ENGINEERING INITIATIVES FOR WATER HYACINTH CONTROL WITH EMPHASIS ON THE DESIGN, CONSTRUCTION AND INSTALLATION OF WATER HYACINTH BOOM (BARRIER) ACROSS RIVER NIGER, NORTH OF KAINJI LAKE

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ABSTRACT

The paper describes the concept, design, component and field layout of a physical barrier to control water hyacinth on Lake Kainji. In spite of the successes of a combination of control methods evolved by the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa with the support of the on-going Nigerian-German Kainji Lake Fisheries Promotion Project (N-G KLFPP) in clearing water hyacinth, yet the weed continued to arrive annually. Thus, construction of a barrier was conceived as the means to prevent the ingression. Towards this, the N-G KLFPP invited and discussed with the consultants to submit suitable proposals and design. The FISESCO-TALON JOINT VENTURE produced the finally acceptable designs in 1999. The designs were vetted and certified by the LAHMEYER INTERNATIONAL (Consulting Engineers for Energy, Water, Environment and Transportation), Germany, appointed by the GTZ Headquarters.

The barrier comprising of two sections, rigid and floating, was funded by GTZ with the Federal Government of Nigeria providing the counterpart funds to ensure maintenance, provide break-up facilities for removal and safe disposal of water hyacinth retained by the barrier. The technology is recommended for use in other water bodies with similar hydrological regimes

INTRODUCTION

The involvement of a sister Company (FISESCO LIMITED) a group of which I am the Chief Executive, in the control of water hyacinth started around 1987 when the weeds drifting from Benin Republic – entered the Lagos lagoon system en-route the eastern part of the coastal inland waterways via Lekki Lagoon down to Ondo State riverine areas. Further spread of the weeds afterwards to other freshwater systems within Nigeria is now history.

Concerned by the deleterious effect of this menace on inland fisheries and water transportation, the then Ministry of Science and Technology constituted a Committee of experts to find ways of utilizing them.

While serious intellectual consultations were made as to the ways the weeds could be utilized, the urgent need to prevent the collapse of artisanal fisheries, which the phenomenon threatened, engaged the attention of the experts. What's more, the hindrance that the carpet of water hyacinth posed to transportation of light crafts had started to stiffle the

economic activities of the riverine communities on its path.

Whilst scientists worked on the possibility of biological control, in particular, the Committee agreed that harvesting the weeds manually or mechanically was the most practical approach to bringing relief to the affected communities. It was at this point that FISESCO LIMITED – a company offering services in the development of fisheries infrastructure and hardware – was invited to propose a contrivance that could be deployed immediately to remove the weeds and free the waterway from Lagos-east to Lekki Lagoon. A crane–barge equipped with a drag-line to which a grab-bucket was attached was contrived and deployed for use for a period of ten months. A lot of experience on mechanical harvesting of water hyacinth was gained thereby.

Experience showed that any mechanical harvester of any manufacture could not be very effective if deployed to grope for clusters of water hyacinth which formed as soon as the harvester dislodged the carpet, thus causing the weeds to drift in several directions. A proverbial "wild goose chase" ensued as the clusters drifted unpredictably, resulting in seemingly uneconomic daily harvests. That is, the time it took to fill a haul barge for disposal was too long to optimize the use of the mechanical option. During this time, manual clearance was made supplemental to the mechanical harvesting method.

It was during this exercise that FISESCO LIMITED experimented on creating a collection point, using interlaced bamboo as barrier across water at selected areas. It was interesting to note that what took the harvester eight (8) hours to remove was accomplished in one (1) hour. Thus, it was found that any mechanical harvesting device that might be introduced for this service must have a barrier or a boom as a complement to optimize the efforts and the investments in the control and evacuation of water hyacinth from waterways.

Noticing the effectiveness and complementarity of the barrier system to the harvester, the National Electric Power Authority commissioned NIGERIAN SUBMARINE DIVERS LIMITED (a sister company to FISESCO LIMITED) to install a well engineered barrier at the water intake area of Sapele Thermal Power Station to aggregate the water hyacinth which continuously got sucked-up with water into their turbines, thus creating the need for very expensive and frequent descaling or flushing of the generating plant. A barrier, well-suited to that application was designed, constructed and installed during 1990. This innovation has aided effective harvesting of water hyacinth from the entrance of the water intake canal of the power plant.

THE RIVER-NIGER EXPERIENCE

CONCEPTUAL FRAMEWORK

The concept of aggregation of water hyacinth for easy evacuation appealed to GTZ – a German Donor Agency that had invested a lot of aid – money into fisheries promotion within and around the Kainji Lake area. The menace of water hyacinth remained the major hurdle to the actualization of its objective of empowering the communities along the river-valley through unhindered water transportation of tradable products and unhindered fishing operations on the River Niger and within the Kainji Lake area.

Because of the difference in water behaviour and wind flow pattern at the

chosen site – Zamare in Kebbi State across to Rofia in Niger State – a different barrier design became imperative. Taking into consideration all the variables, an anchor-buoy arrangement – which is used for mooring commercial fishing vessels mid-stream – was adopted to be replicated and installed in series such that a boom or barrier would be formed across the river valley to aggregate the water hyacinth that drift down the river towards Kainji Lake. Because of variations in water levels which occasion the flooding of the landmass contiguous to the river valley, a steel-mesh design frame was to be adopted. This component which we refer to as the rigid boom and the anchor-buoy arrangement which we refer to as the flexible boom, together constitute the water hyacinth barrier or boom now in operation since May 1999.

This GTZ financed Zamare/Rofia Water Hyacinth Barrier Project which was vetted by LAHMEYER INTER-NATIONAL – a German consultancy firm – was designed, constructed, installed and being maintained by NIGERIAN SUBMARINE DIVERS LIMITED – LAGOS (FISESCO LIMITED's sister Company) under the supervision of NIFFR.

DESIGN CRITERIA OF THE ZAMARE/ROFIA WATER HYACINTH BARRIER

In our design of water hyacinth boom, a lot of factors were considered with a view to achieving a product that is efficient, cost effective and serviceable. These are:

- effectiveness in trapping the weed
- local availability of material (to reduce cost)
- technical/fabrication know-how
- durability of component parts
- ease of maintenance
- resistance to corrosion
- ability of the floating parts to keep afloat
- ability to adjust to varying water levels
- ability to withstand impact load arising from wind, water, weed and wave.
- ability to adjust to wave movement (i.e. flexibility)
- ability to withstand extreme weather conditions.

DETERMINATION OF FORCES

It is very important to determine the forces expected on the boom in order to adequately design its strength and size. The basic forces considered in our design are those due to water, wind, wave, weeds and other debris.

In arriving at these forces, some natural design parameters were physically obtained or determined at the proposed site of the boom. These are

Velocity of Flow of the River:

This was taken at various times during the two seasons experienced in the area i.e. flood and dry seasons. The flooding is between September and February while dry period is between March and August.

1. Density of Water:

This is the mass per unit volume of water. It usually varies from slightly saline to fresh water. Water samples were taken at different times and density

determined in each case. An average of the measurements was then used for the design.

2. Wind Speed:

Speed of wind in the locality was also measured and recorded during the two season. The maximum wind speed value known as the peak value was adopted for the design.

4. Wave Amplitude:

In inland waters, wave amplitude is mostly dependent on wind speed. Efforts were made to measure wave heights during the periods of high wind speed.

5. Variation in Water Level:

There is need to know the maximum and minimum water levels including the spread i.e. maximum and minimum width of the river during high and low waters. This enabled us to determine the tidal heights and width of the flood plain. This became very necessary because of the need to determine the overall length or coverage of the boom, and to know which length of the barrier will be permanently in water and that which will be in partial contact with water i.e. having water during the high water period and dry thereafter.

ESSENTIAL COMPONENTS OF THE BOOM ASSEMBLY

The water hyacinth boom designed and constructed by Nigerian Sub-marine Divers Limited is in two sections. The first section is the rigid barrier while the second is the flexible boom. Due to seasonal flooding on the Kainji Lake, the rigid section is installed on the flood plain, which receives water only between September and February while the flexible part is installed to cover the actual river channel which receives water all the year round.

RIGID BARRIER (APPENDIX 5)

The rigid barrier consists of steel support piles and steel screen.

Support piles

This is made up of steel casings 8 inches diameter driven at 3 metres interval such that the depth of penetration is twice the freeboard (i.e. depth beneath the ground is twice the length above the ground.). The interior of the casing was reinforced with steel rods and filled with concrete for additional strength after which the external portion above the ground was coated with epoxy resin to avoid corrosion.

Steel Screen

The steel screen is made of flat steel bars spaced at 100mm centre to centre. Fabricated in units of 3 metres wide and heights ranging from 1 metre to 3 metres. Each 3 metres length is placed to cover the gap between two support piles and secured firmly by welding on to the pile casing. The screen was also protected against corrosion by applying coats of epoxy resin.

FLEXIBLE BOOM

The flexible boom is the floating part. It has the following members

(a) Steel buoys

(b) Anchor bollard with floating hook

(c) Pile anchors

(d) Warning signal buoys

Steel buoy (APPENDICES 2, 3 & 4)

The steel buoys are designed and fabricated in units of 1.5 metre long x 1.2

metre width and 0.8 metre high. It is made from flat steel sheet and reinforced with steel angles.

Each unit is fitted with 2 No. rubber fenders to prevent buoy to buoy contact which can damage the units. Attached also are eight steel hooks, each of which is capable of resisting 2 KN force and a reflective sticker to define the boom alignment at night.

The unit buoys are linked together by high tensile chain fitted at the ends with bolted shackles. A vent is provided at the top of the buoy to ease internal pressure build-up, which may result from hot weather condition.

Anchor bollard with floating hook (APPENDIX 6)

There are 2 No. bollards situated at the banks of the river channel, to anchor the flexible boom assembly at one end. Each is designed for a horizontal pulls of 90 KN force, capable of holding up to 500 metre length of boom.

The hook on the bollard is also designed for same load (90 KN) with 2 No. floaters attached on the sides to allow for variation in water levels.

Pile anchor (APPENDIX 4)

The pile anchors are submerged in water. They are meant to anchor the flexible boom assembly firmly to prevent drifting and allow for proper alignment. Each of the pile anchor is designed to resist a minimum vertical pull of 9 KN. Link between the buoy assembly and a pile anchor is done with the use of galvanized sling wire rope fitted with shackles, bolts and nuts at both ends.

Warning signal buoys (APPENDIX 7)

Floating warning signals are incorporated into the design to warn the waterway users of an impending obstacle to free flow of traffic. The signal buoys are two sets located one kilometer from the boom up and downstream. Each set consists of three signal buoys, two of which are situated on each bank (left and right) and the last one at the midstream.

Inscriptions on the ones at the bank are in the native language (Hausa) while the one at the midstream is in English Language. Each of the buoys is held in position by 3 No. 350kg concrete anchors placed at the bottom of the river.

BOOM LOCATION AND LAYOUT (APPENDIX 1)

The water hyacinth boom in question is located upstream of Kainji Lake across River Niger at Zamare in Kebbi State and Rofia in Niger State. Zamare is accessible from Kontagora – Sokoto Road while Rofia is the last village on New Bussa – Agwara – Rofia Road. The barrier is aligned at 60° to the river bank on both sides. A five (5) metres wide passage is provided along the rigid barrier to cater for movement of animals and persons during the low water period and canoes that cannot get to the midstream because of wind during high water.

At the midstream, there is a passage-way wide enough (80 – 100 metres) for ferries and passenger boats navigating up and downstream. The configuration is such that the Zamare wing of the boom overlaps the other from Rofia thus preventing weeds from drifting across.

CONCLUSION

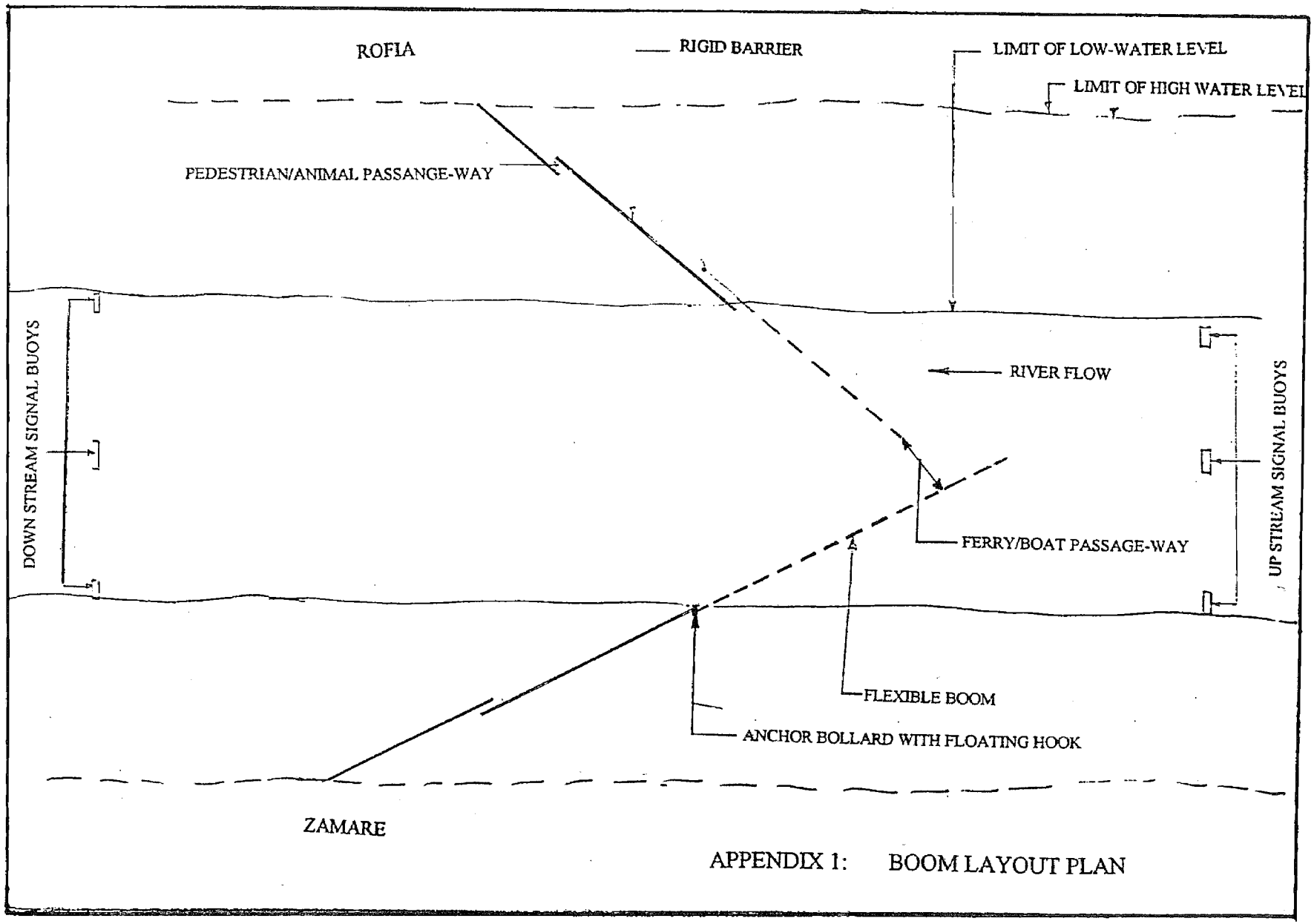
Since the installation of the barrier in May 1999, the influx of water hyacinth

weed into Kainji Lake has reduced drastically. Quite a large volume of the weeds which otherwise would have drifted down the river are being trapped or deterred by the facility at the point of installation, thus making evacuation of the weeds relatively easy for those engaged for this service.

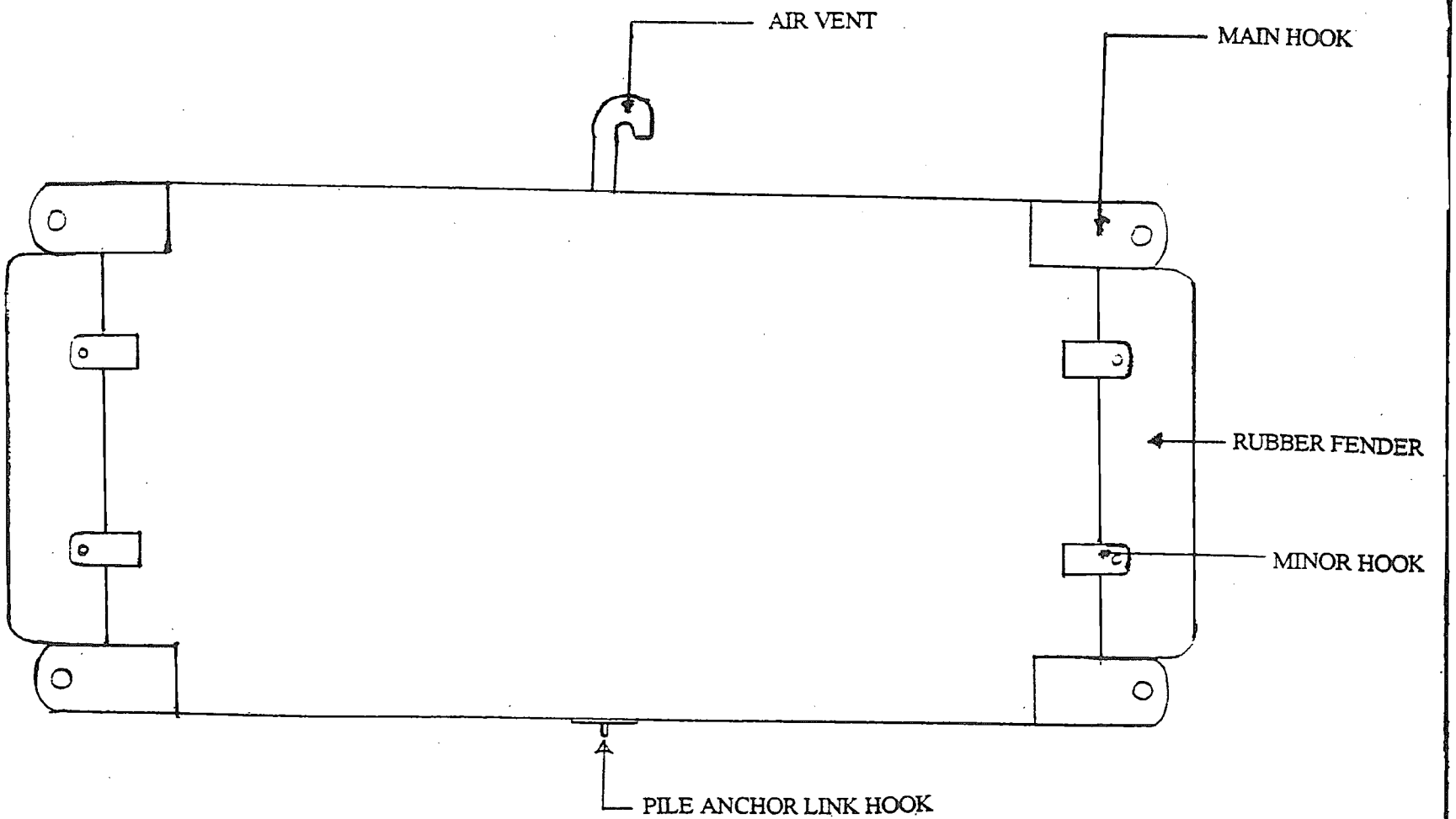
Information reaching us from villages down-stream of the barrier site at Zamare/Rofia indicate tremendous improvement in fisherfolk's ability to operate unhindered by the weeds and the freedom to navigate without any obstacles up to the site of the boom assembly.

Although the aggregation of water hyacinth for harvesting was the object of this initiative, experience at Zamare/Rofia has shown that the barrier – as designed and constructed – effectively aggregates other floating weeds such as Niger grass and other weed species, submerged plants and logs.

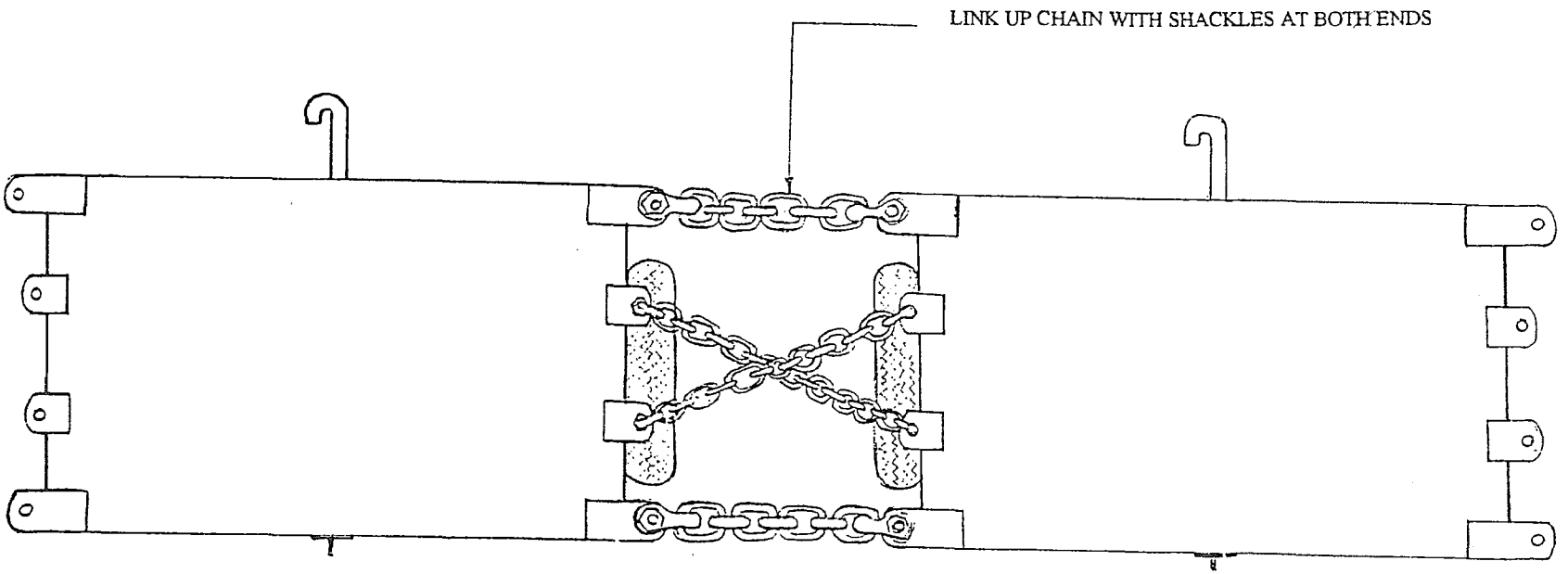
It is to be recommended that where a mechanical harvesting device is contemplated, an aggregating device (a boom or barrier) should be made complementary for optimal control of and evacuation of water hyacinth, in particular, from waterways that may be so infested.



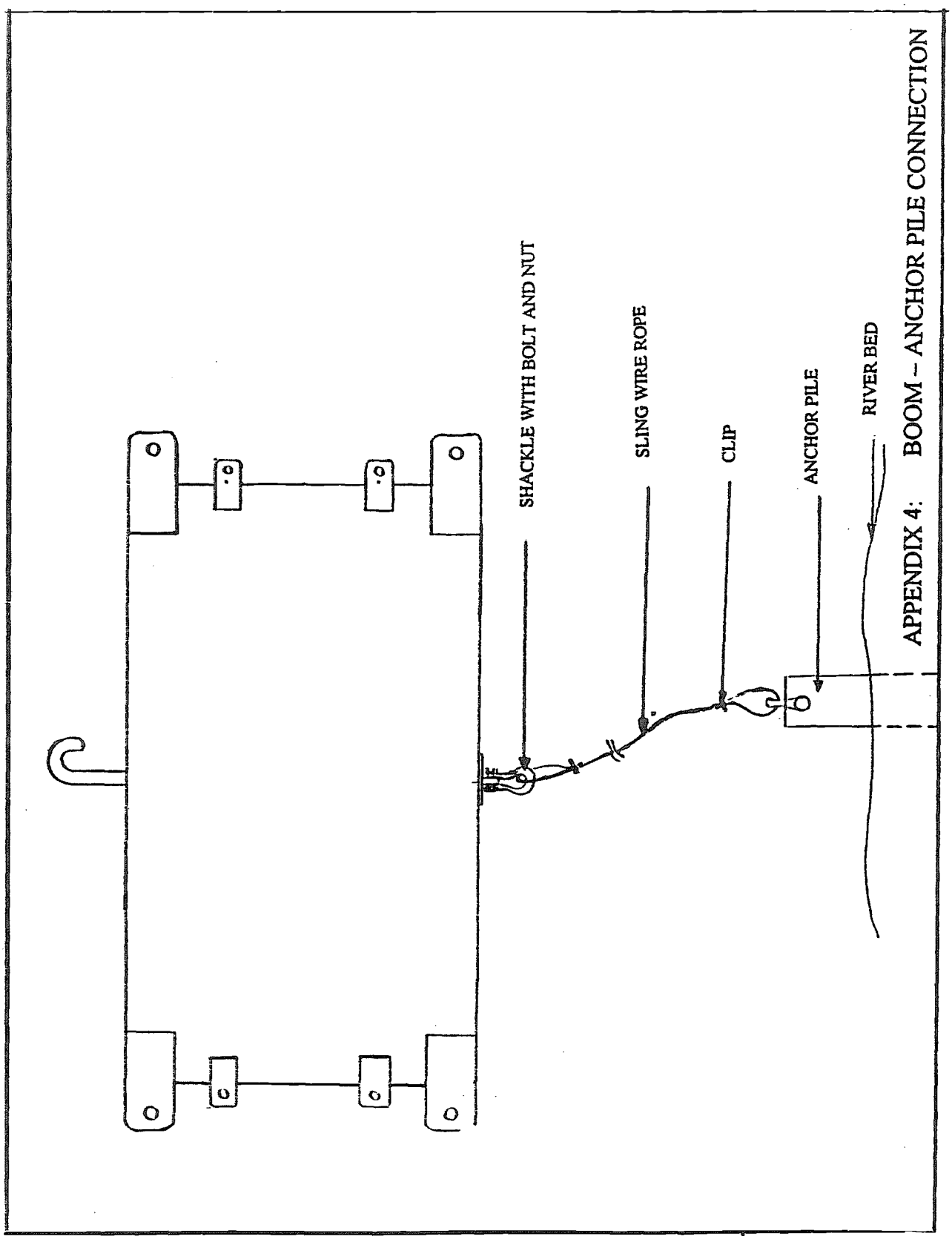
APPENDIX 1: BOOM LAYOUT PLAN



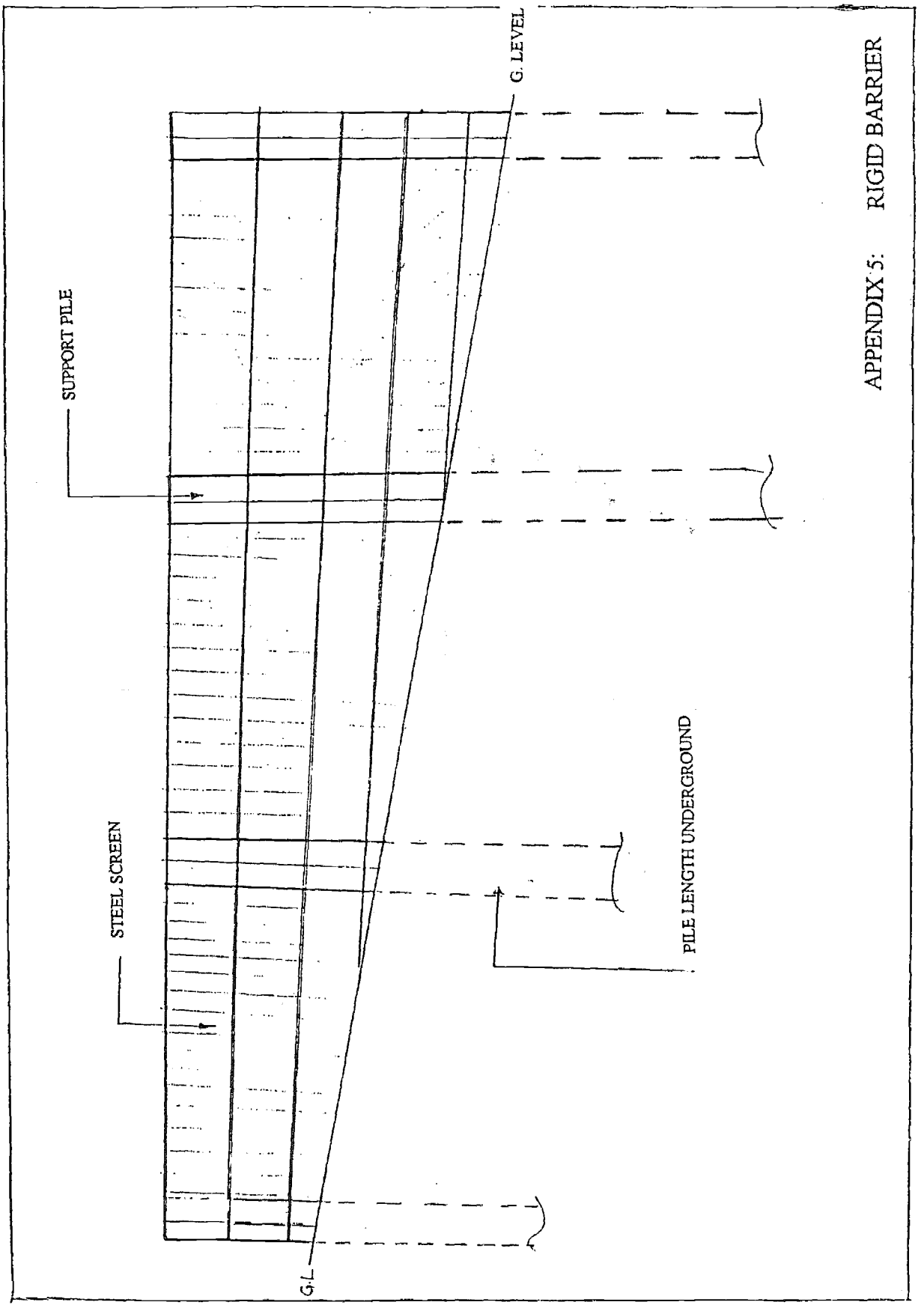
APPENDIX 2: TYPICAL BUOY



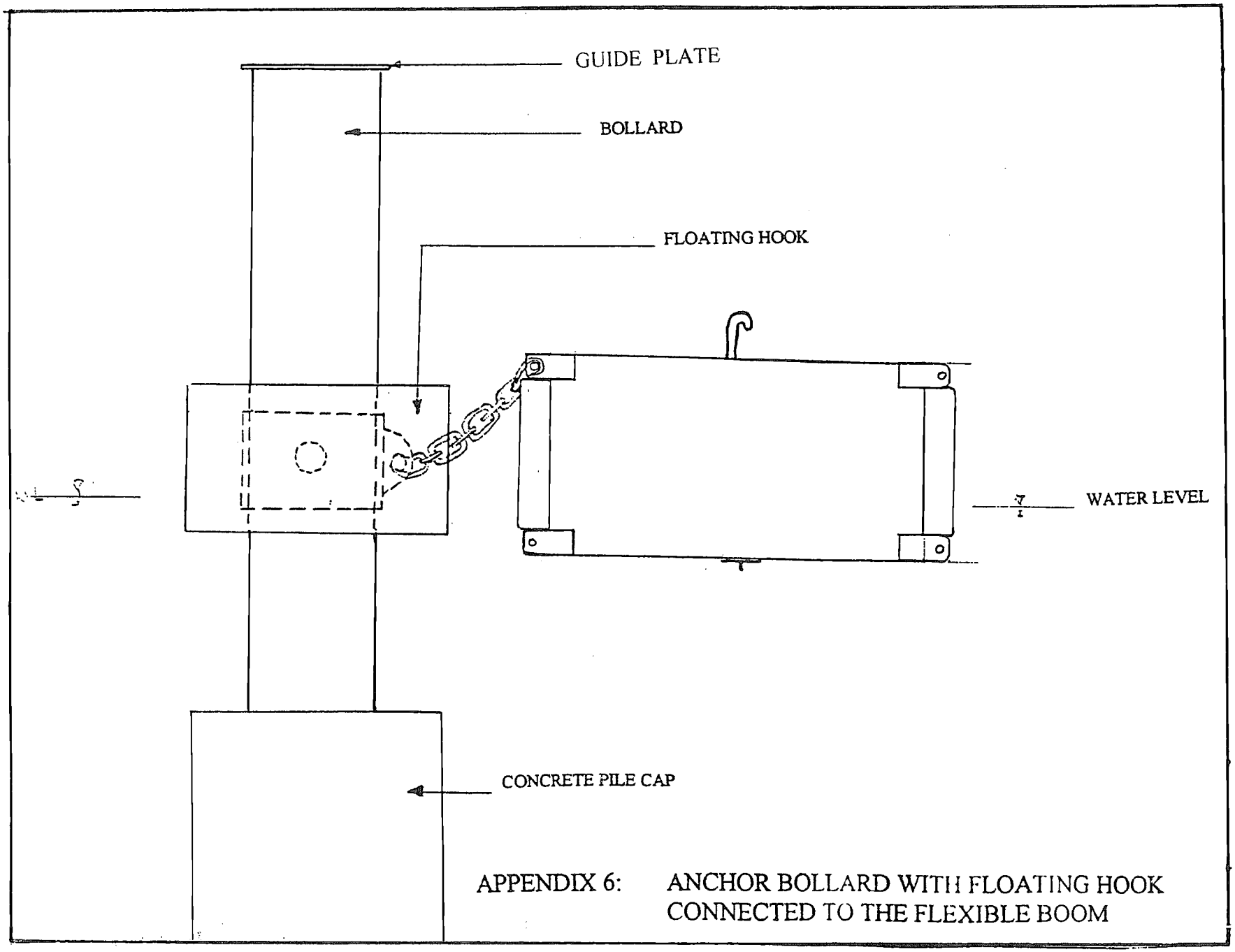
APPENDIX 3: A TYPICAL BUOY – BUOY CONNECTION



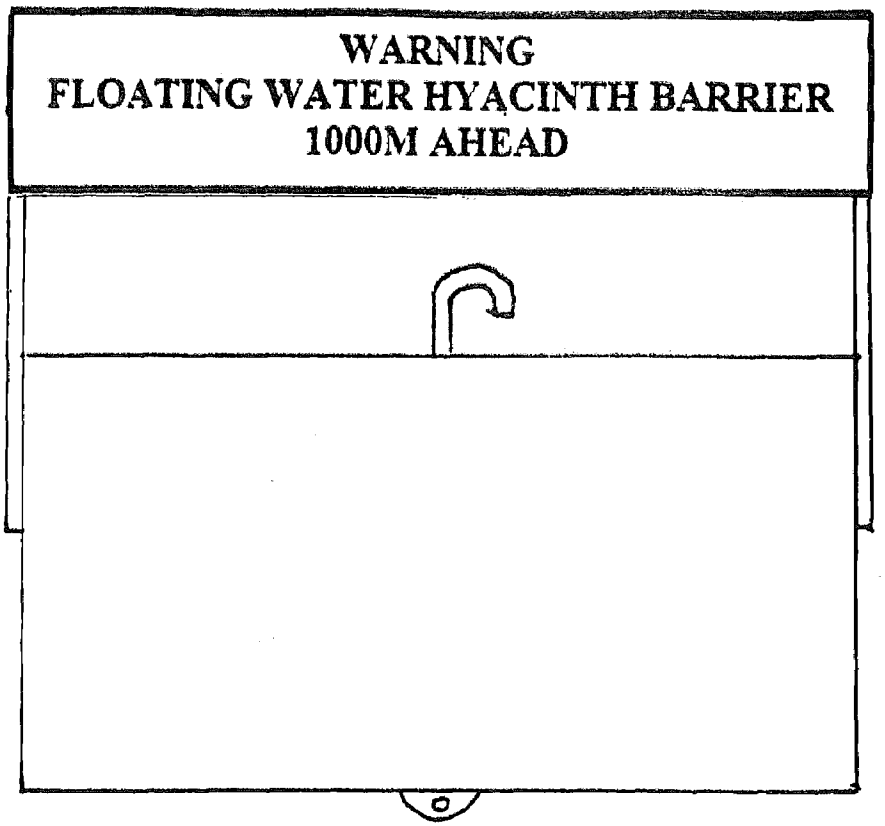
APPENDIX 4: BOOM – ANCHOR PILE CONNECTION



APPENDIX 5: RIGID BARRIER



APPENDIX 6: ANCHOR BOLLARD WITH FLOATING HOOK CONNECTED TO THE FLEXIBLE BOOM



APPENDIX 7: WARNING SIGNAL BUOY