Central City Development Company, Inc.

2201 Market, Suite 820
P. O. Box 545
Galveston, Texas 77553
498 / 762-8881

March 23, 1992

Mr. Armin M. Cantini
Chairman of Board
Chamber of Commerce
621 Moody, Suite 300
Galveston, Texas 77550

Subject: Beach Renourishment Meeting March 20, 1992 and
Tax Zone 9 (Breakwater) Submerged Reef

Dear Armin:

I wish to apologize for Eitel's disruption to our meeting but we must remember he has worked hard for the program and got lost in his emotions as he spoke.

I guess, to prevent any future disburbance, I need to change the generalized classification of "Breakwater" to a more precise grouping "Submerged Reef". They both do the same thing. As the wave breaks over the unit the suspended sand will settle out. Also, in the case of minor hurricanes the unit will absorb form 20 to 40% of the wave energy that would naturally scour the beach.

A subject raised by a non-financial participant was that our structure was a "hard structure". This was true in 1985 but we have incorporated all of the different agencies comments in our redesign and are considering all of the latest concepts in this field. For every "hard structure" we have considered we have two "soft structures" as options. Our rebid documents have been placed on hold as a result of the political situation but one of the bidding design options is "the erosion control mat" by "Hydracor" and a brief description is enclosed for your review if desired.

If there are any questions, please do not hesitate to call.

Sincerely,

Willis Thames

WT:tk

HYDRACOR INTERNATIONAL, INC

Harnessing The Sea to Overcome Soil Erosion

TABLE OF CONTENTS

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Title:			
Client :	Document No	Tech Doc 2.1	
	Page		
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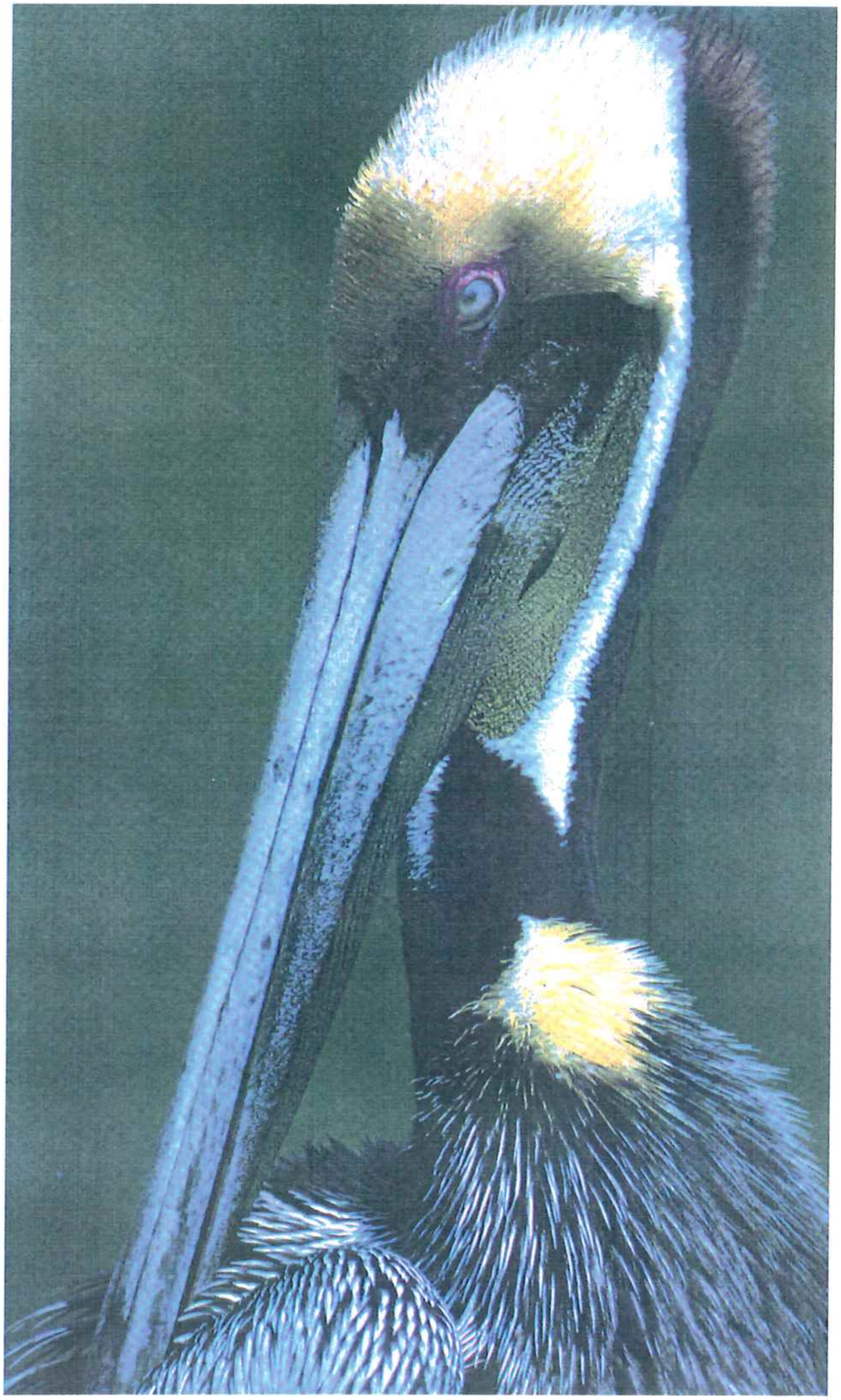
for the Environment, without which we are all lost



INTRODUCTION

INTRODUCTION

Underwater "foundation soil" supporting the "footings" of a substructure are a critical component in the maintenance of the stability of the structure. Establishing the sensitivity of these soils to erosion is an important design factor and great care should be exercised in making this determination.

A solid obstruction (i.e., a substructure "footing") placed on a soil bed in a water flow increases the local current velocity and can put the "soil bed", previously stable, into a state of instability.

The novel "Erosion Control Mat" manufactured by H.I.I. is a reliable proven solution to this problem. Its high resistance to water flow with 3.8 million square inches of wetted area / drag surface per mat retards the current velocity, thereby preventing continued losses of soil by erosion forces. This slower current causes soil, previously transported by the more rapid current, to deposit in the "Erosion Control Mat." This builds up a permanent fiber reinforced soil bank analogous to its natural surroundings.

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Ideally, erosion susceptibility should be determined prior to any underwater construction. If this determination reveals the risk of erosion, preventive action should be taken immediately. Installing erosion control mats concurrently with an underwater structure eliminates potential problems that will soon lead to costly remedial work.

Underwater pipeline constructors, in particular, can greatly benefit by employing H.I.I. "Erosion Control Mats." These mats, with their high initial anchor retention (avg. 24 tons), free pipelines from the cumbersome "weight coats" previously required. The mass fiber reinforced soil bank (avg. 1,000 ft^3) offers unparalleled mechanical protection while eliminating the hazardous problem of spanning. Not only can "weight coats" be forgotten, but H.I.I. mats will also end the need for deep trenching. Installing H.I.I. mats over pipe placed in a shallow trench creates a "buried line" under the generated soil bank. After serving its purpose, the pipeline; covered with more than a meter of fiber reinforced soil; would not need to be recovered -- a process which often proves more arduous than the original pipeline installation.

When installed from the beginning, H.I.I. "Erosion Control Mats" do not significantly add to construction costs and, in some instances, may even reduce these initial costs. These mats, however, will pay for themselves many times over by virtually eliminating the life cycle costs inherent with maintaining any underwater structure.

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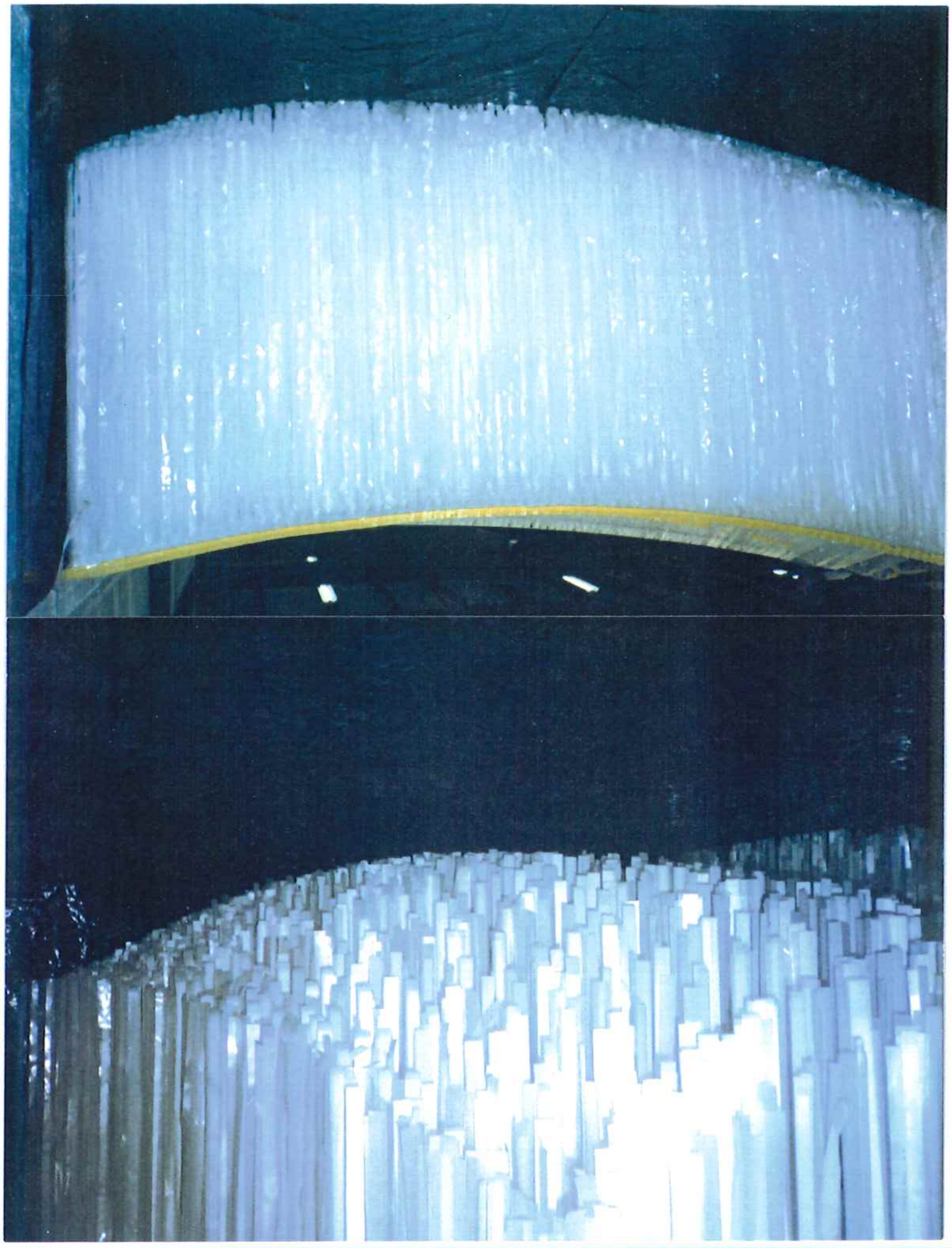

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Title:	Side and Top Views of the H.I.I. Erosion Control Mat Illustrating Frond Density		
Client :		Document No	Tech Doc 2.1
		Page	3
		Prepared	DC 19.11.91
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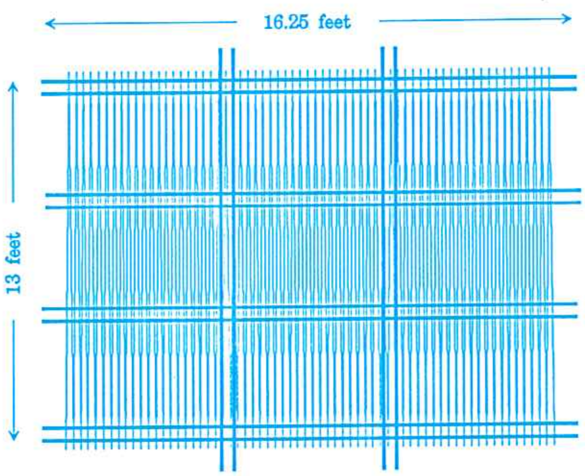
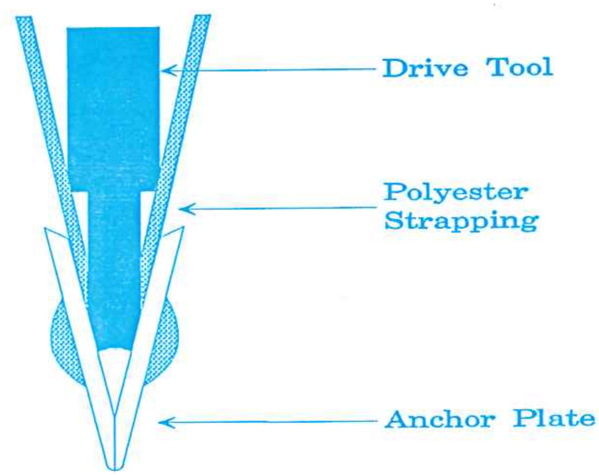
Each mat is anchored into the sea bed with 24 ground anchors. These anchors are driven in pairs to a depth of four feet. Each anchor in the pair has a minimum retention capability of two tons. Each mat installed underwater in silty-sand will have a minimum non-gravitational hold down of 48 tons. Once installed, the mat will develop into a soil bank approximately five feet high with a base measuring 16.25 feet by 13 feet. This soil bank alone will weigh approximately 50 tons. Achieving retention levels to this degree using traditional stone/rip-rap dumping methods would be nearly impossible. Also, such methods would only introduce another obstacle to cause further erosion, limiting such method's effectiveness. Hydracor International, Inc. Erosion Control Mats are a *permanent* solution offering nearly 100 tons of hold down.



Bottom View of The Erosion Control Mat Illustrating the Anchor Strapping Pattern. At the end of each strap pair, a pair of ground anchors is attached and driven down four feet.



Anchor Pair Bent Into Driving Position. As tension is applied to the anchor pair, it will open up and split into two separate plates.

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		Page	4
		Prepared	DC 19.11.91
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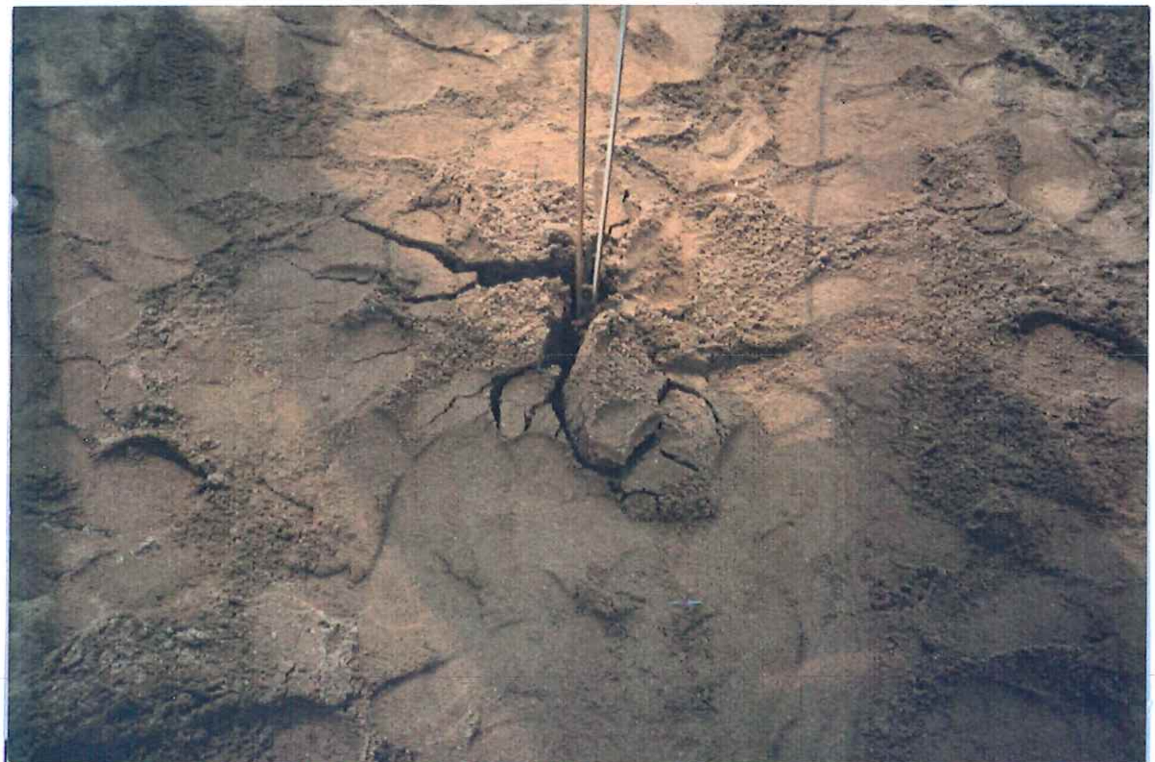

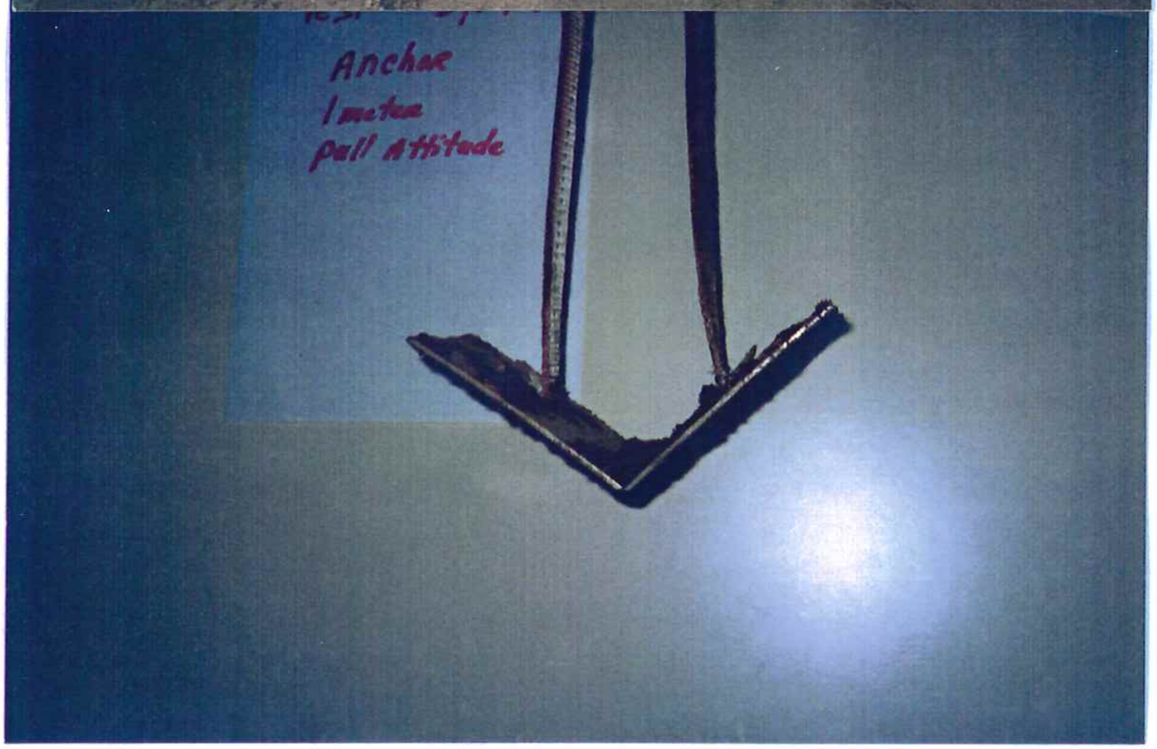

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Title: Anchor Test Photos. Surface Area Breakup and 50 sq. inch anchor after successful 6,000 lbs. test.

Client :

Document No	Tech Doc 2.1
Page	5
Prepared	DC 19.11.91
Approved	

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Title: Final and Permanent Stage - A Reinforced Soil Bank

Client :	
Document No	Tech Doc 2.1
Page	6
Prepared	DC 19.11.91
Approved	

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Theory of Local Scour

Extensive research on local scour has identified the mechanisms which produce erosion and the factors which determine the equilibrium depth of scour. Useful surveys of the subject are given by Breusers et al[2] and by Farraday and Charlton[4].

When an obstacle such as a bridge pier is placed in flowing water, the resulting pressure field around the obstacle can give rise to vortex systems of three types:

1. horseshoe-vortex
2. wake-vortex
3. trailing-vortex

The horseshoe-vortex forms at the base of the obstacle at its upstream end, and is stronger for blunt-nosed piers than for streamlined ones. Vertical differences in stagnation pressure on the upstream face of the obstacle produce a secondary downward flow towards the bed; this causes vorticity in the boundary layer at the bed to roll-up and concentrate into a horseshoe-vortex rotating about a horizontal axis. In an erodible material this type of vortex causes a scour hole to form at the upstream end of the pier; the two arms of the horseshoe are convected downstream by the flow, and may cause erosion along the sides of the pier and downstream of it.

The wake-type vortex is caused by periodic eddy shedding from the downstream end of an obstacle; the axis of rotation is usually vertical, but may become tilted towards the horizontal as it is convected downstream by the flow. This type of vortex causes scour to occur downstream of a pier.

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The trailing-type vortex is shed at points below the water surface where there is a change in the plan shape of a pier, and is analogous to the trailing vortices formed at the tips of aircraft wings. The axis of the vortex is horizontal, and it may not produce significant scour if the level at which the plan shape of the pier changes is well above the bed.

The equilibrium depth of local scour (d_s) at a bridge pier depends upon the following factors:

1. <u>Pier</u> - size (b), shape and angle of inclination to the flow.

2. <u>Bed</u> - particle size (D), grading and specific gravity(s).

3. <u>Flow</u> - depth of flow (y_o)and shear stress (τ) at bed exerted by flow.

It is assumed here that the bed material is cohesionless, and that parameters such as the acceleration due to gravity (g) and the kinematic viscosity (ν) of the water do not vary.

Sediment particles in a plane bed will begin to move when the average shear stress exerted by the flow exceeds a certain value, termed the critical shear stress τ_c. A pier causes a local increase in velocity, and the particles around the pier begin to move when the average shear $\tau > 0.25\ \tau_c$ approximately. Research has shown that the equilibrium depth of scour, d_s, becomes larger as τ increases, but reaches a maximum value, d_{sm}, when the bed as a whole is at the threshold of

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movement, i.e. at $\tau = \tau_c$. For $\tau > \tau_c$, the depth of scour decreases slightly to a figure of between 90% and 100% of d_{sm}; the depth is difficult to define precisely because the passage of ripples or dunes along the bed causes it to vary with time.

The somewhat surprising finding that the depth of scour reaches a maximum when $\tau = \tau_c$ can be explained as follows. When the bed as a whole is in movement (i.e. $\tau > \tau_c$) and the equilibrium depth of scour has been reached, a balance exists between the rates of sediment transport into and out of the hole. This balance is independent of the absolute rates of transport, so the depth of scour does not alter significantly so long as the bed is in general movement. This argument is valid down to the threshold of motion $\tau = \tau_c$, when the rates of transport into and out of the scour hole are just zero.

Laboratory and field measurements of scour around bridge piers indicate that the maximum scour depth (d_{sm}) depends upon the width of the pier (b), the water depth (y_o) and the sediment size (D), in that order of importance. Breusers et al[2] suggest an equation of the form

$$d_{sm}/b = 2.0\, a_1 a_2 \tanh (y_o/b) \qquad (1)$$

where a_1 and a_2 are factors taking account of pier shape and angle of incidence (both equal to unity for a circular pier). Experiments indicate that the maximum scour depth may increase slightly with increasing sediment size, but the effect is small compared with other uncertainties in the prediction equation.

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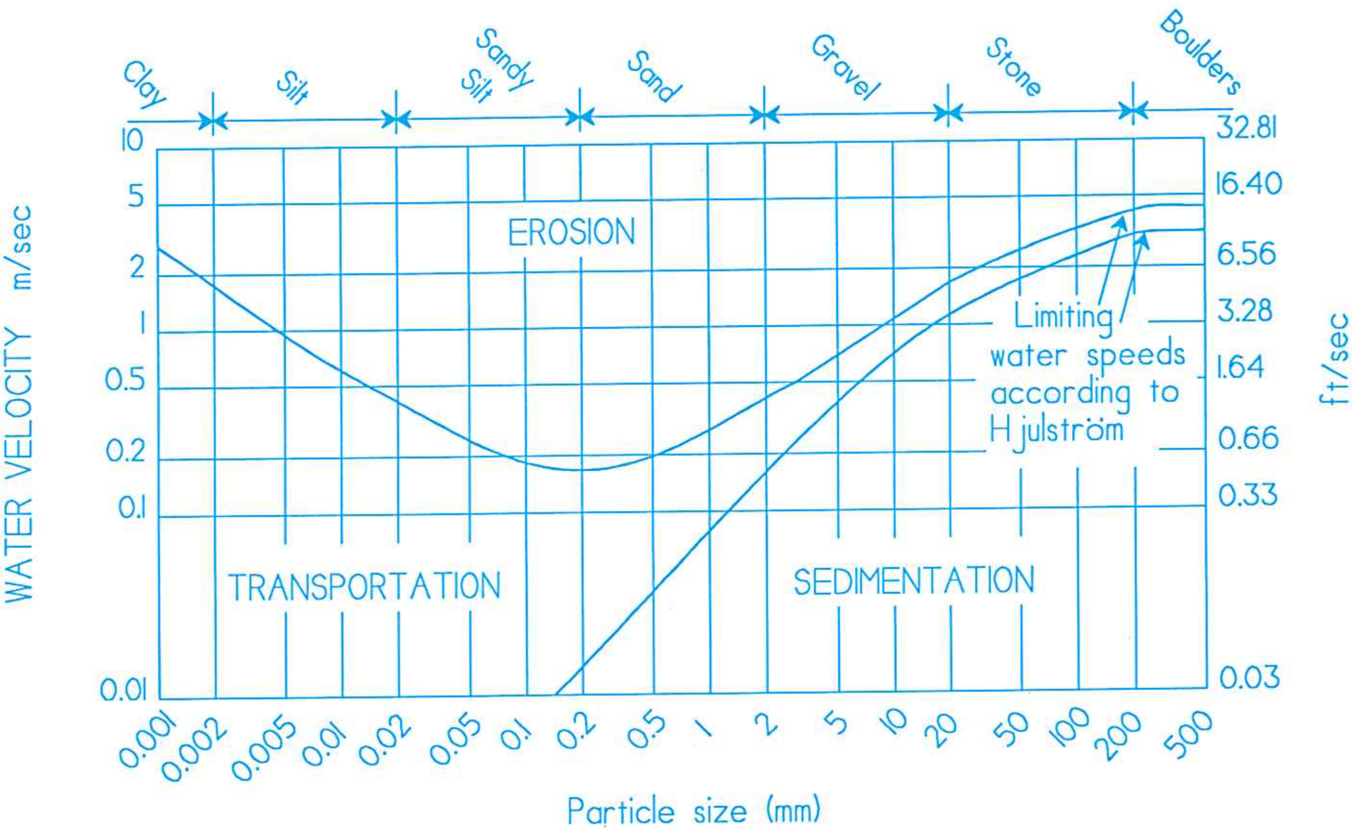
Erosion Susceptibility Chart



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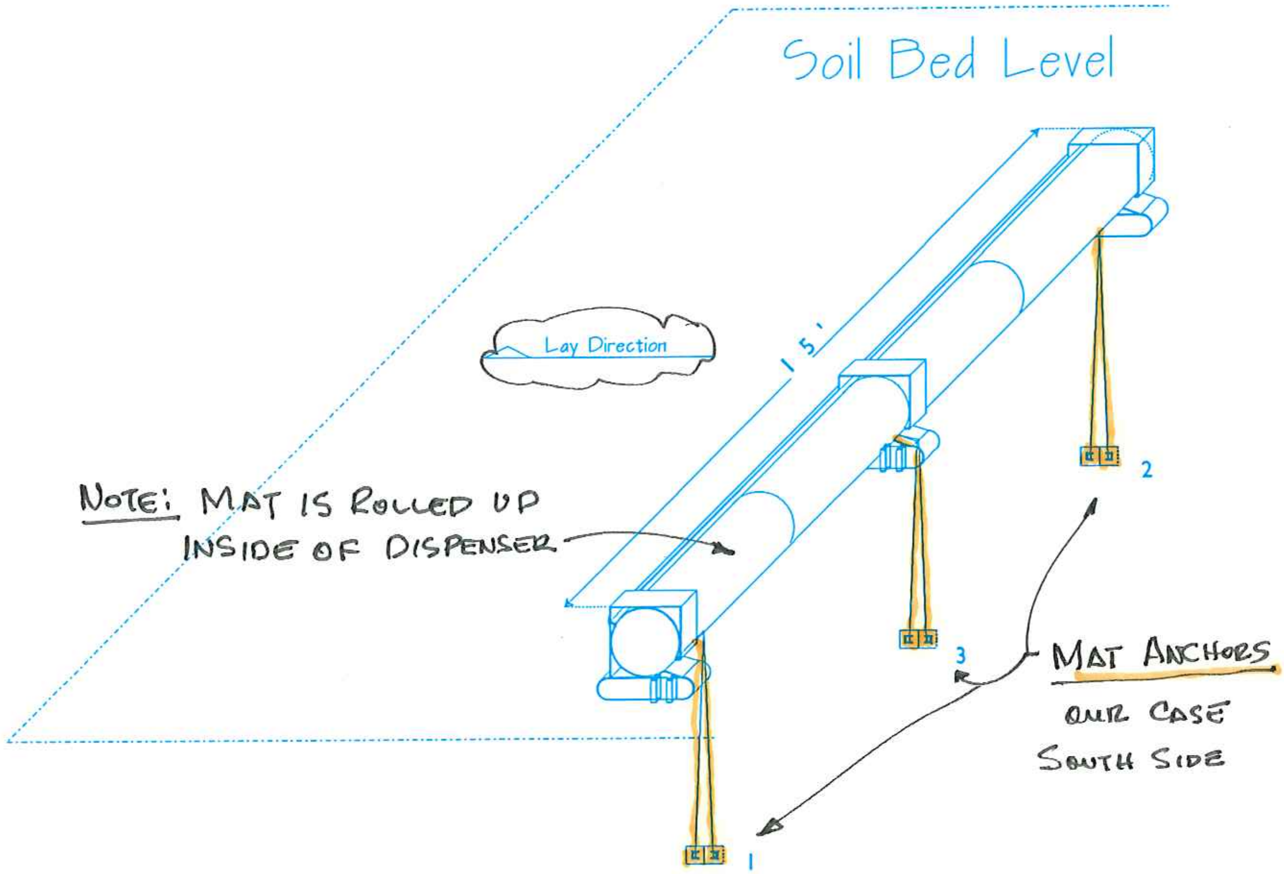
Title:	Erosion Susceptibility in Relation to Water Velocity and Particle Size
Client :	
Document No	Tech Doc 2.1
Page	10
Prepared	DC 19.11.91
Approved	



Stage I

Erosion Control Mat Packed in Dispenser Bottom Side.

Lead Anchors 1, 2, and 3 Secured.

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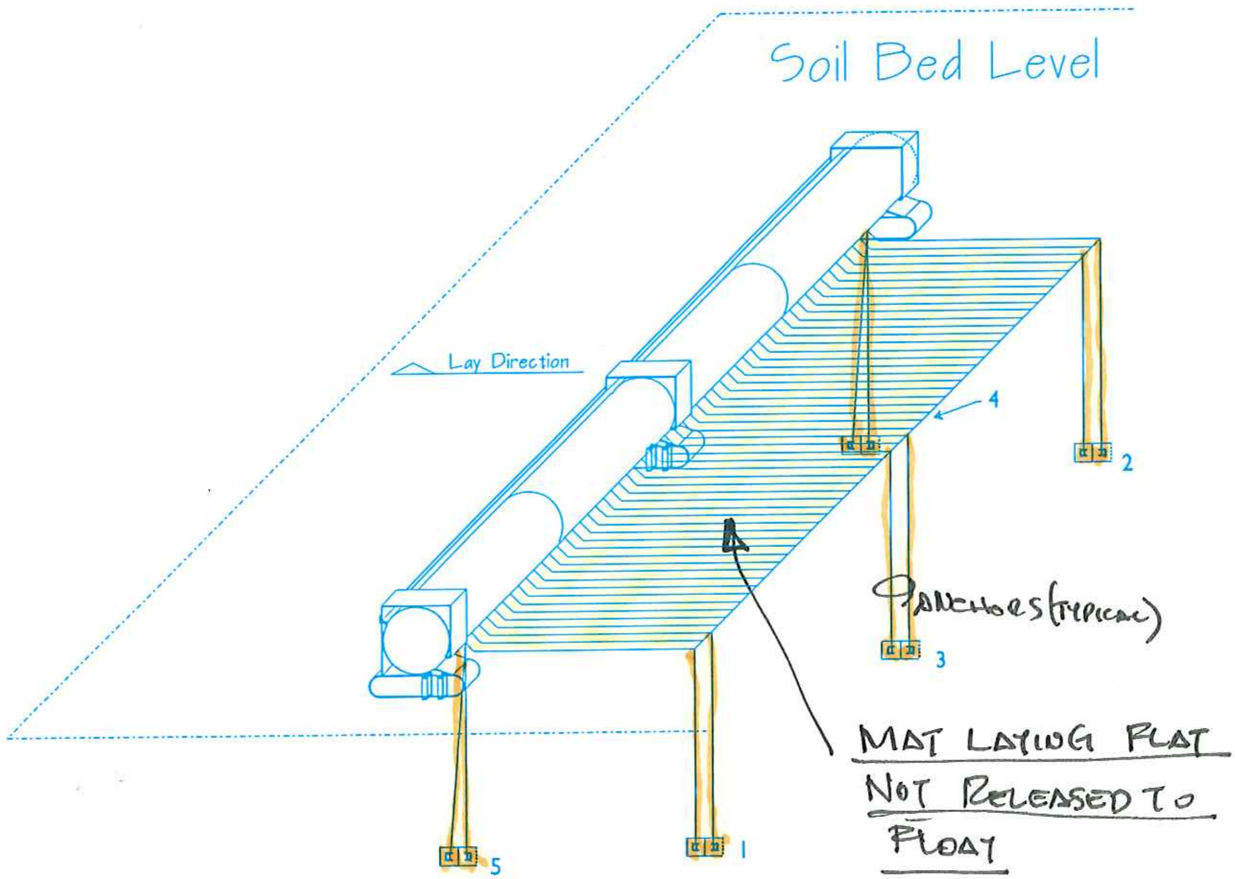
Client :	
Document No	Tech Doc 2.1
Page	11
Prepared	DC 19.11.91
Approved	



Stage II

Dispenser Moved. Mid Anchors 4 and 5 Secured.

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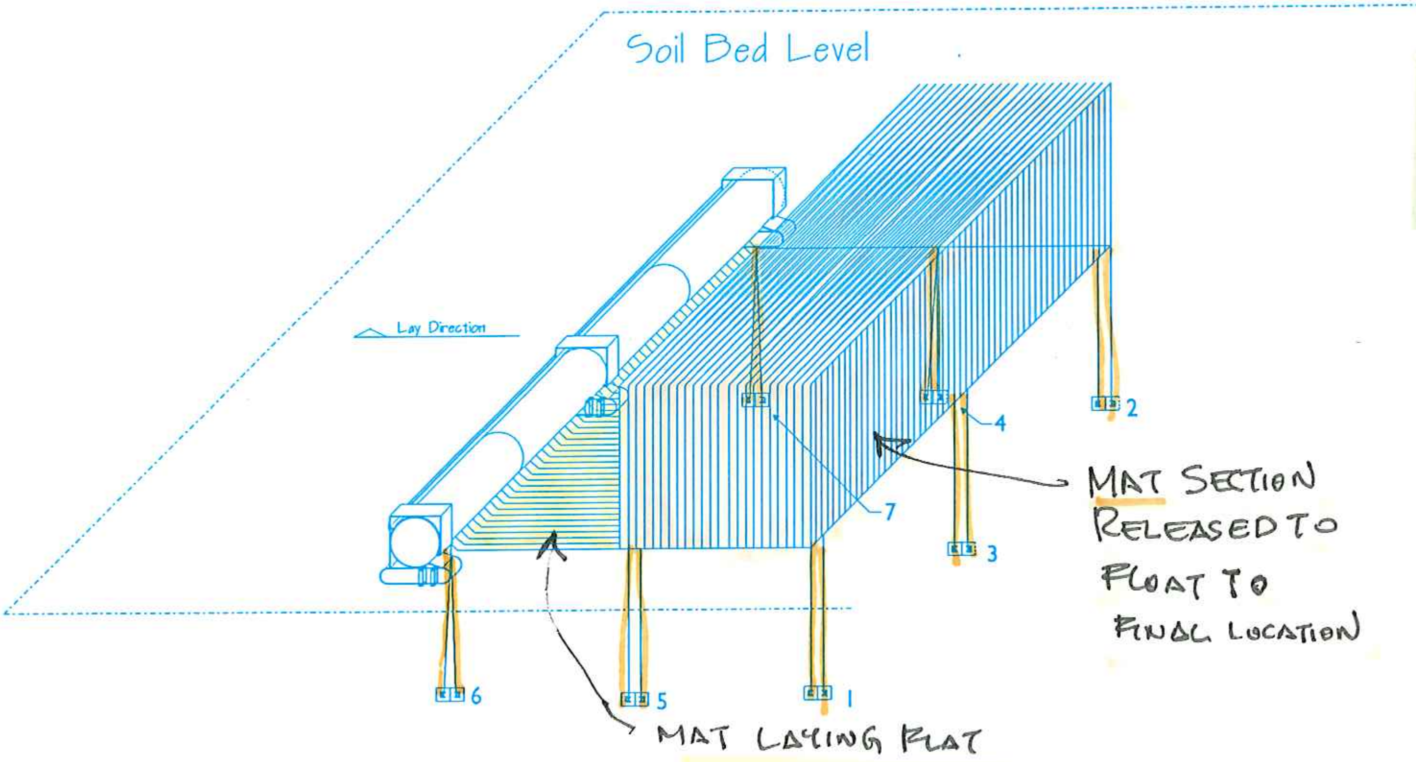
Client :	
Document No	Tech Doc 2.1
Page	12
Prepared	DC 19.11.91
Approved	



Stage III

Dispenser Moved. Mid Anchors 6 and 7 Secured.

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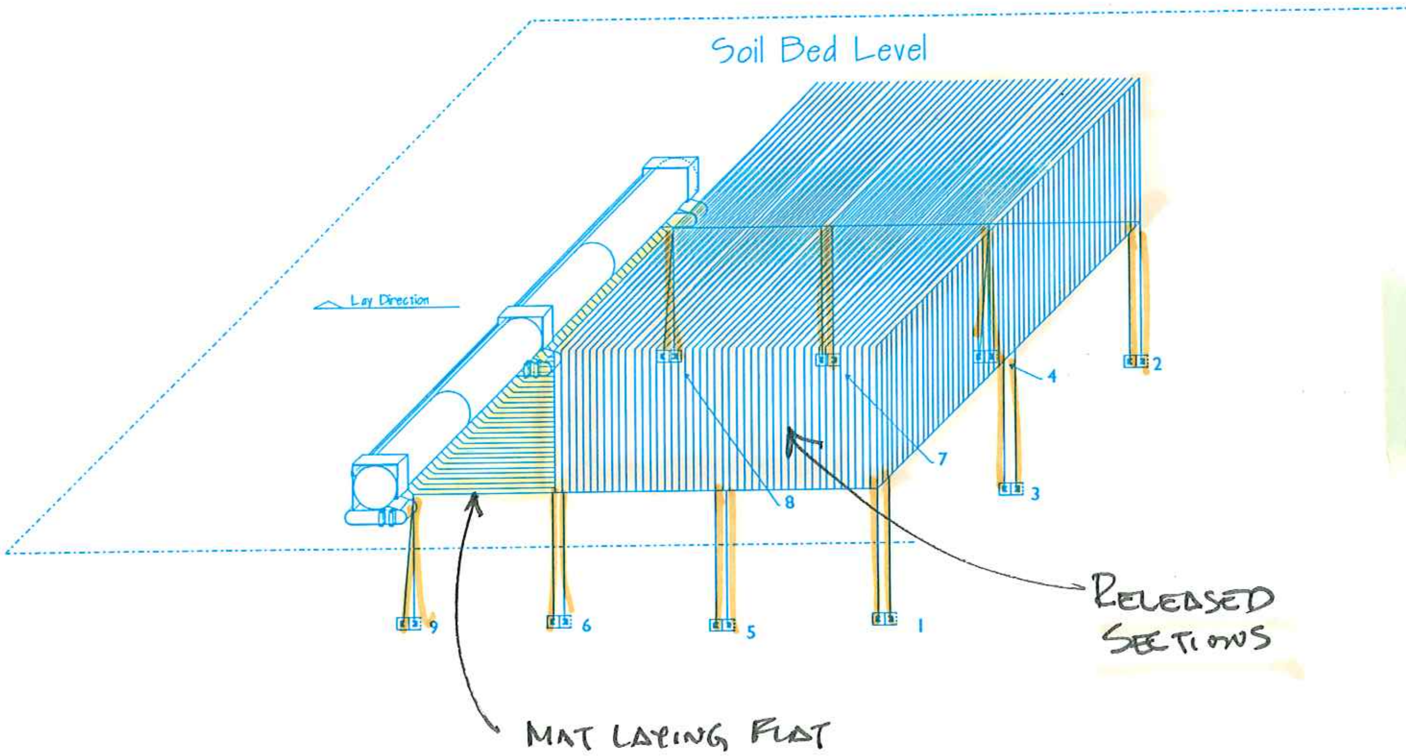
Client :

Document No	Tech Doc 2.1
Page	13
Prepared	DC 19.11.91
Approved	W



Stage IV

Dispenser Moved. Anchors 8 and 9 Secured.

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1725 Duke Street, Suite 680		Page: 14
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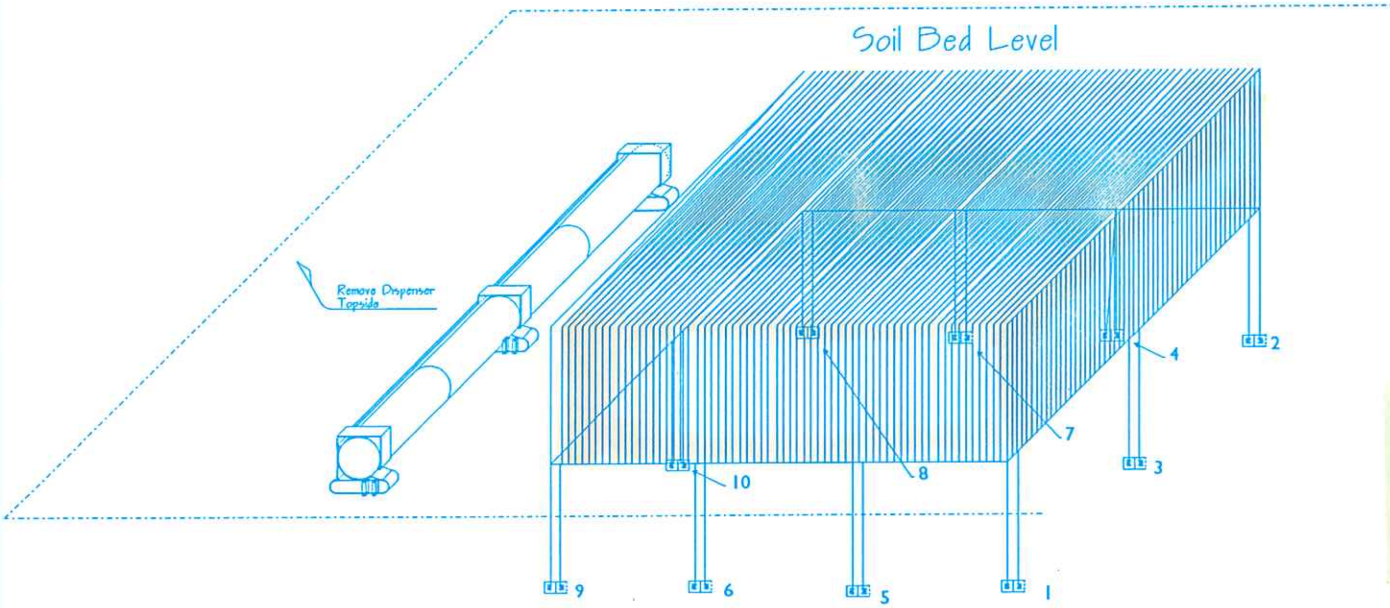

Stage V

Secure Anchor 10. Return Dispenser to Surface.
Mat Fully Developed.

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		Page	15
		Prepared	DC 19.11.91
		Approved	

The following sections illustrate a few examples of H.I.I. Erosion Control "Mat" applications. Obviously in a brochure of this size it would be impossible to include every possible application.

H.I.I. "Mats" are very versatile. They can be used in an initial preventative manner. They can repair scour damage that has already occurred. They can solve any problem large or small. Not only do the mats *prevent* erosion, but they can be used to create underwater banks that will alter the existing water flow patterns and provide controlled erosion, eliminating the need for periodic dredging. Basically, if your problem involves underwater erosion in any way, H.I.I. "Mats" can most likely provide a solution.

Hydracor International, Inc would be pleased to consider your specific problems. Let us assist you in determining if our product can solve your problems.

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Client :

Document No	Tech Doc 2.1
Page	16
Prepared	DC 19.11.91
Approved	

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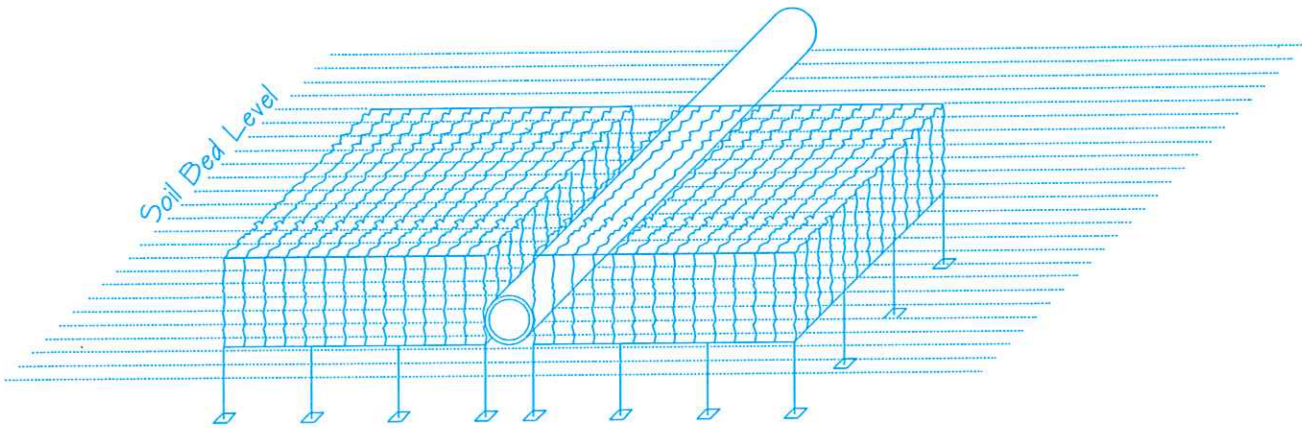

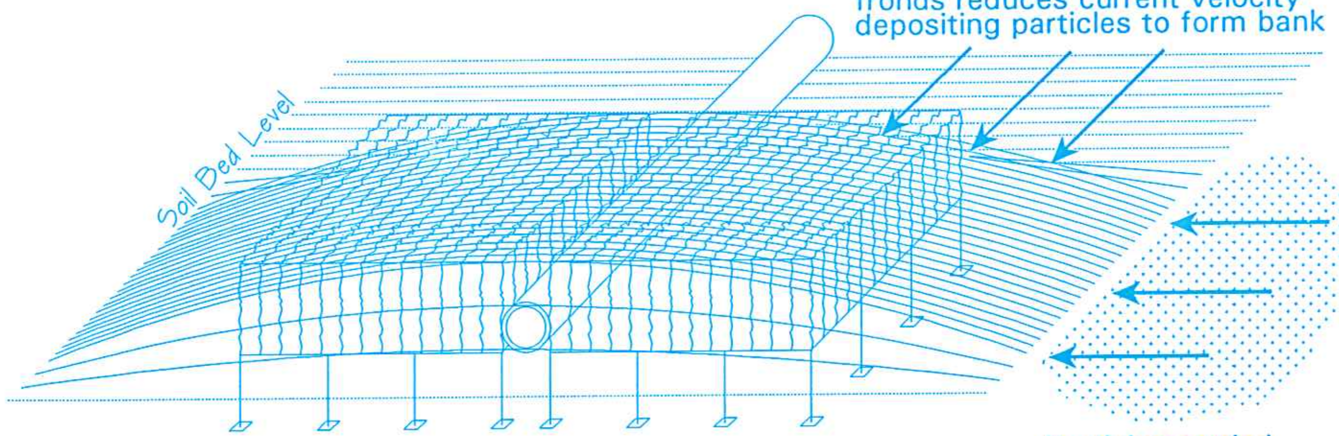

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Title: 2 Erosion Control "Mats" Surrounding a Pipeline. Underwater Viscous Drag to Reinforced Soil Bank.

Client :	
Document No	Tech Doc 2.1
Page	18
Prepared	DC 19.11.91
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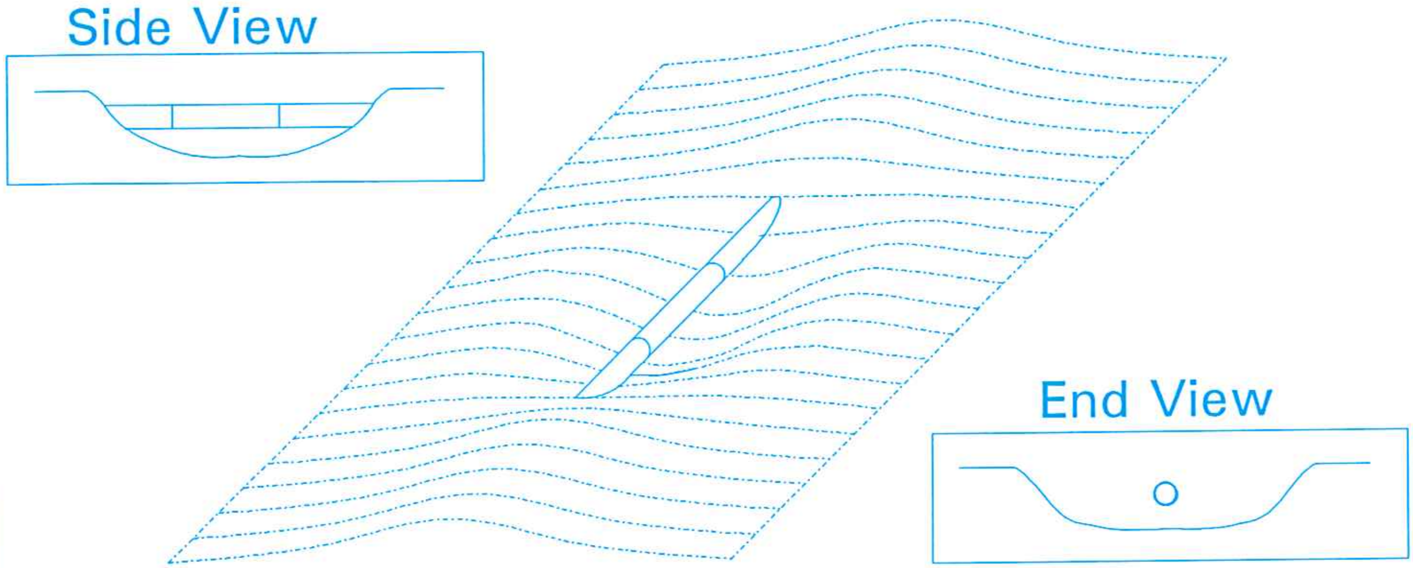

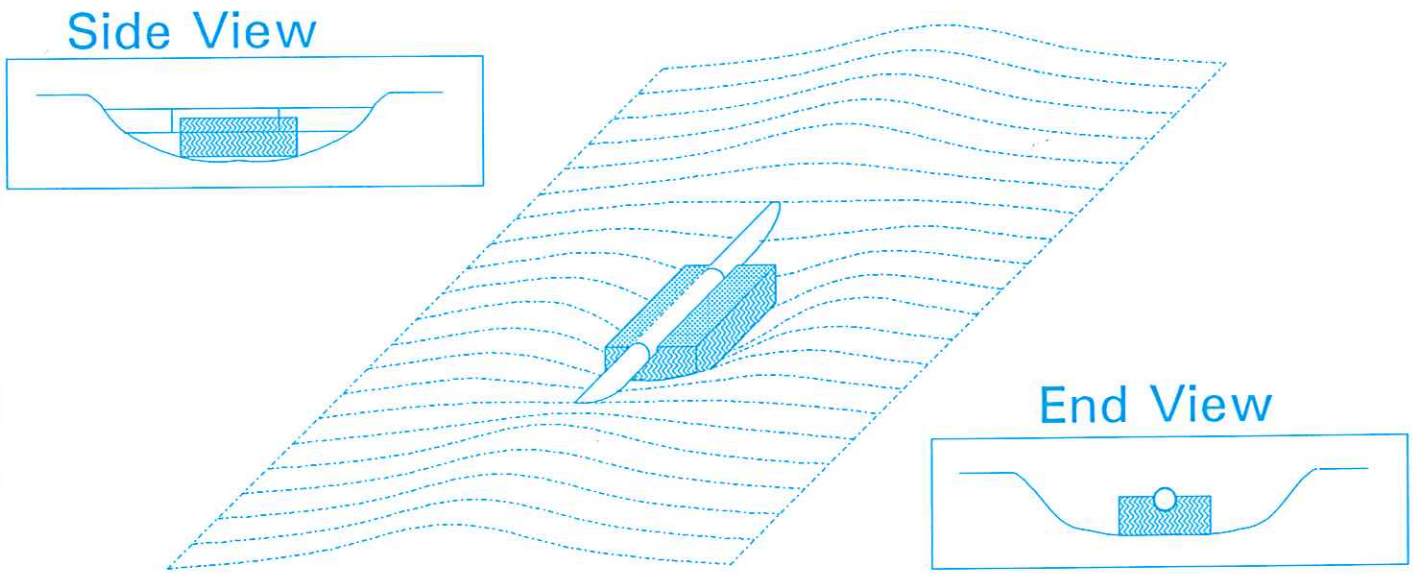

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Document No	Tech Doc 2.1
Page	19
Prepared	DC 19.11.91
Approved	

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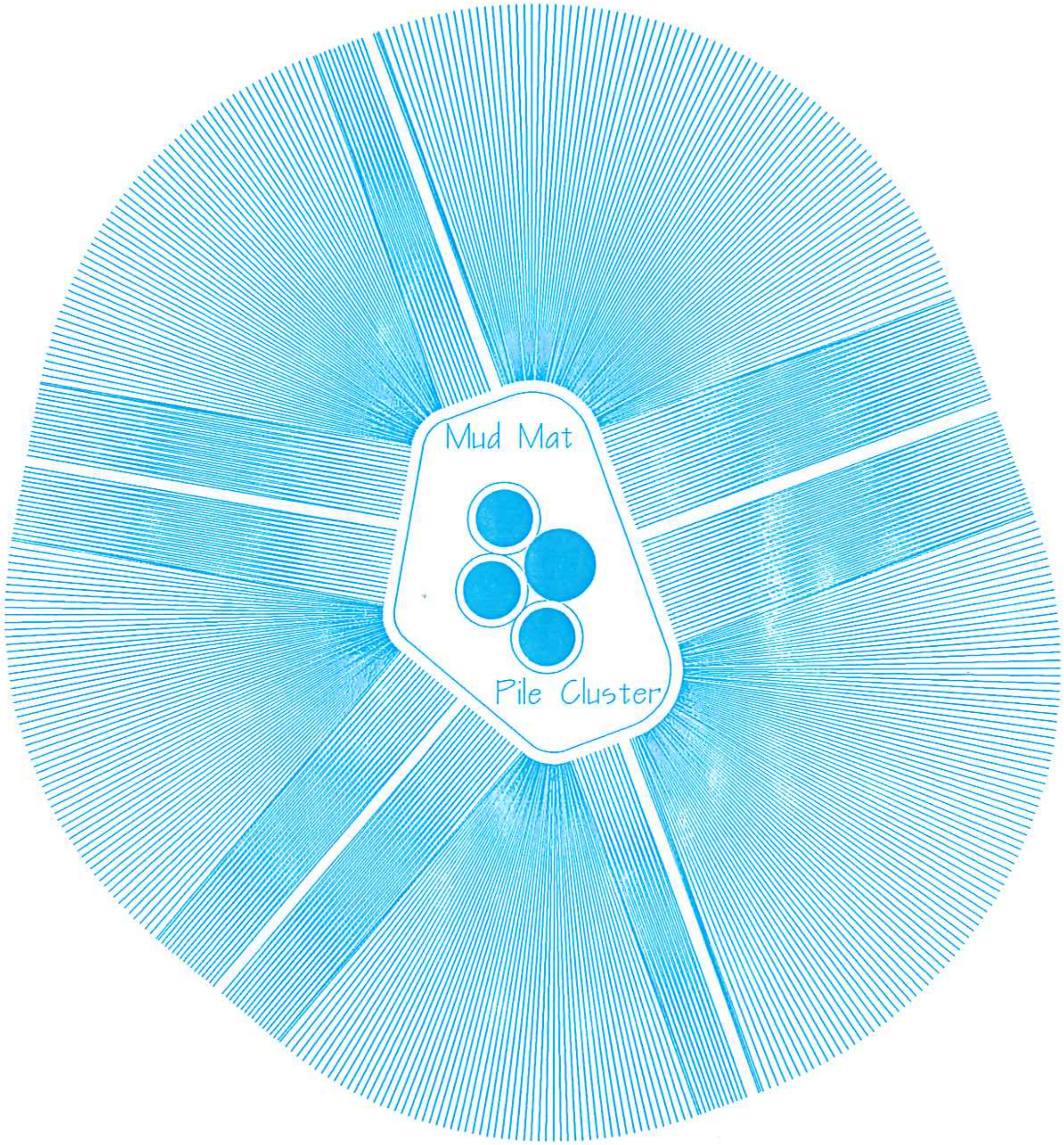

Top View of 5 Erosion Control "Mats" Deployed Around a Fixed Jacket -- Mud Plate.

(Note how the mats follow the contour of the Mud Plate perimeter producing a "fan-like" effect.)

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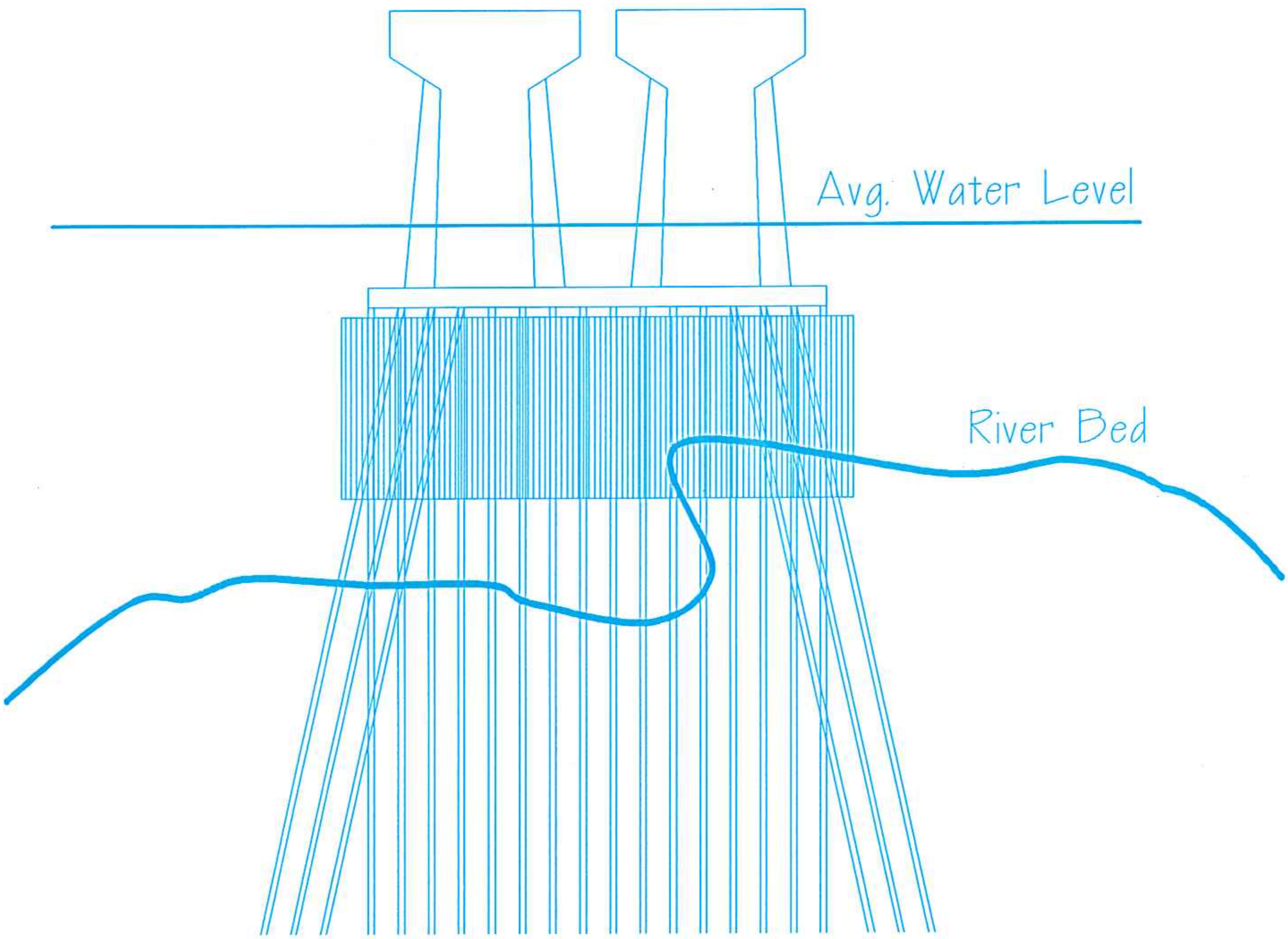
Title:	Erosion Control "Mat." Underwater Pile Protection.
Client :	
Document No	Tech Doc 2.1
Page	21
Prepared	DC 19.11.91
Approved	



Exposed Piles. Bridge Sub Structure.

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Title: Stabilizing Underwater Piles. Bridge Sub Structure.

Client :

Document No	Tech Doc 2.1
Page	22
Prepared	DC 19.11.91
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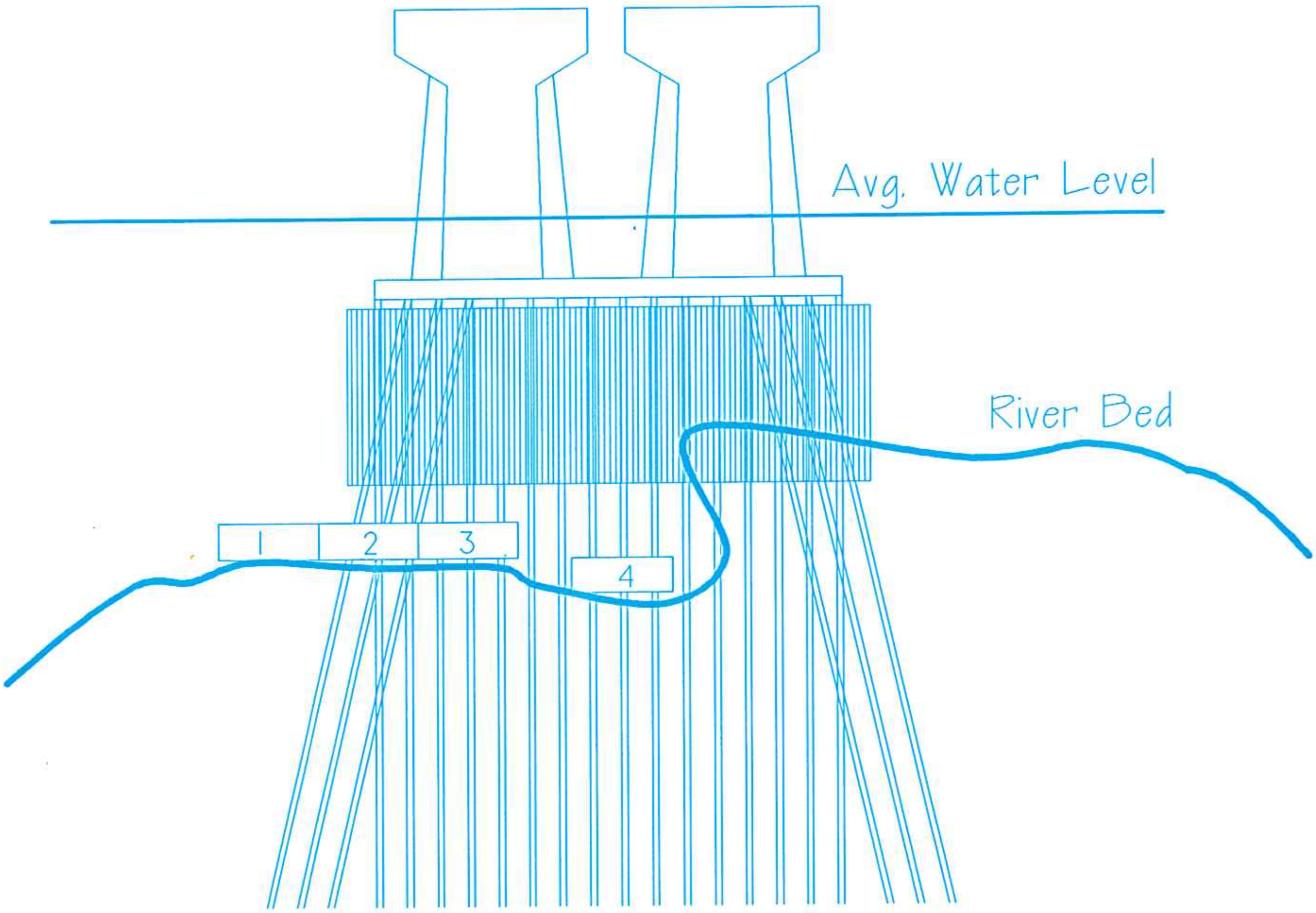

Stage I

4 Erosion Control "Mats" Anchored in Place.

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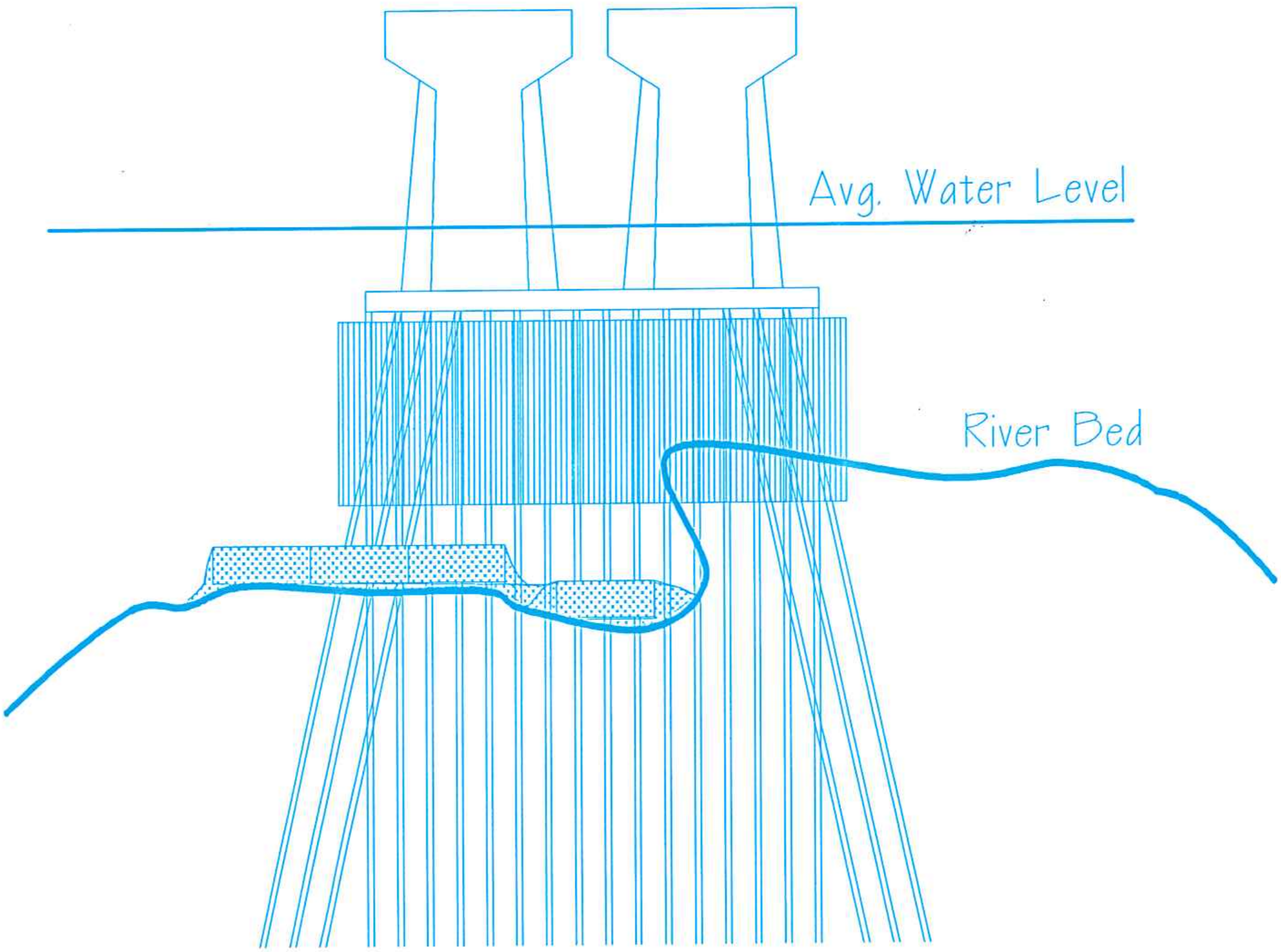
Document No	Tech Doc 2.1
Page	23
Prepared	DC 19.11.91
Approved	



<u>Stage II</u>

4 Erosion Control "Mats." Soil Infilled.

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	Client :	Document No	Tech Doc 2.1
		Page	24
		Prepared	DC 19.11.91
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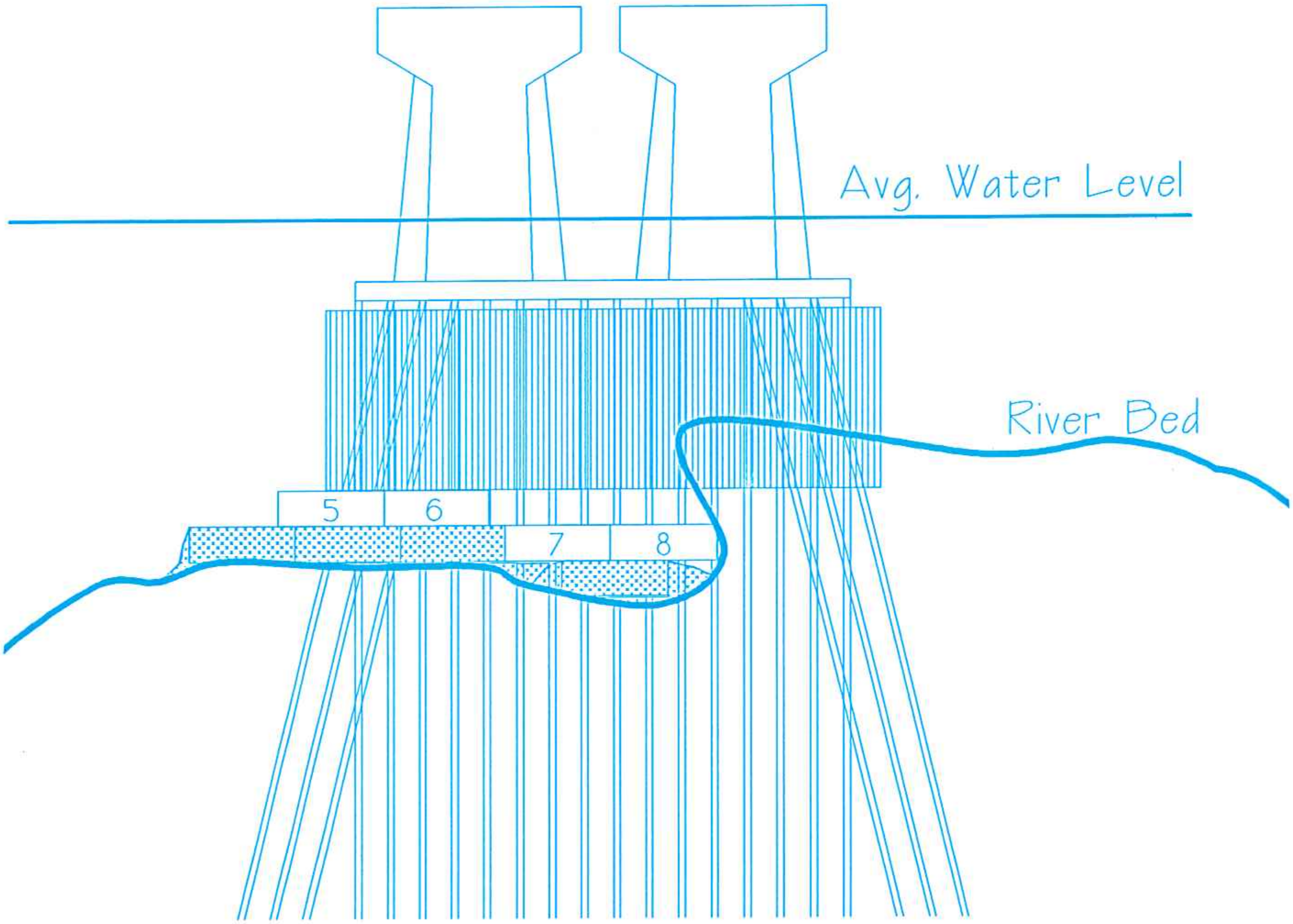

Stage III

4 Erosion Control "Mats" (5-6-7-8) Anchored in Place.

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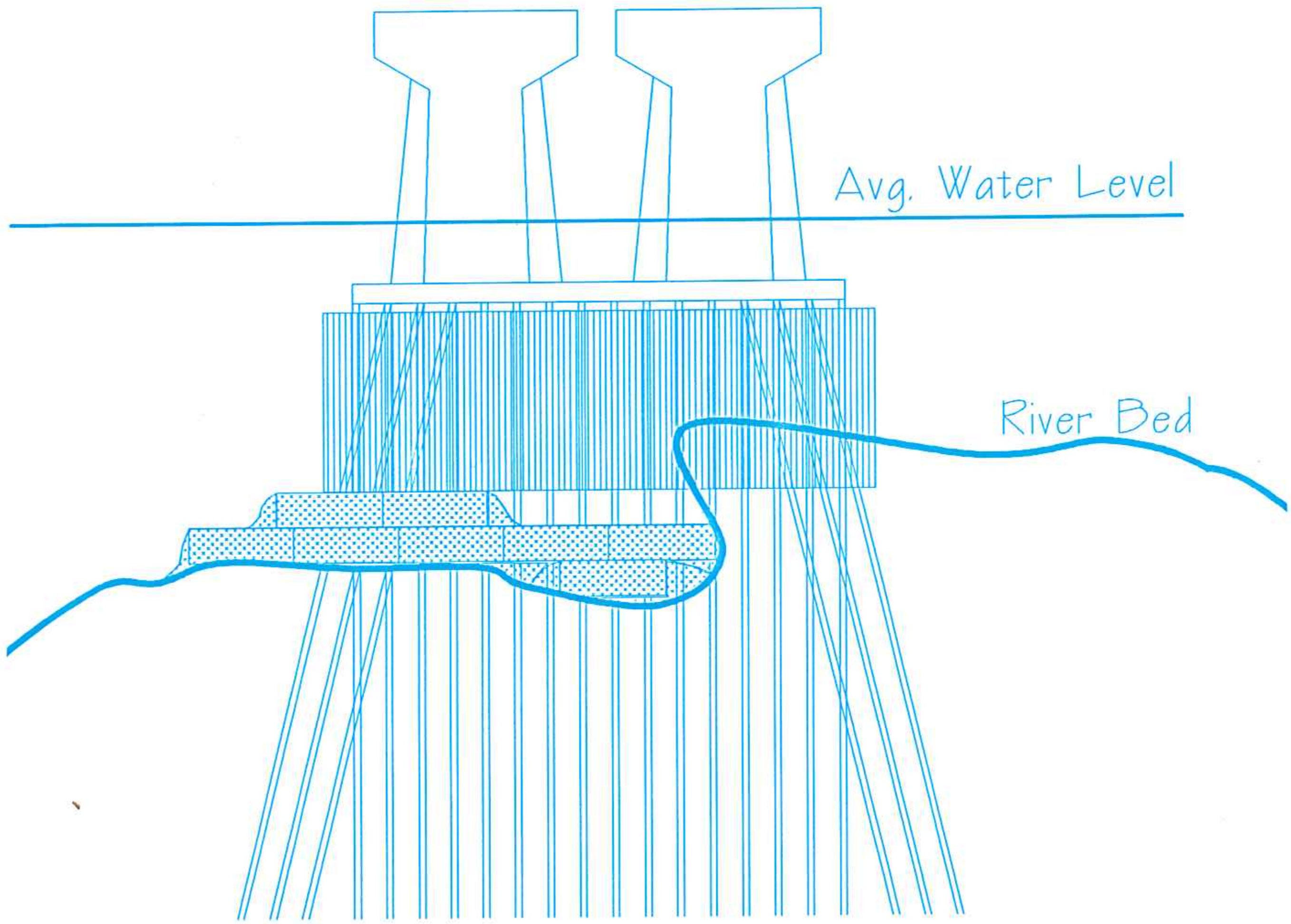
Client :

Document No	Tech Doc 2.1
Page	25
Prepared	DC 19.11.91
Approved	W



Stage IV

4 Erosion Control "Mats" (5-6-7-8). Soil Infilled.

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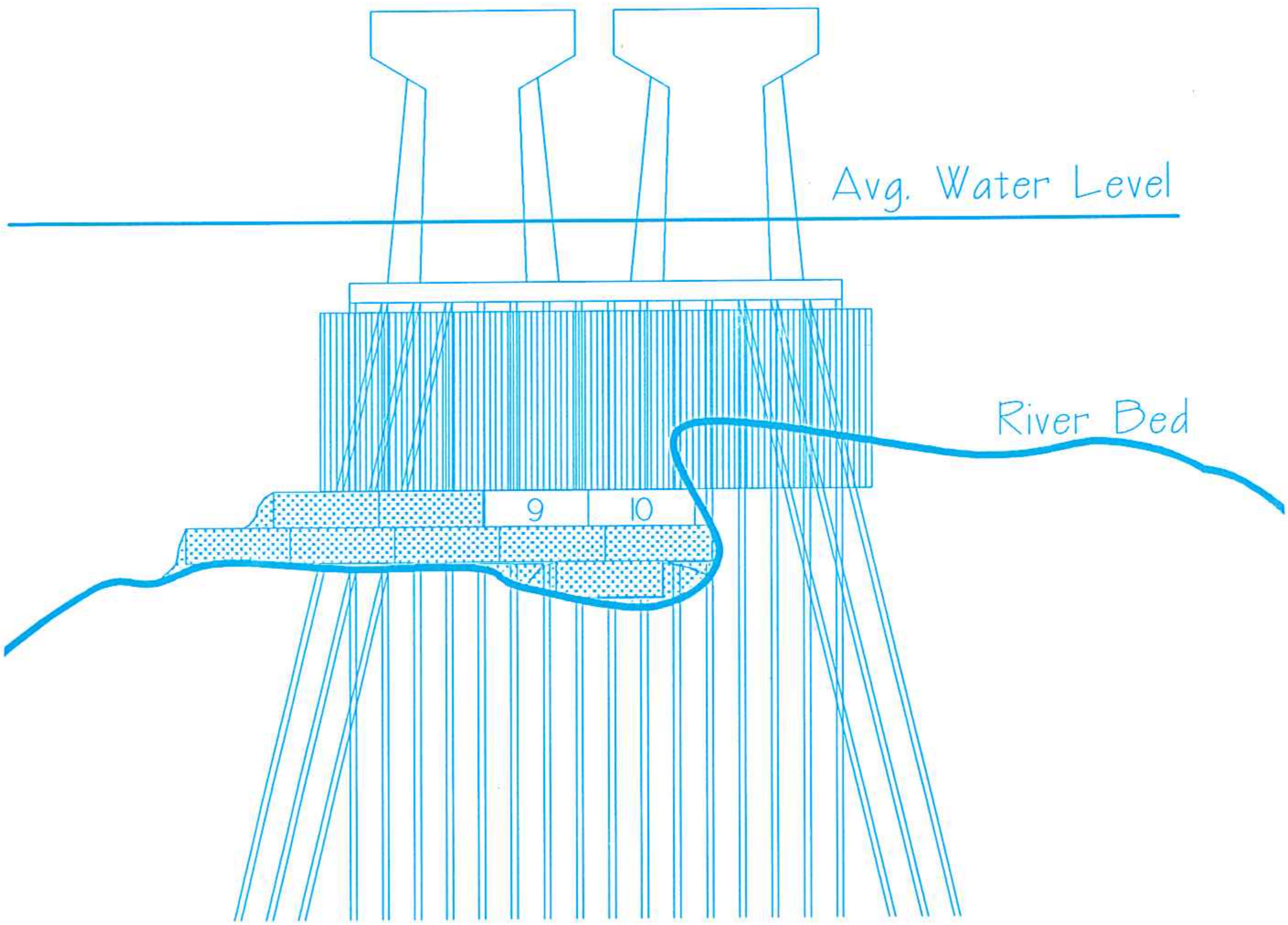
Client :

Document No	Tech Doc 2.1
Page	26
Prepared	DC 19.11.91
Approved	



Stage V

2 Erosion Control "Mats" (9-10) Anchored in Place.

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		Page	27
		Prepared	DC 19.11.91
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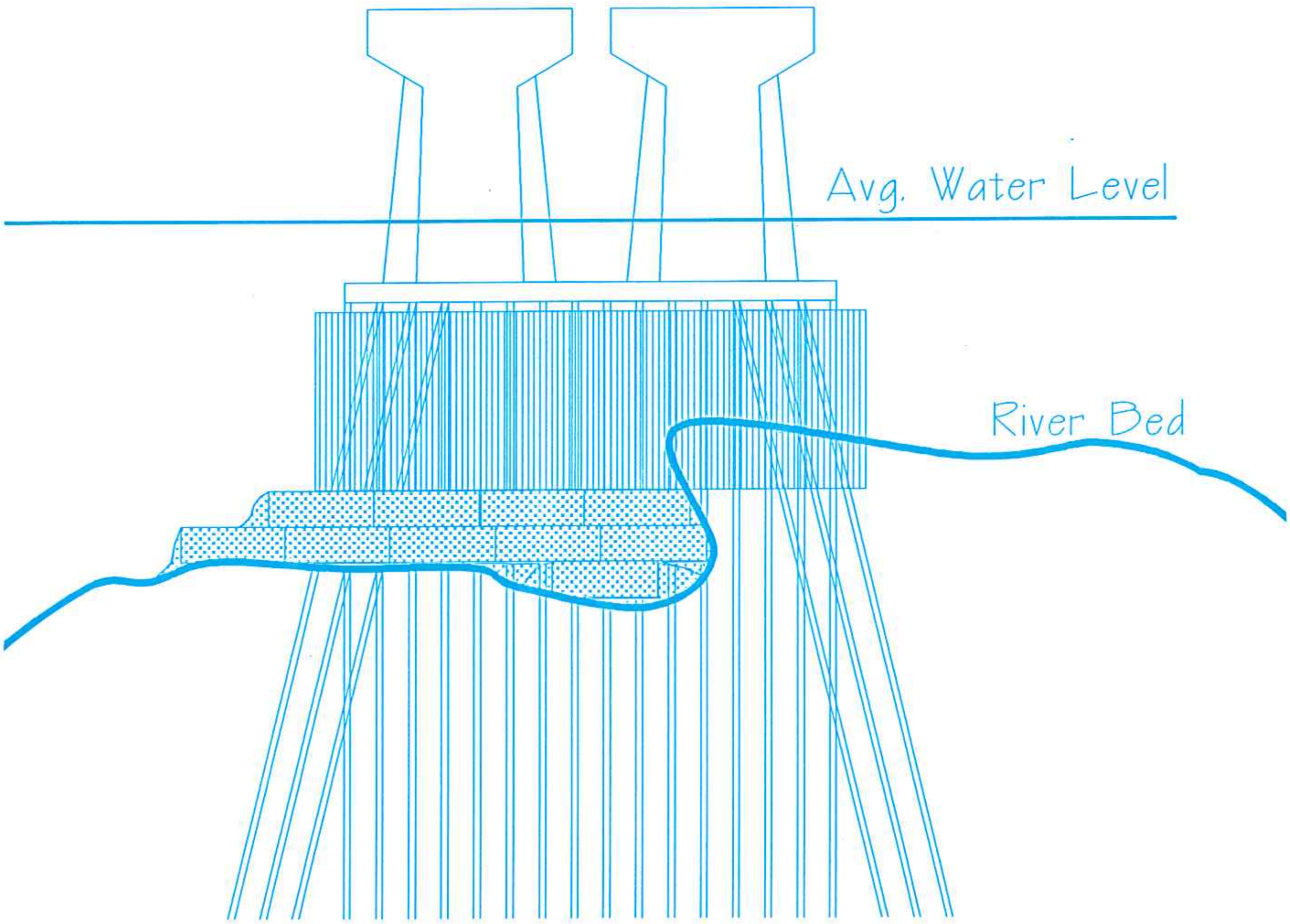

Stage VI

2 Erosion Control "Mats" (9-10). Soil Infilled.

-- Build Up to "Sheet Pile" Base.

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Title: Stabilizing Underwater Piles. Bridge Sub Structure.

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Document No	Tech Doc 2.1
Page	28
Prepared	DC 19.11.91
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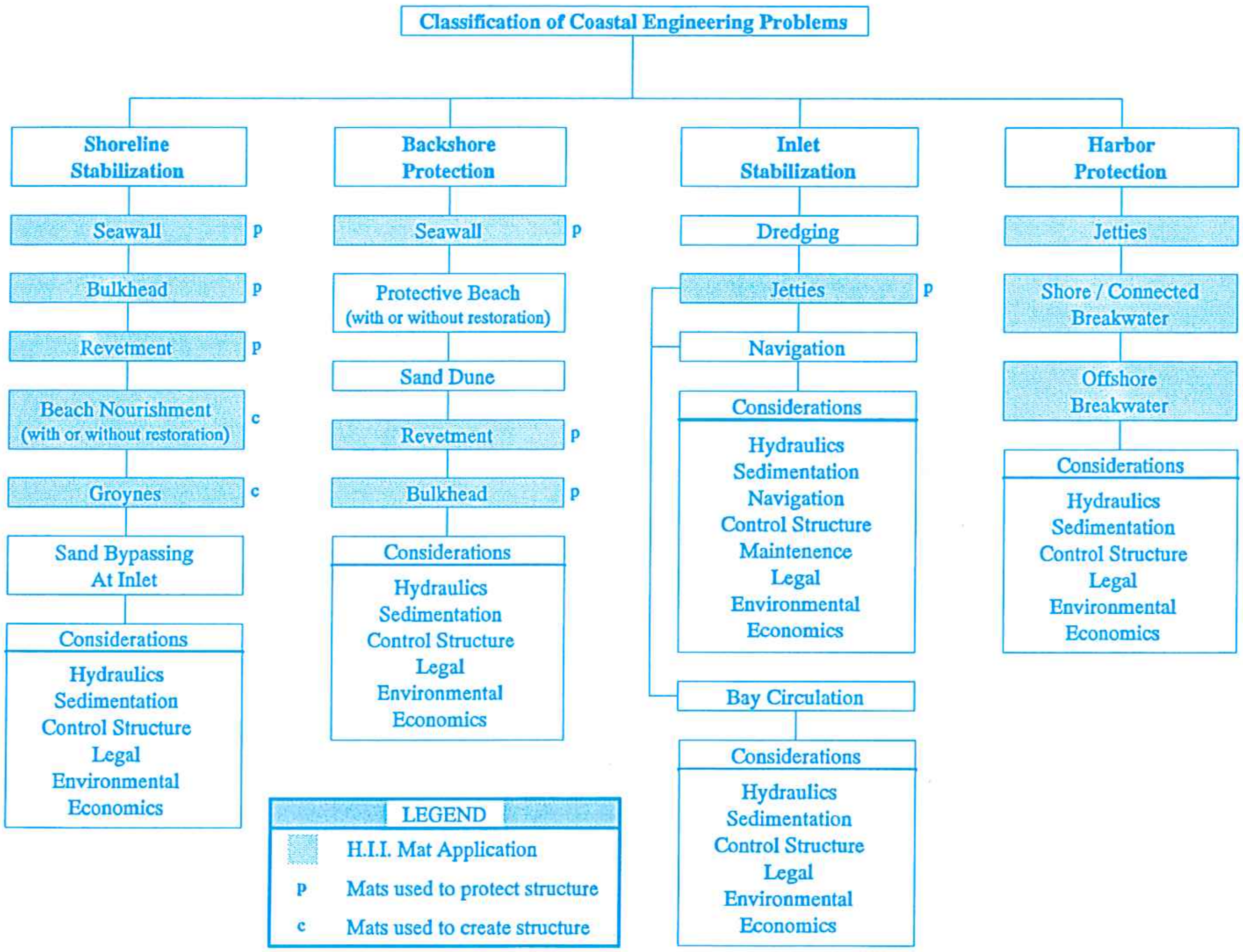
COASTAL PROTECTION



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Title: Coastal Engineering Chart

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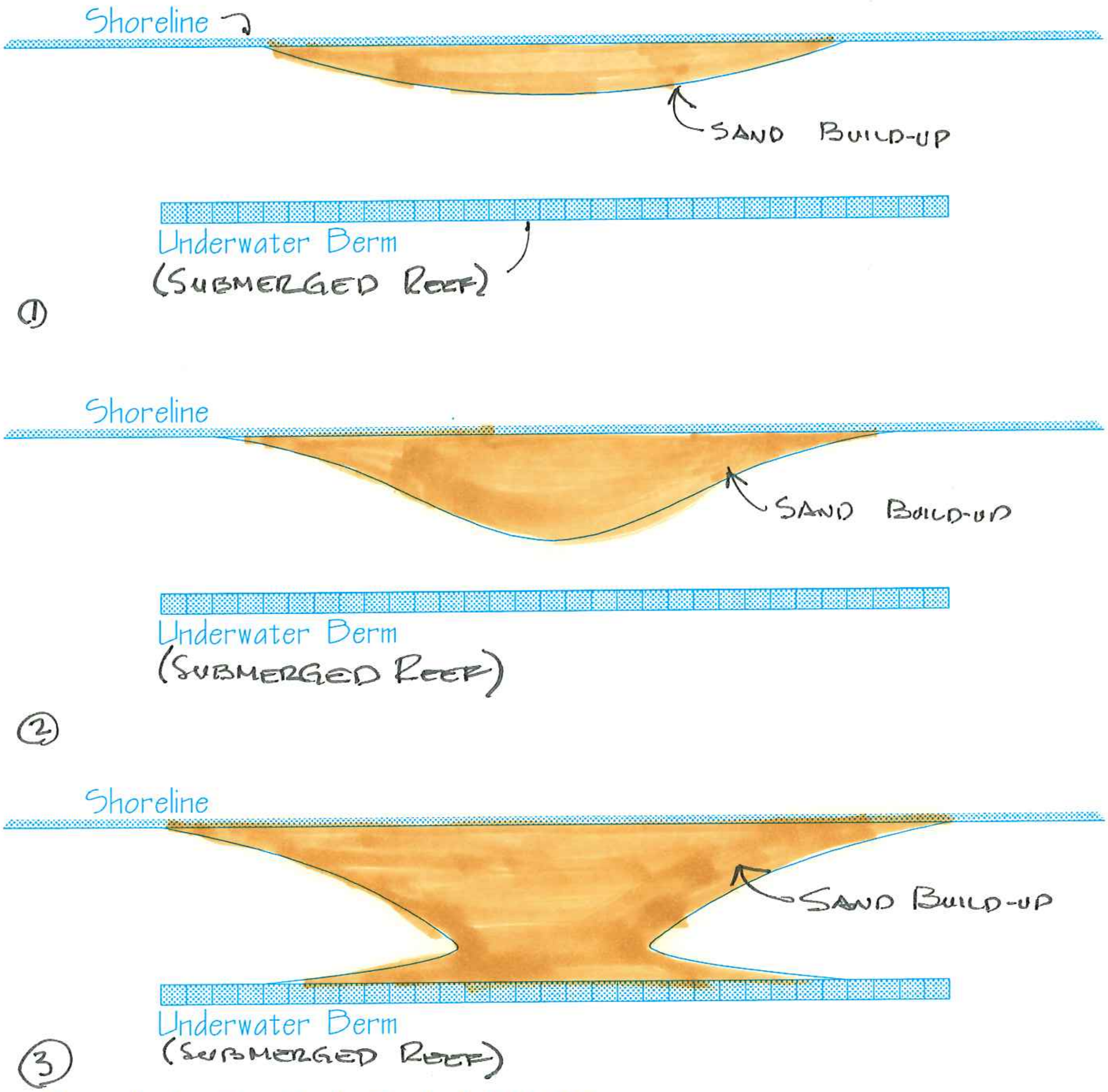
Document No	Tech Doc 2.1
Page	30
Prepared	DC 19.11.91
Approved	



Stages in the Growth of a Tombolo Sand Bar.
Plan View.

SEE PAGE 32 FOR SECTIONS

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Title: Erosion Control "Mats" Used to Create an Underwater Berm Inducing the "Tombolo" Effect.

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Document No	Tech Doc 2.1
Page	31
Prepared	DC 19.11.91
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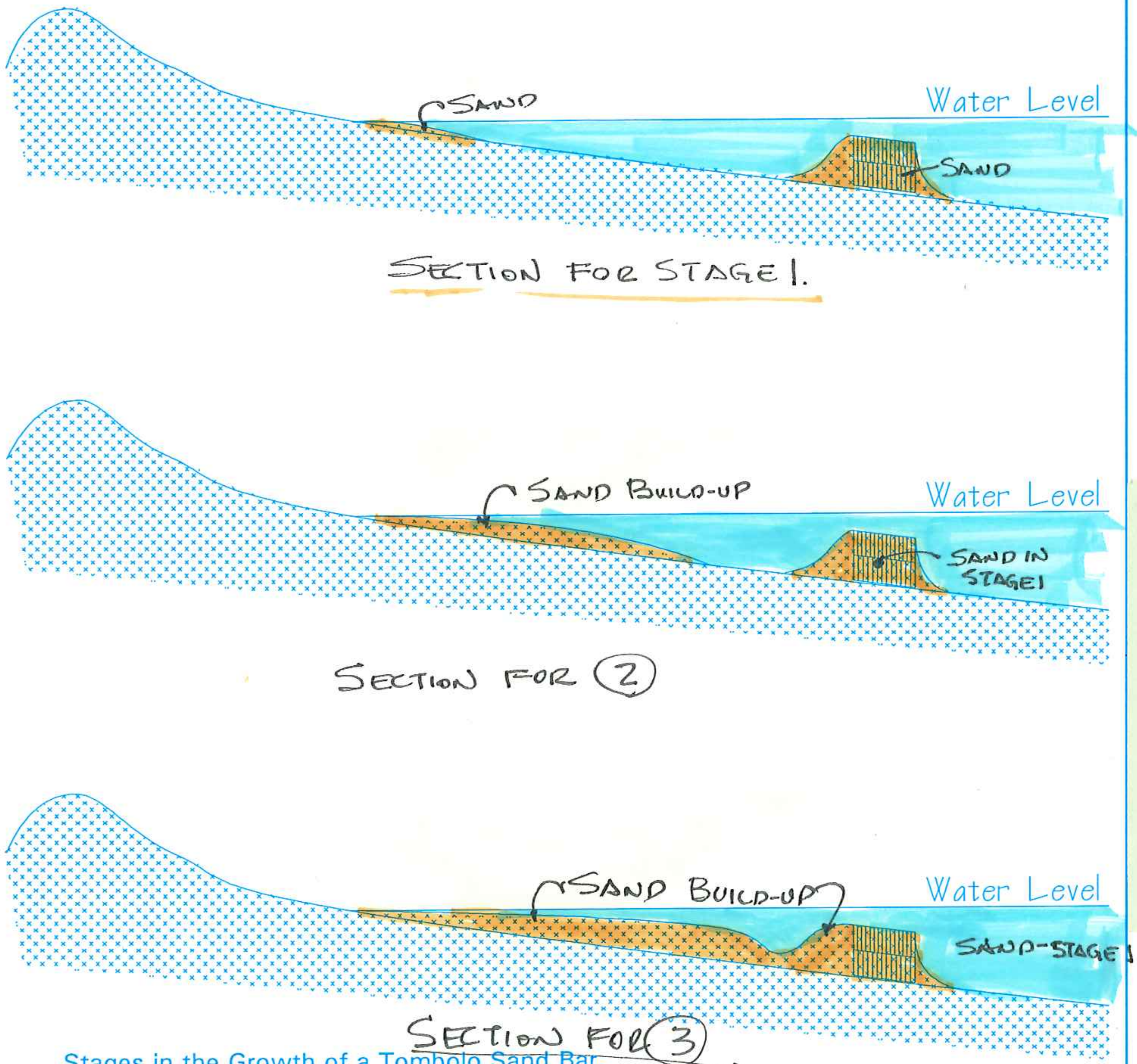

Stages in the Growth of a Tombolo Sand Bar.

Side View.

NOTE: SEE PAGE 31 FOR PLAN OF EACH STAGE

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Document No	Tech Doc 2.1
Page	32
Prepared	DC 19.11.91
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Page	33
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