DESIGNING BARRIERS IN NILE RIVER FOR CONTROLLING WATER HYACINTH FROM REACHING TO CAIRO GOVERNERATE

Hosam Ibrahim

Associate Professor, Channel Maintenance Research Institute, National Water Research Center, Kanater El-Khairiea, Kalubeia, 13621, Egypt

ABSTRACT

The presented study investigates the floating aquatic weeds spread on Nile River through Cairo governerate. Cairo city suffers from severe infestation of floating aquatic weeds water hyacinth on Nile River. The existence of floating aquatic weeds leads to bad influence on Nile scenery, which affect on image of civilization through Nile river. To overcome this problem investigation and designing process were carried out for constructing specific cylindrical barriers supplied with trash rack in El-Marazik territory south Cairo Governerate and El-Malatia territory south Bane-Sweif governerate respectively. The proposed cylindrical barriers and trash racks will control the floating aquatic weeds and prevent water hyacinth from reaching Cairo governerate. To fulfill the objectives of the study, several field measurements were carried out allover the two studied reaches. The intensity, the percentage of infestation, and the moving trend of the floating aquatic weeds were identified in the two studied areas. The detailed designing criterion of the created weed control barriers was developed to establish such aquatic weeds control utilities. Using the collected data which based on the analysis of field studies, certain applicable solutions were suggested to prevent floating aquatic weeds from reaching Cairo governerate which consequently led to control water hyacinth and improve Nile scenery in Cairo City.

Keywords: Aquatic Weeds, Management of Aquatic Weeds

INTRODUCTION

Several experimental investigation researches were carried out concerning the parameters that affect the magnitude of the drag forces exerted by a moving fluid on a floating circular cylinder placed across the channel.

The evaluation of the force on a solid body in a flowing fluid is of primary importance in many engineering problems such as the design of bridges, buildings and many water structures. A knowledge of fluid resistance has become of increasing importance.

An idea of constructing a light bridge supported on a series of floating cylinders which is easy to construct and lift, has been suggested to be used in many purposes specially in navigation canals. Measurements of the force exerted on hydraulic structures of different shapes and configurations have been made on laboratory models.

An extensive mass of literature was published concerning the hydrodynamic forces exerted by a fluid stream on an immersed body. Most of the previous work was devoted to the study of drag forces for different shapes of objects placed in an infinite stream of uniform velocity. The total drag force exerted on any immersed object F_D is always the sum of frictional drag force D_f (gram) which equals the integral of all shearing stresses taken over the surface of the body, and the form or pressure drag D_p which equals the integral of normal forces. The total drag force on an object immersed in an infinite stream is known to depend mainly upon Reynolds number, shape of the object, and its orientation to the flow. If the gravitational forces are taken into consideration, the dimensionless Froude number $F_n = V/\sqrt{gd}$ (ratio of inertia to gravitational stresses), is included, in which: V is the mean water velocity; g acceleration of gravity; and d water depth.

Since the cylinder floats on the free water surface, a deformation of surface wave must take place, and the flow tends to pile up at the front and depresses at the rear. The standing wave thus formed, leads to an increase in the drag due to the differential head which the wave produces. Thus, the total drag force as far as its magnitude is concerned, depends on surface and form resistance. To which is also added the resistance of surface wave. The wave resistance or wave drag was explained by Rouse [10] as the force required to counterbalance the resulting variation in the boundary pressure or maintain the pattern of surface undulations.

The problem of two-dimensional flow around a submerged circular cylinder was investigated mathematically [2] and experimentally [3] over a wide range of Reynolds number. Measurements indicated that the pressure distribution differs considerably from the theory of frictionless motion, depending whether $1.86 \times 10^5 < R_e < 6.7 \times 10^5$. Experimental and calculated values showed a degree of agreement on the front side, but at the rear of the cylinder the discrepancies between experimental and theory were large. On the whole, the pressure distribution at high Reynolds number deviates less from the theoretical at low Reynolds number [11].

The flow under the floating cylinder in an open channel is complicated by the change in the pressure distribution due to the change in both shape and size of flow section. Moreover, the eddying region behind the cylinder causes great influence effect upon the integrated pressure and so the drag force on the cylinder.

Hsieh [5], examined the drag coefficient as it was changed with the Froude number, with the relative depth of the oncoming flow, and also with the relative spacing of the pier. Experimental results indicated that both the pier spacing and the depth of oncoming flow, within the tested range, did not have a pronounced influence on the resistance coefficient in supercritical flow, whereas they do in subcritical flow.

Nece and Unrue [8], on discussing Hsieh paper presented the results of their experiments using circular cylinders of 1- in. diameter mounted vertically in a free surface water channel 14-3/8 in. wide. Data were obtained for cylinders placed in row normal to the approaching flow and also, in a single row oriented diagonally at 45^0 to the approaching flow. Data analysis indicated that for both arrangements, drag coefficient C_D, predictably, increased with decreasing lateral spacing ratio S/D. Each curve approached asymptotically to a value of 1.2 as with the increase of S/D. (D is the diameter of cylinder and S is the Central spacing between cylinders)

Mirajgaoker [9] carried out similar experiments to Hsieh to investigate the effect of shape on the drag coefficient in a 3 feet mass masonry flume. It was concluded that C_D varied inversely with the Froude number in the subcritical and supercritical regions of flow. Between the regions, the resistance decreases as the Froude number increases, and for high Froude number the resistance tends to be constant.

As far as drag force on horizontal circular cylinder is concerned, Khalil [6] investigated the resistance and behaviour of a circular cylinder placed on the bottom of the channel across the flow. The tested cylinder were made of P.V.C tubes, about 30 cm in length, and of diameter 2.14, 2.66, 4.73 and 5.95 cm . The flume was set at three different slopes 0.001, 0.0109 and 0.023 to investigate the cylinder behaviour under slow and fast flow conditions. He concluded that drag coefficient C_D depended mainly upon Froude number irrespective of Reynolds number, and could be expressed by the following relationships:

$$C_D = 2.9\, F_n^{-1.82} \tag{1}$$

Also, the upstream and downstream relative depths came to be functions of Froude number F_n and drag coefficient C_D as follows:

$$F_n = 1.74 \log\left(d_1 / D\right) \tag{2}$$

$$1/\sqrt{C_D} = 1.15 \log\left(d_1 / D\right) - 0.195 \tag{3}$$

$$1/\sqrt{C_D} = 0.25 \log\left(d_2 / D\right) + 0.325 \tag{4}$$

in which:

D = diameter of test cylinder (cm); d_1 = depth upstream of tested cylinder (cm); d_2 = depth downstream of tested cylinder (cm).

Ko and Graf [7] investigated the effect of turbulence on drag coefficient of long smooth circular cylinder. He found that no marked trend between C_D and Reynolds number existed, and that the turbulent intensity exerted noticeable influence upon the drag coefficient while the effect of Reynolds number was less pronounced.

The above mentioned studies revealed that the drag coefficient, the upstream and downstream relative depths came to be functions of Froude number only and the Reynolds number proved to be of no significant influence.

DESCRIPTION OF THE TWO STUDIED AREAS

El-Marazik territory south Cairo governerate is located on Nile river at 54.50 km upstream New Delta Barrage as shown in figure (1). The total length of the studied reach on El-Marazik territory is 1900 m. Three islands are located in El-Marazik territory El-Shobak island, island (1), and island (2). The three mentioned islands form with the left bank of Nile river Khor zone with specific hydraulic characteristics. Khor zone have low water velocities, low water depths, and high infestation percentage by water hyacinth. The sailing direction is illustrated in figure (1) between the right bank of Nile and island (1).

El-Malatia territory south Bane-Sweif governerate is located on Nile river at 168.00 km upstream New Delta Barrage as shown in figure (1). The total length of the studied reach on El-Malatia territory is 2500 m. Two islands are located in El-Malatia territory El-Gozame island, and island (3). El-Gozame island form with the left bank of Nile river Khor zone with specific hydraulic characteristics. Khor Zone have low water velocities, low water depths, and high infestation percentage by water hyacinth. The sailing direction is illustrated in figure (1).

METHODOLOGY

1 Field measurments

Towards achieving the objective of the presented study to prevent the floating aquatic weeds from reaching Cairo governerate, the extensive field measurements were carried out to detect the hydraulic characteristics of the two studied reaches. The extensive field measurements program can be summarized as follows:

- Survey of the entire two reaches at El-Marazik territory and El-Malatia territory.
- Water velocities were measured on seven cross sections located at El-Marazik territory as shown in figure (2), and four cross sections located at El-Malatia territory as shown in figure (3) by using Electro magnetic current meter.
- Survey the mentioned cross sections by using Echo Sounder instrument to identify the cross sectional area and the water depths for each cross section in the two studied reaches.
- Survey of the mentioned cross sections by using Echo Sounder instrument to detect the percentage of the submerged weeds infestation.
- Identifying the moving trend of floating aquatic weeds in the two studied reaches by using floating wood pieces.

- Collecting three soil samples from bed of the river to classify the soil type along the studied reaches.

RESULTS AND DISCUSSIONS

The collected and measured data concerning this study will be briefly discussed.

1. Water velocities

The water velocities were measured on eleven cross sections located in the two studied reaches as shown in figures (2), and (3) by using Electro magnetic current meter. The water velocities measurements were carried out for three different water depths from the water surface 0.5 m, 1.0 m, and 2.0 m.

At El- Marazik territory, it was noticed that the water velocity varied from 0.27 m/sec to 0.62 m/sec for the three different water depths along cross section (1). It was noticed also that the water velocity varied from 0.40 m/sec to 0.61 m/sec along cross section (2), from 0.18 m/sec to 0.37 m/sec along cross section (3), from 0.25 m/sec to 0.50 m/sec along cross section (4), from 0.23 m/sec to 0.54 m/sec along cross section (5), from 0.23 m/sec to 0.54 m/sec along cross section (6), and from 0.40 m/sec to 0.83 m/sec along cross section (7). Figure (4) and table (1) show the water velocities distribution along cross sections (1).

At El-Malatia territory, it was noticed that the water velocity varied from 0.45 m/sec to 0.86 m/sec for the three different water depths along cross section (8). It was noticed also that the water velocity varied from 0.43 m/sec to 1.00 m/sec along cross section (9), from 0.39 m/sec to 1.20 m/sec along cross section (10), and from 0.33 m/sec to 0.51 m/sec along cross section (11). Figure (5) and table (2) show the water velocities distribution along cross sections (9).

2. Aquatic weeds surveying

Surveying of aquatic weeds was carried out through the entire studied reaches. The mentioned eleven cross sections along the two reaches were also examined by using the Echo Sounder to detect the infestation percent of submerged weeds. The results of the monitoring and the Echo Sounder examination at El-Marazik territory indicated that the mean percentage of the infestation was almost 1 % by submerged weeds, 0.5 % by ditch bank weeds, and 10 % by floating weeds (water hyacinth) along the entire reach. The results at El-Malatia territory indicated that the mean percentage of the infestation was almost 1.5% by submerged weeds, 0.7 % by ditch bank weeds, and 11 % by floating weeds (water hyacinth) along the entire reach. Figure (6) shows Echo Sounder survey at cross section (1). It can be concluded from the monitoring investigation that the studied reaches has been suffering from the floating aquatic weeds infestation.

3. Floating weeds moving trend

The moving trend of floating aquatic weeds was identified in the two studied reaches by using floating wood pieces. The movement of three floating pieces were monitored along the studied reaches by using surveying device as shown in figures (7) and (8). Three floating pieces were placed in El-Marazik territory 300 m upstream island (1) at 115 m, 230 m, and 345 m respectively from the right bank of Nile. The floating pieces were placed at equal distances between right bank and left bank of Nile as shown in figure (7) track (1), track (2), and track (3). Second and third floating pieces track (2) and track (3) moved toward Khor zone while the first floating piece track (1) moved directly toward El-Marazik bridge. Another three floating pieces were placed between the right bank of Nile and island (1) track (4), track (5), and track (6). The fourth floating piece track (4) was trapped at the old buoy unit while the fifth and the sixth floating pieces track (5), and track (6) moved directly toward El-Marazik bridge. It can be concluded that, 70 % of floating aquatic weeds in the study reach moved toward Khor zone and the old buoy unit.

Four floating pieces were placed in El-Malatia territory 400 m upstream El-Gozame island at 55 m, 110 m, 165 m, and 220 m respectively from the right bank of Nile. The floating pieces were placed at equal distances between right bank and left bank of Nile as shown in figure (8) track (7), track (8), track (9), and track (10). The seventh and the eighth floating pieces track (7) and track (8) moved toward El-Khor zone while the nineth and the tenth floating pieces track (9) and track (10) settled at the right bank of river 200 m downstream from El-Gozame water station. Another four floating pieces were placed between the right bank of Nile and El-Gozame island track (11), track (12), track (13), and track (14). The three floating pieces track (12), track (13), and track (14) settled at the right bank of river at El-Gozame water station while the eleventh floating piece track (11) moved directly toward the same direction of flow in Nile. It can be concluded that, 80 % of floating aquatic weeds in the study reach moved toward Khor zone and the right bank of river at El-Gozame water station.

4. Soil classification

Three soil samples from bed of the river were collected to classify the soil type along the two studied reaches. A series of laboratory tests were carried out for soil samples collected from the river bed in order to get some of the soil properties and parameters related to the river section. These experiments included grain size distributions by sieve analysis and by wet analysis. From the sieve analysis of the soil samples, the three samples were classified as Fine to Medium Sand with angle of internal friction $\varphi = 29°$. The percentage of sand in the samples is more than 98 % as shown in table (3).

5. Analysis of results

From the above sections (5-1, 5-2, 5-3) the following facts could be stated:

- For the moving floating aquatic weeds; the carrying layer is the upper layer of water surface 0.5 m depth, at which any controlling utility should be installed.
- Weeds always follow the stream direction, and any desired obstruction must be installed against water current direction.
- Each Khor at the two studied reaches works as a weed trap and the majority of the moving floating weeds have directed right to this area, and have left it again following the stream direction of flow as shown in figures (7), (8). Each Khor zone have the lowest water velocities and water depths allover the studied reaches.
- The best locations for installing barriers in El-Marazik territory locate at Khor zone and the old buoy unit at the right bank of river.
- The best locations for installing barriers in El-Malatia territory locate at Khor zone and at the right bank of Nile close to El-Gozame water station.

6. Weed control utilities

To control the floating aquatic weeds in the studied reaches in an efficient mannar, a compound system of barriers supplied with racks were proposed, which consisted of:

1- El-Marazik territory; The first barrier was installed at the outlets of the shallow water at Khor zone, while the second barrier was installed at the old buoy unit at the right bank of river. The barriers locations are presented in figure (9). These barriers are simple floating buoys supplied with submerged trash racks as shown in figure (12), the buoys is fixed to the river bed by using concrete blocks and to the river banks by wires.

2- El-Malatia territory; The first barrier was installed at the outlets of the shallow water at Khor zone, while the second barrier was installed at the right bank of Nile close to El-Gozame water station. The barriers locations are presented in figure (10). Light towers must be used close to the second barrier for safety of sailing boats and barrier from damage. These barriers are identical in designation to the proposed barriers in El-Marazik territory.

The proposed barriers will fulfill its purpose if sufficient maintenance and attention have been taken place. If the proposed system is installed in a complete way (with all components working together in a harmonic manner), and exerting sufficient active maintenance efforts. The system will be capable of controlling the water hyacinth from reaching cairo governerate.

BARRIER DESIGNATION

To overcome this problem, which had an environmental impact, certain utilities have to be introduced. The basic technical data were used, and the famous approaches and special techniques were applied for analyzing, suggesting, and designing such works.

1. The proposed barrier component

Each buoy unit of the proposed barrier consists of the following components which illustrated in figure (11):

1- Frontal Buoy;
2- Trash rack;
3- Rear Buoy;
4- Connecting truss;
5- Mooring point;
6- Foot path;
7- Hand rail;
8- Chain;
9- Embedment anchorage block.

2. The existing forces on each buoy unit and gravity anchorage block

The barrier units had been suggested in a specified shape as shown in figures (12 to 15) to suite its purpose, and all the required calculation and stresses checks have been carried out. The buoyancy of the barrier units was checked with the proposed buoy unit shape. There are three main forces affect on each buoy unit, the drag force F_D, the shear force $F_{\tau w}$ from the accumulated floating aquatic weeds, and the tension force T on chain connected the buoy with the gravity anchorage block. Figure (12) shows the existing forces on each buoy unit.

There are two main forces affect on gravity anchorage block, the frictional resistance force F_r exists on bottom surface of the block with river bed, and the passive earth pressure as illustrated in figure (12).

To obtain final reasonable designation of the control system components, detailed design have been carried out, and the following concepts have been taken into consideration.

2-1 Drag force

Khalil [5] deduced the following equation for obtaining the drag force value for cylindrical shape.

$$F_D = \frac{1}{2} \times C_D \times \rho \times V^2 \times A \qquad (5)$$

in which:

C_D = coefficient of drag (dimensionless); A = projected area of circular cylinder;

D = diameter of test cylinder; L = length of the cylinder = 6 m;
V = maximum measured water velocity at cross section 9 as shown in table (4);
ρ = mass density of water;

Drag coefficient will be calculated by using the following equation:-

$$C_D = 0.45\, F_n^{(-2\, Wr\, \wedge 0.11)} \quad (6)$$

$$Wr = \frac{w}{we}, \; for\ frontal\, cylinder:$$

in which:

W_r = relative weight of the cylinder (dimensionless);
W = The expected weight of the frontal cylinder
= own weight of cylinder + structure Components + life load on the foot path;
W_e = The equivalent weight of water occupied by the volume of the frontal cylinder.

Analysis of the field investigation results is illustrated in table (4). The maximum water velocity at cross section 9 for barrier D as shown in figure (10) will be applied in equation (5) for obtaining the drag force.

2-2 Shear force

Ali [1] deduced the following equation for obtaining the shear force value for accumulated aquatic floating weeds.

$$F_{\tau w} = (V^*_w)^2 \, .\, \rho / g \quad (7)$$

in which:

$F_{\tau w}$ = shear force; V^*_w= shear velocity;
ρ = mass density of water; g = acceleration of gravity;

Shear velocity will be calculated by using the following equation:

$$V_W^* = \sqrt{g\, R_{\,w} S_w - R_w \,.\, a - \left(\frac{P_{av}}{T_w}\right) V_b^{*2}} \quad (8)$$

in which:

R_w = average hydraulic Radius at weed section;
a = acceleration of flow;
S_w = water surface slope at weed existence section;
P_{av} = average perimeter at weed section;

T_w = top surface water width;
V^*_b = Shear velocity for section normal perimeter=V*,
V* can be obtained from: $\frac{V}{V^*} = 5.75 \log\{ \frac{g \times d \times V^*}{V} \}$
where:

d = average top measuring point from surface (≈ 0.5 m distance between water hyacinth roots and the water surface ; the upper measuring point for all section).
V = The average velocity for each section at level 0.5 m (from surface).

2-3 Tension force on chain connected with buoy unit

The total force exists on each buoy unit equal the summation of the drag force and the shear force. $F_{total} = F_D + F_{\tau w} = 0.145 + 0.172 = 0.317$ t/m.

The buoy unit length = 6 m, therefore $F_{total} = 1.902$ t/buoy.
And consequently the tension force on chain connected to the buoy unit T can be obtained.

$$T = F_{total} \times \cos\theta$$

where θ is the angle between the chain and the bottom surface of buoy unit or water surface. The tension force T will transfer to the gravity anchorage block through the chain as shown in figure (12).

2-4 Frictional resistance force on river bed

Frictional resistance force exists on bottom surface of gravity anchorage block with river bed figure (12). This force is defined by the following equation:-

$$F_r = W^/ \times \mu \qquad (9)$$

in which:

F_r = frictional resistance force on river bed; μ = resistance coefficient of bed;
$W^/$ = submerged anchorage block weight;
For obtaining $W^/ = W_{BLOCK} - V_{BLOCK} \times \gamma_w = V_{BLOCK} \times \gamma_{concrete} - V_{BLOCK} \times \gamma_w$
For obtaining $\mu = \tan(0.75 \times \varphi)$

in which:

W_{BLOCK} = anchorage block weight; V_{BLOCK} = anchorage block volume;
$\gamma_{concrete}$ = unit weight of concrete; γ_w = unit weight of water:
φ = angle of friction = 29.

By using the gravity anchorage block with specified dimensions shown in figure (15), the frictional resistance force on river bed can be calculated $F_r = 1.843$ tons.

2-5 The passive earth pressure

The passive earth pressure can be obtained by applying the following equation.

$$E_P = K_P \times e \times \gamma_{sub} \quad (10)$$

in which:

E_P = the passive earth pressure; K_P = passive soil pressure coefficient;
e = void ratio for river bed soil; γ_{sub} = submerged unit weight for river bed soil.

For obtaining $K_P = \dfrac{1+\sin(\varphi)}{1+\cos(\varphi)}$, and $e = \dfrac{n}{1-n}$

For obtaining $\gamma_{sub} = \dfrac{G-1}{1+e}$

in which:

n = porosity (for fine –medium sand = 0.34);
G = Specific gravity for river bed soil.

Then the passive earth pressure can be calculated $E_P = 1.469$ tons. And consequently the total resistance force on the gravity anchorage block $= F_r + E_P = 3.312$ tons. This force is higher than the tension force on chain connected to the buoy unit, and the factor of safety is equal to 1.75.

3. Designation of barrier buoy unit

The barrier buoy unit have been designed to obstruct the floating aquatic weeds directed by the stream. The barrier was suggested in several shapes, and different alternatives were compared to adopt the most suitable one. The developed barrier is a compound buoy system figures (13, 14), each unit consisted of two cylinders, joined together by steel frame, provided with labours walk, and a frontal inclined trash rack. Loads on submerged trash racks according to weeds existence and water current have been considered. A tight steel racks with removable adjustable were used. Rack was adapted to lay in a certain angel of inclination, and allow for easy weed collection. The rack dimension 0.75 meters height and 6.2 meters width for each buoy unit as shown in figure (14).

Each buoy unit can be installed or released easily from Nile water for maintenance purposes. Buoys are built from steel sections and filled with foam for saving buoys from sinking. The buoy units are anchored to each other and to anchorage blocks on the river bed, which are responsible for barrier fixation. Fixation devices have been designed in order to hold the barrier considering all the probable loads, the required fixing anchorage blocks figure (15), and mooring utilities (wires, chains, and locks). All related items such as river bed material frictional capacity with anchorage blocks, water current velocity, and shear stress have been sufficiently considered. The barrier units were designed to fulfill all the following requirements:

- Preventing weeds > 20 cm from passing through the trash rack.
- Sustaining weeds load and water pressure on it (shear, drag and hydrostatic forces).
- To be held completely by the anchorage blocks on the river bed considering all loads on the barrier, and the blocks' frictional resistance on the bed material.
- Validating safety for the barrier by using side anchorage between buoys units, and for the labours by using labours walk for maintenance availability.

CONCLUSIONS

Cairo City suffers from severe infestation of floating aquatic weeds water hyacinth on Nile River. The aim of this study is to investigate, design, and construct specific weed control system of cylindrical barriers supplied with trash rack in El-Marazik territory south Cairo governerate and El-Malatia territory south Bane-Sweif Governerate respectively.

A detailed study was carried out in order to offer the required technical and pratical solutions for this problem. To fulfill the objectives of the study, several field measurements were carried out allover the two studied reaches. The intensity, the percentage of infestation, and the moving trend of the floating aquatic weeds were identified in the two studied areas. Using the collected data and based on the analysis of field studies, certain applicable solutions were suggested to prevent floating aquatic weeds from reaching Cairo Governerate.

The proposed weed control barrier is a compound buoy system figures (13, 14), each unit consisted of two cylinders, joined together by steel frame, provided with labours walk, and a frontal inclined trash rack. Loads on submerged trash racks according to weeds existence and water current were considered.

For the optimum use, performance of the entire system of barriers must provide the system with efficient and sufficient mechanical equipment for continuous maintenance activities.

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Table (1) Measured water velocity at different water depths for cross section (1) at El-Marazik territory

distance (m)	velocity (m/s)		
	depth 0.50 (m)	depth 1.00 (m)	depth 2.00 (m)
0.00	_	_	_
11.07	0.31	0.30	0.28
22.14	0.34	0.34	0.32
33.22	0.50	0.43	0.35
44.29	0.49	0.43	0.25
55.36	0.49	0.47	0.45
66.43	0.49	0.47	0.45
77.50	0.53	0.52	0.43
88.58	0.53	0.52	0.43
99.65	0.54	0.53	0.44
110.72	0.58	0.50	0.44
121.79	0.57	0.52	0.44
132.87	0.57	0.52	0.44
143.94	0.59	0.55	0.46
155.01	0.63	0.60	0.40

Table (2) Measured water velocity at different water depths for cross section (9) at El-Malatia territory

distance (m)	velocity (m/s)		
	depth 0.50 (m)	depth 1.00 (m)	depth 2.00 (m)
0.00	_	_	_
8.57	0.44	0.35	_
17.14	0.46	0.37	_
25.71	0.54	0.48	_
34.29	0.67	0.63	0.46
42.86	0.69	0.68	0.47
51.43	0.72	0.72	0.55
60.00	0.80	0.80	0.62
68.57	0.88	0.91	0.70
77.14	0.90	0.88	0.72
85.72	0.90	0.89	0.74
94.29	0.94	0.88	0.78
102.86	0.96	0.90	0.80
111.43	0.98	0.90	0.82
120.00	1.00	0.90	0.83

Table (3) Grain size distribution of river bed samples

Sample No.	Hydrometer analysis			Sand analysis sieve diameter in mm.								Texture
	Sand (%)	Silt (%)	Clay (%)	2.000	0.850	0.600	0.425	0.300	0.212	0.106	0.063	
				% Finer than the above sieve opening.								
Sample (1)	99.33	0.67	0	100	96.09	86.21	56.76	21.63	6.55	0.99	0.67	Sand
Sample (2)	99.56	0.43	0	99.79	99.64	96.06	65.99	23.76	10.19	0.66	0.43	Sand
Sample (3)	98.53	1.47	0	99.50	98.99	98.25	92.89	62.84	19.06	2.64	1.47	Sand

Table (4) Analysis of field investigation results

Barrier		Max Mes. Velocity (m/s)	L_S (m)	R_e	C_D	F_n
A	“C. S. 1”	0.67	75	2.921		0.092
D	“C. S. 9”	1.0	75	2.969	0.72- 0.75	0.1717
C	“C. S. 3 or 11”	0.51	75	1.780		0.1273

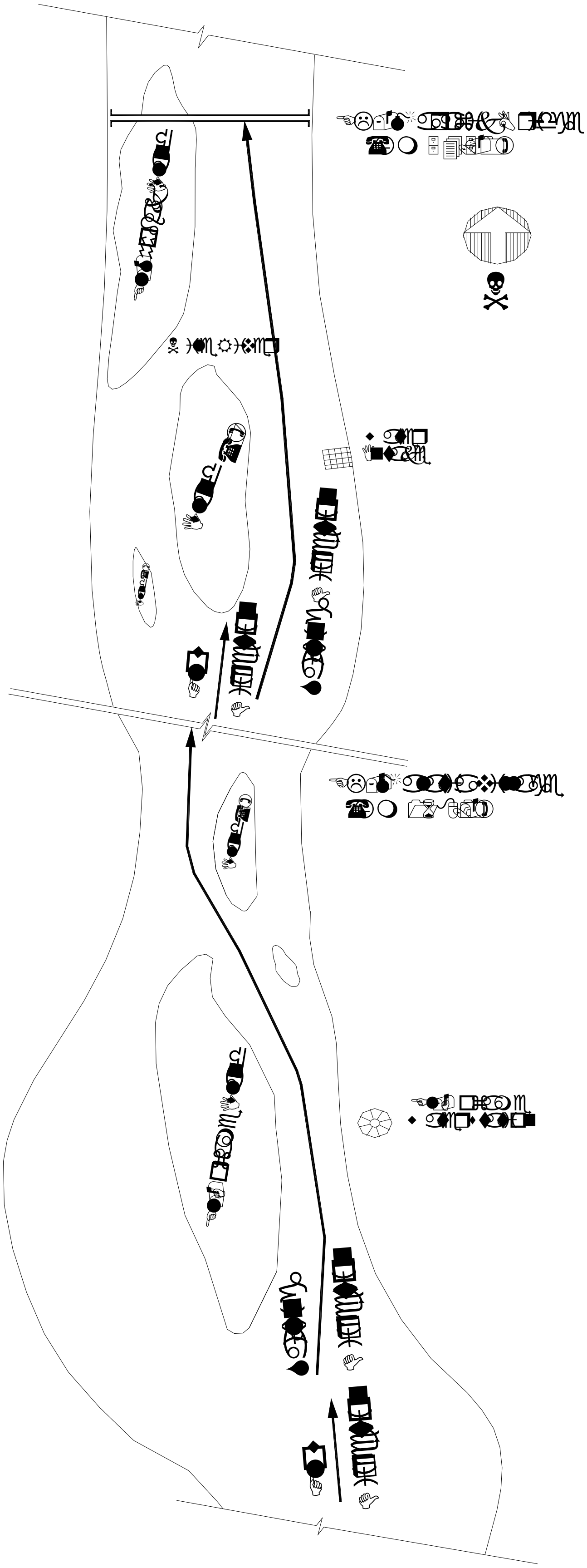


Figure 1. General layout for the two studied reaches

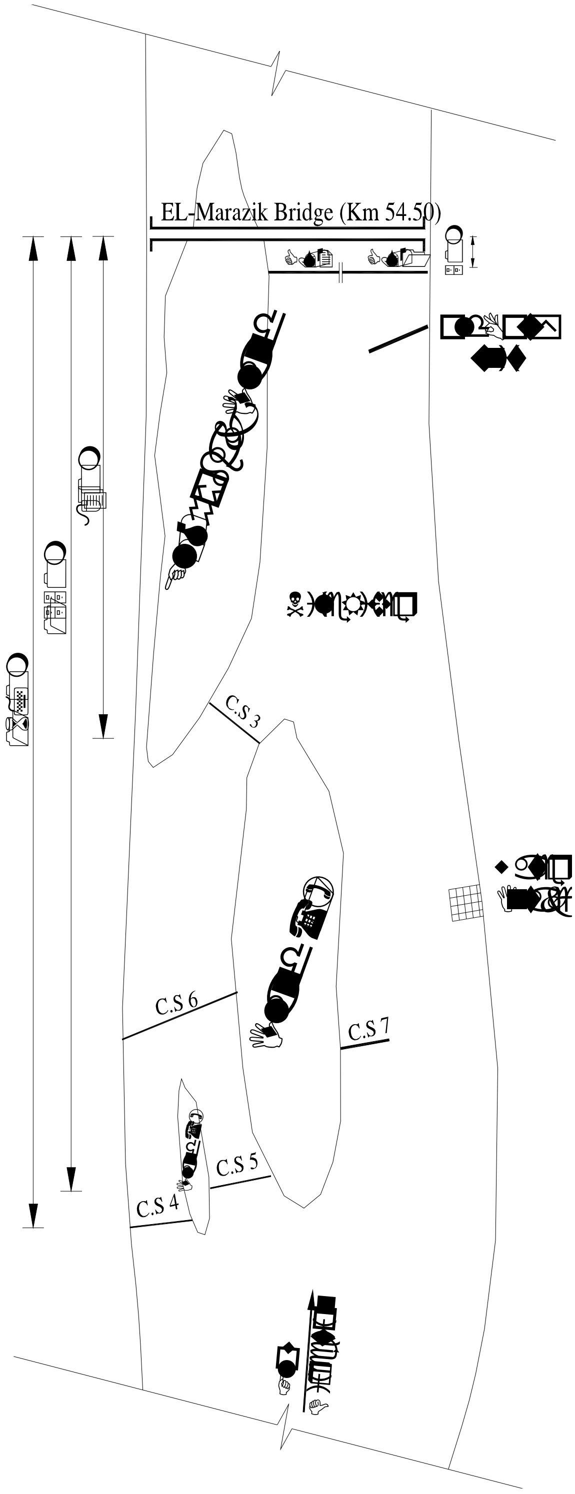


Figure 2. Cross section locations for measuring water velocities at El-Marazik erritory

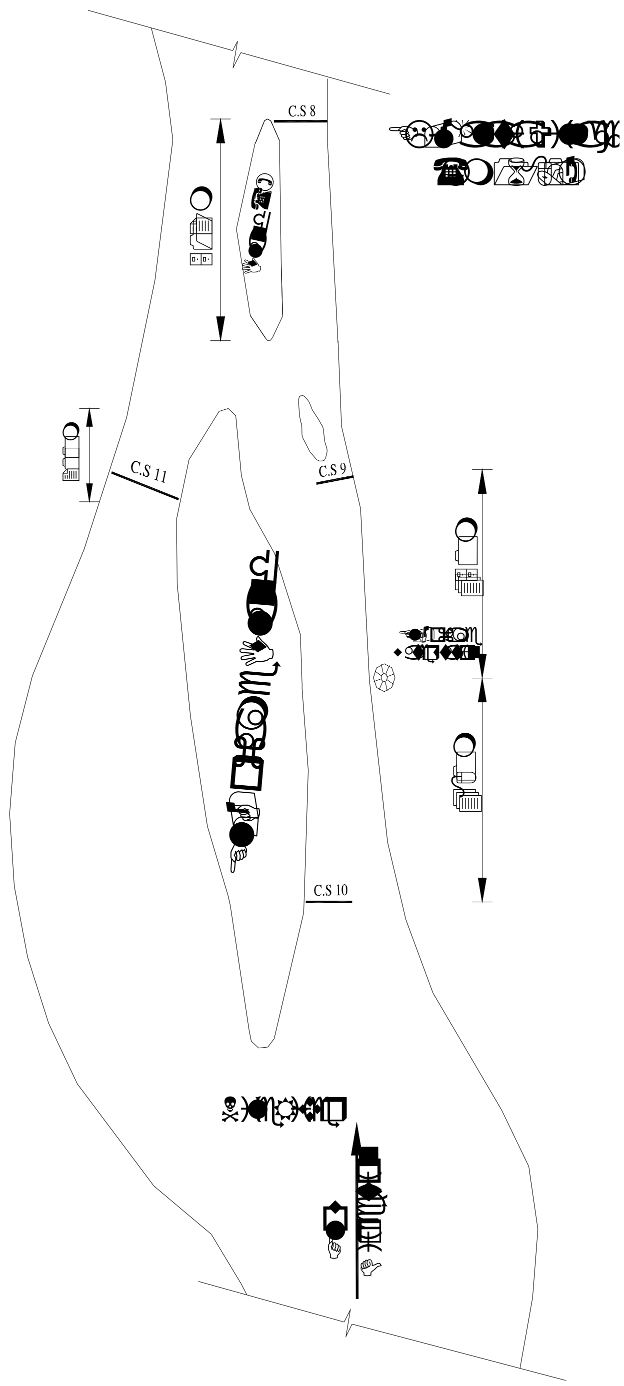


Figure 3. Cross section locations for measuring water velocities at El- Malatia territory

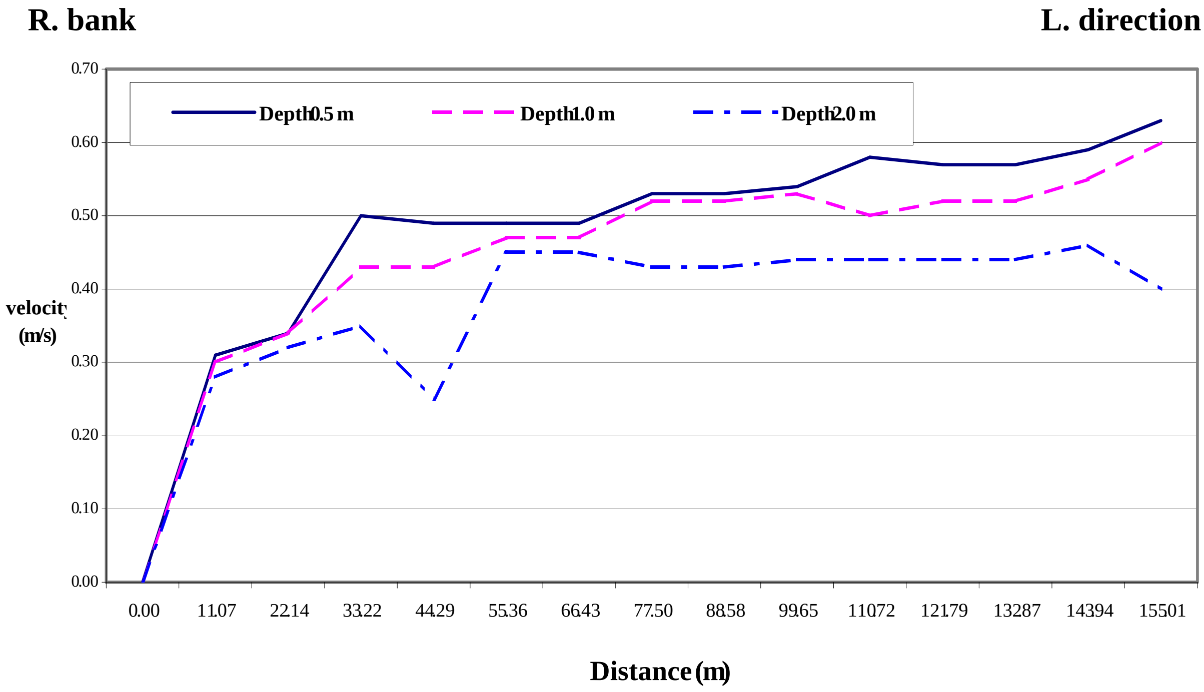


Figure 4. Measured water velocity at different water depths for cross section (1) at El-Marazik territory

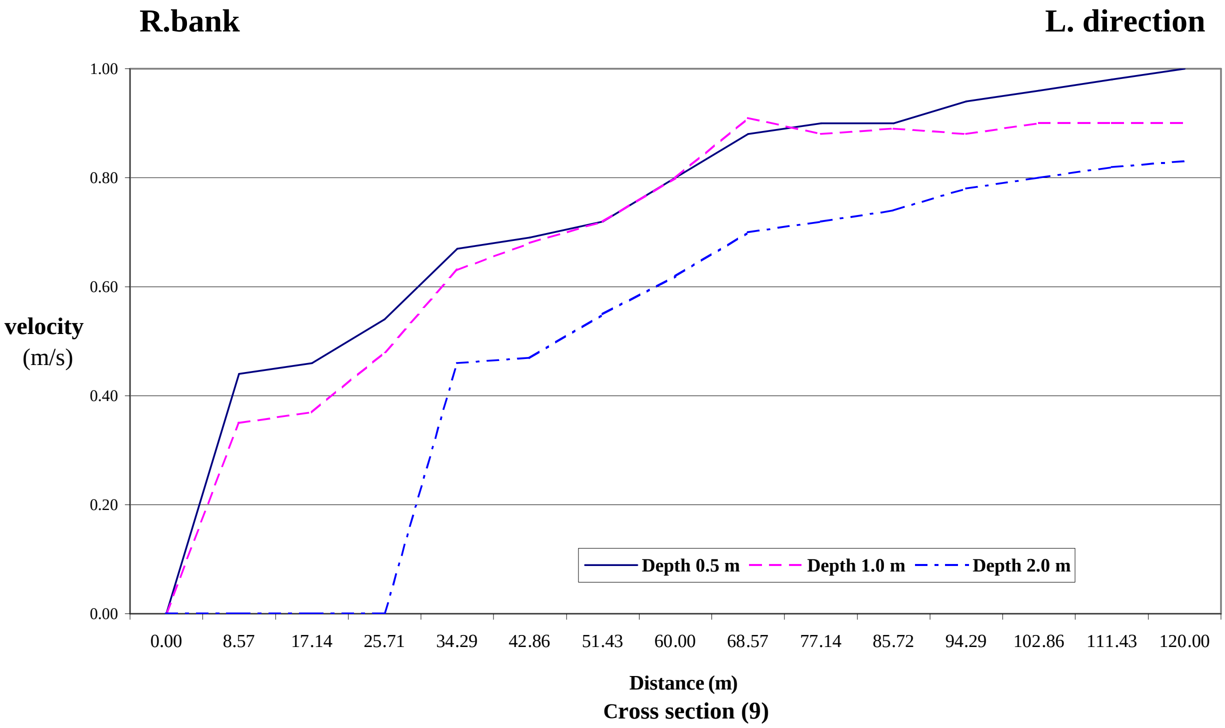


Figure 5. Measured water velocity at different water depths for cross section (9) at El-Malatia territory

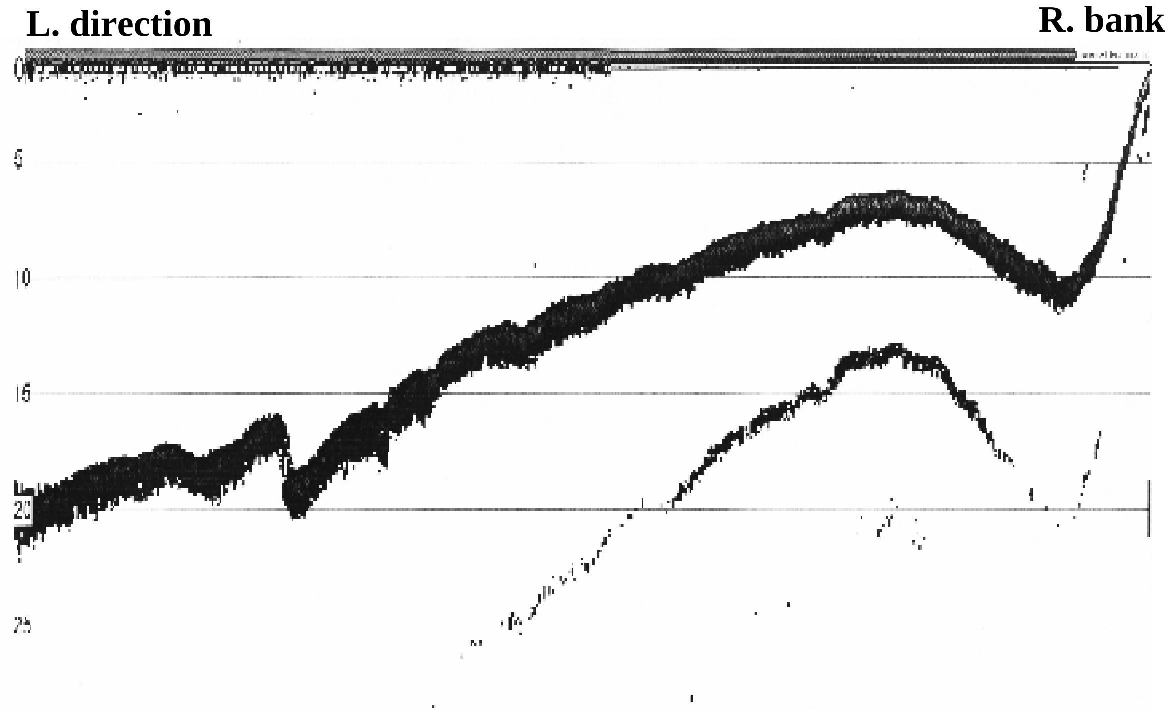
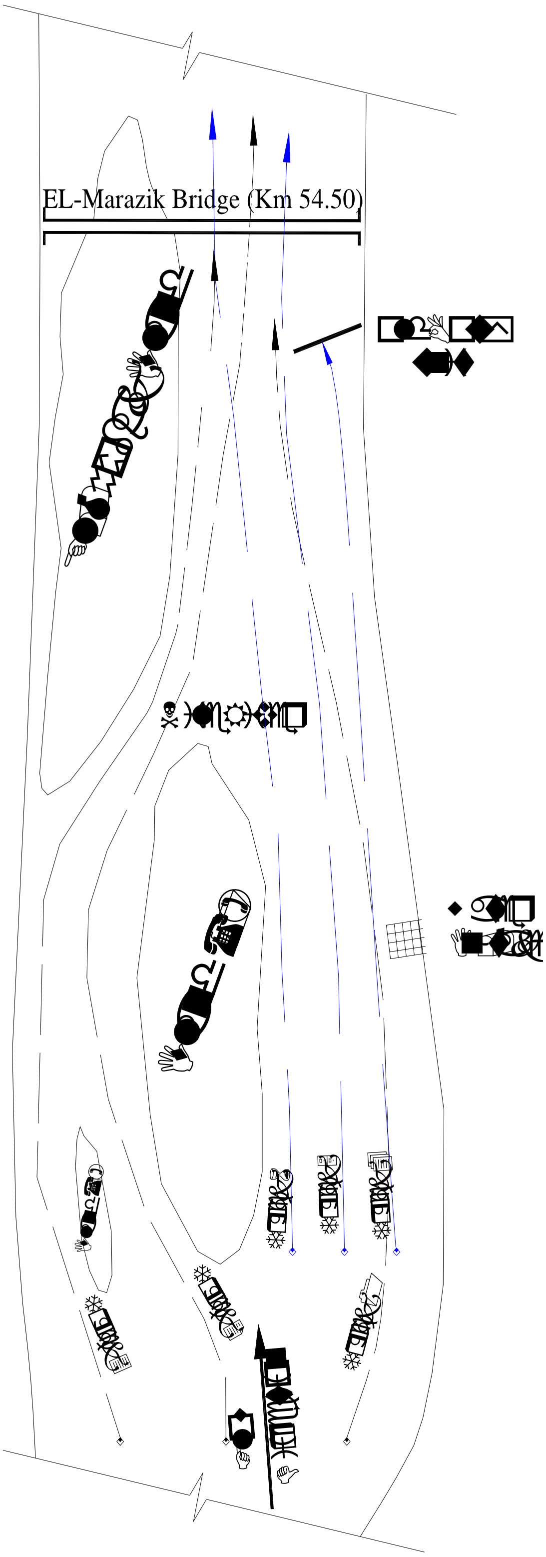


Figure 6. Echo-sounder survey for cross section (1) at El-Marazik territory



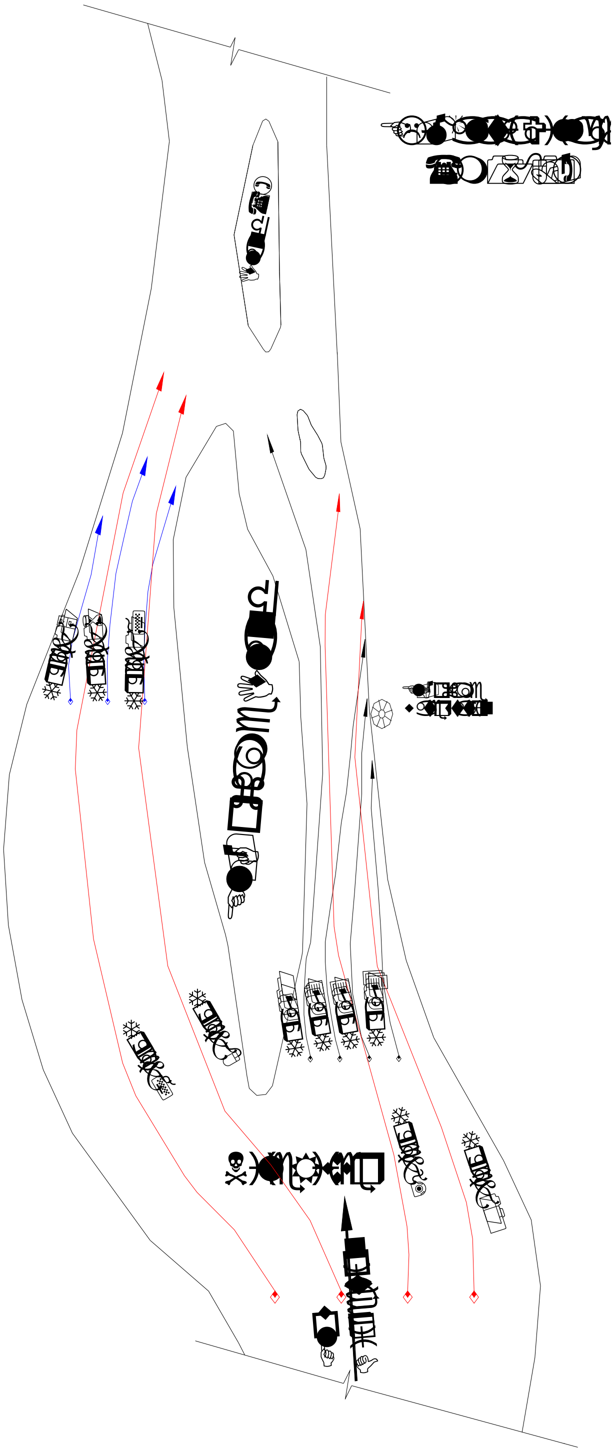


Figure 7. Tracks of floating aquatic weeds at El-Marazik territory

Figure 8. Tracks of floating aquatic weeds at El-Malatia territory

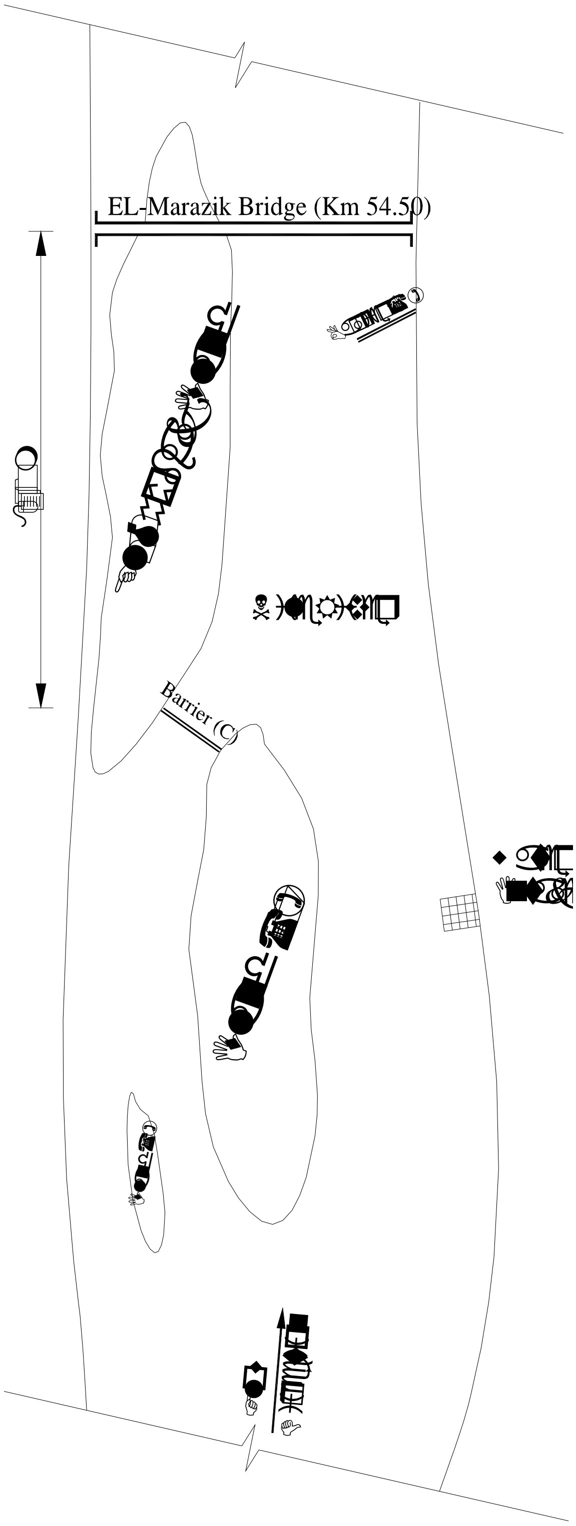


Figure 9. The proposed barriers locations El-Marazik territory

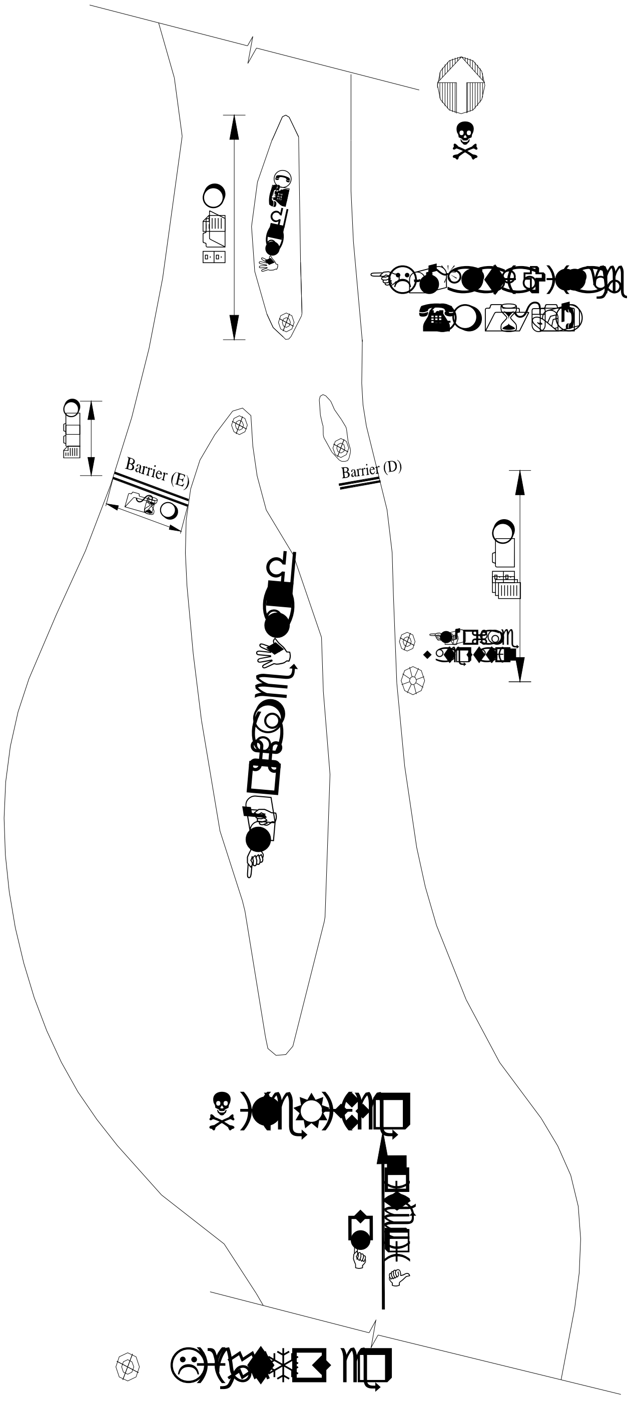


Figure 10. The proposed barriers at locations at El-Malatia territory

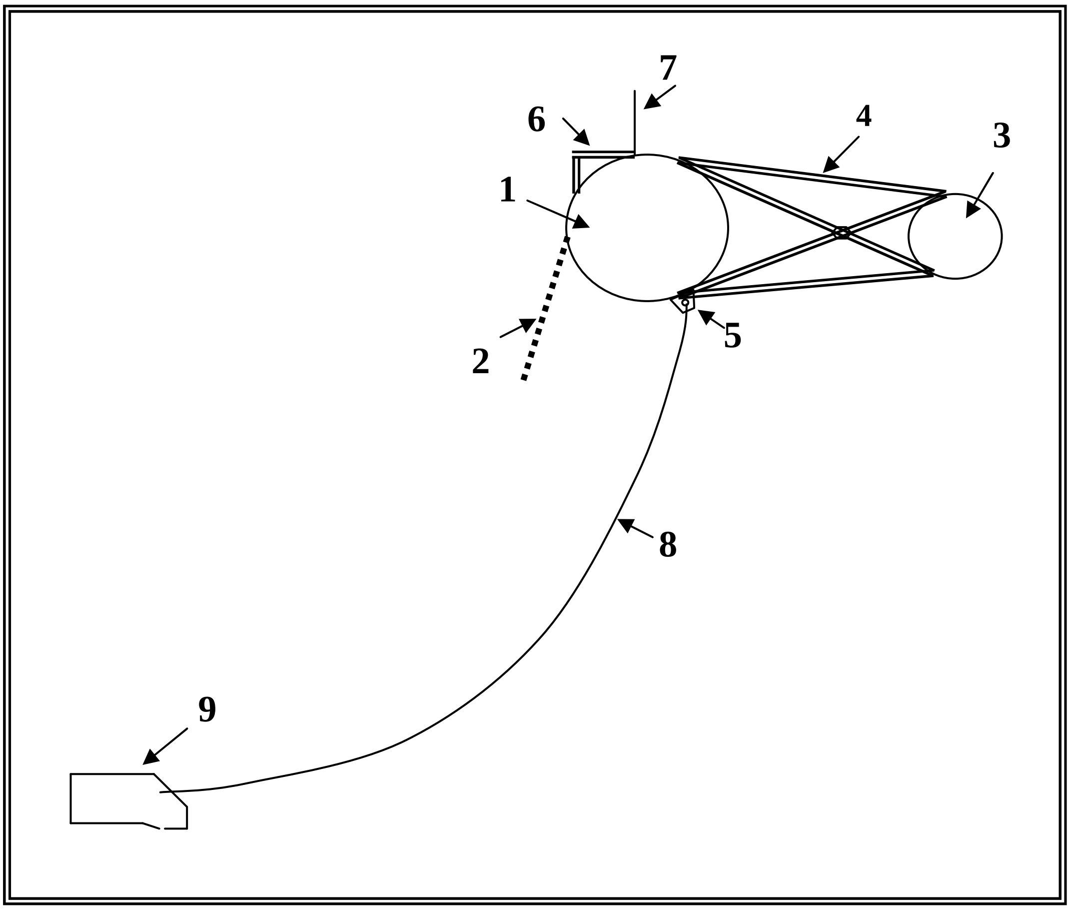


Figure 11. Components of the proposed barrier buoy unit

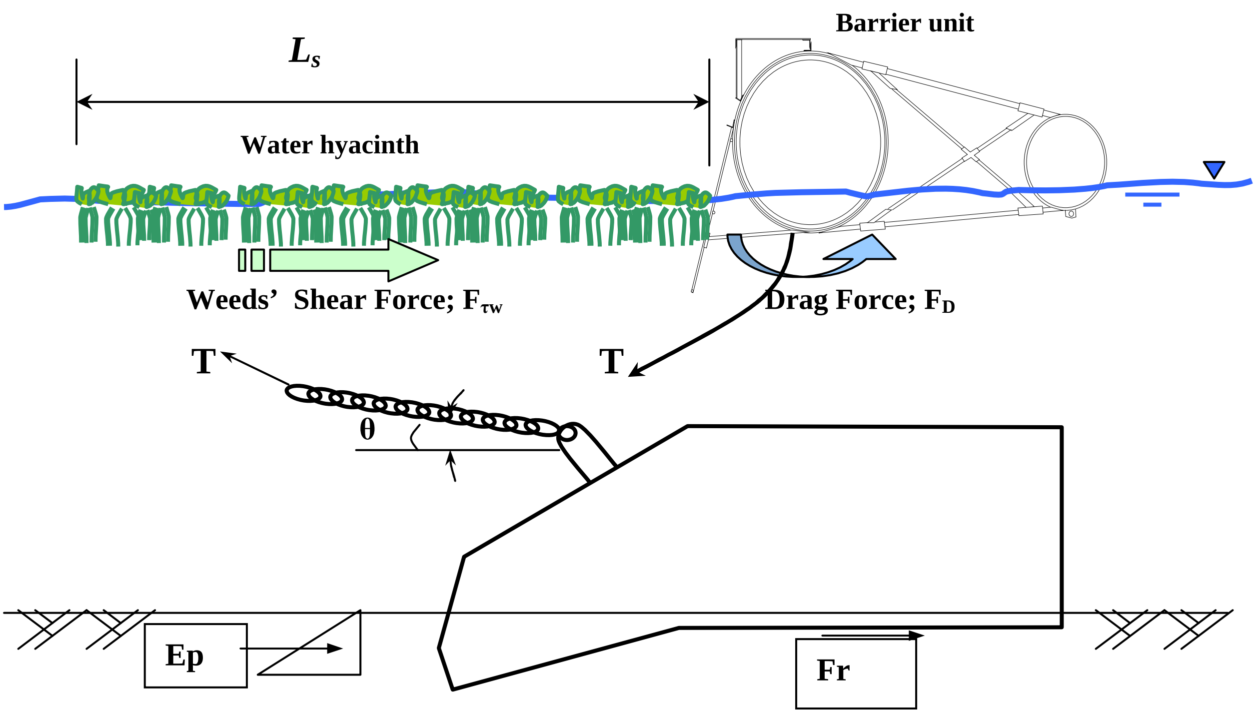


Figure 12. The existing forces on each buoy unit of the barrier and on gravity anchorage block

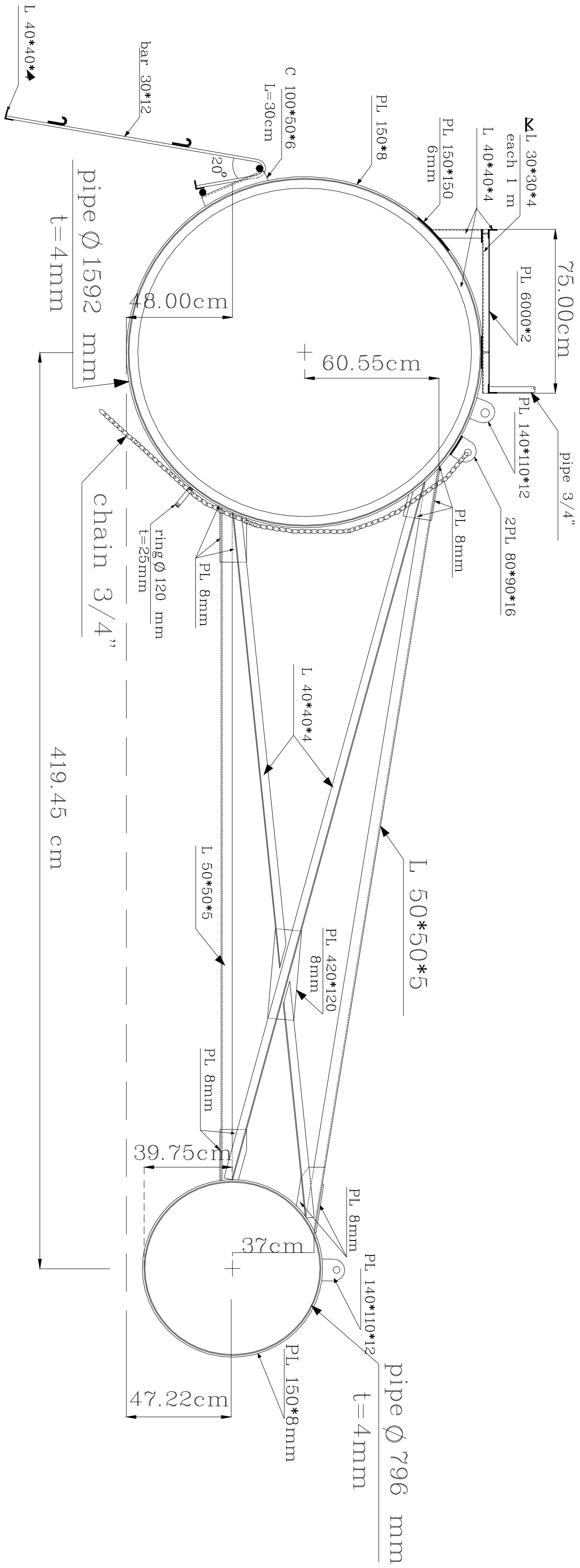


Figure 13. Detailed design of buoy unit in the barrier (Section elevation)

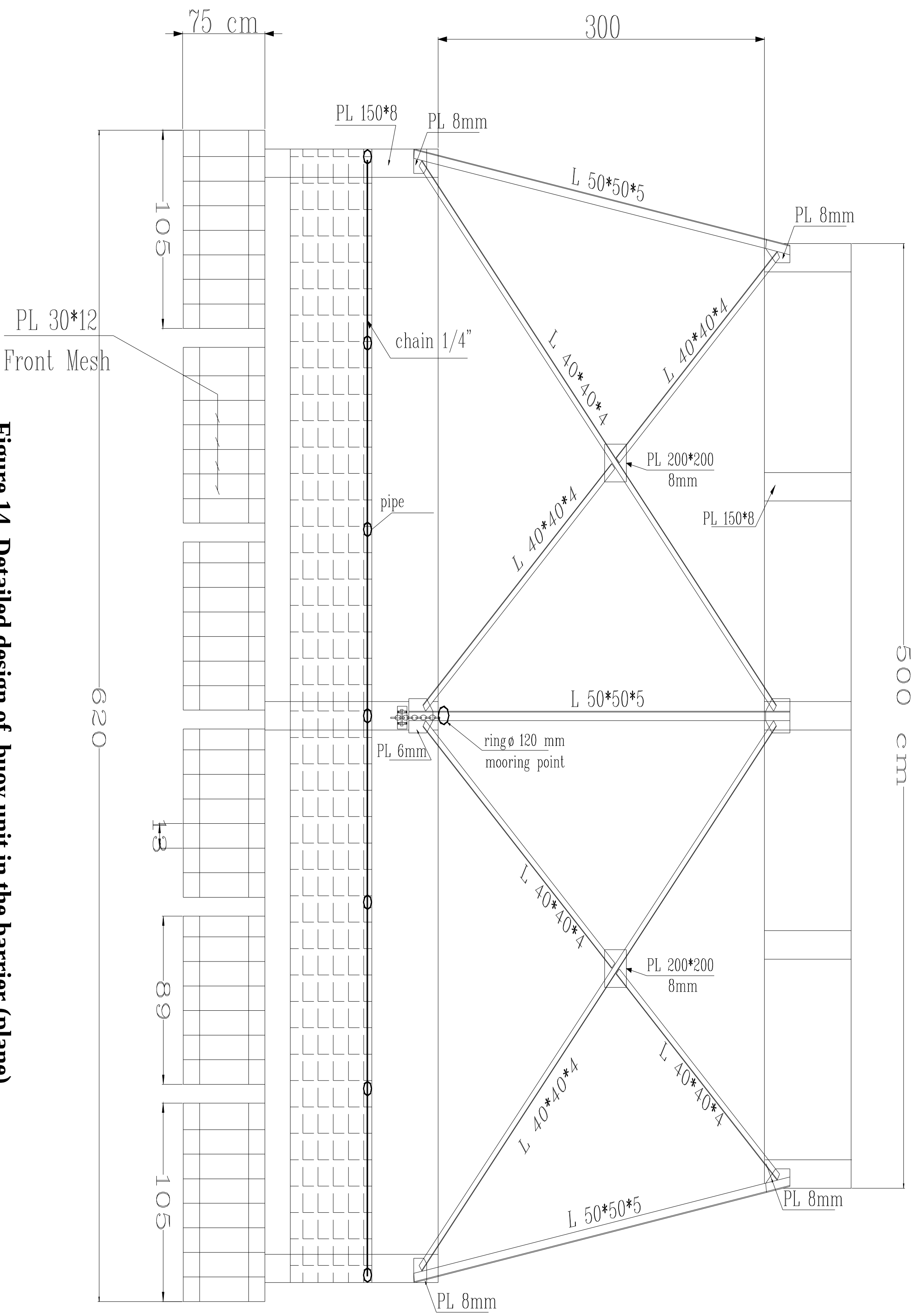
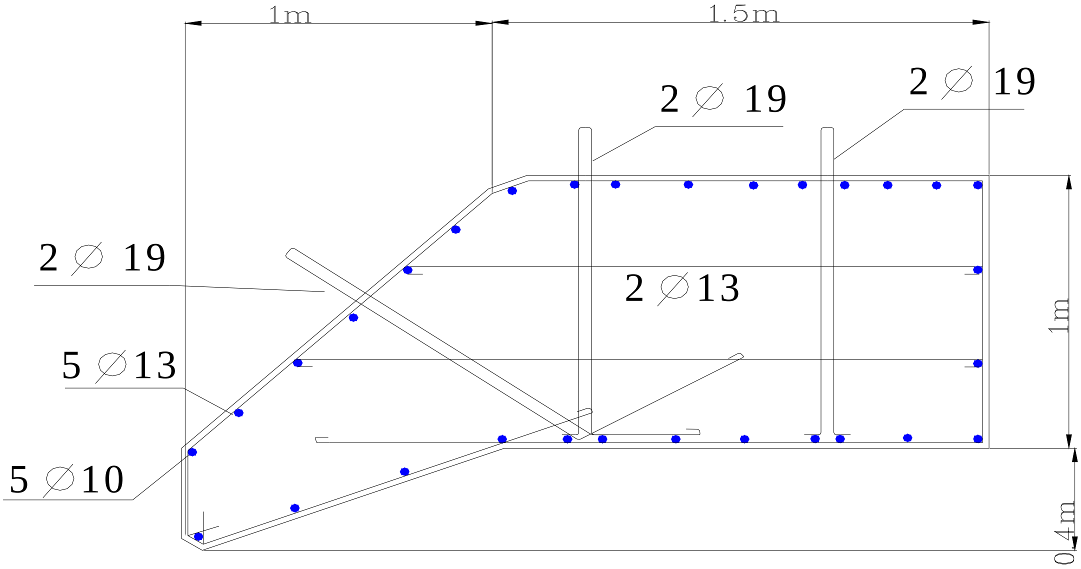
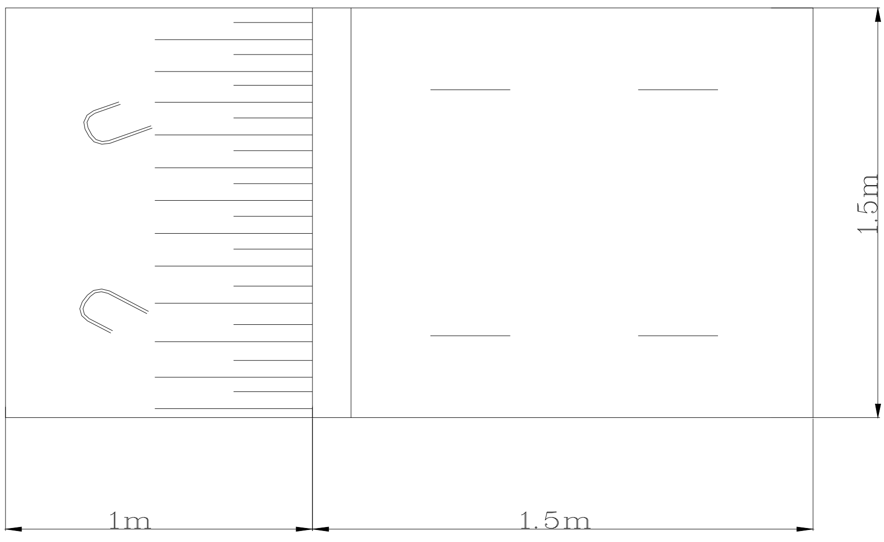


Figure 14. Detailed design of buoy unit in the barrier (plane)



RFT. Details



Anchorage Block Plan

Figure 15. Detailed design of gravity anchorage block