WATER LEVEL MANAGEMENT STUDY

The Lincolnshire Coastal Grazing Marshes Project

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1 Executive Summary

- The Lincolnshire Coastal Grazing Marshes (LCGM) is a unique landscape, steeped in history with a rich cultural and wildlife heritage.
- Changes in agricultural policy and a downturn in the profitability of livestock farming, along with changes in water level management practices have led to the loss of large amounts of functioning grazing marsh since the 1950's. This trend has continued, with surveys showing a loss of 25.6% of permanent grassland in the years between 1990 and 2000, with evidence of further losses since.
- Loss of wet grassland has had an impact on the biodiversity of the area, including a decline in its use by wetland birds. Coastal grazing marsh is a national priority for conservation and the LCGM is a priority area for conservation and restoration in regional and Lincolnshire Biodiversity Action Plans. Recently completed Stewardship schemes have clearly demonstrated that appropriate management results in the return of birds and other species.
- The LCGM project aims to retain, restore and recreate wet grassland in a number of small target areas. The target areas cover 7,500 ha, out of a total 90,000 ha for the entire Character Area. There is no aspiration to return all these target areas wet grassland – the aim is to restore traditional mixed farming, with a mosaic of arable, wet grassland and drier, species-rich and historically important meadows.
- Permanent grassland has also helped to preserve the many archaeological sites and historic features within the area. In particular, organic remains, which provide a picture of past human activity and past environments have survived because they have remained undisturbed and waterlogged, inhibiting bacterial decay.
- Restoring and protecting wet grassland will require establishing discrete hydrological areas to raise water levels to 300 – 150 mm below the surface throughout the year. In summer, this would necessitate maintaining higher water levels in the surrounding ditches. However, in winter, because of the higher rainfall, there would usually be sufficient moisture in the soil to allow levels in the ditches to be lower.
- In wetter periods the land may be temporarily inundated but the aim is not for long-term inundation, which would have a detrimental effect on habitats and species. The proposed changes would be similar to those operating on a traditional basis in the Pevensey Levels, in East Sussex, and the Romney Marshes, in Kent.
- There are 3 ways in which functioning grazing marsh can be achieved:
    - by raising water levels in hydrologically discrete areas;
    - by changing the land profile, to simulate old field systems;
    - by creating washlands along the highland rivers.

  All three methods can bring about benefits to the natural and historic environment. None of them will involve an increase risk of flooding within the wider catchment area, and in some cases may improve protection.
- The Faber Maunsell Study, commissioned by Lindsey Marsh Drainage Board (LMDB), concluded that periodic flooding could provide relief to water levels elsewhere in the system, as long as water was allowed to discharge from the area after a flood event. This could be achieved by installing adjustable sluices in ditches and drains adjacent to the newly created grazing marsh.
- Changing the land profile within fields appears not to affect the functioning of the wider catchment area.

- The creation of washlands can actually assist flood management by providing temporary storage of water during high rainfall and river flow conditions; and diverting water away from more sensitive flood risk areas.

  The consent of the Lindsey Marsh Drainage Board will be required for any changes to water level management. Applications will only be approved if the design is to the Board's satisfaction, and it can be shown not to be detrimental to flood risk, and does not affect neighbouring land and buildings; or the applicant provides and/or funds suitable mitigation.

- LMDB will adopt a cautious approach to giving consent to these schemes, and will reserve powers to enable water to be released during the early stages of, or in anticipation of a flood event

- Grazing marshes need to retain high water tables in the summer, for breeding birds and to protect buried wetland archaeology. In most years, the retained water may be insufficient to maintain a suitably wet sward. Additional water could be supplied to the grazing marsh by pumping from LMDB-maintained drains or by reinstating the traditional water supply system, via sluices located on the highland rivers.

- LMDB have an aspiration to continue research into varying water levels for sustainable flood risk management. The LCGM project offers potential for such research and could complement other work being undertaken, to understand better the changes in water levels necessary for Higher Level Stewardship Schemes and subsequent changes in run off.

- This study concludes that, given certain safeguards, it is feasible to introduce changes to water level management practices that allow the retention, restoration and recreation of functioning grazing marsh within the target area, without compromising flood risk management in the wider catchment area.

2 Historic Water Level Management

The Lincolnshire Coastal Grazing Marshes Project area is within the Lincolnshire Coast and Marshes Joint Character Area. The area's evolution and the historic water level management regime are described below. Some techniques may be appropriate to reinstate to facilitate the creation of additional grassland in the Lincolnshire Coastal Grazing Marshes Project area, subject to a review of the current performance of the catchments.

2.1 Brief Background to the Grazing Marsh

The Lindsey Coastal Grazing Marshes have been subject to considerable accretion in the last 700 years, particularly since the loss of the glacial drift islets in the 13th century (Robinson, 1970). When the saltmarsh became suitable for grazing cattle, a sea dyke was built from North Coates to North/South Somercotes and Skidbrooke/Saltfleet. The cottages occupied by those tending the animals were called "cotes" (hence the name for the villages) while a summer pasture at Fulstow was called "*la Sumerette*" (Robinson, 1970). By the 11th century the land between the parent village and the cotes had been reclaimed and a line of settlements developed as daughter villages: North Coates, Marshchapel, Wragholme, Grainthorpe, Conisholme and North/South Somercotes (Robinson, 1970). The fragmentation of Saltfleetby into St Peter, St Clement and All Saints, and Theddlethorpe into All Saints and St Helen occurred at this time (Robinson, 1970). Saltfleet is not mentioned in Domesday, but three havens are given "*Salfluet*" (now Saltfleet haven), "*Mare"* (now North/South Somercotes boundary) and "*Suine"* (now Grainthorpe) (Robinson, 1970). Reclamation continued with the Saltfleet New Enclosures of 250 acres, completed in 1854, ending the sea-bathing previously associated with residents of The New Inn in Saltfleet (Robinson, 1970).

Twelfth century charters point to an economy based on meadow and pasture at Huttoft, Grainthorpe and Saltfleetby. Arthur Young noted, in 1794, rents of thirty to forty shillings an acre for land that could carry a cow or two sheep (Johnson, 1963). The landscape of irregular fields and roads, some of which mark old embankments, is the result of piecemeal enclosure from the twelfth and thirteen centuries, stimulated by stock rearing and abundant grazing that made the loss of shackage (gleaning on stubble) less serious (Johnson, 1963). Parliamentary enclosure was only undertaken on 15% of the Lindsey Marsh, most had already been subject to private enclosure (Johnson, 1963). Saltfleet St Clement's glebe lands were enclosed between 1606 and 1712, Theddlethorpe St Helen's by 1822. The practise of letting marsh grazing to upland farmers ended with the final disappearance of common fields in the 19th century, while in Croft and Thorpe St Peter there is no suggestion of any open field remaining by 1576 (Johnson, 1963).

The decline in grassland in the 19th century has been documented. Saltfleetby in 1900 had 415 acres of rotational grass and 2,255 acres of permanent grass. 57.8% of the parish was grassland, yet a few years earlier the Tithe commission of 1839 reported, 23% arable land and 76.5% meadow and pasture (Crust, 1995). This decline in grassland may have been influenced by the agricultural depression of 1873-96, with farmers like William Paddison of Saltfleetby growing crops like snowdrops, selling 45,000 bulbs from a 150 acres farming business in 1895 (Crust, 1995). The railway station was opened at Saltfleetby in 1877 and facilitated trade in fertilizers like nitrate of soda (Crust, 1995) that may have influenced the conversion to arable farming.

A survey of grassland was carried out in 1990 by Sally Vernon, John Walker and Graham Weaver. As a consequence, a more detailed survey of the same area was carried out by Penny Anderson Consultants in 1997. In 1999 a third survey was undertaken to cover the areas omitted from the previous two surveys. A fourth and final survey was undertaken in 2000 and involved revisiting the grasslands covered in the 1997 survey.

The conclusion of this work was that there were 3,708 ha of wet grassland remaining in 2000. This was 8.7% of a survey area of nearly 40,000ha. The Natural Area is 86,000ha. The loss of grassland between the first and final survey was 25.6% in the main study area (Keymer, 2002).

2.2 Organisation of Drainage

Drainage in the Lindsey Marsh area was first organised on a statutory basis in 1531 when Henry VIII passed the Statute of Sewers that established the principle "*no benefit, no rates*" (Elkington, 1987). Since the 16th century, appointed Commissioners, working via courts of sewers for Alford, Spilsby and Louth were responsible for:

- Keeping secure sea defence
- Embanking rivers and streams
- Providing adequate outfalls to the sea(Elkington, 1987)

The Land Drainage Act, 1930, abolished the Commissioner of Sewers and formed drainage authorities, catchment boards and drainage boards (Elkington, 1987). The Alford, Louth and Skegness District Internal Drainage Boards amalgamated in November 2000 to form the Lindsey Marsh Drainage Board.

2.2.1 Drainage

In 1534, John Leyland described the area as having "*good wheat and beans in most parts of the low marsh in Lindsey but little barley as in stiff ground*" (Smith, 1907). Thomas Stone in 1800 referred to Theddlethorpe as "*the centre of evil*" in reference to the lack of drainage (Elkington, 1987).

Drainage was via gravity outfalls subject to tidal influence. Numerous improvements to outfalls undertaken after the Napoleonic wars brought prosperity to agriculture. The gravity outfalls often blocked after north/north-easterly gales and up to 25 men were required to dig out Chapel St Leonard's after such an event (Elkington, 1987). Modern pumping stations can normally flush away the accumulated silt and sand. Improvements to Gayton Fen in the mid 19th century included a steam powered pumping station; the Great Eau and Long Eau rivers were sealed by embanking; and many new cuts provided to drain lowland areas - siphoned under rivers to discharge to the sea (Elkington, 1987).

The Agriculture Act, 1937, made provision for grants on drainage work and improvement schemes were prepared for Anderby and the Boygrift drains (Elkington, 1987). The War Agricultural Committee instigated improved agricultural production and pumping stations were designed for Anderby (completed 1945) and Chapel St Leonard's (completed 1948). This work continued with additional pumping stations built and drains improved (Elkington, 1987).

The storm of 31st January 1953 flooded 21,000 acres and caused 35 deaths, when a tidal surge lifted the tide by 6ft. Fortunately this arrived as the tide was falling or the inundation

may have been worse (Robinson, 1993). The Lincolnshire coast has previously been flooded in, 1287, 1421, 1540, 1571, 1645, 1735 and 1810 (Robinson, 1993).

2.2.2 Drain Management

Dyke reeves cut the drains by hand; although the first excavators were purchased in 1937 (Elkington, 1987) hand cutting didn't completely stop until the 1990's. Cutting started in April after levels had been raised and any fencing work completed. Normally main drains were cut twice per season and other drains once, with work continuing until November (Scaman, 2007). In the winter the dyke reeves who normally worked in pairs undertook slubbing out.

2.2.3 Water Supply

Lindsey marsh as a low-lying region was subject to periodic flooding. It would have had difficulties securing drinking water as surface sources were readily contaminated, especially in flood or drought, and may have been frozen in winter (Owen, 1965). Wells more than 12-15 feet may not have been practicable as the water was affected by tides and became brackish. However the principal fen rivers and drains were replenished in summer by water from highland streams that restored the water quality (Wheeler, 1896).

Agreements for providing water date from the thirteenth century, when the River Lymn/Steeping was diverted south at Firsby Clough and east at White Cross Clough (Owen, 1965). The agreement of 1240 allowed water to flow through the old channel for 3 weeks from Easter to refresh the ditches of the manor of Croft and to water the cattle. The flow was then alternated every 3 weeks until Michaelmas. This agreement continued via court of sewers in 1432 and 1501 until at least 1774 (Owen, 1965).

The water supply from boreholes was mechanised when petrol driven pumps were installed (1940's at Sloothby), but after the 1953 floods boreholes weren't useable for 3 years due to saline intrusion (Hill, 2006). Many farms were not connected to electricity until the 1950's and continued to use boreholes until mains water was connected (Hill, 2006).

2.2.4 Theddlethorpe Drain and Water Supply Management

Traditional practice was to let the water flow freely in the winter, and then for the summer grazing water levels were raised - on 6th April (Scaman, 2007). The raised levels provided drinking water for grazing livestock, moisture for grass growth and wet ditches between fields, avoiding the need for fences – the sign of a bad farmer (Scaman, 2007). Water was drawn from the Great Eau via 5 adjustable sluices[1]

This was undertaken according to rainfall/drought to ensure the ditches remained full throughout the grazing season. Water was distributed around the area via leader drains (Scaman, 2007).

Water was retained in the grazing area by 20 staunches; these took a day to install/remove. The sluices were removed during periods of heavy rain in the summer –

[1] A sluice at TF 45149 85009 in the parish of Withern with Stain is for Mablethorpe area.

typically for 3 days (Scaman, 2007). The main drain through the parishes is the Mablethorpe Lower Cut, at that stage it drained to a gravity outlet on Quebec Road in Mablethorpe opposite the Fulbeck Public House.

Table 2.1

Sluice	Grid Ref	Notes
Inlet Drain	TF 45299 85721	Healey Lane
Grove Road Drain	TF 4581987422	2x Sluices, high and low level
NE of Nordale Farm	TF 46656 89521	Not a Board maintained drain
Ship Inn Inlet Drain	TF 46709 89630	Ship Inn Inlet Drain
River Bank Drain	TF 46831 90328	River Bank Drain

Farmers were not always in agreement on water levels, on one occasion the dyke reeve returned home to find two farmers waiting to request changes in water levels; one wanted it raising, the other lowering (Scaman, 2007). In this period sticklebacks were found in most drains and badgers were about but not frequent (Hill, 2006).

In 1956 the Theddlethorpe pumping station was built by the Great Eau in the centre of the Theddlethorpe catchment. The eastern part of the catchment now flows to the Fulbeck pumping station (built 1989). The flows are separated by doors at Bleak House, east of the Gas Terminal, which required the flow reversing in Millfield Drain during its construction **(Map 1)**.

The practise of holding water up ceased in 1971 (Elkington, 1987) as arable farming had became the predominate land use. The change was the result of government policies including; the provision of grants for land drainage work and demands for improved agricultural production that changed land management in the area.

3 Current Water Level Management

The Environment Agency and Lindsey Marsh Drainage Board deliver water level management for the Lincolnshire Coastal Grazing Marshes Project area. This section commences with a study of the area's historic development, details the current legislation and explains the complementary functions of the Environment Agency and Lindsey Marsh Drainage Board.

3.1 Lindsey Marsh Drainage Board

All target areas identified lie within the area covered by Lindsey Marsh Drainage Board (LMDB). **(Map 2).**

The LMDB was formed in November 2000 from the amalgamation of the former Alford, Louth and Skegness District, Drainage Boards. LMDB is an autonomous public body, operating on a statutory legislative basis provided by the Land Drainage Act 1991 and 1994. A Board of 27 members governs LMDB, 13 members are elected by ratepayers, and 14 members are nominated by the district councils. East Lindsey District Council nominates 13 members and North East Lincolnshire Council nominates 1 member.

LMDB's income is from drainage rates levied on the occupiers of agricultural land, and a special levy in respect of domestic and commercial properties paid by East Lindsey District Council and North East Lincolnshire Council (which is heavily subsidised by central government).

LMDB has a responsibility for drainage and flood risk management covering an area of 52,500 Ha, including 949km of maintained watercourse; approximately 77% of the area is pumped by 30 pumping stations.

All works and supervisory activity is undertaken by exercising permissive powers contained in the Land Drainage Act 1991. The Land Drainage Act 1994 extends the duties of the Board to include conservation of biodiversity.

3.1.1 Duties and responsibilities

LMDB's mission statement is:

"To provide land drainage, flood protection and water management services to the community and the environment of the Lindsey Marsh Drainage District to at least the standards recommended by the Department for Environment, Food and Rural Affairs (DEFRA) at a cost that ensures best value for all".

The Board's consent (Land Drainage Act 1991) is required for changes to water level management arrangements in their area[2]:

On Board maintained watercourses; stop up, divert, impede or alter the level of or direction of the flow of water (Byelaw 6).

On all other ordinary water courses; mill dam, weir or culvert that would be likely to affect

[2] Abridged - www.lmdb.co.uk/byelaws.html

the flow (Section 23(1).

The Board's role is limited to water level management activities, applications are approved provided that the design is acceptable and the proposals are not detrimental to flood protection or:

- the applicant provides suitable mitigation (storage or conveyance).
- the applicant funds suitable mitigation that is provided by the Board or a third party.

3.1.2 Water Level Management

Water levels are maintained within the design range for safety and economy within the area. In some catchments water levels are raised during the summer months for environmental, amenity or irrigation reasons.

Water level management is effected by pumping stations, sluices, and gates throughout the Board's area.

Drains are cut annually to maintain flows; the Board's policy is to cut from alternative sides each year where access permits. In 2006 changes to the cutting regime were implemented to avoid damage to water vole burrows, these included leaving fringes against the toe on medium and large drains and a stubble height of 75/100mm specified on all cut drains. Additionally all flails are now fitted with conveyors to remove cut vegetation from the bank, this will reduce the accumulation of "thatch" and promote a more diverse and finer flora on banks.

Special management regimes are implemented for some drains with two stage channels and other areas are cut on rotation to promote biodiversity. New berms are often installed during reforming works to create two stage channels and provide additionally space for water and wildlife.

Drains are desilted and reformed when required, these capital works are informed by Strategic Catchment Management Studies (see section 5.2.1).

3.2 Environment Agency

The Environment Agency was created by the Environment Act 1995, and came into existence on April 1, 1996. The new organisation combined the roles and responsibilities of the National Rivers Authority (NRA), Her Majesty's Inspectorate of Pollution (HMIP) and the waste regulation authorities in England and Wales including the London Waste Regulation Authority (LWRA). The Environment Agency is a public body overseen by the Secretary of State for Environment, Food and Rural Affairs.

3.2.1 Duties and responsibilities

The Agency has no duties with regard to the maintaining of water levels for reasons of land drainage or flood risk management. The only duty it has in this type of work is to 'conserve and enhance' the environment under Section 6 of the Environment Act 1994. Currently, it exercises its permissive powers to undertake maintenance works and operate levels within channels designated as main river to ensure an appropriate standard of protection from flooding.

There are numerous main rivers that convey water from the Wolds across the low lying

fen and coastal strip and discharge these flows into the North Sea via gravity outfalls.

3.2.2 Water Level Management

Water levels are maintained by use of sluices at the outfall of the system or other strategic point within the system. Automated gates accommodate the varying flows and are raised or lowered to ensure a constant level in normal conditions.

In times of high flow these sluices may be fully raised to ensure maximum discharge during low tides and thereby creating maximum storage capacity to accommodate flows during 'tide-lock' periods. During these conditions, extreme high and low levels will be experienced.

The gravity outfalls provide an efficient and sustainable means of discharge of the range of flows experienced within the systems.

Levels are maintained to provide an appropriate level of water within the channels for water abstraction, the maintenance of existing habitats and to provide storage during periods of high flow.

3.2.3 Louth Coastal Catchment Flood Management Plan

The Louth Coastal Catchment Flood Management Plan (CFMP) is a policy document for the catchment wide management of flood risk. It looks to a 50 to 100 year horizon, attempting to identify the policies required for successful and sustainable flood management within that time frame.

The Louth Coastal CFMP (CFMP) catchment covers an area of approximately 1050 km^2. The catchment extends from the Lincolnshire Wolds at its western boundary to the coastline of the North Sea at its eastern boundary and from Gibraltar Point in the South to Tetney Haven in the North. There is general variation in topography from the steep, upland areas of the Wolds to the flat lowland areas along the coast.

Flooding within the catchment may arise from high tide levels, high river levels, high groundwater levels, drainage problems and failure of flood alleviation systems. These flooding mechanisms are investigated and flooding issues within the catchment are summarised in the report.

The main aims of the Louth Catchment Flood Management Plans are to:

- understand the factors that contribute to Flood Risk within a catchment, such as how the land is used
- recommend the best ways of managing the risk of flooding within the catchment over the next 50 to 100 years

The CFMP examine the effects of high tide levels on the fluvial system, coastal flooding risk is considered in Shoreline Management Plans.

The Louth Coastal Catchment Flood Management Plan is currently under review.

3.2.4 Highland Rivers

The nature of the main river systems changes along their course. As they flow within the upland area they are relatively small and un-embanked. They resemble, in many

respects, natural watercourses. As they enter the low lying area they increase in dimension to accommodate both the flow rate required and the amount of storage required to allow for periods of 'tide-lock'. ('tide-lock' is when gravity discharge is prevented due to the tide level being higher than water level retained in the main river).

Table 3.2 Description of highland rivers within the LCGM target area

Target Area	Highland Rivers	Notes
Saltfleet	Greyfleet	The Greyfleet is fed by Louth's Stewton Beck and flows to a gravity outfall at Saltfleet. It is maintained by the EA from the South Cockerington/Grimoldby road TF 3862 8889 were it is the parish boundary, the EA maintain the system from Louth following en-mainment of the Stewton Beck it meanders in a natural manner until TF 4311 9121, were it is canalised for 750 metres through the majority of the LCGM target area. The Greyfleet is a raised river throughout the LCGM target area.
	South Dyke	The South Dyke is fed by LMDB's Grange Beck and flows to a gravity outfall at Saltfleet. It is maintained by the EA from Melholme Lane in North Cockerington TF 3869 9177. The South Dyke is a raised river throughout the LCGM target area.
	Long Eau	See Long Eau Target Area, below.
Long Eau	Head Dyke	The Head Dyke flows from Manby to the Long Eau on the western side of Manby Washlands. 454 metres are maintained by the EA.
Long Eau (cont'd)	Long Eau	The Long Eau flows from Gilwood's Grange TF 3811 8273 as The Beck until the A157 at South Reston TF 3813 8402 when it becomes the Long Eau. The Long Eau joins the Great Eau at TF 4617 8943 where the two rivers border the parish of Great Carlton. The Long Eau meanders in a natural manner throughout its length, all of which is maintained by the EA. The Long Eau is a raised river throughout the LCGM target area. Washlands have been created at Manby TF402 853, by setting back the banks; this provides floodwater storage and wet grassland. The work was undertaken by the EA and complemented by the Countryside Stewardship Scheme.

Table 3.2 Description of highland rivers (cont'd.)

Target Area	Highland Rivers	Notes
Great Eau	Great Eau	The Great Eau flows from the Lincolnshire Wolds; it is maintained by the EA from the parish of Belleau. The Great Eau meanders in a natural manner to Saltfleetby St Clement TF 4687 9126 where it is canalised running parallel to the coast to the gravity outfall at Saltfleet. The Great Eau is a raised river throughout the LCGM target area.
Huttoft	None	
Burgh	None	
Bratoft	Cowcroft Drain/ Little River Lymm	The Cowcroft Drain meanders southwards except for a straightened section around "The Hundreds" to the Little River Lymm and then to the EA pumping station in Croft at TF 501 600 were it joins the Wainfleet Relief Channel. The EA maintain this system from Summergates Lane in Bratoft at TF 4840 6461: it bisects the LCGM Target Area.
	Steeping River	The canalised Steeping River flows from the River Lymn and its tributaries in the Lincolnshire Wolds. The EA maintain this system. The River Steeping is a raised river forming the south-western boundary to the LCGM Target Area.
	Wainfleet Relief Channel	The Wainfleet Relief Channel is a raised river maintained by the EA that takes part of the Steeping River's flow to the North of Wainfleet. The Wainfleet Relief Channel forms part of the southern boundary of the LCGM Target Area.
Gibraltar Point	Steeping Haven	The Steeping Haven is a continuation of the EA's Steeping River and forms part of the south-western boundary of the LCGM Target Area.

3.3 Environmental Duties

The activities of both Lindsey Marsh Drainage Board (LMDB) and the Environment Agency are influenced by:

- Birds Directive 1979
- Wildlife and Countryside Act 1981 (and subsequent amendments)
- Land Drainage Act 1991 and 1994
- Habitats Regulations 1994
- Environment Act 1995
- Water Resources Act 1991
- Natural Environment and Rural Communities Act 2006

In addition to discharging their legal duties to conserve and enhance biodiversity, flood operating authorities carry out their functions within a policy framework that sets goals for biodiversity and environmental performance:

- Making Space for Water

The Making Space for Water Programme is composed of four key themes: an holistic approach; achieving sustainable development; increasing resilience to flooding; and funding.

- Flood Risk Management Outcome Measures Targets

The Government has established a framework of Outcome Measures to allocate flood risk management resources and to guide the activities of flood operating authorities so that they reflect Making Space for Water and Government policy more generally. There is an Outcome Measure for nationally important wildlife sites with an accompanying target that requires flood operating authorities to deliver programmes of measures for bringing SSSIs into favourable condition.

There is also an Outcome Measure for UK Biodiversity Action Plan habitats. Its accompanying target specifies the net increase in the area of priority BAP habitats that the Government expects to result from the activities of flood operating authorities, including IDBs. Thus, all flood operating authorities are expected to demonstrate the benefit to UK BAP habitats that they have contributed through their activities.

- Planning Policy

Overall, the engagement of the IDBs and EA with the planning system should be informed by the Government's objectives for planning - expressed in PPS9 Biodiversity and Geological Conservation:

- Promote sustainable development by ensuring that biological and geological diversity are conserved and enhanced as an integral part of social, environmental and economic development, so that policies and decisions about the development and use of land integrate biodiversity and geological diversity with other considerations.
- Conserve, enhance and restore the diversity of England's wildlife and geology by sustaining, and where possible improving, the quality and extent of natural habitat, geological and geomorphologic sites; the natural physical processes on which they depend; and the populations of naturally occurring species which they support.

3.4 Nature Conservation and Water Level Management

Coastal and floodplain grazing marsh is identified as a nationally important habitat in the UK Biodiversity Action Plan, and a habitat of principal importance for the conservation of biological diversity in England.

The Lincolnshire Coast and Marshes Joint Character Area is considered a priority area for action to conserve and restore this habitat. The Lincolnshire Biodiversity Action Plan (2006) describes coastal and floodplain grazing marsh as: *"..periodically inundated pasture, or meadow, with ditches containing brackish or fresh water. The ditches frequently support a diverse number of plants and invertebrates. The areas of grazing land are grazed or cut for hay and silage. Water-filled hollows and permanent ponds with emergent swamp communities are often a feature of the habitat."*

The Lincolnshire Coastal Grazing Marshes have been classified as a Biodiversity Enhancement Area in the East Midlands Regional Biodiversity Strategy (East Midlands Biodiversity Forum, 2006) and Regional Spatial Strategy (GOEM, 2005). The RSS highlights the need for a step-change increase in the region's biodiversity to begin to reverse past losses.

Drainage improvements over the last 60 years have given farmers the option to use their land with more flexibility. Arable farming in latter years has been more profitable than extensive livestock farming and this has resulted in large-scale cultivation of pasture and alteration to the management regime for drains. This has affected coastal grazing marsh flora and fauna reliant on wet grassland and a network of ditches.

The three main constituent habitats within the grazing marshes i.e. grassland (including temporarily inundated areas), watercourses (ditches and rivers/streams) and permanent standing water, are described below.

3.4.1 Grassland

Typically, grassland within a grazing marsh is wet or damp, with a high ground water level (300 – 150 mm below the surface) throughout the year. In wetter periods the land may be temporarily inundated.

Historically there would have been a high proportion of species-rich grassland within the coastal grazing marshes: Bratoft Meadows SSSI, the Lincolnshire Wildlife Trust Heath's Meadows nature reserve, is one of the last remnants of this type of habitat. The damp fields, managed by low intensity grazing and taking a hay crop, support grassland plant communities rich in species such as green winged orchid (*Orchis morio*) and greater burnet (*Sanguisorba officinalis*).

Now, most remaining grasslands are managed more intensively, receive regular applications of fertilizer and do not have a high diversity of plant species. It is possible to re-introduce wildflower species, as has been done successfully under a Countryside Stewardship scheme in close proximity to Bratoft Meadows SSSI. However, restoration of botanically rich grassland is a relatively expensive option.

Coastal grazing marshes are of particular importance for their wading bird populations. Damp grassland provides ideal conditions for birds to probe the soil to feed on invertebrates; open fields provide good roosting and feeding conditions throughout the year as birds are able to see the approach of predators; and grassland provides good conditions for nesting. Lapwing, snipe, curlew, redshank and oystercatcher still breed in

the grazing marshes, but conditions are no longer suitable for ruff and black-tailed godwit.

Wintering wildfowl require shallow winter flooding to provide food and numbers have dropped as a result of the loss of wet grassland and temporary winter inundation. Only the most adaptable species of wildfowl, such as mallard, breed regularly although species such as shoveller, gargany and teal occasionally rear young.

Extensive flooding for long periods can significantly reduce the invertebrate and earthworm diversity and density required by wading birds: availability of a range of conditions enables a range of species to feed. Ridge and furrow grassland provides such a varied environment, with furrows holding water when surrounding land is dry.

Well-designed habitat enhancement schemes can provide even better conditions and at least three recently approved Stewardship Schemes incorporate features to make all or part of the site more attractive to birds. At one farm near Bratoft, 35 of 46 hectares were entered into a Countryside Stewardship scheme for wet grassland for breeding waders in 2004. Records from the 2007 breeding season showed a density of more than three pairs of waders per hectare, including 74 pairs of nesting lapwing, 4 pairs of avocet, 3 pairs of redshank and 2 pairs of little ringed plover. Other species for which breeding was unconfirmed included snipe, yellow wagtail, skylark, meadow pipit and reed bunting. On the same site, peak counts of wintering birds to date are as follows:

Golden plover	3,200
Lapwing	2000
Widgeon	850
Teal	600
Curlew	450
Redshank	70
Black tailed godwit	36
Whimbrel	25

This particular scheme was designed to benefit wetland birds and is an extreme option, unlikely to be favoured by many farmers. However, installation of adjustable sluices to control water levels and management of the land under Higher Level Stewardship wet grassland options would effectively encourage breeding, passage and wintering birds.

3.4.2 Watercourses

Ditches which hold water throughout the year provide ideal habitat for a range of plant and animal species, some of which are protected under the Wildlife and Countryside Act (e.g. water vole, *Arvicola terrestris*) or are Biodiversity Action Plan priority species (e.g. greater water-parsnip, *Sium latifolium*). Ditches also support a good variety of plants, invertebrates including dragonflies and damselflies and vertebrates including eels.

This most dramatic decline in range of greater water-parsnip occurred between the 1950s (when it was widespread throughout the coastal grazing marshes) and the 1980s. This coincided with a period when considerable work was carried out on the county's drains and river channels to improve drainage, resulting in more regular channels and loss of marginal, catchment and riverside wetlands. Most drainage authorities also adopted a

policy of lowering water levels on main rivers and large drains in winter to accommodate flood water. A side effect of this management is exposure of greater water-parsnip and other sensitive aquatic plants to damaging frosts: previously they would normally have been protected by high water levels and inundation. Exposure to frost tends to promote the dominance of mat forming marginal aquatic plants such as reed sweet-grass (*Glyceria maxima*), common reed (*Phagmites australis*) and canary grass (*Phalaris arundinacea*).

In 2003 only seven greater water-parsnip sites were known to remain in the county, six of which were on nature reserves. One key remaining site was the Saltfleetby and Theddlethorpe NNR. Seed has been taken under licence from this site for propagation and re-introduction to the upper catchment areas of the grazing marshes with the objective of restoring 25 sustainable populations within Lincolnshire by 2010. This will only be successful if there are sufficient suitably managed sites available.

Most species can tolerate short periods of drying out, but maintenance of some water throughout the majority of the year is important. A number of species have been lost from the area, including the floating plant frog-bit (*Hydrocharis morsus-ranae*). This is likely to have been a result of modern water level management and/or eutrophication.

Ditch maintenance is important to prevent drying out and excessive growth of emergent plants, such as common reed (*Phragmites australis*). Rotational maintenance keeps open areas of water and a variety of bankside conditions throughout the network of watercourses.

The Coastal Grazing Marshes appear to be a national stronghold for water vole. However, they are vulnerable to predation by mink and more signs of these have been found recently in the area. A network of drains appears to be an important factor in water vole survival, as is their management. From surveys in the grazing marshes it appears that water voles are more frequently present in watercourses with a water depth of 0.5 – 1m and a width of 1 – 2m. Water voles can not swim for long periods without drowning and rely on stretches of their burrows remaining above water level.

The Great and Long Eau rise in the chalk Wolds and cross the marshes. Water voles and otters are present and the rivers are rich in aquatic invertebrates. Washlands developed at Manby and Great Carlton have become important wildlife habitats.

Reinstatement of traditional water level management would result in a more secure future for priority species such as water vole and greater water-parsnip, and would also restore more diverse plant and animal communities.

3.4.3 Permanent Standing Water

In addition to ditches, small ponds within fields are typical features of the grazing marsh. These can be important for plants, invertebrates and amphibians, including great crested newt (*Triturus cristatus*).

3.4.4 Flooding

Flooding influences the biodiversity of wet grassland, affecting the floristic composition of the grassland and suitability for breeding waders during the spring period. Winter flooding can flush out food material, making it available to wintering birds. However, flooding is not always beneficial: the nature and timing of flooding is the determining factor. See Table 3.3.

Table 3.3 Seasonal effects of flooding on wet grassland flora and fauna (Benstead et al, 1997)

	Plants/Vegetation	**Invertebrates**	**Breeding waders & wildfowl**	**Wintering wildfowl**
Early spring (March)	Before temperatures rise and the growing season commences, most species can tolerate early spring flooding. Maintains botanical diversity and suppresses grass growth	Beneficial for many aquatic species and those that require seasonal pools that dry later in the spring	Provides damp soil and high water table during April & May	Flooded areas provide roosting and feeding sites
Late spring (April& May)	Flooding/waterlogging not tolerated for extended periods by many grasses (i.e. > 4-5 days, but dependant on plant community.	Later flooding becomes increasingly damaging to active stages of terrestrial species that have survived winter flooding	Provides brood-rearing habitat	
Summer	Prolonged flooding during this period will be tolerated by only swamp communities. Grasslands subjected to flooding at this time will revert to swamp vegetation. Prevents grassland management.	Summer flooding is particularly damaging to terrestrial species and can cause stranding of aquatic species, when water subsides	Widespread summer flooding is unusual and prevents waders from nesting.	
Autumn		Flooding in late autumn (October) may prevent autumn flying species from egg-laying on damp ditch margins. Adult beetles which are still active will not have found winter refuges and may drown.		
Winter	Flooding/waterlogging tolerated by many grasses, sedges and wild flowers	Most invertebrates inactive. Prolonged winter flooding can kill invertebrates in the soil layer that are not adapted to continuous submersion e.g. some worm species. Winter flooding can be a problem on newly restored sites, unless contoured during construction.		Shallow winter flooding provides feeding and roosting conditions. Flooding provides food by releasing seeds trapped in vegetation and pushing invertebrates from the winter refuges.

3.5 Conservation of the Historic Environment and Water Level Management

The fact that much of area has been pasture for the last two hundred years has ensured that many of the archaeological sites within the Coastal Grazing Marshes have survived to the present day in far better condition than their counterparts in arable landscapes. This is particularly true for the remnants of unimproved permanent grazing land where some of the area's best-preserved archaeological earthworks survive. Even so, the existing resource represents only a small proportion of the previously existing earthwork sites. Research for the LCGM project has demonstrated that in the target areas, 83% of the ridge and furrow earthwork sites recorded on aerial photographs from the 1940s have been lost in the last 60 years (Palmer and Tann, 2006). Maintaining these earthwork sites (i.e. ridge and furrow and settlement remains) in grassland is therefore essential for their long-term preservation and visibility.

Land drainage is an important element of grassland management within the LCGM. A well maintained land drainage system can be beneficial to the preservation of archaeological sites by preventing surface waterlogging which can lead to poaching by livestock. However, rapid changes in water level or significant differences between summer and winter levels can also affect fragile archaeological material. In particular, organic remains (wood, plant fragments, pollen, textile, leather etc) which provide a picture of past human activity and environments are particularly vulnerable. These materials survive because they have remained waterlogged throughout their burial history and this has inhibited bacterial decay and destruction by soil fauna. These conditions need to be maintained where these wetland archaeological sites exist, otherwise they will dry out and be lost. Careful control of groundwater levels and chemistry is also important for ensuring the survival of archaeological metalwork. Optimum conditions are those with minimum fluctuation of water level, or changes to chemical composition of the water. Repeated cycles of wetting and drying are particularly detrimental.

Thus both buried and visible (earthwork) sites can be damaged by drainage and agricultural improvement. Ploughing physically destroys buried remains (within the depth of ploughing) and removes surface visible features such as ridge and furrow. Equally, the installation and maintenance of drainage systems can also be damaging to archaeological sites. This is particularly true of old tile drains as these may be buried at some depth within archaeological deposits and requires excavation for maintenance or improvement. Ditch clearing and other operations can also damage historic remains, as can re-profiling of fields e.g. creation of scrapes, bunds, foot drains etc.

In addition to the individual archaeological sites, the LGCM represent a highly recognisable and definable historic landscape, much of which illustrates the extent of human efforts to reclaim land from the sea over many hundreds of years. Across the whole of the marshes, the layout of the ditch system demonstrates land reclamation and management events of the past 500 years. This drainage system is itself of fundamental historical and archaeological interest.

Other historical features relating to water management include pumping stations at Anderby and Gayton, and smaller structures such as sluices used to control water levels. Although most are constructed of contemporary materials, sluices and their locations are of historical significance, having been at these sites for many years. Their continued existence and operation ensure the survival of the ancient drainage system, and the maintenance of high water levels that help preserve waterlogged archaeological materials.

4 Water Level Management Planning

4.1 Lindsey Marsh Drainage Board

LMDB's objectives are:

To provide and maintain standards of sound needs-based sustainable flood protection of:-

a). 1 in 50 for urban areas,(aspiration 1 in 100 years),
b). 1 in 10 years for agricultural areas

This is provided by a planned programme of maintenance for drains and pumping stations. The Board promotes capital schemes for drainage and flood defence improvement and deals with planning applications, discharge consents and flood risk assessments. The work is informed by strategy studies undertaken on catchments.

4.1.1 Strategy Studies

LMDB's district is subdivided into discrete catchments. Strategy studies include a performance review of each catchment. This is designed to identify any existing or future deficiencies in the drainage system or operational practices; and to propose potential options for improvement which can be assessed in more detail at a later date. These reviews feed into the Coastal Catchment Flood Management Plan process.

Strategy Studies include hydraulic modelling, which is used to determine the existing capacity of the drainage system and the current standard of service provided by the system. Climate change scenarios are also assessed to determine their potential impact on the system in the future, as are possible land use changes such as planned urbanisation and LCGM project take-up.

4.1.2 Modelling Coastal Grazing Marsh in Strategy Studies,

Early hydraulic modelling undertaken in the strategy studies did not consider the change in land use, from predominately arable to grazing marsh, as proposed by the Lincolnshire Coastal Grazing Marshes Project.

There is significant theoretical basis underpinning relationships between land use and flood risk management but little monitoring data to demonstrate effects (Environment Agency, 2008). Parameters for modelling the change in land use to grazing marsh are required. LMDB commissioned Faber Maunsell to develop a suitable method of modelling the change of land use within the strategy studies, and a report was subsequently published (Faber Maunsell, 2007). This report includes modelling undertaken in the Anderby Catchment and compares different methods of assessing runoff. The method, developed by the United States Soil Conservation Service, of changing the soil type using soil groups defined by the National Resource Conservation Service provides the most reliable approximation of the impact on catchment response due to the recreation of the grazing marsh.

Table 4.1 Modelling and Strategy Studies within LMDB Catchments of LCGM Target Areas

Target Area	LMDB Catchments	Strategy Study	LCGM Modelling
Saltfleet	Fulbeck	Ongoing study with Hannah-Reed, main issues are urban drainage in Mablethorpe – works already taking place.	No plans to extend this study in this predominately urban catchment.
	Howdales	Scheduled for 2009.	LCGM modelling to be included.
	Saltfleetby	Completion due May 2008.	Modelling completed for the LCGM.
	Theddlethorpe	Scheduled for 2009.	LCGM modelling to be included.
	Trusthorpe	Study completed, but not modelled to current specification.	Existing modelling not compatible with LCGM requirements. LMDB/EA are currently considering a joint study and modelling works to address catchment flood issues highlighted since the 2007 floods. Full catchment review scheduled for 2011/2, LCGM effects will be included.
Long Eau	Saltfleetby	See Saltfleetby above.	See Saltfleetby above
	Theddlethorpe	See Theddlethorpe above.	See Theddlethorpe above.
Great Eau	Theddlethorpe	See Theddlethorpe above.	See Theddlethorpe above.
	Trusthorpe	See Trusthorpe above.	See Trusthorpe above.
	Withern Gravity Area	Not scheduled.	Modelling not required for LCGM by LMDB. This Catchment flows to the EA's Great Eau, some water may escape to the Theddlethorpe and Trusthorpe catchment.

Target Area	LMDB Catchments	Strategy Study	LCGM Modelling
Huttoft	Anderby	Completed in May 2006.	Modelling completed for the LCGM. Catchment used for the study: Impact on Catchment Response Study commissioned by LMDB to evaluate the impact of the proposed grazing marsh on the district.
	Chapel Outfall EA/LMDB joint responsibilities and control	Completed 2007. Detailed appraisal to be undertaken.	Not modelled for LCGM – electronic data available. LCGM can be included in the detailed appraisal.
Burgh	Burgh Sluice (includes Burgh Village catchment).	Study completed, but not modelled to current specification.	Existing modelling not compatible with LCGM requirements. Full catchment review scheduled for 2010/11, LCGM effects will be included.
Bratoft	Burgh Sluice		
	Crown Farm	Completed in January 2008.	Modelling completed for the LCGM.
	Thorpe Culvert	Due for completion July 2008.	Will include modelling for LCGM.
Gibraltar Point	Burgh Sluice	Study completed, but not modelled to current specification.	Existing modelling not compatible with LCGM requirements.
	Gibraltar Point	Scheduled for 2009/10	LCGM modelling to be included.

Faber Maunsell (2007) examined three conditions[3]:

- Existing Catchment – currently managed by LMDB
- Periodic flooding – grazing marsh drained after an event
- Seasonal flooding – grazing marsh retaining water after a flood event

4.1.2.1 Periodic Flooding to create New Grazing Marsh

In this technique:

- Grazing marsh is periodically flooded
- There is some relief to water levels elsewhere in the system
- Once the flood subsides, water is discharged from the area
- Storage is available for next flood

Periodic flooding can occur on existing and new wash lands adjacent to the highland rivers that flow across the target areas.

Water levels can also be raised by installing sluices in ditches and drains adjacent to the newly created grazing marsh. LMDB's consent[4] is required for:

- Byelaw 10 structure, or planting tree etc within eight metres of water course
- Section 23(1) mill dam, weir or culvert that would be likely to affect the flow of any ordinary watercourse including those maintained by the Board.

In consenting applications for periodically raising water levels LMDB will reserve powers, requiring that the retained water is released during the early stages or in anticipation of a flood event. This will require the installation of adjustable sluices in new applications to raise water levels for the creation of grazing marsh.

4.1.2.2 Seasonal Flooding to create New Grazing Marsh

In this technique:

- Storage is used when a flood event occurs
- Water is retained throughout the winter period.
- When the next flood occurs, the storage is not available.
- Increased pumping/flooding elsewhere in the catchment

The seasonal flooding condition increases run-off (Faber Maunsell, 2007) when grazing marsh is created by permanently raising water levels. Detailed modelling in the Saltfleetby catchment for the proposed target area increases run off (Sisson, 2008).

[3] LMDB' consent is required for changing water levels
[4] (Land Drainage Act 1991) abridged - www.lmdb.co.uk/byelaws.html

Table 4.2 Impact of Seasonal Flooding of CGM on LMDB Standard of Service

LMDB's standard of service	Current Land Use	All Target Area as Grazing Marsh
1 in 10 years for agricultural areas.	7.26cumecs	8.66cumecs
1 in 100 years for urban areas (aspiration).	13.15cumecs	15.45cumecs

The increased run off from seasonally flooded land is beyond the current pumping/storage/conveyance capacity of the Saltfleet catchment and will require upgrading of assets to maintain the current standards of flood defence.

4.1.2.3 Water Supply for the creation of new Grazing Marsh

Grazing marsh needs to retain high water tables in summer for breeding birds and to protect buried wetland archaeology. In most seasons the retained water may, depending on the technique chosen, be insufficient to maintain a suitable wet sward. Additional water can be supplied to the grazing marsh by pumping from LMDB-maintained drains or via sluices located on the highland rivers.

LMDB have the following licenses[5] to take water from the Great Eau and River Steeping:

4/29/14/*s/0035 Great Eau Saltfleetby St Clem and other linked sites

4/29/14/*s/0073 Great Eau Theddlethorpe A Sts and other linked sites

4/30/14/*S/0006 Steeping River, River Lymn & Cowcroft Drain

4.2 Environment Agency

The Agency's objective is to provide and maintain appropriate standards of sustainable protection based upon guidance provided by Defra. This protection needs to be technically and economically, as well as environmentally, sustainable.

Protection is provided by a planned programme of maintenance for the main river system, its structures and outfalls. The Agency promotes capital schemes for renewal and improvement of flood risk management systems. To maintain access to the system and influence development within the catchment, it comments upon certain planning applications and issues consents for works within, or adjacent to, the main river system.

It will also licence the abstraction of water from aquifers and main rivers. The work is informed by strategy studies undertaken on the main river systems within the project area.

[5] LMDB are charged for this water by the Environment Agency; it is anticipated that landowners participating in HLS will pay for additional water.

4.3 Nature Conservation

The overall objective for the LCGM Project in terms of water level management is to reinstate traditional regimes within targeted areas of the grazing marshes to:

- Restore biodiversity;
- Protect the historic environment;
- Restore the traditional pastoral landscape.

Various guidance has been issued on managing drainage channels for nature conservation, including an NCC guide (Newbold et al, 1989), and guidance on water level management plans issued by MAFF and WOAD in 1992 along with notes on environmental procedures on inland flood defence decision making (UK BAP, 2008). Grazing marshes with characteristics similar to those on the Lincolnshire Coast, including the Pevensey Levels, in East Sussex, and the Romney Marshes, in Kent, have benefited from agri-environment grant schemes over the past two decades; lessons can be learnt from these.

Species typical of grazing marsh habitats require or benefit from:

- a high ground water table throughout the year, 300 – 150mm below the surface;
- a network of drainage channels containing water throughout the year;
- a drainage channel management regime that results in a variety of conditions within a localised network (including a variety of profiles, some with shallow batters; channels exhibiting the full range of conditions from open water to dense emergent vegetation; management from one bank only). This enables rapid recolonisation following management;
- connectivity of watercourses to assist migration of eels, movement of water voles, recolonisation by invertebrates etc.
- periodic inundation of land. This is beneficial to various species, but flooding of large areas for long periods of time is detrimental to many species, including water voles: a mosaic of conditions is preferable;
- lowering water levels in ditches in winter. This can be beneficial to prevent excessive, long-term in-field flooding, providing the ditches retain some water;
- short-term inundation. This is generally beneficial (except during nesting season) and marshes can be managed as washland to reduce the risk of flooding elsewhere;
- higher summer water levels in ditches. This is beneficial, but retaining sufficient water is likely to be problematical as supply may be limited: reinstatement of traditional movement of water from highland carriers would be very beneficial;

Rapid filling or emptying of ditches is not ideal but, providing there is habitat variety within the network, most populations will survive an extreme event

4.3.1 BAP Targets

Appropriate water level management would help achieve the following targets in the Lincolnshire Biodiversity Action Plan:

Grazing marsh:

- Maintain the extent of grazing marsh in Lincolnshire by 2015
- Restore 2000 ha of former grazing marsh by 2015
- Expand the extent of grazing marsh by 1000 ha by 2015 through re-creation at suitable sites.

Rivers, canals and drains

- Achieve favourable condition for all designated rivers, canals and drains by 2010
- Restore 100 ha of degraded floodplain by 2015.

Greater water-parsnip *Sium latifolium*

- Maintain the current (2005) range of greater water-parsnip in Lincolnshire and ensure that viable populations are present at all extant sites by 2015
- Regenerate plants from the seed-bank for further reintroduction and stocking to suitable additional sites in Lincolnshire creating 25 self-sustaining county locations by 2010

Water vole *Arvicola terrestris*

- Maintain the current distribution of the water vole in Lincolnshire (based on 2006 report) with no loss in range by 2015
- Successfully establish the Lincolnshire Key Water Vole Sites project.

Otter *Lutra lutra*

- Maintain the existing population of otters and extent of suitable habitat (based on 2006 report) by 2015.

4.4 Conservation of the Historic Environment

Many of the conditions necessary for creating ecologically functioning grazing marsh habitats (as detailed in section 3.3.1. above) are similar to those needed to secure the long term future of buried wetland archaeological sites. For example,

- a high ground water table throughout the year, held at 300 – 150mm below the surface would protect wetland archaeological sites below this level
- a network of drainage channels containing water throughout the year would help sustain these conditions;

- some questions have been raised about the impact of periodic inundation of land on buried wetland archaeological material. The impacts of this can probably be mitigated by ensuring the ground water table is kept high at all time, but deliberate, regular inundation of particularly sensitive sites should be avoided until further research into this subject has been conducted;
- higher summer water levels in fields and ditches are necessary to stop large seasonal fluctuations in water level which can lead to wetland deposits drying out, and decaying. Recent research conducted at Fiskerton, in the Witham Valley has shown through the burial of replicate materials that fluctuating conditions of wet and dry can cause rapid degradation to take place;

However, there are techniques used in the creation of wetland habitats, such as scrapes, ditch re-profiling, and the excavation or new ditches and construction of new sluices which could, potentially damage shallow archaeological material, or surface earthworks. There are great opportunities for wetland creation schemes to deliver historic, as well as natural environment benefits, and to capitalise on these benefits, it is essential that the impact of any sub-surface excavation is considered and discussed at the earliest possible opportunity with the local authority (Lincolnshire County Council) historic environment staff.

4.5 Environmental Stewardship

Environmental Stewardship (ES) is the current agri-environment scheme for England. It incorporates elements from previous older schemes such as Environmentally Sensitive Areas and Countryside Stewardship.

There are two levels of participation: Entry Level Stewardship/Organic Entry Level Stewardship and Higher Level Stewardship.

4.5.1 Entry (& Organic Entry) Level Stewardship (ELS/OELS).

These are open and available as a 'whole farm scheme' to all farmers. These schemes are not competitive and providing the applications meet the target number of points, farmers are assured of application success. The scheme is designed to be simple to run and administer, with only general written guidance to the farmer on best practice and suitable options for his business.

The intention of the schemes are that, providing a sufficiently large number of farmers take them, there will be widespread benefit across the countryside through: improved water quality; reduced soil erosion; improved habitat for many of the more common and widespread farmland species; encouragement to maintain traditional landscape features e.g. field boundaries; and preservation of the historical environment i.e. archaeological features and traditional buildings.

Many of these will benefit the LCGM. However the scheme does have limitations for some of the more important habitats and features due to the very basic management requirements.

4.5.2 Higher Level Stewardship (HLS)

This is a more detailed scheme that must be combined with a qualifying, concurrent, ELS

or OELS application. This scheme concentrates on more complex types of management and requires more professional advice and support to tailor the schemes for maximum benefit. There are two additional levels of potential financial support in the form of capital payments for agreed works e.g. hedgerow and pond restoration. There are also options to encourage permissive public access in various forms.

Higher Level Stewardship has five primary objectives:

4.5.2.1 Wildlife conservation

This is targeted towards Biodiversity Action Plan habitats and species, and is particularly relevant to the Lincolnshire Coastal Grazing Marshes where it can encourage farmers to retain, restore or recreate various forms of traditional pastoral farming.

Examples of some of the most relevant options are:

A. Maintenance, restoration and recreation of wet grassland

These options can be for both wintering waders and wildfowl, or for breeding waders. These options are especially relevant to the Lincolnshire Coastal Grazing Marshes where improved drainage and the needs of modern farming have reduced water levels to a point where most waders and wildfowl are unable to over-winter or breed successfully. Payments are made to the farmer to compensate for reduced production caused by the return to the various forms of wet grassland. Current payments[6] range from £255/ha for maintenance of wet grassland for wintering waders and wildfowl to £355/ha for creation of wet grassland for breeding waders.

It is usually necessary to reduce water losses by creating a range of structures such as sluices that work in conjunction with other options such as the creation of ponds and scrapes. Capital payments are available for much of the work although not all important aspects are adequately covered.

B Maintenance, restoration and recreation of semi-natural grasslands

Again, this is a very important option for the grazing marsh. It encourages the conservation and restoration of existing biodiversity but also allows for recreation, especially on suitably nutrient-poor soils or adjacent to other high value, botanically rich features, such as old hay meadows. Current payments range from £200/ha for maintenance with up to £280/ha for recreation.

C Maintenance, restoration and recreation of rough grassland for target species

This option can be used where it is not possible to raise water levels or encourage botanical richness but can still benefit important species such as wintering geese or great crested newts. Uptake of this option is generally poor, due to the low payment rates, which range from £130/ha to £210/ha.

[6] All payments quoted in this section refer to 2008 rates.

Supplements

There are a range of supplements that can be added to the above options. These include £75/ha for traditional hay making, £80/ha for certain schemes requiring raised water levels and £85/ha to allow inundation with water. Recently an additional supplement has been introduced to encourage cattle grazing where there is a benefit to conservation. This latter payment of up to £70/ha is especially important in encouraging the revival of many of the 'traditional breeds at risk', including the Lincoln Red.

4.5.2.2 Maintenance enhancement of landscape quality and character

This objective is met principally through the application of options that retain and restore traditional landscape features. In the case of the Lincolnshire Coastal Grazing Marshes these would include the infra-structure associated with pastoral farming e.g. field boundaries, veteran trees, ponds and the old field patterns displayed in the old permanent pasture.

4.5.2.3 Protection of the historic environment

Many of the old field patterns, remnants of deserted villages, ridge and furrow and monastic remains are often best preserved in ancient grassland or by a return to grassland, rather than a cultivated regime. Protecting the historic environment and character is one of the primary aims of the Lincolnshire Coastal Grazing Marshes project and there are several options where HLS can encourage this objective. Some of the most relevant options for the Grazing Marsh include:

A. Arable reversion by natural regeneration

This is a particularly important option with current payment of £500/ha/year. Ceasing cultivation has a huge benefit to underground artefacts and remains, some of which may date back several thousand years to periods where we have only limited knowledge of our ancestors. These deeper remains are sometimes preserved under other historical features such as ridge and furrow that was created on the overlying accreted material.

B. Reduced cultivation depth

This allows the farmer to continue with arable production but with a much reduced risk to the underlying archaeology. This is an unpopular option in the Grazing Marsh due to the level of payment (£70/ha/year) and difficulties or using minimal cultivation techniques on heavy soils.

C. Maintain high water levels to protect archaeology

Studies have shown that many underground archaeological features deteriorate much more quickly when introduced to aerobic activity when water levels are reduced through drainage. This deterioration can also be accelerated in situations where the reduced water table fluctuates causing the artefacts to become wet and dry, further speeding up deterioration. Measures can be introduced with a payment of £240/ha/year to maintain stable, higher water tables to the benefit of the archaeology.

4.5.2.4 Natural resource protection

There are specific payments for options such as Arable Reversion to Unfertilised Grassland, that pays at a rate of £280/ha. However, natural resource protection is often achieved as a secondary result of other options. For example, measures taken under the 5.1.2.1 (Wildlife Conservation) and 5.1.2.2 (Protection of the Historic Environment) can also protect water quality from nutrient losses and erosion. Consequently, these options are not frequently taken up in the Grazing Marsh as it is generally considered better to use other options that also provide the wider benefits to wildlife, archaeology and other features.

4.5.2.5 Public access and understanding of the countryside

It is important that both the local population and high numbers of visitors to this coastal holiday area can learn, understand and enjoy the special character and features of the Lincolnshire Coastal Grazing Marsh. Farmers have proved sympathetic to allowing various forms of permissive access for both able bodied and disabled visitors. There are payments towards both provision of the access and some of the costs of the infrastructure such as styles, bird hides and hard surface pathways for the disabled. The cost of obtaining planning permission is sometimes a problem as there are no direct support payments for these costs.

4.5.2.6 Supplementary payments

A Conservation of genetic resources

This option referred to under Wildlife Conservation can make supplementary payments for encouraging environmental land management using animals from the 'native breeds at risk' register. This option has already been taken up in the Lincolnshire Coastal Grazing Marsh to encourage the use of the characteristic Lincoln Red breed of cattle, and, potentially, the Lincolnshire Longwood Sheep.

B Flood management

This is not one of the five main primary objectives but where quality applications meet a number of the primary objectives, measures can be put in place to assist with flood management. Again, this is particularly relevant for the Lincolnshire Coastal Grazing Marshes with its low lying flat landscape, increasingly at risk from flooding due to rising sea levels, increased urban development and the natural characteristics of the area. There are a number of chalk rivers that rise in the Wolds and pass through the Grazing Marshes on their way to the sea. These rivers have often been embanked but heavy rainfall and high river flows coinciding with a high tide could cause the rivers to burst their banks. Schemes that successfully reduce this risk by creating flood plains and at the same time providing wildlife habitats already exist in the Lincolnshire Grazing Marshes.

4.5.3 Summary

The Environmental Stewardship (ES) Scheme has a very important part to play in the preservation and restoration of the Lincolnshire Coastal Grazing Marsh. There are some excellent examples of schemes that have helped to retain the character and diversity of this threatened landscape. However, there are certain elements of the scheme that

discourage or reduce farmer uptake including inadequate payments for some of the land management options and poor or non-existent capital payments for essential infrastructure. The scheme is also complex and although there is a payment to help towards the farm's assessment, this by no means covers all of the costs. As a consequence, some farmers are reluctant to pay for impartial advice on a scheme that is competitive and may not succeed.

Capital payments are particularly poor for infrastructure costs associated with grazing livestock such as fencing, stock handling or other measure such as landscaping of essential new buildings or manure stores.

5 Techniques for Changing Water Level Management

5.1 Raising Water Levels

Water levels can only be raised in hydrologically discrete areas, unless existing areas are subdivided. Levels can be raised on a periodic or seasonal basis by the installation of sluices. However it should be noted that seasonally raising water levels to field capacity increases run off from the catchment and requires an increase in pumping capacity, storage or conveyance.

Areas with raised water levels rely on rainfall to sustain wet grassland throughout the season for breeding waders. Depending on local soil types this may require the supply of additional water from highland rivers or pumping, from IDB drains, possibly using wind powered pumps if electricity isn't available.

The simplicity of installing sluices combined with the low capital cost and the ease of subsequently reverting land to arable cropping suggest that raising water levels will be the preferred option for creating new grazing marsh on agricultural holdings.

5.1.1 Case Study Saltfleetby

257 acres of former arable land at Saltfleetby, is being converted to grassland via the Higher Level Stewardship scheme.

The work included new fencing. LMDB's byelaw consent included a restriction on height and the provision of access gates on cross fences, to permit the Board's maintenance programme to continue.

Three new sluices required LMDB's section 23 consent. One against the Mardyke Drain on the B1200 and two on the Fleet drain were designed to raise soil water levels by 1.42 and 1.94 metres, average 1.695 metres. These sluices are of the fixed type, consented before the Faber Maunsell report was available. Modification to these sluices will be considered to permit the lowering of water levels in advance of a flood, restoring storage capacity in the catchment.

5.2 Changing Land Profile

With this technique, the objective is to simulate, where possible, the typical profiles found on ancient but previously cultivated land, such as those left behind by old field systems. This is achieved by creating linear channels that mimic wide-spaced ridge and furrow. These channels are unconnected to the ditches and are a modification to the system of foot drains used by the RSPB. The difference is that they are somewhat deeper and spoil is carefully spread to create multiple, discrete, water catchments for each channel. This new system is developed on the same principles that were successful in years gone by for livestock watering using dewponds.

The slopes are subtle to aid the harvesting of water for bird and other biodiversity. The channels provide extensive marginal feeding areas for waders and their chicks but also allow easy access for management tasks with tractors. Birds mostly nest on the drier, slightly raised, slopes with good vision of predators and are unlikely to be flooded out.

The diagram below shows the principles of how this works.

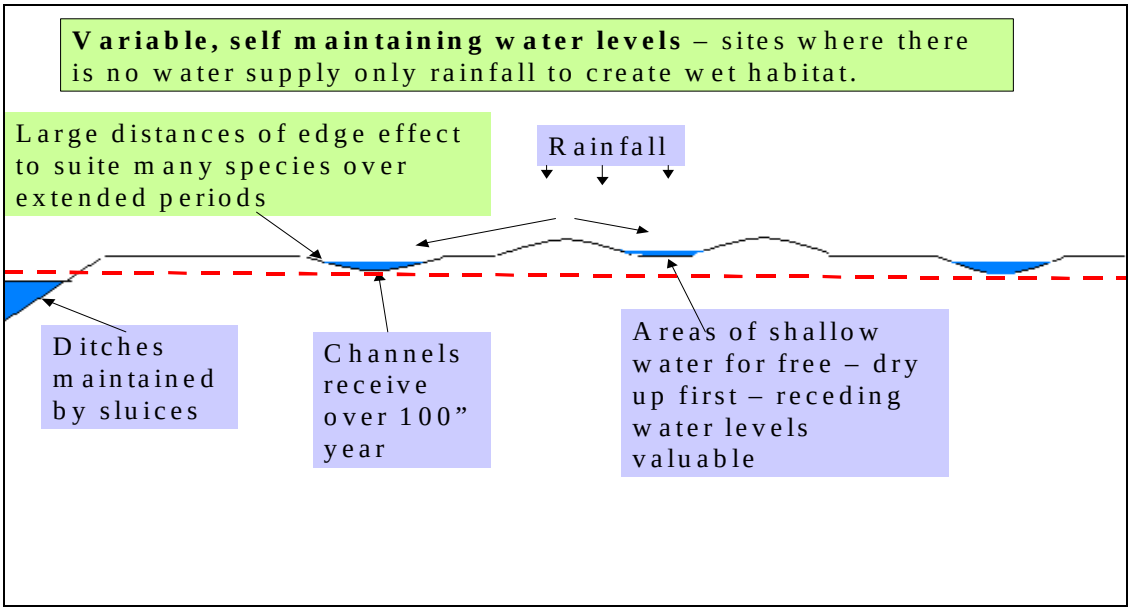

Figure 5-1 Principles of Land Profiling

5.2.1 Case Study – Bratoft

(Author: Roger Wardle, Snr Conservation Adviser, FWAG)

In February 2004, a local farmer made an application to recreate 46 ha (115 acres) of wet grassland and hay meadows on heavy clay land that was at that time in intensive wheat production, at Bratoft.

The project needed to consider many aspects: protection of existing archaeology; landscape influence; avoidance of adverse impact on drainage; and increased flood risk to the local community. Assessments were made of soil characteristics, ground levels, under-drainage and channel systems. This allowed detailed production of the infrastructure including sluices and weirs and the landscaping of spoil.

There was scepticism that this system would work on the site's clay soils but the results have far exceeded expectations. The system is very sustainable as it harvests and stores the rainfall in normal seasons without the need, cost, or energy to pump water. The secondary advantage of this system is the high water quality that enables insect populations to thrive, in turn feeding the birds and attracting other species such as dragonflies, water voles and bats.

Figure 5-2. Arial view of the wet grassland showing linear channels and lapwing nests.

There was great excitement when in the first year the former wheat fields attracted 12 pairs of breeding lapwing together with other scarce species. This was only the start, and by the third year, an incredible 74 lapwing nests were recorded in only nine hours of survey. Other breeding species included redshank (a very scarce inland breeder in recent times, due to lack of suitable habitat). Avocet, ring plover, little ring plover and shoveller ducks are also now breeding. Avocets have built up to a current population of 7 breeding pairs, one of the few sites outside nature reserves where these iconic birds breed. Research is now beginning on assessing the habitat more carefully, including a study on the presence and density of invertebrates that appear - a key to the very high survival rate of the lapwing chicks after hatching.

Credit for the success of the project must go to the landowner and his tenant graziers who have followed recommendations carefully in order to create suitable conditions for the birds. Breeding birds have not been the only success, with huge numbers of wintering and migrating birds, on occasions up to 5000 in number, including 850 grazing widgeon.

The results from this site are being used to encourage other similar projects in the vicinity with a further 75 ha having just been completed under HLS, with early signs of similar success. This latter site has also provided 3.14 km of new access including 3 bird hides close to the town and holiday resort of Skegness. This extensive new system also has two disabled parking areas with hard surfaced paths to hides with disabled facilities.

This scheme has already been colonised by avocet, lapwing and ring plover even before it is properly completed. This is perhaps nor surprising when the marginal feeding areas for birds extend to around 28 km or a distance twice that found around the edges of Rutland Water, one of the largest reservoirs in Europe.

5.3 Making Space for Water – Creating Washlands

Washlands (storage areas) facilitate the temporary storage of water within a given catchment during high rainfall and river flow conditions.

5.3.1 Principles

Modern drainage systems are high flow, high maintenance systems, designed to meet flood return periods typically between 1:10, 1:50 or 1:100 years. Frequently they run within flood banks several metres above ground level in 'highland carriers' or in lowland drains which may drain by gravity or by assisted drainage via electric or diesel pumps. The inclusion of designated washland storage areas within these systems can provide a 'safety valve' within the drainage system to accommodate excess river/drain water during high flow events e.g. following excessive rainfall or snow melt.

5.3.2 Temporary Storage:

The storage of water within the designated washland areas allows river or drainage water (which maybe in excess of that design capacity provided within the embanked river or drain) to be temporarily and safely stored within a controlled environment. Thus allowing the drainage system time to discharge water gathered from a wide catchment by gravity (slow over level ground) or where limited pump capacity or tidal locking hold back discharge into the sea.

5.3.3 Balancing River Flow (over time):

In any high level discharge event, river flows will quickly (or gradually) reach a peak flow and then subside over a period of time. If peak flows are above the design capacity of the drainage system, flooding will occur by over-topping the flood banks, backing up the system or via structural collapse through overloading.

The temporary storage of river flow during these high flow conditions, within well designed and designated washland areas, will reduce the height of the peak flow during the most critical period, reducing, and 'rounding' the watercourse flow profile. However, this will also extend the period of elevated flow and therefore the positioning and design of the washland within the catchment is an important consideration.

5.3.4 Benefits

The generally adopted strategy of removing water off the land as quickly as possible has had a considerable impact on river water courses and their wildlife. The 'canalised' nature of the water courses and regular maintenance and dredging work, in the tightly engineered conditions, have reduced natural river habitats such as riffles and pools (the spawning grounds of fish such as trout and chub) and provide limited room for marginal aquatic plants or riverside trees. In-stream barriers such as locks, weirs and sluices limit fish stocks and prevent local and migratory movements. Washland storage can both increase flood capacity within a drainage system and provide the room for environmental enhancements.

Flood storage in natural flood plans is by far the most environmentally sensitive method of dealing with excess water. The second best, when considering reducing risk and long-term costs are temporary flood storage in designated washland areas.

The benefits of this type of system are:

- Washland storage offers high flood defence standards at the lowest risk;
- Drainage systems with washland storage areas are usually more costly to implement than those without, but are almost always the most medium cost effective system, long-term;
- If sensitively designed, washlands can be environmentally beneficial, as opposed to additional in-channel works and bank raising which are more likely to be damaging.
- Storage is likely to be the most cost effective system to modify and improve with changing circumstance. This may be particularly relevant when considering the implications of climate change and rising sea levels.
- If well designed, storage can provide opportunities to environmentally improve existing up-stream and down-stream river and drainage channels. The additional design capacity within the drainage system may allow reduced maintenance and in-stream habitats. This may also bring maintenance cost savings.
- Natural floodplains and washlands have a far greater potential to provide recreational facilities than heavily modified and engineered water courses.
- Installation of storage washlands are usually far less disruptive than corresponding channel works, especially through urban areas.

5.3.5 Case Study: Manby

Author: M Tarttelin, Director, Wild Planet Ltd

A series of washlands within the coastal grazing marsh catchment were developed throughout the early and mid 1990s. These were established on the Great Eau at Withern and along the Long Eau at Great Carlton and Manby where these washland are connected.

The washlands were developed as a joint project between The Farming and Wildlife Advisory Group, the Countryside Commission (now Natural England), the Environment Agency and individual landowners. The Lindsey Marsh Drainage Board was also engaged in the development of the largest site (12ha) at Manby.

The washlands at Manby and Great Carlton created approximately 425,000 cubic metres of storage, twice the previous capacity of the entire high level drainage system. The works increased a three kilometre length of main river, which frequently overtopped into the low level drainage system from a 1:10 to a minimum of 1:30 standard. Cost included approximately £60,000 for the engineering works and £60,000 for a ten year Stewardship Agreement, which is on-going.

The creation of the washlands (28 hectares in total) not only provided suitable habitats for waterfowl and wading birds but also enabled significant improvements to be made on over 1.5 kilometres of river channel including:

- an additional 350m of wet berm;

- 20 new gravel riffles;
- creation of kingfisher nesting cliffs;
- tree and shrub planting;
- and the sowing of mixed grass and wildflower meadow areas.

Subsequent recording has identified biodiversity improvements for invertebrates, fisheries, with increased use by grayling and brook lamprey, breeding birds including, lapwing, shelduck, mallard, tufted duck and drumming snipe (breeding unproven) and plant life e.g. from seven species of aquatic plant per 500m of river to over twenty.

This area is now also suitable for, and is being used as a re-introduction site for greater water-parsnip and was used as an exemplar for European studies on floodplain restoration**(FLOBAR2 - 2002)**, one of only two UK examples.

6 Feasibility of Changing Water Level Management Practices

6.1 Impact on Catchments

Potentially and based on current understanding, changes to land profile appears not to affect the functioning of the wider catchment. However, research on this technique and its effects on catchments is required.

Raising the water table to create wet grassland can, in certain circumstances, increase run off and reduce the performance of LMDB catchments. The effect on catchments is dependent on the change in field water table and the area of change.

The changes in water table necessary to create the "wet grassland" specified in the Higher Level Stewardship scheme for breeding and wintering waders are currently being explored in a scheme at Saltfleetby.

LMDB are adopting a cautious approach to giving consent to these schemes, reserving powers, requiring that the retained water is released seasonally in the winter period and during the early stages of or in anticipation of a flood event. This will allow the LMDB to continue consenting HLS schemes during this stage of the LCGM project.

Research is necessary to provide a better understanding of the changes in water level necessary for the HLS schemes and subsequent changes in runoff that could affect LMDB catchments. This will allow the HLS schemes to be delivered with a greater certainty of success and provide LMDB with accurate data to analyse the effect of HLS schemes on catchments.

6.2 Catchment Scale Research

The Environment Agency (2008) notes that rainfall-runoff modelling to predict the effects of changes in rural land use and management on flood generation is in its infancy and that research is ongoing. The LCGM project offers a range of techniques for the creation of grazing marsh and may be a suitable study area for the ongoing "Making Space for Water" Studies.

6.3 Highland Rivers

The main river system is operated and maintained for the primary purpose of flood risk management. To satisfy its duties and responsibilities under the various Acts listed above, the Environment Agency will undertake these actions in a way that conserves and enhances the existing flora and fauna. It will endeavour to create additional favourable habitat for a wider range of species.

However, its primary purpose places certain restrictions on the management of the water levels within the numerous systems within the project area. Whilst relying on a combination of gravity outfalls and embanked channels to provide an appropriate standard of protection to adjacent property and land, there is little room to amend existing operating levels.

The water levels are maintained to provide enough water for the needs of existing habitats and licensed abstraction, but also to allow sufficient passage and storage of normal and flood flows, given existing tidal conditions. Where the outfalls rely entirely on gravity, there is no opportunity to provide differing summer or winter retention levels.

As the predicted changes in sea level occur, arrangements for the discharge of fluvial flows may well need to be reviewed to reflect the land use and standard of service appropriate at the time.

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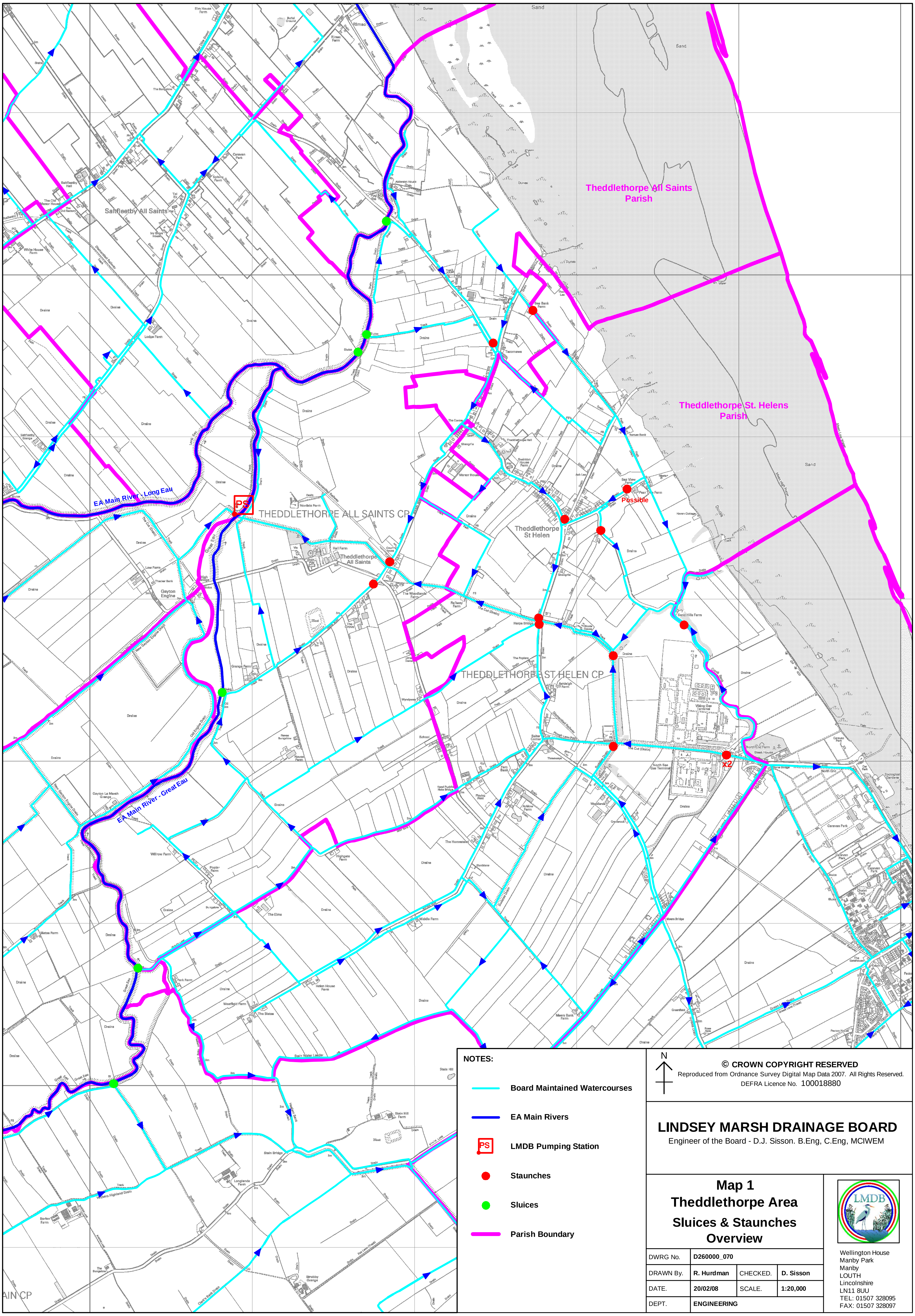
8 Annexes

8.1 LMDB's "Standard Conditions for the installation of sluices within watercourses".

i. The proposed sluice is to be constructed so that it is readily adjustable to allow variations in water level over its entire height. The proposed sluice will include a gauge board for measuring and recording water levels.

ii. The proposed sluice is to be lowered to a specified level, on request from the Board in advance of predicted or during extreme rainfall events. The indicative regime will permit the retention of water from the 1st April to the 31st August annually although this may be varied by agreement in response to unusual weather patterns. The Board are mindful of the environmental benefits provided by the sluice and will endeavour to facilitate the required water level regime.

iii. The Board require a report each January on the operation of the sluice for the preceding year. The report will include the date and level for each adjustment and the level of the retained water for each week the sluice is raised.



NOTES:

- Board Maintained Watercourses
- EA Main Rivers
- PS LMDB Pumping Station
- Staunches
- Sluices
- Parish Boundary

N

LINDSEY MARSH DRAINAGE BOARD

Engineer of the Board - D.J. Sisson. B.Eng, C.Eng, MCIWEM

Map 1
Theddlethorpe Area
Sluices & Staunches Overview

DWRG No.	D260000_070		
DRAWN By.	R. Hurdman	CHECKED.	D. Sisson
DATE.	20/02/08	SCALE.	1:20,000
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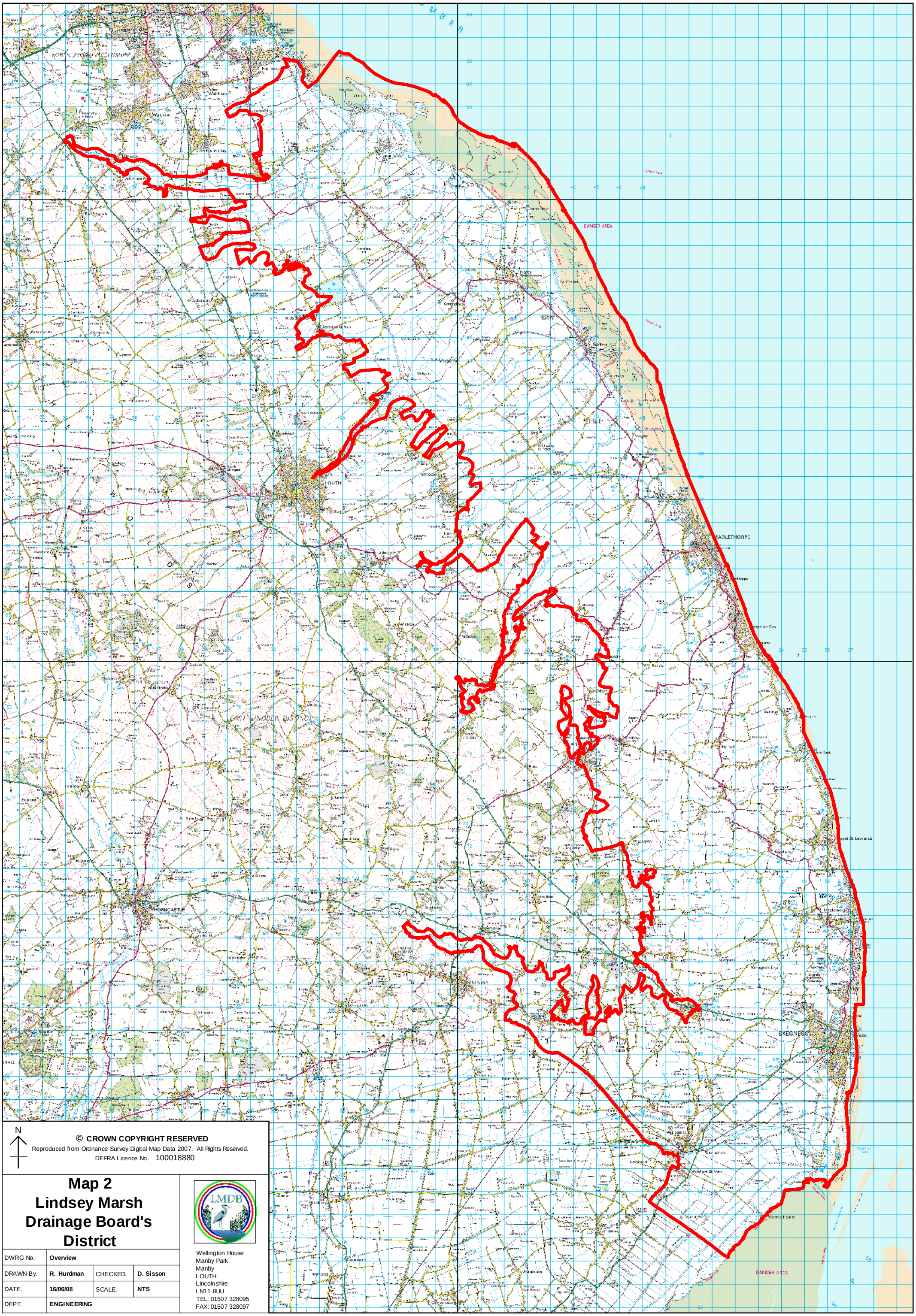

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Map 2
Lindsey Marsh Drainage Board's District

DWRG No.	**Overview**		
DRAWN By.	**R. Hurdman**	CHECKED.	**D. Sisson**
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Environment Agency

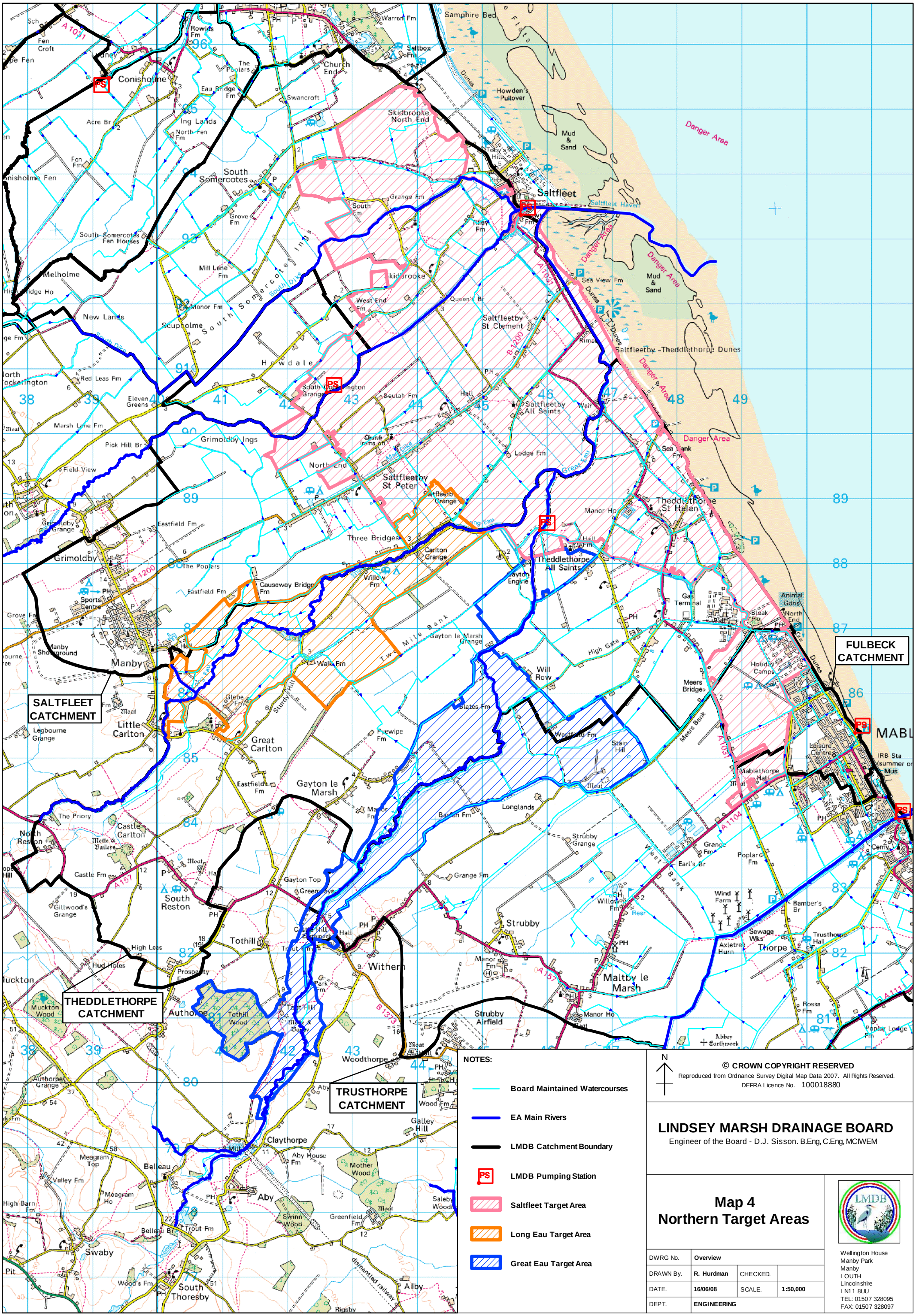
Map 3
Environment Agency Main Rivers

Legend

Lincs Grazing Marsh Target Areas

Environment Agency Main River

Map created by Flood Risk Mapping and Data Management, June 2008.



NOTES:

- Board Maintained Watercourses
- EA Main Rivers
- LMDB Catchment Boundary
- LMDB Pumping Station
- Saltfleet Target Area
- Long Eau Target Area
- Great Eau Target Area

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LINDSEY MARSH DRAINAGE BOARD

Engineer of the Board - D.J. Sisson. B.Eng, C.Eng, MCIWEM

Map 4
Northern Target Areas

DWRG No.	Overview		
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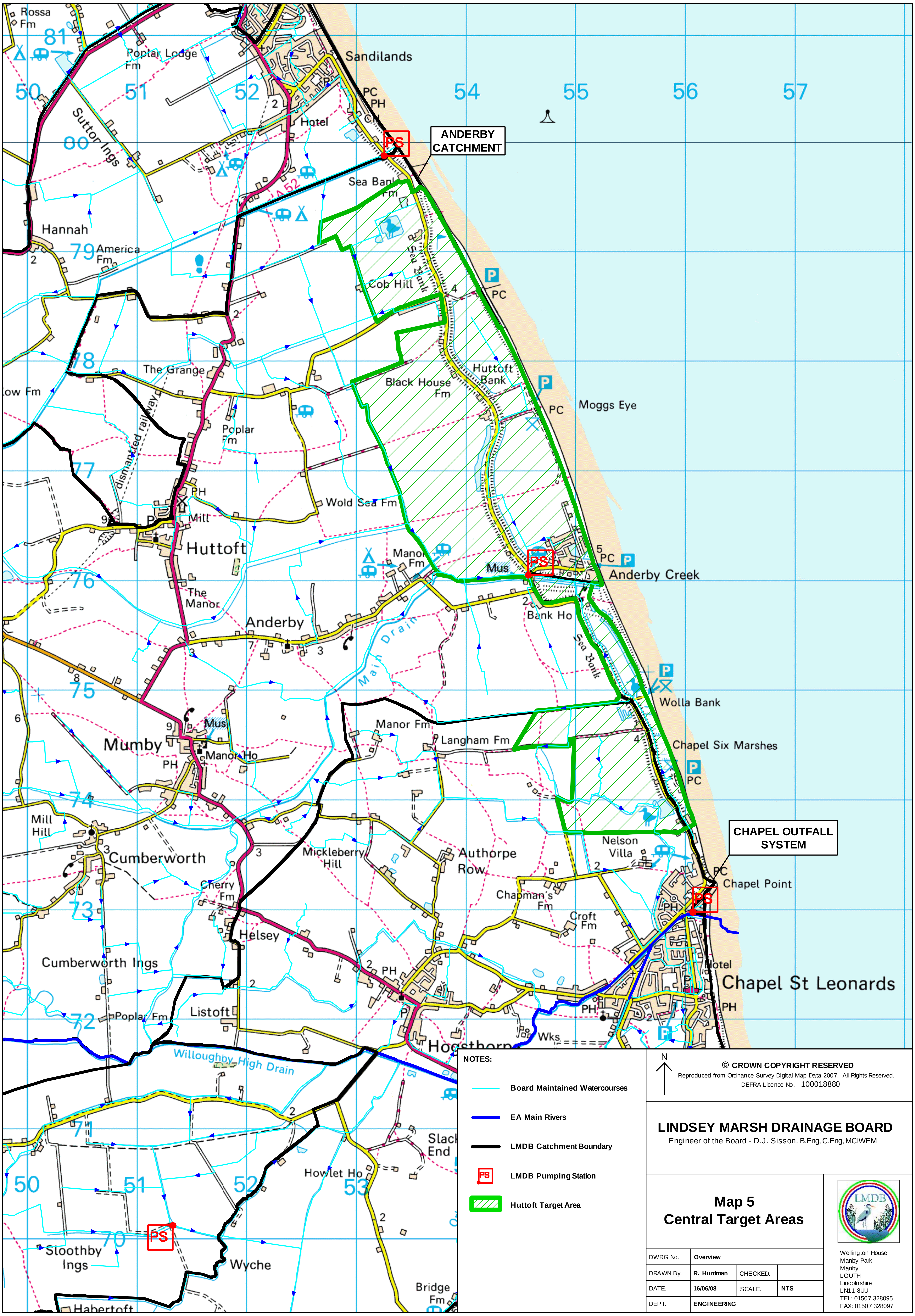

NOTES:

Board Maintained Watercourses	(cyan line)
EA Main Rivers	(blue line)
LMDB Catchment Boundary	(black line)
LMDB Pumping Station	(PS)
Huttoft Target Area	(green hatched)

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Map 5
Central Target Areas

DWRG No.	Overview		
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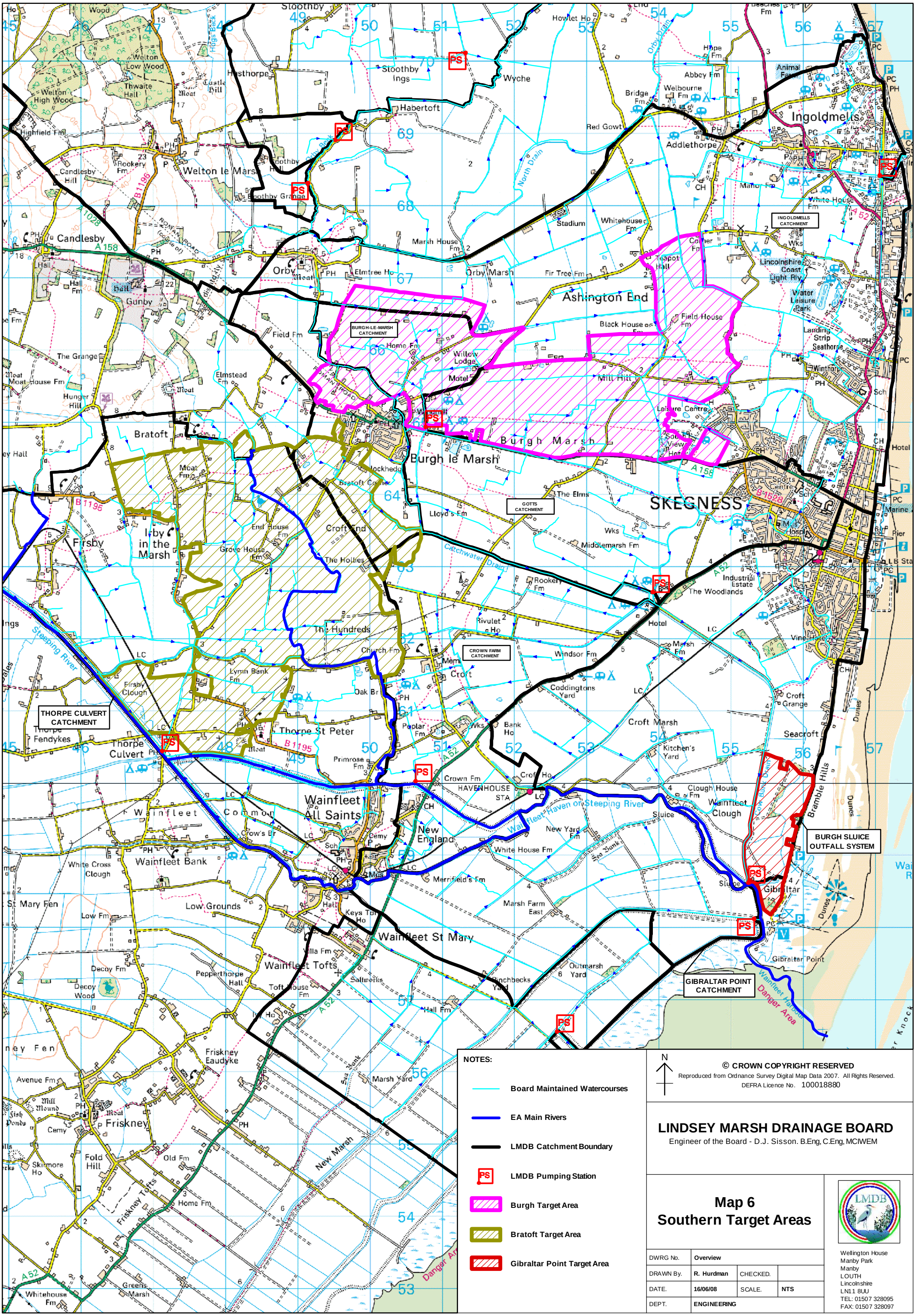

NOTES:

- Board Maintained Watercourses
- EA Main Rivers
- LMDB Catchment Boundary
- LMDB Pumping Station
- Burgh Target Area
- Bratoft Target Area
- Gibraltar Point Target Area

N

LINDSEY MARSH DRAINAGE BOARD

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Map 6
Southern Target Areas

DWRG No.	Overview		
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