3 Lowland water level management and drainage

Context

3.1 Water level management in the lowlands is integral to agriculture and biodiversity in England. Ditch and drain systems can be used to raise or lower water levels in fields, and thus control water levels according to the needs of different land uses.

3.2 The scale and extent of past drainage activity has meant that the majority of our most valued wetland habitats are in fact partially drained systems, for example the Somerset Levels and Moors. At one time the Moors were a complex mix of raised bog, swamp and wet woodland. The area has now lost much of that diversity, but retains considerable value for biodiversity with large areas of species-rich wet grassland and fen, both UK Biodiversity Action Plan (BAP) priority habitats.

3.3 Throughout history, drainage has contributed to the loss of extensive areas of wetlands. Whilst drainage has taken place in stages since Roman times, most of the major field drainage effort in the lowlands has been carried out in the last 200 years.[1] Extensive programmes of drainage were carried out between the First and Second World Wars, to provide employment, as well as to 'reclaim' marginal land for more intensive agricultural production.[2] Between 1971 and 1985, grant aid was available for drainage, and applications were made for works on approximately 1,020,000 ha of farm land in England (of which approximately 20% was for renewal or modification of existing systems).[3]

3.4 Around 40% of wet grasslands have been drained since the Land Drainage Act of 1930[4] and, in Eastern England, approximately 7000 km^2 of wetland are thought to have been drained.[5] Eighty-eight per cent of the land in the fens is cultivated and accounts for almost half of the Grade 1 (most productive) agricultural land in England.[6]

3.5 Approximately 4900 ha of lowland wetland and rivers Sites of Special Scientific Interest (SSSI) are affected by adverse drainage or water-level management. Nearly 7550 ha of lowland neutral grassland SSSI are affected in a similar way.[7]

3.6 No comprehensive mapping is available to show the extent of drained land in England. A map showing the extent of drainage operations between 1971 and 1980 can be accessed at the website for Wetland Vision.[8]

Current industry practice

3.7 Over time, the development of new technologies such as windmills and motor-powered pumps hastened the process of reclaiming land for agriculture. Land drainage for land 'reclamation' is now a high-technology operation involving laser levelling, high-speed trenching and pipe-laying tools.[9]

3.8 Raising or maintaining a high water table and allowing periodic flooding was used historically in some areas to raise nutrient levels in water meadows, to protect valley grassland from frost and for simple irrigation in the summer, using sluices and gravity-fed channels.[10] Coastal and floodplain marsh water levels may be kept relatively high in the summer months to maintain suitable moisture for grass growth. Some floodplain land has been reverted to grazing marsh by raising water levels.[11] Full ditches also serve as 'wet fences', keeping livestock in place.

3.9 Drainage of lowland peat has provided some of the more productive arable land in the UK. Reducing soil moisture levels and lowering the water table exposes the organic matter in peat soils to oxidation, releasing carbon dioxide. Ploughing of drained peat soils exacerbates the oxidation and thus loss of organic matter, lowering the land surface and reducing the agricultural value of the land.[12] Peat is not a renewable resource and cannot be farmed in this way indefinitely. It is estimated that two thirds of the remaining deep fen peat under current drainage and cultivation management will have been lost by 2050.[13]

3.10 Since 1984 grant aid from the Government has shifted from field drainage to flood mitigation and prevention - often involving the use of river valley land as short term 'storage' areas for flood water.

Industry trends and pressures

3.11 With climate change predictions of warmer wetter winters, more storminess and more potential for flooding, there is growing interest in how land may be used for other purposes such as flood mitigation. Land which is susceptible to frequent flooding is generally unsuitable for high value crops, however fertile it may be (see Table below).[14] This land has potential for the creation of wetland or wet grassland habitat and may be appropriate for use as a 'storage' area to buffer peak flows from high rainfall events. These areas are not necessarily permanently wet enough to contribute to a rewetting programme.[15] Irregular summer flooding can itself pose risks for biodiversity objectives on wildlife sites that are dependent on active drainage.

Table 3 Land use according to flooding and soil moisture conditions[16]

	Drainage	Short duration flooding	Medium duration flooding	Long duration flooding
Winter flooding only	**Rapid**	Arable, pasture, hay meadow, woodland	Hay meadow, pasture, woodland	Pasture, woodland
	Moderate	Hay meadow, pasture, woodland	Pasture, woodland	Pasture, woodland
	Slow	Pasture, woodland	Pasture, swamp, woodland	Pasture, swamp, woodland
Flooding at any time of year	**Rapid**	Hay meadow, pasture, woodland	Pasture, woodland	Swamp, woodland
	Moderate	Pasture, woodland	Pasture, swamp, woodland	Swamp
	Slow	Pasture, swamp, woodland	Swamp, pasture	Swamp

Table after J. Morris, Cranfield RELU study

3.12 Currently, requirements for water level management reflect the need for productive land and for natural habitat creation or reversion. Some drainage systems are failing as they silt up or collapse over time, resulting in some areas getting wetter again. More natural communities can potentially start to develop again.[17] This raises the question of whether drainage should be restored to retain the wet grassland (in favourable condition for the features that developed during a past period of more intensive management), or whether it should be returned to wetter conditions (under the natural hydrological regime), allowing a new suite of interest features to develop.

3.13 For current incentives advice and regulation for land drainage, see Annex I to this chapter.

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Plate 3 Large drainage dyke in the fens

Key impacts

3.14 Drainage has contributed to the loss of extensive areas of wetlands in the past. The continuing damaging impact of drainage and water level management on wetland habitats is demonstrated in the area of wetland SSSIs currently in unfavourable condition as a result of these activities. An extensive programme of development and implementation of water level management plans for SSSIs aims to restore water levels through management of drainage systems and, where necessary, through changes to agricultural practices to accommodate such changed drainage patterns.[18]

3.15 Some wetland habitats can continue to survive in partially drained systems where they are maintained by the careful hydrological management of the landscape. For example, the wet grassland of the Halvergate Marshes in Norfolk (SSSI, SPA, SAC, Ramsar site) is maintained by a sophisticated water level management system and extensive pastoral farming.[19] The Ouse Washes SPA and SAC (between the Old and New Bedford rivers in Cambridgeshire) have an extensive system of ditches, with high summer water levels in the dykes maintained to support important freshwater plant and invertebrate communities.[20] In addition, they take flood water from the rivers, helping to control flooding within the catchment. The Somerset Levels host a multiplicity of habitats and species and thus require complex and sophisticated water level management.

3.16 Whilst the lack of subsidy on drainage operations has dramatically reduced the amount of new land drainage that is being carried out, a change in the value of some crops or agricultural products might make it worthwhile for agricultural production to restore existing areas of drainage.

3.17 Some lowland agriculture on drained land is reliant on pump drainage. The cost of the energy expended pumping the water from these areas must be balanced against the agricultural productivity of the soil. Where soils are not robust, the inherent fertility of the land is likely to decline as the organic matter is oxidised, and more of the low-nutrient underlying mineral material is incorporated into the plough layer. Ultimately in these cases, pump draining the land may become uneconomical. Some conservation action within wetlands is also reliant on maintaining major engineering works and structures such as large bunds and pumps, which may not be sustainable in the long term, but are necessary to maintain high water levels within drained systems while longer-term solutions are found.[21]

3.18 Drainage ditches can be valuable habitats. Excessive ditch clearance can harm these habitats, although excess vegetation can impede water flow and increase the local flooding risk. Internal Drainage Boards have recently agreed to produce joint Biodiversity Action Plans by April 2010, in partnership with Natural England and Defra, to improve management of drainage channels.[22]

3.19 Where these soils have a high organic matter content (such as in the Fens) drainage and cultivation cause the peat to oxidise, releasing carbon dioxide.[23]

3.20 Wetland drainage can lead to peat dessiccation and wastage. This wastage leads to the loss of organic materials (wood, leather, textiles) and environment indicators (pollen, wood, leaves, seeds and soil fauna that were trapped as the peat formed) that are important aspects of the historic environment.

3.21 For further factual background to this section, see Annex II to this chapter.

Summary of impacts

Biodiversity

3.22 Water level management and drainage have played a large part in the loss of around 90% of the area of wetland that was present 1000 years ago. The overall impact of such drainage has been the reduction in area and fragmentation of wetland habitats and loss of the species associated with them. The impact has been caused directly by insertion of drainage channels and, indirectly, through a general lowering of the surface water table. A lowered water table can result in the simple modification of hitherto wet habitats and the deterioration of fragile organic archaeological remains that would otherwise be preserved by waterlogging.

3.23 Around 12,450 ha of lowland SSSI wetland and grassland is affected by adverse drainage or water level management.

3.24 In some cases, water level management has contributed to the development of some wetland habitats that we value today, as a by-product of their agricultural use. These areas may still support extensive agricultural systems, such as hay meadows and pasture, for example the Somerset Levels and the Derwent Ings, and these continue to support highly valued habitats and species. In fact, much of the interest in these systems represents relict communities and species from the original wetlands.

Resource management

3.25 Water levels have been manipulated for centuries, controlling both flooding and drainage.

3.26 High-value crops and some terrestrial habitats are generally sensitive to surface water and are thus dependent on effective drainage systems.

3.27 Field drainage can have considerable long-term effect on soils, ranging from increased permeability in heavy soils, due to better root penetration, to desiccation and oxidation in soils high in organic matter. Field drainage can lead to the rapid drainage of land, leading to increased peak flows in water courses down stream.

3.28 Flood alleviation is not necessarily directly related to presence or absence of efficient field drainage, although the use of agricultural land as ‘storage’ areas for peak flows has been used as a way of alleviating flood risk in higher priority areas, for example Exminster marshes in Devon.

Greenhouse gases

3.29 Globally, wetlands are most likely the largest natural source of methane to the atmosphere, accounting for approximately 20% of the current global annual emissions. Climate and related biological interactions that presently control the distribution of wetlands and their methane emissions are expected to change during the next 50-100 years.

3.30 Desiccation of organic matter in the soil due to drainage can be a major source of carbon emissions. High levels of carbon are released into the atmosphere where peaty soils are allowed to dry out.

Landscape

3.31 The landscape we know today is inextricably linked with the history of drainage operations. Some landscapes are particularly valued for the way drainage has affected them, and a number of historic landscapes are being recreated by raising water levels to earlier levels.

Annex I Current incentives, advice and regulation

Commonly, there are four levels of management on land drainage:

- **Environment Agency:** Have powers to undertake works on main (arterial) watercourses (designated 'Main Rivers'), critical ordinary watercourses and embankments. Management of major sluices such as Thames Barrier, Denver Sluice.
- **Internal Drainage Boards (IDBs):** Have powers for works on ordinary watercourses, tidal sluices and pumping stations to provide drainage best suited to the local catchment land use.
- **Local Authorities:** Have powers for works on ordinary watercourses outside IDB and Main River areas.
- **Landowners:** Responsible for the drainage of their own land into main watercourses, and for water. Landowners have a duty to pass drainage water on and not obstruct flows from upstream.

Other regulation:

- Environmental Impact Assessment (EIA)[24]: the EIA regulations are designed to prevent improvements (an increase in productivity) to uncultivated land which may be affected by 'projects' such as drainage.[25]
- Countryside and Rights of Way Act,[26] and Habitats Directive[27]: aim to prevent 'operations likely to damage' habitats and species on SSSIs and other designated sites.

Management incentives

Agri-environment schemes (especially wetland-dominated Environmentally Sensitive Areas, such as the Broads and the Somerset Levels) and the Higher Level Environmental Stewardship Scheme all have options for the creation, maintenance and restoration of wetlands and capital items for water management works. These all involve raising water levels, and some options involve allowing periodic inundation during the winter months.

There are currently no options specifically for drainage operations in agri-environment schemes, although grants may be given for maintenance or restoration of existing drainage channels or water control structures in order to provide the required water level management regime. Water level management must not compromise neighbouring land.

There are currently no direct grants for drainage works which are not linked to agri-environment outcomes. Ditch maintenance options within Entry Level Stewardship are designed to allow periodic clearance, with the minimum disturbance to habitats.

Annex II Impacts of lowland drainage on environmental sustainability

Table 4 Impacts of lowland drainage on environmental sustainability

Habitat quality and diversity	• Since 1870, between 40,000 and 80,000 ponds are thought to have been lost, around 40% of wet grasslands have been drained since the Land Drainage Act of 1930 and, in Eastern England, as much as 7000 km² of wetland are thought to have been reclaimed.[28] In the lowlands, a number of Biodiversity Action Plan (BAP) habitats are directly dependent on appropriate water level management: • Grazing marsh: Requires periods when ditches contain standing water (fresh or brackish) at or near field level, and damp conditions in fields through winter, spring and early summer.[29] • Fen: There are a number of fen types, all of which may be affected by drainage and changes in the availability and source of ground and surface water.[30] In general, fens require high water levels i.e. at or above surface throughout or at least for the majority of the year. Biodiverse reedbeds require open areas of standing water throughout the area. • Raised bog: Surface vegetation is dependent on rainfall, but bogs only develop where very high water levels are maintained, so can be dried out by drainage in the surrounding area or within the bog itself.[31] • Purple Moor Grass and rush-pasture: Requires high water levels near or at the soil surface.[32] • Lowland wet meadows (MG4, MG8): Dependent on natural river flooding and maintenance of relatively high water levels (particularly MG8) to maintain character.[33] All these priority habitats have specific water level requirements which are in conflict with most forms of intensive agriculture.

Table continued...

Species abundance and diversity	• Surveys by the Wildlife Trusts for Bedfordshire, Cambridgeshire and Northamptonshire and Peterborough have shown that the network of fenland drainage ditches is valuable habitat for the water vole. Studies have shown that on average 70% of Internal Drainage Board drains within a study areas have positive signs of water vole.[34]
	• Other species that potentially benefit from re-wetting, or raised water levels:[35]
	  ◦ Mammals: for example; otter.
	  ◦ Invertebrates: for example; Norfolk hawker, Southern damselfly.
	  ◦ Birds: for example; Curlew, Lapwing, Redshank, Bittern, Yellow wagtail.
	  ◦ Amphibians: for example; Grass snake, Great crested newt.
	  ◦ Molluscs: for example; Large-mouthed valve snail.
	  ◦ Wetland plants: for example; Greater water parsnip, Cut-grass.

Water level control	• Intensive arable and livestock farming require high standards of drainage i.e. a relatively low water table, whereas extensive farming or high value wildlife and wetland sites either depend on, or can function with higher water levels, often at or near land surface. • Washlands can help control flooding at local catchment scale[36], but not necessarily throughout catchments.[37] • Efficient field drainage may move water (which can contain a high silt and nutrient load) off the fields more rapidly than naturally drained land. Undrained soils will reach field capacity more quickly and any subsequent rain will run off the surface.[38] • Use of buffer strips can reduce run-off flows and intercept silt and nutrients, although these need to be appropriately sited and managed.[39] • Drainage operations are rarely cost effective on livestock farms, where the main benefit would be to raise stocking rates. To raise the stocking rate from 1.75 cows/ha to 2 cows/ha would improve annual Gross Margin by £150/ha.[40] Cost of draining 1 ha is approximately £2500.[41]
Sediment loads in water	• Impeded drainage (either from a high water table or soil compaction - depending on soil type) can lead to excessive surface flow. Where soils are exposed through lack of vegetation cover, such as on arable land where no cover crop has been established post-harvest, erosion can result.[42]
Nutrient loads in water	• There can be impacts of diffuse pollution where aquifers become the sink for nutrients - these ultimately feed through into natural groundwater seepage. This is seriously enriching some lowland fens and rivers.[43] • Crops in waterlogged conditions are less able to take up soil nutrients. This can contribute to nutrient leaching.[44]

Table continued...

Pesticide control in water	• Aquatic pesticides may be used by land managers to maintain clear flows in watercourses.[45] These can affect local ecosystems and habitats downstream. • Poor vertical drainage in arable fields can raise the risk of pesticides moving into watercourses via surface flow.[46]
Other pollutants	• Land drainage can result in ochre in the watercourse as a product of oxidation of peat soils. This is acidic and can be harmful to aquatic life.[47]
Greenhouse gases	• Methane emissions from high water content; high organic matter soils stop emitting methane almost immediately after drainage.[48] • Waterlogged soils emit higher levels of N_2O. This is largely due to reduced plant uptake of mineralised nitrogen.[49] • A drained and cultivated peatland has been estimated to emit 125 t CO_2e/ha/yr. Rewetting this land is likely to reduce the overall emissions to 15 t CO_2e/ha/yr in the short term and, in the longer term, this is estimated to reduce further to represent a modest sink, absorbing 1.5 t CO_2e/ha/yr.[50] • Wetlands limit decomposition of organic matter, resulting in consequent build up and development of organic matter, which acts as a carbon sink.[51] • Drainage and cultivation causes these peat soils to oxidise into carbon dioxide, resulting in loss of peat depth at rates of up to 30.5 mm[52] each year and typically releasing between 47[53] and 118 t CO_2/ha/yr.[54]
Soil stability (erosion)	• In soils of very high organic matter content (such as in the Fens), drainage can desiccate soils, resulting in considerable loss from erosion over time.[55]
Soil function	• Well drained soil is less likely to become compacted from livestock treading or the passage of machinery. This makes it more suited to intensive cropping systems, by extending the period during which cultivations can be carried out. Thirty-seven per cent of the vegetables produced in England are grown in the Fens[56] due to productive soils and extensive drainage systems. • Eighty-four per cent of our deep fen peat has already been lost[57] and it has been estimated that, if drainage and cultivation continue, two thirds of the remaining peat will have been lost by 2050.[58] • Soil which is not waterlogged is likely to have improved microbial activity and nutrient availability.[59] • An indirect effect of drainage on soil organic matter is through making land available or more suitable for arable cropping. Tillage of soils reduces soil organic matter through desiccation and oxidation.[60,61]

Table continued...

Landscape character		• Natural drainage is more likely to reflect landform, in terms of presence and location of habitats and traditional field boundaries. • Drainage systems and construction have played a major part in the history of some parts of the country for example; work creation between the wars,[62] fenland 'reclamation'. • Climate change may dictate that river channels and sea defences will need modification, or removal, depending on whether there is a requirement to maintain existing features and/or communities. • Archaeological remains in wetland areas are especially fragile and vulnerable. Maintaining high water tables can be of paramount importance in preserving wetland remains.[63]

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Case study: Water abstraction for agriculture and horticulture

Water abstraction is cited as being a contributory cause of unfavourable condition on more than 4000 ha of SSSI, covering 55 sites.[1]

Nationally, agriculture accounts for a very small proportion of total water abstracted. Just under half of this total is taken from surface waters, the rest being abstracted from groundwater.

Irrigation in the Anglian region accounts for the major agricultural and horticultural use (more than the agricultural and horticultural use for the whole of the rest of England), but this is still only about 4% of all water abstracted within the region. In other regions such as the South West, agriculture and horticulture account for less than 0.5% of all water abstracted. Clearly, this is closely related to rainfall, and also farm type within the region. Nationally, water for irrigation and other agricultural purposes (such as dairy washing), accounts for just under 1% of all abstracted water.[2]

Plate 4 Potato field and irrigation reel

Currently, irrigation is primarily used by potato growers and producers of horticultural crops such as soft fruit and vegetables. A small proportion of water abstracted by agriculture is used, for example, for washing down milking parlours and dairy equipment. Since April 2005, usage amounting to less than 20 m^3 per day has not required a licence and thus is less likely to be accurately recorded. Most small to medium dairy enterprises would be likely to use less than this quantity.

One of the main concerns with agricultural water use is that it is predominantly abstracted at a time of year when water levels are already low. In some areas this has led to conflict with SSSI objectives, and failures to achieve target condition for some sites.

The prospect of increasing competition for water, and possibly drier summer conditions due to climate change, has led a number of farmers, particularly in the eastern part of the country, to construct their own reservoirs. Cranfield University reported that in 2005, of those holdings which used irrigation, 42% of them had reservoir storage capacity. In that particular year, rainfall was such that only half of the reservoir capacity was used.[3]

A criticism of many irrigation processes is that the water is not targeted, which is wasteful, and can lead to nutrients and soils being washed into watercourses. As soils become wetter, water infiltration rates reduce, and the likelihood of runoff increases. A NFU survey in 2007 suggested that scientific scheduling is used on 60% of the irrigated area.[4]

Currently Natural England and the Environment Agency are further developing Catchment Abstraction Management Strategies (CAMS), which are designed to provide a consistent approach to local water resources management, and to help to balance the needs of water users and the environment on a catchment scale.[5]

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