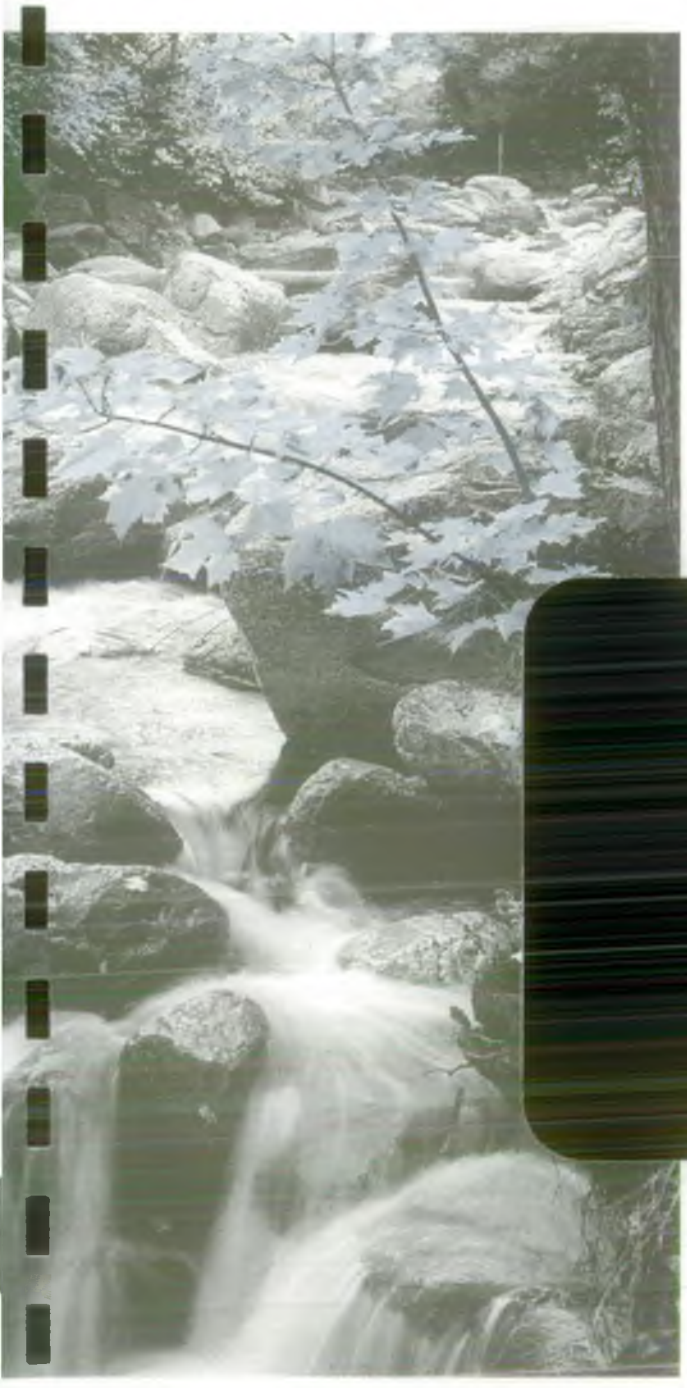

NRA

National Rivers Authority
North West Region

GUARDIANS OF THE WATER ENVIRONMENT

GREATHAM CREEK TIDAL DEFENCES
INTER REGIONAL REVIEW

Prepared for the purposes of legal proceedings

FINAL REPORT
MAY 95

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EXECUTIVE SUMMARY

1. Introduction

1.1 The purpose of the review is to comment on aspects of the implementation of the Greatham Creek Tidal Defence Scheme in accordance with the Brief included as Appendix A.

1.2 Greatham Creek is an embanked tidal tributary of the River Tees with a history of flooding. The site is divided into 4 cells named in accordance with the quadrants of the compass. Although heavily industrialised, damage in the event of flooding is concentrated on the Tioxide plant in the North East Cell. The southern cells are used as brinefields (located underground) where damage would be confined to control and communication equipment.

1.3 The site is located in the midst of the largest area of inter tidal mudflats and saltmarsh on the east coast between Lindisfarne in the north and the Humber estuary in the south and contains 2 Sites of Special Scientific Interest (SSSI) and a Site of Nature Conservation Interest (SNCI). The site falls within the Teeside Development Corporation's proposed International Nature Reserve and the SSSIs have been put forward for designation as Special Protection Areas in accordance with the Habitats Directive.

1.4 A low standard of flood defence at Greatham Creek had been confirmed by the 1978 survey of land drainage functions. Uncertainty regarding benefits inhibited a long term solution until the problem was again highlighted by the 1990 sea defence survey following which an investigation was commissioned.

1.5 A scheme to improve defences at Yarm had raised annual capital expenditure to approximately £1 million during 1991 and 1992 from an average of £300,000. With Greatham Creek being the only other large scheme planned by Northumbria Region, a construction start in 1993 was pursued vigorously to avoid major fluctuations in the programme and hence in the flood defence levy.

1.6 A feasibility study was undertaken by consultant, W S Atkins, with subsequent design and supervision of construction by consultant, Ove Arup. Environmental consultants, EMC, were also appointed at the design stage to produce an Environmental Statement and, in conjunction with Arup, to advise the Authority of the preferred solution. The feasibility study commenced in October 91 with design commencing in January 92 followed by construction between June and October 93. The merger of Northumbria and Yorkshire Regions coincided with the last half of design and the whole of construction.

1.7 A number of solutions were considered as part of the design with the option selected comprising raising and strengthening of embankments and the replacement of 4 sluices.

1.8 The most significant features of the scheme were the importance of environmental factors and the number, size and nature of industrial landowners some of whom, most notably ICI, had a significant interest in the environmental management of their land.

1.9 Contractor, Hall Construction Services Ltd, was appointed in June 93 to construct the works during an environmental window extending from June to mid September of that year. Additional costs were incurred during construction, the most significant of which comprise approximately 80% of additional expenditure and were associated with:

1. Infilling of lagoons forming part of the original defences.
2. Use of an emergency access road serving industrial plants adjacent to the Creek.
3. Construction of an additional sluice in the South East Cell.

1.10 A Form G application in respect of total additional costs of £323,200 was approved by the Board in January 95. However, members expressed concern regarding the reasons for the additional expenditure and agreed that an independent review should be conducted.

2 Findings and Observations

2.1 In terms of engineering, the Greatham Creek project was quite straightforward. However the project was made complex by the nature of the site and the extent of consultation required to identify and implement a solution.

2.2 On the whole the consultation process was well managed and the Authority and our consultants were publicly congratulated by the major consultees. Aspects of the Authority's management of the project, however, could have been more effective. These comprise the following inter related structural, procedural and project specific factors:

1. Responsibility for the management of the project was not clearly allocated to an individual. The person nominated as project engineer was unable to perform the management role without further partial delegation, was not fully responsible for environmental aspects and represented all flood defence interests. Additionally, the contractual role of Engineer was retained in house and performed by the project engineer's line manager. The potential for confusion and misunderstanding between officers, consultant and contractor was high.

2. In line with common practice at the time, select lists for both the feasibility study and design stages appear to have been formed without the benefit of vetting and performance appraisal procedures. The risk of employing inappropriate consultants was high and was realised in the case of Arup whose previous relevant experience was very limited.

3. The contract strategy adopted for the feasibility study was inappropriate. A fixed

price was sought for work which could not be defined. Prices tendered were extremely low and this was reflected in the quality of the investigation which did not culminate in a recommendation which could have been pursued with confidence.

4. The contract strategy for design was also inappropriate. A fixed price was sought for the first stage of design which, due to the limited scope of the feasibility study, was subject to a high degree of uncertainty. In these circumstances it is possible to work to a tendered price by sacrificing quality.

5. The choice of contract strategy appears to have been influenced by national guidance which although acknowledging the need for flexibility in relation to uncertainty also strongly emphasised the desirability of fixed prices.

6. The appointment of 2 consultants to undertake different aspects of the design fudged the issue of responsibility, introduced additional lines of communication and imposed a responsibility on NRA staff to coordinate the work of consultants. The potential for misunderstanding was high and was realised in the case of the South East Cell sluice.

2.3 Of the 3 areas of significant additional expenditure it is likely that Arup have a liability in respect of 2; the infilling of the lagoons and the construction of the additional sluice in the South East Cell.

Although the geotechnical investigation and design relevant to the lagoons is suspect, it is likely that a solution identified during design would have been similar to that adopted during construction and hence similar costs would have been incurred. Although some saving could reasonably have been expected had the work been specified and billed at tender stage, the potential benefit of advance planning is impossible to quantify and substantiate at this stage.

With regard to the South East Cell sluice, although design objectives were not specified and agreed by consultees, there is evidence that Arup were made aware of the dangers inherent in raising the sluice invert level but they failed to appreciate the consequences and made a positive decision to alter the status quo. It is likely therefore that Arup are liable for the cost of the additional sluice despite the blurred contractual position arising from the appointment of separate environmental and engineering consultants. It is unlikely that EMC would attract any liability.

In the light of last minute objections by the Port Authority to the planned use of the emergency access road, it is not surprising that additional traffic management costs were incurred.

2.4 First issued in October 1993, guidance contained in the Project Management PIN was not available to staff dealing with the Greatham Creek project. Although project management procedures are now well established, the project management role throughout the Authority is not well defined. The management of external contractors/consultants and choice of related forms of contract has never been properly addressed. Whilst I would not advocate central prescription there is a need to define the objectives and scope of project management and best practice in relation to contracted services.

3 Recommendations

- The project manager role should be delegated to an individual who has the authority, capability and time to manage the project.

- In line with current project management guidance, authority and accountability should be clearly allocated to project executives and managers. The executive should ideally be the project manager's line manager and he/she should empower the project manager through appropriate delegation of both authority and accountability.

- Formal quality review procedures should be adopted to ensure that functional interests are fully represented by individuals other than the project manager.

- When using the ICE6 form of contract the role of Engineer should be performed by a representative of the consultant responsible for the design of the works. Limits on the Engineer's ability to act independently should be included in the consultancy and construction contracts . Prior to certifying additional payment, the consultant should be required to consult the Authority's project manager who should be designated "Responsible Officer" in accordance with the Procurement PIN.

- Regional consultancy contract strategy should reflect uncertainty at tender stage and ensure that a feasibility study culminates in a robust recommended option.

- Rigorous vetting and performance appraisal systems should be put in place for consultancy appointments.

- Single consultancy appointments should be adopted as the norm for flood defence projects. If, exceptionally, more than one appointment is made, all consultants should report to the Authority's project manager.

- The overall objectives of design should be specified, communicated and agreed at key stages and when significant change occurs.

- Subject to legal advice, the question of liability in relation to the South East Cell sluice should be raised with Arup informally prior to considering legal proceedings.

- The Authority's project and contract management role should be reviewed and defined nationally with the intention of creating a flexible framework which encourages Regions to develop and improve Regional practice and procedures.

- The adequacy of project management resources should be reviewed paying particular attention to the Region's effectiveness in this regard.

1. INTRODUCTION

1.1 Purpose

1.1.1. The purpose of this report is to comment on aspects of the implementation of the Greatham Creek Tidal Defence Scheme in accordance with the Brief included as Appendix A.

1.2 Background

1.2.1 The review was requested by Kevin Bond, Director of Operations, following submission of a Form G application to the Board in respect of additional costs incurred during construction. The review was conducted and the report prepared by Dave Porter, Principal Project Manager, North West Region on behalf of Roger Hyde, Regional General Manager, Yorkshire/Northumbria Region. The review commenced on 9 March 1995 with the draft final report presented to Regional staff in April 1995. Total costs of approximately £10,000 have been incurred.

1.3 Project Summary

1.3.1 Greatham Creek is a tidal tributary discharging to the River Tees estuary. To the north of the creek is the town of Hartlepool and to the south are the heavily industrialised zones of Seal Sands and Teesside. The tidal reach is a meandering and embanked channel intersected by the A178 Teesside to Hartlepool trunk road dividing the site into 4 cells named in accordance with the quadrants of the compass. An emergency access road, owned by the Port Authority, divides the north east cell and provides a second means of access/egress for the refineries and chemical plants to the south of the creek in the event of blockage of the A1185. See Figures 1 and 2 and Plates 1 to 7.

1.3.2 The land adjacent to the creek generally lies below mean high tide level. Prior to construction in 1993, tidal defences comprised single and double embankments formed from a mixture of clay, sand, gravel and slag boulders. Generally, where double embankments were provided, the seaward embankment was porous having been constructed from iron works slag whilst the landward embankment provided defence against seepage and was constructed from a less porous mixture of clay, silt and sand. Lagoons were formed in the area between embankments. Single embankments were similar in construction to landward embankments but with the addition of stone pitching to the seaward face.

1.3.3 The embankments along both sides of Greatham Creek had been breached and overtopped by high tides on many occasions. Damage in the event of flooding would have been concentrated on the Tioxide plant located in the North East Cell. Less significant damage would have resulted from disruption to the A178, disruption of agriculture in all cells and

damage to control equipment for the ICI brinefields located in the South West and South East Cells.

1.3.4 The site is located in the midst of the largest area of inter tidal mudflats and saltmarsh on the east coast between the Lindisfarne National Nature Reserve to the north and the Humber estuary in the south. The Seal Sands Site of Special Scientific Interest (SSSI) is located to the east of the site whilst the Cowpen Marsh SSSI occupies the South West Cell. Part of the North East Cell has been designated as a Site of Nature Conservation Interest (SNCI) and the 2 southern cells fall within Teesside Development Corporation's proposed International Nature Reserve. The Cowpen Marsh and Seal Sands SSSI have been put forward for designation as Special Protection Areas in accordance with the Habitats Directive. The whole of the site plays an important support role in relation to designated areas.

1.3.5 A low standard of flood defence at Greatham Creek had been confirmed by the 1978 survey of land drainage functions which all Water Authorities had been required to undertake under Section 24(5) of the Water Act 1973. However uncertainty regarding benefits inhibited development of a long term solution and action was limited to the repair of defences following breaching. The problem was highlighted again by the 1990 sea defence survey following which an investigation was commissioned.

1.3.6 Prior to 1991, annual capital expenditure in Northumbria Region had averaged approximately £300,000. A scheme to improve defences at Yarm raised annual capital expenditure to approximately £1 million during 1991 and 1992. With Greatham Creek being the only other large scheme planned by the Region, a construction start in 1993 was pursued vigorously to avoid major fluctuations in the programme and hence in the flood defence levy.

1.3.7 Consultant, W S Atkins, was appointed to undertake a feasibility study following which further appointments were made to undertake the design and construction phases. Ove Arup (Arup) and Environmental Management Consultants (EMC) were appointed to review and extend the Atkins study and jointly advise the Authority of the preferred solution. Arup were to be responsible for the design and supervision of construction with EMC providing advice regarding environmental issues.

1.3.8 Arup and EMC considered five main options along with various combinations. The option selected comprised infilling of the lagoons between the twin embankments, raising of the northern embankments to the 100 year level with freeboard and strengthening and, where required, raising of the southern embankments to the 5 year level. In addition 4 existing sluices were replaced and fitted with new flap and gate valves.

1.3.9 The most significant features of the scheme were the importance of environmental factors and the number, size and nature of industrial landowners some of whom, most notably

ICI, had a significant interest in the environmental management of their land.

Maintaining access/egress in the event of an emergency was also of importance to the industrial landowners and the Port Authority.

These factors proved to be significant in the development and implementation of the project.

1.3.10 Approximately 35 organisations were consulted during the development of the project and their comments were incorporated within an Environmental Statement and contributed to the selection and design of the preferred option. The Authority and our consultants have been praised by consultees on the manner in which the consultation was managed.

1.3.11 Contractor, Hall Construction Services Ltd, was appointed in June 1993 to construct the works during an environmental window extending from June to mid September of that year. Additional costs were incurred during construction, the most significant of which comprise approximately 80% of additional expenditure and were associated with:

1. Infilling of the lagoons.

2. Use of the Emergency Access Road.

3. Construction of an additional sluice in the South East Cell.

1.3.12 A Form G application in respect of total additional costs of £323,200 was approved by the Board in January 95. However, members expressed concern regarding the reasons for the additional expenditure and agreed that an independent review should be undertaken.

SITE LOCATION

44833 FIGURE 1

GREATHAM CP

BILLINGHAM - HARTLEPOOL RAILWAY

PHILLIPS PETROLEUM

TIOXIDE EUROPE LTD PLANT

GRAYTHORP DOCK

NE CELL

ARABLE - LAND

TIP

RHM FOODS (ROUGH GRAZING)

NW CELL

GREENABELLA MARSH (SNCI)

EMERGENCY ACCESS

GREENABELLA SEA WALL

SEAL SANDS (SSSI)

ICI BRINEFIELD

SOUTH BANK WEST

NORTH BANK WEST

NORTH BANK EAST

ICI LANDFILL

LEACHATE DISCHARGE

DOUBLE BAILEY BRIDGE

EMERGENCY ACCESS ROAD

Seal Sands

North End

SOUTH BANK EAST

PIPE BRIDGE

SALT WATER LAGOON

ICI BRINEFIELD

COWPEN MARSH (SSSI)

THE LONG DRAG

Cowpen Marsh

Nature Reserve

Holme Creek

Fore Marsh

Cowpen Bewley

SE CELL

SW CELL

A1185

SEAL SANDS ROAD

LEVEL CROSSING

ICI - NORTH TEES WORKS

INDUSTRIAL (PETROCHEMICAL) AREA

N

LEGEND

EXTENT OF CONTAINMENT CELL

EXTENT OF SSSI

BRITISH RAIL RESERVATION (APPROX)

SCALE 1 : 10 000

SITE PLAN

44833 FIGURE 2

NORTH EAST CELL AND TIOXIDE PLANT - MARCH'95
VIEWED FROM GREENABELLA SEA WALL

PLATE 1.

GREENABELLA SEA WALL - MARCH'95
VIEWED FROM DOUBLE BAILEY BRIDGE
LAGOONS INFILLED WITH STONE

PLATE 2

DOUBLE BAILEY BRIDGE CARRYING EMERGENCY ACCESS ROAD – MARCH '95 VIEWED FROM NORTH BANK EAST

PLATE 3

NORTH BANK EAST - MARCH '95
LAGOONS INFILLED WITH STONE
VIEWED FROM A178

PLATE 4

SOUTH BANK EAST – MARCH'95
VIEWED FROM THE A178

PLATE 5

SOUTH EAST CELL SLUICES,RIVERSIDE - MARCH'95
ORIGINAL TWIN REPLACEMENT ON RIGHT
ADDITIONAL SLUICE ON LEFT

PLATE 6

SOUTH EAST CELL SLUICES,LANDWARD SIDE - MARCH'95
ORIGINAL TWIN REPLACEMENT ON LEFT
ADDITIONAL SLUICE ON RIGHT

PLATE 7.

2. FINDINGS AND RECOMMENDATIONS

Findings are set out in normal type with *commentary highlighted in italics* and **recommendations in bold text.**

2.1 History of Key Dates

2.1.1

Scheme included in Medium Term Plan	Oct 91
Feasibility study by Atkins	Oct 91 - Jan 92
Design Stage 1 by Arup	Jan 92 - July 92
Environmental Assessment by EMC	Jan 92 - July 92
Design Stage 2 by Arup	July 92 - June 93
Environmental Statement by EMC	July 92 - Dec 92
Construction of original design	June 93 - Oct 93
Construction of additional SE cell sluice	June 94 - Oct 94

2.1.2 The merger of Northumbria and Yorkshire Regions commenced in January 93. Paul Tullet, the Northumbria Flood Defence Manager, transferred to York in April 93 to take up his new post of Dales Area Manager. All staff were in post by October 93. The merger coincided with the last half of design and the whole of construction of the Greatham Creek project.

2.2 Authority Project Management Structure

2.2.1 Pre and post merger structures are shown in Appendix B.

Key points are:

1. Tony Hardwick was named as the project engineer. However, the environmental consultant, EMC, reported to John Hogger, the conservation officer.

2. Tony Hardwick delegated most day to day involvement to his subordinates, Richard Hackett and later Kim Andrew.

3. The role of Engineer to the Contract was retained in house by Tony Hardwick's line manager, Chris Birks then Paul Tullet and currently Dave Rooke, who also became involved on an occasional basis in the management of the project and Arup.

The above structure does not clearly allocate responsibility for the management of the project to an individual. Internally, the responsibility for coordinating the work of consultants was not clearly defined.

The nominated project engineer was unable to perform the management role without further partial delegation, was not fully responsible for environmental aspects and represented all flood defence interests.

A number of consequences flow from the retention in house of the role of Engineer to the construction contract. These are:

1. *Site supervisory staff supplied by Arup take instructions from and report to NRA staff on all aspects not delegated back to Arup staff i.e. NRA becomes responsible for the actions of Arup site staff.*

2 *The responsibility for changes to design occurring during construction may not be clear.*

3. *The potential for confusion and misunderstanding between officers, consultant and contractor is high.*

Under ICE 6, the form of contract used in this case, The Engineer is required to supervise construction, issue variations needed to complete or improve the functioning of the works, adjudicate in relation to claims and certify payment. Since there is no provision within the contract to split technical and financial responsibility, the role should be performed by an individual employed by the consultant responsible for the design of the works.

If the Region wishes to retain financial control, limits on the Engineer's ability to act independently should be included in the consultancy and construction contracts and the consultant should be required to consult the Authority's project manager prior to certifying additional payment. The Authority's project manager should be designated "Responsible Officer" in accordance with the Procurement PIN. Regional procedures should be reviewed and if necessary amended in line with the above.

The Region should ensure that the project manager role is delegated to an individual who has the authority, capability and time to manage the project.

In line with the Project Management Guidance Manual of March 1995, authority and accountability for major projects should be clearly allocated to project executives and managers. The executive should ideally be the project manager's line manager and he/she should empower the project manager through appropriate delegation of both authority and accountability.

Both project executive and manager must have sufficient time and resources to fulfill their roles.

The project manager should be responsible for the delivery of the whole project and should be impartial i.e. although he/she will probably be associated with a particular function and profession he/she should not represent functional or professional interests. Adoption of formal quality review procedures would allow others to represent functional views and would ensure in most cases that conflicts are resolved by consensus, work completed is signed off, constraints and design criteria are specified and recorded at key stages and common ownership and understanding of the way forward is achieved.

It should be noted that the first draft of the national project management procedures was produced in August 93 but was not issued as a PIN until October 93, coincident with the end of construction at Greatham Creek.

2.3 Appointment of Consultants

2.3.1 Both engineering consultants were appointed under modified versions of standard Association of Consulting Engineers forms of contract.

2.3.2 Feasibility Study

1. Atkins were appointed on the basis of a fixed price of approximately £5000.

A cost reimbursement arrangement would have been more appropriate since the work covered by the fixed fee could not be defined at the time of tender.

2. Atkins feasibility study was no more than a preliminary assessment of the problem and likely solutions and would be better described as a pre feasibility study . It did not produce a solution which the Authority could have pursued with confidence.

A feasibility study should culminate in a robust recommended option. Risk analysis should be used to test the robustness of the recommendation and to identify the scope of the feasibility study. Compliance with current project management procedures should ensure that much of this recommendation is achieved.

3. Guidance concerning the appointment of consultants was contained in the Board paper of March 1993 titled "Management of Consultants for Engineering Works" and sponsored by the Director of Water Management. This guidance was subsequently incorporated in draft versions of the Consultants Manual and the final version issued in September 1994 as Flood Defence Function PIN Vol 022. Although the guidance recommended payment on a time basis for work which could not be defined, the desirability of fixed fees was emphasised strongly and was a significant factor influencing the decision to seek a fixed fee.

Regional project management and procurement procedures should be reviewed and a consultancy contract strategy developed which reflects uncertainty at tender stage and ensures that a feasibility study culminates in a robust recommended option.

Relevant national guidance should be reviewed with the intention of encouraging Regions to develop and improve Regional contract management procedures and capability within a flexible national framework.

2.3.3 Design Stages 1 and 2 and Supervision of Construction - Engineering Consultant

1. I could find no evidence of formal procedures covering the formation of a select list. The reasons underlying the choice of firms are not clear although I understand preference was given to firms based in the North East.

In the absence of rigorous selection procedures. the risk of an inappropriate choice of consultant and consequent poor performance is high. However, although vetting procedures and performance information are now generally available this was not the case during the life of the Greatham Creek project.

2. Design Stage 1 is intended to constitute a review of the outcome of the feasibility study prior to committing substantial resources to the detailed design of the preferred option. In this case Design Stage 1 became a feasibility study in its own right in order to compensate for the limited scope of the Atkins study.

3. A fixed price was required for Design Stage 1 whilst the fee for detailed design (Stage 2) was based on a percentage of final works cost.

The fee structure for Design Stage 1, which was subject to a high degree of uncertainty, was not appropriate.

4. Limited experience of similar work, both for the firm and the individuals put forward by Arup, was highlighted in the tender report. However Arup's price was the lowest submitted and the report concluded that NRA rules were not sufficiently flexible to allow acceptance of a higher offer.

5. Although I cannot be certain, I believe Arup's inexperience of similar flood defence work contributed significantly to problems surrounding the loss of fill material in the construction of embankments and the requirement to construct an additional sluice in the South East Cell - see sects 2.5 and 3. In the case of embankment fill, they did not appreciate the practical difficulty of placing fill in soft ground whereas over reliance on the views of environmental consultees contributed to the cause of inappropriate design of the original South East Cell sluice.

Technical capability should be assessed prior to formation of a select list. Only consultants capable of performing the task, and ideally only the best consultants, should be invited to tender. A distinction needs to be drawn between a high level of technical knowledge (as undoubtedly possessed by Arup) and previous experience of the tasks to be undertaken (not possessed by Arup)

The Region should review procedures to ensure that rigorous vetting and performance appraisal systems are put in place for consultancy appointments.

Whilst it is essential to set targets and manage cost and time it is equally important to select contractual arrangements, payment terms and management techniques which are appropriate to particular circumstances. In this case I believe too much emphasis was placed on the desire to obtain fixed prices and completion within rigid and tight timescales. The bulk of the work performed by Arup could not be defined at tender stage and hence could not be priced with a reasonable degree of certainty. Inability to pre define work also means that there is no absolute measure of performance and hence it is always possible to work to the tendered price by sacrificing quality. Although there is no evidence to suggest that this was an issue, it is a point worth considering in relation to future projects.

2.3.4 Design Stages 1 and 2 and Supervision of Construction - Environmental Consultant

1. Environmental Management Consultants, a subsidiary of Bullen and Partners, were appointed to undertake environmental assessment (EA), produce an Environmental Statement and provide advice.

I understand the reason for a separate appointment was to ensure that independent environmental advice was obtained. However a separate appointment fudges the issue of responsibility, introduces additional lines of communication and imposes a responsibility on NRA staff to coordinate the work of the consultants. The argument concerning independence is weakened by the fact that both consultants are paid by the Authority. In this case, the South East Cell sluice problem may well have been avoided had a single appointment been made.

I believe the difficulty of coordinating the work of the engineering and environmental consultants was exacerbated by the arrangement whereby each consultant reported to a different NRA officer and that the nominated officers delegated some but not all of the role to subordinates.

Communication could not have been helped by the geographic base of the consultants; Arup staff were based at Newcastle whilst EMC staff were based at Newmarket, Suffolk. Internal procurement rules and legislation make it difficult to avoid such circumstances and this provides further argument for a single appointment.

Regional contract strategy should aim to establish adoption of single consultancy appointments as the norm. If, exceptionally, more than one appointment is made, all consultants should report to the Authority's project manager - see Cl 2.2.1.

2.3.5 It is worth noting that a draft report of an internal review of Design Stage 1 undertaken in July 92 by Richard Hackett, immediately after completion of this stage, concluded that:

1. Internal liaison was poor particularly with departments not directly involved in the project e.g. Environmental Quality.

2. A single consultancy appointment would have improved liaison and coordination and suggested that this arrangement should be adopted in future. However John Hogger disagreed on the grounds that consultants with appropriate expertise are required.

3. The programme was tight but realistic. However John Hogger thought that timescales were too tight in relation to the extent of consultation required.

4. Initial reservations regarding Arup's inexperience of flood alleviation schemes were fully satisfied by the appointment of Ian Whittle as a sub consultant.

2.4 Contractual Issues

2.4.1 Arup Brief

1. The Atkins study was not made available to tenderers. I understand that limited confidence in the economic appraisal was the reason for witholding the report.

All information should be made available and qualified where appropriate.

2. The engineering consultant was made aware of the appointment of an environmental consultant and was required to establish intimate liaison with that consultant for the purpose of estimating benefits, costs and jointly advising the Authority of the preferred solution (Cl 2.1.3).

3. The engineering consultant was to be responsible for Site Investigation (Cl 3.1.2).

4. The engineering consultant was required to obtain information on environmental impact from the environmental consultant (Cl 3.1.8/9) who would be responsible for consultation with environmental bodies (Cl 4.1).

5. An Environmental Statement prepared by the environmental consultant was to be appended to the engineering consultant's Design Stage 1 report.

6. The engineering consultant was required to supply site supervisory staff but the NRA would provide the Engineer to the construction contract.

7. The NRA project engineer would have overall control of the project and would arrange monthly progress meetings for the purpose of coordinating the work of the consultants.

Item 2 seeks to make the engineering consultant responsible for establishing liaison with the environmental consultant for the purpose of identifying environmental issues pertinent to development and design of a preferred option. Subsequent clauses (item 4) place the responsibility for consultation with environmental bodies with the environmental consultant and appear to allow the engineering consultant to rely on the advice of the environmental consultant i.e. the engineering consultant does not appear to have a clear responsibility for identifying environmental constraints which impinge on his design responsibility. This is of relevance to the additional costs incurred in relation to the South East Cell sluice - see sects 4.5 and 5.

2.4.2 EMC Brief

1. The Atkins study was not made available to tenderers (Cl 2.3).

All information should be made available - see 2.4.1.

2. The executive summary of an ecological desk study undertaken in 1991 was made available to tenderers (Cl 2.3).

3. Design Stage 1 objectives defined in the Brief were (Cl 3.1):

   a. undertake a detailed assessment of the environmental implications of proposed engineering works.

   b. ensure that all relevant environmental issues are fully considered in selection of the preferred option.

   c. produce an EA report which could be published as an Environmental Statement.

   Associated key tasks were:

   a. Appraise proposed engineering solutions for environmental constraints, predict environmental impacts and identify mitigation measures.

   b. Collate information, determine the scope of the EA and prepare the report.

c. Propose and cost environmental enhancements which could be incorporated within the scheme.

d. Consult all relevant statutory bodies and interest groups to ensure overall public support.

e. Establish and maintain an intimate liaison with the consulting engineer in order to estimate benefits, costs and jointly advise the Authority of the preferred option.

4. Design Stage 2 objective was to advise the NRA and the consulting engineer on incorporation of measures to mitigate environmental impacts and enhance environmental interests as identified at Stage 1 (Cl 4.1).

Associated key tasks were (Cl 4.2):

a. Liaise with the consulting engineer to ensure incorporation of mitigation and enhancement measures identified at Stage 1 and in association with the consulting engineer prepare detailed designs, specification and bill of quantities.

b. Assist in obtaining approvals, completing design and liaise and advise during construction.

5. A summary of the known improvement options was provided and the consultant was given freedom to define the scope of the EA although minimum requirements were stated (Cl 5.1 and 5.2).

6. The environmental consultant was required to assess the impact of engineering options on environmental features and assess the financial value of benefits and dis-benefits (Cl 5.3).

7. External consultation was required as part of the EA; it may be inferred that this was intended to be the responsibility of the environmental consultant but this was not expressly stated (Cl 6.1).

8. Cl 6.2 deals with liaison. Tenderers were informed that monthly progress meetings involving NRA, engineering and environmental consultants and possibly external organisations would be arranged by the project engineer who would exercise overall control of the project.

Tenderers were also informed that close liaison between the environmental consultant and the consulting engineer would be expected and that regular liaison

would be required with the Authority's Conservation and Recreation Officer.

9. A fixed price was required for Design Stage 1 work whilst time based payment would apply to Design Stage 2 work at rates to be agreed at the commencement of Stage 2.

10. At Design Stage 1, the environmental consultant was required to ensure that environmental issues were considered, predict and assess the impact of proposals and undertake all necessary liaison and consultation needed to achieve these aims. The environmental and engineering consultants were responsible jointly for advising the Authority of the preferred option. At Stage 2 the environmental consultant was required to advise the NRA and consulting engineer of mitigation and enhancement measures and again to undertake all necessary liaison and consultation.

Whilst the above conditions clearly impose a responsibility to ensure that the Authority and consulting engineer are fully aware of the environmental impact of proposals developed by the consulting engineer, I believe it would be unreasonable to expect the environmental consultant to predict the behaviour of engineering works. I believe the environmental consultant would be entitled to rely on the advice of the consulting engineer in this regard to allow environmental impact to be assessed.

The environmental consultant is required to develop and recommend in conjunction with the consulting engineer a preferred option. Accountability under such an arrangement is not straightforward. Also, there is no mechanism, other than intervention by the Authority, to deal with conflict and there is considerable scope for misinterpretation. A single appointment would avoid such risks.

Recommendations outlined in Section 2.3, Appointment of Consultants, should be adopted.

2.5 Technical Issues

2.5.1 Use of the Emergency Access Road

1. Consultation with landowners was extensive and protracted. Landowners, and the Port Authority in particular, were extremely concerned about maintaining operational and emergency access to industrial plants during construction. At the last minute, the Port Authority objected to the planned use of the emergency access road. Intensive consultation involving the Authority's Estates Officer then took place culminating in an agreement in line with the original proposal.

Whilst ideally and in most circumstances traffic management arrangements would be

agreed during design, in the circumstances of this case it is not surprising that these details were not agreed at this time.

2.5.2 Raising and strengthening of embankments

1. Defences comprised of double embankments were to be raised by infilling the intervening lagoons with stone. During construction it became apparent that due to compression of the soft upper strata of the lagoon beds more stone fill than had been anticipated would be required. Further additional costs were incurred in dressing of the bulk fill with fine stone prior to placing of the geotextile.

2. Based on Arup calculations supplied to NRA following the meeting of 27 April 1992, geotechnical design and investigation appears to have concentrated on an assessment of the stability and resistance to sliding of embankments and the potential for seepage and internal erosion (N.B. I have not contacted Arup)

3. Site investigation consisted of trial pits which Arup have confirmed were excavated on the landward side of or within the original embankments. Ground conditions in the lagoons were not investigated and I could not find any evidence to suggest that the consequences of placing stone fill directly on the soft upper strata within the lagoon was examined.

The penetration of the stone fill into the soft strata within the lagoons should have been anticipated by Arup during design.

The omission of the fine stone dressing prior to placing of the geotextile appears to have been an oversight on the part of Arup. The NRA report accompanying the Form G application mentions that the use of geotextiles is comparatively new; I cannot agree. Arup should have been aware of the need for a stone dressing.

The associated 25 year guarantee, also mentioned in the Form G report is of dubious value since failure, if it occurred, could probably be attributed to numerous causes falling outside the scope of the guarantee. The guarantee in itself does not justify the additional expenditure; stone dressing to allow placement of the geotextile does provide adequate justification.

2.5.3 South East Cell Sluice

1. The potential for environmental enhancement through controlled inundation of the South East Cell was noted in the EA report and, subsequently, the Environmental Statement. Enhancement was to be achieved through inclusion of a mechanical gate in the sluice structure in place of a tidal flap. Hence inundation could be controlled in circumstances when the tidal flap would have closed. Enhancement

as opposed to maintenance of the status quo appeared to be the main goal of environmental consultees and this was reflected in the tone of EMC's reports.

2. Design criteria appear to have been developed by Arup following discussion with NRA staff, EMC and environmental consultees.

In essence the sluice was designed to evacuate water overtopping the defence during an extreme event prior to the next tidal peak. The design invert level of the sluice appears to have been raised following a meeting on 18 September 1992 with NRA staff and EMC. At the meeting Arup were asked by NRA to consider raising the invert level for safety reasons associated with access subject to the status quo being maintained.

Arup evidently decided to raise the invert by approximately 1 metre to allow safer access for maintenance as stated in their "Engineer's Report" to MAFF of January 93. However it is not clear how they expected the status quo to be maintained in these circumstances. Although the new sluice would have realised the anticipated enhancement by allowing increased saline inundation of the landward pool, inevitably there would also be greater fresh water inundation during periods of rainfall since discharge could not occur until water had reached the raised invert level. This should have been obvious to ARUP and arguably NRA staff.

The question of whether NRA project managers should be expected to identify defective design produced by external consultants raises a number of issues which go beyond the scope of this investigation.

Other high risk areas (mainly commercial) where consultants are weak and checking can profitably be undertaken without a substantial increase in resources may well benefit from such checking - see sect 4, Observations.

3. Once the fresh water problem had arisen, further information came to light. In their letter of 20 April 1994 to Gavin Alexander of Arup, ICI refer to a meeting on 16 April 1993 with Arup and INCA (an environmental group linked to industry) where ICI claim that they expressed concern that the higher invert levels for the new sluices may result in higher levels of water in the ditches across the site but that Arup had reassured them that this would not happen.

Again after the event and in response to NRA queries, Arup contacted Gavin Alexander who had by now moved to New Zealand. He confirmed that ICI's claims were correct and that his attention had been focused on enhancement opportunities and that he had not examined the normal operating condition. Despite this he also confirmed that at the time of the ICI meeting he did not believe that water levels would rise substantially across the site but did not give

a reason for his belief.

In response to post event Arup queries, EMC confirmed that the overall preference of the conservation lobby was for more water in the SE Cell as opposed to maintenance of the status quo. In response to Tony Hardwick, EMC state that they were informed by Arup that the invert level would be raised but understood that this would not result in a larger body of water. They also state that their role was to assess environmental impact which did not encompass agreement of design details with landowners.

Design criteria for the South East Cell sluice were not clearly identified. However there was considerable discussion of the desired outcome at a variety of forums involving different people at different times. As a result it appears that the parties involved each had slightly differing perspectives of the objectives to be achieved by the replacement of the South East Cell sluice. These differences only became apparent after the new sluices had been constructed and actual performance could be assessed.

It is notable that before undertaking remedial work all parties agreed success (or design) criteria. It should also be noted that design criteria for the other sluices were not clearly defined but in these cases the invert level was not changed and hence the status quo was maintained.

Regional procedures should be reviewed to ensure that the overall objectives of design are specified, communicated and agreed at key stages (at least the end of Design Stage 1) and when significant change occurs.

4. The remedial works (construction of an additional sluice) were ordered as a variation during the Defects Correction Period after substantial completion had been certified by the Engineer. The contractor was instructed to undertake the work at tendered bill rates and has subsequently notified his intention to claim a higher rate.

ICE 6, unlike earlier forms of contract, deals specifically with variations issued during the Defects Correction Period. The variation can be ordered legitimately under Clause 51. Clause 52(1) states that where a variation is ordered in these circumstances billed rates shall be used as the basis for valuation only so far as may be reasonable failing which a fair valuation should be made. In this case I believe the use of bill rates to be unreasonable since these penalise the contractor for circumstances falling outside his control.

Arup's advice regarding the cost of the remedial works was poor. Their initial estimate has been increased substantially following the contractor's claim.

3. CONSULTANT LIABILITY

Recommendations are highlighted in bold.

3.1 Regarding the additional stone fill required to provide a stable foundation in the lagoon area, I could find no evidence that Arup considered this risk during design. I believe the risk should have been evident from an inspection of the site and the geotechnical investigation should have encompassed some form of penetration test within the lagoon area.

Had the risk been identified at design stage it is likely that the solution would have been similar to that adopted during construction and hence similar costs would have been incurred. Some saving could reasonably have been expected had the work been specified and billed at tender stage rather than reimbursed during construction on the basis of volumes delivered to site where the incentive to minimise cost is low and the risk of corruption high. However the potential benefit of advance planning is impossible to quantify and substantiate at this stage.

Although I believe Arup to be negligent on this count, there seems little point in pursuing legal proceedings when the Authority would struggle to identify a loss. If however legal proceeding are to be pursued specialist geotechnical and legal advice would be required to support the above view.

3.2 Regarding the South East Cell sluice, I do not believe the contractual position is clear. Although the Brief required Arup to liaise with the environmental consultant for the purpose of jointly advising the Authority of the preferred solution it also required the engineering consultant to obtain environmental information from the environmental consultant. The Brief also informed Arup that the Authority's project engineer would have overall control of the project and would organise progress meetings for the purpose of coordinating the work of the consultants.

With the benefit of hindsight, the position would have been clearer had Arup been required to identify all constraints and design accordingly in addition to being informed of the appointment of an environmental consultant to undertake environmental assessment. Ideally a single appointment would have been made.

In practice Arup did not rely exclusively on EMC and sought information from numerous sources including environmental consultees. During this process they were made aware of the dangers inherent in raising the sluice invert level but they failed to appreciate the consequences and made a positive decision to alter the status quo. In these circumstances it could be argued that they were in breach of their common law duty of care and would thus be liable for the resultant additional cost.

Although legal advice would be required to confirm the above views, I would recommend raising the question of liability in relation to the South East Cell sluice with Arup informally prior to considering legal proceedings. Their performance in relation to infilling of the lagoons could be used in negotiation.

4. OBSERVATIONS

Recommendations are highlighted in bold

4.1 The project management role throughout the Authority is not well defined. Although the new project management procedures clarify some aspects of internal arrangements, the management of external contractors/consultants and choice of related forms of contract has never been properly addressed. Consequently it is not surprising that practice will vary between Regions, Areas and even offices. Whilst I would not advocate central prescription there is a need to define the objectives and scope of project management and best practice in relation to contracted services. This may be achieved through the "Strategic Review of Contract Letting Procedures", the market testing review of capital programme management or the Design and Contracts Group. My own opinion is that in this regard sufficient and adequately qualified and experienced in house resources should be available to identify and manage high risk activities, defined from an Authority perspective, and/or areas where external service providers are weak. However it is essential that the individuals involved are able to perform this role without creating a contractual liability. I believe this is best achieved by reviewing and questioning the work of external contractors without being drawn into creative or detailed aspects of design and construction which tends to lead to an inability to see the wood for the trees. My experience suggests that this role is seldom performed within the Authority and that undue reliance is placed on the advice of consultants in areas where consultants generally are weak.

The Authority's project management role should be reviewed and defined nationally - see also Cl 2.3.2. Regionally, the adequacy of project management resources should also be reviewed paying particular attention to effectiveness in this regard.

5. CONCLUSIONS

5.1 In terms of engineering, the Greatham Creek project was quite straightforward. However the project was made complex by the nature of the site and the extent of consultation required to identify and implement a solution.

5.2 On the whole, the consultation process was well managed and the Authority and our consultants were publicly congratulated by the major consultees.

5.3 Aspects of the Authority's management of the project, however, could have been better. These comprise the following inter related structural, procedural and project specific factors.

1. Responsibility for the management of the project was not clearly allocated to an individual. Effectively, the role was split between the Projects Engineer, an assistant reporting to the Projects Engineer, the Conservation and Recreation Officer and the Flood Defence Manager. Additionally the contractual role of Engineer to the construction contract was performed by the Flood Defence Manager.

   The Projects Engineer was nominated as project engineer but was unable to perform the management role without further partial delegation, was not fully responsible for environmental aspects and represented all flood defence interests.

   The project manager role is weakened when he/she is the sole representative of a particular function. This arrangement probably contributed to the decision to separate the management of environmental and engineering matters.

   Under the above arrangement the potential for confusion and misunderstanding between officers, consultant and contractor is high. The responsibility for changes of design during construction and for the actions of site based staff may not be clear.

   Retaining the contractual role of Engineer in house at a high level undermines the project management role and confuses the line of accountability.

   On balance, the responsibility for managing the project was not clearly defined.

2. In line with common practice at the time, select lists for both the feasibility study and design stages appear to have been formed without the benefit of vetting and performance appraisal procedures. As such the risk of employing inappropriate consultants was high and was realised in the case of Arup whose previous relevant experience was very limited. Lack of relevant experience on the part of Arup was

probably a significant contributory factor to the problems which arose during construction.

3. The contract strategy adopted for the feasibility study was inappropriate. A fixed price was sought for work which could not be defined. Prices tendered were extremely low and this was reflected in the quality of the investigation which did not culminate in a recommendation which the Authority could have pursued with confidence.

4. The contract strategy for design was also inappropriate.

In order to compensate for the limited scope of the feasibilty study, Design Stage 1, which is intended to constitute a review of the outcome of the feasibility study, became a feasibility study in its own right. As such the work was subject to a high degree of uncertainty but nevertheless a fixed price was sought. Inability to pre define work also means that there is no absolute measure of performance and hence it is always possible to work to the tendered price by sacrificing quality.

In addition to Arup's appointment to undertake design EMC were appointed to undertake an environmental assessment and in conjunction with Arup to advise the Authority of the preferred option. Separate appointments fudged the issue of responsibility, introduced additional lines of communication and imposed a responsibility on NRA staff to coordinate the work of consultants. The potential for misunderstanding was high and was realised in the case of the South East Cell sluice.

The belief that engineering and environmental issues should be separated also contributed greatly to the lack of clarity in the Authority's project management structure - see 5.3 item 1.

5. In each case the choice of contract strategy appears to have been influenced by national guidance which although acknowledging the need for flexibility in relation to uncertainty also strongly emphasised the desirability of fixed prices.

5.4 Of the 3 areas of significant additional expenditure it is likely that Arup have a liability in respect of 2; the infilling of the lagoons and the construction of an additional sluice in the South East Cell.

Although the geotechnical investigation and design relevant to the infilling of lagoons is suspect, it is likely that a solution identified during design would have been similar to that adopted during construction and hence similar costs would have been incurred. Although some saving could reasonably have been expected had the work been specified and billed at tender stage, the potential benefit of advance planning is impossible to quantify and

substantiate at this stage.

With regard to the SE Cell sluice, although design criteria were not specified and agreed by consultees, there is evidence that Arup were made aware of the dangers inherent in raising the sluice invert level but they failed to appreciate the consequences and made a positive decision to alter the status quo. It is likely therefore that Arup are liable for the cost of the additional sluice despite the blurred contractual position arising from the appointment of separate environmental and engineering consultants. It is unlikely that EMC would attract any liability.

In the light of last minute objections by the Port Authority to the planned use of the emergency access road, it is not surprising that additional traffic management costs were incurred.

5.5 First issued in October 1993, guidance contained in the Project Management PIN was not available to staff dealing with the Greatham Creek project. Although project management procedures are now well established, the project management role throughout the Authority is not well defined. There is a need to define the objectives and scope of project management and best practice in relation to contracted services.

SUMMARY OF RECOMMENDATIONS

Rec No	Report Para No	Recommendation	Management Comments and Action	Officer Responsible	Implementation Target Date
1	2.2.1	The Region should ensure that the project manager role is delegated to an individual who has the authority, capabilty and time to manage the project.			
2	2.2.1	In line with the Project Management Guidance Manual of March 1995, authority and accountability in respect of major projects should be clearly allocated to project executives and project managers. Ideally the executive should be the project manager's line manager and he/she should empower the project manager through appropriate delegation of both authority and accountability. The Region should ensure that both executive and manager have the time and resources to fulfill their roles.			
3	2.2.1	The Region should adopt formal quality review procedures to ensure that relevant functional interests are fully represented by individuals other than the project manager.			
4	2.2.1	When using the ICE6 form of contract, the Region should ensure that the role of Engineer is performed by a representative of the consultant responsible for the design of the works. Limits on the Engineer's ability to act independently should be included in the consultancy and construction contracts. Prior to certifying additional payment, the consultant should be required to consult the Authority's project manager who should be designated "Responsible Officer" in accordance with the Procurement PIN			
5	2.3.2	Regional project management and procurement procedures should be reviewed and a consultancy contract strategy developed which reflects uncertainty at tender stage and ensures that a feasibility study culminates in a robust recommended option.			
6	2.3.3	The Region should ensure that rigorous vetting and performance appraisal systems are put in place for consultancy appointments.			

7	2.3.4	Regional contract strategy should aim to establish adoption of single consultancy appointments as the norm for flood defence projects. If, exceptionally, more than one appointment is made, all consultants should report to the Authority's project manager.			
8	2.5.3	Regional procedures should be reviewed to ensure that the overall objectives of design are specified, communicated and agreed at key stages (at least the end of Design Stage 1) and when significant change occurs.			
9	3.2	Subject to legal advice, the question of liability in relation to the South East Cell sluice should be raised with Arup informally prior to considering legal proceedings.			
10	2.3.1 and 4.1	The Authority's project and contract management role should be reviewed and defined nationally with the intention of creating a flexible framework which encourages Regions to develop and improve Regional practice and procedures.			
11	4.1	The adequacy of project management resources should be reviewed paying particular attention to the Region's effectiveness in this regard.			

APPENDIX A

THE BRIEF

Following concerns expressed by the Board in relation to the Form G application of January 95, it was agreed that a review of the project would be carried out by Dave Porter of North West Region.

The review will address the following:

1. The concern of Board members regarding the reasons for the most significant items of additional expenditure, namely:

   a. Infilling of the lagoons.
   b. Use of the Emergency Access Road.
   c. Construction of an additional sluice in the south east cell.

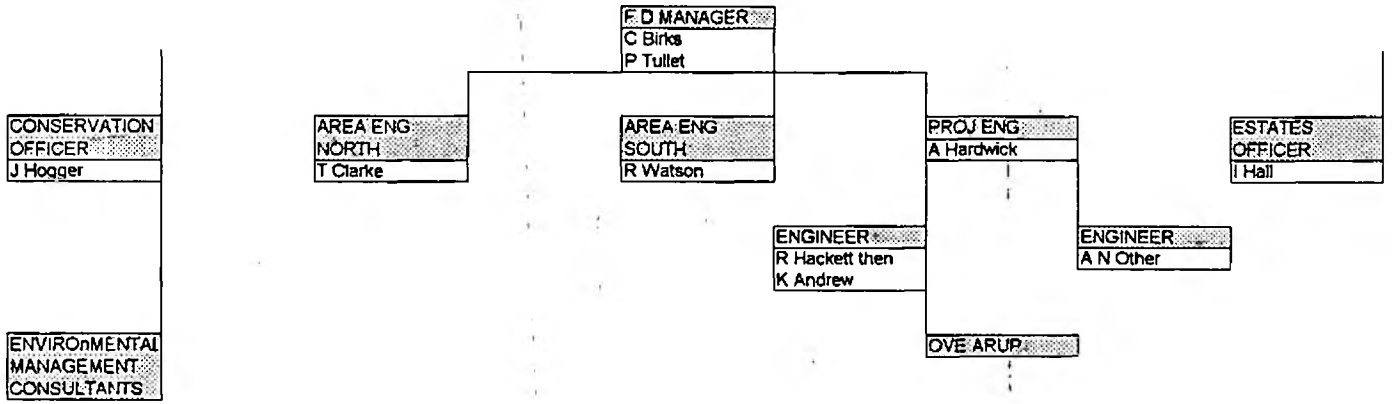
2. Project specific and other factors which may have had a bearing on the effectiveness of the Authority's management of the project.

3. Liability of consultants in respect of additional construction cost.

4. Recommendations regarding the management of major projects.

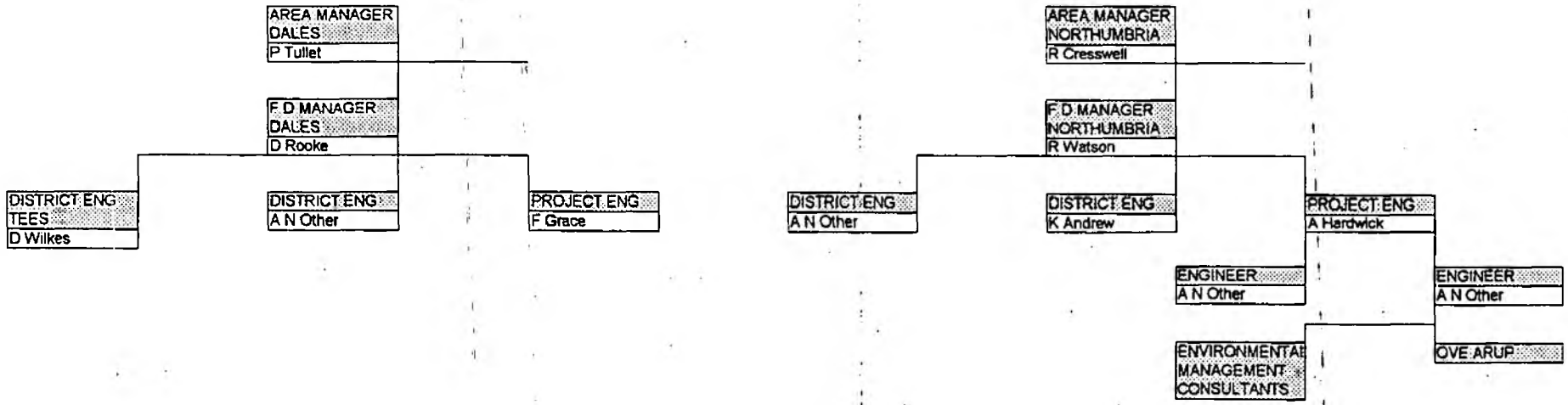
REVIEW OF GREATHAM CREEK TIDAL DEFENCE SCHEME
SUMMARY OF INTERIM FINDINGS/RECOMMENDATIONS AND OBSERVATIONS
APPENDIX B - STRUCTURES
Prepared for the Purposes of Legal Proceedings

PRE MERGER STRUCTURE



Merger commenced Jan 93 and was effective from Oct 93, coincident with completion of construction.
P Tullet involved in merger. T Clarke available to perform "Engineer" role but was not required to act.

POST MERGER STRUCTURE



D Rooke now acting as "Engineer" to whom A Hardwick reports in respect of the Greatham Creek project.
Estates Officer, I Hall, transferred to Leeds.
Conservation Officer, J Hogger, takes up new post as Area Business Services Manager.

Ref GC010495

APPENDIX C

STAFF CONSULTED

I am grateful for the assistance of the following staff when undertaking the review.

Mr A Hardwick, Projects Engineer, Northumbria Area
Ms K Andrew, Flood Defence District Manager, Northumbria Area
Mr R Watson, Flood Defence Manager, Northumbria Area
Mr P Tullet, Dales Area Manager
Mr D Rooke, Flood Defence Manager, Dales Area
Mr G Greenlay, Business Services Manager
Mr R Hyde, Regional General Manager

REFERENCES

Documents

W S Atkins Feasibility Report of December 1991
Authority Engineering Brief
Authority Environmental Brief
Report to Tender Board on appointment of Arup and EMC of April 1992
EMC Environmental Consultation Document of April 1992
Ove Arup Stage 1 Design Report of June 1992
EMC Environmental Assessment Report of 30 June 1992
Allied Exploration and Geotechnics Ltd Ground Investigation Report
EMC Environmental Statement of December 1992
Documents submitted to MAFF prior to an application for approval, dated October to December 1993
Arup Engineer's Report to MAFF of January 1993
Arup report concerning the South East Cell sluice design of July 1994
Form G Board Report of January 1995

Engineering Project Files:

CW803/1 file numbers 1 to 3.
CW803/3
CW803/5 file numbers 1 to 2
CW803/7
CW803/8
CW803/17
Finance file
South East Bank Sluice 1 and 2.

Conservation Project Files

Greatham Creek FDS File 1, 08.05.8
Greatham Creek FDS File 2, 08.05.8
John Hogger copies of environmental correspondence - CW/803/8

NRA

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North West Region

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