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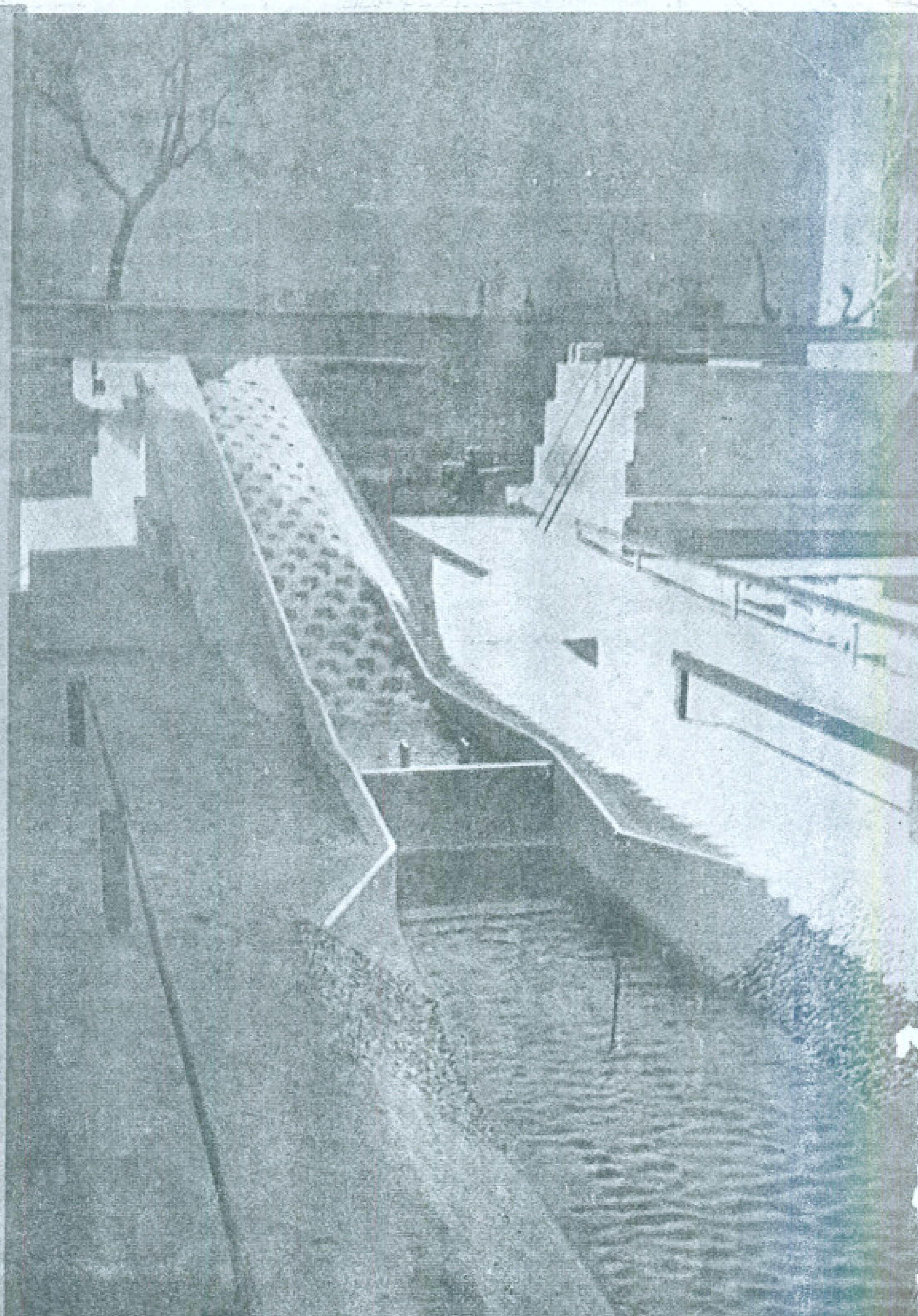

Engineering News

A QUARTERLY JOURNAL OF WEST PAKISTAN ENGINEERING CONGRESS

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SIXTEENTH YEAR OF PUBLICATION

ENGINEERING NEWS

Quarterly Journal of the West Pakistan Engineering Congress

Vol. XVI MARCH, 1971 No. 1

In this issue

TITLE COVER

Model of Mughan Canal (Iran) being studied at Hydraulics Research Station, Nandipur.

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ENGINEERS: BUILDERS OF THE SOCIETY

The developing countries are passing through a crisis of aspirations. The aspirations arising out of the vision for a better life—a life where the sunshine of prosperity had driven away the dark clouds of hunger and want. These nations swam through the sea of blood and fire, sustained only by the dream of attaining a prideful place in the comity of nations. The wars of freedom are not merely the struggles for political liberation but are directed towards economic emancipation to establish a social system free from exploitation, hunger and disease. The goal of political independence is noble enough to match the tribulations and turmoils, so boldly faced by all the struggling nations, but such an independence is imperfect and fleeting if not committed to creating a prosperous and affluent society. This was to be done by harnessing and channelizing the labour potential of vast human resources towards larger production. The technological advancements of the age were to be blended with the ever-increasing manpower of the regions and employed towards the service of nation through the professional capabilities of a trained and dedicated group.

The compulsions of history in a developing society like ours leave no choice but that of making a call on the Government machinery to become the pioneer of change. This has to be so as this was the readily available best organised institution nourished and developed for long by the colonial rulers, although primarily to serve their own purpose. This institution needed a metamorphism to imbibe the characteristics of professionalism. The failure of our society to meet the aspirations of people is in direct proportion to the extent we failed in converting this institution to professionalism. This highlights the necessity for a basic change. This change has unfortunately not come.

By profession we understand a vocation that is learnt through prescribed systematic educational discipline spread over a number of years and the art of practising the specified knowledge so gained in furtherance of rendering a particular service to the developmental cause of the society. A professional by its very definition has to be one, that takes upon itself to meet certain defined needs of the society. For example, an agricultural society geographically located in arid or semi-arid zone has the material necessity, that a group of people learn the science of flow of water and practise this learning to tame and train the flowing rivers to divert them on to the agricultural lands. The fields of production are many and varied. It is the professional who brings about the interaction of technological learning on one hand and the vast sea of human resources on the other. This interaction can produce the optimum results only if a scheme of things is devised to let the professionalism be the motivating force in the production process. Such a scheme of things is not born unless there is a change in outlook. Professionalism is really a way of life and the societies so oriented adopt it as a politico-economic ethos. Let this society search its mind, if it is mentally oriented to adopt this way of life. Let every individual identify himself with the forces of production and determine as to what specified capability has he imbibed to meet a recognized need of society.

The Engineers constitute the premier group of professionals in any society. A great responsibility rests on them to prove by their conduct that the economic emancipation of the society lies in orienting itself towards technology and professionalism. However, it is unfortunate that the image of an engineer in the country is nothing different from a bureaucrat of a typical colonial system. A bureaucrat in our society symbolizes the characteristics of being unresponsive to the people's aspirations and to be unaccountable to them for his deeds or misdeeds. Some of the personal traits attributable to the bureaucrat is to be swollen-headed, stiff-necked, self-conceited, intransigent and impolite. This is an image well earned by the bureaucrat and assiduously implanted by the erstwhile colonial rulers to continue with such an image in anachronism. The engineering group of services never belonged to that "elite" class which was designed to become the local representative of foreign authority. The engineers are to serve and they must rightly claim an opportunity to serve the nation. While it is for the society to create an atmosphere it is also for the engineers to conduct themselves in a way as to become the manifestations of professional service.

The Engineers while demanding the re-organization of services or a better status are in fact inspired by the noble objectives of patriotism and are not merely agitating in the pattern of "Trade Unionism" for more and better plums in the cake. This is not a struggle for pay and privileges but is an effort to equip ourselves for playing our role in the service of nation. The Government deserves congratulation in accepting at least one of the engineers' demands relating to grant of class-I to all engineers. This is symbolic of the realization that those who "serve" should not be inferior to those who "rule". Let there be equality of opportunity and equality of recognition for the efforts in the cause of service to nation. The engineers should not forget that the demands they are pressing for are not the end in themselves, they are only the beginnings to create an atmosphere where every one is expected to excel every other in the cause of service and not in authority to rule.

Irrigation
and
Power

Energy Dissipation on 24 Meter and 6 Meter Falls on Mughan Canal Offtaking from Mill Mughan Headworks (Iran)

By S. M. Ayoob[1] & Ch. Mohammad Ali[2]

INTRODUCTION

Mughan Canal with a discharge of 95 cumecs will be offtaking from right flank of Mill Mughan Dam located between Kyz Gallaxy and Karndoly on Aras River (international river between Russia, Turkey and Iran) and will irrigate lands of Iran.

The Aras river has a combined alimentation, it is fed by snow melting, rains, ground water and partially by springs.

The snow melting flood passes in April, the rainfall flood peak occurs in May. There are no floods usually during Summer, Autumn and Winter. The minimum flow was recorded in July and August. The stream flow regimer is distorted by a considerable abstraction of water for irrigation and by releases of secular water reserves from the Seven Lake into the Aras river.

Frequency	*Discharge in cumecs*
0.01	3,540
0.1	2,460
1	1,830
3	1,550
5	1,430
10	1,250

Aras river discharges of various frequencies at the Mill Mughan Dam site are as given in the Table over here.

The maximum sediment concentration in Aras river at Karndoly is taken as 12400 ppm., which represents the maximum average for 10 days period from 1963 to 1966. The Russian report also gives a figure of 47000 ppm., which occurred on 26-7-39 when the river was in low flow.

The Aras river carries mainly fine sediment of 0.01—0.025 m.m. diameter. The average weighted size of suspended load at Kyz Gallaxy site (at 45 k.m. distance upstream of the Mill Mughan Dam) is 0.09 mm., at Karndoly site (83 k.m. downstream of the Dam)—0.08 m.m. Gravel and course pebbles prevail in the bed load. The average weighted size of the sedimented bed load at the Mill Mughan Dam site proved to be 58.5 m.m.

Mill canal and Mughan canal will be taking off respectively from the left bank and right

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2. *Principal Research Officer (Hydraulics), I.R.I., Lahore.*

bank of Mill Mughan Diversion Dam on Aras river.

The Mill Canal will irrigate the Russian territory whereas the area of the Mughan canal is located along the Aras river right bank in Iran territory. The west border of the area is the diversion dam site at Goradiz, the southern border—the footing of a low mountain ridge which is running from west to east, the southern border is the Aras river valley and the eastern border is the Mughan plain land.

The length of the main Mughan canal is 34.5 km. There are number of falls on the Mughan canal. The maximum drop of the tail fall is 24 meters. The other falls are 6 meter and 3 meter drop structures.

Messrs Associated Consulting Engineers, Karachi, Design Consultants to the Ministry of Water and Power, Government of Iran, for Mughan Irrigation Project, requested Irrigation Research Institute, Lahore to model-test these structures and to check the hydraulic performance of these structures to ensure proper energy dissipation and uniform flow distribution immediately downstream of the fall structures.

The problem of shingle exclusion from Mughan Canal, at its intake by shingle excluder and that of silt exclusion that finds its way into canal by means of silt ejectors, was also referred to Irrigation Research Institute. As a result of detailed model testing it was recommended to construct 3 vortex silt ejectors in the head reach of the Mughan canal. The design of the silt ejector recommended by the Irrigation Research Institute is given in Fig. 1.

The overall combined silt efficiency for the three vortex tube silt ejectors is about 80 per cent.

The 24 meter and 6 meter falls were tested in detail in the Irrigation Research Institute. The hydraulic performance of the original design and finally recommended design for 24 meter and 6 meter canal falls is discussed here briefly.

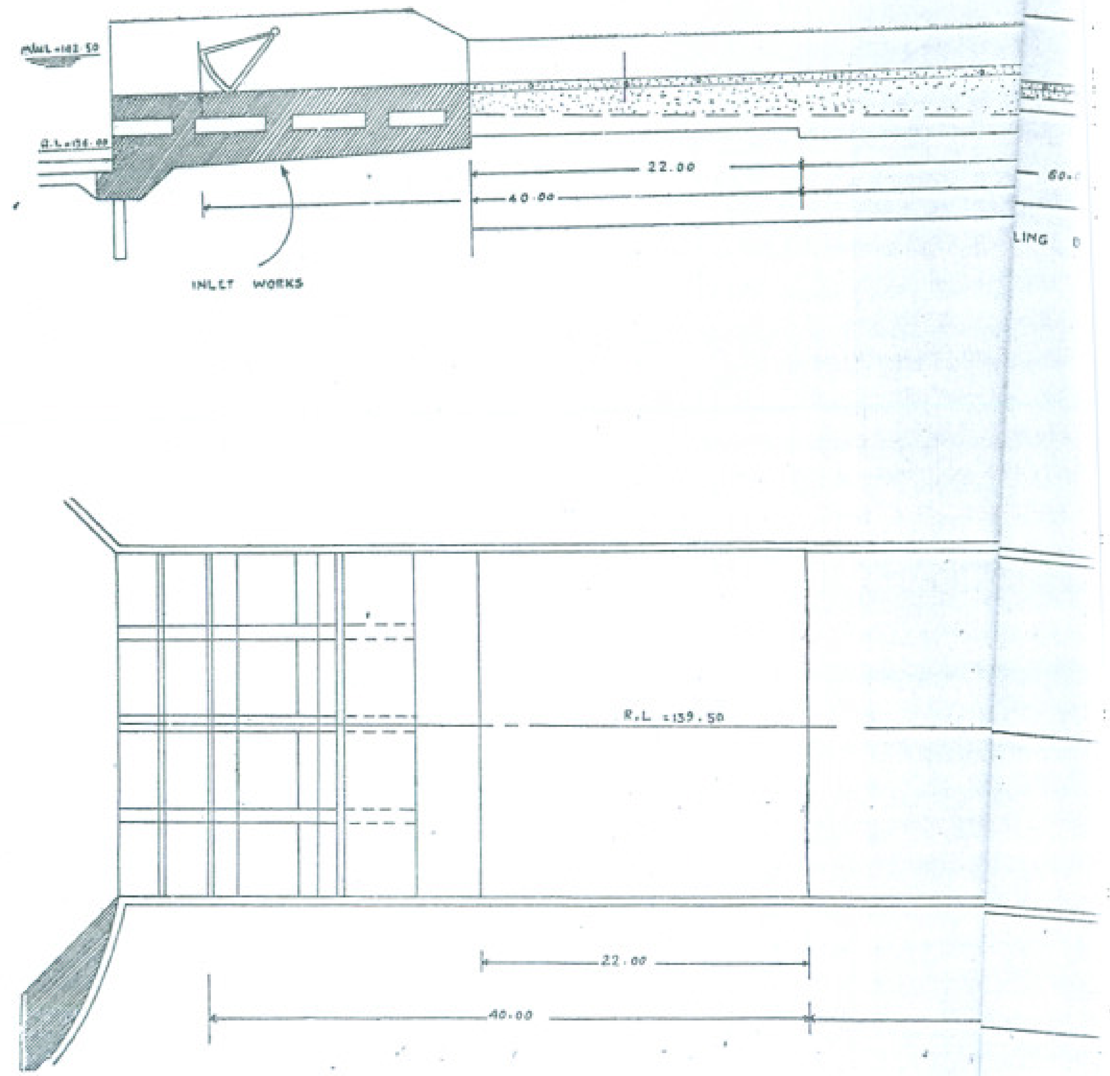
24 Meter fall

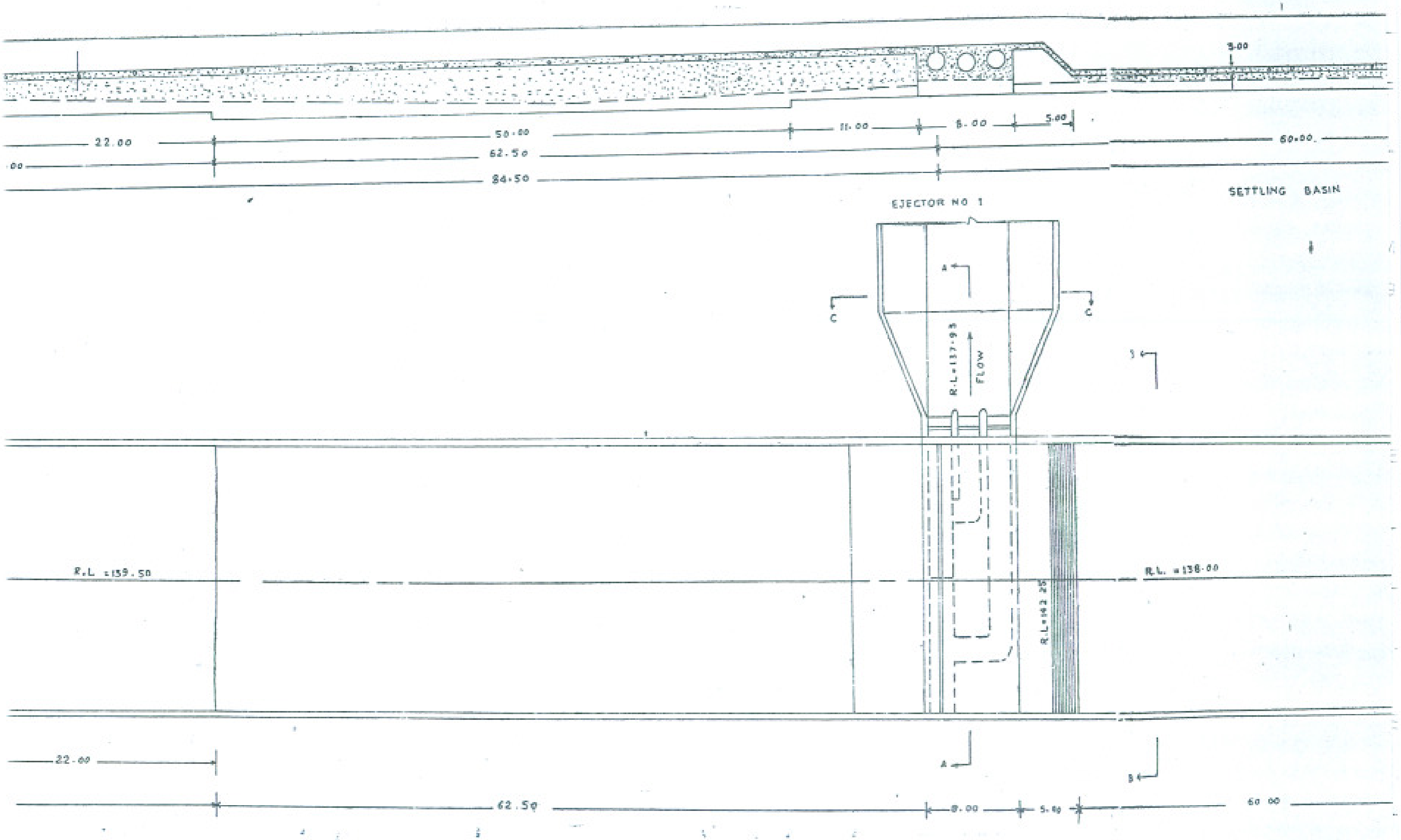
The originally proposed design for this fall is shown in Fig. 2. The design of the structure is tailored to specifications laid by Bureau of Reclamation for Stilling Basin No. IX where discharge per foot run in the chute design does not exceed 60 cusecs.

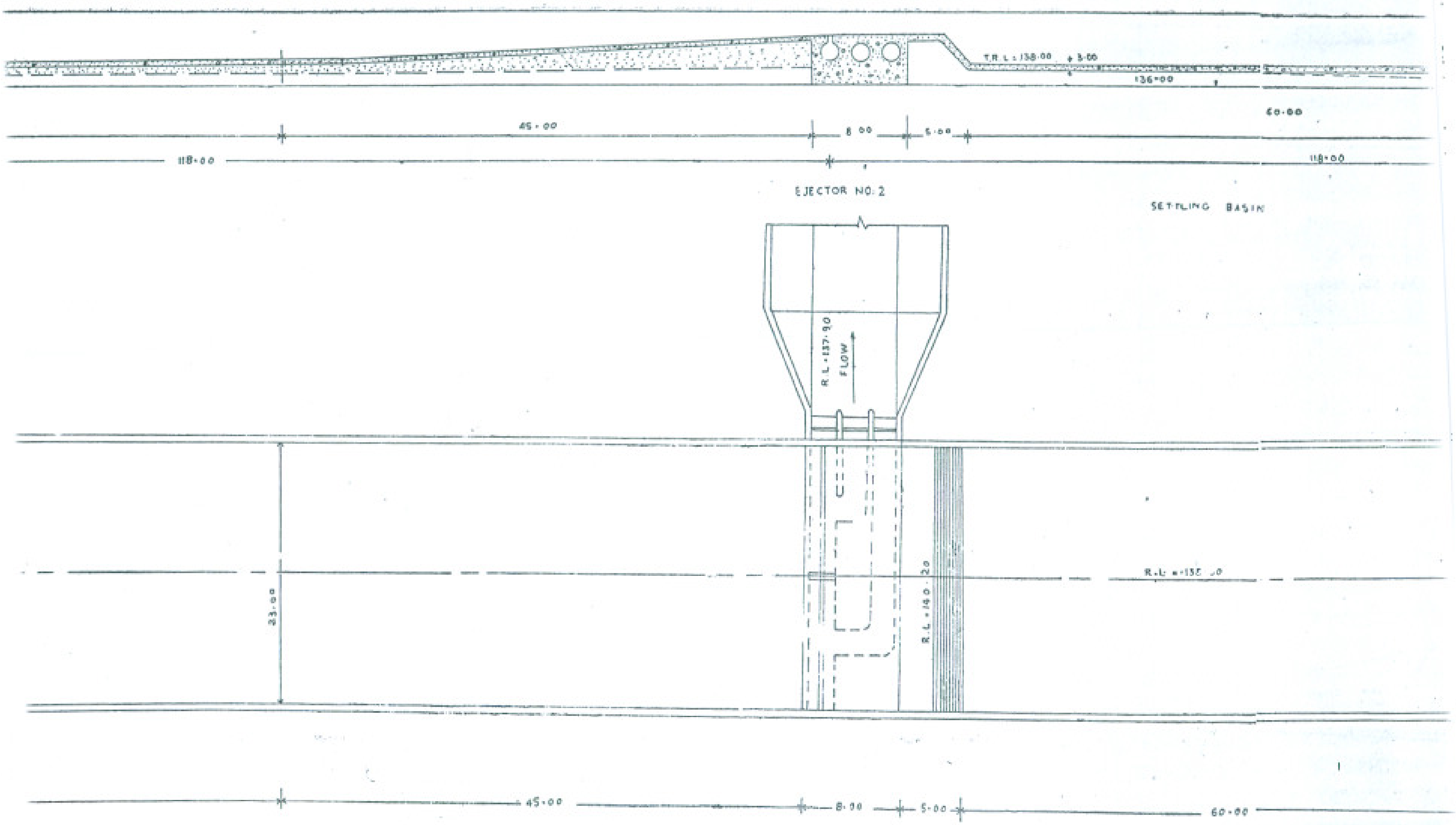
As far as the soil strata for the site is concerned it is stated in design report Vol. 2 "Sta : 22.8-Sta. 34.7. Relatively plain sections alternated by rather steep declivities. The declivities are composed of original clays and sandstone overlain by a layer of talus rock debris and pebbles of various thickness. Relatively flat sections separating the declivities are filled with accumulation of proluvium loamy pebble and pebble of considerable thickness. The proluvium pebble requires antiseepage measures. The sections in original clays are subject to quick weathering, and within the zone of wetting and drying they are to be protected against wave action."

MODEL

A model of the proposed canal fall was constructed to a natural scale of 1/12.5 according to the drawing supplied by the Associated Consulting Engineers. The model included about 76 meters of canal length on the upstream side and about 152 meters downstream of the fall. Mughan canal below the fall was moulded in sieved sand of about 0.18 mm. (mean dia). To maintain the tail level, a tail gate was provided at the

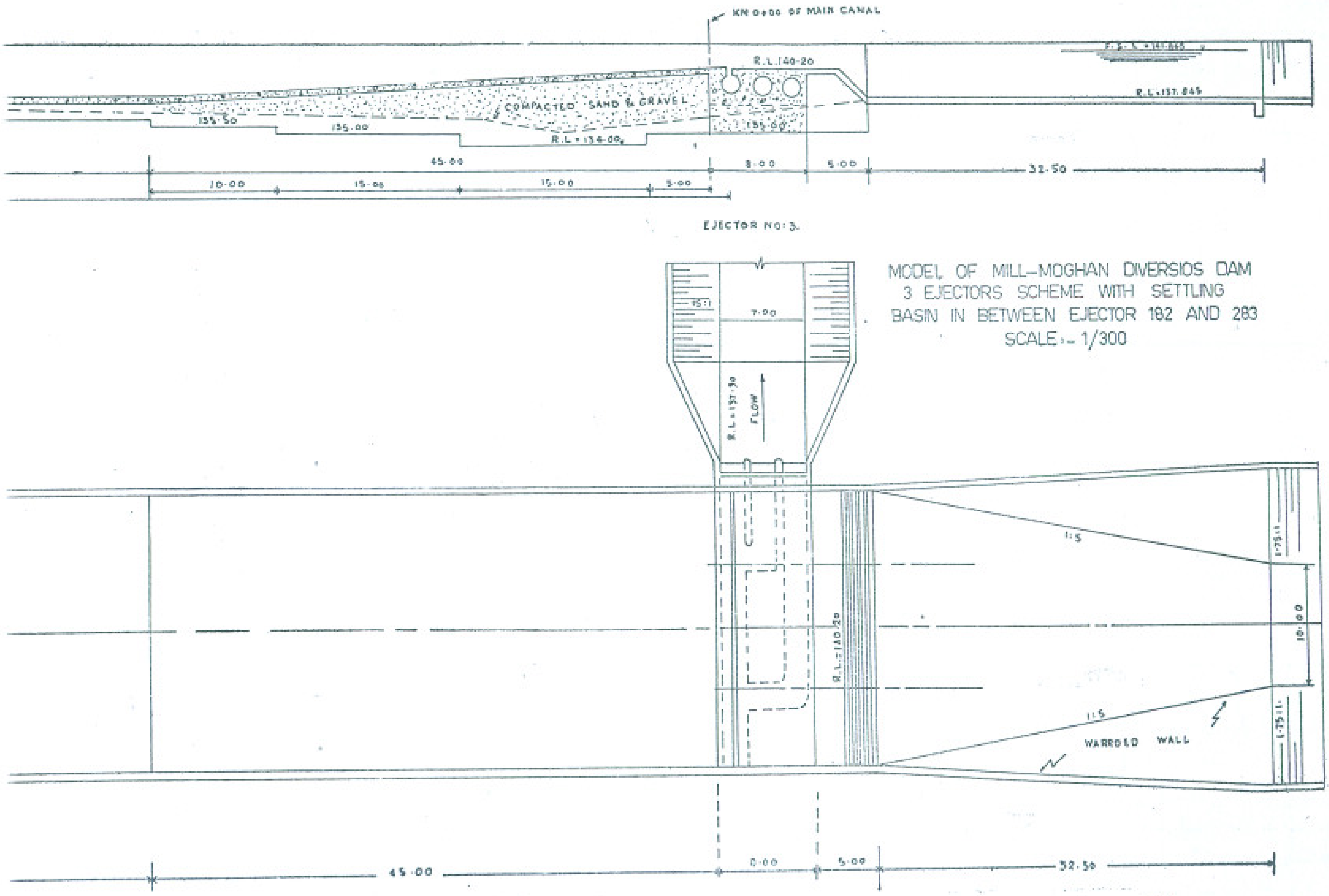

M.W.L = 182.50
G.L = 136.00
22.00
40.00
INLET WORKS
R.L = 139.50
22.00
40.00


5.00
22.00
50.00
11.00
8.00
5.00
60.00
62.50
84.50
SETTLING BASIN
EJECTOR NO 1
R.L.=137.95
FLOW
R.L.=139.50
R.L.=142.25
R.L.=138.00
22.00
62.50
8.00
5.00
60.00



T.R.L.=138.00 +3.00
136.00
60.00
45.00
8.00
5.00
118.00
118.00
EJECTOR NO.2
SETTLING BASIN
R.L.=137.90
FLOW
R.L.=140.20
R.L.=135.00
33.00
45.00
8.00
5.00
60.00

Fig. 1



MODEL OF MILL–MOGHAN DIVERSIOS DAM
3 EJECTORS SCHEME WITH SETTLING
BASIN IN BETWEEN EJECTOR 1&2 AND 2&3
SCALE:– 1/300

6(*a*)

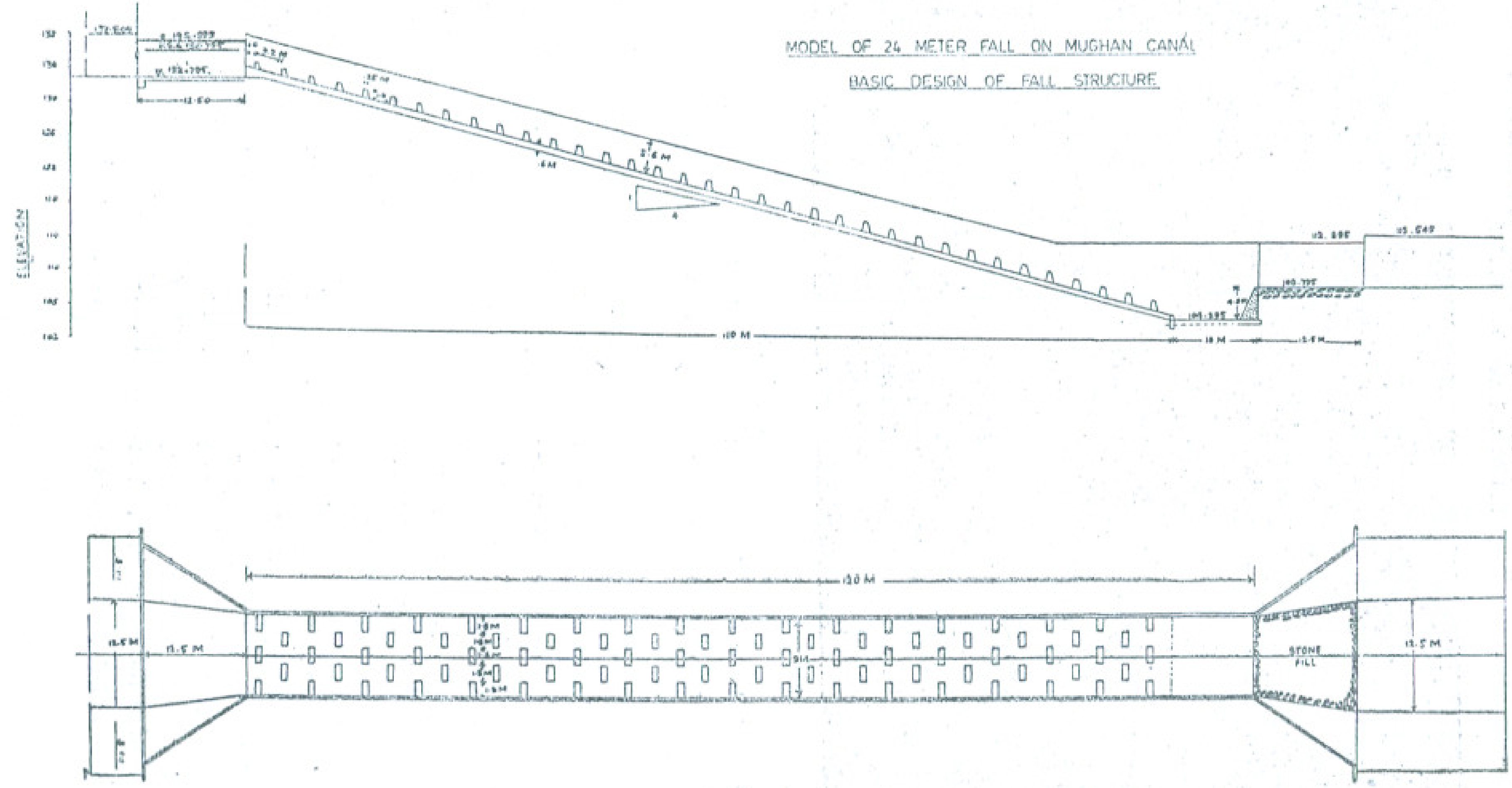

MODEL OF 24 METER FALL ON MUGHAN CANAL
BASIC DESIGN OF FALL STRUCTURE
ELEVATION
STONE FILL
130 M
18 M
13.5 M

Fig. 2

Flow conditions in the chute at designed discharge of 50 cumecs.
Tail Water Level = 112.295

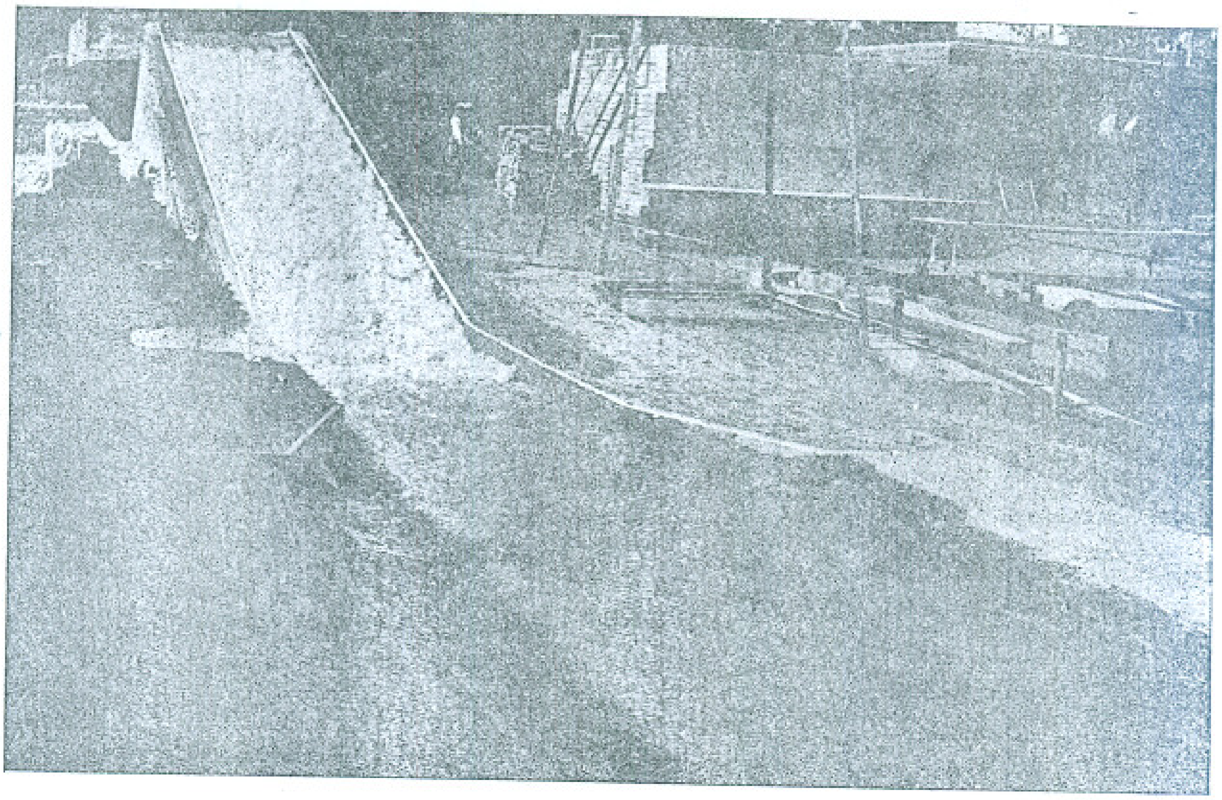


Fig. 3 (*a*)

downstream end of the model. The model discharge was measured by a 1.21 meter long sharp crested weir.

Original design

The chute of proposed 24 meter drop structure (Fig. 2) is 110 meters long, 9 meters wide, laid at a slope of 1 : 4 and is baffled with baffle piers of height equal to 1.2 meters, width 1.8 meters, transverse spacing of 1.8 meters and the rows of baffle piers are spaced 3.2 meters apart. The chute is followed by a cistern with floor level at 104.295 and length equal to 10 meters ending at a 4 meter high baffle wall with 1 on $\frac{1}{2}$ rising slope. The rows of baffle piers prevent excessive acceleration of flow and this provides a reasonable velocity that does not allow cavitation at the baffle piers. The canal bed width upstream and downstream of the fall is 12.5 meters.

With the proposed design, the model was run continuously for 6 hours (equivalent to a period of 20.7 hours on prototype) for the full supply canal discharge of 50 cumecs. The tail level was maintained at 112.295. The flow conditions in the chute are recorded photographically in Fig. 3(*a*). The flow conditions in the chute were quite satisfactory but the surface flow at the tail end of the structure was very rough and turbulent. Due to sharp expansion of side walls, the forward flow was concentrated along axis of channel and flanked by return eddies along the banks. Water surface profile, bed contours and the side erosion recorded after six hours' run are shown in Fig. 3(*b*, *c*) which indicates :—

(*i*) The maximum scour recorded is at

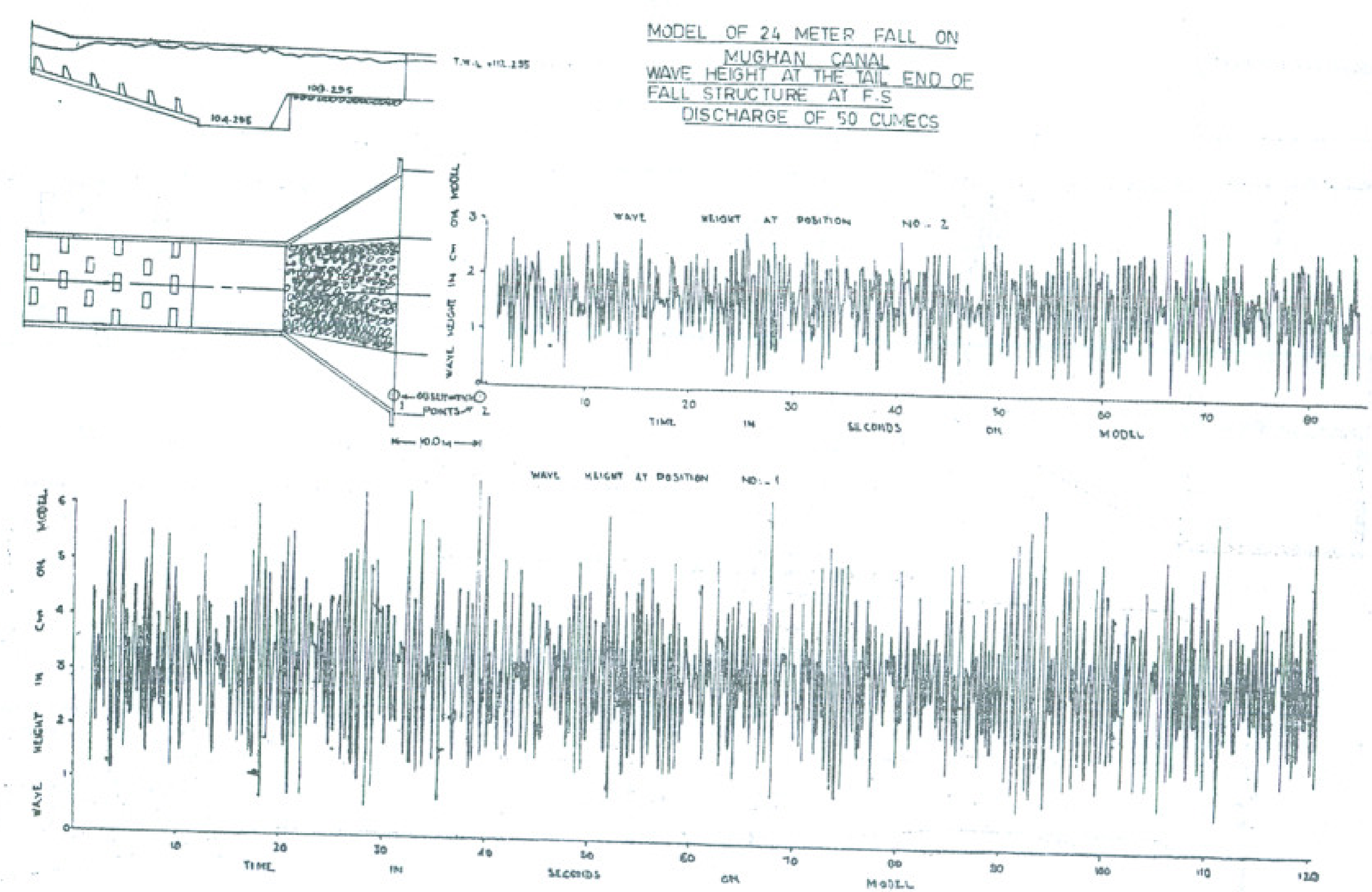
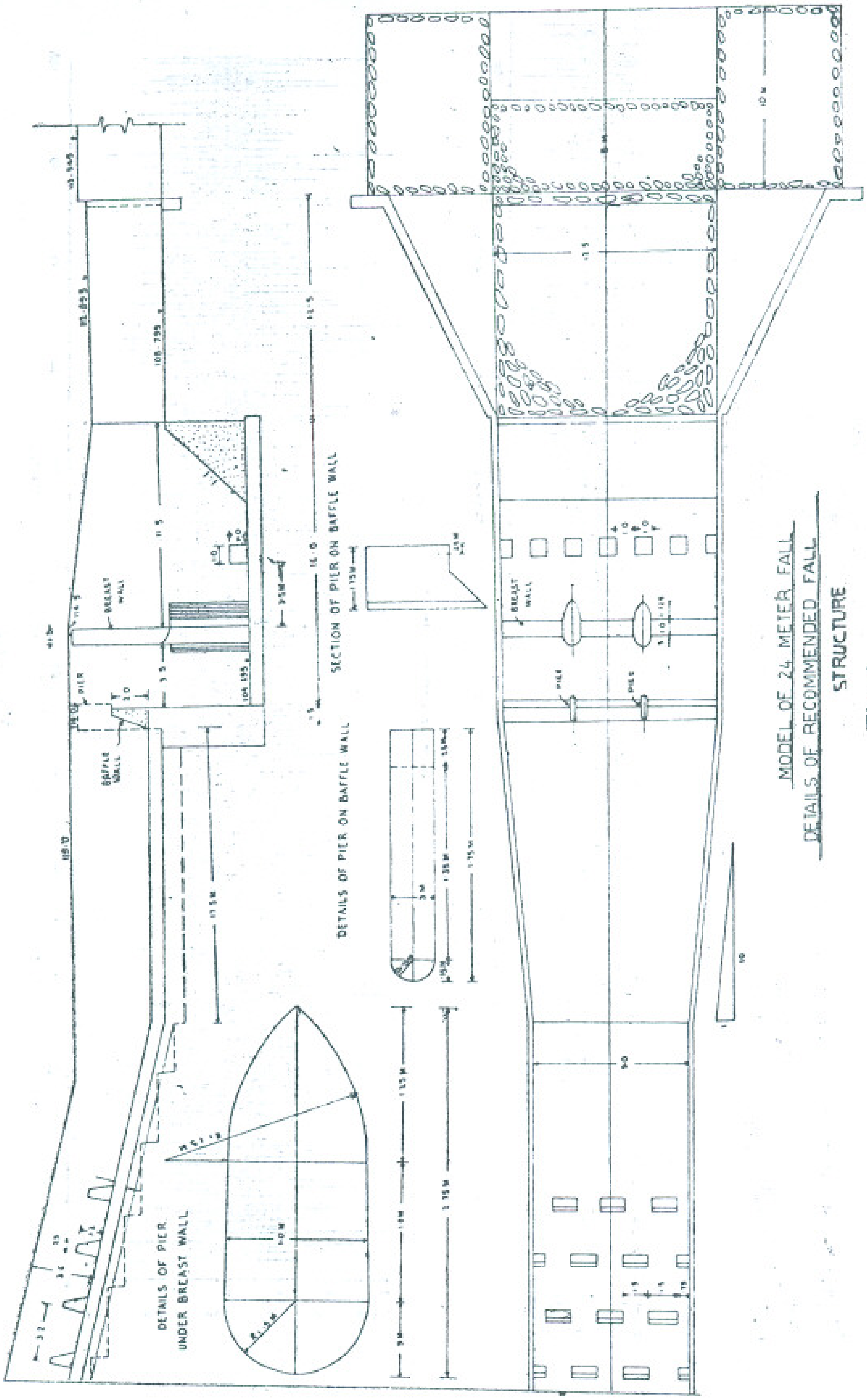

MODEL OF 24 METER FALL ON
MUGHAN CANAL
WAVE HEIGHT AT THE TAIL END OF
FALL STRUCTURE AT F.S
DISCHARGE OF 50 CUMECS
WAVE HEIGHT AT POSITION NO. 2
WAVE HEIGHT IN CM ON MODEL
TIME IN SECONDS ON MODEL
WAVE HEIGHT AT POSITION NO. 1

Fig. 3 (*d*)



MODEL OF 24 METER FALL

DETAILS OF RECOMMENDED FALL

STRUCTURE

Fig. 4

elevation 106.87 which is 1.425 meters below the apron level.

(*ii*) The waves were recorded at different sections with electronic wave recorder. The waves generated at the tail end of the fall had maximum instantaneous height of 0.706 meters and frequency of 99 to 126 CPM, as shown in Fig. 3(*d*).

(*iii*) The waves attacked the sides of canal resulting in flow section with sides of very flat slope excepting near the bed where the slope is a function of angle of repose of bank material. The order of side erosion recorded at intervals of 5 meters from the tail end of the structure shows an erosion of about 4 meters up to a length of 20 meters from the end of the structure.

Devices, such as wave suppressor, secondary drop over a baffle wall near the tail end of chute, and stone pitching of the canal sides downstream of the stilling basin were tested. The wave suppressor worked satisfactorily for full supply discharge but its effectiveness decreased significantly at low discharges. The baffle wall acting as a secondary drop was not effective for complete damping of the pressure fluctuations created by baffle piers in the chute. The stone pitching helps in absorption of the waves but the area of pitching required for full absorption of waves was excessive.

Recommended design for 24 meter fall

To dampen out the waves at the tail end of the fall, an additional stilling basin with floor level at elevation 110, ending in baffle wall of height 2.0 meter, was provided by removing rows of baffle piers at the end of chute and modifying the chute as shown in Fig. 4. The upper stilling basin sides wall have been given a flare of 1 : 10 such that the cross sectional width increased from 9 meters at the toe of chute to 12.5 meters at the upstream end of 2 meter high baffle wall located at the terminus of upper stilling basin.

The upper stilling basin was followed by a deep cistern at elevation 104.295 ending in an end cill with rising slope at 1(v): 1 (H) and top at elevation 108.795. The deep cistern was divided in two portions by a breast wall of 1 meter thickness supported by two cross piers.

The lower stilling basin has a uniform width of 12.5 meters and length of 16.0 meters ending in an end cill with upstream slope of 1 : 1.

Breast wall 1 meter in width with bottom at elevation 108.795 and top at elevation 114.5 has been located at a distance of 3.5 meters from the D/S vertical face of baffle wall at the end of first cistern.

A single row of cubical blocks (1 meter side) placed 1 meter apart has been provided on floor of downstream stilling basin 3.5 meters downstream of downstream face of the breast wall.

The small piers of 0.3 meter width projecting 0.25 meter beyond the downstream face of wall in between two cisterns have also been installed to break the jet and provide proper aeration beneath the nappe.

Only one row of baffle piers was removed at the tail end of chute into the upper stilling basin.

The flow pattern at a discharge of 31.5 and 50 cumecs recorded photographically as in Fig. 5(*a*), shows that rough and wavy surface D/s of structure due to high pressure fluctuations imparted to flow by

Bed contours after 6 hours model run.
Discharge = 50 cumecs.
Tail Water Level = 112.295

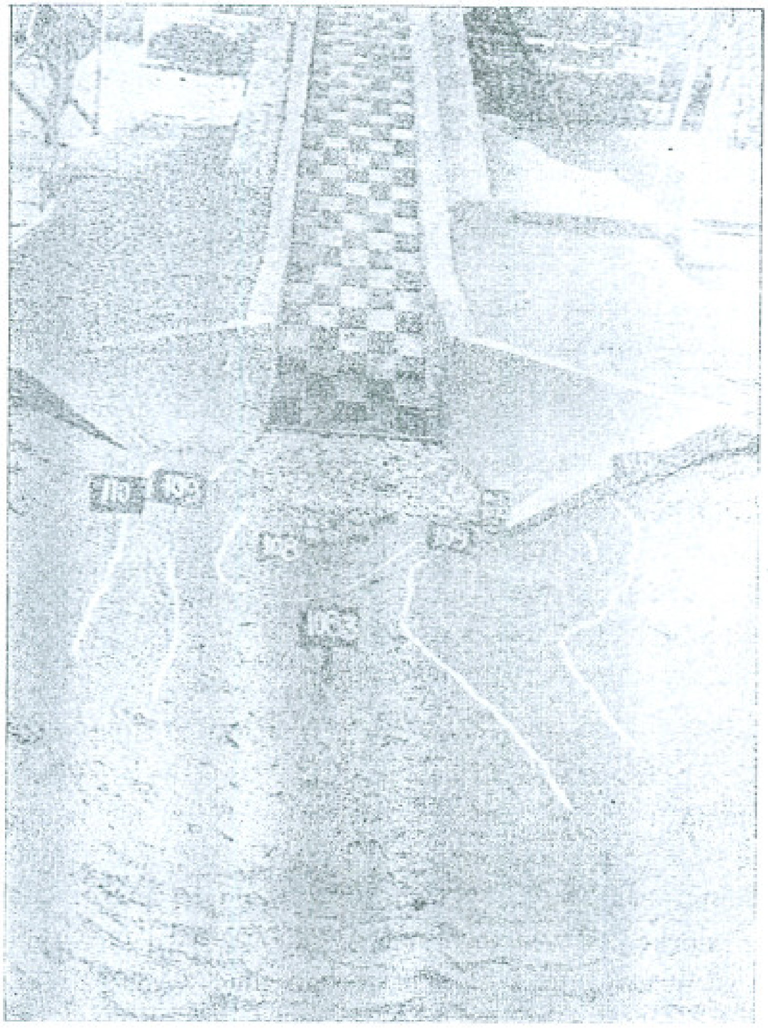


Fig. 3 (*c*)

baffle piers in the original design is tranquil. There is no boil or choppy flow D/S of breast wall. The fluctuations of pressures imparted to flow at end of chute are damped :

(*a*) in the standing wave of upper stilling basin,

(*b*) by impact on the U/S face of breast wall, and

(*c*) heavy churning in the lower stilling basin U/S of breast wall.

With the above-mentioned arrangements, it was observed Fig. 5(*c*) that wave height reduces from .706 meters in original case to .096 meter in this test. The consequential bank cutting and bed scour was completely eliminated.—Fig. 5(*b*).

The contribution of various appurtenances in two stilling basins in reduction of wave height is evident from wave charts from electronic wave recorder reproduced in Fig. 5($_{c1}-_{c5}$) and Table I which shows that :

(*a*) The wave height in the final design is .096 meter against .706 meter in the original design and thus wave height in

24 METER FALL ON MUGHAN CANAL WATER SURFACE PROFILE, BED CONTOURS AND SIDE EROSION AFTER MODEL RUN

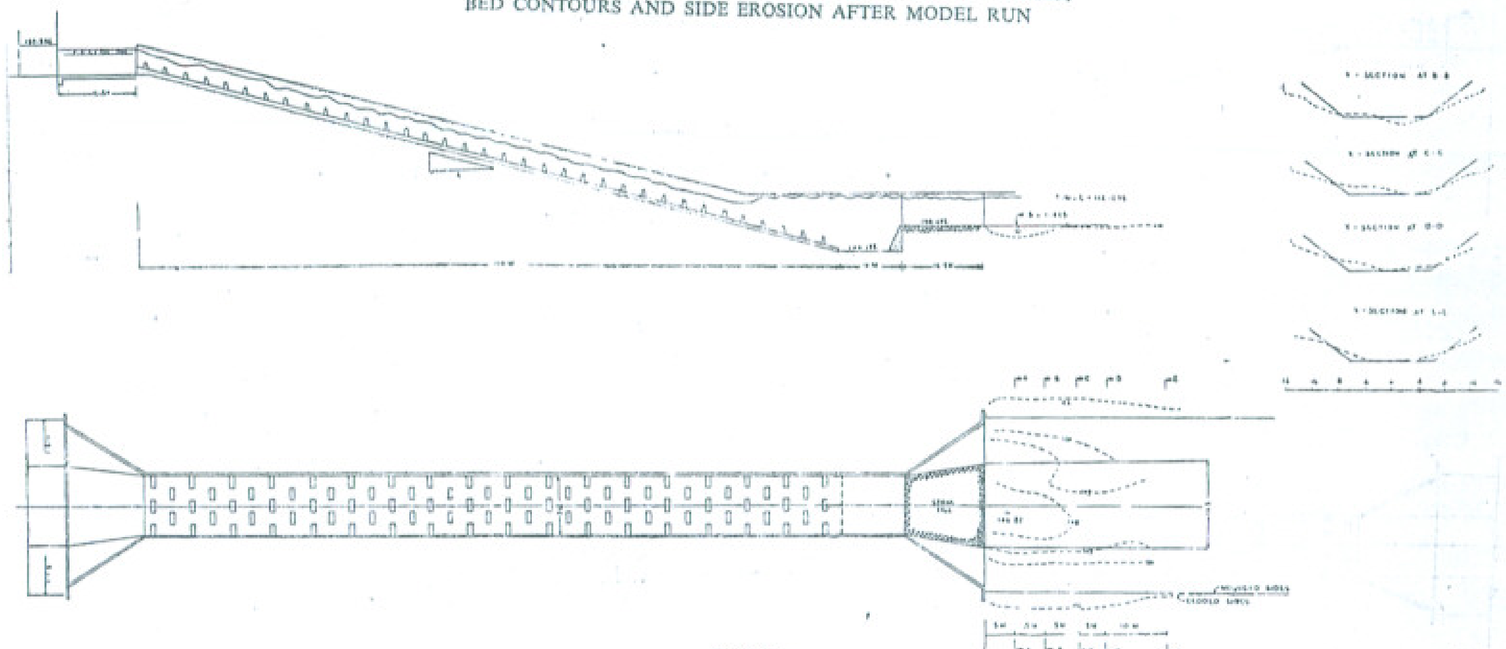
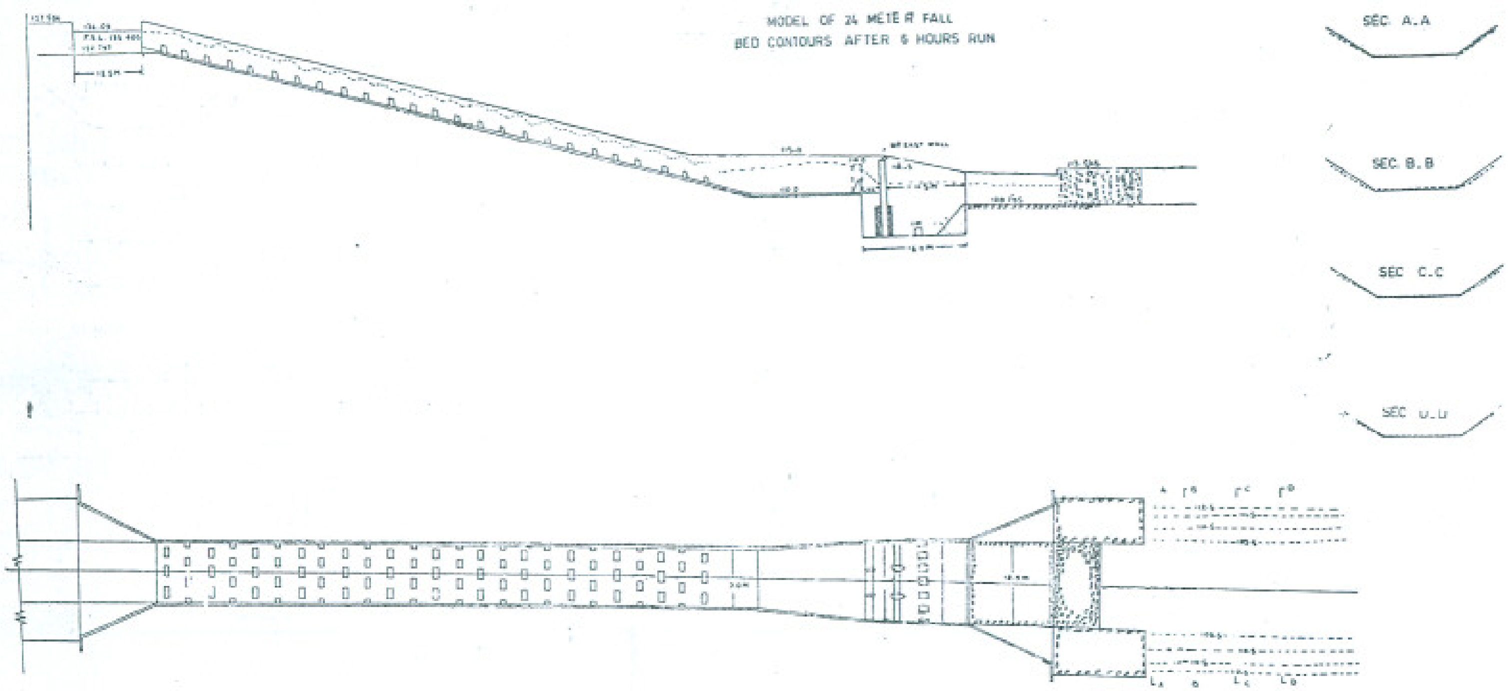


Fig. 3(*b*)



MODEL OF 24 METER FALL
BED CONTOURS AFTER 6 HOURS RUN
SEC. A.A
SEC. B.B
SEC. C.C
SEC. D.D

Fig. 5(b)

Test with 13 meter long bank pitching along with breast wall in cistern. Flow conditions at F. S. discharge of 31.5 cumecs.

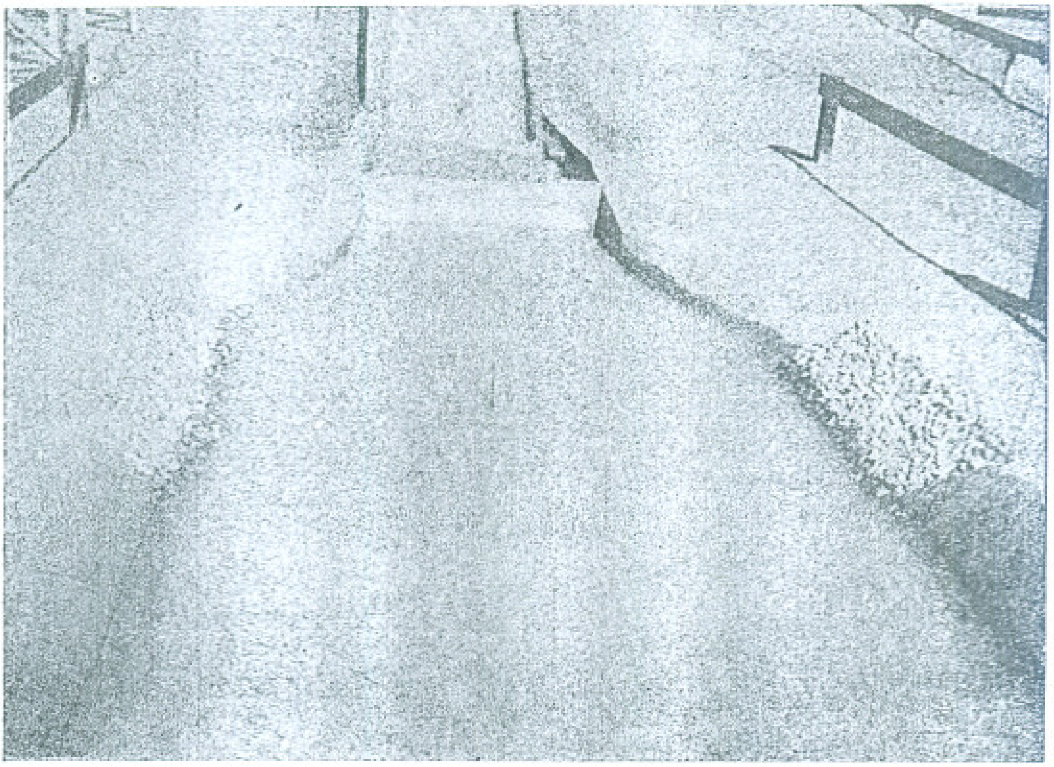


Fig. 5 (*a*)

Test with 15 meter long bank pitching and breast wall in cistern. Flow conditions with 50 cumecs discharge.

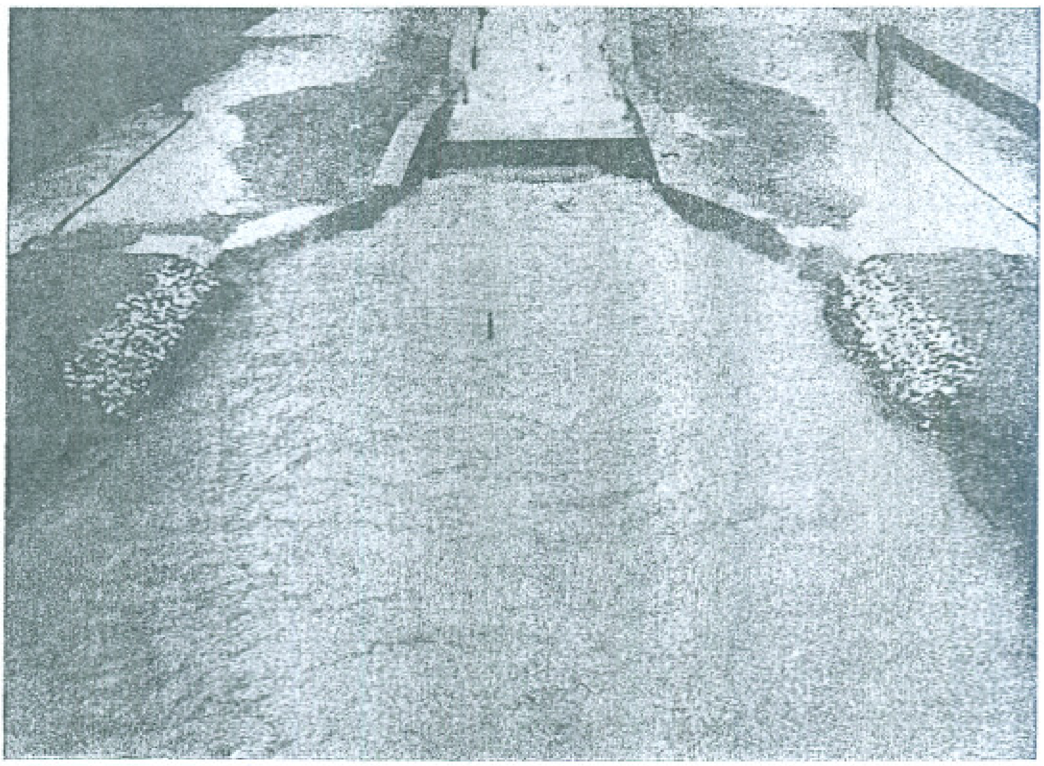


Fig. 5 (a_2)

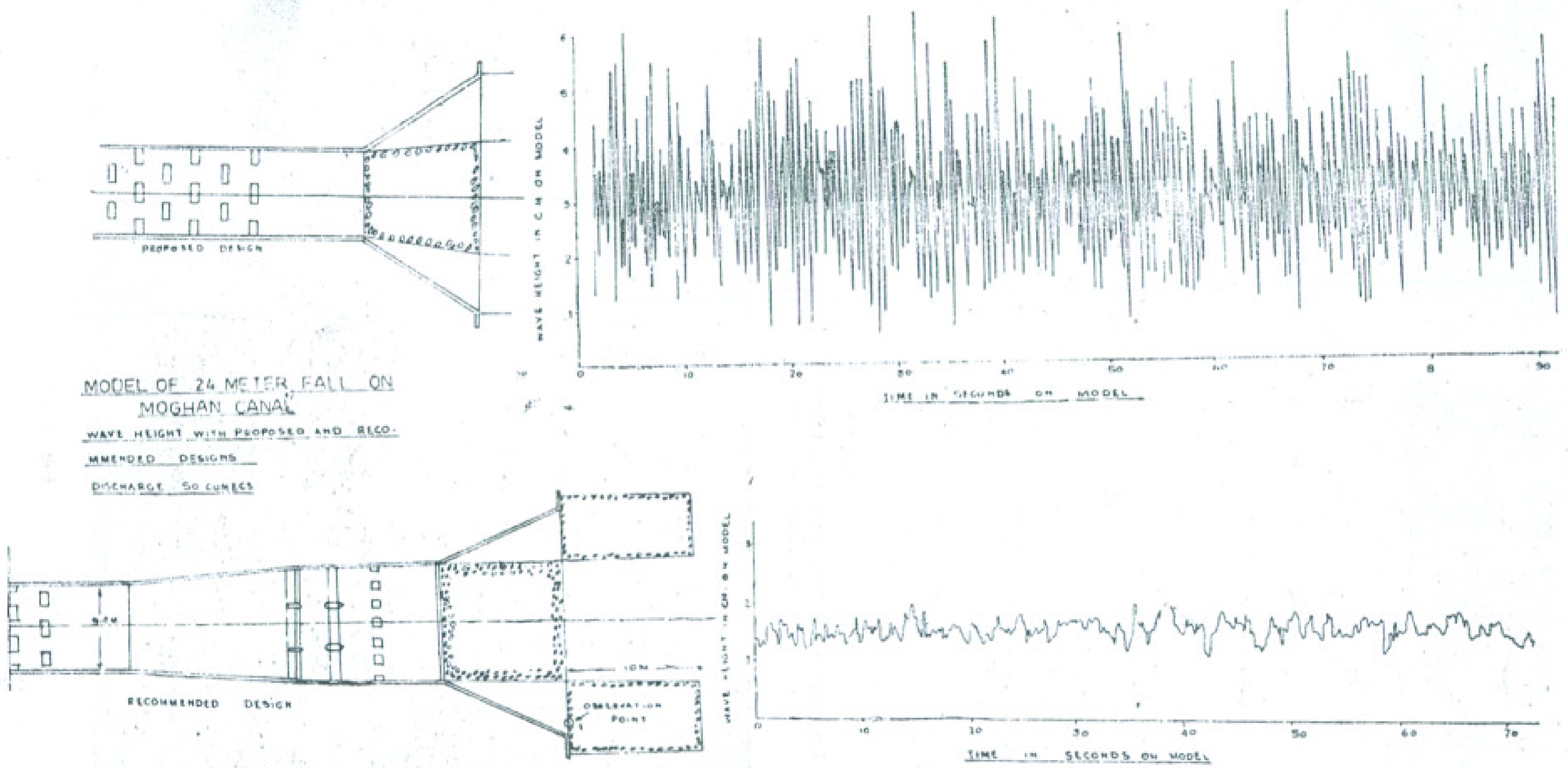

MODEL OF 24 METER FALL ON MOGHAN CANAL
WAVE HEIGHT WITH PROPOSED AND RECOMMENDED DESIGNS
DISCHARGE 50 CUMECS
PROPOSED DESIGN
RECOMMENDED DESIGN
OBSERVATION POINT
WAVE HEIGHT IN C.M. ON MODEL
TIME IN SECONDS ON MODEL

Fig. 5_{c1}

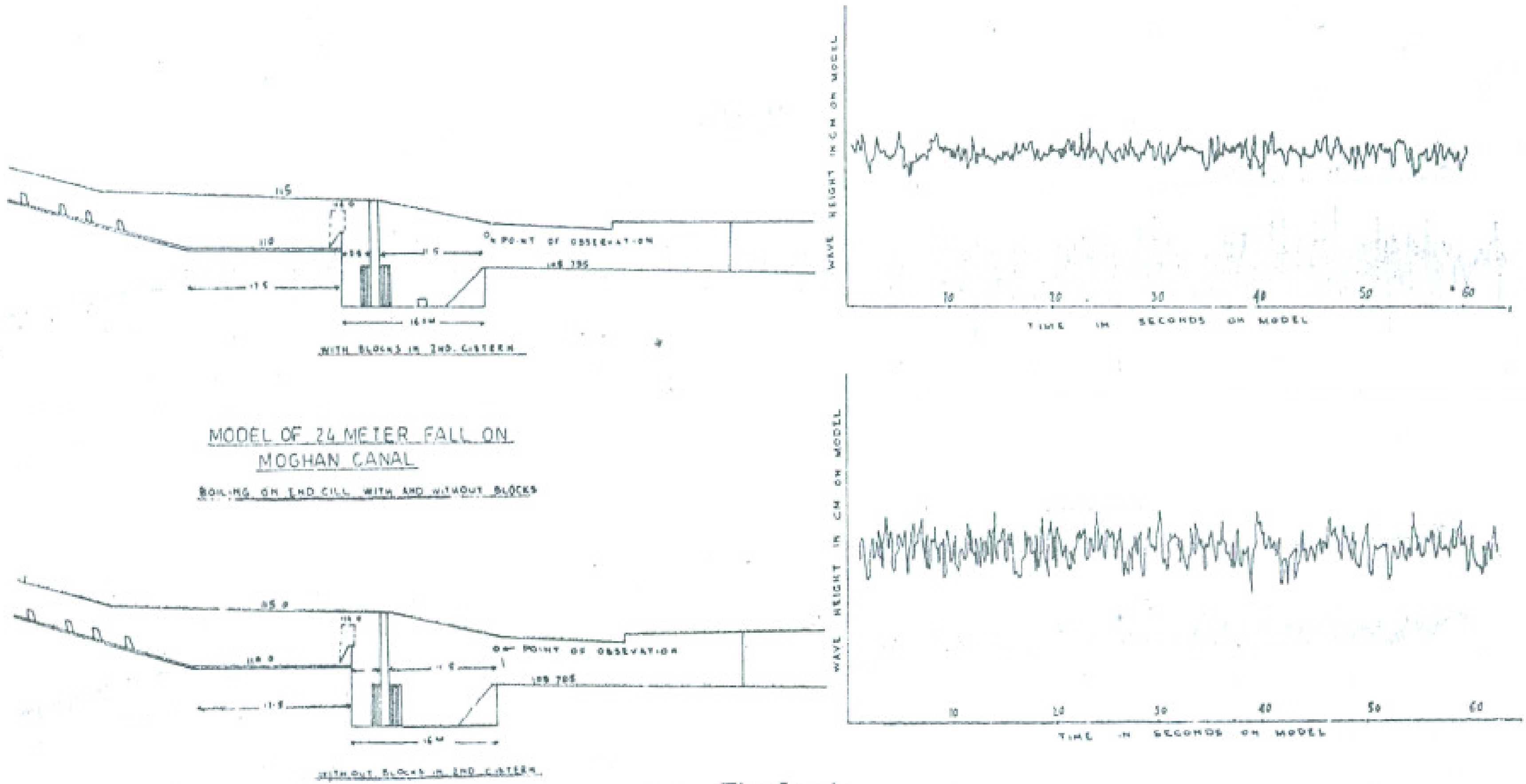

MODEL OF 24 METER FALL ON
MOGHAN CANAL
BOILING ON END CILL WITH AND WITHOUT BLOCKS
WITH BLOCKS IN 2ND. CISTERN
WITHOUT BLOCKS IN 2ND CISTERN
POINT OF OBSERVATION
WAVE HEIGHT IN CM ON MODEL
TIME IN SECONDS ON MODEL
10
20
30
40
50
60

Fig. 5_{c2}

MODEL OF 24 METER FALL
WAVE HEIGHT WITH AND
BAFFLE BREAST WALL
2ND CISTERN

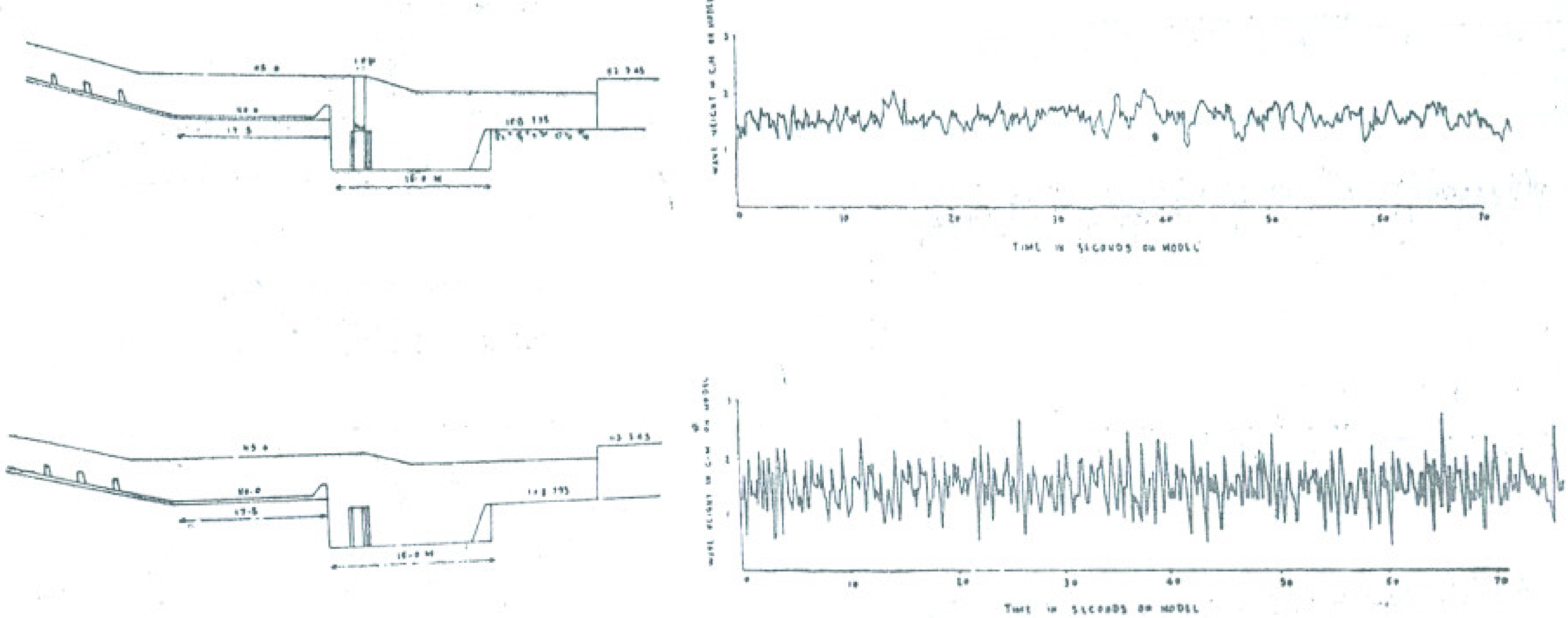


Fig. 5_{c3}

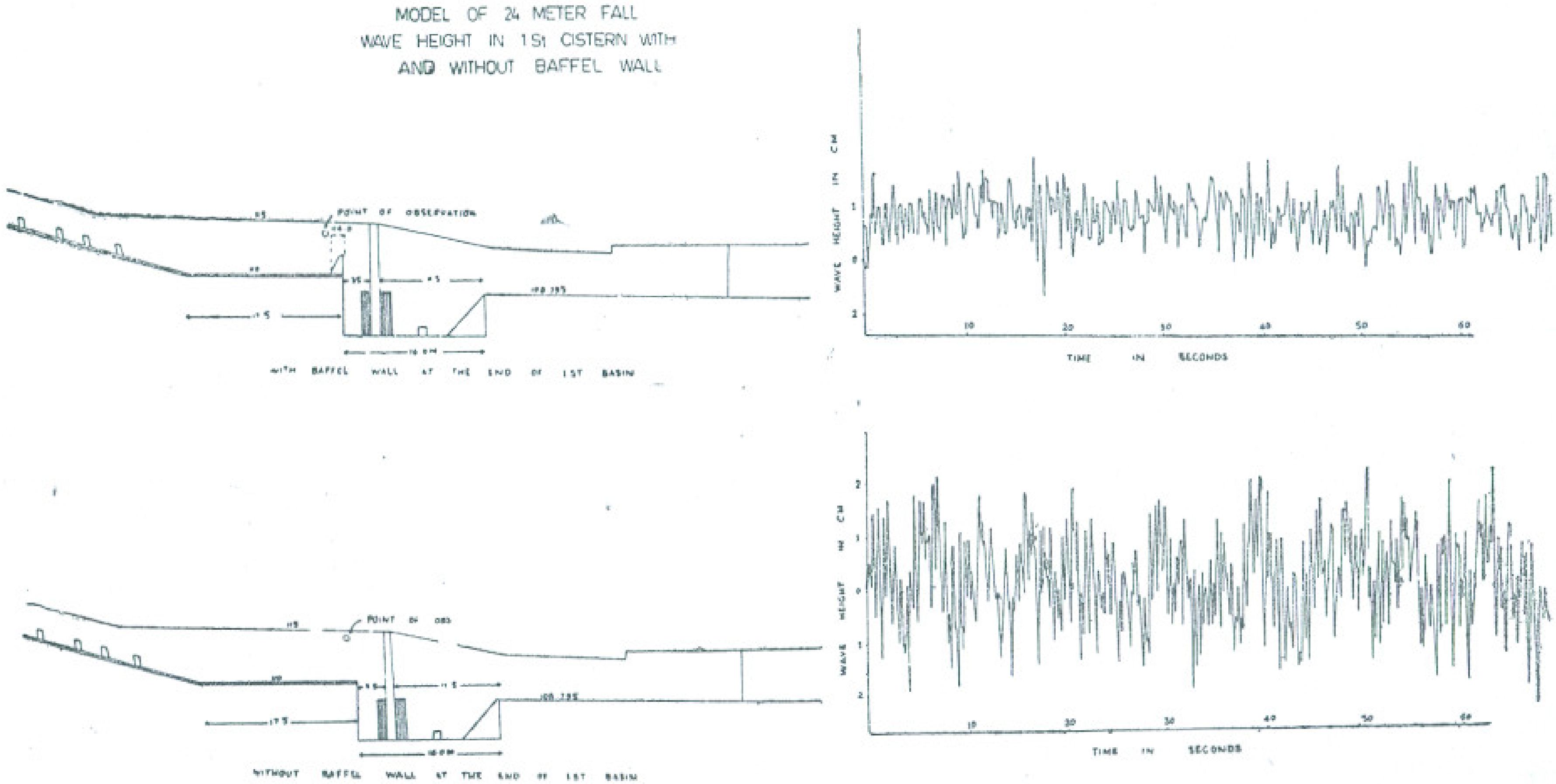

MODEL OF 24 METER FALL
WAVE HEIGHT IN 1St CISTERN WITH AND WITHOUT BAFFEL WALL
POINT OF OBSERVATION
WITH BAFFEL WALL AT THE END OF 1ST BASIN
POINT OF OBS
WITHOUT BAFFEL WALL AT THE END OF 1ST BASIN
WAVE HEIGHT IN CM
TIME IN SECONDS
10
20
30
40
50
60

Fig. 5_{c4}

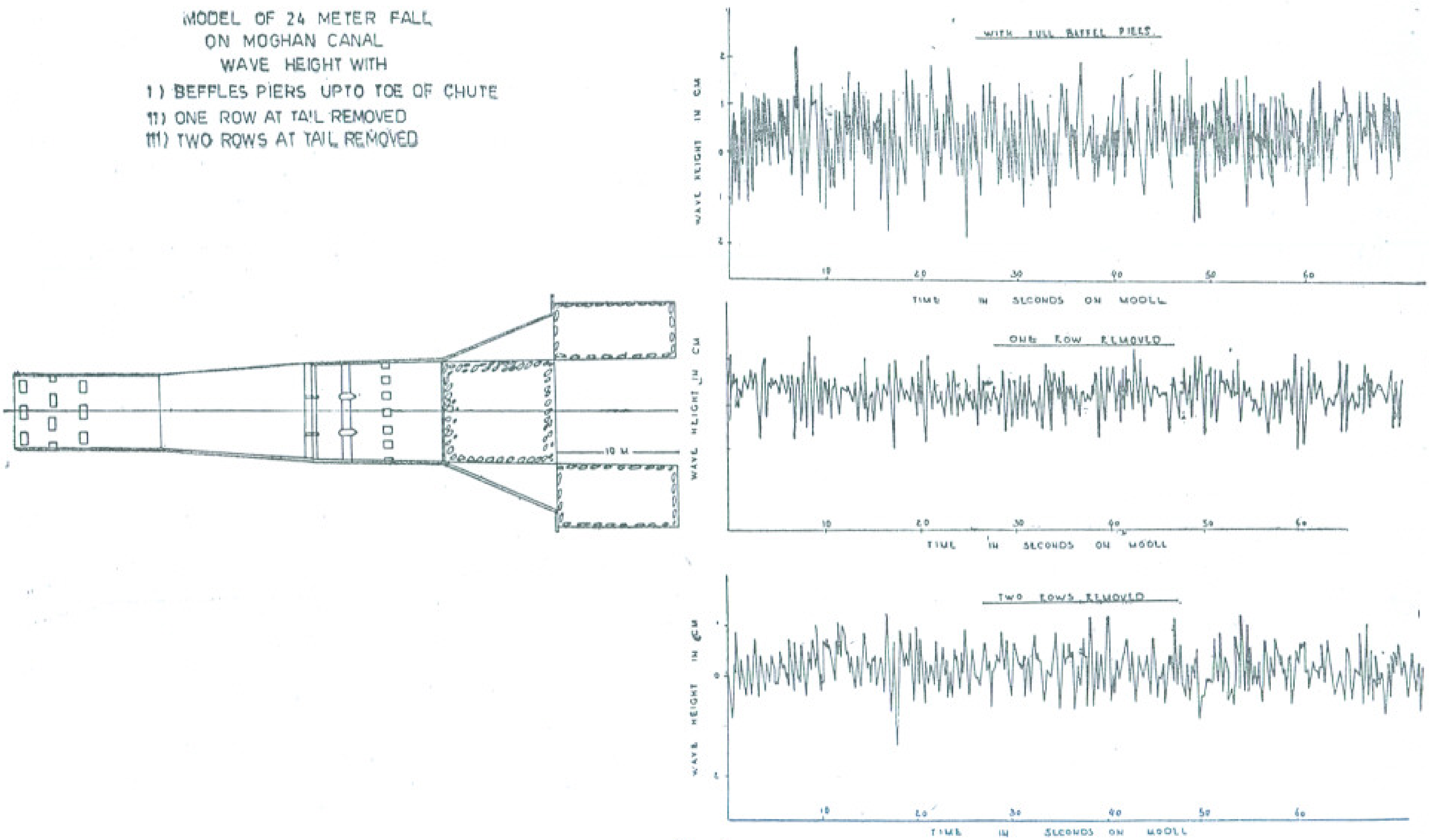

MODEL OF 24 METER FALL
ON MOGHAN CANAL
WAVE HEIGHT WITH
1) BEFFLES PIERS UPTO TOE OF CHUTE
11) ONE ROW AT TAIL REMOVED
111) TWO ROWS AT TAIL REMOVED
10 M
WITH FULL BAFFEL PIERS
ONE ROW REMOVED
TWO ROWS REMOVED
WAVE HEIGHT IN CM
10
20
30
40
50
60
TIME IN SECONDS ON MODEL

Fig. 5_{c5}

recommended design is 1/7.35 of the wave height in original design.

(*b*) The removal of cubical blocks on floor of the lower deeper cistern alone increases the wave height from .096 to .275 *i.e.*, by 186 per cent.

(*c*) With all other features of design the same, the removal of breast wall and cubical blocks increased the wave height from .09 meter to .573 meter *i.e.* by 533 per cent.

(*d*) The removal of end wall (2 meter height) at end of 1st stilling basin increased the wave height at end of 1st stilling basin by 54 per cent.

(*e*) Removal of one row of baffle blocks near the toe of chute reduced the wave height at end of the 1st stilling basin by about 11 per cent.

The contribution of increasing the length of lower stilling basin from 10 meter to 16 meter resulted in reduction of wave height by about 100 per cent.—Fig. 6.

It may be pointed out that the area limiting the rain drops will be more on prototype as degree of aeration will be more on prototype.

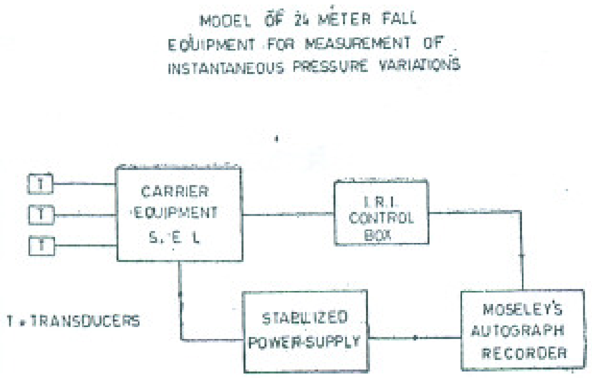


Fig. 7

Transient pressure on two faces of breast wall

The instantaneous pressure variations have been recorded using a pressure transducer, S.E.L. carrier equipment and a strip chart pen-recorder as shown in Fig. 7.

The transducer T is a variable reluctance flush mounting diaphragm type in which two coils are connected in the form of half bridge. The inductance of one coil is changed with the application of pressure while the 2nd coil acts as a temperature compensating element.

The S.E.L. carrier equipment consists of the following :—

(*i*) Input transducer bridge.

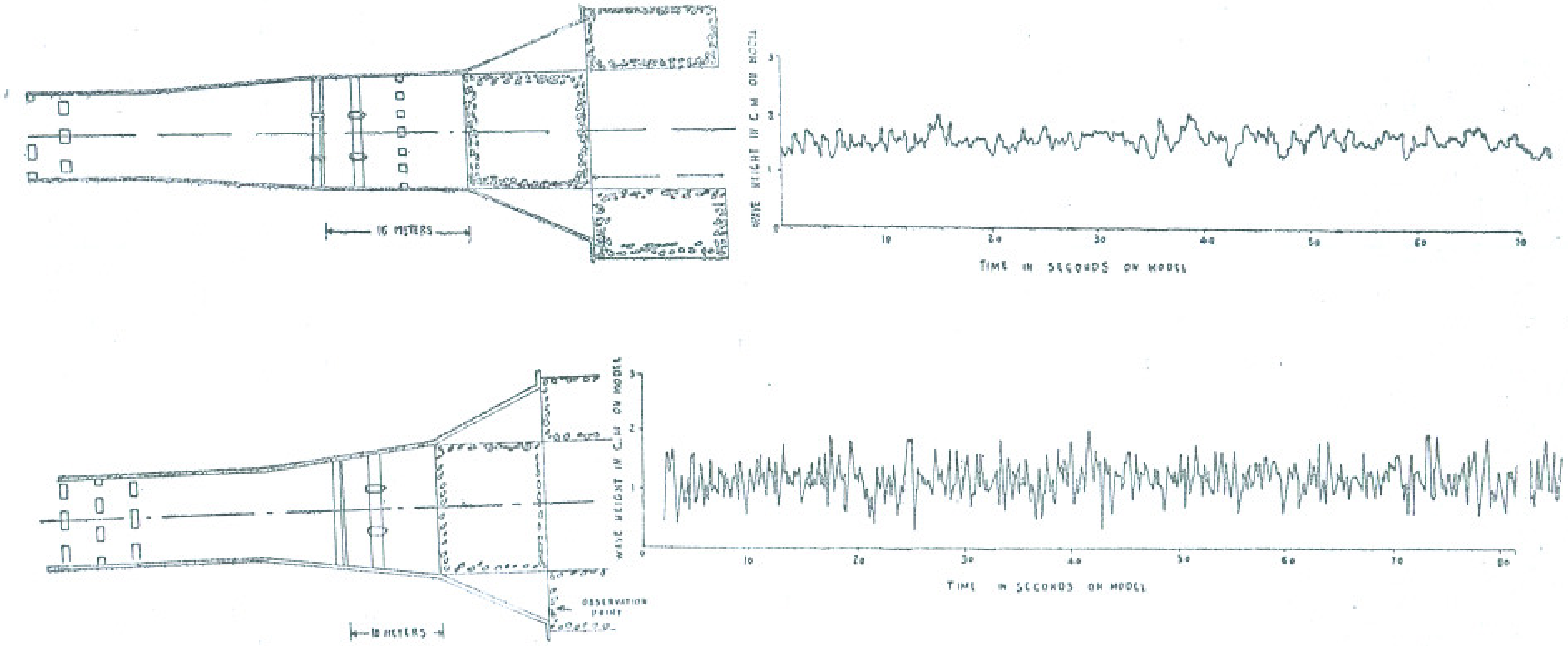
(*ii*) Oscillator, to operate transducer and carrier systems.

(*iii*) Balancing unit and carrier frequency amplifier.

(*iv*) Demodulator (Phase sensitive detector).

(*v*) A filter network to remove the carrier frequency from the demodulator output.

The transducer half bridge is energized from the fixed frequency oscillator. The output of the transducer due to applied pressure variations is in the form of an amplitude modulation of the carrier frequency of the oscillator. The modulated carrier is amplified and converted by the demodulator to an electrical signal proportional and in phase with the mechanical signal (Pressure variations) applied to the transducer input. The low-pass filter then removes the carrier frequency component from the demodulator output and leaves only the d. c. component, which is proportional to the pressure variations, recorded on a recorder. The recorder used is a Moseley electronic strip chart recorded



MODEL OF 24 METER FALL ON
MOGHAN CANAL
WAVE HEIGHT WITH 10 AND 16
METERS LONG STILLING BASIN

Fig. 6

having a servo-amplifier and variable chart-paper speeds.

The transducer points on the two faces of the breast wall are shown in Fig. 8. The pressure variations at all points are listed in Table No. II. The strips of recording at point No. 12 and point No. 16 are reproduced in Fig. 8. The maximum variation recorded at point 8 is 1.75 meters on prototype at a canal discharge of 31.5 cumecs. The pressure variation at the same point for 50 cumecs is 1.25 meters. It may be pointed out that the reduction in pressure variation at 50 cumecs is due to extra cushion of water as a consequent of higher tail level at 50 cumecs.

Recommendations

A twin cistern structure detailed in Fig. 4 was recommended.

6 Meter Fall

The proposed design of the fall structure reproduced in Fig. 9 is tailored to specifications laid by U. S. Bureau of Reclamation for Stilling Basin III where V_1 is not more than 50 ft. per second and Froud Number is above 4.5.

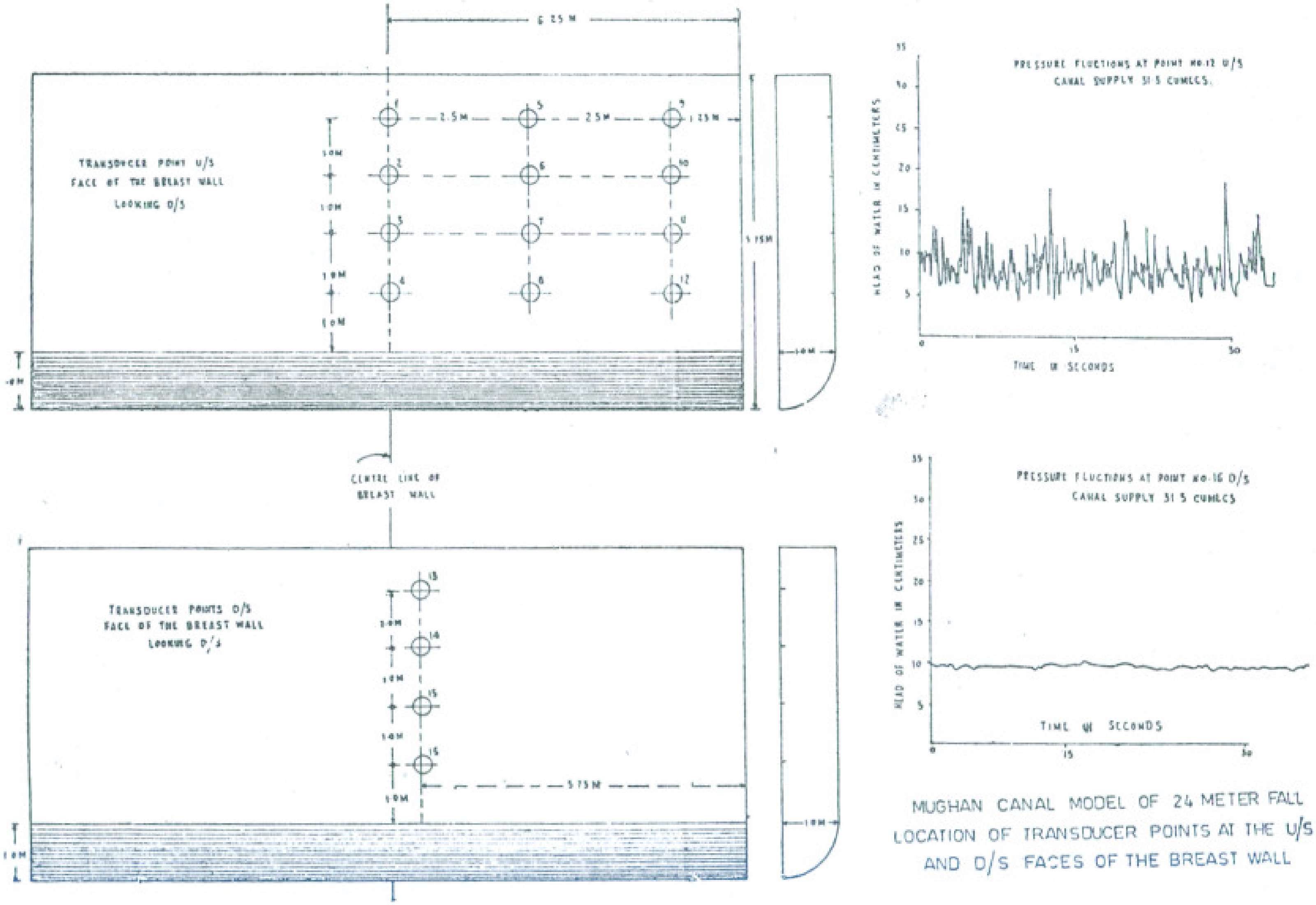
The fall structure at crest comprises of 4 bays, 1.8 meters each and 3 piers each of 0.6 meter width. The downstream glacis of the fall chute is at a slope of 1 on 3 ending in a 6 meter long horizontal stilling basin. The stilling basin is equipped with usual chute blocks at the toe of chute, baffle blocks at a distance of 2 meters from the toe and a 0.47 meter high baffle wall at the end. The width of structure right up to the downstream end of stilling basin is 9 meters against 12.5 meters width of canal at bed. The stilling basin is followed by a 17.5 meters long concrete expansion increasing the bed width from 9 meters to full canal width of 12.5 meters and flattening the side slopes from 1 vertical and 1.5 horizontal.

The channel section of Mughan canal and the fall structure are designed for 50 cumecs, whereas the full supply discharge for the present is fixed at 31.5 cumecs. It was, therefore, desired to check the fall structure for 31.5 cumecs as well as for 50 cumecs canal supply. The water depth downstream of the fall was maintained as 2.7 meters for 31.5 cumecs and 3.5 meters for 50 cumecs.

Test with original design for 6 meter fall

A model of the proposed 6 meters canal fall was constructed to a geometrical scale of 1/10 according to the drawings supplied by A. C. E. The model included 150 meters of canal length on the upstream side of the fall and 200 meters on the downstream side of the fall. The fall structure was in mortar with smooth surface while the model canal above and below the fall was moulded in fine sieved sand of 0.175 m.m. mean dia. To feed the model, a 1.5 meters wide suppressed sharp crested weir was installed at the model inlet while the tail levels were maintained with the help of a flap gate fixed at the tail end of the model.

With the proposed design of the fall structure the model was run for discharges equivalent to 31.5 and 50 cumecs in separate tests. Each discharge was run continuously for 6 hours on the model after moulding the model canal in sand to the designed section. The flow conditions downstream of the fall as recorded photographically are appended in Fig. 10. The bed contours after the test run for both the discharges are plotted in Fig. 11(*a*, *b*). The wave height at the end of the structure was recorded by elec-



MUGHAN CANAL MODEL OF 24 METER FALL
LOCATION OF TRANSDUCER POINTS AT THE U/S
AND D/S FACES OF THE BREAST WALL

Fig. 8

TABLE I

MODEL OF 24 METER FALL ON MUGHAN CANAL

Table showing contribution of different devices in recommended design towards suppressing of wave height at the end of Falls Structure.

S. No.	Description of test	Point of observation	Maximum instantaneous wave height in cm on model	Wave height in meters prototype	Frequency of waves CPM
1 a	Proposed design ..	End of falls structure	5.64	.706	99—126
b	Recommended design ..	,,	0.76	.096	34—40
2 a	With cubical blocks in cistern ..	Top of end cill	0.76	.096	90—94
b	Without cubical blocks in 2nd cistern ..	,,	2.19	.275	99—105
3 a	With breast wall in 2nd cistern ..	End of falls structure	0.76	.096	31—40
b	Without breast wall in 2nd cistern ..	,,	4.58	.573	90—96
4 a	With baffle wall in Ist cistern ..	Top of baffle wall in Ist cistern	4.60	.675	81—101
b	Without baffle wall in Ist cistern ..	,,	7.1		117—139
5 a	With full rows of baffle piers ..	Toe of baffle wall in the Ist cistern	6.1	.762	132—139
b	With one row of baffle piers removed from the tail end of chute ..	,,	4.12	.675	90—112
c	With two rows of baffle piers removed from the tail end of chute ..	,,	5.60	.700	81—101

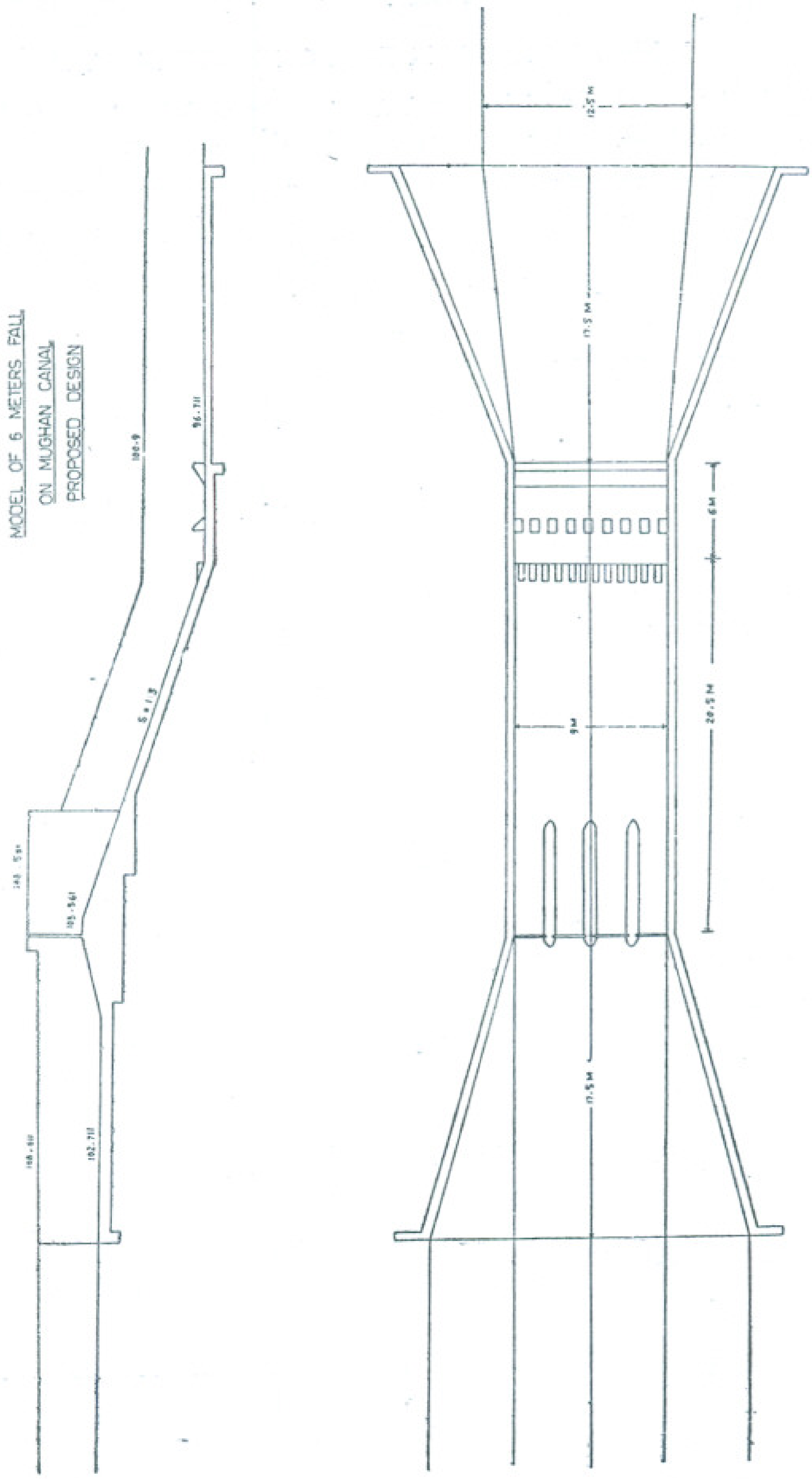
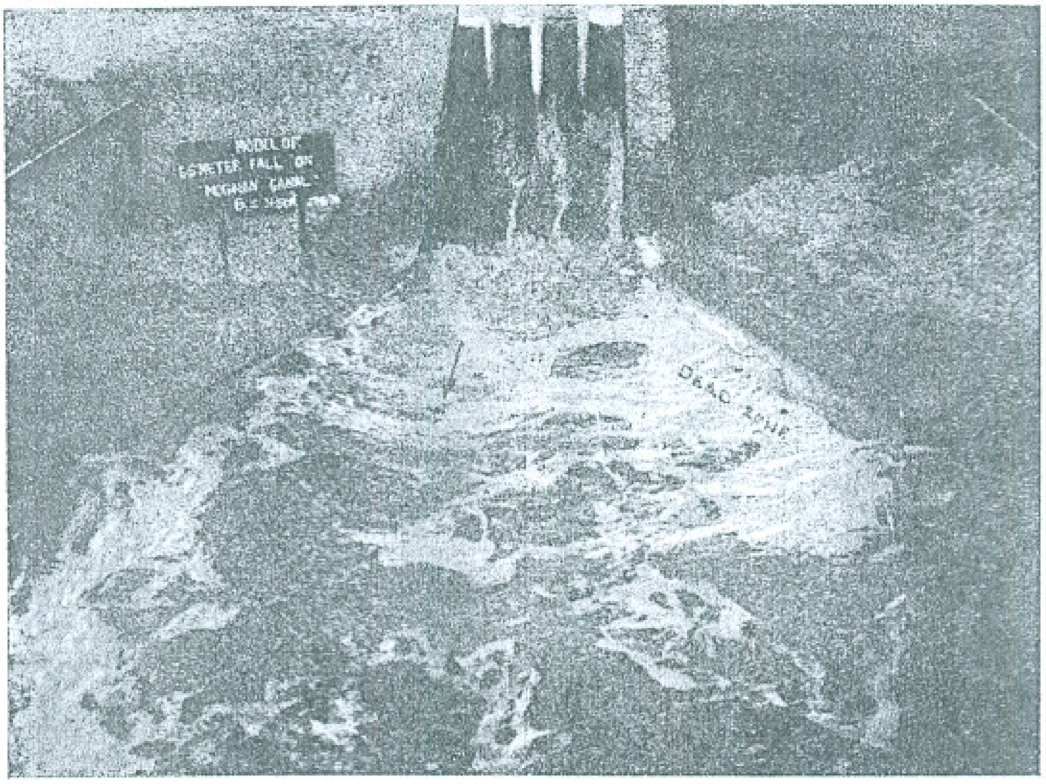

MODEL OF 6 METERS FALL
ON MUGHAN CANAL
PROPOSED DESIGN
12.5 M
17.5 M
6 M
20.5 M
9 M
17.5 M

Fig. 9

Test with proposed design flow condition downstream of the fall at discharges.
$a = 31.5$ cumecs $b = 50.0$ cumecs



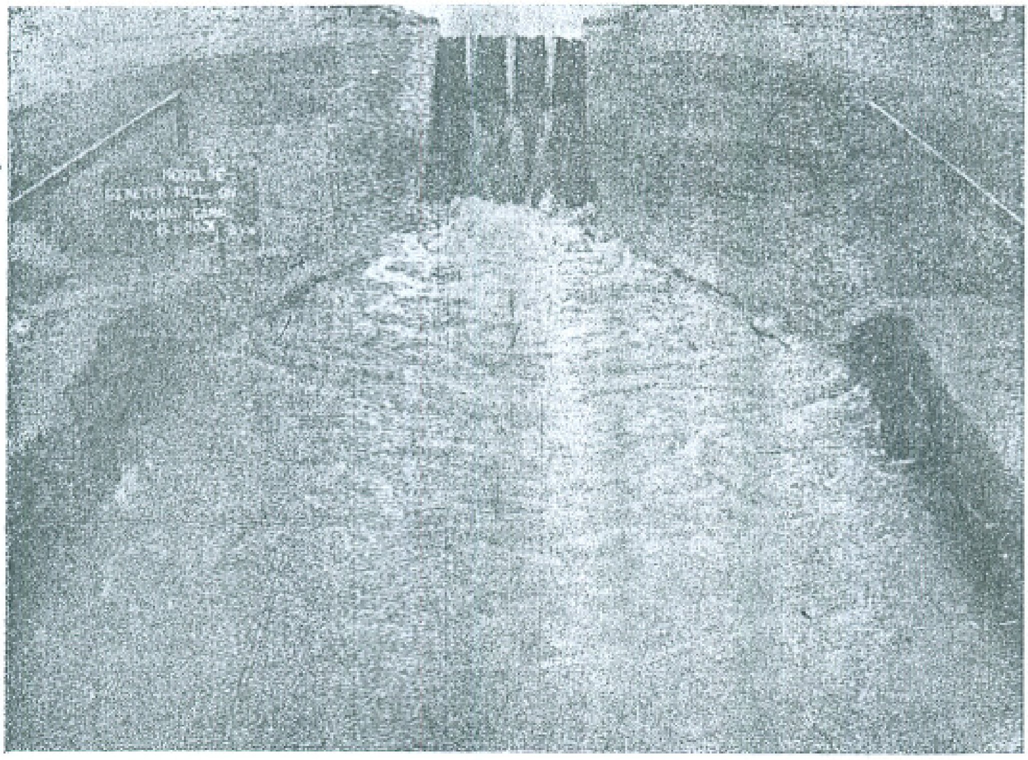


Fig. 10

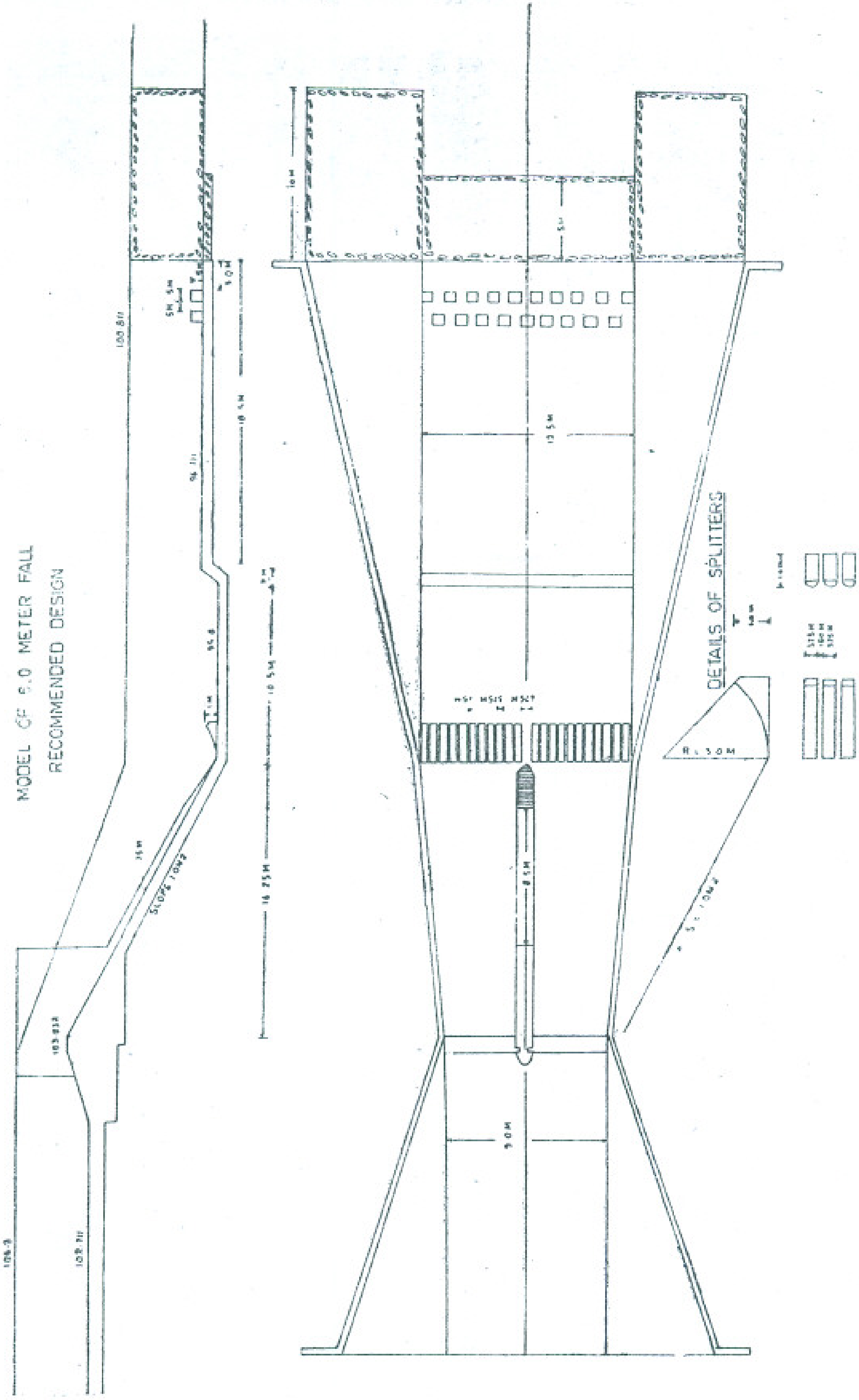

MODEL OF 6.0 METER FALL
RECOMMENDED DESIGN
DETAILS OF SPLITTERS

Fig. 12

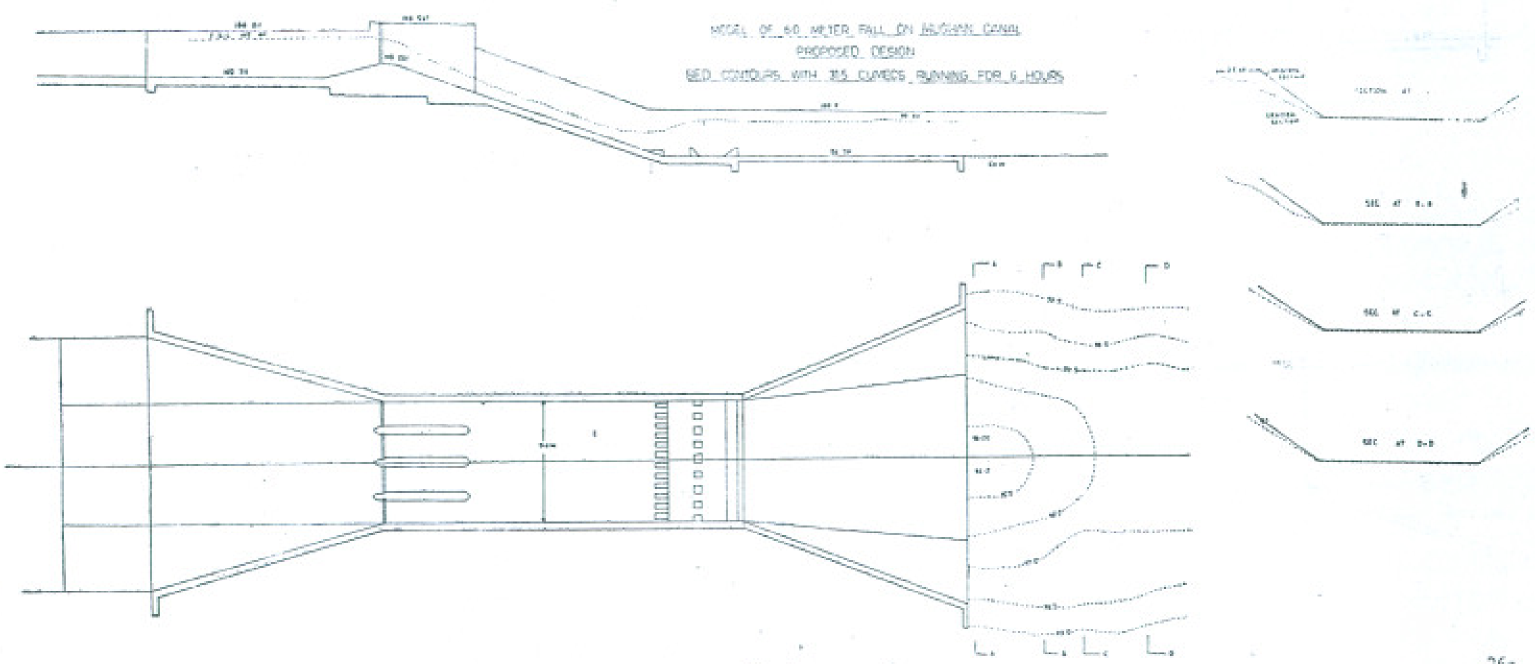

MODEL OF 60 METER FALL ON MUGHAN CANAL
PROPOSED DESIGN
BED CONTOURS WITH 315 CUMECS RUNNING FOR 6 HOURS

Fig. 11a

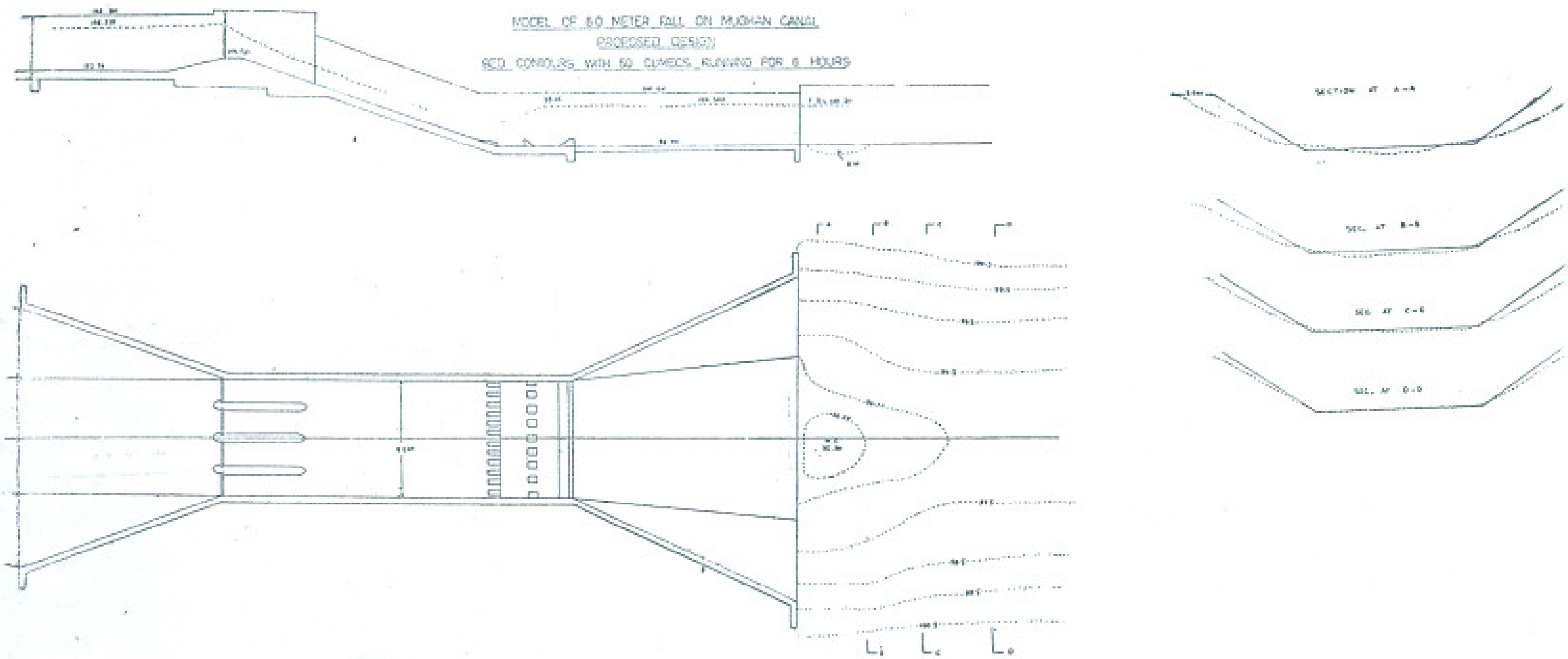

MODEL OF 6.0 METER FALL ON MUGHAN CANAL
PROPOSED DESIGN
BED CONTOURS WITH 60 CUMECS RUNNING FOR 6 HOURS
SECTION AT A-A
SEC. AT B-B
SEC. AT C-C
SEC. AT D-D

Fig. 11b

tronic wave recorder for the two discharges.

From the model it was observed that :—

(*i*) The flow downstream of the fall is very rough and turbulent and is not evenly distributed throughout the concrete expansion downstream of stilling basin. With 31.5 cumecs, there is a dead pocket along one bank with high velocity forward flow along the other bank. In case of 50 cumecs canal supply, the forward flow is rough but central and is flanked by side eddies.

(*ii*) The maximum instantaneous wave height on model for 31.5 and 50 cumecs is 2.74 and 3.35 centimeters respectively which is equivalent to 0.274 and 0.335 meter approximately on prototype.

(*iii*) Due to unstable oscillating flow with choppy surface, the bank erosion just downstream of the fall structure is excessive. It is 2.5 meters for a canal supply of 31.5 cumecs and 3.0 meters for a discharge of 50 cumecs.

(*iv*) The order of maximum bed scour measured below the downstream floor level was 0.51 and 0.8 meter for respcetive discharges of 31.5 and 50 cumecs.

(*v*) High fins generated at the back of each pier are partially instrumental for excessive wave height.

Recommended design

As a result of series of tests the fall geometry detailed in Fig. 12 was found most promising. In this case the expansion of the side walls was started right from the downstream edge of the crest. The No. of bays were reduced from four to two and three piers of. 6 meter width were replaced by one central pier of .75 meter width. The bed width of the chute increased from 9 meters at the crest to 12.5 meters at the downstream toe of chute. Chute slope was also changed from 1 on 3 to 1 on 2. The first 10.5 meter length of the downstream floor was depressed by 0.9 meter at elevation 95.8 (to attain depth of flow$=1.25\ D_2$) while the rest of floor was kept at the normal canal bed level at elevation 96.7. Splitter blocks of height equivalent to 1 meter were provided at the toe of glacis. The geometry of splitters follows the geometry of teeth of submerged roller bucket. The width of teeth was .125 R and gap width at .05 R. No splitter was placed in the wake of the extended pier as it was noticed that the wave height gets magnified due to presence of this splitter. A double row of cubical staggered blocks of height 0.5 meters was fixed 3 meters upstream of the tail end of D/S floor. The warping of the downstream side walls was started from the downstream toe of chute, and was continued right up to tail end of D/S floor. To eliminate fins downstream of it, the pier, it was extended down to the end of chute. The extended part is 0.75 meter high for a length of 8.5 meters from the downstream end of the pier and then tapers down as shown in the figure. Stone pitching in a length of 10 meters on the banks and 5 meters on the bed was provided at the end of concrete structure.

The model was run for a discharge equivalent to 31.5 cumecs for 6 hours and the test was repeated for 50 cumecs as well. The flow conditions downstream of the fall for both discharges are recorded photographically in Fig. 13 which shows a marked improvement in the flow distribution

Test with splitters 1 meter high photograph showing flow conditions downstream of the fall at discharges.
a = 31.5 cumecs b = 50.0 cumecs

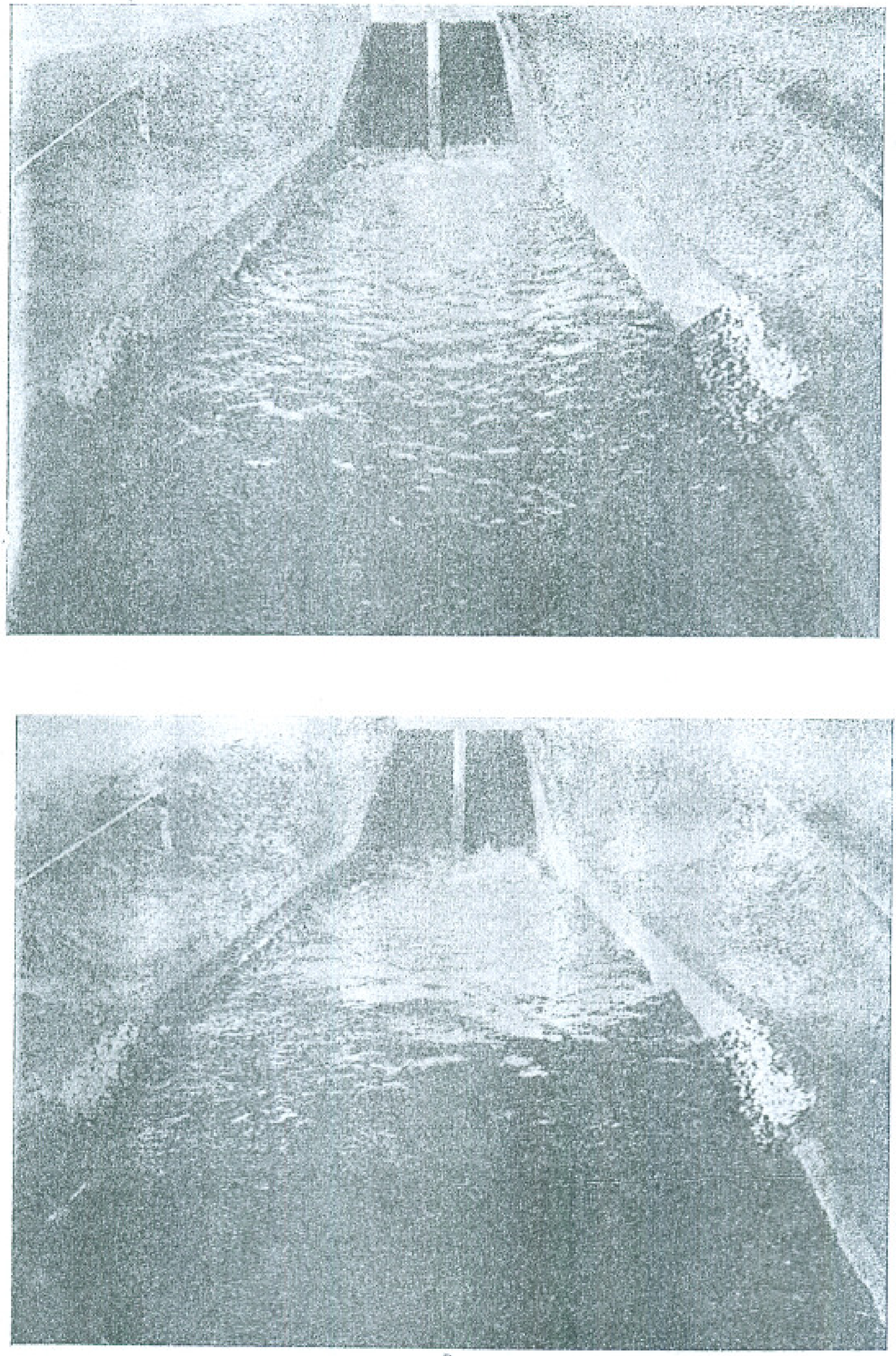


Fig. 13

MODEL OF 6 METER FALL ON MUGHAN CANAL
TEST WITH 1.0 METER HIGH SPLITTER AND
D/S APRON DEPRESSED, BED CONTOURS WITH
31.5 CUMECS RUN FOR 6 HOURS

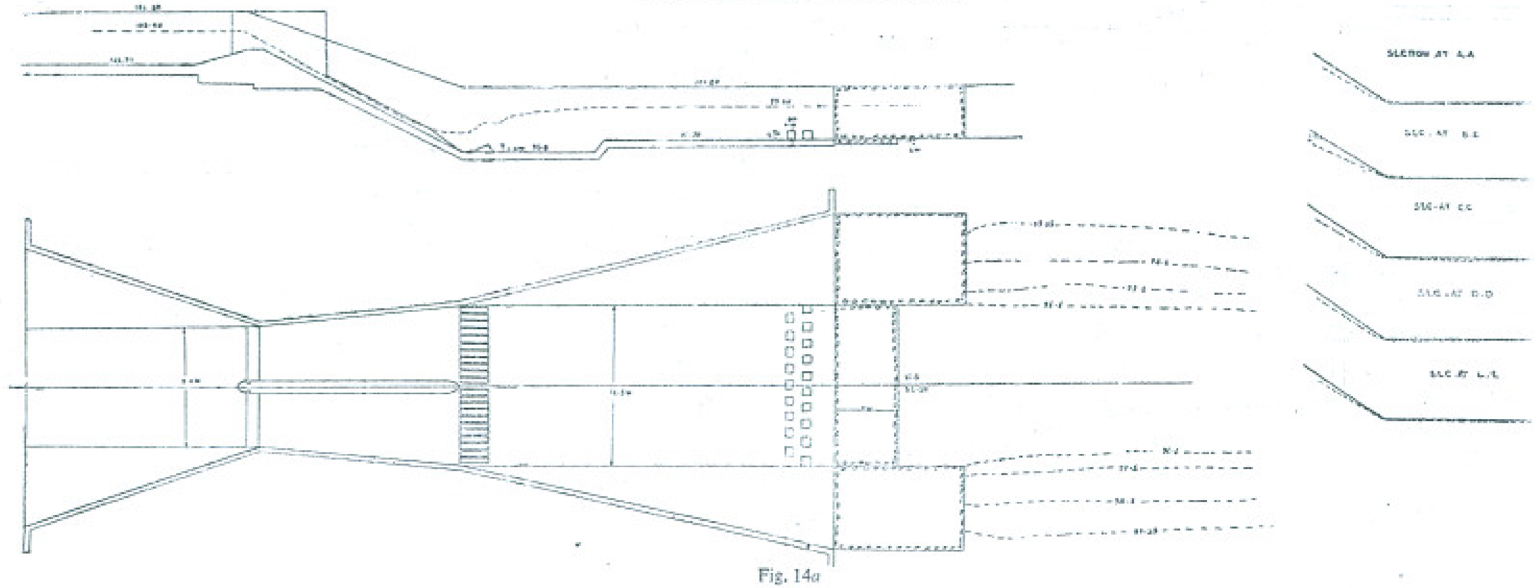


Fig. 14a

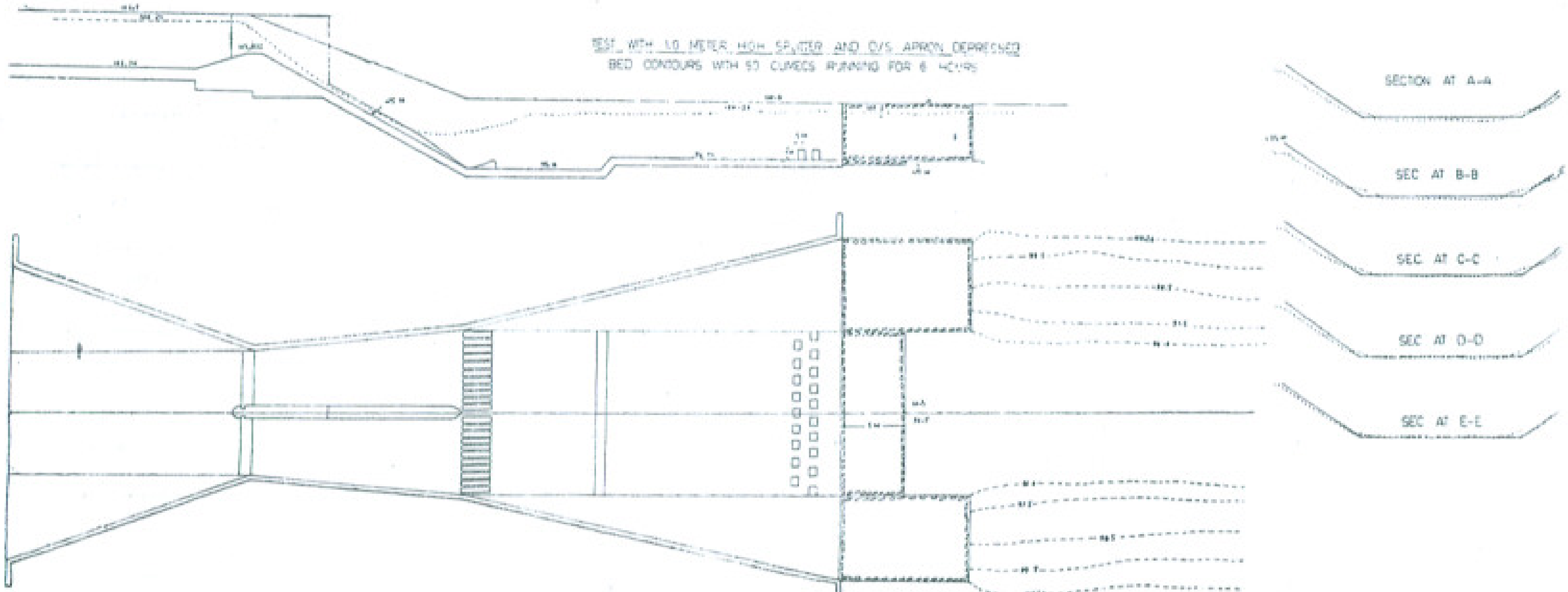

TEST WITH 1.0 METER HIGH SPLITTER AND D/S APRON DEPRESSED
BED CONTOURS WITH 50 CUMECS RUNNING FOR 6 HOURS
SECTION AT A–A
SEC AT B–B
SEC AT C–C
SEC AT D–D
SEC AT E–E

Fig. 14b

TABLE No. II

Model of 24 Meter Fall

Instantaneous pressure variations on breast wall.

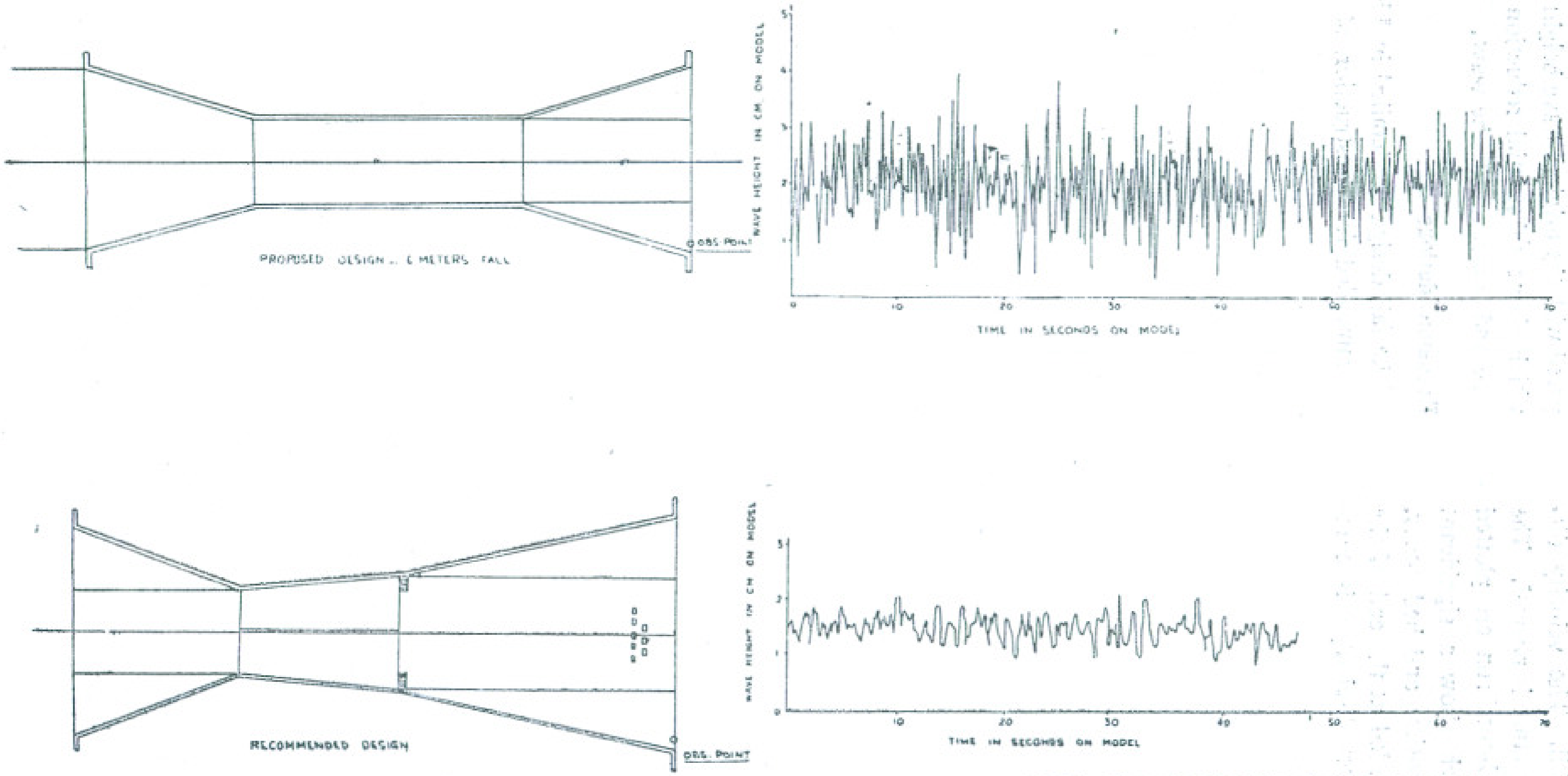
S. No.	Canal discharge in cumecs	Observation point	Instantaneous pressure in terms of centimeters of water head on model. 1	2	3	4	5
1	50	1 U/S	..	..	..	..	..
2	,,	2 U/S	3.5	3.1	3.1	4.0	3.0
3	,,	3 U/S	10.0	9.7	10.5	8.1	7.3
4	,,	4 U/S	4.9	6.0	6.0	4.0	4.2
5	,,	5 U/S	..	..	..	..	..
6	,,	6 U/S	2.2	3.8	3.2	3.2	3.3
7	,,	7 U/S	10.6	10.6	10.0	10.0	10.0
8	,,	8 U/S	8.0	10.0	7.0	9.0	8.2
9	,,	9 U/S	5.4	4.8	6.5	5.5	5.5
10	,,	10 U/S	5.8	5.2	5.3	4.7	4.0
11	,,	11 U/S	10.0	10.2	10.0	10.0	10.5
12	,,	12 U/S	6.2	5.8	6.0	6.2	6.3
13	,,	13 D/S	..	..	..	..	..
14	,,	14 D/S	..	..	..	..	..
15	,,	15 D/S	1.0	1.2	1.1	0.9	0.8
16	,,	16 D/S	0.4	0.7	0.3	0.6	0.6
17	31.5	1 U/S	..	..	..	..	..
18	,,	2 U/S	..	..	..	..	..
19	,,	3 U/S	2.0	1.9	1.9	2.0	2.3
20	,,	4 U/S	8.6	7.6	7.6	6.6	9.8
21	,,	5 U/S	..	..	..	..	..
22	,,	6 U/S	..	..	..	..	..
23	,,	7 U/S	3.0	2.8	2.0	2.5	2.4
24	,,	8 U/S	8.7	11.2	14.0	8.5	7.5
25	,,	9 U/S	..	..	..	..	..
26	,,	10 U/S	..	..	..	..	..
27	,,	11 U/S	3.0	3.0	3.3	2.2	2.1
28	,,	12 U/S	13.5	13.5	9.9	9.2	9.7
29	,,	13 D/S	..	..	..	..	..
30	,,	14 D/S	..	..	..	..	..
31	,,	15 D/S	..	..	..	..	..
32	,,	16 D/S	0.4	0.4	0.3	0.5	0.4

TABLE No. II (*Contd.*)

Model of 24 Meter Fall

Instantaneous pressure variations on breast wall.

S. No.	Maximum instantaneous pressure in meters		Frequency of pressure variations on model	Remarks.
	Model	Prototype		
1	..	..	..	Point remains dry.
2	.04	0.50	96—120 CPM	
3	.105	1.31	136—160 ,,	
4	.06	0.75	120—152 ,,	
5	..	..	..	Point remains dry.
6	.038	0.48	88—112 ,,	
7	.106	1.32	120—168 ,,	
8	.10	1.25	144—160 ,,	
9	.065	0.813	96—112 ,,	
10	.058	0.725	80—104 ,,	
11	.105	1.3	114—160 ,,	
12	.063	0.788	136—160 ,,	
13	..	..	..	Point remains dry.
14	..	..	..	Point remains dry.
15	.012	0.15	48—56 ,,	
16	.007	0.088	32—40 ,,	
17	..	..	..	Point remains dry.
18	..	..	..	Point remains dry.
19	.023	.288	72—96 ,,	Water leaves the point dry at intervals.
20	.098	1.22	128—152 ,,	
21	..	..	..	Point remains dry.
22	..	..	..	Point remains dry.
23	.03	0.375	88—104 ,,	Water leaves the point dry at intervals.
24	.14	1.75	128—144 ,,	
25	..	..	..	Point remains dry.
26	..	..	..	Point remains dry.
27	.033	.412	80—96 ,,	Water leaves the point dry at intervals.
28	.135	1.68	136—144 ,,	
29	..	..	..	Point remains dry.
30	..	..	..	Point remains dry.
31	..	..	..	Point remains dry.
32	.005	.062	8—24 ,,	



MODEL OF 6 METERS FALL ON MOGHAN CANAL
WAVE HEIGHT WITH PROPOSED
AND RECOMMENDED DESIGNS
DISCHARGE = 50 CUMECS

Fig. 15

downstream of the fall. The velocity distribution at end of structure is normal. The bed contours after 6 hours' run are plotted in Fig. 14(*a*, *b*) which show a significant reduction in bank erosion and bed scour. The wave height recorded at the end of the structure for 50 cumecs discharges is compared with the original wave height in Fig. 15 which shows substantial reduction in amplitude and frequency of the wave.

Recommendations

The fall design as detailed in Fig. 12 was recommended for construction at site.

Agricultural Development Possibilities in Irrigated Plains of West Pakistan

By M. ASHRAF ALI AND
MUSHTAQ AHMAD*

Introduction

The following account has been confined to two important irrigated areas in West Pakistan: the northern Indus plains between the Jhelum and the Sutlej rivers, and Lower Sind. Together these areas cover some 24 million acres (gross): about 60 per cent of all the irrigated land in West Pakistan. Of the remaining areas, part has already been surveyed by the Directorate of Soil Survey, West Pakistan, and part remains to be done. Summaries similar to the following are planned as data become available for large contiguous areas.

In the descriptions of mapping units, general terms are used to indicate the extent or proportion of land with different potential for agricultural development. Quantitative data for a number of individual canal commands are listed in tables at the end, and for each individual area surveyed in the soil survey reports of different areas (listed. Specific development of reach kind of land recognized in these surveys are given in Ashraf, Brinkman and Alim 1970.

Northern Indus Plains

In the northern Indus plains, ground water is usable for irrigation in the north-east and along the rivers but generally not in the central and south-western part of the interfluves. Even with full water development as presently envisaged (Lieftinck et al. 1967, 1968/9) not all the irrigable land would receive sufficient supplies. Since water, therefore, is the minimum resource and likely to remain that for many years, agricultural development should be concentrated primarily on land with very high and high potential, ensuing maximum returns to the scarce irrigation water. Particularly the poor (marginal) irrigable land should not be developed at this time, since net economic returns from it are negligible or negative even with modern management.

*Assistant Soil Survey Research Officer and Soil Survey Research Officer, respectively, Directorate of Soil Survey, West Pakistan, Central Soil Research Institute, Lahore.

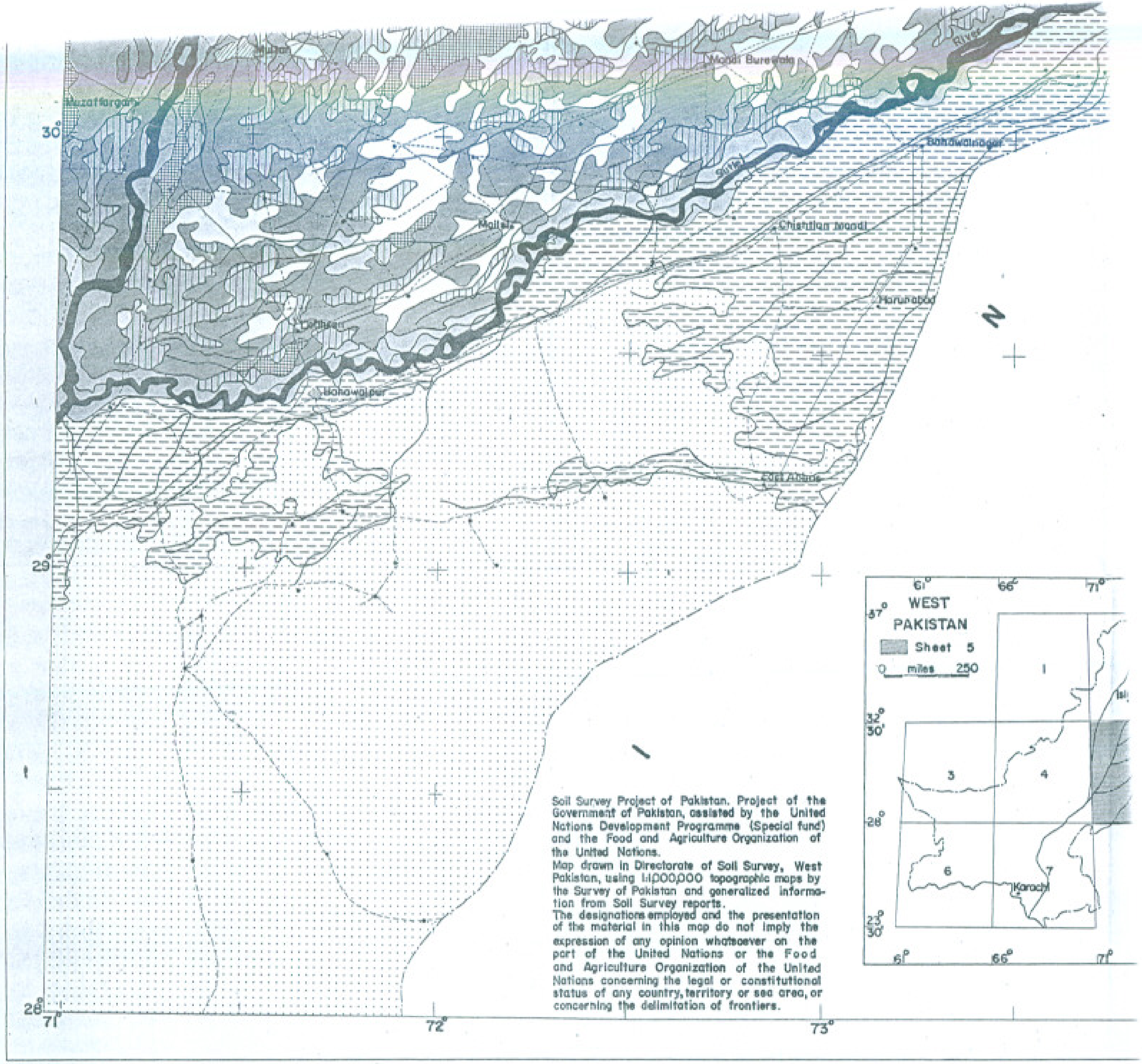
Fifteen mapping units are described below and delineated on map : agricultural development potential, northern Indus plains.

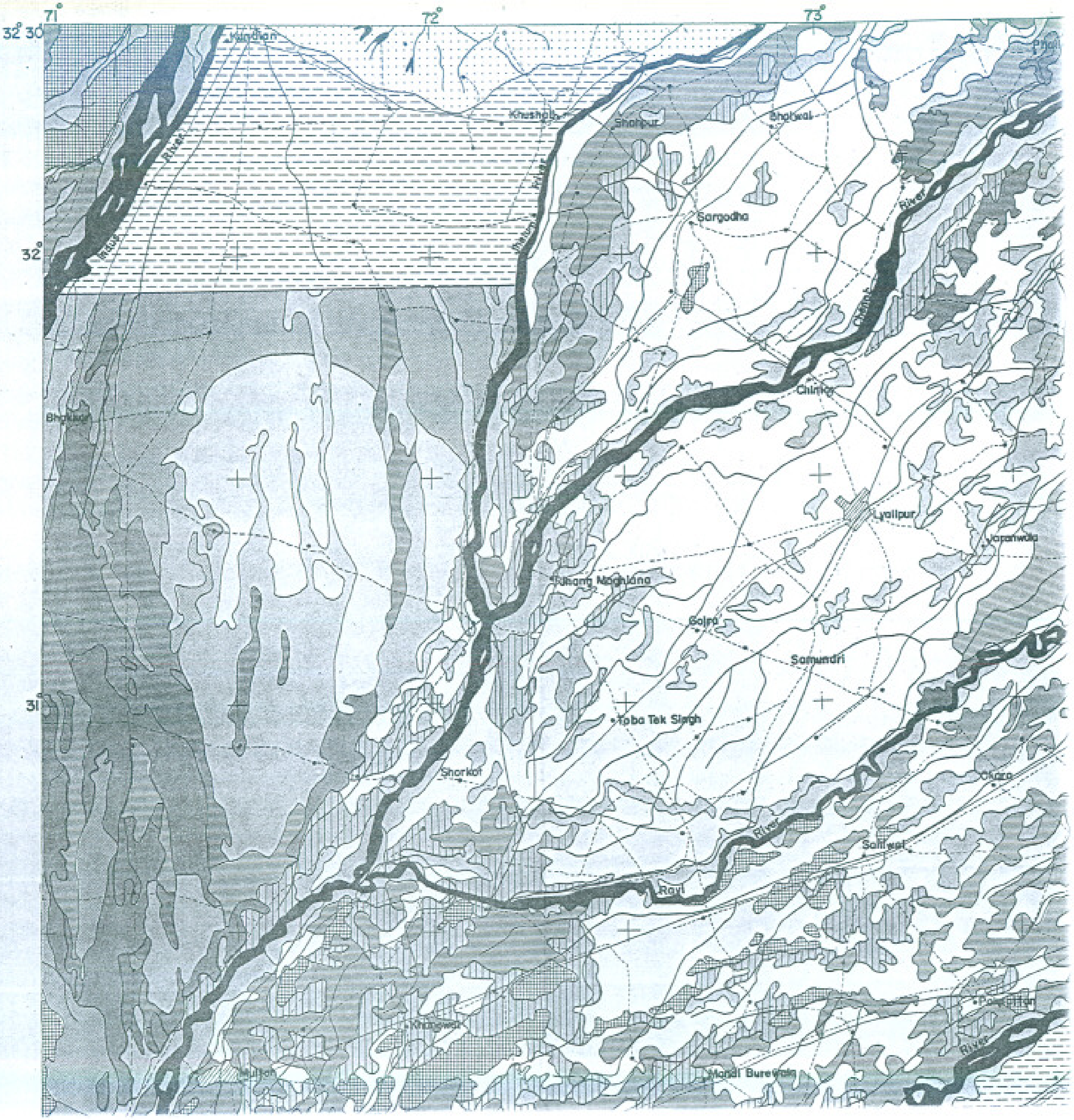
Large areas in the Chaj, Rechna and Bari doabs comprise *land with a very high economic potential under irrigation.* At present inadequate water supply precludes attainment of full potential of this land more than any other factor. Water shortage is directly responsible for the below-optimum yields and low cropping intensities. In a considerable part, ground water is fit for irrigation and the water supply can safely be enhanced by the installation of more tubewells. This measure, however, cannot be applied in areas with saline ground water where the water deficiency can only be met with increased supply of canal water. This land is very well suited for intensive irrigation and could support a wide range of crops. There are no major limitations to a two-fold increase in production from these areas.

Scattered throughout the area but concentrated mostly in the north-eastern part of the Rechna doab and the south-western part of the Bari doab are patches of *land with a high economic potential under irrigation.* Most of this land is clayey with low permeability, posing a minor problem in seed-bed preparation and limiting the choice of crops. Some low-lying patches of this clayey land become wet seasonally, due to collection of run-off. With modern management, including provision of drainage in relatively wetter areas, very high yields of suitable crops (chiefly rice, wheat and berseem) can be obtained. Part of this land is somewhat sandy or has silty soils overlying thick sand strata within a half to 1 metre from the surface. These soils are well-suited to a large number of common crops but not so for orchards. Increased irrigation supplies and split application of fertilizers could increase the agricultural production to a great extent. Strips of such land occurring in Thal include a minor proportion of sandy land with poor grazing potential. There, the water supplies are sufficient and the faulty methods of water application have given rise to a high water-table. Frequent but light irrigations and tubewells are needed to combat the danger of a very high water-table. Small areas, mainly near major canals, have a water-table high enough to limit their productivity. With adequate drainage such areas could become very good irrigated land with a very wide range of crops. Minor parts of this land are slightly saline, requiring a few extra irrigations and subsequent intensive irrigation to produce high crop yields.

Fairly extensive patches of land *have a moderate economic potential under or for irrigation.* Most of this land is saline-alkali but has good structure in the subsoil. Only small areas of such land in Sheikhupura District are irrigated, whereas most of it is lying barren at present and supports poor grazing. However, with relatively high investments on moderate applications of gypsum and some years of leaching, preferably under a rotation of rice and wheat or berseem, this land would attain a high potential, provided drainage is, and remains, adequate. The ground water in some parts of this area is of high quality and may be tapped for irrigation by tubewells.

About one quarter of the Thal comprises land with a *moderate overall economic potential under irrigation.* The major part of this land contains sandy ridges that have, at best, a poor grazing potential which are associated with valley soils. Some of the


Muzaffargarh
Multan
Mandi Burewala
Bahawalnagar
Chishtian Mandi
Lodhran
Bahawalpur
Harunabad
Fort Abbas
Sutlej
River
N
WEST
PAKISTAN
Sheet 5
0 miles 250
Karachi
Soil Survey Project of Pakistan. Project of the Government of Pakistan, assisted by the United Nations Development Programme (Special fund) and the Food and Agriculture Organization of the United Nations.
Map drawn in Directorate of Soil Survey, West Pakistan, using 1:1,000,000 topographic maps by the Survey of Pakistan and generalized information from Soil Survey reports.
The designations employed and the presentation of the material in this map do not imply the expression of any opinion whatsoever on the part of the United Nations or the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.



71°
72°
73°
32° 30'
32°
31°
Kundian
Khushab
Shahpur
Bhalwal
Sargodha
Bhakkar
Chiniot
Lyallpur
Jaranwala
Jhang Maghiana
Gojra
Samundri
Toba Tek Singh
Shorkot
Okara
Sahiwal
Ravi
River
Chenab
Jhelum
Indus
Khanewal
Multan
Mandi Burewala
Pakpattan

74°
75°
76°
32°30'
32°
31°
Phalia
Wazirabad
Sialkot
Shakargarh
Narowal
Gujranwala
Hafizabad
Sheikhupura
Ravi River
LAHORE
Jaranwala
Raiwind
Kasur
Chunian
Okara
Dipalpur
Pakpattan
A
D
CONVENTIONAL SIGNS
National boundary
Soil boundary
Road
Railroad
Canal or drain
River
Town
Urban land
L E G E N D
Land with a very high economic potential under irrigation
Land with a high economic potential under irrigation
Land with a moderate economic potential under irrigation
Land with a moderate economic potential for irrigation*

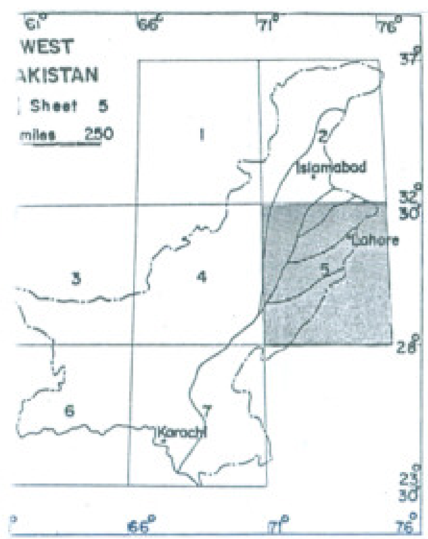
- Land with a moderate economic potential under irrigation
- Land with a moderate economic potential for irrigation*
- Land with a moderate overall economic potential under irrigation
- Land with a moderate economic potential under dry-farming
- Land with a moderate economic potential under flood-watering
- Land with a low to moderate overall economic potential for irrigation*
- Land with a low overall economic potential for irrigation*
- Land with a low economic potential under dry-farming
- Land with a low or no grazing potential with some moderate and poor irrigated land
- Land with a low economic potential for grazing
- Agriculturally unproductive land
- Land with some irrigation potential**
- Land without irrigation potential**

* Subject to availability of water

** Not covered by regular reconnaissance soil survey. Further detail not available.

30°

29°



WEST PAKISTAN
AGRICULTURAL DEVELOPMENT POTENTIAL

SCALE 1:1,000,000

SHEET 5

1970

74° 75° 76° 28°