The Sizewell C Project

9.64/ 10.6 Draft Fen Meadow Plan - Tracked Changes Version

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1 INTRODUCTION

1.1 Context

1.1.1 The Sizewell C (SZC) proposals would lead to the permanent loss of approximately 0.46ha of 'fen meadow' habitat from the Sizewell Marshes SSSI [**Section 2.9D** of AS-209]. This permanent loss arises from the size and location of the SZC main platform to the north of the existing Sizewell B station. The loss of this area of fen meadow is therefore unavoidable.

1.1.2 Sizewell Marshes SSSI is designated in part for its fen meadow habitats and the loss of the fen meadow habitat from the SSSI leads to a need to provide compensatory habitat for this loss.

1.1.3 The original compensatory habitat proposals included two sites but a third site (Pakenham) was added to the proposals in January 2021. This was to address a comment from Natural England at Stage 4 pre-application consultation (Ref. 1) which was:

"We advise that the extent of compensatory habitat required is 9x that which would be destroyed by the development; this is considered a suitable multiplier given the complexity of habitat type to be lost, the risk and uncertainty involved in the habitat restoration being successful and the time to fully functioning habitat…"

1.1.4 SZC Co. is therefore proposing to deliver 4.14 ha of compensatory fen meadow habitat. Natural England now considers the quantum proposed, based on the multiplier, to be sufficient as detailed in issue 49 of their written representation [REP2-153].

1.1.5 The application for development consent includes within the draft order limits, three sites identified for delivery of compensatory fen meadow habitat listed below and illustrated in **Figures 1.1-1.3**[1]:

- Fen Meadow compensation site at Benhall;
- Fen Meadow compensation site at Halesworth;
- Fen Meadow compensation site at Pakenham.

1.1.6 Requirement 14A in the **draft DCO** (Doc Ref. ~~3.1(I~~3.1(J)) prevents clearance of vegetation within the SSSI until ~~a~~ Fen Meadow ~~Plan has~~ Plans for all three sites have been submitted to and approved by the named local authority in consultation with Natural England. The Fen Meadow Plan(s) for

[1] Note that the order limits have recently been reduced at these three site and these figures reflect the updated limits.

Benhall and Halesworth must be approved by East Suffolk Council ~~in consultation with the relevant Statutory Conservation Body. The Plan~~ and the Fen Meadow Plan must be approved by Suffolk County Council. The Plans must be developed in general accordance with the **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A)~~10.16) and this **Draft Fen Meadow Plan** which have been prepared to define SZC Co's commitment to provide appropriate compensation measures for the loss of fen meadow habitat. This will be achieved through the creation of 4.14ha of compensatory fen meadow habitats, and the provision of a contingency fund which is secured through **Schedule 11** of the **DoO** (Doc~~.~~ Ref. ~~**8.17(G)**~~10.4).

1.1.7 The **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A)~~10.16) defines a series of three reports, which will lead to the establishment of the final Fen Meadow ~~Plan~~Plans, ~~that~~ which will further define the approaches to maximise the extent of fen meadow habitats at the three sites. Three reports are proposed:

- **Fen Meadow Plan Report 1**. This was submitted at Deadline 3 [REP3-051 and REP3-052] and provides the baseline reports for the sites and water data available to May 2021;

- **Draft Fen Meadow Plan**, This was submitted at Deadline 6 [REP6-026] providing further interim data and defining, in draft, the management interventions required to create fen meadow habitats. The measures seek to maximise the extent of the establishment of fen meadow at each site and the report describes interventions that may be required to ensure the successfully delivery of the habitats at each site. This is the second version of the Draft Fen Meadow Plan, and presents updates made in response to landowner and stakeholder consultation, with the main changes relating to amendments to the order limits and monitoring commitments.

~~1~~• **Draft Fen Meadow ~~Plan~~ Plans for Consultation** will provide the full scope of the plan after 12 months of water data collection at each site and will be provided for review by the Ecology Working Group. Upon finalisation it will become the Fen Meadow Plan which will be submitted to and approved by East Suffolk Council ~~for approval~~ and Suffolk County Council pursuant to Requirement 14A~~)~~ of the **dDCO**. The final Fen Meadow ~~Plan~~ Plans must be in general accordance with the **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A~~10.16) and this **Draft Fen Meadow Plan** ~~(Doc Ref. 9.64(A))~~

1.1.8 SZC Co. must implement the establishment of the fen meadow in accordance with the approach and implementation timetable set out in the Fen Meadow Plan approved pursuant to Requirement 14A.

1.2 Status of this Draft Fen Meadow Plan

1.2.1 This draft plan is considered to provide sufficient detail to inform the Examining Authority, the Secretary of State and the other stakeholders as to the proposals at each site.

1.2.2 The proposals presented herein have been informed by all data collected up to and including early July 2021. In relation to hydrology this means that a substantive portion of the data for summer period has informed the proposals. This is important as both groundwater and surface water levels are typically lowest in summer and these levels and related seasonal trends are likely to be amongst the most important variables in determining the potential for establishing new fen meadow on the three sites.

1.2.3 Level 1 control documents will either be certified under the DCO at grant or annexed to the Deed of Obligation (DoO). All are secured and legally enforceable. Some Level 1 documents are compliance documents and must be complied with when certain activities are carried out. Other Level 1 documents are strategies or draft plans which set the boundaries for a subsequent Level 2 document which is required to be approved by a body or governance group. The obligations in the DCO and DoO set out the status of each Level 1 document.

1.2.4 This **Draft Fen Meadow Plan** is a Level 1 document. Pursuant to Requirement 14A of the **dDCO**, prior to any vegetation clearance within the Sizewell Marshes SSSI, ~~a~~ Fen Meadow ~~Plan~~ Plans for each of the sites (a Level 2 document) ~~will~~ must be submitted for approval by East Suffolk Council and Suffolk County Council, in consultation with West Suffolk Council, and the relevant Statutory Conservation Body and such ~~plan~~ plans must be in general accordance with this ~~draft~~ **Draft Fen Meadow Plan**.

1.2.5 Where further documents or details require approval, this document states which body or governance group is responsible for the approval and/or must be consulted. Any approvals by East Suffolk Council, Suffolk County Council or the MMO will be carried out in accordance with the procedure in **Schedule 23** of the **dDCO**. The Deed of Obligation establishes the governance groups and sets out how these governance groups will run and, where appropriate, how decisions (including approvals) should be made. Any updates to these further documents or details must be approved by the same body or governance group and through the same consultation and procedure as the original document or details.

1.2.6 Where separate Level 1 or Level 2 control documents include measures that are relevant to the measures within this document, those measures have not been duplicated in this document, but cross-references have been included for context. Where separate legislation, consents, permits and

licences are described in this document they are set out in the Schedule of Other Consents, Licences and Agreements (Doc Ref. 5.11~~) [REP3-011]~~(C)).

1.2.7 For the purposes of this document the term 'SZC Co.' refers to NNB Nuclear Generation (SZC) Limited (or any other undertaker as defined by the dDCO), its appointed representatives and the appointed construction contractors.

1.3 Environmental Statement and Shadow Habitat Regulations Assessment

1.3.1 The proposals described for each of the three locations will create some small scale and local changes to hydrology within the sites and there will be a need to undertake some shallow excavations. Some protected species are present and other receptors are present nearby, including, in some cases, designated sites or features.

1.3.2 The impacts at the three sites related to the creation of fen meadow habitats were considered in **Volume 2**, **Chapter 14** of the **ES** [AS-033] and **Chapter 2** of the **ES addendum** [AS-181]. The impacts at the three sites were revisited in **Volume 1** of the **Fourth ES Addendum** [REP7-030] submitted at Deadline 7, following issue of the **Draft Fen Meadow Plan** ~~**Draft** [REP6-026].~~REP6-026]. However, no change to the significance of effects was predicted.

1.3.3 The fen meadow proposals described in this draft plan will have no adverse effects on integrity for any European Site and there are no consequences in the context of the Habitats Regulations. A note on the potential hydrological consequences on the Abbey Meadows compensation site at Snape of proposals at Benhall was submitted at Examination Deadline 5 in response to the Written Representation by the RSPB (**Appendix L** of [REP5-120]). This concluded that there would be no adverse effect on integrity given the extent of the catchment, the effect on availability of water to the Abbey Farm compensation site.

1.4 Recreation of Fen Meadow Habitats

1.4.1 Whilst the term fen meadow covers more than one botanical community in the National Vegetation Classification (NVC) (Wheeler, Shaw and Tanner, 2009, Ref. 2) the target community in the context of the loss at Sizewell Marshes is M22 *Juncus subnodulosus –Cirsium palustre* fen meadow.

1.4.2 To manipulate site conditions such that conditions are suitable for M22 development it is necessary to recognise the characteristics of the community including appropriate eco-hydrological conditions. The

characteristics of M22 have been described by Wheeler et al. (Chapter 18 in Ref. 2), including floristic composition, landscape situation and topography, substratum types, water supply and level required by M22 can be summarised as:

- Overall, M22 is a community that is botanically variable and can occur in a wide range of eco-hydrological situations. Nonetheless, the key conditions required to support M22 can be summarised as base-rich conditions, but relatively low fertility with limited nutrient concentrations (e.g. phosphate, nitrate); and
- Management, by mowing or grazing, which are crucial to the maintenance of M22.

1.4.3 There is an extensive literature on fen meadow restoration in Europe - notably from the Netherlands, Poland and Germany. Van Diggelen & Marrs (2003, Ref. 3) in particular have categorized four essential steps for conservation and restoration of fen meadow:

- establishing or re-establishing the necessary abiotic conditions;
- supplying (sufficient) propagules of constituent species of the target communities;
- creating and maintaining suitable conditions for the (re-) establishment of target species; and
- appropriate management to keep the conditions suitable.

1.4.4 The **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A)~~10.16) outlines the types of measure likely to be necessary to facilitate development of the compensatory habitat, as represented by the M22 *Juncus subnodulosus – Cirsium palustre* fen meadow community at appropriate sites. A review of the conditions required for recreating fen meadow was presented in response to Examination Question 'Biodiversity 1.86'. The development of the abiotic and biotic conditions for fen meadow referable to the M22 *Juncus subnodulosus – Cirsium palustre* fen meadow community are considered to have the highest chances of success if the following techniques are employed at the three fen meadow sites:

- **Topsoil removal.** Complete or partial topsoil removal will be undertaken within the context of sediment disposition, surface topography and valley flooding regimes, in order to reduce nutrient levels and increase the influence of groundwater on target species.

- **Creation of microtopography.** The ground surface will be sculpted within hydrologically significant tolerances to assist in the successful colonisation and regeneration of target groundwater-dependent species, particularly those with high light requirements, low competitive abilities and low tolerance of drought or flooding.

- **Rewetting from appropriate water sources**. Rewetting will be undertaken using groundwater-dominated sources to facilitate an appropriate hydrological regime for the target vegetation. Sufficient control is likely to be required to minimise the impact of extreme events leading to flooding by nutrient-rich waters and/or periods of drought, within acceptable limits.

- **Use of hay transfers.** The transfer of hay from suitable sites – or of turves from the FMS donor site – will be undertaken following established best practices. The conditions and timing of collection, transfer and introduction of plant propagules – and their initial establishment – will be carefully monitored to meet restoration requirements.

- **Habitat management.** An agreed annual programme of water and vegetation management will be established and undertaken at appropriate times. These operations – and their impact on the developing fen meadows – will be set with a framework of acceptable limits. Appropriate monitoring will be maintained to enable effective and timely management of the habitat management programme to meet target conditions for the restored fen meadow vegetation.

1.4.5 These techniques will be deployed as relevant in the detailed proposals for each of the three sites set out in this draft plan.

1.4.6 Additionally, in accordance with the **Wet Woodland Strategy** (~~–~~Doc Ref. ~~9.8(A)),~~ 10.31) areas at Benhall and Pakenham have been identified for the delivery of wet woodland. The required measures will be set out in a separate plan (the Wet Woodland Plan)**.** The Wet Woodland Plan must be in general accordance with the **Wet Woodland Strategy** (Doc Ref. ~~9.8(A)~~10.31) and the **Draft Wet Woodland Plan** (Doc Ref. ~~9.108~~10.13) and must be approved by East Suffolk Council prior to any vegetation clearance in the Sizewell Marshes SSSI being carried out (Requirement 14B). However~~–~~, given that the compensatory wet woodland will be co-located with fen meadow habitats, the wet woodland areas are also defined spatially in this plan.

1.4.7 The **Wet Woodland Strategy** (Doc Ref. ~~9.8(A)~~10.31) requires the delivery of a total of ~~2.36ha~~ 2.07 ha of wet woodland across the two fen meadow sites at Benhall and Pakenham. The principle of co-location of compensatory wet woodland and fen meadow habitats is supported by

Natural England, given that this replicates the situation at the Sizewell Marshes SSSI.

1.5 Fen Meadow Establishment Management Measures and Monitoring

a) Fen Meadow Establishment Management Measures

1.5.2 The detailed proposals provided in Sections 2 to 4 of this **Draft Fen Meadow Plan** are focussed on the establishment phase which will be undertaken in 'Year 1' of the works as outlined in the **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A)~~10.16). These primarily comprise physical measures to be implemented to create the ground conditions to support fen meadow species and the approach to introducing those species and will be set out in the final Fen Meadow ~~Plan~~ Plans submitted to East Suffolk Council and Suffolk County Council pursuant to Requirement 14A~~)~~.

1.5.3 In subsequent periods (years 2-5 and 6-10), measures outlined focus on continued introduction of species (as detailed in **Fen Meadow Strategy** (Doc Ref. ~~6.14 2.9.D(A))~~ 10.16) and on-going management approaches. These will need to remain flexible and be adjusted, annually if necessary, based on monitoring of habitat development. Progress will be reviewed annually and any adjustments to the habitat management approaches agreed with the Ecology Working Group. Any substantive changes of approach, which could ultimately impact the ability to deliver the quantum of the target habitat by Year 10, will need to be agreed by the Ecology Working Group.

b) Fen Meadow Monitoring

1.5.4 Given the expected extended periods likely required to establish fen meadow habitats, the **Fen Meadow Strategy** (~~[AS-209] as updated by~~ Doc Ref. ~~6.14 2.9.D(A)~~10.16), secured by Requirement 14A, provides that monitoring will extend into the operational period of the power station to ensure the habitats are becoming established and being maintained in accordance with the relevant habitat objectives.

1.5.5 The frequency of monitoring during the construction and operational phases is set out in the **Fen Meadow Strategy** (~~[AS-209] as updated by~~ Doc Ref. ~~6.14 2.9.D(A)),~~ 10.16) and monitoring recommendations are provided in each site section in this draft plan.

1.5.6 In the event that any water control structure that could impede fish and eel passage is introduced at the fen meadow sites, a suitable fish pass will be included in the design. Monitoring will be undertaken to ensure any such structures function as required and do not become a barrier to movement.

1.5.7 The final monitoring details for these sites would be agreed via the approval of the final Fen Meadow ~~**Plan**~~ Plans submitted to and approved by East Suffolk Council ~~fro approval~~ and Suffolk County Council following consultation with relevant Statutory Nature Conservation Body pursuant to Requirement 14A~~—~~.

1.6 Report structure

1.6.1 There is a separate plan for the creation and establishment of fen meadow habitat at each site. The report is structured as follows:

- Section 2 - Benhall;
- Section 3 – Halesworth;
- Section 4 – Pakenham;
- Section 5 – Summary.

2 BENHALL

2.1 Site Baseline

a) Summary of investigations

2.1.2 The investigations being undertaken at Benhall were summarised in the **Fen Meadow Plan Report 1**, with the study reports provided as appendices [REP3-051 and REP3-052]. The studies have mostly been completed, as detailed in Table 2.1 below.

Table 2.1: Status of studies as at July 2021

Site	Study	Status
Benhall	Ecology desk study	Completed in 2020
	Ecology field surveys	Phase 1 habitat survey NVC survey Water vole and otter survey Aquatic invertebrate survey of ditches All completed in 2020
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Installed October 2020
	Topgraphic survey of site and installations	Completed 2020
	Water flow, level and quality monitoring	Commenced November 2020 for 1 year.

2.2 Environmental Setting

2.2.1 The **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Benhall site. The majority of the baseline information is not repeated in detail in this draft Fen Meadow Plan although a summary of the ecological setting is provided below and further hydrological monitoring data are now available so the Water Monitoring Summary – Benhall Site 10 & 11, November 2020 to April 2021, has been updated to July 2021 (**Appendix A**). The updated data have also been further interpreted to update the site conceptual model (**Section 2.3**).

2.2.2 Note that in 2019, two sites were identified, referred to as Site 10 (to the north) and Site 11 (to the south) and there was a gap between them. Subsequently, the site boundaries were revised to combine these sites and include the small parcel of land in between and the combined site was included in the application for development consent. Reference is now made to the northern, central and southern compartments (see **Figure 2.1**).

a) Summary of Ecological Setting from Benhall Ecology Baseline report [REP3-051]

2.2.3 There are no statutory designated sites of nature conservation value within the Benhall site boundary. However, a compartment of Manor Farm County Wildlife Site (CWS) is located within the red line, and a further compartment is located adjacent to the western Site boundary. This latter compartment supports fen meadow habitat.

2.2.4 Coastal and floodplain grazing marsh, deciduous woodland and lowland meadows priority habitats are mapped in MAGIC as occurring on Site.

2.2.5 The site comprises poor semi-improved grassland, inundation vegetation, broadleaved wet woodland, scattered trees, flowing water, with fields divided either by hedges or ditches.

2.2.6 The habitats present on site were broadly categorised, during the NVC survey, as Floodplain and toe slope grasslands (of which three communities, including two rush pasture communities, supported suites of groundwater influenced and typical floodplain species), dry valley side grassland and wet woodland.

2.2.7 Giant hogweed and Himalayan balsam were present along the banks of the River Fromus. A small patch of giant hogweed was also noted within the Site.

2.2.8 No sign of otter presence was recorded on site, although the river and some of the wet ditches provide suitable habitat, and there is an otter record nearby.

2.2.9 Four of the 18 transects surveyed provided optimal aquatic habitat for water voles, with a further two meeting most of the noted habitat requirements but holding less water, and eleven containing relatively shallow water. Water vole presence was confirmed on four transects (two ditches and two river transects).

2.2.10 The aquatic invertebrate fauna of the Benhall site comprises predominantly common and local species.

2.3 Site Conceptual Model

2.3.1 The initial site conceptual model is presented in the hydrogeological report (**Appendix D** of the **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section presents the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

2.3.2 The Benhall site covers an area of 12.9 ha. The surface elevation across much of the northern compartment is relatively flat, generally between 3.8 and 4.0 mAOD (see LIDAR plots in **Appendix A**). At the margins of the site the land surface rises to 6.7 mAOD in the northwest near Aldecar Lane and to 5.2 mAOD in the southwest. The central and southern compartments have a more well-defined slope from west to east towards the River Fromus and contain a cut-off meander channel with a bed level of approximately 3.5 mAOD.

2.3.3 The River Fromus forms the eastern boundary of the Site and flows from north to south.

2.3.4 The bedrock geology at the site is Crag sands (c.10-20m thick) overlying London Clay of the Thames Group. The combined thickness of the Thames Group and Lambeth Group in this locality is thought be c. 25-30 metres in this locality. The Lambeth Group lies over the Chalk Group.

2.3.5 Alluvial deposits of clay, silt, sand and gravel directly overlie the Crag at the Benhall site and borehole logs indicate that they increase in thickness from around 7.7m in the south to >10m in the north of the Site. Head deposits of clay, silt, sand and gravel are mapped at the western edge of the Alluvium close to the boundary of the Site.

2.3.6 The Site is split in two at the boundary of the northern and central compartments by an ordinary watercourse named 'The Canal' which originates to the west of the A12 road. The Canal passes at right angle past two sides of the Benhall Sewage Treatment works before turning east again and discharging to the River Fromus. The Canal is the receiving watercourse for the Benhall Sewage Treatment Works (STW) discharge. The licensed discharge volume is 1.5 Ml/d.

2.3.7 On-site observations suggest that the Canal diverges to the north-east of the STW (downstream of the discharge point) and some water flows into the ditch network which flows northwards towards GB04.

2.3.8 The Benhall site contains a network of land drainage ditches which discharge to the River Fromus at three locations.

2.3.9 There is a licenced surface water abstraction from the River Fromus on the Site boundary (AN/035/0004/017), although this is toward the downstream end of the site away from the potential Fen Meadow areas.

2.3.10 Topographic surveys initially indicated that water levels coming on to the site from the west via the Canal are around 3.9 mAOD and on-site drainage ditches generally between 3.5 and 3.8 mAOD (November 2020). Ditch water levels are slightly lower in the southern half (Ditch W12 and W13) which do not appear to be well connected to other ditches or to the River Fromus.

2.3.11 The ditches in the northern compartment are monitored by GB03, 04 and 05 (**Figure 1.1** in **Appendix**). The STW discharge is upstream of GB03. A plot of the water levels at the three gaugeboards and the groundwater level in the superficial deposits (BHALL_1001_s) shows that the water level at GB03 (which is located on the higher ground to the north-west) appears to be sustained (**Figure C3** in **Appendix**), likely by discharges from the STW. A similar water level response is seen in the downstream gaugeboard at GB04 at the northern boundary of the Site showing the influence of the STW here. GB05 to the centre of the northern compartment, and the groundwater level monitoring well at BHALL_1001_s both show a similar seasonal response with reductions in water levels in mid-April and June and do not appear to be maintained by the discharge. On-site observations have confirmed that this central ditch in Site 10 is significantly drier with very little flow.

2.3.12 At the boundary of the southern and central compartments, the surface water levels are recorded by GB02. The water levels here show no decline in spring despite a drop in the nearby superficial deposits recorded in April and June (BHALL_1002_s and BHALL_1003_s). Again, this is likely to be the influence of the STW discharge to the Canal.

2.3.1 The monitored data available at GB01 suggests that water levels in this ditch are lower than the other watercourses on site. The levels are also lower than the surrounding groundwater levels (shown in the 1102 piezometer and 1104 dipwell), further reiterating earlier assumptions that this watercourse is not well connected to the other ditches on site. This ditch is linked to the River Fromus.

2.3.2 Development of peat has occurred in the northern and central compartments and peat is encountered between 0.4 and 2.5 m below ground surface. The borehole logs indicate a peat thickness of up to 4 m thick in places (Piezometer BHALL_1001_d) with a thickness of 1.1m at

borehole HAL_2803_d. Soil cores show that a silty clay layer is often present above the Peat which may hold a higher water level than that of the underlying sands and gravels. The basal part of the peat was more degraded than the upper part in some areas (Zone C Site 11) which may indicate that the groundwater level is fluctuating through the lower part, though it may rise through the peat during periods of heavier rainfall.

2.3.3 The soil core surveys carried out in April 2019 indicated that the initial water table was generally between 0.5m and 1m below ground level, rising to 0.4 and 0.1m below ground level at two locations after rest. The rising groundwater levels indicates that water in the peat and sands and gravels beneath the silty clay layer near the surface has a positive hydrostatic pressure in some locations. The October 2020 drilling programme recorded similar rest ground water levels (0.48 to 0.84m). General groundwater flow is thought to be towards the River Fromus (west to east) but collected data from the surveys suggest a relatively flat water table at the Benhall site.

2.3.4 The soil core surveys, drilling logs and topographic survey indicate that groundwater levels are in continuity with surface water levels in the on-site ditches. The River Fromus has a bed level of 2.8 mAOD and a water level of 3.51 mAOD at the northern end of the Benhall site and this gently decreases downstream to a bed level of 2.3 mAOD and a water level of 2.9 mAOD at the southern end of the Benhall site, indicating the potential for groundwater discharge to the river.

2.3.5 There is a groundwater abstraction at Ham Farm (7/35/04/*G/0095) which is relatively close to (0.2km), and upgradient of, the Site and has the potential to impact groundwater levels on the Site. The impact is likely to be minimal due to the relatively low abstraction quantities.

2.3.6 The groundwater level plots shown in the monitoring note in **Appendix A** show that the groundwater levels to the north (1001_s, 1002_s, 1003_s) and in the centre (1101_s and 1103_s) of the site in the superficial deposits present a similar pattern with a seasonal response to the dry April causing groundwater levels to decrease.

2.3.7 To the very south of the Site, there is less response to the dry April period in the superficial deposits (1102_s and 1104_s) with a flatter groundwater level hydrograph for these two locations (**Figure A3** in **Appendix A**).

2.3.8 Some of the superficial deposit groundwater levels are showing groundwater levels above the ground level. Notably:

- At 1002_s and 1003_s groundwater levels are above surface in winter (January and early February) but the groundwater level decreases into spring, dropping below ground level (**Figures B3 and B4** in

Appendix A). This results in a depth to water table at these two sites of up to 0.6 m below ground level in spring. Levels in these superficial deposits recovered into early summer.

- At 1104_s the groundwater level is above ground level periodically between November and February and declines to approximately 0.4 m below ground level into spring (**Figure B10** in **Appendix A**).

2.3.9 There is an artesian groundwater level response in two of the Crag boreholes. The groundwater levels at 1101_d is above ground level for most of the monitored data series and at 1102_d the groundwater level goes above ground level periodically (**Figure A4** in **Appendix A**).

2.3.10 The piezometer at 1001 (BHALL_1001_s for superficial deposits, BHALL_1001_d for Crag deposits) shows that the Crag groundwater levels increased slowly over the winter and have now remained static (~3.65 to 3.75 mAOD) since February **Figure A2** in **Appendix A**). Conversely, the superficial deposits are showing more of a seasonal response. It is likely that the Crag here is partly confined. Water levels in the superficial deposits will be supported by the head in the Crag but there may be limited upward flow. It is suspected that the increase of Crag groundwater levels from October to January results from a rebound effect after the cessation of nearby pumping.

2.3.11 It is evident in the 1102 piezometer in the shallow and deep wells (1102_s and 1102_d respectively) that the timing and amplitude of the groundwater fluctuations align very well between the two geological strata (**Figure A4** and **A5** in **Appendix A**). The Crag groundwater level is above that in the superficial deposits, so it is plausible that there is a degree of hydraulic continuity with the Crag in this location which is supporting the water level in the superficial deposits at this location.

2.3.12 Slightly further north at 1101_s and 1101_d the results for the shallow (superficial) and deep (Crag) boreholes respectively show that the magnitude and timing of the fluctuations align well (**Figure A4** and **A5** in **Appendix A**), with the levels marginally higher in the Crag than the superficial deposits, again supporting the theory that there may be some upward flow from the Crag here.

2.3.13 The lowest groundwater level and therefore maximum depth to water in the superficial deposits is listed in **Table 2.2**.

Table 2.2: Groundwater levels and depth to water table

Borehole ID	Ground level (mAOD)	Lowest observed groundwater level (mAOD)	Maximum depth to water table (m)	Highest observed groundwater level (mAOD)	Minimum depth to water table (m)*
BHALL_1001_d	3.91	2.28	1.63	3.98	-0.08
BHALL_1001_s	4.35	3.49	0.85	4.20	0.14
BHALL_1002_s	3.93	3.31	0.62	4.31	-0.38
BHALL_1003_s	3.88	3.29	0.59	4.14	-0.27
BHALL_1101_d	3.91	3.92	-0.01*	4.34	-0.44
BHALL_1101_s	3.91	3.83	0.08	4.24	-0.34
BHALL_1102_d	3.92	3.74	0.18	4.15	-0.23
BHALL_1102_s	3.92	3.50	0.42	4.01	-0.09
BHALL_1103_s	3.95	3.43	0.52	4.17	-0.21
BHALL_1104_s	3.92	3.60	0.32	4.19	-0.28

* negative depth to water table shows where groundwater levels are above ground level.

2.3.14 The groundwater and surface water data shows that the northern compartment of the Site demonstrate two slightly different hydrologic responses:

- In the northern compartment the superficial deposits fluctuate in response to seasonal climatic conditions. Surface water levels in The Canal, central east-west ditch and northern drainage outlet are maintained by the STW discharges. The same is not seen in the central Site 10 ditch which shows a decline in water levels due to its hydraulic continuity with the underlying deposits. The groundwater levels in the data available show that groundwater levels have been above ground level at times, but also extend to around 50-80cm below ground level during the spring and early summer. Further monitoring will be required to assess what happens over the rest of summer 2021 and into autumn. There appears to be limited connectivity with the River Fromus and the underlying Crag here. Groundwater levels in the superficial deposits have peaked at around 4.3 mAOD and have also dropped to around 3.3 mAOD.

- In central and southern compartments, there is a less pronounced impact to seasonal variations in the superficial deposits and it is likely that there is some upward flow from the Crag in the here. This is likely more pronounced at the southern end of the southern compartment.

2.3.15 There is some water quality data available for the Site, with more sampling planned over 2021. The data so far show the following:

- Nitrate concentrations are highest in the ditches to the south of the Site (GB1 and GB2 which measured 48.2 and 71.5 mg/l as NO3 respectively). The concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag.

- The Site generally has very low phosphate concentrations as would be expected, with most samples not showing anything above the level of detection. GB1, GB2 and SP5 locations shows phosphate concentrations at 0.057 mg/l, 11.4 mg/l and 4.77 mg/l respectively whilst the only detected level in groundwater was at 1102_s at 0.053 mg/l.

2.4 Suitability of the site for fen meadow creation

2.4.1 The Benhall site is discussed as three compartments - north, central and south.

a) Northern Compartment

2.4.2 This compartment was identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing a primary locus for fen meadow in the south-western third (1.5ha) in which it was considered that there was good potential for water management to provide the necessary water to support the habitat. This primary locus area was bordered by a potential additional area for fen meadow (0.7ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

2.4.3 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in the northern compartment are indicated to be maintained below ground level at the location of installation BHALL_1001_s. However, this is in an elevated location on a bund alongside the western ditch. Relative to

the majority of the compartment, water levels are at about ground level over winter falling to, at most, 30cm below a typical ground level of 3.8m AOD (June 2021).

- The presence of relict ditches suggests that the compartment was historically wetter, presumably prior to drainage and at which time fen meadow habitats, or at least groundwater dependent fen meadow species, may have been present.

- Water levels in the central ditch (indicated by GB05) are below, but appear to reflect, those of the shallow groundwater, indicating a hydrological link between the two – with the central ditch potentially limiting the groundwater level in this compartment.

- The compartment is bordered to the west and south by the Canal. The main discharge from the Canal is to the Fromus however there appears currently to be a minor link between the Canal and the ditches within the compartment. Whilst water levels in the Canal, and River Fromus would not be controlled as part of this work due to potential effects off site, it is considered that water levels in the ditch network that drains this compartment can be controlled without adversely affecting areas or receptors off site.

- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.

- During high flow events the River Fromus floods the compartment and also backs up the Canal, which is noted as having elevated nitrate and phosphate levels which are likely the result of discharge from the Benhall STW. Whilst river water quality, and that in the Canal, is not considered optimal for fen meadow habitats, during high flow events, nitrate and phosphate concentrations will be diluted and, as indicated in Section 1.5, Wheeler, Shaw and Tanner (2009, Ref. 2) note that the community can accommodate considerable eutrophication without change to its basic composition provided that active management continues.

- Soil data indicates the presence of peat at each of the cored locations, albeit at 50cm+ depth (~~Wood, 2019, Ref. 4~~ **Fen Meadow Compensation Study** [APP-258]).

- A network of land drains is visible on LIDAR (see **Appendix A**). These will be reducing the groundwater levels and drying the fields. However, these can be blocked.

2.4.4 Based on the groundwater and surface water level data, and substrate type, it is concluded that it will be possible, by implementing measures detailed in Section 2.5, to provide groundwater influenced conditions in this northern area, potentially with a peaty or gley substrate, that have the potential to support fen meadow habitat.

2.4.5 Water levels in the Canal, and River Fromus to the east, would not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

a) Central Area of the Site

2.4.6 The southern two thirds of this compartment were identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing a primary locus for fen meadow (0.5ha) as the area adjacent to the western ditch already contained some fen meadow species. This primary locus area was bordered by a potential additional area for fen meadow (0.5ha), focussed on an area showing groundwater influence, within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

2.4.7 Note that the northern third of the compartment was not assessed in ~~Wood, 2019 (Ref 4.~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ and was included subsequently when the boundary was re-drafted.

2.4.8 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits at the northern boundary of this compartment (indicated by BHALL1003_s) are above surface in winter (January and early February) but decrease into spring by up to 0.6 m below ground level.

- Groundwater levels in the shallow deposits in the western central area of the site are indicated to be maintained at about ground level (BHALL_1101_s) over the monitoring period to late June 2021. An upward gradient from the deeper deposits is also maintained over the monitoring period. These installations are in a location that was marked by the presence of plant species indicating groundwater influence (phreatophytes), and was identified in ~~Wood, 2019 (Ref 4.~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as a primary locus.

- East of installation BHALL_1101_s is BHALL_1103_s groundwater levels in the shallow deposits in the eastern central area of the site are indicated to be maintained at about ground level over the winter but fall from March onwards (to 50cm below ground level at the lowest point to date), and show a much more marked fluctuation than BHALL_1101_s. The vegetation at this location was also not suggestive of a groundwater influence at the surface.

- Groundwater levels in the shallow deposits are typically at, or above, the adjacent ditch levels suggesting there is potential for groundwater discharge to the adjacent ditches.

- The presence of relict ditches suggests that the compartment was historically wetter, presumably prior to drainage and at which time fen meadow habitats, or at least more groundwater dependent fen meadow species, may have been present.

- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.

- Water quality data in the western boundary ditch, and the river, indicate elevated nitrate and phosphate levels, likely the result of discharge from the Benhall Sewage Treatment Works, and, possibly (not confirmed at present), septic tank discharge.

- Although a relict ditch remains, there are no active ditches crossing this central area of the site linking to the surface watercourses. The only interaction this area would have with surface water is therefore via periodic overtopping during high flow events in the River Fromus. Whilst river water quality is not optimal for fen meadow habitats, during high flow events, nitrate and phosphate concentrations will be diluted and, as indicated in **Section 1.5**, Wheeler, Shaw and Tanner (2009, Ref. 2) note that the community can accommodate considerable eutrophication without change to its basic composition provided that active management continues.

- Soil data indicates the presence of peat below surface at the northern end of this compartment [APP-258].

2.4.9 Based on the groundwater and surface water level data, and substrate type, it is concluded that it will be possible, by implementing measures detailed in Section 2.5, to provide groundwater influenced conditions in this central area, potentially with a peaty or gley substrate, that have the potential to support fen meadow habitat.

2.4.10 Water levels in the western boundary ditch, and River Fromus to the east, would not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

c) Southern Compartment

2.4.11 This compartment was identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing a potential additional area for fen meadow (0.7ha). The location of this area served to focus the detailed hydrological studies now on-going.

2.4.12 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in this compartment are indicated (BHALL_1104_s) to be maintained at about ground level over the winter but fall below surface from March onwards (to 25cm below ground level at the lowest point to date).
- Whilst the vegetation present is a form of rush pasture, it lacks the key groundwater indicator species present to the north.
- Groundwater levels in the shallow deposits are typically at, or above, the ditch level (indicated by GB01) suggesting there is potential for groundwater discharge to the adjacent ditch.
- Groundwater nitrate concentrations are either below the limit of detection or low in the superficial deposits and underlying Crag, and the same applies to the presence of phosphate.
- Water quality data in the ditch at the northern end of this compartment, indicate elevated nitrate and phosphate levels, likely the result of discharge from the Benhall Sewage Works and, possibly (not confirmed at present), septic tank discharge.
- A small area of peat was identified at depth in this area during the site investigation. However other core samples taken in this compartment indicate an absence of peat.
- Water levels in the ditch that flows through the compartment, and River Fromus to the east, however would not be controlled as part of this work due to potential for effects off site. Additionally, this area is topographically lower than the central and northern compartments and as a result is likely to flood more frequently than these areas.

2.4.13 Based on review of the data available, it is concluded that the potential area that could be made suitable for fen meadow would be too restricted to be viable and fen meadow is not proposed in this compartment. It is, therefore, excluded from the fen meadow habitat creation proposals, although access through this area is still required for establishment and subsequent management of the fen meadow habitat in the northern and central compartments, as the only access to the Benhall site is from the A1094 at the southern end of the site.

2.5 Proposed layout and features

a) Proposed layout – Northern Compartment

2.5.2 For the northern compartment the key aim of the proposals is to exert control over the drainage ditch network, reducing drainage from the compartment and sculpt the ground to increase the groundwater influence at the surface.

2.5.3 Exerting control over the drainage ditch network will support groundwater levels in the shallow deposits such that they are maintained at, or just above, ground level (target approximately 3.85m AOD).

2.5.4 The ground surface to the east of the central (north-south oriented) drain will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 20-30cm of the surface material will need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring during the implementation stage.

2.5.5 Natural colonisation, from the nearby fen meadow habitat on the Manor Farm Meadows County Wildlife Site (CWS), will form a component of the habitat development. However, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

2.5.6 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this approach is subject to programme considerations and will only be undertaken once.

2.5.7 An area for wet woodland creation (0.6ha) has also been identified at Benhall. The approach to creation of this habitat is set out in the **Wet Woodland Strategy** ([Doc Ref. ~~9.8(A)~~10.31).

2.5.8 Site proposals are indicated on **Figure 2.1**. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

i. Physical measures in northern compartment

2.5.9 Physical measures proposed to be implemented in the northern compartment are:

- Controlling water levels by installing a finely adjustable water control structure on the ditch linking to the watercourse that forms the northern compartment boundary. The water control structure will support levels in summer but will also enable any river flood waters getting onto the compartment in winter to escape. The water control structure will be set to around 3.85-3.90 m AOD initially. This could be adjusted up or down, if required, based on effectiveness indicated through monitoring of the levels and the conditions within the habitat creation areas;
- If confirmed that a culvert exists at the southern end of the central ditch, this will be blocked, as will a potential culvert, indicated on **Figure 2.1** on the south-eastern corner of the existing wet woodland;
- Sculpting of the land east of the central ditch, removing up to 20-30cm of soil;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the compartment;
- Removal of a 3-4m wide bund of arisings from ditch clearance from both banks of the central ditch;
- Installation of stock proof fence to control stock access to areas of created habitat;
- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix in the northern compartment.

2.5.10 Additionally, there will be no more dredging of the site drains to allow them to gradually silt up thereby reducing their drainage potential.

b) Proposed layout – Central Compartment

2.5.11 The key aim of the proposals is to sculpt the ground surface to increase the groundwater influence at the surface and create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material will need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring at the time.

2.5.12 Natural colonisation, from the nearby fen meadow habitat on the Manor Farm Meadows CWS, will form a component of the habitat development. However, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

2.5.13 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this approach is subject to programme considerations and will only be undertaken once.

2.5.14 Site proposals are indicated on **Figure 2.1**.

i. Physical measures in central compartment

2.5.15 Physical measures proposed to be implemented in the central compartment are:

- Sculpting of the land to the south, and immediately north of the relict drain, removing up to 30-40cm of soil;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the compartment;
- Provision of a boardwalk along the footpath in the central compartment to provide walkers a dry route;

- Installation of stock proof fence to control stock access to areas of created habitat;
- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix in the central compartment.

a) Habitat creation works

2.5.16 Any additional consents which become necessary will be sought for structures and works where they are located within, or fall within specified distances of, ordinary or Main watercourses.

2.5.17 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 2.2**. Of particular note is that a new bridge will be needed to cross the Canal to enable equipment to access the northern compartment. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

2.5.18 Arisings will be removed from the floodplain, off-site.

2.5.19 The establishment works described above will be undertaken in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

2.5.20 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles. A Protected Species Licence will be sought from Natural England in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

2.5.21 Activities will also be controlled via measures in the **Code of Construction Practice** (Doc ~~Ref. 8.11(E))~~Ref.10.2)) (secured by Requirement 2 of the dDCO).

2.6 Conservation management

2.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below and will be confirmed in the Fen Meadow ~~Plan~~ Plans submitted to East Suffolk Council and Suffolk County Council for approval pursuant to Requirement 14A.

a) Management units

2.6.2 Stock proof fence will be used to control stock access to areas of created habitat in both the Northern and Central compartments, particularly during the sensitive establishment phase in Year 1, and during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on **Figure 2.1**.

2.6.3 Management of areas outside the fen meadow creation areas/fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

2.6.4 Hay transfer will be achieved within a few hours of harvesting, with green hay spread thinly and evenly in the receptor areas on bare ground. Seed-drop from the strewn hay will be completed within 1-3 weeks. Seed will be pressed into the ground using stock (ideally cattle), if ground conditions allow, or a roller.

2.6.5 Where germination is sub-optimal, subsequent hay-transfer during August-September will be undertaken.

2.6.6 Following hay-transfer, colonization of the receptor areas by perennial weeds and/or slug populations will be monitored and, if required, treated appropriately to protect the new seedlings.

2.6.7 In the period after hay-transfer (July-November and again in the early part of the following growing season) germination will be favoured by maintaining a short sward.

2.6.8 During and following the first growing season, further introductions of green hay – or of collected propagules of target species – will be undertaken as appropriate, for example if insufficient vegetation establishment was achieved in the first growing season.

2.6.9 Subject to programme considerations, translocation of turves from the area of M22 being lost at Sizewell Marshes to the Benhall site will take place within a few hours to minimise the potential for drying prior to placement. The turves will be re-laid as a sward to retain the integrity of the turves and maximise the potential for survival of the translocated species.

2.6.10 The water control structure in the northern compartment will require adjustment as appropriate, based on monitoring, to deliver the target water level conditions for fen meadow habitat.

c) Fen Meadow Management – Years 2-5 and 6-10

2.6.11 In the first spring after initial hay transfer cutting, or grazing where ground conditions allow, may be required to avoid seedlings being shaded out.

2.6.12 Any perennial weeds that colonise will be controlled by spot treatment with herbicide and, as in Year 1, slug populations controlled as required.

2.6.13 From Year 3 onwards, the receptor areas will be managed as hay meadows and therefore cut late (for example, after mid July), with swath turning or tedding undertaken to assist seed shedding. The cutting date will be matched to that of the donor meadow, if possible. The use of livestock, particularly for aftermath grazing, is important, where ground conditions allow, because they create gaps in the sward and trample in the seed, which helps the introduced species to spread.

2.6.14 There will be no use of inorganic fertilisers or widespread application of herbicides.

2.6.15 The water control structure in the northern compartment will require adjustment as appropriate, based on monitoring, to deliver the target water level conditions for fen meadow habitat.

2.7 Monitoring

2.7.1 The effects on ground and surface water levels, and surface wetness, will be monitored for effectiveness using existing installations and observation.

2.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte species characteristic of M22. Note that some of the introduced species may take several years to appear and so the success of the hay transfer should not be judged immediately but kept under review.

2.7.3 Monitoring to ensure fish passage is not impeded will also be undertaken.

2.7.4 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

2.7.5 A monitoring report will be submitted to the Ecology Working Group on an annual basis to document works undertaken and the monitoring described above.

2.8 Area of Potential Fen Meadow

2.8.1 The initial primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study**

[APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures in the northern and central compartments will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 2.4 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4 [APP-258])~~the **Fen Meadow Compensation Study** [APP-258].

2.8.2 An additional area of 0.6ha has also been identified for inclusion of wet woodland in the northern compartment.

3 HALESWORTH

3.1 Site Baseline

a) Summary of investigations

3.1.2 The investigations being undertaken at Halesworth were summarised in the **Fen Meadow Plan Report 1**, with the study reports provided as appendices [REP3-051 and REP3-052]. The studies have mostly been completed, as detailed in **Table 3.1** below.

Table 3.1: Status of studies as at July 2021

Site	Study	Status
Halesworth	Ecology desk study	Completed in 2020
	Ecology field surveys	Phase 1 habitat survey NVC survey Water vole and otter survey Aquatic invertebrate survey of ditches All completed in 2020
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Installed October 2020
	Topgraphic survey of site and installations	Completed 2020
	Water flow, level and quality monitoring	Commenced November 2020 for 1 year.

3.2 Environmental Setting

3.2.1 The **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Halesworth site. The majority of the baseline information is not repeated in detail in this Fen Meadow Plan Draft 1.1 although a summary of the ecological setting is provided below and further hydrological monitoring data are now available so the Water Monitoring Summary – Halesworth Site 28, November 2020 to April 2021, has been updated to July 2021 (**Appendix B**). The updated data have also been further interpreted to update the site conceptual model (**Section 3.3**).

a) Summary of Ecological Setting from Halesworth Ecology Baseline report [REP3-051]

3.2.2 There are no statutory, or non-statutory, designated sites of nature conservation value within the Site or immediately adjacent to it.

3.2.3 Coastal and floodplain grazing marsh priority habitats are mapped in MAGIC as occurring on Site. There are no areas of existing fen meadow habitat nearby.

3.2.4 The site comprises a mix of semi-improved neutral grassland (most of it marshy), with scrub, scattered broadleaved trees, a defunct species-poor hedge, flowing and standing water.

3.2.5 Four distinct grassland-types were recorded during the NVC survey. An area of rush pasture flanking the catch-dyke contained species indicating groundwater influence.

3.2.6 No sign of otter presence was recorded on site.

3.2.7 A number of ditches provided optimal water vole habitat and water vole presence was located on seven of the surveyed transects (3 different ditches) in the summer, although no presence was recorded in the autumn hen water levels were high.

3.2.8 The aquatic invertebrate fauna of the Halesworth site comprises predominantly common and local species.

3.3 Site Conceptual Model

3.3.1 The initial site conceptual model is presented in the hydrogeological report (**Appendix F** of the **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section outlines the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

3.3.2 The surface elevation slopes gently from northwest to southeast towards the Walpole River, which is a main river that flows north-easterly. Ground elevations are highest in the northwest at 7.5-8.25 mAOD, flattening out to between 6.6-7 mAOD across much of the Site (see LIDAR plots in **Appendix B**). The Walpole River cuts a channel past the south-eastern boundary of the Site and has relatively steep banks, particularly to the south.

3.3.3 The site contains a network of land drainage ditches, most of which feed into a main catch-dyke.

3.3.4 Surface drainage from Blyth Road industrial estate is culverted beneath the catch-dyke but discharges to an open ditch and is conveyed along the lower part of the site before discharge to the Walpole River via a second culvert.

3.3.5 Topographic surveys initially indicate that water levels in the catch-dyke and attached drainage ditches are between 6.4 and 6.5 mAOD (November 2020). The Blyth Road drainage channel (W6) recorded a water level of 5.69 mAOD during the survey visit and Walpole River levels were 5.6 mAOD.

3.3.6 The bedrock geology at the site is Crag sands (c.21-26m thick) overlying London Clay. Although the Site is near the feather edge of the London Clay it is recorded to have a >10m thickness at the deeper on site borehole. The London Clay overlies the Chalk. Superficial deposits of Lowestoft Sands and Gravels overlie the Crag sands which are in turn overlaid by a combination of Alluvium (clay, silt, sand and gravel) and Head deposits.

3.3.7 Development of peat has occurred on the southern side of the catch-dyke and is encountered between 0.4 and 0.7 m bgl with a thickness of 1.1m at borehole HAL_2803_d. Soil cores show that a silty clay layer is often present above the Peat and is likely to impede movement of groundwater, rainwater and also flood water.

3.3.8 The soil core survey (~~Wood, 2019, Ref 3.~~ the **Fen Meadow Compensation Study** [APP-258]) indicated that groundwater levels were within the Peat (often below its upper surface) between 0.45 and 0.9 m bgl. The October 2020 drilling programme, which occurred during a relatively wet few weeks, showed a slightly higher rest groundwater level between 0.07 and 0.2 m, which indicates that the upper part of the peat may experience seasonal wetting and drying as the water table changes. Groundwater flow is generally toward the Walpole river in the southeast.

3.3.9 Groundwater in the deeper Crag sands is under positive hydrostatic pressure, resulting in slightly artesian conditions at piezometer HAL_2803_d (**Figure A1** in **Appendix B**). This indicates the presence of semi-confining clay layers within the Crag.

3.3.10 Groundwater levels at HAL-2802_s and HAL-2802_d show that the Crag and superficial deposits demonstrate the same magnitude and timing of fluctuations therefore in hydraulic continuity here (**Figure A2** in **Appendix B**). The peaks generally correlate with peaks to the surface water level GB03 (**Figure A2** in **Appendix B**) indicating a response to recharge from rainfall. There may be some upward flow from the Crag.

3.3.11 To the north-east, the superficial deposit groundwater levels exhibit a similar response in HAL-2802_s to those at the centre of the site (**Figure A2** in **Appendix B**). Whilst the surface water levels at GB01 on site decrease during the dry April, the same decrease in water level is not seen in GB02 which receives a discharge from the Blyth Road Industrial Estate which may provide additional support during this dry period.

3.3.12 Groundwater levels recorded in the monitoring installations in the superficial deposits drop to between 6 and 6.2 mAOD (**Figure A2** in **Appendix B**).

3.3.13 The soil core surveys, drilling logs and topographic survey indicate that groundwater levels are in continuity with surface water levels in the on-site ditches. The catch-dyke intercepts groundwater flow from the northwest. Beyond the catch-dyke to the southeast the water table flattens out and is higher than the Walpole River water level, indicating the potential for groundwater discharge to the river.

3.3.14 There are two significant groundwater abstractions licences for public water supply from six boreholes within 1.2km of the Halesworth site. These abstractions are sourced from the Chalk aquifer and their potential impact on near surface groundwater levels below the Site is likely to be small due to the presence of London Clay and semi-confining clay layers within the Crag. Nevertheless, the Site falls within Zone 3 of the groundwater protection zones for those sources.

3.3.15 The Halesworth STW discharges to the Walpole River approximately 50m downstream of the Site. The licensed discharge volume is 3.553 Ml/d. Flow is not gauged in the Walpole River. The closest permanent flow gauging station is located on the River Blyth approx. 2km downstream (east) of the Site at Holton (Ref No. 35013) which has an average flow of 0.46 m3/s (39.7 Ml/d).

3.3.16 The spot flow data for the site shows very limited surface water flows within the onsite drainage channels (**Table 4.1** in **Appendix B**).

3.3.17 There is some water quality data available for the site, with more sampling planned over 2021 and 2022. The data available to date shows the following:

- Nitrate concentrations are very low across the site. Where nitrate is present above the limit of detection it is in the deeper Crag deposits and Walpole River.
- Phosphate concentrations are below the level of detection across the site.

3.4 Suitability of the site for fen meadow creation

3.4.1 The site was identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing a primary locus for fen meadow (1.2ha) spanning the catch-dyke (the west-east aligned ditch that is the main drainage pathway for the site) where the vegetation indicates groundwater influence near to the surface. This primary locus area was bordered by a potential additional area for fen meadow (1.3ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies now on-going.

3.4.2 In 2021 the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits north of the catch-dyke are variable and show a general downward gradient to the deeper deposits. Winter levels in HALL_2803_s and HALL_2804_s fluctuate 15-30cm below ground level, but recess in the spring and early summer to 50-70cm below ground level.

- However, the groundwater levels in the shallow deposits north of the catch-dyke are, in general, above those of the catch-dyke, which has a typical level of between 6.3m AOD and 6.4m AOD (**Figure A1** in **Appendix B**). It is noted also that recorded levels in the catch-dyke at GB01 peaked over winter at about 6.98m AOD, with lesser peaks reaching 6.8m AOD (**Figure A1** in **Appendix B**). At these elevations, significant areas of the site south of the catch-dyke will have been under water, albeit the peaks are very short-lived. These peaks were likely the result of backing up of the catch-dyke as a result of high river levels downstream.

- South of the catch-dyke installations HALL 2802_s and _d show a similar pattern of fluctuation as those to the north but maintain an upward hydraulic gradient. In this area however, the adjacent ditch, that conveys the surface drainage from the nearby industrial estate, to the river is likely acting to drain the nearby surface deposits.

- Whilst not clearly apparent from the spring groundwater level data, the vegetation lying either side of the catch-dyke, represented in the National Vegetation Classification (NVC) survey reported in **Appendix B** of **Fen Meadow Plan Report 1** [REP3-051 and REP3-052], as MG10b *Holco-Juncetum effusi, Juncus inflexus* sub-

community (referred to as stand C2), contained species indicative of flushing with mildly calcareous groundwater.

- Soil data for the area north of the catch-dyke indicates an absence of peat; silty clay and sands forming the full depth of cores taken. To the south of the catch-dyke silty clay overlies peat encountered at around 40cm below ground (~~Wood, 2019, Ref. 4~~ **Fen Meadow Compensation Study** [APP-258]).

- Nitrate concentrations are very low across the site and phosphate concentrations are below the level of detection.

- Water quality data for the catch-dyke indicate a very low concentration of nitrate, and phosphate below detection limits, indicating that the Halesworth STW, is not influencing the ditch water quality.

- A network of land drains is visible on LIDAR (see **Appendix B**). These will be reducing the groundwater levels and drying the fields. However, these can be blocked.

3.4.3 Based on the groundwater and surface water level data, substrate type, and vegetation indicators it is concluded that it will be possible, by implementing measures detailed in Section 3.5, to provide groundwater influenced conditions in the area of the catch-dyke, potentially with a peaty substrate to the south of the dyke, that have the potential to support fen meadow habitats.

3.4.4 Water levels in the River Walpole will not be controlled to support these proposals. This is not required under the proposals and could lead to off-site impacts.

3.5 Proposed layout and features

3.5.1 The key aim of the proposals is to exert control over the drainage ditch network, with the effect of raising the base surface water level and supporting the groundwater levels in the shallow deposits, reducing drainage from the site and sculpting the ground to increase the groundwater influence at the surface.

3.5.2 The target catch dyke water level will be 6.6-6.7m AOD.

3.5.3 To the north of the catch dyke ground levels rise towards the northern site boundary (the northern bank level varying from 6.8-7.1m AOD and rising northwards). Therefore, whilst groundwater at the surface will be unlikely to occur, additional surface water level control will reduce leakage and support flushed situations in the immediate vicinity of the dyke.

3.5.4 Removal of a bund of recently placed arisings from the northern bank of the catch-dyke, will also facilitate a reduction in the ground level by a few centimetres to increase the potential for fen meadow species in this mildly flushed area.

3.5.5 Ground levels to the south of the dyke are lower (the southern bank level varying from 6.6 (at the extreme eastern end) - 6.8m AOD. Raising the dyke water level is expected to support shallow groundwater levels such that groundwater may occur at the surface in the vicinity of the dyke.

3.5.6 The ground surface to the south of the dyke, between the existing ditches, will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material will need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring during the implementation stage.

3.5.7 The three westernmost ditches on site are blind ended and hence retain water. However, the ditch that conveys the industrial estate drainage, and which is likely also draining the near surface deposits, will be infilled and the drainage discharge piped down the river. This will reduce the drainage from the shallow deposits in this area. No works are proposed to the ditch on the eastern site boundary as this will be downstream of the proposed water control structure.

3.5.8 There is no adjacent seed source for natural colonisation. Therefore, green hay transfer, from Sizewell Marshes SSSI, or another nearby fen meadow source, to the sculpted areas in mid-summer will assist with species introduction. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species, that have low tolerance of drought or flooding, to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

3.5.9 M22 species introduction will also occur through translocation of turves from the area of M22 being lost at Sizewell Marshes to within the areas identified for creation of a habitat matrix. This approach has the added benefit of providing the appropriate substrate for the species introduced. Use of this approach is subject to programme considerations and would only be undertaken once.

3.5.10 Site proposals are indicated on **Figure 3.1**. No wet woodland is proposed at this site. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

a) Physical measures

3.5.11 Physical measures proposed to be implemented on site are:

- Controlling water levels by installing a finely adjustable water control structure on the catch-dyke. The water control structure will support levels in summer but will also enable any river flood waters getting onto the site in winter to escape. As indicated above the target level will be 6.6-6.7m AOD, which dictates that it be located adjacent to the bridge crossing the catch-dyke. Much further east the land levels will be too low, and the dyke water could overtop the south bank;
- Setting the water control structure to around 6.7m AOD initially. This could be adjusted up or down, if required, based on effectiveness indicated through monitoring of the levels and conditions within the habitat creation areas;
- Piping the industrial estate drainage to the river and infilling the ditch that currently carries the drainage in an open channel;
- Preventing groundwater from following the path of the former ditch by including clay stanks at approximately 25m intervals;
- Sculpting land to the south of the catch-dyke, removing up to 30-40cm of soil. The sculpting works will extend approximately 60m from the catch-dyke towards the river, working within existing topographic features (e.g. avoiding works to elevated ground alongside the river);
- Removal of a 3-4m wide bund of recently placed arisings from the northern bank of the catch-dyke. This will also facilitate a reduction in the ground level by a few centimetres to increase the potential for fen meadow species in this mildly flushed area;
- Blocking or breaking up land drains, where encountered, to reduce drainage from the site;
- Installation of stock proof fence to control stock access to areas of created habitat;
- Application of green hay to areas of bare earth; and
- Translocation of turves from the area of M22 being lost at Sizewell Marshes to the areas identified for creation of the habitat matrix.

3.5.12 Additionally, there will be no more dredging of the Catch Drain, or other on site drains to allow them to gradually silt up thereby reducing their drainage potential.

b) Habitat creation works

3.5.13 Any additional consents which become necessary will be sought for structures and works where they are located within, or fall within specified distances of, ordinary or Main watercourses.

3.5.14 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 3.2**. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

3.5.15 Arisings will be used to infill the ditch and/or removed from the floodplain, off-site.

3.5.16 The establishment works described above will be undertaken in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

3.5.17 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles. A Protected Species Licence will be sought from Natural England in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

3.5.18 Activities will be controlled via implementation of measures in the **Code of Construction Practice** (Doc Ref. ~~8.11(E~~10.2)) (secured by Requirement 2).

3.6 Conservation management

3.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below and will be set out in the final Fen Meadow ~~Plan~~ Plans approved by East Suffolk Council and Suffolk County Council pursuant to Requirement 14A.

a) Management units

3.6.2 Stock proof fence will be used to control stock access to areas of created habitat, particularly during the sensitive establishment phase in Year 1,

during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on **Figure 3.1**.

3.6.3 Management of areas outside the fen meadow creation areas/fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

3.6.4 As described for Benhall.

c) Fen Meadow Management – Years 2-5 and 6-10

3.6.5 As described for Benhall.

3.7 Monitoring

3.7.1 The effects on ground and surface water levels, and surface wetness, will be monitored for effectiveness using existing installations and observation.

3.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte species characteristic of M22. Note however that some of the introduced species may take several years to appear and so the success of the hay transfer will not be judged immediately but kept under review.

3.7.3 Monitoring to ensure fish passage is not impeded will also be undertaken.

3.7.4 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

3.7.5 A monitoring report will be submitted to the Ecology Working Group on an annual basis to document works undertaken and the monitoring described above.

3.8 Area of Potential Fen Meadow

3.8.1 The initial primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures on site will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 1.0 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4 [APP-258])~~the **Fen Meadow Compensation Study** [APP-258].

4 PAKENHAM

4.1 Site Baseline

a) Summary of investigations

4.1.2 The investigations being undertaken at Pakenham were summarised in **Fen Meadow Plan Report 1**, with the study reports available at the time provided as appendices [REP3-051 and REP3-052]. Since the **Fen Meadow Plan Report 1** [REP3-051 and REP3-052] was produced, the NVC survey and spring water vole and otter survey have been completed and therefore studies are now mainly complete, as detailed in **Table 4.1**.

Table 4.1: Status of studies as at July 2021

Site	Study	Status
Pakenham	Ecology desk study	Completed in 2021
	Ecology field surveys	Phase 1 habitat survey completed May 2021 NVC survey completed June 2021 Spring water vole and otter survey completed May 2021 Aquatic invertebrate survey undertaken late June 2021
	Hydrogeological desk study	Completed in 2021
	Installation of piezometers, dipwell, gaugeboards	Completed March 2021
	Topgraphic survey of site and installations	Undertaken March 2021
	Water flow, level and quality monitoring	Commenced April 2021 for 1 year

4.2 Environmental Setting

4.2.1 The **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052] summarised the findings of a series of baseline reports, provided as Appendices, that described the environmental setting of the Pakenham site. The majority of the baseline information is not repeated in detail in this **Draft Fen Meadow Plan** ~~(Doc. Ref. 9.64(A))~~ although a summary of the ecological setting is provided below, accompanied by a summary of the

results of the NVC and water vole/otter surveys, which are also are provided in:

- Pakenham Site 54 Ecology Baseline (NVC and water vole/otter survey) in **Appendix C**;

4.2.2 Further hydrological monitoring data are also now available and the Water Monitoring Summary – Pakenham Site 54, April 2021, has been updated with data to July 2021 (**Appendix D**). The updated data have also been further interpreted to update the site conceptual model (**Section 4.3**).

a) Summary of Ecological Setting from Pakenham Ecology Baseline report [REP3-051]

4.2.3 There are no statutory, or non-statutory, designated sites of nature conservation value within the Site. However, Pakenham Meadows SSSI is located adjacent to the Site, to the east of Pakenham Stream, and Pakenham Fen Meadows County Wildlife Site is also located to the east of Pakenham Stream. Both of these designated sites contain fen meadow habitat.

4.2.4 Coastal and floodplain grazing marsh and deciduous woodland priority habitats are mapped in MAGIC as occurring on Site.

4.2.5 The site comprises a mix of grassland (some of it marshy), semi-improved and improved grassland, broadleaved wet woodland, swamp, standing water and running water, with fields divided either by hedges or ditches.

b) Pakenham Site 54 Ecology Baseline (NVC and water vole/otter survey) (Appendix C)

i. National Vegetation Classification (NVC) survey

4.2.6 The NVC survey identified vegetation-types from six phytosociological groups within and on the margin of the floodplain. These vegetation types are assigned to the following NVC communities:

Fen meadow

- M22b *Juncus subnodulosus-Cirsium palustre* fen meadow, *Briza media-Trifolium* spp. sub-community; and
- M22a *Juncus subnodulosus-Cirsium palustre* fen meadow, Typical sub-community.

Rush pasture

- MG10b *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community; and
- MG10b/S22c *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community, grading to *Glyceria fluitans* water-margin vegetation, *Alopecurus geniculatus* sub-community.

Inundation grassland

- MG13 *Agrostis stolonifera-Alopecurus geniculatus* grassland.

Floodplain grassland

- MG7b/MG10b *Lolium perenne-Poa trivialis* ley grading to *Holcus lanatus-Juncus effusus* rush pasture, *Juncus inflexus* sub-community;
- MG7b *Lolium perenne-Poa trivialis* leys ; and
- MG7c *Lolium perenne-Alopecurus pratensis-Festuca pratensis* grassland.

Valley footslope grasslands

- MG7d *Lolium perenne-Alopecurus pratensis* grassland;
- MG7a *Lolium perenne-Trifolium repens* leys;
- MG1e *Arrhenatherum elatius* grassland, *Centaurea nigra* sub-community; and
- MG1a *Arrhenatherum elatius* grassland, *Festuca rubra* sub-community.

Fertile reed-fen

- S25a *Phragmites australis-Eupatorium cannabinum* tall-herb fen, *Phragmites australis* sub-community.

Poplar woodland

- W6b *Alnus glutinosa-Urtica dioica* woodland, *Salix fragilis* sub-community.

4.2.7 The grassland habitats present qualify as coastal and floodplain grazing marsh, whilst the woodland qualifies as deciduous woodland, both of which are habitats of principal importance listed under Section 41 (S41) of the Natural Environment and Rural Communities (NERC) Act 2006.

ii. Otter and water vole survey

4.2.8 The Site contains suitable habitat and conditions to support both water vole and otter.

4.2.9 During the presence/absence survey, two water vole latrines were located (one on each of two ditches), as were two feeding stations (both on the same ditch) and small mammal runs on four ditches. No water vole burrows were identified however it is noted that due to unseasonably wet conditions encountered in spring 2021, some of the potential field signs identified during the survey may have been diluted or hidden by rising water levels etc. and hence water vole may make more use of the site than was recorded in May.

4.2.10 A number of otter spraints were recorded, all from the Pakenham Stream. No signs of otter presence were recorded from ditches on site.

4.3 Site Conceptual Model

4.3.1 The initial site conceptual model is presented in the hydrogeological report (**Appendix H** of the **Fen Meadow Plan Report 1 Baseline Report** [REP3-051 and REP3-052]). This section builds on the assessment provided in the conclusions of that report and all monitoring data collected and made available at the time of writing (July 2021). This section presents the findings on the relationship between ground level, groundwater levels, surface water levels and logged geological strata.

4.3.2 The Pakenham Site covers the valley floor of the Pakenham Stream. The bedrock geology underlying the Site is Chalk. The chalk is overlain by superficial deposits of varying thicknesses; the most dominant is Peat, but there are also river terrace sands and gravels and Head deposits which thin towards the western margin. The boundary to the west is the upland toeslope. The margin of this upland is composed of sands and gravels. The upland also has a pronounced sandy terrace toe-slope occupying much of the northern part of this site. To the east, the site is bounded by the Pakenham Stream. There is a buried valley running roughly south of the course of the River Sapiston (Black Bourn) and another which dissects the site which is filled with Glacial Till/ Boulder Clay.

4.3.3 Development of peat has occurred at the site and is encountered between 0.1 and 0.6 m bgl with a thickness of up to 2.9 m at borehole PAK-HA-2. Soil cores show that where present the peat is between 30 and 110 cm thick. Most cores exhibited the deposition of peat over sand, with chalky boulder clay or ‘putty’ chalk proved in cores in the centre of the survey or the south west corner, respectively

4.3.4 The highest ground is to the west of the Site with elevations to over 32.5 mAOD. The catchment topography generally slopes towards the Pakenham Stream to the east, however, LiDAR data for the site shows that the central ditch which bisects the site is the low point at around 30 mAOD (see **Appendix D**). The Pakenham Stream to the east of the site is the main drainage channel for the wider catchment and there is a bund on the left bank which is at about 31.5 mAOD, although a low point is indicated by the LIDAR data (see **Appendix D**) immediately to the north of the footpath, where cattle gather to drink and have eroded the bank. Although not recorded in the available data, during initial visits this area of the site was noted to be under water, arising from flooding from the Stream. Generally, over the main central Pakenham Site the ground levels are between 30.5 and 31 mAOD.

4.3.5 The Pakenham site contains a network of land drainage ditches. The main ditch across the site runs from south to north parallel with the Pakenham Stream. This central ditch is bisected by a second west-east primary ditch; both ditches appear to be carriers for near-surface groundwater. There are several small boundary drains which appear to drain along the upland margin and run to the main central drain.

4.3.6 Data obtained from the topographic surveys initially indicate that water level in the Pakenham Stream is around 31.1 mAOD. The lowest elevation of the channel bed on the short Pakenham Stream reach accessible during the topographic survey (water levels were very high in March 2021) was 29.9 mAOD. The Pakenham Stream is at a higher elevation than the central ditch, although there is still likely continuity between the Pakenham Stream and groundwater levels.

4.3.7 Site visits have identified a breach in the Pakenham Stream bank where the stream crosses over the west-east ditch, which is culverted at this location. The flow, from east to west, in to the site in this ditch, and subsequently in to the central ditch, is being supported by flow from Pakenham Stream via this breach.

4.3.8 The topographic survey indicated initially that water level in the central ditch is around 30.4 mAOD. The lowest channel elevation recorded in the topographic survey was 28.6 mAOD. Groundwater levels across the site recorded at between around 29.5 mAOD and 30.6 mAOD for the same day.

4.3.9 Regionally, groundwater flow in the chalk is towards the Little Ouse but is considered to deflect towards the Pakenham Stream locally and to the north-east regionally. Chalk groundwater levels are generally considered to be at between 32 mAOD and 36 mAOD in the regional groundwater model produced by the Environment Agency.

4.3.10 The water levels in the chalk borehole monitored on Site (BH-2_d,) shows that the piezometric surface of the Chalk is higher than ground level at between 33.25 mAOD in early spring (29th March 2021) and 32.4 mAOD by summer 2021 (12th July 2021). Ground level at BH2 is 32.22 mAOD. The groundwater level data at BH-2_d demonstrates that there has been a generally declining trend over the spring and early summer of 2021 (**Figure A4** in **Appendix D**). BH-2_s which measures the water level in the superficial deposits at the same location shows a clear declining trend over the same period which aligns with that seen in BH-2_d (**Figure A4** in **Appendix D**) indicating some hydraulic continuity of the near surface deposits with the underlying chalk. Groundwater levels are below ground level at 30.25 mAOD in early spring (29th March 2021) and 29.59 mAOD by summer 2021 (12th July 2021).

4.3.11 In the centre of the site, the central ditch has a water level around 30.4 mAOD (as monitored by GB01 and GB03, **Figure A3** in **Appendix D**). There are no significant fluctuations in the observed data. The land to the east of the central ditch is mostly flat between 30.35 and 30.5 mAOD and very similar to the water levels in the ditch.

4.3.12 The ditch to the north-west of the central ditch has a higher water level (GB02) at 31.4 mAOD, most likely a function of the higher topography to the west of the site. The base of the ditch at GB02 is approximately 1.3 mAOD above the base of the central ditch.

4.3.13 The water levels in the near surface dipwells (PAK-HA-1 to PAK-HA-6) all show a similar hydrogeologic response (**Figure A3** in **Appendix D**).

4.3.14 It is noted that the groundwater levels observed are generally similar between the central ditch (GB01 and GB03) and the surrounding boreholes closest to the ditch (HA-3, HA-4 and HA-6) and that groundwater levels here are close to ground level (**Figure A3** in **Appendix D**).

4.3.15 Groundwater levels in PAK-HA-2 are significantly below ground level (~1-1.5m) (**Figure B14** in **Appendix D**) and this is repeated in the soil core sample (Core 1) which shows no obvious water table to 1.25m bgl. Similar depth to water, and corresponding lower absolute water levels (in mAOD), are seen at PAK-HA-1 and PAK-HA-5, reflecting local variability in behaviour of the superficial deposits.

4.3.16 To the north of the Site, the water levels in PAK-HA-1, PAK-HA-2 and PAK-HA-3 show a similar water level trend (**Figure A3** in **Appendix D**). PAK-HA-3 has a higher absolute level than the other two boreholes.

4.3.17 The surface water levels in the GB02 and GB04 are higher than the main central ditch, which is in part a function of the topography which is higher at

these two locations. Water will therefore drain towards the central ditch and ultimately flow northwards.

4.3.18 The groundwater level response in PAK-BH-1 shows less pronounced fluctuations in the groundwater levels. BH-1 measures the groundwater conditions in the buried valley, and close to the surface water abstraction. BH1 is not considered to be in hydraulic continuity with the rest of the superficial deposits at the site.

4.3.19 The lowest groundwater level and therefore maximum depth to water in the superficial deposits is listed in **Table 4.2** below.

Table 4.2: Groundwater levels and depth to water table

Borehole ID	Ground level (mAOD)	Lowest observed groundwater level (mAOD)	Maximum depth to water table (m)	Highest observed groundwater level (mAOD)	Minimum depth to water table (m)*
PAK-BH-1	31.9	30.2	1.7	30.6	1.3
PAK-BH-2_d	32.2	32.4	-0.2*	33.2	-1.0*
PAK-BH-2_s	32.2	29.6	2.6	30.3	2.0
PAK-HA-1	30.7	29.2	1.5	29.8	0.9
PAK-HA-2	30.7	29.1	1.5	29.6	1.0
PAK-HA-3	30.6	30.2	0.4	30.6	0.0
PAK-HA-4	30.7	30.2	0.5	30.7	0.0
PAK-HA-5	30.9	29.5	1.4	30.1	0.8
PAK-HA-6	30.7	30.3	0.5	30.6	0.2

* negative depth to water table shows where groundwater levels are above ground level.

4.3.20 Anecdotal evidence suggests that the ground around HA-1 (current Fen Meadow) is damp underfoot. The groundwater data do not show this, which implies that there is locally perched water table here which is currently not being measured, potentially due to layering in the peat. There is also potential for this area to be supported by winter flooding from Pakenham Stream and the on-site ditches.

4.3.21 Two surface water abstraction points, from one abstraction licence, are located on the ditches on site. One further abstraction, which abstracts during the winter, is located on the Pakenham Stream adjacent to the site and piped to the west under the site.

4.3.22 The soil cores also showed little in terms of water. It is likely that the historical water table relates to the zones of sapric peat or, in Core 9, where manganiferous streaks were proved. It is also evident that where peat is at the ground surface, it is in poor condition, and recorded as earthy peat. The reduction of the water table from the ground surface is clearly long-standing.

4.3.23 The water quality data available to date shows the following:

- Nitrate concentrations are highest at BH2_S in the superficial deposits at 99.7 mg/l as NO3. Concentrations are lower in the underlying chalk (BH2_D) which monitored nitrate at 33.7 mg/l as NO3. Elsewhere concentrations are high at the nearby surface water monitoring point at GB03 (50.8 mg/l as NO3) but low across the main central Pakenham dipwells (<2 mg/l as NO3). The Pakenham Stream nitrate concentrations are at 36.4 mg/l as NO3.

- The site generally has very low phosphate concentrations as would be expected, with most samples below detection limits. The Pakenham Stream shows phosphate concentrations at 0.958 mg/l, and elsewhere there are low concentrations at HA-2 (0.273 mg/l) and GB02 (0.602 mg/l).

4.4 Suitability of the site for fen meadow creation

4.4.1 The Pakenham site is discussed as two compartments, north and south.

a) Northern Compartment

4.4.2 This compartment was identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing two areas of primary locus for fen meadow (totalling 3.2ha), one incorporating the western slope of the site to the west of the central drain, and the other around the north side of an area of existing fen meadow habitat. The western primary locus area was bordered by a potential additional area for fen meadow to the east of the central drain (4ha), within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies.

4.4.3 However, in 2021, the NVC survey identified that the northern primary locus, which sits to the north of existing fen meadow vegetation, is also fen meadow. Therefore~~,~~ no measures to create fen meadow are required in this part of the compartment. Nonetheless, the potential for fen meadow creation in the remainder of this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the

necessary conditions for fen meadow, assessed based on the points presented below:

- Groundwater levels in the shallow deposits in the primary locus area to the west of the central ditch fall significantly below ground level (up to 1.5m in PAK-HA-2), which is also 1m below the ditch water level (around 30.4m AOD). This depth to water reflects the results of a soil core from a similar area reported in ~~Wood, 2019 (Ref. 4 [APP-258])~~the **Fen Meadow Compensation Study** [APP-258], which did not strike water in a depth of 125cm.

- However, to the east of the central ditch shallow water levels remain within 25cm of the ground surface (PAK-HA-3), a similar elevation as the stream water level. It is noted, although not confirmed, that the groundwater levels may be supported by occasional overtopping from the Stream. A soil core in the same area recorded water at 60cm depth.

- Although not recorded in the available data, during initial visits this area of the site was noted to be under water, arising from flooding from the Stream. The lowest point in the bank appears, from LIDAR data (**Appendix D**), to be located immediately adjacent to the north of the footpath crossing the Stream.

- The rush pasture communities present either side of the central ditch at its northern end (MG10b and MG10b/S22c, see NVC report in **Appendix C**), contain a combination of obligate and non-obligate phreatophytes, suggesting that the near surface deposits are, or have been, influenced by groundwater.

- Substrate both sides of the central ditch was found to be peat over marl, and so substrate is appropriate for fen meadow.

- There are some instances of elevated nitrate concentrations in groundwater, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have been recorded from surface water samples, which likely reflects surrounding, arable, land uses. Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- The drainage system is complex and there are a number of factors to consider in respect of supporting water levels on site:

- Due to its linkage with Pakenham Meadows SSSI to the east of Pakenham Stream, it is not possible to raise the levels in the system, without potentially also affecting levels in the SSSI.
- Levels in the system at this end of the site may be being supported by the leak from the Pakenham Stream.
- There is a spring/summer abstraction from the ditches on the western site margin that will depress the ditch water levels, although currently these are being supported by the leak from the Pakenham Stream bank.

- LIDAR data suggests the presence of land drains running parallel north-south between the central ditch and Pakenham Stream, presumably draining to the cross ditches. It is possible, although they are not visible on LIDAR, that similar drains are present in the western compartment. These will be reducing groundwater levels and drying the field surface. However, these can be blocked.

4.4.4 Based on the data available, the substrate type is appropriate and, with implementation of the measures detailed in Section 4.5, it is considered that it will be possible to deliver groundwater influenced surface conditions in this compartment, particularly to the east of the central ditch, and potentially also to the eastern side of the western area alongside the central ditch.

b) Southern Compartment

4.4.5 This compartment was identified in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]~~)~~ as containing an arrow shaped area of primary locus for fen meadow bordering the wet woodland at the southern end of the site (1.7ha). An area of fen meadow habitat is located immediately adjacent to the south-west of the primary locus to the north of the woodland as indicated (see ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258]). The area of primary locus was flanked by a more extensive potential additional area for fen meadow (4.3ha) within which it was considered that more substantial intervention would likely be required to enable the development of fen meadow. The locations of these areas served to focus the detailed hydrological studies now on-going.

4.4.6 In 2021, the potential for fen meadow creation in this compartment has been reviewed based on the available results of the detailed studies, and the measures to deliver the necessary conditions for fen meadow, assessed based on the points presented below:

4.4.7 In respect of the suitability for fen meadow in the area to the north and upslope of the woodland:

- Groundwater levels in the shallow deposits upslope of the primary locus area to the north of the woodland (and its boundary ditch that joins the main central ditch to the north of the woodland/reed fen area) fall significantly below ground level (almost 1.4m in PAK-HA-5), approaching 1m below the ditch water level (around 30.4m AOD). This depth to water reflects the results of Core 14 from a similar elevation reported in ~~Wood, 2019 (Ref 3. [APP-258])~~the **Fen Meadow Compensation Study** [APP-258], which did not strike water in a depth of 125cm. However, downslope of PAK-HA-5 Core 17 struck water at a depth of 63cm.

- The botanical community present in the field north of the woodland is a floodplain grassland, MG7b, which contains no obligate phreatophytes and only low numbers of non-obligate phreatophytes, suggesting that there is little groundwater influence at the surface.

- Upslope to the north of the woodland, substrate was found to be sand to 60cm in Core 14, and predominantly sands and gravels in the PAK-HA-5, however Core 17 downslope was found to be peat. To the east of the woodland Core 16 was earthy peat over marl and then peat. Substrate appears to be more appropriate for fen meadow on the lower margins of this field.

- There are some instances of elevated nitrate concentrations in groundwater at the northern end of the Pakenham site, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have however been recorded from surface water samples, which likely reflects surrounding arable land uses. Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- As indicated for the northern compartment, the drainage system is complex and in general it is not possible to manipulate the levels. However, it is considered that:

  - The ditch separating the fen meadow from the floodplain grassland could be managed without affecting off-site receptors. Although not currently monitored, field observations suggest that it receives run-off, originating as groundwater, from the fen meadow compartment. As such it is expected that water quality would be good.

  - The ditch along the northern edge of the woodland could be controlled without affecting off-site receptors provided that this control occurred before it's confluence with the central ditch. This would reduce drainage from the area, at least from the south-western end of the field.

- No field drains are evident in this field on LIDAR data (**Appendix D**) in this field, although there is a suggestion of presence in the fen meadow field (running north-west to south-east), perhaps evidence of historic efforts to drain the area.

4.4.8 In respect of the suitability for fen meadow in the area to the east of the woodland:

- To the east of the woodland and the central ditch shallow water levels (PAK-HA-6) remain within 45cm of the ground surface, a similar elevation as the stream water level. Core 16 in the area struck water at 80cm below ground level. Core 15 in the same field, but to the north, struck water at 50cm below ground level.

- To the east of the woodland, the floodplain grassland is transitional rush pasture (MG7b/MG10b). This contains a very low number of obligate phreatophytes and a greater number of non-obligate phreatophytes, suggesting a greater current, or historic, groundwater influence at the surface.

- To the east of the woodland Core 16 was earthy peat over marl and then peat, whilst Core 15 was earthy peat over peat. Substrate appears to be appropriate for fen meadow in this field.

- This field is bordered by the central ditch to the west, and Pakenham Stream to the east. No water level control on these watercourses is considered possible without affecting off site receptors.

- There are some instances of elevated nitrate concentrations in groundwater at the northern end of the Pakenham site, although concentrations in most groundwater monitoring installations are low, with phosphate below the level of detection.

- Elevated nitrate concentrations have however been recorded from surface water samples, which likely reflects surrounding, arable, land uses. Phosphate above the level of detection was also recorded from Pakenham Stream, indicating the presence of a sewage treatment works discharge upstream.

- LIDAR data suggests the presence of land drains running parallel north-south between the central ditch and Pakenham Stream (**Appendix D**). It is likely, although they are not visible on LIDAR, that similar drains are present in the western compartment. These will be reducing groundwater levels and drying the field surface. However, these can be blocked.

4.4.9 As for the northern compartment, based on the data available, the substrate type is appropriate and, with implementation of the measures detailed in Section 4.5, it is considered that it will be possible to deliver groundwater influenced surface conditions to the east of the woodland. However, it is concluded that the potential area that could be made suitable for fen meadow to the north of the woodland would be too restricted to be viable. This conclusion is based on the requirement for significant on-going management of water level control structures and any shallow water distribution channels and the very small area in the south-western corner of this field over which conditions for fen meadow habitat could be provided. Fen meadow is therefore not proposed in this area of the southern compartment and it is therefore excluded from the proposals.

4.5 Proposed layout and features

a) Proposed layout (Northern compartment)

4.5.2 The key aim is to achieve groundwater influence at the surface by lowering the surface and reducing the contribution from surface water in the area between the central ditch and Pakenham Stream, and also to the west of the central ditch.

4.5.3 There will be no control of surface water levels in the drainage ditch network. However, the final fen meadow plan will consider the detailed interaction of the proposals with Pakenham Water Mill.

4.5.4 The ground surface between the central ditch and the Pakenham Stream, and also immediately to the west of the central ditch, will be sculpted to create a matrix of terrestrial, wetland and shallow open water habitat niches to maximise the potential for target species to colonise. It is anticipated that 30-40cm of the surface material will need to be removed to deliver the proposed matrix of habitats, subject to the results of focussed soil coring at the time.

4.5.5 There is a nearby seed source from adjacent areas of non-designated fen meadow habitats within the wider site which will support natural colonisation. However, to assist the colonisation process, green hay from on site or, with permission from the owner and Natural England, from Pakenham Meadows SSSI, will be applied to the sculpted areas in mid-

summer. Application to areas of bare earth is beneficial in respect of establishment of species with high light requirements and low competitive abilities, whilst creation of a matrix will maximise the potential for species that have low tolerance of drought or flooding to find an appropriate niche. Application of green hay may be undertaken on more than one occasion.

4.5.6 Site proposals are indicated on **Figure 4.1**. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

i. Physical measures

4.5.7 Physical measures proposed to be implemented in the northern compartment are:

- Sculpting of the land between the central ditch and the Pakenham Stream, and also immediately to the west of the central ditch, removing up to 30-40cm of soil;
- Blocking or breaking up of land drains, where encountered, to reduce drainage from the compartment;
- Raising the western bank of Pakenham Stream immediately to the north of the footpath crossing to the same level as elsewhere on site (level to be determined by further topographic survey) to reduce the potential for site flooding, without affecting the floodplain function of the area. An Environmental Permit will be required from the Environment Agency to enable this work to take place as set out in the **Schedule of Other Consents, Licences and Agreements** (Doc. Ref. ~~5.11(B~~5.11(C))
- Application of green hay to areas of bare earth; and
- Provision of a boardwalk along the footpath to provide walkers a dry route.

4.5.8 Although not physical measures it is noted that:

- Continued operation of the summer surface water abstraction presents a significant risk to the successful provision of appropriate conditions for fen meadow because it suppresses ditch water levels in the summer, which results in a greater drainage effect on the adjacent land, and hence reduced groundwater levels in the northern compartment. Additionally, as the drain from which the abstraction takes place is a continuation of the drain that is culverted under

Pakenham Stream and forms the northern boundary drain of Pakenham Meadows SSSI, the abstraction also has the potential to reduce water levels in the SSSI. However, the full effects of the abstraction on ditch, and adjacent groundwater, levels are currently buffered by the leak from Pakenham Stream (see below), so the level of effect on the ditch, and groundwater, levels is not apparent in the monitoring data. The level of risk to the creation of conditions for fen meadow is therefore not quantifiable at this stage. To maximise potential for fen meadow habitat in this location, and to reduce risks to existing areas of fen meadow, the strong preference is that this abstraction should cease; and

- Retention of the leak from Pakenham Stream supports, and is therefore beneficial to, ditch water levels on site, and also those in Pakenham Meadows SSSI, as it is supporting levels in the ditch forming the northern boundary of the SSSI.

b) Proposed layout (Southern compartment)

4.5.9 The key aim is to achieve groundwater influence at the surface by lowering the surface, sculpting the land to create a habitat matrix. Given the presence of marl in this area to the east in particular it is proposed that the matrix removes a greater depth than proposed elsewhere, up to 45cm, to create areas of calcareous standing water, as well as adjacent wetland habitats, including fen meadow, subject to the results of focussed soil coring at the time during the implementation stage.

4.5.10 The approach to establishing fen meadow species in sculpted areas will be the same in the southern compartment as in the northern compartment.

4.5.11 An area for wet woodland creation (~~1.76~~ 1.47 ha) has also been identified at Pakenham in this compartment. The approach to creation of this habitat is set out in the **Wet Woodland Strategy** Doc Ref. ~~9.8(A)~~10.31) secured pursuant to Requirement 14B).

4.5.12 Site proposals are indicated on **Figure 4.1**.

i. Physical measures

4.5.13 Physical measures proposed to be implemented in the southern compartment are:

- Sculpting the land between the central ditch and the Pakenham Stream to the east of the woodland, removing up to 45cm of soil.
- Blocking or breaking up of land drains, where encountered, to reduce drainage from the compartment to the east of the woodland; and.

- Application of green hay to areas of bare earth.

c) Habitat creation works

4.5.14 Appropriate consents will be sought for works where they fall within specified distances of, ordinary or Main watercourses.

4.5.15 A temporary site compound will be established and access routes marked for the habitat creation works. Indicative locations for site compound and access routes, and notes on accessibility, are provided in **Figure 4.2**. Note that the proposed order limits have been reduced such that they are now focussed on areas in which works will be undertaken whilst also allowing access for construction and future management and monitoring.

4.5.16 Arisings will be removed from the floodplain, off-site.

4.5.17 Works will take place in late spring/summer, avoiding periods with the highest risk of surface inundation and the highest water tables that result in soft ground.

4.5.18 Working areas will be subject to ecological walkovers to confirm and update ecological constraints. Works to ditch banks will be micro-sited to avoid effects on water voles and otters. A Protected Species Licence will be sought from Natural England in the event that one is required, although, based on the reported ecological baseline [REP3-051 and REP3-052] it is considered that effects requiring licensing can be avoided.

4.5.19 Activities will be controlled via implementation of measures in the **Code of Construction Practice** (Doc Ref. ~~8.11(E)~~10.2) secured pursuant to Requirement 2.

4.6 Conservation management

4.6.1 Management measures during the establishment period (Year 1) and in Years 2-5 and 6-10 are summarised below and will be set out in the final Fen Meadow ~~Plan~~ Plans submitted to East Suffolk Council and Suffolk County Council for approval pursuant to Requirement 14A.

a) Management units

4.6.2 Stock proof fence will be used to control stock access to areas of created habitat, particularly during the sensitive establishment phase in Year 1, and during years 2-5, depending upon ground conditions. Proposed fence lines are indicated on **Figure 4.1**.

4.6.3 Management of areas outside the fen meadow creation areas / fence lines will comprise taking a hay crop, followed by aftermath grazing.

b) Fen Meadow Establishment period (Year 1)

4.6.4 Hay transfer will be achieved within a few hours of harvesting, with green hay spread thinly and evenly in the receptor areas on bare ground. Seed-drop from the strewn hay will be completed within 1-3 weeks. Seed will be pressed into the ground using stock (ideally cattle), if ground conditions allow, or a roller.

4.6.5 Where germination is sub-optimal, subsequent hay-transfer during August-September will be undertaken.

4.6.6 Following hay-transfer, colonization of the receptor areas by perennial weeds and/or slug populations will be monitored and, if there is a risk of adverse impacts on the seedlings, treated appropriately to protect the new seedlings.

4.6.7 In the period after hay-transfer (July-November and again in the early part of the following growing season) germination will be favoured by maintaining a short sward.

4.6.8 During and following the first growing season, further introductions of green hay – or of collected propagules of target species – will be undertaken.

c) Fen Meadow Management – Years 2-5 and 6-10

4.6.9 In the first spring after initial hay transfer cutting and where ground conditions allow, grazing may be required to avoid seedlings being shaded out.

4.6.10 Any perennial weeds that colonise will be controlled by spot treatment with herbicide and, as in Year 1, slug populations controlled.

4.6.11 From Year 3 onwards, the receptor areas will be managed as hay meadows and therefore will be cut late (for example, after mid July), with swath turning or tedding undertaken to assist seed shedding. The cutting date will be matched to that of the donor meadow, if possible. The use of livestock, particularly for aftermath grazing, is important, where ground conditions allow, because they create gaps in the sward and trample in the seed, which helps the introduced species to spread.

4.6.12 There will be no use of inorganic fertilisers or widespread application of herbicides.

4.7 Monitoring

4.7.1 The effects on ground and surface water levels, and surface wetness, will be monitored for effectiveness using existing installations and observation.

4.7.2 An annual botanical assessment of the establishment of species in the area will be undertaken, including assessment of the presence of phreatophyte species characteristic of M22. Note however that some of the introduced species may take several years to appear and so the success of the hay transfer will not be judged immediately but kept under review.

4.7.3 Management of the water levels and habitats developing on site will be amended as required based on the monitoring results.

4.7.4 A monitoring report will be submitted to the Ecology Working Group on an annual basis to document works undertaken and the monitoring described above.

4.8 Area of Potential Fen Meadow

4.8.1 The initial primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4~~ the **Fen Meadow Compensation Study** [APP-258] were used to focus the detailed hydrological studies. Based on the data now available it is considered that implementing the proposed measures on site will result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat across 4.73 ha of the site. This figure supersedes the primary loci and potential additional areas for fen meadow provided in ~~Wood, 2019 (Ref. 4 [APP-258])~~the **Fen Meadow Compensation Study** [APP-258].

4.8.2 An additional area of ~~1.76~~ 1.47 ha has also been identified for inclusion of wet woodland in the southern compartment.

5 SUMMARY

5.1.1 Implementation of proposals in this **Draft Fen Meadow Plan** are expected to deliver conditions to support fen meadow species on each of the three sites.

5.1.2 The proposals are intended to result in elevated water levels and/or creation of a habitat matrix, creating the conditions for establishment of fen meadow habitat.

5.1.3 The proposals are therefore anticipated to deliver conditions suitable to support fen meadow habitat across the site areas summarised below:

- Benhall – 2.4 ha of fen meadow, 0.6 ha of wet woodland;
- Halesworth – 1.0 ha of fen meadow; and
- Pakenham: 4.73 ha of fen meadow, ~~1.76~~ 1.47 ha of wet woodland.

5.1.4 In total therefore the plan could deliver up to **8.13 ha** of fen meadow and ~~**2.36**~~ **2.07 ha** of wet woodland.

5.1.5 Within any of the sites, it is not possible to set a single ground level that will deliver appropriate conditions for fen meadow year round allowing for a smaller area to be identified for fen meadow delivery, because of the uncertainties in groundwater level fluctuation with a limited ability to control these on these sites, and uncertainties in the precise development of the habitat in any one particular location within the site. Instead, the sculpting approach proposed, results in a variable micro-topography that will support a range of hydrological conditions, varying from shallow open water through to more terrestrial habitat. This maximises the provision of areas with appropriate hydrology, and hence potentially suitable area for fen meadow, whilst allowing for the uncertainties in groundwater level fluctuation and limited ability to control these.

5.1.6 The proposals in this draft plan have been prepared with reference to the data available to the beginning of July 2021 (**The Fen Meadow Plan Report 1 – Baseline Report** [REP3-051 and REP3-052], provides a summary of data available until May 2021) and data collection is on-going at each site. ~~A final~~ Final Fen Meadow ~~Plan~~ Plans in general accordance with the **Fen Meadow Strategy** (Doc ~~Ref. 6.14 2.9.D(A)~~Ref.10.16) and this **Draft Fen Meadow Plan** (Doc ~~Ref. 9.64(A)~~Ref.10.6) must be submitted to and approved by East Suffolk Council ~~for approval~~ and Suffolk County Council prior to any vegetation clearance in the Sizewell Marshes SSSI being carried out. The Fen Meadow ~~Plan~~ Plans must be implemented as approved.

REFERENCES

1. Natural England (2020). Stage 4 pre-application consultation. [Online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908003/Response_to_Sizewell_C_Development_Consent_Order_stage_4_consultation.pdf

2. Wheeler B.D., Shaw S. & Tanner K. (2009). A wetland framework for impact assessment at statutory sites in England and Wales. Science report: SC030232. Environment Agency, Bristol.

3. van Diggelen R. & Marrs R.H. (2003). Restoring plant communities – Introduction. Appl. Veg. Sci. 6: pp. 105-110.

4. Wood (2019). Fen Meadow Compensation Study – Report of Visits to Target Sites 2019. Report to EDF Energy.

APPENDIX A: WATER MONITORING SUMMARY – BENHALL SITE 10 & 11, NOVEMBER 2020 TO PRESENT (JULY 2021) – REFER TO FEN MEADOW PLAN DRAFT 1 [REP6-026]

APPENDIX B: WATER MONITORING SUMMARY – HALESWORTH SITE 28, NOVEMBER 2020 TO PRESENT (JULY 2021) – REFER TO FEN MEADOW PLAN DRAFT 1 [REP6-026]

APPENDIX C: PAKENHAM SITE 54 ECOLOGY BASELINE REPORT (ADDENDUM) – REFER TO FEN MEADOW PLAN DRAFT 1 [REP6-026]

APPENDIX D: WATER MONITORING SUMMARY – PAKENHAM SITE 54, APRIL 2021 – PRESENT (JULY 2021) – REFER TO FEN MEADOW PLAN DRAFT 1 [REP6-026]

FIGURES