunction with development. In addition, the local and wider social impacts of development need to be considered.

Social aspects include factors such as health, noise and the quality of public services. The principles of social sustainability take into account the overall benefit to the community and are important factors in determining the wider sustainability of the development. Ensuring any development is socially responsible is key in creating a sustainable project.

4.3.3 Economic

For a development to be sustainable, it should be economically viable, both in terms of capital and operational cost. Any development should be capable of functioning efficiently over a long period of time.

As discussed below, although environmental sustainability will form a key part of this report, it is important to ensure that the social responsibility and economic viability of any development is also considered.

4.4 Sustainability assessment of options

The sustainability objectives for this Water Cycle Study have been established jointly through consultation with all stakeholders.

As this study is primarily concerned with environmental sustainability, this aspect has been split into four key performance drivers, each of which will be assessed. Sustainability issues are, however, complex and interlinking and as such no single aspect of sustainability should be assessed in isolation. In light of this, social and economic impacts will also be taken into account.

The strategies for water that have been proposed for Denny St Francis as a result of the findings of the Water Cycle Study investigations have been subject to a high level sustainability assessment, whereby the following sustainability criteria have been applied to assess the impact and performance.

Social – Effects on the immediate and wider community such as health, noise, odour, quality of service/reliability, user interface (if applicable) and creation additional community benefits.

Economic – Assessment of costs including capital and operational.

Environmental –

- Ecology – Impacts upon biodiversity, land take, landscape impact.
- Natural resources – Consumption of potable water and/or raw materials as well as waste production
- Climate change mitigation – Associated greenhouse gas emissions both embodied and operational.
- Climate change resilience – ability to function in, or adapt to, changing climatic conditions (e.g. increased flood risk, drought or extremes of temperature).

5 Water Resources, Supply and Efficiency

5.1 Water demand from Denny St Francis

As shown in Section 3, water demand at Denny St Francis could range between 1.84 Ml/d and 3.16 Ml/d at the end of construction, depending of the development size and per capita water demand scenario.

This water could be sourced from both private and/or public sources, as discussed in Section 5.5.

5.2 Water neutrality

5.2.1 Definition and objectives

The official definition of water neutrality adopted by the Environment Agency and National Government is a situation where the total water use after a development does not exceed the total water use before the development (Environment Agency, 2014).

A water neutral development is one in which local sources of water are used to supply water for domestic use. There is no reliance on external resources outside of the site boundary. Water is instead stored and abstracted from the sub-surface deposits present beneath the proposed development.

To achieve true water neutrality, the water storage capacity and retrieval rates of the system must be sufficient to be able to continue supplying the development through drought periods.

Reducing water demand plays a key role in working towards water neutrality. Methods that can be undertaken to increase efficiency or lower demand, are discussed in the following Sections.

As advocated in the East Cambridgeshire Detailed Water Cycle Study (Cambridgshire Horizons, September 2011), a 'pathway' of steps can be taken by developers and stakeholders to work towards water neutrality, above and beyond those required through legislation. These steps are:

- Technological inputs in terms of physically delivering water efficiency measures on the ground;
- Local planning policies which go beyond national guidance; and
- Partnership initiatives and partnership working (Cambridgshire Horizons, September 2011).

Mott MacDonald

5.3 Code for Sustainable Homes

Cambridgeshire Water Cycle Study

Planning Policy Recommendations: Water Resources

“WR01: New domestic dwellings should achieve 80 l/h/d (potable consumption) through the implementation of water efficient measures and/or rainwater/greywater system.”

(Cambridgeshire Horizons, July 2011, p. 52)

As detailed in the Scoping Study, the Code for Sustainable Homes was published in 2006 to drive a step-change in sustainable home building practice (Department for Communities and Local Government, December 2006). Developed using the Building Research Establishment’s (BRE) EcoHomes System, it forms an assessment methodology for scoring new homes based on their environmental sustainability. It is a tool for developers to demonstrate the sustainability performance of their homes and level of environmental impact.

Water is a key variable of the assessment. The internal potable water consumption of each code level can be seen in Table 5.1. Points are also awarded for providing a system to collect rainwater for use in external irrigation and watering.

Table 5.1: Water usage standards of the Code for Sustainable Homes

Code level	Minimum standard
1	≤ 120 l/h/d
2	≤ 120 l/h/d
3	≤ 105 l/h/d
4	≤ 105 l/h/d
5	≤ 80 l/h/d
6	≤ 80 l/h/d

Source: The Code for Sustainable Homes (Department for Communities and Local Government, December 2006)

The SCDC’s Proposed Submission of the South Cambridgeshire Local Plan has adopted the Code for Sustainable Homes’ water usage standards within its policies for sustainability. Draft Planning Policy CC/4: Sustainable Design and Construction states “*All new residential development must achieve as a minimum the equivalent of Code For Sustainable Homes Level 4 for water efficiency (105 litres per person per day)*" (South Cambridgeshire District Council, July 2013).

In addition, recommendation WR1 in the Cambridgeshire Water Cycle Study states that all new domestic dwellings should achieve 80 l/h/d (potable consumption) through the implementation of water efficient measures and/or rainwater/greywater systems (Cambridgeshire Horizons, July 2011).

5.4 Reducing water consumption

Water neutrality can be worked towards by reducing the water consumption of a new development.

The reduction of potable water demand can be achieved in several different ways:

1. Use of water efficient components
2. Rainwater harvesting
3. Greywater recycling
4. Education of the end user
5. Tiered tarrifs and smart metering (WSP, February 2012).

5.4.1 Water efficient components

To enable the technological pathway towards water neutrality, water efficient components should be utilised. These can include, but are not limited to:

- Low or variable flush toilets;
- Low flow showers;
- Low flow taps;
- Water efficient washing machines; and
- Water efficient dishwashers.

The Code for Sustainable Homes Water Calculator can be used to inform the potential savings that can be made through the above ‘deliverable’ water efficiency measures and where the use of non-potable water can replace potable demand. This is shown in Table 5.2.

5.4.1.1 Domestic properties

The standard specification of water efficiency measures under the Denny St Francis water development scenarios are shown in the following table.

Table 5.2: Reducing domestic water demand through the use of increasingly water efficient components

Component	131 l/h/d	125 l/h/d	105 l/h/d	80 l/h/d
	Increasing water efficiency →			
Toilet flushing	19.2	19.2	16.8	8.4 (+ 8.4 NP)
Taps	42.3	31.8	24.9	18
Shower	24	24	18	18
Bath	25.6	25.6	25.6	22.4
Washing machine	15.3	15.3	15.3	7.65 (+ 7.65 NP)
Dishwasher	3.6	3.6	3.6	3.6
Total per capita potable demand	**130**	**120**	**104**	**78**

Source: (Cambridgeshire Horizons, July 2011, p. 24)
NP = Non-potable water

As can be seen in Table 5.2, the installation of water efficient components can reduce per capital water demand from close to the standard non-metered household usage of 131 l/h/d to nearer the CfSH Level 3/4 usage of 105 l/h/d of potable water.

Additional measures of higher efficiency taps and a smaller capacity bath (120 l as opposed to a 160 l capacity) could reduce this further to around 94 l/h/d.

Including use of non-potable water for toilet flushing and washing machine usage (categorised as “NP” in the table above) is required to allow full progression to CfSH Level 5/6 of 80 l/h/d . If potable water were completely substituted by non-potable water for all toilet flushing and washing machine use, potable demand could be further reduced to only 62 l/h/d.

Non-potable water is discussed in more detail in Section 5.4.2.

5.4.1.2 Non-domestic properties

As with domestic water usage, non-domestic demand can be reduced through similar measures.

Research undertaken for the development of the Northstowe water Conservation Strategy quantified a potential saving of up to 21.7 l/h/d through water efficient fittings and appliances. This can primarily be achieved through efficient taps (6.7 l/h/d), smart urinal flushing systems (7.5 l/h/d) and dual flush WCs (7.5 l/h/d) (WSP, February 2012).

5.4.2 Supplementation with non-potable water

As described above, non-potable water can replace potable water in certain in-house applications. In addition, it could also be used to meet any garden irrigation demand.

Rainwater harvesting and greywater recycling are two potential measures for sourcing and providing non-potable water at Denny St Francis. The use of locally sourced water would again help the development to work towards water neutrality.

The British Standard 8595:2013 provides a code of practice for the selection of water reuse systems (BSI Group, 2013).

5.4.2.1 Rainwater harvesting

As detailed in the Cambridgeshire Water Cycle Study, rainwater harvesting (RWH) is the capture and storage of rainwater that lands on the roof of a property. This can have the following advantages:

- Decreasing surface water management requirements through reducing surface water runoff;
- Lessening flooding issues through reducing surface water runoff; and
- Reducing the volumes of mains water required through the use of rainwater as a direct source (Cambridgshire Horizons, September 2011)[4].

It should be noted that the interception of rainwater can adversely reduce local groundwater recharge; however, given the scale of the development at Denny St Francis, this would not be a concern.

RWH systems typically consist of:

1. A collection area (usually a rooftop)
2. A method of conveying the water from the collection area to a storage tank (gutters, down spouts and pipes)

[4] It should be noted, however, that rainwater harvesting generally does not reduce peak demand since this occurs during periods of low rainfall.

3. A filtration and treatment system (depending on the rainwater quality required)
4. A storage tank
5. A method of conveying the water from the storage tank to taps (pipes with pumped or gravity flow) (Cambridgeshire Horizons, September 2011).

BSI Code of Practice

The British Standard 8515, Rainwater Harvesting Code of Practice gives recommendations on the design, installation, testing and maintenance of rainwater harvesting systems supplying non-potable water (BSI Group, 2009).

The Code of Practice outlines the following types of rainwater harvesting:

1. Water collected in storage tank(s) and pumped directly to the points of use;
1. Water collected in storage tank(s) and fed by gravity to the points of use;
2. Water collected in storage tank(s), pumped to an elevated cistern and fed by gravity to the points of use.

Within the basic types, as listed above, there are the following variations, including:

- Internal or external locations for tanks;
- Single or multiple linked tanks;
- Freestanding or fully or partially buried tanks;
- Communal tanks supplying multiple properties;
- Packaged systems or components.

Rainwater collection and treatment

The Code of Practice for rainwater harvesting notes that hard roof surfaces are considered the most suitable for rainwater collection, although many common roofing materials may also be used. In addition that the collection surfaces are likely to be affected by some form of contamination, such as bird droppings, soil (from green roofs), grit, fertilisers, hydrocarbons and various chemicals.

A filtration system should be incorporated in to a rainwater harvesting system to minimise debris entering the tank. The use of rainwater for toilet flushing, laundry and garden water will require a filtration system. However, should the rainwater be utilised in situations where greater human exposure to the water is anticipated, or where the water is to be used in public premises, the system may need to incorporate additional water quality processing such as ultraviolet light or chemical disinfection. This is further discussed in Section 5.5.1.4.

Storage and maintenance

The British Standard Code of Practice (Rainwater harvesting systems – code of practice +A1 BS 8515:2009) for rainwater harvesting provides guidance for calculating the storage capacity of a rainwater harvesting system (BSI Group, 2009). On the basis of the current concept plan, an estimate of storage required for the entire site has been calculated using the 'intermediate approach' (BSI Group, 2009).

The 'intermediate approach' has been selected as it provides additional flexibility in comparison to the 'simple approach' and the 'detailed approach' was not chosen as it requires inputs only available at a later stage of scheme design. The additional flexibility included in the 'intermediate approach' includes yield coefficient of different types of roofs and hydraulic efficiency of filters treating the rainwater.

A preliminary estimate indicates that approximately a total of 2,600 m^3 of storage for rainwater harvesting would be required for the entire site. The above estimate has been calculated on the basis of the areas of land within the development site designated for residential use and school, commercial and community centre land use; an approximate total roof area of 116 ha.

Anglian Water note that rainwater harvesting systems are not "fit and forget" technology. Anglian Water recommends that regular cleaning and maintenance and removal of debris collected by the filters is needed[5]. Other maintenance recommended includes regular visual inspection of the system components and cleaning and replacement of filters or other parts in accordance with the manufacturer's specification; and ensuring mains water top-up is working and is protected from contamination. In addition, the risks of contamination of potable water supplies through misconnection with non-potable systems should be acknowledged.

---

[5] http://www.anglianwater.co.uk/environment/using-water-wisely/rainwater-harvesting.aspx

Options for Denny St Francis

On the basis of the above and the nature of the development, it is considered that the options for rainwater harvesting for Denny St Francis include:

1. Collection and treatment of rainwater on a building per building basis, as appropriate;
2. Collection and treatment of rainwater on a local neighbourhood scale; or
3. Collection and treatment of rainwater on large scale basis, harvesting rainwater from a number of development buildings simultaneously to a large tank or storage pond.

The options outlined above would have a range of different infrastructure requirements.

– Option 1: Building scale rainwater harvesting

Option 1 would require the fitting of a rainwater harvesting system to each appropriate building in the development. It is noted that this option would allow the least disruption should a maintenance issue arise for one rainwater harvesting system. However, once a property is sold the owners may not use the fitted system and additional information would have to be circulated to provide the necessary information to residents for use and maintenance, as noted in Section 5.3.6 below with regard to water saving fittings.

– Option 2: Local neighbourhood rainwater harvesting

Option 2 would require the installation of large rainwater harvesting tanks in each neighbourhood and a system for each appropriate public building. A management company may need to be established to operate and maintain the system. It is noted that should a maintenance issue arise more users would be affected. However, the community aspect of the rainwater system could encourage use.

– Option 3: Large scale rainwater harvesting

Option 3 would require the installation of large tanks or storage ponds. Again, a management company may need to be established. Should a maintenance need arise, many users would be affected. However, the number of units requiring maintenance at Denny St. Francis would be greatly reduced if Options 2 or 3 were selected.

It is recommended that rainwater harvesting should be incorporated into the Denny St Francis development. However, further calculations will need to be carried out to inform the decision of what rainwater harvesting strategy to progress and to inform the design of the proposed development buildings and roofs.

5.4.2.2 Grey water reuse

Greywater recycling (GWR) is the treatment and re-use of wastewater from shower, bath and sinks for use again within a property where potable quality water is not essential (Cambridgshire Horizons, September 2011).

Greywater collection and treatment

Recycled greywater is not suitable for human consumption or for irrigating plants or crops that are intended for human consumption. The source of greywater should be selected by available volumes and pollution levels, which often rules out the use of kitchen and clothes washing wastewater, as these tend to be the most highly polluted. However, in larger systems virtually all non-toilet sources can be used, subject to appropriate treatment.

The storage volumes required for GWR are usually smaller than those required for rainwater harvesting as the supply of greywater is more reliable than rainfall. In domestic situations, greywater production often exceeds demand and a correctly designed system can therefore cope with high demand application and irregular use such as garden irrigation.

Greywater treatment is discussed in Section 5.5.1.4.

BSI Code of Practice

The British Standard Code of Practice for Greywater systems (Greywater systems. Code of practice BS 8525-1:2010) notes that greywater systems can vary significantly in complexity and size (BSI Group, 2010).

The Code of Practice outlines the following types of greywater systems:

1. Direct reuse systems – with no treatment of the water prior to reuse;
2. Short retention systems – with basic treatment of water prior to reuse, such as basic filtration or skimming of debris from the surface and allowing particles to sink to the bottom of the tank;
3. Basic physical/chemical systems – these systems utilise a filter to remove debris prior to storage and facilitate the treatment of the water by chemical disinfectants which stop bacterial growth;
4. Biological systems – these systems use aerobic or anaerobic bacteria to digest any unwanted organic material in the collected greywater. In the case of aerobic treatment, pumps or aquatic plants can be used to aerate the water; and
5. Biomechanical systems – these systems are the most advanced, and combine biological and physical treatment of the greywater prior to reuse; lastly
6. Hybrid systems – these systems may use a mix of the system types as detailed above.

The Code of Practice notes that the following factors should be identified in order to determine the type and treatment capacity of the greywater system:

1. Demand and yield, based on:-
   a. The number and type of intended applications, both present and future;
   b. The volume and usage patterns of these applications;
   c. Discharge figures for showers, baths, wash hand basins, and washing machines connected for reuse;
2. Water quality guidelines for the intended uses; and
3. Peak capacity treatment rate.

Integration with rainwater harvesting

It is noted that greywater systems can be integrated into rainwater harvesting systems at various points including within the storage tank, within the distribution pipework, or at the point of use. In addition, as with rainwater harvesting tanks, storage tanks for greywater systems can be located above or below ground. Greywater systems also require a sampling point for routine monitoring to indicate or follow up if there is a problem is encountered.

Options for Denny St Francis

Whilst greywater recycling is a reliable source of water, the additional plant required to treat, provide and maintain this would be considerable. In addition, the cost associated with developing a greywater system would be considerably higher than for rainwater harvesting.

There are technical, regulatory and public acceptability issues with greywater, in particular relating to water quality and the prevention of cross-contamination with the potable supply (Northstowe, February 2012). It is also noted that there would be a risk of non-functioning greywater recycling units being left out of service, resulting in an increase in potable water demand (Northstowe, February 2012).

As such, it is recommended that rainwater harvesting is promoted as the primary option for non-potable water supply at Denny St Francis. However, the cost-benefit of large scale greywater recycling could still be explored further in order to fully understand the options available for non-potable water use at the development.

5.4.3 Education

The education of residents in how to use water efficiently, how to reduce water usage and why saving water is important is a fundamental aspect of achieving long-term reductions in water demand.

Education measures can be adopted to instil awareness and understanding. These should be considered for Denny St Francis:

- Home owner welcome packs – information on how to manage water usage and the water efficient components installed in their homes;
- Clearly visible water meters – facilitates monitoring of water usage and reminds the occupier of the financial incentives behind water efficiency;
- Promotional material and literature – distribution of information leaflets, use of posters around a community;
- Free water efficiency products e.g. low flow garden hoses, shower timers;
- Educational events within the local community e.g. school events
- A local 'water champion' officer – helping to raise public awareness of using water wisely.

5.4.4 Metering

All Denny St Francis water supply will be metered. Metering is now compulsory for all new properties and is included in Cambridge Water's WRMP supply-demand planning calculations (Cambridge Water, May 2014).

Metering encourages reduced water usage in a home through a financial incentive. Whilst total consumption can consequentially be lowered, a meter also encourages the installation and use of other water saving products. The Cambridgeshire Water Cycle Study reported the volumetric saving from metering as being as much as 20 l/h/d (Cambridgeshire Horizons, July 2011).

5.4.5 Financial Costs and Savings

The Department for Communities and Local Government have published estimates on the additional costs for building to different levels of the Code for Sustainable Homes. The most recent update was published in 2011 and was based on consultation with home builders combined with an analytical cost modelling exercise (Department for Communities and Local Government, August 2011).

Indicative costs are shown in the table below.

Table 5.3: Packages of water measures appropriate to Code for Sustainable Homes Level 3 & 4 and Level 5 & 6 mandatory standards.

	Code Level 3/4	Code Level 5/6
CfSH standard		
Water consumption (l/h/d)	105	80
Water specification extra-over cost		
Two-bed flat	£150	£6,150
Two-bed terrace	£150	£4,650
Three/four-bed semi	£200	£4,700

Source: Department for Communities and Local Government, 2011.

The wider study found that the largest increased spend between Levels 3/4 and 5/6 was due to increased energy and water efficiency measures. In particular, the substantial additional cost of meeting the advanced standard of Level 5/6 was as a result of the necessity of installing a non-potable recycling system (Department for Communities and Local Government, August 2011).

Conversely, long-term reduced water usage would have financial benefits for Denny St Francis residents through the reduction of water bills (Cambridgeshire Horizons, July 2011). As a rough estimate, reducing water usage from 125 l/h/d to 105 l/h/d (CfSH Level 3/4) could lower annual water bills by £43 per property. Reducing demand to 80 l/h/d could subsequently reduce bills by £97 per property per year[6].

5.5 Available resources

5.5.1 From private sources

Around 1% of the population of England and Wales have private water supplies to their homes or businesses[7]. Local authorities are responsible for regulating private water supplies used for domestic purposes (such as drinking, cooking, and washing) in both domestic and commercial premises, under The Private Water Supplies Regulations 2009 (UK Govenment, 2009). Likewise, the Environment Agency regulates water abstractions greater than 0.02 Ml/d in England and Wales through its licensing system, to ensure abstractions are sustainable and do not damage the environment (Environment Agency, May 2013).

5.5.1.1 Surface water

As detailed in the Scoping Study report, the proposed Denny St Francis site is located within the Cam and Ely Ouse Abstraction Licensing Strategy (CAMS) area. The current CAMS document states that there is limited surface water availability, as shown in Table 5.4.

---

[6] Water saving (l/h/d) * unit cost of water (0.3 pence/litre) * days in a year * occupancy rate (1.97). Calculation follows the methodology adopted by the Cambridge and Major Growth Area Water Cycle Study (Cambridgeshire Horizons, July 2011, p. 27).

[7] Drinking Water Inspectorate http://dwi.defra.gov.uk/stakeholders/private-water-supplies/index.htm

Table 5.4: Surface water resource availability in the Cam and Ely Ouse CAMS catchment

	Cam, Rhee and Granta Assessment Point 6	Ely Ouse Assessment Point 17
Q30 High flows	Restricted water available for licensing	Water available for licensing
Q50 Moderate flows	Water not available for licensing	Restricted water available for licensing
Q70 Below Moderate flows	Water not available for licensing	Water not available for licensing
Q95 Low flows	Water not available for licensing	Water not available for licensing

Source: (Environment Agency, March 2013)

The CAMS document states that in the vicinity of the Denny St Francis site, surface water is available for abstraction from the River Cam for less than 30% of the time (as indicated by the Q30 classification) and from the Ely Ouse for less than 50% of the time (as indicated by the Q30 classification) (Environment Agency, March 2013).

Assessing potential new surface water abstractions requires these issues to be considered:

1. The reliability of supply
   – This is an assessment of projected river flow[8] against both volumetric constraint scenarios (e.g. licenced minimum residual flow (MRF)[9] requirements, pump capacities etc.) and water quality (dependent upon the treatment processes available, the duration of storage, upstream locations of water recycling centre discharges etc.). A 'worst-case' scenario is applied to examine reliability and, consequentially, 'yield'.
2. The provision of storage
   – With a lower reliability comes the requirement for a greater storage capacity to ensure supply through times when abstraction is not permitted or not possible.
3. Demand
   – The potential of a source can be assessed in terms of its reliability for a particular level of demand.

[8] In the analysis of future reliability, historic data is not used as this often does not represent current artificial influences in the catchment (i.e. other current abstractions and discharges). As such, a synthesised series is often adopted, whereby historic flow is edited based on known or projected future artificial influence conditions.

[9] Equivalent to Hands-off Flow (HOF)

Additional considerations include a flow gauging facility, river intake design and construction, abstraction licence charges and potential water quality constraints.

In relation to the availability of raw surface water for abstraction, the Environment Agency has been contacted in order to further understand the potential licensing constraints on a new surface water abstraction in proximity to Denny St Francis. The correspondence is reported in Appendix C and confirmed that a licence Hands off Flow equivalent to Q22 would be applied on the River Cam.

To illustrate the annual variability of the reliability of an abstraction subject to a Hands Off Flow of Q22, the Environment Agency provided flow data and corresponding Q22 from the nearest available river gauging station over the period 2000-2010[10]. As this gauging station only monitors flow in one of the tributaries of the main river, the data can only be interpreted as illustrative and representational in relation to its Q22[11]. However, it demonstrates the inter-annual variability of river flows, such that during the drought years of 2005 and 2006, the river was not above Q22 on a single day (see Section 0).

An abstraction subject to a MRF of Q22 (as would be applied on the River Cam), therefore, would have a reliability below that considered manageable for continuous water resource supply due to the significant storage that would be required.

The options for using local fluvial surface water at Denny St Francis are discussed further in Section 5.6.

5.5.1.2 Groundwater

Geological site conditions

The geological site conditions have been further reviewed, following discussions with the Environment Agency regarding the Scoping Study's geological conceptualisation. This can be found in Appendix D.

In summary, the proposed development site at Denny St Francis comprises strata of River Terrace Deposits, overlying Gault Clay (where

[10] Quy Water at Lode. Station number 33056. Daily mean flow data from 2000-2013, obtained from the Environment Agency, 24th September 2014.

[11] *Pers. comm*. Environment Agency, 24th September 2014. Appendix C.

present). The Gault Clay is underlain by the Woburn Sands Formation of the Lower Greensand Group.

In the central area of the development the superficial deposits are absent and the Gault Clay is in outcrop (British Geological Survey, 1981).

In the north western corner of the site the Gault Clay is absent and the Lower Greensand is unconfined; lying directly under the superficial deposits. It is likely that where Gault Clay is present toward the north western part of the site it will be relatively thin, dipping to the east, where it becomes progressively thicker.

The presence of Fenland Peat on the site is likely to be very limited. It slightly encroaches into the very north eastern margin and potentially the south eastern margin of the site.

Groundwater availability for licensing

As detailed in the Scoping Study, the Cam and Ely Ouse Catchment Management Abstraction Strategy states that no water is available for licensing from the Greensand aquifer, on which Denny St Francis is located (Environment Agency, March 2013).

The eastern and western peripheries of the site, where the River Terrace Deposits are present, comprise a Secondary A aquifer. The Environment Agency define Secondary A aquifers 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. The first and second groups of River Terrace Deposits are similar, consisting of waterlain well-bedded to rather poorly bedded, sandy flint and chalk gravels with a clay matrix.

Where Secondary aquifers lie within areas classed as ‘unproductive strata’ they will be treated on a case by case basis. However, they are more likely to follow the surface water strategy for the catchment subject to local conditions and impacts (Environment Agency, March 2013). This is the case for the Denny St Francis site.

Correspondence with the Environment Agency has confirmed that it is unlikely that they would licence a groundwater abstraction at Denny St Francis (see Section D.1.5).

5.5.1.3 Rainfall

The University of Cambridge Botanic Gardens have been recording daily rainfall since 1904, providing data to the Met Office. Located approximately 11.5 km from Denny St Francis, the Standard Annual Average Rainfall (SAAR)[12] is 563 mm. The highest annual rainfall in 2000 was 699.3 mm with the lowest annual rainfall in 2003 being only 471 mm.

The rain falls fairly evenly throughout the year, with the wettest month on average (by a very slight margin) being August, though evaporation usually exceeds rainfall in summer months.

The Code for Sustainable Homes takes local rainfall, roof area, runoff coefficient[13] and occupancy rate into account to calculate the amount of water available per person. Calculations undertaken by the Cambridge Water Cycle Study on monthly historic rainfall records from 2000 to 2009 showed that rainwater harvesting could supplement a household with 8.3 to 16.5 l/h/d of non-potable water, depending on storage tank size. However, if baseline demand were already 105 l/h/d through the use of metering and water efficient components, it would be unlikely that rainwater harvesting alone would reduce total potable demand to CfSH Level 5/6 of 80 l/h/d. If additional water efficiency measures were adopted *on top* of those already required for CfSH Level 3/4[14], potable demand could achieve CfSH Level 5/6 with rainwater harvesting. This is shown in Appendix E.

The Northstowe Water Conservation Strategy reported similar findings, stating that a rainwater system could typically contribute a volume of 14 l/h/d[15] (Northstowe, February 2012). Their calculations are reproduced in Appendix E and show how the contribution that rainwater harvesting can make to per capita demand can vary considerably, depending upon a number of factors including rainfall depths, roofed area and occupancy rates.

[12] SAAR industry standard of the 1961-1990 average annual rainfall.

[13] Accounting for losses through evaporation, inception etc.

[14] Namely further efficient taps and a smaller capacity bath (Table 5.2) (Cambridgeshire Horizons, July 2011) to reduce usage to 94 l/h/d.

[15] Based on a 2 bedroom home with an occupancy rate of 3.

5.5.1.4 Treatment

The treatment requirements of water at Denny St Francis would depend upon the water strategy options taken forward; specifically the source of the water and its intended usage.

To potable standards

Water Undertakers are appointed by the Secretary of State for the Environment. Any company can apply to become a new appointee to replace the existing water and or sewerage company at a particular site. Only when one of the following criteria is met can an application to be supplied by a new appointee by considered. This is regulated by the water company regulator, Ofwat.

- The unserved criterion. The site has no existing mains water connection and it has no existing mains sewer connection.
- The consent criterion. The existing local monopoly supplier agrees to transfer your site or premises to another company.
- The large user criterion. The local monopoly supplier is based mainly in Wales and more than 250 megalitres of water a year is/will be used or the local monopoly supplier is another company and more than 50 megalitres of water a year is/will be used (Ofwat, 2014).

Denny St Francis would fall under the first of these criteria. A new appointee application would be assessed by Ofwat on the following four principles:

1. Principle 1: New appointees should be recognised as wholesale customers of and competitors to existing appointees (the competitor principle');
2. Principle 2: Assessing applications on a site-by-site and company-wide assessment basis;
3. Principle 3: Ensuring that customers are no worse off and are adequately protected; and
4. Principle 4: Financial viability.

Treatment constraints for private sources are regulated by the Local Authority with support from the Drinking Water Inspectorate, as defined by The Private Water Supplies Regulations 2009 (UK Govenment, 2009).

As shown in the previous sections, the availability of raw water from private sources is limited. Whilst abstracting water from the adjacent River Cam could be permitted at times of high flow (Section 5.5.1.1), the quantities and reliability would not be great enough to negate the need of a level of potable water supply from the locally incumbent water company, Cambridge Water.

The supplementation of supply with on-site potable water treated at times when there is availability of raw water would likely not be robust under financial, sustainability or legislative scrutiny due to the requirement of the construction of a water treatment works and intake structure combined with the variable nature of the source.

To non-potable standards

Rainwater systems can be treated with basic filtration system, to enable it to be used for toilet flushing, garden watering and washing machines. To comply with the British Standard, a rainwater system has to feature filtration before entering the "main body of stored water" (BSI Group, 2009). In addition, the filter system has to meet strict criteria covering its weather resistance, accessibility and efficiency. Storage tanks, whether below or above ground, are also covered by the standard and need to be watertight, discourage microbial growth, avoid stagnation and be sited so as not to allow conditions suitable for Legionella to develop. The Standard also stipulates that if above ground tanks are to be included in the design of a rainwater harvesting system, they should be sufficiently insulated to prevent the water from either freezing or warming (BSI Group, 2009).

Greywater systems require more complex (and costly) treatment processes, which could include a combination of the following, dependent on the source of the greywater and for what purpose the water will be reused:

- Simple (coarse filtration and disinfection)
- Chemical (photo catalysis, electro-coagulation and coagulation)
- Physical (sand filter, adsorption and membrane)
- Biological (biological aerated filter, rotating biological contractor and MBR)
- Extensive (constructed wetlands) (Northstowe, February 2012, p. 24).

The associated capital and operational costs of greywater treatment are often greater than those for rainwater treatment.

The requirement for treatment processes at Denny St Francis should be considered in terms of their sustainability as detailed plans for the water supply strategy progress.

5.5.1.5 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is the artificial recharge and storage of water in a suitable aquifer through an “injection” boreholeduring times when water is available, and recovery of that water from the same borehole during times when it is needed[16].

ASR at Denny St Francis was investigated in 2008 to understand the theoretical feasibility of achieving total water neutrality at the development (RLW Estates Ltd., August 2008). The groundwater modelling carried out indicated that there would have been inadequate volumes of water available to meet demand during extended droughts (1976 magnitude), even with reduced water requirements of only 80 l/h/d. The study noted that summers such as 1976 are likely to become more common with climate change.

It is unlikely that the River Terrace Deposits would be suitable for ASR as the deposits are unlikely to fulfil the necessary physical requirements.

The on-site River Terrace Deposits are described as sandy gravels of chalk and flints with a clay matrix (RLW Estates Ltd., July 2012). The clay matrix will reduce the transmissivity of the deposit making it difficult to get the water to infiltrate. Soil infiltration tests conducted in 2002 found that the ground was unsuitable for soakaways due to the high water levels recorded in the River Terrace Deposit gravels. In addition, the thickness and lateral extent of the deposits are inadequate for storage of additional water. Confined, granular aquifers are generally considered to provide the most suitable hosts for ASR. The Lower Greensand (underlying the Gault Clay) is considered to have good potential for ASR (BGS / EA 1998).

[16] Pyne, R. D. C. (1995) *Groundwater Recharge and Wells*.

General risks associated with ASR include:

- Lack of reliable source water[17];
- Poor recovery efficiency;
- Borehole clogging[18];
- Lack of existing knowledge of properties of, yields, and variability of marginal and deep aquifers suitable for ASR;
- Contamination issues;
- High financial outlay before feasibility of ASR can be established;
- Lack of understanding of operational issues; and
- Licencing complications related to requirements for variable licence.

Other considerations include:

- The Lower Greensand is classed as a Principal Aquifer. It is likely that the Environment Agency would require that any water proposed for injection would have to be of potable quality or at least chemically match the native water. This would have significant implications for cost.
- To establish the suitability of an aquifer and site for ASR, various factors would need to be investigated including:
  - aquifer thickness and areal extent,
  - hydraulic properties,
  - piezometric surface elevation,
  - local hydraulic gradient and groundwater velocity,
  - geochemical compatibility of recharge and native water with host rock and native water quality,
  - existing groundwater abstraction in the area.
- An ASR scheme would need a treatments works, for the injected and abstracted water.
- The volume of water available for recharge needs to be considered carefully and accurately. Average volumes are not useful as they mask underlying trends and seasonal influences.
- ASR investigations will be lengthy and require several phases of investigation, exploratory borehole drilling and cycles of testing and monitoring before it is clear whether or not a scheme would be feasible.

A key uncertainty of the groundwater modelling was how well local ground conditions would allow drainage of water to the collection

[17] Anglian Water have investigated the possibility of ASR within their supply zone and have cited that sourcing of the raw water for injection was a primary constraint to ASR schemes in this region and reason not to undertake further feasibility studies.

[18] Anglian Water have investigated the possibility of ASR within their supply zone and have cited problems with borehole clogging as reasons not to undertake further feasibility studies.

network. The groundwater model indicated a doming effect of the water table between collector drains due to ground permeability. If the predicted volumes of water available through the collector scheme met demand, the feasibility of the scheme would need to be tested using an in-situ pilot drainage scheme that included features not proposed for the planned development. This would include the establishment of hard surfaces or the use of existing ones, the construction of drains within green corridors and possible inclusion of surface water bodies. The effect of the collector system inducing water table doming between drainage collectors is potentially of concern in relation to groundwater flooding (see Section 6.5).

5.5.2 From water company sources

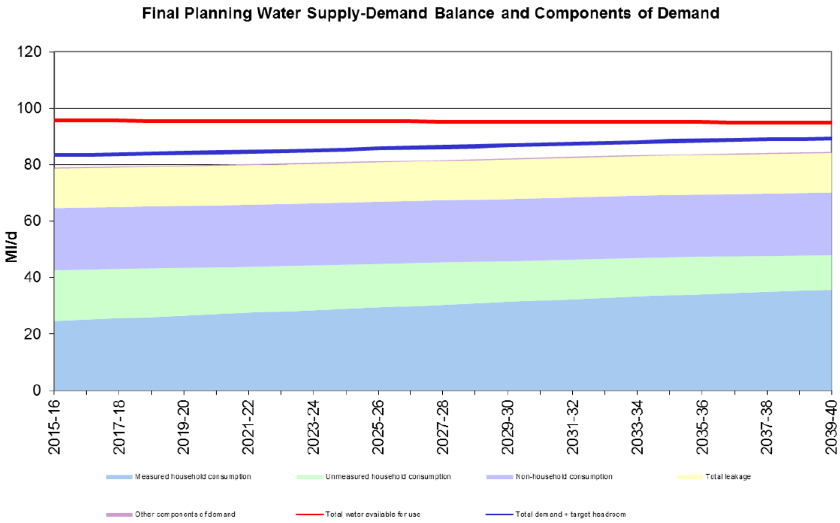
5.5.2.1 Cambridge Water supply demand forecasts

Cambridge Water is the water undertaker supplying potable water to the Waterbeach area.

The Cambridge Water Final Water Resources Management Plan (WRMP) was published May 2014 and covers the period 2015 to 2040 (Cambridge Water, May 2014). The company reports a surplus in deployable output in the baseline supply demand balance for the next 25 years.

Figure 5.1 demonstrates the supply-demand balance based on a dry year annual average from the Cambridge Water WRMP. The assessment included allowance for uncertainty in reductions in available supply, population growth and new demand, environmental concerns and leakage.

Figure 5.1: Cambridge Water revised final supply-demand balance



Key: Blue shading: measured household consumption, green shading: unmeasured household consumption, lilac shading: non-household consumption, yellow shading: total leakage, purple shading: other components of demand, red line: total water available for use, blue line: total demand + target headroom. (Cambridge Water, May 2014).

As reported in the Scoping Study, whilst Cambridge Water's projected future housing growth in the draft Water Resources Management Plan (dWRMP) did not explicitly include an allocation for Denny St Francis, its review of the Local Authorities' draft Local Plans showed no significant changes to the total expected number of properties in the Cambridge Water supply area. The dWRMP's technical assessments, therefore, remained valid (Cambridge Water, November 2013). This has not changed with the publication of the Final Water Resources Management Plan (WRMP) in May 2014 (Cambridge Water, May 2014).

The Cambridge Water WRMP indicates that the company will have surplus resources in 2039/40, based on the planning assumptions used in the plan and the best available information and evidence at the time of its preparation.

A review of the Cambridge Water dWRMP and discussions at the Denny St Francis Water Cycle Study stakeholder engagement workshops prior to the publication of the Final WRMP, confirmed that under existing planning horizon assessment criteria, potable water would be available from Cambridge Water's Cherry Hinton reservoir if the required infrastructure works (pipeline to Denny St Francis etc.) were undertaken. This conclusion remains valid with the publication of the Final WRMP in May 2014.

This does not constitute a *guarantee* that Cambridge Water can supply any future development, but is the appropriate data and information on which to base a review of potential Denny St Francis water supply at this time. Further discussions of these uncertainties can be found in Section 5.5.2.3.

5.5.2.2 Connection to public water supply network

A connection to Cambridge Water's (CWC) Cherry Hinton reservoir would be required, which is located approximately 10 km from the Denny St Francis site.

Information provided by CWC as a part of the WCS stakeholder liaison[19] confirmed that, in order to make sufficient water available, it would be necessary to reinforce the existing network which would involve laying a new strategic main between Cherry Hinton Reservoir and the village of Milton, south of Waterbeach. Further network reinforcement would then be required between Milton and the Denny St Francis development, involving laying a main of approximately 4km.

CWC provided indicative capital costs of such a connection. These are provided below. It was emphasised that these are indicative costs only:

- Capital cost of strategic off-site main (Cherry Hinton Reservoir to Milton): £3,500,000
- Capital cost of strategic off-site main (Milton to Waterbeach): £2,200,000
- Capital costs of on-site mains for dwellings (@ £700/dwelling): £7,000,000
- Total capital costs: £12,700,000

It was confirmed that the developer would be required to make a contribution toward the cost of the required reinforcement works. Whilst not possible to precisely determine the developer's contribution towards the capital costs at the present time, it could be up to 80% of the total.

In addition to the above, normal individual dwelling connection charges and infrastructure charges would apply which would attract water and

[19] Email from Mike Sloan on 14th July 2014.

sewerage infrastructure charges. Cambridge Water provided information as to the standard charges for these and gave quotes of £347.01 and £345.00 respectively (at current rates) (Cambridge Water, 2014).

With regard to the timing of the off-site mainlaying, CWC advised that it would be critical that the reinforcement work is complete before any significant additional demand is placed on the distribution system. CWC suggested that an appropriate lead-in time for the design and laying of the off-site mains would be 18 months to 2 years[20].

5.5.2.3 Future uncertainties

Potable water availability at the Cherry Hinton Reservoir site is dependent on the growth that actually takes place in the CWC area over the coming years. In addition, future uncertainties exist around potential changes to water resource planning and management that could impact upon available supply from Cambridge Water. These changes could come about via Environmental Improvements and Abstraction reform[21].

Actual impacts are unknown at this time and so are difficult to quantify, but in summary could involve:

- The Environment Agency National Environment Programme determines whether abstractions have an impact on the environment, and, as a consequence the Environment Agency can reduce available licenced resources through a sustainability reduction. This can have impacts on the surplus available in future revisions of Cambridge Water's WRMP.
- Under the Water Framework Directive (WFD) and its requirement for No Deterioration, it must be proven that any permanent increases in abstractions would not have an impact on waterbodies and cause deterioration in ecological status (where flows are a supporting factor). Such analysis may involve additional cost and monitoring.
- The increases in abstraction currently incorporated in the Cambridge Water WRMP and, consequentially, its conclusions regarding projected headroom, may not be applicable once all WFD assessments are completed.

[20] Email from Mike Sloan on 14th July 2014.

[21] Cambridge Wate *pers. comm.* May 2014.

- Abstraction reform may change the way water is allocated to companies under a new licensing regime. The allocation could be substantially less than is available now, leading to no surplus and the requirement to find additional water required for development elsewhere.

The consequences of these issues will become clearer over the next 5 to 10 years and will be incorporated into future Cambridge Water Water Resource Management Plans.

5.6 Options for water supply

The above analysis has shown that the Code for Sustainable Homes Level 3/4 of 105 l/h/d could be achievable through the use of water efficient measures alone. The inclusion of additional efficiency measures and a non-potable rainwater harvesting system could enable the development to reduce potable demand further to Code for Sustainable Homes Level 5/6 of 80 l/h/d.

The options for sourcing water at Denny St Francis can be seen below in Table 5.6.

Table 5.5: Options for water supply at Denny St Francis

Option	Source of potable water	Source of non-potable water
A	Cambridge Water Company	None
B	Cambridge Water Company	Rainwater
C	Rainwater & River Cam	Rainwater & River Cam
D	Cambridge Water Company	River Cam

Source: Mott MacDonald

The advantages and disadvantages of each option have been reviewed in terms of their practicality, deliverability, sustainability and implications on cost.

Table 5.6: Review of sourcing options for Denny St Francis water supplies

Ref	Option	Review			
		Practicalities	Deliverability	Sustainability	Cost
A	Potable supply from CWC. No non-potable supply.	• Connection to the CWC network would be required. • On-site storage would be necessary due to the quantities involved. • No water treatment works would need to be constructed.	• With suitable planning, the associated infrastructure could be constructed in time. • Cambridge Water are supportive of a potable connection to their network. • A connection to the local potable network could be part funded by CWC. • A sole-supply system (i.e. excluding a non-potable supply) would be easier to incorporate into construction.	• A source from CWC would offer high, long-term reliability of supply. • Abstractions from CWC are environmentally regulated and incorporate climate change considerations. • Carbon costs of transferring water from Cherry Hinton could be high. • This option would not allow the Code for Sustainable Homes Level 5/6 to be met.	• Connection to the existing CWC network and on-site potable water storage. • A lack of supplementation with non-potable water supply could lead to higher water bill costs for residents.
B	Potable supply from CWC. Non-potable supply from on-site rainwater.	• Connection to the CWC network would be required. • On-site storage would be necessary due to the quantities involved. • A dual-supply system would need to be developed, including incorporation into the architectural design of residential and commercial buildings. • Cross-contamination risks would need to be carefully mitigated.	• With suitable planning, the associated infrastructure could be constructed in time. • Cambridge Water are supportive of a potable connection to their network. • A connection to the local potable network could be part funded by CWC.	• A source from CWC would offer high, long-term reliability of supply. • Abstractions from CWC are environmentally regulated and incorporate climate change considerations. • Carbon costs of transferring water from Cherry Hinton could be high. • Incorporation of a non-potable supply system at Denny St Francis would address the sustainability aspirations of the Local Plan and follow national best-practice guidance on water conservation. In conjunction with high efficiency water components, CfSH Level 5/6 could then be met.	• Connection to the existing CWC network and on-site potable water storage. • Treatment processes would need to be installed for the rainwater non-potable system as well as on-site non-potable storage. There would be associated on-going maintenance costs. • Installation of a dual water supply system in buildings. • A dual supply system would have higher capital costs than a single supply system.

Mott MacDonald

Ref	Option	Review			
		Practicalities	Deliverability	Sustainability	Cost
C	Potable supply from River Cam or rainwater. Non-potable supply from River Cam or rainwater.	• Private abstraction and treatment of potable water requires significant investment and long-term operational responsibilities. • Significant potable water storage would be required. • An abstraction from the River Cam or Ely Ouse would necessitate a transfer pipeline and pumping station system. • An abstraction from the Cam would not be a reliable source of supply due to the licence constraints that would be applied. • A continuous potable supply based on raw water from rainfall and high river flows would have significant risks associated with availability and reliability.	• Surface water requires complex and intensive treatment processes. • A large land-take would be required for both treatment and storage of water. • A long-term commitment to supplying customers, including acceptance of a Duty of Care. • Close liaison with the relevant regulatory bodies including the Local Authority, Environment Agency at during both the design, development and operation phases. • At the time of writing, it is not known whether the River Cam or Ely Ouse is a viable option for abstraction, pending further information and discussions with the Environment Agency.	• Sustainability reductions would be a risk for private abstractors as well as public water companies but with potentially greater consequences for Denny St Francis residents, as CWC have legal obligations to provide water to customers irrespective of licence changes. • The risks associated with private supplies could be much greater than potable supply from a public company. • Incorporation of a non-potable supply system at Denny St Francis would address the sustainability aspirations of the Local Plan and follow national best-practice guidance on water conservation. In conjunction with high efficiency water components, CfSH Level 5/6 could then be met.	• A water treatment works would be required with significant capital costs, including the purchase of a large land area. A river intake (and associated transfer system) would need to be constructed, mindful of the environmental constraints of its location and design. • There would be very high operational costs for potable water treatment processes and raw water abstraction. • Abstraction licence charges from the Environment Agency. • Construction of a river gauging station for abstraction licence compliance. • Treatment processes would need to be installed for the non-potable system as well as on-site non-potable storage. • Installation of a dual water supply system in buildings.
D	Potable source from CWC. Non-potable supply from River Cam.	• Connection to the CWC network would be required. • On-site storage would be necessary due to the quantities involved. • A dual-supply system would need to be developed, including incorporation into the architectural design. • An abstraction from the Cam would not be a reliable source of supply due to the licence constraints that would be applied.	• With suitable planning, the associated infrastructure could be constructed in time. • Cambridge Water are supportive of a potable connection to their network. • A connection to the local potable network could be part funded by CWC. • At the time of writing, it is not known whether the River Cam is a viable option for abstraction, pending further information and discussions with the Environment	• A source from CWC would offer high, long-term reliability of supply. • Abstractions from CWC are environmentally regulated and incorporate climate change considerations. • Carbon costs of transferring water from Cherry Hinton could be high. • Incorporation of a non-potable supply system at Denny St Francis would address the sustainability aspirations of the	• Connection to the existing CWC network and on-site potable water storage. Part funding opportunities could be explored. • A river intake (and associated transfer system) would need to be constructed, mindful of the environmental constraints of its location and design. • A fluvial abstraction would necessitate annual licence charges to the Environment Agency. • Construction of a river gauging

Ref	Option	Review			
		Practicalities	Deliverability	Sustainability	Cost
		• Cross-contamination risks would need to be carefully mitigated.	Agency.	Local Plan and follow national best-practice guidance on water conservation. In conjunction with high efficiency water components, CfSH Level 5/6 could then be met.	station for abstraction licence compliance. • Treatment processes would need to be installed for the non-potable system as well as on-site non-potable storage. • Installation of a dual water supply system in buildings. • A dual supply system would have higher capital costs than a single supply system.

Source: Mott MacDonald

Option B comprises a potable raw water connection to Cherry Hinton and a non-potable on-site system to supplement household supply and reduce potable demand. It combines the reliability and low risk of a potable supply from CWC and the lower costs associated with a rainwater non-potable system as opposed to the construction and annual charges of a fluvial abstraction (as in Option D).

Option B works with the local hydrological constraints to provide the greatest reliability and long-term sustainability of the options assessed and follows the Code for Sustainable Homes' recommendations surrounding the inclusion of non-potable systems for sustainability (Department for Communities and Local Government, December 2006). It also helps works towards the Local Plan aspirations of Denny St Francis being an '*exemplar of sustainability*'.

The preferred option for water supply at Denny St Francis would therefore be Option B: Potable connection to CWC plus a non-potable supply system based on rainwater harvesting.

5.7 Water resources, supply and efficiency sustainability assessment

The preferred strategy points for water resources, supply and efficiency at Denny St Francis have been assessed in terms of their social, economic and environmental sustainability credentials in Table 5.7 .

Table 5.7: Sustainability assessment of preferred water resources options for Denny St Francis

	Potable water connection to CWC network	Inclusion of non-potable system	Installation of water efficient components at the household level
Social			
	A source from CWC would offer high, long-term reliability of supply. Cambridge Water provides customers with the second lowest bills in England and highest levels of customer service (as measured by Ofwat), benefiting future residents.	Reducing potable water usage at Denny St Francis would address the sustainability aspirations of the Local Plan and follow national best-practice guidance on water conservation. Social perceptions of non-potable water supply would need to be managed through active education and engagement with residents. Cross-contamination risks both within buildings and in the public realm would need to be carefully mitigated.	The installation and advocating of water efficient components within households would address the sustainability aspirations of the Local Plan and follow national best-practice guidance on water conservation. Per capita water usage would be reduced and become embedded in the water usage culture of households. This would need to be reinforced by education and awareness raising to ensure the continued support of residents
Economic			
	A connection to the CWC network would be required, as would on-site storage. A connection to the local potable network could be part funded by CWC. Potable water storage would, however, be necessary regardless of its source. An indicative cost of a connection to Cherry Hinton reservoir is being provided by Cambridge Water company to inform the development of the Denny St Francis water supply plans.	Treatment processes would need to be constructed for the non-potable system. Storage would also need to be provided. There would be capital and operational costs of treatment processes. Lowering potable water usage would have financial benefits for customers through lower water bills. Installation of a dual water supply system in buildings may incur additional cost, including for on-going maintenance. The dual system would, however, result in long-term reductions in Denny St Francis residents' water bills.	Lowering potable water usage would have financial benefits for customers.

	Potable water connection to CWC network	Inclusion of non-potable system	Installation of water efficient components at the household level
Environmental			
Ecology	Abstractions from CWC are environmentally regulated to minimise environmental impact.	Reducing potable water consumption would lower environmental impacts of abstraction. If rainwater were part of a non-potable system, its capture would reduce on-site runoff rates and pressures on the surface water drainage system.	Reducing the generation of used water would lower the volumes of treated effluent discharges to the environment.
Natural resources	Construction materials would be required for the necessary pipeline and pumping stations to connect to the CWC network. The potential to source these locally should be maximised where possible.	Additional materials would be required to build a non-potable collection, treatment and distribution system. Reducing potable water demand would reduce any net increase in local total raw water abstraction from the environment.	Water efficient components do not adversely impact natural resources and could reduce total raw water abstraction.
Climate change mitigation	The carbon costs of transferring water from Cherry Hinton could be high.	Reducing the volume of potable water consumption would reduce carbon costs associated with potable treatment processes.	Per capita water usage would be lowered, thereby reducing carbon costs of water capture, treatment and distribution.
Climate change resilience	Abstractions from CWC incorporate climate change considerations.	If rainwater were part of a non-potable system, its capture would reduce on-site runoff rates and pressures on the surface water drainage system, providing greater climate change resilience from high rainfall events.	Lowering water consumption and instilling water efficiency into day-to-day living enhances resilience to the potential future impacts of climate change.

Source: Mott MacDonald

5.8 Proposed strategy for water resources, supply and efficiency

Based on analysis of available data, understanding of the opportunities and constraints, and the above sustainability assessment, it is recommended that the strategy for water resources, supply and efficiency at Denny St Francis consists of:

Water resources, supply and efficiency
WR 1: All properties should be installed with a smart water meter • Following regulatory guidance, water meters should be installed in all properties. • Installation of the meters in a prominent, visible place would encourage water users to actively monitor and use them to reduce their water demand. Section 5.4.4
WR 2: Installation of water efficient components in homes and businesses • This could reduce per capita water demand to Code for Sustainable Homes Level 3/4 (105 l/h/d of potable water). • Further efficiency in taps and a smaller bath size could reduce demand to 94 l/h/d of potable water. Section 5.4.1
WR 3: Active education of residents in water efficiency • Education will be fundamental to achieve long-term reductions in water demand. • A number of education measures can be adopted to instil awareness and understanding, including home welcome packs, promotional material and engagement events. Section 5.4.3
WR 4: A connection to Cambridge Water Company would provide the most practical and deliverable source of potable water • Cambridge Water's supply-demand balance is forecast to be in surplus throughout the current water company planning period (2015- 2040) and would provide Denny St Francis residents with high levels of service, reliability and quality. Section 5.7
WR 5: Installation of non-potable rainwater supply systems in all dwellings and appropriate other buildings • The use of rainwater could further reduce per capita potable water use to Code for Sustainable Homes Level 5/6 of 80 l/h/d. • The quantities available would depend on the tank size adopted, roofed area and occupancy rates. • Rainwater harvesting would offer a sustainable system of water supply, reduce wider raw water abstraction pressures, follow national guidance on

the promotion of water efficiency and result in lower water bills for Denny St Francis residents.

- The capture of rainwater would also have benefits for the Denny St Francis drainage system by reducing runoff rates.
- The sustainability of a non-potable rainwater supply system should be revisited at the detailed design stage, including an assessment of total carbon footprint.

Sections 5.4.2.1 & 5.5.1.3

5.9 Further work

To further understand the opportunities (and constraints) of groundwater inclusion in a water supply system at Denny St Francis, further information is required on the geological and hydrogeological conditions across the site.

Site specific hydraulic testing would be required to demonstrate the effectiveness of the River Terrace Deposits for water storage and transmittance and to better gauge heterogeneity within the material overlying the Gault Clay.

In addition, groundwater level monitoring should be undertaken across the site to more accurately conceptualise the hydrology of the Denny St Francis.

6 Flood Risk Management

6.1 National and local policy

Appropriate flood risk management is a key component of sustainable development and at the heart of a number of national and local planning policies.

6.1.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF) (Department for Communities and Local Government, 2012) replaced previously existing national and regional planning policy including Planning and Policy Statement 25 (Department for Communities and Local Government, 2010), and constitutes guidance for Local Planning Authorities in drawing up plans and determining development applications.

Setting out Government policy on delivering sustainable development, the NPPF provides a national framework for land use planning for development in flood risk areas. Its aims are to:

- Ensure that flood risk is taken into account at all stages in the planning process;
- Avoid inappropriate development in areas at risk of flooding; and
- Direct development away from areas at highest risk.

Where new development is, exceptionally, necessary in such areas, the policy aims to make it safe, without increasing flood risk elsewhere and, where possible, reducing flood risk overall.

The NPPF (and its associated NPPF Technical Guide) includes Government policy and ambitions for flood risk management, with notice given to the impact of climate change. In Table 5 of the Technical Guide, the impact of climate change on flood risk is considered. Flood risk is predicted to increase in the future as a result of more frequent intense rainfall events in winter and higher peak flows in rivers. The NPPF suggests that rainfall intensity may increase by up to 30% within 100 years, and that peak river flows may increase by up to 20% over the same period (Department for Communities and Local Government, 2012).

6.1.2 Flood and Water Management Act

The Flood and Water Management Act placed responsibility for managing the risk of local floods on the Lead Local Flood Authorities, but allows for the delegation of flood risk management functions to other statutory authorities.

The Act aims to improve both flood risk management and the way in which water resources are managed by creating clearer roles and responsibilities and instilling a more risk based approach. It transposes the EC Floods Directive (Directive 2007/60/EC on the assessment and management of flood risks) into domestic law and implements its requirements. It places duties on the Environment Agency and local authorities to prepare flood risk assessments, flood risk maps and flood risk management plans.

The Act requires flood and coastal erosion risk management authorities, which include the Local Authority, to aim to contribute towards the achievement of sustainable development when exercising their flood and coastal erosion risk management functions (Department for Environment, Food and Rural Affairs, 2010).

6.1.3 Land Drainage Act

The Land Drainage Act 1991 requires that a watercourse be maintained by its owner in such a condition that the free flow of water is not impeded (Department for Environment, Food and Rural Affairs, 1991).

The Act (and its 1994 amendment) gives Internal Drainage Boards (IDBs) the responsibility to maintain a network of watercourses within designated areas and to provide drainage. The IDBs are required to provide flood protection and water level management services.

The Waterbeach IDB have this responsibility for the area proposed for the Denny St Francis development.

The Land Drainage Acts of 1991 and 1994 require IDBs to:

- Provide general supervision over all aspects of land drainage within its District;
- Improve and maintain the drainage system, including the operation of pumping stations;

- Regulate activities in and alongside the drainage system, other than on those waterways designated as main river and under the EA's control;
- Provide duties of conservation; and
- Raise income to support land drainage works (South Cambridgeshire District Council and Cambridge County Council, September 2010).

6.1.4 South Cambridgeshire Local Plan

The Proposed Submission of the South Cambridgeshire Local Plan was published by SCDC in July 2013, to cover the planning period 2011 to 2031.

The Local Plan identifies Denny St Francis (known as "Waterbeach New Town" in the Local Plan document) as one of four major strategic sites for development in South Cambridgeshire. Policy SS/5 states that Denny St Francis will "*deliver an example of excellence in sustainable development*" (South Cambridgeshire District Council, July 2013).

The Plan requires development proposals to adapt to the effects of climate change and demonstrate that flood risk from all sources has been avoided or managed (Policy CC/9):

Policy CC/9: Managing Flood Risk

1. In order to minimise flood risk, development will only be permitted where:
    a. The sequential test and exception tests established by the National Planning Policy Framework demonstrate the development is acceptable (where required). For undeveloped sites, floor levels are 300mm above the 1 in 100 year flood level plus an allowance for climate change where appropriate and/or 300mm above adjacent highway levels where appropriate;
    b. Suitable flood protection / mitigation measures are incorporated as appropriate to the level and nature of flood risk, which can be satisfactorily implemented. Management and maintenance plans will be required, including arrangements for adoption by any public authority or statutory undertaker and any other arrangements to secure the operation of the scheme throughout its lifetime;
    c. There would be no increase to flood risk elsewhere, and opportunities to reduce flood risk elsewhere have been

explored and taken, including limiting discharge of surface water (post development volume and peak rate) to natural greenfield rates or lower; and

   d. The destination of the discharge obeys the following priority order.
      i. Firstly, to the ground via infiltration;
      ii. Then, to a water body;
      iii. Then, to a surface water sewer;
      iv. Discharge to a foul water or combined sewer is unacceptable.

2. Site specific Flood Risk Assessments (FRAs) appropriate to the scale and nature of the development and the risks involved, and which takes account of future climate change, will be required for the following:
   a. Development proposals over 1ha in size;
   b. Any other development proposals in flood zones 2 and 3;
   c. Any other development proposals in flood zone 1 where evidence, in particular the Strategic Flood Risk Assessment or Surface Water Management Plans, indicates there are records of historic flooding or other sources of flooding, and/or a need for more detailed analysis.
3. FRAs will need to meet national standards and local guidance (including, here, recommendations of the South Cambridgeshire and Cambridge City Strategic Flood Risk Assessment (2010) and the Phase 1 and 2 Water Cycle Strategy or successor documents).

6.1.5 CIRIA Flood Risk Sustainable Development

The Construction Industry Research and Information Association (CIRIA) have published guidance on how a development should be sustainable in terms of flood risk.

The C624 Flood Risk Sustainable Development checklist includes:

- A standard of flood protection that is in agreement with national planning policy guidance and/or the requirements of the Local Planning Authority;
- Design that takes into account the potential impact of future climate change on flooding;
- Design that takes into account the potential of any future changes to the nature of the site;
- Limited anticipated disruption to the normal operation of the development during a flood event;
- Acceptable predicted impacts on upstream flood risk;

- Acceptable predicted impacts on downstream flood risk; and
- The development will not compromise any existing strategic flood risk management plans (Construction Industry Research and Information Association, 2004).

6.2 Historic flooding events

As reported in the Scoping Study report, there have been no known historic occurrences of flooding at the Denny St Francis site (RLW Estates Ltd., February 2014).

During the severe Cambridgeshire flooding events of 2000/2001 and 2001/2002, flooding occurred in the Waterbeach area approximately 1 km south of the Denny St Francis site, affecting the Waterbeach railway station car park and five properties in Whitmore Way. Aerial photography of the Waterbeach area, taken during the October 2001 flood event, shows clearly that the flood defences successfully retained the flood waters (Figure 6.1).

Figure 6.1: Aerial view of Waterbeach from the south west after the 21st October 2001 storm

Source: (RLW Estates Ltd., August 2012)

More recently, there have been occurrences of flooding in Waterbeach village during December 2013 to January 2014. The source of this flooding was principally sewer flooding as a result of the extreme rainfall experienced, and not fluvial flooding. The existing Waterbeach foul sewer network is a combined system and therefore vulnerable to such weather events (as discussed further in Section 8).

6.3 Fluvial flood risk

A site-specific flood risk assessment (FRA) was carried out for Denny St Francis in 2002 and updated in 2009 and 2012 (RLW Estates Ltd., August 2012). The assessment reviewed fluvial flood risk from:

- Fluvial flooding;
- A breach of the existing River Cam flood defences;
- Failure of the existing River Great Ouse/Old West River flood defences;
- Climate change;
- Increased Water Recycling Centre effluent discharges;
- Increase in catchment urbanisation;
- Failure or obstruction of Bottisham Lock; and
- Failure of IDB pumping stations.

Information was drawn primarily from the South Cambridgeshire and Cambridge City Level 1 Strategic Flood Risk Assessment (South Cambridgeshire District Council and Cambridge County Council, September 2010), Cambridgeshire Preliminary Flood Risk Assessment (Cambridgeshire County Council, March 2011) and Cambridgeshire Surface Water Management Plan (Cambridgeshire County Council, April 2011).

6.3.1 Existing fluvial flood risk

The EA Flood Zones map shows the undefended fluvial flood extent for the 1% Annual Exceedance Probability (AEP) and 0.1% AEP events.

Flood Zones are defined as:

- Flood Zone 1 is classified as land where the risk of flooding is less than 1 in 1000 years (i.e. less than 0.1% annual probability of occurring). It is classed as an area of 'low probability' risk of fluvial flooding.
- Flood Zone 2 is classified as land having between 1 in 100 and 1 in 1000 year annual probability of fluvial flooding (i.e. 1%-0.1% annual probability of occurring). It is classed as an area of 'medium probability' risk of fluvial flooding.
- Flood Zone 3a is classified as land having a potential to flood for storm events greater than 1 in 20 year return period and up to 1 in 100 year annual probability (i.e. greater than 1% annual probability of occurring). It is classed as an area of 'high probability' risk of fluvial flooding.
- Flood Zone 3b is classified as land having the potential to flood for storm events up to 1 in 20 year return period (i.e. 5% annual probability of occurring). It is classed as 'functional floodplain'.

As reproduced in Figure 6.2 and reported in the Denny St Francis FRA, the majority of the site lies in Flood Zone 1 (low probability of flooding).

The far south eastern corner of the site lies within Flood Zone 2 (medium risk of flooding without flood defences) and there are small areas within the site along the north western and south western boundaries, and in the far north eastern corner of the site, which lie within Flood Zone 2 and Flood Zone 3.

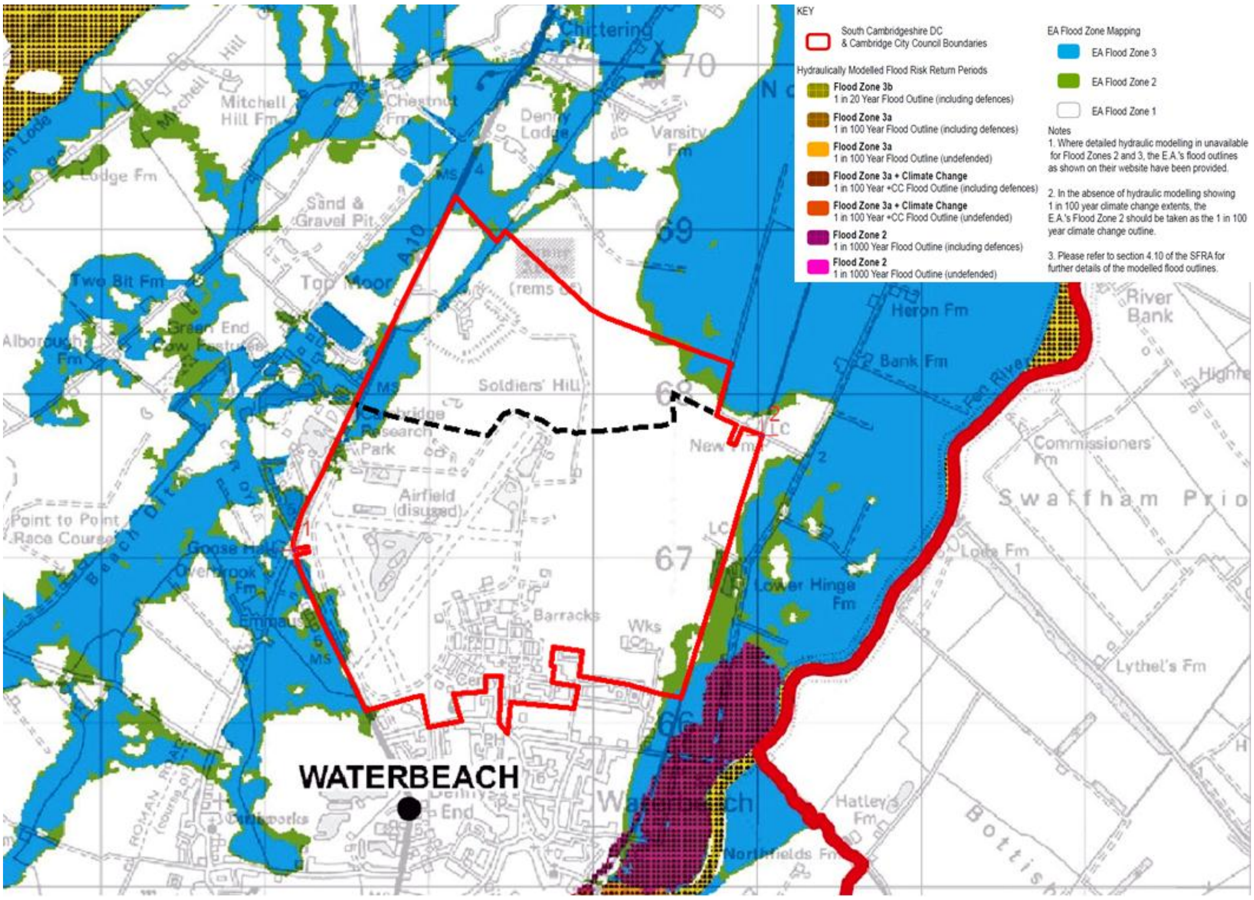
A detailed topographic survey of the site was undertaken as a part of the site-specific FRA in 2012. The western area of the site is above 4 mAOD, which is higher than the east of the site. As reported in the Denny St Francis FRA, correspondence between the Environment Agency and Mott MacDonald in 2012 confirmed that the EA Flood Zones map predominantly depict the fluvial flooding influence of the River Cam and, given the detailed topographical information, it was therefore considered unlikely that flooding from the River Cam would inundate the west of the site. The EA confirmed that they did not consider the western part of the site to be at risk of flooding (RLW Estates Ltd., August 2012).

In addition, correspondence between the Environment Agency and Mott MacDonald in 2012 clarified that a small area of land near Cambridge Research Park is on relatively high land (4 mAOD), and is also therefore not considered to be at risk from flooding (RLW Estates Ltd., August 2012, p. 69).

The area in the north eastern corner of the site that is shown to lie within Flood Zone 2/3 is to the north of the development boundary of Denny St Francis. As such, vulnerable development will not be located in this area.

Further details and records of the correspondence can be found in Appendix D of the Denny St Francis FRA (RLW Estates Ltd., August 2012).

Figure 6.2: Flood risk constraints



Source: Extract from Figure D 1.2, South Cambridgeshire and Cambridge City Level 1 Strategic Flood Risk Assessment (South Cambridgeshire District Council and Cambridge County Council, September 2010) with Denny St Francis redline boundary (red line) and development boundary (black dashed line) overlaid.

6.3.2 Existing flood defences

A topographic and condition survey of the River Cam flood defences between the confluence with the Old West River and Waterbeach Sailing Club (near Clayhithe Bridge) was carried out on behalf of Mott MacDonald in 2002 (a summary of which was reported in Appendix B of the 2012 FRA). The survey concluded that the current defences are well maintained up to the 1.0% AEP fluvial flood level. It was therefore considered appropriate that the present day fluvial flood risk to the proposed Denny St Francis development was considered with the defences in place.

The existing left (west) and right (east) bank defences are currently maintained by the Environment Agency. The future maintenance of these defences is currently in question, given uncertainties surrounding Environment Agency funding. If the Denny St Francis development were to be planned based on the assumption of protection from the flood defences, there could be a requirement for the developers to contribute towards the cost of the maintenance programme. This is discussed further in Section 6.6.

6.3.2.1 Risk from a breach of existing flood defences

When river levels reach the extremes expected during a 1% AEP flood or larger flood event, the possibility of an embankment breach needs to be considered.

River Great Ouse/Old West River

As a part of the Denny St Francis FRA, failure of the River Great Ouse/Old West River flood defences was considered. The main risk from the River Great Ouse system for the Denny St Francis site would be a flood bank breach upstream of Earith Sluice. The effects of a flood bank breach were analysed using a breach and floodplain cell model.

It was found that the A10 provides protection up to the 4.0 m AOD level, with the A10 acting as a flood barrier due to the absence of any culverts under the road between Waterbeach and the Old West River. The floodplain storage provided between the Great Ouse and the A10 was calculated and shown to be greater than what would be required under even a 0.1% AEP flood (RLW Estates Ltd., August 2012).

River Cam

A breach in the left (west) bank of the River Cam at any location between Waterbeach and the river's confluence with the Old West River could result in flooding of land to the west of the river and potentially parts of the Denny St Francis development.

Breach analysis work was conducted on behalf of the Environment Agency in 2010 and reported in the South Cambridgeshire and Cambridge City Level 1 Strategic Flood Risk Assessment (South Cambridgeshire District Council and Cambridge County Council, September 2010). The scenarios presented in the SFRA allowed for closing of the breach 36 hours after the initial failure but did not detail the location of the simulated breaches.

Whilst this existing published information showed that the site would not be inundated during 0.1% AEP breach event (a more extreme event than is required to be considered by the NPPF), the FRA and Water Cycle Study Scoping Study highlighted the ongoing uncertainties surrounding this review given the lack of clarity surrounding the location of the modelled breaches.

Review of Strategic Flood Risk Assessment breach modelling

To address the recommendation proposed by the Scoping Study, the breach model used for the modelling reported in the 2010 Strategic Flood Risk Assessment was obtained from the Environment Agency and reviewed. This is reported in Appendix F.

The review found that the modelled breach locations and scale and duration of the breach do give a 'worst-case' scenario for flow leaving the River Cam adjacent to the Denny St Francis site. However, the modelled extent was restricted by the extent of the TUFLOW grid used in the SFRA model and therefore there could be the potential for a larger area of the site to be at risk. In addition, it was acknowledged that there was also the potential for the railway embankment to provide protection to the lower elevations of the site; however culverts in the embankment could also provide flow paths for some of the floodwaters. The railway embankments and culverts were also not represented in the SFRA model.

Additional flood risk assessment breach modelling

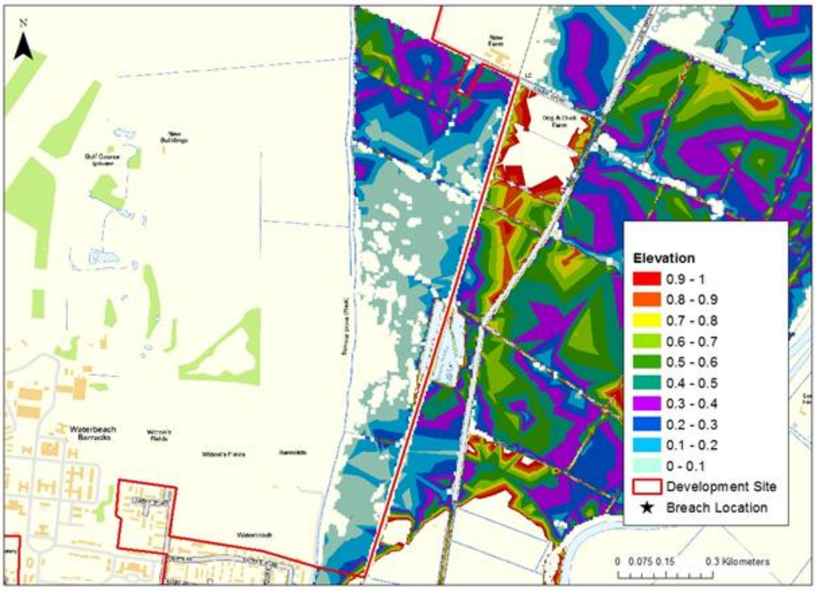
To address this, an updated breach model was developed by Mott MacDonald, which extended the TUFLOW grid and included representation of the railway and other embankments on the floodplain and the culverts underneath the railway embankment. The updates made to the model were reported in a Breach Modelling report (RLW Estates Ltd., August 2014).

The objective of the updated breach model was to determine the residual risk of flooding at the proposed Denny St Francis site from a breach in the River Cam flood defences under a 1 in 100 year plus climate change flood event; the event against which mitigation should be provided as stated Policy CC/9 in the South Cambridgeshire Local Plan (South Cambridgeshire District Council, July 2013). Four breach locations that were used in the SFRA model were tested under a 36 hour scenario – the standard modelled breach duration recommended by the Environment Agency for a fluvial breach.

The modelling found that that the Denny St Francis site is at residual risk of flooding from a breach at only one of the tested locations (Location '2e') during the 1 in 100 year plus climate change event. It was also noted that the duration of the breach for this magnitude event has an effect on the extent and depth of flooding, due to the occurrence of a second peak during the flood.

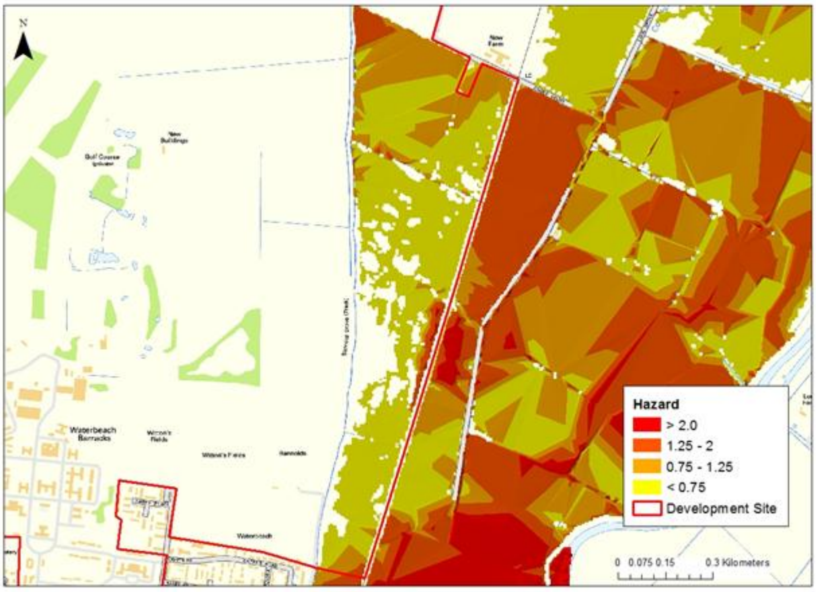
As shown in Figure 6.3, the area of land towards the east of the proposed development site is at residual risk from a breach at location '2e'. It can be seen that generally the depth of flooding is shallow; less than 0.2m. Towards the north of the site, where ground levels are lower, the depths are greater with depths of up to 0.7m possible here. Floodwater is clearly being restricted by the embanked road that runs through the site.

Figure 6.3: Breach 2e flood extent and depth: 1 in 100 year plus climate change 36 hour scenario



A hazard map was created that showed that the majority of the site has a hazard rating of less than 0.75, which is a "low" hazard meaning "Caution: flood zone with shallow flowing water or deep standing water." Towards the north of the site, where flood depths are greater, the hazard rating increases up to 2.0, which is a "significant" meaning "Danger: flood zone with deep fast flowing water":

Figure 6.4: Breach 2e Hazard Map: 1 in 100 year plus climate change 36 hour scenario



Contains Ordnance Survey data Crown copyright and database right © 2014

Further tests were run under 1 in 1000 year plus climate change flows and a longer duration breach event. The findings of these scenarios were reported in the full Breach Modelling report (RLW Estates Ltd., August 2014). It is noted that the further modelling had a limited impact on the inundation area beyond the 1 in 100 year plus climate change extent, and that it was predominantly the north eastern-most corner of the site that was affected.

Conclusions

The site is not at residual risk from a breach in the River Great Ouse/Old West River flood defences.

The modelling conducted as a part of the 2014 River Cam breach modelling review concluded that the majority of the site is located outside of the 1 in 100 breach flood extent for the lifetime of the development (i.e. including an allowance for climate changes impacts over the next 100 years) (RLW Estates Ltd., August 2014).

The eastern side of the site is at residual risk from a breach in the western bank of the River Cam at location '2e', if a 36 hour breach under a 1 in 100 year plus climate change flood event were to occur.

It is noted that floodwater would be restricted by the embanked road that runs through the site and that the extent of flooding may increase if this road is altered.

6.3.3 Water Recycling Centre discharges

Additional used water discharge volumes as a result of the proposed Denny St Francis development should be considered to ensure that there is no net impact on downstream flood risk. Based on earlier investigations and associated reporting, it can be assumed that used water from Denny St Francis would be discharged to the River Cam system as opposed to the Old West River.

The conservative used water development scenarios for Denny St Francis have calculated that the development could contribute an additional 6.4 Ml/d of flow to the River Cam by the end of the construction period (Section 3.3).

As reported in the Denny St Francis FRA report, the present day 5% AEP peak flow in the River Cam at Bottisham Lock gauging station is 47 m^3/s[22]. Adding a further ~75 l/s to this as a result of treated used water discharges would represent a 0.15% increase in flow. It is therefore considered that increased discharges as a result of the proposed development at Denny St Francis would not impact notably on flood risk from the River Cam.

6.3.4 Risk to associated off-site Denny St Francis development

As part of the wider development plans, a new railway station is proposed at the Denny St Francis site. Flood risk management of this site would need to be carefully considered. It is assumed that the platform and associated buildings for the railway station would be at the level of the embanked railway, and therefore above the flood level. It is not considered that any further protection would be required for a new station.

Access to and from the station, however, would likely be restricted and would need to be considered. Assessments of impact and potential mitigation measures would need to be prepared as a part of the railway station development flood risk planning.

[22] Predicted from frequency analysis of historic records compiled from the last 50 years of annual maximum flows at Bottisham Lock gauging station (RLW Estates Ltd., August 2012).

6.4 Tidal flood risk

The Denny St Francis site-specific flood risk assessment also reviewed risk from:

- A combined tidal and fluvial events; and
- Sea level rise.

Approximately 50 to 60 km downstream of Waterbeach, the combined rivers of the Ely Ouse system outfall into the Wash. A potential risk is that an extreme tidal event in the Wash could occur at the same time as a fluvial event, thus raising water levels as far upstream as Waterbeach and leading to failure and/or overtopping of the defences. Whilst only the lower portion of the Ely Ouse river system is tidal (from about 40 km downstream of Waterbeach), the lower parts of the rest of the system can be influenced by tidal events by a process known as tide lock: at high tide, water cannot be discharged into the Wash sufficiently rapidly and it backs up the rivers.

It was shown that Bottisham Lock is not sensitive to normal tidal cycles and the probability of an extreme tidal and an extreme fluvial event occurring at the same time and causing failure of the River Cam flood defences would be very low indeed – in the region of 0.01% to 0.005% (RLW Estates Ltd., August 2012).

The Denny St Francis FRA also considered potential impacts from sea level rise as a result of both climate change and land tilt. It was concluded that sea level rise due to climate change is unlikely to have an impact on flood levels in the River Cam within the next 80 years, and even after that, any impact is likely to be of the order of a few millimetres. Even when the effects of climate change and land tilt are combined, the effect at Waterbeach would be negligible (RLW Estates Ltd., August 2012).

6.5 Groundwater and pluvial flood risk

Groundwater flooding occurs when the subsurface becomes fully saturated and groundwater is unable to flow away into surface water drainage. Groundwater rises to the surface where it emerges as seepages and springs and can become ponded in depressions. Groundwater flooding generally takes longer to recede than surface water flooding.

The British Geological Survey (BGS) has a useful explanation of the main mechanisms of groundwater flooding (see Appendix D). The description of flooding in a shallow unconsolidated sedimentary aquifer setting is pertinent to the Denny St Francis site, as at the site there are permeable gravel terrace deposits overlying the impermeable Gault Clay (see Section D.1.1).

The BGS produces mapping indicating areas that are considered to be potentially susceptible to groundwater flooding. Consequentially, the available mapping for Denny St Francis (shown in Figure D.2 in Appendix D) shows that, as described above, the gravel terrace deposits across the site are categorised as potentially susceptible to groundwater flooding.

This mapping tool gives a high level indication of groundwater flooding on a wide geological scale. Information on site-specific conditions should then be used to refine these classifications.

Groundwater was encountered at relatively shallow depths in the superficial gravel terrace deposits at the site (as reported in Section D.1.3. (A F Howland Associates, December 2002). The surface water levels around the Denny St Francis site and Waterbeach are artificially maintained through drainage by the IDB (see Section 7.3). Recent floods have shown that the site was protected from surface water flooding by the existing flood protection measures (see Figure 6.1) and there are no known reports of groundwater flooding during this or other flood events. Therefore, although the site falls within an area that is potentially susceptible to groundwater flooding, this is considered unlikely given the existing surface water management of the area by the IDB's pumping and drainage infrastructure.

As part of the surface water strategy for the development, groundwater in the superficial deposits would continue to drain to the IDB's surface water drainage ditches as at present (see Section 7). Water in the IDB ditches is pumped into the River Cam. Even at times of high river flows the IDB ditches are able to be drained, as the operation of the IDB pumps discharging the water would not be significantly adversely affected by high water levels in the river. As such, the combined situation of high groundwater levels, high surface water flows into the IDB drains and high river levels in the River Cam would have a minimal cumulative impact on Denny St Francis.

6.6 Flood risk mitigation measures

It has been shown that the Denny St Francis site is at risk from the following flood events:

- A small area in the north east corner of the site under an undefended 1 in 100 year fluvial flood event (Flood Zone 3). This area of land does currently, however, benefit from defences.
- A small area in the north east and south east corners of the site under an undefended 1 in 1000 year fluvial flood event (Flood Zone 2)[23].
- The area of the site to the east of Barnold Drove track under a flood defence breach during a 1 in 100 year fluvial flood event including climate change.

Flood risk mitigation measures can include both hard engineering defences (e.g. structural barriers) and more sustainable techniques (e.g. land use placement and land level raising).

In line with the principle of the sequential approach within the National Planning Policy Guidance (“Reducing the causes and impacts of flooding”) (Department for Communities and Local Government, 2012), appropriate development should be located within these areas.

Land use placement locates sensitive land uses away from potential flood extents. The land use vulnerability classification used in the NPPF Technical Guidance is summarised as essential infrastructure, more vulnerable, less vulnerable and water compatible (Department for Communities and Local Government, 2012).

Land level raising can be incorporated into the design and construction of a development in order to raise buildings or infrastructure above predicted flood peaks, thereby removing residual risk of flood inundation.

Flood bunds/embankments can also be constructed around vulnerable land uses to protect and redirect floodwaters. With flood bunds, however, there remains a residual risk of the bund being damaged at the time of a flood and maintenance to maintain the standard of protection would also be required. To mitigate against an increase in flood depth caused by displacing floodwaters through the construction

[23] Whilst this area of land could benefit from the Cam defences during this extreme event, the defences do not currently have a standard protection of 1 in 1000 year flood.

of a flood bund, a "volume-for-volume" floodplain compensation storage area could be constructed.

The options for Denny St Francis have been evaluated. In all cases, any residual impacts on flood extent and depths in the surrounding area must be considered and avoided. Model runs were undertaken to better understand the benefits and disbenefits of different flood mitigation options and are reported in Appendix F.

Recommendations for Denny St Francis

For Denny St Francis, it is recommended that the area of land in the north east corner of the site in Flood Zone 2 and 3 should remain as green open space. A significant percentage of the Denny St Francis site is already designated as water compatible. This includes the northern area of the proposed development, which is allocated for open space in the Development Framework (see Figure 1.2).

Some built development, in the form of commercial and residential development, is proposed in the southern areas of the site where water levels from a breach in the flood defence are generally less than 0.2m, and the hazard associated with this event is very low. Land level raising or flood bunding is recommended here. Residential development could be raised above the peak flood level for a breach during the 1 in 100 year plus climate change event of 2.6mAOD. A protective bund could alternatively be constructed (as detailed in Appendix F). The consequential impact of the bund on the residual flood risk of the surrounding area has been assessed. Mitigation could include extending the bund to incorporate existing properties.

The existing Barnold Drove track embankment should be retained to preserve the additional floodwater protection it would offer to the site during a flood defence breach event. Alternatively, the road could be removed or relocated if required as long as its function as a flood levee is replicated. This would allow for a more flexible design. The impact of this would need to be modelled to determine any changes to the residual flood risk at the site.

Taking into consideration the above mitigation measures, it is not considered that the Denny St Francis development would be relying on the protection from existing flood defences and no on-going maintenance agreement would therefore need to be made.

6.7 Flood risk management sustainability assessment

The mitigation measures discussed in Section 6.6 above for addressing flood risk at Denny St Francis have been assessed in terms of their sustainability credentials in Table 6.1.

Table 6.1: Flood risk management options sustainability assessment

	Land use placement	Land level raising	Flood bunding
Social			
	Additional community benefits could be had from the development of water compatible areas – high amenity/aesthetic value.	Provides a development that is at very low risk of flooding even if a breach of the flood banks were to occur.	Provides a development that is at very low residual risk of flooding even if a breach iof the flood banks were to occur.
Economic			
	Reduces the financial costs of flooding through avoiding vulnerable land uses. Minimal direct maintenance or construction costs.	Costs of construction would in-part be incorporated into wider development construction but would result in higher overall costs. There would be low on-going maintenance costs, although settlement will need to be monitored to ensure raised ground levels are maintained.	Costs of construction could potentially be high, and would include capital material costs. There would be associated ongoing maintenance costs of a flood bund.
Environmental			
Ecology	This management strategy promotes the development of riparian and wetland habitats.	Minimal landscape impact as measures incorporated into architectural design.	A flood bund could be incorporated into the ecological habitats plan for the development.
Natural resources	Locating water-compatible areas in higher risk locations would likely have minimal impacts on natural resources.	This option could provide improved drainage and surface water disposal opportunities.	This option would require raw materials for its construction.
Climate change mitigation	The carbon cost of this option would likely be low.	On-site activities would be incorporated into original development construction. Therefore, although activities would increase, the associated emissions are expected to be minimal.	This option would have higher carbon costs during its construction.
Climate change resilience	Additional allowance would be incorporated into the design to allow for climate change. Reducing vulnerability of a development	Additional allowance would be incorporated into the design to allow for climate change. Reducing vulnerability of a development provides a medium to long-term approach to	Additional allowance would be incorporated into the design to allow for climate change. Reducing vulnerability of a development

	Land use placement	Land level raising	Flood bunding
	provides a medium to long-term approach to flood risk management.	flood risk management.	provides a medium to long-term approach to flood risk management.

Source: Mott MacDonald

The provision of a long term, sustainable flood mitigation solution could be achieved by a combination of sequential land use placement (where possible), raising ground levels to the predicted 1% AEP flood level (including the predicted effects of climate change) and localised flood bunding (providing a physical barrier to flood waters). This would include all access routes and roads, but would exclude water compatible land use areas such as parks and school playing fields. The entire site, with the exception of the water compatible land uses, would therefore be in Flood Zone 1 over the lifetime of the development (including a freeboard) and therefore appropriate for all types of land use. On-site mitigation is considered to be the most appropriate solution and is also in line with the principles set out in the NPPF (Section 6.1.1).

These mitigation measures would provide a development which meets all the key aims of creating a sustainable development in terms of flood risk. The site would not be at a significant risk of flooding, nor would it increase flood risk elsewhere.

6.8 Proposed strategy for flood risk management

Based on analysis of available data, understanding of the opportunities and constraints, and the above sustainability assessment, it is recommended that the strategy for flood risk management at Denny St Francis consists of:

Flood risk management
FRM 1: On-site flood mitigation measures would be the most sustainable form of flood protection at Denny St Francis • Sequential land use placement, land level raising and/or flood bunding should be incorporated into the architectural design of the development, these should have minimal visual impact. • Additional community benefits could be had from the development of the required water compatible areas. • The localised impacts of flood bunding should be considered, further assessed and mitigated against. Section 6.6
FRM 2: The Denny St Francis development should be designed so as not to rely on the protection of existing flood defences • Residential development could be raised above 2.6mAOD to the east of the Barnold Drove track, or a flood bund constructed, to eliminate flood risk in this area from a breach in the River Cam defences. • Water-compatible land uses should be located in the north eastern corner of

the development.

Section 6.6

FRM 3: The raised on-site embankments should be retained

- The Barnold Drove track embankment should be retained, in order to maintain the protection offered during a flood defence breach event.
- If it is necessary to remove the existing embankment, a replacement flood levee should be installed in order to retain the function performed. The impact of this would need to be considered and modelled.

Section 6.6

FRM 4: A Level 3 Flood Risk Assessment will need to be undertaken

- The Denny St Francis development meets the criteria required for a Level 3 FRA. This should be undertaken as a part of the on-going investigations.

Section 6.9

FRM 5: Off-site associated development should be flood resilient

- Flood risk should be assessed and appropriate mitigation investigated and proposed for off-site assets, including consideration of associated access routes.

Section 6.9

6.9 Further work

A Level 3 Flood Risk Assessment is required if the proposed development is greater than 1ha or located within Flood Zone 2 or 3. As such, a Level 3 FRA will need to be undertaken for Denny St Francis.

To increase understanding of on-site groundwater levels and seasonal variations, a programme of groundwater level monitoring should be undertaken across Denny St Francis. This would support the understanding of groundwater flood risk as well as provide useful data on the local hydrology that would also support development of the water resources, surface water management and ecology strategies for the site.

An assessment of the volume and source of material required for land level raising has not been undertaken as a part of this water cycle study. A review of this is recommended with a focus on sustainability.

Further detailed flood breach mitigation modelling work will be required to inform the most appropriate mitigation measures.

7 Surface Water Management

7.1 Introduction

The vision for sustainable surface water management should include environmental enhancement and should provide amenity, social and recreational value.

Sustainable surface water management systems benefit in the following ways:

- Reduced capital and operational costs (less 'hard' engineering and pumping required);
- Reduced carbon emissions (less 'hard' engineering and pumping required);
- Enhanced water quality and a reduction in polluted runoff;
- Opportunities to integrate surface water management into amenity areas and enhance biodiversity through development;
- Contribute to a 'network of protected sites, nature reserves, green spaces and greenways' (as defined in Cambridgeshire Horizons Green Infrastructure Strategy); and
- They are considered 'best practice' as advocated by the CIRIA SUDS Manual. (Cambridgeshire Horizons, July 2011).

The Cambridge Water Cycle Strategy provides three main areas to be considered:

1. A strategy to manage surface water runoff from the development sites to control flood risk to drainage of the river systems downstream;
2. A strategy to manage runoff within the development area; and
3. A strategy to manage flood risk in the development site from surface runoff entering from outside the development site.

7.2 Geology

The geology of the site is discussed in Section 5.5.1.2 and Appendix D. In summary, the site geology comprises strata of River Terrace Deposits (where present), overlying Gault Clay. The Gault Clay is underlain by the Woburn Sands Formation of the Lower Greensand Group.

As noted in the 2012 Drainage Strategy, the Howland Associates 2002 Ground Investigation found that infiltration drainage is limited by impermeable soils and shallow groundwater tables on site (A F Howland Associates, December 2002). The soakaway tests indicated that infiltration on the central part of the site, over Gault Clay, will not be feasible. Infiltration drainage may be possible in the west and east sides of the site, but the potential is likely to be limited by the shallow groundwater table (RLW Estates Ltd., August 2012).

7.3 Existing drainage system

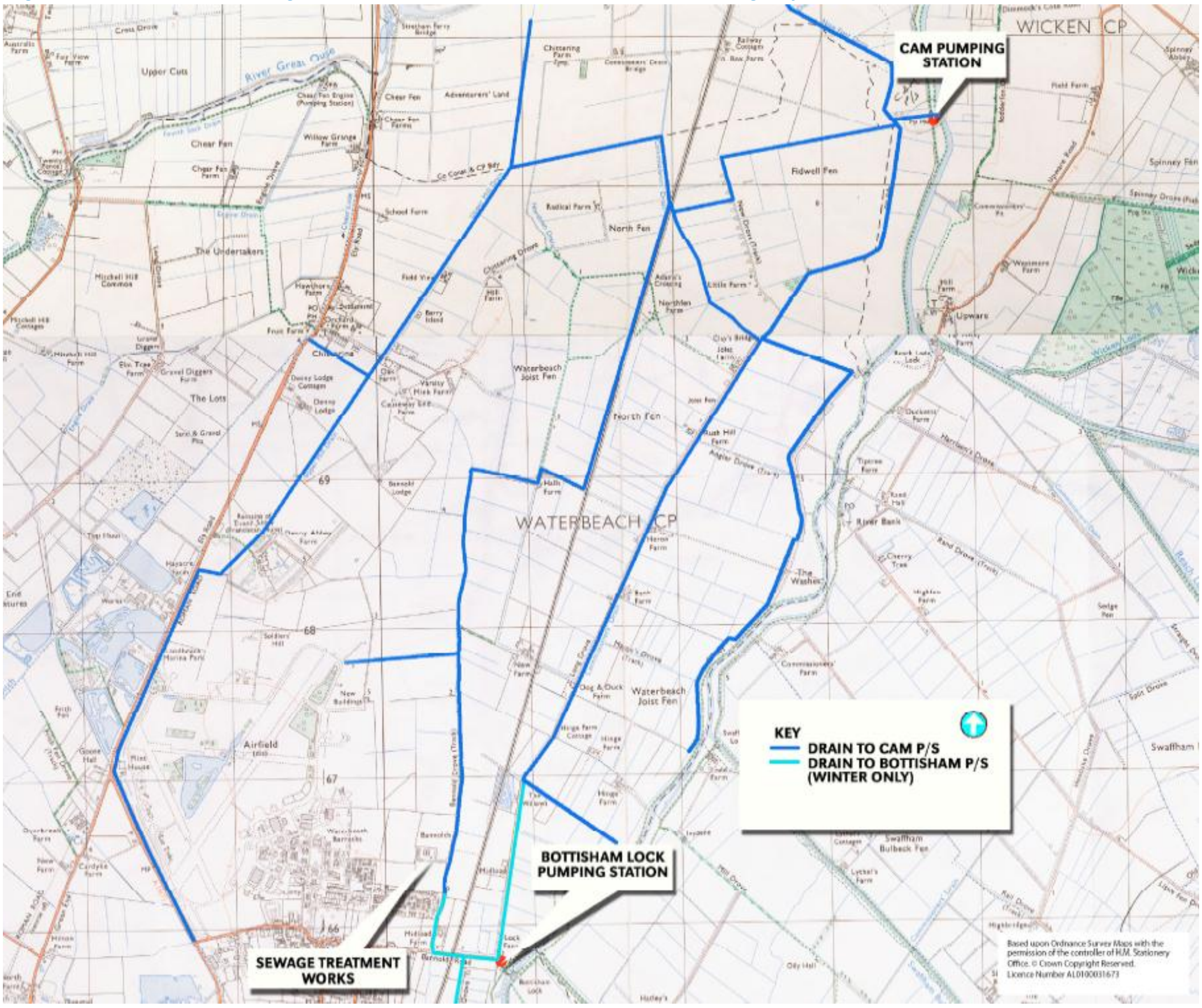
7.3.1 Waterbeach Level Internal Drainage Board

The area covered by the development lies entirely within the boundary of the Waterbeach Level Internal Drainage Board (IDB) District. The area is a pumped catchment reliant on the IDB for operation of pumping plant and drain maintenance for all surface water drainage discharge.

The existing drainage system at the site consists of a network of open channel gravity surface water drains which discharge into the River Cam via Bottisham Locks Pumping Station and Cam Pumping Station (Figure 7.1).

The Bottisham Locks Pumping Station drains approximately 300 ha of land and the Cam Pumping Station drains approximately 2,300 ha of land. The pumping stations have been sized to discharge surface water runoff from agricultural land at the rate of 1.1 l/s/ha.

Figure 7.1: Plan of existing Waterbeach Level IDB surface water drainage system



Source: (RLW Estates Ltd., August 2012, p. 16)

7.3.2 Required site runoff rate

The National Planning Policy Framework (NPPF), notes that a development must be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall (Department for Communities and Local Government, 2012).

In order to maintain the current runoff rate of 1.1 l/s/ha from the pumping stations into the River Cam and ensure that flood risk is not increased elsewhere, the surface water drainage network for the proposed development will need to be designed to limit discharge to 1.1 l/s/ha of the overall developed area[24].

7.4 Existing Drainage Strategy

A conceptual Drainage Strategy for Denny St Francis has been developed which outlines a broad strategy for surface water drainage for the proposed development (RLW Estates Ltd., August 2012). The strategy includes Sustainable Drainage Systems (SUDS) features and a preliminary estimate of the land take required for the SUDS. The proposed SUDS included swales, balancing ponds (for attenuating flows) and wetlands. The proposed SUDS will work with the site constraints and complement the fenland concept plan design aspirations. More detail on the proposed SUDS is outlined in Section 7.5.

As the details of the proposals are progressed, the Drainage Strategy for the site will need to be developed, both reflecting and informing the concept plan. The development of the concept plan in tandem with the Drainage Strategy will help maximise the opportunity for utilising SUDS in the development and will feed into the development of other site-specific plans including environmental (see Section 9), amenity, social and recreation, and transport.

7.5 Sustainable drainage systems

7.5.1 Proposed system

The CIRIA SUDS Manual describes Sustainable Drainage Systems as systems designed to minimise the impacts from the development on the quantity and quality of the runoff, and maximise amenity and biodiversity opportunities (Construction Industry Research and Information Association, 2007).

SUDS aim to replicate, as closely as possible, the natural drainage from the site. To do this, a “management train” is required that mimics catchment processes. This concept is fundamental to designing a successful SUDS scheme. Drainage techniques in series incrementally reduce pollution, flow rates and volumes of runoff. This reduces the

[24] *Pers. comm,* Waterbeach Level Internal Drainage Board.

need for large flow attenuation and control structures (Construction Industry Research and Information Association, 2007).

Effective sediment management is vital to ensuring the long-term effectiveness of SUDS techniques. Appropriate source control measures have been highlighted by the Water Cycle Study stakeholders as an important consideration in the development of SUDS systems. Maintenance burdens are dependent upon the appropriate inclusion of sediment traps or fore bays to prevent the build-up of sediment and consequentially the removal or provision of additional attenuation capacity. It was noted that past experience has shown this to often be overlooked by developers at the detailed design stage, resulting in retrofit measures being required.

CIRIA has produced a number of guidance documents covering a range of opportunities and challenges related to general water management, to specific SUDS components. The more notable publications are 'CIRIA C697: The SuDS Manual' and the more recent publication 'CIRIA C713: Retrofitting for Surface Water Management'.

Typical components of SUDS management trains include:

- Detention basins;
- Filter strips;
- Green roofs;
- Infiltration basins;
- Pervious surfaces;
- Rainwater harvesting;
- Swales;
- Wetlands;
- Ponds; and
- Bio-retention SUDS[25].

The selection of SUDS specified for a site largely depends on the nature of the site constraints. On the basis of the site constraints at Denny St Francis, and further to the 2012 Drainage Strategy, the SUDS will comprise, but not be limited to, rainwater harvesting, swales, balancing ponds and wetlands. In addition, a reservoir could also be incorporated to store redirected flows for farmland irrigation during the summer (see Section 7.6.5).

[25] Bio-retention based SUDS include storm water planters, bio-retention basins, tree pits, etc.

As indicated by the 2002 Howland Associates Ground Investigation Report, the Mott MacDonald 2012 Drainage Strategy and summarised in Appendix D, part of the site comprises impermeable Gault Clay and other parts of the site superficial deposits are permeated by relatively shallow groundwater.

The impermeable superficial deposits on site will negate any infiltration potential; therefore the SUDS for the impermeable areas will focus on controlling surface water at source and attenuating flows. The relatively shallow groundwater will facilitate maintaining a 'wet zone' in the SUDS wetlands; however, groundwater ingress would compromise the attenuation capacity of balancing ponds. Therefore, some SUDS management train features may need to be lined with an impermeable geotextile liner to prevent groundwater ingress.

The combination of attenuation and treatment of surface water on site prior to discharge off site to Waterbeach Level IDB drains would mitigate any negative impacts of the development on the existing IDB drainage network by maintaining the maximum discharge rate of 1.1 l/s/ha.

It is considered that the proposed SUDS would be suitable for both the 8,000 and 10,000 development dwelling scenarios. However, if the 10,000 dwelling option is pursued, the slightly larger area of impermeable surfacing will require additional attenuation of surface water in comparison to the 8,000 dwelling option in order to maintain the discharge rate of 1.1 l/s/ha.

Overall, it is considered that the implementation of the SUDS will mitigate the increase in impermeable surface as part of the development of the Denny St Francis site, improve the surface water drainage on site and provide betterment over the existing established drainage system for Waterbeach Barracks (see Section 7.6.1).

The advantages and disadvantages of the proposed components of Denny St Francis SUDS management trains are outlined in Table 7.1 as per the CIRIA SUDS Manual 2007 (Construction Industry Research and Information Association, 2007).

The table highlights the amenity and ecological diversity benefits of lined balancing ponds, swale, wetlands, a reservoir, pervious surfaces and green roofs. In addition to those advantages outlined in Table 7.1, it is intended that the design of the SUDS will be used to help define the character of different parts of the site (LDA Design, September 2013).

Table 7.1: Advantages and disadvantages of proposed SUDS

Waterbody	Advantages	Disadvantages	Ecology & amenity potential	Pollutant removal	Maintenance burden
Balancing pond and attenuation waterbodies– with liner to prevent groundwater ingress	• Can cater for a wide range of rainfall events • Can be used where groundwater is vulnerable via a liner • Simple to design and construct • Potential for dual land use • Easy to maintain • Safe and visible capture of accidental spillages	• Little reduction in runoff volume • Detention depths may be constrained by system inlet and outlet levels	• Moderate ecology potential • High amenity potential	• Moderate total suspended solids removal • Low nutrient removal • Moderate heavy metal removal	• Low maintenance cost if appropriate source control is provided
Swale	• Easy to incorporate into landscaping • Good removal of urban pollutants • Reduces runoff rates and volumes • Low capital cost • Maintenance can be incorporated into general landscape management • Pollution and blockages are visible and easily dealt with	• Not suitable for steep areas • Not suitable in areas with significant roadside parking • Limits opportunities for incorporating trees in landscaping • Risks of blockages in connecting pipes	• Moderate ecology potential • Moderate amenity potential	• High total suspended solids removal • Low nutrient removal • Moderate heavy metal removal	• Moderate maintenance cost
Wetlands	• Good removal capability of urban pollutants • If lined can be used where groundwater is vulnerable • Good community acceptability • High potential ecological,	• Land take is quite high • Requires baseflow to prevent stagnation • Limited depth range for flow attenuation • May release nutrients during non-growing	• High ecological potential • High amenity potential	• High suspended solids removal • Moderate nutrient removal • High heavy metal removal	• Moderate maintenance cost in initial stages. • Low maintenance cost once vegetation is established.

Waterbody	Advantages	Disadvantages	Ecology & amenity potential	Pollutant removal	Maintenance burden
	aesthetic and amenity benefits • May add value to local property	season • Little reduction in runoff volume • Not suitable for steep sites • Colonisation of invasive species would increase maintenance • Performance vulnerable to high sediment flows • May require fencing			
Reservoir – as a pond, may require impermeable lining.	• Can cater for all storms • Good removal capability of urban pollutants • Can be used where groundwater is vulnerable or ingress may occur, if lined • Good community acceptability • High potential ecological, aesthetic and amenity benefits • May add value to local properties	• Anaerobic conditions may occur without regular inflow • Land take may limit use in high density sites • May not be suitable for steep sites • Colonisation by invasive species could increase maintenance • May require fencing	• High ecological potential • High amenity potential	• High suspended solids removal • Moderate nutrient removal • High heavy metal removal	• Moderate maintenance cost
Pervious surfaces	• Effective in removal of urban runoff pollutants • Significant reduction in volume and rate of surface runoff • Suitable for installation in high density development • Allows dual use of land space • Eliminates surface ponding if constructed and	• Not suitable for use where large sediment loads may be washed/carried onto the surface • Man not be suitable on steep sites • Risk of long term clogging and weed growth if poorly maintained	• Low amenity potential • Low ecological potential	• High suspended solids removal • High nutrient removal • High heavy metal removal	• Low maintenance cost

Waterbody	Advantages	Disadvantages	Ecology & amenity potential	Pollutant removal	Maintenance burden
	maintained appropriately • Good community acceptability				
Green roofs	• Significant reduction in volume and rate of surface runoff • Good community acceptability • High ecological and aesthetic benefits • Acts as insulation lowering demand for energy in winter and moderates high temperatures in summer • Allows dual use of land space	• Not suitable for all roofs • Colonisation by invasive species could increase maintenance • Sediment discharged from roof limits potential for rainwater harvesting • Likely to require fencing, subject to desired amenity use	• High ecological potential • Moderate amenity potential, subject to roof design	• High capacity to treat fine suspended sediments and dissolved pollutants	• High maintenance cost

Source: Mott MacDonald

The information from the SUDS Manual 2007 in Table 7.1 above shows that the proposed SUDS have a generally high amenity and moderate to high ecological benefit.

7.5.2 Adoption of SUDS

The implementation of the Flood and Water Management Act (2010) in England and Wales was a significant driver for SUDS development. The County Council was designated the 'Lead Local Flood Authority' in Cambridgeshire. As part of this designation, the County Council will be a SUDS Approving Body (SAB). Therefore, the County Council will become responsible for determining SUDS applications for new developments and adopting and maintaining the appropriate SUDS. The adoption of SUDS by the County Council will apply for shared SUDS only, serving two or more properties, but adoption is not expected for private sites such as flats, business sites or industrial units.

However, at the time of writing, Schedule 3 of the Flood and Water Management Act is currently in draft format. In addition, a date for the commencement of Schedule 3 has not been set.

It is expected that the majority of the SUDS on the site will be adopted and maintained by the SAB. In addition, SUDS related to the drainage responsibilities of the IDB are likely to be adopted and maintained by the IDB.

If the SAB is not in place by the commencement of the planning application and/or construction of Denny St Francis, an alternative strategy should be implemented to ensure that appropriate management is provided in the interim period. This could include the setting up of a management body by the developers, in conjunction with relevant stakeholders.

Consideration of the outcome of the Department for Environment, Food and Rural Affairs' (DEFRA) 2014 consultation on delivering SUDS will be required[26]. The consultation document set out proposals to deliver sustainable drainage systems through changes to the current planning regime. The consultation period ended on the 24th October 2014 and, at the time of writing, the responses are being reviewed. Any changes to

[26] https://consult.defra.gov.uk/water/delivering-sustainable-drainage-systems

planning policy as a result of this consultation would come into force in Spring 2015.

7.6 Additional considerations

7.6.1 Betterment for local drainage system

The existing surface water drainage system on the Waterbeach Barracks site is extensive and drains large hard-standing areas on the site. This surface water discharges to the IDB drain via a balancing pond and controlled discharge. However, the discharge rate appears to be higher than the agreed greenfield runoff rate for the Denny St Francis site. As such, the proposals for drainage at Denny St Francis will provide significant betterment over the existing surface water discharge from the Waterbeach Barracks and reduce flood risk in the IDB drainage network.

7.6.2 Amenity opportunities

Water is a key component of the architectural vision for Denny St Francis (LDA Design, September 2013). Reviewing the hydrological and hydraulic practicalities of the inclusion of waterbodies for amenity within the Drainage Strategy would comprise part of the detailed drainage and surface water management design.

7.6.3 Ecological opportunities

The SUDS will provide the opportunity for greater biodiversity of flora and fauna on site and provide amenity value for residents with no (or little) additional land take or maintenance costs.

The inclusion of SUDS systems throughout Denny St Francis can help to bring green infrastructure into the core of the site, improving integration between habitats and development.

The ecological opportunities at Denny St Francis are further discussed in Section 9 Ecology and Biodiversity.

7.6.4 Denny Abbey

Denny Abbey is located adjacent to the north of the site. The design of Denny St Francis is being developed on the basis of minimum intrusion into the area around the Abbey, in order to protect and prevent disturbance of buried archaeology arising from surface water influences (as well as other factors).

7.6.5 Local summer irrigation demands

During the summer months, the IDB drainage system is operated so as to support the irrigation demands of local agriculture (as described in Section 8.2.2). Whilst not a legal requirement of the Waterbeach IDB, it has historically been an important aspect of their surface water management strategy[27].

The proposed drainage strategy for Denny St Francis would protect the IDB from an increase in surface water discharge rates above what can be effectively managed by their existing infrastructure (see Section 7.3). It could also, however, reduce the volumes of water in IDB drains through the capture or attenuation of rainfall and runoff over the development site. During the irrigation season, this could limit the water available for the IDB to redirect for the irrigation needs of local agriculture.

There is the opportunity for the Denny St Francis drainage strategy to support the local community through the inclusion of a reservoir in the system design. This could store water for later abstraction during summer months.

It is noted that further discussions with the IDB will facilitate a better understanding of the volume of water required for summer irrigation and help to understand how their needs (of both water quantity and quality) could be met as part of the Denny St Francis surface water drainage strategy.

It is expected that the operation and maintenance associated with a reservoir would be carried out by Waterbeach IDB.

7.7 Surface water management sustainability assessment

The CIRIA SUDS Manual notes that appropriately designed, constructed and maintained SUDS management trains are more sustainable than conventional drainage methods due to the mitigation of adverse effects of stormwater runoff on the environment. The Manual lists how SUDS achieve this level of sustainability, as follows:

[27] *Pers. comm,* at meeting held between Mott MacDonald, Waterbeach IDB and Anglian Water Services on 3rd April 2014.

- Reducing runoff rates, thus reducing the risk of downstream flooding;
- Reducing the additional runoff volumes and runoff frequencies that tend to be increased as a result of urbanisation, and which can exacerbate flood risk and damage receiving water quality;
- Encouraging natural groundwater recharge (where appropriate) to minimise the impacts on aquifers and river baseflows in the receiving catchment;
- Reducing pollutant concentrations in stormwater, thus protecting the quality of the receiving water body;
- Acting as a buffer for accidental spills by preventing a direct discharge of high concentrations of contaminants to the receiving water body;
- Contributing to the enhanced amenity and aesthetic value of developed areas; and
- Providing habitats for wildlife in urban areas and opportunities for biodiversity enhancement (Construction Industry Research and Information Association, 2007).

The measures proposed for surface water management at Denny St Francis have been assessed in terms of their sustainability credentials in Table 7.2.

Table 7.2: Surface water management sustainability assessment

	Basing surface water management on SUDS	Inclusion of biodiversity considerations in design	Inclusion of a reservoir to support local IDB network
Social			
	Above ground drainage systems can provide secondary aesthetic benefits. Adopting SUDS strategies would follow the mandate of an '*exemplar of sustainable development*'.	Incorporating ecological habitats and biodiversity considerations would provide additional community benefits of enhancing the environmental landscape at Denny St Francis.	Providing storage for summer irrigation demands would support the local community and enable the IDB to continue their current practices. A reservoir would provide amenity value if suitably designed.
Economic			
	Consideration of legal adoption requirements for SUDS. There would be no (or very limited) pumping costs associated with the proposed SUDS system for Denny St Francis.	The costs of ecological mitigation could be incorporate into drainage system costs. Construction and maintenance costs may be slightly higher due to potentially larger capacity systems being required to offset habitat areas. Greener streets and the presence of water environments have been shown to increase the resale value of houses.	A reservoir would have moderate maintenance costs associated with it. Operational costs would need to be considered, including any inflow or outflow pumping required.
Environmental			
Ecology	Makes best use of geological constraints. Imitating natural drainage processes where possible can limit environmental impacts and 'connects' the development to the surrounding ecosystems. Discharge water quality from SUDS systems would be higher than with conventional drainage systems.	Additional and more diverse habitats would be present at Denny St Francis, providing an improvement on the existing conditions. This strategy could facilitate Green Infrastructure linkages (see Section 9 Ecology and Biodiversity).	A reservoir could have high ecological potential.

	Basing surface water management on SUDS	Inclusion of biodiversity considerations in design	Inclusion of a reservoir to support local IDB network
Natural resources	SUDS systems require low volumes of man-made construction materials. The site-wide irrigation demand of aesthetic green spaces would be reduced, or even negated, if opportunities for combining drainage and amenity were maximised; as can be achieved with SUDS systems.	Limited natural resources would be required to incorporate biodiversity considerations in drainage systems.	The potential to source construction materials locally should be maximised where possible.
Climate change mitigation	Other than initial construction and limited maintenance interventions, there are no on-going carbon costs associated with SUDS systems. Green roofs have been shown to increase insulation and reduce the need for air-conditioning.	Habitats would be provided for species potentially under pressure from climate change i.e. wetlands. Additional benefits of greater carbon capture would be had.	
Climate change resilience	SUDS systems would be more resilient to the high intensity rainfall events associated with climate change than hard engineering options.	Habitat creation would provide future benefits of ecological protection and resilience.	Supporting local irrigation systems would help to support the climate change resilience of the local community.

Source: Mott MacDonald

7.8 Proposed strategy for surface water management

Based on analysis of available data, understanding of the opportunities and constraints, and the above sustainability assessment, it is recommended that the strategy for surface water management at Denny St Francis consists of:

Surface water management
SWM 1: The surface water management strategy should be based on SUDS
• SUDS management train options should be developed and implemented at Denny St Francis, with appropriate source control measures carefully considered. • This follows the sustainable surface water management strategy put forward by the Cambridge Water Cycle Study. • Limiting surface water runoff to 1.1 l/s/ha would both negate any adverse pressures on the existing Waterbeach IDB drainage system and provide benefits through reducing the current runoff occurring from the Waterbeach Barracks site. • SUDS will mitigate the increase in impermeable surface as part of the development of the Denny St Francis site. • The use of SUDS surface features that can be incorporated into the green infrastructure of the development should be prioritised.
Section 7.5
SWM 2: Biodiversity and amenity considerations should be included in the drainage design
• SUDS will provide the opportunity for greater biodiversity of flora and fauna on site and provide amenity value for residents and social and recreation value. • Best practice guidance should be followed to ensure that ecologically sensitive and appropriate systems are developed. • The implications of this on both construction and maintenance should be considered at the earliest stages of the detailed design.
Section 7.5
SWM 3: The potential to incorporate a retention pond in the drainage system should be promoted
• The opportunity to include a storage reservoir in the Denny St Francis drainage system should be investigated and progressed as a part of the detailed drainage design. • Capturing and storing runoff for later use by the Waterbeach Internal Drainage Board, a storage reservoir could provide summer irrigation water for local agriculture, thereby supporting the local community. • A reservoir would also benefit the drainage system by providing additional storage at times of high runoff.
Section 7.6.5

328331/BNI/EAD/12/D 02 December 2014
PiMS Ref: 1573734126

7.9 Further work

Additional data will be required as the concept plan and drainage design are developed, including groundwater level monitoring, to better understand the water table and its seasonal variance. Water level data loggers could potentially be installed in the existing boreholes on site, or a programme of monthly manual water level dips could be undertaken

A better understanding of the thickness of the Gault Clay in the north western area of the site would assist with appropriate drainage design, particularly if there is hydraulic connectivity between the River Terrace Deposits and the Lower Greensand in this part of the site.

Further infiltration tests should be undertaken to determine the infiltration potential in the areas of the site not underlain by Gault Clay.

The concept plan will be developed in tandem with the Drainage Strategy, to help maximise the opportunity for utilising SUDS in the development, environmental enhancement, and for providing amenity and social and recreation value. Surface water management will be one of the key structuring elements of the masterplan.

8 Used Water Management

8.1 Introduction

Used water management includes the collection, treatment and discharge of used water from a site.

8.2 Existing assets

There are two water recycling centres (WRCs) of note in the area. Waterbeach village is currently served by its own WRC, located to the north east of the existing settlement. Approximately 5.5 km to the south west, on the northern fringe of Cambridge, is the larger Cambridge WRC.

8.2.1 Cambridge Water Recycling Centre

Cambridge WRC has a volumetric discharge consent for 37,660 m^3/d, with a population equivalent (PE) consent of 127,887[28]. Used water is collected and treated at its site off Cowley Road. Treated effluent is then discharged to the River Cam near the A14 road bridge, approximately 6 km upstream of the Denny St Francis development site.

Whilst currently there is residual capacity at Cambridge WRC, Anglian Water has confirmed that this has already been allocated to other development in the Cambridge area (RLW Estates Ltd., February 2014). As such, Cambridge WRC would not be able to accommodate the used water from the proposed development without a major upgrade.

Whilst this could in theory be possible as there is no limitation on space at the Cowley Road site, there would be significant implications for the existing discharge consent which controls the water quality standards to which the works must treat. Any change to the consent in terms of flow permit would trigger a tightening of the water quality permits. As such, both a volumetric as well as a quality variation would be required.

[28] Discharge consent number ASCNF10357.

8.2.2 Waterbeach Water Recycling Centre

The existing village hosts a population of 4,710 people[29]. Used water from the village drains to the small Waterbeach treatment works off Bannold Drove. Treated effluent is discharged into the Waterbeach Level Internal Drainage Board's Bannold Drove Drain. During the winter months, this flows south to the IDB's Bottisham Lock pumping station, but in the summer months is dammed by the IDB and flows north towards their Cam pumping station[30]. Both of these pumping stations discharge to the River Cam.

The locations of these assets are shown on Figure 7.1. Waterbeach WRC and Bannold Drove Drain are located within the proposed development site.

The works has a volumetric discharge consent for 1,350 m^3/d, with a population equivalent (PE) consent of 6,276[31]. The existing headroom within the Waterbeach WRC consent is very limited in relation to the PE requirement for Denny St Francis. In addition, the volumetric capacity of the infrastructure at the works would be severely limiting and require a major upgrade to the entire treatment steam.

8.3 Options for used water collection and treatment

The development scenarios in Appendix B estimate the Denny St Francis population to comprise up to 19,700 domestic residents and 15,440 non-domestic residents.

For the new settlement, used water would be completely separated from surface runoff. The conservative used water development scenarios for Denny St Francis have calculated that the development could generate up to 6.4 Ml/d of used water flow by the end of the construction period (Section 3.3).

The locations where the Denny St Francis effluent could be treated are discussed and reviewed below. These include treatment at Waterbeach

---

[29] Source: https://www.scambs.gov.uk/sites/www.scambs.gov.uk/files/documents/Waterbeach_0.pdf

[30] *Pers. comm,* at meeting held between Mott MacDonald, Waterbeach IDB and Anglian Water on 3rd April 2014. The low gradients in the Bannold Drove Drain allow the IDB to reverse its flow when required.

[31] Discharge consent number ASCNF10357.

WRC, treatment at Cambridge WRC and a new purpose built WRC close to Denny St Francis. In addition, the potential implications for the existing Waterbeach village residents have been contemplated in terms of their used water service, with any potential benefits considered. These options are shown in Table 8.1 below.

Table 8.1: Options for Denny St Francis (DSF) and Waterbeach village used water collection and treatment

	Treatment location			Capital works required		
Ref	**For Waterbeach village**	**For Denny St Francis**	**Pipeline connections**	**Waterbeach WRC**	**Cambridge WRC**	**New Denny St Francis WRC**
1	Waterbeach WRC	Waterbeach WRC	DSF to Waterbeach WRC	Major upgrade	-	-
2	Waterbeach WRC	Cambridge WRC	DSF to Cambridge WRC	-	Major upgrade	-
3	Waterbeach WRC	New Denny St Francis WRC	DSF to New DSF WRC	-	-	Construction
4	New Denny St Francis WRC	New Denny St Francis WRC	DSF to New DSF WRC Waterbeach village to New DSF WRC	Decommission	-	Construction

Source: Insert source text here

Each option has been reviewed in terms of its practicalities, deliverability, sustainability and implications on cost in Table 8.2.

Table 8.2: Review of options for Denny St Francis and Waterbeach village used water collection and treatment

Ref	Option	Review			
		Practicalities	Deliverability	Sustainability	Cost
1	Treatment of Denny St Francis effluent at the existing Waterbeach WRC, via a major upgrade to the works.	• Utilises existing buildings and an already developed site. • The upgrade would require considerable land take within the boundary of the Denny St Francis development, where the existing WRC is located.	• An upgrade to the IDB drains and pumping station that transfer Waterbeach WRC's effluent to the River Cam would be required. • An increase in the treated effluent discharge into the IDB watercourse may not be acceptable . • A change to the treatment stream may be required due to the trigger of a new discharge consent and associated conditions. • Permit limits would likely be beyond those currently considered achievable by conventional treatment processes, due to the limited dilution available in the watercourse.	• This option would have associated social impacts of a large WRC within a developed area – amenity, odour etc. • Expansion of Waterbeach WRC would also impact on Waterbeach village, due to its proximity to the village centre. • Increased effluent in the IDB drains may not be environmentally sustainable.	• The complete redevelopment of Waterbeach WRC, likely involving quality upgrades as well as volumetric capacity upgrades. • Particularly stringent permit limits would have a major impact on the monetary and carbon cost of this option. • Upgrade to IDB drains and Bottisham pumping station. • Use of a significant area of land within the development site.
2	Treatment of Denny St Francis effluent at the existing Cambridge WRC, via a major upgrade to the works.	• No development of a new site at Denny St Francis would be required. • Cambridge WRC does not have the headroom to accommodate Denny St Francis effluent on top of that forecast from other confirmed developments. Therefore a upgrade to the works would be required, further to those already planned by AWS.	• Makes use of an existing asset where there is space for expansion. • A new discharge consent would be required that could likely trigger more stringent controls at Cambridge WRC and consequentially necessitate quality as well as quantity upgrades at this major works.	• There would be increased pressure on a strategic WRC. • The transfer of water from Denny St Francis would require construction of a 5 km pumping main with associated construction impacts, energy and carbon costs.	• A major upgrade to Cambridge WRC would be required, likely involving quality upgrades as well as volumetric capacity upgrades. • A pipeline and associated pumping station will be required to transport the effluent from Denny St Francis to Cambridge. A number of difficult route crossings would have to be made, including the A14. • Capex and Opex costs of pipeline and pumping to Cambridge WRC. • AWS advised that the potential for septicity at the Cambridge

Ref	Option	Review: Practicalities	Deliverability	Sustainability	Cost
					WRC inlet would need to be considered and its control would have associated chemicals opex costs.
3	Treatment of Denny St Francis effluent at a new WRC at Waterbeach.	• A nearby purpose-built WRC would provide optimum treatment capability.	• No long-distance pipeline or pumping station would be required. • Land is available close to the River Cam and away from existing or proposed dwellings.	• The existing Waterbeach WRC would remain operational with the associated negative impacts on the surrounding area. • Operating two WRCs in close proximity to each other would not take advantage of the opportunity for economies of scale.	• Design and construction of a new WRC, including adequate flood protection. • Capex and Opex costs of operating two WRCs would be significantly higher than a single works.
4	Treatment of Denny St Francis and Waterbeach village effluent at a new WRC at Waterbeach.	• A nearby purpose-built WRC would provide optimum treatment capability. • Decommissioning the existing Waterbeach WRC would stem the negative impacts of the WRC on the surrounding area.	• No long-distance pipeline or pumping station would be required. • Land is available close to the River Cam and away from existing or proposed dwellings.	• Would require new land to be developed in the R Cam floodplain. • Associated construction impacts with regards to energy and carbon emissions, such as increased transportation during construction. • Combining both effluent streams would be more operationally cost-effective than running two adjacent works. • Opportunity to deliver a new WRC making best use of efficient a sustainable treatment processes.	• Design and construction of a new WRC, including adequate flood protection. • Decommissioning and demolishing of existing Waterbeach WRC. • Capex and Opex costs of operating one WRC would be significantly lower than two works.

Source: Mott MacDonald

8.3.1 Preferred option

A review of the issues shown in Table 8.2 shows the most suitable and sustainable option for treatment of Denny St Francis effluent is option 4:

- Construction of a new WRC at Denny St Francis and closure of the existing Waterbeach WRC.

Given the challenges for the Cambridge WRC to accommodate flows from Denny St Francis, the most practical option would be the construction of a new WRC at Denny St Francis. This would also negate the requirement of considerable carbon and pumping costs of transfer to Cambridge WRC, reduce additional pressure on a key strategic site, and offer a potentially higher quality treatment through the incorporation of new innovate solutions in the WRC design. It would also provide betterment to the existing residents of Waterbeach village through the provision of an improved treatment works and higher quality used water service to customers.

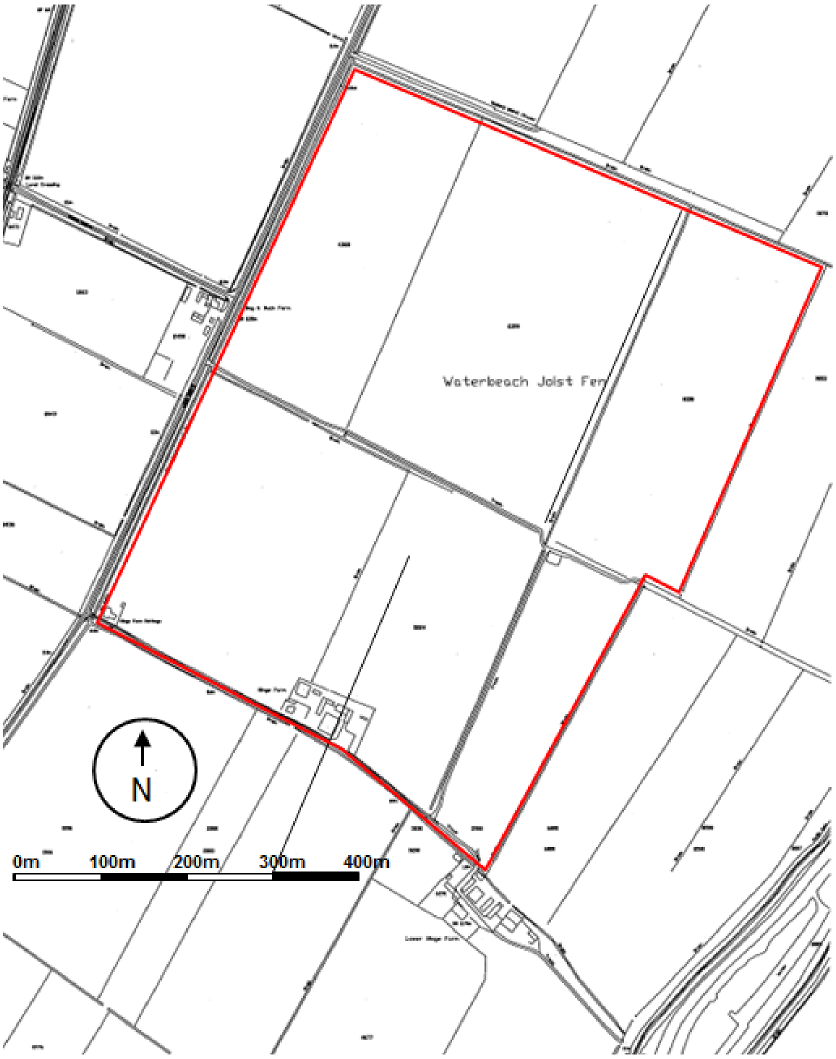
This option has been progressed through the following Sections of this report.

8.3.2 Location

The social implications of locating a WRC include consideration of potential adverse impacts of noise, smell and amenity. As such, an off-site location would be preferable, away from residential areas. To reduce carbon and pumping costs of transporting treated effluent to a River Cam outfall location, a works should be located to the east of the proposed development. In addition, its location should account for ecologically designated sites, surface water drainage and flood risk.

A 41 ha area of land is available to the east of the Cambridge to Ely railway line, between Lower Hinge Farm and Mason's Drove track. A new foul sewer would cross under the railway embankment, and treated effluent would be routed to a new river outfall on the Cam.

Figure 8.1: Potential location of a new Water Recycling Centre at Denny St Francis



Source: Mott MacDonald, 2002

8.3.2.1 Flood risk

This site is located with the EA Flood Zone 3, with and without flood defences.

Whilst the site as a whole could be protected by building bunds or flood walls, it is recommended that any future WRC development in this area is designed to be flood resilient; for example, by raising critical assets to be above the predicted flood level, or housing assets in water tight kiosks etc.

Flood resilient construction is the most sustainable solution to mitigate against flood risk. In addition, by designing the site to be flood resilient it negates operational and maintenance issues during a flood event, such as shutting of the flood gates.

8.3.3 Flows

The new works at Denny St Francis would be required to treat the following:

1. Sewage effluent from Denny St Francis
2. Sewage effluent from Waterbeach Village
3. Surface water runoff from Waterbeach Village

To estimate the potential discharge for the new works into the River Cam, flows for the new development and the existing catchment were calculated separately and summed.

As discussed in Section B.4, the average flow from the Denny St Francis development was estimated to be 5.2 Ml/d to 6.4 Ml/d, with a Flow to Full Treatment (FFT) up to 13.2 Ml/d. Details of these calculations can be found in Appendix B.

For the existing catchment, the Anglian Water flow records were used for the years 2010, 2011 and 2012. A full data set was not available for 2013. DWF was calculated from the highest Q90 value of the analysed years. The average daily flow was taken to be the highest average of the three individual years. FFT was taken to be the consent value for the works (Section 8.2.2).

The treated used water flows of a new Denny St Francis works could therefore be calculated as in Table 8.3.

Table 8.3: Denny St Francis WRC flow estimates

	Lower development scenario			Upper development scenario		
Component	DWF	Mean	FFT	DWF	Mean	FFT
Denny St Francis – Effluent	4.1 Ml/d	5.2 Ml/d	10.7 Ml/d	5.1 Ml/d	6.4 Ml/d	13.2 Ml/d
Waterbeach – Effluent Waterbeach – Surface water runoff	1.2 Ml/d	1.6 Ml/d	3.9 Ml/d	1.2 Ml/d	1.6 Ml/d	3.9 Ml/d
TOTAL	5.3 Ml/d	6.8 Ml/d	14.6 Ml/d	6.3 Ml/d	8.0 Ml/d	17.1 Ml/d

Source: Mott MacDonald

It should be noted that the surface water strategy proposed in Section 7 would reduce the surface water runoff contribution from the Waterbeach Barracks site into the Waterbeach village combined sewer system. As such, basing the estimated contribution from Waterbeach to a new WRC on historical flow data is a conservative approach.

8.4 Discharge consenting

A review of the water quality implications and constraints of a new used water discharge at Denny St Francis are discussed in the following Sections. For comparison, the existing discharge consents for Cambridge and Waterbeach WRCs are provided in Table 8.4.

Table 8.4: Discharge Consents for Waterbeach and Cambridge WRCs

Consent parameter	Waterbeach WRC	Cambridge WRC
Domestic Load (PE)	6,276	127,887
Flow Permit (m^3/d)	1,350	37,660
Suspended Solids (mg/l)	40	20
BOD (mg/l)	20	15
Ammonia (mg/l)	15	5
Phosphate (mg/l)	-	1

Source: Anglian Water

8.4.1 Overview

A new WRC at Denny St Francis would require a new discharge consent.

A review of water quality is required during the development process to ensure that development does not adversely affect water quality, and does not hinder the ability of a water body to meet the Water Framework Directive. Development can adversely affect water quality in two principle ways with respect to used water:

- Increases in final treated used water (or effluent) load from WRCs which causes a deterioration of water quality; and
- Increase in intermittent discharges from combined sewer overflows, pumping stations, and storm tanks at WRCs.

Surface water runoff in Denny St Francis will be managed in a separate system to used water and therefore increased intermittent discharges are not a risk of the development.

Based on the review undertaken in Section 8.3, Option 4 has been taken forward for further detailed assessment. The technical methods adopted to assess the impact of the discharge of used water from Denny St Francis into the River Cam are reported in Appendix G.

8.4.2 Current environmental context

The River Cam (GB105033042750) is classified as a heavily modified waterbody under the Water Framework Directive. Its ecological potential status was reported in the 2009 River Basin Management Plan (RBMP) as Moderate (Environment Agency, 2009).

The Environment Agency provided water quality and WFD status information based on monitoring data collected at Bottisham Lock (sample point reference 33M09). The information differs to that reported for the wider River Cam waterbody as the RBMP reports an aggregate status across the whole waterbody. Bottisham is immediately downstream of a major sewage treatment works discharge (Cambridge WRC) so river quality recorded at 33M09 is worse than elsewhere in the waterbody.

The WFD chemical designations and target statuses can be seen in Table 8.5:

Table 8.5: WFD chemical classifications for River Cam (GB105033042750)

	RBMP classification	Current status	Target WFD status
Biological Oxygen Demand (BOD)	High	High	High
Ammonia	Moderate	Moderate	Good
Phosphate	Bad	Poor	Good
Notes	Data collected 2006 to 2008, and reported in 2009	Data collected 2009 to 2011, reported in 2012	-

Source: Environment Agency, *pers. comm*. 18th January 2013.

The improvement in phosphate status is due to P-removal at Cambridge WRC, and other WRCs in the upstream catchment, which started in 2009. River concentration continues to drop year-on-year as more actions are delivered to reduce phosphate inputs.

The Environment Agency sample water quality in the River Cam at Bottisham Lock; approximately 5.5 km downstream of the Cambridge WRC discharge. Whilst it is not specifically known where the sample point at the lock is in relation to the existing Waterbeach WRC discharge (which enters the Cam via the IDB pumping station at Bottisham Lock), the Environment Agency have commented that the relative impact on overall water quality on the river as a result of this small discharge will be limited and, as such, the 33M09 sample point could be taken as indicative of upstream water quality conditions in the River Cam. A review of existing data for this sample point can be found in Section G.1.

8.4.3 Water quality impact assessment

The environmental impact of effluent from the Denny St Francis development has been assessed using the Environment Agency's River Quality Planning (RQP) tool. The RQP model is a Monte-Carlo simulation mass balance model developed by the Environment Agency.

The model was used to estimate the maximum concentrations of BOD, Ammonia and Phosphate of a new discharge at Denny St Francis to ensure No Deterioration under the Water Framework Directive, and thereby the likely discharge consent conditions that could be expected to apply.

Water quality modelling has been undertaken to confirm that there would be no breach of WFD requirements due to the new discharge alone. The rationale for this approach is that river quality throughout the upstream catchment will need to improve in order to achieve, at the very least, Good Ecological Potential by 2027. It should be assumed that those improvements will occur and that upstream river quality is at mid-Good status[32].

The modelling methodology has been reported in Appendix G, Section G.2.

8.4.4 Likely discharge consent conditions

The RQP modelling has estimated permitting limits for a new discharge at Waterbeach to be as in Table 8.6.

Table 8.6: Estimated water quality limits for a new discharge permit at Denny St Francis

	Lower development scenario			Upper development scenario		
	BOD	Ammonia	Phosphate	BOD	Ammonia	Phosphate
River downstream of discharge						
'Predicted' current status	High	Good	Good	High	Good	Good
Quality target (90%ile mg/l)	4	0.6	-	4	0.6	-
Quality target (mean mg/l)	-	-	0.12	-	-	0.12
Discharge quality needed						
Mean quality (mg/l)	-	-	0.85	-	-	0.74
95%ile quality (mg/l)	52.48	5.18	-	45.28	4.54	-

Source: Mott MacDonald

8.4.5 Discussion

Analysis of the RQP modelling highlights the following main points relating to potential required effluent water quality standards at Denny St Francis:

[32] *Pers. comm.* Environment Agency 10th April 2014. Even if this status is not achieved, the modelling conclusions would remain valid as it is assessing the most challenging situation.

- Meeting the criteria for Biological Oxygen Demand will not be a concern under either the Lower or Upper used water development scenario.
- Likewise, meeting an Ammonia consent of 5.18 or 4.54 mg/l would be achievable given modern technologies; and
- Maintaining a mean phosphate concentration of less than 0.85 or 0.74 mg/l would be the most challenging of the quality parameters.

The implications of the calculated potential water quality discharge standards on the design of a new water recycling centre are discussed in the following Section.

8.5 Treatment

As detailed above, the new works is likely to be subjected to tight ammoniacal nitrogen and total phosphorus consents. Almost inevitably, the need to use chemical dosing to remove phosphorus will lead to an iron consent as well. For the purposes of initial assessment the following consent conditions have been assumed:

- TSS 40 mg/l;
- BOD 20 mg/l;
- Amm-N 3 mg/l;
- Total Phosphorus 0.5 mg/l; and
- Total Iron 3.0 mg/l.

8.5.1 Treatment processes

Anglian Water have a process selection matrix for WRC treatment options. The new plant would fall into the population band 10,000 to 50,000 in the matrix. To meet the consent values above, the matrix specifies the following process stream.

- Screening;
- Grit removal;
- Storm tank;
- Primary settlement (optional);
- Nitrifying activated sludge plant (ASP);
- Ferrous chloride dosing system (to ASP);
- Backup iron salt dosing system; and
- Tertiary solids removal.

With the use of ASP it should not be necessary to provide any tertiary treatment down to 1 mg/l of total phosphorus. However, if a consent as low as 0.5 mg/l was applied, tertiary solids removal would probably be required.

The activated sludge process has numerous configurations but all are quite energy intensive. Low energy treatment processes such as trickling filters and reed beds would not be able to meet the tight consents year round.

8.5.2 By-product uses

The treatment process will produce a number of by-products including screenings, grit and sludge.

The size of the works would be too small to make any on-site recovery options of economic benefit. There may, however, be potential to send some of the by-products to existing recovery plants.

Screenings quantities will be small and the most likely disposal route is to landfill.

Grit quantities will also be relatively small and are also likely to end up in landfill unless there is an existing grit recovery plant nearby.

There are two potential sources of sludge - primary treatment and Suplus Activated Sludge (SAS). Energy can be recovered from sludge through processes such as anaerobic digestion. Primary sludge is more digestible than SAS. It is preferable that sludge for digestion contains at least 50% primary sludge. If it is decided not to include primary settlement all the sludge produced would be SAS.

It is likely that the new treatment works at Denny St Francis would be too small to economically support the construction and operation of on-site anaerobic digestion. However, the opportunities for this could be further explored in conjunction with Anglian Water. The nearby Cambridge WRC has a sludge digestion facility which could accept the sludge from Denny St Francis, particularly if it was all SAS. If Anglian Water's preference was for off-site digestion, sludge pre-treatment would still be required on the Denny St Francis site, comprising sludge thickening and sludge storage.

8.6 Used water sustainability assessment

The preferred options for used water management at Denny St Francis have been assessed in terms of their sustainability credentials in Table 8.7.

Table 8.7: Sustainability assessment of used water management preferred options

	Treatment at new Denny St Francis WRC & closure of Waterbeach WRC	Location of new Denny St Francis WRC to east of the Denny St Francis site
Social		
	A nearby purpose-built WRC would provide optimum treatment capability for customers.	This would ensure the WRC was outside of developed areas, thereby reducing issues of odour, amenity etc.
	Decommissioning the existing Waterbeach WRC would stem the existing negative impacts of the WRC on Waterbeach village residents.	Land is available close to the River Cam.
		Appropriate flood protection would be required to ensure resilience of the site and, therefore, a high level of customer service.
Economic		
	Combining both effluent streams would be more operationally cost-effective than running two adjacent works.	Locating a works in proximity to the River Cam increases potential for gravity flow to be used and subsequently reduce the length of pumping mains and lower financial costs for pumping.
	The potential value of the land currently used for the existing Waterbeach WRC would be made available.	
	No long-distance pipeline or pumping station would be required if effluent were to be treated close to Denny St Francis.	
	There would be the financial implications of construction of a new WRC, including adequate flood protection.	
	The costs of decommissioning the existing Waterbeach WRC should not be overlooked.	
Environmental		
Ecology	A new works would be subject to stringent water quality discharge constraints, thereby ensuring that the River Cam environment is protected.	The proposed landtake area does not include any environmentally designated sites.
	A new works would treat Waterbeach village used water to a higher water quality standard than at present, benefitting the River Cam.	

	Treatment at new Denny St Francis WRC & closure of Waterbeach WRC	Location of new Denny St Francis WRC to east of the Denny St Francis site
	There would be a negligible impact on flow in the River Cam from the additional population at Denny St Francis and no increase in flood risk to the local area.	
Natural resources	There is the opportunity to deliver a new WRC making best use of current efficient and sustainable treatment processes. Additional construction materials will be required. The potential to source these locally should be maximised where possible.	Locating a works in proximity to the River Cam increases potential for gravity flow to be used and subsequently reduce the length of pumping mains and lower carbon costs for pumping.
Climate change mitigation	Combining both effluent streams would be less carbon intensive than running two adjacent works. No carbon costs would be required for long-distance pumping of effluent to Cambridge WRC.	
Climate change resilience	A new WRC would need to be resilient to climate change; in particular flood risk.	The design of flood protection of a new WRC would need to ensure that climate change has been fully considered and assessed.

Source: Mott MacDonald

8.7 Proposed strategy for used water management

Based on analysis of available data, understanding of the opportunities and constraints, and the above sustainability assessment, it is recommended that the strategy for used water management at Denny St Francis consists of:

Used water management
UWM 1: A new Water Recycling Centre should be built at Denny St Francis
• The most sustainable option for used water would be the construction of a new treatment works. • This would negate the requirement of considerable carbon and pumping costs of a transfer to Cambridge WRC, reduce additional pressure on a key strategic site, and offer a potentially higher quality treatment through a tighter discharge consent and the incorporation of new innovate solutions in the WRC design. Section 8.3.1
UWM 2: Waterbeach Water Recycling Centre should be decommissioned
• Waterbeach effluent and surface water runoff should be transferred to the new Denny St Francis works. • This provides betterment for Waterbeach village residents through the provision of an improved treatment works and higher quality used water service to customers. • It is also more sustainable than operating two treatment works in tandem. Section 8.3.1
UWM 3: The location of a new WRC should continue to be explored
• The location of a new WRC should continue to be explored, with particular consideration of flood risk protection requirements. The latest legislation and guidance on the siting of essential infrastructure should be referenced. Section 8.3.2
UWM 4: Green treatment technologies should be adopted where possible
• Whilst there may be limitations to the potential to use green technologies due to the size and water quality constraints of the new works, these should still be investigated and their full potential reviewed. Section 8.5

8.8 Further work

A WRC site specific flood risk assessment should be at the core of any further development plans for a new WRC. This needs to be undertaken at the earliest opportunity in order to ensure that the planning of essential infrastructure is managed in a sustainable, holistic manner from the outset.

9 Ecology and Biodiversity

9.1 Introduction

Ecological impacts of development can arise from both on-site direct impacts, such as construction or changes to the water regime, and off-site impacts via, for example, remote raw water abstraction for supply and downstream impacts of any used water discharges.

9.2 Local ecological features

As a part of the Scoping Study, three designated sites were identified as being within 5 km of the proposed development at Denny St Francis.

Sites would be potentially relevant to this assessment where:

- They are either:
  - directly associated with the proposed development site, and therefore potentially vulnerable to local changes in runoff, drainage etc; or
  - associated with an area from which new water abstraction would be required, and therefore potentially vulnerable to changes in water quantity; or
  - associated with a watercourse downstream of the potential development site or the water recycling centre serving the new development, and therefore potentially vulnerable to changes in water quantity and quality;
- And they are sensitive to changes in water quantity or water quality.

Due to the large number of potable water sources feeding Cambridge Water's Cherry Hinton reservoir, it is not feasible to assess all ecological features potentially associated with the raw water abstraction for Denny St Francis. The environmental impact of CWC abstractions is regulated by the Environment Agency to ensure no adverse ecological impacts under the Water Framework Directive. As such, it can be considered that impacts of raw water abstraction for supplying Denny St Francis are already adequately investigated and controlled.

9.2.1 Internationally designated sites

The only internationally designated site identified as potentially relevant to this assessment on the basis of this criteria is:

- Wicken Fen Special Area of Conservation (SAC) and Ramsar site.

9.2.1.1 Wicken Fen SAC / Ramsar Site

Wicken Fen is located 4 km at its nearest point north east of the Denny St Francis site and is downstream of the development.

This site is a marginal remnant of the original peat fenland of the East Anglian basin. It has been preserved as a flood catchment area and its water level is controlled by sluice gates. The vegetation has a strongly mosaic character due to extensive peat-cutting and different systems of crop exploitation. Areas of the site subjected to frequent cutting have a greater species diversity including many sedges, rushes, spike rushes and marsh orchids with corresponding insect associations (Joint Nature Conservation Committee, 1995).

The site is also important for its wildfowl including, mallard (*Anas platyrhynchos*), teal (*Anas crecca*), wigeon (*Anas penelope*), shoveler (*Anas clypeata*), pochard (*Aythya farina*) and tufted duck (*Aythya fuligula*). Wicken Fen is nationally renowned for its species diversity; as well as its international designations. It is also designated nationally as a Site of Special Scientific Interest (SSSI) and a National Nature Reserve (NNR) (Natural England, 2013a).

Located off the eastern bank of the River Cam, the site is owned and maintained by the National Trust. As discussed in Section 8, the River Cam would receive treated used water discharges from Denny St Francis.

Screening assessment

The potential consequences for downstream flows and water quality have been assessed in Section 80 and it has been shown that Denny St Francis would not adversely impact on the condition of the river. In addition, the 2011 Cambridgeshire Water Cycle Study (Cambridgeshire Horizons, July 2011), reports that Wicken Fen is topographically higher than the River Cam and drains via Wicken Lode then Burwell Lode towards the river.

As it is not fed by the Cam, there are no associated risks which could arise from additional used water effluent discharge from Denny St Francis, irrespective of any changes in effluent flow or quality from that site, so such scenarios have not been considered further in this assessment. Wicken Fen is further discussedin Section 9.4.

Wicken Fen can therefore be screened out of any further assessment.

9.2.2 Nationally designated sites

Two nationally designated sites identified as potentially relevant to this assessment are:

- The Cam Washes SSSI; and
- Stow cum Quy Fen SSSI.

9.2.2.1 Cam Washes SSSI

Covering an area of 170 hectares, the Cam Washes SSSI is situated approximately 1.5 km to the north east of the site along the route of the River Cam. It comprises low lying pastures subject to seasonal flooding. This seasonal flooding, along with the range of grassland and wetland habitats present makes it an important site for wintering and breeding wildfowl and waders.

Consultation with Natural England on the Denny St Francis Water Cycle Study Scoping Study (RLW Estates Ltd., February 2014) included the following comments:

"The Cam Washes SSSI is notified for its breeding bird assemblage of lowland wet grassland and also supports an important wintering bird interest. Areas of the site also support species rich grassland.

These features may be affected by changes in water quality within the River Cam, for example, an increase in phosphate levels may have the potential to alter the vegetation towards a community that is less suitable for the breeding birds or to support species rich grassland.

Part of the River Cam is within the boundary of the SSSI, and the aquatic flora, particularly at the river's edge, includes vegetation which supports some of the notified breeding birds, hence any changes in water quality within the river may have an adverse effect on this (composition, structure, invertebrate populations etc.) and hence on the breeding bird species which it supports". Many of the wetland species present at the Cam Washes SSSI are now becoming increasingly scarce as breeding birds in lowland England due to loss of suitable habitat (Natural England, 2014a).

The current status of the Cam Washes SSSI is 74% favourable, 26% unfavourable. Compiled in April 2014, the condition assessment for its unfavourable unit cites hydrological and grazing management issues as reasons for its status (Natural England, 2014a).

Screening assessment

Given that additional used water effluent discharge from the Denny St. Francis site will be discharged into the River Cam, there is potential for this site to be negatively affected by the proposed development should the effluent flow or quality alter conditions to the current water quality of the River Cam.

The water quality review undertaken in Section 8 has shown that used water from Denny St Francis and Waterbeach village can be managed and treated to the standards required to maintain Water Framework Directive targets on water quality. In addition, there will be no discernable change to the hydrological flow regime as a result of the proposed development.

Provided the required level of treatment is obtained, the Cam Washes SSSI can be screened out of any further assessment.

9.2.2.2 Stow cum Quy Fen SSSI

Stow cum Quy Fen SSSI is located approximately 3 km to the south east of the proposed development, on the eastern side of the River Cam and possesses areas of floristically rich calcareous loam pasture. In addition, a number of pools formed on Chalk Marl are present and these support a range of aquatic plants including some uncommon species. Both the grassland and open water habitats are rare in the UK.

The grassland is characterised by the presence of herbs such as purging flax (*Linum catharticum)*, cowslip (*Primula veris)*, salad burnet (*Sanguisorba minor)* and the quaking grass (*Briza media)*.

The pools have a good range of emergent and aquatic vegetation including reed (*Phragmites australis)*, unbranched bur-reed (*Sparganium emersum)*, mare's-tail (*Hippuris vulgaris)* and bladderwort (*Utricularia vulgaris)*. The open water habitats are inhabited by dragonflies and damselflies including the emperor dragonfly (*Ajax imperator)*.

The site is additionally of importance due to its location within an otherwise intensively cultivated area where semi-natural habitats are rare (English Nature, 2014b).

The condition of the Stow cum Quy Fen SSSI compiled in April 2014 is 100% unfavourable/recovering but no reasons are given for its unfavourable status (Natural England, 2014b).

Screening assessment

Given the distance of Stow cum Quy Fen SSSI from the Denny St Francis site and its positioning upstream on the River Cam, there are no associated risks which could arise from additional used water effluent discharge from Denny St Francis, irrespective of any changes in effluent flow or quality from that site. Consequently, such scenarios have not been considered further in this assessment.

Stow-cum-Quy SSSI can therefore be screened out of any further assessment.

9.2.3 Locally designated sites

There has been a local petition received by the Wildlife Trust of Cambridgeshire, Bedfordshire and Northamptonshire on behalf of the Wildlife Sites Partnership, to designate the land around the disused airstrip and Denny Abbey as a County Wildlife Site (CWS). CWS is a local non-statutory designation for sites of county significance for wildlife or geology. Positive management of CWSs is encouraged and development affecting them is controlled by Local Plan policies. Communication with both the Cambridgeshire Council Biodiversity Officer and Wildlife Trust County Wildlife Site Office has revealed that there are currently no immediate plans by the Trust to designate this area as a CWS. Whether the site is designated or not does not alter that the disused airfield area as a whole is likely to be of County value and therefore warrants careful consideration in terms of design and programme.

9.3 On-site ecological features

Ecological surveys have been undertaken at the Denny St Francis site by Landscape Design Associates (now LDA Design) in 2002, 2008 and 2009 (summarised in LDA Design, 2012). A number of significant water-dependent habitats and features with potential to support protected species were identified within the site, descriptions of which are provided below. Biological records from the Cambridge and Peterborough Records Centre were reviewed at the survey stage and have been incorporated into the findings of the ecological assessment.

9.3.1 Habitats

The key habitats on site are associated with the species rich unimproved neutral grassland which lies immediately adjacent to the disused airfield runway and the lake within the disused airfield which supports islands dominated by willow (*Salix sp.)* and common reed (*Phragmites australis)*. The mosaic of habitats within the disused airfield is likely to be of County conservation importance in the context of its surroundings. In addition, there are also homogenous habitats also within the airfield of negligible value, which include arable and poor semi-improved grassland.

The retention of the species-rich grassland and 'green corridors' in order to link the habitats to a wider landscape are therefore important considerations in the development of the concept plan for the site.

9.3.2 Protected and/or notable species

The following protected water-dependent species have been identified on the Denny St Frances site during the LDA surveys in 2002, 2008 and 2009:

9.3.2.1 Great crested newts

A medium-sized population of great crested newt (*Triturus cristatus)* has been recorded in the ponds centred around the golf course and the disused airfield (ten ponds in total). The ponds within the Denny Abbey complex have also been highlighted as having potential to support this species. In most cases, great crested newts were confirmed breeding.

Great crested newts are protected under the Habitats Regulations (2010) and the Wildlife and Countryside Act (1981) (as amended). They are a species of principal importance for the conservation of biodiversity in England.

9.3.2.2 Water voles

Water voles (*Arvicola amphibius)* are present on the Denny St Francis site within the many peaty ditches that hold water and marginal vegetation in the proximity of the old Drovers Track running north south along the eastern side of the site. There is potential for this species to be present in the large on-site lake also.

Water voles are protected under the Wildlife and Countryside Act (1981) (as amended). They are a species of principal importance for the conservation of biodiversity in England.

9.3.2.3 Aquatic macroinvertebrates

Consultation by LDA Design with the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire in 2013 has highlighted that there may be nationally scarce aquatic macroinvertebrates on the Denny St Francis site, within the field ditches and the main lake (LDA Design, *pers. comm*.). Several notable species of wetland plant have also been recorded within these waterbodies including corky-fruited water dropwort, slender rush and floating pennywort (the latter being notifiable as an invasive species under Schedule 9 of the Wildlife and Countryside Act (1981)).

9.3.2.4 Non water-dependent species

The rough edges of the golf course, the mosaic of habitats within the disused airfield, the field edges and ditches of the main part of the site and rougher areas of grassland around Denny Abbey all have the potential to support the common species of reptiles in the UK (i.e. slow worm (*Anguis fragilis*), adder (*Vipera berus*) and common lizard (*Zootoca vivipara*)).

Denny Abbey and its surrounding buildings have good potential for roosting bats, as does the derelict barn on the edge of one of the arable fields adjacent to the golf course. The buildings within the Waterbeach Barracks also support some features suitable for roosting bats. In addition, mature trees across the whole site are likely to have potential for roosting bats.

The site has the potential to support a wide range breeding birds, including reports of kingfisher on the main lake and barn owl using the barn adjacent to the golf course. Species noted within the site during surveys also included skylark (*Alauda arvensis*) and lapwing (*Vanellus vanellus*) (LDA Design, 2012). Both species are considered to be of priorities for nature conservation.

Badger setts have also been identified on the site.

9.4 Links with local ecological strategies and plans

9.4.1 The Cambridgeshire Green Infrastructure Strategy

Green infrastructure refers to the network of multi-functional green spaces and green links, including conservation areas, commons and greens, waterways and waterbodies. The Cambridgeshire Green Infrastructure Strategy was produced in 2011 by Cambridge Horizons and funded by a partnership of local organisations, including Local Authorities and nature conservation organisations and charities (Cambridgeshire Horizons, 2011).

The strategy highlighted shortages in certain parts of the district regarding access to countryside open spaces and highlighted the pressures that planned development would have on existing green infrastructure in the area.

The vision for the strategy is to:

"create a comprehensive and sustainable network of green corridors and sites that:

- *enhance the diversity of landscape character,*
- *connect and enrich biodiversity habitats,*
- *extend access and recreation opportunities and enhance the historic environment,*

for the benefit of the environment as well as current and future communities in the Cambridge Sub-region" (Cambridgeshire Horizons, 2011).

The Green Infrastructure Strategy identifies a range of opportunities for enhancement in a number of strategic networks of which 'Cambridge and the surrounding areas' is one. The Denny St Francis site lies adjacent to the River Cam Green Infrastructure corridor.

9.4.2 Wicken Fen Vision

One of the major projects supported by the Cambridgeshire Green Infrastructure Strategy is the Wicken Fen Vision; a long term plan developed by the National Trust to enlarge the existing Wicken Fen to cover an area of 56 km^2.

The National Trust plans to use ecological restoration techniques to create and restore wildlife habitats on a landscape scale and to provide visitors with new access to nature and green space. The aim is to create a mosaic of wetland habitats: wet grasslands, reed beds, marsh, fen and shallow ponds and ditches, as well as establishing chalk grassland and woodlands where soil and topography dictate.

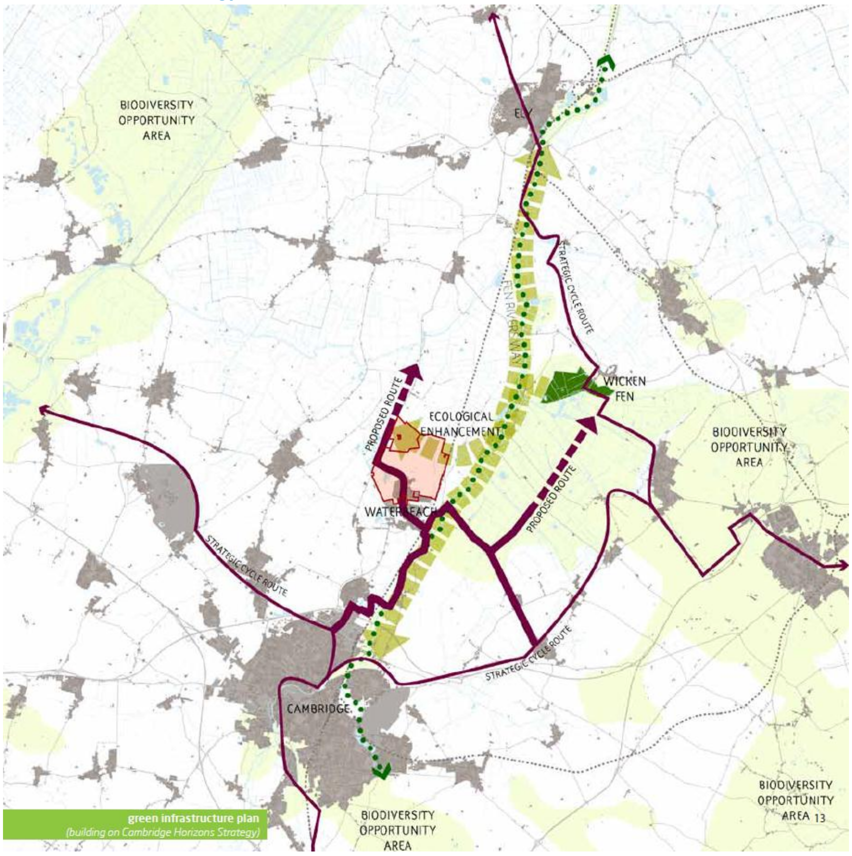
The ambitious plan envisions extension of the fen south and westwards of the current reserve towards Cambridge over the next 100 years, and promotes habitat creation and amenity opportunities along the River Cam. This would extend an area of high conservation value to the land directly adjacent and east of the Denny St Francis site, on the eastern bank of the River Cam (National Trust, 2009).

The surface water management proposals for Denny St Francis will not adversely affect the local hydrology of the area, nor would the proposals alter water levels or water quality in a way that could impact or impede the current plans of the Wicken Fen Vision. As detailed in the following sections, Denny St Francis would provide land use and habitat that would be supportive of, and could potentially connect to, the Wicken Fen Vision as part of the wider Green Infrastructure network.

9.4.3 Opportunities for Denny St Francis

A high level strategy for the Denny St Francis site has been developed by LDA, known as the ‘Denny St Francis Vision’ (LDA Design, September 2013), to attempt to incorporate links to the adjacent Wicken Fen Vision and the objectives of the Green Infrastructure Strategy. This is depicted in Figure 9.1.

Figure 9.1: Potential links of Denny St Francis to the Cambridgeshire Green Infrastructure Strategy



Source: LDA, September 2012.

Within the Denny St Francis site, the Green Infrastructure Strategy will be specifically achieved with the retention of some of the unimproved neutral grassland present on site, and key green infrastructure routes will be created in order to link the main habitat corridor along the River Cam with a crescent corridor along the north of the proposed settlement site, to the land around Denny Abbey. This in turn links the site along the River Cam corridor north and southwards, to areas highlighted as ‘key biodiversity areas’ in the Cambridgeshire sub-region (Wicken Fen and south Cambridge) (Cambridgeshire Horizons, 2011).

Any lost habitats will be replaced on land within the setting of Denny Abbey, and to the east of this in the area of low lying ‘fenland’ character. The changing levels in this part of the site will allow a range of habitats to be created, including dry grassland and new fenland.

The Denny St Francis Vision states that:

"The site will provide an opportunity for much needed fen restoration works. Having suffered a biodiversity decline based on the loss of traditional management practices, unreliable water supplies and fen isolation, our proposal is that Denny St. Francis will contribute to a broader fen restoration movement stitching the development into the fabric of Cambridgeshire's evolution towards a sustainable future" (LDA Design, September 2013).

9.5 Inclusion of ecological measures in wider development

There is potential for the masterplan of the proposed new settlement at Denny St Francis to protect, create and enhance onsite habitats for ecological gain. Features can be incorporated into the design stage of the proposals of both SUDS and amenity resources.

9.5.1 SUDS

As detailed in Section 7, the proposed Drainage Strategy for the new settlement is based on the SUDS approach and would make use of the existing natural drainage pattern and the well-established drainage infrastructure. The proposed drainage methodology will ensure that there will be no material increase to the existing discharges to the River Cam, and no material changes to water quality.

A benefit of SUDS features is that they will provide new habitat opportunities, enhancing the ecological value of the site (LDA Design, September 2013). Specific to the Denny St Francis site, SUDS proposals will aim to bring about enhancement especially for water vole, aquatic invertebrates, wetland plants and birds. This can be readily achieved through the creation of sensitively engineered waterbodies that are allowed to develop through natural colonisation. This will be in keeping with the vision for Wicken Fen, and provide connectivity through the site, northwards towards the Green Infrastructure Strategy corridor of the Cam Washes.

Ecological considerations in the design of SUDS

SUDS should not be considered as wholly engineered features, but can be adapted for ecology by appropriate ecological design, sensitive construction and continued monitoring to ensure that the system is working appropriately for wildlife. The SUDS hierarchy identifies that the softer and composite solutions are the most sustainable.

The following points should be considered when designing SUDS features that are sustainable for wildlife:

- The design of the SUDS system should have an ecological basis and mechanism for supervision, aftercare and continuing management for wildlife conservation;
- Wetlands should be of appropriate and variable depths, and will have soft substrates suitable for rooting, varied margins and islands to ensure a wide range of micro-habitats that are essential for ecological sustainability;
- Balancing ponds and flood storage reservoirs only hold water temporarily and therefore will require enhancing for wildlife such as by ensuring they have some deeper areas where water is retained for longer, thus creating ecologically diverse ephemeral wetland features;
- Lagoons provide lentic conditions for settlement and can be modified for wildlife by ensuring that they have vegetated margins;
- Retention ponds detain water for longer periods and so can be managed as ephemeral wildlife ponds; and
- Wetlands have the greatest potential for wildlife, especially if other features in the SUDS chain are also managed for wildlife. Initial planting schemes will be appropriate for the locality and preferably be locally sourced.

Careful phasing (and/or positioning) of newly created waterbodies and ditches will be vital in ensuring that they are not colonised by water vole (and potentially other protected species) too early in the scheme thus inhibiting the natural colonisation process expected with freshwater systems, and potentially causing early development constraints by the spread of protected species throughout the site.

Guidance documents

Consultation on national standards for SUDS in England and Wales is ongoing (as described in Section 7) but standards are likely to present a framework for designing SUDS schemes and selecting components, with developers and local authorities expected to work together to plan SUDS schemes for new developments.

As part of the update of the CIRIA SUDS manual (Construction Industry Research and Information Association, 2007), a series of priority checklists and frameworks on the planning, design, construction and maintenance of SUDS has been produced. This includes guidance on pond and wetland design, maintenance plans and general design principles and should be used as a guiding document at the detailed design stage.

The SUDS Manual notes that pond and wetland ecology and biodiversity can be developed in two phases:

- Phase 1: establishes the basic shape and structure of the pond/wetland; and
- Phase 2: undertaking fine tuning of the scheme, after one to two years, which could include minor re-profiling of pond margins to increase the extent of seasonal water level variations and maximising the potential of unplanned habitats that occur on most sites and the encouragement in development of multiple species of plants.

9.5.2 Amenity resources

The new settlement's vision of sustainability will integrate the proposed green corridor with a network of green amenity spaces, public cycle path and footways; thus creating a complementary mix of habitat creation and recreation facilities. This will support the wider Wicken Fen initiative for fenland creation and incorporating a public amenity value to nature conservation on the site (LDA Design, September 2013).

This approach allows the design to build sympathetically upon the existing landscape character in terms of form, tree planting and fenland vegetation. The site will provide a complementary mix of habitat creation and recreational facilities, while providing an opportunity for much needed fen restoration works. In an area that has suffered a bio-diversity decline based on the loss of traditional management practices, unreliable water supplies and fen isolation, the Denny St Francis site will contribute to a broader fen restoration movement while incorporating recreational cycle paths and footways to access the newly created natural features.

It has been recommended in the ecological survey reports (RLW Estates Ltd, 2012) that the species rich unimproved grassland in particular is a habitat which is rare in the locality, given the dominance of peat and wetland habitats in the area. Therefore it would be difficult to recreate this habitat type within areas outside of the development footprint to the east of Denny Abbey which is the only sensible area for consideration of habitat creation in proximity to the site. Therefore, the retention of species-rich grassland has been strongly recommended. It would be possible to create an amenity value to this area as well as managing it for its biodiversity interest. It would be used as a focus of open greenspace for public use within the settlement, and would serve with both an amenity and conservation function if sufficient space is provided. Public use would, however, need to be encouraged in less sensitive areas within the mosaic of retained habitats and a holistic consideration of the integration of amenity and ecology would need to be undertaken.

9.6 Ecological constraints at Denny St Francis

Protected species have been identified on the site (great crested newts, water voles) therefore these species warrant consideration in the masterplan design of the Denny St Francis development.

The presence of water voles and great crested newts is likely to require significant mitigation and/or compensation measures to be implemented, including suitable aquatic and terrestrial habitat creation which should be completed and allowed time to become established before any existing habitats are lost. This should be undertaken where habitat conditions are suitable to support these species and where colonisation can occur naturally from existing populations. The fields immediately around Denny Abbey may provide opportunity for new habitat creation for great crested newts, but design will have to be carefully pre-planned, given that habitat creation is an amenity feature of the site.

It should be noted that Natural England guidance dictates that SUDS cannot be presented as compensation for disturbance to great crested newts, therefore habitat creation for this species should arise separately to this.

9.7 Ecology and biodiversity sustainability assessment

The mitigation measures for ecology and biodiversity at Denny St Francis have been assessed in terms of their sustainability credentials in Table 9.1

Table 9.1: Ecology and biodiversity sustainability assessment

	Inclusion of biodiversity considerations in Surface Wwater Management design	Linking ecological requirements with amenity provision	Linking with local green infrastructure strategy
Social			
	Maximising opportunities to incorporate ecology into SUDS design is advocated by national guidance. Additional environmental habitats will provide community benefits through amenity and ascetics. The diversity of the landscape character will be enhanced. Additional Green Infrastructure networks could be created, with further linkages to the Cambridgeshire Green Infrastructure Strategy and Wicken Fen Vision.	Habitat creation would help to maximise the aesthetic potential of amenity provision. Recreational facilities could provide dual benefits for the local community – both functional and aesthetic. The diversity of the landscape character could be enhanced.	This would embed Denny St Francis into wider ecological strategies/plans and provide a notable benefit to the local communities. Creation of additional community benefits, socially, aesthetically and recreationally.
Economic			
	Incorporating biodiversity into drainage construction could reduce ecological mitigation costs. There may be increased maintenance costs associated with a combined ecological/drainage system.	There may be the potential for additional works being required. However, the incorporation of ecological mitigation into amenity design could reduce overall ecological mitigation costs. Maintenance costs of amenity areas may be reduced through habitat protection areas.	N/A
Environmental			
Ecology	Early management would be required to ensure natural colonisation of the area. Wider and more diverse habitats could be created at Denny St Francis.	There might be the opportunity for more extensive and diverse habitat network at Denny St Francis, if ecology were to be considered in the design of amenity provisions.	This would embed Denny St Francis into wider ecological strategies and plans and provide a notable benefit to the local environment.

	Inclusion of biodiversity considerations in Surface Wwater Management design	Linking ecological requirements with amenity provision	Linking with local green infrastructure strategy
Natural resources	As mentioned above, further Green Infrastructure could be created. This would have a beneficial environmental impact.	Amenity areas could provide environmental betterment. Open spaces would be maximised through dual purpose benefits. Existing habitats could be maintained, utilised and developed.	Promotion of ecological ‘routes’. Linking to the existing strategy would enhance the diversity of the landscape.
Climate change mitigation	Drainage works and habitat creation would be undertaken at the same time, therefore minimising construction impacts, including transportation.	Encourage local community to utilise outdoor space.	A wider network of green corridors with local access could encourage further use by the local community.
Climate change resilience	The creation of ecological wetland features could aid water retention during extreme rainfall events. Habitat creation would provide future benefits of ecological protection and resilience.	Habitat creation would provide future benefits of ecological protection and resilience.	The creation of ecological wetland features could aid water retention during extreme rainfall events. Habitat creation would provide future benefits of ecological protection and resilience.

Source: Mott MacDonald

9.8 Proposed strategy for ecology and biodiversity

Based on analysis of available data, understanding of the opportunities and constraints, and the above sustainability assessment, it is recommended that the strategy for ecology and biodiversity at Denny St Francis consists of:

Ecology and biodiversity
ECO 1: Opportunities for the Denny St Francis ecological mitigation programme to link with wider strategies • This includes the Cambridgeshire Green Infrastructure Strategy and the Wicken Fen Vision • This would offer an opportunity for the development to benefit both the wider environment and local community. Section 9.4
ECO 2: Ecological opportunities should be maximised within the design and development of amenity features on the site • As well as inclusion in the surface water management system (see recommendation SWM 2) amenity features should try to incorporate habitat creation and/or habitat compensation. Section 9.5
ECO 3: Water should underpin the Denny St Francis landscape structure • Utilising water as a key part of the landscape design will help to conserve and enhance the landscape character, as well as deliver a range of secondary functions such as amenity, ecology etc. Section 9.5
ECO 4: Development should be sensitive to the existing habitats and species of Denny St Francis • The existing ecology should be protected and maintained where possible and is an important consideration in the development of the concept plan for the site. Section 9.5

9.9 Further work

It is recommended that the current status of protected species is assessed on the site before plans for mitigation are finalised, with dedicated surveys undertaken for great crested newts and water voles in particular. Ecology surveys have not been undertaken since 2012. On-site conditions may have altered and so all ecological survey data should be updated. The results of these surveys should be used to inform the mitigation measures designed for the site.

Meetings should be arranged with Cambridgeshire Green Infrastructure Strategy and Wicken Fen Vision representatives to discuss and develop plans for mutual collaboration and to investigation ways in which the Denny St Francis aspiration for water and ecology can work with and support these wider strategies.

10 Proposed Water Cycle Strategy for Denny St Francis

Development of an appropriate, sustainable strategy for water requires the holistic consideration of all aspects of water management. The findings reported in this Detailed Study have highlighted the complex interconnections within the water cycle at Denny St Francis. These need to be considered throughout the development of the masterplan for the site.

An important part of developing a sustainable water strategy is fully understanding any wider impacts on the surrounding area and ensuring that these are in no way disadvantageous to local communities. This has underpinned the development of this strategy.

From the results of the analysis, the following strategy is recommended for Denny St Francis.

Water resources, supply and efficiency

WR 1: All properties should be installed with a smart water meter

- Following regulatory guidance, water meters should be installed in all properties.
- Installation of the meters in a prominent, visible place would encourage water users to actively monitor and use them to reduce their water demand.

Section 5.4.4

WR 2: Installation of water efficient components in homes and businesses

- This could reduce per capita water demand to Code for Sustainable Homes Level 3/4 (105 l/h/d of potable water).
- Further efficiency in taps and a smaller bath size could reduce demand to 94 l/h/d of potable water.

Section 5.4.1

WR 3: Active education of residents in water efficiency

- Education will be fundamental to achieve long-term reductions in water demand.
- A number of education measures can be adopted to instil awareness and understanding, including home welcome packs, promotional material and engagement events.

Section 5.4.3

WR 4: A connection to Cambridge Water Company would provide the most practical and deliverable source of potable water

- Cambridge Water's supply-demand balance is forecast to be in surplus throughout the current water company planning period (2015- 2040) and would provide Denny St Francis residents with high levels of service, reliability and quality.

Section 5.7

WR 5: Installation of non-potable rainwater supply systems in all dwellings and appropriate other buildings

- The use of rainwater could further reduce per capita potable water use to Code for Sustainable Homes Level 5/6 of 80 l/h/d.
- The quantities available would depend on the tank size adopted, roofed area and occupancy rates.
- Rainwater harvesting would offer a sustainable system of water supply, reduce wider raw water abstraction pressures, follow national guidance on the promotion of water efficiency and result in lower water bills for Denny St Francis residents.
- The capture of rainwater would also have benefits for the Denny St Francis drainage system by reducing runoff rates.
- The sustainability of a non-potable rainwater supply system should be revisited at the detailed design stage, including an assessment of total carbon footprint.

Sections 5.4.2.1 & 5.5.1.3

Flood risk management

FRM 1: On-site flood mitigation measures would be the most sustainable form of flood protection at Denny St Francis

- Sequential land use placement, land level raising and/or flood bunding should be incorporated into the architectural design of the development and should have minimal visual impact.
- Additional community benefits could be had from the development of the required water compatible areas.
- The localised impacts of flood bunding should be considered, further assessed and mitigated against.

Section 6.6

FRM 2: The Denny St Francis development should be designed so as not to rely on the protection from existing flood defences

- Residential development could be raised above 2.6mAOD to the east of the Barnold Drove track, or a flood bund constructed, to eliminate flood risk in this area from a breach in the River Cam defences.
- Water-compatible land uses should be located in the north eastern corner of the development.

Section 6.6

FRM 3: The raised on-site embankments should be retained

- The Barnold Drove track embankment should be retained, in order to maintain the protection offered during a flood defence breach event.
- If it is necessary to remove the existing embankment, a replacement flood levee should be installed in order to retain the function performed. The impact of this would need to be considered and modelled.

Section 6.6

FRM 4: A Level 3 Flood Risk Assessment will need to be undertaken

- The Denny St Francis development meets the criteria required for a Level 3 FRA. This should be undertaken as a part of the on-going investigations.

Section 6.9

FRM 5: Off-site associated development should be flood resilient

- Flood risk should be assessed and appropriate mitigation investigated and proposed for off-site assets, including consideration of associated access routes.

Section 6.9

Surface water management

SWM 1: The surface water management strategy should be based on SUDS

- SUDS management train options should be developed and implemented at Denny St Francis, with appropriate source control measures carefully considered.
- This follows the sustainable surface water management strategy put forward by the Cambridge Water Cycle Study.
- Maintaining surface water runoff to 1.1 l/s/ha would both negate any adverse pressures on the existing Waterbeach IDB drainage system and provide benefits through reducing the current runoff occurring from the Waterbeach Barracks site.
- SUDS will mitigate the increase in impermeable surface as part of the development of the Denny St Francis site.
- The use of SUDS surface features that can be incorporated into the green infrastructure of the development should be prioritised.

Section 7.5

SWM 2: Biodiversity and amenity considerations should be included in the drainage design

- SUDS will provide the opportunity for greater biodiversity of flora and fauna on site and provide amenity value for residents and social and recreation value.
- Best practice guidance should be followed to ensure that ecologically sensitive and appropriate systems are developed.
- The implications of this on both construction and maintenance should be considered at the earliest stages of the detailed design.

Section 7.5

SWM 3: The potential to incorporate a retention pond in the drainage system should be promoted

- The opportunity to include a storage reservoir in the Denny St Francis drainage system should be investigated and progressed as a part of the detailed drainage design.
- Capturing and storing runoff for later use by the Waterbeach Internal Drainage Board, a storage reservoir could provide summer irrigation water for local agriculture, thereby supporting the local community.
- A reservoir would also benefit the drainage system by providing additional storage at times of high runoff.

Section 7.6.5

Used water management

UWM 1: A new Water Recycling Centre should be built at Denny St Francis

- The most sustainable option for used water would be the construction of a new treatment works.
- This would negate the requirement of considerable carbon and pumping costs of a transfer to Cambridge WRC, reduce additional pressure on a key strategic site, and offer a potentially higher quality treatment through a tighter discharge consent and the incorporation of new innovate solutions in the

WRC design.

Section 8.3.1

UWM 2: Waterbeach Water Recycling Centre should be decommissioned

- Waterbeach effluent and surface water runoff should be transferred to the new Denny St Francis works.
- This provides betterment for Waterbeach village residents through the provision of an improved treatment works and higher quality used water service to customers.
- It is also more sustainable than operating two treatment works in tandem.

Section 8.3.1

UWM 3: The location of a new WRC should continue to be explored

- The location of a new WRC should continue to be explored, with particular consideration of flood risk protection requirements. The latest legislation and guidance on the siting of essential infrastructure should be referenced.

Section 8.3.2

UWM 4: Green treatment technologies should be adopted where possible

- Whilst there may be limitations to the potential to use green technologies due to the size and water quality constraints of the new works, these should still be investigated and their full potential reviewed.

Section 8.5

Ecology and biodiversity

ECO 1: Opportunities for the Denny St Francis ecological mitigation programme to link with wider strategies

- This includes the Cambridgeshire Green Infrastructure Strategy and the Wicken Fen Vision
- This would offer an opportunity for the development to benefit both the wider environment and local community.

Section 9.4

ECO 2: Ecological opportunities should be maximised within the design and development of amenity features on the site

- As well as inclusion in the surface water management system (see recommendation SWM 2) amenity features should try to incorporate habitat creation and/or habitat compensation.

Section 9.5

ECO 3: Water should underpin the Denny St Francis landscape structure

- Utilising water as a key part of the landscape design will help to conserve and enhance the landscape character, as well as deliver a range of secondary functions such as amenity, ecology etc.

Section 9.5

ECO 4: Development should be sensitive to the existing habitats and species of Denny St Francis

- The existing ecology should be protected and maintained where possible and is an important consideration in the development of the concept plan for the site.

Section 9.5

11 References

A F Howland Associates. (December 2002). *A Report on a Ground Investigation at Waterbeach Barracks, Cambridgeshire.*

Anglian Water Services Ltd & Environment Agency. (2010). *Water Cycle Study Framework.*

Anglian Water Services Ltd. (2008). *Design and Installation Guide (Section 2.03), Rev 17.1.*

British Geological Survey. (1981). *Cambridge: Sheet 188. Solid and Drift Edition.*

British Water. (2009). *Code of Practice. Flows and Loads - 3.*

BSI Group. (2009). *BS 8515:2009. Rainwater harvesting systems. Code of practice.*

BSI Group. (2010). *BS 8525-1:2010 Greywater systems Code of practice.*

BSI Group. (2013). *BS 8595:2013 Code of practice for the selection of water reuse systems.*

Building Research Establishment Environmental Assessment Methodology. (2014). *Wat 03 Water meter*. Retrieved March 28, 2014, from http://www.breeam.org/domrefurbmanual/content/07water/wat_03_water_meter.htm

Cambridge Water. (2014). *New water supply connection estimate charges, 20mm bore with a 15mm meter.*

Cambridge Water. (March 2013). *Cambridge Water Draft Water Resources Management Plan.*

Cambridge Water. (May 2014). *Final Water Resources Management Plan 2014.*

Cambridge Water. (November 2013). *South Staffs Water – Cambridge Region: Statement of Response to Representations on the 2013 Draft Water Resources Management Plan.*

Cambridgeshire County Council. (April 2011). *Cambridgeshire Surface Water Management Plan. Strategic Assessment Report.*

Cambridgeshire County Council. (March 2011). *Cambridgeshire Preliminary Flood Risk Assessment. Final Preliminary Assessment Report.*

Cambridgeshire Horizons. (2011). *Cambridgeshire Green Infrastructure Strategy .*

Cambridgeshire Horizons. (July 2011). *Detailed Water Cycle Strategy up to 2031. Major Growth Areas in and around Cambridge. Phase 2 - Detailed Strategy. Choosing a water services infrastructure future.*

Cambridgshire Horizons. (September 2011). *East Cambridgeshire District Council Water Cycle Study. Detailed Study: Stage 2 Report. .*

Construction Industry Research and Information Association. (2004). *Development and flood risk - guidance for the construction industry (C624).*

Construction Industry Research and Information Association. (2007). *The SUDS Manual (C697).*

Department for Communities and Local Government . (2012). *National Planning Policy Framework.*

Department for Communities and Local Government. (2010). *Planning Policy Statement 25: Development and Flood Risk.*

Department for Communities and Local Government. (2012). *National Planning Policy Framework.*

Department for Communities and Local Government. (August 2011). *Cost of building to the Code for Sustainable Homes. Updated cost review.*

Department for Communities and Local Government. (December 2006). *Code for Sustainable Homes.*

Department for Environment, Food and Rural Affairs. (1991). *Land Drainage Act*. Retrieved from http://www.legislation.gov.uk/ukpga/1991/59/contents

Department for Environment, Food and Rural Affairs. (2010). *Flood and Water Management Act*. Retrieved from http://www.legislation.gov.uk/ukpga/2010/29/contents

English Nature. (2014b). *Sites of Special Scientific Interest. SSSI information: Stow cum Quy Fen SSSI.* Retrieved May 2, 2014, from http://www.sssi.naturalengland.org.uk/citation/citation_photo/1002332.pdf

Environment Agency. (2009). *River Basin Management Plan – Anglian River Basin District.*

Environment Agency. (2009). *Water Cycle Study Guidance .*

Environment Agency. (2014). *Water Neutrality.* Retrieved March 18, 2014, from http://www.environment-agency.gov.uk/research/library/publications/40737.aspx

Environment Agency. (December 2011). *H1 Annex E Surface Water Discharges (complex) v2.1.*

Environment Agency. (March 2013). *Cam and Ely Ouse Abstraction Management Strategy.*

Environment Agency. (March 2014). *Comments on Water Cycle Study Scoping Report for Proposed New Settlement (Denny St Francis). Land North of Waterbeach, Cambridgeshire. Ref: AC/2014/120560/01-L01.*

Environment Agency. (May 2013). *Managing Water Abstraction.*

Environment Agency. (November 2013). *What's in your backyard?* Retrieved 11 21, 2013, from http://apps.environment-agency.gov.uk/wiyby/default.aspx

Institute of Plumbing. (2002). *Plumbing Engineering Services Design Guide.*

Joint Nature Conservation Committee. (1995). *Information Sheet on Ramsar Wetlands. Wicken Fen.* Retrieved from http://jncc.defra.gov.uk/pdf/RIS/UK11077.pdf

LDA Design. (2012). *Denny St. Francis New Settlement, Waterbeach. Ecology Phase 1 Updated Report.*

LDA Design. (September 2013). *Denny St Francis Vision Document.*

Mott MacDonald. (2007). *Waterbeach New Settlement. Reducing Potable Water Consumption.*

Mott MacDonald for RWL Estates. (2014). *Denny St Francis Water Cycle Study: Scoping Report.*

National Trust. (2009). *Wicken Fen Vision*. Retrieved 01 29, 2014, from http://www.wicken.org.uk/wickenfen/vision/

Natural England. (2013a). *Sites of Special Scientific Interest*. Retrieved from http://www.sssi.naturalengland.org.uk/Special/sssi/index.cfm

Natural England. (2014a). *Sites of Special Scientific Interest. SSSI information: Cam Washes*. Retrieved May 2, 2014, from http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1004020

Natural England. (2014b). *Sites of Special Scientific Interest. SSSI Information: Stow-cum-quy Fen*. Retrieved May 2, 2014, from http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1002332

Northstowe. (February 2012). *Phase 1 Planning Application. Water Conservation Strategy.*

Ofwat. (2014). *New appointments and variations – a statement of our policy.* Retrieved from http://www.ofwat.gov.uk/competition/inset/pap_pos110228navpolicy.pdf#page=15

RLW Estates Ltd. (2012). *Report 3321: Denny St Francis Ecology Phase 1 Update - Summary Report .*

RLW Estates Ltd. & Defence Infrastructure Organisation. (October 2013). *South Cambridgeshire District Council Local Plan Pre-Submission Consulation. Statement of Responses.*

RLW Estates Ltd. (August 2008). *Waterbeach New Settlement. Summary of Water Neutrality Work.*

RLW Estates Ltd. (August 2012). *Drainage Strategy. Denny St Francis New Settlement, Waterbeach.*

RLW Estates Ltd. (August 2012). *Flood Risk Assessment. Denny St Francis New Settlement.*

RLW Estates Ltd. (August 2014). *Denny St Francis. Breach Modelling.*

RLW Estates Ltd. (February 2014). *Denny St Francis Water Cycle Study. Scoping Report.*

RLW Estates Ltd. (February 2014). *Denny St Francis Water Cycle Study. Scoping Report.*

RLW Estates Ltd. (July 2012). *Report 19: Phase I Geo-Environmental Risk Assessment: Denny St Francis New Settlement, Waterbeach.*

RLW Estates Ltd. (June 2002). *Waterbeach New Settlement. Wastewater Treatment Works.*

RLW Estates Ltd. (September 2013). *Denny St Francis Employment Requirement.*

RLW Estates Ltd. (September 2013). *Denny St Francis Land Use Schedule and Concept Plan 3321_S201A.*

South Cambridgeshire District Council and Cambridge County Council. (September 2010). *South Cambridgeshire and Cambridge City Level 1. Strategic Flood Risk Assessment.*

South Cambridgeshire District Council. (February 2014). *South Cambridgeshire Local Development Scheme 2014.*

South Cambridgeshire District Council. (July 2013). *Local Plan 2011-2031: Publication of Proposed Submission Local Plan.*

South Cambridgeshire District Council. (March 2013). *South Cambridgeshire Local Plan. Sustainability Appraisal Report.*

UK Govenment. (2009). *The Private Water Supplies Regulations 2009.* Retrieved from http://www.legislation.gov.uk/uksi/2009/3101/contents/made

University of Cambridge. (April 2013). *North West Cambridge - Potable Water Supply Strategy.*

Water UK. (2012). *Sewers for Adoption. 7th Edition.* WRc plc.

WFD UK TAG. (April 2008). *UK Environmental Standards and Conditions.*

WSP. (February 2012). *Northstowe Phase 1 Planning Application Water Conservation Strategy.*

Appendices

Appendix A. Denny St Francis Water Cycle Study stakeholder workshops

Waterbeach Denny St Francis Water Cycle Study

Summary of discussions from the first stakeholder workshop

Summary

The first Denny St Francis Water Cycle Study was held at South Cambridgeshire District Council's offices in Cambourne on Wednesday 13th February 2014. Representatives of the following organisations were present:

- Chris Swain, Environment Agency (EA)
- David Roberts, South Cambridgeshire District Council (SCDC)
- Mike Sloan, Cambridge Water Company (CWC)
- Nicholas Wyke, Cambridgeshire County Council (CCC)
- Rob Morris, Anglian Water (AW)

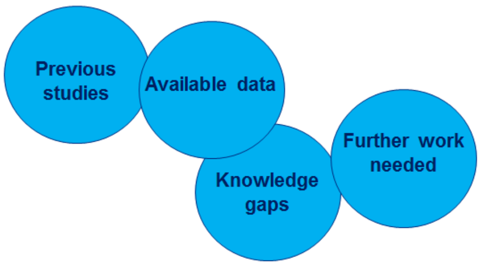
Unfortunately the Waterbeach Internal Drainage Board (IDB) was unrepresented due to operational issues on the day.

Objectives of Workshop 1

The objectives of the first water cycle study workshop were:

1. Refine and confirm WCS opportunities and constraints
2. Agree the proposed approach for the detailed study

Key areas for discussion included:



Summary of Discussions

Water Resources & Neutrality

Supply

It was agreed that the most suitable source of water for Denny St Francis would be from Cambridge Water Company, due to the limited 'new' raw water availability in the area. The site would likely be supplied from CWC's Cherry Hinton reservoir. Various associated issues were raised and debated:

- Extension of existing CWC network to Denny St Francis. CWC suggested that a new main would likely need to be laid (with associated costs).
- On-site (or nearby) storage should be considered to increase

resilience. Storage at ground level would be cheapest but would require a booster.

- Unforeseen reductions to CWC's existing raw water abstraction licences could change the company's forecasted supply. The Environment Agency are providing details of future sustainability reductions and licences potentially at risk. A view will be taken by CWC on the consequential impact on Cherry Hinton reservoir. CWC have offered to further investigate their supply-demand balance for the purposes of the Denny St Francis water cycle study, if required.
- Water industry and Local Authority planning horizons do not align. Cambridge Water's draft Water Resources Management Plan (WRMP) (from which their assessment of available supply originates) covers the period 2015 to 2040 and therefore does not cover the whole of SCDC's proposed Denny St Francis construction period. The study needs to demonstrate that we can be confident to allocate the site for the development of a new town in the knowledge that it will have a water supply over the long term. All assumptions should be discussed in the Detailed Study report.

Demand

It was appreciated that low water usage levels on new developments can not be guaranteed due to a lack of control over in-house appliances and systems once a home is occupied. For example, a site-wide rainwater harvesting system could be controlled and guaranteed, whereas the usage of low usage appliances can not. Despite the aspirations for low water usage on the Denny St Francis site, Cambridge Water would have to assume 125 l/h/d consumption for resilience reasons and in line with industry standards.

It was acknowledged that concentrated areas of development (as advocated in South Cambridgeshire District Council's (SCDC) Local Plan) are easier to join to existing supply networks than small pockets of development located across the county. In addition, economies of scale could be achieved if a Denny St Francis pipeline were to also benefit another area of urban development (for example, future development at Cottenham, should it go ahead).

The Environment Agency raised the issue of future changes in the scale of development in CWC's supply area and questioned how this would be dealt with. This should be further considered and discussed in the Detailed Study, potentially as a part of sensitivity testing.

The wide ranging benefits of water efficiency for consumers should be discussed in the Detailed Study. Education would be an important part of gaining resident acceptance of, and support for, any water recycling or low-usage system.

A demand profile should be developed which incorporates the timetable for delivery.

Water Neutrality

Regarding water neutrality, a clear definition was requested from the stakeholders. It was agreed that water neutrality should be discussed rather than reassessed for the Detailed Study, with the preference placed on water efficiency above neutrality. Neutrality may need to be reassessed at some point in the future and this could comprise a component of a future water cycle study.

Key Agreements

- Cambridge Water should supply Denny St Francis
- Lessons should be learnt and best practice taken from Northstowe, Cambourne and North-West Cambridge.

Key Actions

- Cambridge Water to contact Cambridge University for information on their proposed water efficiency and reuse system.
- A clearer definition of water neutrality should be included in the final Scoping Study report.

Flood Risk & Surface Water Management

Flood Risk

It was suggested that the Waterbeach IDB review the Denny St Francis Flood Risk Assessment and a meeting should be arranged between the IDB, EA and Mott MacDonald (MM).

The key area of outstanding information relating to flood risk is the current assessment of risk to the development from breach of the River Cam flood defences. Given that a reassessment of breach risk is not within the scope of this water cycle study, discussions were had with the stakeholders regarding the best way in which to make progress in this area in the Detailed Study. It was suggested that:

- The Detailed Study must address this issue and provide some measure of progress in this area.
- The project team should find out the locations of the breach(es) used by the SCDC/Cambridge City Council in their 2010 Strategic Flood Risk Assessment (SFRA).
- A review of the relative suitability of the location(s) for use as a site-specific breach analysis for Denny St Francis.
- Comment on whether a future site-specific flood defence breach assessment is required.

The above would enable a view on the importance of the existing River Cam flood banks to Denny St Francis and whether future maintenance of the banks would need to be considered. The criteria adopted by Defra for determining future investment in flood defences (including routine maintenance) involves cost-benefit analysis for *existing* settlements. As such, the EA may not be required to maintain any stretch that is key for protection for Denny St Francis. Selective maintenance may need to be discussed in the Detailed Study. It was advised that the project team review the Defra Flood Risk Management Strategy as well as commenting more on the River Great Ouse Catchment Flood Management Plan.

In addition, the Detailed Study should state whether the railway line is key in protecting the site from fluvial flooding. It was advocated that Network Rail are involved in the Detailed Study, due to the railway line being on embankment between the site and the River Cam. Mott MacDonald will contact Network Rail to initiate discussions on:

- The locations of culverts under the railway, as these could potentially channel flood water to/from the Denny St Francis site.
- Information on maintenance or future plans for the line/embankment,

if the above breach assessment shows it to be key to the protection of Denny St Francis.

Surface Water Management

The stakeholders requested that, in order for the development to demonstrate it is an ‘exemplar of sustainable development’, any surface water management system developed for Denny St Francis should improve upon the existing situation, rather than just aiming to maintain the status quo. It will be important to demonstrate this and data collection will be essential.

Data and assessment were further discussed, with the following comments made:

- Baseline data will be required to provide comparison against the future situation and should be reported in the Detailed Study. This information could originate from the IDB and the EA.
- A comparison should be given between the existing and future extents of hard surfaced areas on the site.
- It should be stated whether existing runoff from the site will be diverted away from the existing Waterbeach village combined sewer system, reducing its load.
- Additional monitoring of the existing situation may be required to provide baseline data for comparison against and, if so, highlighted and discussed in the Detailed Study.
- Monitoring would need to be included in any future management system.
- Quantitative demonstration of enhancements in surface water management will help to provide proof of improvements and protection from challenges from external bodies.

The development at Northstowe would be an example of where surface water management has been improved upon. The Environment Agency have confirmed that WSP worked on the Northstowe development (key contact: Alastair Atkinson in the Basingstoke office). The project team should find out whether it would be possible for the Denny St Francis project team to review their approach.

Stakeholder Engagement

Lessons should be learned from all stakeholders, in particular from experiences with Northstowe and Cambourne. It was advocated that the project team again try to engage with the Waterbeach Parish Council. The project team will discuss this with the Mott MacDonald social research team and discuss the best way forward with the client.

Key Agreements

- Breach analysis should be the main focus of flood risk work in the Detailed Study.
- The importance and implications of maintenance of the railway line and flood defences should be assessed.
- Lessons should be learnt and best practice taken from Northstowe and Cambourne.

Key Actions

- Meetings should be arranged with Waterbeach IDB to discuss surface water management.
- Mott MacDonald will engage Network Rail for the Detailed Study.
- The Environment Agency will look in to the possibility of reviewing the surface water management approach adopted by the Northstowe developers and their consultants.
- Anglian Water will provide information on the existing Waterbeach village sewer system for the Detailed Study.

Wastewater & Water Quality

Terminology

Anglian Water requested that the term “wastewater” is replaced with “used water” throughout the water cycle study and its documentation, in line with recent industry preferences. This was agreed by the group and the Scoping Study report will be amended accordingly for the final version.

Standard text was developed for a previous water cycle study that discusses the collaborative approach to promoting efficient and safe used water systems that was developed by the stakeholders involved in that project. Anglian Water will send this to the project team for inclusion in the final Scoping Study report.

Used water collection and treatment

Whilst is was agreed that the preferred option would be a new treatment works at Waterbeach, all options for used water collection and treatment should be progressed to the Detailed Study. It was requested that a further option is considered, making a total of four:

- Treatment at the existing Waterbeach Water Recycling Centre (WRC) via a major upgrade to the works.
- Transfer at the existing Cambridge WRC via a major upgrade to the works.
- Building a new WRC at Waterbeach for Denny St Francis.
- *NEW* – Building a new WRC at Waterbeach for Denny St Francis AND Waterbeach village.

It was noted that the conveyance of used water for the Cambridge WRC option should be included in the review of infrastructure requirements. Details of the planned upgrades to Cambridge WRC, including any known changes to the discharge permit, will be provided by Anglian Water.

Anglian Water confirmed that it would pursue closing Waterbeach WRC if this provided its existing customers with an improved service. The WRC could then be converted to a pumping station, if required.

It was highlighted that impacts on the existing Waterbeach IDB system should be considered, as the current Waterbeach WRC discharges into their watercourse network. This will need to be discussed in the Detailed Study.

The timescales for effluent quantities should be provided in the Detailed Study, to understand the options for phased development of water recycling centres and phased discharge consents. This should be based on SCDC timescales and give an indication of the number of new properties that could be treated by the existing WRC before a new treatment option was required.

A per capita consumption of 131 l/h/d was suggested for this assessment, in line with AW methodologies.

Previous assessments of the costs of treatment options for Denny St Francis should be revisited for the Detailed Study.

Discharge consents/permits

The issue of used water discharge was discussed and agreed to be a key area for progress in the Detailed Study.

- River flow and water quality data will be required (and have already been requested from the Environment Agency). Additional data may be available from the IDB.
- Anglian Water will provide historic recycled water discharge flows for Cambridge and Waterbeach WRCs.

Key Agreements

- Timescales for WRC developments are long with extensive lead times, so a phased development of used water collection, treatment and permitting should be investigated.
- All four options for used water treatment should be considered in the Detailed Study.

Key Actions

- Anglian Water will provide the standard text about AW/EA water cycle study involvement for inclusion in the final Scoping Study report.
- Anglian Water will provide details of the planned upgrades to Cambridge WRC.
- Anglian Water will provide historic daily discharges from both Cambridge and Waterbeach WRC.
- Where available, data from the Waterbeach IDB will be requested.
- A meeting should be held between Waterbeach IDB and Anglian Water regarding wastewater and water quality. A representative of the Environment Agency may also need to be present.

Ecology and Biodiversity

The environmental constraints map produced for the draft Scoping Study was reviewed by the stakeholders. No further sites or areas of interest were noted.

The suggestions for collaboration with the Wicken Fen Vision and Cambridgeshire Green Infrastructure were supported. The potential for cross-funding and multi-functional habitat creation was advocated.

The following issues and considerations were raised for inclusion in the Detailed Study:

- Is there enough water to develop compensation areas?
- Review the work done at Northstowe in ‘over-engineering’ of ponds for biodiversity reasons.
- The impact of the development on the water environment in terms of pollution should be investigated through consideration of the before and after situation. This would include understanding any changes to the source-pathway-receptor conceptualisation. For example, a new drainage regime incorporating SUDS may offer more protection

to local watercourses from pollution events than one based on a pumped system.

Key Agreements

- Review the existing ecology survey data from a water perspective in the Detailed Study.
- Continue to explore cross-organisation opportunities.

Key Actions

- Obtain information on Northstowe's biodiversity SUDS ponds.
- Liaise further with the ecologists at Cambridgeshire County Council and South Cambridgeshire County Council.

The Agreed Approach for the Detailed Study

The stakeholders with previous experience of water cycle studies stressed that a water cycle study report should be a 'live' document.

Occupancy rates

The occupancy rates that should be used for assessments in the Detailed Study were discussed at length:

- Anglian Water use 2.3 for their used water calculations.
- Cambridge Water will provide information and explanation of the occupancy rates used for their potable water demand assessments.
- The Cambridge water cycle study (2011) used 2.15 or 2.16.
- The rates used for design of the Cambourne and Northstowe developments should be looked at.
- The Environment Agency suggests using the rate in Cambridge Water's Water Resource Management Plan as the starting point – variation on this could be evidenced in discussions with Cambridge Water and South Cambs DC .

The occupancy rates require further discussion and should be agreed at the earliest opportunity. It is anticipated that water demand assessments use Cambridge Water's preferred occupancy rate, to align with its Water Resources Management Plan. Any review of WRC capacity may need to be based on Anglian Water's used water assessment occupancy rate.

Consumption rates

- Anglian Water use 131 l/h/d as the basis of their used water assessments.
- Cambridge Water use 125 l/h/d for potable water demand assessments, in line with the Building Regulations.
- The Cambridge water cycle study (2011) used different consumption rates for different developments, based upon the regulations at the proposed time of construction. This method is equivalent to 125 l/h/d for Denny St Francis.

Development Scenarios

A key objective of the first water cycle study workshop was to discuss and debate the development scenarios to be used in the Detailed Study. The scenarios proposed (and reported in the draft Scoping Study report) were:

Scenario	Number of dwellings	Per Capita Consumption
1. Baseline: dWRMP Existing homes	10,000	131 l/h/d
2. Building Regulations 2010: New dwellings	10,000	125 l/h/d
3. Code for Sustainable Homes: Levels 3 & 4	10,000	105 l/h/d
4. Code for Sustainable Homes: Levels 5 & 6	10,000	80 l/h/d

The consumption rates suggested in the draft report were agreed. It was advised that a higher population rate is also considered, to allow consideration of any further growth in the Denny St Francis development size. SCDC will lead on this and look at the developers latest assessments and provide a suggested higher dwelling figure.

A degree of sensitivity testing may be required with regard to timescales. Not least because development may commence sooner than the draft Local Plan trajectory, to ensure an adequate supply of housing in the district. This should be considered and agreed with all stakeholders for the Detailed Study.

Key Agreements

- Development scenario consumption rates.

Key Actions

- Occupancy rates need to be agreed through a process of information gathering (from Cambridge Water, SCDC and previous water cycle studies) followed by further group discussion during the Detailed Study.
- Cambridge Water will provide information on the occupancy rates used for their supply-demand assessments.
- The Environment Agency will offer their view on occupancy rates.
- The project team will include an additional, higher, number of dwellings scenario. SCDC will lead on this.

Next Steps

Scoping Study

Final report issued – 28th February 2014

Detailed Study

Teleconference kick-off – Early March 2014

- To approve and discuss the agreements and actions stated in this summary document.

Workshop 2 – Change of date: Tuesday 1st April 2014

- Presentation and discussion of the existing infrastructure capacity to serve the proposed development.

- Assess and discuss the key technical issues of the water cycle study

Draft Detailed Study report issued – Early May 2014

Workshop 3 – Thursday 8th May 2014

- Present and review the sustainability assessment of the water management options and future management issues.
- Review the proposals as part of the detailed report

Final Detailed Study report issued – June 2014

Waterbeach Denny St Francis Water Cycle Study

Summary of discussions from the second stakeholder workshop

Summary

The second Denny St Francis Water Cycle Study was held at South Cambridgeshire District Council's offices in Cambourne on Monday 7th April 2014. Representatives of the following organisations were present:

- Adam Ireland, Environment Agency (EA)
- Steve Hopper, Environment Agency (EA)
- Ben Corne, Environment Agency (EA)
- David Roberts, South Cambridgeshire District Council (SCDC)
- Jonathan Dixon, South Cambridgeshire District Council (SCDC)
- Daniel Clark, Cambridge Water Company (CWC)
- Nicholas Wyke, Cambridgeshire County Council (CCC)
- Rob Morris, Anglian Water (AW) (latter part of the meeting)

Unfortunately the Waterbeach Internal Drainage Board (IDB) was unable to attend.

A summary of the discussions held is provided below, with key actions highlighted in **blue**.

Objectives of Workshop 2

The objectives of the second water cycle study workshop were to:

1. Refine and agree Detailed Study methods and objectives
2. To provide guidance for the detailed study

Summary of Discussions

Development Scenarios

The below Development Scenarios for water and wastewater were agreed, pending clarification/confirmation on non-domestic water usage; specifically:

- What CWC use in their water demand WRMP assessments
- What AWS use in their used water demand WRMP assessments
- What the developer's aspirations are for the number and type of non-domestic properties at Denny St Francis
- What SCDC's aspirations are regarding non-domestic allocation at Denny St Francis

Water scenarios:

Scenario	Population (dwellings)	Construction phasing	Per Capita Consumption (l/h/d)
Lower 1 (L1)	8,000	SCDC	131
Lower 2 (L2)	8,000	SCDC	125
Lower 3 (L3)	8,000	SCDC	105
Lower 4 (L4)	8,000	SCDC	80
Upper 1 (U1)	10,000	RLW	131
Upper 2 (U2)	10,000	RLW	125
Upper 3 (U3)	10,000	RLW	105
Upper 4 (U4)	10,000	RLW	80

Used water scenarios:

<table>
<tr><th>Scenario</th><th>Population (dwellings)</th><th>Construction phasing</th><th>Per Capita Consumption (l/h/d)</th></tr>
<tr><td>Lower 1 (L1)</td><td rowspan="4">8,000</td><td rowspan="4">SCDC</td><td rowspan="4">131</td></tr>
<tr><td>Lower 2 (L2)</td></tr>
<tr><td>Lower 3 (L3)</td></tr>
<tr><td>Lower 4 (L4)</td></tr>
<tr><td>Upper 1 (U1)</td><td rowspan="4">10,000</td><td rowspan="4">RLW</td><td rowspan="4">131</td></tr>
<tr><td>Upper 2 (U2)</td></tr>
<tr><td>Upper 3 (U3)</td></tr>
<tr><td>Upper 4 (U4)</td></tr>
</table>

Instead of including additional sensitivity testing, a nominal 10% will be added to the calculated demands in each scenario, to account for ‘organic growth’, higher occupancy rates during the early stages of development and other uncertainties. This will provide a conservative review of impacts.

Key Agreements

- MM to add 10% to water demand in all development scenarios for sensitivity testing
- 1.97 to be used as the water demand base occupancy rate
- The proposed scenarios were agreed, pending the confirmation of non-domestic property number and standard usage quantifications

Key Stakeholder Actions

- **CWC (Daniel Clarke) to provide details of their WRMP non-domestic usage calculations and assumptions**
- **AWS (Rob Morris) to provide information on their WRMP non-domestic usage calculations and assumptions**
- **SCDC (David Roberts/Jonathan Dixon) to provide information on any non-domestic allocation aspirations they may have for Denny St Francis**

Sustainability Assessment

It was proposed that the water cycle study’s sustainability assessment of selected options should follow the standard economic, social and environmental aspects. The environmental aspect will be split into four key performance drivers of ecology, natural resources, climate change mitigation and climate change resilience.

It was suggested that the MM project team should review the sustainability assessment methodology adopted by SCDC for their Local Plan and, where possible, link in with this.

Key Agreements

- The WCS should assess sustainability qualitatively under the above headings.

Water Resources

The review of CWC’s available water should take the form of a further review of their WRMP methods and conclusions, building upon that in the Scoping Report. The assumptions made regarding sustainability reductions should be clarified and discussed.

There are likely to be significant regulatory and legislatory changes to the water industry prior to the start of construction at Denny St Francis, which could impact on the availability of supply to the development.

Behavioural change should be discussed in the Detailed Report, as should public health implications of grey-water reuse schemes.

Proposed Approach

- Available resources
  - Private (local) sources
  - Water company sources
- Water neutrality
  - Costs of Code for Sustainable Homes
  - Reducing potable consumption
  - Supplementation with non-potable water
- Review of options for water supply
  - Degree of water neutrality
  - Assessment against development scenarios
  - Sustainability assessment

Key Agreements

- The proposed approach, as detailed above and in the workshop powerpoint slides, was agreed by the workshop stakeholders
- The potential future changes to the water industry should be highlighted within the report. Given the significant uncertainties, at this time assumptions will just need to be made in order to complete this water cycle study's water resources assessment. These will need to be stated and discussed adequately in the report.

Key Stakeholder Actions

- **CWC (Daniel Clark) to provide MM with further information as to the potential future changes to water industry management and planning, for inclusion in the Detailed Report.**
- **CWC (Mike Sloan) to provide MM with an indicative cost of connection to Denny St Francis, as discussed.**

Flood Risk

It was highlighted that the MOD have recently conducted their own review of flood defences at Waterbeach. The EA will provide details as to when the information might be published and whether it can be used by this water cycle study.

The previous work on surface water, groundwater and pluvial flood risk from the existing Denny St Francis FRA should be summarised in the Detailed Study.

The area where the Agency Flood Risk maps encroach on the Denny St Francis development site should be further reported and discussed in the Detailed Study.

Proposed Approach

- Risk of breaching of the R Cam flood defences

- Review of SFRA modelling
    - Review of topography
    - Risk to Denny St Francis
    - Maintenance
- Opportunities for flood risk
- Constraints for flood risk
- Sustainability assessment

Key Agreements

- The proposed approach, as detailed above and in the workshop powerpoint slides, was agreed by the workshop stakeholders

Key Stakeholder Actions

- **EA (Ben Corne) to find out when the MOD flood defence review report will be available**
- **EA to provide details of Cam breach flood modelling (via MM's formal data request)**
- **EA to provide topographical survey information of the Cam river banks (via MM's formal data request)**

Ecology & Biodiversity

The ecology and biodiversity section of the Detailed Study report should in addition highlight the linkages to the Water Framework Directive; in particular in relation to the requirement for 'no deterioration'.

Strategies being implemented for the North West Cambridge development should be reviewed if possible.

The linkages between ecology and surface water management were again discussed.

Proposed Approach

- Local ecological features
    - Screening assessment
- On-site ecological features
    - Screening assessment
- Links to the Cambridgeshire Green Infrastructure Strategy
- Opportunities for ecology & biodiversity
    - In drainage strategy
    - In amenity
    - In collaboration with other groups
- Sustainability assessment

Key Agreements

- The proposed approach, as detailed above and in the workshop powerpoint slides, was agreed by the workshop stakeholders

Surface Water Management

The challenges relating to SWM should be raised in the Detailed Study; notably providing amenity value, summer resilience, flood attenuation and water quality protection.

The future SAB (SuDS Approval Body) needs to be considered and included in the report.

SuDS adoption should be discussed further. A recent meeting with the IDB and AWS highlighted the fact that the IDB may be open to this.

All improvements to the existing situation in relation to surface water management for both the residents of Waterbeach village and the IDB should be clearly stated. Where possible, this should be quantified.

Proposals for SuDS should follow CIRIA and Cambridgeshire County Council guidance; including standards for water quality, pollution control and WFD constraints.

It was agreed that there is significant potential for a new SWM system to bring improvements to the local area and that it would be important for such a strategy to be in place at the earliest stages of development.

Proposed Approach

- Review of geology
- Site run-off rates
- Review of existing DSF drainage strategy
- SuDS
  - Potential for SuDS
  - Adoption of SuDS
  - Opportunities and limitations
- Impact on IDB
- Sustainability assessment

Key Agreements

- The proposed approach, as detailed in the workshop powerpoint slides was agreed by the workshop stakeholders
- The WCS Detailed Report should clearly state any improvements to the existing SWM system that would occur as a result of the Denny St Francis development.

Key Stakeholder Actions

- **Cambridgeshire County Council (Nicholas Wyke/Sass Pledger) will provide examples of SuDS best practice.**

Wastewater & Water Quality

River Quality Planning (RQP) modelling was discussed, with the Agency advising as to the methodology to be adopted for the Detailed Study. Regarding the location of the Bottisham Lock sampling point in relation to the Waterbeach WRC discharge, it was commented that the influence of the Waterbeach WRC on water quality in the River Cam can be assumed to be minimal. The Agency offered to provide data to be used in the assessment, as detailed below.

Terminology should be carefully used within the report to prevent any misunderstandings. A glossary should be provided to mitigate this.

The issue of non-domestic usage was again raised as this not only impacts upon treatment volumes but also treatment methods (through water quality variation). SCDC offered to review how this was considered when Northstowe was being planned.

Proposed Approach

- Options for collection & treatment
  - Four options
  - Reviewed against practicalities, deliverability, sustainability and implications on cost
- Impacts on IDB system
- Water quality
  - Water quality of the R Cam
  - RQP modelling
  - Discharge consent conditions
- Treatment method options
- Sustainability assessment

Key Agreements

- The proposed approach, as detailed in the workshop powerpoint slides was agreed by the workshop stakeholders
- The four treatment options should be reduced to one, if possible, before undertaking detailed modelling work

Key Stakeholder Actions

- **EA (Steve Hopper) to provide upstream river flow statistics for use in the RQP modelling work**
- **EA (Steve Hopper) to provide details of the downstream water quality targets to be used for reviewing "no deterioration" and the ability to achieve good ecological potential.**
- **SCDC (Jonathan Dixon) to review the assumptions on non-domestic wastewater that were used for planning the development at Northstowe**

Other

SCDC submitted their Local Plan on 28th March 2014. Examination will likely be some time after July 2014.

GVA have been appointed development manager for Denny St Francis by Defence Estates. **SCDC (David Roberts) will send contact details of GVA to the MM project team.**

The Scoping Report should be sent to Waterbeach Parish Council by Mott MacDonald, with a summary of work to date and clarifying the main aims and objectives of the water cycle study being the development of a sustainable, improved water situation for the area.

The cumulative impact of other planned developments in the Waterbeach catchment must be considered in any quantitative assessment. **The SCDC will provide details of these developments to the project team.**

Next Steps

Draft Detailed Study report issued – Early May 2014

Workshop 3 – Thursday 8th May 2014

- Present and review the sustainability assessment of the water management options and future management issues.

- Review the proposals as part of the detailed report

Final Detailed Study report issued – June 2014

Waterbeach Denny St Francis Water Cycle Study

Summary of discussions from the third stakeholder workshop

Summary

The third and final Denny St Francis Water Cycle Study was held at South Cambridgeshire District Council's offices in Cambourne on Thursday 8th May 2014. Representatives of the following organisations were present:

- Rob Morris, Anglian Water (AW)
- Nicholas Wyke, Cambridgeshire County Council (CCC)
- Adam Ireland, Environment Agency (EA)
- Steve Hopper, Environment Agency (EA)
- Ben Corne, Environment Agency (EA)
- David Roberts, South Cambridgeshire District Council (SCDC)
- Andrew Newton, Waterbeach Internal Drainage Board (IDB)

Unfortunately, Cambridge Water Company (CWC) were unable to attend.

A summary of the key discussions is provided below.

Objectives of Workshop 2

The objectives of the third water cycle study workshop were to:

1. To agree the conclusions of the Detailed Study
2. To review the sustainability assessment
3. To highlight any outstanding issues to be addressed

Summary of Discussions

Sustainability Assessment

The sustainability assessment should additionally make reference to:

- Contamination; and
- Water quality.

Water Resources

The water resources chapter should clearly state that Cambridge Water can not plan for any less than 125 l/h/d when it comes to planning potable connections, for reasons of regulatory responsibility.

The option for capturing high flows from the River Cam was discussed and will be reviewed as a part of the Detailed Study report. A number of issues will need to be considered, including:

- Sustainability

- Responsibility (including legal)
- Cost and operation of a treatment works
- Limited benefit to flood risk due to relative volumes involved
- Storage requirements – timings, size, location. It was mentioned that there is a proposal for a rowing lake between Milton and Waterbeach.
- Benefits and/or related issues for the IDB

Anglian Water's non-domestic WRMP usage assumptions will be published next week and could be used as a reference source.

Non-potable system issues should be fully discussed, such as health risks (treatment and storage). Education of home owners would be essential.

Protected rights should also be reported e.g. existing licences on the Upper Mill Drain.

Flood Risk

A review of the SFRA flood risk modelling of a breach in the R Cam has shown that the existing model grid did not extend across the whole Denny St Francis site. Consideration is being given to extending the model to do this and running addition scenarios. The results of this work would likely form an addendum to the final Detailed Report.

The social, economic and environmental issues surrounding on-site vs off-site flood protection options were debated.

The implications for other local stakeholders were also discussed, including any downstream impacts of strategies (redirection of flood water elsewhere, betterments for Waterbeach village etc.).

The flood risk of locating a new WRC to the east of the railway line was discussed. It was noted that this critical infrastructure should be considered at an early stage of the masterplanning of the new town. The national policy on flood risk and essential infrastructure may dictate potential locations. Bunding or land level raising could be mitigation measures. A site-specific flood risk assessment would be required.

Groundwater flooding will need to be explicitly commented on.

Surface Water Management

If Denny St Francis limits discharge into IDB drains it will provide betterment for the IDB as under existing conditions the Barracks can currently contribute a large flow into its system.

If ecological benefits are to be incorporated into SUDS design, this must be considered at all times during the design process.

An example of a combined hard engineering, partial and full SUDS system is present in Northampton. It was reported that the full SUDS option (incorporating biodiversity into design) was selected from their cost-benefit analysis.

The pros and cons of land take should be considered – e.g. greater open space vs limiting land available for development. SUDS land take needs to be included in the land use budget for the new town.

The IDB will provide information on those locations in their network where they suffer from water stress during the irrigation season. They will also send indicative information on costs of retention ponds and maintenance.

Wastewater & Water Quality

The social benefits for existing residents of Waterbeach village that would come from closing Waterbeach WRC should be reported. The existing works could potentially be converted to a pumping station, if the topography necessitates.

The potential location of a new WRC will need to consider carbon/financial costs of pumping, land ownership and social implications (e.g. from noise, smell, visual etc). Locating the new works within the development should be included in the Water Cycle Study review for completeness (almost as a sub-option of extending Waterbeach WRC). A new works must not be seen from Denny Abbey for historical heritage reasons.

Preliminary discharge consent calculations for a new works have shown that the phosphate standard will likely be the tightest control on the discharge; although it was considered that the proposed value would be achievable within current processes. Ammonia and BOD will likely not be an issue. Treating to high qualities will have associated carbon costs (NB sustainability), but it would not impact upon the land take required.

Utilising sludge from the works for energy generation would not be feasible if the works were sized only for Denny St Francis and Waterbeach village.

Ecology & Biodiversity

There will need to be joined-up thinking in the setting of a strategy for ecology at Denny St Francis. Existing plans should be bought into, especially the Wicken Fen Vision. This joined-up thinking would potentially allow for a green infrastructure corridor to be opened up to the west of Cambridge.

Other

Solutions must be strategic and linked – not piecemeal.

The stakeholders agreed that signed letters were the most appropriate option for formal ‘sign-off’.

Appendix B. Development scenario calculations

Details of the development scenarios and calculations used in the Denny St Francis Water Cycle Study assessments are summarised below.

Assumptions were made regarding:

- Development construction,
- Property occupancy rates,
- Water demand rates; and
- Used water contribution rates

B.1 Development construction

B.1.1 Development size

The SCDC Local Plan states the proposed allocation for the development to be between 8,000 and 9,000, with the final allocation to be determined through an Area Action Plan (South Cambridgeshire District Council, July 2013).

As detailed in Section 1.3, RLW/DIO submitted representations supporting a development of between 9,000 and 10,000 dwellings (RLW Estates Ltd. & Defence Infrastructure Organisation, October 2013).

For the purposes of this Water Cycle Study, a development size of both 8,000 and 10,000 dwellings was considered:

1. 8,000 dwellings – SCDC lower (L) estimate
2. 10,000 dwellings – RLW higher (U) estimate

B.1.2 Land use schedule

A detailed land use schedule for Denny St Francis was provided by RLW Estates Ltd. A breakdown of the land use schedule, including area, can be seen in the below table (RLW Estates Ltd., September 2013).

Table B.1: RLW Estates Ltd's Denny St Francis land use schedule (3321_S201A, September 2013).

Land Use	Details	Area (ha)
Residential dwellings	9,942 units	237.29
Non-residential development	7 primary schools	16.1
	2 secondary schools	17.2
	2 park and ride	5.4
	Employment sites	26
	Strategic road infrastructure	15.4
	Leisure, community and energy centre	4
Mixed Use	District and local centres plus residential	10
Open Space	Retained habitat – grassland and woodland	36.8
	Retained habitat - waterbodies	7.29
	Sports pitches	38.97
	Open space	51.07
	SuDS	9.6
	Balancing ponds	5.6
Denny Abbey	Biodiversity compensation	47.13
	Heritage landscaping	49.8
Total		**577.65 ha**

Source: (RLW Estates Ltd., September 2013)

Whilst based on a domestic development size of 9,942 dwellings, the information provided on non-domestic activities at Denny St Francis has been applied to both the upper (U) and lower (L) domestic development scenarios outlined in Section B.1.1.

Information from the developers has indicated that approximately 9,440 jobs will be created at Denny St Francis. In addition, 3,500 primary school places and 2,500 secondary school places will be provided (RLW Estates Ltd., September 2013).

B.1.3 Development phasing

B.1.3.1 Construction start date

The SCDC Local Plan states a proposed start to housing delivery in 2026.

RLW Estates Ltd. propose a start date for development of 2021.

For the purposes of this Water Cycle Study, start dates of both 2021 and 2026 were considered:

1. 2021 – RWL proposed earlier start date
2. 2026 – SCDC Local Plan proposal

B.1.3.2 Construction rate

The SCDC Local Plan states that 1,400 houses would be built between 2026 and 2031. After this, it has been assumed that construction will continue at a rate of 400 houses per annum.

RLW Estates Ltd. propose 3,500 dwellings by 2031, continuing at 400 per annum thereafter.

No information is available as to the construction rate of non-domestic properties. Whilst an overly conservative assumption, it has been assumed that *all* non-domestic properties are constructed within the first year of development.

B.1.4 Development construction scenarios

The domestic construction scenarios therefore considered are shown in the below figure and table:

Figure B.1: Denny St Francis Water Cycle Study domestic property construction scenarios

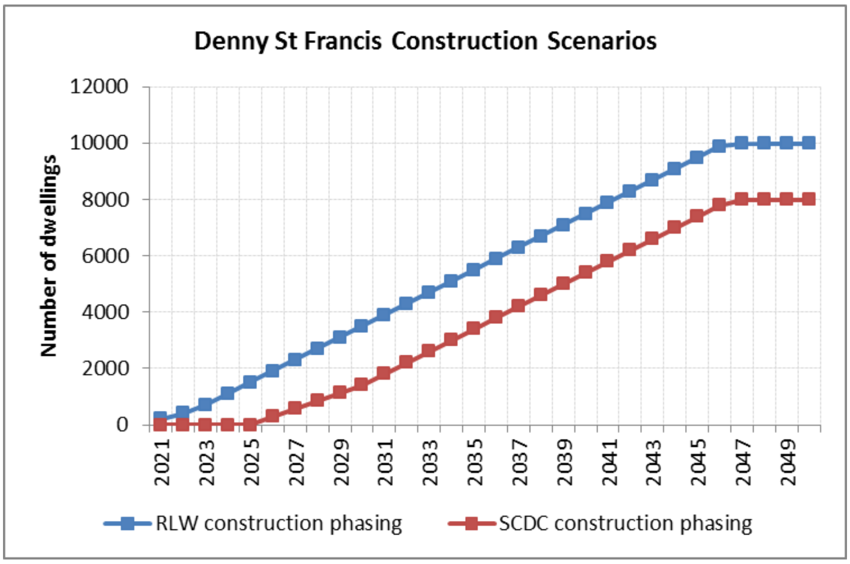


Table B.2: Domestic property construction scenarios

Year	Upper estimate (RLW Estates Ltd. proposal)	Lower estimate (SCDC proposal)
2021	200	-
2022	200	-
2023	300	-
2024	400	-
2025	400	-
2026	400	280
2027	400	280
2028	400	280
2029	400	280
2030	400	280
2031	400	400
2032	400	400
2033	400	400
2034	400	400
2035	400	400
2036	400	400
2037	400	400
2038	400	400
2039	400	400
2040	400	400
2041	400	400
2042	400	400
2043	400	400
2044	400	400
2045	400	400
2046	400	400
2047	100	200
TOTAL	**10,000 dwellings**	**8,000 dwellings**

For the purposes of the development scenario calculations (and as detailed in Section B.1.3.2), *all* non-domestic properties will be assumed to be constructed within the first year of development.

B.2 Occupancy rates

B.2.1 Domestic properties

Cambridge Water's demand forecasts in their revised draft Water Resources Management Plan (dWRMP) for new household properties was based on a domestic metered property occupancy rate 2.05 persons (Cambridge Water, March 2013). This was revised in their Statement of Response to the dWRMP consultation in November 2013 to 1.97 persons per property; on the basis of a forecast lower population growth from Local Authorities during the course of the planning period (Cambridge Water, November 2013). It was maintained at 1.97 in the Final WRMP (Cambridge Water, May 2014).

A domestic occupancy rate of 1.97 persons per household was used for the Denny St Francis water scenarios.

For the used water scenarios, however, a methodology based on the Anglian Water Design and Installation Guide was adopted (Anglian Water Services Ltd, 2008). As such, an occupancy rate of 2.1 has been applied to the used water scenarios.

B.2.2 Non-domestic properties

As the number of non-domestic properties at Denny St Francis is not known, occupancy rates cannot be applied. Instead, the number of jobs created has been used as the method for assessing development scenarios (as described in the following Sections).

B.3 Consumption rates of water

B.3.1 Domestic properties

The scenarios are based on a range of per capita consumption rates ranging from Cambridge Water's WRMP14 base year assumption of 131 l/h/d for metered existing homes (Cambridge Water, May 2014), to a more aspirational consumption rate of 80 l/h/d, depicted as Level 5/6 in the UK Government's Code for Sustainable Homes (Department for Communities and Local Government, December 2006):

1. Baseline: WRMP metered existing homes – 131 l/h/d
2. Building Regulations 2010: New dwellings – 125 l/h/d
3. Code for Sustainable Homes: Level 3/4 – 105 l/h/d
4. Code for Sustainable Homes: Level 5/6 – 80 l/h/d

B.3.2 Non-domestic properties

Cambridge Water's dWRMP used a metered non-domestic household consumption rate of 2,274 l/prop/d for demand forecasting (Cambridge Water, March 2013). The Final WRMP was based on a metered non-domestic household consumption rate of 2,341 l/prop/d (Cambridge Water, May 2014). The number of non-domestic properties at Denny St Francis, however, is not known at this stage.

The Plumbing Engineering Services Design Guide (Institute of Plumbing, 2002) is a widely used industry standard for estimating water demand for a range of building uses. The demand figures originate from a number of sources including BS 6700, the Chartered Institute of Building Services Engineers and Environment Agency studies (Institute of Plumbing, 2002).

Non-domestic consumption assessments undertaken for the Northstowe development for the Phase 1 planning application reported a typical industry standard commercial potable water demand of 50 l/p/d (WSP, February 2012). This is roughly in-line with the Institute of Plumbing consumption rates for offices and shops.

It is appreciated that non-domestic water demand can vary greatly depending on the industry. For the purposes of this Water Cycle Study, it is considered that a set 50 l/p/d can be adopted across all employment types, with the assumption that it would provide a suitable *average* quantification of employment demand.

The demand for water from education can also be assessed following the Institute of Plumbing methodology; with demand from primary schools estimated to be 15 l/h/d and at secondary schools 20 l/h/d (Institute of Plumbing, 2002).

B.4 Generation rates for used water

B.4.1 Domestic properties

As the key stakeholder for used water collection, treatment and disposal, the methods adopted by Anglian Water in the estimation of domestic used water generation from new developments has been used as the basis for the calculation of domestic used water consumption in this Water Cycle Study.

Following Anglian Water guidelines (Anglian Water Services Ltd, 2008) a set 145 l/h/d consumption rate is assumed for all new properties, regardless of the water efficiency measures proposed by the developers. This precautionary approach offers security against the under-development of assets and reflects an awareness of the lack of control that can be had over the longevity of efficiency measures at the individual house-level.

As such, for the purposes of this Water Cycle Study, a domestic used water flow rate of 145 l/h/d has been applied in *all* used water scenarios.

B.4.2 Non-domestic properties

Calculations undertaken for the foul water strategy for the North West Cambridge development applied the Sewers for Adoption (SfA) (7th Edition) design flows to non-domestic properties (Water UK, 2012). A domestic flow element of 0.6 l/s/ha was added to a set trade effluent design peak flow of 0.5 l/s/ha of industrial developments (Water UK, 2012).

As the number of predicted jobs and school places at Denny St Francis is known, a more accurate quantification can be adopted based on population numbers.

For the purposes of this Water Cycle Study, standard industry precautionary assumptions have been made on non-domestic used water flow rates, as per the British Water Code of Practice for Flows and Loads (British Water, 2009):

- Employment: 50 l/h/d
- Secondary school with canteen: 90 l/h/d
- Primary school with canteen: 90 l/h/d

B.5 Selected development scenarios

The development scenarios tested will incorporate a degree of sensitivity testing by investigating a range of per capita consumption rates against both the lower and upper construction estimates as described in Section B.1.4:

Table B.3: Development scenarios for water

Scenario	Construction phasing	Population (people) Domestic	Population (people) Non-domestic	Per Capita Consumption Domestic	Per Capita Consumption Non-domestic
Lower 1 (L1)	SCDC	15,760	15,440	131 l/h/d	15/20/50 l/h/d
Lower 2 (L2)				125 l/h/d	
Lower 3 (L3)				105 l/h/d	
Lower 4 (L4)				80 l/h/d	
Upper 1 (U1)	RLW	19,700		131 l/h/d	
Upper 2 (U2)				125 l/h/d	
Upper 3 (U3)				105 l/h/d	
Upper 4 (U4)				80 l/h/d	

Table B.4: Development scenarios for used water

Scenario	Construction phasing	Population (people) Domestic	Population (people) Non-domestic	Per Capita Contribution Domestic	Per Capita Contribution Non-domestic
Lower 1 (L1)	SCDC	15,760	15,440	145 l/h/d	50/90 l/h/d
Lower 2 (L2)					
Lower 3 (L3)					
Lower 4 (L4)					
Upper 1 (U1)	RLW	19,700			
Upper 2 (U2)					
Upper 3 (U3)					
Upper 4 (U4)					

The variations in the per capita contribution volumes from domestic and non-domestic properties between the water and used water scenarios are as a result of the requirement to consider peak values in used water assessment methodologies and industry standard methodology guidelines.

B.6 Development scenarios' water demand

B.6.1 Domestic Water Demand

The total water demand for each of the development scenarios is shown in Table B.5; based upon the following assumptions:

- Domestic property consumption rate of 1.97 persons per property (Section B.2.1).

Based on the predicted residential populations for the lower and upper scenarios, the baseline total residential water consumption at 131 l/h/d would be either **2.06 Ml/d or 2.58 Ml/d** (depending on the construction scenario adopted).

Adopting the Code for Sustainable Homes Level 5/6 requirement of only 80 l/h/d would require reducing total domestic water use at Denny St Francis to either **1.26 Ml/d or 1.58 Ml/d**.

Table B.5: Water consumption scenarios for domestic demand

Scenario	Population (dwellings)	Population (people)	Per capita consumption (l/h/d)	Total water demand (Ml/d)
Lower 1 (L1)	8,000	15,760	131	2.06
Lower 2 (L2)			125	1.97
Lower 3 (L3)			105	1.65
Lower 4 (L4)			80	1.26
Upper 1 (U1)	10,000	19,700	131	2.58
Upper 2 (U2)			125	2.46
Upper 3 (U3)			105	2.07
Upper 4 (U4)			80	1.58

B.6.2 Non-domestic water demand

As detailed in Section B.1.2, approximately 9,440 jobs will be created at Denny St Francis, along with 3,500 primary school places and 2,500 secondary school places (RLW Estates Ltd., September 2013). Basing assumed usage on figures from the Plumbing Engineering Services Design Guide (Institute of Plumbing, 2002) (as described in Section B.3.2), this would give a total estimated non-domestic water demand of **0.57 Ml/d** at the end of construction.

B.6.3 Total water demand

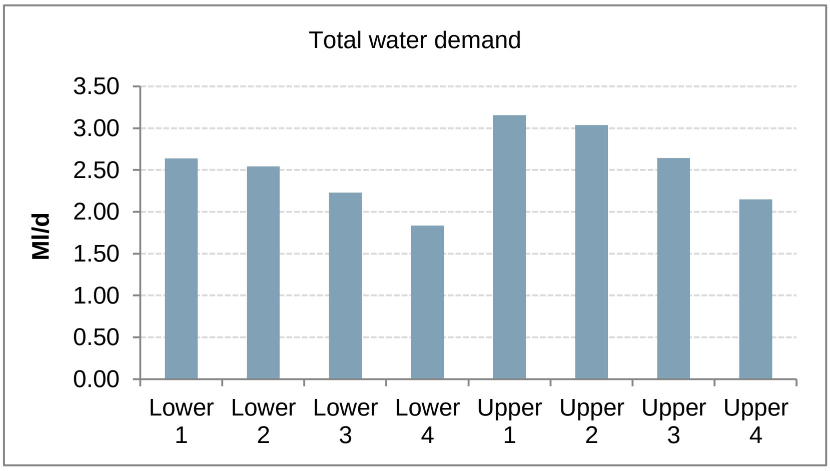
As the construction phasing of the employment and education non-domestic areas is unknown (Section B.1.3.2), the total non-domestic demand has been applied to each year of the construction scenarios; providing a worst-case estimate of the onset of water demand at the development.

Based on the above, total water demand at Denny St Francis can be estimated to range from **1.84 Ml/d to 3.16 Ml/d** at the end of construction.

Table B.6: Total water demand under development scenarios

Water scenario	2047
Lower 1 (L1)	2.64 Ml/d
Lower 2 (L2)	2.54 Ml/d
Lower 3 (L3)	2.23 Ml/d
Lower 4 (L4)	1.84 Ml/d
Upper 1 (U1)	3.16 Ml/d
Upper 2 (U2)	3.04 Ml/d
Upper 3 (U3)	2.64 Ml/d
Upper 4 (U4)	2.15 Ml/d

Figure B.2: Total water demand under development scenarios



B.7 Development scenarios' used water contribution

B.7.1 Domestic properties

The total used water generation of domestic properties for each of the development scenarios is based upon the following assumptions:

- Domestic property used water flow rate of 145 l/h/d (Section B.4.1).

Two scenarios for the number of residential dwellings were considered. For the lower scenario, the clean water development scenario occupancy rate of 1.97 was used (Section B.2). For the higher scenario, the Anglian Water Design Guide value of 2.1 was used (Section B.2) (Anglian Water Services Ltd, 2008). This covers the range of both potential development size and occupancy rates.

B.7.2 Non-domestic properties

The total used water generation for each of the development scenarios is based upon the following assumptions:

- 9,440 jobs at 50 l/h/d
- 2,500 secondary school places (with canteen) at 90 l/h/d
- 3,500 primary school places (with canteen) at 90 l/h/d (Section B.4.2).

B.7.3 Total used water contribution

As the construction phasing of the employment and education non-domestic areas is unknown (Section B.1.3.2), the total non-domestic used water generation has been applied to each year of the construction scenarios; providing a worst-case estimate of the onset of used water generation at the development.

Estimating the potential used water flows from Denny St Francis requiring treatment involves additional assumptions being made as to the percentage of used water reaching the sewer and infiltration. These are then applied to the standard water recycling centre flow calculation equation of $DWF = PG + I + E$, factored to account for the ratio of Dry Weather Flow to average flow [33]. The detailed methodology is given below.

[33] Where DWF = Dry Weather Flow, PG = Foul sewage flow, I = Infiltration and E = Trade

Per capita domestic sewage flow

It has been assumed that 100% of water consumption ends up in the sewer.

In line with Anglian Water methods, a domestic consumption rate of 145 l/h/d for domestic consumption.

For employees, a flow of 50l/h/d has been applied.

For schools, it has been assumed that canteen facilities will be present, so 90 l/h/d has therefore been used. This is based on the British Water Code of Practice – Flows and Loads 3 (British Water, 2009).

Dry weather infiltration

For Infiltration, the Anglian Water Design Guide has been followed; with infiltration set to 25% of foul flow.

Trade effluent

We have assumed that trade flow will be zero in the new development.

Dry Weather Flow

Dry Weather Flow is calculated using the following equation:

$DWF = PG + I + E$

where DWF = Dry Weather Flow, P = Population in catchment, G = per capita domestic sewage flow, I = Dry weather infiltration and E = Trade effluent.

Average Flow

For estimating average flow, the ratio for average to DWF has been taken as 1.25, as per the Anglian Water Design Guide (Anglian Water Services Ltd, 2008).

effluent.

Flow to Full Treatment

For Flow to Full Treatment (FFT), the following equation has been used:

3DWF = 3PG + I + 3E

where DWF = Dry Weather Flow, P = Population in catchment, G = per capita domestic sewage flow, I = Dry weather infiltration and E = Trade effluent.

Results

Table B.7 shows the relevant steps in the calculations of Dry Weather Flow, average flow and FFT of Denny St Francis under the different used water development scenarios.

Table B.7: Calculation of used water contribution from Denny St Francis under development scenarios.

Variable	Units	Lower scenario	Upper scenario
Housing			
Nr of dwellings		8,000	10,000
Occupancy rate		1.97	2.10
Population data			
Population - Resident		15,760	21,000
Population - Non Resident		-	-
Population domestic		15,760	21,000
Employees		9,440	9,440
Primary schools		3,500	3,500
Secondary schools		2,500	2,500
Total Population		31,200	36,440
Sewage Contribution			
Per capita consumption domestic	l/head/day	145	145
Percentage Water to Sewage		100%	100%
Domestic per capita sewage cntribution	l/head/day	145	145
Employees (no canteen)	l/head/day	50	50

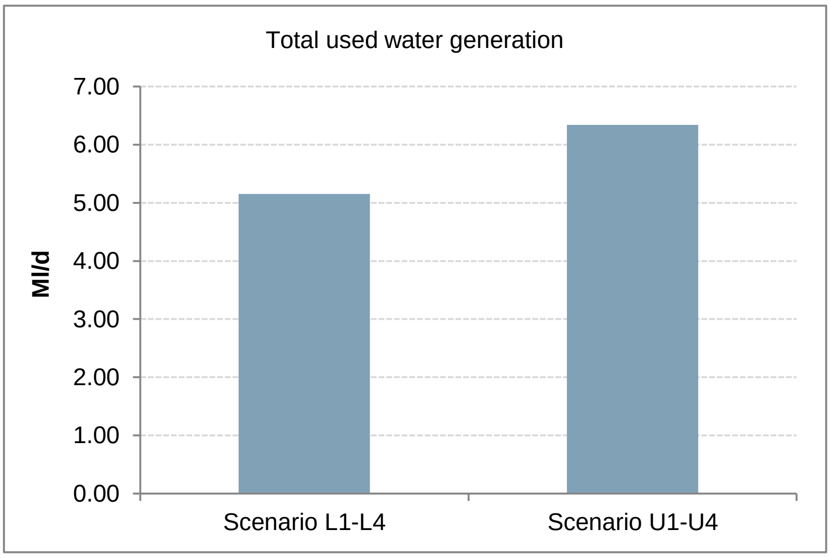
Variable	Units	Lower scenario	Upper scenario
Primary school with canteen	l/head/day	90	90
Secondary school with canteen	l/head/day	90	90
Domestic Foul Sewage Flow, PG			
	m³/day	3,297	4,057
Infiltration			
Infiltration Allowance	% Domestic Foul flow	25%	25%
Infiltration, I	m³/day	824	1,014
Trade Effluent			
Trade effluent flow to Sewer - E (m³/d)	m³/day	-	-
Tankered Flow to Works			
Cesspool flow - C (m³/d)	m³/day	-	-
Total Dry Weather Flow from Denny St Francis			
	m³/day	4,122	5,071
Average Flow from Denny St Francis			
ADF: DWF ratio		1.25	1.25
ADF	m³/day	5,152	6,339
Flow to Full Treatment from Denny St Francis			
3(PG+E)+I	m³/day	10,716	13,185

Based on the above, the average total used water from Denny St Francis requiring treatment can be estimated to range from **5.2 Ml/d to 6.4 Ml/d** at the end of construction.

Table B.8: Average total used water generation under development scenarios (Ml/d)

Used water scenario	2047
Lower 1 (L1)	5.15 Ml/d
Lower 2 (L2)	
Lower 3 (L3)	
Lower 4 (L4)	
Upper 1 (U1)	6.34 Ml/d
Upper 2 (U2)	
Upper 3 (U3)	
Upper 4 (U4)	

Figure B.3: Total used water generation under development scenarios



Appendix C. Hydrology

C.1 Water available for licensing

C.1.1 Environment Agency comments on fluvial abstraction

The following was received from the Environment Agency on 27th May 2014:

From: Chapman, Andrew [mailto:andrew.chapman@environment-agency.gov.uk]
Sent: 27 May 2014 18:34
To: Peaver, Louisa D
Cc: Ireland, Adam
Subject: RE: Abstraction of surface water at Denny St Francis

Would the Agency actually allow a new abstraction?

In principal the Agency would be able to licence a new abstraction in the area of the proposed Denny St Francis site either from the Cam or the Gt Ouse. However, the abstraction would only able to be licensed for periods of when there is an abundance of water in the system, usually during the winter. Unfortunately the conditions on any licence would prevent abstraction during the summer unless water levels far exceed those we would normally expect eg. during 2012.

What conditions might be applied to a new licence?

Our current Cam & Ely Ouse CAMS document outlines that the HOFs for each source would be fairly restrictive. A new licence from the Ouse would have a HOF based on the downstream critical assessment point which is Denver. The HOF would be set at Q32 which would equate to approximately 350 Ml/d. Unfortunately we do not have a gauging station in the area and so a monitoring site (level and/or flow) would have to be installed to keep a check on when the HOF is exceeded.

The less reliable option would be from the Cam, the HOF in this area downstream of the city would be set at Q22 which equates to approximately 330 Ml/d. Unfortunately we do not have a gauging station in this area either and so a monitoring site (level and/or flow) would have to be installed to keep a check on when the HOF is exceeded.

Do you have information on potential abstraction reliability/quantities/yields?

CAMS suggests that abstraction might be available for approx 116 days per year from the Ouse and only 80 days from the Cam. Our general rule for new abstraction is that the instantaneous pump rate should be no more than 10% of the HOF.

Ultimately I think the agency would be able to issue new licence(s) in the area that you are interested in but the restrictions and conditions that would be included would make them pretty unreliable to a point where they would not really be fit for purpose.

Andrew Chapman
Environment Planning Specialist
Integrated Environment Planning Team, Cambridgeshire and Bedfordshire Area

The following was received from the Environment Agency on 24th September 2014:

From: Chapman, Andrew [mailto:andrew.chapman@environment-agency.gov.uk]
Sent: 24 September 2014 16:58
To: Peaver, Louisa D
Subject: RE: Abstraction of surface water at Denny St Francis

Please find attached flow data taken from our Lode gauging station on Bottisham Lode/Quy Water. As this gauging station only monitors flow in one of the tributaries of the main river, the data should only be interpreted as illustrative/representational, but the location is much closer to the proposed development site.

I have included data from 01/01/2000 to present. The Q22 value taken over the same period is 335 litres per second, I have formatted the spreadsheet to flag the data red when it is equal to or below this value.

Hopefully this data will help your client's visualise the restrictions on new abstraction in the area. For example there would have been no abstraction allowed during the entire calendar year of 2011.

Andrew Chapman
Environment Planning Specialist
Integrated Environment Planning Team, Cambridgeshire and Bedfordshire Area

C.1.2 Flow reliability

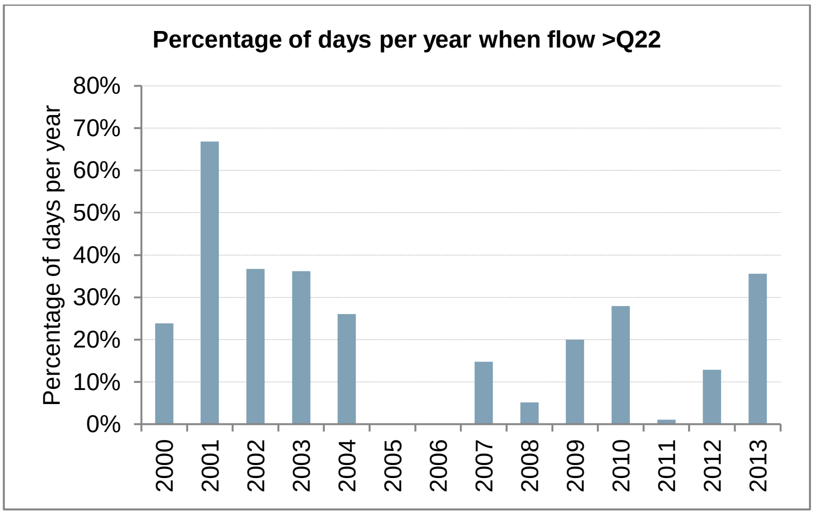
There is no operational gauging station at Waterbeach. Daily mean flow data for 2000-2013 was received from the Environment Agency for Quy Water at Lode[34]. As this gauging station only monitors flow in one of the tributaries of the main river, the data should be interpreted as illustrative and representational of the wider catchment conditions.

[34] Quy Water at Lode. Station number 33056. Daily mean flow data from 2000-2013, obtained from the Environment Agency, 24th September 2014. Section C.1.1.

A Q22 Hands off Flow (HOF) during the period 2000-2013 is equivalent to a flow of 335 l/s. An abstraction based on a HOF of Q22 would only have been allowed when flow in the river was above 335 l/s.

To illustrate annual variability, the flow data was assessed against its Q22 and the days on which abstraction would have been permitted reviewed. As shown in the table below, annual abstraction reliability varies greatly due to natural hydrological variability. During the drought years of 2005 and 2006, for example, the river did not reach above its Q22 and therefore abstraction would not have been possible in either of these calendar years.

Figure C.1: Illustration of annual abstraction reliability variability, Quy Water at Lode 2000-2013.



Source: Environment Agency, Quy Water at Lode. Station number 33056. 2005 included one day >335 l/s but this was considered an erroneous data point. 2003 reliability during Jan-Mar was estimated due to an incomplete data record.

Appendix D. Hydrogeology

D.1 Site conditions

D.1.1 Geological site conditions

The geological conceptualisation reported in the scoping phase of the project has been reviewed and updated, following comments received from the Environment Agency's formal review of the Scoping Report (Environment Agency, March 2014).

The proposed development site at Denny St Francis comprises strata of River Terrace Deposits, overlying Gault Clay, where present. In the central area of the development the Gault Clay is in outcrop, where the superficial deposits are absent (British Geological Survey, 1981).

The Gault Clay is underlain by the Woburn Sands Formation of the Lower Greensand Group. In the north western corner of the site the Gault Clay is absent and the Lower Greensand is unconfined; lying directly under the superficial deposits. It is likely that in the north western area of the site where the Gault Clay is present it will be relatively thin, dipping to the east, where it becomes progressively thicker.

The first and second groups of River Terrace Deposits are similar, consisting of waterlain well-bedded to rather poorly bedded, sandy flint and chalk gravels with a clay matrix.

The presence of Fenland Peat on the site is likely to be very limited. It slightly encroaches into the very north eastern margin and potentially the south eastern margin of the site.

The anticipated stratigraphical succession at the site is shown in Table D.1 below.

Table D.1: Anticipated Stratigraphical Succession at the Site

Geological Unit	Description	Likely Maximum Depth (m)
Made ground	Slightly sandy clay with gravels and brick fragments	0 to 0.9 mbgl
Peat	Organic rich, wet, brown humic deposits	Unknown
First Terrace Deposits	Waterlain, well-bedded to rather poorly bedded, sandy flint and chalk gravels, locally with a clay matrix	Up to 3.5 mbgl (on eastern side of site only)
Second Terrace Deposits	Waterlain, well-bedded to rather poorly bedded, sandy flint and chalk gravels, locally with a clay matrix	Up to 6.2 mbgl (on western side of site only)
Gault Clay	Grey clay or marl. The basal beds are commonly glauconitic, sandy and pebbly, with phosphatic nodules	Up to 25.5 mbgl
Lower Greensand	Fossiliferous brown to greenish-yellow glauconitic sandstones or unconsolidated pebbly sands	Proven to 31.9 mbgl

Source: (RLW Estates Ltd., July 2012)

D.1.2 Hydrogeological site conditions

The site slopes gently to the east and west, with the central area being the highest ground where the superficial deposits are absent. As such, water is likely to drain to the perimeter of the site, where the River Terrace Deposits are present with properties that could allow percolation and storage of infiltration water.

The underlying Lower Greensand is classified as a Principal Aquifer. The overlying Gault Clay, however, is considered to provide a degree of protection to this Principal Aquifer across the majority of the site, particularly the central and eastern parts (RLW Estates Ltd., July 2012).

The eastern and western peripheries of the site, where the River Terrace Deposits are present, comprise a Secondary A aquifer which has the potential storage to support local water supplies, with the overlying soils having an intermediate leaching potential (Environment Agency, November 2013). The groundwater vulnerability is assessed as being ‘Minor Aquifer Intermediate’ across the eastern and western parts of the site (Environment Agency, November 2013).

The central area of the site, underlain directly by the Gault (and possible reworked Gault deposits) is classified as Unproductive Strata.

To protect drinking water from pollution, the EA has designated groundwater Source Protection Zones (SPZ) around major groundwater abstraction points. The zones restrict the type of activities and development permitted within their boundaries to protect the groundwater reserves. The Environment Agency website indicates that the site is not located within a Source Protection Zone (Environment Agency, November 2013).

D.1.3 On-site groundwater levels

In 2002, ten cable percussive boreholes were drilled across the Denny St Francis site. In addition, eleven trial pits and three soil infiltration pits were excavated (A F Howland Associates, December 2002). The locations of these are shown in Figure D.1.

As indicated by the 2002 investigation and the 2009 Denny St Francis Drainage Strategy (RLW Estates Ltd., August 2012), in parts of the site the superficial deposits are permeated by relatively shallow groundwater.

Table D.2: Borehole depth and groundwater levels from the 2002 ground investigations.

	Ground level	Depth	Groundwater level	
Borehole	mAOD	mBGL	mBGL	mAOD
BH1	4.2	10.0	DRY	DRY
BH2	3.0	6.2	1.53	1.47
BH3	5.3	10.0	1.95	3.35
BH4	4.1	10.0	DRY	DRY
BH5	5.6	10.0	DRY	DRY
BH6	5.7	10.0	DRY	DRY
BH7	2.6	10.0	1.84	0.76
BH8	1.85	10.0	2.71	-0.86
BH9	4.5	10.0	DRY	DRY
BH10	2.8	10.0	DRY	DRY

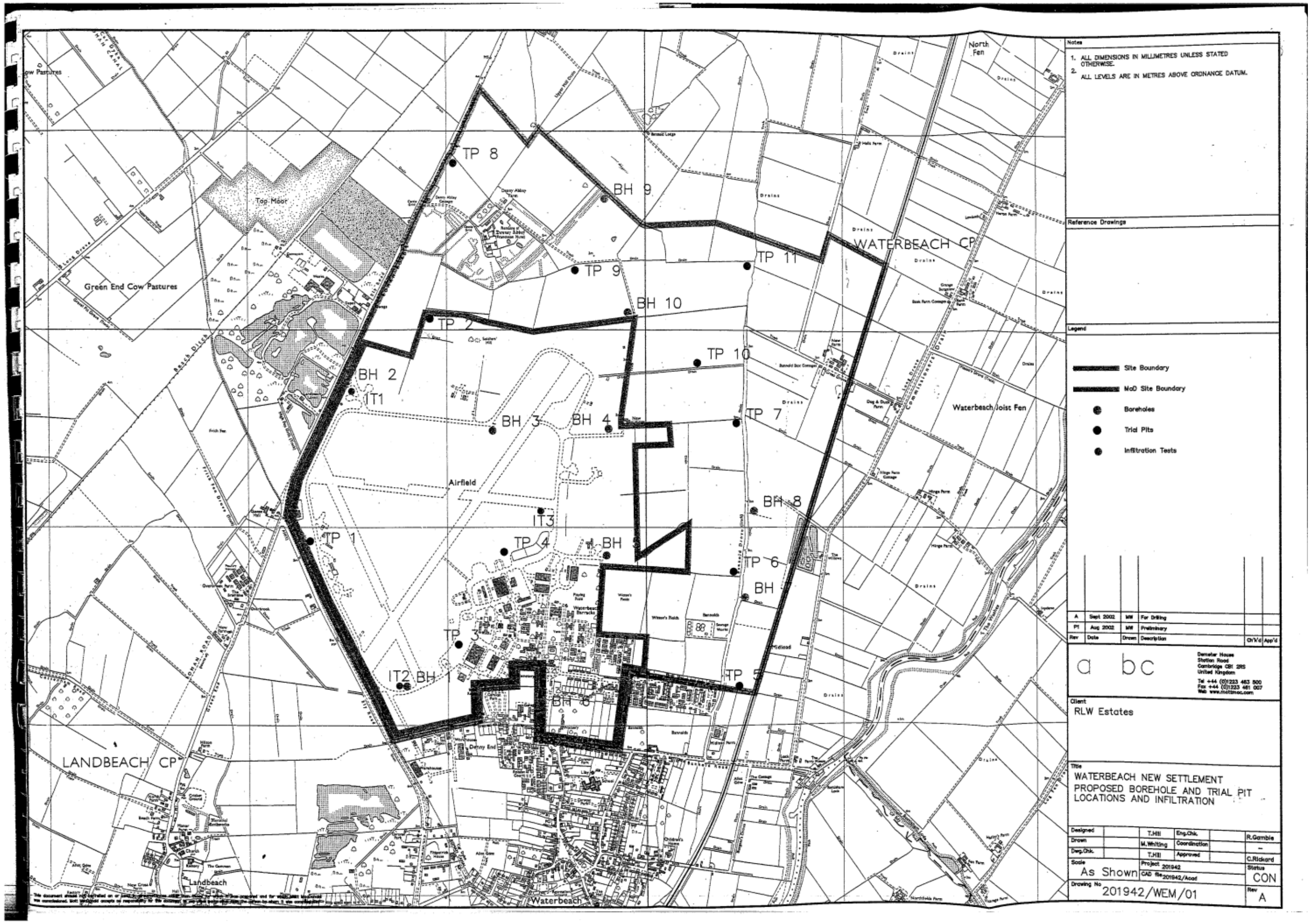
Source: (A F Howland Associates, December 2002)

D.1.4 Soil infiltration

The three soil infiltration tests undertaken in 2002 were located in the main airfield area of the site (Figure D.1). As groundwater was struck in each pit before reaching the required overall depth of 2.5 mBGL, the tests were unable to strictly accord to BRE Digest 365 procedures (A F Howland Associates, December 2002).

The pits rapidly filled with water to ground level. Left to drain overnight, additional infiltration tests were conducted with the observations indicating that the ground conditions at those points were not suitable for soakaways. In addition, the high groundwater table would limit the storage capacity in any soakaway chamber.

Figure D.1: Borehole, trial pit and infiltration test locations in the 2002 ground investigations (A F Howland Associates, December 2002).



D.1.5 Groundwater flooding

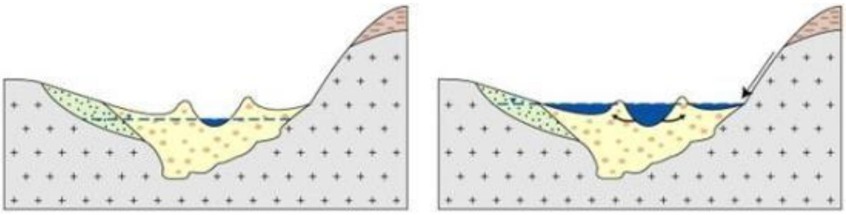
Groundwater flooding occurs when the subsurface becomes fully saturated and groundwater is unable to flow away into surface water drainage. Groundwater rises to the surface where it emerges as seepages and springs and can become ponded in depressions. Groundwater flooding generally takes longer to recede than surface water flooding.

The British Geological Survey (BGS) has a useful explanation of the main mechanisms of groundwater flooding. The description of flooding in a shallow unconsolidated sedimentary aquifer setting is pertinent to the Denny St Francis site, as at the site there are permeable gravel terrace deposits overlying the impermeable Gault Clay (see Section D.1.1).

Groundwater flooding is often associated with shallow unconsolidated sedimentary aquifers which overly non-aquifers. These aquifers are susceptible to flooding as the storage capacity is often limited, direct rainfall recharge can be relatively high and the sediments may be very permeable, creating a good hydraulic connection with adjacent river networks.

Groundwater levels are often close to the ground surface during much of the year. Intense rainfall can cause a rapid response in groundwater levels; rising river levels, as the upstream catchment responds to the rainfall, can create increased heads that drive water into the aquifer.

The use of soakaways for stormwater disposal /management can exacerbate the problem, producing a rapid rise in groundwater levels.



Groundwater flooding due to rising water table in a shallow unconsolidated sedimentary aquifer setting, from BGS
http://www.bgs.ac.uk/research/groundwater/flooding/unconsolidated.html accessed 18/05/2014

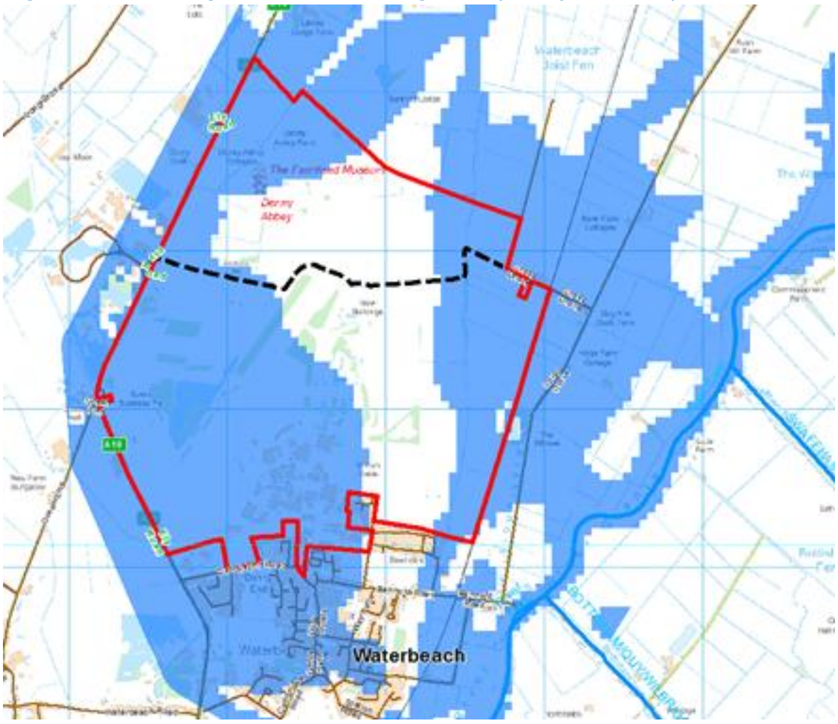
Natural levees and man-made structures can allow river levels to rise without breaking their banks; groundwater flooding will occur in low-lying areas beyond the banks, preceding any fluvial flooding and lengthening the overall period of flooding.

However, flooding in these systems can be relatively short-lived as rivers, returning to pre-flooding levels, quickly drain the highly permeable aquifer.

These hydrogeological settings often coincide with urban areas and it is clear that the role of groundwater in flooding needs to be addressed as the traditional engineered methods of flood protection may be circumvented by flow through the subsurface.

The BGS produces mapping indicating areas that are considered to be potentially susceptible to groundwater flooding. Consequentially, the available mapping for Denny St Francis (shown in Figure D.2 below) shows that, as described above, the gravel terrace deposits across the site are categorised as potentially susceptible to groundwater flooding.

Figure D.2: BGS groundwater flooding susceptibility zone map



Source: NERC, 2014. Contains Ordnance Survey data: Crown copyright and database right © 2014.

This mapping tool gives a high level indication of groundwater flooding on a wide geological scale. Information on site-specific conditions should then be used to refine these classifications.

The surface water levels around the Denny St Francis site and Waterbeach are artificially maintained through drainage by the IDB (see Section 7.3). Recent floods have shown that the site was protected from surface water flooding by the existing flood protection measures (see Figure 6.1) and no reports of groundwater flooding at this or other times are known about. Therefore, although the site falls within an area that is potentially susceptible to groundwater flooding, this seems unlikely if the existing pumping and drainage system is maintained and not overwhelmed by additional surface water. Groundwater in the superficial deposits would be expected to continue to drain to surface water drainage ditches and streams as it does currently.

D.2 Use of on-site groundwater for raw water abstraction

As detailed in the Scoping Study, the Cam and Ely Ouse Catchment Management Abstraction Strategy states that no water is available for licensing from the Greensand aquifer, on which Denny St Francis is located.

The eastern and western peripheries of the site, where the River Terrace Deposits are present, comprise a Secondary A aquifer. These deposits are 6.2m thick on the western side of the site and only up to 3.5m thick on the eastern side of the site (RLW Estates Ltd., July 2012).

Where Secondary aquifers lie within areas classed as ‘unproductive strata’, abstraction licensing applications will be treated on a case by case basis. However, they are more likely to follow the surface water strategy for the catchment subject to local conditions and impacts (Environment Agency, March 2013). This is the case for the Denny St Francis site.

As described in Section 5.5.1.1, there is minimal surface water available for licensing. Correspondence from the Environment Agency regarding the likelihood of authorising a groundwater abstraction at Denny St Francis is reproduced below.

D.2.1 Environment Agency comments on groundwater abstraction

The following was received from the Environment Agency on 9th May 2014:

From: Ireland, Adam [mailto:adam.ireland@environment-agency.gov.uk]
Sent: 09 May 2014 11:06
To: Peaver, Louisa D
Subject: Denny St Francis Water Cycle Study - Groundwater

<u>Groundwater</u>

The river terrace deposits are an expansive aquifer in the surrounding area, however they are less expansive directly beneath the Denny St Francis site. In addition, the superficial deposits are of limited thickness, roughly 1 – 5 metres thick. This could potentially affect the yield of abstraction, however that would entirely depend on what yield was wanted. We have no records of groundwater levels within the superficial deposits in the area, but usually the water table is relatively shallow (i.e. close to the surface, thus making most of the aquifer saturated).

There are currently no licensed abstractions, however we do have records of de-regulated abstractions close by. The volumes of these abstractions were small, hence why they were de-regulated. We do have a record of an abstraction very close by, however we cannot be sure whether it is taken from the river terrace sands and gravels, or whether it is from the Woburn Sands principal aquifer underlying it.

If developers wished to go ahead with the abstraction they would need to perform a '*water features survey*' to confirm whether there were any abstractions nearby that may be affected by their abstraction. This would include private abstractions of which records would be held by South Cambs DC.

There is a drain (Upper Mill Drain) that runs across the river terrace sands and gravels and it could be in hydraulic connectivity with the groundwater. There are several surface water abstractions from this drain, so the connectivity between this drain and the river terrace sands and gravels would need to be looked into. Otherwise we would have to err on the side of caution and assume they are in connectivity, which could potentially restrict the scope for (or prevent) any groundwater abstraction at Denny St Francis.

In order to proceed, the proponents of the site would have to show that any groundwater abstraction would not affect the Upper Mill drain or any of the abstractions sourced from it. Equally they would have to provide a report which would show that any abstraction from the Secondary A aquifer would not detrimentally affect or deteriorate the current status of the groundwater body. Due to the lack of data available from this groundwater source coupled with the thickness of the aquifer affecting the available yield, <u>it is unlikely</u> that we would be able to issue an abstraction licence from this source.

Adam Ireland

Principal Planning Advisor

Environment Agency, Bromholme Lane, Brampton, Huntingdon, PE28 4NE.

D.3 Use of on-site geology for raw water storage and recovery

Aquifer Storage and Recovery (ASR) is defined (by Pyne, 1995) as:

The storage of water in a suitable aquifer through a well during times when water is available, and recovery of the water from the same well during times when it is needed.

In contrast, other authors (Dillon and Pavelic, 1996) use the term more generally to describe using boreholes for any form of artificial recharge. Artificial Recharge (AR) includes any artificial recharge to an aquifer, be it via boreholes or recharge basins. It may be used strategically where an aquifer is already over-exploited (and where no further abstraction would be allowed without artificial recharge occurring) or where lack of recharge prevents it being utilised. In these cases, water could be abstracted from the wells that were used for injection or from wells or springs down-gradient of the injection wells. This would be described as a neutral water balance approach.

D.3.1 Site potential for Aquifer Storage and Recovery

It is unlikely that the River Terrace Deposits would be suitable for ASR due to a number of constraints; mainly that they are unlikely to fulfil the physical requirements generally considered necessary for ASR success.

The on-site River Terrace Deposits are described as sandy gravels of chalk and flints with a clay matrix (RLW Estates Ltd., July 2012). The clay matrix will reduce the transmissivity of the deposit making it difficult to get the water to infiltrate. Soil infiltration tests conducted in 2002 found that the ground was unsuitable for soakaway use due to the high water levels recorded in the River Terrace Deposits gravels. In addition, the thickness and lateral extent of the deposits are inadequate for storage of additional water.

Confined, granular aquifers are generally considered to provide the most suitable hosts for ASR. The Lower Greensand (underlying the Gault Clay) is considered to have good potential for ASR (BGS / EA 1998). Binnie and Partners (1982) reported on the Lower Greensand of the Leighton Buzzard and Ely area and found AR to be a practical proposition. However, they suggested the Ousel and Ivel rivers as sources, which is inappropriate for the Denny St Francis site, although the River Cam may be suitable.

General risks associated with ASR include:

- lack of reliable source water
- poor recovery efficiency
- borehole clogging
- lack of existing knowledge of properties of, yields, and variability of marginal and deep aquifers suitable for ASR
- contamination issues
- high financial outlay before feasibility of ASR can be established
- lack of understanding of operational issues
- licencing complications related to requirements for variable licence and lack of Environment Agency experience in type of licence

Other considerations include:

- The Lower Greensand is classed as a Principal Aquifer. It is likely that the Environment Agency would require that any water proposed for injection would have to be of potable quality or at least chemically match the native water. This would have significant implications for cost.
- To establish the suitability of an aquifer and site for ASR, various factors would need to be investigated including:
  - aquifer thickness and areal extent,
  - hydraulic properties,
  - piezometric surface elevation,
  - local hydraulic gradient and groundwater velocity,
  - geochemical compatibility of recharge and native water with host rock and native water quality,
  - existing groundwater abstraction in the area.
- An ASR scheme would need a treatments works, for the injected and abstracted water.
- The volume of water available for recharge needs to be considered carefully and accurately. Average volumes are not useful as they mask underlying trends and seasonal influences.
- ASR investigations will be lengthy and require several phases of investigation, exploratory borehole drilling and cycles of testing and monitoring before it is clear whether or not a scheme would be feasible.

Anglian Water have previously investigated the possibility of ASR within its supply zone and has cited perceived problems with borehole clogging and problems with obtaining adequate water for injection as reasons not to undertake further feasibility studies.

Appendix E. Calculations for rainwater harvesting

The Cambridge Water Cycle Study calculated rainwater harvesting to potentially contribute 8.3 to 16.5 l/h/d to properties in the Cambridge area. Their calculations were based on the monthly rainfall record from the Cambridge University Botanic Gardens from 2000 to 2009.

The assessment was based on a standard usage of both 105 l/h/d (CfSH Level 3/4) and 94 l/h/d (CfSH Level 3/4 plus additional efficiency measures, see Table 5.2). A standard occupancy rate of 2.16 was used, along with a runoff coefficient of 90% and a filter coefficient of 90%. Two household tank sizes were tested – 600 l and 1,200 l. The results are reproduced below.

Table E.1: Use of rainwater harvesting to meet CfSH Level 5/6 as reported in the Cambridge Water Cycle Study

Average roof area (m^2)	Tank size (litres)	Baseline demand prior to RWH (l/h/d)	Saving per person (l/h/d)	Average consumption over 10 year period (l/h/d)
25	600	105	8.3	96.7
		94.1		85.8
50	1,200	105	16.5	88.5
		94.1		77.6

Source: (Cambridgeshire Horizons, July 2011)

The Northstowe Water Conservation Strategy reported similar findings, stating that a rainwater system could typically contribute a volume of 14 l/h/d[35] (Northstowe, February 2012). Their calculations are reproduced in Table E.2 and were based on an annual rainfall of 550 mm, a standard usage of 105 l/h/d, a runoff coefficient of 90% and a filter coefficient of 90%.

[35] Based on a 2 bedroom home with an occupancy rate of 3.

Table E.2: Indicative estimates of rainwater collection volume from the Northstowe Water Conservation Strategy

Number of occupants	Total consumption	Roof area	Storage tank size	Potable water saving per person		Consumption with rainwater harvesting
	l/day	m^2	m^2	%	l/day	l/h/day
1	105	13	0.44	14	15.4	90
1	105	10	0.44	11	12.1	93
1	105	25	0.88	28	30.8	74
2	210	25	0.88	14	15.4	97
3	315	25	1.32	9	9.9	102
4	420	25	1.76	7	7.7	100
1	105	50	1.32	52	57.2	48
2	210	50	1.76	28	30.8	90
3	315	50	1.32	18	19.8	98
4	420	50	1.76	14	15.4	101

Source: (Northstowe, February 2012, p. 28)

Table E.2 shows how the contribution that rainwater harvesting can make to per capita demand can vary considerably, depending upon a number of factors including rainfall depths, roofed area and occupancy rates.

Appendix F. River Cam flood defence breach review

F.1 Background

In 2012 a Flood Risk Assessment (FRA) was carried out by Mott MacDonald for a proposed development at Waterbeach Barracks, known as Denny St Francis (RLW Estates Ltd., August 2012). The development boundary is shown on Figure 1.1. The FRA drew on outputs from the 2010 South Cambridgeshire Strategic Flood Risk Assessment modelling work conducted by JBA, including flood defence breach modelling for the River Cam. The Environment Agency has shown concern that the locations of the breaches that were included in the model were not at the “worst-case” locations for Denny St Francis, and that basing conclusions on that work may be underestimating the risk to the development.

The 2010 TUFLOW model was obtained from the Environment Agency and reviewed. TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as those which occur from floods and tides.

F.2 2010 Strategic Flood Risk Assessment model

The Strategic Flood Risk Assessment (SFRA) model included a number of breach locations along the River Cam, as shown in Figure F.1. It is considered that the breach locations are suitable for determining the impact of a breach at the site of Denny St Francis. The breach locations are suitably spaced apart along the watercourse of the River Cam which flows from south to north, to the east of the development site. Breach 2e is located 600 m from the south east corner of the site, breach 3e is located 1100 m from the eastern edge of the site and breach 4e is located 1500 m from the north east corner of the site. These are appropriate spacings to ensure that the risk of flooding to the Denny St Francis site from breaching of the defences is fully considered.

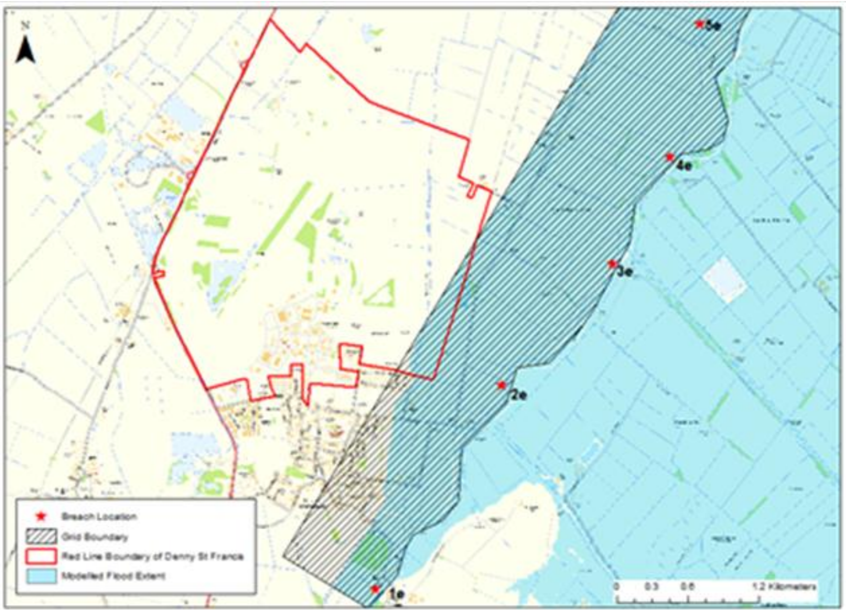
The “worst-case” breach scenario modelled was the 1 in 1000 year plus climate change, with the breach opening for 72 hours, and a 40m breach width. The standard modelled breach duration recommended by the Environment Agency for a fluvial breach, however, is 36 hours.

The breach was simulated once the river channel reached bank full. Due to the use of a Head-Time boundary to simulate the inflow of water, extracted from the River Cam model, there is an assumption that the breach doesn’t have an impact on the level of water in the channel (e.g. even with the breach there is a continued supply of water to keep the channel full). Therefore the maximum flood extent may be an overestimate due to the very conservative assessment of the hydrology used. It is therefore considered that this is very much a “worst-case” breach scenario.

The model results showed that the south-east corner of the site is at risk from a breach in the River Cam flood defences (Figure F.1). However, it was found that the modelled extent is restricted by the extent of the TUFLOW grid used in the SFRA model, and therefore there is the potential for a larger area of the site to be at risk (Figure F.1).

There is also a railway embankment which runs to the east of the Denny St Francis site, between the site and the River Cam. This railway embankment has not been represented in the breach model and there is the potential for the embankment to provide protection to the lower elevations of the site which may be at risk; however culverts in the embankment would provide flow paths for some of the floodwaters. The railway embankments and culverts are not represented in the JBA model.

Figure F.1: 2010 SFRA: Breach locations, model extent and modelled inundation from a 1 in 1000 year plus climate change 72 hour scenario



F.3 Development of an improved breach scenario model

An updated breach model was developed, which extended the 2010 SFRA model's TUFLOW grid and included z-lines to represent the railway and other embankments on the floodplain. ESTRY units have been included in the model to represent the culverts underneath the railway embankment[36]. Table E.1 below details the updates made to the original SFRA model.

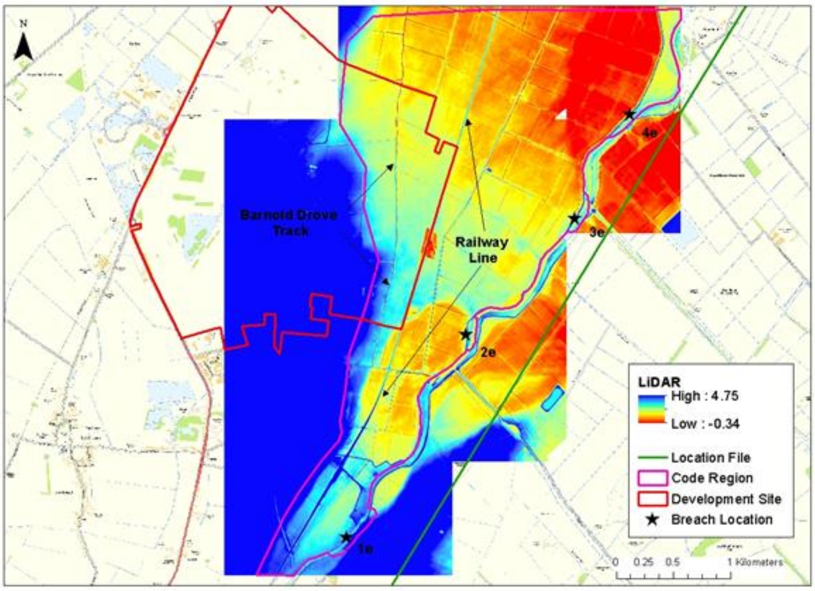
Table F.1: TUFLOW model updates

Updates	JBA 2010 Model	Mott MacDonald 2014 Model
LiDAR Data	2m grid size LiDAR data for the majority of the study area, and SAR data where the LiDAR coverage was incomplete.	1m grid size LiDAR data for the majority of the study area, and 2m grid size LiDAR data where the 1m LiDAR coverage was incomplete.
Model Extent	Limited by the code region.	Model extent extended to ensure the flood extent is not limited by the code region, with appropriate boundary conditions added to allow flow to leave the model to prevent glass walling and artificial ponding of water
Railway, Road and Drainage Ditch Embankments	No z-lines included to represent features on the floodplains.	z-lines included to represent the railway and other embankments on the floodplain.
Culverts	No culverts included	Culverts represented using ESTRY

Detail of the local topography was used to determine the appropriate model extent in order to ensure that the full extent of flooding due to the breach is captured. Figure F.2 below shows the location of the model boundary (code region) as well as the location file used to determine the orientation of the model grid.

[36] The locations of these were confirmed on a site visit conducted with National Rail in June 2014.

Figure F.2: Revised TUFLOW model extent and updated LiDAR topography data



The topography analysis shows that the western area of the site is above 4 mAOD and is higher than the east of the site. Low lying areas are found to the east of Barnold Drove track, with the lowest area of land in the north eastern corner.

F.4 Breach risk scenario testing

F.4.1 Objectives

The objective of the updated breach model was to determine the risk of flooding at the proposed Denny St Francis site from a breach in the River Cam flood defences under a 1 in 100 year plus climate change flood event; the event against which mitigation should be provided as stated Policy CC/9 in the South Cambridgeshire Local Plan (South Cambridgeshire District Council, July 2013).

The standard modelled breach duration recommended by the Environment Agency for a fluvial breach is 36 hours, and it is therefore recommended to mitigate against the 36 hour breach scenario 1 in 100 year plus climate change event and the key objective of the breach scenario model testing was to understand risk from this event.

F.4.2 Scenarios

Under the 1 in 100 year plus climate change flood event, four breach locations that were used in the SFRA model were tested under a 36 hour scenario – the standard modelled breach duration recommended by the Environment Agency for a fluvial breach.

Whilst not required for planning purposes, a more extreme scenario was also tested at each breach location – a 72 hour breach during 1 in 1000 year plus climate change flood event. The results are reported here for completeness. A full description of all the scenarios tested is reported in the 2014 Breach Modelling Report (RLW Estates Ltd., August 2014), with a summary provided below.

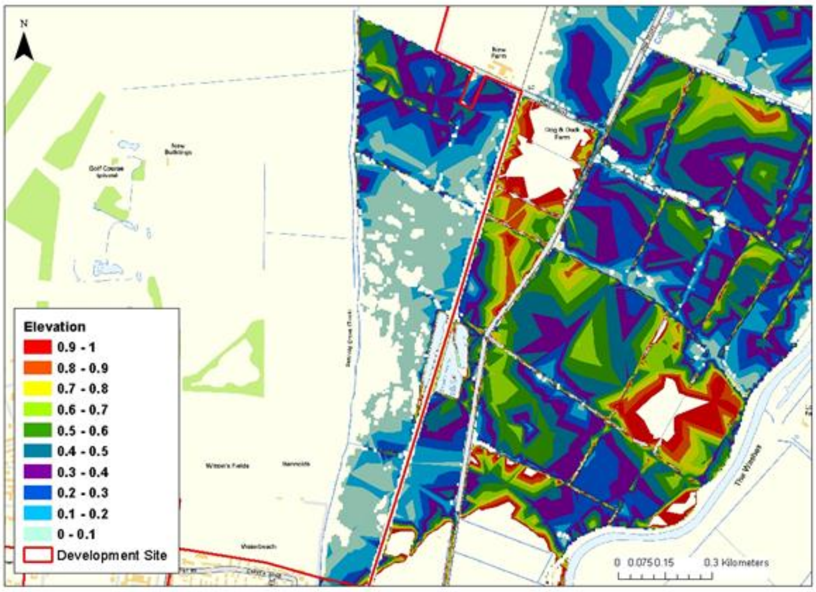
F.4.3 Results

The key result from the modelling was that the eastern side of the site could be at risk from a breach in the western bank of the River Cam at location '2e', if a 36 hour breach to occur under a 1 in 100 year plus climate change flood event were.

The modelling found that that the Denny St Francis site is at risk of flooding from a breach at only one of the tested locations (location '2e'). It was also noted that the duration of the breach for this magnitude event has an effect on the extent and depth of flooding, due to the occurrence of a second peak during the flood.

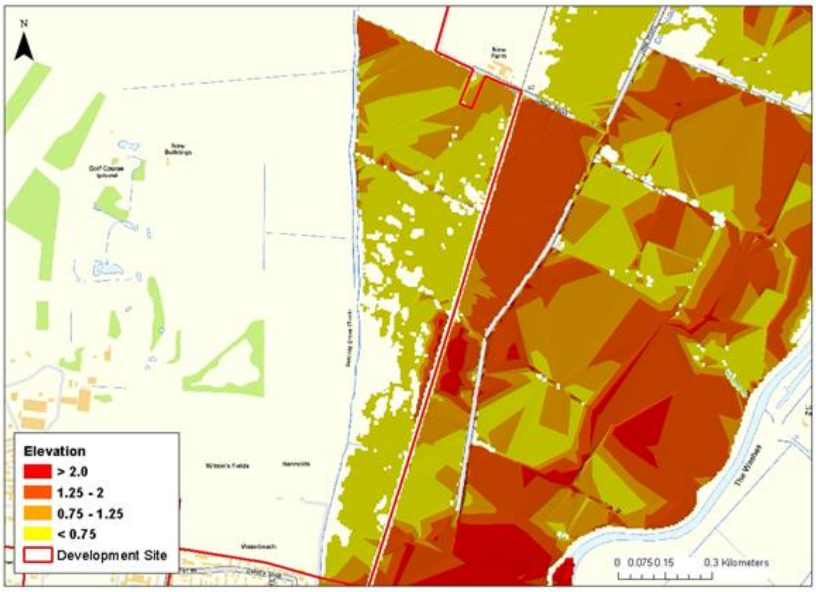
As shown in Figure F.3, the area of land towards the east of the proposed development site is at risk from a breach at location '2e'. It can be seen that generally the depth of flooding is shallow; less than 0.2m. Towards the north of the site, where ground levels are lower, the depths are greater with depths of up to 0.7m possible here. Floodwater is clearly being restricted by the embanked road that runs through the site and the extent of flooding may increase if the embankment is altered.

Figure F.3: Breach 2e flood extent and depth under a 1 in 100 year plus climate change 36 hour scenario



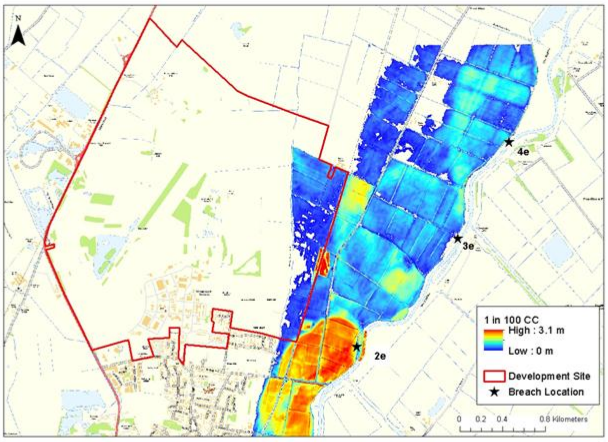
From these results a hazard map was created (Figure F.4) that showed that the majority of the site has a hazard rating of less than 0.75, which is a “low” hazard meaning “Caution: flood zone with shallow flowing water or deep standing water.” Towards the north of the site, where flood depths are greater, the hazard rating increases up to 2.0, which is a “significant” meaning “Danger: flood zone with deep fast flowing water”.

Figure F.4: Breach 2e Hazard Map: 1 in 100 year plus climate change 36 hour scenario



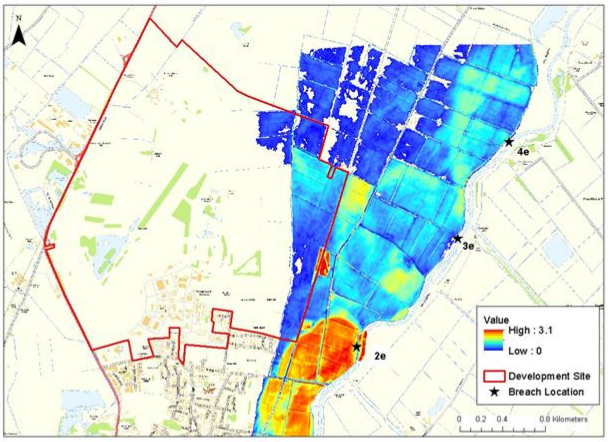
Further tests were run under 1 in 1000 year plus climate change flows and a longer duration breach event. The findings of these scenarios were reported in the full Breach Modelling report (RLW Estates Ltd., August 2014) and are not of significance for planning purposes. It can, however, be noted here that it had a limited impact on the inundation area beyond the 1 in 100 year plus climate change extent, and was predominantly the north eastern-most corner of the site that was effected. This is shown in the two figures below.

Figure F.5: Breach 2e flood extent and depth under a 1 in 100 year plus climate change 36 hour scenario



Source: Contains Ordnance Survey data Crown copyright and database right © 2014

Figure F.6: Breach 2e flood extent and depth under a 1 in 1000 year plus climate change 72 hour scenario



Source: Contains Ordnance Survey data Crown copyright and database right © 2014

F.5 Breach risk mitigation testing

In line with the Land Use Vulnerability Classification table in the NPPF Technical Guidance (Department for Communities and Local Government, 2012), the northern area of the Denny St Francis site is currently designated as “open space” in the Development Framework. Some built development, in the form of commercial and residential development, is proposed in the southern areas of the site where water levels from a beach in the flood defence would be generally less than 0.2m, and the hazard associated with this event is very low.

Residential development in this area could be raised above 2.6mAOD – the peak flood level for a 36 hour breach during the 1 in 100 year plus climate change event.

Alternatively, a flood bund could be constructed around the area proposed for residential development, to mitigate the residual flood risk. The potential location of a flood bund is shown in Figure F.7.

The consequential impacts of constructing this bund on the surrounding area were tested by the model, by investigating the impacts on the flood extent and depths from a 36 hour breach at location 2e during the 1 in 100 year plus climate change flood event. It was found that by displacing the floodwater, the depth of flooding would increase between the flood bund and the railway line to the east, as flood waters are restricted by the railway embankment and the bund and would cause the water to pond. The extent of flooding would increase marginally.

In order to mitigate this increase in flood depth, a “volume-for-volume” floodplain compensation storage area could be constructed.

The volume of floodwater inundating the residential area due to a 36 hour breach at location 2e during the 1 in 100 year plus climate change flood event, prior to the construction of a flood bund, is approximately 45,400 m^3. The area designated for floodplain compensatory storage (as shown in Figure F.8) has a footprint of approximately 163,600 m^3. If this area were to be lowered by 0.3 m this would provide a compensatory flood storage volume of 49,080 m^3[37]. This area of land was selected as it is outside of the proposed development area, but is land under the control of the developer. It is also within the breach flood extent, so it is possible for floodwater to flow freely into the storage area.

This floodplain compensation storage area was included in the breach model along with the flood bund. Providing compensatory storage in this location would prevent flood depths from increasing towards the extreme south of the site, but would have little effect elsewhere (see Figure F.8). This is because the compensation area is located to the east of the railway embankment. Flood waters from Breach 2e flow in a north westerly direction across the floodplain, and then back up behind the railway embankment. As backing up occurs some floodwater will flow underneath the railway embankment through the culverts, inundating the Denny St Francis site, but the majority of the floodwaters continue to flow north. The construction of the flood storage area would result in the storage area filling, but then floodwaters continuing to back up behind the railway embankment and flow through the culverts, which are the primary control on the volume of water reaching the development site. The flood storage area will slightly decrease the volume of flood water then flowing north; however, due to the mechanism of flooding via the culverts, it has little impact on the overall depth of flooding on the site.

The modelling indicates that there could be an off-site impact to existing development to the north east of the Denny St Francis site, with a potential increase in flood depth with the bund in situ. This would need

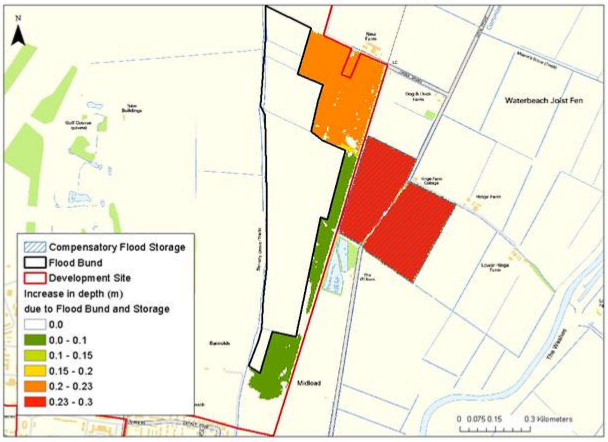
[37] This could also potentially provide soil for land raising of the residential areas, dependent upon the nature of the material.

to be mitigated against, with the bund potentially extended to incorporate this area.

Figure F.7: Impact of the construction of a flood bund on the flood depth from the 1 in 100 year plus Climate Change 36 hour breach scenario at breach location 2e.

Source: Contains Ordnance Survey data Crown copyright and database right © 2014

Figure F.8: Impact of the construction of a flood bund and compensatory flood storage on the flood depth from the 1 in 100 year plus Climate Change 36 hour breach scenario at breach location 2e.



Source: Contains Ordnance Survey data Crown copyright and database right © 2014

F.6 Conclusions

The detailed breach modelling carried out indicated that the Denny St Francis site is not at risk from a breach at location 1e, 3e or 4e during a 1 in 100 year plus climate change flood event (RLW Estates Ltd., August 2014).

A breach in the River Cam flood defences at location 2e would cause flooding along the eastern boundary of the Denny St Francis site during the 1 in 100 year plus climate change event. Floodwater is being restricted by the existing embanked road that runs through the site. It is recommended that this embankment is retained as part of the development proposals.

During the 36 hour breach scenario for the 1 in 100 plus climate change event the depth of flooding at the Denny St Francis site is generally less than 0.2m. Towards the north of the site, where ground levels are lower, the depths are greater. Depths up to 0.7m may be expected here.

In line with the Land Use Vulnerability Classification table in the NPPF Technical Guidance (Department for Communities and Local Government , 2012), the northern area of the Denny St Francis site is currently designated as open space in the Development Framework. Some built development, in the form of commercial and residential development is proposed in the southern areas of the site where water levels from a beach in the flood defence are generally less than 0.2m, and the hazard associated with this event is very low. It is recommended that residential development in this area is raised above the peak flood level for a breach during the 1 in 100 year plus climate change event of 2.6mAOD.

If a flood bund were to be constructed around the residential area at residual risk, the depth of flooding between the flood bund and the railway line would increase. This may not be a cause for concern since almost all the area involved is currently designated for recreational uses, and would therefore not be significantly impacted by a small increase in flood depth. There is a small rectangle of land, close to New Farm to the north east of the area concerned, which is outside of the development boundary. If necessary it would be possible to protect this with additional bunding.

The breach assessment analysis is very conservative in terms of the modelling assumptions used to develop the model, and therefore the results are considered to be ‘worst case’. Raising the finished floor level of residential dwellings above the 1 in 100 year plus climate change event during a breach at the critical location on the River Cam would protect all vulnerable land uses on the Denny St Francis site from the effects of a failure of the existing flood defences on the River Cam in line with NPPF Technical Guidance (Department for Communities and Local Government, 2012).

Appendix G. River Cam water quality analysis

G.1 Current environmental context

The current WFD status of the River Cam has been reported in Section 8.4.2, Table 8.5.

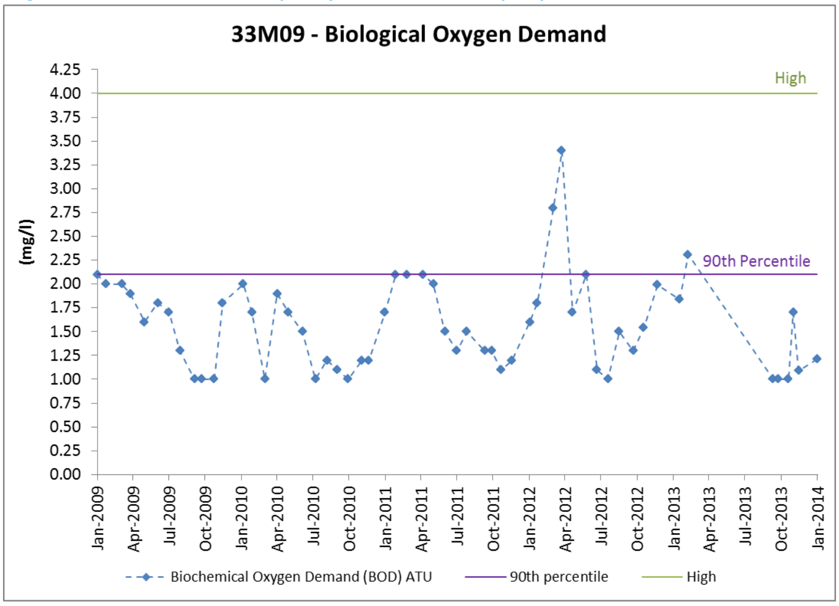
Water quality information was obtained from the Environment Agency under data request CCC/2014/19630. Water quality data was monitored approximately once monthly between January 2009 and January 2014.

A summary of the existing conditions can be found in the Sections below. Water quality data has been reviewed against the UK Environmental Standards and Conditions for the relevant parameter from the UK Technical Advisory Group (UK TAG) on the Water Framework Directive (WFD UK TAG, April 2008) and statistical variance has been assessed. Maximum values for UK Environmental Standards are illustrated in the figures.

G.1.1 Biological Oxygen Demand

The mean BOD and one standard deviation for monitored results is 1.57 ± 0.49 mg/l. Peak concentrations generally occur in March, with minimum concentrations in October -November. Monitoring results have been compared to the UKTAG Biological Oxygen Demand (BOD) standard for lowland and high alkalinity non salmonoid rivers based on the 90th percentile of the data. All BOD levels measured throughout the monitoring period are lower than the maximum limit for the high standard.

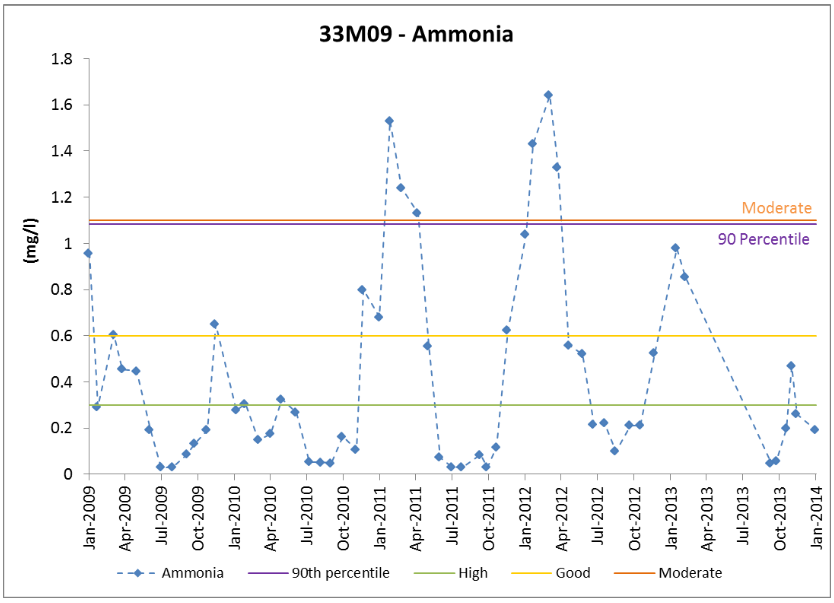
Figure G.1: BOD water quality data from sample point 33M09



G.1.2 Ammonia

The mean ammonia concentration and one standard deviation is 0.43 ± 0.43 mg/l. However the 90th percentile is far higher (1.085 mg/l) and based on this the river water quality falls within the UKTAG moderate standard based on the classification of the River Cam as a lowland and high alkalinity non salmonoid river. Major peak concentrations occur between January-March and exceed the moderate standard. Minimum ammonia concentrations occur between August -October.

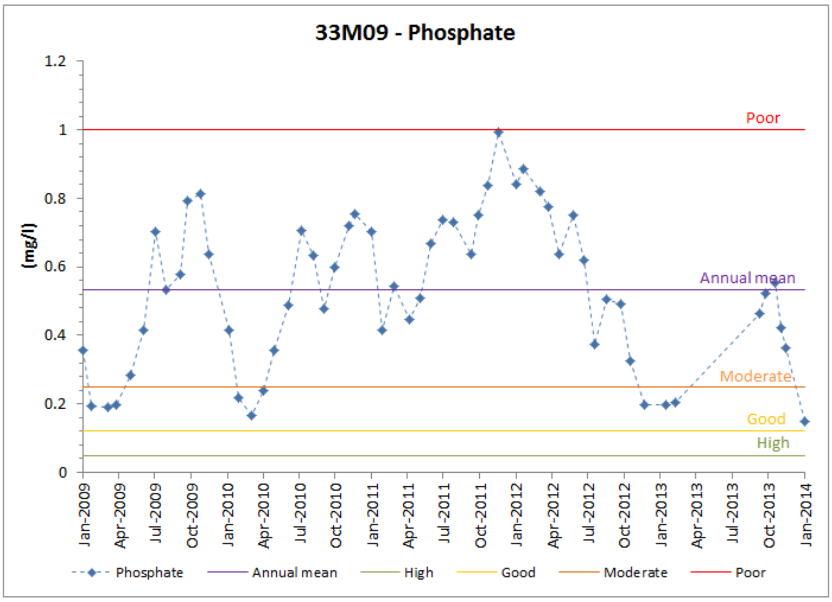
Figure G.2: Ammonia water quality data from sample point 33M09



G.1.3 Phosphate

The mean phosphate concentration and one standard deviation is 0.53 ± 0.22 mg/l. Peak concentrations occur in October-November, with minimum concentrations occurring between January-March. UKTAG standards for nutrients are based on annual mean concentrations and vary according to the river typology. The River Cam falls within the type 3n, based on annual mean alkalinity >50 mg/l $CaCO_3$ and altitude < 80 mAOD. Based on annual phosphate concentrations the River Cam falls into the poor UKTAG standard classification.

Figure G.3: Phosphate water quality data from sample point 33M09



G.2 The River Quality Planning model

G.2.1 Background

The Environment Agency's River Quality Planning (RQP) tool is a Monte-Carlo simulation mass balance model developed by the EA.

For the purposes of the water quality modelling, the following data (or estimated values) are normally required:

- Upstream flow: Mean and Q95 (i.e. the flow that is exceeded 95% of the time);
- Upstream water quality: Mean and standard deviation for each required parameter;
- Discharge flow: Mean and standard deviation; and
- Discharge water quality: Mean and standard deviation for each required parameter; or
- Downstream water quality: Quality target downstream of discharge for each required parameter.

Given the uncertainties about the timing and impact of future increases in discharges upstream from the Cambridge WRC (and within the whole river catchment upstream), an alternative method has been advocated by the Environment Agency for this Water Cycle Study. The RQP model has been used to confirm that there will be no breach of WFD requirements due to the new discharge alone. The rationale for this approach is detailed below:

River quality throughout the upstream catchment will need to improve in order to achieve, at the very least, Good Ecological Potential by 2027. If it is assumed that those improvements have already happened, it can be assumed that upstream river quality is at Mid-Good status and the new discharge can be assessed in isolation. It is then not required to have quantified the potential pre-development changes in river flow and quality in the River Cam before carrying out the Denny St Francis assessment.

The implications of this in terms of model set-up are described in the following Sections.

G.2.2 Model set-up

River flow

Flow data assumed for the modelling is given in Table G.1.

Table G.1: Assumed flows for RQP modelling

		Flow (m3/day)		
Location	**Scenarios**	**Mean**	**Q95**	**Standard Deviation**
Upstream flow	All	301,000	50,100	-
Discharge flow	L1 – L4	6,807	-	2,269
	U1 – U4	7,994	-	2,665

Source: Environment Agency *pers. comm*. 2014 and Mott MacDonald.

Upstream river flows were provided by the Environment Agency. The figures were a combination of an estimate of river flow upstream of Cambridge WRC (using Low Flows Enterprise, calculated March 2013) and the flow from the Cambridge WRC. Figures were rounded to three significant figures but give a good approximation for modelling the impact of a new discharge at Waterbeach (Environment Agency, *pers. comm*. April 2014).

The discharge flows used in the assessment have been calculated based on the development scenarios for used water discussed in

Appendix B. The average total used water generation figure under the lower and upper development scenarios (6,807 m^3/d and 7,994 m^3/d as per Table 8.3) were set as the mean flows. As no quantification of variation was available, the standard deviation was estimated as one third of the mean, as suggested in the Horizontal Guidance on Surface Water Discharges (Environment Agency, December 2011, p. 31).

Water Quality

Upstream water quality would normally be calculated based on recorded data from a location upstream of the proposed discharge location, as per that reported in Section G.1.However, as the discharge compliance assessment for this particular study assumes that the Cam, Rhee and Granta WFD waterbody had achieved good ecological potential by the start of development at Denny St Francis, theoretical upstream water quality values were used.

The BOD target is to ensure No Deterioration from the River Basin Management Plan, whilst the ammonia and phosphate targets are based on the WFD Objective of achieving Good status by 2027. In setting these targets it is assumed that, in accordance with the Objective, upstream quality/status will have improved by 2027 (Environment Agency *pers. comm*. 2014).

For the purposes of estimating new permit limits, the upstream water quality in the River Cam can therefore be assumed to sit in the middle of the target band.

RQP requires an estimate of the ratio between the mean and standard deviation of the discharge data. As detailed in the RQP help file:

"*In calculations where we calculate automatically the discharge standard needed to meet a river target the mean and standard deviation input for the discharge quality need to reflect the sort of ratio normally found in a works that would achieve the required discharge standard. This ratio is not necessarily the same as the ratio for the recent quality*."

RQP therefore works out the discharge standard according to how tightly the discharge quality will (or plans to) be controlled. Again following the Horizontal Guidance document, a reasonable assumption is that the standard deviation is one third of the mean. Given modern WRC processes and a separate foul sewer and storm drainage network for Denny St Francis itself, it could be argued that this assumption is overly conservative. It does, however, offer a good starting point for assessment.

The downstream river quality targets have been based on the target WFD status and river quality standard for BOD (High - 4 mg/l 90%ile), Ammonia (Good - 0.6 mg/l 90%ile) and Phosphate (Good - 0.12 mg/l Annual Average), as provided by the Environment Agency..

The water quality parameters for the modelling are given in Table G.2.

Table G.2: Assumed water quality for RQP modelling

Parameter	Scenarios	Upstream		Discharge		Downstream	
		Mean	Standard Deviation	Mean	Standard Deviation	90%ile	Mean
BOD (mg/l)	All	1.15	0.69	1	0.33	4.0	-
Phosphate (mg/l)	All	0.085	0.085	1	0.33	-	0.12
Ammonia (mg/)	All	0.26	0.15	1	0.33	0.6	-

Source: Mott MacDonald

G.3 Consents to meet no deterioration

The following Sections detail the consent standards that would be required for a new WRC discharge at Denny St Francis in order to meet the WFD requirement of No Deterioration in the River Cam waterbody.

For reference, the current discharge consents for both Waterbeach and Cambridge WRCs have been tabulated below.

Table G.3: Discharge Consents for Waterbeach and Cambridge WRCs

Consent parameter	Waterbeach WRC	Cambridge WRC
BOD (mg/l)	20	15
Ammonia (mg/l)	15	5
Phosphate (mg/l)	-	1

Source: Anglian Water

G.3.1 Biological Oxygen Demand

The results of the no deterioration assessment for BOD are shown in Table G.4.

Table G.4: BOD consent required at Denny St Francis WRC to ensure no deterioration

	Denny St Francis WRC	
	Lower scenarios	Upper scenarios
River upstream of discharge		
'Predicted' current status	Mid High	
Quality target (mean mg/l)	1.15	
Quality target (standard deviation mg/l)	0.69	
River downstream of discharge		
'Predicted' current status	High	
Quality target (90%ile mg/l)	4.0	
Discharge quality needed		
95%ile quality (mg/l)	52.48	45.28

Source: Mott MacDonald

Figure G.4: RQP model output - BOD

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 15.59

Name of discharge	Denny St Francis New WRC - Scenarios L1-L4
Name of river	River Cam
Name of determinand	BOD

INPUT DATA	
UPSTREAM RIVER DATA	
Mean flow	301000
95% exceedence flow	50100
Mean quality	1.15
Standard deviation of quality	0.69
90-percentile	2.01
DISCHARGE DATA	
Mean flow	6807
Standard deviation of flow	2269
Mean quality	1
Standard deviation of quality	0.33
... or 95-percentile	1.61
DOWNSTREAM RIVER QUALITY TARGET	
Quality target	4
Percentile	90

RESULTS	
RIVER DOWNSTREAM OF DISCHARGE	
Mean quality	2.37
Standard deviation of quality	1.2
90-percentile quality	4
95-percentile quality	4.62
99-percentile quality	6.11
Quality target (90-percentile)	4
DISCHARGE QUALITY NEEDED	
Mean quality	32.83
Standard deviation of quality	10.62
95-percentile quality	52.48
99-percentile quality	64.15
99.5-percentile quality	67.74

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 16.01

Name of discharge	Denny St Francis New WRC - Scenarios U1-U4
Name of river	River Cam
Name of determinand	BOD

INPUT DATA	
UPSTREAM RIVER DATA	
Mean flow	301000
95% exceedence flow	50100
Mean quality	1.15
Standard deviation of quality	0.69
90-percentile	2.01
DISCHARGE DATA	
Mean flow	7994
Standard deviation of flow	2665
Mean quality	1
Standard deviation of quality	0.33
... or 95-percentile	1.61
DOWNSTREAM RIVER QUALITY TARGET	
Quality target	4
Percentile	90

RESULTS	
RIVER DOWNSTREAM OF DISCHARGE	
Mean quality	2.37
Standard deviation of quality	1.19
90-percentile quality	4
95-percentile quality	4.59
99-percentile quality	6.06
Quality target (90-percentile)	4
DISCHARGE QUALITY NEEDED	
Mean quality	28.32
Standard deviation of quality	9.16
95-percentile quality	45.28
99-percentile quality	55.35
99.5-percentile quality	58.44

Source: Mott MacDonald

G.3.2 Ammonia

The results of the no deterioration assessment for Ammonia are shown in Table G.5.

Table G.5: Ammonia consent required at Denny St Francis WRC to ensure no deterioration

	Denny St Francis WRC	
	Lower scenarios	Upper scenarios
River upstream of discharge		
'Predicted' current status	Mid Good	
Quality target (mean mg/l)	0.26	
Quality target (standard deviation mg/l)	0.15	
River downstream of discharge		
'Predicted' current status	Good	
Quality target (90%ile mg/l)	0.6	
Discharge quality needed		
95%ile quality (mg/l)	5.18	4.54

Source: Mott MacDonald

Figure G.5: RQP model output - Ammonia

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 16.07

Name of discharge	Denny St Francis New WRC - Scenarios L1-L4
Name of river	River Cam
Name of determinand	**Ammonia**

INPUT DATA		RESULTS	
UPSTREAM RIVER DATA		**RIVER DOWNSTREAM OF DISCHARGE**	
Mean flow	301000	Mean quality	0.38
95% exceedence flow	50100	Standard deviation of quality	0.17
Mean quality	0.26	90-percentile quality	0.6
Standard deviation of quality	0.15	95-percentile quality	0.71
90-percentile	0.45	99-percentile quality	0.92
		Quality target (90-percentile)	0.6
DISCHARGE DATA			
Mean flow	6807	**DISCHARGE QUALITY NEEDED**	
Standard deviation of flow	2269	Mean quality	3.24
Mean quality	1	Standard deviation of quality	1.05
Standard deviation of quality	0.33	95-percentile quality	5.18
... or 95-percentile	1.61	99-percentile quality	6.33
		99.5-percentile quality	6.68
DOWNSTREAM RIVER QUALITY TARGET			
Quality target	0.6		
Percentile	90		

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 16.08

Name of discharge	Denny St Francis New WRC - Scenarios U1-U4
Name of river	River Cam
Name of determinand	**Ammonia**

INPUT DATA		RESULTS	
UPSTREAM RIVER DATA		**RIVER DOWNSTREAM OF DISCHARGE**	
Mean flow	301000	Mean quality	0.38
95% exceedence flow	50100	Standard deviation of quality	0.17
Mean quality	0.26	90-percentile quality	0.6
Standard deviation of quality	0.15	95-percentile quality	0.71
90-percentile	0.45	99-percentile quality	0.91
		Quality target (90-percentile)	0.6
DISCHARGE DATA			
Mean flow	7994	**DISCHARGE QUALITY NEEDED**	
Standard deviation of flow	2665	Mean quality	2.84
Mean quality	1	Standard deviation of quality	0.92
Standard deviation of quality	0.33	95-percentile quality	4.54
... or 95-percentile	1.61	99-percentile quality	5.55
		99.5-percentile quality	5.86
DOWNSTREAM RIVER QUALITY TARGET			
Quality target	0.6		
Percentile	90		

Source: Mott MacDonald

G.3.3 Phosphate

The results of the no deterioration assessment for Phosphate are shown in Table G.5.

Table G.6: Phosphate consent required at Denny St Francis WRC to ensure no deterioration

	Denny St Francis WRC	
	Lower scenarios	Upper scenarios
River upstream of discharge		
'Predicted' current status	Mid Good	
Quality target (mean mg/l)	0.085	
Quality target (standard deviation mg/l)	0.085	
River downstream of discharge		
'Predicted' current status	Good	
Quality target (mean mg/l)	0.12	
Discharge quality needed		
Mean quality (mg/l)	0.85	0.74

Source: Mott MacDonald

Figure G.6: RQP model output – Phosphate

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 16.04

Name of discharge	Denny St Francis New WRC - Scenarios L1-L4
Name of river	River Cam
Name of determinand	**Phosphate**

INPUT DATA

UPSTREAM RIVER DATA	
Mean flow	301000
95% exceedence flow	50100
Mean quality	0.09
Standard deviation of quality	0.09
90-percentile	0.18
DISCHARGE DATA	
Mean flow	6807
Standard deviation of flow	2269
Mean quality	1
Standard deviation of quality	0.33
... or 95-percentile	1.61
DOWNSTREAM RIVER QUALITY TARGET	
Quality target (Mean standard)	0.12

RESULTS

RIVER DOWNSTREAM OF DISCHARGE	
Mean quality	0.12
Standard deviation of quality	0.09
90-percentile quality	0.22
95-percentile quality	0.27
99-percentile quality	0.44
Quality target (Mean)	0.12
DISCHARGE QUALITY NEEDED	
Mean quality	0.85
Standard deviation of quality	0.27
95-percentile quality	1.35
99-percentile quality	1.66
99.5-percentile quality	1.75

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 18/09/2014 at 16.05

Name of discharge	Denny St Francis New WRC - Scenarios U1-U4
Name of river	River Cam
Name of determinand	**Phosphate**

INPUT DATA

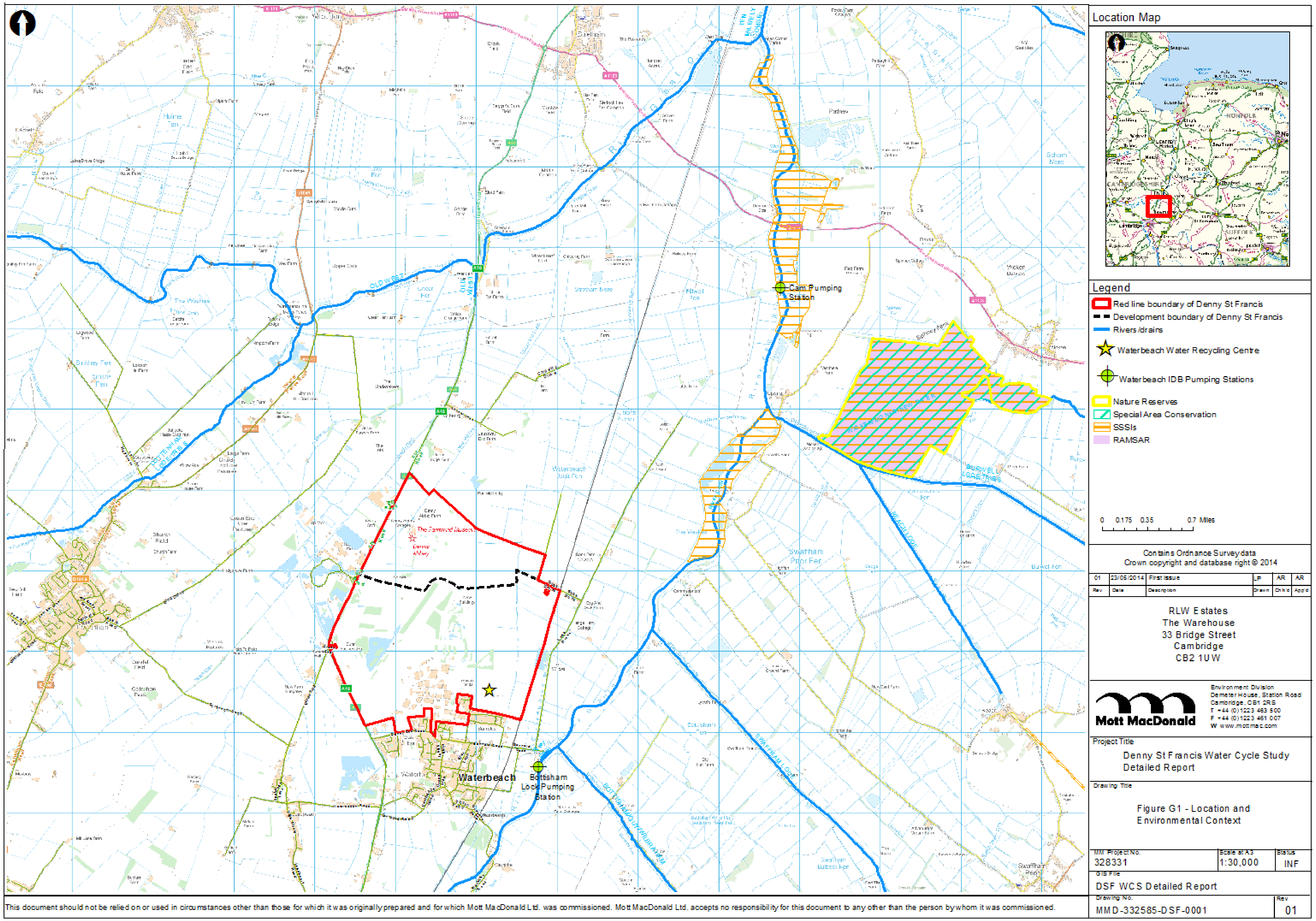
UPSTREAM RIVER DATA	
Mean flow	301000
95% exceedence flow	50100
Mean quality	0.09
Standard deviation of quality	0.09
90-percentile	0.18
DISCHARGE DATA	
Mean flow	7994
Standard deviation of flow	2665
Mean quality	1
Standard deviation of quality	0.33
... or 95-percentile	1.61
DOWNSTREAM RIVER QUALITY TARGET	
Quality target (Mean standard)	0.12

RESULTS

RIVER DOWNSTREAM OF DISCHARGE	
Mean quality	0.12
Standard deviation of quality	0.09
90-percentile quality	0.22
95-percentile quality	0.27
99-percentile quality	0.44
Quality target (Mean)	0.12
DISCHARGE QUALITY NEEDED	
Mean quality	0.74
Standard deviation of quality	0.24
95-percentile quality	1.19
99-percentile quality	1.45
99.5-percentile quality	1.53

Source: Mott MacDonald

Appendix H. Figures


Location Map
Legend
Red line boundary of Denny St Francis
Development boundary of Denny St Francis
Rivers/drains
Waterbeach Water Recycling Centre
Waterbeach IDB Pumping Stations
Nature Reserves
Special Area Conservation
SSSIs
RAMSAR
0 0.175 0.35 0.7 Miles
Cam Pumping Station
Bottisham Lock Pumping Station
Waterbeach
Contains Ordnance Survey data
Crown copyright and database right © 2014
01 23/05/2014 First issue LP AR AR
Rev Date Description Drawn Chk'd App'd
RLW Estates
The Warehouse
33 Bridge Street
Cambridge
CB2 1UW
Mott MacDonald
Environment Division
Demeter House, Station Road
Cambridge, CB1 2RS
T +44 (0)1223 463 500
F +44 (0)1223 461 007
W www.mottmac.com
Project Title
Denny St Francis Water Cycle Study
Detailed Report
Drawing Title
Figure G1 - Location and
Environmental Context
MM Project No.
328331
Scale at A3
1:30,000
Status
INF
GIS File
DSF WCS Detailed Report
Drawing No.
MMD-332585-DSF-0001
Rev
01
This document should not be relied on or used in circumstances other than those for which it was originally prepared and for which Mott MacDonald Ltd. was commissioned. Mott MacDonald Ltd. accepts no responsibility for this document to any other than the person by whom it was commissioned.

Appendix I. Stakeholder validation letters

Anglian Water
Services Limited
Thorpe Wood House,
Thorpe Wood,
Peterborough,
Cambs,
PE3 6WT

Tel 0772341018

Our ref

Your ref

F.A.O. Louisa Peaver
Mott MacDonald
Mott MacDonald House,
8-10 Sydenham Road,
Croydon,
Surry,
CR0 2EE

1 December 2014

Dear Sir,

Denny St Francis Water Cycle Study Sign Off

Anglian Water Services Ltd agrees to the release of the Water Cycle Study Report (Rev C Dated October 2014) for Denny St Francis Detailed Water Cycle Study and as such, in its current form, this report may be published either in paper or electronic format.

Under Clause 4.1.1 of our Confidentiality Agreement dated 3 March 2014 this release being granted, Anglian Water Services Ltd confirms that this text is no longer contained within the possession of Mott MacDonald (the Receiver) and as such is henceforth exempt from Clause 7 of said Agreement.

Yours Sincerely,

Rob Morris
Senior Growth Planning Engineer

Our ref DNC/A2/DennyStFrancis
E danielclark@cambridge-water.co.uk
Your ref 328331/BNI/EAD

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

27/10/2014

Dear Mr Rawlings

Endorsement of Denny St Francis Water Cycle Study Strategy

Cambridge Water has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Cambridge Water, I can confirm that the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C) includes the relevant water supply and availability information as correct at the time of publication.

Daniel Clark
Environmental Manager

My ref: CCC/Dennystfrancis
Your ref: 328331/BNI/EAD
Date: 21/10/2014
Contact: Sass Pledger
Direct dial: 01223 699976
E mail: sass.pledger@cambridgeshire.gov.uk

Cambridgeshire County Council

Economy, Transport & Environment
Executive Director: Graham Hughes

Flood and Water Team
Box No. CC1216
Castle Court
Castle Hill
Cambridge
CB3 0AP

Endorsement of Denny St Francis Water Cycle Study Strategy

Dear Mr Rawlings,

The Growth & Economy service has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Cambridgeshire County Council, I can confirm that we endorse the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

SIGNED

S C Pledger.

Business Manager – Floods and Water

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

Our ref: AC/2014/120560/04-L01

Your ref: 328331/BNI/EAD

Date: 29 October 2014

Dear Mr Rawlings

Denny St Francis - Final Water Cycle Study

We, the Environment Agency, have been a member of the Denny St Francis Water Cycle Study (WCS) stakeholder engagement group and have been actively engaged in the development of the report. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping and Detailed Reports.

Overall the majority of our previous comments have been integrated into this version of the study. This detailed report a very good example of everything a WCS should be. As we have previously commented: “The water quality / wastewater sections are generally well written and comprehensive. The data presented and conclusions drawn are robust and well considered.”

In respect of water efficiency and demand management, this is also considered to be a holistic, rational approach which also includes the education of the local population, an issue which is hardly ever considered within WCS’.

There are detailed sections exploring rainwater harvesting, greywater recycling, and on-site storage. Different supply options have been considered against social, economic and environmental criteria and the conclusions that have been reached are robust and have been based on the evidence provided.

We have a minor outstanding concern that the water cycle study could be limiting any future drainage strategy to certain drainage features through being too prescriptive in some of it conclusions. These should be removed to allow for as flexible approach as possible to be taken. This is on page 80 (Final Paragraph) and as there is no need to be specific at this point we would prefer the existing sentence...

> "*On the basis of the site constraints at Denny St Francis, and further to the 2012 Drainage Strategy, the SUDS will comprise rainwater harvesting, swales, balancing ponds and wetlands*."

...to be removed or amended so as not to restrict the possible inclusion of other forms of SuDS (i.e. *will comprise, **but is not limited to**, rainwater...*).

We are pleased to see that reference has been made to the incorporation of a SuDS management train in the Denny St Francis development. However, care will be needed going forward with the development of the site that that it is implemented appropriately.

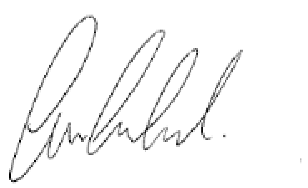
In addition, we have some suggested minor amendments you should consider prior to finalising the document. These are listed in the Annex to this letter.

Conclusion

The success, in terms of the final WCS is, we suspect, in large part due to the early engagement with all parties before drafting an initial report. Louisa and her colleagues at Mott MacDonald should be congratulated on their work on this WCS.

On behalf of the Environment Agency, subject to the aforementioned amendment, I can confirm that we endorse the water infrastructure proposals for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

Yours sincerely



Adam Ireland
Principal Planning Officer

Direct dial 01480 483962
Direct e-mail adam.ireland@environment-agency.gov.uk

Annex 1: Suggested Minor Amendments

We feel that there remains a few sections that need rewording, including:

1. Executive summary - Pg iii – SuDS are referred to as “Sustainable Urban Drainage Systems (SUDS)”, this is an outdated term and should be amended to **Su**stainable **D**rainage **S**ystems.

2. Pg67 – Conclusions – River Cam residual risk – The site has been identified as being at residual risk – need to remove the ‘could be’.

3. Pg70 – I would like to see a clear hierarchy being set out – 1st land use planning/Sequential approach, 2nd ground raising, 3rd new embankment. Although written in order of preference it is not clear that this is the hierarchy that they should be considered. This could be reinforced through the arrangement of table 6.1 i.e. placing land use planning in the first column.

4. Table 6.1 – social – flood bund – a new bund would not remove all restrictions as there will remain a residual risk of flooding. Resilience/resistance measures at a minimum would be required.

5. Table 6.1. – Economic – Land raising – settlement will need to be monitored to ensure the FFL is maintained.

6. Table 6.1 - economic – land use – no construction and maintenance costs

7. Table 6.1 - ecology – Land use – promotes riparian/wetland habitats

8. Pg71 – para 4 – typo – Beach – Breach.

9. 7.5.2 – SuDS Adoption – consideration will need to be given to the Defra Consultation paper on SuDs adoption as this fundamentally changes the responsible parties for suds review and adoptions.

10. SWM1 – It would be beneficial to state a preference for the use of surface features that can be incorporated into the green infrastructure of the development, over underground, engineered approaches.

End

South Cambridgeshire Hall
Cambourne Business Park
Cambourne
Cambridge
CB23 6EA

t: 03450 450 500
f: 01954 713149
dx: DX 729500 Cambridge 15
minicom: 01480 376743
www.scambs.gov.uk

South Cambridgeshire
District Council

Mott MacDonald
Cambridge

To	A	I	C	Sign	Date

-3 NOV 2014

File no. 328331
Return to

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge CB1 2RS

30th October 2014

Dear Mr Rawlings

DENNY ST FRANCIS WATER CYCLE STUDY STRATEGY

This is to confirm that South Cambridgeshire District Council has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group. We were invited to and attended the three stakeholder engagement workshops and reviewed and commented on the Scoping Report and the Detailed Report (Ref 328331/BNI/EAD/12/C).

Yours sincerely

David Roberts

David Roberts

Principal Planning Policy officer

WATERBEACH LEVEL INTERNAL DRAINAGE BOARD

ENGINEER: ANDREW NEWTON
CLERK: JEAN HEADING

DRAINAGE OFFICE
MAIN STREET
PRICKWILLOW
CAMBS. CB7 4UN
TEL: ELY (01353) 688296
FAX: (01353) 688561

A Rawlings Esq
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

Our ref: AN/tlr

21st October 2014

Dear Mr Rawlings

Endorsement of Denny St Francis Water Cycle Study Strategy

Waterbeach Level Internal Drainage Board has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Waterbeach Level Internal Drainage Board, I can confirm that we endorse the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

Yours sincerely,

A Newton
Engineer

Glossary

AAP	Area Action Plan
ASP	Activated sludge plant
AWS	Anglian Water Services
BAP	Biodiversity Action Plan
BRE	Building Research Establishment
CAMS	Cam and Ely Ouse Abstraction Licensing Strategy
CfSH	Code for Sustainable Homes
CWC	Cambridge Water Company
CWS	County wildlife site
DIO	Defence Infrastructure Organisation
DSF	Denny St Francis
dWRMP	Draft Water Resources Management Plan
EA	Environment Agency
GWR	Greywater recycling
HOF	Hands-off Flow
IDB	Internal Drainage Board
LPA	Local Planning Authority
MOD	Ministry of Defence
MRF	Minimum residual flow
NPPF	National Planning Policy Framework
RWH	Rainwater harvesting
RBMP	River Basin Management Plan
SAAR	Standard annual average rainfall
SAB	SUDS Approval Body
SAS	Surplus activated sludge
SCDC	South Cambridgeshire District Council
SUDS	Sustainable Drainage Systems
SWM	Surface water management
WCS	Water Cycle Study
WFD	Water Framework Directive
WRMP	Water Resources Management Plan

APPENDIX THIRTEEN – WATERBEACH WATER CYCLE STUDY STAKEHOLDER CORRESPONDENCE

WATERBEACH LEVEL INTERNAL DRAINAGE BOARD

ENGINEER: ANDREW NEWTON
CLERK: JEAN HEADING

DRAINAGE OFFICE
MAIN STREET
PRICKWILLOW
CAMBS. CB7 4UN
TEL: ELY (01353) 688296
FAX: (01353) 688561

A Rawlings Esq
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

Our ref: AN/tlr

Your ref:

21st October 2014

Dear Mr Rawlings

Endorsement of Denny St Francis Water Cycle Study Strategy

Waterbeach Level Internal Drainage Board has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Waterbeach Level Internal Drainage Board, I can confirm that we endorse the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

Yours sincerely,

A Newton
Engineer

Matt Clarke

From: Jean Heading <jean@elydrainageboards.co.uk>
Sent: 01 February 2017 16:01
To: Hervas Gamez, Carmen
Subject: RE: Waterbeach New Settlement- WCS SoCG Preps

Dear Carmen,

I can confirm that the Board still supports the Denny St Francis Water Cycle Strategy as per the Board's letter to your company dated 21st October, 2014.

Best Regards,

Andrew

From: Andrew Newton [mailto:andrew@elydrainageboards.co.uk]
Sent: 30 January 2017 10:59
To: jean@elydrainageboards.co.uk
Subject: FW: Waterbeach New Settlement- WCS SoCG Preps
Importance: High

From: Hervas Gamez, Carmen [mailto:Carmen.HervasGamez@mottmac.com]
Sent: Monday, January 30, 2017 10:57 AM
To: andrew@elydrainageboards.co.uk
Cc: Rawlings, Andrew M; Chris Goldsmith
Subject: Waterbeach New Settlement- WCS SoCG Preps
Importance: High

Dear Andrew,

I am writing to you in relation to the Waterbeach New Settlement site.

The South Cambridgeshire District Council (SCDC) Local Plan is currently under examination and the next hearing session is scheduled for 28th March 2017. As part of the SCDC Proposed Submission Local Plan (July 2013) Policy SS/5: Waterbeach New Town: *'a new town of 8,000 to 9,000 dwellings and associated uses is proposed on the former Waterbeach Barracks and land to the east and north'.*

We are preparing the evidence base in support of this development. One key piece of evidence is the Denny St Francis Water Cycle Strategy (2014), which you participated in as a key stakeholder and provided the attached letter in support of the findings of the report in 2014 (your ref.: IDB ref.: AN tlr dated 21st October 2014). For ease, please see here the download link to the full 2014 Water Cycle Strategy (which last 7 days only, (https://ftp.mottmac.com with the following credentials: username: Ca0647, password: MhJw9Un1Es).

Could you please confirm that your position remains the same in support of the Denny St Francis Water Cycle Strategy (2014)?

Given the tight timescales, we will be grateful if you could please confirm this at your earliest opportunity (ideally, before the end of this week).

Many thanks in advance

Carmen Hervás Gámez
MEng MSc
Infrastructure Engineer

D +44 (0)1223 463 809 T +44 (0)1223 463 881 F +44 (0)1223 461007
Carmen.HervasGamez@mottmac.com

Mott MacDonald
22 Station Road
Cambridge CB1 2JD
United Kingdom

Website | Twitter | LinkedIn | Facebook | YouTube

Anglian Water
Services Limited
Thorpe Wood House,
Thorpe Wood,
Peterborough,
Cambs,
PE3 6WT

Tel 0772341018

Our ref

Your ref

F.A.O. Louisa Peaver
Mott MacDonald
Mott MacDonald House,
8-10 Sydenham Road,
Croydon,
Surry,
CR0 2EE

1 December 2014

Dear Sir,

Denny St Francis Water Cycle Study Sign Off

Anglian Water Services Ltd agrees to the release of the Water Cycle Study Report (Rev C Dated October 2014) for Denny St Francis Detailed Water Cycle Study and as such, in its current form, this report may be published either in paper or electronic format.

Under Clause 4.1.1 of our Confidentiality Agreement dated 3 March 2014 this release being granted, Anglian Water Services Ltd confirms that this text is no longer contained within the possession of Mott MacDonald (the Receiver) and as such is henceforth exempt from Clause 7 of said Agreement.

Yours Sincerely,

Rob Morris
Senior Growth Planning Engineer

Our ref DNC/A2/DennyStFrancis
E danielclark@cambridge-water.co.uk
Your ref 328331/BNI/EAD

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

27/10/2014

Dear Mr Rawlings

Endorsement of Denny St Francis Water Cycle Study Strategy

Cambridge Water has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Cambridge Water, I can confirm that the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C) includes the relevant water supply and availability information as correct at the time of publication.

Daniel Clark
Environmental Manager

My ref: CCC/Dennystfrancis
Your ref: 328331/BNI/EAD
Date: 21/10/2014
Contact: Sass Pledger
Direct dial: 01223 699976
E mail: sass.pledger@cambridgeshire.gov.uk

Cambridgeshire County Council

Economy, Transport & Environment
Executive Director: Graham Hughes

Flood and Water Team
Box No. CC1216
Castle Court
Castle Hill
Cambridge
CB3 0AP

Endorsement of Denny St Francis Water Cycle Study Strategy

Dear Mr Rawlings,

The Growth & Economy service has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group and has participated in the development of the strategy. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping Report and the Detailed Report.

On behalf of Cambridgeshire County Council, I can confirm that we endorse the water cycle strategy proposed for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

SIGNED

S C Pledger.

Business Manager – Floods and Water

South Cambridgeshire Hall
Cambourne Business Park
Cambourne
Cambridge
CB23 6EA

t: 03450 450 500
f: 01954 713149
dx: DX 729500 Cambridge 15
minicom: 01480 376743
www.scambs.gov.uk

South Cambridgeshire District Council

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge CB1 2RS

30th October 2014

Dear Mr Rawlings

DENNY ST FRANCIS WATER CYCLE STUDY STRATEGY

This is to confirm that South Cambridgeshire District Council has been a member of the Denny St Francis Water Cycle Study stakeholder engagement group. We were invited to and attended the three stakeholder engagement workshops and reviewed and commented on the Scoping Report and the Detailed Report (Ref 328331/BNI/EAD/12/C).

Yours sincerely

David Roberts

David Roberts

Principal Planning Policy officer

Matt Clarke

From:	Roberts David <David.Roberts@scambs.gov.uk>
Sent:	30 January 2017 15:54
To:	Hervas Gamez, Carmen; Dixon Jonathan
Cc:	Rawlings, Andrew M; Chris Goldsmith
Subject:	RE: Waterbeach New Settlement- WCS SoCG Preps

Dear Carmen,

I can confirm that our position remains the same as set out in our letter of December 2014.

Kind regards,

David

David Roberts | Principal Planning Policy Officer

South Cambridgeshire Hall | Cambourne Business Park | Cambourne | Cambridge | CB23 6EA
t: 01954 713348 | e: david.roberts@scambs.gov.uk
www.scambs.gov.uk | facebook.com/south-cambridgeshire | twitter.com/SouthCambs

---

From: Hervas Gamez, Carmen [mailto:Carmen.HervasGamez@mottmac.com]
Sent: 30 January 2017 10:59
To: Roberts David <David.Roberts@scambs.gov.uk>; Dixon Jonathan <Jonathan.Dixon@scambs.gov.uk>
Cc: Rawlings, Andrew M <Andrew.Rawlings@mottmac.com>; Chris Goldsmith <chrisgoldsmith@turnstoneestates.com>
Subject: Waterbeach New Settlement- WCS SoCG Preps

Dear David and Jonathan,

I am writing to you in relation to the Waterbeach New Settlement site.

The South Cambridgeshire District Council (SCDC) Local Plan is currently under examination and the next hearing session is scheduled for 28th March 2017. As part of the SCDC Proposed Submission Local Plan (July 2013) Policy SS/5: Waterbeach New Town: *'a new town of 8,000 to 9,000 dwellings and associated uses is proposed on the former Waterbeach Barracks and land to the east and north'.*

We are preparing the evidence base in support of this development. One key piece of evidence is the Denny St Francis Water Cycle Strategy (2014), which you participated in as a key stakeholder and provided the attached letter in support of the findings of the report in 2014 (your ref.: SCDC letter 1st December 2014). For ease, please see here the download link to the full 2014 Water Cycle Strategy (which last 7 days only, (https://ftp.mottmac.com with the following credentials: username: Ca0647, password: MhJw9Un1Es).

Could you please confirm that your position remains the same in support of the Denny St Francis Water Cycle Strategy (2014)?

Given the tight timescales, we will be grateful if you could please confirm this at your earliest opportunity (ideally, before the end of this week).

Many thanks in advance

Carmen Hervás Gámez
MEng MSc
Infrastructure Engineer

D +44 (0)1223 463 809 T +44 (0)1223 463 881 F +44 (0)1223 461007
Carmen.HervasGamez@mottmac.com

Mott MacDonald
22 Station Road
Cambridge CB1 2JD
United Kingdom

Website | **Twitter** | **LinkedIn** | **Facebook** | **YouTube**

Mr Andrew Rawlings
Project Director
Mott MacDonald
Murdoch House
Station Road
Cambridge
CB1 2RS

Our ref: AC/2014/120560/04-L01

Your ref: 328331/BNI/EAD

Date: 29 October 2014

Dear Mr Rawlings

Denny St Francis - Final Water Cycle Study

We, the Environment Agency, have been a member of the Denny St Francis Water Cycle Study (WCS) stakeholder engagement group and have been actively engaged in the development of the report. We were invited to and attended the three stakeholder engagement workshops and reviewed and contributed towards both the Scoping and Detailed Reports.

Overall the majority of our previous comments have been integrated into this version of the study. This detailed report a very good example of everything a WCS should be. As we have previously commented: "The water quality / wastewater sections are generally well written and comprehensive. The data presented and conclusions drawn are robust and well considered."

In respect of water efficiency and demand management, this is also considered to be a holistic, rational approach which also includes the education of the local population, an issue which is hardly ever considered within WCS'.

There are detailed sections exploring rainwater harvesting, greywater recycling, and on-site storage. Different supply options have been considered against social, economic and environmental criteria and the conclusions that have been reached are robust and have been based on the evidence provided.

Environment Agency
Bromholme Lane, Brampton, Huntingdon, PE28 4NE.
Customer services line: 03708 506 506
www.gov.uk/environment-agency
Cont/d..

We have a minor outstanding concern that the water cycle study could be limiting any future drainage strategy to certain drainage features through being too prescriptive in some of it conclusions. These should be removed to allow for as flexible approach as possible to be taken. This is on page 80 (Final Paragraph) and as there is no need to be specific at this point we would prefer the existing sentence...

> *"On the basis of the site constraints at Denny St Francis, and further to the 2012 Drainage Strategy, the SUDS will comprise rainwater harvesting, swales, balancing ponds and wetlands."*

...to be removed or amended so as not to restrict the possible inclusion of other forms of SuDS (i.e. *will comprise, **but is not limited to**, rainwater...*).

We are pleased to see that reference has been made to the incorporation of a SuDS management train in the Denny St Francis development. However, care will be needed going forward with the development of the site that that it is implemented appropriately.

In addition, we have some suggested minor amendments you should consider prior to finalising the document. These are listed in the Annex to this letter.

Conclusion

The success, in terms of the final WCS is, we suspect, in large part due to the early engagement with all parties before drafting an initial report. Louisa and her colleagues at Mott MacDonald should be congratulated on their work on this WCS.

On behalf of the Environment Agency, subject to the aforementioned amendment, I can confirm that we endorse the water infrastructure proposals for Denny St Francis, as reported in the Denny St Francis Water Cycle Study Detailed Report, October 2014 (Ref 328331/BNI/EAD/12/C).

Yours sincerely

Adam Ireland
Principal Planning Officer

Direct dial 01480 483962
Direct e-mail adam.ireland@environment-agency.gov.uk

Annex 1: Suggested Minor Amendments

We feel that there remains a few sections that need rewording, including:

1. Executive summary - Pg iii – SuDS are referred to as "Sustainable Urban Drainage Systems (SUDS)", this is an outdated term and should be amended to **S**ustainable **D**rainage **S**ystems.

2. Pg67 – Conclusions – River Cam residual risk – The site has been identified as being at residual risk – need to remove the 'could be'.

3. Pg70 – I would like to see a clear hierarchy being set out – 1st land use planning/Sequential approach, 2nd ground raising, 3rd new embankment. Although written in order of preference it is not clear that this is the hierarchy that they should be considered. This could be reinforced through the arrangement of table 6.1 i.e. placing land use planning in the first column.

4. Table 6.1 – social – flood bund – a new bund would not remove all restrictions as there will remain a residual risk of flooding. Resilience/resistance measures at a minimum would be required.

5. Table 6.1. – Economic – Land raising – settlement will need to be monitored to ensure the FFL is maintained.

6. Table 6.1 - economic – land use – no construction and maintenance costs

7. Table 6.1 - ecology – Land use – promotes riparian/wetland habitats

8. Pg71 – para 4 – typo – Beach – Breach.

9. 7.5.2 – SuDS Adoption – consideration will need to be given to the Defra Consultation paper on SuDs adoption as this fundamentally changes the responsible parties for suds review and adoptions.

10. SWM1 – It would be beneficial to state a preference for the use of surface features that can be incorporated into the green infrastructure of the development, over underground, engineered approaches.

End