NOTES OF 3rd STEERING GROUP MEETING HELD ON THURSDAY 30TH NOVEMBER 2006, COUNTY HALL, NORTHALLERTON

MIRO/MIST PROJECT: Water-based quarry restoration: Methodologies, Technologies & Approaches

Produced by P Ellis, Hafren Water

Attendees: P Ellis, Hafren Water
C Leake, Hafren Water
M Barnett, NYCC
J Birkinshaw, NYCC
R Smith, NYCC
S Warwick, SUWT
C Arditto, Tarmac
D Park, Lafarge
J Pacey, Environment Agency
M Hammond, Consultant Ecologist
R Smithyman, Consultant Landscape Architect
S Jay, Yorkshire Wildlife Trust
P Eckersley, English Nature

Apologies: M Fuller, Environment Agency

1. Introduction

Hafren Water welcomed the members of the steering group including new representatives from English Nature and the Yorkshire Wildlife Trust and indicated that the project had been on-going for 16 months and had another 2 months to run. The project was in the final reporting stage and any input from the steering group should be received in the near future in order to be incorporated in the final research findings. The meeting was scheduled to include PowerPoint presentations by P Ellis on Hydrology and by M Hammond on the ecological setting and habitat restoration potential of the study area. Hafren Water presented the project objectives and progress to date. For the purposes of the study water-based restoration is taken to include the following:

- Open waterbodies below the watertable
- Perched waterbodies above the regional watertable
- Areas of habitat dependent on wet conditions
- Areas subject to frequent inundation
- The use of groundwater and surface water within a potential restoration

The project objectives are:

- Review methods of water-based restoration
  - Determine physical/practical constraints for each restoration scheme
  - Develop assessment criteria
  - Consider hydrological/hydrogeological implications & engineering requirements
- Inform planning

Potential afteruses for water-based quarry restoration are summarised below:

Water supply/reservoirs/irrigation
Watercourse management/supplement
Flood risk management
Water treatment
Run off management
Amenity Sailing/fishing/diving
Wildlife habitat
Fishery/aquaculture
Industrial process (cooling)
Energy production, Hydropower, biofuels, ground source heating
Lakeshore residential housing
Landfill (hydraulic containment)

Table 1: Potential afteruses for water-based quarry restoration

The study area is located in North Yorkshire primarily around the catchments of the Swale and Ure Rivers and, as discussed previously, comprises 7 case study areas comprising different hydrogeological settings and stages of restoration (see Table 2 and Figure 1).

Name	Map N^{o}	Grid Ref	Type	Status
Kiplin Hall Quarry	99	SE 272 973	Floodplain sand and gravel	Restored
Marfield Pit	99	SE 215 827	Terrace sand and gravel	Active/restored
Nosterfield	99	SE 284 807	Floodplain sand and gravel	Active/restored
Dry Rigg Quarry	98	SD 800 695	Deep mudstone quarry	Active
Scorton	93	NZ 235 007	Floodplain sand and gravel	Active
Wensley	99	SE 065 920	Hillside limestone, horizontal	Active
Staveley	99	SE 360 630	Floodplain sand, gravel and clay	Restored

Table 2: Case study areas

A combined assessment of each site has been undertaken involving expert input on ecological, landscape, hydrology, hydrogeology, engineering and quarry operations.

2. Progress summary

Since the last progress meeting in September the literature review has been completed and is being edited. The ecological (M Hammond, Consultant) and hydrological surveys have been completed and the last fieldwork involving a round of water quality sampling has recently been undertaken (results awaited). Pro-forma datasheets have been completed for each site allowing comparison of attributes between sites and the resulting differences in restoration potential. Given the large volume of data available for the seven case study areas, and the time constraints, it has been decided not to seek additional sites outside the study area as was the original intention of the project. An assessment of the landscape and engineering options for restoration is being undertaken by Pleydell Smithyman Ltd, Consultant Landscape Architects. The Landscape Agency (Consultant Landscape Architects) are to produce diagrammatic planning guidance based on the findings of the work to date and in consultation with NYCC by the beginning of January. It is proposed to circulate the draft report for comment in mid-January, prior to final report submission to MIRO at the end of January.

3. Hafren Water presentation – hydrology and hydrogeology

3.1 *Planning for variability in restoration*

The topic of uncertainty in the prediction of final water levels was reviewed in detail at the last Steering Group meeting and was briefly summarised again. A primary consideration is climatic variability which affects surface run-off, evapotranspiration rates, river flows and groundwater levels. Annual rainfall in part of the study area ranged between ~450 mm and 950 mm in the period 1985-2004. Climate change is predicted to produce even greater variability in seasonal rainfall and increase storm intensities. Data was presented (Figure 1) from the national groundwater archives for a monitoring borehole at Brick House Farm in the Magnesian Limestone at Tadcaster (to the south of the study region). The hydrograph shows groundwater levels have varied from a peak in 2003 to a low in 2004, close to both the upper and lower extreme values recorded over the entire 23-year monitoring period (1979-2002). Levels are still below the monthly average but appear to be recovering. The Magnesian Limestone is a low storage aquifer and subject to greater variability in watertable fluctuations than high storage sand and gravel aquifers.

3.2 *Reedbeds*

The potential for reedbeds was discussed for other functions in addition to wildlife habitat. Additional uses included water treatment and CO_2 sequestration and carbon accounting.

3.3 *Carbon accounting*

Both Tarmac and Lafarge have policies for the assessment of carbon emissions throughout the company. This was driven by shareholders, government guidance and potential future legislation. Significant CO_2 emissions related to quarrying were related to transport. A reduction in carbon emissions was a company target. The use of reedbeds to offset carbon emissions had, as yet, not been implemented. The reedbeds and other peat-forming vegetation remove CO_2 from the atmosphere and incorporate the carbon within the plant structures. Under anoxic (water-logged) conditions the vegetation does not decay to release CO_2 but instead forms peat. Exposure and desiccation of peat can potentially lead to oxidation and the release of CO_2 from storage. Appropriate methods for the temporary storage of peat during the operational phase of a quarry could be considered.

3.4 *Water treatment*

Reedbeds and other wetland species such as willow can be used to treat waste water effluent from industrial processes, sewage treatment works and farm and road run-off. The principles of treatment are to provide suitable residence times, surface areas and redox conditions to allow microbial action to occur. The resultant breakdown products of contaminants/nutrients can then be consumed during plant growth. Contaminants are also filtered out or stored within sediment. Settlement ponds are often incorporated within a system design.

Other treatment systems can involve vertical water flow and floating macrophyte basins (eg duckweed or water hyacinth). It is noted that willows also have potential to remove metals from contaminated water for reed beds. Surface area requirements are generally 5 m^2 per population equivalent (PE) for secondary sewage treatment (ie after settlement), for tertiary treatment (polishing) 1 m^2 per PE is usual.

A major purpose of the reeds/willow is to provide large surface areas within the root zones suitable for the microbial populations. Natural systems primarily rely on surface flow of water through the wetland. However, constructed wetlands are generally more efficient and rely on the flow of water through a generally 60 mm thick granular substrate in which reeds are planted at a density of ~4 per m^2.

There is potential for natural treatment systems to be incorporated within a range of end uses at a site. Reedbeds could be incorporated within treatment systems for the local population, generating potential income. Aquaculture and agricultural practices may require water treatment, and nutrient content of influent water could potentially be reduced for sensitive ecology. The natural treatment systems are primarily effective during the growing season and are less so during the winter period.

3.5 *Comparison of site data*

Hafren Water presented comparative data taken from the 7 case study sites. To allow direct comparison between sites information was generally displayed on a per hectare basis.

3.6 *Potential water interacting with the restoration*

As discussed at the previous meeting information on the potential water types (qualities) and volumes interacting within a site is useful in optimising a restoration design (Figure 2).

Figure 2 illustrates the potential variability in the water balance for each site, ranging from ~10,000 m^3/yr/Ha to 25,000 m^3/yr/Ha (0.3 – 0.8 l/s). A 'coarse' estimate of the water balance for each site has been calculated using the following assumptions:

- Direct precipitation has been calculated on the basis of site area multiplied by the effective rainfall. The effective rainfall was defined as precipitation minus evapotranspiration. When evapotranspiration exceeded precipitation then the effective rainfall was taken as zero. Rainfall data was obtained from the Environment Agency for the closest monitoring station. Regional evapotranspiration data was obtained from MAFF Technical Bulletin, 37.

- Surface drainage has been calculated based on the surface catchment area that could potentially interact with the site, multiplied by the effective rainfall. Surface drainage incorporates field drainage systems and surface watercourses up-gradient of the site.

- *Simplified*. Groundwater inflows are estimated based on the Darcy flow equation of saturated thickness multiplied by the hydraulic gradient and the hydraulic conductivity of the aquifer. Calculations assume horizontal flow (ie limited input from bedrock) and estimates of hydraulic conductivity as follows:

Sand and gravel	20 m/d
Other	0.1 m/d

- In cases where piezometric data was unavailable, the watertable was assumed to follow the topographic gradient. There is potentially an over-estimation in the site water balance due to 'double counting' of the effective precipitation which is included within the surface drainage estimate but may also recharge the groundwater system. However, the water balance is thought to provide an indicative method of site assessment and comparison.

3.7 *Surface drainage*

It is noted that in many cases surface water is not utilised within the restoration, but is potentially available if required. For example, at Kiplin Hall, the Kiplin Beck passes alongside (within 15 m) of the northern fishing lake but a direct connection is prevented due to the poor water quality of the stream particularly during flood events. On the other hand at Staveley the entire water-based restoration (fen meadow, reedbeds, etc) is dependent on surface water inflow from a catchment of some 117 Ha. Much of the catchment is underlain by Magnesian Limestone beneath superficial deposits.

At Staveley the surface water quality is apparently sufficient to sustain nutrient-sensitive species. This may be explained by the 'natural treatment' system that operates. The surface water inflow passes through 2 lakes allowing settlement of suspended solids (and sorbed phosphate) before entering the site and flowing through an extensive area of reedbed prior to entering the main site lake. It is noted that a change to this inflow (eg off-site impoundment) would have serious consequences for the nature reserve, as would (to a lesser extent) changes in catchment land use management.

Nosterfield Nature Reserve is an example of where the surface drainage system could potentially be utilised to supplement the site water supply when required. Several catchment areas could be considered including the 1.02 km^2 area field system immediately to the west of the site and the 1 km^2 catchment of the stream draining from Caberry Bank to the northwest of the site. Average effective rainfall over a 1 km^2 catchment has been estimated as 855,900 m^3/yr. Water quality would need assessment and potentially require some form of settlement and natural treatment. However, it is considered unlikely that high nutrient content will have a significant adverse effect on the sites primary purpose of providing habitat for bird life.

3.8 *Precipitation and evapotranspiration*

The effect of regional climatic variation is clearly visible in the direct precipitation estimates for each site ranging from ~15,000 m^3/yr/Ha for Dry Rigg in an upland setting (220 mAOD) to 2,357 m^2/yr/Ha at Kiplin Hall (~40 mAOD).

It is noted that the value for Scorton, which lies 4 km northwest of Kiplin Hall, is slightly greater at 3,845 m^3/yr/Ha, as a result of lying closer to a different rainfall station (Richmond –vs- East Courton). Evapotranspiration also shows significant regional variability as indicated in the table below.

MAFF Area	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
4	-1	5	24	44	69	77	76	60	36	15	0	-3
5	3	10	30	50	72	82	80	63	41	20	4	0
6	-1	3	22	42	66	73	72	56	30	15	0	-3
12	3	10	30	53	77	87	86	69	43	22	5	1
MAFF Areas: 4 - Wensley 5 - Kiplin Hall, Scorton 6 - Dry Rigg 12 - Marfield, Nosterfield, Staveley												

Table 3: Average regional potential evapotranspiration data in mm (from MAFF Technical Bulletin B4 Climate and Drainage)

Summer water deficits (Figure 3) were calculated as the volumes of water required to fully satisfy the potential evapotranspiration requirements over the entire summer period. It should be noted that these are based on evapotranspiration rates for standard grassland and may be modified dependent on final vegetation type.

Estimated summer deficits ranged from 941 m^3/Ha at Staveley to zero at Dry Rigg. This information is useful in combination with water held in storage when planning site water requirements eg spray irrigation for agriculture or inflows for reedbed maintenance.

3.9 *Water in storage*

Water resources held in storage within the restoration form an asset for use both within and beyond the site boundaries.

Initial estimates of storage for each site were based on the area of open water multiplied by the average depth. In many cases the exact depth of the waterbodies was unknown in which case a depth of 3 m was assumed. Total storage ranged from 7,500 m^3 at Wensley (hillside limestone quarry) to 3,480,000 m^3 at Dry Rigg (deep hard rock quarry) (Figure 4). However, the aquifer type and recharge rate will also be significant when determining potential abstraction volumes. For example, gravel pit lakes may be readily recharged by the surrounding groundwater system; whereas Dry Rigg has a very limited groundwater inflow derived from fractures in the rock and will be dependent for recharge on the annual effective rainfall (39,551 m^3/yr). Abstraction in excess of this will lead to a net drawdown. The pit lake is estimated to require some 13 years to fill upon cessation of working. As discussed previously yearly variation in precipitation is considerable and water available in storage can be used to offset any potential deficit during drought periods. As an indication of potential water supply, UK water usage per person in a residential dwelling is estimated as some 200 l/day (73 m^3/yr) (source: Environment Agency).

Following receipt of more detailed information from SUWT the storage in Nosterfield Nature Reserve has been revised from ~700,000 m^3 to 237,000 m^3 (ie average depth 2 m). This is based on a water level of 41 mAOD, thought representative of water levels during the winter/spring season when the nature reserve becomes inundated. The nature reserve has been designed to operate over a seasonal range in water levels to maximise the wildlife conservation value. A complex, gently sloping topography comes into play from ~39.8 mAOD, below this level the lakes are relatively steep-sided. During dry periods water levels fall below 39.6 mAOD with a consequent reduction in open water area and storage capacity as indicated in the table below.

Water level (mAOD)	Area of open water (Ha)	Storage in waterbodies (m^3)
38.5	<4.1	8,708
39	5	26,490
39.6	6.9	53,937
40	10.33	95,209
40.5	15.33	157,528
41	19.53	236,782
41.5	28.53	363,482
42	35.53	535,982

Table 4: Nosterfield Nature Reserve potential variation in open water area and storage volumes including old silt lagoons (supplied by SUWT)

Due to the shallow topographic gradient of the reserve, water held in storage or alternatively surface water required to achieve inundation varies significantly with the elevation of the water surface.

At Nosterfield Nature Reserve areas of open water storage volumes and shoreline were calculated by SUWT using AUTOCAD and a topographic site survey (including lake bottoms). At other sites this level of detail was unavailable so areas and shorelines were calculated by hand from the largest scale map available.

3.10 *Areas of open water and shoreline*

Areas of open water per hectare ranged from a minimum of 2% at Wensley (hard rock hillside quarry) to the restored sites in superficial deposits which ranged from 20% to a maximum of 37% at Nosterfield Quarry (Figure 5). Areas relate to the entire planning boundary rather than just extraction areas and include stand-offs, batter slopes and unworked areas. Site areas ranged from 27 Ha at Dry Riggs to 136 Ha at Scorton.

3.11 *Impact of seasonal variability on site statistics*

Nosterfield Nature Reserve has been designed with a complex topography to cope with and benefit from the anticipated seasonal variation in water levels.

At seasonal low water levels of less than ~39.8 mAOD, water level fluctuations show little change in areas of open water or shoreline, as the topography of the lake sides is relatively steep below this level. Above 39.8 mAOD the topography of the site rises at a shallower gradient incorporating numerous scrapes, which become more attractive to an interesting range of species when water levels reach ~40 mAOD. The seasonal variation in surface water coverage varies significantly as indicated on Figures 7 and 8. As discussed at the 2nd Steering Group meeting, maintenance of the seasonal wet grassland coverage is key in maintaining the sites conservation interest and HLS funding.

3.12 *Shoreline length*

Shoreline lengths range from 39 m/Ha at Dry Rigg to 83 m/Ha at Nosterfield Nature Reserve (Figure 8).

Water edge length is particularly important, as the smaller it is the more concentrated the birds become and therefore prone to predation. Shoreline lengths at Nosterfield Nature Reserve increase from 3,880 to 4,750 with an increase in water level of 39.6 – 41 mAOD. A measure of the complexity of the open water features is indicated by the ratio of shoreline to open water, which at Nosterfield decreases from 530 to 245 m per ha of open water with an increase in water levels from 39.6 – 41 mAOD. The other sites range from 174 m/Ha at Kiplin Hall to 337 m/Ha at Nosterfield Nature Reserve. Wensley has a value of 550 m/Ha, a result of the very small nature of the waterbody (Figure 8).

3.13 *Hydrogeological constraints*

What can be achieved through a restoration depends to a large extent on the geology of the mineral deposit, volumes of overburden, base of extraction and depth of the watertable, all of which dictate the volume of fill material available. The height of the restored land surface above the watertable is also significant. Typical site restorations are to a mixture of agriculture (previously a planning requirement) and open water. Typically agricultural land surface is restored to ~1.2 m above the mean watertable (although this is nationally variable). Potentially restorations back to wetland habitat with the watertable at or near the ground surface would require less fill material per m^2 allowing the additional fill material to be used in the reduction of the areas of open water created. Wetland habitat is of high conservation value versus the often low quality of restored agricultural land, and under the high level stewardship scheme (or similar) could provide income comparable to an agricultural usage.

Site-specific details dictate what is achievable; however it is possible to assess the theoretical site restoration potential for a range of hydrogeological conditions. A simple spreadsheet model has been used to calculate fill volumes and open water for a standard 1 Ha extraction area for a range of scenarios. A uniform flat-lying topography, watertable and geology were assumed. The area of open water created (as a fraction of the whole extraction area) was calculated relative to restored land surface elevation above the watertable. The base of the open waterbody was assumed to coincide with the base of mineral. All sides were initially considered to be vertical. Scenarios were examined for overburden depths (OB) of 1 and 2 m, a watertable (WT) depth of 3 m and depths to base of mineral 9M) of 5, 7 and 9 m. For deposits with a low ratio of overburden to saturated mineral such as 10B-9M-3WT the additional land area created varied very little, from 86% open water at a restored surface of 1.2 m above ground level to 83% when the restored surface was level with the watertable. At the other extreme

(20B-5M-3WT) the % of open water varied considerably from 38% with a restored surface 1.2 m above the watertable to 0% when the surface was at the watertable elevation. It is noted that 10B-5M-3WT and 20B-7M-3WT have the same overburden to saturated mineral ratio and are equivalent when restoration is back level with the watertable.

Another important factor is the content of silt or waste material within the mineral. The site model was calculated assuming a silt/waste content of 15% (Figure 9). For the deepest deposit (10B-9M-3WT) the maximum area of open water reduces from 86% to 69% and from 38% to 23% for 20B-5M-3WT under an agricultural restoration (ie surface 1.2 m above watertable). Where sufficient data was available for the case study sites, overburden thickness was in the range 1 – 3 m, mineral thickness was in the range 6 – 15 m and the average depth to the watertable ranged from 2 – 11.5 m.

As discussed previously, the % open water for the case study sites generally ranged between 20 and 35 primarily as a result of land within the planning boundary in addition to the extraction area. A restoration ‘envelope’ beyond the extent of the main extraction area may provide additional material for the restoration depending on the slope angle employed. Obviously the shallower the angle the more material will be released for restoration and the better it will blend in with the surrounding landscape. However, the total area of land required will increase. The spreadsheet model was used to assess the impact of side slope angle and restoration envelope size on the % of open water (Figure 10). For a side slope angle of 1 in 5 the maximum area of open water ranges from 65% to 48% with height of surface above WT for 10B-9M-3WT. The additional marginal land area (as a % of extraction over 1 Ha) required to accommodate the slope increases from 36% to 60% with a decrease in restored surface elevation from 1.2 to 0 m above the watertable. This is a significant increase in the area of land required relative to the extraction area, although as the size of the extraction area increases the perimeter length increases at a relatively smaller rate, eg an increase in a regular (square) extraction area from 1 Ha to 4 Ha (400%) results in a 400% increase with a corresponding increase in perimeter and associated marginal area from 400 m to 800 m (200%). There are obviously significant economies of scale in terms of the relative cost of marginal areas. It is noted that it is assumed mineral is not extracted from these marginal areas, all material being used for restoration.

The impact of a variation in side slope angle on open water area was assessed, assuming a wetland restoration back to watertable (Figure 11). Areas of open water were reduced significantly for side slope angles of between 1:3 and 1:20. the deposit 10B-9M-3WT with the greatest thickness of saturated mineral was reduced to 3% open water at a marginal slope angle of 1:20, however this required an additional ‘restoration envelope’ of 240% land area. It is noted that the fraction of open water referred to is relative to the extraction area and does not include marginal restoration areas which would lower the overall fraction considerably (more similar to the cast study values reported).

It is recognised that site-specific information and detailed design work is required in combination with estimated muck shifting volumes to develop a final site restoration scheme. However, a similar methodology as discussed above could be used for initial site assessment potentially incorporated within a GIS.

3.14 *GIS*

For strategic planning on a regional scale a GIS will prove a valuable tool for spatial analyses of data. Scoping studies of using a GIS were performed as part of the Swale and Ure Washland project (Figure 12).

The RSPB are also understood to be performing a GIS analyses to determine the most appropriate habitat creation objectives on a regional scale.

The results of this study indicate several factors that could be incorporated within the GIS system to assess a site's potential for the range of water-based restorations and end uses identified.

The factors of interest are those identified on the site pro-forma datasheets. Unfortunately local data is often unavailable and estimations must be made with regard to water levels and mineral thickness. Often considerable data may rest with individual companies but not in the public domain. Such things as mineral thickness would be considered confidential, but potentially groundwater and surface water monitoring data could be released to improve both the regional scale assessment and local hydrogeological assessments.

3.15 *Water companies*

Hafren Water considered it worthwhile to engage with water companies to examine the possibility of utilising quarries for local water supply or water treatment.

3.16 *Conservation -vs- other end uses*

A discussion was held on the relative merits of conservation versus other potential end uses. Several factors tend to push restorations towards conservation end use including the undoubted benefit for wildlife and the relative strength of the lobby for wildlife. Restoration for nature conservation is often seen as relatively uncontroversial, as opposed to more complex proposals which may delay or jeopardise planning permission which is not in a minerals company interest. Final development of a site may occur under a separate Planning Application after mineral extraction and the proposed site restoration will therefore not be optimised for the final end use.

Another factor is that often a landowner, although wishing to obtain income from a site, may not be familiar with the range of potential options. Therefore, a 'formal' consideration of each afteruse option, perhaps linked to the regional strategic overview, may increase the range of quarry afteruse. Tarmac indicated that NYCC could perhaps provide a range of potential end uses for sites in various locations that NYCC would find acceptable/encourage. Nature conservation can be incorporated within most proposed restorations in conjunction with other end uses. Involvement of the end user in the initial restoration planning is also greatly beneficial in optimising the restoration. Regular meetings can then be used to modify the restoration scheme over time.

It was also suggested that some sites could be entirely devoted to nature conservation, with creation of more specific habitat types appropriate to local priorities and of viable size, avoiding the creation of 'parkland'. Mineral operators indicated the difficulty of public perception of 'bare earth' and the drive towards rapid 'greening' of restored areas, rather than perhaps longer term restoration required to establish more 'difficult' habitat.

3.17 *Restoration size*

Indications of the research project are that bigger is generally better, rather than the field-by-field approach currently in operation. Large areas allow greater potential for strategic planning, larger (more viable) habitat creation and major works such as flood alleviation schemes.

However, negative public perception of large areas demarcated for extraction may lead to problems in obtaining planning permission. In addition these large areas may contain in excess of the ~20-year resource usually incorporated within the minerals plan and permitted to the minerals operators. Concentration of extraction in one area may also pose other problems with transport and distribution. Multiple land ownership may also make matters more complex. However, to employ planning strategy on a landscape scale, a method of meeting large-scale objectives is required.

3.18 *Flood alleviation schemes*

Incorporation of flood alleviation and summer baseflow support schemes as part of quarry restoration are often discussed but have not become standard practice in quarry restoration. Wildlife benefits would be considerable, but large areas are required before effects on downstream flooding are significant. Reasons for reticence include the unpredictability of river interaction with a site. Liabilities are associated with long-term maintenance and impacts on surrounding land and downstream siltation. A considerable capital investment may also be required if engineered inlets/outfalls are to be used. Potentially the Environment Agency could contribute to the works/ management; however local priorities, budgets, etc will not necessarily coincide with the proposed restoration period unless incorporated in a regional strategy.

Specific flood alleviation schemes must generally be relied upon to operate at the ‘push of a button’ or at specific level/time on a flood hydrograph. Therefore considerable investment in modelling etc may be required which is only likely to be justified for a project of significant size. Areas with potential for flood alleviation schemes do exist, such as the corridor along the River Swale, south of Catterick.

3.19 *Site closure reports*

Hafren Water discussed the benefit of a restoration closure report summarising the data for the site, eg rainfall, geology, water levels, fill material, which could be utilised for the subsequent afteruse of the site and incorporated within any relevant site management plan. Data from the completed reports could perhaps enter the public domain and be incorporated within the regional spatial planning GIS.

4. Martin Hammond presentation – wetland re-creation on mineral sites in North Yorkshire

4.1 *Historic context*

An understanding of wetlands in the Swale and Ure Washlands prior to mineral extraction allows us to:

- Plan habitat restoration relevant to the local landscape context
- Understand functional attributes of habitats/communities under threat
- Reconnect and expand remaining fragments

Historic changes in wetland habitats can be traced through cartographic evidence and an extremely rich archive of natural history recording, dating back to the 1660s and unbroken since the late 18th century (Figure 13).

4.2 *Characteristic types of wetland in the Swale and Ure Washlands*

Wetland type	Examples	Current status	Habitat/vegetation
Meres and associated wetlands formed in deeper basins in glacial till	Snape Mires, Cowtons Meres	Drained and converted to intensive agriculture. Pepper Arden Bottoms re-wetted	Mesotrophic shallow lakes? Reedbeds?
Peatlands formed in shallow basins in glacial till	Ainderby Mires, Newby Carr, Newsham Carr, Halnaby Carr, Pilmoor	Pump-drained, converted to intensive agriculture. Pilmoor SSSI small, deteriorating remnant	Fens (NVC M9?, S27?) Purple moor-grass/ rush pastures (NVC M22, M23, M24) Mesotrophic ditches (NVC A4)
Open water transitions associated with gypsum sink holes	Sharow Mires	Sharow Mires eutrophicated and planted with trees	Fen (NVC S24 at Sharow)
Valley fens irrigated by springs and seepages	Marfield Fen, Fox Covert (RPTA)	SSSIs at Marfield and Ripon Parks	Seepage fens (NVC M10, M13, M22)
Floodplain fens	Bishop Monkton Ings	Sole extensive example is SSSI	Fen meadow (NVC M22), grazing marsh, seepage fen on valley slopes
Raised bogs	Leckby Carr, Marton Carr	Leckby Carr destroyed	Raised bogs with Sphagna, cranberry, cotton-grass (NVC M2a, M18)

Table 5: Characteristic types of wetland

4.3 *Loss of wetland biodiversity*

- Wetlands covered well over 1,000 hectares in the Washlands in the 18th century.

- Surviving wetlands cover approximately 83 ha (= 92% loss). This figure excludes gravel pit lakes as these are eutrophic waterbodies but includes fens on minerals sites (eg Staveley NR).

- Archival data based mainly on botanical records though some other losses are evident, eg breeding waders formerly widespread on the Vale of Mowbray Carrs.

- Wetland species represent about 37% of all local plant extinctions during the past 200 years (Figure 14). Species from broken ground and arable fields have also suffered significant losses whilst woodland plants have suffered very few.

4.4 *Importance of low nutrient habitats*

The plant species and communities most at risk of extinction in the Washlands have been those associated with low-nutrient conditions (Figures 15 and 16). This applies particularly to wetlands but is a strong trend across all habitats.

4.5 *Strategic context for wetland restoration on minerals sites*

- Site afteruse plans negotiated between operator/land owner and minerals planning authority.

- Government Minerals Planning Guidance (MPS1), County guidance (North Yorkshire Minerals Local Plan/Minerals & Waste Development Framework), draft Swale and Ure Washlands Mineral Site Afteruse Strategy.

- UK Biodiversity Action Plan (priority habitats and species).

- Local Biodiversity Action Plans (district-based, published or available in draft form for all districts and National Parks in North York except for City of York Unitary Authority area).

BAP priorities are slow to be assimilated but statutory authorities have a legal obligation (CROW Act 2000/ Natural Environment & Rural Communities Act 2006) to promote the UK BAP.

Habitats
Coastal and floodplain grazing marsh
Eutrophic standing water
Fens
(Lowland raised bog)
Mesotrophic standing water
Purple moor grass and rush pastures
Reedbeds
Wet woodland

Table 6: UK BAP Priority habitats relevant to water-based minerals site restoration in North Yorkshire (= CROW Act S74 Habitats of Principal Importance)

An example of Local BAP targets relevant to water-based quarry restoration: Extracts from the Richmondshire Biodiversity Action Plan

Fen Habitat Action Plan
Objective: "To increase the fen resource through habitat creation, while maintaining all sites in a favourable ecological condition".
Local status: 22.3 ha of fen exist in Richmondshire district.
Opportunity: Habitat creation through mineral restoration schemes.

Target: Create 3 ha. by 2010; "Advise Mineral Planning Officers and mineral extraction companies on fen habitat creation and encourage them to deliver new fen sites".

Standing water Action Plan

Background: "While mineral extraction operations result in large water bodies being created, the opportunity to make these into areas that have high value for nature conservation needs to be delivered. This action plan supports the pursuit of larger and more wildlife orientated restoration schemes, incorporating a range of appropriate BAP habitats."
"The creation of water bodies that subsequently attract flocking birds, particularly gulls and wildfowl, is in conflict with aviation policy regarding bird strikes…In the District this potentially affects the Vale of Mowbray with its extensive mineral extraction industry and this issue needs to be addressed."

Opportunity: "Large scale wildlife-focussed habitat creation, including standing water and other BAP habitats, at gravel extraction sites as part of restoration schemes."

4.6 *Wetland restoration in the wider countryside*

- Fen/mire SSSIs within/fringing Swale & Ure Washlands: Pilmoor, Upper Dunsforth Carrs, Ripon Parks, Marfield Fen, Farnham Mires, Bishop Monkton Ings.
- Widely scattered SINCs and a few undesignated sites with wetland components. Several of these relate to minerals sites.
- Wetland creation/restoration: Foxglove Covert (MoD), Pepper Arden Bottoms (CCT), Staveley NR (YWT) (Figure 17).
- Remnants of peatland in Vale of Mowbray (Snape Mires, Spudding Dyke) but few realistic opportunities for re-wetting and inherent problems with water supply and quality (Figure 18).
- Minerals sites provide the only realistic opportunity for re-creation of large scale wetlands with the possible exception of Pepper Arden Bottoms.

4.7 *Key issues for wetland re-creation on mineral sites in North Yorkshire*

4.7.1 *Water quality*

- Sites typically with base-rich water, neutral to moderately alkaline pH. Some sites show very high electrical conductivity (measure of solute content), eg Staveley NR, Nosterfield Quarry – influenced by evaporite deposits in magnesian limestone?
- At Dry Rigg, water from siltstone quarry more base- and nutrient- rich than expected so wetland creation target revised from acidic bog to mesotrophic fen.
- Very little data on other water quality parameters but trophic status is critical in determining target vegetation types for restoration schemes. Some plant communities have very specific requirements in terms of water and substrate

chemistry, eg alkaline but very nutrient-poor (especially in P) in case of seepage mires (NVC M10/M13).

- In larger waterbodies, biotic influences may affect water quality: fish stocks, waterfowl.

- Quarries probably much better buffered against P enrichment than farmland but impact of diffuse N pollution is unknown.

4.7.2 *Economic extraction profiles -vs- need for extensive shallow water or waterlogged substrates*

- The economic constraints are understood; even so simple opportunities to create smaller, sheltered, fish-free ponds, pool complexes and ditches are not being exploited.

4.7.3 *Examples of wetland creation on mineral sites in Yorkshire*

- Dry Rigg quarry (Lafarge, siltstone quarry): mire fed by outflow water from quarry, contiguous with Swarth Moor SSSI. Infrastructure completed 2006; good initial regeneration of some target vegetation from soil seed bank.

- Ribblehead Quarry (Carboniferous limestone): seepage fen communities on quarry floor (Figure 19).

- Marfield (Lafarge, aggregates): extensive wetlands and ponds with complex water level management.

- Staveley NR (Yorkshire Wildlife Trust, originally Northern Aggregates): complex of open water, reedbed, swamp, fen, grassland and scrub (Figure 17).

- Wensley Quarry (Tarmac, Carboniferous limestone): small, shallow calcareous lake; base-rich fen developed at edge of agricultural restoration site.

- Nosterfield Quarry (Tarmac, aggregates): reedbed creation by LUCT. Experimental use of peat.

- Hatfield Moor (S Yorkshire) (English Nature, originally Tarmac, aggregates): part of Humberhead Peatlands NNR. Proposed mire restoration.

- Eastrington (E. Yorks): 19th century clay pit (extraction ca. 1880) spontaneously colonised by *Sphagnum* raft.

- Niblum Quarry (Rotherham) (magnesian limestone): seepages in quarry floor support rare invertebrates associated with limestone springs.

4.8 <u>Possible approaches: substrates with a significant capillary fringe</u>

- Substrates with a significant capillary action (ie draws water above the watertable) often associated with a high proportion of fine material (clay) or organics (peat) can support wetland vegetation with a watertable significantly below surface. The substrates may also often have low permeability associated with poor surface drainage.

- Peat is not the only medium which can support wetland plant communities with sub-surface water levels.

- At Staveley NR, silt/clay-rich backfill is kept permanently moist by a relatively stable watertable within 0.5 m of the surface. This supports important fen-meadow communities in continuum with open water, reedbed and sedge swamp. Variations in topography create diversity.

4.9 <u>*Possible approaches: seepage fens*</u>

- Rare and localised habitat associated with continuous percolation of groundwater at or just below the surface around springs or flushes.

- Could be created in restored quarries by using springs opened up in exposed faces or by using seepages where porous overburden lies over impermeable substrates.

- Attempts to engineer seepages involve circulating water through perforated pipes within permeable embankment underlain by aquaclude (impervious layer). Initial attempt at Dry Rigg unsuccessful (water 'leaked' to base of bund, no discernible seepage).

- Water supply can be calcareous, soft or neutral but needs to be nutrient-poor.

- Even small areas potentially have very high nature conservation value but must link in to other wetland or grassland habitats.

- Ribblehead Quarry: Carboniferous limestone at 320 mAOD in Yorkshire Dales. Fissures in quarry face vent water over quarry floor supporting rich seepage flora including abundant birdseye primrose (Figure 18). NB cold, wet climate. More constant irrigation would be needed in warmer, drier lowlands east of the Pennines.

- Dry Sandford Pit in Oxfordshire: disused sand quarry with calcareous seepages – supports black bog-rush fen, important stonewort assemblage, rare seepage invertebrates (eg soldierflies), Southern Damselfly (potential SAC for this species of European conservation concern). The site is close to Cotthill Fen, one of a complex of calcareous fens on the Midvale Ridge.

4.10 <u>*Possible approaches: floating fens*</u>

- Floating rafts of vegetation characterise some wetlands. Key raft-building plants establish a thick, ramifying mat of rhizomes and shoots over which a deep carpet of mosses develops.

- Rafts often suspended over aqueous 'mush' and move vertically in response to changes in water level. Some extend over deeper open water (*schwingmoors*).

- Rare habitat: European priority ('quaking mires') and UKBAP Priority. Even small areas would have high conservation value. Very important invertebrate habitat.

- Potential benefits in addition to habitat creation (e.g. reduction in open water in bird strike risk zones). Objective should be to establish a living, growing raft not just a floating island.

- Problems:

  - Limited testing and in different scenarios to quarries (Norfolk Broads, peat mining sites)

  - Ecology of floating rafts not well-understood

  - Probably vulnerable to wave action, substrate erosion and grazing/trampling by waterfowl

  - Engineered structures likely to be prohibitively expensive on large scale

4.11 *Possible approaches: connectivity with river corridors*

The Ure and Swale are amongst the most significant rivers on the east side of the Pennines because their upper to middle reaches remain relatively unmodified, support important bird, fish and invertebrate communities and provide habitats such extensive ERS (exposed riverine sediments) (Figure 20).

ERS support specialised plant and invertebrate communities (including UK BAP Priority Species) as well as providing nesting habitat for some waders.

Exposed gravel and draw-down zones in aggregate quarries provide similar conditions (Figure 21).

Could some hydrological connectivity with adjacent rivers (eg side channels allowing controlled flooding) be used to maintain permanently open gravel habitats?

5. Pleydell Smithyman – engineering, restoration opportunities and analyses

Pleydell Smithyman indicated their familiarity with quarry restoration design and that the proposed input to the project was to include:

A) Mineral sterilisation volumes and tonnages within restoration batters
B) Quarry operational techniques to enhance edge treatment/maximise mineral reserves
C) Bank stabilisation techniques/costs
D) Description and illustration of the idealised efficient placement of silt and surface water lagoons to maximise mineral extraction areas.

6. Tentative conclusions

- NYCC to present a range of preferred afteruse options from a strategic plan
- A greater range of afteruse options warrant consideration

- Restoration for nature conservation should give greater priority to nutrient-poor and fen-type habitat creation
- Where necessary, greater areas of lake shallows, ponds and wetland at or just above the watertable should be encouraged at the expense of returning limited areas to 'high' grade agricultural land. However, it should be noted that sterilisation of mineral to achieve this is not ideal
- Considerable difficulty exists in transferring from regional (GIS-based) strategic policy (eg NYCC, RSPB, BAP) to the site-specific level, as a result of localised variability in geology and hydrology.

7. Date of next meeting

It was decided to wait until after submission of the final report before scheduling another meeting. Comments on the draft report would be circulated and discussions, if necessary, could occur via e-mail/telephone. NYCC proposed holding a workshop in early March to disseminate the findings of the project.