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EXPERIENCE GAINED FROM INTERCEPTOR DRAINS INSTALLED IN LBOD STAGE-1 PROJECT

BY

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EXPERIENCE GAINED FROM INTERCEPTOR DRAINS INSTALLED IN LBOD STAGE-1 PROJECT

Yawar Hamid [1]

ABSTRACT

About 500 000 ft long interceptor drains along with 54 pump stations have been installed in Nawabshah Sub-project of LBOD Stage-1 Project and are in operation since 1992. In addition to it about 654 000 ft long interceptor drains along with 111 pump stations are proposed to be installed in Sanghar and Mirpurkhas Sub-projects. This paper describes the experiences gained from sub-surface investigations, design and operation of interceptor drains in LBOD Stage-1 Projeect. If proper sub-surface investigations are conducted and drains are installed only along canals reaches underlain by coarse textured soils, then the interceptor drains become an economically viable means for the interception of canal seepage.

INTRODUCTION

Interceptor drains were installed in Nawabshah Sub-project of the LBOD Stage-1 Project during the period February 1990 to October 1992. These are sub-surface pipe drains installed parallel and close to Nasrat, Amerji and Gajrah branch canals of Rohri canal system. Rohri canal offtakes from Sukkur Barrage located at the river Indus. Corrugated and perforated PVC pipes surrounded by an envelope material were laid as interceptor drains at depths ranging from 7.5 to 11 ft below ground surface. Design distance of the drain from the outer toe of canal embankment was 30 ft for a single drain line; and 30 and 90 ft for a twin drain line. Actual drain distances varied according to the site conditions. Diameters of the drain pipes were 6, 8, 10 and 12 inches. Total length of the installed drains, along 255 000 ft length of canals, is 499 730 ft. Fifty four pump stations having total installed capacity of 126 cusec have been constructed to pump out the drain effluent into the adjacent canals. The drains are designed to intercept 65 cusec of canal seepage. Total construction cost of the drains including pump stations and cross drainage structures was Rs 256 million [1].

In addition to the installed interceptor drains in Nawabshah Sub-project, 654 000 ft long interceptor drains along with 111 pump stations, having total installed capacity of 173 cusec, are proposed for Sanghar and Mirpurkhas Sub-projects of LBOD Stage-1 Project. The proposed drains are designed to intercept about 160 cusec of canal seepage from Mithrao canal, Jamrao canal, Dim branch, Shahu branch and West branch of Nara canal system offtaking from Sukkur Barrage.

The objectives of installation of interceptor drains are:

1. To intercept and reuse canal seepage before it mixes with highly saline ground water and is rendered useless for irrigation.
2. To reduce the sub-surface drainage requirements of the area adjacent to canals.

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3. To reduce the size of saline effluent disposal system.

SUB-SURFACE INVESTIGATIONS

Sub-surface investigations were carried out along the canals of LBOD Stage-1 Project, where interceptor drains were proposed to be installed. Ten ft deep auger holes were drilled at selected locations to determine soil texture at different depths, hydraulic conductivity by pump out test, depth to water table and water table profiles by drilling 5 to 6 auger holes along sections starting from the canal water edge and extending upto 300 ft away from the canal. Some of the auger holes were drilled upto 16 ft depth.

In Nawabshah sub-project hydraulic conductivity tests were conducted in auger holes drilled at an interval of 5000 ft along the canals. After construction and testing of drains it was felt that 5000 ft interval of investigations is too large as some of the drain lengths were less than 5000 ft and missed the investigations completely. Drain length is defined as a complete individual length of an interceptor drain, starting from the smallest diameter pipe size upto the outfall point into a pump sump. There are 123 drain lengths in Nawabshah sub-project and their lengths vary from 940 to 9230 ft. Also during the testing of interceptor drains actual drain discharge was found to be significantly different from the designed discharge. Further investigations were carried out for such drain lengths at an interval of 1000 ft along the canal. Additional investigations gave a totally different picture of sub-surface conditions and actual drain discharges were compatible with the new results. In the light of these findings it was decided to reduce the investigation interval, for future contracts, from 5000 to 1000 ft. As a result reaches of low hydraulic conductivity were better demarcated and interceptor drains for such reaches were deleted. It is recommended that if the soil texture varies too frequently along the canal, then the investigation interval may further be reduced to 500 ft. Additional cost of investigations is compensated by eliminating drains along low hydraulic conductivity reaches. In Sanghar and Mirpurkhas sub-projects, about 554 000 ft length of interceptor drains were deleted due to this reason which is about 45 percent of the total canal length. Estimated saving as such is Rs 530 million.

Watertable Profiles

Ground water profiles were prepared at 188 locations along the project canals. Five to six auger holes were drilled along a section starting from the canal water edge and extending upto 300 ft away from the canal. Elevations of canal water level at each section; and ground surface and water table elevations at every auger hole site were determined and plotted. Depth to watertable at zero distance is the canal water elevation. The shape of water table profile gives some indications about the canal seepage pattern at each investigation site. Three typical types of the water table profiles for Amerji, Gajrah and Nasrat branch canals have been identified as shown in Figures 1 to 3.

Type-I profile shows an almost flat water table starting from the edge of the canal and extending upto the observation distance. However, seepage from the canal creates a small watertable mound near the canal. Type-II profile is intermediate between Type-I and Type-III profiles. Type-II profile shows a relatively high watertable mound below the canal and an almost flat water table away from the mound. Type-III profile shows a clear seepage line starting from the edge of the canal and extending upto 300 ft away.

DESIGN

Drain Interception Rate (Qd)

Drain interception rate is the discharge of the unit length of drain. It depends upon many factors such as canal width, canal depth, canal command, distance of drain from the canal, drain depth, depth to water table, hydraulic conductivity and an-isotropy ratio of the soil [2]. Using finite element mathematical model drain interception rates were determined for different canal sections and field hydraulic conductivities [3]. The model assumes flat ground surface along the canal. Relationships of Qd with different above mentioned parameters, based on model studies, are shown in Figure 4 and discussed below.

1 Qd increases as the canal width increases. Canal widths in LBOD Stage-1 project vary from 18 to 120 ft.

2 Qd increases as the canal depth increases. Canal depths in the project vary from 2 to 10.5 ft.

3 Qd increases as the canal command (CC) increases. Canal command is defined as the height of canal water above natural ground surface. Canal commands in the project vary from 2 to 12 ft. A typical plot of Qd versus CC is shown in Figure 4 and is based on canal top width (TW) = 16 m, canal depth (CD) = 2.0 m, drain depth (DD) = 3.0 m, depth to watertable (WT) = 2.5 m, drain distance (S) = 30 m, hydraulic conductivity of the soil (Ka) = 0.5 m/d, and an-isotropy ratio of the soil ® = 8.

4 Qd decreases as the drain distance from the canal increases. Model results show that drain interception is maximum close to the canal. A typical plot of Qd versus S is shown in Figure 4 and is based on TW = 16 m, CD = 2.0 m, CC = 3.0 m, DD = 3.0 m, WT = 2.5 m, Ka = 1.0 m/d and R = 8. As the drain distance from the canal increases drain interception decreases at a diminishing rate. After some value of drain distance the drain interception becomes practically constant. If site conditions allow then the drain distance adopted for project drains is 30 ft from the outer toe of the canal embankment.

5 Qd increases as drain depth is increased. Average drain depth adopted for the project is 10 ft. A typical plot of Qd versus DD is shown in Figure 4 and is based on TW = 16 m, CD = 2.0 m, CC = 3.0 m, WT = 2.5 m, S = 30 m, Ka = 0.5 m/d, and R = 8.

6 Qd decreases as the depth to water table, away from the canal, increases. A typical plot of Qd versus WT is shown in Figure 4 and is based on TW = 16 m, CD = 2.0 m, CC = 3.0 m, DD = 3.0 m, S = 30 m, Ka = 1.0 m/d and R = 8. Model results show that for a drain depth of 10 ft drain interception is negligible if depth to water table is more

than 8 ft. Design depth to water table in LBOD Stage-1 project is 7 ft for areas with drainage wells and 5 ft for areas with tile drains.

7 Qd increases as the hydraulic conductivity of the soil increases. Hydraulic conductivity values of the soils along the project canals vary from less than 0.1 to more than 65 ft/day as the soil texture vary from place to place from silty clays to fine sands. Average and median values of hydraulic conductivity are 4.2 and 2.6 ft/day, respectively. More than 60 percent of the hydraulic conductivity values fall within a range of 0.5 to 3.0 ft/day.

8 Qd decreases as the an-isotropy of the soil increases. An average value of 8 is adopted for the an-isotropy of project soils. A typical plot of Qd_i versus R is shown in Figure 4 and is based on TW = 24 m, CD = 2.0 m, WT = 2.5 m, CC = 3.0 m, DD = 3.0 m, S = 30 m and Ka = 2.0 m/d.

Design values of drain interception rate for Nawabshah Sub-project were 0.07 to 0.25 cusec/1000 ft of drain.

For Sanghar and Mirpurkhas sub-projects the lower limit of design interception rate has been fixed as 0.15 cusec/1000 ft and no drains will be installed at places where estimated interception rate is less than this limit. Design interception rate ranges from 0.15 to 0.35 cusec/1000 ft of drain.

Canal Seepage Interception By Two Drains

For LBOD Stage-1 Project; where average drain depth is 10.0 ft, depth to watertable is 7.0 ft and average value of an-isotropy ratio is 8; drain interception by a single interceptor drain varies from 25 to 30 percent of the canal seepage. If a second drain is also installed at a distance of 100 ft from the first drain, then the total interception is about 1.5 times the interception by one drain. If the depth to water table, remote from the canal, is shallower than 7.0 ft, then seepage interception by two drains increases and is between 60 to 80 percent of the canal seepage when depth to watertable is 5.0 ft [3].

INSTALLATION

All the interceptor drains in Nawabshah Sub-project were installed with the help of a drain trencher. Gravel envelope was successfully placed with the help of a power feeder. At two sites, where the design envelope material was natural gravel but it could not be transported to the site due to boggy soils, interceptor drains with synthetic geo-textile fabric envelope were installed. Therefore, geo-textile fabric becomes a preferred envelope material in difficult soil conditions.

Four inches diameter pipes, as given in the Bill of Quantities, were not installed by the contractor. In its place 6 inches diameter pipes were installed at the price of 4 inches pipes. Reason for this change was that at every pipe diameter change a lot of time was consumed to change the trencher boot. By eliminating one pipe diameter about 20 percent of the boot changing time was saved. Saving of installation time means an increase in the total length of drain installed per day. Additional cost of the 6 inches diameter pipe, instead of 4 inches diameter pipe, is compensated by the savings due to increased progress.

During interceptor drain operation it was observed that drain water is ponded in some of the manholes. The sites were excavated and the drain pipe was found to have collapsed but not

broken. Flow area of the pipe was reduced resulting in ponding of the water in upstream direction. Collapsed length of the pipes was replaced. The collapsed pipes could not be detected during the drain installation period as the drains were not tested for this defect. For future contracts it is recommended that all the drain pipes be tested, after installation, by pulling a steel bar ball through the pipes.

PERFORMANCE

Drain Discharge

To check the performance of the interceptor drains discharge of every drain length was measured by the contractor after the completion of the installation works in Nawabshah Sub-project. During subsequent measurements, only the combined discharge of all the drains outfalling into a pump station was estimated by measuring the recovery of water level inside the pump sump. Discharges of 54 pump stations, measured at different timings, are given in Table 1.

Drain interception rates, at the time of acceptance tests, ranged from 0.039 to 0.94 cusec/1000 ft of drain. Actual drain interception rates differ from the design rates because of the following reasons:

1. Actual watertable depth is shallower than the design depth of 7.0 ft.
2. Actual hydraulic conductivity of the soil is different from the value adopted for the design. For the design purposes one or two point values of hydraulic conductivities are used for a single drain length. Whereas, actual drain discharge is based on the actual hydraulic conductivities of the soil strata falling within the entire length.
3. Actual an-isotropy of the soil is different from that adopted for the design.

Fig. 5 shows the variation of discharge with time for some of the selected pump stations. Table 1 and Figure 5 show that discharge of almost all the pump stations have reduced. This is because of the fact that, due to the operation of interceptor drains and drainage wells, watertable has gone down and as discussed in drain design that drain discharge is inversely proportional to the depth to watertable. Hence, the drain discharge is supposed to decrease till the watertable is stabilized and attains design depth of 7 ft [4,5]. However, from Table 1 and Fig. 2, it appears that the discharge of interceptor drains have become almost constant to a value of about 76 cusec against a design discharge of 65 cusec.

Minor changes in the discharges of individual pump stations are due to fluctuations in the depth to watertable.

Drain Water Quality

A single line of interceptor drain installed close to the canal, when depth to water table remote from the canal is 7 ft, intercepts water equal to about 30 percent of the canal seepage from one side while the rest of seepage water mixes with the ground water. Water quality of the drain water indicates that it is not pure canal water but some saline ground water has also mixed with it and thus has increased its salt content. Electrical conductivities of canal water, drain water and ground water are 300 to 500, 410 to 1850 and 7000 to 27000 micro mohs per centimetre, respectively. Electrical conductivity of drain water from most of the pump stations is less 1000 micro mohs per centimetre. Average value of the electrical conductivity of drain water, at the time of acceptance tests, was 850 micro mohs per centimetre [4].

Envelope Material

Three different drain envelope materials were used in Nawabshah sub-project. The envelope materials were 4 inches thick layer of natural graded gravel, 2.5 mm thick synthetic geo-textile fabric and 4 inches thick layer of local sand around 2.5 mm thick synthetic geo-textile fabric. As far as the filtration and separation properties of these three envelope materials are concerned all perform well and are acceptable. But, drain entrance head loss is different for various envelope materials due to radial flow of water towards the drain and effective radius of the drain. Due to radial flow of water, rate of head loss due to water flow through the soil increases as the water approaches towards the drain. If, radius of the drain is more then the total head loss is less. As the effective radius of gravel and sand packed pipes is more due to thick layer of envelope, therefore, total head loss is much less with these materials. Loss of head is more pronounced in fine textured soils due to low hydraulic conductivity. Therefore, the use of synthetic geo-textile fabric can only be justified in sandy soils because total head loss is very low due to high value of hydraulic conductivity [6].

Induced Seepage From The Canals

The shape of Type-I profile indicates that there is no hydraulic connection between the water table and water in the canal. Water seeps from the canal at a constant rate depending upon the soil characteristics and canal geometry. Canal seepage is not affected by the changes in depth to water table. Hence, with the installation of interceptor drains there will be no effect on the canal seepage and no induced recharge will take place. Such profiles canal be related to sites where the canal passes through fine textured soils and hydraulic conductivity of the sub-strata is relatively low.

The shape of Type-II profile indicates a very poor hydraulic connection between the water table and water in the canal. Water seeps from the canal at a constant rate depending upon the soil characteristics and canal geometry but at a relatively higher rate. Canal seepage is not affected by the changes in depth to water table. Hence, with the installation of interceptor drains there will be no effect on the canal seepage and no induced recharge will take place. Such profiles canal be related to sites where the canal passes through fine textured soils and hydraulic conductivity of the sub-strata is relatively more than that for Type-I profile.

The shape of Type-III profile indicates a hydraulic connection between the water table and water in the canal. Water seeps from the canal at a variable rate depending upon the depth of

water table, water level in the canal, soil characteristics and canal geometry. With the installation of interceptor drains there will be an increase in the canal seepage due to lowering of water table or induced recharge will take place. Such profiles can be related to sites where the canal passes through medium and coarse textured soils and hydraulic conductivity of the sub-strata is relatively high.

PUMPING STATIONS

Drains are laid at a gradient and outfall, flowing from both the upstream and downstream sides of the canal, into a pump sump. In Nawabshah Sub-project 54 pump stations, having total installed capacity of 126 cusec, have been constructed to pump 65 cusec of interceptor drain effluent. Turbine pumps coupled with vertical hollow shaft motors have been installed in a 10 ft diameter and 18 ft deep pump sump. Each pump station is equipped with two pumping sets of equal size. One pump and motor act as standby pumping set for most of the pump stations. Three pump sizes i.e 1.0, 1.5 and 2.0 cusec have been installed in the project. Motor ratings are 10, 15 and 20 HP, respectively, for the above mentioned pump sizes. Discharge pipes coming out from the pumps, installed within the pump sump, are joined outside the pump house and a single 8 inches diameter pipeline disposes of the drain effluent into the adjacent canal. Average length of the discharge pipe is about 80 ft. Disposal of the drain effluent was mostly into Amerji, Gajrah and Nasrat branch canals. However, 8 pump stations disposed of the drain water into small minor canals and faced disposal problems like resistance from the water users or due to closure of the channels. Pumps were installed on a concrete pedestal 6 inches above the pump house floor. During a canal breach flood water entered the pump sump and the pump impellers were choked with mud, floating matter and animals like fish and snakes. The pumps are not provided with strainers at the suction end.

Cost of the pump stations is very high and amounts to about 40 percent of the overall project cost. Cost of the pump stations can be reduced and hence certain changes were made in the design of future contracts.

In Sanghar and Mirpurkhas Sub-projects of LBOD Stage-1 Project 111 pump stations are proposed to be installed. Each pump sump will be 7 ft in diameter, 18 ft deep and equipped with one pumping set only. There will be no standby pumps and motors for this project. Reduction in the diameter of pump sump and the elimination of standby pumping set was aimed at to reduce the cost of the pump station. There are only two pump sizes i.e. 1.5 and 2.0 cusec. Total installed capacity of 111 pump stations will be 173 cusec. The drains are designed to intercept 160 cusec of canal seepage.

ECONOMIC JUSTIFICATION

Economic analysis was carried out during the year 1996 for the feasibility of interceptor drain installation in Sanghar and Mirpurkhas sub-projects. For these sub-projects six different interception rates, i.e. 0.15, 0.18, 0.20, 0.25, 0.30 and 0.35 cusec/1000 ft of drain, were adopted for the design of interceptor drains. Cost of the drain installation and benefits from the reuse of intercepted water were considered in the economic analysis. The analysis shows that the drains are economically feasible to be installed if drain interception rate is equal or more than 0.15 cusec/1000 ft of drain. Economic feasibility for the interceptor drain installation improves as the drain interception rate increases.

RECOMMENDATIONS

Following recommendations are made for the design of interceptor drains from the experiences of LBOD Stage-1 Project:

1. Extensive sub-surface investigations should be carried out before the design of interceptor drains. Additional cost incurred on investigations is compensated by the savings due deletion of interceptor drains in low seepage reaches.
2. Interceptor drains should be installed along canal reaches which are underlain by highly saline ground water and if tubewells were installed to intercept the canal seepage would yield saline water.
3. Interceptor drains shall be installed along canal reaches which are underlain by coarse textured formations so that more water flows to the drains. Drains shall not be installed along canal reaches where soil layers of low hydraulic conductivity are found within drain depth.
4. Canal reaches where depth to watertable, remote from the canal, is more than 8 ft, interceptor drains should not be installed.
5. Canal reaches where estimated drain interception rate is less than 0.15 cusec/1000 ft of canal length, interceptor drains should not be installed.
6. Drains should be installed as close to the canal as possible. In this way maximum canal seepage will be intercepted and length of the pump discharge pipe will be minimum.
7. Synthetic geo-textile fabric envelope performs well in sandy soils, therefore, can be used if natural gravel is very costly or not available.
8. Synthetic geo-textile fabric is a choice envelope material for the sites where gravel cannot be transported due to difficult soil conditions.
9. All the drain pipes should be tested, after installation, by pulling a steel bar ball through the pipes.
10. Drain water should be disposed off into main and branch canals only.
11. Pumps should be installed at least 2 to 3 ft above the ground surface and a strainer shall be provided at the suction end of the pump.
12. Cost of the pump station can be reduced by reducing the sump diameter, elimination of standby equipment and by using simple motor control panel.

CONCLUSIONS

Following conclusions can be drawn from the experience of interceptor drains installed in LBOD Stage-1 Project:

1. Interceptor drains are economically feasible if installed at proper location and according to proper design.
2. If, depth to watertable is shallow i.e. close to 5.0 ft, remote from the canal, two or more lines of interceptor drains can be considered for installation.
3. Quality of drain water is acceptable and is not hazardous to the canal water.

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TABLE: 1

DISCHARGES OF INTERCEPTOR DRAIN PUMP STATIONS

Pump Station Number	Q(pt) (cusec)	Q(com) (cusec)	Q(man) (cusec)	Q(smo) (cusec)
NAR-1	4.08	2.08	2.37	1.96
NAR-2	3.04	2.09	1.40	
NAR-3	2.06	1.21		1.07
NAR-4	1.11	1.16	0.88	0.65
NAR-5	3.12	2.17	1.93	
NAR-6	0.95	0.99	0.96	0.59
NAR-7	2.73	1.32	1.81	
NAR-8	0.86	0.96	0.67	
NAR-9	1.57	1.26	1.44	1.11
NAR-10	1.03	1.22		
NAL-1	4.80	2.13	1.85	
NAL-2	6.41	2.48		
NAL-3	1.05	1.19	0.97	
NAL-4	3.52	2.11	1.39	
NAL-5	0.57	0.96	0.44	0.57
NAL-6	3.43	1.87	1.77	1.70
NAL-7	1.76	1.01	0.89	
NAL-8	0.68	0.86	0.38	
NAL-9	0.80	1.17	0.79	
NAL-10	2.72	1.10	1.47	1.23
NGR-1	0.78	0.64	0.52	0.27
NGR-2	6.66	2.74		2.12
NGR-3	2.75	1.51	2.10	1.50
NGR-4	2.64	1.42	1.57	1.40
NGR-5	4.30	2.41		2.28
NGR-6	2.54	1.51	2.10	2.12
NGR-7	5.30	1.95	2.58	2.28
NGR-8	1.56	1.31	1.06	
NGR-9	0.45	1.04	0.47	0.65
NGL-1	0.56	0.94	0.60	0.82
NGL-2	4.38	2.27	2.66	2.29
NGL-3	3.62	2.42	2.58	2.42
NGL-4	0.80	1.36	0.64	0.30
NGL-5	1.03	1.17	0.85	0.54
NGL-6	3.12	1.54	2.37	1.73
NGL-7	3.18	2.27	2.56	1.33
NGL-8	2.66	1.20	1.77	
NGL-9	3.63	2.21	1.43	1.71
NGL-10	2.05	1.46	1.08	
NGL-11	2.92	1.34	0.81	1.39
NNR-1	1.23	1.30	1.37	
NNR-2	1.52	1.46		1.83
NNR-3	1.68	1.23	2.00	
NNR-4	2.08	1.41	1.52	
NNR-5	4.30	1.39	1.54	
NNR-6	2.04	1.39	1.90	
NNR-7	1.38	1.24	1.03	
NNL-1	2.99	2.14	2.27	2.08
NNL-2	1.52	1.34	1.79	
NNL-3	1.63	1.34	1.66	
NNL-4	1.68	1.17	0.99	
NNL-5	1.53	1.14	1.05	
NNL-6	0.68	0.88	0.48	
NNL-7	3.26	2.20	1.55	
Average	2.38	1.51	1.42	1.41
Total	128.7	81.7		

Q(pt) Discharge at the time of Performance Test during the period May-1991 to May-1992.

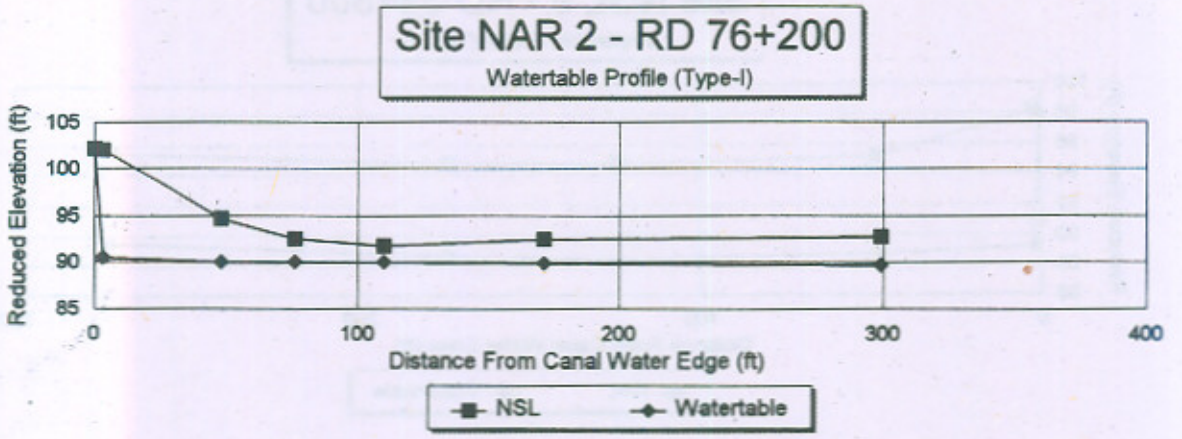
Q(com) Discharge at the time of Commissioning during the period Jul-1992 to Sep-1992.

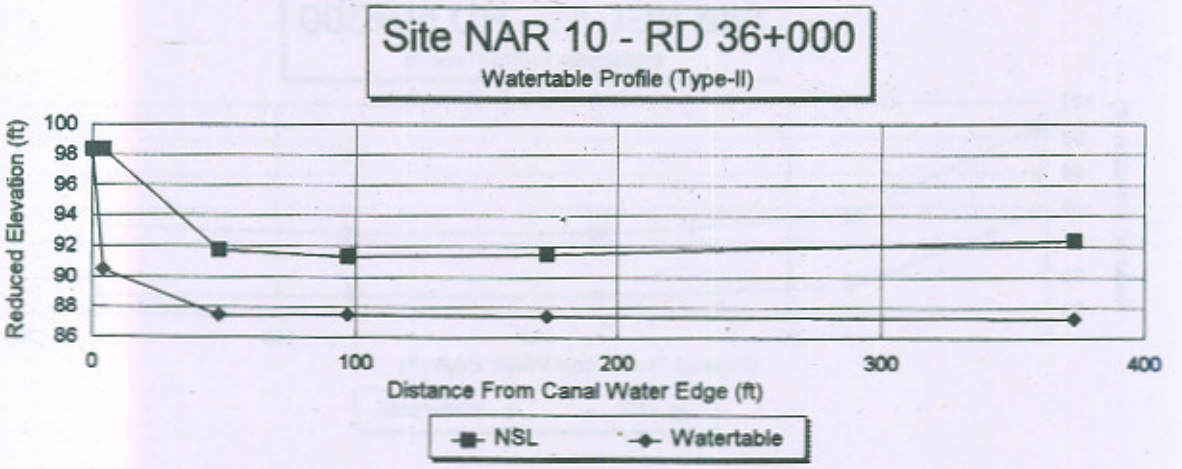
Q(man) Discharge during Maintenance period period Jul-1993 to Aug-1993.

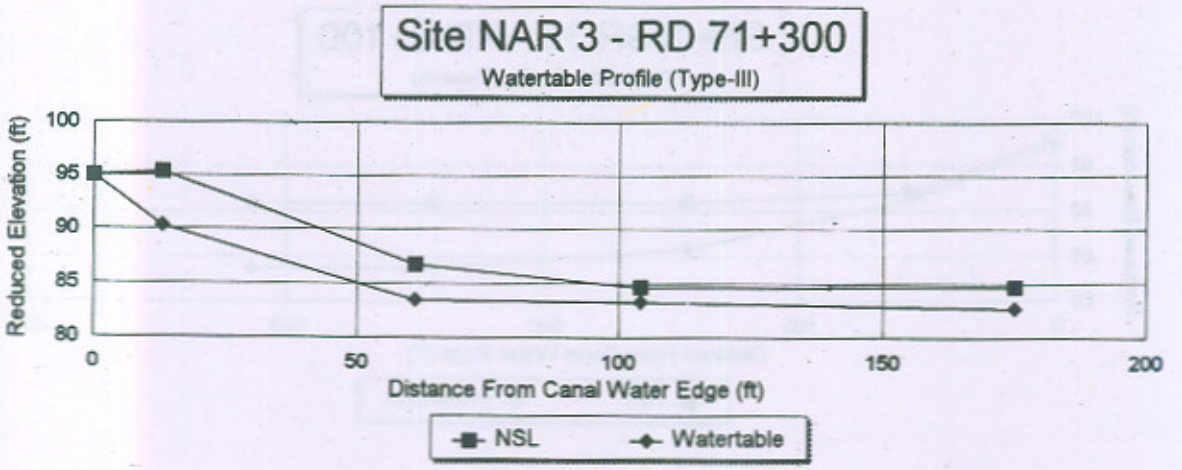
Q(smo) Discharge measurement by SMO, WAPDA during the period Aug-1995 to Dec-1995.

pec-fig4.wk1

NAWABSHAH INTERCEPTOR DRAINS Figure 1
WATER TABLE PROFILES
CANAL: AMERJI BRANCH



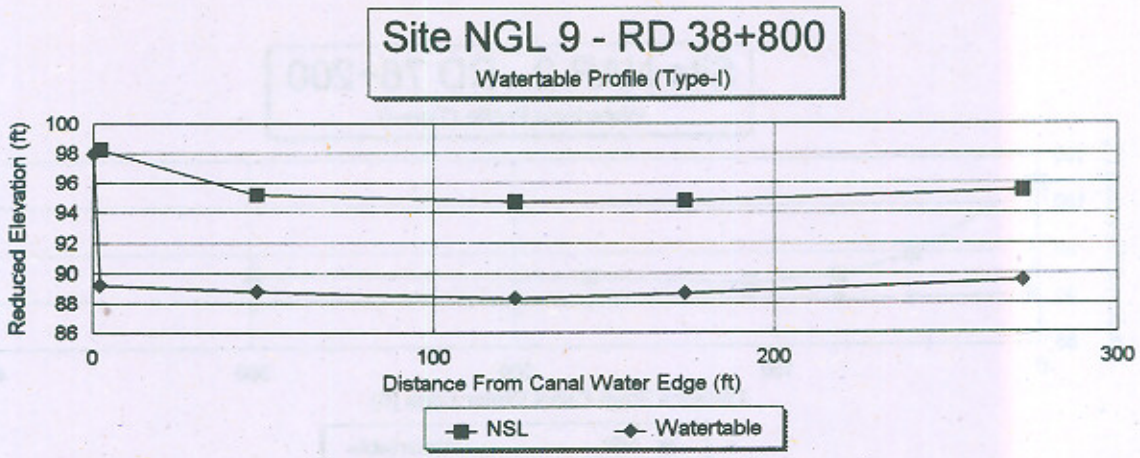


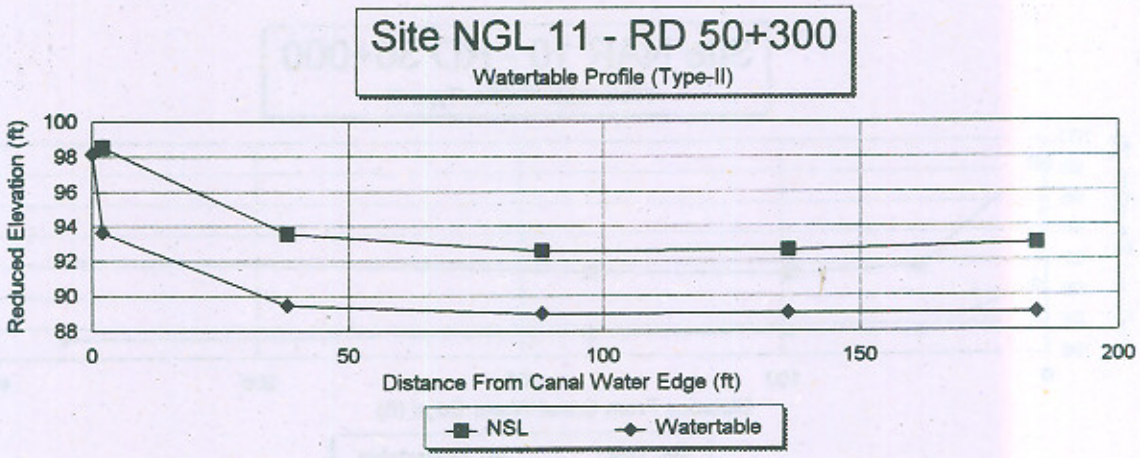


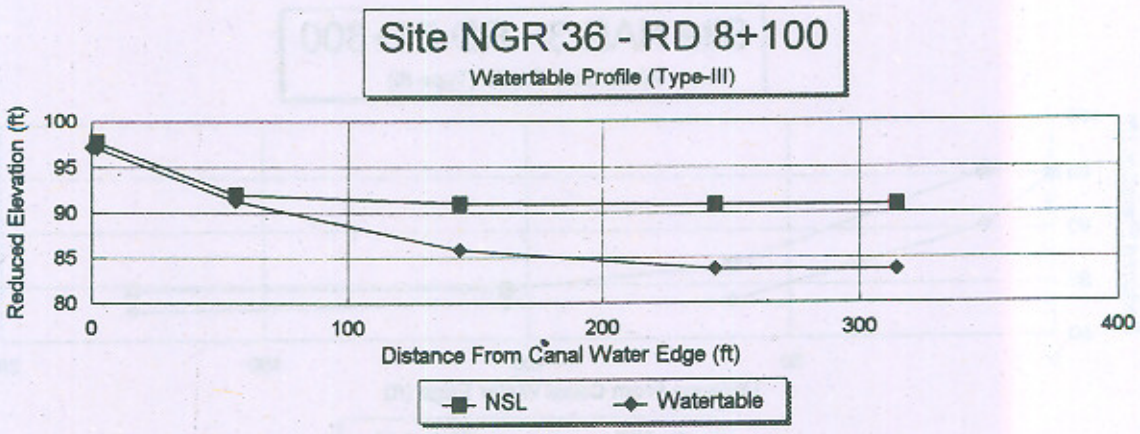
pec-fig1.wk1

NAWABSHAH INTERCEPTOR DRAINS
WATER TABLE PROFILES
CANAL: GAJRAH BRANCH

Figure 2

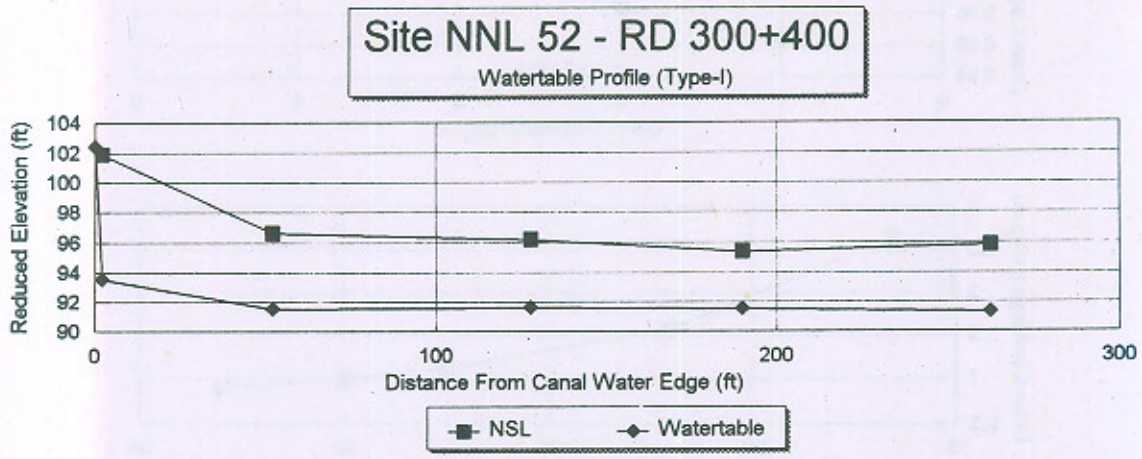


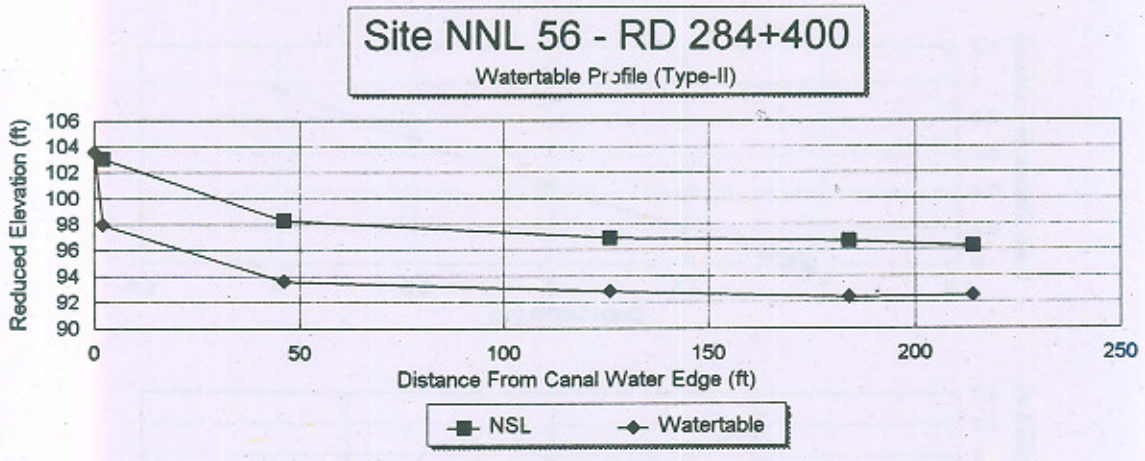


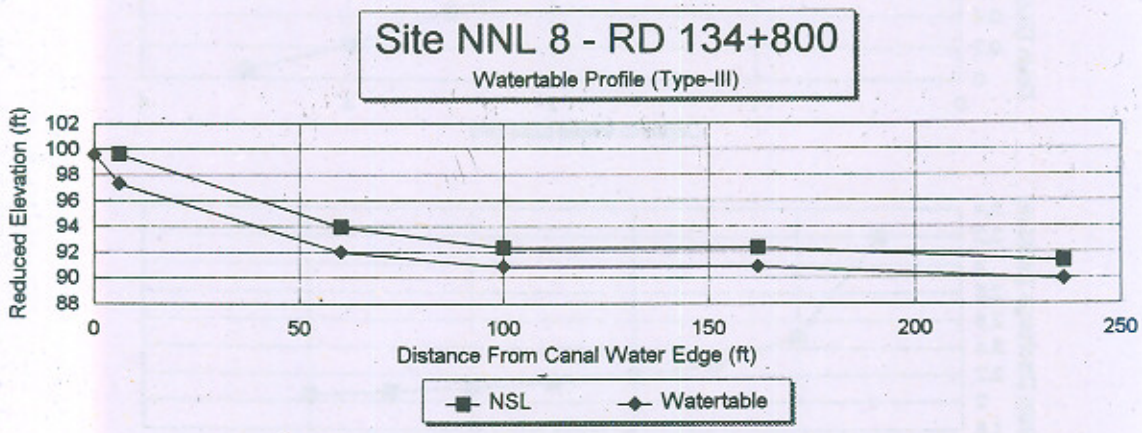


pec-fig2.wk1

NAWABSHAH INTERCEPTOR DRAINS Figure 3
WATER TABLE PROFILES
CANAL: NASRAT BRANCH

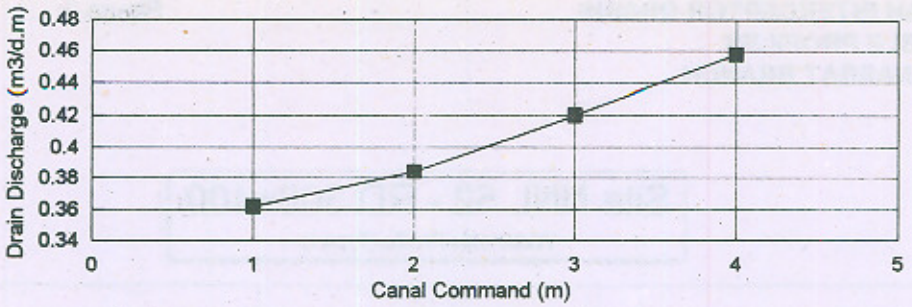


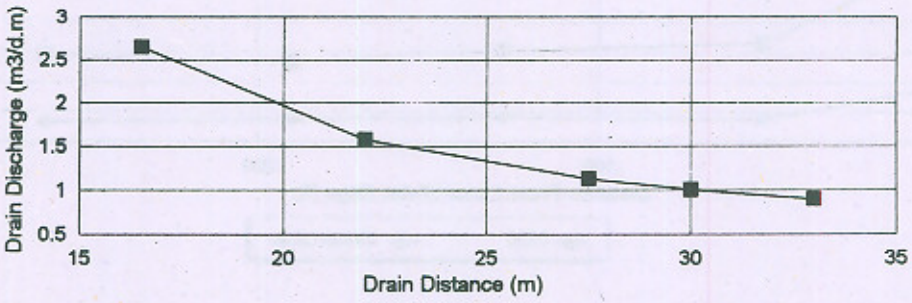


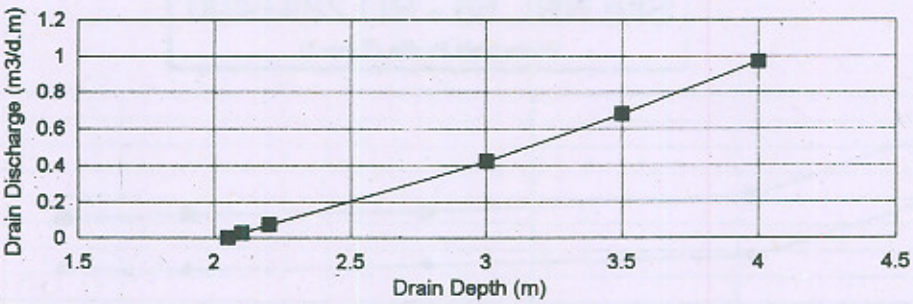


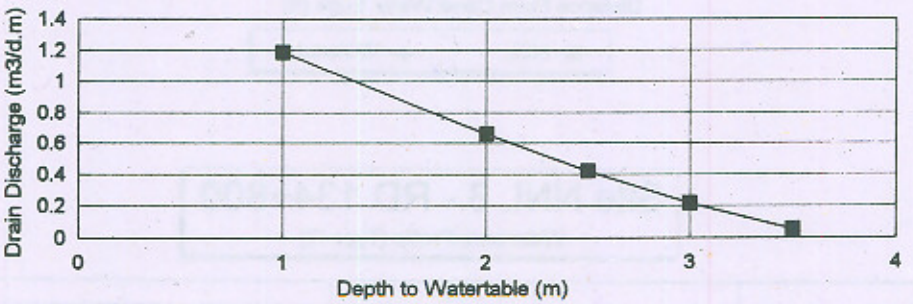
pec-fig3.wk1

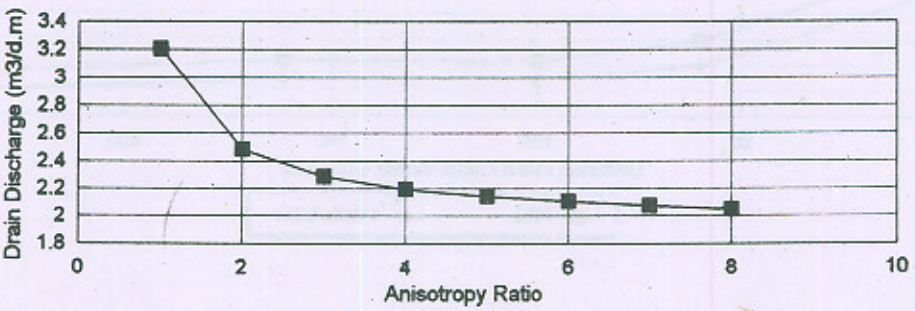
Figure 4
INTERCEPTOR DRAINS





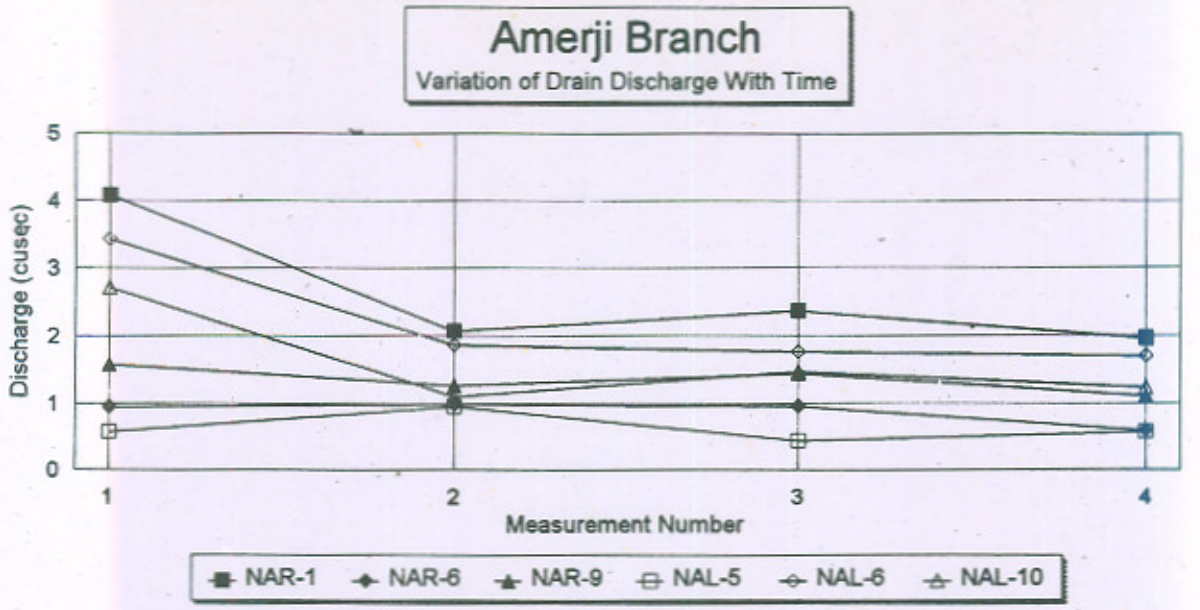


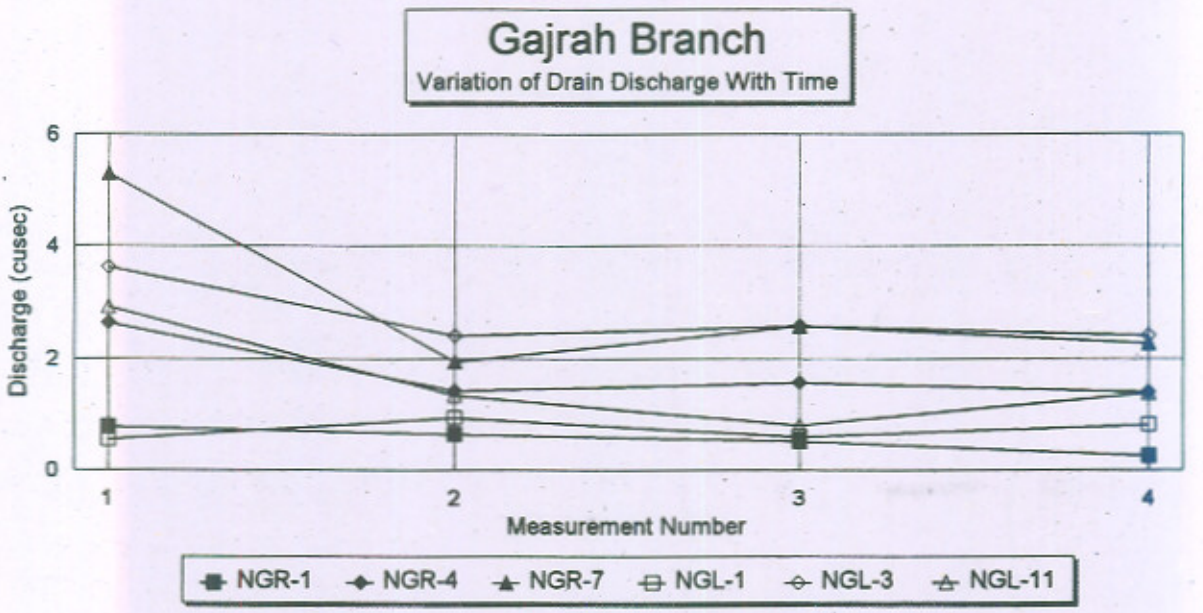


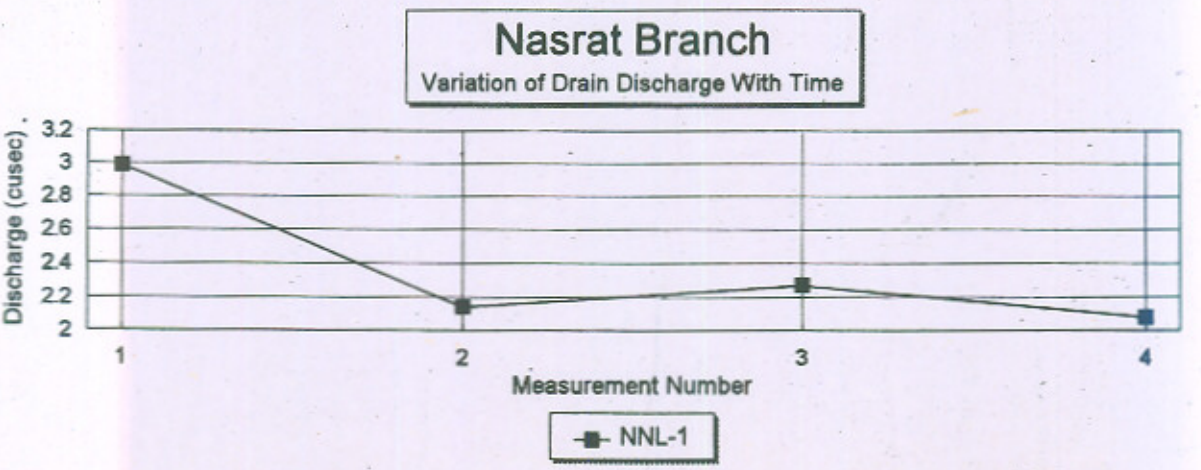


pec-fig4.wk1

Figure 5


Amerji Branch
Variation of Drain Discharge With Time
Discharge (cusec)
Measurement Number
NAR-1
NAR-6
NAR-9
NAL-5
NAL-6
NAL-10


Gajrah Branch
Variation of Drain Discharge With Time
Discharge (cusec)
Measurement Number
NGR-1
NGR-4
NGR-7
NGL-1
NGL-3
NGL-11


Nasrat Branch
Variation of Drain Discharge With Time
Discharge (cusec)
Measurement Number
NNL-1