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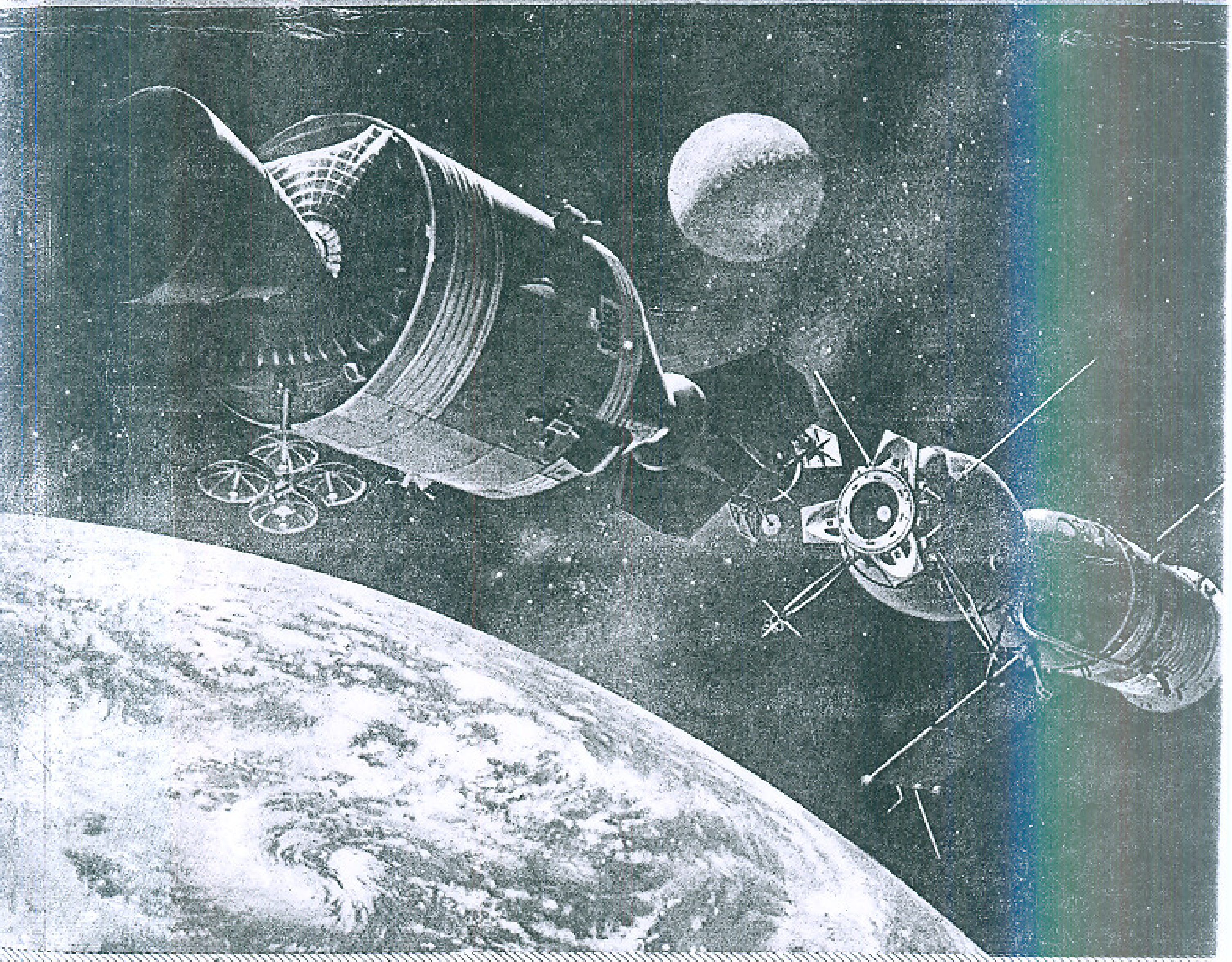

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In this Issue

TITLE COVER

Apollo and Soyuz spacecrafts just before docking in orbit around the earth.

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Silent Spectators

After centuries of dreaming and scheming, scientists and engineers have broken the gravity barrier to invade the interplanetary space and man is beginning to violate the virginity of heavenly bodies.

The average person pauses to wonder whether he is looking through a magic mirror or witnessing reality as he watches manned space-ships docking in orbit around the earth or landing casually on the surface of the moon-all from the cosy comfort of his living room. He understands little of the marvels that unfold across his television screen but seems complacently happy over man's remarkable triumphs, often falling into the misconception that modern technology will enable man to conquer the universe.

Nothing could be farther from the truth. In fact, the sum-total of man's exploits in space can be compared to someone just beginning to learn the alphabets of a highly complex new language in which his vocabulary is still less than elementary and his grasp of grammar or usage almost nil.

Stretching beyond the moon, which now carries man's foot-prints, lies a fantastic expanse of virtually unknown universe whose sheer immensity dwarfs man and all his achievements into stark insignificance. Nearest home are the planets of our solar system, beyond them the stars of the milky-way and, farther still, countless galaxies with myriads of other stars and, possibly, worlds similar to our own. The problems of intersteller travel within our galaxy and beyond the milky-way are vastly more complex than the problems of manned travel within the solar system. Some of these problems defy even a theoretical solution at the present moment. In such a vast and complex scheme of things, how far can man reach ? How far does he dare dream ?

Man's dreams have a remarkably consistent record of fulfilment. Radio, Television. Telephone, Camera, Aeroplane and Moon Rocket are just a few of the many wild dreams that came true. It is, therefore, quite possible that, one day, man will develop new technologies, overcome the obstacles that seem insurmountable in the light of his present knowledge and reach the inaccessible corners of outer space. Apparently, in the estimated 6,000 million years remaining before our sun turns into a red giant, there is time enough to discover, explore and inhabit new worlds.

There is, however, another side to this picture. The modern man presents a classic illustration of an old proverb that the star-gazer is at the mercy of puddles on the road. With his space-age magic carpets, man is at home millions of miles from his traditional environment but finds himself unable to cope with some basic problems nagging him on this tiny planet. Hunger, poverty, disease and war are rampant in the world and there is no end to man's ruthless exploitation of man. Add to this the ever increasing hazards of modern destructive weapons or environmental pollution, and man's future appears to be dangerously uncertain. The optimists amongst us, however, maintain that man has enough sense and resillience to cope with himself or his present knowledge and not just survive but continue to thrive.

Here, in Pakistan, we have been silent spectators of the space-age drama that has gripped the world for the last fifteen years. It is true that in any field of human endeavour a few lead and others follow but, right now, we do not have the means or the knowledge even to follow in the race to the stars. This unhappy position we share with a majority of nations, if that is any consolation. However, we do have the resources and knowledge to improve the living standard of our common man and there is no reason why we should remain silent spectators of the miseries of our teeming millions.

The common man in Pakistan spends his entire life struggling, sweating and toiling relentlessly, only to eke out a meagre sub-standard living. He is unable to provide even the absolute minimum care and comfort for himself and his family. He is compelled to live in sub-human conditions, eat food that is unfit for human consumption and go without medical aid or any other amenities whatsoever. It is a matter of great shame and concern that such conditions prevail after 28 years of living as a free nation. After all, what good is freedom and all the wealth of human knowledge and capability if man's lot on this earth remains as pitiable as ever.

We may not be in a position to join the race to the stars, yet, but with our manpower & other available resources we can certainly transform this country into a small paradise on earth and make life really worth living. Here is a challenge equal to, if not greater than, the challenge of space exploration which our engineers, scientists, planners and administrators can, and must, meet.

Irrigation and Power Section

Radical Remodelling of Dipalpur Canal

by

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SYNOPSIS

In normal Irrigation practice remodelling of existing channels is indicated when one finds chronic shortage of supplies at the tails ; widespread complaints of individual outlets ; drowned bridges ; excessive silting up and frequent silt clearance ; necessity for running excessive supply over the authorised full-supply discharge at head to feed the tail ; and poor command at head of a distributary or at heads of minors. However, in case of Dipalpur Canal none of the above troubles was diagnosed but it was a unique problem, perhaps never hitherto experienced in the history of Punjab Irrigation.

The partition of the sub-Continent in 1947 resulted in mass killings, broken homes and seggregated families in the two parts of undivided India which formed two sovereign states of India and Pakistan. The unjust and unscrupulous award of the Boundary Commission headed by Mr. Radcliffe did not spare even the natural and man-made public utilities while demarcating the boundaries of the newly formed states. The compact geographical unit of Indus Basin was slashed into two parts so ruthlessly that certain barrages and sources of supply were apportioned to India while the off-taking canal-systems were awarded to Pakistan. The Dipalpur Canal was also one of the worst affected victims of the indiscriminate and trecherous award given by Radcliffe. After ratification of the Indus Waters Treaty of 1960 Dipalpur Canal was completely deprived of its historic source of supply from Ferozepur headworks and Pakistan had to provide a completely new source of supply to the entire system with a discharge of 6,950 cusecs at the head. Incidentally the Punjab Government had built B.S-I Link in 1954 to make up the shortage of supplies at Suleimanki Headworks. This Link, while traversing from Balloki to Suleimanki, cuts the Dipalpur system into two parts-one on the right of B.S-I Link and the other on its left. Whereas the

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main stem and distributaries of Dipalpur Canal on the right side of B.S. Link could easily be fed from the link itself, the channels on the left side had no source at all. Ultimately the Punjab Government arranged to feed the upper stem of main canal and its distributaries falling on the left of B.S.I Link from Marala Headworks on Chenab river through M.R. Link, a Sub-link and the B.R.B.D. Link, but the discharge requirement on this system was only 2,283 cusecs against an original value of 6,950 cusecs. This needed a radical remodelling of the main canal and the distributaries and their structures in respect of reduction in lengths, discharges, bed widths and changes in slopes. The classical methods of remodelling could not be applied to these channels due to the abnormal extent of reductions and this generated a series of controversies among the various engineering authorities dealing with this subject. How this vexed problem of remodelling the channels and the controversial issues were ultimately settled has been described in the subsequent paras of this paper, for the information of professional engineers, by the authors who were responsible for the Design and Construction of the Remodelling works from the years 1962 to 1966.

1.0 The Problem

With ratification of the Indus Waters Treaty of 1960, the longstanding dispute between Pakistan and India over the distribution of waters of the Indus River system was resolved. In order to implement the provisions of the Treaty, however, massive multipurpose works were necessary to impound, regulate and transfer waters of the rivers located within the Indus River Basin which collectively form the Indus Basin Project. The specific works of the Indus Basin Project (I.B.P.) included : two large storage reservoirs, one on the Jhelum River at Mangla and another on the Indus River at Tarbela ; five barrages, namely, Sidhnai on the Ravi, Mailsi Syphon on the Sutlej, Rasul on the Jhelum, Qadirabad on the Chenab and Chasma on the Indus ; three systems of new Link Canals ; and the remodelling of various existing link canals, barrages and canal systems. The new link canals constructed in three phases consist of eight Links, viz. Trimmu-Sidhnai, Sidhnai-Mailsi and Mailsi Bahawal (First Phase) ; Rasul-Qadirabad, Qadirabad-Balloki, and Balloki-Suleimanki-II (Second Phase) ; and Chasma-Jhelum and Taunsa-Panjnad (Third Phase).

One of the existing canals seriously affected by the Indus Waters Treaty was the Dipalpur Canal, which was originally fed from Sutlej river through Ferozepur Head-works but was deprived of its historic source of supply. In order to maintain irrigation supplies in this system alternative sources had to be provided.

1.1 Solution of the Problem

The Balloki-Suleimanki-I Link ; already constructed by Pakistan Government in 1954, before signing of the Treaty; while traversing the doab between Ravi and Sutlej rivers intercepted the Dipalpur Canal system and divided it into two portions as shown in Figure-1. It was proposed that the area and parts of the channels of this system falling on the left of B.S-1 Link would be irrigated with supplies taken from the Chenab river through the existing M.R. Link, Sub-Link and the B.R.B.D. Link. The area and the channels lying on the right and western side of B.S. Link could be irrigated from the link itself by means of off-take regulators provided at suitable locations to feed the intercepted distributaries and the main stem of the canal. Fortunately, such regulators had already been envisaged and built during the construction of B.S-I Link. The water requirements of these channels were proposed to be met from Balloki-Suleimanki-I Link. Now the main problem was to feed the head reach of the main channel and its off-takes, intercepted and located on the left side of B..S-I Link. A project to cater for the remodelling of this portion of Dipalpur Canal and its off-takes was prepared in 1961 by the Remodelling Organization of the Irrigation Department which is briefly summarised hereunder :

2.0 Brief Summary of 1961 Project

The following were the salient features of the original project of 1961 :—

2.1 Dipalpur Canal from its head to

R.D. 18,500 was to be abandoned because the feeding link from tail B.R.B.D. Link joined at this point (See Figure-1).

2.2 Dipalpur Canal would also be abandoned from R.D. 2,08,367 to R.D. 2,69,056 where it now crosses B.S. Link-I.

2.3 Dipalpur Canal would receive 2,000 cusecs at R.D. 18,500 to feed its off-takes lying on left of B.S-I Link. The discharge provision of 2,000 cusecs at R.D. 18,500 was based on the supplies earmarked for Dipalpur Canal at Tail of B.R.B.D. Link.

2.4 Reduction in discharges and lengths of such channels was considerable as shown in the Appendix 'A'. All the channels would be remodelled for the reduced discharges.

2.5 Tightening of sections of channels was proposed by earthen spurs protected by staking and bushing at the noses.

2.6 Almost existing. Full Supply Levels and Slopes were adopted in the revised L-Sections with a view to cause the least disturbance in the existing irrigation system. Flatter slopes despite reduced discharges were adopted to encourage the silting required in the channel.

2.7 Masonry works were to be remodelled only to cater for the tightening of sections.

2.8 Manuwal distributary lying on the left of B.S. Link was proposed to be fed from the Link itself by giving reverse slope to the channel connecting the existing channel.

3.0 Cost Estimate Original Project of 1961

The cost estimate framed according to the original thinking and proposals at the rates prevalent in 1961 was at Rs. 10,75,500 as abstracted in Appendix-'B'.

4.0 Review of the Original Project by WAPDA Consultants

4.1 M/S T&K's Review of 1962

M/s T&K in their review submitted during October and December, 1962 observed that further consideration ought to be given to designing the remodelling sections throughout their lengths for higher silt factors and corresponding steeper slopes than those proposed by the Irrigation Department. Adoption of higher silt factors was based by them on the fact that M.R. Link, which in future would feed the Dipalpur Canal System through B.R.B.D. via a Sublink, was being remodelled to a slope of 1/8000 with a corresponding silt factor of 1.08, and Sublink has been remodelled for a silt factor of 1.08 with a corresponding slope of 1/6666. In order to impose the steeper slopes they recommended elimination of falls, raising of banks, where necessary; silt clearance in tail reaches; raising of bridges and remodelling of head regulators and falls etc.

4.2 Messrs Harza Engineering Co. International's Thinking

Harzints presented their thinking on the problem of remodelling Dipalpur Canal during January, 1963. The following points arising out of reduction in discharge and change in source of supply were discussed and concluded by them.

4.2.1 **Change in Sediment Conditions Due to Change in Source of Supply**

Harza's conclusion on this point was that the quantity and grade of sediment that would be conveyed to the Dipalpur system would be no greater and, possibly less, than under the existing conditions.

4.2.2 **Loss of Command at Off-takes Due to Lower Full Supply Levels Caused by Reduction in Discharge**

It might be cheaper and more satisfactory to construct Regulators fitted with needles, where such do not exist to control levels for command in off-takes than to remodel the canal for reduced discharge.

4.2.3 **Possible Change in Slope Due to Reduction in Discharge**

Sediment deposition due to low velocities would lead to changes in canal slopes and cross-sections. It was, however, by no means certain that the changes would lead to steeper slopes than at present.

4.2.4 **Meandering and Bank Erosion Which Might Develop Due to Reduction of Discharge**

Unless corrective measures were taken the channel would meander between the existing banks. In view of the low velocities and discharges involved, it was believed that erosion, if it occurred, could be controlled by normal maintenance even if no corrective measures were taken initially.

4.2.5 **Seepage Losses**

Changes in discharge not accompanied by reduction in wetted area might cause seepage losses forming a significant part of the total canal discharge. The difference in absorption losses between the present and the remodelled conditions for the canal between R.D. 18,500 to 2,08,357 would be 120 cusecs at the rate of 8 cusecs per million sq. ft. which alone would not justify the remodelling.

4.2.6 **Harzint's Conclusions**

In the end they concluded that :

(a) Remodelling works proposed by Remodelling Organization were in general needed to cater for long term changes in the regime of the system.

(b) A change in source of supply did not warrant remodelling of any channel in which there would be no change in discharge.

(c) Remodelling programme should be confined to the works needed to ensure command of off-takes and outlets.

(d) Channel stabilization and raising of banks be deferred for several years until more is known of the behaviour of the channels under the new conditions.

5.0 **Need for Revision of Project**

The different suggestions offered by various reviewing agencies regarding the adoption of silt factors and corresponding bed slopes changed the entire concept of the original project of 1961 and necessitated the need for its revision.

Various silt factors tried by various agencies at different occasions on which alternative studies for the system were carried out are shown tabulated in Appendix-'C'. During the course of discussions on the subject it was realised by all agencies that the problem of Remodelling Dipalpur Canal system was not as simple as it looked and, therefore, needed a thorough consideration. WAPDA, therefore, decided to revise the scheme. Keeping in mind the views expressed by the various agencies, the directive from WAPDA to revise the scheme and by virtue of further studies on the subject including CHOP data, Remodelling Organization re-appraised the whole problem and prepared the revised Project Report and Estimate as described in the subsequent paragraphs.

6.0 Revised Project August, 1963 Discussions

6.1 General

Before giving the details of the Revised Project of August, 1963, the various points involved in the intricate remodelling of the Dipalpur Canal System are discussed and concluded in the following paragraphs :

6.2 Capacity of the Canal at Head

The revised capacity of Dipalpur Canal at R.D. 18,500 (which would virtually be the new head) worked out to be 2,283 cusecs as shown in Appendix-'D'. The capacity statement given in this Appendix took into consideration the normal losses at the rate of 8 cusecs per million sq. ft. of the wetted perimeter according to the proposed channel dimensions. The provision of a discharge of 2,000 cusecs at R.D. 18,500 in the original project was based on the supplies earmarked for Dipalpur Canal at the tail of B.R.B.D. Link.

6.3 Absorption Losses

A comparative study given in Appendix-'E' indicates that there is practically no reduction in the absorption losses over the prevailing ones if the reduced discharges are run in the existing sections of the canal. In the existing conditions the losses have been estimated at 315 cusecs while if the reduced discharges are run, without tightening the sections, the losses would be 304 cusecs. This figure would, however, be still higher if we consider the effects of ponding upstream of control points in the main canal. Losses from the proposed channel dimensions with reduced discharges have been estimated at 125 cusecs and as such an extra 179 cusecs would be necessary to allow for absorption losses in case the tightening of the section is proposed by spurs. These losses are a significant percentage of the total discharge available at the head of a non-perennial canal on which the off-takes cannot be run by rotation to make up for the shortage.

6.4 Variation of Silt Factor With Distance Due to Silt Attrition

According to one school of thought it is believed that due to the phenomenon of silt attrition the silt particles become finer and finer as they travel from head to tail of a canal system. This is evident from the rivers where pebbles are ground down first to coarse sand and then to fine

6.5.2 Problem of Time for Silting Up

Besides the above argument in favour of shifting the bank, it was calculated that the silt deposit required for silting the main canal and its major off-takes to the required sections with the help of spurs worked out to be 24,04,00,000 cft. and the time taken by this process would be 15 years. The main canal alone needed 21,67,00,000 cft. of silt deposit to attain the required section and the time required would be 13 years.

It is, therefore, advisable to shift one bank of the canal and thus reduce considerably the quantity of silt deposit required and the absorption losses and also bring down the channel to required regime in a period of three to four years.

6.5.3 Problem Due to Reduction in Velocities

The idea of silting the section of main canal by help of spurs had also to be dispensed with in view of the fact that the velocities likely to be attained in the various reaches of the channel, if the reduced discharges are run in the existing sections, vary from 0.41 feet/sec. to 1.12 ft./sec. which are too low to transport any silt beyond the first reach. So, the phenomenon of silt transport will travel to the downstream reaches very slowly and by that time the spurs constructed to encourage silting may not be existing.

6.5.4 Additional Advantages in Shifting of Bank

The proposal of shifting one bank has the following additional advantages :

(a) It eliminates the necessity of daff walls or ditch channels which would, otherwise, be essential to feed the direct outlets.

(b) It also provides better command to the off-takes sited away from the existing control-points immediately after the change over.

(c) It reduces the expected head across the falls which, otherwise, would be much more and result in more extensive and expensive remodelling.

(d) It will save heavy recurring expenses which, otherwise, will have to be incurred for the maintenance of the spurs till the canal is silted up to the required section.

6.5.5 Exception to Shifting of Bank

In the reach RD 18,500 to 43,000 of Dipalpur main canal, spurs on one side only have been proposed because of the following reasons :

(a) There are no off-takes to be fed in this reach.

(b) Absorption losses in this reach would be nominal because the sub-soil water level is above the bed level of the canal.

(c) These spurs will serve as an experiment, and check meandering of the channel within the existing banks.

6.6 Elimination of Falls

It is argued according to a certain school of thought that if we impose steeper slopes, command would automatically improve and hence the existing falls could be eliminated to avoid raising of banks and changes to structures but this is far from a realistic view of the problem. The control points are always essential at suitable intervals in order to maintain the designed full supply levels which are in turn needed to command the outlets sited upstream of such structures. Moreover control points keep the different reaches of a channel independent of each other, otherwise any change in the regime of one reach due to some artificial or natural phenomenon will affect the entire channel as a whole, which is not desirable. In fact, only those falls whose exclusive object was to lower the full supply line in a country side having a slope steeper than the canal slope, to avoid abnormal filling in channels, could be eliminated without causing any repercussions.

7.0 The Revised Project 1963-Salient Features and Design

7.1 Salient Features

Important points and proposals of the Revised Project are briefly described as below :

7.1.1. Reduction in Lengths and Discharges of Channels

Dipalpur Canal is to be abadoned from head to R.D. 18,500 and from R.D. 2,00,367 to R.D. 2,69,056 as proposed in the original project. Some minor adjustments in the proposed tails of distributaries have also been made to provide tail clusters for at least two outlets subject to the limitations on the length of water courses. Proposed lengths of channels are indicated in Figure-1. A comparison of the existing and proposed lengths and discharges of the channels is given in Appendix-A.

7.1.2. Design of Channels

7.1.2.1 Adoption of Silt Factors

While designing the channels proposed silt factors have been fixed with due regard to the following :

(a) Existing silt factors. They have been worked out from the Lacey's Discharge-Slope relationship $S = \frac{(f)\ 5/3}{(Q)\ 1/6} \times 0.000542$ because it has been concluded in para 6.4 that the average grade of silt reaching this canal after the change-over is not likely to be coarser than that being transported into the system at present. In calculating the existing slopes, average conditions of the reaches were considered.

(b) Silt factor of the parent channel- As far as possible the value of 'f' in the offtaking channels have been adopted the same as that adopted in the upstream reach of the parent channel at the point of offtake.

(c) Chop Data Tabulation 1962. They also indicate that the grade of silt in Marala waters reaching Dipalpur Canal is not likely to be coarser than that of Sutlej waters being supplied at present. Silt factors finally adopted in the Revised Project have been shown in Column 11 of Appendix-'C'.

After adoption of silt factors as explained above, channel dimensions and regime slopes were worked out by following the Lacey's equations which result in remodelling of existing channel sections for increased slopes resulting from the reduction in discharges.

7.1.2.2. Fixation of F.S. Levels

F.S. Levels at the new tails have been fixed with due regards to the existing commands of offtakes but in cases where the F.S.L. was governed by the command of the areas on the lower reaches of the channels (and now served by B.S. Link-I) and was higher than required, the same has been proposed to be lowered to avoid excessive raising in the upper portion of the channel.

7.1.3. Remodelling Proposals

7.1.3.1. Tightening Section of Main Canal

Tightening section of the main canal has been proposed by shifting in of the non-patrol bank as shown in the plan in Figure-3 except for the reach R.D. 18,500 to 43,000 in which earthen spurs have been suggested on one side only as shown in Figure-4. For adopting the section of the new bank the main canal has been treated as a branch because the magnitude of its discharge and location at the tail of a long canal system does not justify retention of its old status of a Main Canal.

7.1.3.2. Tightening Sections of Distributaries

Tightening the sections of distributaries, where required, has been mostly proposed by killa-bushing spurs as shown in Figure-5. However, where the reduction in discharge and bed width is abnormal and the channel is not likely to silt up in a reasonable period shifting of one bank has been proposed.

7.1.3.3. Remodelling of Falls and Regulators

All the Falls and Regulators have been proposed to be remodelled against increased heads across, reduced water-ways and raised bed levels.

7.1.3.4. Elimination of Unnecessary Falls

Falls whose exclusive object is to lower the F.S. Line in a steep country-side have been proposed to be eliminated in the ultimate conditions while for the present most of them have been allowed to exist as they will help in early silting up of the channel to required sections and attaining the proposed F.S. levels.

7.1.3.5. Treatment of Bridges on Main Canal

No raising of bridges has been proposed in the main canal. However, side-slopes of new banks will be brick-pitched to guard against erosion.

7.1.3.6. Treatment of Bridges on Distributaries

Bridges on Distributaries where necessary have been proposed to be raised by jacking up where the decking consists of an R.C. slab and by reconstructing the decking in the case of arches.

7.1.3.7. Daff Walls for Feeding Isolated Outlets

For feeding certain isolated outlets beyond the effect of control points "daff walls" have been proposed to raise the F.S. Levels locally.

7.1.3.8. Flexible Outlets for Locations with Changing F.S.L.

In the reaches away from the influence of control points, as the proposed F.S.L.

will be attained gradually, flexible pipe outlets capable of cheap adjustments will be fixed.

7.2. Design and Proposals for Individual Channels

Detailed notes on the designs and proposals for individual channels have been dealt with in Appendix-G of the Revised Project and Estimate for Remodelling Dipalpur Canal System-1963 and need not be dealt with in this paper.

7.3 Hydraulic Summaries

Summaries of hydraulic designs of all the channels were dealt with in Appendix-H of the Revised Project of 1963. Summary of the Dipalpur Main Canal is attached as Appendix-'F' to this paper.

7.4 Longitudinal Sections of Channels

L. Sections of all the 13 channels of Dipalpur Canal System showing last designed, existing and the proposed data were presented as Volume-II of the Revised Project, 1963. However, a reduced scale L-Section of Dipalpur Main Canal is attached as Figure-6.

7.5 Revised Project-1963-Cost Estimate

The cost of the Revised Project of August, 1963 was estimated at Rs. 56,65,000 as shown in the Abstract of Cost attached as Appendix-'G'.

8.0 Changed Proposal for Remodelling of Dipalpur Main Canal

8.1 A New Project for Dipalpur Main Canal

Remodelling work on Distributaries of Dipalpur Canal was completed during 1964-65 as per "Revised Project Report and Estimate for Remodelling D/Canal System Vol-I (Text) August, 1963". The Remodelling of main Dipalpur Canal was not taken up as per Project mentioned above as the proposals contained therein were again changed and also the work of remodelling of main canal was to be implemented under the financial control of the Central Government for which a separate administrative approval was required. As a result of this change a separate project for the Remodelling of Main Dipalpur Canal was prepared.

The broad features of this Project were as follows :

8.1.1. Dipalpur Canal was to be abandoned from head to R.D. 18,500 and from R.D. 2,08,367 to R.D. 2,69,056, and only portion from R.D. 18,500 to 2,08,367 was to be remodelled. The following table shows the percentage reduction in discharge and bed width of main canal in various reaches :

Reach R.D.	Discharge in Cs.		Bed Width in Feet		Ratio of Proposed to existing expressed as a percentage.	
	Last Designed	Proposed	Last Designed	Proposed	Disch :	Bed Width
18500	6950	—	—	—	—	—
35870	6861	2283	276	110	33	40
45600	6493	2257	266	110	33	41
56748	6493	1895	252	100	29	40
92000	4904	918	172	70	19	41
113412	4815	760	175	63	16	36
141000	4815	749	175	62	16	35
157390	4454	733	157	62	16	40
174007	2696	340	106	41	13	39
208367	2696	317	106	38	12	36

In view of the heavy reduction in the discharge and bed width of the Main Canal, it was decided to tighten the section by shifting of the non-patrol bank. This decision was confirmed in the 27th meeting of the Indus Basin Development Board held on 31st December, 1964. The top width of the bank to be shifted was kept as 20′ in the reaches where the discharge was more than 500 cs. while it was only 12′ where the discharge was less than 500 cs. This was in accordance with the decision taken in the 29th Meeting of the IBDB held on 14.7.1965.

8.1.2. In order to feed the high level Fateh Mohammad Disty system, which off-takes from R.D.1,56,860 L. Dipalpur Canal, F.S. Levels of Main Canal had been raised by 1.05′ from the D side of fall R.D. 1,13,400 to R.D. 1,57,390. Banks in the reach were accordingly raised, having a free board of 2.5′.

8.1.3. It was also essential to induce formation of berms, along the new bank, in order to protect it against erosion. This was proposed to be done by means of short killa-bushing spurs.

8.1.4. Since a bank was being shifted, appropriate adjustments in the masonry works and feeding arrangements of offtakes were necessary which are described below :

(a) It was proposed to remodel the existing falls at R.D. 56,728, 92,000, 1,13,412 & 1,57,390 for reduced waterways.

(b) The existing fall at R.D.1,74,000 would remain to work as a cross regulator and adjusted accordingly.

(c) The head regulators on the non-patrol bank were provided with approaches. These were Chorkot Disty, Sodi Disty, Katora Branch, Usmanwala, Kul, Kanganpur and Laluguddar Distys.

(d) The head regulators of all the offtakes including escape regulator at R.D. 26,430 were to be re-modelled.

(e) The waterway of bridges were suitably tightened and protected with pitching.

(f) All the outlets on the Main Line were to be reconstructed.

The cost of Remodelling Dipalpur Main Line and Manuwala Disty. came out to be Rs. 79,52,000 as shown in Appendix 'H'.

9.0 **Execution of Works**

The construction work for the Re-modelling of Dipalpur Canal system was executed in two phases, comprising the eleven out of the twelve distributaries (Phase-I) and Main Canal and the Manu-wala Disty. (Phase-II) as described hereunder :

9.1 **Distributaries**

The Ist Phase-work relating to Distri-butaries (except Manuwala Disty.) was completed during 1964-65 under the finan-cial control of Wapda and Administrative control of Irrigation and Power Depart-ment, Government of West Pakistan, through Executive Engineer, Kasur Divi-sion as a 'deposit work' at a cost of Rs. 6,77,188/61. Details of expenditure as compared to the estimated cost are as given in Appendix-'I'. This work was carried out by a newly opened Sub-division with its Headquarters at Kanganpur under the supervision of existing Revenue Division of Irrigation Department at Kasur.

9.2 Main Canal

The Second Phase-work relating to the remodelling of Main Dipalpur Canal and Manuwala Disty. was decided to be implemented under the direct financial control of the Central Government and not through WAPDA. This change was approved in the 28th meeting of the Indus Basin Development Board.

As the work of Remodelling Dipalpur Main Line was to be carried out during one non-flow season, the following detailed programme was prepared to be strictly followed for timely completion of the work :

1.	Preparation of Contract Documents	... 28.3.65
2.	Prequalification of Contractors	... 15.3.65
3.	Receipt of Tenders	... 15.5.65
4.	Award of Contract	before 15.7.65
5.	Completion of Works	... 31.3.66

The award was to be given before 15.7.65 to enable the contractors to mobilize and arrange machinery, labour and materials before the closure of canal on 15.10.1965.

The importance of this work could be appreciated from the fact that the West Pakistan Government were paying nearly Rs. 30 Lacs, in sterling, to India yearly as seigniorage charges for the maintenance of Ferozepur Headworks in order to feed the Dipalpur Canal. If the work was not done during 1965-66 non-flow season, Pakistan Government would have to pay an other 30 lacs of rupees.

The Contract Documents were prepared on 28.2.65 and the Tenders were received and opened on 3.5.65 and according to the Departmental procedure the rate for earthwork was approved by Chief Engineer Lahore Zone on 2.8.65. Finally the contract was awarded to M/S. Hastam Khan Inayatullah Khan & Co. on 3.8.65. The rate for masonry works could not be approved for which tenders were reinvited to be opened on 31.8.65. The contract of the masonry works was also awarded to Messrs. Hastam Khan Inayatullah Khan & Co. on 15.10.1965, being the lowest tenderers.

9.3 Progamme and Execution

9.3.1. Earthwork

A detailed schedule of working was prepared in consultation with the Contractor according to which the work was to be commenced on 16.10.65 and completed by 31.3.66. According to this programme, different reaches were allotted to the machines and donkey labour, keeping in view the leads etc. for the working of draglines and the dozers. Unfortunately, when every thing was ready and all quarters were waiting to start the work on 15.10.65, the September, 1965 Indo-Pakistan war suddenly broke in. Dipalpur Canal runs almost parallel and very close to the border. The Contractor and the officers could not keep up the pace, for making arrangement to take up the work as scheduled. Any-how, right from the Ceasefire date the concerned officers and the Contractor again started their arrangements with full force and zeal. Apart from so many other problems, in the border area, which the Kasur Division had to tackle on the demand of the Pakistan army, this work was given top-priority.

Under the circumstances, all planning of shifting the right bank was done in consultation with and under the advice of army officers. That upset all the programmes and planning and top-priority had to be given to the defence of the country.

Fresh planning had to be done under Army's advice. Under the new programme no work was to be done from R.D. 18,500 to 76,000. This portion, was to be kept filled with water upto 5.0′ depth. This was done by diverting Rohi Nallah into Link Channel which outfalls on the D/S side of tail R.D. 537 of BRBD Link. The BRBD Link was also damaged at R.D. 496 and all its water was flowing into Rohi Nallah. This water was again brought into Dipalpur Canal via Rohi Nallah, Inundation Link and Link Channel upto R.D. 18,500 Dipalpur Canal.

The work was started from R.D. 86 to 208 on the new scheduled dates. The work was planned out in such a way, that, least hinderance was created to the movements of Pakistan Army. Under Army's advice the bank was to be shifted in such a manner that, on a notice of 6 hours only, the Canal could be run with atleast 5.0 ft. deep water. This was done by shifting half the old bank to the new site, and raising the half of new bank to its full height, before touching the remaining half of old bank. Initially some difficulties were experienced in tackling the kharkars (Sub-Contractors owning donkey labour) but the same were overcome by educating them and arousing their sentiments in the name of defence of homeland.

The E/Work from R.D. 86,000 to tail went on smoothly but it was apprehended that the Army might not allow the construction work in the reach from R.D. 18,500 to R.D. 86,000. Had this reach not been released by the Army for completing the work, it would have lingered on to the next non-flow season. This might have created some legal and technical problems in settling the Contractors. Eventually, after Tashkand declaration during February, 1966, when border situation was eased out a little, the Army authorities were explained the legal and technical aspects of the problem and the implications of not tackling this portion during current non-flow season. Showing a great spirit of co-operation and understanding the Army authorities allowed to complete the work in the said reach. All Army requirements were kept in view, very strictly, while executing the earthwork in this reach. To compensate the Contractor for such unforeseen delays, his completion date was extended from 31.3.1966 to 15.5.1966.

9.3.2. Economy in Earth Work Compaction

In order to avoid leakages, a compacted core in the right bank was provided

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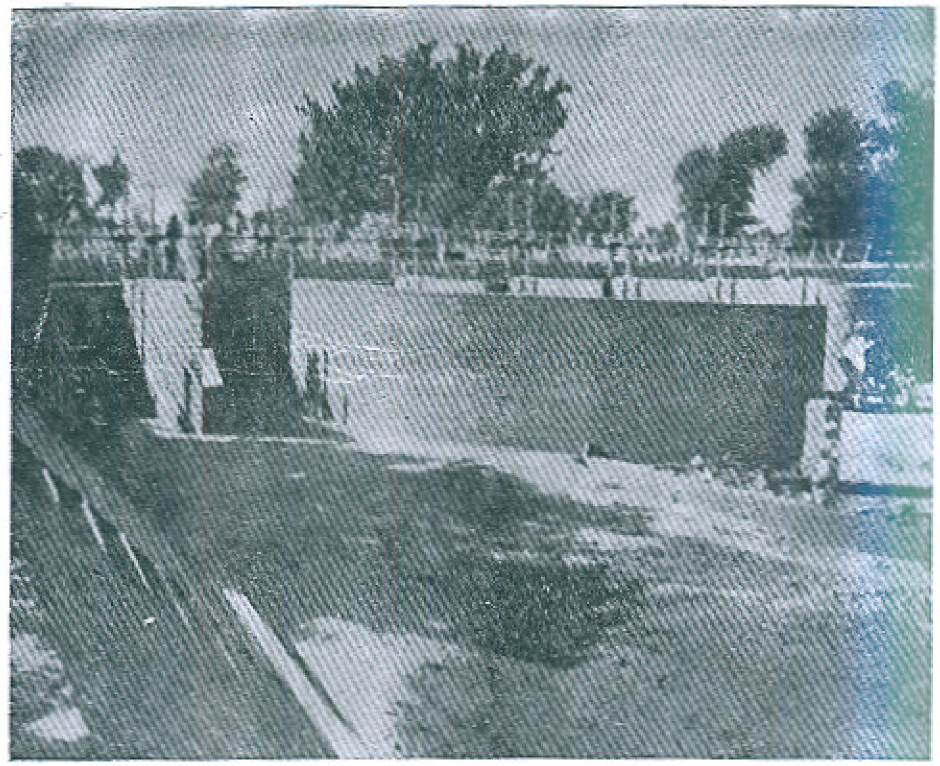
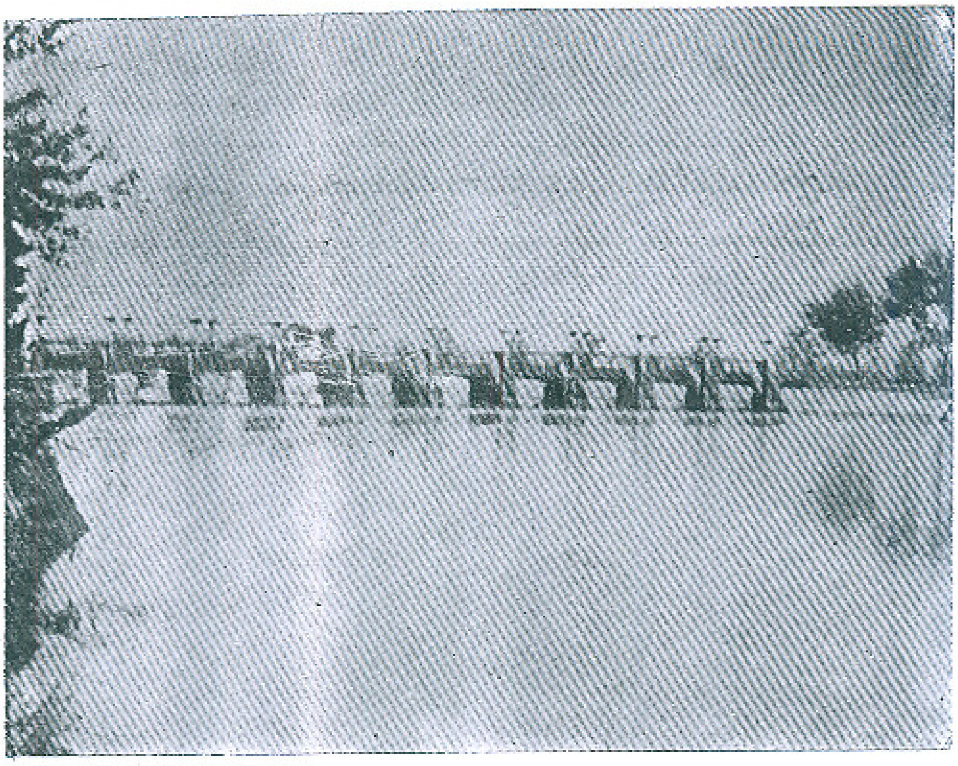
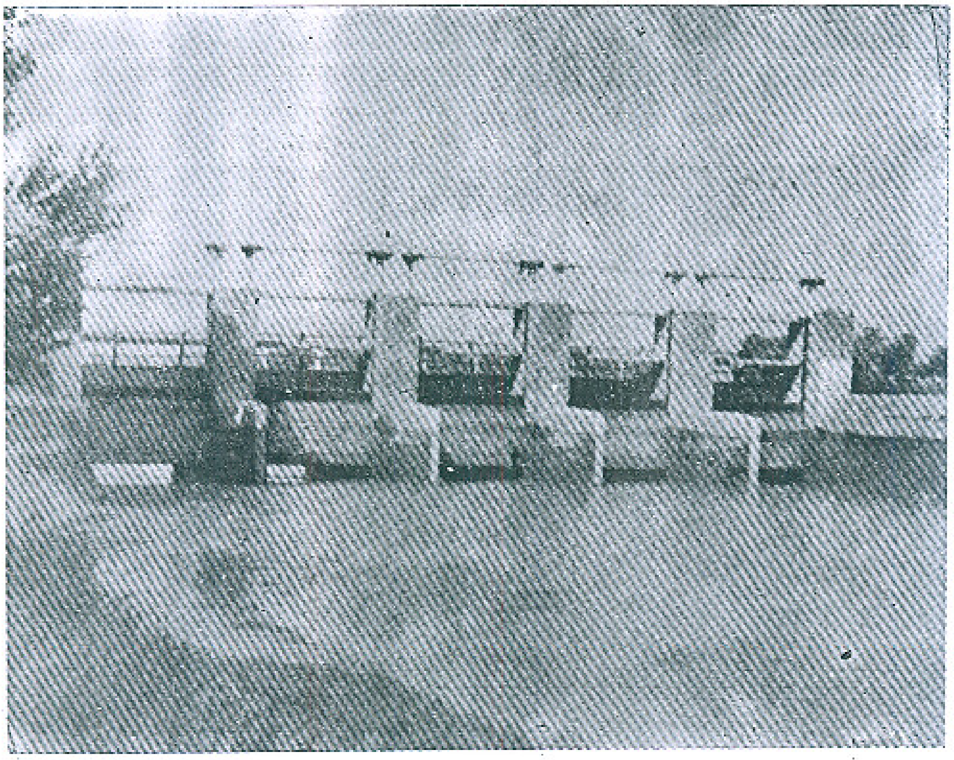


Fall structure at R.D. 157017 Depalpur Canal after Remodelling

Reducing the Earthen section of Depalpur Canal as Remodelling Operation was carried out by Mian Bashir Ahmad



Regulator on Depalpur Canal before Remodelling



Regulator on Depalpur Canal after Remodelling Operations in the project estimate from R.D. 18,500 to 2,08,367. In certain reaches of the main line, some channels run along the right bank. The left bank of these channels and the right bank of the main canal was common. Taking advantage of these channels it was decided to eliminate the compacted core in reaches wherever channels were existing parallel to the right bank of main line. In the absence of compacted core it was contended that if any mishap occurred, the water would remain standing in between the left bank of the existing channel and the shifted bank. With this amendment the compacted core was constructed only in the reaches where there were no parallel channels. Technical sanction of the estimate for Rs. 52,34,548/- was accorded by the Chief Engineer, Lahore Zone, accordingly. This resulted in a total saving of Rs. 5,37,260 from the Project estimate in the item of earth work only.

9.3.3. **A New Proposal to Feed Certain Outlets**

All the direct outlets were constructed in time. Some of these outlets, especially in reach R.D. 56,000 to 74,000 left side, could not draw their share, as the full supply of main canal was 3.0 ft. lower than the designed full supply level. Unless the full supply level was attained in this reach by gradual silting up of the canal these outlets could not draw their authorised discharges.

To feed these outlets, a parallel channel was taken off from the U/S side of regulator at RD 56,728 to feed the starving outlets from RD 56,000 to 74,000. The work was executed at site, at a total cost of Rs. 23,448/-.

9.3.4. **Masonry Works**

Remodelling of masonry works was also started on 15.10.65 to be completed within 5½ months. The design of remodelling of each work was done in the office of the Chief Engineer, Remodelling Organization, Lahore. The S.S.W.L. was lowered wherever necessary by tubewell pumping. The schedule of construction was framed in such a way, that, masonry works in one reach were grouped together and were to be started simultaneously. On completion of one such group, the machinery etc. was to be shifted to the next group and so on. The construction of masonry works offered no unusual problem and were completed within the scheduled time.

9.3.5 **Killa Bushing for Berm Formation**

The following three types of spurs were constructed at R.D. 86,500 for on-the-site approval by the Chief Engineer, Lahore Zone.

(a) In the Ist type, 6-inch dia. compacted rolls were filled in-between the two rows of killas fixed at 2′ apart. The rolls were filled, from the existing bed to 1.0′ above the proposed F.S.L.

(b) In the 2nd type, inter-twining of killas was done with 6-inch dia. compacted brushwood rolls. The hollow portion in side killas was left unfilled.

(c) In the third type, portions in-between the killas were filled with brushwood only. The brush-wood was placed in layers which used to be compacted by the body weight of the labourers. The top of the killas were inter-twined with Munj Ban, so that the brushwood could remain intact. This type was approved by the Chief Engineer, Lahore Zone, and was followed.

9.3.6. **Manuwala Disty.**

The Head Regulator of Manuwala Disty. was constructed as per plan received from Chief Engineer, Remodelling. It was a small channel of 2 Cs. capacity and the channel was constructed by giving a reverse slope to existing Manuwala Disty.

ACKNOWLEDGEMENTS

The authors express their gratitude to Mr. Wizaratullah Khan Ex-Assistant Design Engineer, Remodelling Organization, for his valuable assistance and untiring efforts in the development of design proposals and compilation of the Revised Project Report for Remodelling Dipalpur Canal System-1963 ; Mr. S. Nisar Shah, Ex-SDO, Incharge of Remodelling Dipalpur Canal for supplying the construction photographs ; Mr. Karamatullah, Secretary ETC, for his painstaking work in repeatedly typing the manuscripts ; and the drafting staff of ETC for preparing the original tracings of the drawings included in this paper.

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4. I.B.P. Completion Report on the Design and Construction of Link Canals Volume-V, Balloki-Suleimanki-III Link Canal, by Tipton & Kalambach Inc. Engineers, Denver, Colorado, 1971.

Remodelling Dipalpur Canal System

Statement Showing Lengths and Discharges of Dipalpur Canal System as mentioned in original Project of 1961

S. No.	Name of Channel	Length in Feet		Discharge in Cusecs	
		Existing	Proposed	Existing	Proposed
1.	Dipalpur Canal	—	189,867	6,950	2,000
2.	Katora Branch	42,900	42,900	1,155	901
3.	Chunian Distributary	190,000	106,435	396	178
4.	Attari Distributary	104,430	128,900	493	435
5.	Sial Minor	46,900	17,794	51.5	16
6.	Kanganpur Distributary	128,270	94,161	237	234
7.	Bejanpur Distributary	2,285	12,849	136.3	10
8.	Jandran Distributary	28,205	19,950	32	16
9.	Jethpur Distributary	90,600	22,080	127	15.4
10.	Kalarkalan Disty.	72,900	72,900	188	156
11.	Dograi Minor	36,450	32,330	53.4	39.5

Appendix-B

Cost Estimate

Remodelling Dipalpur Canal System
Original Project of 1961

1.	Remodelling Dipalpur Canal.		
	(a) Tightening Section R.D. 18,500 to 62,000	1,41,815	
	(b) Tightening Section R.D. 62,000 to 157,000	2,23,200	
	(c) Tightening Section R.D. 157,000 to 200,000	91,458	
	(d) Remodelling Masonry Work R.D. 18,500 to 2,08,000	2,25,180	
	Sub-total	6,80,853	6,80,853
2.	Remodelling Katora Branch		3,458
3.	Remodelling Chunian Distributary		57,722
4.	Remodelling Attari Distributary		38,478
5.	Remodelling Sial Minar		2,789
6.	Remodelling Kanganpur Distributary and construction of a Link Channel		1,29,478
7.	Remodelling Bejanpur Distributary		3,361
8.	Remodelling Jandran Distributary		7,347
9.	Remodelling Jethpur Distributary		5,861
10.	Remodelling Kalar Kalan Distributary		20,646
11.	Remodelling Dograi Minor		5,891
12.	Remodelling Manuwala Distributary		20,000
		Grand Total (Works)	9,75,804
	Establishment One Sub-Division for two years at 40,000/- per year		80,000
	Ordinary T&P 1% of works		9,758
	District charges		10,65,562
	Indirect charges 1% of works		9,758
		Total cost	10,75,320
		Say	10,75,500

Appendix-C

Revised Project 1963
Remodelling Dipalpur Canal System

STATEMENT SHOWING VARIOUS SILT FACTORS PROPOSED FOR REMODELLING

Dipalpur Canal System

Name of Channel	Reach	Values of Silt Factors: Last Designed	As Existing	Original Project 1961	T&K Proposals of 8.10.1962	Via-media Proposed on 11.12.62	Decided in a meeting on 18.12.62 & agreed by T&K	Decided in a meeting on 16.4.63	Adopted by Xen. Kasur in revised L. Sections on 16.5.63	Now proposed by Remodelling Orgn. for Revised Project 1963
1	2	3	4	5	6	7	8	9	10	11
Dipalpur Link Channel.	Whole			.87	1.00	1.00	—	—	—	.95
Dipalpur Canal	Head		1.09 to 0.95	.86	1.00	.95	1.00	.95	.95	.95
	Tail	Designed on Kanedy No value of "F" given	.88	.85	.95	.90	.90	.90	.90	.90
Katora Branch	Head		1.10	.80	1.00	—	1.00	.95	.95	.95
	Tail		.98	.90	1.00	—	.95	.90	.95	.95
Chunian Disty.	Head		1.00	.76	.95	—	.95	.90	.95	.90
	Tail		.92	.75	.95	—	.85	.80	.80	.80
Attari Disty.	Head		.69	.90 to .92	.95	—	.95	.90	.99	.90
	Tail	.75	.82	.76	.95	—	.85	.80	.80	.80
Sial Minor	Head	.80	.90	.30	.95	—	.90	.85	.85	.85
	Tail	.80		.75	.95	—	.85	.80	.80	.80
Kanganpur Disty.	Head	.75	.82	.75	.95	—	.93	.99	.90	
	Tail	.75	.68 to .80	.70	.95	—	.85	.80	.80	.90 .80
Jandran Link	Head	—	—	—	.95	—	.90	.85	.85	.85
	Tail	—	—	—	.95	—	.90	.85	.85	.85
Jandran Bejanpur & Jethpur Disty.	Head	.80	.86 to.75	.70	.95	—	.90	.85	.85	.85
	Tail	.80	—	.72 to .76	.95	—	.85	.80	.80	.80
Kalar Kalan Disty.	Head	.80	1.03	.78	.90	.85	.90	.90	.90	.90
	Tail	.80	.68 to .76	.64 to .70	.90	.80	.85	.80	.80	.75
Dogra Minor	Head	.85	.84	.75	.90	—	.90	.85	.85	.85
	Tail	.80	—	.80	.90	—	.85	.80	.80	.80

Appendix-D

Revised Project 1963

Remodelling Dipalpur Canal System

REVISED CAPACITY STATEMENT OF DIPALPUR CANAL

R.Ds	Reach	Side	Name of Offtake	Discharge of offtake	Total Discharge of offtake by reaches	Absorption losses at Q=O.133 (Oq) 5626	Total discharge at head of the reach Col. 8+7+6	Remarks
1	2	3	4	5	6	7	8	9
208367	208367	T.R	Kalar Kalan Disty.	155.0				
208367	To	T.L	Laluguddar Disty.	151.0				
174007	174007		Regulating Bridge		306.00	11.43	317.43	Existing fall eliminated
173854	To	L	Chachal Ditch Disty.	17.0				
157390	157390		Bridge and Fall	—	17.00	5.81	340.24	
157390		R	Kanganpur Disty.	232.0				
157390	To	R	Kul Disty.	24.00				
156860		L	Fateh Mohd Disty.	128.00				
140967	140967				384.80	8.95	733.19	Fall & Bridge washed off.
113412	113412		Fall	—	—	15.29	748.48	
92000	92000		Fall	—	—	11.99	760.47	
91950		R	Usmanwala Disty.	44 00				
86500		L	Bakerke Disty.	77 00				
82665		L	Outlet	1.13				
74570	To	L	Outlet	2.92				
68500		L	Outlet	3.83				
66500		L	Outlet	2.77				
57246		L	Outlet	4.24				
56728	56728		Regulating fall	—	135.89	21.69	918.05	
56100		R	Sodi Disty.	70.00				
56100		R	Kotora Branch	891.00				
50680	To	R	Outlet	1.52				
50550		L	Outlet	3.27				
46000		R	Outlet	1.31	967.10	10.27	1895.42	
45600	45600	R	Chorkot Disty.	342.00				
44565		L	Outlet	4.58				
43665	To	L	Outlet	5.25				
35870	35870		Bridge	—	351.83	9.92	2257.17	
28400		R	Outlet	1.17				
28286	To	R	Outlet	6.08				
20200	20200		Bridge	—	7.25	16.03	2280.45	
18500	18500		Junction with Dipalpur Feeder			2.22	2282.67	
					Say		2283 cusecs.	

Re-marks

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...xisting fall ...inated

Fall & Bridge washed off.

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Appendix-E

STATEMENT SHOWING COMPARISON OF ABSORPTION LOSSES UNDER EXISTING AND PROPOSED CONDITION IN DEPALPUR MAIN CANAL

		Existing Condition							Proposed Condition without Berm Formation or Shifting of Bank.							Proposed Condition with Shifting of One Bank Or After Formation of Berms.								
R.D	Length	Q_1 in Cs	B	D_1	K	W.P in Lft	Area in Sq. Ft Col 2 x 7	Q_4 at 8 Cs per Mill	Q_3 in Cs	K	D_2	Av : D Col 5+12 × ½	W.P. in Lft	Area in Sq. Ft Col. 2 × 14	Q_4 @ 8 Cs Per Mill	Pro D	Av : D Col 17+5 × ½	Pro B	W.P in Lft	Area in Sq. ft Col 2 × 20	Q_4 @ 8 Cs Per Mill	Dif Col 9 & 16	Dif Col 9 & 22	Dif: Col: 16 & 22
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
18500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35870	17370	6950	278	8.4	200	297	5158890	41	2283	200	4.4	6.4	292	5072040	40	6.9	7.7	110	127	2205990	18	1	23	22
45600	9730	6861	261	9.5	167	282	2743860	22	2257	167	4.8	7.1	277	2698210	22	5.9	8.2	110	130	1264900	10	—	12	12
56728	11128	6483	235	8.9	170	255	2837640	23	1895	170	4.3	6.6	250	2782000	22	6.5	7.7	100	117	1301976	11	1	12	11
92000	35972	4904	187	8.5	139	206	7266032	58	918	139	4.2	5.9	200	7054400	56	5.3	6.9	70	86	3093592	25	2	33	31
113412	21412	4815	194	7.7	160	211	4517932	36	760	160	2.6	5.2	206	4410872	36	5.0	6.4	63	77	1648724	13	—	23	23
141000	27588	4815	187	8.0	150	207	5710716	46	749	150	2.7	6.4	201	5545188	44	5.0	6.5	62	77	2124276	17	2	29	27
157390	16390	4454	178	7.8	145	195	3196050	26	733	145	2.7	5.3	190	3114100	25	5.0	6.4	62	76	1275640	10	1	16	15
174007	16617	2696	131	7.2	100	147	2442699	22	340	100	2.1	4.7	142	2359612	19	3.9	5.6	41	54	897316	7	3	15	12
208367	34360	2696	136	6.2	128	150	5154000	41	317	128	1.7	4.0	145	4982200	40	3.8	5.0	38	49	1682640	14	1	27	26
Total								315							304						125	11	190	179

Note :- 1. D2 in Col : 12 that is Depth of water in existing section for the the pro : reduced discharge have been worked out from the formula Q = KD 5/3

2. Wetted perimeters in Col : 7,14 and 20 have been worked out by assuming ½ : 1 side slopes.

3. Average depth in Col : 13 and 18 adopted with due regard to ponding up at falls and back water effects.

Results :- 1. Absorption losses with the existing and existing Preimeters. = 315

2. Absorption losses with reduced discharge and exist : perimeters without bank shifting and berm formation. = 304

3. Absorption losses with pro : discharge after shifting of bank or complete formation of berms. = 125

4. Difference in 1 and 2. = 11

5. Difference in 2 and 3. = 179

6. Difference in 1 and 3. = 190

From tde above it is concluded that :-

(a) Shifting of one bank of main canal can save 179 Cs.

(b) Absorption losses from the Canal with the existing perimeters (without tightening of section) and reduced discharge would differ from the existing losses only by 11 Cs.

Revised Project 1963

Appendix-F

Remodelling Dipalpur Canal System Hydraulic Summary

12. Dipalpur Main Canal Hydraulic Data.

R.D.	Reach Length	Structure	Discharge Original	Discharge Remo-delled	'f' Exist-ing	Adop-ted	B	D	5%o	Loss	F.S.L.	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
18500	—	Junction with Feeder	—	—	—	—	—	—	—	—	649.90	Tail Link
								Dipalpur Feeder from BRBD				
20280	1700	D.R. Bridge	6950	2233	—	0.95	110	6.9	0.14	0.24	646.66	
35870	15670	V.R. Bridge	6950	2280	0.95	0.95	110	6.9	0.14	2.19	644.47	
45600	9730	H/Regulator Chorkot Disty	6861	2257	0.95	0.95	110	6.9	0.14	1.36	643.11	
56728	11128	H/Regulator Katora branch & Fall	6483	1895	0.95	0.95	100	6.5	0.14	1.56 / 0.50	641.55 / 641.05	Fall retained
92000	35272	V.R. Bridge & Fall.	4904	918	—	0.95	70	5.3	0.16	5.64 / 5.00	635.41 / 630.41	,,
113412	21412	V.R. Bridge & Fall	4815	760	—	0.94	63	5.0	0.16	3.42 / 2.00	626.99 / 624.99	,,
140967	27555	Washed off Bridge & Fall site	4819	749	—	0.94	62	5.0	0.16	4.41	620.58	
							Washed off Bridge and Fall					
157390	16423	H/Regulator Kanganpur Kul. Distys. & Fall	4454	733	—	0.93	62	5.0	0.16	2.63 / 2.50	617.95 / 615.45	
174007	16617	Bridge & Fall	2696	340	—	0.90	41	3.9	0.17	2.82	612.63	Fall elimina-ted
20836	34360	Tail & H/Reg : of Lalu Guddar and Kalar Kalan Distys.	2696	317	0.88	0.90	38	3.8	0.18	6.18	606.45 fall	Exist closed

Appendix-G

Revised Project 1963

Remodelling Dipalpur Canal System
General Abstract of Cost

		Rs.	Rs.
1.	Dipalpur Main Canal Offtakes	39,25,400	39,25,400
2.	Katora Branch	nil	
3.	Attari Disty.	42,200	
4.	Sial Minor	6,200	
5.	Chunian Disty.	1,14,700	
6.	Kanganpur Disty.	1,59,700	
7.	New Jandran Link	1,18,000	
8.	Jethpur Disty.	19,200	
9.	Jandran Disty.	1800	
10.	Bejanpur Disty.	6,700	
11.	Kalar Kalan Disty.	1,21,400	
12.	Dogria Minor	8,000	
13.	Manuwala Disty.	37,900	6,35,800
		Sub Total :	45,61,200
	Add contigencies @ 15%		6,84,180
			52,45,380
	Add Administration and Engineering @ 8%		4,19,630
		Grand Total	56,65,010
		Say Rs.	56,65,000

Remodelling Dipalpur Canal

Dipalpur Canal (Main Line and Manuwala Disty.)
General Abstract

1.	(a) Earthwork (on tender rates) (b) Compaction (on tender rates) (c) Running Jeep for inspection		59,40,664
2.	Masonry work (on tendered rates)		7,55,154
3.	Balli spurs (on tendered rates)		3,25,000
4.	Manuwala Disty. (on estimated rates)		48,000
		Rs.	70,68,818
5.	Engineering Administration @ 12%		8,83,602
		Rs.	79,52,420
		Say Rs.	79,52,000

DETAILED ESTIMATE

1. Earthwork Estimate of Remodelling Dipalpur Canal From R.D. 18503 to 208367

1.	12,02,06,000 cft. Earth work including all leads Jungle clearance, wetness, hardness allowance at Rs. 40/% by machines and donkey labour		48,08,240
2.	Compaction. 4,18,25,000 cft. at the rate of Rs. 20/-% cft.		8,36,500
		Total :	56,44,740
	Add work charge establishment 2%		1,12,895
		Total :	57,57,635
	Running one Jeepster and Jeep L.S.		10,000
		Total :	57,67,635
	Add Contingencies at 3%		1,73,029
		Total :	59,40,664

2. General Abstract of Cost For Remodelling Masonry Works of Dipalpur Canal R.D. 18500 to R.D. 208367

1.	D. Bridge R.D. 20,200	4,385
2.	H/Regulator of escape channel RD 26430-L	10,012
3.	V.R. Bridge R.D. 26,470	5,937

(*Contd.*)

4.	V.R. Bridge R.D. 35870		2,786
5.	D.R. Bridge R.D. 44,950		2,810
6.	H/Regulator of Chorkot Disty. 45600-R		44,236
7.	H/Regulator of Katora Branch and Sodi Disty. RD 56,100 and V.R. Bridge and fall RD 56,728		1,30,898
8.	D.R. Bridge R.D. 60,900		4,899
9.	V.R. Bridge R.D. 76,085		4,820
10.	V.R. Bridge R.D. 83,300		3,691
11.	H/Regulator of Bakerke Disty. 86500		338
12.	H/Regulator of Usmanwala Disty. 91500		17,868
13.	V.R. Bridge and fall R.D. 92000		1,33,107
14.	V.R. Bridge R.D. 98865, 105514, 119637, 130914		19,168
15.	V.R. Bridge and fall R.D. 113,412		60,588
16.	V.R. Bridge R.D. 148,217		4,415
17.	Bridge and fall R.D. 157,390 combined with head regulator of Kul Disty. and Kanganpur Disty.		1,07,054
18.	D.R. Bridge R.D. 165,497		5,691
19.	H/Regulator of Chahal Ditch Disty. R.D. 173854		1,397
20.	Bridge and fall R.D. 174017		44,585
21.	Foot Bridge R.D. 180950		4,874
22.	V.R. Bridge R.D. 87967		4,700
23.	V.R. Bridge R.D. 192367		6,022
24.	Foot Bridge R.D. 199317		4,002
25.	H/Regulator of Lalugudder and Kalar Kalan Disty. and closing fall at R.D. 208,367		30,677
	Pilchi pitching D/S fall R.D. 56,000,92,000, 113,412,157,000		39,722
	Remodelling 11 No. outlets		51,436
	Addl : L.S. for running jeep and jeepester for inspection purpose L.S.		5,000
		Total :	7,55,154

3. Estimate For Providing Balli Spur Bushing Along Shifted Non-Patrol Bank of Dipalpur-Canal R·D. 18,500 to 208,367

324 Chains at tender rate of Rs. 1,000/- per chain		3,24,000
Running Jeep		1,000
	Total:	3,25,000

4.	Manuwala Disty. (on estimated rates)	48,000

Remodelling Off-Takes of Dipalpur Canal System

Comparison of Estimated and Actual Cost

Name of Disty		Estimated Cost in the Project (Rs.)	Actual Expenditure (Rs.)
1.	Katora Branch	Nil	
2.	Attari Disty	42,200	63,493
3.	Sial Minor	6,200	961
4.	Chunian Disty	1,14,700	1,84,143/32
5.	Kanganpur Disty	1,59,700	2,52,667/13
6.	New Jandran Link	1,18,000	1,84,456/44
7.	Jethpur Disty.	19,000	15,805/71
8.	Jandran Disty.	1,800	1,596
9.	Bejanpur Disty.	6,700	8,399
10.	Kaler Kalan Disty	1,21,000	1,20,767/51
11.	Dograi Minor	8,000	4,899/50
	Total :	5,97,900	6,77,188/61
	Add contigencies at 15%	89,685	
	Total :	6,87,585	
	Add Administration and Engineering at 8%	55,00	
	G. Total	7,42,592	
	Say	7,43,000	6,77,188/61

Mian Alim-ud-Din, Ex-Chief Engineer, Irrigation Lahore Zone, giving instructions to Incharge Officers and the contractor at site during Remodelling of Dipalpur Canal

. giving instruc-
Remodelling of

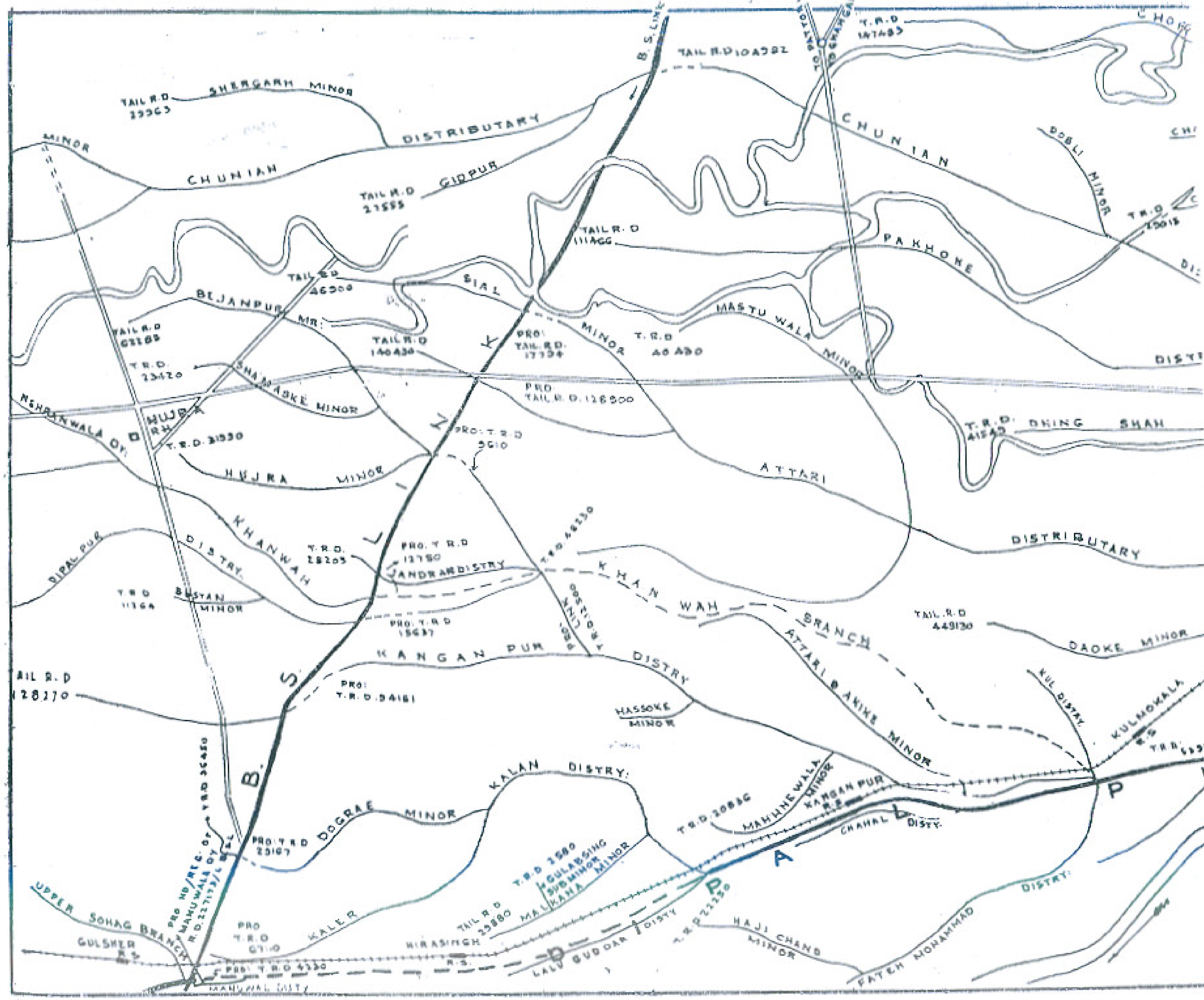
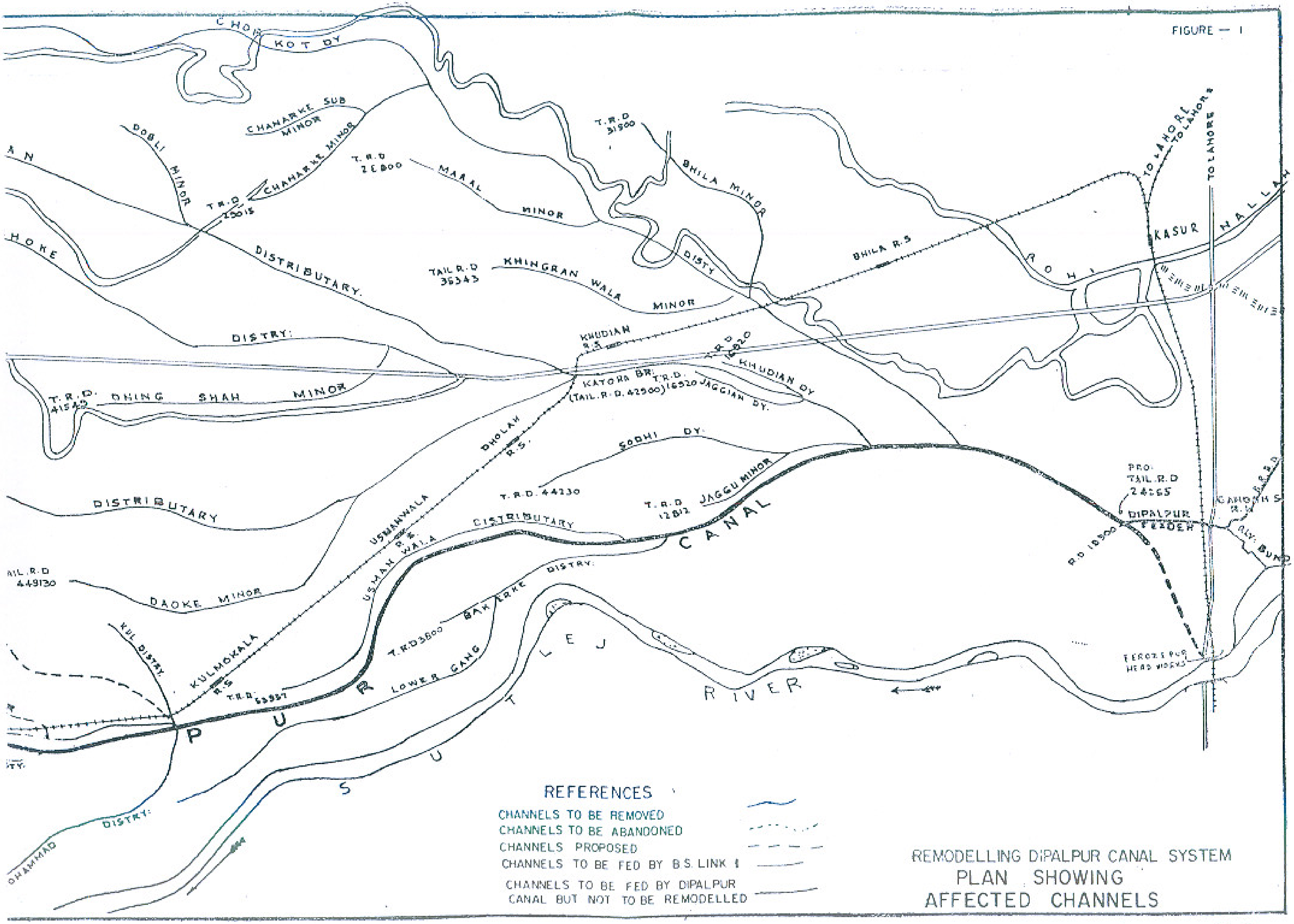
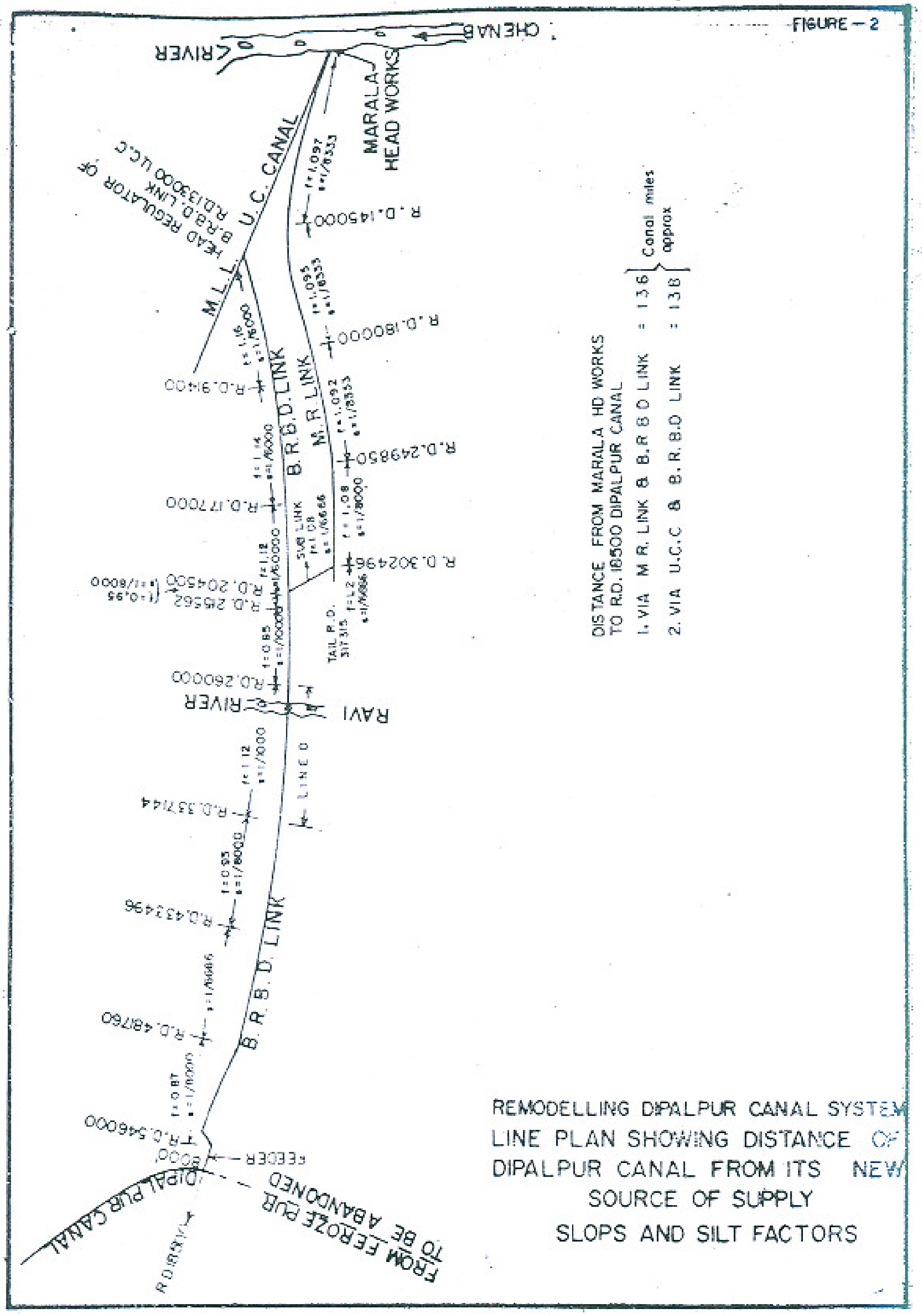


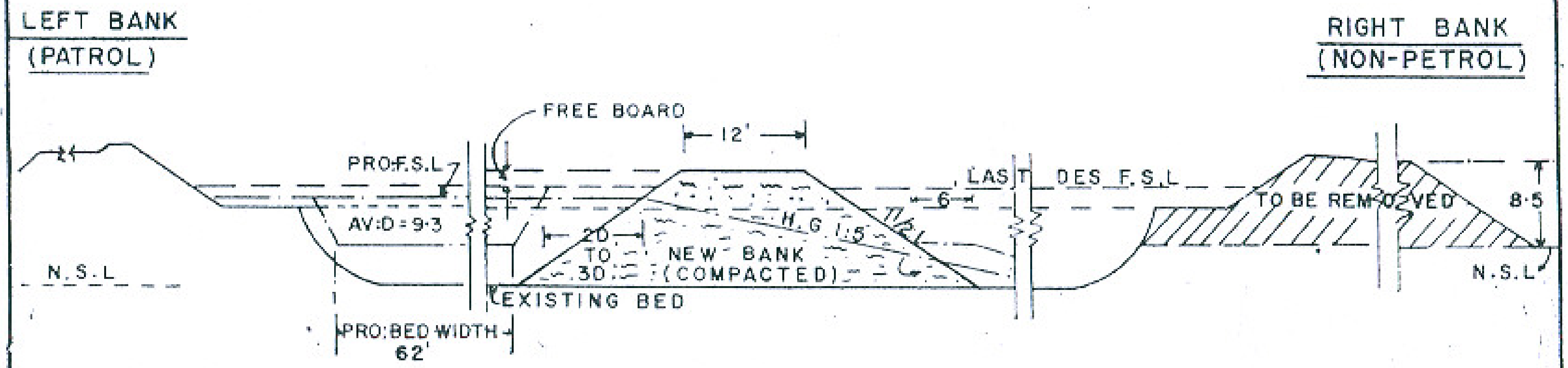
FIGURE — 1



REMODELLING DIPALPUR CANAL SYSTEM
PLAN SHOWING
AFFECTED CHANNELS



REMODELLING DIPALPUR CANAL SYSTEM
LINE PLAN SHOWING DISTANCE OF DIPALPUR CANAL FROM ITS NEW SOURCE OF SUPPLY
SLOPS AND SILT FACTORS



REMODELLING DIPALPUR CANAL SYSTEM

PLAN SHOWING PROPOSED ARRANGEMENTS FOR TIGHTENING SECTION OF THE MAIN-CANAL

FIGURE-3

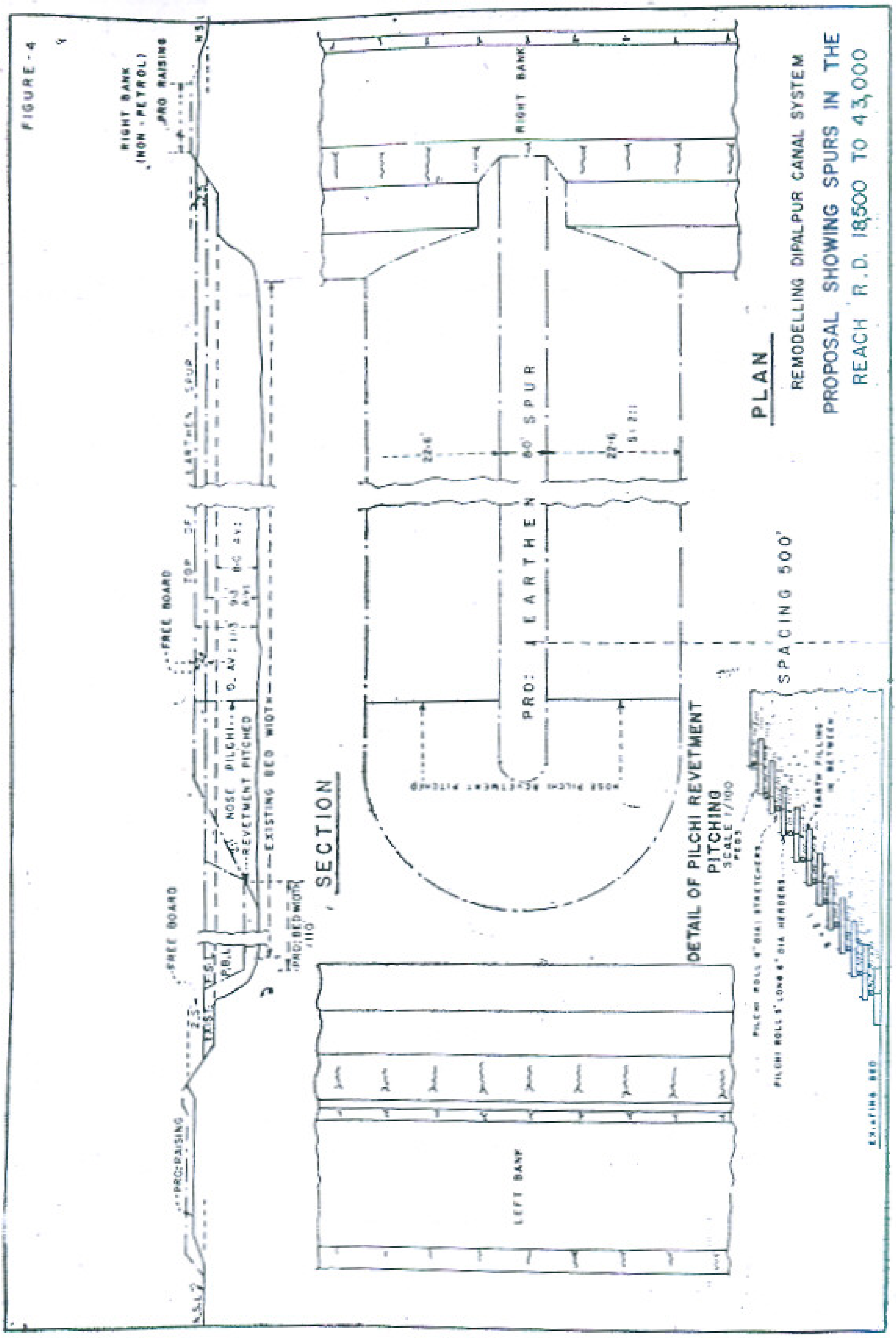
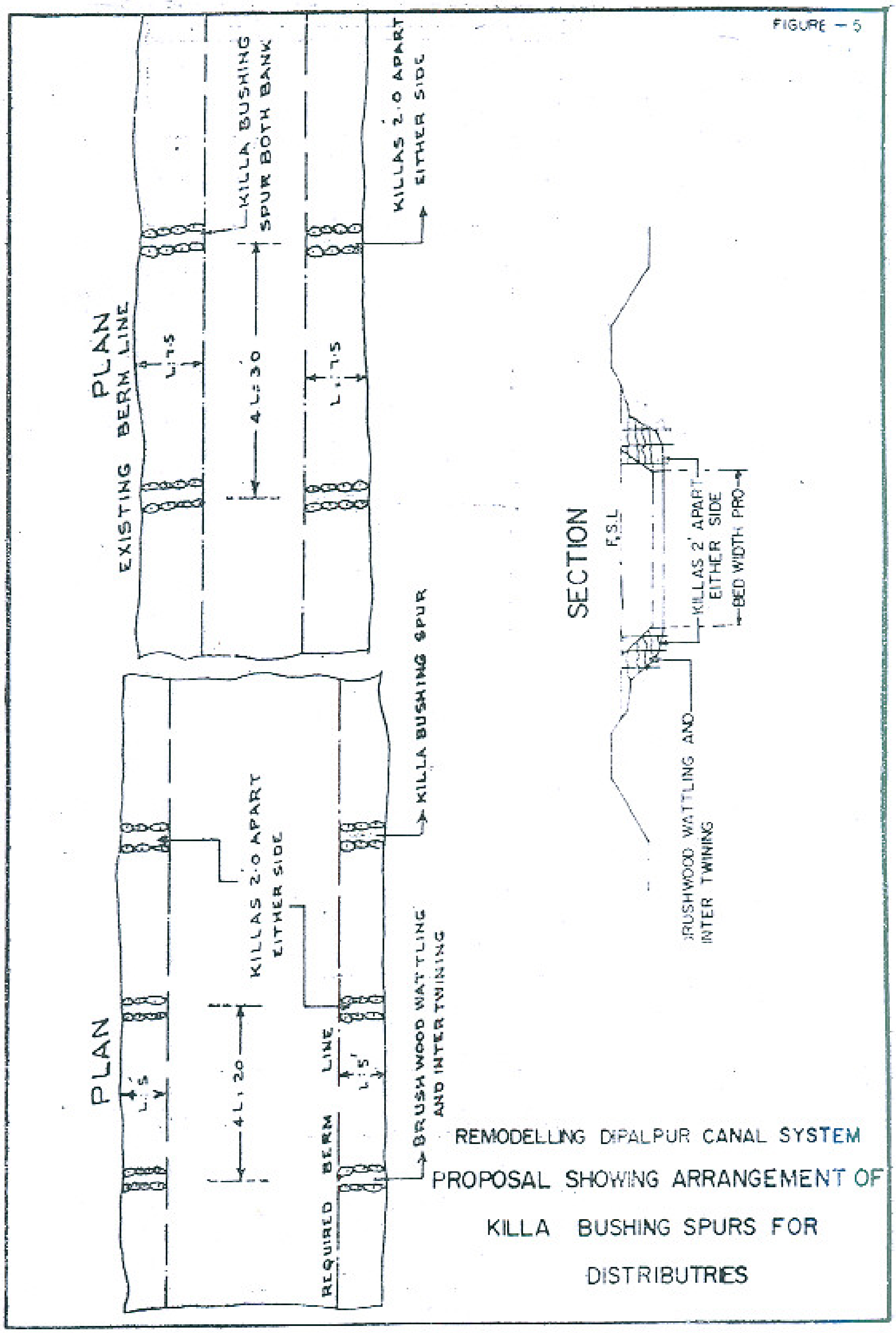


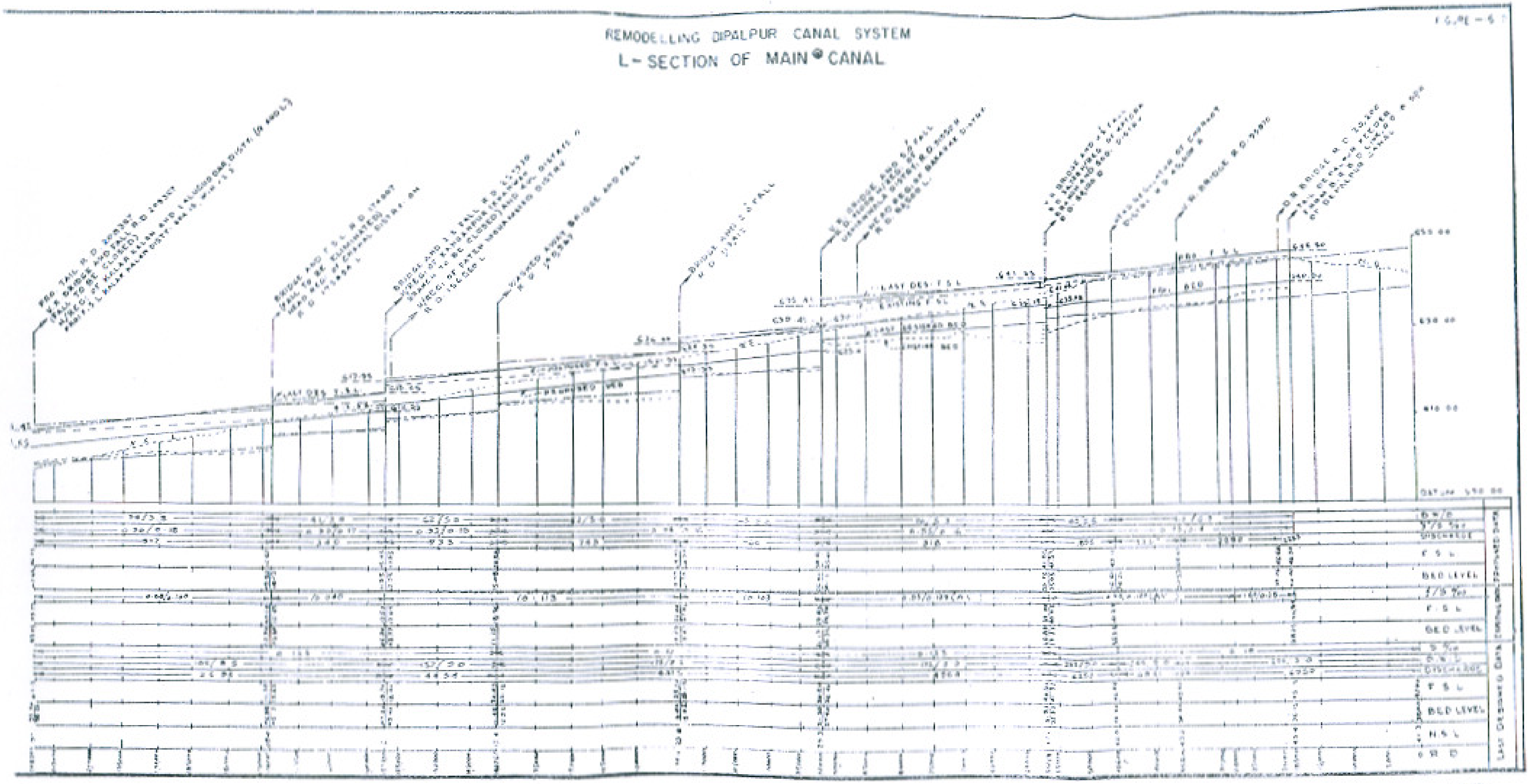
FIGURE - 4
RIGHT BANK (NON-PETROL)
PRO RAISING
EARTHEN SPUR
FREE BOARD
NOSE PILCHI
REVETMENT PITCHED
EXISTING BED WIDTH
PRO: BED WIDTH 110
SECTION
RIGHT BANK
PRO: EARTHEN 60' SPUR
SPACING 500'
LEFT BANK
DETAIL OF PILCHI REVETMENT PITCHING
SCALE 1/100
PLAN
REMODELLING DIPALPUR CANAL SYSTEM
PROPOSAL SHOWING SPURS IN THE REACH R.D. 18500 TO 43,000



REMODELLING DIPALPUR CANAL SYSTEM
PROPOSAL SHOWING ARRANGEMENT OF
KILLA BUSHING SPURS FOR
DISTRIBUTRIES

REMODELLING DIPALPUR CANAL SYSTEM

L-SECTION OF MAIN CANAL



Latest Developments in the Techniques of Reducing Evaporation from Lakes and Reservoirs*

The continuing growth of industry and agriculture is placing increasing demands on nations' water resources, already limited in many countries. For more than half a century, researchers have tried in many ways to increase the available water by reducing evaporation from open water bodies. These range from wind-breaks to films one molecule thick and to floating covers of various types. Grundy (1958) reported promising results from a series of experiments in East Africa in the 1950s, achieved through the application of chemical films. However, before applying this method operationally, further research was required, both in the laboratory and in the field, to solve problems connected with the application of the film to the water surface, the effects of wind and waves on the film and the wastage of the biological oxidation.

The present article reviews work in various countries on the reduction of evaporation from lakes and reservoirs ; it is based on a report by Mr. C. E. Hounam (Australia) and on replies to a questionnaire.

Techniques

Evaporation from water surfaces can be reduced by using granular particles to form a floating surface which is highly reflective to solar radiation. The substances tried, include white perlite ore, polystyrene beads, chopped styrofoam and white hydrophobic amorphous $CaCo_3$ powder. Under still conditions, reductions in evaporation as high as 50 per cent have been obtained, but when the wind velocity exceeds 10 km/h, the reduction does not appear to be significant.

Another common technique is the use of chemical monomolecular films. The manner in which a monolayer reduces evaporation is well described by McArthur (1959).

> "When a long-chain fatty alcohol such as hexadecanol is placed on the surface of water, because the work of adhesion between the hydroxyl group of the molecule and the water is greater than the work of cohesion between the alcohol molecules, the latter separate from the mass and move across the water surface to form an orientated surface film one molecule thick. Spreading continues from the source until the monolayer becomes condensed with molecules closely packed and exerting the equilibrium surface pressure of about 40 dynes/cm. Under these conditions the resistance offered by the monolayer to the passage of molecules of water is at a maximum. The monolayer exhibits the property

*Source : *WMO Bulletin*, April, 1974.

of a liquid in that it can flow over the surface of the water under application of pressure, as for example under wind. If the surface pressure becomes reduced by removal of alcohol molecules from the surface by attenuation of the monolayer by wind, further spreading will take place from the source until the equilibrium surface pressure is regained."

The transfer of water vapour through a normal, saturated alcohol monolayer decreases with increasing chain length. The efficiency of C_{11} to C alcohols increases with a decrease in temperature. At low temperatures, however, the longer-chain alcohols show a decrease in evaporation resistance, which is attributed to the difficulty of their spreading at low temperatures. A compromise must therefore be reached as far as chain length is concerned.

The unsaturated fatty alcohols have lower melting points but, because of their bent chain structure, they do not form compact films and are less effective evaporation retardants.

A typical fatty alcohol with a molecular weight of about 250 requires approximately two kg to cover one km^2. The rate at which this coverage is obtained depends partially on the physical form of the material. Molecules leave the source only at the air-water-solid interface; consequently, the more finely the material is divided, the more rapidly will coverage be obtained. The adverse effects of wind, consumption and contamination by organisms and losses by natural causes make it necessary to apply much more than the theoretical minimum treatment.

Very little has been published on the rates of application of chemicals and some of the literature is rather conflicting. Not unexpectedly, rates for effective control differ according to conditions; for example, Frasier and Myers (1968) applied 56 kg per ha per month of powdered alkanol to reduce evaporation from outdoor tanks by 15 per cent under adverse testing conditions. Under the same conditions, only 11.2 kg per ha per month of dispersed alkanol reduced evaporation by 28 per cent.

Beard and Gainer (1970) have experimented with coloured monolayers; a large number of dyes were investigated, but in no instance did the dyes colour the monolayer or form a monolayer themselves. A yellow oil film on a water surface was found experimentally to reflect solar energy about 70 per cent better than a plain water surface and also to reduce the evaporation rate. In addition, the film was extremely difficult to remove from a water surface.

Substances used

From a practical point of view, any material to be used for reducing evaporation must be nontoxic to plants and animals; form a continuous film over the water surface at normal temperatures; be able to form a film which can repair itself after being broken; be relatively impervious to water vapour; and be in a form that can be readily applied at a practical cost. The most commonly used alcohols which meet the above conditions are hexadecanol (cetyl alcohol) and octadecanol (stearyl alcohol). Mixtures of the two are also frequently used in the form of emulsions, suspensions and dry powder. Puskharev and Levchenko (1967) report that secondary, unsaponifiable substances formed as by-products of synthetic aliphatic acids are also suitable ; these inexpensive alcohols, which are now being produced in large quantities, are as effective as alcohols obtained from natural fats and oils.

Methods of Application

Chemicals may be dispersed intermittently or continuously and manually or automatically, depending on the requirements. Research is still being carried out into improving methods of dispersal. As there is some evidence that alcohols encourage bacterial and algal growth, algicides or bactericides have been added to dispersions.

Several methods have been used for the application of chemicals to water surfaces :

Beads from a raft-The original method was the spreading of solid cetyl alcohol from an anchored raft, but this method has now been superseded ;

Solvent application-This method has a number of limitations : the monolayer invariably suffers from contamination by retained solvent and not only does this reduce its efficiency, but the tendency for the film to collapse on compression is increased. The spreading pressure of a concentrated solution is only half the spreading pressure of solid cetyl alcohol. In addition, the cost of the solvent is an appreciable part of the total cost. For these reasons, other methods are generally used ;

Power application - Several large-scale investigations have been conducted using this method. In a typical case, a fine powder of cetyl alcohol is produced, using a grinderduster mounted on a boat, and the powder is then blown on to the water surface ;

Application as emulsion-Although this method wastes material because of the reduced spreading power of prewetted alcohol powder, it seems to have some advantages for small reservoirs where powder application is not suitable ;

Hot spray application - Cetyl alcohol has been dispersed automatically in this way in tests at several storages. The method was discontinued in Australia because of the inferior spreading characteristics of hot sprayed powder compared with cool-dusted powder and the comparative complexity of equipment relative to non-automatic application ;

Aerial application-This method appears to be effective over larger reservoirs ; at an aircraft speed of 160 km/h, 40 ha/min may be covered.

Effect of Meteorological Conditions on Efficiency

Experimenters refer to the adverse effect of wind on a chemical film on a water surface ; 24 km/h seems to be about the upper limit to efficient operation ;

winds above this speed break the film and transport the chemicals to the shore. Wind variability is important, as a reversal of direction would halt the on-shore drift of film and redistribute it to some extent. Australian work suggests that the efficiency of a chemical film is inversely proportional to the square of the wind speed.

Granular materials also tend to pile up on windward shores during windy periods, but the cover provided by them is easier to re-form than a film. Over small surfaces, granular materials tend to redistribute themselves when the wind abates.

In the USSR, much research is being carried out on ways of sheltering reservoirs or test-sites from wind. Shelter in itself is a reasonably effective way of reducing evaporation, and when used in conjunction with monolayer films good results have been obtained. For a medium-sized reservoir of about one ha, it was found that a tree-belt 10 m high gave a reduction of 25 per cent ; a 30 per cent reduction was obtained with a tree-belt 20 m high. It is important to note that the efficiency of this method depends on the area of the water surface.

Work in India suggests that air temperature can also be an important factor, because it influences the equilibrium film pressure, the rate of spreading and the rate of bacterial decay of the chemical film.

Biological Effects

Research has demonstrated that surface monolayers have some physical and chemical effects on plant and animal life in the water. For example, Meshkova (1966) studied the effects of films produced by fatty alcohols on various aquatic organisms and on biological processes occurring in water bodies ; one interesting conclusion was that, because aquatic insects were adversely affected, films should not be used on water bodies which are important for fisheries since the food resources of the fish would be diminished. However, some United States authorities are of the opinion that hexadecanol applied in the quantities required to produce a monolayer has no toxic effect.

Linton and Sutherland (1958) studied the influence of a hexadecanol monolayer on the rate of transfer of oxygen from the air into water and concluded that it appeared safe to spread this alcohol on any water surface which was initially 90 per cent saturated with oxygen, as a 50 per cent reduction in the oxygen transfer coefficient would only lower the oxygen content to 80 per cent saturation which is still a satisfactory oxygen level.

Both proteins and bacteria have a destructive effect on surface films and seem to be the main cause for the reduction in film efficiency. Until an effective means is developed for controlling bacterial growth, the most efficient suppression method in the field is to apply chemicals in a continuous manner.

Evaluation of Evaporation Reduction

Evaporation reduction is easy to evaluate if the water budget can be determined accurately. On Lake Hefner in the United States, extensive research has been carried out using the energy budget and mass transfer methods, and a great deal is known of the hydrological regime. Expensive instrumentation was needed to give accurate and continuous measurements of the water-surface temperature, wet-and dry-bulb temperature, wind speed, incident and reflected radiation, and water temperature with depth at selected locations.

On a smaller scale, simplified methods may be employed by considering evaporation losses and savings in relation to a few easily determined parameters: coverage factor, evaporation reduction factor or film efficiency measured in pans at the site, wind speed, and saturated vapour pressure.

Researchers in India point out that, over large water surfaces with high evaporation rates, a measured efficiency of up to 30 per cent would be in the same order as the accuracy of measurement with pan evaporimeters; extensive studies of the variation of pan reduction coefficients should therefore be carried out at each site before quantitative estimates can be made.

Estimated Savings and Costs

Florey (1966) estimated that the annual water loss due to evaporation in the 17 western states of the United States is 1.7×10^{10} m^3, taking into account only large lakes and reservoirs of an area greater than 2 km^2. Estimating the average annual consumption per capita from municipal systems to be 0.6 m^3/day, equivalent to 219 m^3/ year, and a yearly cost per person of $US 10, the cost of the evaporation loss would be nearly $US1,000 million per year.

No figures are available for the cost of application and operation of evaporation retardants, but, subject to further research and improved efficiency, there seems to be no doubt as to the economic feasibility of suppression techniques.

Conclusions

Loss of water by evaporation from reservoirs is considered a potential problem in arid and semi-arid zones of the world. In the humid zones with temperate climates and in the more developed countries of the world, where much of the research is carried out, the results of which will be of great value to the problem areas, the problem is not so great.

The general principles involved in evaporation suppression mainly in the monolayer film method, have been outlined in this article. Much doubt is still attached to the over-all effectiveness of the film methods, which should encourage investigation into other possible methods. More research is therefore still needed, especially under a greater range of natural field conditions, before positive conclusions and recommendations can be made.

Postscript - One should perhaps not neglect the alternative or rather supplementary approach to reducing evaporation proposed by G. Stanhill (1970), namely: "... diverting the paper used to report research on this topic to provide an evaporation reducing cover for open water surfaces ... The area of paper currently devoted to research was calculated to be 4,750 x 55 x 11.2/2 x 476 cm^2

= 69,638 m^2/yr

... There is, however, important additional saving in water resulting from the publication of the results of evaporation reduction research. This is due to the reduction of evapotranspiration and the increase in water yield from forested catchment areas denuded to provide newsprint for scientific publication . . . It may be concluded from the above that the mere act of publishing the present volume of evapotranspiration reduction research results in a water saving of 91 m^3/yr via a reduction in evapotranspiration. This figure could be enhanced five hundred and seventy-four fold, if the publications were spread upon the waters" . . . or eight hundred and sixty-one fold if hydrophobic paper was used exclusively !

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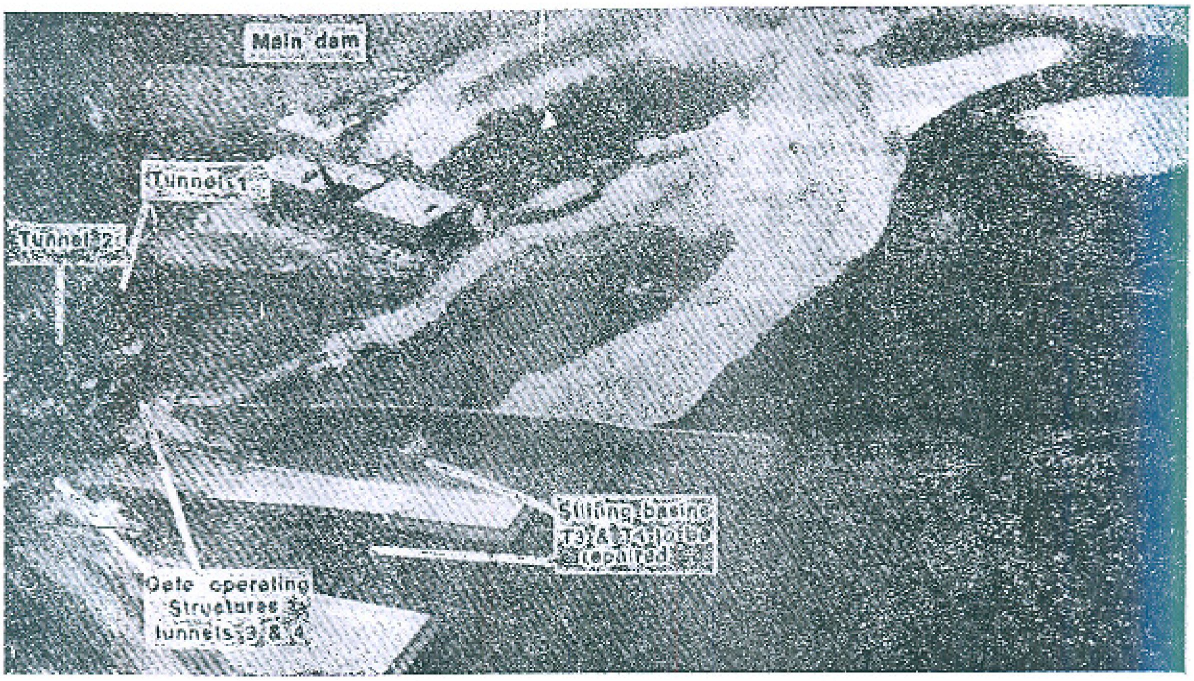
Erosion blow rocks troubled Tarbela Dam



Another serious blow has hit troubled Tarbela dam. Extensive erosion to concrete stilling basins at irrigation tunnel outlets will require a crash emergency repair programme which could last into next spring.

The first sign of trouble was spotted on 16th August when huge chunks - believed to be either boulders or concerete were seen being thrown up by waves and spray in the stilling basins of tunnels 3 and 4. With all gates open and the reservoir near maximum elevation, the basins were absorbing most of the 5Mhp they were designed to dissipate. Gates to both tunnels were immediately closed and divers ordered to investigate. Their reports dismayed engineers.

Erosion in tunnel 3's later-basin floor extended through the 3m-thick reinforced concrete basin lining an estimated 12-15-m into the poor quality rock below. Laterally, the damage ran under the left hand (outer) wall of tunnel 3 into the adjacent rock. To the opposite side, major areas under and through the concrete wall separating stilling basins for tunnels 3 and 4 were worn away.

Depth and murky water has severely limited diver visibility and the extent of damage under and through this wall is still not known. Some damage, although relatively minor, occurred in the tunnel 4 stilling basin. British underwater construction expert Strongwork Diving (International) has been called in to help

Reproduced from New Civil Engineer, 18 September, 1975 Issue

place 50,000M³ of concrete for repairs.

Placing the tremie concrete began on Monday, launching the repair programme described by consultant Tippetts-Abbett-McCarthy-Stratton (TAMS) as 'extremely difficult'. While the irrigation tunnels will be closed during the repair period, some water can still be released through the dam's spillway for irrigation over the winter months.

Ironically, the Italian-led consortium, Tarbela Joint Venture, had planned to close down the two tunnels just six days later to repair damage that occurred during last summer's dramatic emergency drawdown (see *NCE* 3 October, 1974). The work had been considered a significant but not a major operation, requiring placement of concrete and reinforcing steel to repair erosion, varying, according to TAMS, 'a few inches to several feet' in the spilling basin lining. The job was originally targeted for completion at the end of this year. Another 2-4 months have now been added to that.

The original damage occurred last year when both tunnels 3 and 4 were operating in what TAMS calls a 'one-legged configuration'– only one of the two gates operating on each tunnel. Boulders entering the basin from downstream caused the damage.

With both gates open, engineers at the site kept a careful eye on the basins this year, conducting soundings every eight days to make sure no further erosion was taking place. But, for some reason, soundings were not taken in early August.

TJV had originally planned to dewater the basin and carry out repairs with either tremic concrete or some form of prepack. Now, however, TAMS says a decision has been taken not to dewater because of uncertainty about stability of the basin wall between tunnels 3 and 4.

Tyler Marshall

Buildings
Bridges
and
Highways
Section

Methodology of Concrete Construction

by

CH. GHULAM HUSSAIN*

Introduction

The use of concrete has very rapidly superseded brick masonry, woodwork, and steel fabrications in various types of modern structures. Besides, the poured in-place construction techniques, the development of precast-concrete and prestressed conrete units for incorporation in structures has received widespread popularity in the recent years.

The poured-in-place construction cannot always enjoy favourable conditions. There may be a wide variance in the quality of concrete components ; the compounding of its ingredients, the control of its chemical processes, and the arrangement of its parts being often performed by unskilled workers. This is in marked contrast to structures that are built of concrete or steel units prefabricated in factories by proficient workmen and assembled in the field by expert foremen.

The materials, plant and equipment, construction techniques and measures, required for the production of a good quality concrete and the remedies for the practical difficulties that a resident engineer, who has to supervise a poured-in-place construction, may encounter on the site, are discussed in this article.

2, Concrete And its Ingredients

Concrete consists of cement, sand aggregate, and water. In order to improve certain qualities of concrete some admixtures are also added to it.

2.1 Cement

The use of ordinary portland cement, because of its expected smaller shrinkage, is preferable in the construction of permanent works, However, high early-strength (rapid hardening) cement is mostly used for prestressed concrete. Highalumina cement should not be used in areas of high temperature and humidity since, in that case, the strength of the concrete would decrease. Supersulphate cement, which has high resistance to sulphate attack and extremely low heat of hydration, is most valuable in certain cases.

Characteristics of cement should be tested for conformity with applicable provisions of ASTM : C-150 or/British standards before its use in the construction. Table 1 shows the physical characteristics, as tested in WAPDA Central Labortory, of ordinary portland cement used in the permanent structures of Chashma-Jhelum Link Canal. However, the use of some recognised standard brand of cement can be adopted on the small jobs

*Executive Engineer, Task Force, WAPDA

or the far-flung sites where the testing of cement characteristics is not possible.

Suitable storage must be provided for cement at place convenient to the work. It should be observed that cement at all time be carefully protected against moisture and exposure to air. Cement warehouses should be water-tight having tight floors set at proper level above the natural ground surface. Warehouses should be large enough to maintain sufficient supply of cement on hand to prevent delays or interruptions in the work. The floor-space of warehouse should be sufficient for storing each car load of cement separately and affording convenient access thereto for sampling, conuting of packages, and removal. Cement in packages should not be piled to a height exceeding 7 feet.

2.2 Aggregate

Aggregates may be of either natural or artificial origin. Because of wide spread distribution, natural sand, gravel and mechanically crushed rock are commonly used aggregates.

The term "sand" is used to designate aggregate in which the maximum size of particles is 3/16", It may be processed from gravel deposits or manufactured from quarried rock. The term "Aggregates" is used to designate aggregates which are reasonably well-graded within the range of 3/16" to 3" or any size or range of sizes within such limits.

The sand or aggregates should consist of well-shaped, hard, dense, durable, uncoated inorganic rock fragments, free from injurious amounts of clay lumps, soft or flaky particles, shale, alkali, organic matter, loam, mica, and other deleterious substances. Aggregates may be rejected if they fail to meet the following test requirements.

(a) Los Angeles rattler test (ASTM Designation : C 131). If the loss exceeds ten percent, by weight, at 100 revolutions, or 40 percent, by weight, at 500 revolutions.

(b) Sodium-Sulphate test for soundness (ASTM Designation : C88). If the weighted average loss after five cycles is more than ten percent by weight.

(c) Specific gravity (ASTM Designation : C 127). If the specific gravity (saturated surface dry basis) is less than 2.60.

2.21 Gradation :

ASTM and B.S. set quite wide limits for the gradation of sand and aggregates to be used for producing concrete. Nevertheless, reasonably graded aggregate is an important requirement for obtaining good-quality concrete. For instance, of 1¼ in, down aggregate is recommended for mix-design, then every load must contain some materials of all sizes, i.e. 1½ in, 1 in, ¾ inch, ½ inch. No load must consist of entirely 1½ inch, 1-inch stones or contain no 1½ inch stone.

Table 2 gives ASTM Gradation requirements for sand and aggregate and typical test results of sand and coarse aggregates used for producing over 1,34,000 cubic yards of structural concrete on Chashma-Jhelum Link Canal.

..., and other deleterious
...regates may be rejected
...eet the following test re-

...eles rattler test (ASTM
...ion : C 131). If the loss
...ten percent, by weight, at
...lutions, or 40 percent, by
... 500 revolutions.
Sulphate test for sound-
...STM Designation : C88).
...eighted average loss after
...s is more than ten per-
...eight.
...gravity (ASTM Designa-
127). If the specific
(saturated surface dry
less than 2.60.

B.S. set quite wide limits
... of sand and aggregates
...oducing concrete.
...onably graded aggregate
requirement for obtaining
...crete. For instance, of
...regate is recommended for
every load must contain
...of all sizes, i.e. 1½ in,
...h. No load must consist
...h, 1-inch stones or contain

... ASTM Gradation require
...nd aggregate and typical
...nd and coarse aggregates
...ing over 1,34,000 cubic
...ral concrete on Chashma-
...nal.

TABLE - 1

CHASMA JHELUM LINK CANAL-SOURCES AND CHARACTERISTICS OF PORTLAND CEMENT

Brand name of Cement.	Country of Origin.	Period of use on Project.	Average Physical Characteristics Determined by Testing							
			No. of Tests.	Fineness (Specific Surface sq. cm/gm)	Soundness (mm)	Setting Time Minutes		Compressive Strength		Loss on Ignition (percent
						Initial	Final	at 3 Days (psi)	at 7 Days (psi)	
Maple Leaf	Pakistan	9/67-12/1976	1	3670	0.5	160	310	4140	5100	1.0
Maple Leaf	Pakistan	1/68-3/1968	16	3125	1.1	145	252	4345	5635(a)	1.4
Maple Leaf	Pakistan	4/68-6/1968	13	3043	1.0	135	206	3608	4623	1.0
Maple Leaf	Pakistan	7/68-9/1968	3	2625	1.3	94	144	4204	4672	1.0
Maple Leaf	Pakistan	10/68-12/1968	9	3014	1.6	108	160	3092	4612	1.1
Maple Leaf	Pakistan	1/69-3/1969	3	2797	1.2	143	185	3817	4787	0.9
Maple Leaf	Pakistan	4/69-6/1969	5	3346	1.0	76	130	3759	4782	0.7
Maple Leaf	Pakistan	7/69-9/1969	4	2705	1.1	67	106	3918	4495	2.0(b)
Maple Leaf	Pakistan	10/69-12/1969	14	2945	1.0	90	122	3908	4777	1.7
Maple Leaf	Pakistan	1/70-9/1969	2	2352	1.7	103	195	3885	4100(c)	0.5
Specification Requirements.				2250	10 Maz.	45 Min	600 Max	2200 (Min) (d)	3400 (Min) (d)	3.0 Max.

British Standard 12 :
(a) Average of 14 tests.
(b) Average of 2 tests.
(c) Result of 1 test.
(d) Requirement for 2.78 inch mortar cube composed of 1 part cement and 3 parts sand.