Natural England Commissioned Report NECR141

New Forest SSSI Ecohydrological Survey Overview

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

The New Forest contains significant areas of habitats that are now rare and fragmented across lowland Western Europe, including lowland heath, valley and seepage step mire or fen, and ancient pasture woodland, including riparian and bog woodland. It is also important for its stream network, that drains the mire habitats, which form an unusual community due to the combination of nutrient-poor, acid waters and outcrops of neutral, enriched soils.

The damage caused by historical drainage activities and contemporary engineering/ management of the mire systems and modification of rivers and streams is frequently cited as a reason for unfavourable condition of the New Forest SSSI units. Natural England aims to restore these to favourable condition and to do this needs to understand the physical habitat and ecohydrological processes and forms of the mire/wetland floodplain habitats. This includes:

1) Undertaking a geomorphological analysis and ecological interpretation of physical impacts on the river and floodplain.
2) Identifying the floodplain features and SAC habitats associated with the abandoned and active floodplains and describing the impact of watercourse modification and other drainage activities.
3) Preparing ecohydrogical/hydrogeological characterisation of the mires following a full analysis of data already available supplemented by field data.
4) Providing brief details of the physical restoration opportunities for each mire and their logical sequencing at hydrological catchment and New Forest scales.
5) Reviewing the current body of evidence and suggest what longer term monitoring could be put in place to provide a national set of scientific evidence to support wetland restoration.

This report provides an overview of the ecohydrological survey conducted in the New Forest. Annexes A to W contain the individual reports for each survey area. It supports the annexes and includes the background information used to help populate the individual annexes. Other reports that contribute to the project are:

- New Forest SSSI Geomorphological Survey Overview (NECR140);
- Geomorphic and Ecohydrological Monitoring and Prioritisation Report (NECR142); and
- Latchmore Brook Restoration Options Appraisal (NECR143).

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Further information
This report can be downloaded from the Natural England website: **www.naturalengland.org.uk**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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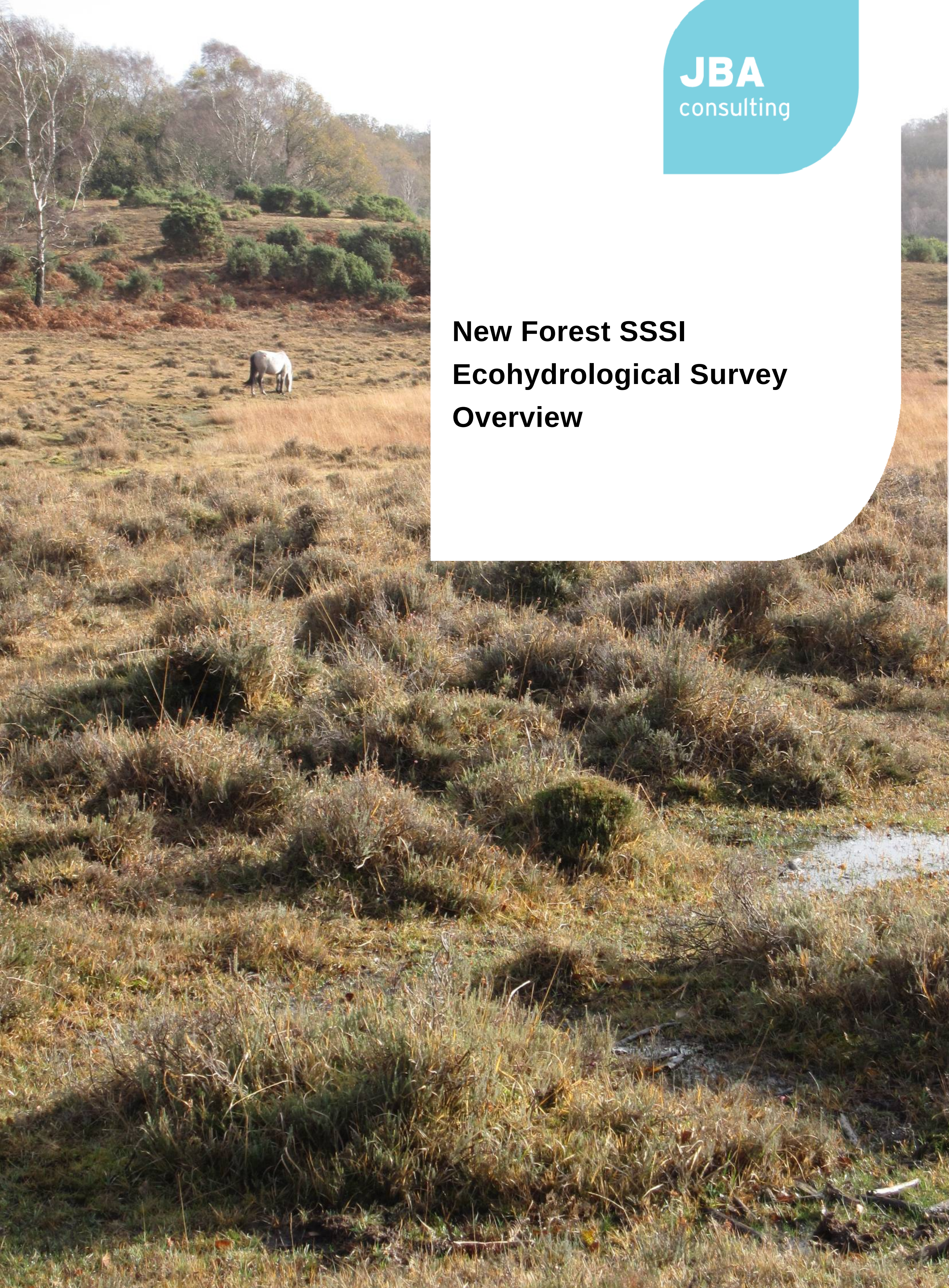

New Forest SSSI Ecohydrological Survey Overview

Executive Summary

This report gives an overview of the ecohydrological survey of several New Forest SSSI units conducted by JBA on behalf of Natural England in the autumn/winter of 2012.

The report outlines the methodology and background information used to support the 23 Ecohydrological Assessment Area reports. These Ecohydrological Assessment Areas were formed of proximal SSSI units with broadly similar ecohydrological mechanisms. The reports outline and discuss the findings of ecological surveys, ecohydrological conceptual models, outline restoration plans and monitoring requirements that have been developed for each assessment area.

In general most of the wetlands assessed only require minor restoration work to improve them. This report gives some indication as to the priorities of that work and the priorities for monitoring.

The restoration plans are designed to help restore, maintain and improve the existing extents of the wetlands present. This, however, creates potential difficulties as the existing wetlands, their extent and type, often are the result of historic drainage and grazing management. This means that the extent and nature of important features of interest are the result of long term degradation and replacement of more natural habitats that were present previously. The restoration plans attempt to strike a balance in improving existing wetland, but not the restoration of former wetland types through the removal of existing important ones. It is however recommended that all the restoration measures suggested by this study are reviewed in light of robust restoration objectives being developed for the sites.

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Abbreviations

BGS .... British Geological Survey
CEH .... Centre for Ecology and Hydrology
FEH .... Flood Estimation Handbook
GIS .... Geographic Information System
JNCC .... Joint Nature Conservation Committee
LIDAR .... Light Detection And Ranging
OS .... Ordnance Survey
SAC .... Special Area of Conservation
SPA .... Special Protection Area
SSSI .... Site of Special Scientific Interest
WETMECS .... WETland water supply MEChanismS

1 Introduction

1.1 Overview

This report gives an overview of the ecohydrogical survey of several New Forest wetlands conducted by JBA on behalf of Natural England in the autumn/winter of 2012. The results of the ecohydrogical survey for each site is presented in a series of separate Annexes, however they are dependant upon background information presented in this overview report.

The results of the geomorphological and ecological surveys within the stream dominated units are provided within a separate report.

1.2 The New Forest

The New Forest is of exceptional ecological importance, containing significant areas of habitats that are now rare and fragmented across lowland Western Europe, including lowland heath, valley and seepage step mire, or fen, and ancient pasture woodland, including riparian and bog woodland (Natural England, 1987). The New Forest is also important for its stream network, often draining the mire habitats, which form an unusual community due to the combination of nutrient-poor, acid waters and outcrops of neutral enriched soils.

The forest is also internationally important for breeding bird populations and over-wintering bird populations (e.g. Hen Harrier *Circus cyaneus*, Dartford Warbler *Sylvia undata*); for its rich invertebrate fauna, including Stag Beetle *Lucanus cervus* and Southern Damselfly *Coenagrion mercuriale*; number of scarce plants and fungi (e.g. Hampshire Purslane *Ludwigia palustris*, Wild Gladiolus *Gladiolus illyricus*, Pennyroyal *Mentha pulegium* and Slender Marsh Bedstraw *Galium constrictum*, Dorset Heath *Erica ciliaris*) and rare fauna including Bechstein's Bat *Myotis bechsteinii*, Sand Lizard *Lacerta agilis*, Smooth Snake *Coronella austriaca* and Great Crested Newt *Triturus cristatus*. Consequently, the area has been designated as a Special Area of Conservation (SAC), Special Protection Area (SPA), a Ramsar wetland and a Site of Special Scientific Interest (SSSI) and the UK government has a responsibility to ensure that the site is in good condition. The location of the designated areas is shown in Figure 1-1 below.

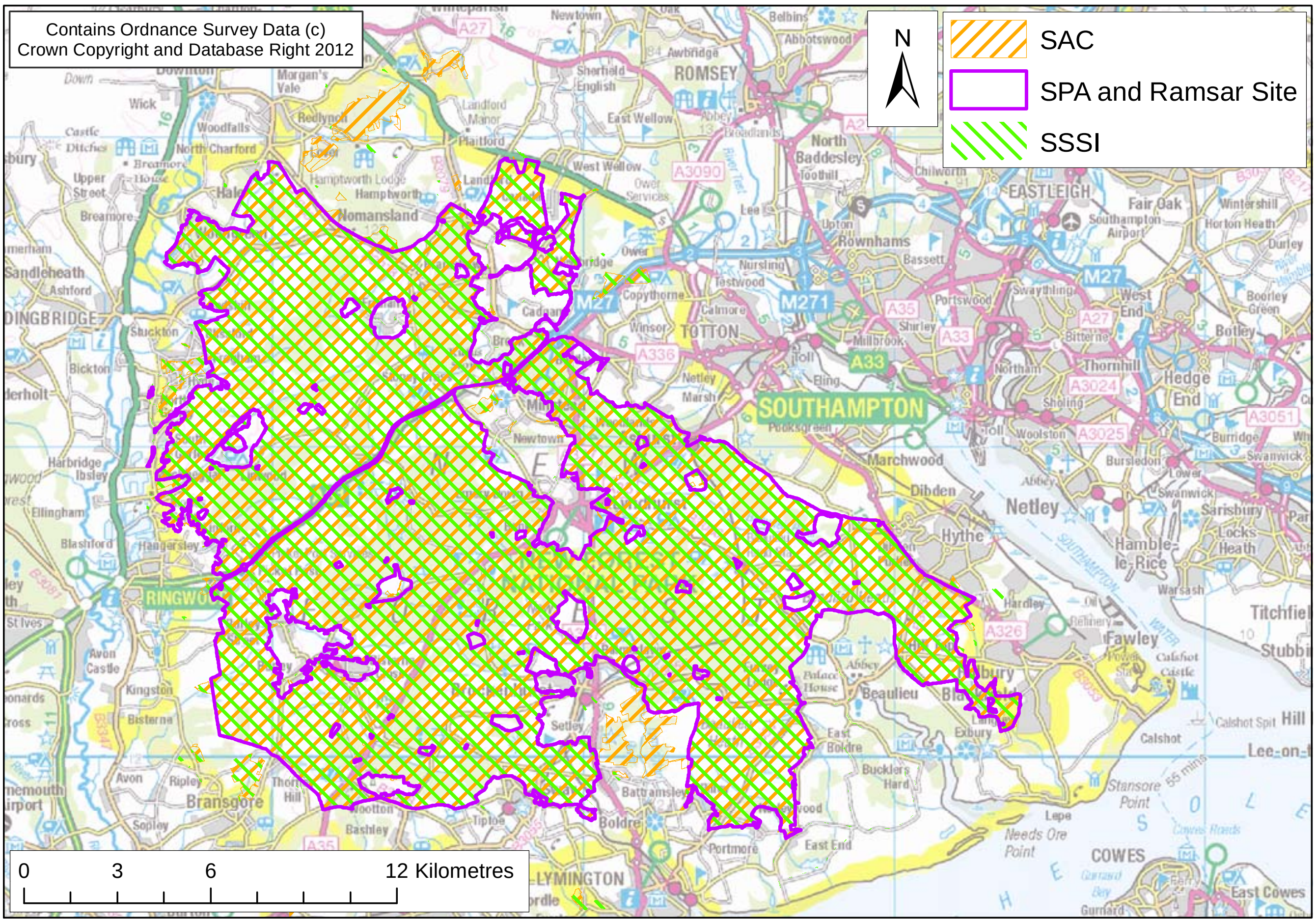


Figure 1-1: The New Forest Designated Site Boundaries

1.3 Project Background

One of the key factors causing concern in the New Forest is the damage caused by historical drainage activities and contemporary engineering/management of the mire systems and modification of rivers and streams which impacts on the ecohydrogical functioning of these interlinked systems. This is frequently cited as a reason for 'unfavourable condition' of the SSSI. Natural England's objective in the New Forest is to restore favourable condition to habitats that have been impacted by direct modification. Natural England is therefore looking to develop a restoration plan to bring the New Forest SSSI into favourable condition through a programme of ecohydrogical characterisation of the mires, which will result in the generation of recommendations for functional restoration of the New Forest SSSI.

1.3.1 Project Aims and Objectives

The aim of the project is to establish the physical habitat and ecohydrogical processes and forms typical of the mire/wetland floodplain habitats within a number of units of the New Forest SSSI to provide clear baseline data and recommendations on which a strategic operational restoration programme can be designed.

The specific objectives are:

1. To identify the floodplain features and SAC habitats associated with the abandoned and active floodplains and describe the impact of watercourse modification and other drainage activities;
2. To prepare ecohydrogical/hydrogeological characterisation of the mires following a full analysis of data already available supplemented by field data;
3. To provide brief details of the physical restoration opportunities for each mire and their logical sequencing at hydrological catchment and New Forest scales;

4. To review the current body of evidence and suggest what longer term monitoring could be put in place to provide a national set of scientific evidence to support wetland restoration.

1.3.2 Purpose of Report

This report provides an overview of the ecohydrogy survey conducted in the New Forest. Individual reports have be written for survey area however this report provides background information and discussions which support the information contained within the individual reports. The reports should therefore be read in conjunction with each other.

2 Methodology

2.1 Introduction

The following chapter outlines the methodology employed in undertaking the ecohydrogical assessments of the selected mire units

2.2 Ecohydrogical Investigation Methodology

To fully understand the ecohydrogical functioning of the mire systems a conceptual model has been developed for each distinct mire (or mire group), based on an analysis of existing information supplemented by additional fieldwork (see below for further details). In some cases a number of mire units have been grouped together due to similar characteristics and geographical location for ease of assessment; these are termed 'Ecohydrogical Assessment Areas'. Figure 2-1 below shows the location of the Ecohydrogical Assessment Areas, of which there are 24 labelled A to X as detailed in Table 2-1.

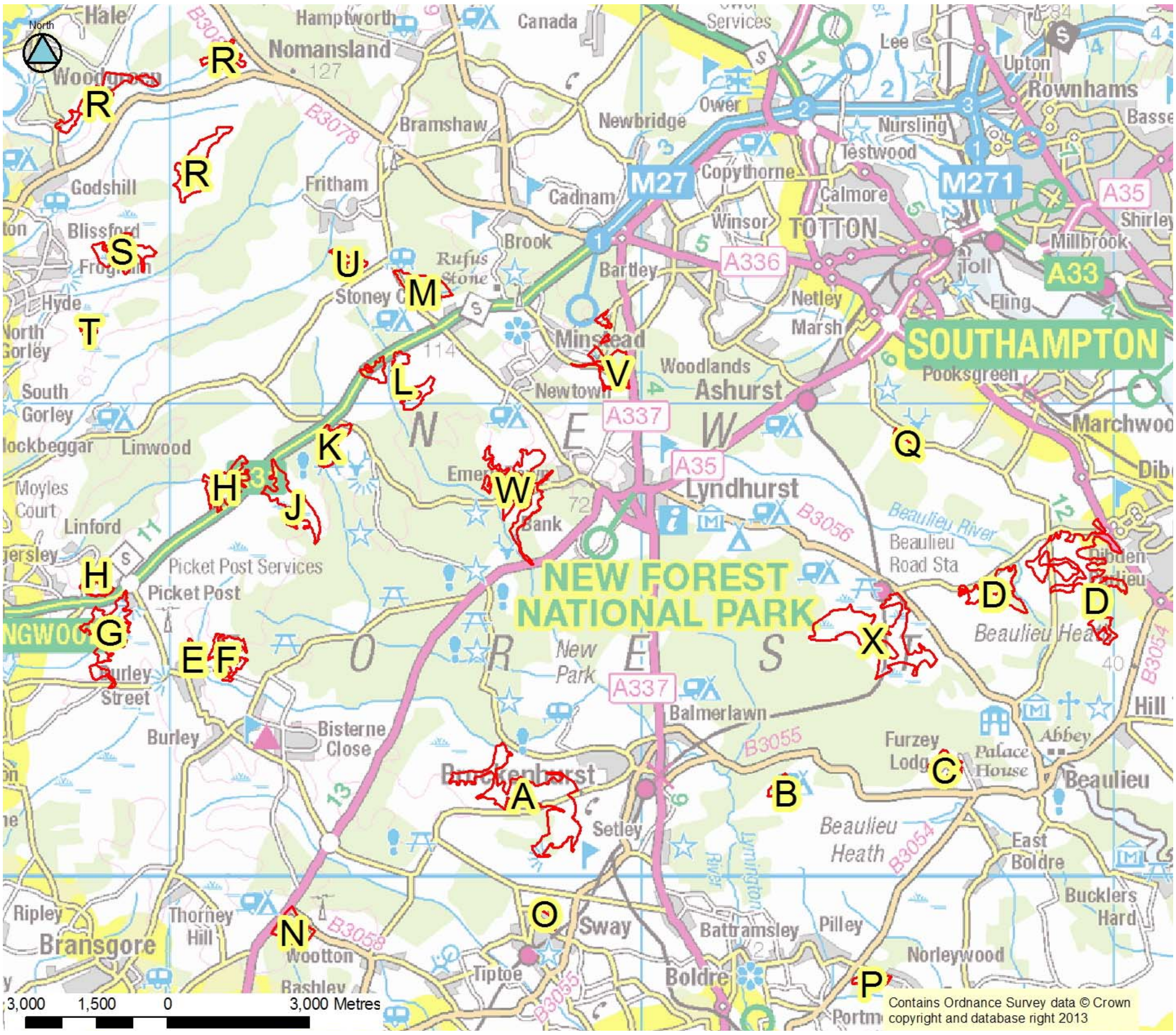


Figure 2-1: Ecohydrogical Assessment Areas

Table 2-1: Ecohydrogical Assessment Areas

Ecohydrogical Assessment Area	SSSI Units	Site Names
A	509, 511, 512 and	Holmhill/Redhill Bogs (Silver Stream), North Weirs

Ecohydrological Assessment Area	SSSI Units	Site Names
	515	Mire 1, North Weirs Mire 2 and Hincheslea Bog East
B	446	Lodge Heath Mire
C	447	Furzey Lodge Mire
D	417, 418, 419 and 425	Dibden Bottom 1 & 2 and 3, The Noads Mire and Ferny Croft North
E	130	Common Moor
F	129	Whiteshoot Bottom
G	125, 132 and 133	Ma 3 wet Foulford Bottom, Vales Moor 1 and Vales Moor 2
H	90 and 95	Shobley Bottom Mire and Buckherd Bottom
J	123	Soldiers Bog
K	341	Ma 5 Wet (Bratley)
L	341	Ma 5 Wet (Fritham - Withybed)
M	112	Long Beech
N	538	Little Wootton Pond
O	521	Sway Mire
P	444	Norley Mire
Q	413	Longdown Mire
R	32, 33 and 41	Deadmans Bottom, Millersford Bottom Mires and Ashley Hole Mire
S	43 and 44	Thompsons Castle and Latchmore Mire
T	50	Ogdens Mire
U	75	Suburbs Wood Mire
V	376	Hazel Hill Lawns
W	341	Ma 5 Wet (Pilmore Gate Heath, Millyford and Warwick Slade Bog)
X	388, 427 and 428	Denny Bog West, Denny Bog East and Penny Moor
N.B. there is no Site I- the area was initially included but removed from the study before the survey stage		

For each Ecohydrological Assessment Area a separate stand alone annex report has been written; developing a conceptual model for each area and discussing restoration and monitoring requirements.

In order to develop the conceptual model for each Ecohydrological Assessment Area the following information was required:

- Site location and topography,
- General climatic setting,
- Soils, geology, hydrology and hydrogeology,
- Wetland vegetation and hydro-ecology,
- WETland water supply MEChanismS (WETMECS classification - Environment Agency, 2009),
- Any drainage, peat cutting, river modification, forestry, or other relevant land management practices that may have had an impact on the mire.

The following sections detail how the above information was collected and how the conceptualisation for each Ecohydrological Assessment Area was formulated.

2.2.1 Desk study

The first stage of developing the conceptual model for each Ecohydrological Assessment Area was a desk-based study to collate and review existing available data to provide a broad understanding of the topographical, geological, hydrological and ecological characteristics of the site. The following data sources were utilised (where available):

- Information held by Natural England on the SSSI units, including SSSI citation, unit locations, condition assessments, vegetation information and other relevant background information.
- Ordnance Survey (OS) mapping.
- Aerial photography.

- Digital elevation models:
- LIDAR data.
- NEXTMap 5m data.
- General climatic data based on the Flood Estimation Handbook (FEH) CD-ROM (CEH, 2009) and Meteorological Office website.
- Geological mapping by the British Geological Survey (BGS)
- Soils mapping (the Soil Survey of England and Wales (1:250,000 - Soil Survey of England and Wales, 1983)).
- Borehole records from the BGS online borehole archive.
- Aquifer classifications and properties from the Environment Agency website and aquifer properties manuals (Allen *et al*., 1997; Jones *et al*., 2000).
- Environment Agency flood mapping (Environment Agency website).
- Water quality data from the Environment Agency website.
- Existing vegetation mapping/surveys including:
- Background information on the WETMEC classification scheme (Environment Agency, 2009).
- Previous assessments of the ecohydrogy of the New Forest mires (Weymouth and Cooch, 2000; Allen, 2005; Wheeler *et al*., 2009)
- Any other relevant reports or datasets held by Natural England.
- Existing studies undertaken (Wheeler *et al.*, 2009; Allen, 2005 and Cooch and Weymouth, 2000).
- New Forest SAC Management Plan

2.2.2 Ecohydrological Walkover Survey

Each Ecohydrological Assessment Area was visited by a hydrogeologist and ecologist and a walkover survey was conducted. All sites were visited between the 19th and 23rd November 2012.

In terms of the hydrogeological aspects, the purpose of this survey was to ground-truth interpretations made during the desk study, and to fill any gaps in the conceptual understanding of the site. A detailed photographic record of the site was also taken. Also, on several of the units, limited shallow ground investigations were undertaken using a hand auger. This helped to characterise the soils (including von Post peat classification, if appropriate) and other substrates present, and to investigate the presence of shallow groundwater.

For the ecological aspects of the investigation, an Extended Phase 1 Habitat survey was conducted during the walkover survey of each Ecohydrological Assessment Area, with particular emphasis on seepage faces, raised mire surfaces and trackways, These were then mapped in accordance with the Handbook for Phase 1 Habitat Survey (JNCC, 1990). This recorded the key habitats present within each area and the key botanical components of each. However, the Phase 1 Habitat Survey was conducted at a sub-optimal time of year, and a full botanical survey was not commissioned. This limited the number of species recorded, especially in terms of any rare and notable species. This habitat data, along with the information reviewed as part of the desk-based assessment, was then used to infer the indicative likely National Vegetation Classification (NVC) communities present within each Ecohydrological Assessment Area. This was done by referencing the relevant NVC publications (Rodwell *et al.* 1991-2000), reviewing the SAC Management Plan and from surveyor experience. It should be noted that a full NVC survey was not conducted as part of this study and only indicative NVC communities were determined. Consequently, the habitat mapping that was undertaken was not backed-up by any analytical quadrat data and, as such, it is at a much coarser scale than is typically found in full NVC surveys. As a result, any the fine-scale habitat variation within each unit will not be picked-out in the current survey.

2.2.3 Development of Conceptual Model (including WETMEC classification)

All of the information gathered in during stages 2.2.1 and 2.2.2 has been used to develop a conceptual ecohydrogical/hydrogeological model of each EcoHydrological Assessment Area. An ecohydrological conceptual model is a synthesis of how a hydrological system is believed to work and how it creates ecological niches.

Conceptual models for each wetland system take into account all that is currently known about a site to understand how water is supplied to them. This uses information about the following to understand the nature and distribution of the wetlands:

- Geology,
- Hydrogeology,
- Topography,
- Hydrology,
- Ecology,
- Damage observed (e.g. drainage, poaching and scrub/forest encroachment).

Further details on typical wetland systems of the New Forest and their WETMECs is presented in section 3 and the initial key findings of the conceptual models are presented in section 3.5.2.

2.2.4 Restoration and Monitoring recommendations

The basis and principles for the restoration and monitoring are discussed further in section 3.6 and 3.8.

2.3 Mire to Stream Transition Sites

There are 11 mire to stream transition SSSI Units within the study. They were subject to a geomorphological assessment, or an ecohydrological investigation, or both, as required (see Table 2-2). In general the transition sites fell into two categories:

- Sites with mires and streams (or rivers) but the two were separate with little transition.
- Sites with mires transitioning into small streams from collects.
-

Only Unit 33 fell into the first category. It was important that this site was surveyed by using both the Geomorphological (see geomorphological overview report) and ecohydrology methodologies. For the latter and larger group, both survey methodologies were likely to identify areas of damage and suitable restoration measures. This is because both surveys focused on small streams within and discharging from the mires, and the potential damage both within and surrounding those features.

Table 2-2: Survey types completed on Transitions SSSI Units

Unit Number	Geomorphological Survey	Ecohydrology Survey
43	Yes	Yes
422	Yes	No
129	No	Yes
123	Yes	Yes
419	No	Yes
33	Yes	Yes
423	Yes	No
91	Yes	No
112	Yes	Yes
95	Yes	Yes
126	Yes	No

For the six SSSI unit which were only surveyed by one survey group (either geomorphological or ecohydrological), the unit or Ecohydrological Assessment Area reports will cover both aspects required. The ecohydrological and geomorphological reports for the remaining sites will cross reference their findings.

3 Ecohydrological Investigation - Background

3.1 Introduction

This section provides background information that has been used within the ecohydrogical investigation to inform the conceptual models of the Ecohydrological Assessment Areas. The section goes on to discuss the types of damage that were observed during the field surveys and suitable restoration techniques. Lastly the section discusses monitoring requirements for the wetlands.

3.2 Geology and Soils

3.2.1 Solid (Bedrock) Geology and Structure

Geologically, the New Forest lies within the Hampshire Basin, a sedimentary basin containing strata of Tertiary age (Melville and Freshney, 1982). The bedrock beneath the Forest consists of interbedded sands, gravels, silts and clays belonging to the Lambeth, Thames, Bracklesham, Barton and Solent Groups (Table 3-1). Although they are classified as bedrock, these deposits are generally relatively soft (Smith, 2006). Underlying the Tertiary strata are rocks belonging to the Upper Cretaceous Chalk Group (Table 3-1).

The structural geology of the Tertiary rocks is relatively simple. In general the strata dip at a low angle (up to about 2.5°) to the southeast, south or southwest (Edwards and Fresnhey, 1987; Bristow *et al*., 1991; Barton *et al*., 2003). The oldest rocks are exposed in the north-western part of the area, and the youngest are exposed in the southeast. There are some gentle anticlinal and synclinal folds affecting the Tertiary strata, with axes trending east-west or northwest-southeast; these are related to structures in the underlying Mesozoic rocks (Edwards and Freshney, 1987). 1:50,000 geological mapping by the BGS shows only one fault mapped within the Tertiary strata of the New Forest: a north-south trending fault close to Denny Bog and Penny Moor, near Beaulieu (BGS DiGMapGB-50).

3.2.2 Superficial (Drift) Geology

Across large parts of the New Forest the Tertiary and older rocks are covered by superficial (drift) deposits of Quaternary age. The oldest superficial deposits were deposited during the Pleistocene Epoch. The youngest were deposited during the Holocene Epoch, which continues to the present day.

The Pleistocene saw dramatic climatic oscillations, with glacial periods alternating with warmer interglacials. During the glaciations, glaciers advanced across much of England, although they did not reach the area now occupied by the New Forest (Edwards and Freshney, 1987). The fact that the ice did not reach the area explains the absence of glacial till (boulder clay), a poorly sorted deposit dumped by melting glaciers. However, the area was influenced indirectly by the glaciers: head deposits (see Section 3.2.2.1) formed under periglacial conditions and glacial meltwater rivers transported vast quantities of sand and gravel (Bristow *et al*., 1991). The rivers were often graded to base levels different to modern sea level (Bristow *et al*., 1991), and so their deposits are preserved as river terraces above the modern floodplains.

The Holocene saw the deposition of alluvial deposits in river valleys, and also the local accumulation of peat.

3.2.2.1 Head

Head consists mainly of weathered material that has moved downhill by solifluction, a process in which waterlogged sediment moves slowly down-slope. Solifluction is particularly characteristic of periglacial environments where the spring/summer thaw gives rise to a saturated mobile layer of weathered material (broken up by freeze/thaw action) overlying an impermeable layer of permafrost. Other processes also contribute to head formation, including soil creep and the accumulation of wind-blown material, and some head may represent *in situ* regolith (Edwards and Freshney, 1987; Bristow *et al*., 1991; Barton *et al*., 2003).

As head is largely locally-derived, its lithology depends on the nature of the up-slope source material. In general it consists of poorly sorted clay, silt, sand and gravel (Edwards and Freshney, 1987; Barton *et al*., 2003). In the Southampton area the head is "typically a yellowish brown to orange-brown, silty clay or clayey sand, commonly with scattered angular flints." (Edwards and Freshney, 1987, p.78)

A thin skin of head (commonly < 1 m) covers most of the Tertiary Formations in the area, although this is not shown on published geology mapping (Edwards and Freshney, 1987). The published mapping shows head to be concentrated within valleys and on valley slopes. The minimum mapped thickness of head is 1 m; 2 to 3 m is typical and up to 5 m not uncommon (Barton et al., 2003).

3.2.2.2 River Terrace Deposits

River terrace deposits occur at a number of levels from about 0.5 to 100 m above the present-day floodplains (Barton *et al*., 2003). They consist mainly of sandy flint gravel, although finer material (silt and clay) is also present, especially in the upper parts of terraces (Edwards and Freshney, 1987; Bristow *et al*., 1991; Barton *et al*., 2003). In the Ringwood District, most river terrace deposits consist of an upper layer of gravelly sandy clay (typically about 0.8 m thick) overlying 1 to 2 m of mixed sand and gravel with a gravel base (Barton *et al*., 2003). Bedding within river terrace deposits is locally disrupted, reflecting cryoturbation ("frost churning" due to freezing and thawing) (Edwards and Freshney, 1987).

River terrace deposits are widespread within the New Forest. They commonly occupy the higher ground and interfluves, with the valley bottoms being floored by modern alluvium. Head deposits commonly blanket the slopes between the river terraces and modern floodplains.

3.2.2.3 Alluvium

Alluvial deposits occur along streams and river valleys. These deposits may consist of clay, silt, sand and/or gravel. In the Ringwood District, alluvium typically consists of up to 2.5 m of silt and clay (commonly organic or peaty) overlying a thin layer of "suballuvial" gravel (Barton *et al*., 2003). The alluvial sequences of the smaller streams of the Southampton District commonly consist of a layer of silty clay and clayey sand (up to 1.5 m thick) overlying a layer of sand and flint gravel (up to 1.5 m thick) (Edwards and Freshney, 1987).

3.2.2.4 Peat

The distribution of peat appears from the survey to be relatively poorly mapped within the New Forest. Within the survey, peat deposits were rarely observed to be over 0.5 m thick and the majority was less than 0.3 m thick. The thickest deposits were observed within valley basins.

Table 3-1: Stratigraphy of the New Forest and Surrounding Area

Age	Group	Formation	Member/ other	Description	Thickness
Quater-nary			Alluvium	CLAY, SILT, SAND and GRAVEL.	Up to 10 m
			Peat	Peat	
			River terrace deposits	CLAY, SILT, SAND and GRAVEL.	
			Head	CLAY, SILT, SAND and GRAVEL.	
Tertiary (Eocene)	Solent Group	Headon Formation / Headon Hill Formation		Greenish grey shelly CLAY with laminated SAND, SILT and CLAY.	Up to 49 m
			Lyndhurst Member	Greenish grey CLAY and fine-grained SAND with thick-shelled molluscs.	12 – 13 m
	Barton Group	Becton Sand Formation		Yellow/buff fine- to very fine-grained well sorted SAND.	6 – 70 m
			Becton Bunny Member	Grey/brown shelly CLAY.	0 – 8 m
		Chama Sand Formation		Greenish grey fine- to very fine-grained and rather clayey/silty SAND;	6 – 15 m

Age	Group	Formation	Member/ other	Description	Thickness
				slightly glauconitic. Also sandy CLAY.	
		Barton Clay Formation		Greenish grey to olive grey, glauconitic CLAY; may contain fine-grained sand and shells (mainly bivalves and gastropods).	26 – 80 m
	Bracklesham Group	Selsey Sand Formation		Fine-grained SAND, sandy SILT and sandy CLAY; locally shelly and glauconitic.	0 – 50 m
		Boscombe Sand Formation		Fine- to medium-grained SAND with local pebble beds.	0 – 25 m
		Branksome Sand Formation		Fine- to coarse-grained, commonly lignitic, sand with lenticular CLAY beds.	0 – 70 m
		Marsh Farm Formation		Laminated CLAY, and SAND with clay laminae.	0 – 25 m
		Earnley Sand Formation		Green, glauconitic, clayey, silty fine-grained SAND and sandy SILT.	0 – 25 m
		Wittering Formation		Laminated CLAY, and SAND with clay laminae.	0 – 57 m
		Poole Formation		Fine- to very coarse-grained (locally pebbly) cross-bedded, commonly lignitic, SAND. Interbedded with pale grey to dark brown, carbonaceous, lignitic and (commonly) laminated CLAY. Red-stained structureless clay and silty clay present locally.	25 – 110 m
	Thames Group	London Clay Formation		Brownish grey to grey, sandy to silty CLAY. Also clayey and sandy SILT and silty SAND. Commonly glauconitic. Thin beds of flint pebbles present locally.	30 - 115 m
			Whitecliff Sand Member	Fine- to medium-grained cross-bedded SAND, locally pebbly.	0 – 21 m
Tertiary (Palae-ocene)	Lambeth Group	Reading Formation		Grey (usually red-stained) CLAY passing in places into coarse-grained cross-bedded SAND. Local clay-breccia, and pebble beds. Partly glauconitic.	0 – 45 m
Cret-aceous	Chalk Group (White Chalk Subgroup)	Portsdown Chalk Formation		White CHALK with scattered flints.	

Sources:
BGS digital 1:50,000 geology mapping, Melville and Freshney (1982), Edwards and Freshney (1987), Bristow *et al*. (1991), Jones *et al*. (2000), Barton *et al*. (2003), and Neumann *et al*. (2004).

3.2.3 Soils

Table 3-2 describes the Soil Associations present within the sites of interest. Most of the soils are prone to seasonal waterlogging due to the presence of slowly permeable subsoil layers or pans (Smith, 2006; Allen, 2005). Many of the soils are susceptible to poaching and structural damage during the winter (Smith, 2006). Poaching is the physical breakdown of soil structure under load causing compaction, for example from the passage of animals or vehicles.

Table 3-2: Soils of the New Forest Wetland Sites

Soil Association Code	Soil Association	Description	Distribution
571s	Efford 1	Argillic brown earths. Well-drained fine loamy soils, often over gravel. Associated with similar permeable soils variably affected by groundwater.	Developed on river terrace gravels in the southern part of the area.
572j	Bursledon	Stagnogley argillic brown earths. Deep fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging. Associated with deep coarse loamy soils variably affected by groundwater. Some slowly permeable, seasonally waterlogged, loamy over clayey soils. Landslips and associated irregular terrain occur locally.	Developed on Tertiary clay. Present along the western edge of the New Forest, and also in the area between Lyndhurst and Ringwood.
631c	Shirrell Heath 1	Sandy-humo-ferric podzols. Well-drained, very acidic, sandy soils with a bleached subsurface horizon. Some similar soils with slowly permeable subsoils and slight seasonal waterlogging. Some sandy and coarse loamy soils affected by groundwater, often with a humose surface horizon. Droughty in the summer.	Developed on Tertiary sand. Present in the south-western part of the area.
643a	Holidays Hill	Naturally very acidic stagnogley-podzols. Sandy over clayey and loamy over clayey soils, locally with humose or peaty surface horizons. Slowly permeable subsoil layers/pans and slight seasonal waterlogging. Some very acidic well-drained sandy soils, and some deep sandy soils (affected by groundwater) with humose surface horizons. Vulnerable to poaching and compaction in winter. In the winter there may be standing water on level sites.	Developed on Tertiary sand and clay.
643c	Bolderwood	Naturally very acidic stagnogley-podzols. Coarse loamy over clayey soils with a bleached subsurface horizon. Slowly permeable subsoils and slight seasonal waterlogging. Vertical water movement impeded by subsoil pans and other slowly permeable layers. Local development of humose or peaty surface horizons (these are vulnerable to erosion). Some shallow, very flinty, soils. Excess winter rain ponds on surface and is absorbed slowly, but there is little runoff.	Developed on river terrace deposits. Located on the higher ground.
711g	Wickham 3	Typical stagnogleys. Slowly permeable, seasonally waterlogged, fine loamy over clayey and coarse loamy over clayey soils, and similar more permeable soils with slight waterlogging. Some deep	Developed on Drift over Tertiary clay. Very widespread in the New Forest.

Soil Association Code	Soil Association	Description	Distribution
		coarse loamy soils affected by groundwater. In the New Forest the soils often have thin humose surface horizons. Landslips and associated irregular terrain occur locally. Waterlogged for long periods during the winter, but moderately droughty in the summer. Poaches easily.	
711h	Wickham 4	Slowly permeable, seasonally waterlogged, fine loamy over clayey and fine silty over clayey soils associated with similar clayey soils, often with brown subsoils.	Developed on Drift over Tertiary clay. Present in northern and central areas.
841b	Hurst	Argillic gley soils with coarse loamy horizons. Coarse and fine loamy permeable soils mainly over gravel. Waterlogged by groundwater for much of the winter, but can be droughty in summer.	Developed on river terrace gravels.
841d	Shabbington	Argillic gleys. Deep fine loamy and fine loamy over sandy soils variably affected by groundwater (but tend to be affected by high water levels). Some slowly permeable, seasonally waterlogged, fine loamy over clayey soils.	Developed on river terrace deposits.
Too small to be mapped by the Soil Survey of England and Wales (1983)	Peat	Fibrous or semi-fibrous peat with raw un-decomposed surface layers.	Peat soils occur in many valley bottoms. They tend to occur within the Holidays Hill and Wickham Associations, and also on seepage steps at the boundary of the Bolderwood and Wickham Associations.
Notes: Sources: Soil Survey of England and Wales (1983), Smith (2006) and Allen (2005). *Stagnogley soils are slowly permeable, seasonally waterlogged, soils sometimes called "surface water gleys".			

3.3 Hydrogeology

3.3.1 Bedrock

Table 3-3 summarises the bedrock hydrogeology.

3.3.1.1 Chalk

The Chalk is a Principal (formerly Major) Aquifer of strategic importance for water supply in southern England (Allen *et al*., 1997; Environment Agency website). It has a high intergranular porosity, but the small size of the pores means that the hydraulic conductivity of the matrix is very low (~10^{-4} m/d) (Allen *et al*., 1997). However, the Chalk contains fractures, and these impart a high permeability. Most groundwater flow takes place within the upper 50 m of the aquifer, where fractures and bedding planes have been enlarged by solution (Allen *et al*., 1997).

Although the Chalk is often described as a dual porosity aquifer (with the intergranular pores providing storage and the fractures providing permeability), the small size of the intergranular pores means that they are not readily drained and that most of the effective storage is within the fracture network (Allen *et al*., 1997). As the fracture porosity is small, the specific yield is only about 1%, and the aquifer typically shows large seasonal fluctuations in groundwater level

(Price, 1996). Groundwater levels may fluctuate by as much as 20 to 40 m during the course of a year (Jacobs, 2007).

3.3.1.2 Tertiary

In the present context, the most important hydrogeological units within the bedrock are the Tertiary Formations because they crop out within the New Forest, where they may exert a direct influence on watercourses and wetlands. Of these Formations, the Barton Clay and much of the London Clay are classified as non-aquifers and the other Formations are classified as Secondary A (formerly Minor) aquifers (Jones *et al*., 2000; Environment Agency website). The Secondary A classification includes "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers" (Environment Agency website).

As a whole, the Tertiary succession forms a multi-layered aquifer system in which the sand layers act as aquifers and the silt and clay layers as aquitards. The aquifer layers are often discontinuous as the sand layers pinch out, and may be hydraulically isolated from other permeable units (Neuman *et al*., 2004). Confined and semi-confined conditions are common, as are perched water tables (Neuman *et al*., 2004). Groundwater flow and storage within the Tertiary aquifers takes place mainly within the intergranular pore system. Where the basal Tertiary strata are permeable they are likely to be in hydraulic continuity with the underlying Chalk.

Aquifer properties within the Tertiary succession are highly variable. Jones *et al*. (2000) quote the following values for the Palaeogene (Palaeocene, Eocene and Oligocene) of the Hampshire Basin: transmissivity 1.1 to 1600 m^2/d with an arithmetic mean of 429 m^2/d and a geometric mean of 72.2 m^2/d (8 records); storage coefficient 0.00002 to 0.05 (6 records). Transmissivities of 50 to 100 m^2/d have been obtained from the Bracklesham Group where it is in hydraulic continuity with the Whitecliff Sands (Jones *et al*., 2000), and the Environment Agency employs an estimated regional transmissivity of around 20 m^2/d for the Poole Formation (Neumann *et al*., 2004). For the Becton Sand (Barton Group), transmissivities are estimated to be of the order of 50 to 100 m^2/d (Neumann *et al*., 2004). The storage coefficient is estimated as 0.02% where the Becton Sand is confined and 5% where it is unconfined (Neumann *et al*., 2004). Porosities of 29 to 40% have been recorded within the Palaeogene strata (Neumann *et al*., 2004).

Table 3-3 provides information about typical borehole yields and positions of spring lines. The information on yields is useful in the present context in that it provides an indication of permeability and indicates which layers are the main aquifer units. Springs and seepages are likely to occur at the base of sand units that overlie lower permeability silt and clay.

3.3.2 Superficial Deposits

The alluvium and river terrace deposits are classified as Secondary A Aquifers (Environment Agency website). Within these deposits, sands and gravels will act as aquifers, and silts and clays as aquitards. The head deposits are classified as Secondary Aquifers (undifferentiated); this means that they may include both permeable horizons (Secondary A Aquifers) and lower permeability layers that may store and yield limited amounts of groundwater (Secondary B Aquifers) (Environment Agency website). Where permeable drift deposits overlie Tertiary sands, the two are usually in hydraulic continuity (Bristow *et al*., 1991). Table 3-3 summarises the superficial hydrogeology.

Table 3-3: Hydrogeology of the New Forest and Surrounding Area

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
Quater-nary			Alluvium	Aquifer / Aquitard	Yields from alluvium and terrace gravels are often obtained from the adjacent rivers.
			Peat	Aquifer / Aquitard	
			River terrace deposits	Aquifer / Aquitard Spring lines may be present at the base of high level river terraces.	
			Head	Aquifer / Aquitard	
Tertiary	Solent Group	Headon		Aquifer / Aquitard	Sandy strata

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
(Eocene)		Formation / Headon Hill Formation	Lyndhurst Member	Aquifer / Aquitard Confines underlying Becton Sand.	may provide yields sufficient for domestic or small agricultural use.
	Barton Group	**Becton Sand Formation**		**Aquifer** The most permeable and reliable aquifer within the Barton Group.	Yields up to 600 m^3/d in the south; in the north they rarely exceed 200 m^3/d.
			Becton Bunny Member	Aquitard	Little useable groundwater
		Chama Sand Formation		**Aquifer**	May yield small supplies
		Barton Clay Formation		Aquitard	Little useable groundwater
	Bracklesham Group	Selsey Sand Formation		Aquifer / Aquitard Spring line at base	Variable lithology makes borehole yield hard to predict. Boreholes up to 200 mm in diameter may yield up to 200 m^3/d; boreholes over 400 mm diameter have yielded more than 1800 m^3/d from sandier strata. However, boreholes with little or no yield have been recorded.
		Boscombe Sand Formation		**Aquifer** Effectively a single multi-layered aquifer	
		Branksome Sand Formation			
		Marsh Farm Formation		Aquifer / Aquitard	
		Earnley Sand Formation		**Aquifer**	
		Wittering Formation		Aquifer / Aquitard	
		Poole Formation		Aquifer / Aquitard Spring line at base	
	Thames Group	London Clay Formation		Aquitard Springs common at base of sand layers.	Sandy beds may provide small yields of up to 100 m^3/d; initial yields often diminish with time.
			Whiteclif f Sand Member	**Aquifer**	Yield up to 500 m^3/d.
Tertiary (Palae-ocene)	Lambeth Group	Reading Formation		Aquifer / Aquitard	Locally yields up to 200 m^3/d, although some of this water may come from the underlying Chalk. Usually yields less than 100 m^3/d. Boreholes may be dry where sands are thin or absent.
Cret-aceous	**Chalk Group (White Chalk**	**Portsdown Chalk Formation**		**Aquifer**	Principal Aquifer. Yields of 2000 m^3/d or more

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
	Subgroup)				can be expected from boreholes of 300 mm diameter. However, borehole yields depend on the intersection of water-bearing fissures. Water quality generally good.
Sources: BGS digital 1:50,000 geology mapping, Melville and Freshney (1982), Edwards and Freshney (1987), Bristow *et al*. (1991), Jones *et al*. (2000), Barton *et al*. (2003), and Neumann *et al*. (2004).					

3.3.2.1 Water Quality

Different hydrogeological units will provide groundwater of different qualities to wetlands. The acidity of the groundwater is likely to have a strong impact on the type of vegetation and habitats. Allen (2005) states that:

- The river terrace deposits and tertiary sandy strata tend to be base-poor (or acidic),
- Headon Beds and Barton Clays tend to be more neutral.

The Headon Beds and Barton Clays are low permeability strata and therefore often are not a major source of water inputs to a system. This means that even where they underlie wetlands, acidic waters from higher more permeable layers are often the main source of water (and thus the main control on local water quality).

3.4 Ecology

Within the mire and mire to stream transition units a number of habitat types were recorded during the Extended Phase 1 Habitat survey, including valley mire, wet heath, broad-leaved woodland/scrub and dry heath. The following section summarises the key features of the main habitat types recorded and the vegetation composition within these; however, as discussed above the time of year at which the survey was conducted has limited the species lists compiled.

3.4.1 Valley Mire

Valley mire habitat, as described by the JNCC Phase 1 Habitat Survey classification, encompassed those habitats found both in the boggy valley bottoms and in seepage areas on valley sides. Within these areas broadly described as 'valley mire' under the Phase 1 Habitat Survey classification, a number of distinct communities were recorded.

The most extensive community recorded was that dominated by Deer-grass *Trichophorum germanicum* and White Beak-sedge *Rhynchospora alba*. Within this relatively dense sward of medium-sized sedges, species-richness was quite high with Sharp-flowered Rush *Juncus acutiflorus*, Bog Asphodel *Narthecium ossifragum*, some scattered Heather *Calluna vulgaris*, Cross-leaved Heath *Erica tetralix* and Purple Moor-grass *Molinia caerulea* and a number of bog mosses (e.g. *Sphagnum papillosum, S. denticulatum*). In some of the valley mires surveyed stands of Common Sedge *Carex nigra* were also extensive (e.g. Dibden Bottom, Denny Bog). In general, these areas were very boggy and are considered to be most closely represented by the NVC community M21a *Narthecium ossifragum - Sphagnum papillosum* valley mire.

Figure 3-1: M21a Valley Mire Community in Dibden Bottom

Amongst the M21a community, along the seepage lines where water preferentially drains along the valley bottom or down the valley side, a more open, extremely boggy community was recorded. This community did not cover large areas and was confined to where water was channelled. Within this community a range of species were recorded, with Creeping St. John's-wort *Hypericum elodes* and Bog Pondweed *Potamogeton polygonifolius* abundant, with frequent Bog Asphodel and bog mosses (e.g. *Sphagnum denticulatum*). In places the non-native New Zealand Willowherb *Epilobium brunnescens* was also relatively frequent. It is considered that this community most closely equates to M29 *Hypericum elodes - Potamogeton polygonifolius* soakaway community.

Figure 3-2: Examples of M29 Soakaway Community on Vales Moor 1 (left) and Foulford Bottom (right)

Another mire community recorded during the field survey work was Purple Moor-grass mire. This mire community was generally species-poor, with Purple Moor-grass and Bog Myrtle *Myrica gale* the dominant species. Some Cross-leaved Heath was also recorded from within this mire community, which is considered to most closely equate to M25a *Molinia caerulea - Potentilla erecta* mire: *Erica tetralix* sub-community. In places this community was exceptionally tussocky, with large Purple Moor-grass tussocks interspersed with Bog Myrtle shrubs.

Some areas of standing water appear within the mire surfaces which are closely correlated to M1 *Sphagnum auriculatum* community. These also appeared where the topography affected trackways forming nick points slowing up flows.These bear some resemblance to the bog pool communities of raised and transition mires in the west of the UK, although here they typically occur on soligenous mires on gentle slopes. They are generally not that well developed and also generally lack the bogbean component of the NVC class which is characteristic of the community. This may be as a result of grazing or other disturbance although more work would be needed to verify this. Some supporting evidence for this hypothesis is the observation that this community was also present where the existing topography affected trackways, forming knick points slowing up flows: in the mire systems of the New Forest many of these nick points are the result of channel works downstream.

Figure 3-3: M25a community on Foulford Bottom

3.4.2 Wet Heath

Wet heath was an extensive community recorded in the units surveyed. This community contained abundant Cross-leaved Heath, Heather and Purple Moor-grass. In places this community was exceptionally tussocky and contained a variety of other species, interspersed between the tussocks, including Devil's-bit Scabious *Succisa pratensis*, Carnation Sedge *Carex panicea* and Yellow-sedge *Carex viridula ssp. oedocarpa*.

The wet heath community was considered to be represented by the NVC community M16a *Erica tetralix - Sphagnum compactum* wet heath; typical sub-community or, where more tussocky and species-rich, the M16b *Erica tetralix - Sphagnum compactum* wet heath; *Rhynchospora alba - Drosera intermedia* sub-community. However, there was generally a gradual transition between the wet heath communities of M16a/M16b and the Purple Moor-grass mire M25a, and the boundary between the two was often not distinct.

This habitat occurs widely over the higher valley sides and shoulders between the mire systems within the forest, and at its upper end transitions into dry heathland. It is often dominated by stands of Gorse *Ulex europea* or occasionally Holly *Ilex aquifolium*. In places this habitat is heavily grazed, especially around the margins of lawns where it may be reduced to tussocks with Cross-leaved Heath on them and a carpet of sedges and grasses in between. Many areas of wet heath were noted as having been burnt relatively recently, possibly to encourage the growth of grasses and reduce the cover of dwarf shrubs, including Heather and Gorse species.

Figure 3-4: Wet Heath on Ferny Croft North

An additional habitat, which is considered as a New Forest speciality, is known as Humid Heath, this shares many characteristics with H2c *Calluna vulgaris - Ulex minor* heath; *Molinia caerulea* sub-community and H3a *Ulex minor - Agrostis curtisii* typical sub-community heath but is distinctive owing to its lack of *Erica cinerea*, for which the ground is too wet, and *Sphagnum* mosses, for which it is too dry. Where there is a large component of *Cladonia* lichens this almost reaches the NVC community H3b *Ulex minor - Agrostis curtisii* heath; *Cladonia ssp*. sub-community.

3.4.3 Wet Grassland

Where grazing pressures were particularly high, often adjacent to roads or where watercourses had been over-deepened or straightened, a wet grassland community with an exceptionally short sward has developed; these are the characteristic 'wet lawns' of the New Forest. Species recorded in these wet lawn areas included Purple Moor-grass, Carnation Sedge and Yellow-sedge. It is considered that the wet grassland community most closely equates to the NVC M24 *Purple Moor-grass - Cirsium dissectum* fen-meadow community.

Many of the heavily grazed wet lawns contain a high proportion of rushes and are an unusual form of M23a *Juncus effusus/acutiflorus - Galium palustre* rush pasture; *Juncus acutiflorus* sub-community. This community is widespread across the British Isles, but the grazing regime within the New Forest maintains an extremely tight sward unlike that found elsewhere.

As many of the wet lawn areas were located adjacent to watercourses this community is regularly inundated after periods of heavy rain and, when surveyed, many were under water or contained pools of standing water.

Figure 3-5: Wet Lawn areas on Whiteshoot Bottom (left) and unit 341 (right)

3.4.4 Broad-leaved Woodland/Scrub

Within the mire units, woodland was often present in the valley bottoms, along the preferential drainage lines and watercourses. This has resulted in many units containing narrow, linear strips of woodland or dense scrub. This was most commonly dominated by Grey Willow *Salix cinerea*, with frequent birch (both Downy Birch *Betula pubescens* and Silver Birch *Betula pendula*) and occasional Oak *Quercus robur*. The ground flora is generally sparse, and similar in character to valley mire habitat which generally surrounds the linear woodland strips. It is considered that this woodland type most closely relates to W4b *Betula pubescens - Molinia caerulea* woodland; Juncus effusus sub-community; a typical bog woodland community. It should be noted that many of the Grey Willow trees within these woodlands may be of considerable age, having grown, fallen over and regrown a number of times. In view of this these trees and their associated woodlands are likely to be home to very specialist invertebrate assemblages.

3.4.5 Dry Heath

On the boundaries of many of the mire units, rising up the valley sides, the habitat moved from wet heath into a much drier heath community dominated by Heather, with occasional Cross-leaved Heath and Purple Moor-grass. Scattered Gorse *Ulex europaeus* and Dwarf Gorse *U. Minor* was also frequent. This habitat is represented by the H2 *Calluna vulgaris - Ulex minor* heath NVC community. H3c *Ulex minor - Agrostis curtisii* heath; *Agrostis curtisii* sub-community, also forms a significant proportion of the dry heaths. These stands often represent areas with slightly less intensive grazing pressure and slightly moister soils.

Figure 3-6: Dry Heath Habitat on Vales Moor 2

3.4.6 Other Habitat Types

In places extensive stands of Bracken *Pteridium aquilinum* were present. These were either dense and contained few other species, or were more scattered and interspersed with Heather and Gorse. These Bracken dominated areas were generally found on higher, drier areas, within the dry heath H2 community.

In a number of units (e.g. Whiteshoot Bottom, Dibden Bottom, Ferny Croft North) bog pools were recorded within the wet heath, wet grassland and valley mire habitats. These were generally species-poor with extremely dystrophic water. Species recorded from within these pools included Bog Pondweed, Creeping St. John's-wort, Floating Club-rush *Isolepis fluitans* and tussocks of Purple Moor-grass. In areas where grazing and poaching occurred the species diversity of the bog pools was noted to increase, with species including Floating Sweet-grass *Glyceria fluitans*, Yellow Water-lily *Nuphar lutea*, Ivy-leaved Water-crowfoot *Ranunculus hederaceus* and Round-leaved Water-crowfoot *R. omiophyllus* recorded. This increased species-richness may be associated with the nutrient enrichment generated by the grazing and associated dunging. Similar more species-rich assemblages were also often recorded alongside boardwalks and at crossing points along streams where water was ponded.

Figure 3-7: Dystrophic Bog Pools at Dibden Bottom (left) and Ferny Croft North (right)

An infrequent habitat occurs where the seepage face flows over basic clays. The resulting vegetation contains the mosses *Palustriella commutata* and *Scorpidium revolvens,* and most closely corresponds with M10a *Carex dioica - Pinguicula vulgaris* mire: *Carex demissa - Juncus bulbosus /kochii* sub-community.

In a few number of units (e.g. Soldiers Bog, Whiteshoot Bottom, Buckherd Bottom) stands of Common Reed *Phragmites australis* were also recorded. These were generally depauperate and very species-poor with Common Reed by far the most dominant species. Also on Soldiers Bog was a small stand of Common Reedmace *Typha latifolia*.

Figure 3-8: Reedbed at Soldiers Bog

3.5 WETland Water Supply MEChanismS and New Forest Wetland Types

3.5.1 Introduction

This section presents two basic ecohydrogical wetland system types that have been regularly observed during the on-site survey. Wetland Water Supply Mechanisms (WETMECs) have been used to identify mechanisms within these general types that lead to different niches and habitats. WETMECs were developed in partnership between the Wetland Research Group at the University of Sheffield, the Environment Agency, English Nature (now Natural England) and Countryside Council for Wales. WETMECs are ecohydrological classifications of how water can be supplied to a wetland to create distinguishable habitats. The system is relatively complex, with 20 different WETMECs (and 36 sub-classifications). Not all WETMECs are present in the New Forest area (e.g. lowland raised mires) so the section below focuses on the WETMECs relevant to this study in the New Forest area.

3.5.2 Identifying WETMECs

The type of WETMECs (and therefore general ecohydrogical conditions) present on a site is dependant mainly on the following factors:

- Underlying strata -aquifers, aquitards, etc.
- Topography- slopes, basins, troughs, drainage paths, etc.
- The permanence of the water supply - i.e. are there periods where water is not supplied.
- The thickness of peat.

WETMEC uses a number of terms which together describe the water source and topography of the habitats. In general, WETMECs that include the word 'seepage' are supplied directly from groundwater, whereas 'flushed' suggests water that originated from a seepage but has run over an impermeable surface. 'Basins', 'Troughs' and 'Bottoms' denotes wetlands within depressions. 'Flow Track' denotes an area where surface water run-off focuses but before it becomes a true stream. A 'Quag' denotes a quaking (or buoyant) surface within a depression. The majority of the WETMEC identified in this study are shown below.

Table 3-4: Typical WETMEC identified in the New Forest Study

WETMECs Name	Description
W9 - Groundwater Fed Bottom	Troughs or basins, usually on quite deep peat With underlying no aquitard. Marginal springs / seepages often less evident. GW supply often inferred from hydrogeological data.
W10b Diffuse Seepage	Summer-wet surface, usually sloping and shallow peat; seepages usually visible, over permeable substratum. Often elongated seepages, often forming a valleyside zone.
W11 Intermittent and part-drained seepages	As WETMEC 10 but water well below surface in summer or year round; also more often on flat surfaces or in sumps. They often lie immediately above WETMEC 10 on a slope.
W13 Seepage Percolation Basin	Unconsolidated (quaking / buoyant) surface in groundwater-fed basins (WETMEC 10) and sumps etc.
W14 - Seepage Percolation Trough	Soft or quaking (rarely buoyant) surfaces in groundwater fed valleyheads and troughs. More sloping than WETMEC 13
W15 - Seepage Flow Tracks	Groundwater-fed flow paths in mires, often embedded in WETMEC 14 but occasionally alone. Unconsolidated watery surface
W16 - Groundwater-Flushed Bottoms	Surfaces in groundwater-flushed valleyheads and troughs. Often similar to WETMEC 14 but over aquitard and often with thinner peat. Marginal springs / seepages often evident.
W17 - Groundwater Flushed Slopes	GW-flushed slopes (rarely flats) with thin peat over aquitard, below springs or seepage line (often narrow). Where fed by a strong seepage = W17a Groundwater Flushed Slope Where fed by a weak seepage = W17b Weakly Groundwater Flushed Slope.
W17d - Groundwater-Flushed Flow Tracks	Groundwater-fed flow path, often embedded in W17a and b (where water from a seepage collects into a flow path) but occasionally alone. Unconsolidated or watery surface.
W18 - Percolation Troughs	Soft or quaking (rarely buoyant) surfaces in groundwater fed valleyheads and troughs dominated by rainfall run-off
W19 - Flow Track	Flow track often within WETMEC 18, like W17d but on thicker peat in a trough or like W15 with limited groundwater input.
W20 - Percolation Basins	Like WETMEC18 but in a larger basin. Mainly run-off feed with deep peats. Where rafting - WETMEC20a Percolation Quag Where there is an adjoining area of open water next to WETMEC18a - WETMEC 20b Percolation Water Fringe

These WETMECs are rarely found in isolation (Table 3-4). Within the New Forest most wetlands fall into the two following Wetland Types:

- ***Flush Dominated Wetlands*** - Wetlands underlain by aquitards, supplied by water from an aquifer layer further up the hill, which then runs downhill over impermeable surfaces.
- ***Seepage Dominated Wetlands*** - Wetlands underlain by an aquifer and received water mainly from groundwater sources.

These are not topographical definitions of wetlands. Within both these types are valley side wetlands and valley basin wetlands. The type and position of the WETMECs within these systems is shown in the figures below (Figure 3-10 and Figure 3-11). Within the selection of Ecohydrological Assessment Areas studied on site as part of this project, there appears to be a bias towards sites underlain by aquitards or weak aquifers (Figure 3-9). This has resulted in a higher proportion of wetlands being identified as flush dominated than would likely be the case overall within the New Forest. Work by the likes of Wheeler *et al.* (2009) and Allen (2005) show there are a number of seepage dominated wetlands across the centre of the New Forest, mainly underlain by the Becton Sands.

Figure 3-9: Ecohydrological Assessment Areas, Bedrock Hydrogeology and Mire Distribution

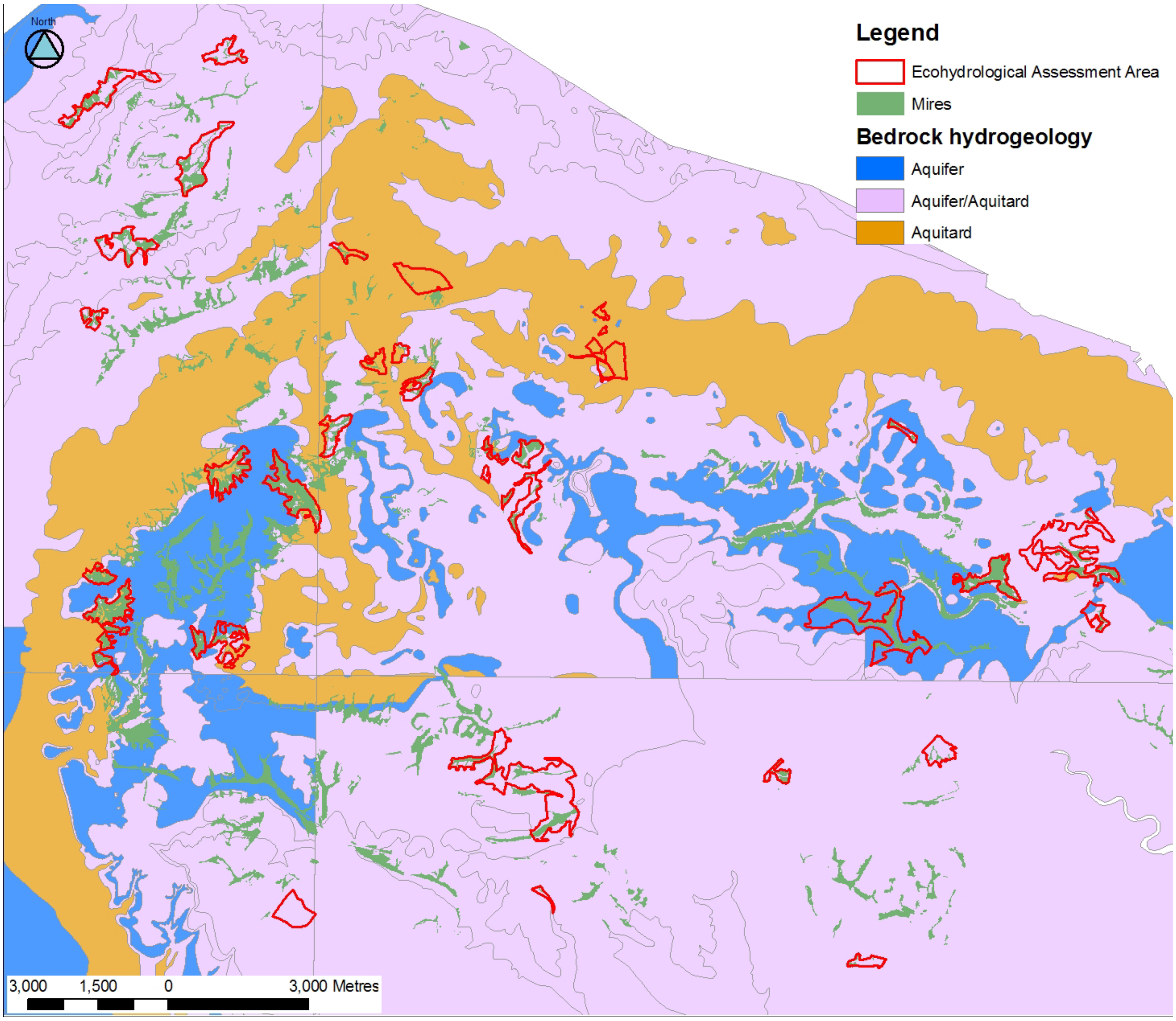


Figure 3-10: Flush Dominated Wetlands

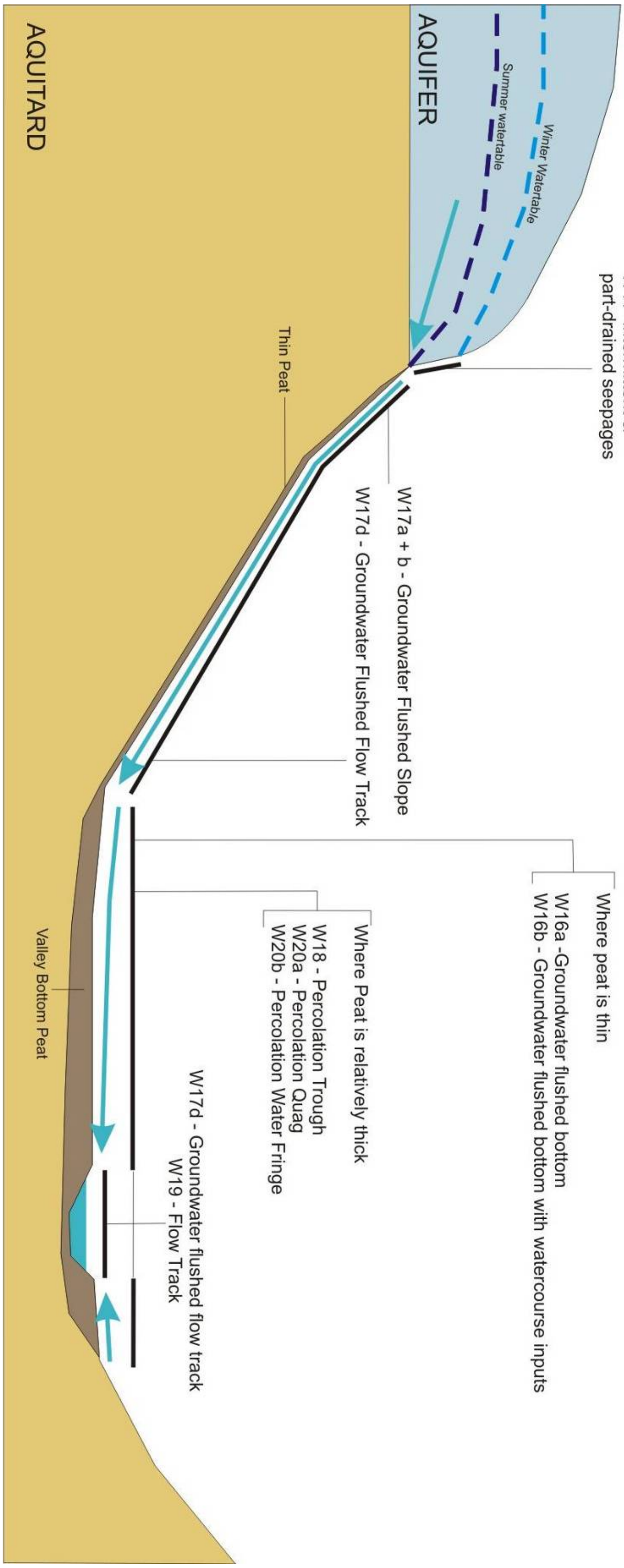
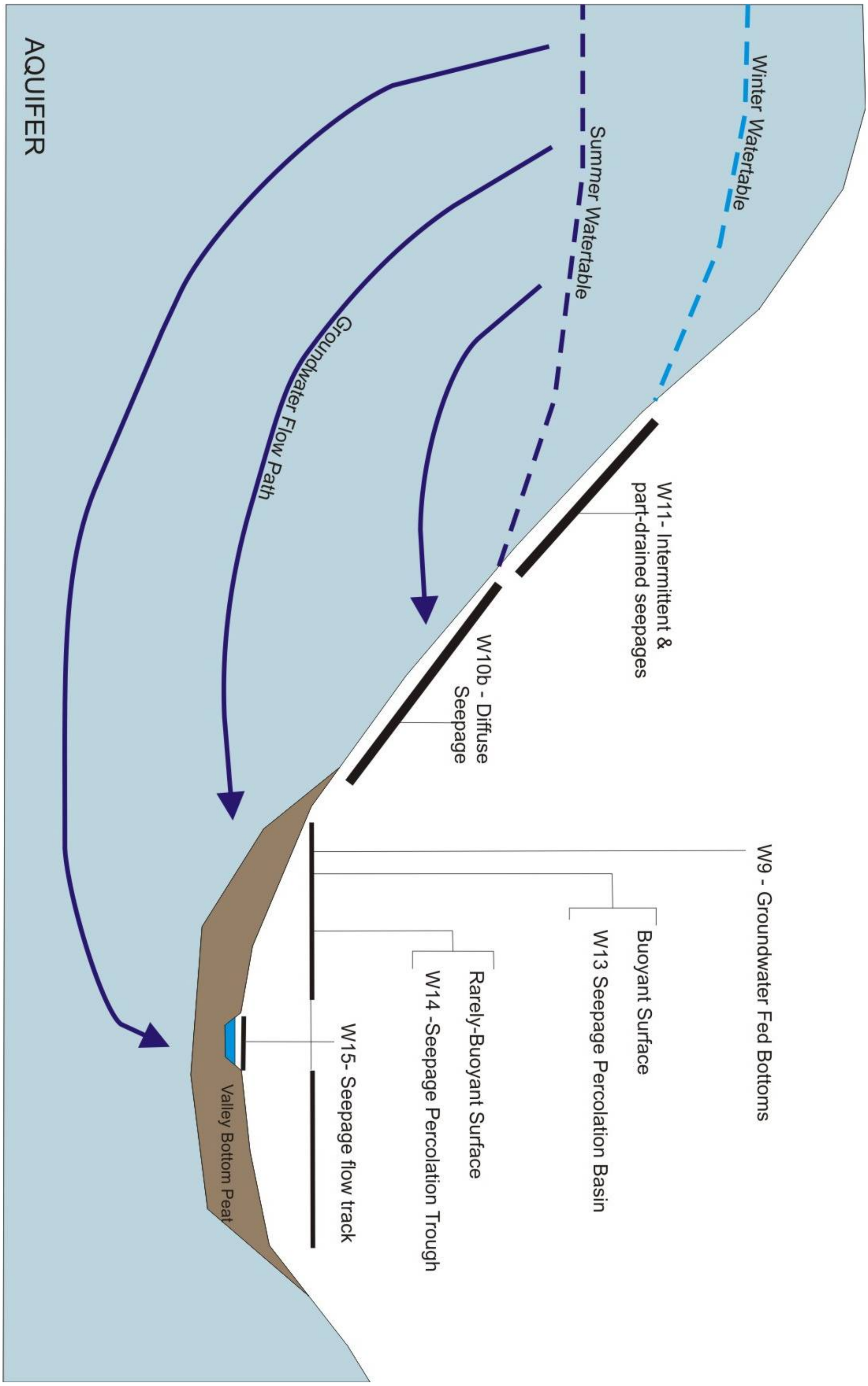


Figure 3-11: Seepage Dominated Wetland



Within New Forest types studied in this project, the Flush Dominated Wetlands are more common than the Seepage Dominated Wetlands. Valleys are frequently cut through bedrock aquitards (or relatively low permeability aquifers). On their upper slopes the valleys also often cut through relatively high permeability river terrace gravels. At the junction between these deposits a seepage line is commonly found. The groundwater from this runs downhill over the low permeability bedrock forming WETMEC 17 - Groundwater Flushed Slopes and supplying water to the valley basins and troughs below.

Unlike the valley side wetland for which each Wetland Type only has a limited number of WETMECs classes, within the valley basin wetlands there can be many different WETMECs depending on the following:

- Peat thickness;
- Peat buoyancy;
- Basin size (and slope).

These factors lead to different habitats despite the underlying hydrogeology and the way that water is supplied to these basins being broadly similar.

An additional feature of New Forest wetlands that often make them different from others in the UK is the more acid nature of many of the groundwater inputs (Allen, 2005). This leads to habitats which in typical situations require a relatively thick peat or peaty soils, but which in the New Forest are being supported on thin peaty soils or mineral substrates.

3.6 Wetland Damage and Restoration

3.6.1 Introduction

The wetlands of the New Forest have been subject to a range of damaging activities and processes that have had a negative impact on their condition. This section outlines many of the generic types of wetland damage that have been observed within the ecohydrogical survey. Except in rare situations, damage observed has been relatively small in scale or has been the result of historic drainage that has since become less effective than it originally was. In certain situations, such as some lawn creation, damage to wetlands has occurred over a sufficient period of time for the original habitat to be completely removed and replaced by another which may also have considerable ecological value.

3.6.1.1 Typical types of Mire Damage

The mire damage that has been observed generally falls into the following categories:

- Drainage;
- Scrub encroachment and forestry;
- Overgrazing and poaching;
- Footpath erosion and recreational pressures;
- Non-native, invasive species.

Erosion can be associated with all of these types of damage, which can exacerbate the scale of damage caused. Erosion that would naturally happen (i.e. that has not been initiated by human intervention, including stocking) has not been categorised as causing mire damage.

3.6.1.2 Drainage

Drainage within the surveyed New Forest wetlands is often historic and over time its effectiveness has reduced since it was first installed. The main exceptions to this are where the anthropomorphic drainage concentrates flows such that they are able to erode the stream beds (or at least maintain them as open). This tends to be on steeper slopes or within larger valleys.

Valley Basin Wetlands

Within Valley Wetlands there are four types of historic drainage features:

- Central Drains - these are often large drains which have been cut through the bottom of the valley. Sometimes, probably due to access issues, they are cut along the edge of the valley bottom (e.g. Silver Stream),

- Herringbone Drains - these are drains that are cut at an angle to the central drain (often through the raised spoil embankments of the central drain) to allow water to be quickly removed from the valley basin (e.g. White Moor);
- Depression draining ditches - small sections of drains which are cut to drain otherwise poorly drained topographic depressions within a valley bottom;
- Lawn creation - some valley bottoms have been subject to herringbone and central drains as well as managed grazing which appears to have led to the wastage of peaty soils together with the removal of the wet heath and mire vegetation that was supported by it. This habitat has been replaced with neutral wet grasslands on mineral soils.

Some examples of these drainage types are given in the photographs below.

Figure 3-12: Valley Basin Central Drain on Hincheslea Bog

Figure 3-13: Enlarged, straightened and deepened valley basin stream at Millersford Bottom (with floodplain modified to wet grassland)

Figure 3-14: Drainage for lawn creation at South Weirs

Figure 3-15: Aerial photography of herringbone drainage south of Dibden Bottom

Figure 3-16: Ditch cut to drain a depression at Long Heath Mire

Valley Side Wetlands

On Valley Side Wetlands the following general types of historic drainage features have been observed during the survey:

- Drains to concentrate water in flushes - small individual drains are often dug through flushed slopes to concentrate overland flow into small channels. On OS mapping, these are often marked as 'Collects' (although a high proportion of collects are natural features);
- Regular drainage oriented downslopes - this type of drainage is similar to gripping (small, shallow open drains) which is seen in upland blanket peat areas. Within the survey area, this type of drainage was rarely seen. One exception to this was the continuation of lawn creation drainage onto the sloped sides of White Moor;
- Forestry drainage - small drains are often cut between lines of plantation forestry or around blocks of plantation woodland. Within the survey area, this drainage was often relatively muted (small relict features) or none existent;
- Parallel seepage collection drains (gutters) - on rare occasions drains are cut along the slope below a seepage face to intercept seepages. These drains were effective at limiting the extent of flushed slopes. Sometimes these drains are associated with paths. Raised paths can have similar impacts acting divert and collect water on flushed slopes.

Some examples of these drainage types are given in the photographs below.

Figure 3-17: Forestry Drainage at Little Wooton Inclosure

Figure 3-18: Regular valley side drainage at Millersford Bottom

Figure 3-19: Path with culvert through (bottom right) collecting and focusing flush flows at Longdown Mire

Figure 3-20: Historic parallel seepage collection drain at Sway Mire (bright green linear feature)

In all these situations natural processes can then act to enlarge the drains and cause headward and downslope erosion. In addition, footpaths (with or without deliberate drainage) can act to drain wetlands.

Figure 3-21: Headward Erosion on Vales Moor 2

3.6.1.3 Scrub Encroachment

In several of the mire units it was noted that scrub, predominantly Scots Pine *Pinus sylvestris*, but in some cases birch, was beginning to encroach into the wet heath and valley mire areas. Gorse, willows and Holly *Ilex aquifolium* were also observed within raised ground in mires. Rhododendron *Rhododendron ponticum* occurred in several locations, often associated with the edges of older woodland blocks, but sometimes seedlings were discovered quite remotely from existing stands. This is discussed in more detail in section 3.6.1.7 below.

Figure 3-22: Scots Pine Encroachment on Denny Bog (east)

3.6.1.4 Grazing and Poaching

Grazing was present throughout the units surveyed; by ponies and cattle in most places, but also deer and donkeys. Where grazing pressures were particularly high, poaching was observed, however, this tended to be localised and was often associated with fording points for drains and streams, where it was a significant problem in several places, often exacerbated by footpath erosion (see section 3.6.1.5).

Poaching collapses the banks and can led to the spread of flows across a wider area. Where this wider area is formed from peat or peaty soils (or any easily erodible surface) significant local damage can be caused to the wetland, with vegetation cover completely removed over very localised areas. Fords can also cause deeper sections of streams to form which leads to headwater and downslope erosion.

Figure 3-23: Ford on a drain at Millersford Bottom leading to the collapsing of banks

Figure 3-24: Animal fording point at Lay Gutter Valley leading to the creation of a large pool with head ward erosion

Figure 3-25: Poaching and footpath erosion causing significant problems across watercourse at Whiteshoot Bottom

3.6.1.5 Footpath Erosion and Recreational Pressure

The New Forest is traversed by a number of footpaths and bridleways and, as a whole, is a well used creational resource; this can cause problems through footpath erosion. Footpath erosion, like poaching, was found to be particularly severe at the crossing points of watercourses, although other areas also suffered considerably if well used, for example around car parks. Similarly to poaching, this impacts on the wetland habitat, leaving localised areas denuded of vegetation, resulting in erosion which can cause the collapse of stream banks.

Associated with the crossing points of footpaths, water was frequently observed to pond, both upstream and downstream of the structures, as the current structures present an impediment to the movement of water. Where water has ponded, the mire community has frequently been replaced by a much wetter, bog pool over a localised area usually upstream of the structure. Downstream there may also be ponding due to the deposition of material eroded (scoured) from around the structures themselves.

Figure 3-26: Significant footpath erosion in unit 341 (left) and near the car park in the north of Dibden Bottom (right)

3.6.1.6 In a few of the units there was also evidence of vehicular pressures on the heathland areas, with rutted tracks evident.

3.6.1.7 Non-native Invasive Species

The most significant infestation of a non-native invasive species was Rhododendron, which was found to be encroaching into the heathland areas of several units. In most cases, the specimens were relatively small and isolated, and did not cover significant areas and were generally associated with older woodland blocks.

In the north of Dibden Bottom, in a pooled area of water immediately upstream of the boardwalk crossing the stream, a small patch of New Zealand Pigmyweed *Crassula helmsii* was recorded.

Figure 3-2728: Rhododendron at Vales Moor 1

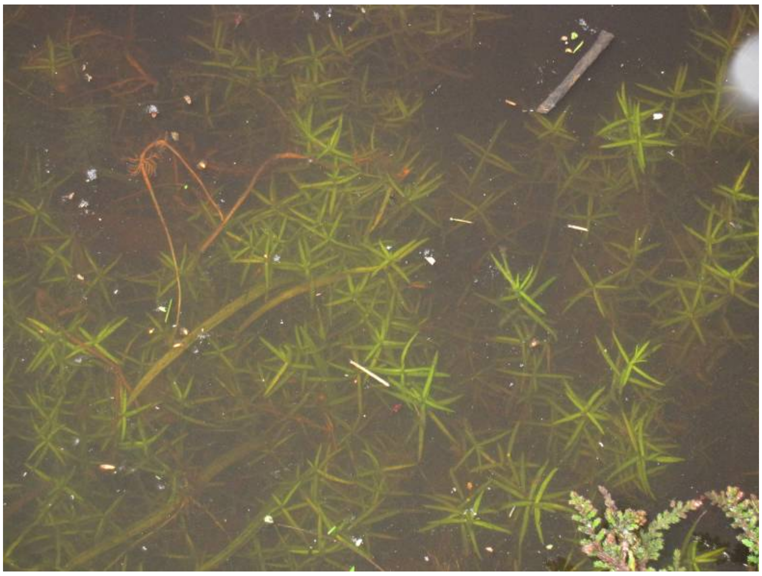


Figure 3-29: New Zealand Pigmyweed at Dibden Bottom

3.6.2 Restoration Techniques

3.6.2.1 Drainage

Drainage that requires restoration falls into three main categories:

- Small drains on low gradients:
  - In these situations a range of materials (earth, peat, wood, etc.) can be used to plug the ditches without a risk of those materials being rapidly eroded away, as the water passing along the ditch has little erosive power;
- Small drains or gullies on steep gradients:
  - Drains on steeper slopes or any gulley is likely to have the potential to erode simple plugs. In these cases the watercourse can be infilled (which gives instant results) or blocked with small dams after which the drain will hopefully naturally infill with time;

- Medium to large scale drain (approximately over 1.5 wide and 1m deep):
    - o Larger drains with significant flows are often cut through the bottom of valleys. Despite the shallow gradients of these drains, their size and the large flows through them means that formally engineered weirs may be required to block them.

These categories of drainage and their restoration techniques are discussed below in more detail.

Small Drains on low gradients

Small drains on low gradients are unlikely to have the erosive power to remove all bar the weakest most poorly constructed plugs. As a result a range of materials can be used to block them including, earth, heather bales, wood or stone; however the end result must be a plug that is water tight.

Where a drain is cut through peat, with no mineral substrate revealed, plugs of earth and stone may contaminate and change the vegetation. In many cases, peat plugging is likely to be the best solution. This involves a 'peat plug' being placed in the drain to effectively block the flow and dam surface water upstream from that point. The peat plug material is cut out by machine close to the dam.

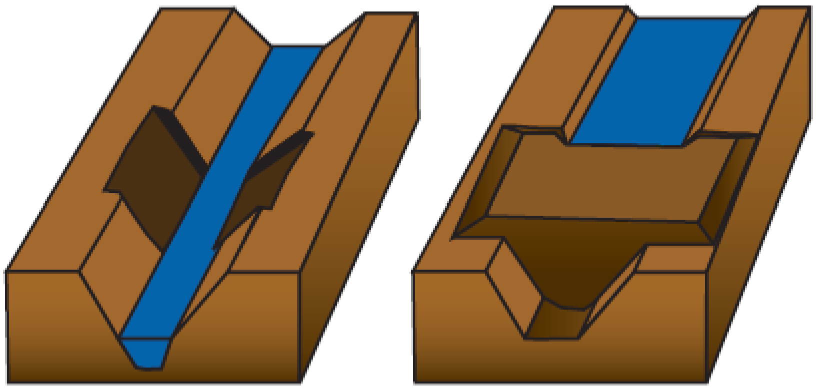


Figure 3-3031: Installation of a peat plug (from Quinty and Rochefort, 2003)

The following principles are recommended when creating peat dams (Quinty and Rochefort, 2003):

- Use wet peat;
- Simply pushing surface peat into a ditch and driving over it with a tractor often leads to leaking or breakage of the dam after one or two years. It is much better to scrape and remove the dry surface peat and use the wet, more decomposed peat underneath. Scraped off peat can then be used to fill the depression created;
- Clean both sides of the ditches to be dammed of vegetation. Fresh wet surfaces provide better contact and sealing for the peat plugs;
- Compact the blockage thoroughly with heavy machinery such as the excavator;
- Blockages should be around 2 m wide (in the direction of ditch/drain) to better resist erosion;
- Blockages should be higher than the surrounding surface by about 30 cm and extend approximately 1 m on both sides of the ditches;
- Do not cut into the mineral substrate because it can lead to loss of water and contaminate the restoration site with mineral soil and favour colonisation of non-peatland vegetative species.

Where drains cut through or down to mineral substrate, non peat materials should be used to form the plugs. Peat plugs are therefore only likely to be suitable where there is sufficient peat in the area to provide the material for the plugs. This means that it is a technique probably limited in the New Forest to valley mire areas with deeper peat.

Drains on Steep Gradients and Gulley Blocking

Surface water from flashy storm events enter gullies and cause erosion, thus structures used in their restoration must be able to stand running water passing over them. Many types of simple plugs are not suitable as they are easily washed away. Evans *et al.* (2005) consider that both plastic piled and wood dams are suitable techniques for blocking gullies (Figure 3-32).

Figure 3-32: Plastic Sheet Pile Dam (left) and Wooden Pile Dam (right) (from Evans *et al.*, 2005 and http://www.exmoor-nationalpark.gov.uk/wetland_award_project_final_report.pdf)

Both plastic (including recycled plastic) and wooden dams have their advantages and disadvantages. Wooden dams tend to be more expensive than plastic dams, and are harder to install in remote locations because of their weight. However, their overall visual impact may be less. In addition to this, plastic dams can be built taller than wooden ones which means that they can be spaced further apart. Within the proposed restoration scheme, only plastic dams are referred to, however, depending on several factors, those who install the dams may prefer in some instances to install wooden dams instead (especially if the wood is readily available locally).

The spacing of plastic/wooden dams along the length of the gulley is important. They should be placed such that the water spilling over a dam hits the surface of the pool created by the next dam further downstream rather than bare ground, as this would cause erosion and undercutting of the dam (Figure 3-33). Some erosion is still likely to happen when heavy rainfall following a dry period, where downstream pools are not filled up, but the degree of erosion will be restricted.

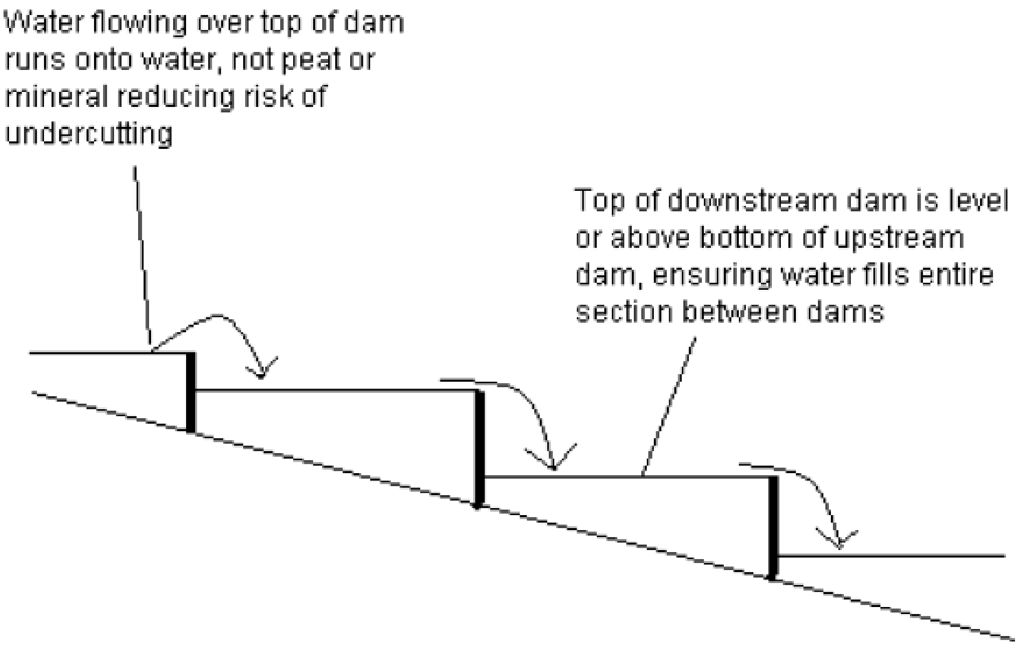


Figure 3-33: Spacing of Dams in a Gulley (from Evans et al., 2005)

It is important to seal the seams and/or reinforce the dams on their upstream surface with a peat plug (see Figure 3-34).

Figure 3-34: Peat Use to reduce the permeability of a dam (from http://www.exmoor-nationalpark.gov.uk/wetland_award_project_final_report.pdf)

Successful gulley damming a should result in sediment build up behind the dam and in certain situations revegetation (see Figure 3-35 and Figure 3-36)

Figure 3-35: Infilling of a gulley with sediment behind wooden dams (from Evans et al., 2005)

Figure 3-36: Infilling a gulley with vegetation after the installation of plastic sheet piling (from Evans et al., 2005)

An alternative to regular dams along a gulley is infilling. In the New Forest, this has been trialled already using heather bales and clay plugs (Forestry Commission, 2006) (see Figure 3-37). This immediately limits the impact of gullies on draining mires; however, their continued success is dependant on the heather bales withstanding the erosional force of water that may continue to run over the new raised surface of the infilled gulley line (see Figure 3-38).

Figure 3-37: Gulley Infilling Technique (Forestry Commission, 2006)

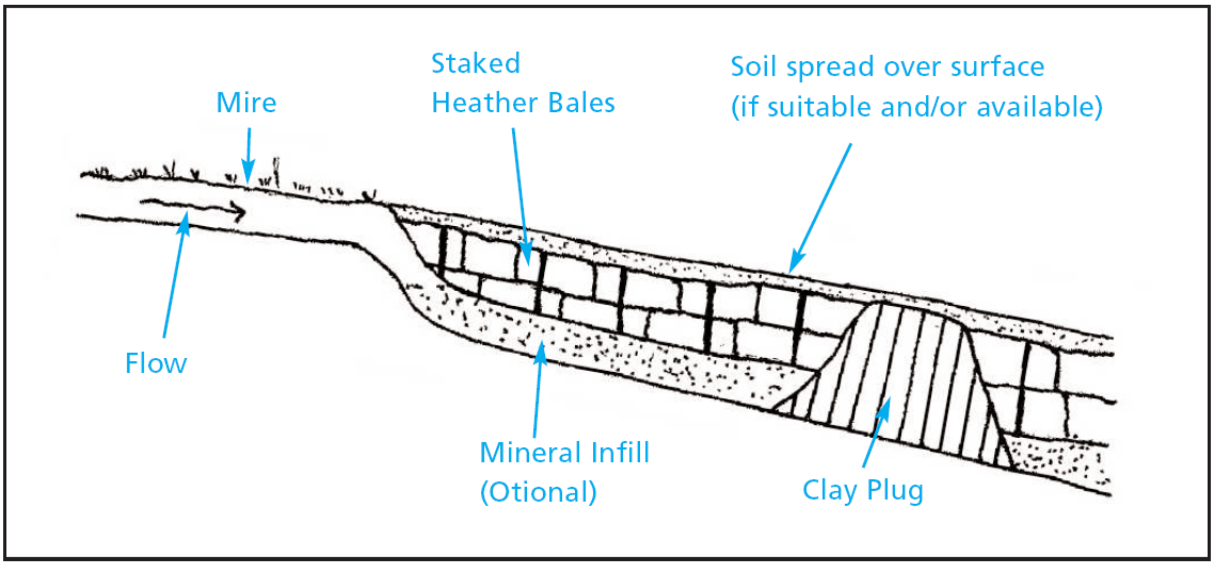


Figure 3-38: A failing staked heather bale infill in SSSI Unit 95

Alternatives to heather bales, such as clay (or earth) can be used to infill. These materials are less likely to be prone to erosion however could contaminate peatland areas with mineral input.

Medium to large scale drain

In situations where medium to large drains have been installed to replace natural channels, channel naturalisation is recommended. However, there are situations where medium to large drains are cut through mires, where no channels (natural or otherwise) existed before. The aim in these situations should be to block the drains and remove their drainage influence. Despite the shallow gradients of these drains, their size and the flows through them means that formally engineered weirs may be required to block them. Depending on the size, intended lifespan, flows etc. such dams can be made from plastic sheet or steel piling. However such structures require formal engineering design and often Environment Agency consent (see Figure 3-39).

Figure 3-39: An example of a simple steel sheet pile dam on Thorne Moors (Photograph A Jones)

3.6.2.2 Scrub Encroachment and Forestry

In several of the units scrub encroachment, usually from adjacent or nearby forestry plantations, was identified as an issue. Where this is beginning to encroach into wet heath and mire habitats, degradation of habitats can occur as the scrub can lead to localised drying of conditions. The predominant invading species was Scot's Pine, although in places Gorse and occasionally Holly was identified as an issue. Where this is identified as a major factor, control should be undertaken, either through mechanical cutting or herbicide application; the method selected will be dependent on the extent of invasion, the size of the plants and accessibility to the site. Where encroachment is only a minor issue, monitoring of the extent of invasion may be a more appropriate and cheaper solution, as the ground conditions may not allow for further encroachment into the unit, therefore control may not be necessary.

The issue of Rhododendron control is discussed below.

3.6.2.3 Overgrazing and Poaching

Due to the nature of the grazing rights within the New Forest, and the open, unfenced landscape, restricting grazing in many areas would be very difficult. Working in partnership with graziers, areas of overgrazing could be more effectively shepherded in order to reduce the impact of livestock.

In areas of extreme, localised poaching, temporary fencing could be installed to help vegetation communities re-establish.

3.6.2.4 Footpath Erosion and Recreational Pressures

Localised footpath erosion was identified as an issue in several of the mire units, leading to damage of the vegetation on the mire surface. Eroded footpaths on slopes, in a number of units, also provided a conduit for water flow, further exacerbating the erosion problem. This was particularly identified as a problem at crossing points and, therefore, the construction of appropriate crossing points should be considered to prevent further erosion and allow vegetation communities in these localised areas to recover.

However, in some units, inappropriate crossing points were identified as problematic as they have created an impediment to the movement of water, leading to localised ponding of water and replacement of mire communities with a surface water pool. The crossing points constructed must therefore be of an appropriate size and design to not cause impediment to water flow; a boardwalk structure, rather than a culvert, may be a more suitable type of crossing point.

Where existing structures have been identified as potentially causing an impediment to water movement and causing localised ponding, consideration should be given to modification of these structures, for example through replacement with boardwalks or culvert upsizing, to reduce the localised ponding of water and help to restore the natural mire communities.

Vehicle pressure, through rutting of the peat surface, was also identified as a problem in some units. This may be a difficult issue to resolve, although education of land managers and appropriate signage to control vehicle movements may be sufficient.

3.6.2.5 Non-native, Invasive Species

Rhododendron was the most frequently observed non-native invasive species and this was prevalent in many units. In some of these unites this species is now beginning to spread into mire and wet heath habitats. There are a number of control and management techniques available for Rhododendron, including (Edwards, 2006):

- Herbicide application (foliar application of regrowth, foliar application of whole plant or stump treatment);
- Hand pulling (of seedlings);
- Mechanical flailing;
- Manual cutting.

The method, or combination of methods, selected for control will be dependant on the extent of invasion, the size of the plants and the accessibility of the site.

New Zealand Pigmyweed was also identified in one unit (Dibden Bottom). The eradication of this species is extremely difficult and, therefore, a containment strategy should be implemented. Mechanical control is not recommended as fragmentation can cause further spread. Chemical control is often the only suitable management technique available, although new novel control techniques may become available in the future. The Hampshire and Isle of Wight Wildlife Trust are currently running the New Forest Non-Native Plants Project to control the spread of invasive non-native plants in the New Forest, particularly along watercourses and in wetland habitats (see http://www.hiwwt.org.uk/pages/living_landscap-new-forest-non-native-plants-project-1384.html). Working in partnership with this project could be a method of containing the spread of this species on this site.

3.6.3 Restoration Objectives

Clear and realistic restoration objectives should be developed for all the sites in the study. Without these objectives it is difficult to develop restoration plans.

Damage caused by historic drainage activities, often hundreds of years old, has led to the complete removal of many of the original wetland habitats. Examples of this can be found all over the New Forest. In some cases it appears that many lawns that are now present may once have been valley bottom mires, which then have been subjected to drainage activities and significant peat wastage. This creates three basic situations:

- The drainage has been very effective and the mire is completely removed;
- The drainage is not effective at all and the mire is not damaged or self repairs;
- The mire is slightly damaged, some degraded peaty soils remain, but the drainage was not good enough to completely remove the mire and replace it with lawn.

In the majority of cases these situations are found grading into each other in very close proximity. Areas of degraded mire can therefore be a transition area between lawn (or wet grassland areas) and mire.

The outcome of this is that protecting or improving the areas of degraded mire may not be possible without impacting upon the lawn areas. As a result three main restoration principles behind the objectives for the site are possible:

- Restore all habitats back to a situation pre-drainage:

- o This would aim to restore many areas of lawn back to mire, however, this could be a long term outcome, on the scale of possibly centuries, in areas where peat and peat soils would have to redevelop.;
- Accept that where habitats are in equilibrium with the current drainage, no restoration is required:
  - o Restoration would therefore only be required where the drainage is increasing (e.g. eroding gullies) or the drainage is relatively recent and is causing degradation;
- Only restore degraded areas of mire, where the restoration does not have a significant effect on surrounding wetlands.

Across the New Forest, it is envisaged that a mixture of these principles should be used depending on the specifics of the unit (e.g. area of damaged mire to lawn, ecological value of the lawn, the ease with which areas can be hydraulically isolated from each other).

3.7 Restoration Findings

Restoration measures were recommended for 17 of the 23 Ecohydrological Assessment Areas (see Table 3-5). There are only a few sites where large scale works are required (defined as those that would require an engineered structure). The majority of sites require medium scale works, which are defined as equivalent to 10-30 simple plugs or a few (e.g. 5) wooden dams. The benefits of the work have been judged on whether they are required for habitat protection (e.g. stopping a gulley from continuing headward erosion into a mire) or habitat improvement (e.g. blocking drains in a degraded mire). In general there is a correlation between the scale of works and the benefits that it will bring, however, there are situations where this is not the case (e.g. where a large engineered weir is required in a gully to protect a small area of mire from ongoing headward erosion that would at some future date begin to erode the mire). It is difficult to rank the restoration priority against each other, as it is difficult to weigh benefits against costs. If costs are lightly weighed, then the scale of benefits would be the main control on priorities, whereas if costs are heavily weighed in the analysis, smaller scale schemes would be the priority. However, it is clear that at some sites the benefits of restoration are proportional to the cost (e.g. Longdown Mire), whereas others restoration would achieve less benefits for similar outlay (e.g. the Enlarged Drain on Ashley Hole Mire). Restoration priorities will also potentially change as robust restoration objectives are developed for the sites.

Table 3-5: Restoration Recommendation Summary

Code	Name	Size (Ha)	SSSI Units	Restoration Required	Restoration Area	Habitat Protection (Note 1)	Habitat Improvement (Note 1)	Scale (Note 2)	Access issues (Note 3)
A	North Weirs Mire et al.	173.9	509, 511, 512 and 515	Y	Silver Stream	3	N/A	3	3
					White Moor	N/A	2	3	2
					Trenley Lawn	2	N/A	2	3
B	Lodge Heath Mire	12.0	446	Y	-	1	1	1	1
C	Furzey Lodge Mire	26.4	447	Y	-	1	2	2	1
D	Dibden Bottom and Noads Mire	179.0	425, 417, 418, and 419 (43)	Y	-	2	2	2	3
E	Common Moor	12.5	130	N	-	N/A	N/A	N/A	N/A
F	Whiteshoot Bottom	34.8	129	N	-	N/A	N/A	N/A	N/A
G	Vales Moor and	68.4	125, 133 and 132	Y	-	1	N/A	3	2

Code	Name	Size (Ha)	SSSI Units	Restoration Required	Restoration Area	Habitat Protection (Note 1)	Habitat Improvement (Note 1)	Scale (Note 2)	Access issues (Note 3)
	Foulford Bottom								
H	Picket and Buckherd Bottom	62.8	90 and 95	Y	-	2	N/A	1 to 2	1
J	Soldiers Bog	64.4	123	Y	-	N/A	2	2	1
K	Bratley	28.5	341	N	-	N/A	N/A	N/A	N/A
L	Ma 5 Wet 5 part 2	42.9	341	N	-	N/A	N/A	N/A	N/A
M	Long Beech	43.6	112	N	-	N/A	N/A	N/A	N/A
N	Little Wootton Pond	38.1	538	Y	-	N/A	3	2	2
O	Sway Mire	5.0	521	Y	-	1	N/A	2	2
P	Norley Mire	13.5	444	Y	-	N/A	1	1	1
Q	Longdown Mire	7.4	413	Y	-	N/A	2	2	1
R	Deadmans Bottom, Millersford Bottom Mires and Ashley Hole Mire	140.6	33, 32 and 41	Y	Valley Side Drainage	N/A	2	2	2
					Enlarged Drain	1	N/A	3	2
S	Lay Gutter Valley	49.1	43 and 44	Y	-	2	N/A	1	2
T	Ogden's Purlieu	13.9	50	Y	-	1	2	2	1
U	Suburbs Wood	11.6	75	Y	-	N/A	1	1	1
V	Hazel Hill Lawns	41.8	376	N	-	N/A	N/A	N/A	N/A
W	Acre Down and Warwick Slade Bog	65.6	341	Y	-	N/A	3	2	2
X	Denny Bog	137.6	428, 427 and 388	Y	-	2	3	3	2 to 3

Table notes
1. Benefits - 1 = Small, 2 = Medium, and 3 = large
2. Scale - 1 = Small (e.g. Couple of simple plugs or small wooden dam weirs), 2 = Medium (e.g. 10-30 simple plugs and a number of small wooden weirs), 3 = large (e.g. Engineered Structures)
3. Access 1 = Easy (e.g. Machines would have a short distance to travel and no matting required), 2 = Medium (e.g. Machines would have a long distance to travel and no matting required), 3 = Large (e.g. Matting required due to buoyant peat surfaces)

3.8 Monitoring Requirements

This section outlines the general principles of ecological and hydrological monitoring recommended for the New Forest Wetlands. Then it outlines the specific requirements for each Ecohydrological Assessment Area and attempts to give some suggestion to the priorities.

3.8.1 Vegetation Monitoring General Principles

Within the individual Ecohydrological Assessment Area reports vegetation monitoring recommendations are made. This generally takes three forms:

- Fixed point camera surveys;
- Fixed point quadrat surveys;
- Transect studies.

These techniques are designed to collect the most useful data possible, in a relatively cost-effective and rapid manner. Full site resurveys, Phase I habitat surveys of ecological audits or NVC surveys could be conducted, but these would be costly and time consuming.

The fixed point camera surveys are primarily to assess long-term changes in the overall habitat and character of specific units, for example to assess the extent of scrub encroachment within a unit over time (which could then trigger restoration action). Fixed point camera photography could also be used to monitor critical areas, such as watercourse crossing points, to assess the continued impact of footpath erosion/inappropriate crossing points, or the re-establishment of mire/wet heath communities following restoration.

The fixed point quadrat surveys are to record more quantitative data following implementation of restoration measures, to assess vegetation community change. Within a unit, a number of carefully selected quadrat points (geo-located and feno-marked (a type of metal GPS marker) on the ground for ease of repeat surveying), for example adjacent to a blocked drain, can be used to assess how, and over what time period, mire and wet heath communities will be restored.

Transect studies incorporate two different study methods. The first would involve a simple alternating quadrat study at regular intervals along the transect from one habitat to another looking at the number or percentage cover of the invading species in each. This is ideal when looking for colonisation of open heathland by gorse, Rhododendron or Bracken. The second method would again involve dividing the transect into regular intervals and recording the nearest tree species found, its distance from the transect and its diameter at breast height (DBH) measurement. This would be used in areas where tree colonisation was being studied.

3.8.2 Species Monitoring General Principles

The New Forest also supports a number of notable and protected species, and the restoration measures detailed within this report have the potential to impact on a number of these species, both negatively and positively. Monitoring may therefore also be implemented to assess the impact on selected species; this should be done prior to implementation to establish a baseline and determine what species are present now and post-restoration to ascertain long term impacts.

Table 3-6 below provides brief details on species monitoring protocols and recommendations; where suitable habitats are present in units identified as sites for restoration the appropriate species survey/monitoring can then be conducted. This will also help to establish any environmental change arising from the measure implemented.

Table 3-6: Species Monitoring Recommendations

Species/Group	Survey/Monitoring Protocol	Reference
Great Crested Newt	Can undertake Habitat Suitability Index (HSI) assessments of pond (this is not a substitute for presence/absence surveys). Presence absence surveys involve conducting 4 visits to a pond, and utilising a number of survey techniques (e.g. bottle trapping, torching, egg searching, netting, refuge searching). For population estimates 6 visits are recommended. These surveys can only be conducted at the optimal time of year (March-July). Monitoring of presence/absence or population size pre- and post-restoration would give an indication of impact on this species.	Langton *et al.* (2001)
Breeding Birds (e.g. Dartford Warbler)	The breeding bird populations within the New Forest have been subject to considerable survey effort by the Forestry Commission (and others) and this should be continued. Birds are often used as indicator species as they adapt very quickly to environmental change. Therefore using historical survey data in comparison to future, post-restoration surveys, will	Bibby *et al* (2000) Gilbert et al (1998)

Species/Group	Survey/Monitoring Protocol	Reference
	highlight any changes resulting from the proposed works. Should works take place in sites not currently monitored, then, should time before construction allow, surveys should commence during the 2013 season to provide a baseline against which future monitoring can be compared. These surveys should be undertaken monthly as a minimum, and preferably fortnightly between April and July.	
Overwintering Birds (e.g. Hen Harrier)	Efforts to monitor over-wintering bird populations should continue post-restoration, and during construction-phase, to determine the impacts on bird species. Where not already covered as part of routine, on-going survey efforts, vantage point surveys are recommended. The topography of most of the wetland complexes lends itself to this method of survey, many having raised ground above them, making vantage point selection relatively simple. It is recommended that these are carried out monthly.	
Southern Damselfly	A number of life stages of the southern damselfly could be monitored, including number of adults emerging (exuvia counts) or counting adults or larval populations. The type of monitoring protocol adopted depends on the resources available, and should be influenced by historical ecological records of this species. Fixed transects, counting adults, could be a useful, relatively rapid way of monitoring impacts on this species, with transects established across the relevant units.	Thompson *et al.* (2003)
Notable Plants (e.g. Hampshire Purslane, Wild Gladiolus, Pennyroyal, Slender Marsh Bedstraw, Dorset Heath	Due to the time of year at which the field surveys were conducted, few notable plant species were noted, however, the New Forest has been subject to extensive botanical surveys which should continue and inform future monitoring. Therefore, in order to assess the potential impact of restoration on notable plant species, a walkover survey of the restoration areas will be required, with counts of plants made if appropriate. This can then be followed by repeat monitoring counts to assess how the populations are impacted upon by the restoration schemes.	n/a
Sand Lizard	Reptiles have the potential to be present within the restoration areas. Surveys should therefore be conducted prior to restoration to establish their presence/absence and population size (if necessary). Post-restoration monitoring should therefore be conducted to determine any impacts. This will require 6 visits (2 in April and 4 in May; weather dependant). The survey will involve searching the area around for reptiles whilst they are basking in the open or in partial cover and also checking any potential refuges. Artificial refugia should also be used, although for some species (e.g. sand lizard) detection rates are low. Capture-Mark-Recapture techniques could also be used for monitoring populations.	Edgar *et al.* (2010)
Smooth Snake		

3.8.3 Water Level Monitoring General Principles

Within the individual Ecohydrological Assessment Area reports water level monitoring recommendations are made. Water level monitoring, where recommended, takes two main forms:

- Boreholes (or dipwells) which monitor groundwater levels;
- Stilling wells which monitor water levels in watercourses (including drains and ditches) and other open water bodies.

No monitoring is recommended to provide baseline information for sites unless:

- The vegetation does not seem to be in equilibrium with the current drainage. This is because, if vegetation appears to be in equilibrium with the current drainage, then the habitats which are there are supported by the current water level conditions. This means that monitoring is unlikely to add further useful information;
- And/or restoration plans are recommended for the site. Monitoring can be useful in confirming the need for restoration and in assessing its impacts.

Groundwater monitoring is not recommended in flush dominated wetlands - these are reliant on water running across the surface of the ground. This is relatively difficult to monitor with boreholes which monitor groundwater levels. The only potential exception to this is within valley bottoms with significant peat deposits, where water levels can be monitored in the peat.

In order to characterise the baseline hydrological condition of an area under investigation, prior to the implementation of any restoration plan, is recommended that the water level monitoring is continued for at least one whole calendar year and preferably for three whole calendar years from the date of the installation of the measurement equipment. This should allow the site to be monitored over a range of climatic and seasonal conditions and permit the magnitude and temporal patterns of water level variation to be quantified. Following the implementation of any restoration plan it is recommended that the hydrological monitoring continues for a minimum of 3-5 years, and preferably much longer. The resulting water level datasets should be regularly reviewed and assessed to provide further insights into the site hydrology, together with evaluating the impacts of any restoration works and the identification of any further works or management/maintenance that might be required.

Information about the nature and cost of installation arrays is given in Table 3-8.

Table 3-7: Cost and details of recommended approaches to Monitoring

Generic monitoring approach	Cost	Method description
Monitoring of groundwater levels (boreholes) and surface water levels (stilling wells)	Indicative costs: Basic network (3 installations): £6,500 Medium network (7 installations): £8,500 Large network (10 installations): £9,500	Initial site visit to finalise and agree monitoring network with NE and NFNPA (+ any other 3rd party) Installation of monitoring boreholes (within shallow hand-auger holes) and stilling wells (within ditches/streams). Purchase of automatic water level monitoring devices (data loggers) and installation of these within boreholes and stilling wells. One year of monitoring, including three download visits and associated data processing. The costs assume that JBA staff travel from Yorkshire to undertake the downloads. A saving of approximately £2,500 could be made if Natural England (or another local representative/contractor, as an in-kind contribution) were to undertake the download visits. Outputs would be: (i) the installed monitoring network and (ii) one year's worth of processed monitoring data. The costs do not allow for any interpretation of the monitoring data or for production of a report. These tasks could be undertaken at additional cost if required.

3.8.4 Monitoring Requirement for the Ecohydrological Assessment Areas

Table 3-8 outlines the suggested monitoring requirements for each Ecohydrological Assessment area. An indicative prioritisation ranking has been given to the sites based on the value and scale of restoration works indicated in Table 3-5. Those sites that require large scale works and/or might experience significant improvement through restoration (i.e. currently more degraded) have been given higher priority for monitoring. The total monitoring costs for the different ranking groups (based on mid range costs) are summaries in Table 3-9.The total is 118.5k for the first year of monitoring, although it is only £38.5k if only the high priority sites are monitored. The subsequent years for the hydrology monitoring elements would be significantly cheaper as the bulk of the initial costs are for the installation equipment.

Table 3-8: Summary of Suggested Monitoring for each Ecohydrological Assessment Area

Eco-hydrological Assessment Area	Size (Ha)	Site Names	Requirements for monitoring: ecology			Requirements for monitoring: hydrology		Priority
			Type of monitoring	Monitoring Requirement	Annual Costs	Type of monitoring	First year Costs	
A	17 3.9	North Weirs Mire et al.	Fixed point camera survey (specifically focussing on areas where footpaths are impeding flows and poaching) Fixed point quadrat survey to establish baseline.	20 sites plus collation and interpretation of results 10 quadrats plus data processing and analysis	£2–2.5k	8 boreholes and 2 stilling wells (10 installations in total) Plus associated monitoring and data processing	£7-9.5k	H
B	12	Lodge Heath Mire	Fixed point camera survey (specifically focussing on extent of Rhododendron encroachment and areas of poaching) Fixed point quadrat survey (focussing on recovery of poached areas) Alternating transect study to quantify size and extent of Rhododendron spread.	10 sites plus collation and interpretation of results 5 quadrats plus data processing and analysis 3 transects	£2-2.5k	6 boreholes and 1 stilling well (7 installations in total) within the valley mires Plus associated monitoring and data processing	£6-8.5K	L
C	26. 4	Furzey Lodge Mire	Fixed point camera survey (specifically focussing on extent of pine scrub encroachment). DBH transect study to measure extent of colonisation.	10 sites plus collation and interpretation of results 5 transects	£1-1.2k	Flush dominated wetland – little peat – no monitoring recommended	-	M
D	17 9	Dibden Bottom and Noads Mire	Fixed point camera survey (specifically focussing on extent of pine scrub encroachment, areas where footpaths are impeding flows and footpath erosion/poaching) Fixed point quadrat survey to establish baseline prior to restoration works. DBH transect study to quantify extent of pine colonisation.	20 + 10 (30) sites plus collation and interpretation of results 10 quadrats plus data processing and analysis 5 transects	£3.5-4k	6 boreholes and 4 stilling wells (10 installations in total): 417: 3 boreholes and 2 stilling wells 418: 1 boreholes and 1 stilling well 419: flush-dominated – no monitoring recommended 425: 2 boreholes and 1 stilling well Plus associated monitoring and data processing	£7-9.5k	M
E	12. 5	Comm on Moor	Fixed point camera survey Fixed point quadrat survey (specifically focussing on the western part of unit where restoration is proposed to monitor impacts on mire and wet heath communities)	10 sites plus collation and interpretation of results 5 quadrats plus data processing and analysis	£1-1.5k	3 boreholes and 3 stilling wells (6 installations in total) Plus associated monitoring and data processing	£6-8.5K	V L
F	34. 8	Whites hoot	Fixed point camera survey (specifically	10 sites plus collation and	£1-1.5k	Flush dominated	-	V L

Eco-hydrological Assessment Area	Size (Ha)	Site Names	Requirements for monitoring: ecology			Requirements for monitoring: hydrology		Priority
			Type of monitoring	Monitoring Requirement	Annual Costs	Type of monitoring	First year Costs	
		Bottom	focussing on areas where footpaths are impeding flows and footpath erosion/poaching) Fixed point quadrat survey	interpretation of results 5 quadrats plus data processing and analysis		wetland – little peat – no monitoring recommended		
G	68.4	Vales Moor and Foulford Bottom	Fixed point camera survey (specifically focussing on extent of pine and Rhododendron scrub encroachment) DBH and alternating transect studies to quantify rates of spread of these species.	10 sites plus collation and interpretation of results 10 transects	£3-3.5k	Flush dominated wetland – little peat – no monitoring recommended	-	L
H	62.8	Pickets and Buckherd Bottom	Fixed point camera survey (specifically focussing on extent of pine and Rhododendron scrub encroachment) DBH and alternating transect studies to quantify rates of spread of these species.	10 sites plus collation and interpretation of results 10 transects	£3-3.5k	Flush dominated wetland – little peat – no monitoring recommended	-	M
J	64.4	Soldiers Bog	Fixed point camera survey (specifically focussing on areas where footpaths are impeding flows and footpath erosion) Fixed point quadrat survey (specifically to monitor redevelopment of valley mire and wet heath habitats where restoration is implemented)	20 sites plus collation and interpretation of results 10 quadrats plus data processing and analysis	£2–2.5k	Flush dominated wetland –little peat – no monitoring recommended	-	M
K	28.5	Bratley	Fixed point camera survey (to monitor extent of scrub encroachment, focussing on extent of Gorse) Alternating quadrat study to quantify Gorse colonisation.	10 sites plus collation and interpretation of results 5 transects	£2-2.5k	Flush dominated wetland – little peat – no monitoring recommended	-	VL
L	42.9	Ma 5 Wet 5 part 2	Fixed point camera survey (specifically focussing on extent of pine scrub encroachment, and areas of footpath erosion/poaching at crossing points) Fixed point quadrat survey to establish baseline conditions	10+10 (20) sites plus collation and interpretation of results 5 quadrats plus data processing and analysis	£2.5-3k	Mostly flush dominated – no monitoring recommended	-	VL

Eco-hydrological Assessment Area	Size (Ha)	Site Names	Requirements for monitoring: ecology			Requirements for monitoring: hydrology		Priority
			Type of monitoring	Monitoring Requirement	Annual Costs	Type of monitoring	First year Costs	
			prior to restoration. DBH transect study to monitor pine colonisation.	5 transects				
M	43.6	Long Beech	Fixed point camera survey Fixed point quadrat survey	10 sites plus collation and interpretation of results 5 quadrats plus data processing and analysis	£1-1.5k	Flush dominated wetland – little peat – no monitoring recommended	-	VL
N	38.1	Little Wootton Pond	Fixed point camera survey (specifically focussing on extent of Rhododendron encroachment) Alternating transect study to measure extent of Rhododendron colonisation. Fixed point quadrat survey (to monitor development of wetland habitats) and establish baseline conditions.	10 sites plus collation and interpretation of results 5 transects 5 quadrats plus data processing and analysis	£2.5-3k	Flush dominated wetland – little peat – no monitoring recommended	-	H
O	5	Sway Mire	Fixed point camera survey (specifically focussing on areas of poaching) Fixed point quadrat survey (to monitor extent and quality of wet grassland areas, and recoveryof previously poached areas)	5 sites plus collation and interpretation of results 3 quadrats plus data processing and analysis	£0.8-1k	Flush dominated wetland – fixed point camera survey of gulley head	-	L
P	13.5	Norley Mire	Fixed point camera survey (specifically focussing extent of scrub encroachment in western areas) Alternating transect study to quantify scrub colonisation. Fixed point quadrat survey (focussing on recovery of poached areas) and to establish baseline. Fixed point camera survey to qualitatively monitor vegetation change in response to restoration measures.	5 sites plus collation and interpretation of results 3 transects 3 quadrats plus data processing and analysis 5 sites plus collation and interpretation of results	£1.7-2k	3 boreholes in the valley mire Plus associated monitoring and data processing	£4-6.5k	L
Q	7.4	Longdown Mire	Fixed point camera survey (specifically focussing on extent of pine and	5 sites plus collation and interpretation of results	£1.7-2k	Flush dominated wetland –no monitoring recommended	-	M

Eco-hydrological Assessment Area	Size (Ha)	Site Names	Requirements for monitoring: ecology			Requirements for monitoring: hydrology		Priority
			Type of monitoring	Monitoring Requirement	Annual Costs	Type of monitoring	First year Costs	
			Rhododendron scrub encroachment and poaching) DBH and alternating transect studies to quantify rates of spread of these species. Fixed point quadrat survey (focussing on recovery of poached areas) to establish baseline conditions. Fixed point camera survey to qualitatively assess vegeatation change over time.	3 transects 3 quadrats plus data processing and analysis 5 sites plus collation and interpretation of results				
R	14 0.6	Deadmans Bottom, Millersford Bottom Mires and Ashley Hole Mire	Fixed point camera survey (specifically focussing on extent of pine, Rhododendron and other scrub encroachment and poaching) DBH and alternating transect studies to quantify rates of spread of these species. Fixed point quadrat survey	20 sites plus collation and interpretation of results 10 transects 10 quadrats plus data processing and analysis	£4-5k	Fixed point camera survey of gulley in Unit 41	-	M
S	49. 1	Lay Gutter Valley	Fixed point camera survey to qualitatively assess vegetation change in response to restoration measures. Fixed point quadrat survey to establish baseline and quantify vegetation change.	20 sites plus collation and interpretation of results 10 quadrats plus data processing and analysis	£2-2.5k	3 Boreholes (3 installations in total) Plus associated monitoring and data processing	£4-6.5k	M
T	13. 9	Ogden's Purlieu	Fixed point camera survey Fixed point quadrat survey	10 sites plus collation and interpretation of results 5 quadrats plus data processing and analysis	£1-1.5k	6 boreholes and a stilling well (7 installations in total) Plus associated monitoring and data processing	£6-8.5K	M
U	11. 6	Suburbs Wood	Fixed point camera survey Fixed point quadrat survey	10 sites plus collation and interpretation of results 5 quadrats plus data processing and analysis	£1-1.5k	Flush dominated wetland – no peat – no monitoring recommended	-	L
V	41. 8	Hazel Hill Lawns	No restoration measures proposed and no grazing or scrub	None		Flush dominated wetland – no peat – no monitoring		VL

Eco-hydrological Assessment Area	Size (Ha)	Site Names	Requirements for monitoring: ecology			Requirements for monitoring: hydrology		Priority
			Type of monitoring	Monitoring Requirement	Annual Costs	Type of monitoring	First year Costs	
			encroachment pressures - no monitoring recommended			recommended		
W	65.6	Acre Down and Warwick Slade Bog	Fixed point camera survey (specifically focussing on areas of footpath erosion/poaching) Fixed point quadrat survey (specifically focussing on restoration areas on the largest part of this complex of sites)	20 sites plus collation and interpretation of results 10 quadrats plus data processing and analysis	£2-2.5k	5 boreholes and 5 stilling wells (10 installations in total) Plus associated monitoring and data processing	£7-9.5k	H
X	137.6	Denny Bog	Fixed point camera survey (specifically focussing on extent of pine scrub encroachment, areas where footpaths are impeding flows and footpath erosion/poaching) Fixed point quadrat survey to establish baseline conditions. DBH transect study to quantify colonisation of pine.	20 sites plus collation and interpretation of results 10 quadrats plus data processing and analysis 10 transects	£6-7k	The following new installations are recommended, although existing dipwells could also be used for groundwater monitoring on Denny Bog 5 boreholes and 5 stilling wells (10 installations in total) Plus associated monitoring and data processing	£7-9.5k	H
Priority Classification - H - High, M = Medium, L = Low and VL = very low Annual cost of processing, collation and analysis of hydrological data is estimated to be about £1,000 (based on a local free resource trained to visit and download the information)								

Table 3-9: First Year and Subsequent Annual Monitoring Costs for the Priorty Groups

Priority Group	Total First Year Costs (£)	Total Subsequent Annual Costs (£)
High	38,500	16,750
Medium	41,450	23,700
Low	22,500	12,000
Very Low	16,000	9,750
All	118,450	62,200

3.9 Background Review of Information

A review of available background literature has been undertaken to identify:

- Previous restoration projects / measures within the New Forest, and elsewhere that justify the selection of restoration measures in this project.
- Previous monitoring techniques both within and outside of the New Forest that could be utilised as part of the monitoring strategy for the SSSI sites assessed in this project.
- Previous monitoring results within the New Forest associated to restoration measures suggested for some of the SSSI units assessed in this project.

- Previous conceptualisation of New Forest Wetlands.

Table 3-10 provides a summary of the document reviewed, the comment within that document and the relevance of that comment to this study in respect of the above. A full reference list can be found at the end of this document.

Table 3-10: Literature review summary

Document	Comment	Relevance to this study
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Mechanical removal of rhododendron within Open Forest heathland. Removed bush and roots where possible.	Rhododendron identified as an invasive in this study if SSSI sites. Should now be manageable in annual programmes undertaken by the Forestry Commission. Sites seen to be impacted in this study should be communicated to the Forestry Commission.
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Conifer plantation removal was most successful where complete de-stumping was undertaken alongside infilling the artificial drains and a rake over the surface to level the ploughed ridge and furrow systems.	Conifer plantations have been identified as a pressure in this study and recommendations for removal have included removal and infilling if the artificial drainage network.
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Bog woodland restoration involved removal of conifer plantations, artificial drain infilling and heather bale plugging.	Where artificial drainage networks and conifer plantations have been identified as a pressure in this study, recommendations have involved conifer removal and artificial drain infilling. In many cases however wetlands have been completely removed by forestry drainage.
LIFE 3 (2006) – Sustainable wetland restoration in the New Forest	LIFE 3 restored 184.5 ha of valley mires. In many of the areas drainage and gully erosion had led to the replacement of mires with broadleaf scrub and secondary woodland. Restoration schemes have been implemented at Stony Moors, Holmsley Bog, Wilverley Bog, Brommy Bottom, Holly Hatch and 9 other mire sites. Restoration scheme have also been implemented on 6 lawn creation areas focusing on area of resent scrub encroachment.	Extensive mire restoration has already occurred in the New Forest. Some of this appears to be recreating works of mires which have since been removed. The restoration techniques on mires involved: heather bale plugs, clay plugs, pine scrub removal, timber dams, drain infilling with clay and gravel, spraying saplings, stablisation of poached crossing points with staked heather bales, and grazing management.
LIFE 3	Monitoring techniques used as part of the LIFE 3 project to determine response to restoration included aerial photograph and site walk-overs. It appears that there were no dipwells or boreholes installed in the mire habitats.	Some of these monitoring techniques have been employed as part of the restoration monitoring for the SSSI assessed for this study. This has been supplemented with more cost-effective approaches given the wide scale of the restoration.
LIFE 3	Ecological monitoring pre- and post-restoration suggested that short term declines in species diversity and abundance immediately after works would soon recover to pre-restoration levels.	This provides confidence that short term disturbance created by the works will not impact ecological diversity in the long term.
HLS -New Forest Wetland Management Plan	Valley mires tend to be underlain by impermeable subsoils. They tend to be acidic in natural except when underlain by certain bedrock	This is in agreement with many of our conceptualisations

	units (e.g. Headon Beds).	
HLS - New Forest Wetland Management Plan	Existing monitoring programmes for the New Forest Mires are limited to Wader Breeding Surveys by the RSPB and Statutory monitoring (e.g. SSSI condition assessments).	Existing formal monitoring of New Forest Mires appears to be limited.
HLS - New Forest Wetland Management Plan	Heather bales are deemed to be a useful technique across the New Forest for halt nick point erosion in mires. A range of others restoration techniques are also discussed.	These techniques are discussed further in the restoration technique section.
Denton (date unknown) - Assessment of potential effects of different grazing regimes in Wootton Coppice and Holmsley Inclosures.	Increasingly the over-grazing of the open forest is depleting invertebrate communities of richness. Precipitative action cannot be justified, and limited seasonal grazing is clearly the best approach accompanied by regular monitoring so that informed decisions can be made as to whether the density/timing needs to be modified.	This report begins to describe the impact of over-grazing on open forest communities. Over-grazing has been identified as an issue in some of the SSSI unit restoration plans.
Armstrong *et al.* (2007) - Grip Blocking Best Practice Guide	Various recommendations for gulley and grip blocking are recommended based on erosion conditions, vegetation type, slope and soil type amongst others. Mitigation includes peat turve dams, heather bailing, plastic piling and wooden dams.	This paper highlights other suitable restoration measures, other than heather bailing, that could be used to infill gullies in mire and mire to stream transition units where energy conditions are appropriate.
Evans *et al*. (2005) - Understanding gulley blocking in deep peat	This highlights similar measures to Armstrong et al (2007) and also notes the importance of suitable spacing of mitigating measures depending on the slope and level of erosion / incision.	Again highlights other suitable restoration measures for mire and mire to stream transition units where energy conditions are appropriate and how measures should be spaced to ensure sustainability.
WETMECs (2009) - Appendix 3c- Ecohydrological site accounts for the New Forest	This appendix of the report presents a series of ecohydrological conceptualisation of a series of New Forest wetlands	A number of these sites are also included or partly included within the sites in this report. It also gives some general guidance as to the range of WETMECs identified in New Forest wetlands.
MJ Clarke (date unknown) - PhD Thesis - Past and Present Mire Communities of the New Forest and their Conservation, Southampton University	Thesis presenting information on the origin and development of a number of valley mires	The conceptualisation presented within the thesis appear to be within a continuum of mire types identified in this and other studies of the New Forest wetlands.
Sanderson (2008) Changes In The Area Of Wet Lawn Since The1860's On The New Forest Grazings	A desk study assessment using a range of data sources including aerial photographs were used to map the distribution and changes in wet lawns across the New Forest.	This study can help to understand the development of wet lawn areas identified in our surveys and help managers develop management criteria.

As shown in Table 3-10, there is considerable evidence supporting wetland conceptual models developed by this study and the restoration and management measures proposed for the sites.

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