Government of the People's Republic of Bangladesh
Bangladesh Water Development Board

River Training Studies of the Brahmaputra River

Master Plan Report

1994

Technical Annexes
Annex 5
Operation and Maintenance

Sir William Halcrow & Partners Ltd.
in association with

Danish Hydraulic Institute
Engineering & Planning Consultants Ltd.
Design Innovations Group

HALCROW

Government of the People's Republic of Bangladesh
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FOREWORD

The BRTS Master Plan Report was issued on 28 June 1993. Comments from BWDB and FPCO were received from July 1993 onwards, and responses to those comments were issued in a single volume on 7 March 1994. The report was approved at the 20th FAP Technical Committee Meeting on 9 August 1994 subject to certain amendments. The amendments have duly been incorporated and the report was reissued in its present form in December 1994.

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RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER

MASTER PLAN REPORT

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GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
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1. INTRODUCTION

The study Terms of Reference require that recommendations be made for the operation and maintenance of the river training works proposed under the Master Plan.

During the World Bank Pre-Appraisal Mission, in April 1992, the consultants were requested to prepare outline proposals for the Operation and Maintenance requirements to be built into the River Bank Protection Project, in preparation for the final appraisal scheduled for July 1992. In particular, in paragraph 55 of the Aide Memoire, dated 11 April 1992, the consultants are asked to expedite issue of:

> (vi) a nominal list and cost estimate of specialized monitoring and maintenance equipment that may be procured for BWDB under the proposed project;
>
> (viii) revised budget estimates of recurrent maintenance expenditure that may be incurred during the first five years after construction and "guesstimate" for the later period.

This is of considerable importance to the Master Plan in that the first works to be implemented will be the Priority Works, and it is self-evident that the arrangements made for the monitoring, operation and maintenance of those works will form the basis of the expanded arrangements which will be required as river training works are constructed at new locations.

In so far as the river training works are passive structures, no operation of them is required, and the term is used only in its accepted and conventional sense to indicate activities in the post-construction period. The only part of the project where operation, as it is usually understood, is required is in the operation of the regulating structures along the BRE.

In the context of the river training works, the concept of monitoring is of much greater significance, with regard both to the performance of the structures themselves and to changes in river planform in the vicinity which may affect the security of the structures.

Consideration has been given to the setting up of a monitoring and maintenance unit within BWDB, and to the alternative suggestions of extending the construction contract to a number of years of maintenance by the construction contractor, or to letting an entirely separate maintenance contract (see Appendix A). It is concluded that the preferable course is to institute a monitoring and maintenance unit within BWDB. Monitoring, as distinct from maintenance, should in all cases remain the responsibility of the BWDB.

Cost estimates of the maintenance work, as required by the Terms of Reference, are given in this report, and form the basis of the operation and maintenance costs used in the Economic Assessment (Annex 2 to the Master Plan Report).

2. THE MONITORING AND MAINTENANCE TASKS INVOLVED

The responsibilities of the BWDB unit will fall into two main categories:

(i) Monitoring

(a) monitoring the performance of the structural works, including the stability of the armour layer, the deformation of the apron and the stability of earthworks.

(b) Monitoring river planform changes, particularly in the close vicinity upstream and downstream that may have an impact on the security and effectiveness of the works.

(c) Monitoring flow velocities, water levels and channel geometry, in the vicinity of the works, at least four times a year.

(d) Preparing monthly reports and an annual summary report covering these subjects; the annual report will contain a review of priorities for further investment and identify any constraints that may be adversely affecting the effective operation of the unit.

(ii) Maintenance

(a) Carry out routine preventative maintenance of the structural works

(b) Carry out any additional bank stabilization measures that may become necessary as a consequence of extreme or unexpected morphological conditions or the more rapid development of bank erosion upstream or downstream than anticipated. Such works would be in the nature of emergency measures but carried out to established engineering specifications, to hold the situation until contractors can be mobilized to construct any permanent additional works required.

(c) Maintain specified minimum levels of stocks of construction materials, fuels, precast units and operational plant at strategic locations for rapid deployment as required.

Some circumstances leading to (b) that could be envisaged are:

- exceptionally high velocities due to a rare combination of conditions that displace some of the armour layer;
- exceptionally deep scour at the toe of the revetment that results in some local slope failure;
- localized slumping of the armoured slope due to severe earthquake effects;
- the development of an unusually severe embayment upstream of a hard point that threatens the cross-bar.

3. PLANT AND EQUIPMENT REQUIREMENTS

Plant and equipment requirements fall into the following categories:

- Monitoring of river parameters such as directional velocity measurements, general bathymetric survey.

- Monitoring of structural performance, which will require more detailed and accurate survey above and below water level to identify and quantify armour movement and slope deformation. The same equipment would be suitable for monitoring the placement of materials in the course of the remedial work.

- Position fixing equipment of sufficient accuracy for each task, suitable for both monitoring and remedial work.

- Land and water transport adequate for carrying out the survey work at all times of the year.

- Interpretation of aerial photography and satellite imagery, particularly for large scale planform monitoring.

- Land facilities for loading, offloading, storing and stockpiling construction materials.

- Water transport and floating plant for the movement of armour and other materials to the construction site and their controlled placement for both routine and urgent remedial work. This must be capable of operation at all river stages.

- Facilities for holding floating plant in position while placing or dumping material.

Specific requirements for each of the tasks identified above are:

(i) <u>Monitoring</u>

(a) Structural Performance Monitoring

Above water level the survey will be by conventional theodolite and levelling techniques or plane tabling. Regular traverses along fixed lines before and after each monsoon will identify any subsidence/slumping and movement of marked armour blocks.

Local bench marks to be checked at intervals of not more than five years by second order levelling to the nearest national bench mark.

Below water level echo sounder traverses to be carried out along fixed lines at the same frequency as for the above water line survey. Any areas of apparent movement to be investigated using side scan sonar equipment and diver reconnaissance. Areas of unusually deep scour to be similarly inspected. The deformation of the apron to be particularly closely monitored.

Position fixing accuracy must be as good as possible, better than 1m is the order required to pick up incipient failures. Since the distance out from the bank is not very great and velocities outside the monsoon period will not be too high, it may be feasible to use a tag line fixed between a monument on the bank and a moored vessel; a small boat equipped with the echo-sounder then follows this line. It would still be necessary to check the position of the boat at intervals using a land based EDM, or similar equipment.

The more accurate position fixing system such as manufactured by Racal and Motorola will be required in higher flows although they are costly and require specialist servicing.

(b) River Planform Monitoring

The bankline 10 km upstream and 5 km downstream of all bank stabilization works to be surveyed by land based techniques at least twice while the river is within bank and twice while it is out of bank. In reaches where active erosion is taking place the frequency to be increased to monthly during the high flow period.

Landsat TM imagery computer compatible tapes for two scenes to be procured as soon after each monsoon as possible and river bankline, thalweg and char bankline movement to be analysed in conjunction with bathymetric survey to give warning of potentially dangerous bend development.

(c) Monitoring Velocity and Channel Properties

Near bank velocities to be measured along the same fixed lines as used for (a) and at 20, 50 and 80 percent depths to provide velocity profiles during the peak flow period. The object is to build up a better picture of the pattern of velocities in the vicinity of the works for varying discharges and morphological conditions, which can be used to interpret any movement of the armour material and to improve design standards for future works.

Equipment requirements will be normal directional flow meters but the winch must be heavy duty to permit the use of sufficiently large sinker weights.

Bathymetric surveys to be carried out by either cross-sectioning or longitudinal traverses, or a combination at sufficient frequency to provide the requisite detail for assessing scour development. One survey to be made in February/March and a second in June/July. If any severe scour is identified then further survey to be carried out in August/September and October/November. Extent of the survey to be the full width of the anabranch for a distance of 5 km upstream and 5 km downstream. The object is to help assess any persistent consequence of the works, to provide further information on channel dynamics and to provide warning of impending attack.

Equipment requirements will be normal echo-sounders.

For both purposes position fixing with an accuracy of better than 10m and preferably 5m will be required. The vessel used must be capable of holding a stable position during the monsoon season, while having as shallow a draft is possible.

(d) Plan Update and Reporting

The main equipment requirement will be the microcomputer hardware and software for interpreting the satellite imagery. Initially this will be available through FAP-19 but longer term provision will be required.

Hardware and software will also be required for bathymetric contour plotting, data processing, analysis and storage.

(ii) Maintenance

(a) Routine maintenance will normally be carried out during the low flow period and the plant and equipment requirement can be simpler than that for emergency work during the monsoon period.

It is anticipated that routine maintenance will consist mainly of dumping additional armour material in areas where the armour layer has become too thin or the apron has not launched evenly. But it may also be necessary to place some new revetment complete with geotextile if, for example, the upstream embayment is threatening the termination or the cross-bar.

Since the design is intended to be reasonably conservative, it is not anticipated that the magnitude of this task will be great in most years. As will be seen later, the "normal" maintenance cost has been calculated as approximately 1 per cent of the capital cost per annum, and allowance has been made for further expenditure amounting to 5 per cent of the capital cost every 5 years as a provision for additional works which many be required. The average annual operation and maintenance cost thus works out at approximately 2 per cent of the capital cost. Clearly 5 years is an average figure and if a major flood occurred then the additional works might have to be carried out sooner. In order to avoid having to have a large amount of plant committed to this task, it would probably be better to limit the BWDB unit to a core fleet that would be supplemented by hiring or employing local contractors as necessary.

The minimum equipment required for this purpose would be a powerful tug, barges for transporting armour and geotextile sandbags, a land based crane and possibly a barge mounted hydraulic arm for placing material accurately. Accommodation could also be pontoon mounted. Depending on the lessons learnt during construction of the main works, the underwater geotextile filter may be laid either in sheet form or in the form of geotextile sandbags. The latter being considerably easier but possibly more costly.

Position fixing would have to be accurate for this purpose but need not be sophisticated if conventional procedures give adequate accuracy.

(b) Urgent Bank Stabilization Measures

These works are likely to be necessary, if at all, during the high flow period and thus the major requirements are engine power and the ability to hold position while placing/dumping in velocities that may locally be more than 3.5 m/s (mean velocity less than 2 m/s). Accuracy of placing would not be the primary concern but obviously the more accurate the better. The material used would probably be mainly 0.75 cubic metre geotextile sandbags that can be dumped or placed.

(c) Maintenance of Minimum Stocks and Operational Plant

This is self-explanatory and does not require any specialized plant or equipment.

4. DETAILS OF THE PROPOSED MONITORING AND MAINTENANCE UNIT

4.1 Introduction

The organizational structure of the monitoring and maintenance unit is illustrated in Figure 4.1 and will broadly reflect its functions.

These functions as set out in Chapter 2 of this report will consist primarily of the monitoring and evaluation of the performance of the works and of their impact on the river's behaviour. Also required will be the subsequent planning, scheduling and execution of the necessary maintenance and remedial works.

These maintenance and remedial works will need to be carried out and supervised to an appropriate standard and within an acceptable time frame, and their subsequent performance also monitored and evaluated, along with the rest of the works.

In view of these functions it is proposed that the unit would be called Monitoring and Maintenance Unit and the organization chart has been entitled accordingly.

An inventory of the plant and equipment which it is anticipated the Unit will require, together with indicative capital and recurrent costs, is given in Appendix C.

4.2 Functions

(a) Monitoring and Evaluation

One of the major challenges for the operation and maintenance unit will be successfully monitoring and evaluating the performance of the works, and their impact on the river's behaviour.

Such monitoring and evaluation will be essential if a rational maintenance and remedial works programme is to be planned and scheduled, and if the success of the works in continuing to restrain the river, over the longer term, is to be confidently predicted.

(b) Maintenance

The maintenance activities can be categorized as follows:

- land based (the river embankment and cross bars);
- river based (the revetments and aprons);
- routine preventative, and
- emergency repairs.

4.3 The Organizational Structure

In addition to recognizing the importance of its stated functions, the other key consideration in deciding the structure of the organisation is the geographical distribution of the works for which it will be responsible.

The Priority Works will be situated at Sirajganj, Sariakandi and Mathurapara, over a reach of some 60 km of river. It is considered that a single maintenance unit, based at Sirajganj, will be adequate to cope with both Sirajganj and the Sariakandi/Mathurapara sites. As, however, it is to be expected that second phase works will evatually be constructed, covering locations further to the south and to the north over a reach of 150 km or more, it is recommended that a Head Office/District Office organisation be implemented. A second district office can then be set up further north in the future without entailing extensive reorganization.

Again, as Sirajganj is the most important of the centres for the Priority Works, it is proposed that the Head Office of the organisation should be located there. However, in order to avoid Sirajganj District dominating the resources of the organisation, particularly with a view of future expansion, it is felt important that the District Office should be physically separate from the Head Office.

It is considered that the Sirajganj Head and District Office arrangement would be able to cover the Phase 1A and Phase 1B works, i.e. the Priority Works and the stabilized reaches north of Sariakandi and Sirajganj, albeit with some augmentation as the Phase 1B works are completed.

By the time that the first Phase 1C works are completed, Fulchari and Kazipur in ten to fifteen years time, an additional District Office will be required in view of the increased number of structures to monitor and maintain, and because of the distance of some 90 km between Sirajganj and the most northern of the "hard-points". It is suggested that the new District Office, which will have the same facilities as the Sirajganj District Office, including the Marine Maintenance Unit, Land Based Maintenance Unit and Storage Yard Unit, be set up at Fulchari. It will then have the advantage of good rail and river connections for bringing in heavy materials, and be well placed to command the northern reach of the river.

The Fulchari District Office would be equipped in similar manner to that at Sirajganj, though with the benefit of some years operational experience in the selection of equipment, and with a view to augmentation as construction of the longer term works under the Master Plan commences.

4.3.1 Head Office

The Head Office will have overall responsibility for the successful operation of the organization, but in order to maintain accountability and be better in touch with operations, it should be located at Sirajganj and not in Dhaka.

The Head Office will also be responsible for the Central Services Units of the River Planform Monitoring Unit, the Marine Survey Group, the Survey Equipment Maintenance Workshop and the Central Casting and Storage Yard.

4.3.2 The River Planform Monitoring Unit

The River Planform Monitoring Unit will be responsible for identifying the priorities for and specifying the necessary detail for the bathymetric surveys which it has been assumed will cover 5 km both upstream and downstream of the revetment works.

The purpose of this monitoring will be to identify any significant changes in the route and regime of the anabranches on which the revetment works are to be constructed. In view of the large areas involved, analysis will be by visual identification of areas of erosion and deposition using bed contour maps. It is proposed that these maps be generated by the SIMPLEPLOT and GRIDDER software packages using data selected from a central INFAMEX data base of survey records.

This work should be able to be carried out on a Personal Computer and printer, and would require a computer literate engineer familiar with data entry, extraction and analysis on a computer.

This unit will also be responsible for procurement of the appropriate satellite imagery tapes and their processing and analysis using a tape- reader and micro computer. ARCINFO software, and a digitising tablet, would enable identification of river movements and correlation to existing survey bases.

This work in conjunction with the bathymetric survey will enable the development of any potentially dangerous bend formations to be observed and predicted at an early stage.

Training for local staff in parallel with the first few years' operation of the system will ensure satisfactory operation of the unit and the potential for its continuation under local operation.

4.3.3 The Marine Survey Group

The Marine Survey Group will be responsible for carrying out both the structural surveys of the revetment works and the bathymetric surveys for the river planform monitoring. It will be responsible to the Central Services Unit Executive Engineer and will provide data to the District Office and to the River Planform Monitoring Unit.

The Marine Survey Group will consist of both land based and marine based staff. The land based staff will be required to set up and maintain the positioning system, be it "Trisponder" or "Microfix" equipment, and to provide land based support for communication and supplies to the marine staff.

The marine staff will be required to be familiar and competent with the equipment and procedures for marine survey using electronic position fixing, echo sounder and side scan sonar equipment (see Appendix B for typical details).

This "hi-tech" equipment is necessary in order to ensure sufficiently accurate data for the structural survey work. The inaccuracies and cumbersome nature of traditional position fixing systems would not allow accurate correlation between an echo sounder read-out and a boat position, especially in a rapid river flow when boat position would only be able to be maintained steady for a few moments at a time.

Moreover the speed of electronic position fixing will allow the surveys to be carried out more quickly and permit higher utilization of the expensive echo sounder and side scan equipment.

However, whilst echo sounder equipment is now acknowledged to be reliable, side scan sonar and position fixing systems are less so. The survey technicians will therefore be required to be able to undertake basic repairs on site.

If communications prove to be a problem, a portable satellite system could be purchased.

4.3.4 The Survey Equipment Maintenance Workshop

The Survey Equipment Maintenance Workshop will where necessary retain a second "back-up" set of marine survey instruments together with a comprehensive repairs kit, and be capable of regular servicing and maintenance of both the marine and land survey equipment.

4.3.5 The Central Casting and Storage Yard

The Central Casting and Storage Yard will be responsible for the manufacture and storage of the concrete blocks required for maintaining the revetments and for the storage of other materials required in the maintenance of the works. The first year's maintenance requirements estimated at 5 per cent of the total will be provided by the Contractor for the initial construction of the works, but the subsequent years' demands (estimated at 1 per cent or approximately 20,000 blocks per annum for the Priority Works, and increasing thereafter) will be required to be manufactured.

The other plant and equipment at the Yard will consist of what would be required to allow movement of materials and finished products (concrete blocks or geotextile mattresses) around the yard and onto the maintenance gang's transport, which would most likely be barge or to a lesser extent flat bed trailer.

The equipment at the Yard could also double in an emergency as a secondary land based maintenance unit (crane, dozer and dump truck).

Some revision of these arrangements would be required if rock armouring were to be used in one or more of the revetments. Certainly a stockpile of rock armour would have to be maintained.

4.3.6 The District Office

The District Office will be responsible for specifying and programming both the land and marine based survey needs. This responsibility will stem naturally from its overall responsibility for the integrity of the river training works.

The District Office will therefore have an all-important data analysis, monitoring and evaluation function. This will involve storage of the cross-sectional survey information for the revetment works on a data base such as "INFAMEX" and its retrieval for report and evaluation purposes on a package such as "SANDS", which will enable viewing and comparison of cross sections of the structures, and whether or how they are changing with time.

The "SANDS/INFAMEX" data base would also allow correlation of river flood events with the corresponding damage caused to the revetments, or changes in the river bed planform.

4.3.7 The District Land Survey Group

The District Land Survey Group will be responsible for the bankline survey which is proposed for 10 km upstream and 5 km downstream of all bank stabilization works.

The frequency of these surveys is proposed to be at least four times annually for the whole of each reach (twice "in-bank", and twice "out-of-bank") and probably monthly for reaches where active erosion is taking place.

As this involves almost 40 km of bank for each survey, and more than one location may require monthly monitoring, it is possible that two or more land survey groups may be required. This will also depend on the difficulty of terrain and time taken to carry out each survey.

Traditional survey equipment, rather than "hi-tech" tacheometry, is proposed, because of cost, ease of operation and reliability. Traditional equipment can be purchased at approximately one third of the cost of the latest technology.

Cross sectional survey data produced for any embankments related to river revetments will be transferred to the "INFAMEX/SANDS" data base, to enable checking of overall embankment stability and correlation with any revetment erosion.

The Land Survey Group will also be responsible for setting out of the shore stations which will enable the Marine Survey Group to position themselves for the structural performance monitoring echo sounder traverses.

4.3.8 The Marine Maintenance Unit

The Marine Maintenance Unit will be responsible for carrying out both routine preventative maintenance and urgent bank stabilization measures. Where appropriate, it will also provide the barges needed for materials transport for the Land Based Maintenance Unit.

The major part of the Marine Maintenance Unit's work will be transport and either dumping or placing of concrete blocks to repair or extend the revetment works.

During the monsoon (or high damage risk) season at least one barge will be permanently loaded with a full cargo of blocks allowing quick dumping should any scour holes or erosion of aprons become evident.

The minimum loaded draught for a bottom dump, split hopper or riffler barge of 60 ton capacity is about 2m and the greatest problem of draught will arise with the tugs which, if 650 HP capacity, will probably need 3 or 4m draught. To facilitate quick plugging of very active and/or dangerous erosion it is therefore proposed to specify a larger barge of the order of 150 ton capacity. (Approximately 375 No. of 550mm blocks, 75m^3 at 20% bulking factor).

To ensure access in as many situations as possible the other barge should be of a lower capacity say 60 tons - perhaps requiring a lower power and shallower draught tug.

Dumping by barge could take place in not less than say 3 m depth of water. This would be approximately 40 m out from the crest of the revetment in normal low flow conditions, say LWL + 2 m, allowing for clearance above the blocks dumped during construction. In similar conditions, a pontoon mounted with a hydraulic arm would be able to place blocks within about 30 m of the crest i.e. to approximately LWL. A large land based crane, with a boom of the order of 40 m long, will be required to carry out repairs necessary above that level. A suitable crane would be the RB (Lincoln) CH 50, which can be fitted with booms up to 51 m long. In this case a 39 m long boom would be appropriate. The crane would then be able to stand on the revetment, lift blocks from a flat-bed, and place them up to 30 m out onto the revetment, i.e. to within the range of pontoon mounted hydraulic arm.

It is suggested that the concrete blocks could be tied together into "slabs". This would allow quicker and easier placing of the large numbers of blocks which construction or repair of the revetments (above LWL) may require. A slab of eight 550mm cubes will weigh approximately 3.2 tonnes (depending on type of aggregate) and for the 720mm cubes approximately 7.2 tonnes. The CH 50 can place 1.6 tonnes at 34 m, or 12 tonnes at 10m i.e. 4 and 30 no. 550 mm cubes, 2 and 13 no. 720mm cubes, or 1 and 8 no. 850 mm cubes. Thus the CH 50 can place the largest cubes at full radius and 8 of the largest cubes even at 12m radius. Details of the RB CH 50 are given in Appendix C.

Such a crane however weighs nearly 50 tonnes and would require a crest width of 6 m. The necessary crest width is allowed for in the design.

If any dredging works were required, for instance to enable extension of the lengths of revetment, then they would presumably be classified as capital works and a dredging contractor could be brought in specifically to accomplish these works.

4.3.9 The Land Based Maintenance Unit

The Land Based Maintenance Unit will primarily be involved in dry season construction or reconstruction of embankments and cross bars.

The over-riding importance of properly controlled compaction dictates that a direct labour organization with appropriate plant and equipment be used. The land based unit therefore includes plant for compaction, but it has been assumed a large element of the earthmoving could be conducted manually, and by contract labour. If considered appropriate, hire contracts could be let for the standard plant items required instead of purchase.

The land based unit includes the heavy crawler crane which could unload concrete blocks at the site specific storage yards, and also assist in construction/repair of revetment sections where placing of the concrete blocks is required, as detailed in the notes on the Marine Maintenance Unit set out above.

4.4 Counterpart Expatriate Staff

It is proposed that training of BWDB staff in works supervision, quality control, instrumentation and management is undertaken by secondment of these personnel to the consultant's team for the supervision of construction of the Priority Works. Further, the contractor(s) will be required to give practical training to assigned BWDB staff in the use of specialized instrumentation and equipment of the type to be used later in the monitoring and maintenance of the works. Payment to the contractor(s) for this service will be subject to the Engineer's certification that a satisfactory standard of training was provided.

Further, provision is made in the Priority Works contracts for the contractor(s) to assist the BWDB for a period of one year after completion of the Works, i.e. to the end of the Defects Liability Period, by assigning key personnel to provide training and practical experience in the monitoring, operation and maintenance of the works. Depending on progress, arrangements could be made under a separate contract to extend this assistance for a second year. By the time that the Phase 1B and subsequent works are built, it is expected that BWDB will have acquired sufficient expertise not to require further such assistance.

The general procedures for operation and maintenance will be covered in the Operation and Maintenance Manual to be prepared by the consultants during construction, in consultation with the contractor(s) and BWDB.

The performance of the River Training Works will be required to be fully monitored and evaluated, and their impact on the river planform quickly recognised and analysed. In order properly to evaluate the behaviour of the revetments and the river planform, and to modify the monitoring programme in response to that behaviour, a detailed knowledge of the design criteria and assumptions will be required. Moreover, the design criteria may need refinement in response to the observed behaviour.

This is a very different function and requires a totally different mode of training and support to the advice on operation and maintenance provided by the contractor's personnel. These roles would most naturally be executed by staff of the consultants responsible for the original design. It is therefore proposed that a Technical Assistance programme be set up to provide this service for the first two years (at least) after the completion of the works.

Such an arrangement would enable the designs to be refined and optimum maintenance requirements to be formulated with the minimum of effort. It would also facilitate early recognition of any unforeseen behaviour of the works or of the river in response to the works.

It is proposed that over the minimum two years duration of the Technical Assistance programme, staff from the consultants' organisation be provided as follows:-

(i) River Training Engineer (RTE) - full time

(ii) Hydraulic Engineer/Morphologist (HEM) - part time

These personnel would provide all the assistance required at level 2 in the organisation chart, and the River Training Engineer would in addition give technical advice to management at level 1.

Figure 4.1 shows the proposed organisation chart. It is suggested that for the first two years of operation, counterpart staff be provided at each level of management. The position and outline terms of reference at each level would be as follows:

(a) Contractor's Staff

Chief Construction and Maintenance Adviser (level 1)

To assist management in the long term and day-to-day running of the unit, in planning and scheduling maintenance operations and production of materials for maintenance purposes; to advise in the procurement of plant for current and future needs.

Engineering Adviser (level 3)

To advise on the execution of construction and maintenance work, and to advise the land and marine survey groups in consultation with the Data Analysis and Monitoring Engineer.

Construction Supervisor (level 4)

To advise the Maintenance Units and the central casting and storage unit on the practical aspects of construction and maintenance.

(b) Technical Assistance Staff

The duties of the Technical Assistance staff would be as set out below.
River Training Engineer

(i) Advising on the planning, programming and resourcing for appropriate survey, routine preventative maintenance, and emergency maintenance in consultation with senior BWDB and contractor's personnel.

(ii) Monitoring performance of survey, evaluation and maintenance teams and reallocating resources, re-programming as required.

(iii) Supervising the work of the HEM in identifying unpredicted or potentially dangerous behaviour of embankment works, revetment works and river planform.

(iv) Identifying in conjunction with the HEM any deviation in data or behaviour from design criteria or assumptions.

(v) Observing river bank movement relative to the BRE and advising on retirement of the BRE.

(vi) Identifying with the HEM priorities for future investment.

Hydraulic Engineer/Morphologist

The key role of this post would be to train the Unit's staff in order to ensure collection of appropriate data, the validity of that data and its correct interpretation and evaluation to ensure adequate monitoring of the works. This specialist would therefore liaise closely with the proposed local Data Analysis and Monitoring Engineers, whole roles would be similarly defined for the revetments and embankments and for the river planform analysis.

Specific duties for this training and assistance role would therefore be to assist the local engineers in:

(i) Agreeing with the RTE an appropriate survey programme and supervising that programme to ensure valid data collection.

(ii) Specifying appropriate satellite imagery for procurement by the BWDB and its interpretation and evaluation in cooperation with FAP-19.

(iii) Supervising data storage on the relevant data bases and its subsequent retrieval for performance analysis. This would be for both embankment and revetment profiles and river planform using appropriate software packages.

(iv) Review of data collected for both river characteristics and performance of the works and its comparison with the specific design criteria and assumptions for the works.

(v) Refinement of river behaviour predictors.

This input could conceivably be achieved on an intermittent basis with say a 3 month initial input to ensure implementation of the survey and satellite imagery programme and subsequent inputs to ensure the continuing process of data collection, storage and analysis at appropriate junctures.

4.5 Training in the use of marine survey equipment, survey database management, analysis and evaluation, and satellite imagery processing and analysis

Procurement of the equipment for the above activities will need to be supported by appropriate training packages.

It is proposed that the contracts for provision of the relevant equipment should include for an initial period when the supplier would be required to carry out the activity for one complete package of the relevant work.

The advantage of this approach is that the BWDB would then be confident that the whole system works and that no unforeseen problems would arise on those areas of the work for which only outline work procedures were provided.

In the cases of the survey database and its use, and the satellite imagery processing and analysis, Halcrow could provide the appropriate software and training support (and if so, the desired hardware too).

The marine survey equipment and its use is, however, very specialized and it is proposed to let a contract for the initial survey of all structures and the desired area of river planform. The contract would include for training of the client's staff whilst executing the survey and also for handover of the survey equipment and appropriate spares on completion.

5. CAPITAL AND RECURRENT OPERATION AND MAINTENANCE COSTS

5.1 Staff

The BWDB, counterpart and survey specialist staff are listed in Appendix D. In Appendix E, the annual cost of the staff complement (including transport, etc) is calculated. For this purpose it is assumed that the counterpart staff remain for two years after completion of the works, i.e. during the Defects Liability Period and for one year afterwards. The exact duration will, of course, depend on circumstances nearer the time.

5.2 Procurement of Survey Equipment

Orientative quotations have been obtained from various specialist organizations for the survey equipment listed in section 1 of Appendix D. The information in section 3, covering satellite imagery processing, was based on equipment recently purchased for FAP-4. Duties and taxes on the various items of equipment were calculated as shown in paragraph 5.3 below. It is assumed that all plant and equipment for the Sirajganj offices will be purchased during the Defects Liability Period of the Priority Works.

5.3 Procurement of construction plant for on-going maintenance activities

Appendix F includes proposed marine and land based plant in sections 4 and 5.

New and secondhand prices have been obtained where possible. In the costing analysis it is assumed that good condition secondhand plant will be purchased be when available. It may be possible for BWDB to purchase some of the contractor's plant on completion of construction, although this will depend on the proven suitability of the plant and on the circumstances prevailing at the time.

Based on information received from the Customs Department, taxes and duty on imported plant, equipment and materials have been calculated as follows:

Duty	50.0 %	on CIF value
Surcharge	6.0 %	" " "
Advanced income tax	2.5 %	" " "
Import tax	2.5 %	" " "
VAT = 15 % on CIF + duty = 15 % on 150 % CIF	22.5 %	
Total duty and taxes	83.5 %	on CIF value

For electronic equipment, similar taxes apply except that duty is charged at 100 per cent CIF value, leading to a total of duty and taxes amounting to 141.0 per cent of the CIF value.

5.4 Materials

The principal materials required on an annual basis have been assessed at a rate of use of 1% per annum of the quantities used in the Priority Works, except for the first year when it

is assumed that a stockpile of materials will be prepared under the construction contracts. The estimated costs are given in Appendix G.

5.5 Summary of Costs

The capital and recurrent costs for the Priority Works are summarized in Table 5.1 below. They are based on May 1992 prices and rates of exchange.

Staff costs reduce from some Tk 51.4 million in the first year and Tk 47.4 million in the second, while the counterpart staff are on site, to Tk 9.7 million per annum in subsequent years.

Specialist equipment costs, for survey and monitoring, and operation and maintenance plant costs, are summarized in Table 5.2 below.

Table 5.1: Summary of Capital and Recurrent Costs (Tk. million)

Year	1	2	3	4	5
Staff					
BWDB	9.70	9.70	9.70	9.70	9.70
Counterpart Staff	37.68	37.68	0.00	0.00	0.00
Contract Staff (Survey)	4.00	0.00	0.00	0.00	0.00
TOTAL STAFF	51.38	47.38	9.70	9.70	9.70
Survey Equipment					
Land Based (capital)	0.44	0.00	0.00	0.00	0.00
(recurrent)	0.03	0.03	0.03	0.03	0.03
Marine (capital)	69.90	0.00	0.00	0.00	0.00
(recurrent)	2.71	2.71	2.71	2.71	2.71
TOTAL SURVEY	73.08	2.74	2.74	2.74	2.74
Computer Equipment					
Capital	3.35	0.00	0.00	0.00	0.00
Recurrent	0.05	0.05	0.05	0.05	0.05
TOTAL COMPUTER	3.40	0.05	0.05	0.05	0.05
Satellite Imagery					
Capital	1.55	0.00	0.00	0.00	0.00
Recurrent	0.10	0.10	0.10	0.10	0.10
TOTAL SATELLITE IMAGERY	1.65	0.10	0.10	0.10	0.10
Marine Plant					
Capital	47.83	0.00	0.00	0.00	0.00
Recurrent	1.56	1.56	1.56	1.56	1.56
TOTAL MARINE PLANT	49.39	1.56	1.56	1.56	1.56
Land Based Plant					
Capital	58.05	0.00	0.00	0.00	0.00
Recurrent	4.53	4.53	4.53	4.53	4.53
TOTAL LAND BASED PLANT	62.58	4.53	4.53	4.53	4.53
Materials	0.00	14.53	14.53	14.53	14.53
TOTAL ANNUAL COST	241.48	70.89	33.21	33.21	33.21

Assume repairs equivalent to 5 % of the capital cost of the Priority Works are required in fifth year:		
5 % of Tk 3,525 million	=	176.25
TOTAL COST IN FIFTH YEAR	=	**209.46**

Table 5.2 Plant and Equipment Costs (Tk million)

	Capital	Recurrent (p.a.)
Survey & monitoring equipment	75.24	2.89
O & M Plant	105.88	6.09
TOTAL	181.12	8.98

Materials costs over the four years following the first year are steady at Tk 14.5 million per annum. Materials for the first year will be supplied under the construction contracts.

The recurrent costs for staff, equipment and materials total some Tk 33.2 million per annum, which is just below 1 per cent of the capital cost of the works. Plant, equipment and materials alone account for Tk 23.5 million per annum, approximately 0.7 per cent of the recurrent costs.

The percentage recurrent cost is rather above that assumed in the Second Interim Report (0.5 per cent p.a.) which was derived on the basis of six sites. Certain items of plant, e.g. the crane, and equipment, e.g. the survey vessel and on-board electronics, would have been able to cover all six sites, hence, when the recurrent cost is expressed as a percentage of the cost of the works, the percentage is inevitably higher for three sites than for six. This does, however, indicate that future expansion of the Unit to cover later phases of the works will be relatively cheaper, and indeed the organizational structure proposed will facilitate that expansion. Further, an element of the cost of the monitoring and planning activities could reasonably be assigned to maintenance of the BRE.

The estimate includes an allowance of 5 per cent of the capital cost of the priority works for substantial repairs in the fifth year. This assessment is open to conjecture and such an event could occur earlier, later, or not at all, or such repair work could be spread over more than one year.

5.6 Future Predictions

Beyond the initial five year period discussed in paragraph 5.5 above, costs become less easy to predict. Depreciation of plant and equipment is already allowed for in the costing.

It is possible that as time goes on, the revetments will require relatively more attention, and it would be prudent to allow an increase of 5 per cent per annum to the recurrent plant and materials cost, to allow for increased replacement of materials and the increased plant use in so doing.

It would similarly be prudent to allow for a further event, or events, requiring a cost equivalent to 5 % of that of the priority works, at a speculative date 10 years after the completion of the works.

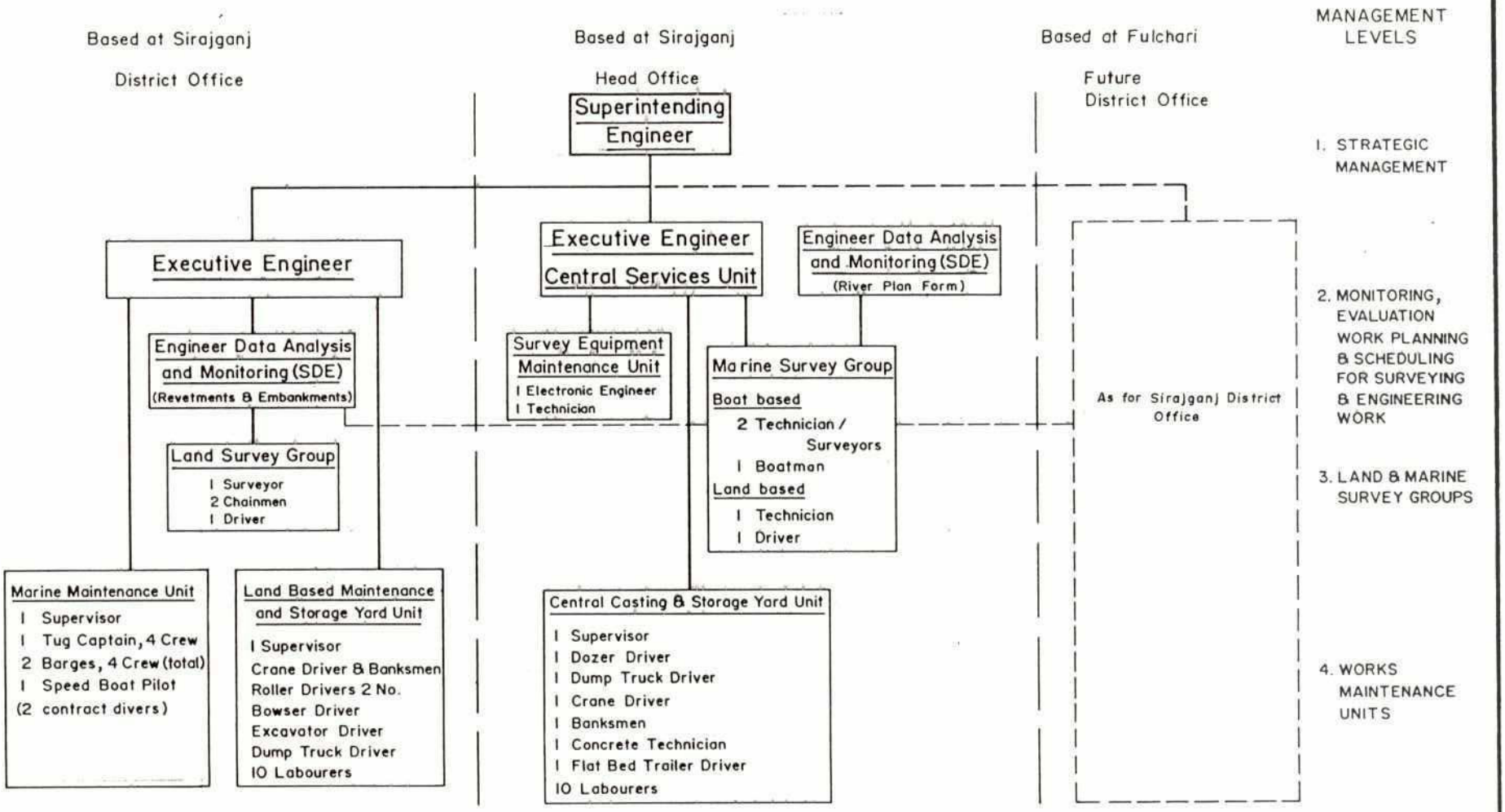
5.7 Conclusion

Throughout this Annex to the Master Plan Report, considerable attention has been paid to the operation and maintenance, or monitoring and maintenance, of the Priority Works (the Phase 1A works). The Master Plan involves many more structures and a far longer construction timespan than the Priority Works, and indeed expansion of the Monitoring and Maintenance Unit to cover those work is discussed herein.

Nevertheless, it will be during the period immediately following completion of the Priority Works that the Unit will be set up and expertise gained. As has been explained, expanded coverage for future works will be very closely based on the organizational structure and procedures established at this early stage in the overall programme for river bank stabilization. Further, it is on the basis of the monitoring and maintenance costs for the Priority Works given in this chapter and the appendices, and the capital cost of those works as determined from detailed item by item cost estimates, that the operation and maintenance component of the Economic Assessment (Annex 2 of the Master Plan Report) has been derived.

FIGURES

Monitoring and Maintenance Unit: Organization Chart



NOTE:

Counterpart staff not shown. It is suggested that counterpart staff be provided at the rate of one person per management level throughout the first two years of operation.

Halcrow/DHI/EPC/DIG

May 1993

Annex 5

Figure 4.1

APPENDICES

HALCROW

APPENDIX A

ALTERNATIVE APPROACHES TO MAINTENANCE

MASTER PLAN REPORT - ANNEX 5

APPENDIX A

ALTERNATIVE APPROACHES TO MAINTENANCE

BACKGROUND

1. For individual structures to remain effective it will be necessary to carry out maintenance works from time to time.

2. It will also be necessary, both for the individual structures and for the river training project as a whole, accurately to monitor changes in the river.

3. In the long term both these functions should be carried out by BWDB.

4. In the short term the options that have been considered are:

   i. to add a period of routine maintenance to the construction contract, or

   ii. to provide training as part of the construction contract with no extra responsibility on the contractor beyond the end of the defects liability period (any extension of the training beyond this date would be the subject of a separate contract) or

   iii. to let a separate maintenance contract for a period of a few (up to say 5) years, once construction has been completed.

5. The river monitoring and the physical maintenance of structures are separate issues operationally, though obviously closely linked. The monitoring is not being considered as part of a maintenance contract.

MAINTENANCE AS AN ADDITION TO THE CONSTRUCTION CONTRACT

6. The contractor would presumably be required to provide equipment, to be handed over at the end of the maintenance contract period, to maintain that equipment, to carry out maintenance work as and when necessary, and to train local staff while doing so.

7. Such a requirement would be unattractive to most contractors. It would either tie up some of their good staff, whom they would prefer to have employed on major contracts where their skills could be expected to maximise the contractor's returns, or they would make available less qualified or experienced men, which would be unsatisfactory to the Employer.

8. It would also be unattractive to most contractors because it would constitute a comparatively small sideline to their mainstream activities, one for which their organisation and their skills are not directly appropriate.

9. It is most unlikely that the staff and operators who had been engaged in constructing the works would be made available for long term maintenance, so any benefits of continuity could well be more imagined than real.

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10. For these reasons it is likely that a construction contractor would be reluctant to undertake the commitment and would submit on unrealistically high price as a consequence.

11. The contractual arrangements necessary to ensure that a reluctant contractor fulfilled his obligations would be difficult to draw up without rendering the work even less attractive to the contractor.

TRAINING DURING THE CONSTRUCTION CONTRACT

12. The contractor would be required to train the Employer's staff in the use of equipment and, where relevant, in the techniques used in construction.

13. The contract could usefully provide for the contractor to supply the maintenance equipment during the contract period - perhaps six months before the end of construction. This would allow training on the actual maintenance equipment to be used later, rather than on similar but different contractor's equipment.

14. The advantages of the alternative would be:

- training by those actively involved in construction
- observation by the future maintenance staff of the actual construction techniques used.
- little or no additional time commitment for the contractor's key personnel.
- monitoring and maintenance would be directly controlled and managed by the Employer at an early stage.

SEPARATE MAINTENANCE CONTRACT

15. A maintenance contract would be awarded by competitive tendering procedure, and a contractor appointed for a period of say 5 years.

16. Such an arrangement may or may not include requirements for training of the Employer's staff.

17. Smaller contractors who would not be capable of carrying out the main construction contracts might be interested in bidding.

18. The contract would be a pure maintenance contract rather than a small extra requirement on a construction contract.

19. The maintenance contractor would probably have no direct experience of the construction methods used.

20. Setting up maintenance contracts, where the amount of work required and the time at which it is required are unknown, is known to be difficult.

FUTURE DEVELOPMENT

21. If it is assumed that river bank training works will proceed, there will be a gradually increasing number of structures requiring maintenance.

22. The BWDB will necessarily assume full responsibility for, and carry out, monitoring and maintenance at some stage.

23. It should be easier to set up a monitoring and maintenance system when only a few structures are involved and to develop it gradually, rather than to introduce such a unit later when its scope would be much greater.

CONCLUSIONS

24. The setting up of a system as soon as possible, trained by the contractor as part of the construction contract, appears to be the most logical way of tackling the problem.

25. If this is not possible, the award of separate maintenance contracts should be considered.

26. Adding a maintenance contract to a construction contract is likely to be expensive and unsatisfactory.

APPENDIX B

IMAGENEX 855 SIDE SCAN SONAR

ENDEAVOUR HOUSE · TEL 0493 850723
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GREAT YARMOUTH · FAX 0493 852106
NORFOLK NR30 3NG UK ·

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A Division of Gardline Shipping Limited

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YOUR REF.

OUR REF. GSD/lg

17th February 1992

Sir William Halcrow & Partners
Burderop Park
Swindon
Wiltshire SN4 0QD

WH BRT 40
IAJB
CSG AJB JB
2 copies received in T.P
one copy to file

Attention: Mr. E. Evans/Mr. A. Barnham

Dear Sirs,

Bangladesh - River Training Studies
Requirement for Survey and Monitoring Equipment and Telecommunication Equipment

Further to your fax of 6th February we are pleased to respond with further details.

Survey and Monitoring Equipment

We understand the requirement to be to check and monitor sub-surface concrete blocks, rock and other material dumped along the course of a river.

It is accepted that visual observation is not practical due to the sediment load of Bangladeshi's rivers and to measure depths and profiles with echo sounders is inappropriate due to shallow water and the nature of rock dumping.

The most practical approach in our view is to use a sonar technique 'looking' obliquely at the rock dump.

A towed side scan sonar would be inappropriate due to the impractical nature of either towing the tow fish or pole mounting.

The most appropriate system would be to use a high frequency colour imaging sonar with a print out facility.

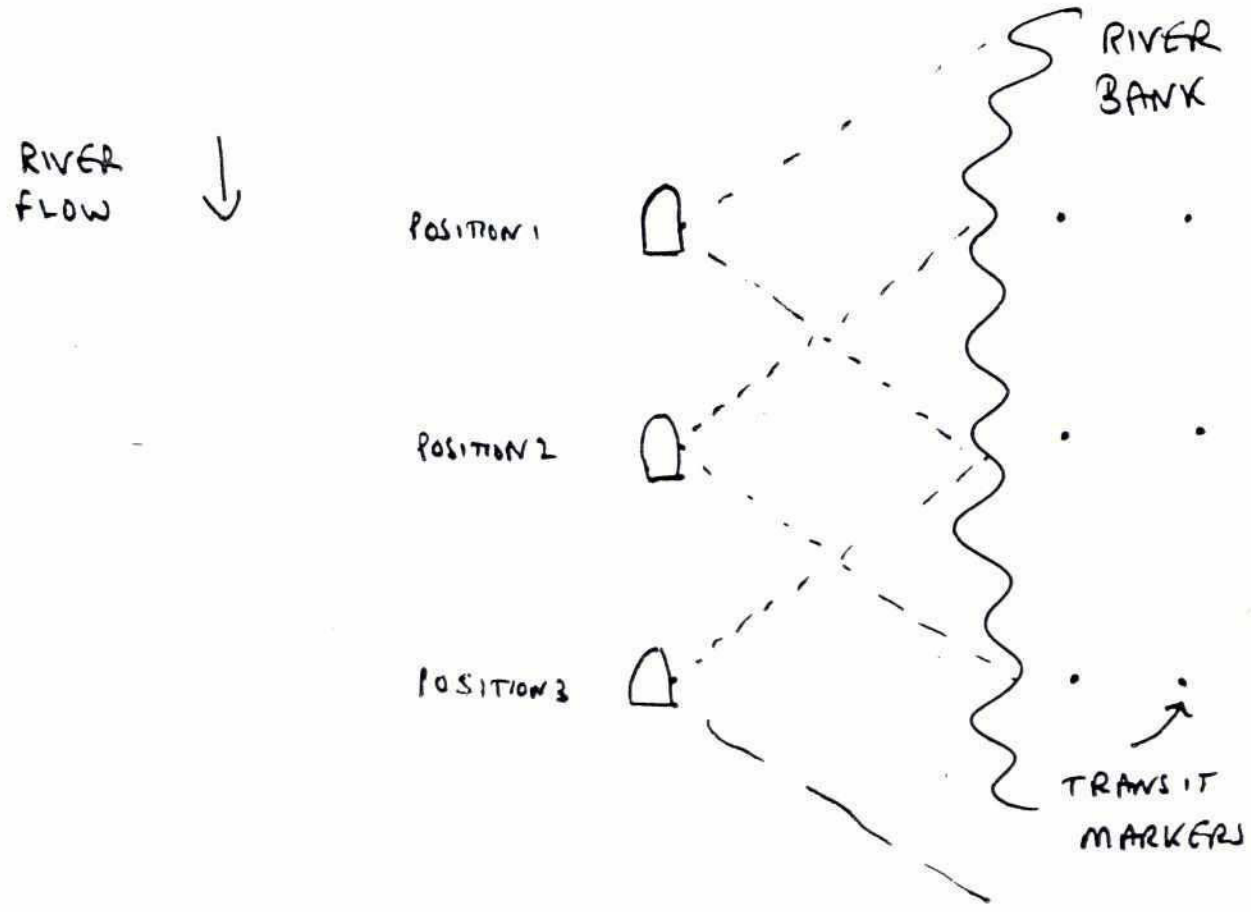
We suggest a modern high frequency system such as an Imaginex 855 (brochure enclosed). Although primarily developed for ROV applications this high resolution 675 Khz sonar can be mounted on an over the side bracket to a small survey boat. The only constraint would be to hold station on the boat for a sufficient time to 'build up' a clear image - this is 11 seconds +. The image would then be 'dumped' to a printer and recorded on VHS video tape, then the boat would move to the next location and so on. Positioning of the boat would best be done by transit marks pre-positioned on the bank. In order to have comparable images the same distance from the bank should be maintained if at all possible, 10m would be fine.

For this application we suggest a 180° rotating head operating at 5-50m range from the river bank.

The approximate purchase price for a Sonar system and plotter would be £18,500.

<u>Sketch of Operation to monitor dumped rocks along a River Bank</u>

Not to Scale



As the survey boat progresses downstream it stops at each transit point for about 11 seconds and allows the imaging sonar to built up an acoustic picture.

The system would require tuning against the reflectivity of material to obtain optimal results - this would take we estimate two days. An operator could be trained in the U.K. should you so wish.

The U.K. agent for Imaginex is a subsidiary of Gardline, and you may wish to view the system and or negotiate direct, please contact:

Malcolm Kirby (Managing Director)
M.K. Services
24 Eden Way
Pages Industrial Park
Billingham Road
Leighton Buzzard
Beds LU7 8TZ

Tel: 0525-382333
Fax: 0525-850073

Telecommunication Equipment

When in Dhaka I mentioned to Andrew Russell that we had successfully used previously Inmarsat Std-C mobile satellite systems.

These small portable devices operate on a telex message basis and can both send and receive messages from any worldwide location using the Inmarsat satellite system.

They are inexpensive and easy to use - a complete system costs £8,000, including P.C., printer, power supply etc. Consequently it can also be used as a 'mobile office'.

IMAGENEX

MODEL 855 COLOR IMAGING SONAR

FEATURES

-High quality color sonar images

-Selection of underwater scanning units (NEW)

-Window zooms and menus

-Digital signal processing

-Compact surface processor

-Sonar data recording (NEW)

-Full resolution playback (NEW)

-Reasonable price

The Imagenex Model 855 Color Imaging Sonar System is the result of years of experience in imaging sonar technology, combined with the latest and most powerful graphics and signal processing technology available.

Using precisely controlled, high frequency sonar beams, the Model 855 produces the kind of sharp, detailed sonar images that the Imagenex design team is known for around the world. This is a flexible and affordable sonar system, that does not compromise image quality.

The 855 system consists of an easy to use, compact, rack mount Processor, and a growing family of Underwater Scanning Units, to suit many applications.

The Model 855-000-101 Subminiature Scanning Unit, has been designed specifically for the smallest ROVs, where small size, light weight, and low cost are important criteria.

The Model 855-000-110 Miniature Scanning Unit is slightly larger, and more rugged. It has been designed for the rigors of oilfield use, on larger ROVs and at greater depths. It is also the first choice for more demanding site survey, well reentry, underwater engineering, and sonar profiling applications.

For search applications, on vessel mounted struts, towed bodies or ROVs, the 855-000-150 Dual Transducer Side Scan Module complements the rotary scan underwater units.

An important optional feature is the ability to record sonar data on the Audio HI-FI tracks of a VCR. This data can be played back to produce sonar images at no loss of resolution.

The recorded data can be inspected at various ranges, and the zoom and range/bearing features can be used on playback.

IMAGENEX TECHNOLOGY CORP., 209–1875 BROADWAY ST., PORT COQUITLAM, B.C. CANADA, V3C 5W2, TEL: (604) 944–8248, FAX: (604) 944–8249

IMAGENEX

MODEL 855 COLOR IMAGING SONAR

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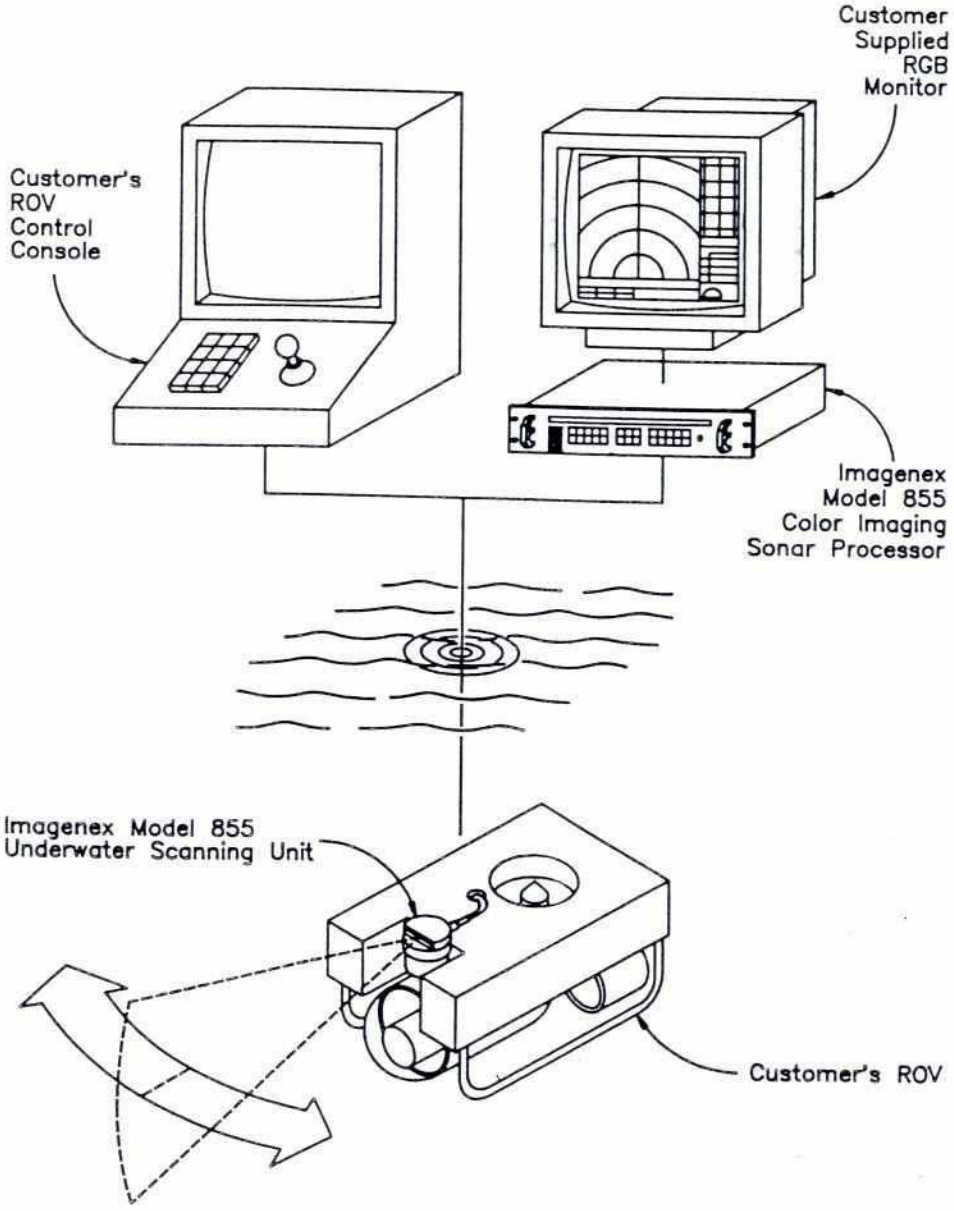

Typical Small ROV Installation

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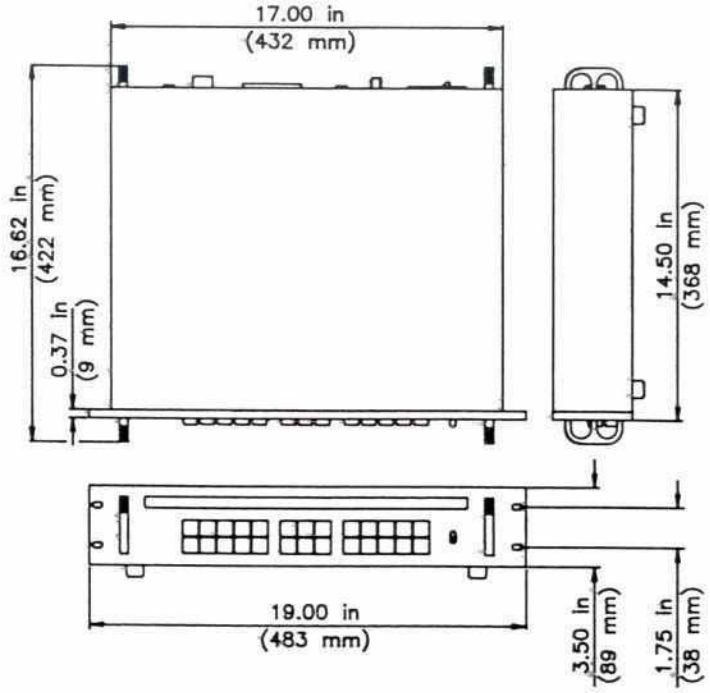
IMAGENEX

MODEL 855 COLOR IMAGING SONAR



IMAGENEX MODEL 855-000-001
COLOR IMAGING SONAR
PROCESSOR
SPECIFICATIONS

Display Modes: Freeze Display, Clear Display, Sector Mode, Polar Mode, Side Scan Mode, Window Zoom (X2, X3 and X4), Range/Bearing to Targets

Sector Size: 0 to 180 degrees, 10 degree increments

Ranges: 0-5,10,20,30,40, 50,60,80,100 Meters (select also feet)

Transducer Training:
Model 855-000-101, 270 to 0 to 90 degrees, 10 degree increments
Model 855-000-110, 170 to 0 to 190 degrees, 10 degree increments

Scanning Speeds: Slow, medium, fast, extra fast, mixed

Timing Resolution: 7 microseconds equivalent to 0.4 inch (10 mm)

Display Resolution: 640 X 480 Pixels, 128 Colors

Monitor: supplied by customer, multisync type analog RGB, standard 9-pin D-submin connector

Optional Display:
-003, NTSC or PAL composite video using external adapter

Optional Interfaces:
-002, RS-232 serial to allow external characters display on screen.
-004, Record sonar data on VCR Hi-Fi audio tracks for full resolution playback through processor.

Dimensions: 19.0 inch (482 mm) wide
3.5 inch (89 mm) high
15.0 inch (381 mm) deep

Weight: 15 Lbs. (6.8 Kg.)

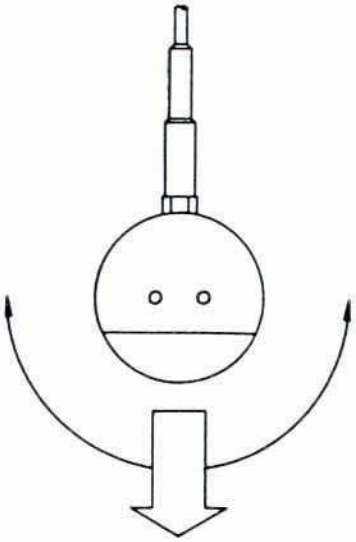
Power Requirement: 110/220 Volt 50/60 Hz, 0.5 Amp

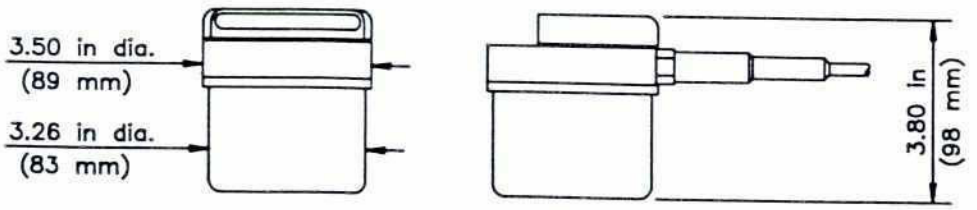
Specifications subject to change without notice

IMAGENEX TECHNOLOGY CORP., 209–1875 BROADWAY ST., PORT COQUITLAM, B.C. CANADA, V3C 5W2, TEL: (604) 944–8248, FAX: (604) 944–8249

IMAGENEX

MODEL 855 COLOR IMAGING SONAR





IMAGENEX MODEL 855-000-101 SUBMINIATURE UNDERWATER SCANNING UNIT SPECIFICATIONS

Frequency: 675 KHZ
Beamwidth: 1.7 degree horizontal, 20 degree vertical (fan beam for imaging)
Typical Maximum Range: to 90M
Mechanical Resolution: 0.25 degree
Mechanical Rotation: 180 degrees
Power Supply: 16 to 24 V DC at 500 MA max.
Connector: Impulse XSG, 4 Conductors, 2 for signal, 2 for power.

Cable Length: 600M (2,000ft) typical maximum
Materials: aluminum 6061-T6, 300 series stainless steel, pvc, acetal homopolymer, epoxy
Finish: hard anodize
Maximum Depth: 300M (1000 Ft)
Dimensions: 89mm (3.5in) diameter X 98mm (3.80in) high
Weight: in air 1kg (2.2lb), in water 0.4kg (0.8 lb)

Specifications subject to change without notice

IMAGENEX TECHNOLOGY CORP., 209–1875 BROADWAY ST., I
CANADA, V3C 5W2, TEL: (604) 944–8248, FAX: (6(

MK SERVICES LTD

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PAGES INDUSTRIAL PARK
BILLINGTON ROAD
LEIGHTON BUZZARD
LU7 8TZ
TEL: 0525 382333
FAX: 0525 850073

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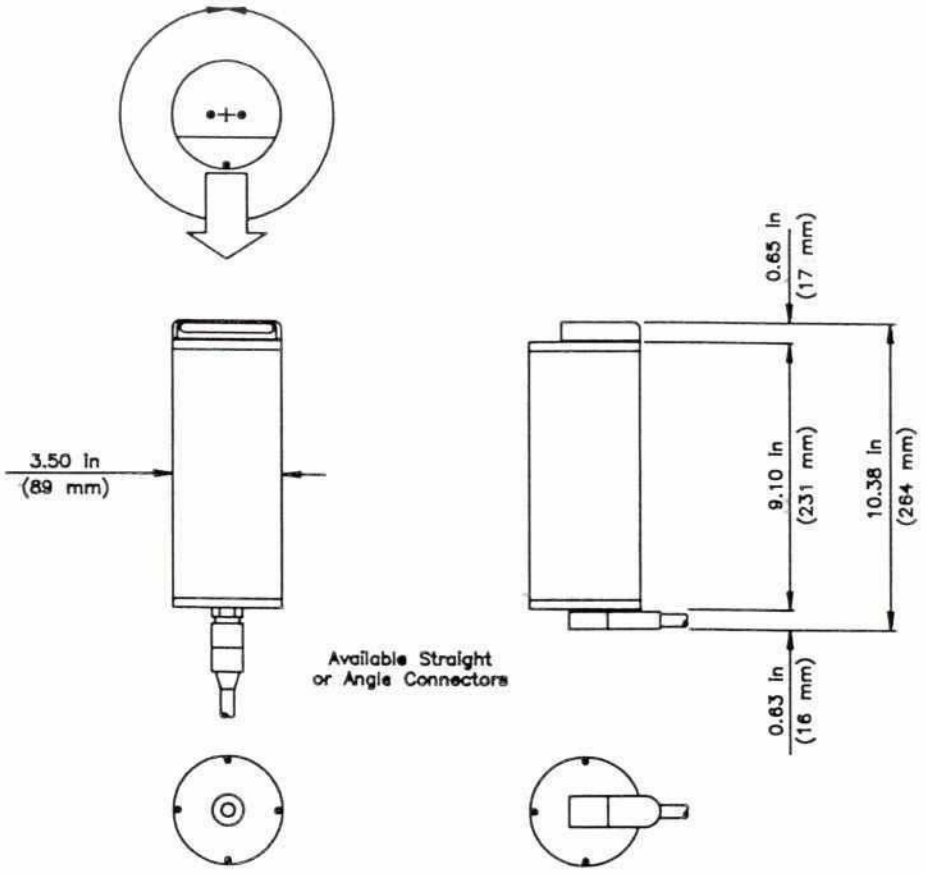
AB1 2AT
TEL: 0224 213323
FAX: 0224 213373

IMAGENEX

MODEL 855 COLOR IMAGING SONAR



IMAGENEX MODEL 855-000-110
MINIATURE UNDERWATER SCANNING UNIT
SPECIFICATIONS

Frequency: 675 KHZ
Beamwidth: 1.7 degree horizontal, 30 degree vertical (fan beam for imaging)
Typical Maximum Range: to 90M
Mechanical Resolution: 0.25 degree
Mechanical Rotation: 380 degrees
Power Supply: 22 to 26 V DC at 1 A max.
Connector: Impulse wet mateable, 4 Conductors, 2 for signal, 2 for power.
Cable Length: 1,000M (3,300Ft) typical maximum, longer available
Materials: aluminum 6061-T6, 300 series stainless steel, pvc, acetal homopolymer, epoxy
Finish: hard anodize
Maximum Depth: 1,000M (3,300Ft)
Dimensions: 89mm (3.5in) diameter X 264mm (10.38in) high
Weight: in air 3kg (6.5lb), in water 1.5kg (3.3 lb)

Specifications subject to change without notice

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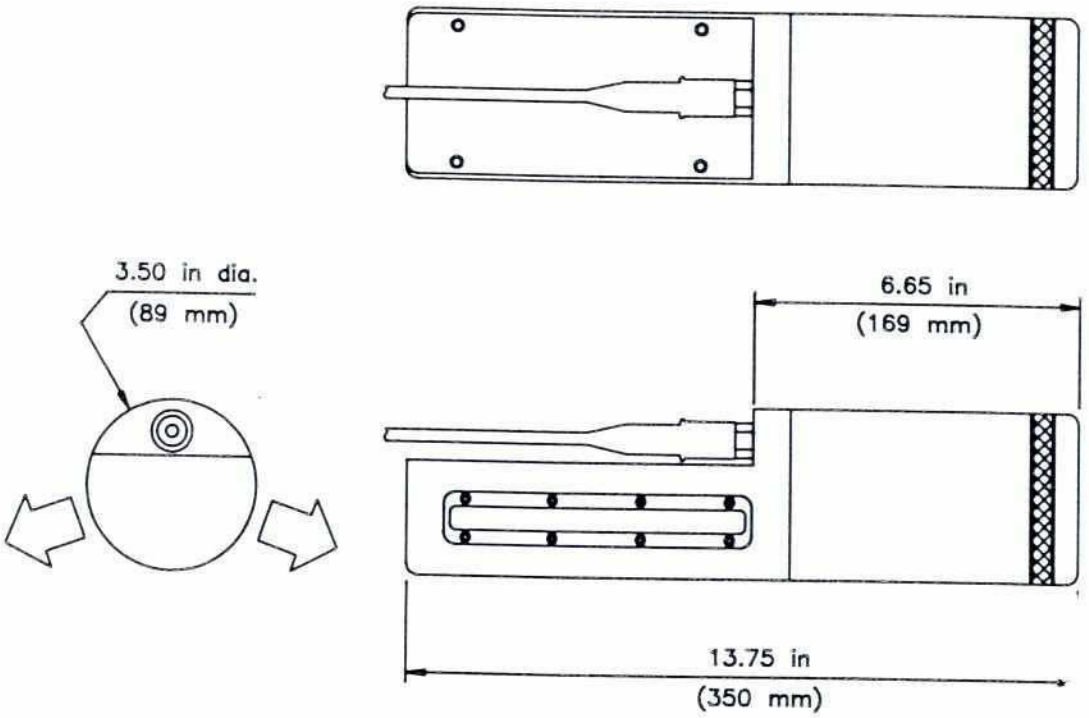
IMAGENEX

MODEL 855 COLOR IMAGING SONAR

APPENDIX C

RB (LINCOLN) CH50 CRANE



IMAGENEX MODEL 855-000-150
330 KHZ DUAL TRANSDUCER
SIDE SCAN SONAR
UNDERWATER MODULE
SPECIFICATIONS

Frequency: 330 KHZ
Beamwidth: 1.9 degree horizontal, 60 degree vertical
Typical Maximum Range: to 200M
Power Supply: 16 to 24 V DC at 500 MA max.
Connector: 4 Conductors, 2 for signal, 2 for power.
Cable Length: 600M (2,000ft) max.

Materials: aluminum 6061-T6, 300 series stainless steel, pvc, acetal homopolymer, epoxy
Finish: hard anodize
Maximum Depth: 300M (1000 Ft)
Dimensions: 89mm (3.5in) diameter X 350mm (13.75in) long
Weight: in air 3.2kg (7.0 lb), in water 1.4kg (3.0lb)

Specifications subject to change without notice

IMAGENEX TECHNOLOGY CORP., 209–1875 BROADWAY ST., PORT COQUITLAM, B.C. CANADA, V3C 5W2, TEL: (604) 944–8248, FAX: (604) 944–8249

APPENDIX C

RB (LINCOLN) CH50 CRANE

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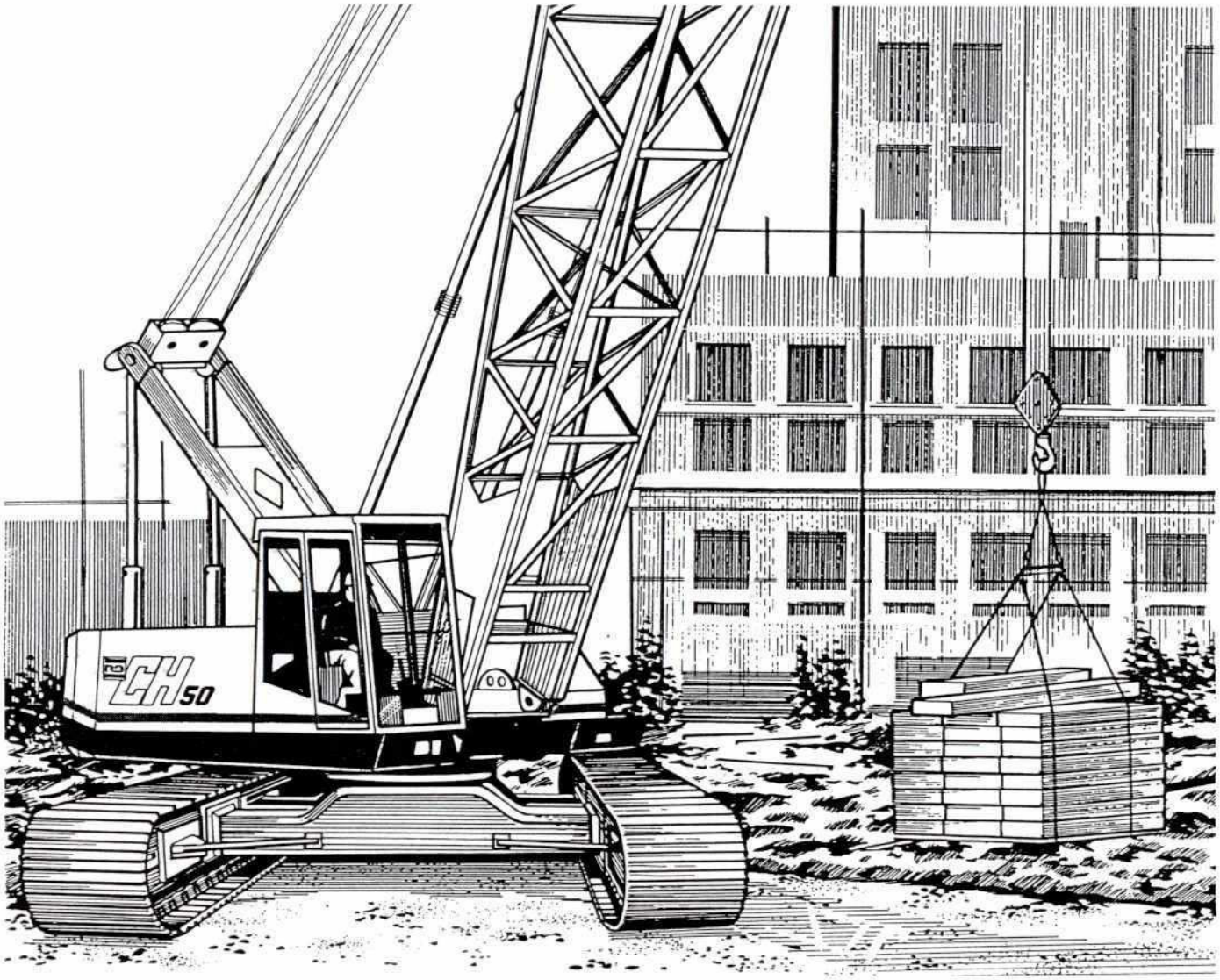
CH50

the most advanced hydraulic crane available
Der fortschrittlichste Hydraulikkran, den es gibt
La grue hydraulique la plus perfectionnée qui soit disponible

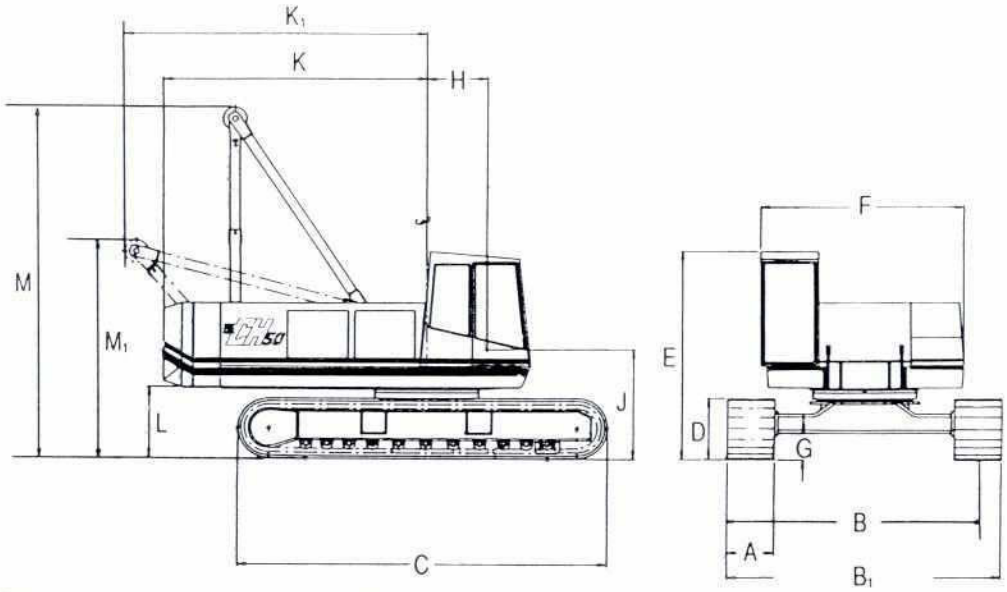


- *50 tonne capacity at 3.7 m*
- *51 m pin-jointed boom*
- *18 m pin-jointed fly jib*
- *Load sensing hydraulics*
- *3.3 m transport width.*

- *50 Tonnen Leistung bei 3,7 m*
- *51 m Bolzengelenk-Ausleger*
- *18 m Bolzengelenk-Kragarm*
- *Lastabhängige Hydraulik*
- *3,3 m Transportbreite*

- *Capacité 50 tonnes à 3,7 m*
- *Flèche articulée 51 m*
- *Volée articulée 18 m*
- *Système hydraulique avec détecteur de charge*
- *Largeur de transport 3,3 m*

Machine Dimensions Maschinenabmessungen Dimensions de machine (mm)



A Width of track links
B Width of tracks extended
B_1 Width of tracks retracted
C Length of tracks
D Height of tracks
E Height of operator's cab
F Width of cab
G Clearance under machine
H Boom foot pin from centre of rotation
J Height of boom foot pin
K Radius of rear end
K_1 Radius over folded A frame
M Height over A frame
M_1 Height over folded A frame
L Clearance under rev. frame

A Breite der Raupenglieder
B Spurbreite bei ausgefahrenen Ketten
B_1 Spurbreite bei eingefahrenen Ketten
C Länge der Raupenketten
D Höhe der Raupenketten
E Kabinenhöhe
F Breite der Kabine
G Bodenabstand der Maschine
H Ausleger-Fußgelenk ab Drehungsmittelpunkt
J Höhe des Ausleger-Fußgelenks
K Radius über Heck
K_1 Radius über eingeklapptem Dreiecksrahmen
M Höhe über Dreiecksrahmen
M_1 Höhe über eingeklapptem Dreiecksrahmen
L Bodenabstand des Drehgestells

A Largeur des tuiles de chenilles
B Largeur des chenilles sorties
B_1 Largeur des chenilles rentrées
C Longueur des chenilles
D Hauteur des chenilles
E Hauteur de cabine d'opérateur
F Largeur de cabine
G Garde au sol sous machine
H Articulation de flèche à partir du centre de rotation
J Hauteur de l'articulation de flèche
K Portée de l'extrémité arrière
K_1 Portée sur membrure A pliée
M Hauteur sur membrure A
M_1 Hauteur de membrure A pliée
L Garde au sol sous châssis arrière

A - 750	B - 4320	B1 - 3300	C - 5770	D - 960	E - 3260	F - 3200	G - 420
H - 940	J - 1720	K1 - 4700	K - 4160	L - 1120	M - 5550	M1 - 3450	

Machine Weights Maschinengewichte Poids de machine

Machine Maschine Machine		Working weight (t) Arbeitsgewicht (t) Poids de service (t)	Counterweight (t) Gegengewicht (t) Contrepoids (t)
Lift Crane Hebekran Grue	Dragline Schleppschaufelbagger Dragline	47.6	14.0
	Clamshell Greifer Benne preneuse	47.2	14.0

Weights are given with Basic Boom only.
Es ist jeweils nur das Gewicht mit Grundausleger angegeben.
Les poids sont indiqués avec la flèche de base uniquement.

Lifting Capacities on Main Boom
Tragfähigkeit am Hauptausleger
Forces de levage sur flèche

Boom (m) Ausleger Flèche	Radius (m) Ausladung Portée	Rated Load (t) Nennlast in (t) Charge nominale (t) BSS 1757 1986 BSS 1757 1986	US Rating factors US-Nennwertfaktoren Facteurs product. E.U.
12	3.7 4.0 4.5 5.0 5.5 6.0 7.0 8.0 9.0 10.0 11.0 11.6	50.00 45.60 38.50 33.20 29.00 25.77 20.61 17.09 14.53 12.58 11.04 10.26	50.00 45.60 38.04 32.03 27.62 24.24 19.41 16.11 13.73 11.89 10.45 9.72
15	3.9 4.5 5.0 6.0 7.0 8.0 9.0 10.0 12.0 14.5	45.00 38.40 33.10 25.75 20.59 17.08 14.53 12.59 9.84 7.58	45.00 38.03 32.03 24.23 19.40 16.11 13.72 11.91 9.33 7.22
18	4.5 5.0 6.0 7.0 8.0 10.0 12.0 14.0 16.0 17.0	37.00 33.00 25.71 20.54 17.03 12.55 9.81 7.95 6.61 6.06	37.00 32.01 24.20 19.37 16.07 11.88 9.31 7.57 6.31 5.80
21	5.0 5.5 6.0 7.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0	32.00 28.90 25.69 20.52 17.01 12.53 9.80 7.95 6.61 5.60 4.80	31.96 27.58 24.19 19.35 16.06 11.86 9.30 7.57 6.32 5.37 4.62
24	5.5 6.0 7.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 23.0	27.50 25.64 20.47 16.95 12.46 9.72 7.88 6.55 5.54 4.74 4.10 3.83	27.50 24.16 19.31 16.01 11.81 9.24 7.51 6.26 5.32 4.58 3.98 3.72
27	6.0 7.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 25.0	24.00 20.45 16.93 12.44 9.70 7.85 6.52 5.52 4.73 4.09 3.56 3.33	23.98 19.30 15.99 11.79 9.22 7.49 6.24 5.30 4.56 3.97 3.48 3.26
30	6.6 7.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0	21.00 20.38 16.85 12.36 9.62 7.77 6.44 5.44 4.65 4.02 3.50 3.07 2.69	20.91 19.24 15.93 11.72 9.15 7.42 6.18 5.24 4.50 3.91 3.42 3.02 2.67

Boom (m) Ausleger Flèche	Radius (m) Ausladung Portée	Rated Load (t) Nennlast in (t) Charge nominale (t) BSS 1757 1986 BSS 1757 1986	US Rating factors US-Nennwertfaktoren Facteurs product. E.U.
33	7.1 8.0 9.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0	18.00 16.25 14.25 12.31 9.56 7.71 6.38 5.37 4.58 3.95 3.43 3.00 2.62 2.30	18.00 15.90 13.50 11.68 9.11 7.37 6.12 5.18 4.44 3.85 3.36 2.96 2.61 2.31
36	7.6 8.0 9.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 33.0	16.50 16.00 14.17 12.23 9.48 7.63 6.30 5.29 4.51 3.88 3.36 2.92 2.55 2.24 1.96 1.83	16.50 15.84 13.44 11.62 9.04 7.31 6.06 5.11 4.38 3.79 3.30 2.90 2.55 2.25 1.99 1.88
39	8.2 9.0 10.0 12.0 14 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0	14.50 13.50 12.15 9.40 7.54 6.21 5.20 4.42 3.79 3.27 2.84 2.47 2.16 1.88 1.64	14.50 13.37 11.55 8.97 7.23 5.98 5.04 4.30 3.71 3.23 2.82 2.48 2.18 1.93 1.70
42	9.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0	12.30 11.60 9.36 7.50 6.16 5.15 4.37 3.73 3.21 2.78 2.41 2.09 1.81 1.57	12.30 11.52 8.94 7.20 5.94 5.00 4.26 3.67 3.18 2.77 2.43 2.13 1.87 1.64
45	9.2 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0	11.50 11.00 9.28 7.42 6.08 5.07 4.28 3.65 3.13 2.70 2.33 2.01 1.73 1.49	11.50 11.00 8.87 7.13 5.87 4.93 4.19 3.60 3.11 2.70 2.36 2.06 1.80 1.58
48	10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0	9.50 8.50 7.33 5.99 4.98 4.19 3.56 3.04 2.61 2.24 1.92 1.65 1.41	9.50 8.50 7.05 5.80 4.85 4.11 3.52 3.03 2.63 2.28 1.99 1.73 1.45
51	12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0	7.50 6.70 5.88 4.87 4.08 3.44 2.92 2.49 2.12 1.80 1.53 1.29	7.50 6.70 5.70 4.76 4.02 3.42 2.93 2.53 2.18 1.80 1.53 1.29

APPENDIX D

PROPOSED STAFF COMPLEMENT

MASTER PLAN REPORT - ANNEX 5

APPENDIX D

PROPOSED STAFF COMPLEMENT

(Extracted from Figure 4.1 except for details of expatriate staff)

LOCAL STAFF

MANAGEMENT, SURVEYING & ENGINEERING GROUP

1	Superintending Engineer
2	Executive Engineers
2	Engineers (SDE)
1	Land Surveyor
2	Chainmen
2	Marine Surveyors
1	Electronics Engineer
1	Workshop Technician
2	Drivers
1	Boatman

CASTING YARD, LAND AND MARINE WORKS MAINTENANCE UNITS

3	Supervisors
1	Tug Captain
8	Crew
1	Speedboat Pilot
2	Contract Divers (say 4 man weeks)
1	Concrete Technician
2	Crane Drivers
2	Banksmen
1	Dozer Driver
2	Dump Truck Drivers
1	Flat-Bed Trailer Driver
2	Roller Drivers
1	Bowser Driver
1	Excavator Driver
20	Labourers

COUNTERPART EXPATRIATE STAFF

Contractor's Staff

Chief Construction & Maintenance Adviser

Engineering Adviser

Construction Supervisor

Technical Assistance

River Training Engineer

Hydraulic Engineer/Morphologist

Contract Staff

Land and Marine Survey Specialists

APPENDIX E

STAFF COSTS

APPENDIX E

STAFF COSTS

LOCAL STAFF (BWDB)

		Monthly Payroll Cost Tk	Total Monthly Payroll	Annual Payroll Cost Tk
MANAGEMENT SURVEYING & ENGINEERING GROUP				
1	Superintending Engineer	16 500	16 500	198 000
2	Executive Engineers	15 000	30 000	360 000
2	Engineers (SDE)	11 000	22 000	264 000
1	Land Surveyor	6 000	6 000	72 000
2	Chainmen	4 000	8 000	96 000
2	Marine Surveyors	9 000	18 000	216 000
1	Electronics Engineer	11 000	11 000	132 000
1	Workshop Technician	5 000	5 000	60 000
2	Drivers	5 000	10 000	120 000
1	Boatman	4 000	4 000	48 000
CASTING YARD, LAND AND MARINE WORKS MAINTENANCE UNIT				
3	Supervisors	10 000	30 000	360 000
1	Tug Captain	6 000	6 000	72 000
8	Crew	4 000	32 000	384 000
1	Speedboat Pilot	4 000	4 000	48 000
2	Contract Divers (say 4 man weeks)	13 500	13 500	13 500
1	Concrete Technician	10 000	10 000	120 000
2	Crane Drivers	9 000	18 000	216 000
2	Banksmen	3 000	6 000	72 000
1	Dozer Driver	9 000	9 000	108 000
2	Dump Truck Drivers	9 000	18 000	216 000
1	Flat Bed Trailer Drivers	5 000	5 000	60 000
2	Roller Drivers	9 000	18 000	216 000
1	Bowser Driver	9 000	9 000	108 000
1	Excavator Driver	9 000	9 000	108 000
20	Labourers	3 000	60 000	720 000
	Total Annual Payment			4 387 500
	Add 50% overheads (say)			2 193 750
	TOTAL BWDB STAFF COST			6 581 250

BWDB Staff Transport Cost (including drivers)

3 cars @ Tk 20000 per month	= Tk 720 000 p.a.
3 No. 4WD @ Tk 30000 per month	= Tk 1 080 000 p.a.
2 minibuses @ Tk 25000 per month	= Tk 600 000 p.a.
2 pickups @ Tk 25000 per month	= Tk 600 000 p.a.
BWDB Staff Transport Cost	= Tk 3 000 000 p.a.
Speedboat @ Tk 10000 per month	= Tk 120 000 p.a.
Total BWDB staff and transport cost	= Tk 9.70 m p.a.

COUNTERPART STAFF

Position	Charge rate p.m (US$)	Annual Cost (US$)
Chief Construction & Maintenance Adviser	17 500	210 000
Engineering Adviser	14 000	168 000
Construction Supervisor	12 500	150 000
River Training Engineer	16 000	192 000
Hydraulic Engineer/ Morphologist (6 month)	13 000	78 000

Total Counterpart Staff Charges	US$ 798 000 p.a.
Airfares, travelling etc. say 15 @ US $ 3000 p.a	= US$ 45 000 p.a.
Accommodation, 4.5 @ say US $ 20000 p.a	= US$ 90 000 p.a.
Total Counterpart Staff Costs	= US$ 933 000 p.a.
@ US $ = Tk 39.10	= Tk 36.48m p.a.

Counterpart Staff Transport Costs (including drivers)

2 cars @ Tk 20000 per month	= Tk 480 000 p.a
2 no. 4WD @ Tk 30000 per month =	Tk 720 000 p.a
	= Tk 1 200 000 p.a

Total Counterpart Staff and Transport Costs = Tk 37.68 m p.a

CONTRACT STAFF

Land and marine survey specialists, inclusive of all costs (orientative quotation obtained from Dillingham & Associates, UK)

Initial structural performance survey	£ 7 800
Initial bathymetric survey	£ 31 000
Initial current meter survey	£ 17 500
Total Land & Marine Survey Specialists	£ 56 300
@ £ Stg. = Tk 71.1	Tk 4.00 m

Grand Total of Staff and Transport Costs (Tk million)

Year	1	2	3 onwards
BWDB	9.70	9.70	9.70
Counterpart Staff	37.68	37.68	0.00*
Contract Staff (Survey)	4.00	0.00	0.00
TOTAL	**51.38**	**47.38**	**9.70**

* depending on need for continuing services

APPENDIX F

INVENTORY OF PLANT AND EQUIPMENT REQUIRED FOR MONITORING AND MAINTENANCE

MASTER PLAN REPORT - ANNEX 5

APPENDIX F

INVENTORY OF PLANT AND EQUIPMENT REQUIRED FOR MONITORING AND MAINTENANCE

Exchange rates taken as £1 = Tk 71.1 and 1 US$ = 39.1 Tk

1 SURVEY EQUIPMENT

		COSTS			
		Capital		Recurrent	
Land Based Equipment		New Price	Recondi-tioned	Total	
Manual					
Theodolite			£ 2 265		
Level & Staff		£ 1 020			
100m tape and repair kit		£ 146			
Total	(per set)	£ 3 431			
Automatic Tacheometer	(per set)	£ 12 724			
					£ 4 690
NB. 2 or more sets required: (assume adopt manual option)					
Total (for manual option)				£ 3 431	£ 377 p.a.
		Equivalent to		Tk 0.24m	
		Add duty @ 83.5% CIF	=	Tk 0.20m	
			TOTAL=	Tk 0.44m	Tk 0.03m p.a

NB. 1. Total recurrent cost estimated at 1% of the CIF cost per annum for repairs, and straight line depreciation of capital cost over 10 years.

2. This estimate does not include for land transport (say 1 No 4WD vehicle). It has been assumed this would be leased from a local hire company rather than purchased outright, and thus be entered as local recurrent costs (along with staff costs ie driver + vehicle).

Marine Equipment

1. Survey Vessel	New Price	Recurrent
Alluminium hull twin engine survey vessel, 40 ft long, equpped with winch and derrick, accommodation, etc.	£ 200 000	
Mechanical spares	£ 25 000	
Add for CIF Chittagong (including survey equipment)	£ 15 000	
TOTAL CIF	£ 240 000	£ 14 400
Add duty at 83.5 % CIF	£ 200 400	
Add inland transport at say 0.5 % CIF	£ 1 200	
Setting up and testing survey equipment & boat	£ 21 800	
Total for boat and spares	£ 463 400	£ 14 400
Equivalent to	Tk 32.95	Tk 1.02 m

NB. Total recurrent cost estimated at 1% per annum for repairs and straight line depreciation of capital cost over 10 years.

2. Marine Survey Equipment	New Price	Recurrent
Position fixing equipment (Microfix or similar) 2 No. @ £ 66 500	£ 133 000	
On board p.c	£ 2 500	
Side scan sonar (Imagenex 855 or similar) 2 @ £ 18 500	£ 37 000	
Echo sounder	£ 15 000	
Hydrographic survey computer program	£ 6 000	
On-board A3 x-y plotter	£ 1 250	
On-board printer	£ 400	
	New Price	Recurrent

Shore based AO plotter	£ 7 500	
Recording tide guage	£ 6 500	
Current meter (direct reading, electromagnetic)	£ 6 000	
	£ 215 650	£ 23 720
Add duty @ 141 % CIF	£ 304 070	
TOTAL CIF + duty	£ 519 720	
Equivalent to:	Tk 36.95 m	Tk 1.69 m

N.B Total recurrent cost estimated at 1 % CIF per annum for repairs and straight line depreciation of capital cost over 10 years.

Orientative quotations for marine survey were obtained from:

Total Marine Equipment (Tk. million)	Capital	Recurrent
Survey vessel	32.95	1.02 p.a.
Marine survey equipment	36.95	1.69 p.a.
TOTAL	Tk 69.90 m	Tk 2.71 m p.a.

Dillingham and Associates, UK	-	survey vessel, echo sounder, computer equipment, position fixing equipment, tide guage
Gardline Surveys, UK	-	side scan sonar
W.S. Ocean Systems, UK	-	current meter

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2. COMPUTER EQUIPMENT FOR SURVEY DATA PROCESSING

Revetment Cross Sections and Bathymetric Contour Plotting, Data Processing, Analysis and Storage

	COSTS	
	Capital	Recurrent
Hardware		
2 No 80mb 486PC 4mb RAM workstations	£ 3 000	
2 No 24pin wide carriage dot matrix printers	£ 1 000	
2 No A3 Colour printers	£ 2 000	
Software		
SANDS (including in-built licence for INFAMEX database)	£ 5 000	£ 650 p.a.
SIMPLEPLOT	£ 100	
GRIDDER/CONTOURER	£ 1 000	£ 100 p.a.
Standard customisation	£ 4 000	
Further development work to customize specifically for river training	nominal	
	£ 3 500	

Total	£19 600	£ 750 p.a.
Equivalent to	Tk 1.39m	
Add duty @ 141% CIF =	Tk 1.96 m	

	Tk 3.35 m	Tk 0.05 m p.a.

N.B Recurrent costs are fees to software licensee for updates, newsletters, etc.

3. SATELLITE IMAGERY PROCUREMENT AND COMPUTER EQUIPMENT FOR APPROPRIATE PROCESSING

	Capital (£)	Capital (Tk)	Recurrent (Tk)
386 Computer		187 000	
Digitiser - A1 Size		262 000	
Plotter - A1 Size		265 000	
PC ARC INFO Module	9 000		
PC TINS	2 700		
	11 700	= 832 000	
TOTAL		1 546 000	
Say		TK 1.55 m	Say Tk 0.10m

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4. MARINE PLANT

	COSTS	
	Capital	Recurrent
1 No 650 HP Tug @ £ 200 000 each	£ 200 000	
1 No 150 Tonne barges:		
(new) @ £ 250 000		
(15 year old) @ £ 75 000	£ 75 000	
1 No 60 Tonne barge:		
(new) @ £ 100 000		
(15 year old) @ £ 30 000	£ 30 000	
1 No pontoon with hydraulic arm (10 year old)	£ 20 000	
Total cost (using 2nd hand plant when available)	£ 325 000	
with c.i.f. Chittagong @ 12½%	£ 40 625	
	£ 365 625	
Add duty @ 83.5 % CIF =	£ 305 300	
Add inland transport @ say 0.5 % CIF	£ 1 830	
TOTAL	£ 672 755	
Equivalent to	Tk 47.83 m	
Recurrent cost @ 1% CIF p.a. and straight line depreciation of capital cost over 20 years		£ 21 940 p.a.
Equivalent to		Tk 1.56 m

NB. 1. This estimate does not include for speedboats for supervisor's transport. It has been assumed these would be leased from a local hire comp any, and thus entered as a local recurrent cost (along with staff cost, ie pilot + boat).

5. LAND BASED PLANT

		COSTS		
	New Price	Capital	Secondhand	Recurrent (Operating + replacement)
RB CH 50 crane	£ 200 000			Tk 1.35 m
Dump Truck 10t			(1990) 20 000	Tk 0.28 m
Sheepsfoot Roller 10t	£ 27 240			Tk 0.21 m
Road Roller 10t	£ 30 000		(1989) £ 20 000	Tk 0.21 m
Water Bowser 5t			(nominal 2nd hand) £ 15 000	Tk 0.28 m
Hydraulic Excavator ($0.5m^3$) 15t	£ 59 000		(1991) £ 35 000	Tk 0.86 m
150HP Dozer	(1990) £ 102 000		£ 65 000	Tk 1.34 m
Concrete Mixer	£ 11 100			
				Tk 4.53 m

Total (using 2nd hand equipment where available)		£ 393 340
+12½% c.i.f Chittagong		£ 49 170
	TOTAL CIF	£ 442 510
Add duty @ 83.5 % CIF		£ 369 490
Add inland transport @ say 1% CIF		£ 4 430
	TOTAL	£ 816 430
	Equivalent to	Tk 58.05 m

NB.

1. Recurrent costs for these items of plant have been estimated from the Caterpillar Performance Handbook which lists ownership period as "dependant on operating conditions" which have been taken as average. Where equivalent plant is not available in the Handbook, costs have been based on similar power rated machines of a similar working method.

2. Two No cranes and dump trucks may be required, one of each for the casting yard and for the land based maintenance crew. However, dependent on the nature and timing of work, it may be possible to deploy the one item of plant for both crews. The land based maintenance crew only requiring the plant intermittently.

SUMMARY SHEET

	Capital (Tk million)	Recurrent (Tk million p.a.)
Land and Marine Survey Equipment	70.34	2.74
Computer Equipment		
Bathymetric Contouring etc	3.35	0.05
Satellite Image Processing	1.55	0.10
Marine Plant	47.83	1.56
Land Plant	58.05	4.53
GRAND TOTAL	**181.12**	**8.98**

APPENDIX G

MATERIALS COSTS

MASTER PLAN REPORT - ANNEX 5

APPENDIX G

MATERIALS COSTS

(based on 1 % of principal materials per annum)

1.	Concrete blocks: 20000 no.	
	16 000 x 550 mm cubes @ Tk 369	Tk 5.90 m
	2 000 x 720 mm cubes @ Tk 828	Tk 1.66 m
	2 000 x 850 mm cubes @ Tk 1362	Tk 2.72 m
		Tk 10.28 m
2.	Geotextile above LWL	
	1300m² @ Tk 426	Tk 0.55 m
3.	Geotextile and fascine below LWL	
	2350 m² @ Tk 486	Tk 1.14 m
4.	Geotextile bags (0.75 m^3)	
	say 1000 no @ Tk 1240	Tk 1.24 m
	Total 1 + 2 + 3 + 4	Tk 13.21 m
	Minor materials items @ 10 %	Tk 1.32 m
	Total materials costs	Tk 14.53 m p.a.