13 SURFACE WATER DRAINAGE, HYDROLOGY AND HYDROGEOLOGY

13.1 INTRODUCTION

13.1.1 This chapter has been prepared by Arup and describes the assessment of potential environment impacts of the proposed Heyford Park development with regards to surface water drainage, hydrology and hydrogeology. The chapter considers the current baseline conditions relating to surface and groundwater. Based on the understanding of the Heyford Park development the chapter predicts and assesses the potential impacts from both construction and operational activities. Mitigation measures required during the construction and operational phases of the Heyford Park development are proposed in order to ensure that the environmental status is not compromised.

13.1.2 Potential impacts on surface and groundwater quality are the subject of a separate assessment reported in Chapter 11 on water quality.

13.1.3 In assessing the potentially significant impacts to the surface water drainage, hydrology and hydrogeology, this chapter adopts the following structure:

i. Description of the planning policy framework relating to surface water drainage, hydrology and hydrogeology;

ii. Description of the approach adopted by the assessment of impacts;

iii. Description of the baseline surface water drainage, hydrological and hydro-geological conditions at, and within, the influence of Heyford Park;

iv. Description of the prediction and assessment of significance of potential impacts to surface water drainage, hydrology and hydro-geological resources;

v. Identification and description of mitigation measures to be adopted for potentially significant impacts; and

vi. Provide a description of the residual impacts following mitigation.

13.1.4 A Flood Risk Assessment has been conducted and information regarding flood risk is essential to the impacts relating to water courses. This is also detailed within this assessment.

13.2 PLANNING POLICY FRAMEWORK

13.2.1 Water is an essential element in preserving life and as such a reliable source of fresh, clean water is a defining factor on the health and well being of a population. In addition, water is also essential for maintaining a healthy environment with water scarcity or changes in water quality being one of the major causes for reductions in species and habitat diversity around the world.

13.2.2 The essential characteristics of water put high demands on the relatively small reserves of fresh water. In addition modern society also requires water use for a range of different activities that are not essential. Surface water drainage is the removal and disposal of rain water from the surface of any impermeable area this can be achieved by both surface and sub-surface systems. Surface water drainage is becoming a main focus of any development and due to policies such as PPS 25[1] it is now beginning to drive the development. Hydrology (the movement and distribution of surface water) is an aspect of water resources which is now becoming increasingly scarce and is in need of sustainable management. Hydrogeology (an aspect of hydrology distribution and movement of groundwater in soil and rock) is also important and again in need of sustainable management.

13.2.3 This section reviews the current planning and legislative context, illustrates the legal and policy instruments that make the assessment necessary and highlights the key guidance material used in its preparation.

13.3 EUROPEAN LEGISLATION

Water Framework Directive

13.3.1 See Section 11.2 in Chapter 11.

13.4 NATIONAL LEGISLATION AND POLICY

13.4.1 The EA was established under the Environment Act (1995) [2]. Under this act the EA have the following duties;

- Contribute to sustainable development,
- Responsible for matters related to flood defences, for rivers demarcated as 'main' and groundwater
- Compile information related to pollution and follow developments in technology and techniques
- Implement procedures for the identification, investigation and remediation of contaminated land.

Flood Risk

13.4.2 The flood risk issues of a proposed development have to be identified and mitigation measures proposed. A flood risk assessment includes the involvement of the local planning authority and the EA. Within this administrative context, those proposing particular developments are responsible for:

- Providing an assessment of whether any proposed development is likely to be affected by flooding and whether it will increase flood risk elsewhere and of the measures proposed to deal with these effects and risks; and,
- Satisfying the local planning authority that any flood risk to the development or additional risk arising from the proposal will be successfully managed with the minimum environmental effect, to ensure that the site can be developed and occupied safely.

13.4.3 It is in the developer's interests to deal with these matters, since they may well affect the value of land and the cost of developing it. It is then for the local planning authority, advised as necessary by the EA and other relevant organisations, to determine an application for planning permission taking account of all material considerations, including the issue of flood risk and how it might be managed or mitigated. The developer needs to comply with the requirements of the Planning Policy Statement 25 (PPS 25) on Development and Flood Risk[3] which is implemented by the local planning authority.

13.4.4 PPS 25 has outlined the way flood risk should be addressed and how flood risk assessments should be administered by a developer at the planning stage. This document gives a clearer indication of what is required at the planning stage and defines a more rigorous scope of work for areas that are within potential flood zones. This includes more conservative allowances for climate change.

13.4.5 Further advice related to the work required to address flood issues for a development is supplied in CIRIA document C624 'Development and Flood Risk - Guidance for the Construction Industry' (C624) [4] and the EA guidance document produced by HR Wallingford 'Flood Risk Assessment Guidance for New Development (FD2320) [5]. Water Quality and Pollution

13.4.6 The Water Resources Act, 1991[6] regulates water resource management by specifying that causing or allowing polluting matter to enter 'controlled waters' without permission is a criminal offence. Controlled waters describe rivers, estuaries, coastal waters and groundwater. Accordingly the EA have set discharge limits for particular substances.

13.4.7 In addition, the Groundwater Regulation 1998[7] the Water Act 2003[8] aims to improve water resource management and promote water conservation.

Water Supply

13.4.8 The Water Industry Act 1991[9] ensures that the provision of public water supply and sewerage treatment is adequately regulated.

13.4.9 The Private Water Supplies Regulations[10] address the quality of water from private supplies in England and Wales for drinking, washing, cooking or food protection purposes. The Regulations supplement Chapter III of the Water Industry Act 1991. The responsibility for enforcing the Private Water Supplies Regulations lies with the Local Authorities.

Regional and Local Planning Framework

13.4.10 The regional and local planning framework is explored in detail in Chapter 4.

Other Relevant Guidance material

13.4.11 The EA have produced an extensive series of 'Pollution Prevention Guidelines' (PPG's). These give prescriptive guidance on how to avoid certain types of pollution. The guidelines of relevance to the water environment and the proposed development are:

- PPG1 – General Guide to the Prevention of Pollution[11]
- PPG03 – Use and Design of Oil Separators in Surface Water Drainage Systems[12]
- PPG5 – Works In, Near or Liable to Affect Watercourses [13]
- PPG6 – Working in Construction or Demolition Sites[14]
- In addition, the EA produce technical advice documents related to flood risk management. The key text in this series is FD2320 - 'Flood Risk Assessment Guidance for New Development[15].

13.4.12 As well as EA guidance, there are also other bodies which supply guidance, which inform how the impact of development on the water environment can be limited. One such organisation is the Construction Industry Research and Information Association (CIRIA), who have produced the following relevant publications;

- C630 – Sustainable Water Management in Land Use Planning[16]
- C515 – Groundwater control – Design and Practice[17]
- C609 – Sustainable Drainage Systems. Hydraulic, Structural and Water Quality Advice[18]
- C624 - Development and Flood Risk - Guidance for the Construction Industry' (C624) [19]
- C697- The SUDS manual[20]

Assessment Approach

13.4.13 The impact of the proposed development on the local water environment is assessed in the following desk based study.

Approach

13.4.14 In the first instance, the baseline conditions relating to the water environment have been ascertained and described by reference to the appropriate existing sources of information.

These include:

- 1:25000 scale Ordnance Survey Map, Sheet 191 Explorer Series
- Geological Maps Published by British Geological Society (BSG) – 1:63,360 Geological Map Sheet 218 Chipping Norton, 1968
- Site investigation information on ground conditions from previous intrusive investigations these include;
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Aspinwall & Company, October 1999)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros and Aspinwall, November 2000)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros Consulting, May 2003)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros Consulting, October 2003)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros Consulting, May 2004)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros Consulting, October 2004)
  - Surface and Groundwater Monitoring at Upper Heyford - Results from Sampling (Enviros Consulting, November 2005)
  - RAF Upper Heyford Groundwater Quality Monitoring Assessment – Final Report (Aspinwall & Company, September 1998)

- Former Upper Heyford Environmental Statement (The Barton Wilmore Planning Partnership, June 1999)
- RAF Upper Heyford Infrastructure Report (Buchanan Consulting Engineers, March 1997)
- Upper Heyford RAF Base Process Survey Report (Thames Water Process Dynamics, May 1999)
- RAF Upper Heyford Infrastructure Report (Buchanan Consulting Engineers, March,1997)
- Data held on the EA website such as indicative floodplain mapping, water quality data and groundwater zone.

Based on this information it is possible to:

- Identify and locate all the significant existing and historic surface water drainage arrangements, surface water and groundwater features;
- Describe the interaction between the surface water drainage arrangements, surface water and ground water features;
- Identify the 1 in 100 year flood zone associated with the main site;
- Identify groundwater units, aquifers and possible sub-surface flow paths;

13.4.15 When the baseline conditions have been established it is then possible to determine impacts on the water environment caused by the proposed development.

Significance Criteria

13.4.16 There are no national standards against which to make comparisons for many of the observed effects. It is broadly accepted, however, that the significance and severity of an effect reflects the relationship between two factors;

- The magnitude of an impact (i.e. the actual change taking place to the environment); and
- The values of the affected resource or receptor and its sensitivity to the impact.

13.4.17 This approach has been reinforced by the Environmental Impact Assessment Regulations 1999[21], which provide guidance on the eligibility of projects for assessment on the basis of their scale and character, and the sensitivity and status of the location.

13.4.18 The assessment of the magnitude of the expected effects is dependent on the predicted effects of the development on the exposed attributes. The magnitude of the potential impact is completely independent of the value of the attribute affected and therefore gives no indication of significance when considered alone. Qualitative criteria for assessing the magnitude of the expected effect are given in Table W.01.

Table W.01: Criteria for Impact Magnitude

Magnitude	Impact
Major	Permanent changes in the regional hydrological or hydro-geological regime
Medium	Permanent changes in the local hydrological or hydro-geological regime Some noticeable or temporary changes to the regional regime
Minor	Some noticeable or temporary changes to the local hydrological or hydro-geological regime

Table W.01: Criteria for Impact Magnitude	
Magnitude	**Impact**
Negligible	No perceptible changes to the hydrological or hydro-geological regime

13.4.19 The significance of a potential impact is estimated based on its magnitude and the importance of the affected attribute. Following the implementation of standard practice mitigation measures, the assessment of the significance of the residual impacts is made using the qualitative criteria outlined in Table W.02

Table W.02: Significance Criteria	
Degree of Significance	**Impact**
Severe	Severe irreversible detrimental effect irreversible reduction in the quality or quantity of a potable groundwater or surface water resource of local, regional or national importance. Irreversible or severe detrimental effect on animal or plant populations. Irreversible detrimental effect to nationally important aquatic habitat.
Major	Severe temporary or irreversible reduction in the quality or quantity of a potable groundwater or surface water resource of local, regional or national importance. Irreversible or severe temporary detrimental effect on animal or plant populations. Irreversible detrimental effect to nationally important aquatic habitat.
Moderate	Slight or moderate, local-scale reduction in the quality or quantity of potable groundwater or surface water resources of local, regional or national importance, reversible with time. Reversible widespread reduction in the quality or quantity of groundwater or surface water resources used for commercial or industrial abstractions. Medium-term, reversible detrimental effect on animal or plant populations. Medium-term, reversible detrimental effect to nationally important aquatic habitat.
Minor	Temporary, slight or moderate detrimental effect in the quality or quantity of groundwater or surface water resources that are used for, or have the potential to be used for, commercial or industrial abstractions. Short-term, reversible detrimental effect on animal or plant populations. Short-term, reversible detrimental effect to nationally important aquatic habitat.
Negligible	No perceptible changes

Limitations, Constraints and Assumptions

13.4.20 This report is based on publicly available information and consultation with respect to the site. Site based investigation, analysis or assessment has been previously been undertaken by others on site.

Scoping Report and Consultation

13.4.21 Whilst undertaking completion of this report the following organisations have been consulted:

- The Environment Agency
- Cherwell District Council
- North Oxfordshire Consortium
- Thames Water Ltd

13.5 BASELINE CONDITIONS

Surface Water Drainage

13.5.1 This section considers the existing surface water drainage issues at the site.

Existing Surface Water Runoff

13.5.2 Surface water from the existing site is currently positively collected from hard surfaces by building downpipes, footway and road gullies and catch pits that discharge directly to surface water sewers. The surface water system is also complemented by drainage ditches adjacent to Camp Road. The extent of the existing surface water sewers and numerous interceptors and outfalls to local watercourses are shown in Figure W.A.02 and W.A.03.

13.5.3 Following a CCTV survey on the main existing surface water sewers in the site it is clear that the majority of the existing drainage infrastructure is not to adoptable standards. It was also confirmed that surface water pipes directly connect into the foul sewer network and that groundwater infiltration is also largely present.

13.5.4 The sewers shown on the statutory utility records and previous owners plan only show the main sewers. Many secondary sewer systems serving individual areas will exist, but no details of these are available. In general all of the sewers crossing Camp Road carry drainage from north of the proposed development area

13.5.5 The main sewers do not follow the existing road layout. The only exception would appear to be Dacey Drive and the road in the Trident area running directly north from the main gatehouse entrance.

13.5.6 The Institute of Hydrology 124 (IoH 124) [22] method for calculating existing rates of surface water runoff has been used to calculate discharge rates as the precise existing off-site surface water discharge rates are currently unknown and would require a very detailed drainage area study to determine. It is known that none of the surface water outfalls are currently flow controlled and therefore, the actual discharge rates are not fixed and will fluctuate with rainfall intensity (and therefore generated runoff) falling across the site.

13.5.7 Furthermore, while the original surface water design parameters are not known (assumed as the 1 in 2 year or 50% return period event), it is safe to assume they were significantly less onerous than contemporary requirements; for example, there is no flow control or attenuation in the system.

13.5.8 During a very intense storm period event, it is likely that the surface water system would surcharge, resulting in localised flooding and overland flows and continue to discharge uncontrolled rates of surface water into the local watercourses. By implementing contemporary sustainable drainage best management practices, the proposed Heyford Park surface water infrastructure will address all of these unsatisfactory levels of service and reduce overall development flood risk and flood risk off site.

Calculated Existing Surface Water Runoff Rates

13.5.9 After consultation with the Environment Agency, the Institute of Hydrology 124 (IoH 124) method for calculating existing rates of surface water runoff was adopted for the Heyford Park development. The 69.4 hectares of the main development area in the catchment was analysed against the IoH 124 method and the following runoff rates were determined:

Table W.03: Calculated Surface Water Runoff Rates

Return Period (years)	Design Flow (m^3/s)	Site Specific Water Runoff (l/s/ha)	Total Permissible Off-site Discharge Rates (l/s)
2	4.86	5.70	399
100	17.64	20.70	1449

(The total permissible off-site discharge rates have been factored against the catchment area of 69.4ha for the settlement development used in the hydraulic model).

Existing Surface Water Drainage System

13.5.10 The site currently outfalls via petrol interceptors or soakaways/ ditches located within the site and around the perimeter fence of the site. The surface water is then discharged into the Gagle and Gallos Brook which eventually discharges into the River Ray, the River Great Ouse and the River Cherwell.

13.5.11 The Buchanan Infrastructure Report (1997) [23] states that there is a surface water balancing facility located 800m south of the sewerage treatment works which controls the rate of discharge into the Gallos Brook.

13.5.12 The Barton and Wilmore Planning Partnership Environmental Statement[24] suggests there is a large balancing pond downstream of Crowfoot Pond downstream from the M40. It is understood that the pond has been designed to a capacity sufficient to attenuate storm runoff from upstream catchment areas, including the former airbase.

Surface Water Features

13.5.13 The major water features in the vicinity of the Heyford Park development have been described below.

Spring Series

13.5.14 A series of springs rise around the plateau surface on which the former airbase is located shown in Figure W.A01. The series of springs are a result of a layered aquifer system. There are at least 13 active springs within 1km of the site boundary (20 were identified in 1999). These rise at elevations of between 90 and 125m AOD, the lower elevation springs generally being to the west of the site. The range in water levels for these springs suggest that they represent discharge points for a number of aquifer layers and that there is no one single water table beneath the site.

13.5.15 Several of the springs (at locations B, K, G, I and L on figure W.A01) are associated with site storm outfall points, some of which are understood to discharge off site via oil interceptors. Historic site drainage plans show some sections of the drains which discharge to the outfalls to be French Drains. These may have been installed to capture springs present in the area prior to construction of the air base, or possibly to locally lower groundwater levels.

13.5.16 Springs C2, D, F, P and R located west of the site, flow a short distance before entering the River Cherwell.

13.5.17 Spring N (north of the site) flows dominantly eastward through the village of Ardley to form the Padbury Brook, which is a tributary of the River Great Ouse.

13.5.18 Springs A, M, T and U on the southern side of the site form the Gallos and Gagle Brooks which are a tributary of the River Ray which eventually enters the River Cherwell.

13.5.19 Since the Upper Heyford Land Quality Assessment in 1997, surface and groundwater has been sampled and monitored at Heyford Park. The results have been issued in reports[25] that are produced every 6 months. The results describe the flow rates, and water level of the groundwater as well as the issue of the springs.

13.5.20 The flow rates of the surface water springs are regularly monitored. The regularly monitored surface water springs that have been sampled are A, B, C2, D, F, G, I, M, N, P, R, T and U shown in Figure W.A01. The flow rate results obtained from the springs/outfalls is very variable in comparison with records of previous results. The behaviour of a spring's flow regime is dependent on many on the natural hydrological and hydro-geological regime of the area.

13.5.21 There are no consistent flow rate results for the monitored springs (beginning since 1997). The most recent results demonstrate that springs A, F, and N have dried up and no results for these springs could be obtained. The flow rates obtained from Enviros Consulting[26] in November 2005 are shown in Table W.04 to demonstrate the flow rates the springs in the area surrounding the site are discharging water.

Source: Adapted from data from the Surface and Groundwater Monitoring at Heyford Park Results from Sampling (Enviros Consulting in November 2005)

Table W.04: In situ Flow rates at spring/outfalls around Heyford Park

Spring (Figure W.A.01)	Date	Flow (Q) l/sec
A	09/11/05	DRY
B	09/11/05	6.75
C2	09/11/05	0.028
D	09/11/05	2.31

Table W.04: In situ Flow rates at spring/outfalls around Heyford Park

Spring (Figure W.A.01)	Date	Flow (Q) l/sec
F	09/11/05	DRY
G	08/11/05	0.698
I	08/11/05	2.88
M	09/11/05	0.7
N	09/11/05	DRY
P	09/11/05	0.83
R	08/11/05	0.02
T	09/11/05	6.8
U	09/11/05	11.9

Water Courses

13.5.22 Surface water courses in the vicinity of the site are described below. Water quality is addressed by a separate assessment, reported as Chapter 11.

River Cherwell

13.5.23 The River Cherwell is 1km at its nearest point West of the Heyford Park site. The River Cherwell is a north-south flowing river that is a tributary of the River Thames. The River Cherwell is part of the Upper Thames Tributaries Environmentally Sensitive Area (ESA) which is an area that has been identified to have a rich and diverse mix of landscape features, wildlife and ecological value, and a wide range of historical features, that combine to form a strong riverine character. Classification of the area as an ESA aims to maintain and often to enhance the conservation, landscape and historical value of the key environmental features of an area.

Oxford Canal

13.5.24 The Oxford Canal runs adjacent to the River Cherwell (only separated by the embankment and a footpath at their closest positions) in the Cherwell valley and connects to the Coventry Canal. The Oxford Canal is approximately 1km to the west of Heyford Park. The Oxford Canal is an important link between the midlands and the Thames and to London. The canal is a crucial asset in terms of amenity and recreational value.

Padbury Brook

13.5.25 The Padbury Brook flows in a west-east direction towards Buckingham where it becomes a tributary of the River Great Ouse.

Gallos Brook

13.5.26 The Gallos Brook is a north-south flowing brook starting from the southern boundary of Heyford Park until it enters the River Ray which is a tributary of the River Cherwell.

Gagle Brook

13.5.27 The Gagle Brook is a south-east flowing brook that flows in to the River Ray and eventually the River Cherwell.

River Ray

13.5.28 The River Ray is a south-west flowing river flowing 32km to its confluence to the River Cherwell. The River Ray joins the River Cherwell at Islip - it is the largest tributary. The Gallos Brook and the Gagle Brook are both tributaries of the River Ray.

Minor Water Features

13.5.29 In addition to the aforementioned water features there are a small number of ponds and pools located off site. The Crowfoot Pond north of the site (NGR SP 5263 2737), Trow Pool (NGR SP 5466 2492) and several smaller ponds and pools around Ardley and on local farms.

Hydrogeology

13.5.30 Information on the geology is based partly on the solid and drift 1: 63,360 geological map (Sheet 218 Chipping Norton – 1968[27] publication). Reference is also made to the British Regional Geology Memoir for London and the Thames Valley (4th edition 1996) [28], for modern nomenclature of the middle Jurassic strata present. The shallow ground conditions are taken from the Aspinwall's report dated June 1997, "RAF Upper Heyford Land Quality Assessment, Phase Two: Intrusive Survey Factual Report, Appendices".

Solid Geology

13.5.31 The Solid Geology of the site comprises the Middle Jurassic Great Oolite Limestone – White Limestone Formation (part of the Great Oolite Group) which consists predominantly of fine grained limestones up to 20m thick. Beneath the White Limestone Formation, the Lower part of the Great Oolite Group comprises a series of thin interbedded limestones, sandstones and mudstones. The overall thickness of Great Oolite Group is about 25m.

13.5.32 The underlying Inferior Oolite Group is thin (<10m) and includes sand, sandstones and thin mudstone of the Lower Estuarine Series, and sandy limestone, shelly limestones and sandstones of the Northampton Sand.

13.5.33 The strata beneath the site dip gently in a south-easterly direction. To the north-west (just beyond the western site boundary) the Great Oolite Limestone forms a strong scarp feature. The geological map shows a series of east-north-east trending faults to the north of the site. No faults are recorded beneath the site, with the nearest being 4km to the north-west.

Groundwater

13.5.34 Aspinwall[29] report that groundwater was present within a number of horizons depending upon the lithology present.

13.5.35 The Landmark Envirocheck[30] report indicates a Minor Aquifer beneath the site, surrounded by a Major Aquifer. The outline of the Minor Aquifer coincides remarkably well with the site boundary. There appears to be no geological reasons for the presence of the Minor Aquifer.

13.5.36 Therefore, based on currently available information, it is considered that groundwater beneath and surrounding the site should be considered as a Major Aquifer, until otherwise determined.

13.5.37 The limestone bands form a layered aquifer that can allow rapid groundwater movement. As the site is close to the scarp edge, to the west, groundwater beneath the western part of the site may flow north-westwards towards the Cherwell Valley. Most of the groundwater flow is likely to be south-eastwards down the dip slope. Groundwater sampling indicates that water quality is generally good.

13.5.38 Groundwater is discharged at a number of good quality springs around Heyford Park. Some of these coincide with storm water outfall points. These discharge to the headwaters of two river systems. The receiving watercourses are generally of good quality.

13.5.39 The Cherwell Abstraction Management Strategy issued by the Environment Agency shows that the aquifers in the area are used for local water supply as well as abstractions from surface water courses via springs and seepages. Licensed groundwater abstraction has been obtained from the Environment Agency (The Cherwell Abstraction Management Strategy). The information indicates that in the Upper Heyford area there two abstraction locations. One is located on the western side of the River Cherwell where between 0 – 0.005 Ml/d of water is abstracted and the abstraction on the eastern side of the River Cherwell abstracts 0.005 – 0.025 Ml/d. The abstraction of groundwater in the Heyford Park vicinity can be expanded further from information from the Upper Heyford Environmental Statement (1999). The information indicates that there are fourteen abstractions within 3 km of the boundary of the former airbase. Of these, four are from the Inferior Oolite on the Western side of the River Cherwell and therefore isolated from the strata beneath the site. Nine are from the Great Oolite and one from the Inferior Oolite in the vicinity of the base.

13.5.40 Boreholes have been drilled by Aspinwall & Company in 1997 as part of a land quality assessment (Figure W.01) they have been re-used to test and monitor the water quality and the water levels. The water level monitoring indicates that groundwater movement is radially outwards from the site in all directions, discharging at a number of springs. The presence of mudstone bands can limit vertical water movement and has resulted in a layered aquifer exhibiting different water levels at different depths.

13.5.41 In addition to their use for monitoring, the boreholes were also used to assess the permeability of the geological formations. The results of this testing indicate that the permeability is very variable, as would be expected for such a heterogeneous aquifer. At a number of locations significant fractures and fissures have been penetrated by the boreholes as indicated by the elevated permeability. This confirms that rapid groundwater movement can take place beneath the site.

13.5.42 There has been no significant change in the ground water levels at the boreholes since the monitoring of the water began in 1997. The results of the groundwater level monitoring on the site have been illustrated in Figure W.01 the borehole (BH) locations are shown on Figure W.A.01. The results show that there has been no significant change in the groundwater levels beneath the site. This does not indicate that there have been any significant changes in the hydrological system beneath the site.

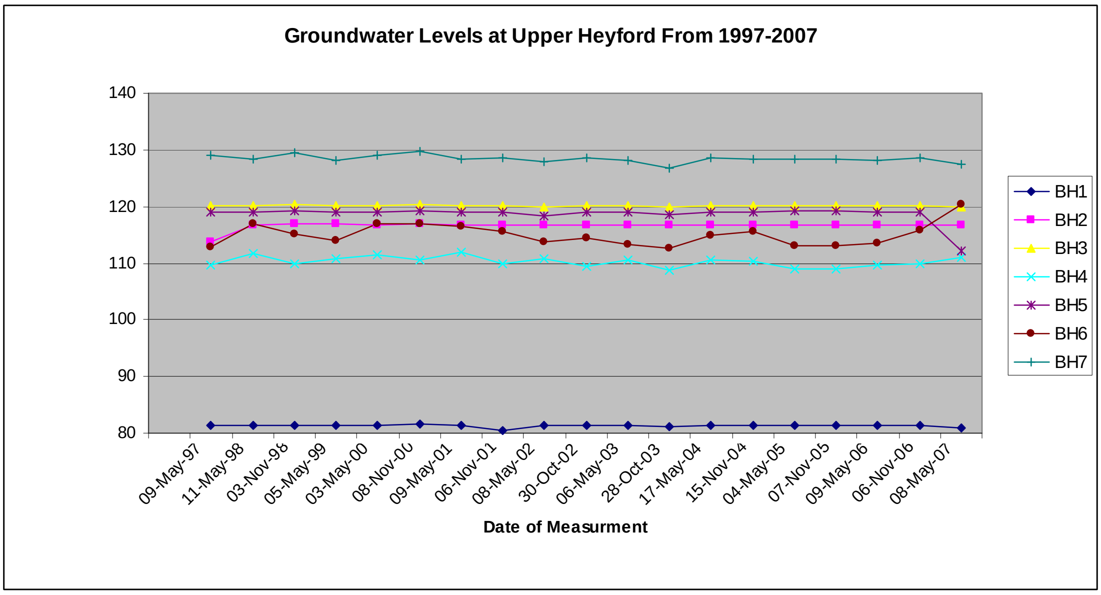

Figure W.01; Ground Water Levels at Heyford Park

Source: Surface and Groundwater Monitoring at Heyford Park from 1997 to 2005

Flood Risk

13.5.43 Any development proposals in the UK have to assess the risk from flooding under the Planning Policy Statement 25 (PPS25) under changes to the General Development Procedure Order. Under these orders a full Flood Risk Assessment (FRA) of the site has to be undertaken.

13.5.44 The flood risk considerations associated with this site are addressed in full in a Flood Risk Assessment (FRA) document, which will accompany the Environmental Statement. The findings of this document are described briefly below.

Fluvial Flooding

13.5.45 From flood maps obtained from the Environment Agency website[31] there appears to be no flood risk on the site.In accordance with PPS25 site descriptors, the site is located in Flood Zone 1. There is a flood risk within 0.5 km of the site. There is a 1% (1 in 100 years) flood risk from the River Cherwell. This also poses a 0.1% (1 in 1000 year) flood risk. The Padbury Brook to the north-east of the site pose a 1% flood risk however the size of the flood is relatively small.

Groundwater Flooding

13.5.46 Flood risk from high groundwater has been considered by the FRA. Based on the information received from geological reports, high groundwater is not a significant problem in the area. However despite this, it is suggested that services are installed at shallow depths to prevent them from being affected by groundwater and that groundwater is considered particularly in the construction phase of the development.

13.6 PROPOSALS

13.6.1 The surface water management strategy for Heyford Park incorporates the implementation of sustainable drainage system (SUDS) best management practices (BMPs) to contemporary standards. This will provide the platform to mimic the response of the existing catchment and its surfaces and ultimately with some betterment, negating any increased off-site flood risk. The proposed surface water drainage network is shown on Figure W.A.04 (is an indicative sketch , subject to detailed design and solutions will fall within the red line boundary).

13.6.2 A contemporary sustainable drainage methodology for managing surface water runoff will use BMPs to focus on three key areas; controlling surface water quantity, improving surface water quality and providing added development amenity value. It is anticipated that contemporary sustainable drainage techniques shall be used throughout the Heyford Park development plan to manage and control surface water runoff. Three key tenets will be developed as part of an integrated Heyford Park surface water management strategy:

- Maximise natural runoff losses through infiltration techniques;
- Maximise surface water runoff quality improvements through natural BMP techniques such as bioremediation;
- Attempt to reduce the total volume of surface water runoff discharged.

13.6.3 In an attempt to ensure that the future Heyford Park sustainable drainage system is designed to mimic the original characteristics of the catchment and attain the key tenets above, including betterment in terms of a reduced overall rate of runoff, the surface water management train will ensure that surface water runoff is addressed through a number of key stages during conveyance to the local fluvial system; these will be prevention – source control – site control.

13.6.4 This will be achieved by designing and implementing a blend of natural and proprietary sustainable drainage BMPs, complemented by traditional drainage techniques, all integrated into the development's infrastructure to create Heyford Park's "Green Streets". Such integrated techniques may include, although not be limited to the following:

Natural Sustainable Drainage BMPs

13.6.5 These structures will be focussed around natural materials and integrated into the landscape, which may include utilising engineered highway features. They include surface water planter boxes (in footways or as kerb extensions into the highway), rainwater gardens (located in larger landscaped garden areas), swales, infiltration trenches, open channels, detention basins (dry features), balancing ponds (wet features) and temporary floodable areas (where deemed safe in terms of flood risk). They can be designed to operate with or without infiltration and all will afford excellent attenuation and bioremediation properties.

Proprietary Sustainable Drainage BMPs

13.6.6 These BMPs are a range of manufactured techniques that include porous or pervious surfacing, cellular storage systems, rainwater harvesting systems, on or off-line detention tanks, flow control devices and pipework. They will generally be hidden below ground, integrated into the surface water drainage infrastructure.

Integration with the Landscape

13.6.7 It is essential that the "Green Streets" structures are seamlessly integrated into the proposed landscape architecture. This is essential for the successful implementation of contemporary sustainable drainage on any development site and this will be inherent to the Heyford Park sustainable drainage implementation. This would require the following:

- Successfully integrating engineered sustainable drainage BMP structures into the landscape and highway infrastructure features, to maximise the amenity value and overall aesthetics.
- Adopting pervious or porous surface finishes to designated paved areas where technically feasible and/or aesthetically required.
- Disconnecting roof drainage down pipes wherever technically feasible and managing the surface water runoff within the landscape (either in water collection systems or as discharge onto ground).
- Utilising the potential of both existing mature trees across Heyford Park and planned tree planting, for maximising evapotranspiration potential and long-term sustainable catchment management.
- Integrating landscape features into the sustainable drainage infrastructure; this will include a series of natural structures acting as primary drainage channels, the use of strategic planting to provide source control and promoting natural filtration and bioremediation properties available from plants.

Proposed Attenuation and Flow Control

13.6.8 As the development site is large, complex and capable of generating significant amounts of surface water runoff, the proposed attenuation volumes required to control surface water runoff in storm conditions will ultimately be administered across the whole catchment as source control wherever feasible. This source control will be reinforced by strategically located attenuation and storage structures across the catchment.

13.6.9 The preliminary design has assumed that surface water will be discharged into the local watercourses at no greater than the existing situation with some betterment and discharge being limited by employing complex and staged flow controls to maximum rates of the 1 in 2 year (50%) and 1 in 100 year (1%) return period events. The staged complex flow control philosophy has been adopted to reflect the current developed state of the catchment, with its extensive and uncontrolled existing surface water infrastructure.

13.6.10 The proposed complex flow control for the site will be as follows:

- Stage 1 Flow Control: 5.7l/s x contributing area (ha) for the 1 in 2 year return period;
- Stage 2 Flow Control: 20.7l/s x contributing area (ha) for the 1 in 100 year return period.

13.6.11 Complex flow control will be achieved by staging a series of Hydro-Brakes in bespoke chambers. The Hydro-Brakes will be set at differing inlet levels determined by detailed hydraulic modelling to achieve the staged flow control. It is likely, given the size and complexity of the site, that a number of these complex flow control chambers will be required across the catchment at strategic locations, finalised at the future detailed design stage. This preliminary design has assumed four such chambers, one each in four distinct subcatchments.

13.6.12 This will also provide a degree of betterment from the existing situation, whereby the current system can and would increase for storm events of increasing intensity, the redeveloped surface water infrastructure, the off-site impacts will be improved as the staged discharges will be flow controlled (by Hydro-Brakes) and attenuated on-site to the maximum flow rates. This flow control effectively reduces the amount of surface water runoff able to leave the redeveloped site during storm events, in comparison to the current situation.

13.7 IMPACT ASSESSMENT

13.7.1 The following provides a description of the key likely significant effects the proposed Heyford Park development may cause with regard to the surface water drainage, hydrology and hydrogeology of the site. Impacts have been predicted and assessed assuming simultaneous development of all facilities and therefore may be considered to represent the worst case scenario. Operational impacts are also described.

13.7.2 It is accepted that the Heyford Park development will reduce the developed area which could change the flood risk. As a result, it is now a requirement to inform the planning process of how flood risk is to be moderated at the time planning permission is sought. For the Heyford Park development, flood risk has been examined in detail in the Flood Risk Assessment. The Flood Risk Assessment concluded that the proposed development will not adversely affect onsite, neighbouring or downstream developments and their flood risk. Having identified and categorised the potential sources of flood risk, it has also been possible to identify mitigation measures for each of the sources of potential flooding. If the documented flood mitigation measures outlined in the Flood Risk Assessment are adhered to, such incorporation of sustainable drainage techniques to retain any flooding up to the 100 year return period (+30% for climate change) on the site, it is recommended that the site is considered suitable for the proposed development.

Construction Phase

13.7.3 Construction works undertaken within undeveloped areas may lead to a reduction in the ground surface permeability and thus a reduction in water infiltration. In the initial stages of construction, this is caused by the movement of machinery compacting the ground, although as construction progresses, natural ground could possibly be replaced by areas of temporary or permanent hard-standing.

13.7.4 There are two negative effects of a reduction in infiltration. An increase in surface water run-off following rainfall events, leading to increased flow rates in watercourses and flood risk. The impact of this will be moderate in significance. The other effect of a reduction of infiltration is a reduction in groundwater recharge and the disruption of groundwater flow paths. As the aquifer beneath the site is considered as a major aquifer (see 13.5.35 Groundwater, above) the potential impact is considered to be minor.

13.7.5 Earthworks and ground excavations may expose sub-surface water bearing strata and ground water seepage may require dewatering and off site disposal. Seepage and migration of groundwater may contribute to a lowering of local groundwater levels and settlement within underlying strata. The heterogeneous behaviour of the aquifers and the varying flow rates of groundwater the flow rates can be rapid and the impact is likely to be minor. Similarly, the impact to groundwater levels and flow-paths, and interaction with surface waters, as a result of dewatering or piling is expected to be minor.

13.7.6 Excavations may disturb sediment, which can be transported and deposited within water bodies and watercourses across and downstream of the site. The increase in sediment within the water courses and waterbodies could potentially change the regime of the waterbodies. The effect on the aquatic flora and fauna will be of medium magnitude and moderate significance.

13.7.7 The predicted impacts on the existing surface water regime during the construction stage will be due to the alteration of flows to the watercourses (diversions and quantity). The impact of construction on the surface water regime could also cause contamination of flows in to watercourses. However these impacts would only be temporary and the magnitude of the impact will be expected to be minor and the significance of these impacts is also expected to be minor.

Operational Impacts

13.7.8 The Heyford Park development seeks to increase the numbers of residents and associated facilities including retail, employment areas and amenity spaces. An increase in the local population may result in a corresponding increase in local water consumption and waste water production. As a component of the development the water supply network and the waste water network would be developed to meet national standards. Based on consultation with Thames Water Utilities it is considered that the water supply network of Oxfordshire is adequate to support the expected rise in population, and therefore the impact on water consumption would be negligible. The waste water network and treatment works is also to be redeveloped to effectively treat the waste water produced from the proposed development and the potential impact of increased waste water would also be negligible.

13.7.9 If the subsurface structures are sealed against ingress of groundwater, they will form impermeable blocks, thus potentially resulting in local changes to groundwater levels and flow paths. The impacts of the different structures will be aggregated. This may affect groundwater flow to the local springs and the flow to any of the fourteen abstraction locations within 3km of the site. Due to the location of the abstraction locations and the magnitude of the impact of a subsurface structures being negligible the impact is perceived to be negligible.

13.7.10 A variation in the regimes of the surface water features where the outfalls discharge the surface water. This could alter the existing environmental and hydrological equilibriums of the surface water features. Due to the nature and location of the outfall receptors, however, the magnitude of the impact has been perceived to be minor and the significance of this impact to be minor as well.

13.8 SUMMARY

Table W.05 below summarises the result of the assessment of impacts from the development on utilities.

Table W.05: Summary Table of Impacts

Impact	Summary Description	Duration of Impact	Significance of Impact
CONSTRUCTION PHASE			
Construction causing reduction in groundwater infiltration	An increase in surface water run-off	Medium term Negative	Negative Moderate
	A reduction in groundwater recharge and the disruption of groundwater flow paths	Long term	Negative Minor
Earthworks and ground excavations	Seepage and migration of groundwater contribute to lowering of local groundwater levels	Medium term	Negative Minor
	Seepage and migration of groundwater due to dewatering or piling	Short term	Negative Minor

Table W.05: Summary Table of Impacts			
Impact	**Summary Description**	**Duration of Impact**	**Significance of Impact**
New surface water sewers	Additional/replacement/existing connections from the site	Short term	Negative Minor
Separation on site of storm and foul flows	Separate storm and foul sewers on the site provide future flexibility for separating flows off site thus reducing impact of foul sewer overflows	Long term	Positive Minor
OPERATIONAL PHASE			
Quantum of new potable supplies to the site	Limit new supplies and off site works required to those absolutely necessary and thereby ensure a sustainable approach to water supply	Long term	Positive Minor
New foul flow discharges from the site	Increased foul flows within an overall combined flow not exceeding existing flows	Long term	Negative Negligible
Subsurface sewers and structures sealed	Local changes in groundwater levels and flow paths	Medium term	Negative Negligible
Variation in the regimes of the surface water features	Existing environmental and hydrological equilibrium of surface water features altered	Long term	Negative Minor

13.9 MITIGATION PROPOSALS

13.10 CONSTRUCTION PHASE

13.10.1 Ground permeability will be retained by limiting ground compaction during the construction process and by using materials in the construction processes that are designed to allow water to infiltrate, whilst being robust enough to allow building works to continue. In addition, these mitigation measures will help prevent any increase in the risk of flooding.

13.10.2 Dewatering of the site is likely to have a negligible impact. However dewatering should only be undertaken when it is absolutely necessary and the effects of dewatering should be monitored and checked regularly. The use of cut offs is preferable but again should only be used where appropriate.

13.10.3 The release of sediments to the water environment, during the construction phase will be limited by the adoption of sediment control measures such as sediment traps and fences. This will reduce the impact of increased sedimentation on the surface water environment to minor.

13.10.4 The alteration of flows to watercourses during construction will be mitigated where required by the temporary works on the water courses and the diversions of the outfalls being consented by the Environment Agency under the land Drainage Act 1991 to ensure that the surface water features are not affected by the alterations caused by construction. The temporary outfall locations will be diverted and the affect on the flow regimes of the outfall locations will be minor.

13.10.5 The mitigation of the contamination of the flows to the water courses has been summarised in Chapter 11 Water Quality, as this is a water quality issue.

Operational Phase

13.10.6 The permeability of ground will be retained in developed areas by using appropriate materials for areas of hardstanding that allow infiltration and by landscaping so that areas of natural vegetation are retained. These measures combined with an appropriate drainage system, which will be designed to a 100 year return period +30% this has been discussed in further detail in the FRA,.The impact to the proposed development will be reduced to negligible, in terms of both groundwater recharge and flood risk.

13.10.7 The expected increase in water use and waste water production will be mitigated by ensuring the services and facilities in place are adequate to serve the population. Also, by communicating the detailed development proposals to the responsible service provider as the plans evolve.

13.10.8 In order to prevent unwanted flow paths being created both above and below ground, and vertically and horizontally, flow cut offs would be used where appropriate at strategic locations. Materials such as concrete and clay will be utilised to prevent movement of water within service trenches for example. Flow can be actively encouraged to move in a predetermined way preferably using the on-site drainage system. Consequently, the residual impact will be negligible.

13.10.9 The design depth of subsurface structures will consider the interaction of groundwater, so that the impediment of existing groundwater flow paths is minimised. This will ensure that the impact is negligible.

13.10.10 Liaison between developers, suppliers of infrastructure and services and planning bodies is essential to ensure that development is sustainable. This liaison will ensure that the development can be catered for in terms of water resource and foul water infrastructure. Such discussions and liaison as already in progress to ensure that the impact of the development is minor.

13.10.11 Without appropriate mitigation measures the most significant impacts on the water environment related to the proposed development is the effect of sediment releases on aquatic flora and fauna, during construction. This will be mitigated by employing appropriate sediment control measures during construction. In addition, simple flow control measures, primarily through the construction phase would preserve the existing surface and groundwater regime.

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