SEEPAGE AND EVAPORATION EVALUATION OF SCARP-VI, RAHIM YAR KHAN

Project submitted in partial fulfillment of the requirements for the degree of
BE Civil Engineering

Syndicate Members

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NATIONAL UNVERSITY OF SCIENCE AND TECHNOLOGY
MILITARY COLLEGE OF ENGINEERING RISALPUR

This is to certify that the

BE Civil Engineering Project entitled

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Submitted By

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Has been accepted towards the partial fulfilment of the requirement for BE Civil Engineering Degree

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Col Nawab Ali Dogar

ACKNOWLEDMENTS

First, we would like to thank the Almighty Allah because whatever we are, whatever has been achieved by us is solely due to Him alone. We would like to express our very great appreciation to our supervisor Col. Nawab Ali Dogar for his valuable and constructive suggestions during the planning and development of this work, as well as their invaluable guidance throughout this Endeavor. Finally, we wish to thank our parents for their support and encouragement throughout our study, and the love they have shown to us in this life. Without them we would not be here.

All Syndicate members

Thank You

Dedication

Our worthy instructors for their unquantifiable love and their support, our beloved Parents for their unquantifiable love and their support, and to our Project Advisor for sharing his wisdom and guidance and encouraging us to complete this project successfully.

Last but not the least, to our Institution and home for providing us with such platform.

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Abstract

A project Salinity Control and Reclamation Project (SCARP) was launched in Cholistan and Bahawalpur division to increasing agricultural production. This project was launched by WAPDA in 1981 and completed in 1989. On its completion it was handed over to Irrigation Department, Government of Punjab and later in 1992 it was placed under supervision of Pak army to utilize the evaporation ponds for defence purpose. The project with collaboration of Pak Army and Irrigation Department is not only reclaiming 1.34 Million Acre of land of Channi Goth, Feroza, Liaqatpur, Khanpur, Sadiqabad and Manthar but also maintaining an Evaporation Pondage area (water obstacle), of 104 KMs length. The research work is divided into two major phases. First phase incorporates the geotechnical analysis of SCARP-VI. Seepage analysis of two major drains has been performed for examining the effect drains seepage on water logging in neighboring areas. The seepage analysis has been performed with the help of computer software GeoStudio SEEP/W 2018 R2. Sustainability of the pondage area located near the international border is evaluated in the second phase of research. Additionally, it includes the development and the assessment of area in subsequent years after the commencement of the project since its beginning. Various techniques to reduce evaporation in the ponds have also been discussed in the research work.

Chapter 1

Introduction

1.1 General

The process when the radical zone of soil when saturated with water is called water logging. The saturation of the soil with water by the elevation of the table of underground water to the surface of soil achieved by the persistent filtering of water from the top surface. The inability of soil to bear plant life resulting from the amassing of salts in it is term as salinity.Salinity and water logging go hand in hand.

This can be attributed to the following factors:

- Declined corporeal soil condition and existence of abundant quantity of salts.
- Botching of irrigation water and excess irrigation
- Disruption of the organic drainage system
- The irrigation network being saturated by salts due floods or salt mountain ranges etc.

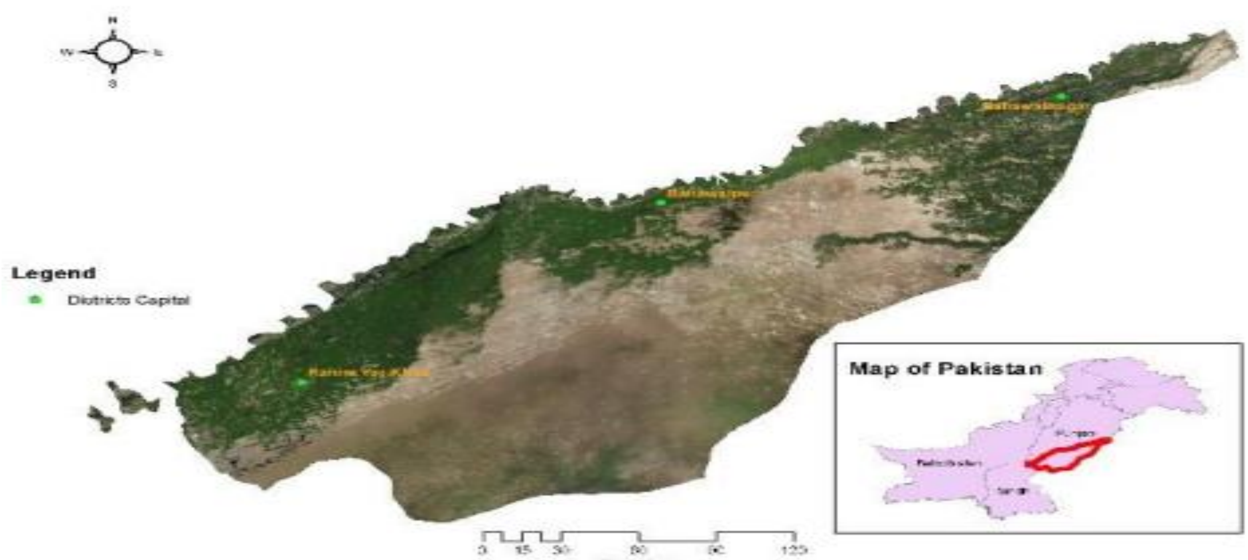
The problem in water table rise started in the 1940’s. From observations, it was discovered that the issue rooted from the disruption of the dynamic equilibrium between the recharge and discharge of ground water cause using canal irrigation leading to problems of logged water and salinity. An elevated recharge rate and diminished aquifer discharge led to a rise from 1.5 ft to 2.0 feet in Northern Zone (upper Indus plane). In areas catered by canals, a 3.3 MA highly saline, 2.6 MA modestly saline and a slight salination of 4.6 MA resulted in a total estimated 10.5 MA saline area. Although this issue is existent in all provinces, but Punjab and Sindh have it the worse having a total of almost higher than 47% of their area being saline. Areas include Gujranwala, Sheikhupura, Faisalabad, Shahpur, Jhang, Multan etc. Water logging is existent is thirty eight percent of Pakistan’s total lands of irrigation, salinization is 14% while only 45% of cultivable land is used at once. Pakistan is most affected by salinity and then water logging. These soil diseases affected our farmers decreasing their fertile land and in-turn they sale it to rich farmers at low prices. They caused food shortages in places of high salinity and water logging, degradation of environmental water (water pollution) and even affected transportation as building roads on such lands is quite challenging.

To overcome the problem and prevention of expansion of affected lands earlier strategy of controlling canal seepage and fixing already affected lands by vertical and horizontal drainage. Looking at the seriousness of the problem our government and private sector gave high priority to control and reclamation efforts. Tube-wells were installed to discharge ground water and to fix seepage form canals channels they were lined.

Between the time frame of 3.5 decades 1960 – 1995, WAPDA has completed 55-SCARPS and drainage projects clearing an area of 15.78 MA whereas 14 projects covering an area of 6.521 MA near completion.

1.2 Background

The shortage of appropriate drainage in agriculture facilitated by irrigation is the reason for water logging and salinity. A concise stating of the cause is available since they were not either known very well or documented adequately. In the Indus plain, the building of irrigation network based on weir-control was started by the British at the end of the 19th century. The start of this construction led to a steady increase in the groundwater table. The seepage from watercourses and canals resulted in a significant provision to the increase of the water table. Furthermore, the losses of deep seepage owing to irrigation also added to the issue. The obstruction of the organic drainage resulted from lack of sound cross drainage facilities in road and railway networks and the establishment of flood and irrigation bunds. Ponds were formed in the depressions due to excessive monsoon rains and this resulted in an increase in water seeping volume and blending with groundwater. Climatic state, initial composition of soil, land use, irrigation exercises, and water table depth are the root causes of soil salinity in Pakistan.



<u>Figure 1.1: Location Map of project Area</u>

The Government's Salinity Control and Reclamation Program (SCARP) was conceived in the late 1950s. Its first project became operational in 1963. To date, more than 8,000 publicly owned tubewells have been installed in both saline and fresh groundwater areas to lower the water table and to enable reclamation of land and increase irrigation. Private enterprises have installed over 150,000 tubewells in areas where the groundwater is suitable for irrigation. However, in areas where the groundwater is saline, and in fresh groundwater areas where the water table is so high that profitable irrigation cannot take place without first lowering the water table no private groundwater development has taken place. In many parts of the SCARP VI area, in both the fresh and saline groundwater zones, the water table is so high that it hinders the profitable agriculture. Consequently, freshwater tube well development, while substantial, lags that of the rest of the Punjab. In addition to the effects of the high-water table, some of the soils have become saline due to deliberate under-irrigation by farmers. Consequently, in 1967 the ISS report had established that remedial action would be necessary to lower the water table, dispose of saline effluent and to provide more irrigation water to leach the salt-affected soils. A project plan was prepared in 1968. In 1973, when the Federal Planning Commission prepared its "Proposals for an Accelerated Program for Salinity and Waterlogging Control", the need for the project was confirmed.

Areas of Punjab especially south Punjab and Sindh are neighboring this project. The land which was once saline and waterlogged is now suitable for irrigation and cultivation. After the commencement of the project a steady increase is observed in the agricultural produce which indicates the success of the project.

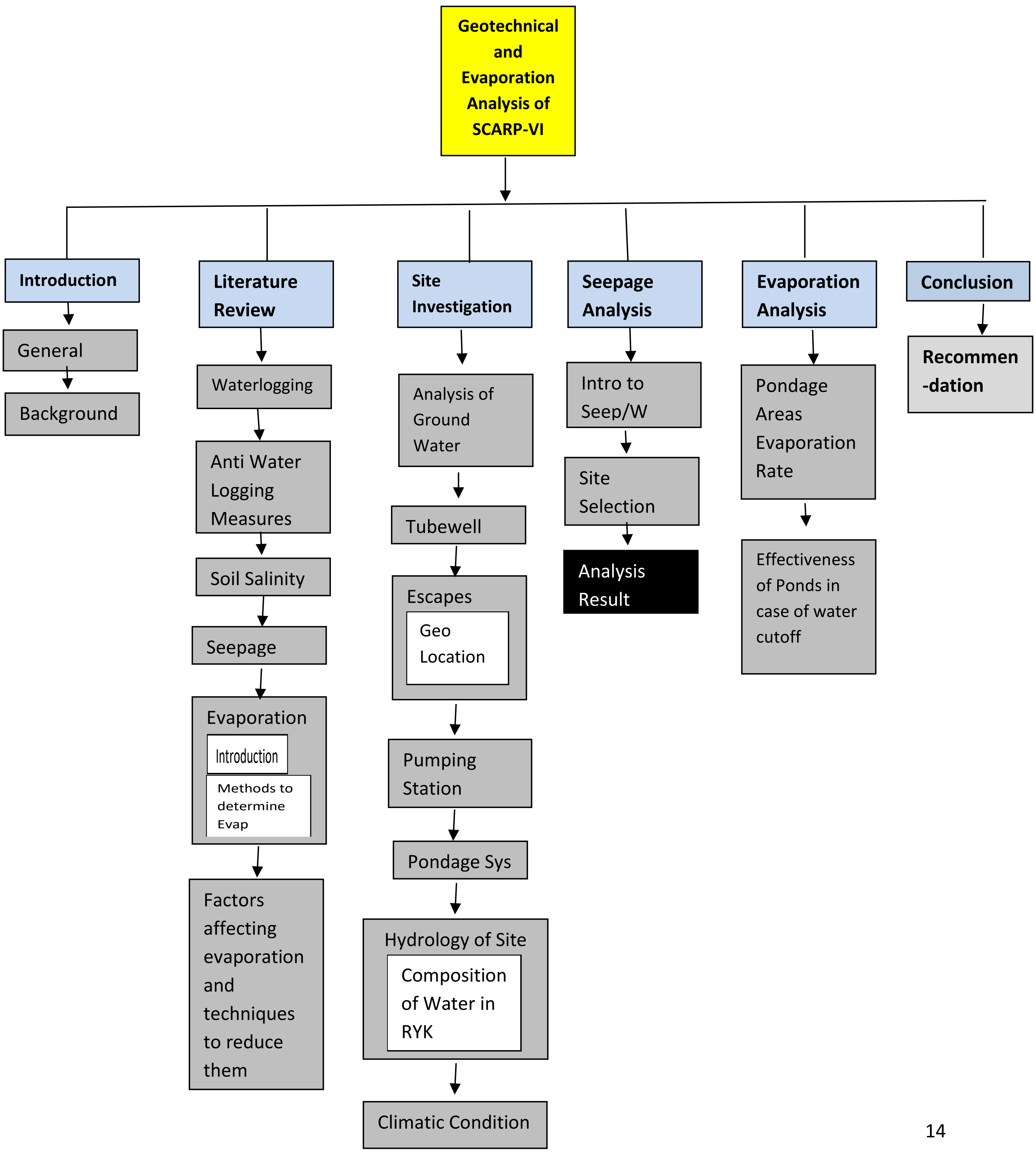
1.3 Problem Statement

Seepage from canals and reservoirs and poor irrigation practices have resulted in widespread problems of water logging and salinity the area of Rahim Yar Khan. Therefore, this study proposes to analyze the canal seepage at 2 drains and to analyze the evaporation of the pondage area to ascertain the effectiveness of project at times of water discontinuity.

1.4 Objectives

a. To do seepage analysis of Khanpur and Manthar drains.
b. To do evaporation evaluation of pondage area.

1.5 Research Methodology Flow Chart



Chapter 2

Literature Review

2.1 Background

The SCARP venture began in 1961 with 2,100 open tube wells to give seepage to over 0.6 million ha land in Punjab. The regulation of the groundwater table was achieved by the wells by the extrapolation of water out of the ground. By considering the nature of the water, it was delivered in 3 different regions. Namely, based on suitability the networks for water system purposes were catered by fitting new groundwater, similar the trench water for water systems were mixed in with moderately saline water, and dumping in stores method was used for water with higher salinization [WAPDA, 2015]. The SCARP wells dispensed with the waterlogging issues in the anticipated zone and an aggregate of 60% of saline arranged land was recovered. Also, the SCARP wells twofold the measure of water for the water system, which expanded the editing force by 50 percent. SCARP wells not just disposed of the twofold danger issue of Pakistan, yet it additionally expanded agrarian profitability. Subsequently, the establishment of SCARP wells proceeded with covering 3.7 million ha of land. In any case, numerous experts in the 1960's begun addressing the establishment of SCARP wells in regions that previously had noteworthy new groundwater accessible.

A plan based upon incentivizing ranchers by providing them credit for the development of wells and provisions of funding on power in areas with abundant accessibility of groundwater in order to provide and management and support initiative for private tube wells was made in 1977. It was believed that the salinity issue will be catered by this step of privatizing tube wells. The shallowness of the privatized tube wells releasing seven to twenty-eight compared to SCARP tube wells profound depth of 40-120m releasing sixty to hundred and forty liters of water per second gave them a significant edge on costs with table lower than ten meters. The extraction of improved quality of groundwater from the top spring piece eliminates the accumulation of salt in the dirt. In Pakistan, salinization is an extensive issue and although the private tube wells offer a short-term solution but has a downside of amalgamating the problem with time. Since no guarantee of stability of water table can be provided since there is a lack coordination between the huge quantity of private tube wells.

The subsurface seepage comprises of covered authority and field channels. Most of the subsurface seepage requires release into a sump because zones with the twin danger are level areas in Pakistan. The profundities of these channels are kept at a profundity well underneath the root zone for two reasons: to diminish salinization of the root zone that came about because of slim ascent and furthermore more profound frameworks were less expensive because more profound channels permit bigger channel space.

2.1.1 History of SCARP-VI

In the late sixties and mid-seventies, because of extreme precipitation and substantial floods, approximately 1.67 million sections of land of farming place where there is Khanpur, Rahim Yar Khan, and Sadiqabad became waterlogged. The subsoil water table rose to the ground surface and the immense region of rich land got fruitless.

SCARP VI was propelled by WAPDA in 1981 with the budgetary help of the World Bank for the recovery of this infertile land. 1.44 million sections of land infertile land were focused on and out of the target region, 1.33 million sections of land have been recovered until now.

2.1.2 Development of project in different time periods

- When SCARP began, at first there was SCARP well utilized for salinity control and waterlogging purposes.
- After 1990s, the SCARP wells ended in the territory because of lackluster showing, significant expenses, and short operational life related to the infrastructure. The Government of Pakistan urges the establishment of tube wells to decrease waterlogging issues.
- For instance, the legislature gives sponsorships to the ranchers to introduce tube wells. Additionally, there is no limitation on the use and establishment of tube wells; subsequently, the tube wells are effectively accessible for the ranchers to introduce.
- SCARP VI became operation under Irrigation and Power (I&P) Department of Government of Punjab (GOP) in 1989.
- The activity and upkeep (O&M) obligation were given over to Pak Army (5 Corps) in 1992.

- Initially saline water of SCARP VI was arranged off in the dissipation lakes normally existing in the desert.
- These dissipation lakes have been astutely used by spreading the water in a straight shape along the global fringe to transform it into an imposing obstruction, providing a conviction that all is good in the most undermined Sec of Reti – Rahim Yar Khan.

Salient Features of SCARP-VI

Area Covered	6077 Sq Km
Date of Commencement	Jul 1981
Date of Completion	Mar 1994
Cost	Rs 1.5 Billion
Funded by	World Bank
Handed over to Army	Jul 1992

2.1.3 Effectiveness of Project

- 1.44 million sections of land infertile land were focused on and out of target area, 1.33 million sections of land have been recovered until now.
- Soil salinity additionally diminished in the zones where subsurface funnels were introduced.
- From the long stretches of 1984 to 2000, the salt-free zone expanded from 56% to 73%. Along these lines, the general improvement was 17%. The improvement is chiefly because of the draining of the salt beneath 180 cm profundity by bringing down the water table.
- During the SCARP wells activity, the harvest yield expanded 11 to 14 percent since all the newer water opened through the SCARP ventures.

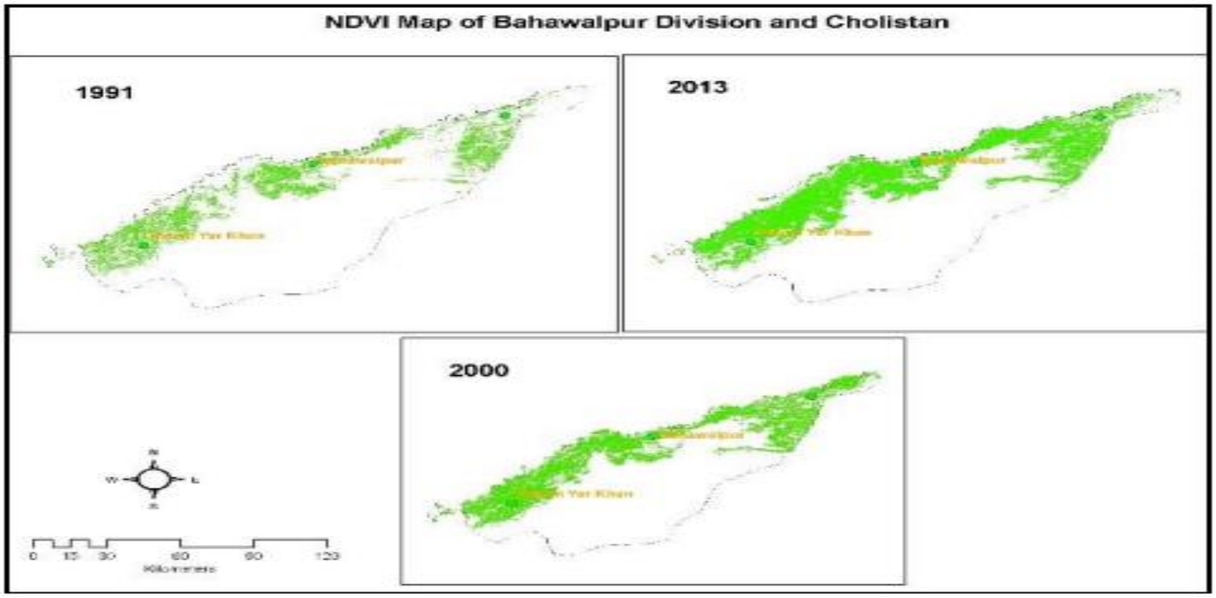


Figure 2.1: NDVI based vegetation map of the Bahawalpur Division and Cholistan

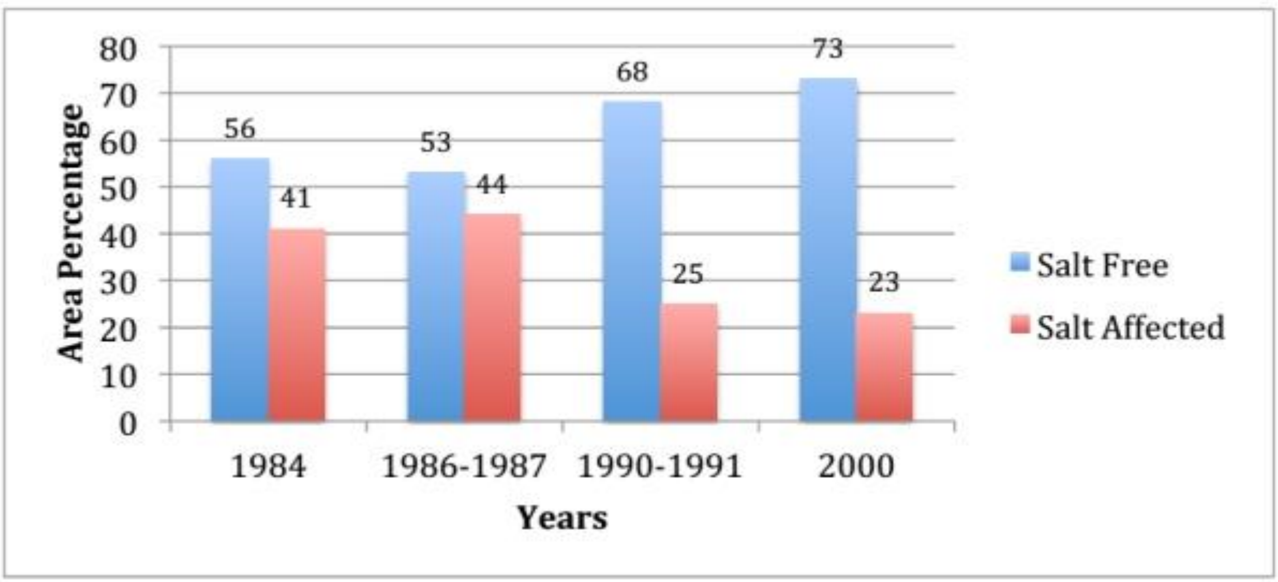


Figure 2.2: Soil profile in FDP area source

2.2 Water Logging

The rise of water table to the ground is known as water logging. This is a condition in land where the soil pores within the root zones of the crops gets saturated with the subsoil water.

2.2.1 Symptoms and Causes

- Over irrigation
- Heavy rainfall
- Percolation through canal
- Percolation through dam
- Seepage through rivers/waterways
- Floods
- High water table
- Improper cultivation

2.3 Anti water logging measures

1. Sufficient surface drainage

A crucial step would be the timely removal of the rainwater by a fitting surface or open drain.

2. Structured under-drain

The disposition of surplus subsoil water by the provision, at suitable depths underneath the ground surface, of tile drains.

3. Restraining Water loss by seepage from the canals

This would involve a measure to lower the canal's F.S.L. This can be achieved by using a fitting impervious material to line the canal. In this way enabling an economic use of irrigation water and a controlled intensity of flow of irrigation.

4. Adjusting the irrigation system

A failure to cater the needs of an area by an irrigation system calls for a change better suited for the conditions.

5. Disposing excess water

A disposing of excess of surplus from on a regular basis ensuring the fertility and yield of the land should be done to prevent the land from water logging.

6. Averting seepage from reservoir

Prevention of water seepage from the reservoir calls for its proper maintenance.

7. Lining channels of field

A reduction in the seepage loss to a considerable extent can be achieved by correct lining of canals and channels making them watertight.

2.4 Soil Salinity – Causes and Management

Salinity is of two types: soil salinity and water salinity. Soil salinity is one of the main issues faced by the areas such as Rahimyar khan in Pakistan. Soil salinity is the appearance of salts on the surface causing hinderance in the growth of plants and decreasing the fertility of the land.

Causes

Salinity is caused by the rise in water table of that area. When water arises and appears on the land, it generally brings the salts present in the soil strata on the ground. This process is irreversible, that means once it has appeared on the surface it cannot go back in the ground. Soil salinity can be caused by following things: -

- Water logging.
- Water salinity.
- Accumulation of the fertilizers.

Due to water logging, the surface is submerged in water. When that water evaporates, it leaves salts on the ground causing salinity. The other cause is due to water salinity. In water salinity, the water rises till the root level of the plants. It brings the salts from the strata and accumulate that in the root zones, resulting in the fatality of the crops. The usage of too much fertilizers also causes salinity in the soil.

Management

The best way to manage the salinity is to let the water drain from the fields. The draining water dissolves the salt from the surface and takes them away. Providing proper drainage causes the water to leave the surface quickly hence not providing anytime to stay on the surface. This is the best way to counter soil salinity. Proper and calculated usage of the fertilizers also helps in managing the soil salinity.

2.5 Seepage

The ease with which a fluid flows through a porous medium is measured in terms of the permeability of the fluid. The fluid is taken to be water and the porous medium the soil in geotechnical engineering at ambient temperature. A coarse soil offers more permeability due to a greater size of voids and hence gravels have a higher permeability compared to slits.

Measures for controlling seepage

Canal seepage can be controlled through various means that have proven to be quite efficient. Controlling the seepage from the water bodies results in control in water logging. Reduce the water loss. Increase the water quality of water. Stop algae and HAB (harmful alga bloom) to grow in the water, it increases the discharge rate of the canals etc. Following are the means through which we can control canal seepage: -

- Seepage-control lining of canals made from cast-in-situ concrete
- Reinforced-concrete slabs
- Asphalt
- Rock
- Watertight barriers beneath canals made from polymer films.
- Clay and loam
- Bentonitic clays

2.6 Evaporation

2.6.1 Introduction to Evaporation

Evaporation is the procedure of a substance in a fluid state changing into a vaporous state because of an increment in temperature or pressure.

Water changes from a fluid to a gas or fume. It starts to evaporate at 32 ºF (0º C); it just happens incredibly gradually.

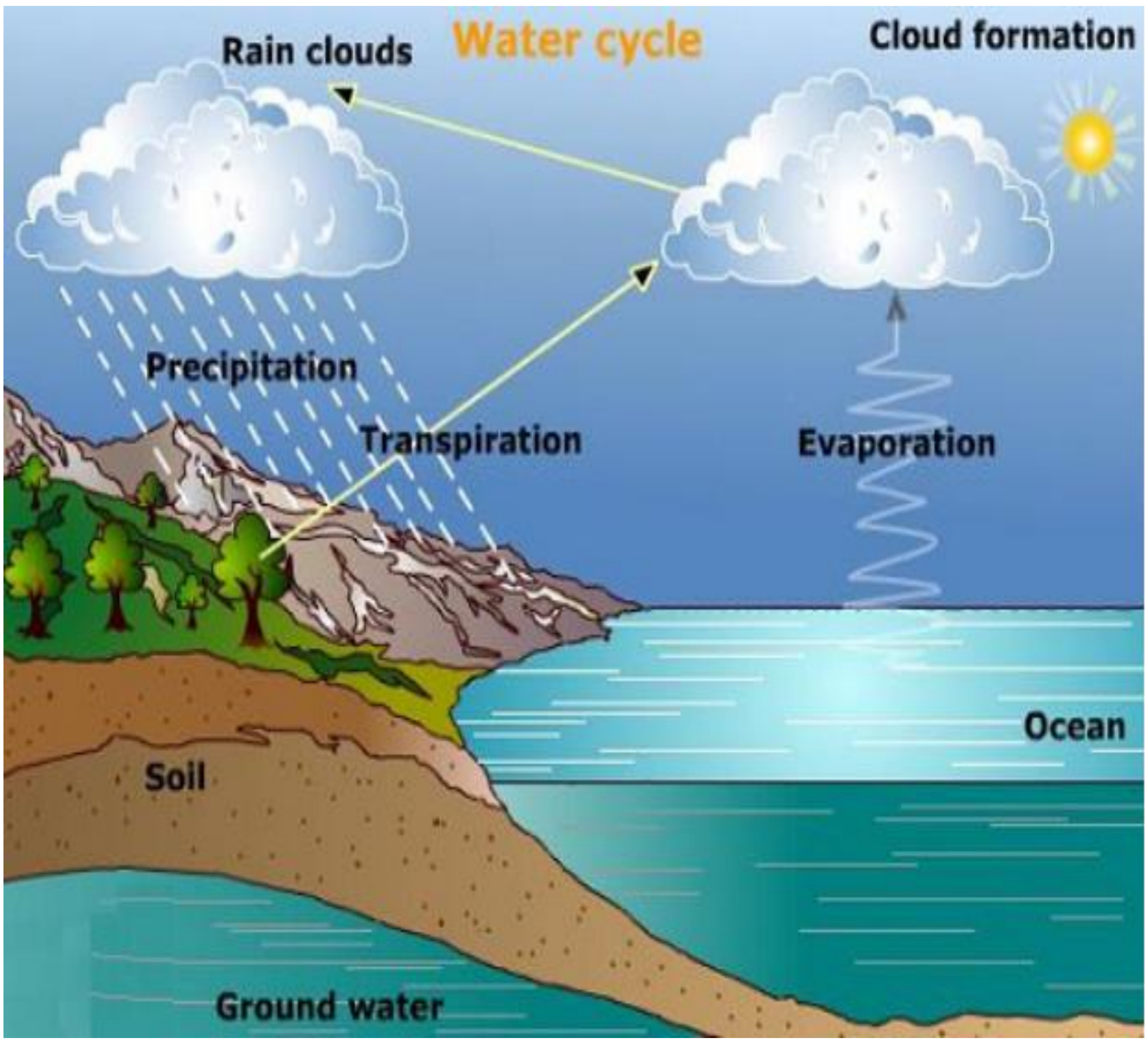


Figure 2.3: Basic Schematic of Evaporation

2.6.2. Factors affecting Evaporation

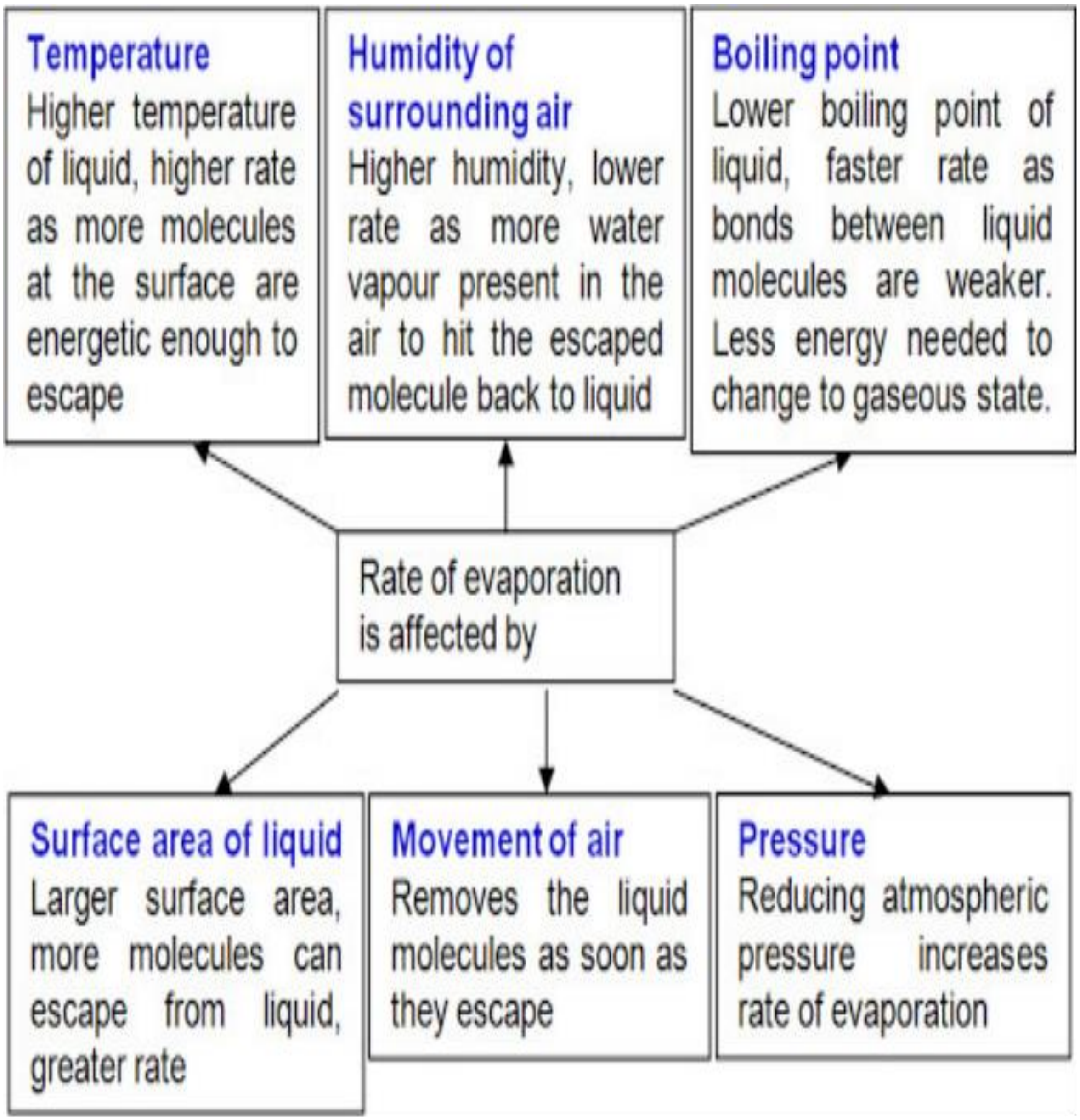


Figure 2.4: Factor affecting rate of Evaporation

2.6.3. Techniques to reduce Evaporation

There are many methods used to try to reduce evaporation losses from the surface of water bodies. Each scientific approach attempts to influence one of the main factors described above: reducing the exposed surface; Reduce the water temperature; Reduce the impact of wind; And so on. Some techniques are as below.

- Underground water stockpiling (naturel and counterfeit)
- Chemical treatment with water Evapo-retardants (WER)
- Reduction of uncovered water surface
- Wind breakers

Some methods of practical importance are listed below

1. **By keeping up the base surface territory of the water**

- The area of the supply can be picked so the proportion of region to capacity is insignificant.
- To abstain from losing water the water can be put away underground.
- When there are various supplies on one stream, water can be put away in one enormous repository when conceivable rather than a few little stores.

2. **Spreading the surface films on reservoirs and lakes:**

Although still in its exploratory stage, this technique when utilized will end up being increasingly affordable and handy helpful. The technique depends on the rule that a slim layer of oil when spreading over the outside of the water can decrease evaporation to an enormous degree. Examinations have indicated that a compound called hexadecimal or acetyl liquor got from fat, sperm oil or coconut oil is equipped for shaping a solitary atom layer on the outside of the water. It shapes a monomolecular film on the water surface. The film so framed is just around 15 x 10-4 mm thick yet it is sufficiently tight to forestall water particle from getting away from the water body. It is assessed that such a film may decrease dissipation by 33%. Hypothetically just 25 gm of hexadecenal is adequate to spread a mono-sub-atomic film on one hectare of water surface.

Chapter 3

Site Characterization

3.1 Drainage System

Drainage system is a system by which water is drained on or in the soil to enhance agricultural production of crops. It may involve any combination of stormwater control, erosion control, and water table control. There are two drainage systems in Rahimyar khan.

3.1.1 Khanpur Drainage System

Some of the major portion of the Khanpur drainage system and their calculated dimensions are shown below.

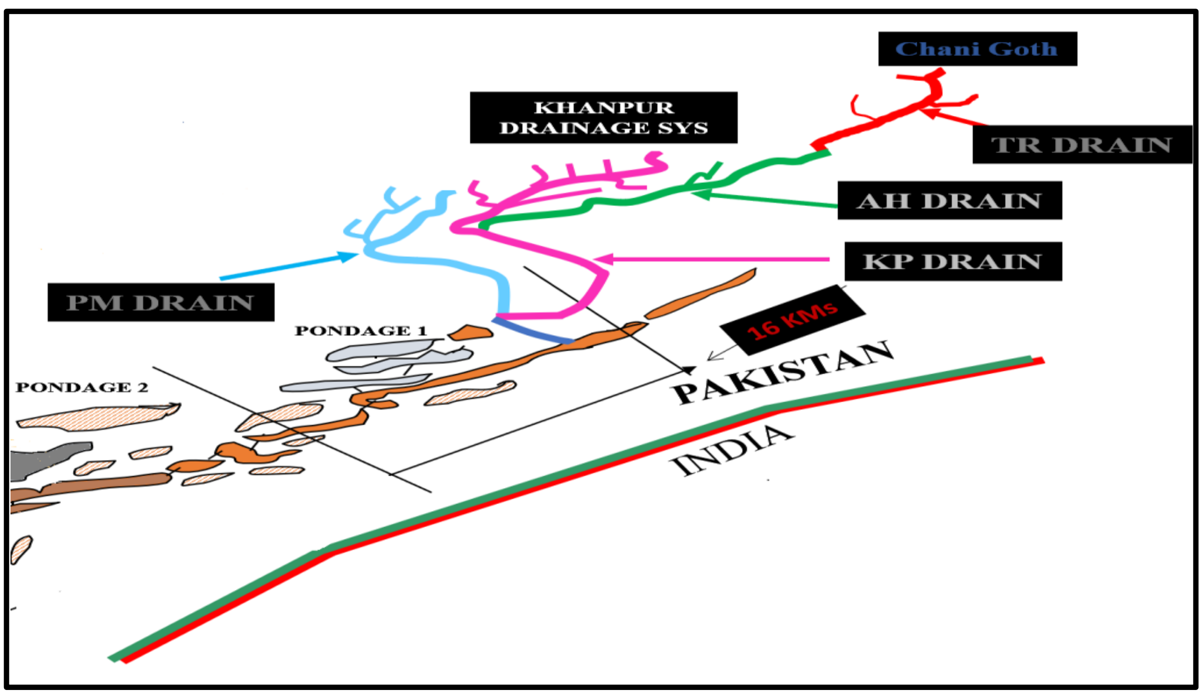


Figure 3.1: RYK Drainage System

Table 3.1: Detail Analysis of Khanpur Drainage System

DRAINS	LENGTH (KM)	TUBEWELLS	DISCHARGE (Cusecs)
Khanpur	115	113	947
Pattan Munara	65	78	250
Aab-e-Hayat	67	48	351
Tarukari	82	123	278
TOTAL	329	362	

3.1.2 Manthar Drainage System

This shows the complete Drainage system of SCARP VI. The two major Drainage system that are under discussion here are:

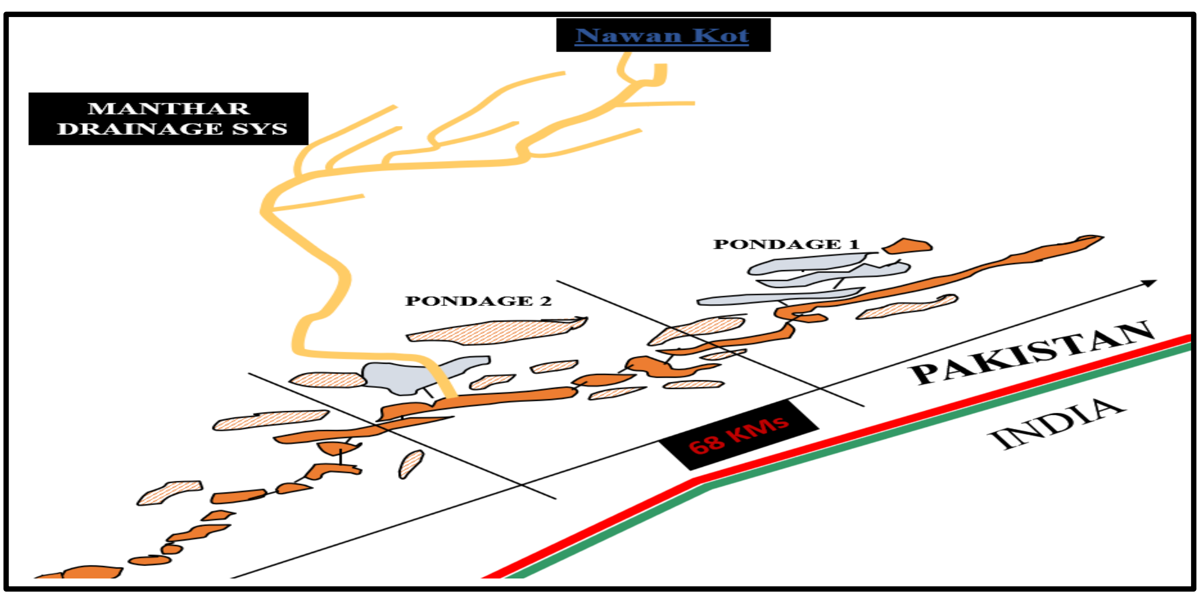


Figure 3.2: Manthar Drainage System

Table 3.2: Detail analysis of Manthar Drainage System

Length	140 km
Tube wells	152
Discharge	431cusecs

3.2 Tube wells

- A schematic diagram of tube well process is shown below:

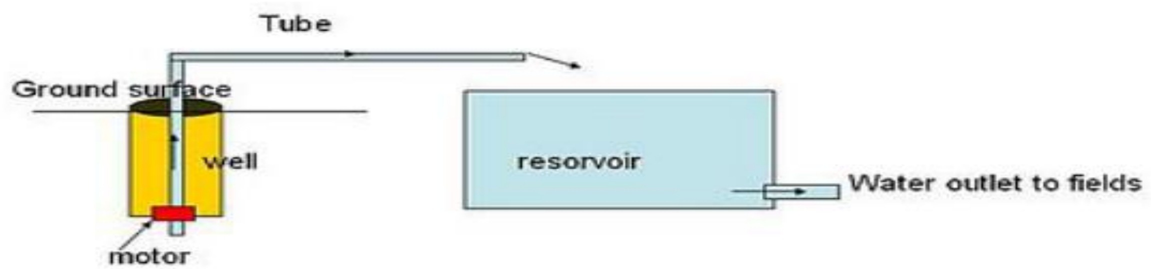


Figure 3.3: Schematic of tube well

- This shows the total number of tube wells system used along the Indus Basin.

Table 3.3: Tube wells Detailed Analysis

DRAINS	TUBEWELLS
Khanpur	113
Pattan Munara	78
Aab e Hayat	48
Tarukari	123
TOTAL	362
Manthar Tubewell system	152
GROSS TOTAL	514

3.2.1 Escapes

The removal of surplus water into an organic drain from an irrigation drain namely main, branch or distributary canal is done through this side channel.

a. **Escape 1**

(1) Located near Jetha Bhutta

(2) Links Abbasia Feeder with Abe-Hayat Drain

(3) Capacity is 250 Cusecs

b. **Escape 2**

(1) Located near Bhatta Sheikhan

(2) Links Aab e Hayat (AH) distributary with AH drain

(3) Capacityis 50 Cusecs

c. **Escape 3**

(1) Located near Gulmerg.

(2) Links AH distributary with AH drain

(3) Capacity is 50 Cusecs

d. **Escape 4**

(1) Located near Goth Tillu

(2) Links Lakhi Minor with Manthar drain

(3) Capacity is 50 Cusecs

e. **Escape 5**

(1) Located near Goth Tillu

(2) Links Gullan distributary with Manthar Drain

(3) Capacity is 50 Cusecs

f. **Escape 6**

(1) Located on Rainee Canal at RD 181

(2) Links Rainee Canal with Dhar-5 of SCARP-VI

(3) Capacity is 3500 Cusecs

Now w.r.t to Indus Basin the escapes and their data that was concluded in result of SCARP VI and were basically based in RYK their data is given below.

Table 3.4: Escapes

ESCAPE LOCATION	LINK	CAPACITY (Cusecs)
Jetha Bhatta	Abbasia Feeder Aab e Hayat Drain	250
Bhatta Sheikhan	1-L Minor Aab e Hayat Drain	50
Gulmerg	Aab e Hayat Disty- Aab e Hayat Drain	50
Goth Tillu	Lakhi Minor- Manthar Drain	50
Goth Tillu	Gullan Disty- Manthar Drain	50
Rainee Canal	Rainee canal Dhar 15 (SCARP VI)	3500

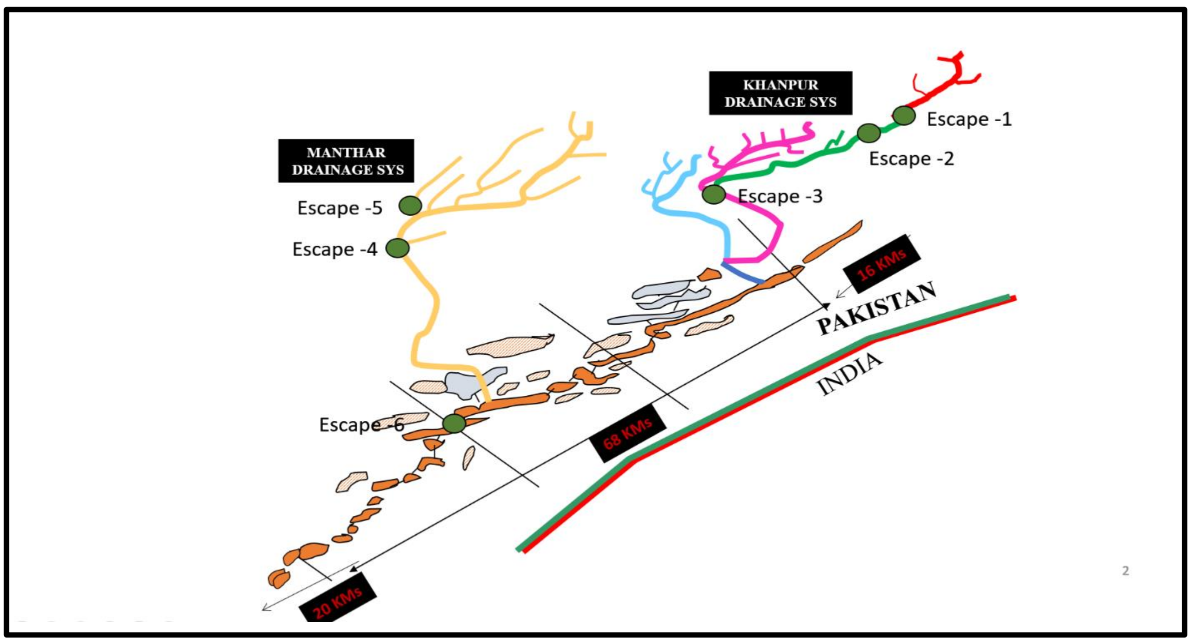


Figure 3.4: Escapes mapped along Indo-Pak Border

3.2.2 Pumping Station

Pumping stations, also called a pumphouse in situations such as drilled wells and drinking water, are facilities including pumps and equipment for pumping fluids from one place to another.

Table 3.5: Pumping station Geo-Location

PUMPING STATION	LOCATION	NO. OF PUMPS	DISCHARGE (Cusecs)
PS-1	Pattan Manara Drain	3	15
PS-2	Pattan Manara Drain	5	100
PS-3	Manthar Drain	13	260

3.2.3 Pondage System

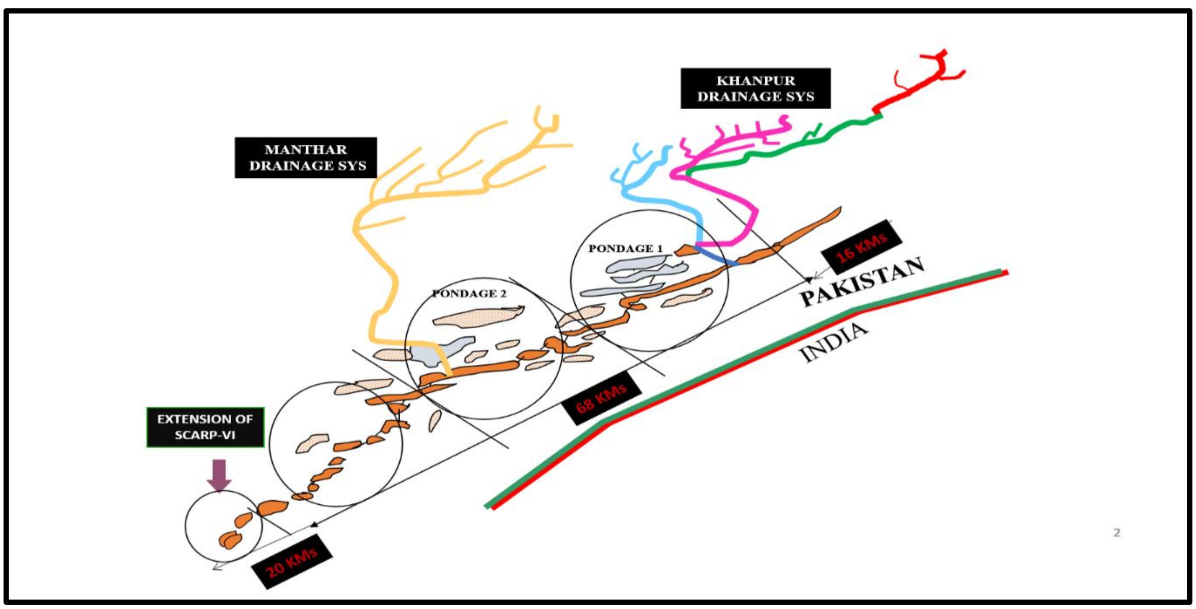


Figure 3.5: Geo location for pondage Area In RYK

Table 3.6: Detailed analysis of Dhars and Channels along Manthar and Khanpur Drain

Ser	Dhars/ Channels	Length (KM)	Width (KM)	Bed Lvl	Area (Acre)	Avg Depth (ft)	Total Capacity (Cft)
1	Dhar - 4	11.5	1.00	235	2,841.71	8.5	1,052,172,246
2	Dhar - 5	6.70	0.50	228	827.80	16	576,945,600
3	Dhar - 6	3.75	3.00	226	2,779.94	12	1,453,127,911
4	Dhar - 7	10.5	1.50	230	3,891.91	13	2,203,910,665
5	Dhar - 9	3.50	1.25	232	1,081.09	7.5	353,190,812
6	Dhar - 13	2.00	1.00	232	494.21	7	150,694,746
7	Dhar - 14	2.00	1.40	237	691.90	6	180,833,696
8	Dhar - 15	1.50	1.00	219	370.66	5.5	88,802,261
9	Dhar - 16	1.50	1.00	219	370.66	8	129,166,925
10	Dhar - 16A	4.00	1.00	219	988.42	8.5	365,972,955
11	Dhar - 17	2.00	1.00	214	494.21	8	172,222,567
12	Dhar - 18	2.50	1.10	210	679.54	7.5	222,005,653
13	Channel - 1B	4.60	50 ft	243	17.32	4	3,018,373
14	Channel - 4	0.90	50 ft	242	3.39	4	590,551
15	Channel - 6	0.50	40 ft	237	1.51	4	262,467
16	Channel - 7	1.00	40 ft	237	3.01	4	524,934
17	Channel - 13	1.10	30 ft	237	2.49	4	433,071
18	Channel - 14	0.6	30 ft	237	1.36	2	118,110
19	Channel - 15	1.79	20 ft	235	2.70	2	234,908

20	Channel - 16	2.07	20 ft	223	3.12	2	271,654
21	Channel - 16A	0.85	20 ft	222.5	1.28	2	111,549
22	Channel - 17	1.50	20 ft	220	2.26	2	196,850
23	Channel - 18	8.20	30-50 ft	217	24.70	2	2,152,231
24	Dhar – 19	1.80	0.30	212.67	133.44	5.0	29,062,558
25	Dhar - 20	0.50	0.30	209.32	37.07	3.3	5,408,865
26	Dhar - 21	1.50	0.75	206.95	277.99	3.7	44,199,307
26	Dhar - 22	0.60	0.20	204.04	29.65	0.9	1,149,586
27	Dhar - 23	1.90	0.90	199.41	422.55	6.4	117,248,047
28	Dhar - 24	1.90	0.35	196.18	164.33	3.8	27,486,722
29	Dhar - 25	1.30	0.60	193.39	192.74	2.9	24,347,965
30	Dhar - 26	1.80	1.20	195	533.75	1.0	23,250,047
31	Dhar - 27	1.50	0.45	190.54	166.80	4.8	34,802,413
32	Dhar - 28	0.30	0.20	187.78	14.83	4.4	2,848,131
33	Channel - 19	1.65	20-40 ft	212.67	3.73	1.5	243,602
34	Channel - 20	3.62	20-40 ft	210.6	8.18	1.5	534,449
35	Channel - 21	2.80	20-40 ft	204.93	6.33	1.5	413,386
36	Channel - 22	1.22	20-40 ft	205.78	2.76	1.5	180,118
37	Channel - 23	2.70	20-40 ft	200.02	6.10	1.5	398,622
38	Channel - 24	2.30	20-40 ft	196.29	5.20	1.5	339,567
39	Channel - 25	3.90	20-40 ft	193.89	8.81	1.5	575,787
40	Channel - 26	4.90	20-40 ft	195.33	11.07	1.5	723,425
41	Channel - 27	3.45	20-40 ft	192.19	7.80	1.5	509,350

3.3 Hydrology of site

Hydrology basically is a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

3.3.1 Groundwater Table of Rahim Yar Khan

The Rahim Yar Khan (RYK) district in southern Punjab of Pakistan has an arid climate characterized by high temperature (up to 49 degree C), low rainfall, irregular humidity and, generally, high evaporation rates. May and June are the hottest months with a maximum mean temperature of 43- & 39-degree C. January is the coldest month with a minimum mean temperature of 4-degree C.

Mean annual precipitation is 9 cm, of which 70% occurs in the monsoon period of July and August. The areas where the permeability is high the water table increases rapidly and the areas where the permeability is less the water table subsides. The quality of water in the ground depends upon the geology and the composition of the area.

In case of Rahim Yar Khan. The depth of the water table varies from 75ft to 250ft. This value varies from place to place and area to area. The quality of water in the shallowest range is better as compared to the quality of water as we start going to the depth. The reason behind this thing is the presence of salts in the strata. In the top layer of the water table, the water usually comprises of the water from the irrigation that is done from the distributaries of the Indus River and the water that percolates during precipitation whereas as we go down, the water tends to get hard because of the presence of salts and bicarbonates.

3.3.2 Composition of water in Rahim Yar Khan

Composition of water determines the quality of water. If the water is carrying more salts and impurities, then then the allowed amount then it makes it useless for irrigation and human consumption. Although, there is more difference between the water quality that can be used for human consumption and for the irrigational purposes, but the aim is to target the quantity of salts in it.
The water table of Rahimyar khan varies from shallow to deep horizons. The shallow water table may be found at a depth of 6-7ft whereas the deep may reach up to 250ft.

Shallow water table

The quality of water in the shallow range is different from that of in the deep range. The water in the shallow range mostly comprises of the direct seepage from the rainfall, canal seepage, the seepage through the Indus river, the seepage through the irrigation fields etc. the quality of the water in the shallow water table is good, it can be used for the irrigation purposes. It contains less amounts of salt impurities then the deeper water table.

Deep water table

In deep water table, the quality of water deteriorates as the seeping water percolates through the strata which is carrying large quantities of different salts. The water from deep water tables is also contaminating the water in the shallow region since it is being pumped up. The salt composition of some of the tube wells is as following: -

Table 3.7: study of water sample form tube wells

TUBE WELL	pH	EC µ/CM AT 25ºC	ORG.SUB MG/L	T.D.S MG/L	S.A.R
8	7.10	27100	183.97	17615	43.46
11	7.20	30050	174.49	19532	38.51
14	7.00	34600	29.71	22490	41.52
15	7.10	32000	22.76	20800	35.45
18	7.30	26200	38	17030	31.47
21	7.70	26300	155.52	17095	32.21
37	8.10	32400	88.50	21060	32.67
45	7.80	31100	25.29	20215	34.85
49	8.00	3150	8.85	2047	9.86
59	8.00	40000	92.30	26000	47.85

3.3.3 Results and discussion

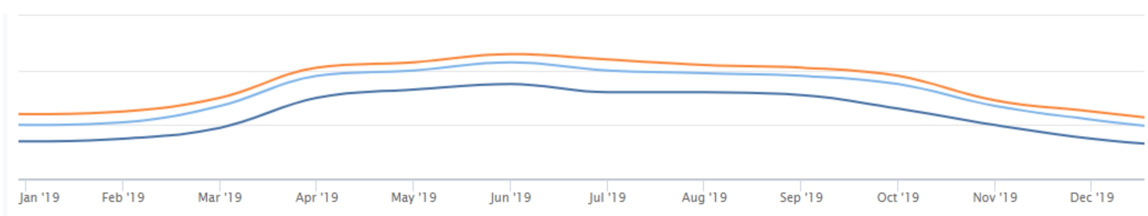
The groundwater in RYK can be divided into two categories; one occurring at depth in aquifer prior to the inception of irrigation, and the other at the shallow depths, assumed to be the result of seepage from the Indus river and irrigation system. Analytical data of some samples of water, collected at the depths of 75 to 250 ft, indicate the water is slightly too highly mineralized. The groundwater is mainly of sodium chloride type, however, water from some wells is of sodium sulphate type. Mineralization increases from north east to south west.

There is general chemical uniformity, suggesting that the groundwater belongs to a simple large aquifer. Near the northern boundary of the area, occurrence of local zones of relatively fresh water at depths of 75 to 250 ft suggests some degree of dilution caused by river and canal seepage, and precipitation of direct infiltration by rainfall. These are also the important factors for groundwater recharged to a depth of a few hundred feet, diluting and flushing out highly saline groundwater from the area.

3.4 Climatic Conditions

3.4.1 Temperature of Rahim Yar Khan

The area has an arid climate characterized by high temperature (up to 49ºc), May and June are the hottest months with the maximum mean temperature of 43ºc. January is the coldest month with a minimum mean temperature of 4ºc.



maximum temperature (24-46ºc)

moderate temperature (20-43ºc)

minimum temperature (14-35ºc)

Figure 3.6: Temperature Analysis

3.4.2 Rainfall in Rahim Yar Khan

Low rainfall, irregular humidity and, generally high evaporation rates. Mean annual precipitation is 9 cm, of which 70% occurs in the monsoon period of July and August.

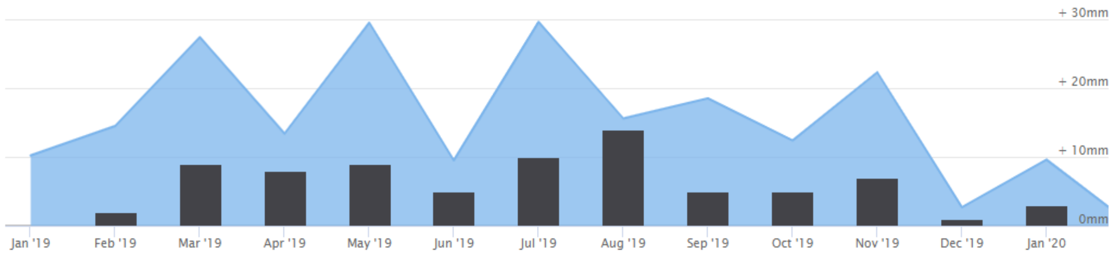


Figure 3.7: Rainfall data of Rahimyar khan -2019

Chapter 4

Seepage Evaluation

4.1 Flow Law

SEEP/W is formulated on the basis that the flow of water through both saturated and unsaturated soil follows Darcy's Law which states that:

$q = ki$

where:

q = specific discharge

k = hydraulic conductivity

i = gradient of fluid head or potential

Darcy's Law was originally derived for saturated soil, but later research has shown that it can also be applied to the flow of water through unsaturated soil. The only difference is that under conditions of unsaturated flow the hydraulic conductivity is no longer a constant but varies with changes in water content and indirectly varies with changes in pore-water pressure.

Darcy's Law is often written as:

$v = k*i$

where v is known as the Darcian velocity.

The actual average velocity at which water moves through the soil is the Darcian velocity divided by the porosity of the soil. SEEP/W computes and presents only the Darcian velocity.

4.2 Requirements to model an embankment

To model the seepage in an embankment, information about the following is required:

- Embankment dimensions i.e. Embankment side slopes, embankment height, crest width.
- Ground profile i.e. ground elevations along centerline of embankment.
- Sub surface profile i.e.

  1. types of materials in the foundation.
  2. Thicknesses of different layers in the foundation.
  3. permeabilities of the different layers present beneath the embankment.
  4. depths of different layers below the normal surface level.
  5. Permeability ratio i.e. Kh/Kv.

4.3 Draw Flow Paths

You can draw a path that a drop of water would travel from the reservoir to the exit point on the ground surface downstream of the dam.

- Choose Flow Paths from the Draw menu.
- The cursor changes from an arrow to a crosshair, and "Draw Flow Paths" appears on the status bar to indicate the current mode.
- Move the cursor to a point somewhere in the middle of the flow region and click the left mouse button.
- A flow path is projected in both directions to the boundary.
- Move the cursor and click at each point you want to draw a flow path.
- Sometimes the paths will encounter a zone with little or no flow and SEEP/W will not be able to complete the path. You will see a warning message if this occurs.
- Click the right mouse button to finish drawing flow paths.

4.4 Site Selection & SEEP/W Analysis

4.4.1 Khanpur drain: -

Khanpur drain is a part of Khanpur drainage system which is also comprising of three more drains of Pattan Munara, Aab-e-Hayat and Tarukari. These all combine to form Khanpur drainage system. Khanpur drain has a total length of 115 kms. It has 113 tube wells in it. These tube wells help to pump the water and suppress the water from rising to the surface. They have an average discharge of 127 cusecs.

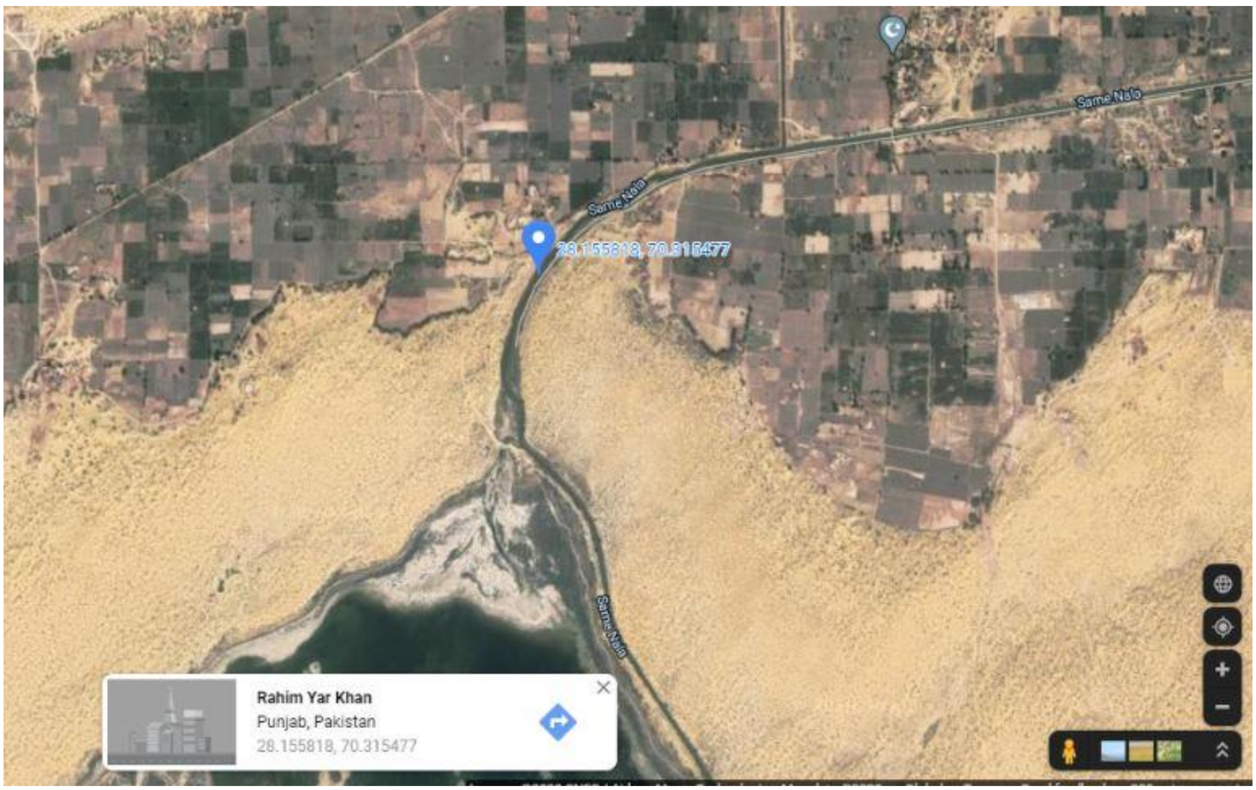
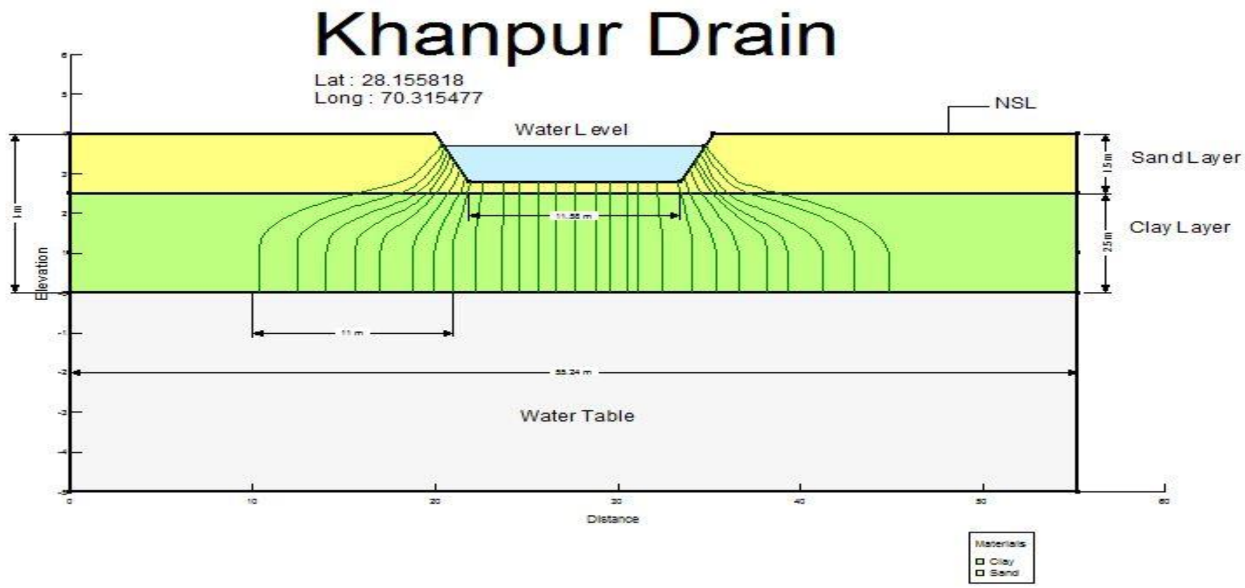


Figure 4.1: Geo Mapped Site location of Khanpur Drain

We have selected a cross-section in the Khanpur drain to analyze the seepage patterns as located in the figure above.



Discussion:

The results from the analysis of cross-sections of Khanpur drains show that the water is seeping directly to the water table present downwards. The seepage lines suggest that the water is finding its way downwards after travelling to 36 ft at maximum.

4.4.2 Manthar drain: -

Manthar drain is a part of Manthar drainage system which pumps water from the ground and keeps the channels running. There are total three pumping stations in Rahimyar Khan, district from which one is on the Manthar drain. It has 13 water pumps in it with a total discharge of 260 cusecs.

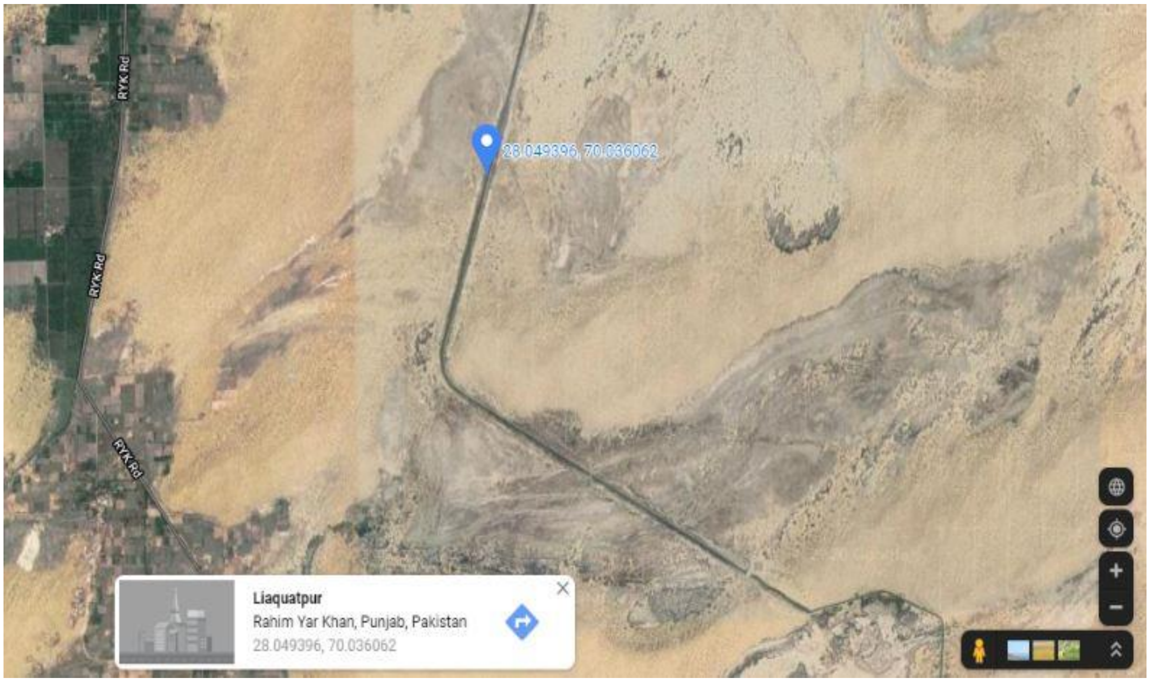
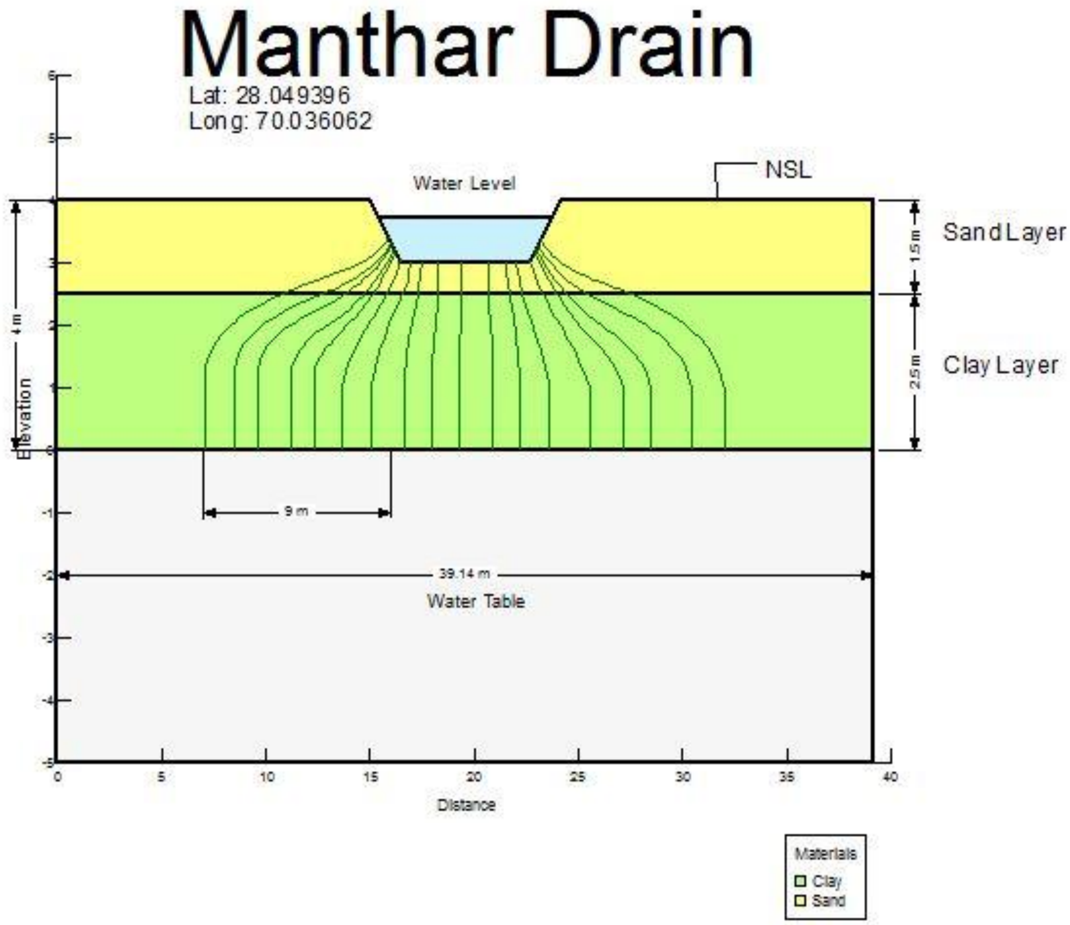


Figure 4.2: Geo-location view of Manthar Drain

We have selected a cross-section in the Khanpur drain to analyze the seepage patterns as located in the figure above.



Discussion:

The results from the analysis of cross-sections of Manthar drain shows that the water is seeping directly to the water table present downwards. The seepage lines suggest that the water is finding its way downwards after travelling to 35 ft at maximum.

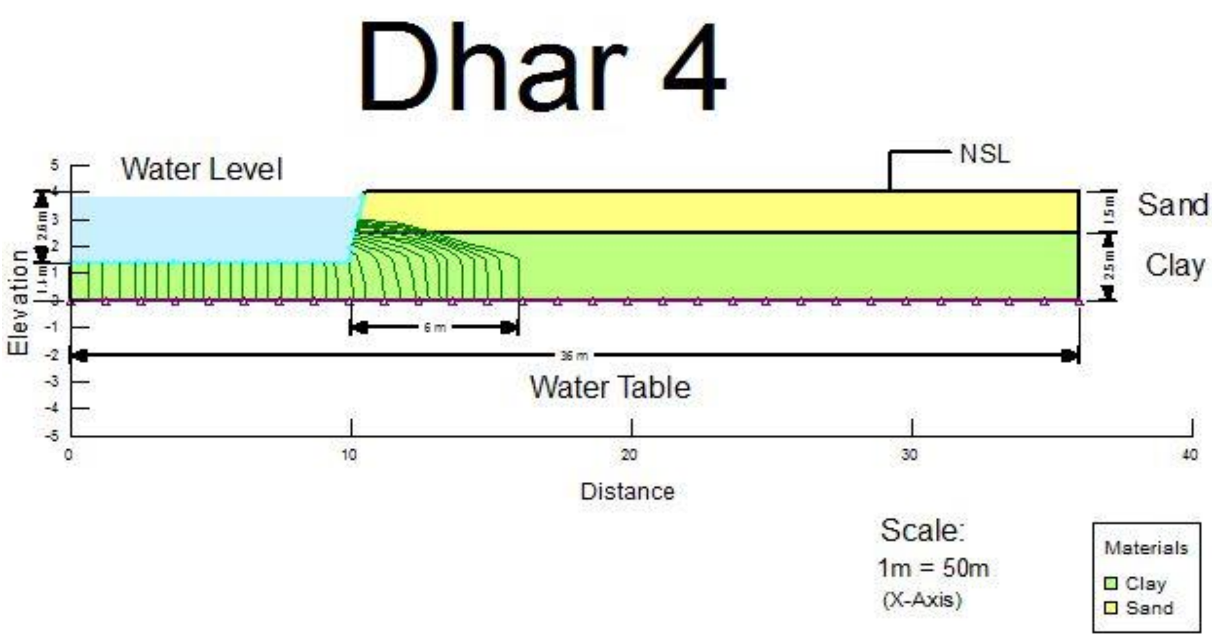
4.4.3 Dhars: -

Dhars are pondages which are used to store water. The water from the tube wells in brought through the channels into theses pondages. These Dhars are comprising of the saline water from the tube wells which is left in the open to dry out through the process of evaporation. These Dhars are also performing the function of formidable obstacle against the neighboring country.

Length (Km)	Width (Km)	Bed Lvl (ft)	Avg Depth (ft)	Area (Acres)
11.5	1.00	235	8.5	956

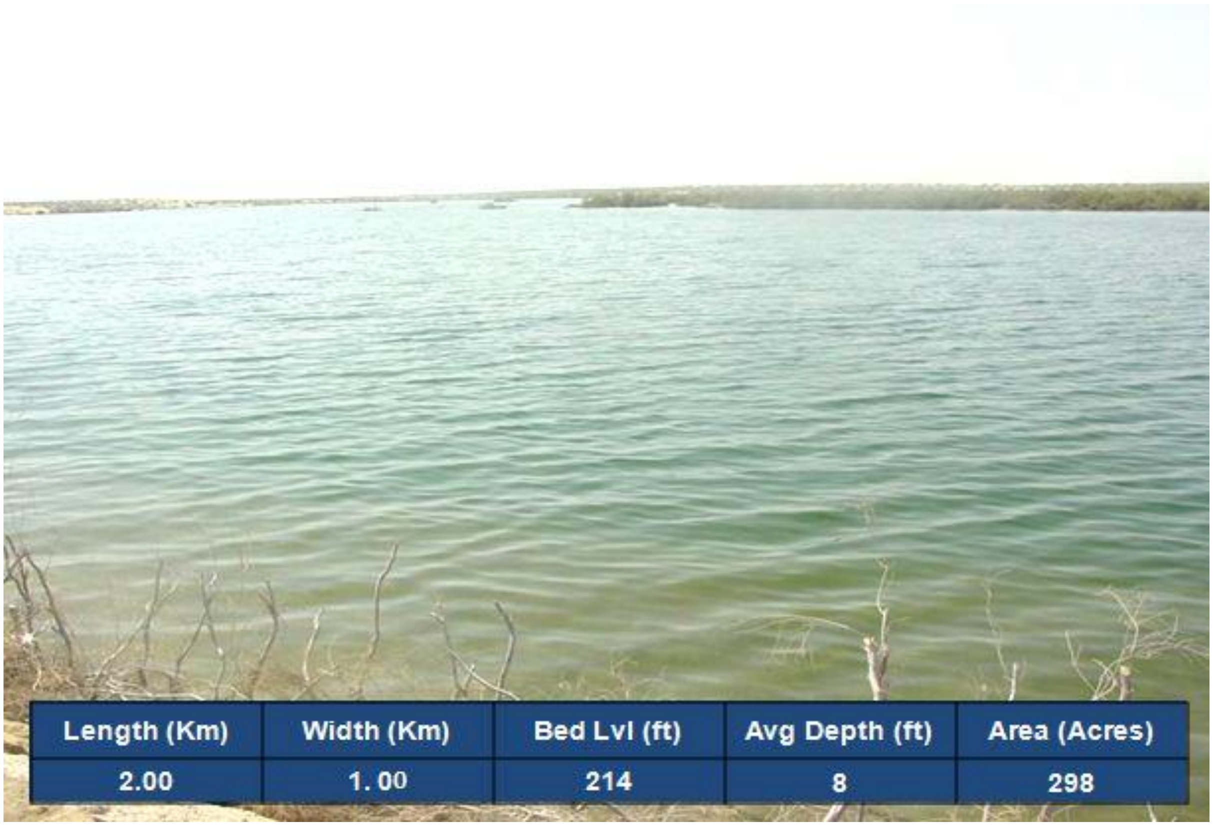
Figure 4.3: Site view of Dhar-4

We have selected a cross-section in Dhar-4 to analyze the seepage patterns as located in the figure above.



Discussion

The results from the analysis of cross-sections of Dhar-4 shows that the water is seeping directly to the water table present downwards. The seepage lines suggest that the water is finding its way downwards after travelling to 300 m at maximum.



<u>Figure 4.4: Site View of Dhar-17</u>

We have selected a cross-section in Dhar-17 to analyze the seepage patterns as located in the figure above.

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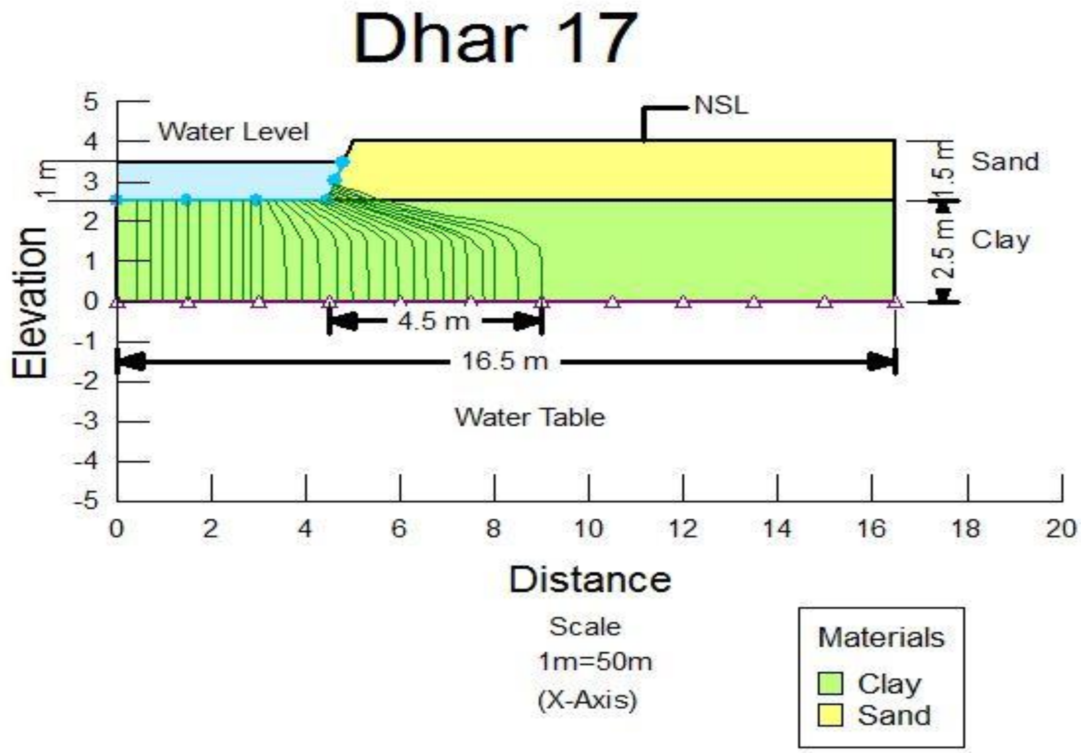


Discussion:
The results from the analysis of cross-sections of Dhar-17 shows that the water is seeping directly to the water table present downwards. The seepage lines suggest that the water is finding its way downwards after travelling to 225 m at maximum.

4.5 Results of analysis of Khanpur and Manthar drain sections through GeoStudio seep/w 2018: -

The results from the analysis of cross-sections of Manthar and Khanpur drains and Dhar-4 and Dhar-17 suggest that the water is seeping directly to the water table present downwards. The seepage lines suggest that the water is finding its way downwards after travelling a lateral distance of 11.5m at maximum, Dhars have shown more lateral seepage since they are storing water in static condition. The lateral distance travelled by water is 300m at maximum in Dhars. Direct under the drains and Dhars, the water is percolating into the ground water table in comparatively straight lines as compared to the embankments of the drains and Dhars, from where the water is travelling some distance and submerging into the ground water table.

However, as we move up from the bottom of the drains and Dhars, we analyze the seepage lines of the percolated water to be relatively horizontal in movement but it is insufficient to cause any sort of water logging as it is submerging in the ground water after some distance.

The movement of water into the ground vertically and horizontally is relatively slow since the distance being travelled by the water is different in all the case. Due to the presence of clay under the sheet of 3-5ft of sand makes it difficult for the water to travel downwards quickly. Since, the permeability of clay is greater than sand hence water seeps down slowly.

Chapter 5

Ponds

5.1 Effectiveness of ponds in case of water cutoff

If the supply of water to the ponds will stop, due to mechanical, electrical or any other unknown issue, we can calculate the maximum amount of time we will be having to address the issue by considering the seepage and evaporation rate of water from the ponds.

Table 5.1 : Dhar wise pondage capacity and total pondage capacity of System:

Ser.	Dhar's/ Channels	Length (KM)	Width (KM)	Area (Acre)	Avg Depth (ft)	Total Capacity (Cft)	
						Mn Cft	Mn Pounds
1 .	Dhar - 4A	16.00	0.60	2,372.21	4	413.33	25,804.44
2 .	Dhar - 4	10.00	1.00	2,471.05	7.6	914.93	57,119.21
3 .	Channel-4	0.90	50 ft	3.39	4	0.59	36.90
4 .	Dhar - 5	6.70	0.50	827.80	15	576.95	36,018.74
5 .	Channel-6	0.50	40 ft	1.51	4	0.26	16.36
6 .	Dhar - 6	3.7	3.00	2,742.87	12	1,433.75	89,509.20
7 .	Channel-7	1.00	40 ft	3.01	4	0.53	32.78
8 .	Dhar - 7	10.5	1.50	3,891.91	13	2,203.91	137,590.10
9 .	Channel-13	1.10	30 ft	2.49	4	0.43	27.03
10 .	Dhar - 9	3.50	1.25	1,081.09	6.5	353.19	22,049.71
11 .	Dhar - 13	2.00	1.00	494.21	7	150.70	9,407.89
12 .	Channel-14	0.60	30 ft	1.36	2	0.12	7.37
13 .	Dhar - 14	2.00	1.40	691.90	6	180.83	11,289.47
14 .	Channel-15	1.70	20 ft	2.56	2	0.22	13.92
15 .	Dhar - 15	1.50	1.00	370.66	5.5	88.80	5,543.91
16 .	Channel-16	2.00	20 ft	3.01	2	0.26	16.36
17 .	Dhar - 16	1.50	1.00	370.66	8	129.17	8,063.90
18 .	Channel-16A	0.8	20 ft	1.21	2	0.11	6.56
19 .	Dhar - 16A	4.00	1.00	988.42	8.5	365.97	22,847.69
20 .	Channel-17	1.50	20 ft	2.26	2	0.20	12.30
21 .	Dhar - 17	2.00	1.00	494.21	8	172.22	10,751.88
22 .	Channel-18	8.00	30-50 ft	24.10	2	2.10	131.10
23 .	Dhar - 18	2.50	1.10	679.54	7.5	222.01	13,859.84
24 .	Dhar - 19	1.80	0.30	133.44	5.0	29.06	1,814.40

25 .	Channel-19	1.60	20-40 ft	3.62	1.5	0.24	14.73
26 .	Dhar - 20	0.50	0.30	37.07	3.3	5.41	337.68
27 .	Channel-20	3.60	20-40 ft	8.13	1.5	0.53	33.15
28 .	Dhar - 21	1.50	0.75	277.99	3.7	44.20	2,759.34
29 .	Channel-21	2.80	20-40 ft	6.33	1.5	0.41	25.78
30 .	Dhar-22	0.60	0.20	29.65	4.0	1.15	71.80
31 .	Channel-22	1.20	20-40 ft	2.71	1.5	0.18	11.05
32 .	Dhar - 23	1.90	0.90	422.55	6.4	117.25	7,319.79
33 .	Channel-23	2.60	20-40 ft	5.87	1.5	0.38	23.97
34 .	Dhar - 24	1.90	0.35	164.33	3.9	27.49	1,716.01
	Total	**104**		**18,613**	**5**	**7,437**	**464,284**

5.2 Evaporation and seepage rates and quantities:

- Average rate of Evaporation = 17.2 inch/month -NAC, PMD.
- Average rate of Evaporation = 5 inch/month - Literature Research
- Average of above 2 Evaporation = 11.1 inch/month
- Average rate of Seepage = 4.6 inch/month - Agri Dept. of Punjab
- Average rate of seepage =2 inch/month - Literature Research
- Average of above 2 Evaporations = 3.3 inch/month
- Total loss = (11.1+3.3) = 14.4 inch = 1.2 ft/month

5.3 Sustainability of ponds:

Table 5.2: Rate of Evaporation

Month	Inch			Ft
	Evaporation	Seepage	Total	
Jan	4.92	3.30	8.22	0.69 (Min)
Feb	10.20	3.30	13.50	1.12
Mar	12.60	3.30	15.90	1.32
Apr	24.48	3.30	27.78	2.32
May	30.84	3.30	34.14	2.84 (Max)
Jun	28.32	3.30	31.62	2.64
Jul	24.84	3.30	28.14	2.34
Aug	20.40	3.30	23.70	1.98
Sep	18.96	3.30	22.26	1.86
Oct	15.00	3.30	18.30	1.53
Nov	8.88	3.30	12.18	1.01
Dec	6.84	3.30	10.14	0.85
Total	**206.28**	**39.60**	**245.88**	**20.50**
Avg	**17.19**	**3.30**	**20.49**	**1.71**

Table 5.3: Sustainability by land

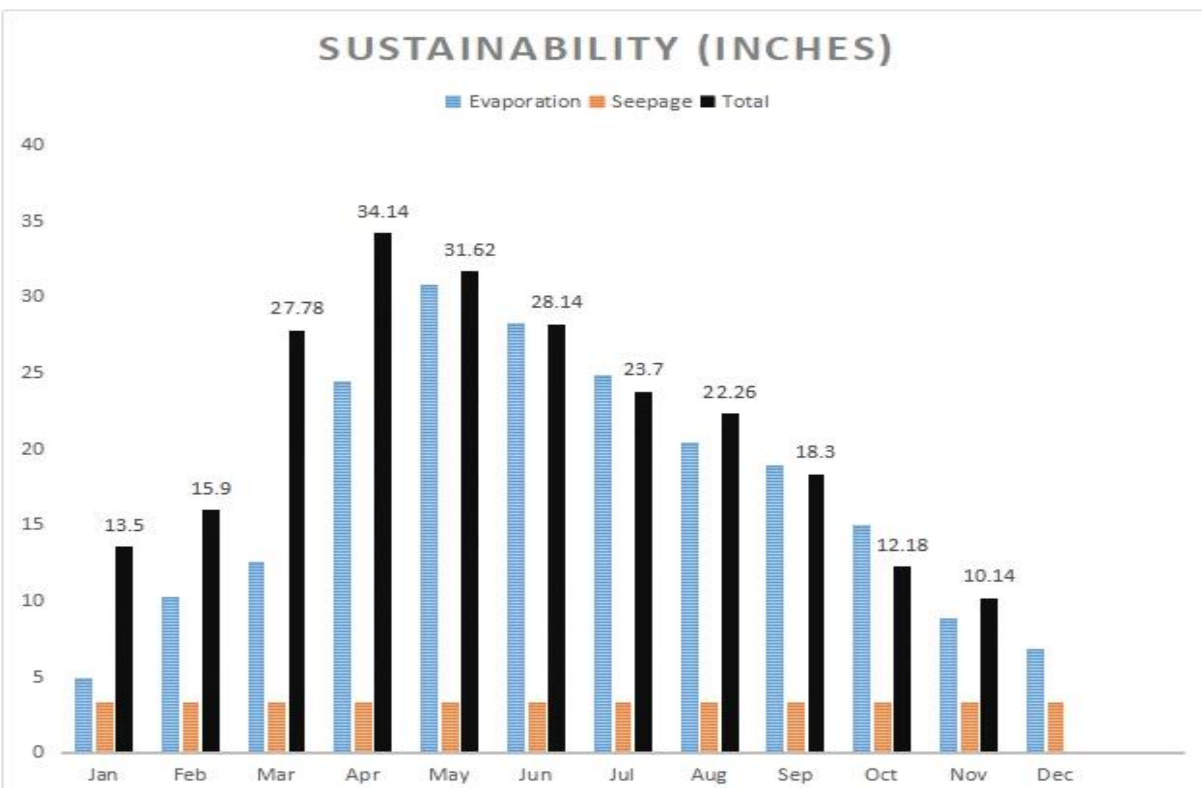


Table 5.4: Annual Sustainability Graph I

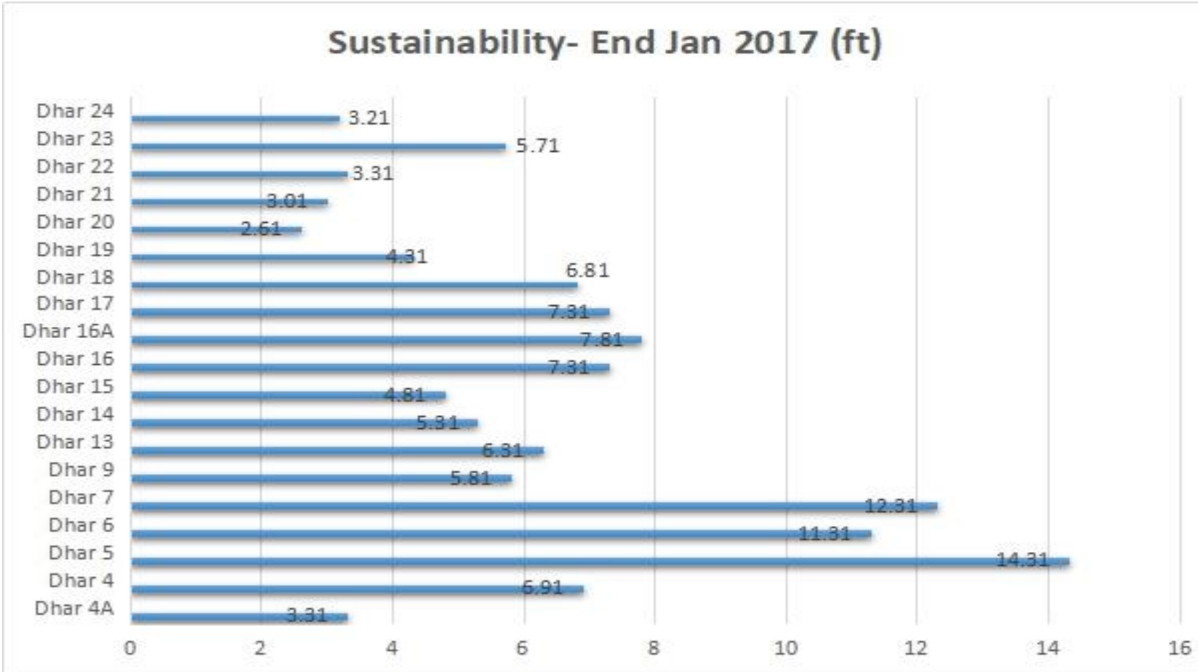


Table 5.5: Annual Sustainability Graph II

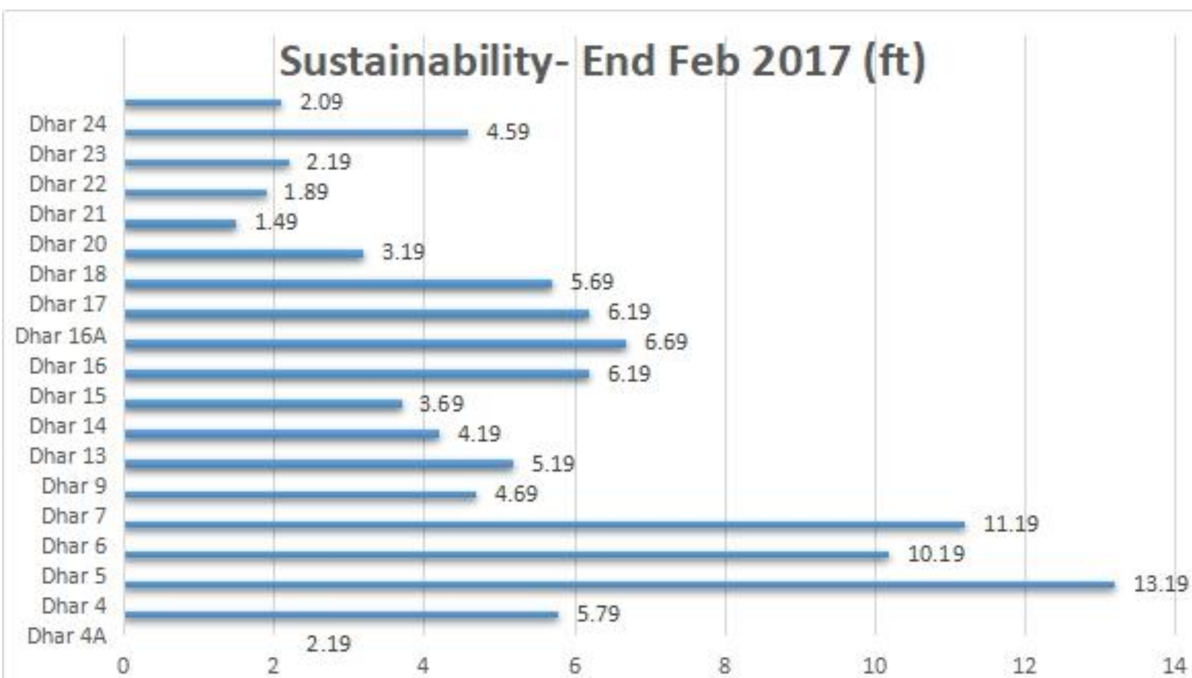


Table 5.6: Annual Sustainability Graph III

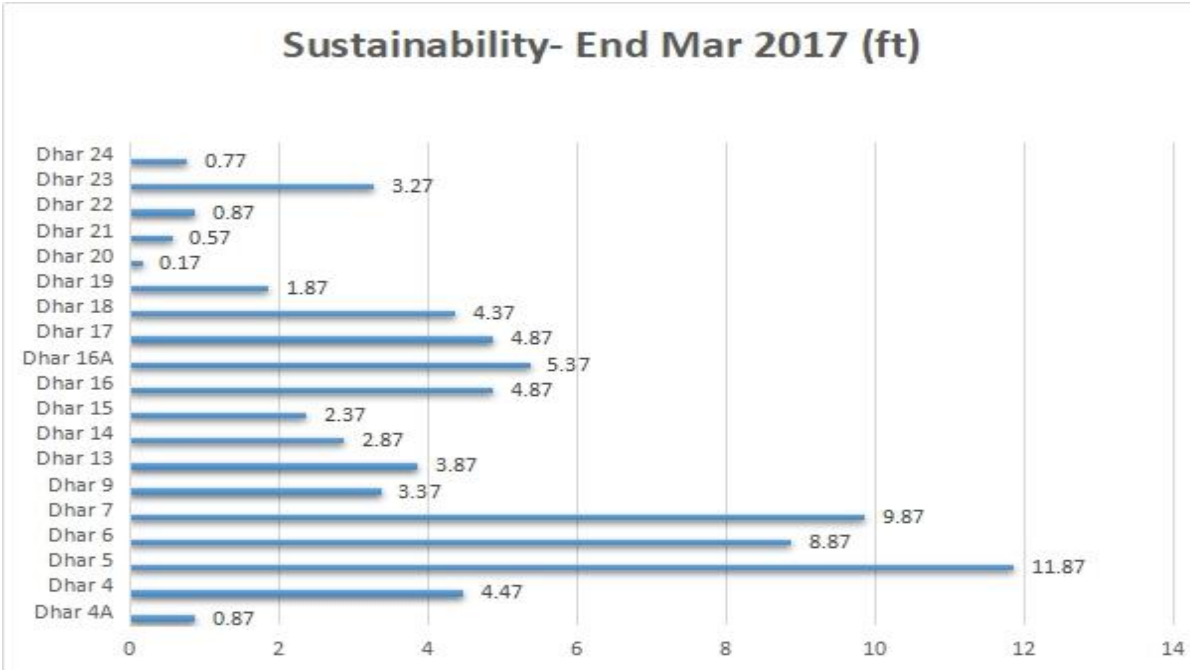


Table 5.7: Annual Sustainability Graph IV

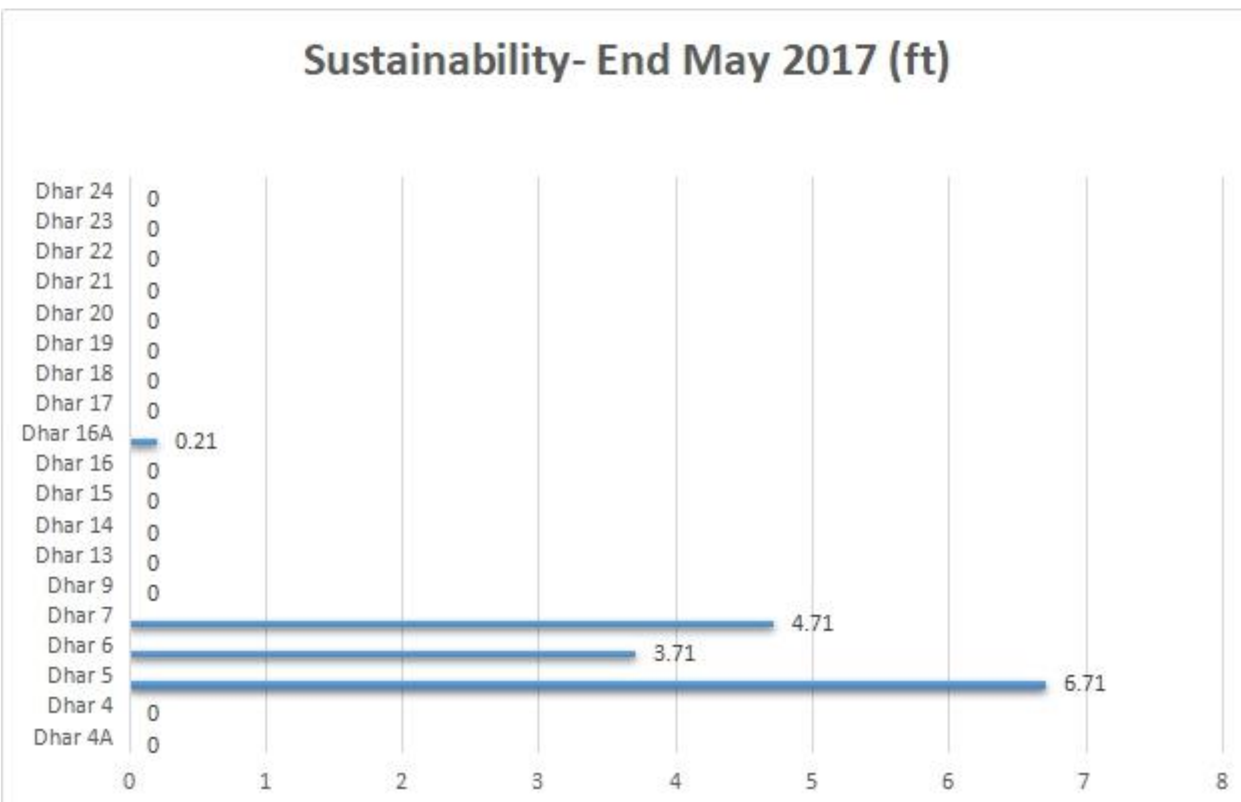


Table 5.8: Annual Sustainability Graph V

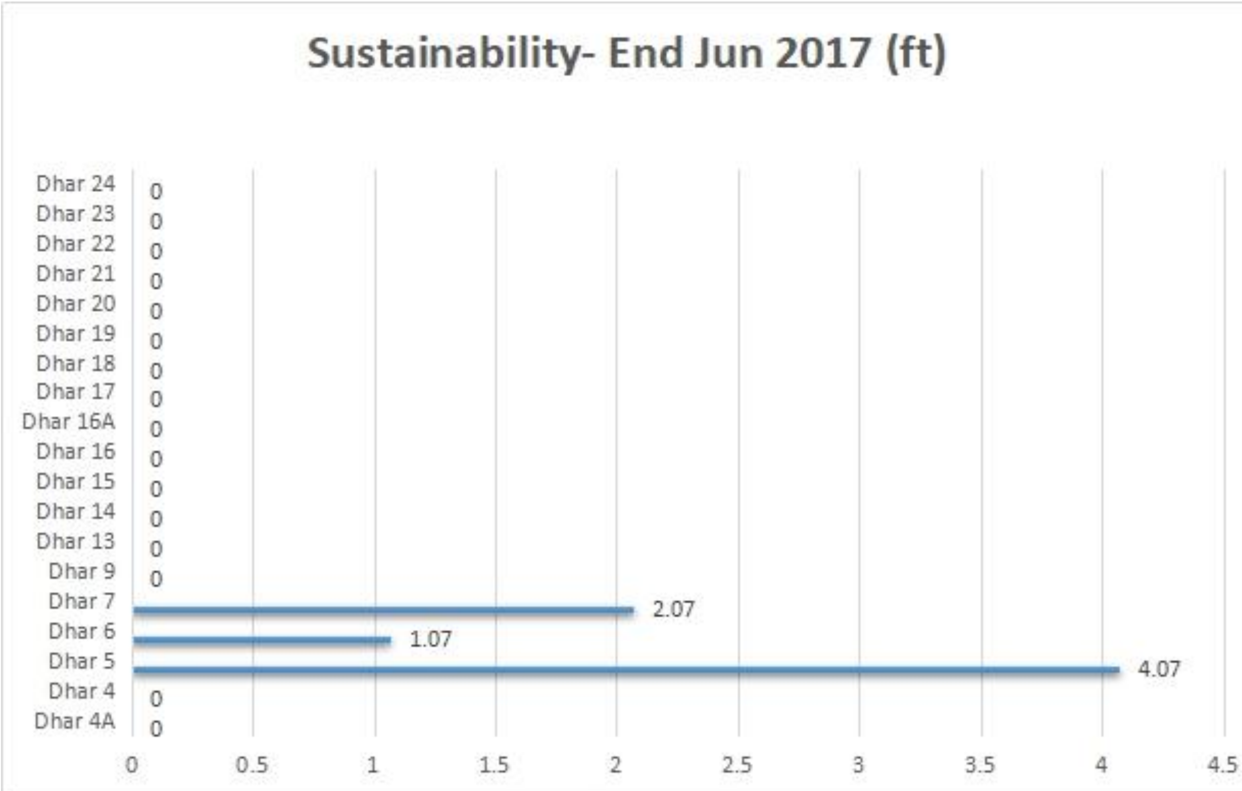


Table 5.9: Annual Sustainability Graph VI

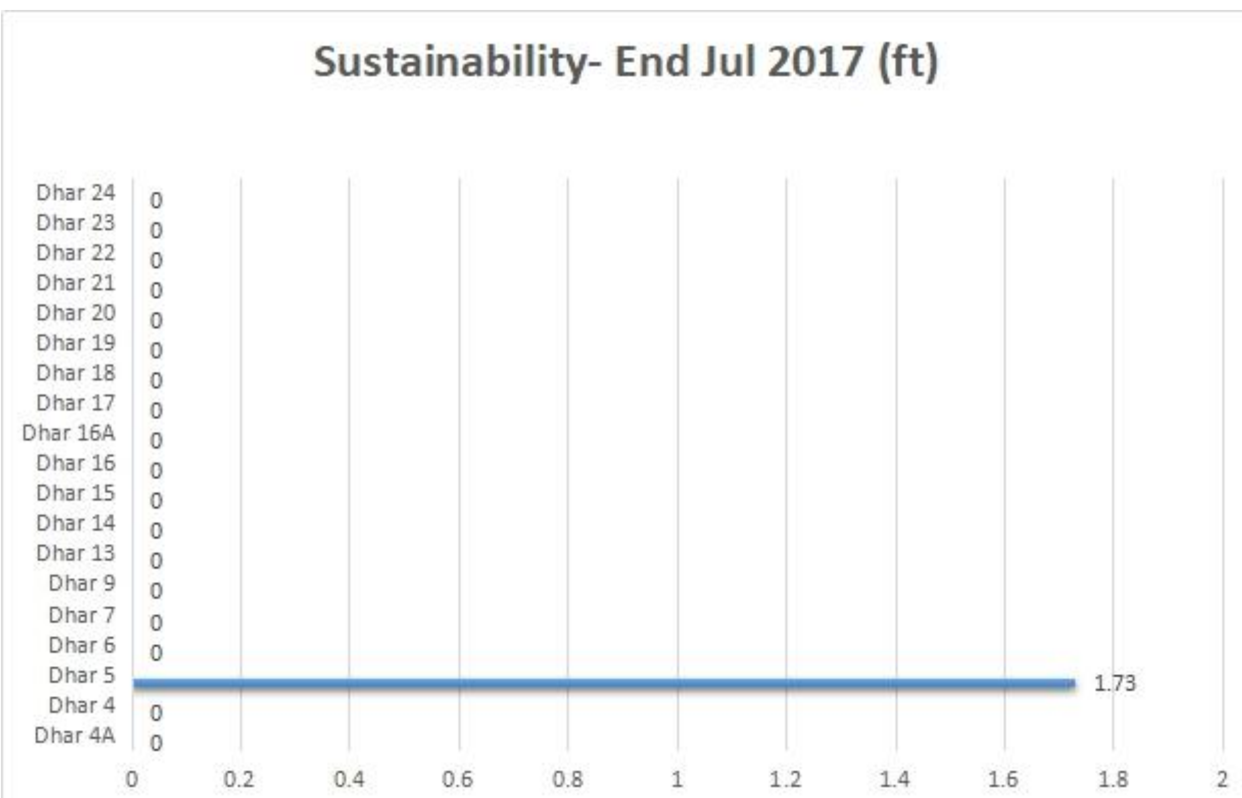
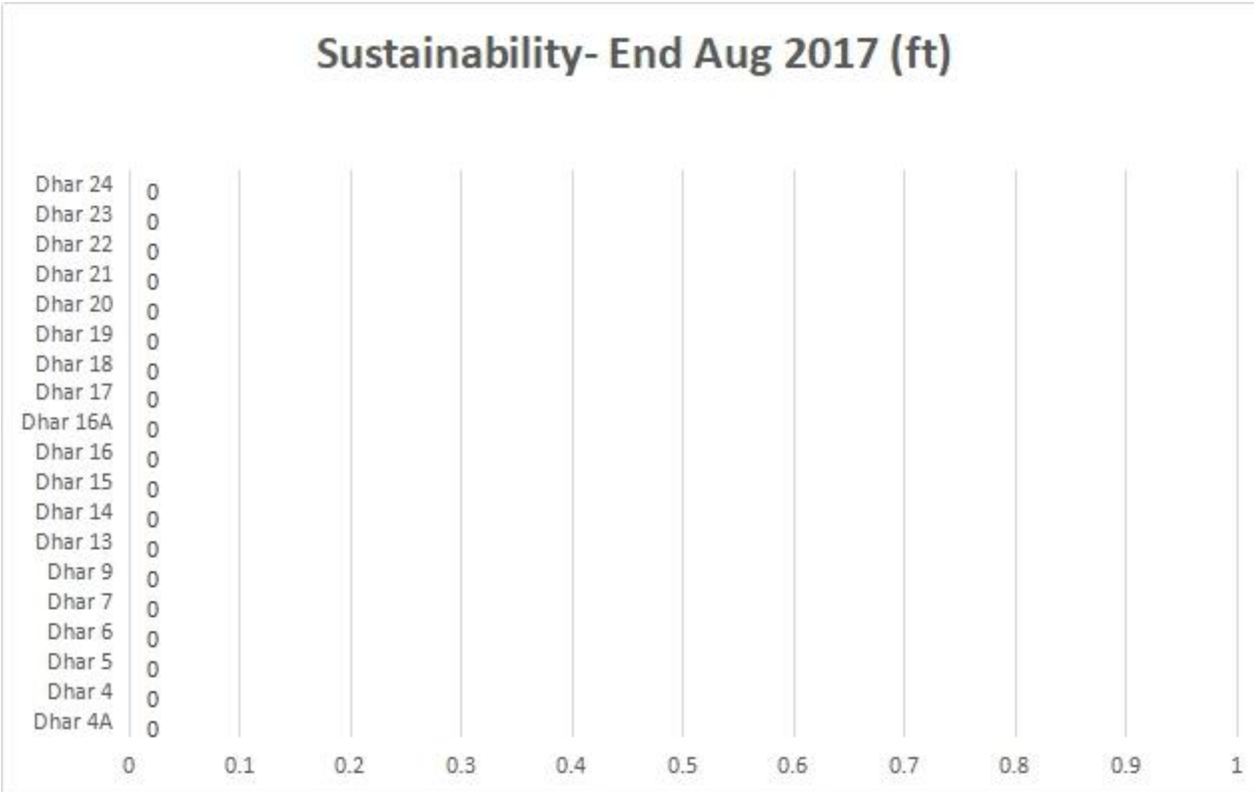


Table 5.10: Annual Sustainability Graph VII



5.4 Calculation/Evaluation:

Area of ponds = 18613 ha

= 18613 x 8 (canals) x 20 (marlas) x 272 (ft^2)

$= 8.1 \times 10^8\ ft^2$

Volume of ponds = 5 ft. (Avg depth) x $8.1 \times 10^8\ ft^2$

$= 4.05 \times 10^9\ ft^3$

As the Avg of above 2 Evaporation = 11.1 inch/month (0.925 ft/month)

and

Avg rate of 2 seepage =3.3 inch/month (0.275 ft/month)

Loss of water due to evaporation = $8.1 \times 10^8\ ft^2 \times 0.925$ ft/month

= 749.2 Mn ft^3 /Month

Loss due to seepage $= 8.1 \times 10^8\ ft^2 \times 0.275$ ft/month

= 222.7 Mn ft^3 /Month

Total loss (seepage + evaporation) = 749.2 Mn ft^3 /Month + 222.7 Mn ft^3 /Month

= 971.9 Mn ft^3 /Month
$= 9.719 \times 10^8\ ft^3$ /Month

Time to be taken by water (for completely vanishing from ponds)

$= 4.05 \times 10^9\ ft^3 / 9.719 \times 10^8\ ft^3$ per Month

= 4.16 Months (approx.)

Chapter 6

Conclusions and Recommendations

6.1 Conclusions:

- The results of the seepage analysis indicated that seepage from drains have no effect on the water logging in neighboring areas.
- The maximum lateral distance travelled by seepage flow paths in drains is 11.5m.
- The maximum lateral distance travelled by seepage flow paths in Dhars is 300m.
- Since the drains and Dhars are already made on a cut so, the seepage flow lines are directed towards the ground water table under the action of gravity.
- Hence, the areas neighboring the drains and Dhars remain unaffected from the seepage of drains and Dhars.
- Seepage flow path that appeared in the analysis results depicts that the drains are already made on a cut. Hence, seepage flow is towards the ground water table.
- The evaporation analysis of the project resulted that, approximately it will take 4 months for the water to completely evaporate from the pondage area in case of any breakdown in the system.
- The crops requiring high water are being cultivated by the farmers which is resulting in water logging since the strata of Rahimyar khan is comprising mostly of clay

6.2 Recommendations:

- Through awareness campaigns, general populace of the area be informed about the positive effectiveness and contribution of the project in prosperity of the region.
- General populace be informed that the drains do not have any seepage effects beyond the maximum lateral distance of 11.5m from the edge of the drain.
- Similarly, general populace be informed that the Dhars do not have any seepage effects beyond the maximum lateral distance of 11.5m from the edge of the Dhar.
- Government policy should be made that the crops i.e. cotton, wheat etc. requiring low to medium water should only be cultivated in the region of Rahimyar Khan.
- The crops i.e. rice, sugarcane etc. with high water requirement should be banned in the region of Rahimyar Khan by the Government since they charge the aquifers back through seepage.
- To ensure long term sustainability, the water charging should not be stopped for more than two months.
- Concrete structure should be made at any cross section of the drains for the water flow measurement and seepage for the future research.
- Installation of more tube wells should be ensured by the Govt. in the areas where they are insufficient.

References: -

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