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Technical Report Series 15.

THE INTEGRATED APPROACH OF WATER HYACINTH CONTROL ON LAKE KAINJI:

WITH SPECIAL REGARD TO THE DESIGN, CONSTRUCTION AND INSTALLATION OF A WATER HYACINTH BARRIER ACROSS THE RIVER NIGER

by Dr. J.S.O. Ayeni and M. Mdaihli

**Nigerian-German (GTZ)
Kainji Lake Fisheries
Promotion Project**

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September, 1999

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1. Project Background

The Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project (NG-KLFPP) started its operations in May, 1993 with the purpose to prepare, test and implement a fisheries management plan for sustainable exploitation of the fisheries resources of the Lake.

At the time when the Project was conceived, there was no water hyacinth (WH) on Kainji Lake (Fig. 1). Indeed, throughout the first decade (1969-79) after its creation, the lake had less than 10% of its maximum 1,270 Km^2 surface area colonized by aquatic plants dominated mainly by the Niger grass Echinochloa stagnina (Retz). The vegetation community then was of no threat to the fishes which rather preferred to hide within them; the vegetation also provided ideal nesting sites for breeding fishes (Imevbore, 1971; Chachu, 1977). Some of the plants were also utilized by the lake area dwellers for livestock fodder, and in formulating several medicinal concoctions for both livestock and human beings (Ayeni, Obot and Mbagwu, 1994; Morton and Obot, 1984; Obot, 1985).

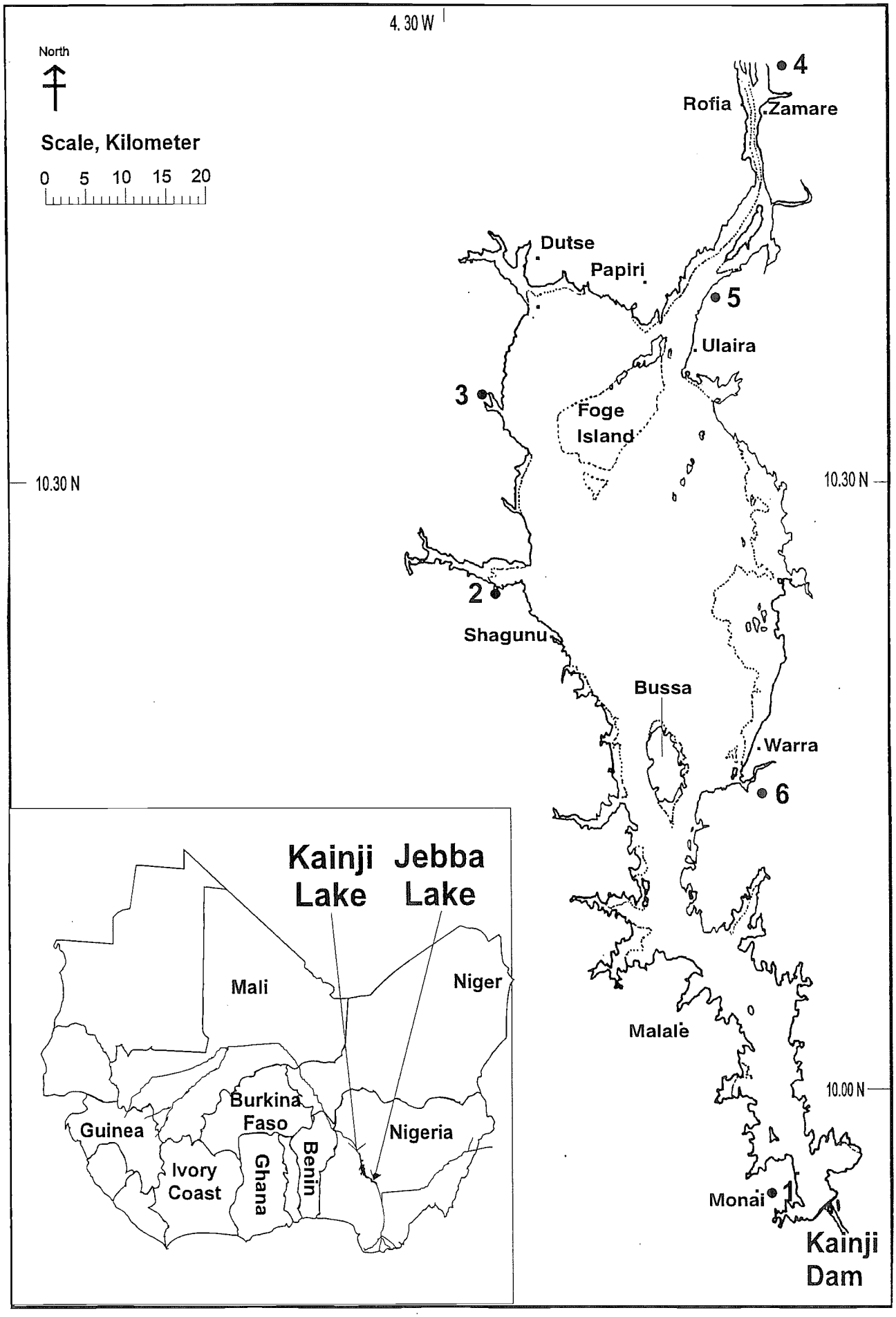
Nevertheless, the second decade after lake creation (1979 - 1989) witnessed rapid changes in both hydrology and weed population of the lake. The lake designed for maximum draw-down of 10m reached draw-down of up to 16m (Joint Consultants, 1961; Sagua and Fregene, 1979; Obot, 1989), and because of reducing water inflow from the upper reaches of river Niger into the lake, the lake management authority had to stop regular spillage by closing the spillway gates to conserve water. Consequently, the lake water turn-over rate which was 1:4 per annum in the first decade decreased to 1:2 during the second decade of lake operations (Ayeni et al, 1995).

The recent longer water residence in the lake had increased the rate of siltation, as well as improved the build-up of aquatic plant species, such that by 1984, 28% of the lake surface was covered by vascular aquatic plant (VAP) communities. It was during the same second decade that the National Institute for Freshwater Fisheries Research (NIFFR) first considered introducing a management programme on the plant populations of Kainji Lake.

Before the end of 1989, small mats of floating water hyacinth (WH) Eichhornia crassipes (Martius) started to appear for the first time on Lake Kainji. By 1994, WH was ubiquitous throughout the lake with frequency of observations as high as 91%. By 1995, among all VAP, WH alone covered 23% of the lake surface area (Ayeni et al, 1995).

On the lake, WH increases the evapo-transpirational water loss, and thus reduces water availability for electricity generation, and for irrigation agriculture (Ayeni, Obot and Mbagwu, 1994). It also reduces free movement of transportation boats.

Figure 1: Map of Kainji Lake within the Economic Community of West African States (ECOWAS)



To the fisherfolks, the weed "sends away fish", harbours snakes, blocks beaches and fish breeding grounds (Fig.2), dislodges set nets and kills livestock (if fed on it). The WH also kills out desirable species of vegetation such as the Niger grass on which livestock feed during the peak of the dry season.

The above listed undesirable effects of WH on fisheries (Fig 2) and the lake necessitated the Nigerian-German Kainji Lake Fisheries Promotion Project (NG KLFPP) in 1996 to include an integrated WH control programme in its on-going fisheries management and development activities on the lake.

2. Control of Water Hyacinth on Kainji Lake

Although the present report is concerned mainly with details about the design, construction and installation of a WH Barrier, yet it is important to note that several control measures, with relative merits and successes, were embarked upon by NIFFR with support and collaboration of the NG KLFPP. An approach which combines biological and manual control with the construction of a WH Barrier proved to be very effective on Kainji Lake. Natural control and chemical control approaches were considered, but the latter only stopped at the planning stage of acquiring knowledge for capacity building of NIFFR staff by experts from the Obafemi Awolowo University, Ile-Ife. Should a quick emergency intervention be required in areas where there are minimal prospects for toxicity to build up, as well as no contacts with human and livestock populations, it was planned that chemical control of WH could be carried out by the trained NIFFR staff.

2.1 Biological Control Efforts

The biological control agents used are insect weevils (Neochetina bruchi {Hustache} and Neochetina eichhorniae {Warner}) which feed exclusively on WH. The weevils were obtained from the Biological Control Unit of the International Institute for Tropical Agriculture (IITA), Cotonou, Benin Republic; and the National Agency for Science and Engineering Infrastructure (NASENI) insectary at the National Institute for Horticultural Research (NIHORT), Ibadan (Fig 3a & 3b).

The weevils were multiplied by NIFFR in plankton net 'hapas' constructed over healthy WH in the open lake, from where they were released to infest WH throughout the lake. Unfortunately the moths of the lepidopteran Samoede sp. whose larvae were said to be effective in destroying flowering stages in WH, although requested by this Project, is yet to be delivered by the IITA, Benin.

It was observed that reliance on the biological control method alone was too slow to produce the desired quick eradication of WH on the lake, hence recourse by the project to the combined control measures.

Figure 2: Map of Kainji Lake Showing the Overlapping of some Fish Breeding Grounds by Water Hyacinth Cover, 1996

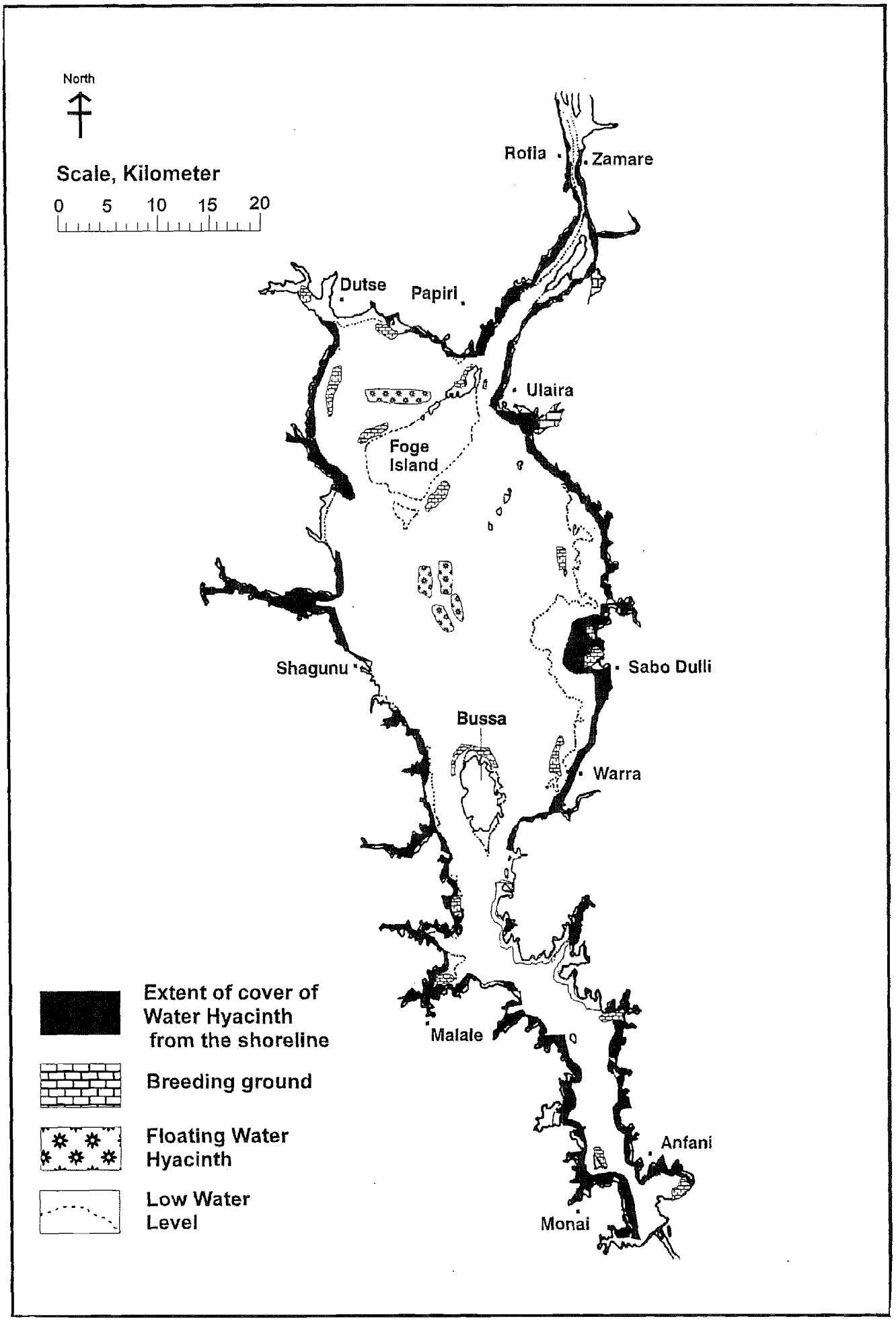
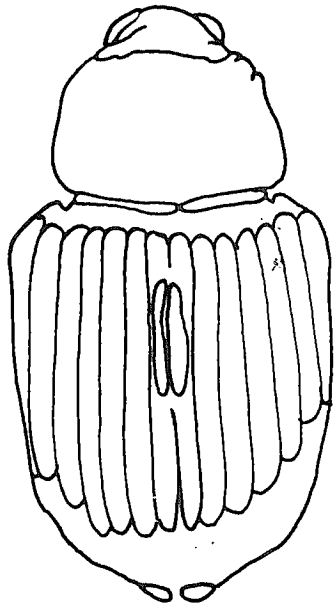


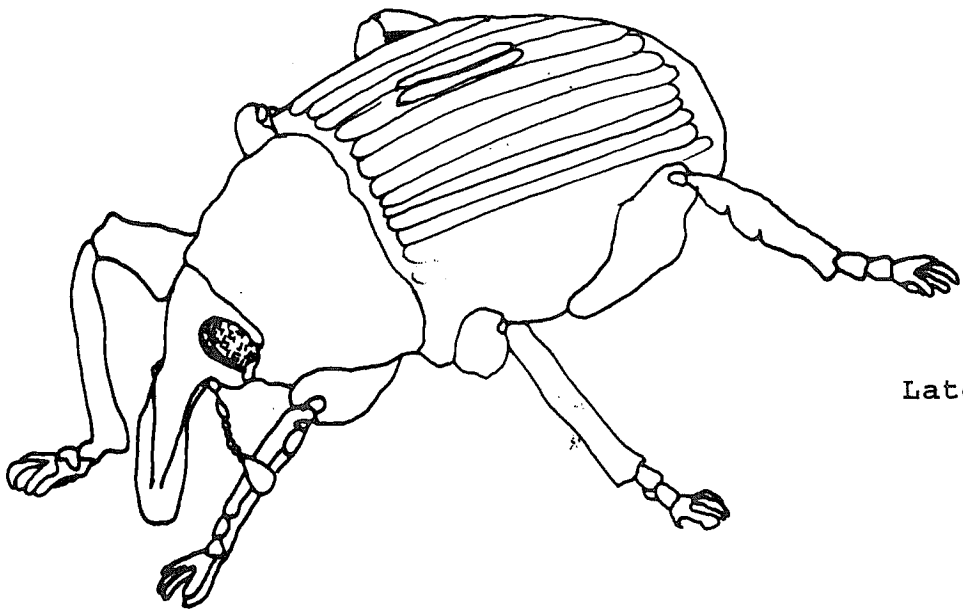
Figure 3a: Dorsal and Lateral Views of Neochetina eichhorniae



Dorsal View

Scale

1mm

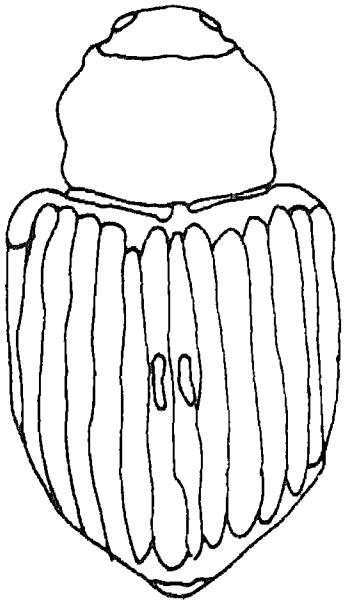


Lateral View

Scale

1mm

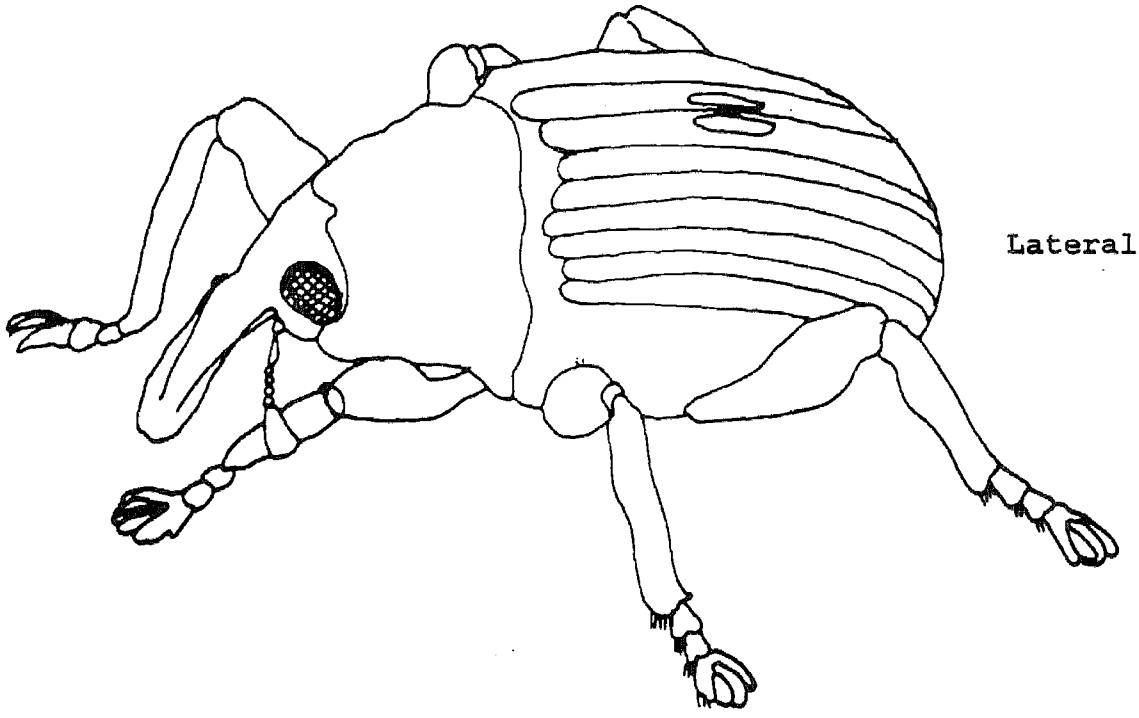
Figure 3b: Dorsal and Lateral Views of Neochetina bruchi



Dorsal View

Scale

1mm



Lateral View

Scale

1 mm

Nevertheless, by 1997/98 during the floods, about 90% of all WH inspected on the lake showed evidence (feeding scars) of weakening due to weevil attacks.

2.2 Natural Control

The flood regimes of Kainji Lake support natural control of WH during its draw-down phase. Aquatic plants, especially rhizophytic grass communities, and amphibious shrubs along the lake entrap WH during the draw-down. The entrapped WH soon dry up and are easily burned with other vegetation when the entire savanna is annually subjected to wild bush burning. The report that ashes of burned hyacinth effect rapid growth of agricultural crops encourages many farmers to gather and burn hyacinths along the draw-down flood plains (Fadama) where they grow dry season crops such as onions, pepper, okra, tomatoes and sometimes rice and beans. This farming practices entailing collecting and burning WH along with the attendant dry season bush burning of vegetation along the shores of lake, constitutes incidental natural control measure.

2.3 Manual Control

In order to elicit the support of the local communities, the Local Government Authorities, States Fisheries Divisions and State's Extension Agents were sensitized on problems constituted by WH and on needs to remove the weed manually before help comes from the Government. Radio programmes, jingles, village singers, drama groups and posters were used along with training in community mobilization by the Project to disseminate information on the need for WH control in the villages.

In 1995 and 1996 dry water periods, it was estimated that out of about 1.4 million metric tonnes of WH entering the lake annually, about 1 million metric tonnes of the weed was removed through community efforts, free of any cash payment or other incentives. This kept the lake relatively free of weed since the remaining pockets were either burned up with the annual bush fires or destroyed through the biological control agents (Ayeni and Daddy, 1996).

The Federal Government of Nigeria (FGN) through its Ecological Disaster Fund in the Presidency, provided money to enable NIFFR carry out research on aquatic vegetation generally, and to mobilize communities to regularly clear WH.

2.4 Control by WH Barrier

In spite of the successes of a combination of the already described control methods in clearing WH on the lake, fresh WH continued to arrive annually with the flood waters from Niger and Mali Republics.

It was therefore conceived that a barrier would be needed to prevent fresh hyacinths from entering the lake to re-infest previously cleaned shoreline areas.

The WH Barrier was funded by GTZ with the FGN providing the counterpart funds to ensure maintenance after the construction as well as provide back-up for removal and safe disposal of water hyacinth retained by the barrier.

3. Conceptualization, Design and Layout Details of the WH Barrier

With a rough idea of what the proposed barrier could look like, the NG KLFPP invited and discussed with consultants to submit proposals and designs suitable for the job at hand. The FISESCO-TALON JOINT VENTURE produced the finally acceptable design in 1997. The designs were vetted and certified with the help of the LAHMEYER INTERNATIONAL (Consulting Engineers for Energy, Water, Environment, & Transportation), Germany, appointed by the GTZ Headquarters.

3.1 Design Considerations

The design considers many factors with a view to achieve a product that is efficient, cost effective and serviceable; these include:

- effectiveness in trapping water weeds;
- durability of all component parts;
- ease of maintenance;
- resistance to corrosion;
- ability of the floating part to remain afloat;
- ability to adjust to varying water levels where appropriate;
- ability to withstand water, weeds, wave and wind loads;
- ability to withstand extreme temperatures and other elements of weather, and
- local availability of materials, fabrication and installation know-how.

3.2 Design Concept

For the design, consideration was given to the available records on flood regimes before and since lake impoundment. Studies carried out on site and reports on Kainji Lake indicates that flooding takes place between September and February. During this time, the Niger River at Zamare and Rofia overflows its banks to a size of about 1,200m width, covering the flood plains of appr 245m and 315m at Zamare and Rofia respectively.

Between March and August (period known as dry water season) the flood reduces and the river shrinks back to a width of 640m. In view of this and for the security of the boom after installation, two types of barriers were incorporated in the design concept.

The first is the flexible section that remains afloat when placed in water. It can also adjust to variation in water levels. This type was installed across the main channel of the river where there is constant supply of water all the year round.

The second type is the rigid barrier section. This is a form of screen wall rising from the river bed to a height well above the high water level and secured permanently to piles. The rigid screen was installed on the flood plain which receives no water during the dry water period, but is an area of intensive human activities such as draw-down farming and animal husbandry during late dry season. The screen however, does not lend itself easily to abuse by the local people. It has the advantage of not only being cheap to construct, and install, but also cheap to maintain.

Both barrier types have been designed to effectively trap WH and other floating water weeds; resist all forces due to water, wind, wave and weeds, have minimal need for maintenance and have adequate protection against corrosion and abrasion.

Figure 4 shows the layout of the flexible and the fixed sections of the barrier. The rigid section of the barrier is divided such that about half of its length is located within the draw-down area respectively on each of the two banks of river Niger at Rofia and Zamare villages. At the divide, the rigid section provides pedestrian crossing space to enable livestock and people to pass through during the low water period, and for canoes to pass during high water period. At the same time, the overlap between the fences/screen arrangement prevents floating WH from passing through the gaps.

Figure 5 is a diagram of a pair of booms; the assemblage of which constitutes the flexible mid-water boom section on each side of the river course. Each boom is held in position through mooring ropes attached to concrete anchors.

The stretches of the booms are about 380m (Rofia axis) and 390m (Zamare axis) long, and kept in place by chain attachments to piled abutments or bollards of hollow steel piles casing filled with rods reinforced concrete. A gap of about 85m between ends of each booms assemblage from either side of the river course provides required space for inland water vessels, barges, boats and canoes to pass up and down the river along the deepest point of its original course. The sheltering arrangement of one stretch of booms over the other prevents WH from escaping through this gap/space just described above.

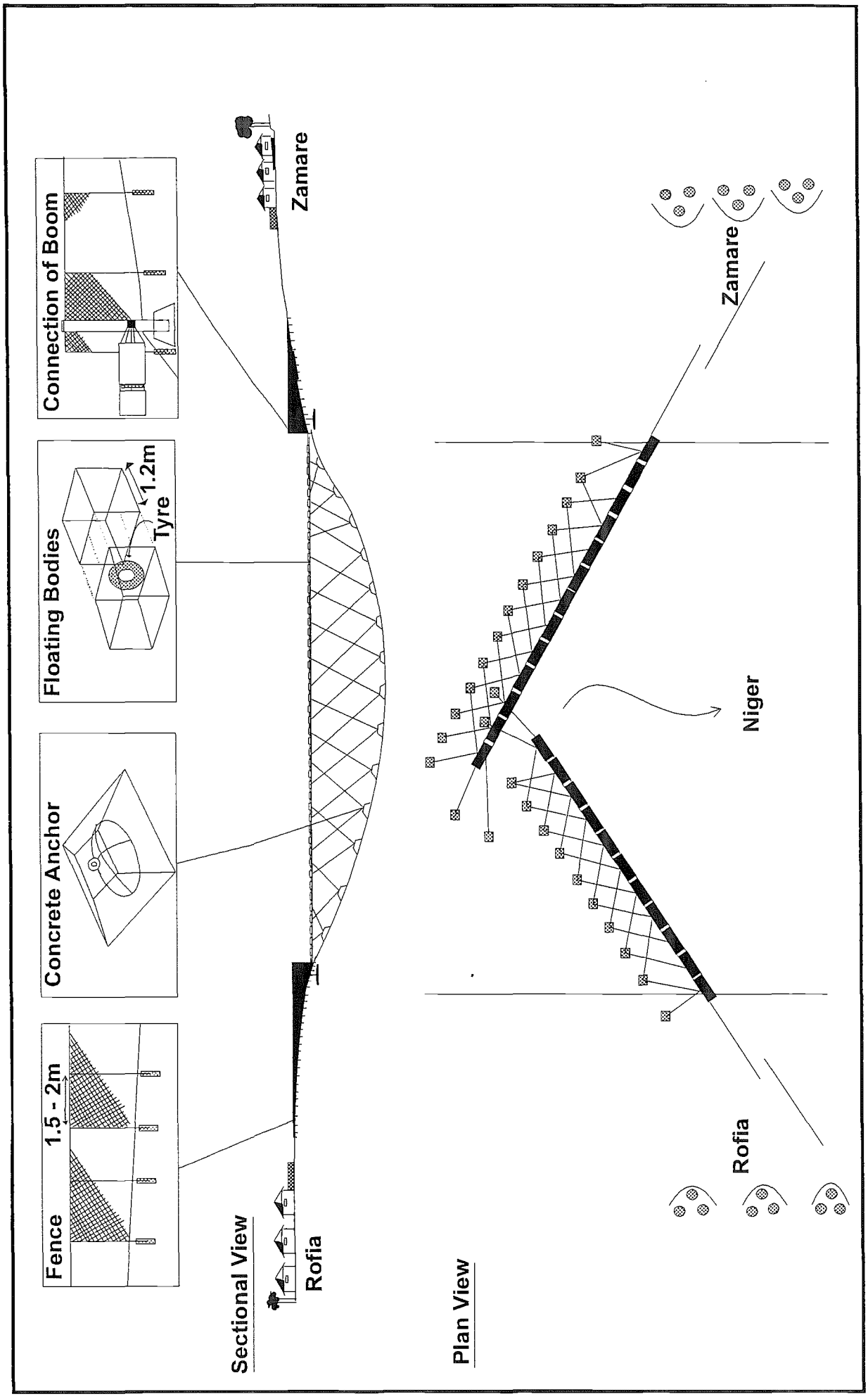


Fig. 4 Sectional and Plan View of Water Hyacinth Barrier Between Rofia and Zamare on Kainji Lake

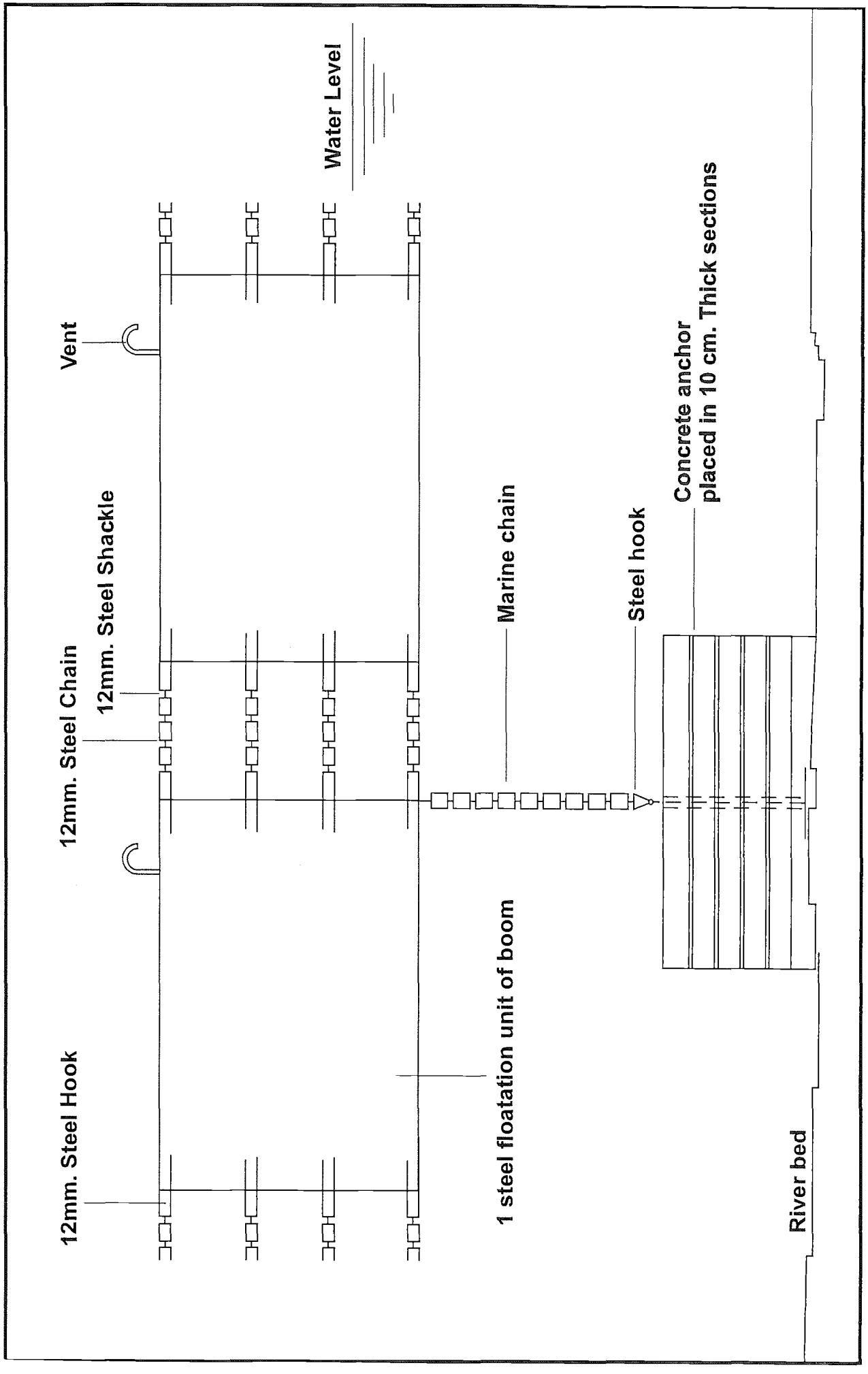


Fig. 5 Cross Sectional View of the Boom Showing the Anchor and Floatastion Unit Assembly

3.3 Details of the Rigid Section of the Barrier

The rigid barrier segment for the WH control consists of a support pile and a flat steel bar mesh.

3.3.1 Support Pile

Each pile is made of tubular steel casing (175mm diameter and 8mm thick) driven down to depths corresponding to two parts in the ground to one part above, and filled with steel reinforced concrete. It is designed to resist a shearing moment of 5.11 Kilo Newton per meter (KN/m) which could be exerted on the pile by the action of all the forces (wind, water, wave & weeds). They are spaced at 2.5 meters apart, a spacing considered adequate enough to prevent deflection of the screen bar.

The loose and saturated nature of the soil made piling on the site inevitable in order to achieve a firm and durable support for the rigid screen.

The tubular steel casings were coated with the approved epoxy tar before piling work commenced, to protect it against corrosion and rust.

3.3.2 Screen Mesh

Studies have shown that WH floats with the stems projecting to about 0.7m above the water surface and the roots to 0.3m below water surface. As the WH flow, they aggregate into clusters of up to 0.5 meters in diameter or more. Based on those physical characteristics of the weed aggregation, the screen aperture was taken as 100mm (width) x 300mm (hight) to effectively trap the weeds. The mesh was fabricated using flat steel (5mm thick, 500mm wide) bars spaced at 150mm apart on the horizontal axis and 350mm on the vertical axis. The intersections were welded together.

The screen mesh section was fabricated in four different units of 2.5m x 1.5m, 2.5 x 2.0m, 2.5m x 2.5m, and 2.5m x 3.0m and installed according to the land topography such that a projected height of 1m was uniformly left during high water level.

All the steel components including the weld beads were protected against corrosion appropriately.

3.4. Details of the Flexible Section of the Barrier

This section of the booms assembly is made up of rectangular steel buoys linked together by chain and shackles for flexibility, and secured to the river bed by concrete anchors to absorb some of the forces impacted on the boom and restrict drift. The booms are linked to the mooring concrete anchors with chain and shackle for stability.

The shore-end of the boom assemblage is connected to a pile abutment to allow for proper anchorage while the midstream end is secured on two additional anchors in the direction of the boom assemblage. Danger indicators with caution signs are placed on either side of the booms at appropriate distances to warn the lake users approaching the booms.

3.4.1 Steel Buoy

The steel buoy was designed for stability and strength. It was fabricated in units of 1,500mm length x 1,200mm width x 800mm height using 5mm thick mild steel plates. Each unit weighs 363.8kg and has an internal reinforcing frame made of 50mm x 50mm x 5mm steel angle bars to withstand a lateral force of 596 Newton. It is designed to a buoyancy force of 9.6 KN and a submerged depth of 300mm and freeboard of 500mm when floating.

The eight (8) hooks at the corners of the boom are designed to withstand tractional force of 45KN each; considering that during the combined action of all the forces, the buoy tend to rock in all directions and only two hooks are engaged at any one time. The other hooks hold chain braces to disallow weeds from flowing through the link between the booms. With the exception of the buoy bottom hook, all other hooks withstand vertical pull of 18.75KN. All weld beads have a minimum throat thickness of 3.5mm.

Air vent is provided at the top of the buoy to allow escape of expanding air and other gases during hot weather. A plate carrying 'C-caution' engraved with Neon reflective paint is welded only on one side of the buoy. As a protection against corrosion and rust, each buoy has three (3) coats (375 microns d.f.t) of the appropriate epoxy coatings.

3.4.2 Buoy Link Chains and Shackles

The attachment of buoys to each other is by means of 16mm diameter high tensile (H.T) galvanized steel chain, 19mm diameter H.T galvanized steel shackles at the corner hooks, 10mm and 13mm diameter H.T. galvanized steel chain, and shackles respectively for other hooks, including the top hook holding the rubber baffle. This system of attachments was chosen to make the boom assembly flexible in all directions and robust while still ensuring that no weed pass through.

3.4.3 Rubber Baffle

The rubber baffle is made of used tyre of size 165 x r13. It has an external diameter of 600mm and a width of 125mm. The baffle was incorporated to prevent the buoys from hitting together, which might cause wear and tear. It is sandwiched between two (2) buoys and held by 10mm galvanized steel chain and corresponding steel shackle.

Holes were made on the lower part of the baffle to drain trapped water which might add to the weight on the buoy, and also so as to make the baffles less attractive to thieves.

3.4.4 Concrete Anchor and Anchor Chain

The long spans (380m and 390m) of the booms assemblage necessitated the use of anchors to restrict drifting to within a very limited amplitude. Accordingly, the anchors were spaced at 3.8 meters interval throughout the entire spans of the booms assemblage by linking two alternate buoys for stability. The anchors are saucer shaped mass concrete weighing 383.20kg. A 12mm diameter H.T. steel hook is embedded in the concrete to project 50mm to the surface. Four hollow steel pipe legs (300mm long each) are incorporated to increase drag resistance of the anchor. The link between the boom assemblage and the anchor line consists of 10mm H.T. galvanized circular ring.

Water stage studies from available records and from high water marks showed that the deepest portion of the lake at the project installation site is midstream. The depth at this point varies from a minimum of nine meters at low water level to a maximum of eleven meters during high water level.

The length of the anchor line varies according to the bottom profile of site. The Admiralty Manual of Seamanship Volume III stipulates that anchor line should be 3.5 times the depth at the point of mooring on the high sea where wave amplitude could be as high as 10m.

Based on the recommendations in the manual just referred, the minimum value of "three times the depth" was adopted considering the low wave amplitude of 0.7m and water level difference of not more than 2.5 meters for the Kainji Lake at the WH Barrier site.

The anchors were laid during low water level, and the length of the anchor chain determined by multiplying by a safety factor of 3 to the measured depth at each anchoring point. The horizontal distance of the anchor from the boom assembly (anchor offset) was determined by Pythagoras theorem.

3.4.5 End Abutment

Two pile abutments moor each length of the booms assemblage at the shore. Each abutment is designed to withstand a lateral traction of 90KN transmitted from the boom assembly. The pile is made of 305mm tubular steel casing 8mm thick and 18m long driven down to a depth of 14.5m; leaving a free board of 3.5m. They are filled with good quality concrete and reinforced with 6 x 25 rods to a depth of 12m from the top of the pile.

A floating hook was incorporated to allow for variation in water levels. A mild steel plate (400mm diameter by 10mm thickness) was welded to the top of the pile to act as a stopper for the floating hook.

The approved anti-corrosion protective coatings was applied to the tubular pile casing before piling commenced and the freeboard touched up after all works were completed on the pile.

3.4.6 Danger Indicators

The presence of the WH Barrier constitutes a partial obstruction to flow of traffic on the lake. It was therefore important to incorporate danger indicators into the design to warn the lake users of the presence of such an obstruction. Two types of indicators are provided for in this design as follows:

Danger indicator on the boom
These are triangular steel plates measuring 300mm on all the sides and coated with reflective Neon Yellow Paint as back-ground, and a Letter 'C' engraved with Red Neon Paint at the center.

Barrier approach danger indicator
They are installed at 1,000m distance either way of the WH Barrier and firmly secured to the river bed by mooring on three concrete anchors. Each buoy carries an aluminum plate sign-board 1,400mm long x 200mm wide held on two 25.4mm diameter aluminum hollow pipes (4mm thick) with clamps, stainless steel bolts and nuts. A total of six approach danger indicators are installed; three on either side of the WH Barrier.

4. Materials Specification for the WH Barrier

Listed below are the material specifications upon which the WH Barrier design is based.

4.1 Steel Materials

All steel materials conformed to the following specification;

(i) mild steel sheet
tensile strength = 250N/mm^2; yield point = 125N/mm^2

(ii) high tensile galvanized steel (shackles, chain and/or O-ring)
tensile strength = 410N/mm^2; yield point = 165N/mm^2

(iii) tubular steel pipes
tensile strength = 390N/mm^2; Yield point = 245N/mm^2
elongation at rupture not less than 26%

(iv) steel reinforcement
tensile strength = 410N/mm^2

(v) covered electrode for the manual area welding of mild steel grade 43 complied with BS 639 section 1 & 2. The allowable stress on fillet welds = 115N/mm^2

4.2 Concrete

Concrete grade 30 is used inside the pile casing and also in casting concrete anchors. Strength of concrete at 28 days was not less than $30N/mm^2$.

4.3 Anti-corrosion Coating

All coating complied with the following specifications in order to protect steel material against corrosion:
- resistant to water,
- excellent resistance to corrosion,
- good resistance to chemically polluted water,
- good resistance against abrasion,
- applied at a d.f.t. of 125 microns in one operation,
- resistant against temperatures of not less than 90^0 C,
- minimum interval before over-coating less than 6 hours.

5. WH Barrier Construction

Following International Competitive Bidding by tenderers selected by the GTZ Headquarters, the NIGERIAN SUBMARINE DIVERS (NSD), Lagos was identified in May, 1998 to carry out the construction of the barrier.

Activities at the project site did not fully take off until July, 1998 due to some red-tape delays caused by the Chartered Bank Limited, Lagos on advance payments (made by the GTZ to the NSD) domiciled with the Bank.

Progress of work in July, 1998

The following aspects of project execution were assessed on 28th July, 1998:

i) Mobilization of personnel; including supply of materials for the construction of accommodation in Yauri, and site office at Zamare.

ii) Supply of the following materials to site:
   - 615 pcs. of 2.4m x 4.8m x 5mm mild steel plates
   - 2,200 pcs. of 50mm x 5mm thick mild steel flat bars
   - 1,131 pcs. of 50mm x 50mm x 5mm thick angle iron
   - 734 pcs. of R13 fairly used tyres
   - 162 pcs. of 175mm dia. x 12m long steel casings

iii) Erection of site office consisting of the fence, office building, store, toilets, and workshop; as well as refurbishment of buildings for staff accommodation.

The various quantities and total value of the jobs completed and evaluated by the GTZ Project Engineer/representative are summarized on Table 1. After deduction of 5.5% contained in the contract agreement the amount of =N=18,229,995 (eighteen million, two hundred and twenty nine thousand, nine hundred and ninety five Naira) was paid to the contractors.

Table 1: Estimated Value of Jobs Completed in July, 1998

ITEM ON BoQ	DESCRIPTION	BoQ QTY	QTY COMPLETED	BoQ N	AMOUNT
6.1.1.0	Mobilize piling equipment and crew to site	lump sum	100%	1,000,000.00	1,000,000.00
6.1.2.0	Allow for erection of site office and workshop	lump sum	100%	750,000.00	750,000.00
6.1.3.5	Supply and deliver 50mm x 5mm thick mild steel flat bars	26 tonnes	26 tonnes	78,600.00	78,600.00
6.2.1.0	Mobilize welding and installation equipment and crew to site	lump sum	100%	750,000.00	750,000.00
6.2.3.1	Supply and deliver 2.4m x 1.2m x 5mm thick mild steel plate	1,230 No	1,230 No	8,900.00	10,947,000.00
6.2.3.2	Supply and deliver 6m long 50mm x 50mm x 5mm thick mild steel angle	1,131 No	1,131 No	1,900.00	2,148,900.00
6.2.5.1.	Supply and deliver rubber buffer (used tyre 165 x 13)	734 No	734 No	2,250.00	1,651,500.00
				Total	19,291,000.00

Progress of work in August, 1998

The valuation of the following works carried out on the WH Barrier took place on 25th August, 1998:

i) Supply and delivery of 175mm dia 6mm thick tubular steel casings including coating of casing with appropriate anti-corrosion coating.
ii) Handle, pitch and drive 175 mm dia tubular steel casing set at 3.0m apart to the required penetration depth.
iii) The following surveying, testing, constructional and installation works were also accomplished:
   - confirmatory drill test,
   - layout survey,
   - installation of screen support (piling),
   - fabrication of screen mesh,
   - coating of screen mesh,
   - installation of screen mesh.

The various quantities and total value of the jobs completed and evaluated by the GTZ Project Engineer/representative in August are summarized on Table 2. After a deduction of 5.5% contained in the contract agreement the amount of =N=6,699,672 (six million, six hundred and ninety nine thousand, six hundred and seventy two Naira) was paid to the contractors.

Progress of work in September, 1998

The valuation of the following works carried out on the WH Barrier took place on 5th October, 1998:

i) Supply of 1,000m of 16mm dia. H.T galvanized steel chain,
ii) Supply of 1,000 pcs. of 20mm dia. H.T galvanized bow and shackles with bolts and nuts,
iii) Fabrication of the following screen meshes were accomplished:
   - 24 units of 3.0m x 3.0m
   - 62 units of 3.0m x 2.5m
   - 40 units of 3.0m x 2.0m
   - 50 units of 3.0m x 1.5m
   - 65 units of 3.0m x 1.0m
iv) Completion of installation of bollard and screen support (piling) on the Zamare side of the lake.

The bollard to secure the flexible booms assembly on the Rofia side could not be installed at the designated point due to an obstructing outcrop of rock located at 5m depth; whereas by design, the piles (4 No 175mm dia.) were to be driven 10m down below the river bed.

Table 2: Estimated Value of Jobs Completed in August, 1998

ITEM ON BoQ	DESCRIPTION	BoQ QTY	QTY COMPLETED	BoQ N	AMOUNT
6.1.1.0	Mobilize piling equipment and crew to site	lump sum	100%	1,000,000.00	1,000,000.00
6.1.2.0	Allow for erection of site office and workshop	lump sum	100%	750,000.00	750,000.00
6.1.3.1	Supply and deliver 12m long dia and 6mm thick tabular steel casing including coating of the casing with appropriate anti-corrosion coating	162 No	162 No	43,300.00	7,014,600.00
6.1.3.2	Handle, pitch and drive 175mm dia tubular steel casing at 3.0m c/c to required penetration depth as shown in the appropriate working drawing	1,473m	150m	500	75,000.00
6.1.3.5	Supply and deliver 50mm x 5mm thick mild steel flat bars	26 tonnes	26 tonnes	78,600.00	78,600.00
6.2.1.0	Mobilize welding and installation equipment and crew to site	lump sum	100%	750,000.00	750,000.00
6.2.3.1	Supply and deliver 2.4m x 1.2m x 5mm thick mild steel plate	1,230 No	1,230 No	8,900.00	10,947,000.00
6.2.3.2	Supply and deliver 6m long 50mm x 50mm x 5mm thick mild steel angle	1,131 No	1,131 No	1,900.00	2,148,900.00
6.2.5.1.8	Supply and deliver rubber buffer (used tyre 165 x 13)	734 no	734 No	2,250.00	1,651,500.00
				Total	26,380,600.00

A quick solution was found by the NSD which recommended the installation of the bollard at 80m from the designed position, nearer to the Rofia shoreline, but still along the alignment of the booms assemblage.

Table 3 is a summary of the valuation certificates issued for works executed up till end of September, 1998. After deduction of 5.5% contained in the contract agreement the amount of =N=4,963,291.20 (four million, nine hundred and sixty three thousand, two hundred and ninety Naira and twenty Kobo) was paid to the contractors.

Progress of work in October, 1998

Evaluation of works executed in October, was carried out on 3rd November, 1998. The following jobs were accomplished:

i) 16 Piles left as a result of obstructing underlying bed rock were completed by a specialized piling method known as "diamond drilling".

ii) Reinforcing and concreting of piles commenced on 2nd of October and lasted till 26th.

iii) Fabrication of unit buoys of the flexible part of the barrier assemblage began. Only 15 booms could be completed out of 40 planned, due to breakdown of electricity power generation plant.

iv) 3 buoys were coated with epoxy.

v) Materials supplied included the following:
   - 1,400 pcs of 20mm dia H.T Galv. bow shackles with bolt and nuts
   - 2,500 pcs of 13mm dia H.T Galv. bow shackles with bolt and nuts
   - 4,000m of 14mm dia Galv. slung wire rope
   - 500pcs of 13mm Galv. steel o-ring

Based on a request made by the contractors and agreed to by the GTZ, deduction of the 10% retention due in the contract agreement was not recovered until the advance payment of =N=30,000,000.00 (thirty million Naira), domiciled in the Chartered Bank Limited, Lagos was fully drawn down by the NSD. Since the value of jobs executed till end of September, 1998 was =N=31,632,760.00 of which =N=29,892,958.20 was paid to the NSD the 10% due on the whole advance payment was first recovered en-block from the NSD in October, 1998.

Table 4 is a summary of the valuation certificates issued for works executed up till end of October, 1998. After all deductions contained in the contract agreement, the amount of =N=6,045.921.89 (six million, forty five thousand, nine hundred and twenty one Naira and eighty nine Kobo) was paid to the contractors.

Table 3: Valuation Certificate for September, 1998

PROJECT:	CONSTRUCTION AND INSTALLATION OF WATER HYACINTH BARRIER ACROSS RIVER NIGER, NORTH OF KAINJI LAKE
CONTRACTOR:	NIGERIAN SUBMARINE DIVERS LIMITED 68, JUBRIL MARTINS STREET SURULERE, LAGOS
PROJECT NO:	91.2094.0 & 01.100
COMMENCEMENT DATE:	MAY, 1998
COMPLETION DATE:	FEBRUARY 1999
CONTRACT SUM:	=N=60,819,246.25
FINAL COST:	=N=60,819,246.25

Work executed on site and materials	=N=31,632,760.00
Less Repayment of 5.5% Discount	=N= 1,739,801.80
Balance	**=N=29,892,958.20**
Less Retention	- - - - - - - - -
NET VALUATION	=N=29,892,958.20
Amount previously certified	=N=24,929,667.00
Amount recommended for payment	**=N= 4,963,291.20**

Amount in words: Four million, nine hundred and sixty three thousand, two hundred and ninety one Naira, twenty Kobo.

Table 4: Site Progress Report of Site Visit on 27th Octover, 1998

ITEM	DESCRIPTION	QTY	PRICE/UNIT	AMOUNT =N=
6.1.3.3	Supply, deliver and place 12mm H.T. steel bars as pile reinforcement.	12 tonnes	60,000	720,000.00
6.1.3.4	Supply, deliver and place 10mm dia H.T. steel bars as stirrup.	0.4m	55,000	22,000.00
6.1.4.1	Supply and place fresh concrete grade 30 into the driven down pile casings.	$28m^3$	8,900	249,200.00
6.1.6.2	Supply and place 25mm dia H.T. steel bar to a max depth of 12m as reinforcement.	6 no	3,850	23,100.00
6.1.6.1	Supply, deliver and drive 18m long, 305mm dia x 10mm thick tubular steel casing to a penetration depth of 14.5m rate to include coating of pile against corrosion.	1 no	145,000	145,000.00
6.1.6.3	Supply and place fresh concrete grade 30 into the pile casing.	$0.8m^3$	8,900	7,120.00
6.2.3.3	Fabricate rectangular steel buoy 1,500mm long, 1,200mm width and 800mm high with 5mm thick m/s. plate and reinforced with 50mm x 50mm m/s. angle	15 No	9,800	147,000.00
6.2.5.1.2	Supply and deliver 20mm dia H.T. galvanized steel bow and shackle with bolt and unit nut.	2,400	2,200	5,280,000.00
6.2.5.1.3	Supply and deliver 13mm dia H.T. galvanized steel bow and shackle with bolt and nut.	2,500	700	1,750,000.00
6.2.5.1.5	ditto - 13mm dia H.T. galvanized steel o-ring	500 No	1,520	760,000.00
6.2.5.1.7	ditto - 10mm dia H.T. galvanized steel wire rope.	4,000m	380	1,520,000.00

Total valuation for October	=N=10,623,420.00
Less Discount 5.5%	=N= 584,288.10
	=N=10,039,131.90
Less Retention 10%	=N= 1,003,913.10
	=N= 9,035,218.71
Less 10% Retention on part of advance payment of =N=30,000,000.00 paid to the Chartered Bank Limited, Lagos	=N= 2,989,295.82
Balance due to Contractors on October valuation	**=N= 6,045,922.89**

Progress of work in November, 1998

The valuation of works executed in November was done on 3rd December, 1998. The following were the jobs accomplished, and supplies made:

i) supply of 18m long, 305mm x 10mm tubular casing, delivered and driven to depth of 14.5m, including coating of pile against corrosion.
ii) supply and placement of 25mm dia H.T steel bar to max. depth of 12m as reinforcement
iii) supply and placement of fresh concrete grade 30 into the pile casing
iv) demobilization of piling equipment and crew from site
v) fabrication of 88 rectangular steel buoys 1,500mm x 1,200mm x 800mm with thickness of 5mm m/s plate and reinforced with 50mm x 5mm thick m/s angle
vi) application of epoxy by sandblasting exposed surfaces of 103 buoys
vii) supply and application of 3 coats of 588 lts. high performance coal tar epoxy coating to buoys including weld beads
viii) supply and delivery of 25mm dia H.T Galv. bow shackle with bolt and nut
ix) supply and delivery of 20mm dia Galv. H.T bow shackle with bolt and nut
x) supply and delivery of 13mm dia H.T Galv. bow shackle with bolt and nut
xi) supply and delivery of 25mm dia Galv. steel o-ring
xii) supply and delivery of 10mm dia H.T Galv. steel wire rope

Table 5 is a summary of all works evaluated up till end of November, 1998. After the deductions contained in the contract agreement, the amount of =N=4,070,518.56 (four million, seventy thousand, five hundred and eighteen Naira and fifty six Kobo) was paid to the contractors.

Work-site Closure in December, 1998

Application for closure of works site was made by NSD in December because of Christmas and other public holidays.

Progress of work in January/February, 1999

Work resumed on 12th January, 1999. Evaluation of works was carried out on the 12th of February, 1999.

The following jobs were accomplished by the contractors:

i) fabrication of 125 buoys
ii) all buoys were given 3 coats of epoxy
iii) casting of 210 concrete anchors

Table 6 is a summary of the estimated value of jobs completed between January 12th and 12th February, 1999.

Table 5: Estimated Value of Jobs Completed in November, 1998

ITEM ON BOQ	DESCRIPTION	BOQ QTY	QTY COMPLETED	BOQ ₦	AMOUNT
6.1.6.1	As described in the Contract Bill of Quantities	2 No	1 No	145,000.00	145,000.00
6.1.6.2	ditto	12 No	6 No	3,850.00	23,100.00
6.1.6.3	ditto	1.6 m^3	0.8 m^3	8,900.00	7,120.00
6.1.7.0	ditto	L/S	100%		500,000.00
6.2.3.3	ditto	377 No	88 No	9,800.00	862,400.00
6.2.3.4	ditto	377 No	103 No	650.00	66,950.00
6.2.3.5	ditto	2,150 lts	588 lts	1,520.00	893,760.00
6.2.5.1.1	ditto	4 No	4 No	3,700.00	14,800.00
6.2.5.1.2	ditto	2,472 No	72 No	2,200.00	158,400.00
6.2.5.1.3	ditto	4,100 No	1,600 No	700.00	1,120,000.00
6.2.5.1.4	ditto	2 No	2 No	3,250.00	6,500.00
6.2.5.1.7	ditto	6,600m	2,600m	380.00	988,000.00

Total: =N=**4,786,030.00**
Less 5.5% Discount: =N= 263,231.65
=N=**4,522,798.40**

Less 10% retention: =N= 452,279.84

Amount recommended to contractor: =N=**4,070,518.56**

Table 6: Estimated Value of Jobs Completed in January/February, 1999

ITEM ON BOQ	DESCRIPTION	BOQ QTY	QTY COMPLETED	BOQ N	AMOUNT
6.2.3.3	As described in the Contract Bill of Quantities	377No.	125No.	9800.00	1,225,000.00
6.2.3.4	Ditto	377No.	125No.	650.00	81,250.00
6.2.3.5	Ditto	2150 litres	712.87 litres	1,520.00	1,083,562.41
6.2.4.0	Ditto	210No	210No	3,000.00	630,000.00

Total: =N=**3,019,812.41**
Less 5.5% Discount: =N= 166,089.68
=N=**2,853,722.73**

Less 10% retention: =N= 285,372.37

Amount recommended to contractor: =N=**2,568,350.36**

After the deductions contained in the contract agreement, the amount of =N=2,568,350.36 (two million, five hundred and sixty eight thousand, three hundred and fifty Naira, thirty six Kobo) was paid to the contractors.

Progress of work up till end of March, 1999

Valuation of works done between 12th February and 29th March was carried out on 30th March, 1999. The following works were accomplished during the reporting period:

i) Completion of Fabrication of Buoys
A total of 149 buoys were fabricated; this brings the total number to 377 (that is required for the entire project). The buoys were given epoxy coatings as appropriate.

ii) Fabrication of Floaters
A total number of 16 floaters of 1.0m x 0.5m x 0.5m dimension were fabricated and coated as done to the buoys. This is part of the additional works approved for the relocation of the abutment on the Rofia side.

iii) Materials Supplied
Supplied for additional jobs for the abutment relocation:
1. 160m of 16mm H.T. Galv. Chain
2. 1/2 inch Galv. wire rope clips
3. 12mm dia. Galv. bolt and nuts with washers.

Table 7 is a summary of the estimated value of jobs completed up to the end of March. After the deductions contained in the contract agreement, the amount of =N=2,422,419.36 (two million, four hundred and twenty-two thousand, four hundred and nineteen Naira, thirty six Kobo) was paid to the contractors. This amount was paid in the first week of April, 1999.

Also, as a result of request by the Contractors for an upward review of the contract price due to changes in the general market prices of consumable items used for the project, and in order to offset costs of approved additional jobs recommended by the contractors and approved by the GTZ, the amount of =N=2,134,724.00 (two million, one hundred and thirty four thousand, seven hundred and twenty four Naira) was approved by the GTZ Headquarters as additional contract price. This amount was paid in the first week of May, 1999.

Table 7: Valuation of Works Completed and Materials on Site up till End of March, 1999

A:

ITEM ON B/Q	DESCRIPTION	QTY COMPLETED	BOQ UNIT PRICE N	AMOUNT N
6.2.3.3	as in BOQ	149 No	9,800.00	1,460,200.00
6.2.3.4	as in BOQ	149 No	650.00	96,850.00
6.2.3.5	as in BOQ	849.13 lts	1,520.00	1,290,677.60
Sub Total				2,847,727.60

Less 5.5% discount: =N= 156,625.02

Less 10% retention: =N= 269,110.26

Add underpayment from last valuation: =N= 427.00

Total amount recommended: **=N=2,422,419.32**

B: Contract Addition

DESCRIPTION	AMOUNT
Add variation on floaters and chain links	=N= 406,788.80
Add fluctuation on general price levels	=N= 942,500.00
Add variation on clips and steel bolts and nuts	=N=1,045,000.00
Total amount recommended for payment on valuation certificate 008	=N=2,134,724.00

At the end of March, 1999 the following details summarize the draw down of funds for the WH Barrier project:

Original contract price:	=N=60,819,246.25
Less 5.5% discount	=N= 3,345,058.54
Original sub-total	**=N=57,474,187.71**
Add variation on general price level	=N= 942,500.00
Items not covered in original contract BoQ	=N= 1,045,000.00
New contract sub-total	**=N=59,461,687.71**
Works executed and materials on site	=N=52,371,629.30
Less 10% retention	=N= 5,237,162.93
Amount paid to Contractors till date	=N=47,134,466.37

Progress of work in April and May, 1999

There was "work closure" between the 27th March and 12th April, 1999 because of Sallah and Easter holidays and also to put some of the project vehicles in good working order, in readiness for the boom installation.

Installation of Rigid Barrier

Transportation of screen mesh started from Zamare on the 19/4/99 and from Rofia on the 26/4/99. Installation of mesh on the two banks was scheduled for completion in three weeks from the 19/4/99, but this was not possible because of breakdown of the two self generating welding machines. Repair work could not be completely effected until after one week, hence the request for a change of the valuation date from the 13/5/ to 21/5/99.

Fixing of the screen mesh including 'anti-abuse' protector in areas where screen height is less than 1.5m was completed by 12/5/99.

Installation of Flexible Section of the Barrier

a) Coupling of Buoys

Work commenced on the flexible barrier section on the 19/4/99 with the coupling of unit buoys together using 16mm H.T Galvanized steel chain shackles. The entire buoys were coupled on the 12/5/99 by a team of 4 divers who stored the buoys on water at Zamare lake shore.

b) Depth Sounding

Water depth sounding along the flexible barrier section was carried out between 13/05 and 14/5/1999. This was to enable the divers to determine the depth of water at various anchor points relative to the bollard base.

c) Preparation of Anchorage Sling Wire Rope

After knowing the various depths of water at anchor points in relation to the bollard base, sling wire ropes were measured making allowance to take care of those depths and including the additional lengths (6m) for maximum high water level. The various lengths were then cut and looped at both end using 1/2" galv. Steel clips.

d) Warning Signal Buoys

Six warning signal buoys were prepared and installed; 3 each at 1,000 meter on both approaches to the boom.

On each of the approaches, the warning signals are situated thus:

- centre signal written in English and placed midstream.
- end signals (2) written in Hausa and placed to the riverbank

All the six warning signals were installed between 15th May and 17th May, 1999. They were secured with 3 concrete anchors.

e) Installation of Bollard Hooks and Hook Stopper

The 2 bollard hooks for Zamare and Rofia were installed on the 10th and 17th of May, 1999 respectively. These also include 2 separate 10mm. circular plates to serve as stoppers for the hooks during high water period.

f) Installation of Booms Assemblage
Floating booms for Zamare and Rofia were secured to their bollard on the 17th May and 19th May, 1999 respectively.
At the Rofia end, the 16 floaters for the long length of chain were secured to the chain at 5m interval with the appropriate shackles.
g) Alignment of Boom Assemblage and Placing of Concrete Anchors
These activities planned for the 19th and 20th of May, 1999 could not be accomplished as scheduled due to heavy wind action on the river. Heavy wind (gale) started from the 17th and continued through to the 22nd May 1999; which made alignment of the buoy assemblage impossible. This is why the concrete anchors could not be laid before the stipulated date (20th May) for final evaluation of work.

Table 8 is a summary of jobs evaluated as completed between April 1st and May 20th. The amount recommended for payment to the contractor was =N=4,516,069.95 (four million, five hundred and sixteen thousand, sixty nine Naira and ninety five Kobo).

Between 24th and 28th of May, the gale subsided and the alignment of boom assemblage on both Rofia and Zamare ends including laying of concrete anchors were carried out accordingly.

Nigerian Inland Waterways Authority (NIWA)
The officials of the National Inland Waterways Authority, from their Yauri Office were invited to observe the final laying of the booms from the 24th to 28th in accordance with their letter Ref. M/YYAO/207/VOL.I/14 dated 21st April 1999.

Representatives of NIWA including the Area Manager, Surveyor Ogugua P. Nnalo were present throughout the period of alignment of the booms and expressed satisfaction that the barrier would constitute no danger to navigation.

Table 8: Estimated Value of Jobs Completed between April 1 - MAY 20, 1999

ITEM ON BOQ	DESCRIPTION	BOQ QTY	QTY COMPLETED	BOQ N	AMOUNT
6.1.5.0	As described in the Contract Bill of Quantities	650m	650m	700	455,000.00
6.1.6.4	ditto	2 No	2 No	12,500	25,000.00
6.1.6.5	ditto	2 No	2 No	1,700	3,400.00
6.2.3.6	ditto	6 No	6 No	10,000	60,000.00
6.2.3.7	ditto	12 No	12 No	2,500	30,000.00
6.2.5.2	ditto	770 No	770 No	6,050	4,658,500.00
6.2.5.4	ditto	6 No	6 No	13,000	78,000.00

Total: =N=**5,309,900.00**

Less 5.5% Discount: =N= 292,044.50
=N=**5,017,855.50**

Less 10% retention: =N= 501,785.50

Amount recommended to contractor: =N=**4,516,069.95**

Demobilization of Equipment and Personnel
By the 31st May 1999, all equipment not needed for the maintenance period were demobilized from site. Also all personnel excepting those that are required to carry out final inspection of work with the Engineer/representative were demobilized from site.

Final Inspection
Final inspection of works not completed by May 22nd, i.e. alignment of boom assembly, placing of concrete anchors and demobilization of equipment and personnel was carried out on the 5th June 1999 by the Engineer/representative. Tables 9 & 10 show the values of jobs completed by the end of May, 1999 and the summary of all payments made till the time the WH Barrier was completed. In accordance with the contract agreement 50% of the contract retention fees amounting to =N=2,917,905.49 (two million, nine hundred and seventeen thousand, nine hundred and five Naira and forty nine Kobo) was added to the final valuation certificate amount =N=871,762.50 (eight hundred and seventy one thousand, seven hundred and sixty two Naira and fifty Kobo).

Guarantee/Liability Period
During the guarantee period, a programme of daily inspections of the barrier was emplaced by the contractor. Table 11 is a list of daily preventive maintenance activities/inspection of works to be carried out or checked by staff trained by the Contractors.

Handing over
The Water hyacinth Barrier was handed over to NIFFR on 12.07.1999 as the Institution responsible to the Federal Government of Nigeria for WH control on the lake. NIFFR was funded by FGN to cater for barrier maintenance and clearing of hyacinth retained by the barrier.

Community support and encouragement from government
During the period of water hyacinth barrier construction and installation representatives from communities were taken to construction site where explanation on the lay-out and use of the facilities were given. At an earlier stage the villagers in Zamare and Rofia were sensitized and their support obtained to locate the facility on their land. They were willing to be employed to clean water hyacinth retained by the barrier. As expression of community cooperation and contribution no compensation was demanded for any damage caused to farms through which the contractors traversed during barrier alignment and installation phases.

On another occasion the Emirs of Yauri, Borgu and Kontagora visited the WH Barrier installation site to encourage the Contractors and to enlist support of their subjects in looking after the barrier located in their farmlands.

The Honourable Minister of Agriculture and Natural Resources visited the construction site after a similar visit by the new Director of NIFFR and praised the efforts of GTZ Fisheries Project and the generousity of German authorities which provided funds for the Project.

Both the Contractors and the villagers demonstrated good sense of warmliness throughout the period of project execution.

It was all joy and a sense of relief throughout the lake, the hope given that WH Barrier will overcome most problems of WH infestation of their lake and the lakeshores (Table 12)

Both the Honourable Commissioners of Agriculture of Niger and Kebbi States paid familiarization visit to acquaint themselves with the progress of the WH Barrier construction. Through letters of commendation the respective Military Administrators (Governors) highly praised the NG-KLFPP on control of WH.

Table 9: Estimated Value of Jobs Completed by End of May, 1999

ITEM ON BoQ	DESCRIPTION	BoQ	QTY COMPLETED	BoQ =N=	AMOUNT
6.2.5.3	As described in the Contract BoQ	210 No	210 No	2,500	525,000.00
6.2.6.0	ditto	L/S			500,000.00

Total:	**=N=1,025,000.00**
Less 5.5% Discount:	=N= 56,375.00
	=N= 968,652.00
Less 10% retention:	=N= 96,862.50
Amount recommended to contractor:	**=N= 871,762.50**

Table 10: Financial Report at the Completion of the Construction and Installation of Water Hyacinth Barrier across River Niger North of Kainji Lake

CERTIFICATE NO	AMOUNT PAID	CUMULATIVE DISCOUNT	RETENTION	REMARK
001	18,229,995.00	1,061,005.00		
002	6,699,672.00	1,450,933.00		
003	4,963,291.00	1,739,801.00		
004	6,045,922.00	2,324,089.90	3,993,209.00	
005	4,070,518.56	2,587,321.00	4,445,488.85	
006	2,567,923.36	2,753,383.00	4,730,813.66	
007	2,422,419.36	2,910,036.25	4,999,971.38	
008	2,134,724.00	2,932,409.00	5,237,162.93	additional payment on variation and fluctuation
009	4,516,069.95	3,224,454.00	5,738,948.00	
010	3,789,667.99	3,280,829.00		
	55,440,204.12		2,917,905.47	50% retention included in C 010

Total amount paid to contractor: **=N= 55,440,204.32**
50% of Retention to be released
after guarantee period: **=N= 2,917,905.49**
Final payment at end of contract: **=N= 58,358,109.81**

NOTE: Discount of =N= 3,280,829.00 excluded in payment

Table 11: Daily Preventive maintenance Checklist

S/N	ROUTINE CHECK	REMEDY
1.	Check the bollard assembly floater with the shackles and chain attached to the hook on the first buoy for any loosening. - if there is any loose nut - if any nut looses away	 - re-tightening - replace
2.	Check each buoy shackle and chain assembly both on the upper and lower hooks at both sides of the buoys for any loose nut. - if any nut looses away - if any thread on the bolt is worn out	 - replace - replace that bolt with new one, make sure it is well tightened
3.	Check for any wear and tear on the hook and shackle links. - if wear has reduced drastically to a dangerous level on the hook eye - if there is a serious wear on the shackles	 - make a special report on the affected buoy - replace the shackle
4.	Always make daily report on all your checks. make sure you always report any re-placed part in your daily report.	

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