National Rivers Authority - Anglian Region

Regional Flood Defence Committee
Technical Visit to Bremen
22 - 24 May 1995

Acknowledgments

The Anglian Regional Flood Defence Committee acknowledges and thanks Dr Hans Kunz and colleagues for the hospitality, friendship and technical excellence of the visit to Upper Saxony in May 1995.

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ATTENDEES

Mr J S Martin	RFDC Chairman
Mr J M Childs	Chairman - Great Ouse Local Flood Defence Committee
Sir E Greenwood	Vice Chairman - Norfolk & Suffolk Local Flood Defence Committee
Mr D J Riddington	Chairman - Welland & Nene Local Flood Defence Committee
Ms F J Madgwick	Member of Regional Flood Defence Committee - Broads Authority
Mr W H R Squier	Chairman - Essex Local Flood Defence Committee
Mr C J Groome	Chairman - Regional Rivers Advisory Committee and a member of the Regional Flood Defence Committee
Mr R Payne	Member of Great Ouse Local Flood Defence Committee and of Bedfordshire County Council
Mrs B M Goble	Member of Great Ouse Local Flood Defence Committee and of Hertfordshire County Council
Mr D J Fisher	Vice Chairman - Essex Local Flood Defence Committee
Mr T E Dale	Member of Essex Local Flood Defence Committee and of Essex County Council
Mr R J Epton	Chairman - Lincolnshire Local Flood Defence Committee
Mr R Runcie	Regional Flood Defence Manager
Mr A Baxendale	Area Flood Defence Manager (Northern)
Mr I W Hart	Area Flood Defence Manager (Central)
Mr J Hesp	Area Flood Defence Manager (Eastern)
Mr M Child	Regional Manager Special Projects

REGIONAL FLOOD DEFENCE COMMITTEE

TECHNICAL VISIT TO BREMEN 22/24 MAY 1995

ITINERARY

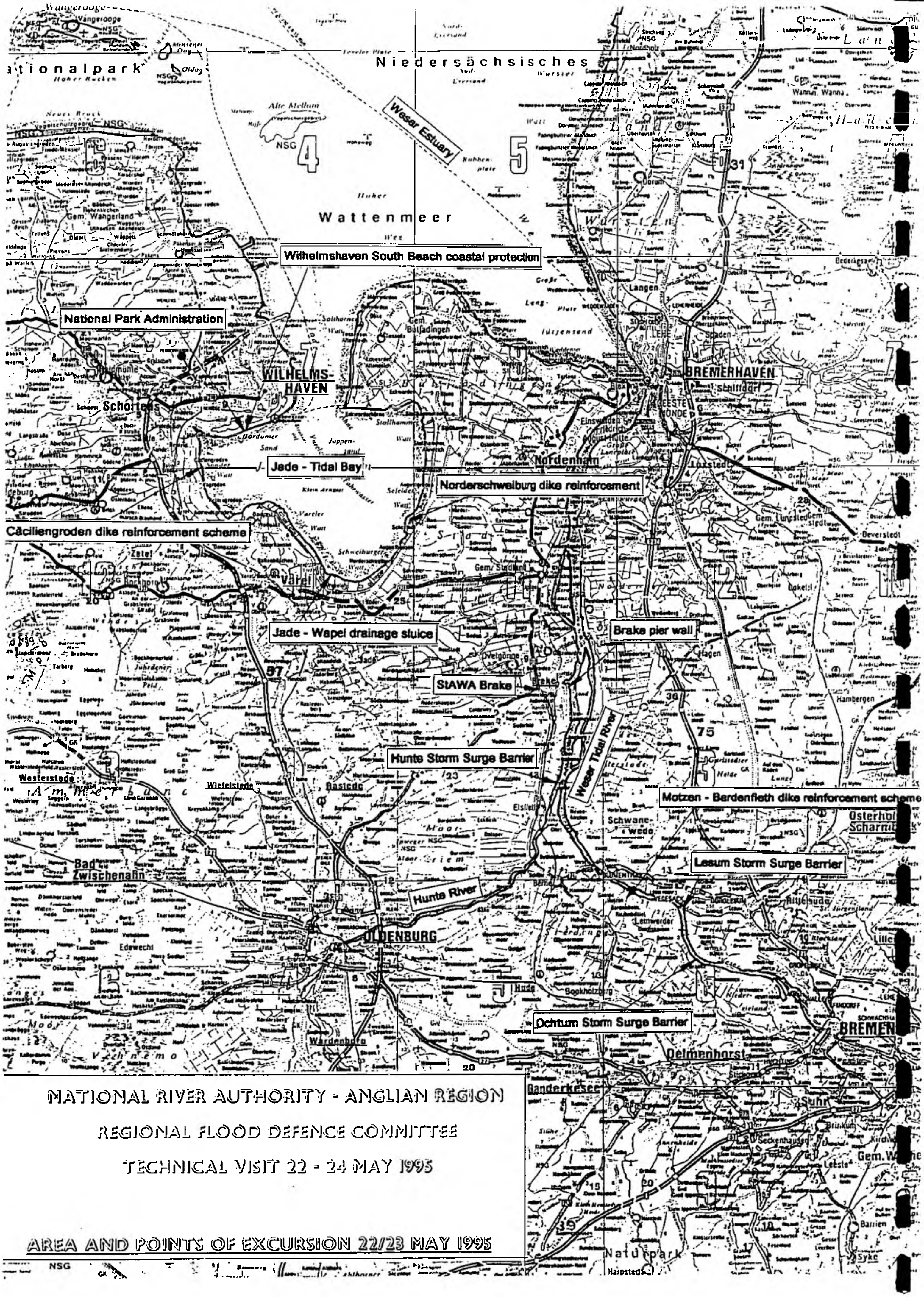
Monday 22 May:

5.00pm (BST) 7.30pm (local time)	Leave Stanstead Arrive Bremen
	Transfer to Übersee Hotel, informal dinner followed by sightseeing walk around centre of Bremen (time permitting).

Tuesday 23 May:

8.45am/9.00am	Depart from hotel by bus to Department of flood protection/Sena für Umweltschutz und Stadtentwischlung, Hansestadt, Bremen.
9.00am - 10.30am	The flood protection of the Bremen area; demonstration of the storm flood forecast system (Head of the Department and his staff).
10.30am - 12.00pm	By bus from Bremen to Elsfleth (Hunte Gate) with some stops for explanations.
12.00pm - 1.30pm	Technical visit of the Hunte Gate (Storm Surge Barrier) and lunch. Presentations on the flood protection of the Lower Weser Estuary and its tributaries (especially Hunte with Oldenburg town) by the STAWA, Brake - Head and his staff.
1.30pm - 2.30pm	From Elsfleth to Brake with stops in Brake village (flood protection constructions).
2.30pm - 4.30pm	Lectures, tea and cake in the STAWA, Brake (Head and staff):- - Organisation of the flood protection in Lower Saxony/Germany. - Protection of the low lying marshes along the North Sea against water (storm flood, fresh water runn off). - Dike and Water Boards.
4.30pm - 6.00pm	From Brake to Varel with stops on the Jade Bay (natural resort, pumping station, tide gate).

6.00pm - 7.30pm	Hotel Friesenhof in Varel, relaxing or casual walk around town.
7.30pm onwards	Informal dinner with representatives of STAWA Brake, Dike Board and Contractors; with lectures and discussions concerning development of the coastal protection for Germany and actual problems, such as integrated concepts, managed retreat etc. (Lead by our host, Dr Hans Kunz, Director of the Lower Saxonian Central Board for Ecology).
<u>Wednesday 24 May</u>	
9.00am - 10.30am	Reinforcement of the sea dike in Groden/Jade Bay:- - Technical solution - Problems concerning clay and sand reclamation for the construction
10.30am - 12.00pm	Dangast, Petershörne, Wilhelmshaven (by bus with stops), for the "Südstrand", part of Wilhelsmhaven town. With representatives of: Contractors for sea dike, CRS, Norderney/Dep. Wilhelmshaven; Dike Board.).
12.00pm - 00.30pm	Walk to the office of the National Parc Agency for Lower Saxony (by bus if weather is bad).
00.30pm - 4.00pm	National Parc Authority Trilateral Wadden Sea Group Public Information Centre - lectures and discussions combined with lunch break. Various aspects of flood defence work to be covered depending on availability of time.
4.00pm - 7.15pm	Head back to Bremen Airport.
7.15pm - 8.00pm	There should be an opportunity to get a snack and tea/coffee at airport prior to departure.
8.00pm	Leave Bremen
8.15pm (BST)	Arrive Stanstead



NATIONAL RIVER AUTHORITY - ANGLIAN REGION

REGIONAL FLOOD DEFENCE COMMITTEE

TECHNICAL VISIT 22 - 24 MAY 1995

AREA AND POINTS OF EXCURSION 22/23 MAY 1995

NATIONAL RIVERS AUTHORITY - ANGLIAN REGION

REGIONAL FLOOD DEFENCE COMMITTEE

TECHNICAL VISIT TO BREMEN, GERMANY

22 - 24 MAY 1995

INTRODUCTION

The technical visit by the Committee to Bremen developed out of links established between engineers working on common coastal protection issues around the North Sea. In particular, strong links had been established with Dr Hans Kunz of the German Coastal Research Station based at Nordeney in Germany. Dr Kunz in liaison with Robert Runcie, Regional Flood Defence Manager, extended an offer to organise a visit of representatives from the Anglian Region Flood Defence Committee to Germany to see coastal protection works, to explore the ways in which our countries deal with common coastal protection problems and build technical links.

The visiting party was led by John Martin, the Regional Flood Defence Committee Chairman, and included the Chairman and/or representatives from each of the Local Flood Defence Committees as well as the Regional and Area Flood Defence Managers.

The visit began on the evening of the 22 of May 1995 and a full itinerary of visits and discussions took place over the next two days. The presenters included a number of those responsible for land drainage, flood defence and environmental protection in the areas visited.

BACKGROUND TO THE AREA

The general area visited was around Bremen in the state of Lower Saxony in Northern Germany. The area has much in common with East Anglia having a coastline which includes both areas subject to wave attack and protected areas at risk from high tide levels, behind which lie extensive low lying agricultural areas and navigable tidal rivers extending some distance inland to urban and industrial centres.

Lower Saxony has a coastal area of around 8000 km^2 and flood defence works including 1100 km of sea, channel and river embankments, 12 storm surge barriers and extensive defence works in the form of embankments as well as beach and dune protection works on the offshore east Friesian Islands.

The planning and development of flood defence works on the mainland is undertaken by Regional Agencies for Water and Waste Management, with Regional Government being responsible for considering feasibility and economic factors in conjunction with the Lower Saxony Minister for the Environment. At local level Dike Associations are responsible for the maintenance of the dikes and works to replace them where necessary.

The Dike Acts which prescribe the duties and responsibilities of the various organisations were established principally following major flooding in the state in 1962 and these Acts prescribe the design standard of the defences which must be maintained. This has a profound effect on the promotion of flood defence works when compared with the situation in England and Wales.

DAY 1 - 23 MAY 1995

FLOOD CONTROL AND WARNING - BREMEN AREA

The first visit was to meet staff of the local authority for environmental protection and town development in Bremen (which has State status). Hugo Wohlleben our presenter is responsible for flood warning and protection for the area around Bremen and Bremenhaven, and he outlined to the group the general warning and protection systems in place and demonstrated some of the systems used for monitoring and forecasting storm surges.

The area has some 170 km of flood embankments along the River Weser and its tributaries (the Lesum, Ochtum and Geeste). Following flooding in Holland in 1953 and in Lower Saxony in 1963 the tidal embankments were improved to design standards up to 1:1000 and 3 tidal barriers were constructed. Funding for these works were met from Federal (70%) and State (30%) sources. Modelling work to aid barrier design predicted that water levels downstream of the barriers would be increased by 0.7m and improvements in embankments were completed prior to barrier commissioning.

The design standard and requirements of flood defence schemes are set in the Dike Acts and as such no cost benefit analysis is needed or carried out in support of capital schemes. The mean discharge for the River Weser is 300 cumecs (flood flows around 4200 cumecs) and the barriers close in a set sequence for water levels over 1.0m above mean high water levels. The Weser is navigable and navigation is an important influence on river management and barrier closure strategies. In 1994 the barriers were closed 113 times and it is estimated that without closure 80% of these level events would have caused some flooding.

Flood warning and forecasting is done locally for the Bremen area by Mr Wohlleben's team and is based on forecasting models which operate automatically based on telemetry data. Individual warnings are passed by telephone to industrial areas and public warnings are passed to the local 'emergency planning' department who decide whether to issue warnings via local radio and loud hailers. If flood damage occurs without a warning being issued financial compensation is paid and is funded from local taxes.

DIKE REINFORCEMENT SCHEME - MOTZEN

The group visited the site of flood defence construction works at a disused industrial site adjacent to the River Weser downstream of the tidal barriers. The Dike Board are constructing a sheet piled tidal defence. Jürgen Kathmann of the Agency for Water and Waste Management at Brake described the works to the group.

At the time of bank raising prior to barrier commissioning the ownership of the defences was returned to local landowners/industries. No structured system of responsibility for maintenance and replacement was established and a large number of individually negotiated arrangements were developed.

Whilst the Dike Boards do have compulsory purchase powers these have never been used. Where the Dike Board wishes to do works, as at Motzen, they must first buy the land on which the defence stands by negotiation. Works are therefore carried out on an opportunistic basis.

The area has a number of flood gates across access etc. and the responsibility for closing these in flood events may lie with the Board, the factory owner or an individual householder. In practice the closure arrangements work very well (notified by telephone call when closure necessary).

HUNTE STORM SURGE BARRIER

The group were introduced at the site to Diethard Ness who is Director of the Agency for Water and Waste Management at Brake, Jan Renken, Chairman of 2nd Oldenburg Dike Board, and Mr Buschan, manager of the local Dike Board, and to the operators of the barrier including Mr Davis, a Scotsman who was passing through the area, liked it, and settled there many years ago!

After a lunch the group were given a guided tour of the barrier by Mr Ness and his team.

Following urban flooding from the storm surge of 1962, options to improve defences included extending the polder system or the construction of a single or multiple barriers. Poor ground conditions mitigated against polder extension and a single barrier was discounted for technical reasons. The preferred 3 barrier system (at Hunte, Ochtum and Lesum) was completed in 1979.

The Hunte barrier consists of two flood openings with a clearance of 20m and two navigation openings with a clearance of 26m. Each flood opening and navigation opening has two hydraulically operated gates. The provision of two gates in each opening is for security in case of damage.

The Hunte gate is closed if a water level of 1.0m above high water is forecast.

The 3 barrier system, constructed at a cost of 342 million DM (approximately £153 m), has successfully protected the area from flooding.

The works were funded 70% by Federal Government, 20% by Lower Saxony State and 10% by Bremen State. Operation and maintenance costs are borne by the States. A formal operating agreement between the two States was necessary for the scheme.

WATER AND WASTE MANAGEMENT AGENCY - BRAKE

Mr Ness and two of his team, Mr Jürgen Kathmann and Mr Matthias Popkes, along with local Dike Board managers gave the group further details of the organisation and management of flood defence and other aspects of water management in the area.

The Agency has 5 departments concerned with water resource management, water quality management (including waste management), flood defence, water protection and data and administration support. The Agencies with coastal areas have responsibility for both fluvial and coastal flood protection.

Below this management tier lie the Dike Boards of which there are 27 in Lower Saxony. In the local area there are the Oldenberg 1st, 2nd and 3rd Boards. The Boards own the Dikes and are legally responsible for maintenance and capital works. The Agency maintain an overseeing role of planning and development. The Agency's consent is required for work within 50m of the defences. A charge is made for consent. The majority of the maintenance work is contracted out to local contractors by the Boards at an annual cost of 30m DM (approximately £13.5m).

In addition to the Dike Boards there are Drainage Associations. The Dike Boards operate through a Steering Committee which is elected by landowners every 5 years with voting power based on land value. Local land drainage charges of around £20 - £100 pa are levied for small companies/houses and around £6 per hectare for agricultural land.

The majority of the dikes are built on poor ground which is constantly settling at a rate of around 1m every 30 years. The maintenance/rebuilding programme is therefore ongoing. To date only 30% of the coastal dikes meet the statutory standard.

There are standard designs for 'river dikes' and 'coastal dikes'. Earthen dikes are preferred at all locations due to their low cost although due to the dimensions of the standard design, other designs (concrete walls, piled defences) are necessary in confined areas.

JADE BAY NATIONAL PARK

The Jade Bay is a large tidal embayment on the coast. It is a National Park and an important conservation area. On its western side lies Wilhelmshaven which is a deep water port. The Bay has extensive saltmarsh areas and local conditions have led to development of what is called a 'floating moor'.

The perimeter defence of the bay is principally and earthen dike defence with a sheet pile crest defence in restricted places. The shape of the bay has changed constantly over the last 800 years and shifts in eroding and depositional areas continue today.
There are ongoing programmes of dike reconstruction around the Bay to meet the design standard. The Bay has historically been a source of clay and sand material for dike construction and this is currently a source of concern between engineers and conservationists over protection of both the flood defence and conservation assets.

As at other sites the sea dikes are large structures, with access roads on both seaward and landward sides. At Jade Bay the grass is controlled by sheep flocks which are financially subsidised for the purpose.

The Group were informed by Mr Renken that further detailed consideration of the management issues of Jade Bay would be provided on day two.

JADE WAPEL DRAINAGE SLUICE

The group were introduced to the site by the Dike Board Chairman, Mr Gerd Haschen and the Pumping Station Superintendent Mr Ehmen. The pumping station lies on the landward side of the sea dike. It drains 24000 hectares and has around 1000km of watercourse. The 4 vertical impeller pumps can discharge up to 34 cumecs into the tidal Jade Bay. Within the drainage area 300 km of watercourse are maintained by the Board and the remainder by riparian owners. The design of the drainage arrangement is such that 85% of the time the old gravity sluice station is used and the pumping station is used only for 15% of drainage water.

The outfall channel into Jade Bay is 10km long and annually 200,000 m^3 of silt is 'removed' from this channel by agitating the silt and letting the tidal current flush the sediment - which of course returns and the process is ongoing.

Land drainage charges are around £6 per hectare.

DAY TWO - 24 MAY 1995

DANGAST AND CÄCILIENGRODEN SEA DIKE REINFORCEMENT SCHEME - JADE BAY

At Cäciliengroden on the edge of Jade Bay the group were shown the ongoing dike reconstruction works. The works were presented by the Gerhard Weiß, Chief Engineer (Dike Board) and the Contractor to the works. At Dangast the defence consists principally of an earthen sea dike but there are other areas of natural sand moraine defence with ancillary retaining walls. A gravity sluice drains a large storage basin behind the defence which uses an upstream pumping station to store up to 3 times tide lock water volumes. Only low lift pumps and associated energy costs are required because high tide levels do not have to be overcome.

The whole of this area around Jade Bay is founded on poor ground and subsidence is constantly occurring. This has required a dike reconstruction scheme which the group viewed at Cäciliengroden.

Because the standard and design of defence required is defined by statute the engineers have to consider what materials to use and where to obtain them from, given the prevailing conservation considerations. Borrow Pits for clay and sand (sand is used for the dike core because insufficient clay is available) are obtained from both the bay (seaward) and landward sides. In promoting such proposals the engineers, in conjunction with environmentalists, define available material source options, along with the environmental implications and submit them to the State Minister for the Environment who gives direction on what options to adopt. This process is normally concluded within 2 years of option identification.

Work on the sea dikes is only permitted during the summer months (May - September).

Whilst there is no cost-benefit assessment required for the work, money is allocated to the schemes on an annual basis and this tends to prolong construction times. For the 9.5 km reconstruction scheme at Dangast the cost will be 70m DM (approximately £31m) and will take 7 years to complete (annual financial limitations).

Historic borrow pit development in the Bay has initially created new habitats but after 10-30 years initial conditions are restored. The conservationists advise the engineers on the areas where borrow pits will cause least environmental damage.

There has been substantial saltmarsh development works in the bay using artificial channels to encourage waterflow and siltation. Brushwood groynes are then used to encourage saltmarsh development.

Additional environmental opportunities/enhancements are provided for these dike reinforcement schemes by developing new wetland conservation areas from any borrow pits used on the landward side and in addition land close to the defence is taken out of agricultural production to compensate for the disturbance effects of the works.

At Cäciliengroden 30 hectares is being taken out of production (note use is agricultural -dairy) for 6 years.

WILHELMSHAVEN

The group were taken on an informal, but informed visit to inspect the Wilhelmshaven tidal defences by Ommo Tjardes. The careful landscaping of the defences of the defences to blend in with this attractive harbour town were a major feature.

NATIONAL PARK AGENCY FOR LOWER SAXONY

The group had several presentations from Reinhard Zander (Vice Director), Dr Hubert Farke and Klaus Wonneberger of the National Park Agency. Volkert de Jonge of the Trilateral Working Group on Conservation in the Waddensea widened the discussion to cover the Southern North Sea.

The Acts setting up the Park require the Agency to protect natural systems - so the Agency is seeking so far as possible to eliminate human interference (no maximised bio-diversity).

The Agency start work with the engineers at an early stage on identification of opportunities to minimise the impacts from the dike reinforcement schemes. However, the conservationists accept the vital importance of the flood defence work and in any event the flood defence requirements are embodied in the Dike Acts.

The Agency work within the Dike Boards to identify options for minimising environmental impact. These are then forwarded with supporting information to the Environment Minister for direction on which option is to be delivered and funded.

The Agency team gave additional presentations on the potential ecological impacts of borrow pits on saltmarshes, on public access to the Park and on the Trilateral Working Group on conservation in the Wadden Sea (Germany, Denmark and Netherlands).

REVIEW

The technical visit was an excellent opportunity to view how our German colleagues deal with coastal flood defence and maintenance issues and to draw parallels and variances with the UK situation.

John Martin thanked all those who had played a part in a most successful visit and gave thanks especially to Hans Kunz for the excellent itinerary and very warm German hospitality.

Opportunities were discussed for the Anglian Region to host a return visit for Dr Kunz and his colleagues at some time in the future.

Andy Baxendale
Area Flood Defence Manager

June 1995

CONTACTS IN GERMANY

1. Staatliches Amt für Wasser u Abfall (StAWA)
   Heinestraße 1
   26919 **Brake**

   - Diethard Ness (Director)
   - Matthias Popkes
   - Jürgen Kathmann
   - Mr Buschan (Hunte Gate)
   - Ommo Tjardes (guide in Wilhelmshaven area)

2. Senator für Umweltschutz u Stadtentwicklung, Abt. 6 Wasserwirtschaft
   Hansestadt Bremen
   Theodor - Heuss - Allee 21
   28215 **Bremen**

   - Hugo Wohllenben (Director)

3. Wasser-und Bodendenverbände im Landkreis Wesermarsch
   Franz-Schubert Str 31
   26919 **Brake**

   a) Jan Renken, *Vorsteher des 11 Oldenburgishcen Deichbandes

   b) Gerd Haschen, * Vorsteher des Entwässerungsverbandes Jade

   - Mr Ehmen (Jade Pumping Station)

   please write a) ...in Wasser und ...
   b) ...in Wasser und ...

4. Wasser und Bodenverbände,
   III Oldenburgischer Deichband
   Anton Günther Str 22
   26441 **Jever**

   - Hans Neinrich Schriewers (Vice-Chairman of the Dike Board)
   - Mr Bartels (Head of Staff)

5. Arbeitsgemeinschaft "Cäciliengrodendeich"
   Flutstr 92
   26388 **Wilhelmshaven**

   - Gerhard Weiß (Chief Engineer)
   - Jürgen Quadfasel

* "Vorsteher" is "Chairman"

6. Nationalparkverwaltung Niedersächsisches Wattenmeer
Virchowstr 1
26382 **Wilhelmshaven**

- Reinhard Zander (Vice Director)
- Hubert Farke, Dr.
- Klaus Wonneberger

7. Trilaterales Wattenmeersekretariat
Virchowstr 1
26382 **Wilhelmshaven**

- Volkert de Jonge

PHOTOGRAPHS

1. Mr Wohlleben outlining the flood defence system for Bremen.
2. Sheet piled tidal defence protecting properties at Motzen.
3. Sheet piled defence adjacent to tidal River Weser at Motzen.
4. Mr Kathman outlining the Motzen scheme to the group.
5. Hunte Tidal Barrier.
6. Hunte Tidal Barrier - one of the pairs of navigation and flood discharge gates.
7. Group enjoying lunch at the Hunte Barrier.
8. The National Park of Jade Bay, Nr Varel, (sheet pile defence in foreground).
9. The sea dike (landward side) with sheet piled crest and grazing sheep at Varel.
10. Group at Jade Bay, Nr Varel.
11. Outfall into Jade Bay from pumping station at Wapel.
12. Storage basin upstream of drainage sluice at Dangast.
13. John Martin and Hans Kunz (second right) at the Cäciliengroden scheme site office.
14. Group inspecting dike reconstruction progress at Cäciliengroden.
15. A section of reconstructed dike (looking seaward) at Cäciliengroden.
16. Group Photograph

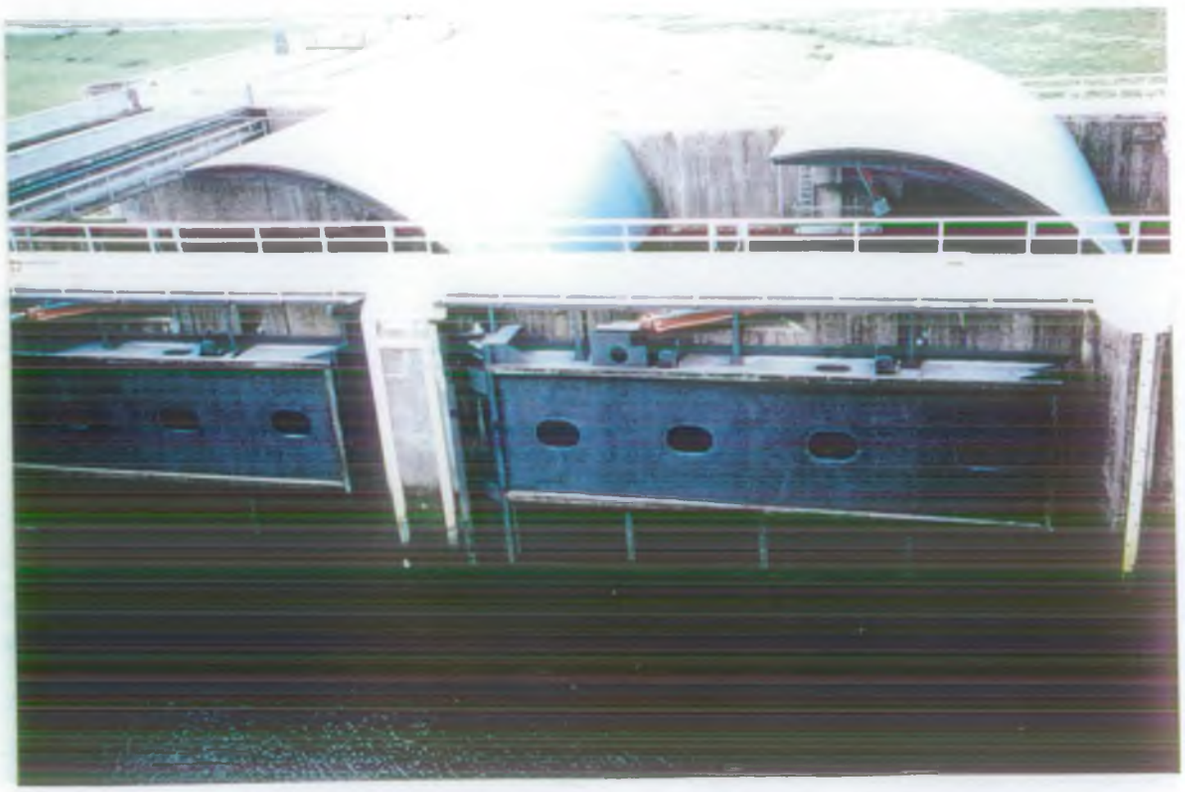
1. Mr Hugo Wohlleben outlining the flood defence system for Bremen

2. Sheet piled tidal defence protecting properties at Motzen

3. Sheet piled defence adjacent to tidal River Weser at Motzen

4. Mr Jürgen Kathmann outlining the Motzen scheme to the group

5. Hunte Tidal Barrier



6. Hunte Tidal Barrier - one of the pairs of navigation and flood discharge gates

7. **Group enjoying lunch at the Hunte Barrier**

8. **The National Park of Jade Bay, Nr Varel (sheet pile defence in foreground)**

9. The sea dike (landward side) with sheet piled crest and grazing sheep at Varel

10. Group at Jade Bay, Nr Varel

11. Outfall into Jade Bay from pumping station at Wapel

12. Storage basin upstream of drainage sluice at Dangast

13. John Martin and Hans Kunz (second right) at the Cäciliengroden scheme site office

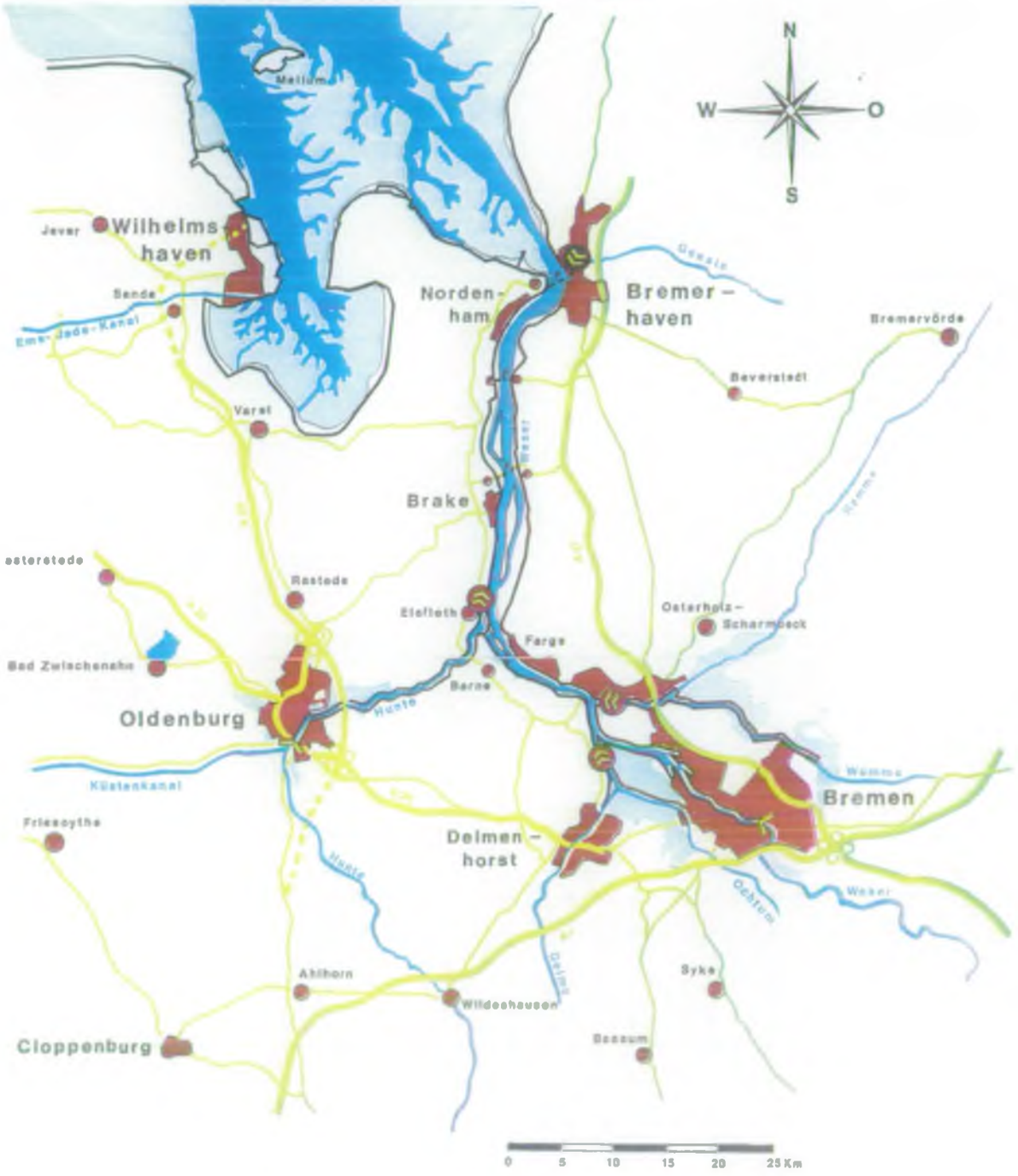
14. Group inspecting dike reconstruction progress at Cäciliengroden

15. A section of reconstructed dike (looking seaward) at Cäciliengroden

16. Regional Flood Defence Committee and German Colleagues
Bremen - 22/24 May 1995

MAPS

General Area of the Technical Visit



The Hunte Storm Surge Barrier

Ansicht von oberstrom

SUPPORT DOCUMENTS

1. General information on the Lower Saxony area and Water Management administration.
2. Flood warning and control in Bremen - details.
3. Typical defence cross-section at Motzen.
4. Hunte Tidal Barrier - background details.
5. Jade Bay - typical sea dike cross sections.
6. Cäciliengroden - typical reconstructed dike cross section.
7. Jade Bay National Park - Conservation details.
8. Wadden Sea - trilateral areas of conservation.

NATIONAL RIVER AUTHORITY - ANGLIAN REGION

REGIONAL FLOOD DEFENCE COMMITTEE

TECHNICAL VISIT 22 - 24 MAY 1995

GENERAL INFORMATION AND DATA

1 Government and Administration in Lower Saxony:

State of Lower Saxony
Government of Lower Saxony
Minister of Environmental Protection
4 Administrative Regions (Provinces)
39 Rural Districts (Counties)
9 City Districts (Municipalities)
7 Independent Greater Cities
1 Special Status City
409 Community Districts

2 Water and Waste Management Administration in Lower Saxony:

2.1

Affairs of Water Management and Protection, Waste Management, Coastal Protection;
Federal and State Water Management and Protection Acts;
Federal and State Waste Management Acts;
Lower Saxony Dike Act;

2.2

Supreme Authority - Minister of Environmental Protection;
Superior Authorities - Governments of the Administrative Regions;
Inferior Authorities - Rural and City Districts;
State Agency for Environmental Affairs with ist Department for Coastal Research;
11 Regional Agencies for Water and Waste Management;
1 Agency for Island and Coast Protection;

3 The Regional Agency for Water and Waste Management in Brake (StAWA Brake)

3.1 The Region:

Area	3488 km²,
Population	~725.000 inhabitants,
Density of population	~208 l/km²,
Land use:	
Agriculture, Horticulture	67%,
Forestry	5%,
Waters	3%,
Traffic	6%,
Other use	19%,
Land elevation	-2,0 m NN to +55,0 m NN

3.2 The Administration:

StAWA Brake lies within the Administrative Region of Weser-Ems with its government seat in Oldenburg.
The region of the StAWA Brake consists of
4 rural districts (Ammerland, Friesland, Oldenburg, Wesermarsch),
3 city districts (Delmenhorst, Oldenburg - City, Wilhelmshaven),
within them 31 communities.
3 local „Dike Associations" are legally responsible for all coast protection works, especially maintenance of the dikes.

3.3 More statistics of the StAWA Brake agency and its region:

Staff of about 120 men and women,
5 departments with 14 subject offices,
1 hydrochemical laboratory,

Length of designated main dikes	243 km
Coastal area protected by dikes and storm surge barriers	1.743 km²
River Weser - Estuary	~55 km
River Weser - Tidal River	~70 km
Tidal section of the river Hunte	~25 km
River Hunte (above tidal influence)	~60 km
Waters of secondary order	3.600 km
Tidal gates and pumping stations in the coastal main dikes (drainage sluices)	28 structures
Lowland pumping stations	128

Popkes, StAWA Brake, May 19, 1995

The Coastal Protection Administration of Lower Saxony, Federal Republic of Germany

The protection from storm surges of the Lower Saxony coastal area of about 8000 km², its population and property is achieved by about 1.100 km sea, channel and river embankments, 12 storm surge barriers, extensive defense works in front of embankments and a system of approach roads for embankment maintenance and cases of emergency. In addition to this there are beach and dune protection works on the East Friesian Islands.
The aim of the „Lower Saxony Coastal Programme" is to build these coastal works in line with latest knowledge. The most recent expression of this programme is still the 1973 „General Plan for Coast Protection in Lower Saxony" laying down standards for further coast protection. An updated and slightly modified version is presently in process of completion.

The „Lower Saxony Dyke Act" (Niedersächsisches Deichgesetz) lays down that the landlords of all plots of land situated within a potential flood plain and sheltered by embankments or a storm surge barrier are jointly responsible for the maintenance of the embankments. Some 27 local Dyke Associations (Deichverbände) have been founded to carry out this task . They own most of the embankments and as far as their property is concerned they act as applicants for new schemes and rehabilitation projects. The maintenance of an embankment includes establishing or re-establishing the prescribed dimensions of such embankment and related works.

On the other hand the Dyke Act assigns certain tasks to the State of Lower Saxony itself. These include the building, operation and maintenance of all storm surge barriers and coastal protection measures on the East Friesian Islands. In addition to this the State of Lower Saxony bears the whole cost for carrying out reconnaissance surveys.
For this reason, the „Regional Agencies for Water and Waste Management" (Staatliche Ämter für Wasser und Abfall) which locally represent the Lower Saxony State Administration have taken over most of the planning and development of coast protection measures on the mainland.
Prooving the feasibility and economicy of coastal protection schemes is the task of the Regional Government Weser-Ems and the Regional Government Lüneburg respectively (Bezirksregierung Weser-Ems, Lüneburg) which also officiate as supervising authorities i.e. „Superior Dyke Authorities" (Obere Deichbehörden) to the Embankment Associations.
The Lower Saxony Minister for Environment, the highest level Dyke Authority, has retained the privilege to agree to or to veto plans. „Rural District Authorities" (Landkreise) and Municipalities of concerned areas represent the „Inferior Dyke Authorities" (Untere Deichbehörden) which are mainly in charge of organising emergency defense measures and regular technical inspection of the entire line of embankments, drainage sluices and storm surge barriers. The latter is usually done in close cooperation with the Regional Agency for Water and Waste Management.
The „Government Agency for Island and Coast Protection" in Norden (Staatliches Amt für Insel- und Küstenschutz) signs responsible for various special tasks like land reclamation and coastline conservation schemes as well as all coast protection measures on the East Friesian Islands.
The „Coastal Research Department" (Forschungsstelle Küste) on the island of Norderney is involved in a broad scale of scientific research projects which among others includes basic research to be taken into consideration for coast protection policies.

revised and updated from „Coastal Engineering System Organisation and Administration" , compiled by Josef Sindern in „Die Küste" Archive for Research and Technology on the North Sea and Baltic Coast, Heft 32, 1978, published by Kuratorium für Forschung im Küsteningenieurwesen (German Committee for Coastal Engineering Research), Kiel, FRG

Bremen, 15.05.1995
Wo/Te

Floodprotection for the Bremen area
(Visiting of British engineers
23. May 1995)

Ladies and gentlemen -

I welcome you in Bremen!

I am glad that you are visiting the authority for environment protection and town development of the Free Hanse-Town Bremen; this smallest country of the Federal Republic of Germany consists of the two towns Bremen and Bremerhaven placed at the River Weser.

These together have about 685 thousands inhabitants.

One of the essential things is to protect Bremen and Bremerhaven against storm-gale floods.

Therefore exists 170 km dikes along the River Weser and the affluents Lesum, Ochtum and Geeste.

4 river-barriers are shortening the main line of the dikes: in Bremerhaven the Geestesperrwerk, in Lower Saxony the Huntesperrwerk and Ochtumsperrwerk and in Bremen the Lesumsperrwerk.

In the earlier days the tidal range of the River Weser was not as high as today.

About 1887 the regular tidal rise in Bremen-town was nearly half a meter.

With the systematic development of the watercourse of the River Weser between Bremerhaven and Bremen beginning 1887 the mean tidal range increased to 4 meters, during the highest high-tides to 9 meters.

After the „Holland - Storm-gale-flood" 1953 the whole coastal protection plan was overhauled. New heights for the dikeconstructions was laid down as rules.

Bremen developed new dikeconstructions at once. At the same time the Federal Government, Lower Saxony and Bremen commisioned the Franzius-Institut at the University of Hannover to find out by model tests which waterlevels are possible by different conditions for storm-gale-floods and run-offs from the Weser-catchment area. Also they should find out which effects constructions as harbour-plants, developing the navigable water or barriers to the affluents can have.

These model tests give the following results:

1. The highest expected high-tide watermarks were calculated.

2. The safest and most useful protection of the areas along the rivers Lesum, Wümme, Ochtum and Hunte is obtained by barriers to the three affluents Lesum, Ochtum and Hunte.

3. The closing of the barriers raise the high-tide water-levels of the Weser in front of the barriers. 40·68m

4. Significant is only the construction of all three barriers.

The storm-gale-flood 16. and 17. February 1962 brought new unknown water-marks. The mark for Bremen Vegesack was +5,22 m NN (over mean sea level). That was 1 meter higher than ever before.

The dimensioning watermark for the year 2100 had been ascertained again and again new heights for the dikeconstructions was laid down as rules.

The new height for 2100 is grounded on the following points:

1. The project to construct 3 barriers for Lesum, Ochtum and Hunte means that the water marks for the gauge Vegesack would increase until to 68 cm.

2. It was supposed that even more unfavourable storm-gale situations could come as there were in the high tide night 16. to 17. February 1962.

   Additional there could be a higher Weser-run-off as the then being high-tide.

3. The so called secular rising of the sea level, that means the common rising of the North sea-level, was calculated for the period of 100 years with 20 cm.

4. Developing measures decreasing the waterlevel for instance harbourplants-developing has been regarded to the water mark 2100.

Round about 69 km dikes was built up higher until 1972;

- the barrier Lesumsperrwerk was 1974,

- the barrier Ochtumsperrwerk 1976 and

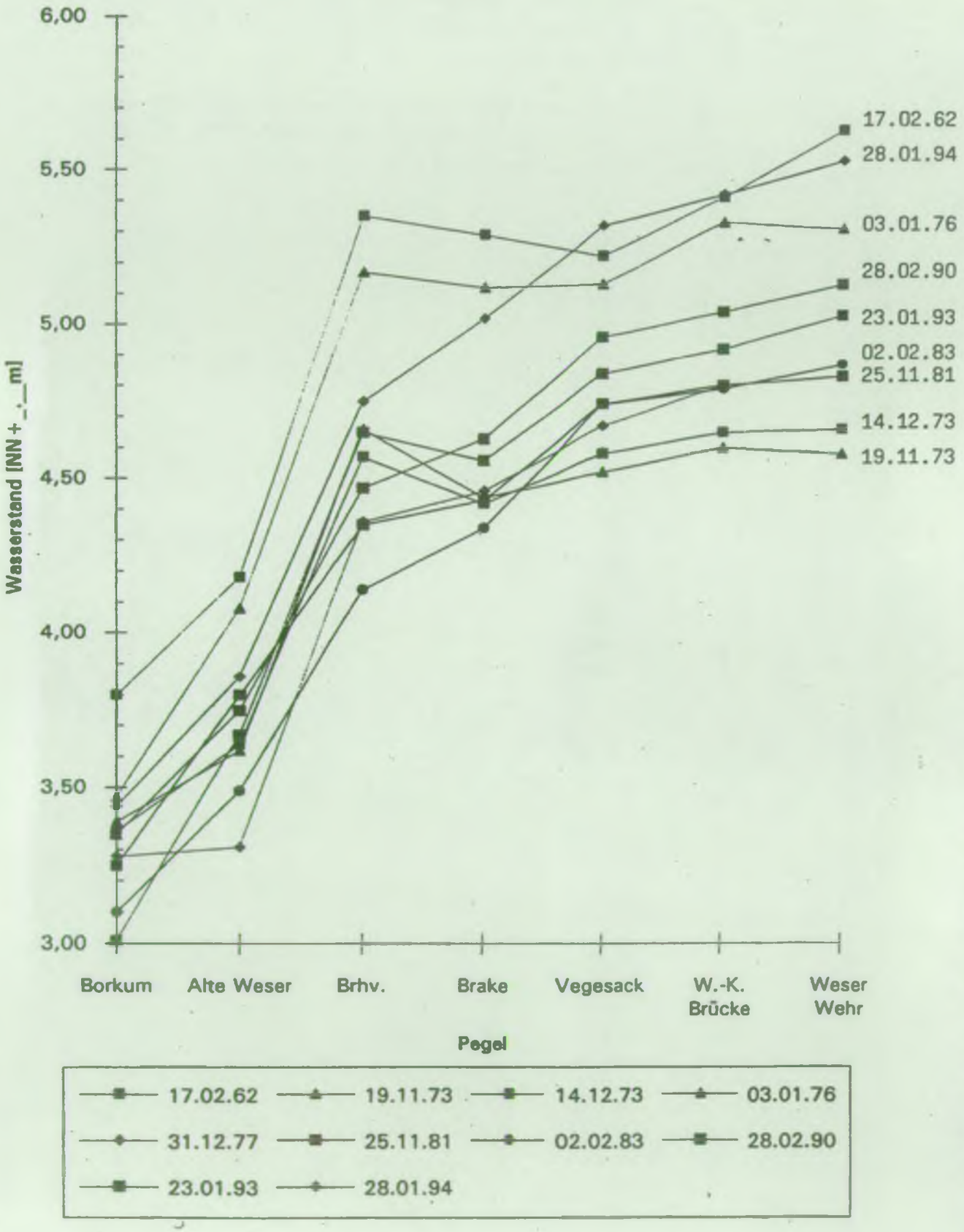
- the barrier Huntesperrwerk 1979 ready for working. Together they were set running in November 1979. Since 1955 nearly 300.000.000,-- DM were spent for the flood-protection developing in Bremen and Bremerhaven.

The annexed picture shows the crown-water-levels of the tenth highest storm-gale-floods registered from 1900 until today for the water level gauges along the River Weser between Bremen and Bremerhaven and for the German bight.

One of the main points out of the management on flood protection is the high tide forecasting.
(see also the corresponding text with date 15.05.1995)

Annex: 1

Scheitelwasserstände der 10 höchsten, in diesem Jahrhundert am Pegel Vegesack aufgetretenen Sturmfluten und die entsprechenden Wasserstände an den Pegeln der Unterweser und Deutschen Bucht.



- Stand 09.11.1994 -

H. Wohlleben
c/o Senator for Environment-Protection
and Town-Development

Bremen, 15.05.1995
Wo/Te

Short Version of:

High tide forecasting for the town of Bremen

In the year of 1979 three river-barriers were set running in the area of the River-Weser between Bremen and Bremerhaven.

These barriers makes it possible to held definite waterlevels in the affluents Lesum, Ochtum and Hunte (Picture „Abb. 2“).

(The three barriers are: „Lesumsperrwerk, Ochtumsperrwerk and Huntesperrwerk“.)

The table „Tabelle 1“ on page 3 shows the numbers of the closings of the „Lesumsperrwerk“ from the year 1980 to the year 1994.

The definite closing-water-level to protect the dikes along the River-Lesum and River-Wümme is +2,70 m NN (above the mean sea level). For instance in 1994 the „Lesumsperrwerk“ was closed 113-times.

To forecast the right moment in relation to the definite water-level of 2,70 m NN is very important on one hand. On the other hand there are additional steps of water-levels to start the high-water-protection organisation because of gale-warning.

In the first years all the time the persons concerned have to forecast by own hand on day and night; therefore they have to go to the official bureau.

We develloped a forecast-system based on computer ringing up the persons concerned.

So we can avoid frequent walking to the official bureau.

Using the water-level-gauge „Borkum“ and „Alte Weser“ the computer works out the forecast for the water-level-gauge „Vegesack“ and „Lesumsperrwerk“. (Picture „Abb. 2“).

Table „Tabelle 3“ on page 9 shows you an example of a forecast-occurence for the night-high-tide belonging to the gauge „Vegesack“.

Eleven minutes past two in the morning the high-tide should reach „Vegesack“ on 16. March 1995.

The first high-water-level-forecast („1. Hochwasservorhersage") is plotted at three minutes to nine o'clock in the evening 15. March 1995 („15.3.95, 20.57").

That is about 5 hours before the astronomical time for „Vegesack".

The computer ist calculating on two improvements one and two hours later.

The computer rings up the person concerned.

This automatic system works since ten years without a servant.

The computer uses five-minutes-median numbers of water-level-informations, which are coming on-line as analog informations.

During the next year the on-line remote transmission will be change to a digital signal, what means a new hardware equipment for round about 400.000,-- DM.

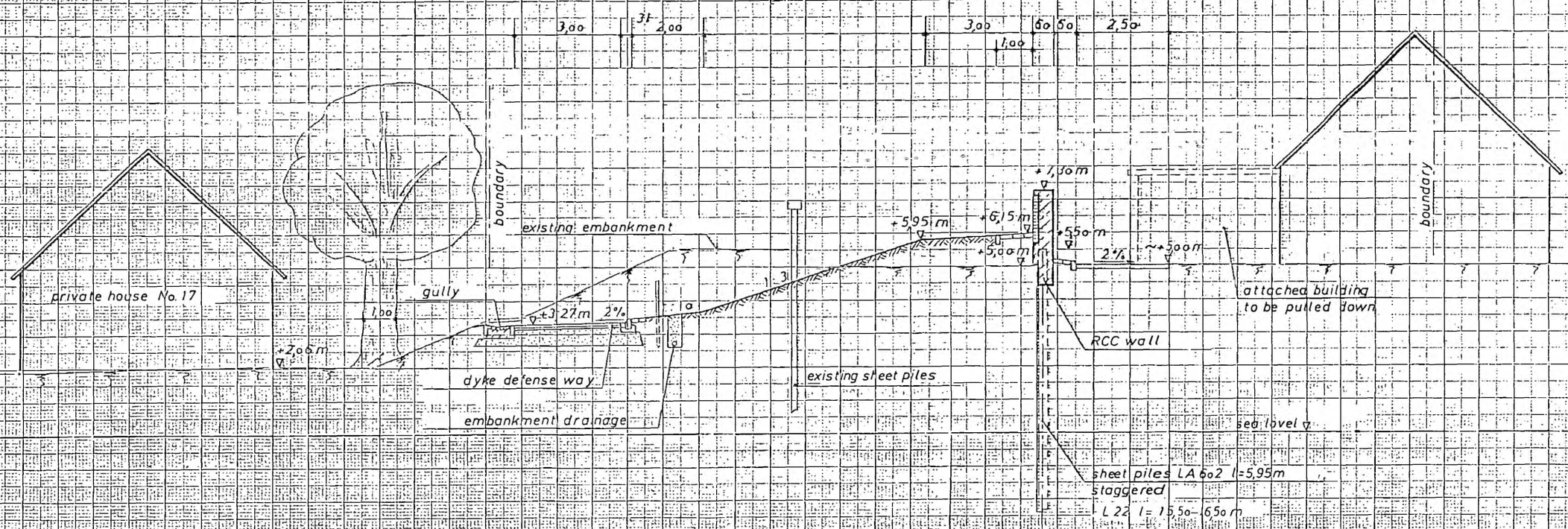
In case of a gale-warning combined with a forecast more than +3,50 m NN (above mean sea level) it is possible to use additional water-level gauges along the River-Weser similar to the flood running in from „Borkum" via „Alte Weser", „Bremerhaven", „Brake", „Vegesack" to „Große Weserbrücke".

Gauge „Oslebshausen" is a self anounce gauge and gives the actual water level.

Hints to the tables and pictures:

Table „Tab. 1", Page 3:	Management of the Lesumsperrwerk (River-barrier for the River-Lesum) - number and frequency of closing the barrier.
Table „Tab. 2", Page 4:	Temporal running of the tides for the example of the night-high-tide in Bremen from 15. to 16. March 1995. (The time difference between the water-level-gauges Borkum and Vegesack is 3 hours and 57 minutes.)
Tabel „Tab. 3", Page 9:	Example of high-tide-forecast for the night-high-tide gauge Vegesack from 15. to 16. March 1995.
Picture „Abb1":	Hardware equipment and water-level recorder for the high-tide-forecasting-system.
Picture „Abb2":	Locality-map to the position of the water-level-gauges for the high-tide-forecasting-System in Bremen.

Motzen - Baarentleth embankment reinforcement scheme
Cross section at dyke km 446,881



The Hunte gate

In 1953 the Netherlands were struck by an extrem high tide. One year later at Christmas a similar high water happened on the German coast. The water level reached nearly the crown of the dikes at that time.

Both events caused the federal administration as well as the governments of the north German federal countries to check the security of their coastal dikes and other constructions on the sea. As a result of it in the fifties a big "coastal protecting programme" was started.

Very soon it became clear, that most of the dikes were too low and the structures within not safe enough. So the dikes along the coast had to be made higher and get minor step side slopes. Along the tidal rivers Elbe, Weser and Ems it was more difficult to reinforce the dikes in the same way. A lot of buildings of any kind often gave not enough room for the needed measurements. This was even more true for the tributary rivers of the Elbe, Weser and Ems, because of the weak ground, which is not strong enough to carry the higher weight of a new and greater dike.

So at the mouth of the tributary rivers gates were projected. Those gates are both the best flood control and the most economic plant.

At the beginning of the project in 1954 hydraulic researches of the Weser river basin took place at the Technical University of Hannover. The purpose of these experiments was, to find out how large the opening of the gates must be, so that the normal tide can pass without any backwater. But the research also showed, that when the gates are closed, the level of high water in the Weser will increase. The reason for it is, the flood absorption effect of the reservoirs in the tributary valleys can no longer be filled.

. . .

In case of an extraordinary flood, as in 1962 and 1976, an increase of the flood peak from 0 cm in Bremerhaven up to 67 cm in Bremen must be expected.

In 1968 the federal countries of Lower Saxony and Bremen contracted a joint project for the tributary rivers of the Weser, which are the Lesum and Ochtum near Bremen and the Hunte. The definite project plan was finished in 1969. To get the formal acceptance by the department concerned was hard work, because 955 objections to the project were registered. Most of the objections were caused by the increase of the flood peak and protecting measures were claimed. The formal acceptance was given on the 18.01.1971 and the work could start.

The work began at the Lesum gate in 1971, the Ochtum gate followed in 1972. At last the construction of the Hunte gate started in 1976. On Oct. 1, 1979 the three gates and the flood protecting measures were finished.

The Hunte gate was built on the north point of the Elsflether Sand, a small island at the mouth of the Hunte. As the building site was outside the dike, at first a cofferdam was built with crown on NN + 6,0 m to protect it against high water. Inside the wall the foundation concrete had to be put in submerged, because groundwater draw down in the needed depth was not possible. A settlement of the week soil below the town auf Elsfleth would have brought the houses into danger of damage.

The Hunte gate has got two flood openings with a clearance of 20 m and two navigation openings with a clearance of 26 m. Each flood opening has got two radial gates and the navigation openings two mitering gates. Two gates in each opening are necessary for further security in case of a damage. The gate has got a bridge too, maximum load 30 t. The parts of the bridge crossing the navigation openings are a rolling lift-bridge-construction. The gates and the lift-bridges have got an oil-hydraulic-drive. The running pressure is approximately 100 bar. In case of overload security valves leads the oil back into the oil-tanks.

. . .

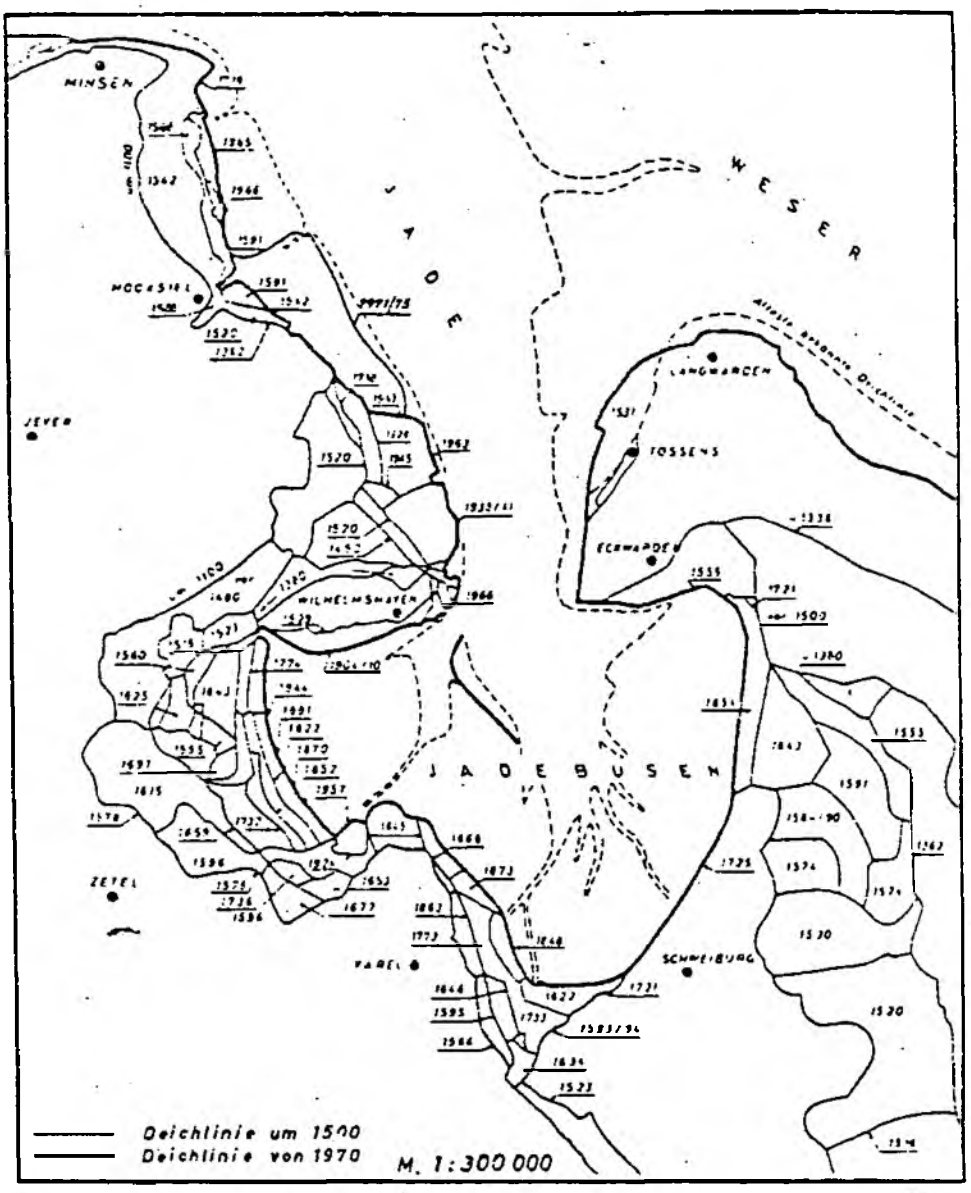
The Hunte gate has to be closed, if a water level of 1,0 m or more than mean high water is expected. That happened at an average of 23 times in the last years. By this the areas outside the dike in Elsfleth have not been overflooded since then and the train connections from Hude to Nordenham have not been interrupted.

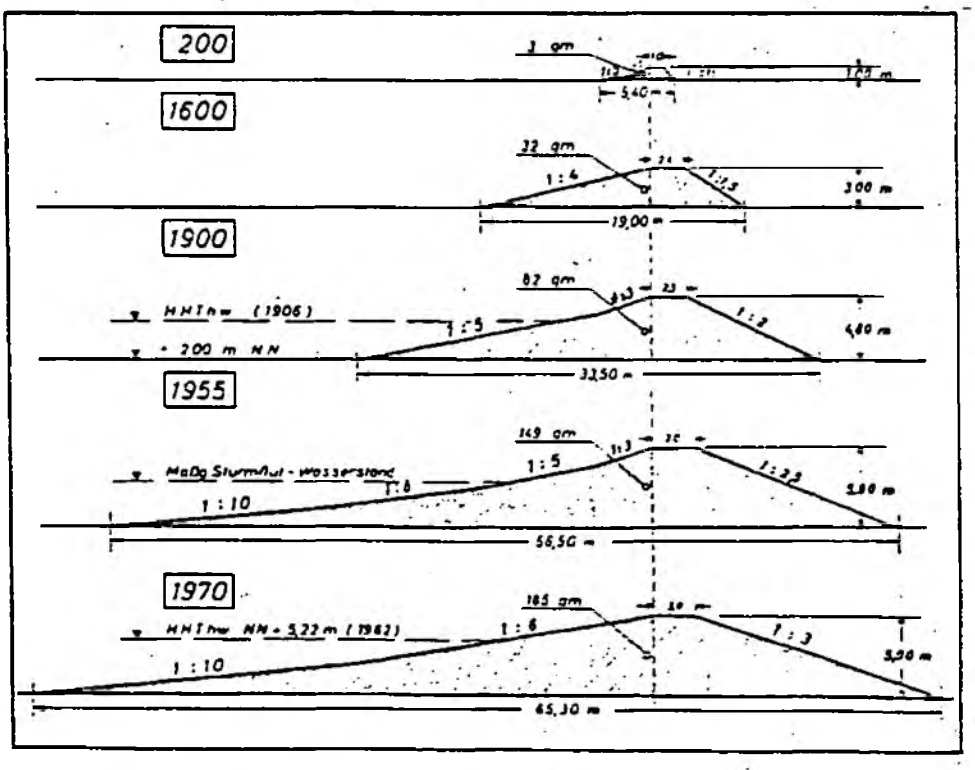
The whole system is controlled and driven from the controll-center on a tower. It is on work round the clock.

A system of gauges, organised and watched by the watermanagement board of Bremen and Brake give the alarm to shut the gate in time.

The construction costs of the three gates at the Weser including the protecting measures amounted to 341,7 Mill. DM including the Hunte gate with approximately 110 Mill. DM. The whole sum was raised with 70 % by the Federal Government, 20 % by Lower Saxony and 10 % by Bremen.

The operation and maintenance charges are raised by Lower Saxony and Bremen.

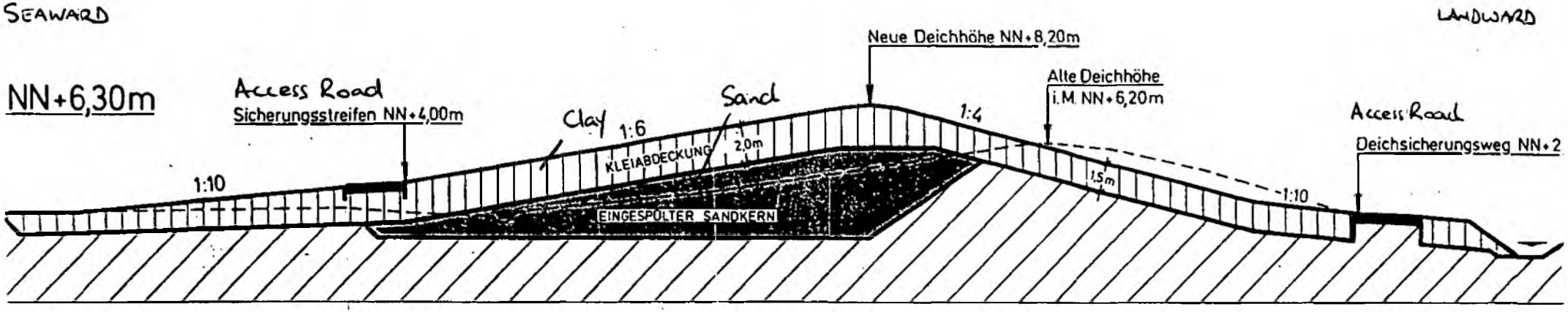




Deichbau an Jade und Jadebusen

— Neues Deichprofil —

Bin



ca. 90,0m

Introduction to the National Park „Niedersächsisches Wattenmeer“ (NLP)

The NLP in Lower Saxony was founded in 1986. The area is 2.400 square kilometres.
Included are the tidal flats, the saltmarshes along the shore and the islands between the rivers of Ems and Elbe. The landside border is the main dike, the seaside border is fixed by the geographical line in the map.

The purpose of the foundation of the NLP is to ensure a large coherent natural site with it's natural processes, vegetation and wildlife. The east frisian wadden sea is of great importance as

- resting and moulting place in the migration of birds (east atlantic flyway)

- nursery for North Sea fish

The included ecosystems are:

- tidal flats, which flooded and left dry again with the changing tides;

- saltmarshes
  and
- dunes with it´s special species of plants and animals.

In the region of the wadden sea people live and work since some hundred of years. So the ecosystem is not real natural in the scientific sence of „without any influence of human being". For example there are enforcements of the islands on their eastern parts. So the trend of natural movement of the islands to the southeast is reduced.

Other traditional activities in the NLP are fisheries, farming or tourism.

The east frisian coast is the most important region for the tourism in Lower Saxony.
Because of the difference between the NLP-idea in the sence of IUCN and the reality of human utilisation the NLP-decree is a compromise. A system of zoning is set up.

Zone I is the care zone of nature conservation. It covers the most sensitiv areas like nursery places of seals etc.

All human activities which are able to influence the ecosystem are forbidden. It is only allowed to enter Zone I on official streets, paths or routes.

Zone III is the recreation zone. It includes the traditional beaches with function for recreation.

The regulation of Zone II are a compromise of the other. The special purpose is here to ensure the character of the landscape. For example it is forbidden to make noise, to destroy the vegetation, to construct buildings etc. Quiet recreation, agriculture, hunting are allowed.

The shipping routes, harbours, airports and villages on the islands are not part of the NLP.

In the following the special problems of keeping natural processes of succession in a very dynamic ecosystem in relation to the demands of the inhabitants were explained by dike enforcement, measures in the western Jadebusen.

Natural values of the ecosystem

The tidal flats and saltmarshes of the Jadebusen are very important resting, moulting and breeding areas. For example:

500 breeding pairs of Redshank per year.
3600 moulting Avocets (30 % of all Avocets of the east
atlantic fly way).
2700 Shellducks per month are resting.

The saltmarshvegetation is nearly natural (60 % are wether grazed or mowed).
There are natural conditions for an increasing of the saltmarsh biotopes. Special problems of the dike enforcement measure (worked out in a environmental impact study).

conflicts:

a) enforcement to the seaside lost of saltmarsh biotopes as consequence of the expandation of the dike basis
b) destruction of saltmarshes as consequence of the take off the clay for the dike construction

c) limited destruction of tidal flat biotopes as consequence of the take off the sand for the dike construction

d) limited disturbances as consequence of the construction activities like movement and noise of people and machines. The value of the breeding and resting places birds is reduced.

Objectives of landscape planing

These problems have to be managed in the permission act of the administration in order of the Nature Conservation Law and the National Park Decree.
The Objective is to avoid environmental impacts as far as possible. For all environmental impacts compensation measures have to be constructed.

To avoid impacts, the NLP-administration prefers the dike extension to the inland side.

Suggestions for compensation measures in the actual planing are:

- areas for the development of natural saltmarshes have been chosen.
  Grazing and mowing activities have to be stopped,

- to ensure areas for the development of brackish bio topes and managing of medows as breeding areas for birds.

At least, all is a problem of the costs.
The NLP-administration prefers a dike widening variant that costs 8.6 Mio. DM more than the cheapest technical variant. So it is the state´s decision „How much money shall nature conservation costs?"

information facilities in the Wadden Sea National Park of Lower Saxony

In the national park of Lower Saxony in total 17 information facilities are planned, 15 of which have already been built up. Among these are 3 bigger "Nationalpark Zentren", which have to offer environmental education programmes for schools and adults. At the beginning the smaller "Nationalpark-Häuser" have had their emphasis in information work, but environmental education today also takes place.

"Nationalpark-Zentren" are situated in Norden/Norddeich, Cuxhaven and Wilhelmshaven. The Wilhelmshaven center will finally be opend in 1996 and will be the biggest one in the park.
"Nationalpark-Häuser" are already situated on 5 of the 7 inhabitated Eastfrisian Islands of Borkum, Juist, Norderney, Baltrum and Wangerooge; Langeoog and Spiekeroog will follow within the next years. On the mainland "Nationalpark-Häuser" are located in touristic areas.

All information facilities are run by local authorities, in most cases in cooperation with different NGO´s. The government of Lower Saxony gives financial support to the local authorities as well for building up and installing the facilitiy as for the working costs including staff. The amount depends on the type of facility and the local position in the park. Those facilities which are situated on the islands get some more money as those on the mainland.

The "Nationalpark-Zentren" get about 180.000 DM a year each, the "Nationalpark-Häuser" between 120.000 DM and 135.000 DM. The facilities are opend throughout the whole touristic season and during holidays in winter, the "Nationalpark-Zentren" are more or less opened the whole year.

All facilities have an exhibition on the wadden sea. The contents of the exhibition is not standardized by the national park administration but each facility shows local aspects and problems of the wadden sea and the national park. The elder facilities by and by will be redesigned with regard to a "corporate design" which is common for the whole Government of Lower Saxony now.
Besides this the facilities offer the following programme in different emphasis:
- Guided tours to dunes, salt marshes or tidal flats
- Floristic or ornithollogic excursions
- Seminars of one or more days
- Lectures, also in cooperation with local tourist offices

Staff

by financial support of the government

Nationalpark-Zentren:	2 each
Nationalpark-Häuser:	1,5 each

This staff is supported by volonteers of NGO´s.

Ecological problems concerning dyke reinforcements with reference to the effects on saltmarshes and wadden sea in the National Park „Lower Saxonian Wadden Sea"

At the coast of Lower Saxony mainly the increased requirements on coastal defense have caused the necessarity for raising and reinforcing large parts of the sea dykes. These building projects have diverse effects on the saltmarsh and wadden sea ecosystems, which particularly after foundation of the National Park „Lower Saxonian Wadden Sea" in 1985 cause some conflicts between coastal defense and protection of nature. The most important contentious issues are the removal of clay from the saltmarshes, the destruction of saltmarshes by building over and the removal of sand from the wadden sea. As only a few investigations were available to provide help for decisions with regard to this problems in the approval proceedings, more intensive research was necessary. Since 1989, the NLÖ - Forschungsstelle Küste (NLÖ - FSK) carries out research on these subjects; the backgrounds and aims of the investigations are explained below.

Clay removal from the saltmarshes

From the beginning of dyke building the necessary clay was usually taken from the saltmarshes outside the dykes because this was the cheapest solution and the - from an economic point of view - more valuable land inside the dykes was saved. In the recent years the aspect of nature conservation has come to the fore; therefore the question arose if in general a further removal of clay from the saltmarshes should be allowed in this ecologically valuable area which anyway is a part of the national park.

For finding an answer to this question, at first it was necessary to research the refilling and developing of former clay pits and to determine their ecological value within the saltmarsh ecosystem. For this purpose the NLÖ - FSK is investigating clay pits at the age of 2 to 40 years and - for comparison - saltmarshes with different agricultural treatment in the Jadebusen and Elisabeth-Außengroden since 1990. The clay pits are examined for refilling with sediment (i. e. soil development and level), for recolonization with plants and evertebrate fauna and for acceptance by resting and breeding birds.

The investigations have shown that a clay pit first - for a few years - is withdrawn from its function as a biosphere for plants and animals, but in the long term valuable saltmarshes can develop again. The different morphological structures between former clay pits with their natural developed mud flats and the man-made ditch structure of the old saltmarshes is obviously (fig. 1). Also the vegetation and its valuation in relation to the surrounding saltmarshes can differ a lot; in saltmarshes which are very rich in species and flowers, for example on the east side of the Jadebusen, a clay pit means a reduction of the vegetation because some species which depend on reaping don't recolonize a clay pit even within 30 years (fig. 2, 3). On the other hand, in areas with very monotonous saltmarshes clay removal in the long term rather may enrich such saltmarsh systems.

The evertebrates and birds usually recolonize former clay pits rather fastly; in many older clay pits even relatively high abundances of quite a lot specialized saltmarsh inhabitants are found.

A second field of work within the saltmarsh research is the examination of selected saltmarsh areas with regard to their suitability for future clay removal. For this purpose the same parameters are investigated as described above. The valuation of these areas by ecological and nature conservation criterions shall provide a better basis for the proper authorities for further decisions whether and where clay is to be removed from the land outside the dykes.

Destruction of saltmarshes by building over

For raising a dyke its basis has to be widened out; mostly two building variants are possible, a widening inwards or outwards the dyke. In case of a widening outwards a strip of saltmarsh of 30 m width will be built over, and the saltmarsh in this strip will be destroyed permanently.
In 1992, the ecological value of this strip of saltmarsh close to the dyke in relation to the areas following seawards was examined for large areas of the Jadebusen by the NLÖ - FSK. The results are used for the approval proceedings to determine the impacts of the dyke building on the environment. A criterion for the decision on which side the dyke is to widen must also be the ecological value of the relevant area inside the dyke.

Sand removal from the wadden sea

Since 1962, dykes are not any more built exclusively with clay but contain a heart of sand. The material for this purpose usually was taken from the wadden sea where the pits get refilled with sediments and recolonized by benthic organisms within a few years. Research on the development of such areas is carried out by the NLÖ - FSK since several years.

Also in the future the removal of sand from the Wadden Sea National Park can't be completely avoided. Therefore it is necessary to find out where from an ecological point of view are the most appropriate locations, for example in which no particularly sensitive benthic species or communities are living or in which a very quick recolonisation can be expected.
Concerning the dyke reinforcement on the west side of the Jadebusen (sand requirement about 1.300.000 m³), the NLÖ - FSK has investigated the benthic fauna of several potential areas for sand removals in 1992 and 1994. On the basis of this research a removal from the eulitoral zone and from two sublitoral, more valuable locations was excluded. But there could be found two relatively appropriate locations in the sublitoral zone which showed no occurence of endangered species and which can be expected to get refilled and recolonized comparable to the status quo over a short period of approximately 6 years.

Fig. 1:
Morphological structure of saltmarshes and a former clay pit on the east side of Jadebusen (infra-red aerial picture)

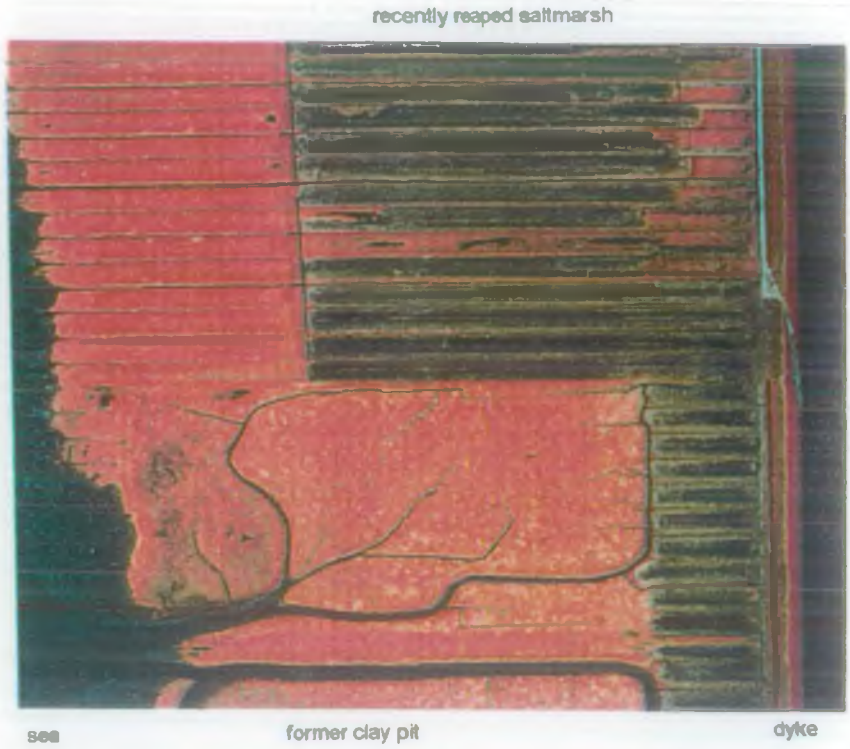


Fig. 2:
Detail of saltmarsh vegetation (east side of Jadebusen) with *Limonium vulgare* and *Artemisia maritima*

Fig. 3:
Typical vegetation of a former clay pit (east side of Jadebusen) with *Puccinellia maritima*, *Atriplex portulacoides* and *Aster tripolium*

Ecosystem Research in the Wadden Sea

Peter Knauer, Federal Environmental Agency, Berlin

In 1978, the Federal Environmental Agency (Umweltbundesamt) commissioned a feasibility study on behalf of the Federal Ministry for the Environment concerning the establishment of applied ecosystem research. In this study, the deficits existing at that time in ecological research were described as follows:

- Not even for the most important ecosystems functional relationships and control mechanisms have been investigated.
- The pollution load in and the load capacity of living systems has not been sufficiently clarified.
- Comprehensive ecological information is available only for parts of the Federal Republic.
- Long-term ecological monitoring is not practiced.

This analysis of deficits prompted the Federal Government to establish a long-term ecosystem research program, with the objective of clearing up the functions, structures and processes of the most important and representative ecosystems in the Federal Republic of Germany.

The approach pursued in this ecosystem research program was confirmed by the Federal Government in its "Guidelines on Anticipatory Environmental Protection" of 1986, which called for the "building up of a network of representative permanent monitoring areas (= main research areas) to record changes in the most important ecosystems with the long-term aim of obtaining reliable findings regarding the effects of material and structural burdens".

Following comprehensive preliminary work, the first main research area was established in 1981 in Berchtesgaden within the framework of the MAB-6 project "human impacts on ecosystems in high mountain regions". The project's monitoring and data compilation phase has meanwhile been completed, the assessment and data evaluation phase has been in progress since the beginning of 1989.

Since 1985 the Federal Environmental Agency, on behalf of the Federal Minister for the Environment, Nature Conservation and Nuclear Safety, has endeavoured to apply this approach to a second area to be designated as main research area. The Wadden Sea has been chosen not only because of the current situation. Due to this ecosystem's sensitivity and the acute dangers it faces, also its selection as the second ecosystem research project did not follow the principle of areal representativity, but took place under the aspect of its meriting particular protection.

Also starting in 1985, Wadden Sea National Parks and the corresponding administrative units had been created in the Federal States Schleswig-Holstein and Lower Saxony. The Federal Environmental Agency subsequently entered into a cooperation with the National Park administrations in Tönning and Wilhelmshaven with the aim to establish the second main research area.

The most important results of this cooperation are the two feasibility studies:

- Christoph Leuschner: "Wadden Sea ecosystem research - development of the concept and organization of the overall project(sub-project Schleswig-Holstein)", and

- Thomas Höpner: "Conception of the ecosystem research programme for the Wad-

den Sea of Lower Saxony (sub-project Lower Saxony)", which were jointly prepared and published by the two National Park administrations and the Federal Environmental Agency.

The two studies set the following goals for the main phase of the Wadden Sea ecosystem research programme which is starting now:

1. To obtain a basic understanding of the functioning of the system nature/man in the Wadden Sea, particularly for the purpose of solving future environmental problems, the possible consequences of which are unknown to us today.
2. To generate the knowledge early enough that is necessary to solve or alleviate environmental problems currently encountered in the Wadden Sea.
3. To develop evaluation criteria and to provide a set of instruments to fulfill the long-term tasks associated with the protection and monitoring of the Wadden Sea.

Thereby the Federal Environmental Agency will contribute to the extensive tasks to be tackled within the main phase of the Wadden Sea ecosystem research programme.

Umweltbundesamt
Bismarckplatz 1

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Applied Ecosystem Research

Aim: analysis of natural processes and human impacts, development of monitoring strategies and ecological targets, scientific background for the further development of the national park concept

19 research projects

a. **eutrophication**
   - phytoplankton development
   - effects of Phaeocystis - blooms on blue mussels
   - black spots (pysical, biochemical, microbial changes, reaction of meio- and macrobenthos)

b. **musselbeds**
   - structure and functions of natural mussel beds, seed, culture lots
   - effects of mussel fisheries
   - effects of bird predation

c. **monitoring and ecological targets**
   - strategies for benthic communities, fish(es)
   - accumulation of pollutants in the food web
   - development of ecological targets

d. **fisheries**
   - shrimp fishery as a food source of sea birds
   - socio-economical development of the fisheries in the NLP of Lower Saxony

e. **interpretation of aerial photography with a GIS**

f. **numerical modelling of ecological systems**

g. **steering board (organization, operation, synthesis)**

Additional Projects Approved for Research in the Wadden Sea

Ecosystem Research in Lower Saxony

Sabine Dittmann, National Park Administration Lower Saxonian Wadden Sea, Wilhelmshaven, FRG

With the establishment of national parks for the Wadden Sea in Germany, an ecosystem research scheme was inaugurated in the late 1980s. The scheme set up consists of two corresponding parts carried out in Schleswig-Holstein and Lower Saxony, each composed of two branches: one focussing on applied and the other on basic sciences. Projects are well under way in Schleswig-Holstein, and since 1989 for the applied science part in Lower Saxony. Here, after completing a pilot phase for the basic branch in March 1993, work can now continue on key questions of the ecology of this ecosystem.

The Federal Ministry of Research and Technology gave the go-ahead for eleven further projects under the theme of "ELAWAT" (Elastizität des Ökosystems Wattenmeer - Resilience of the Wadden Sea ecosystem). The projects are financed with a total budget of 7.3 Mill. DM over a three year duration. Administration for ELAWAT is assigned to the Research Center Terramare, and scientific coordination will be achieved by the project management located at the National Park Administration Office, both situated in Wilhelmshaven.

To analyze the resilience of the Wadden Sea, the projects investigate temporal and spatial patterns on every hierarchy level of the ecosystem and record their variations following simulated disturbances. How can we judge whether a resilient response has occurred? What are the main ecological processes in action for the functioning of such a complex system as the Wadden Sea? Ultimately, this research will identify key components and processes which require prime conservation status.

Over forty scientists of eight institutions participate in ELAWAT, covering "classic" disciplines, but applying latest methods. They deal with microbes, benthic and pelagic microalgae, meio- and macrobenthos as well as with birds of the Wadden Sea. Hydrography, sedimentology, sediment chemistry and meteorology are further subjects. Mathematicians analyze similarity of temporal and spatial patterns. The projects are linked by working groups to assure an interdisciplinary approach. Work has commenced this autumn and will continue till late 1996. Main study areas are the tidal flats sheltered by the East Frisian island of Spiekeroog.

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Long-term Impact Study for the Europipe Development Project

Manfred Vollmer, National Park Administration for the Lower Saxonian Wadden Sea, Wilhelmshaven, FRG

The Norwegian company STATOIL plans the construction of the gas pipeline "Europipe" to deliver more natural gas from the Norwegian gasfields to Germany. This gas delivery is part of an international treaty ("Europipe agreement") between the Kingdom of Norway and the Federal Republic of Germany. To land the pipeline at the German coastline, the proposed route, fixed in the "Landesplanerischen Feststellung" of the "Raumordnungsverfahren", follows the tidal inlet and the tidal channel between the islands of Baltrum and Langeoog and continues through the Accumersieler Balje and beneath the tidal flats of the "Dornumer Nacken". This subsurface crossing of the mudflats requires a tunnel of 2.6 km length, where the pipeline will be laid in.

Extensive sediment dredging has to be done for laying the pipeline in the tidal channels. To provide access for the laybarge to the Accumersieler Balje, a temporary channel must be dredged through the sand bar separating the Accumer Ee tidal inlet from the sea. This and the fact that the pipeline has to be permanently covered with sediments require the dredging work. The direct effects of the construction cover an area of 80 ha, the indirect effects will cause disturbances to the Wadden Sea behind the islands of Baltrum and Langeoog. To document effects of the "Europipe-landfall" on the ecology of the area, extensive scientific investigations are necessary. The long-term impact studies began in early 1993 and will continue for several years until an ecological evaluation of the impact is possible. The studies are carried out by several research institutes and are coordinated by the National Park Administration in Wilhelmshaven. The necessity for the environmental investigations and the position of the National Park Administration are documented in the "Planfeststellungsbeschluß" of the Oberbergamt.

The impact studies cover the following disciplines with a main emphasis on:

- hydrography: measurements of wave height, wave direction, tidal height, turbidity, current speed and current direction;
- morphology: monitoring of the tidal channels in the Accumer Ee;
- sedimentology: sediment composition and distribution, measurements of sedimentation and erosion processes, investigations of suspended matter and on bedform development;
- biology, this part is divided into the three following compartments:
  a. fish and decapode crabs: species richness, population density, population dynamic and recruitment pattern, and studies on the black spot disease of brown shrimps;
  b. benthos: diversity of habitats, studies on seasonal dynamics of selected species, monitoring of macrofauna in subtidal creeks, a survey of the threatened species and investigations on juvenile flatfish;
  c. birds: monitoring of breeding birds and breeding success (number of young fledged per pair), monitoring of migratory birds and time spacial pattern of selected species.

Results from the impact studies will be compiled over six-months terms and published annually.

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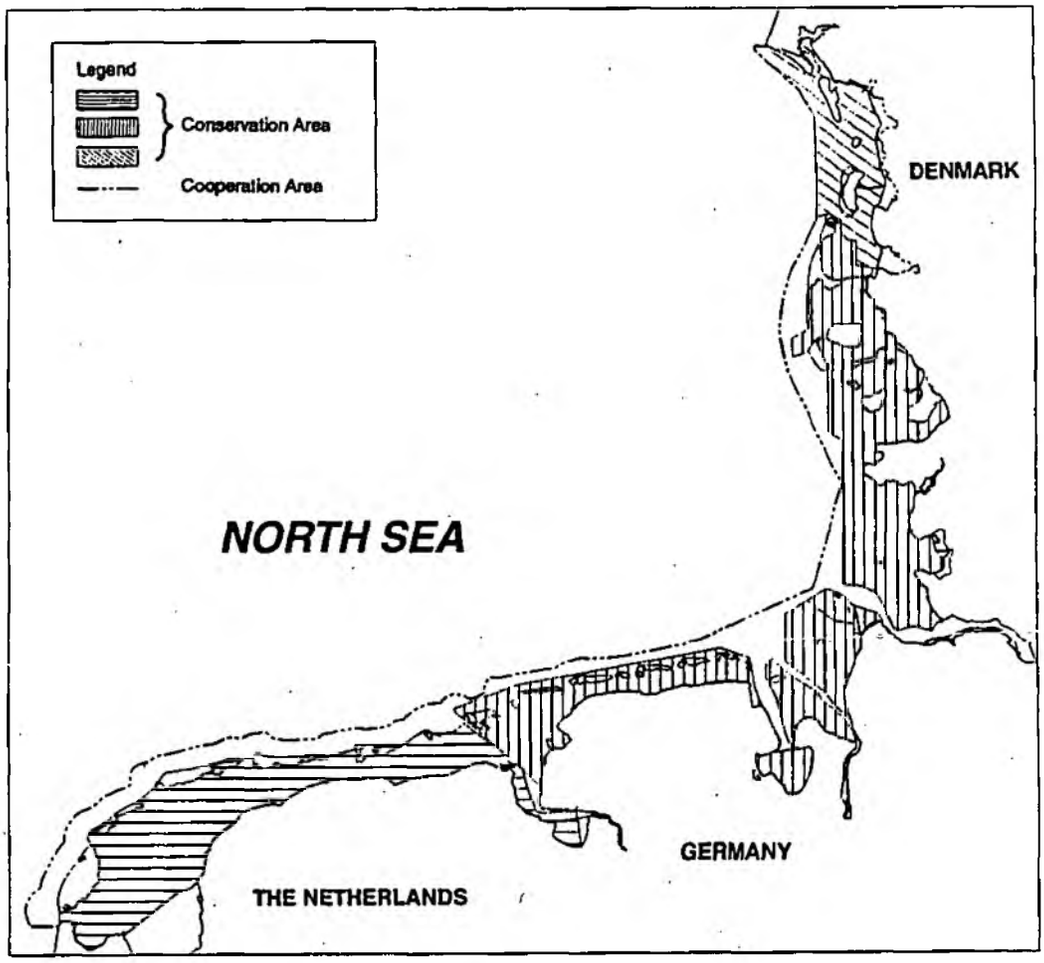

Wadden Sea - cooperation area and present trilateral areas of conservation