GOVERNMENT OF THE YEMEN ARAB REPUBLIC
MINISTRY OF AGRI. & FISHERIES RESOURCES
TIHAMA DEVELOPMENT AUTHORITY

WADI MAWR PROJECT

DRAFT REPORT
SHORT STUDY ON WATER REGULATION AND DISTRIBUTION

ENG. FAROUK ABDEL RAHMAN SHAHIN
MPWWR, EGYPT
MARCH, 1990

PRF -02

12.3.1990

The Chairman,
Tihama Development Authority
Hodeidah
Yemen Arab Republic

Draft Report
Short Study On Water Distribution
And Regulation Of Wadi Mawr

Dear Sir

I have honour to submit 15 copies of the Draft Report on Short Study on Water Distribution and Regulation of Wadi Mawr.

The study in proceeeded according to your appointment telex on Feb. 10 1990

Reffering to your letter No. 2204/89 dated Nov. 21, 1989, giving 25 days between th submittion of the Draft and Final Reports. You are requested to inform me with your revision comments as early as possible and with 15 days to have the chance of including it in the final report.

Best regards.

Yours fiathfully

F. Shahin
Mar. 22. 90

Eng. Farouk Abdel Rahman Shahin
444, Al-Ahram Street, Giza,
Arabic Republic of Egypt.

i; A C K N O W L E D G E M E N T

I would like to acnowledge and thank the Tihama Devlopment uthority for the Assistance and help given during stay in YAR.

Jithout the help assistance and patience of all the TDA Staff in he H.Q. or in the project site, this report could not be mplemented in this short period of time.

I would like to express my gratitude spcially to ;

hairman - Mr. Ibrahim A. Jabbar Al-Doumi
irector General -Mr. Abdul Momen Haza'a
ir. of Engg. & Irrig. Mr. Saleh Bin Raba'a
ir. Oper. & Maint. Mr. Abdul Rahman Rashed
enior Consultant, Mr. Kamal Abdu
ir. of W. Mawr Proj. Mr. Abdu Farei Al Romaih
adi Mawr Project Engineers and Agronomists Mdr. Ali Salam Al l Awsagi, Eng. Khalid El Attas, Eng. Abdulla Aglan, Eng. otfalla Saad.

I would also wish to thank the TDA Secretary and Specially for r.s Belquis Abdo for her incredible effor to finalize the report nd Mr. Adel Kudshi.

C O N T E N T

NNEXES :

Annex A, Terms Of Reference

Annex B, Mapping

Annex C, Field Visits

Annex D, Socio-Economic Survay

T A B L E S

D R A W I N G S

1.1. STUDY OBJECT

s as stated in the terms of refference Annex A, to do a short tudy on regulation of Wadi Mawr water distribution and to make ecommendation for future equitable distribution of wadis water. Both base flow and floods) with different measures and lternatives.

he subject was raised when IDA mission for the revue of Tihama V egional Agriculture Development Project, in July 2, 1989 ecommended that, a short study of the experience of water egulation of Wadi Mawr over the last period, to be carried by an ndependent consultant who should evaluate the equity or therwise the water distribution to the farmers over that period.

n December 4, 1989, I received a letter TDA's letter SN. 2204/89 ncluding the TOR of the requested short study. Such that ubmitting of th draft is requird to be before Feb. 1, 1990 and he final report before Feb. 25, 1990.

proposed that a short study could be done in 30 days trip for he draft report submittion, the final report could be submitted thin 15 days from receiving the comments.

he appointment to commence with the study as received on Feb. 1, 1990, My arrival to Hodeidah was on Feb. 21, to commence with tudy.

he result of this study is based on the available information nd data which I obtained, my field visits, dicussions, nvistigations and surveys, and within the time limits.

he TOR and the itenary of the visit is shown in Annex A, and agram A1.

1. HYDROLOGY BACK GROUND

1.1 General

In centuries the water distribution system of Wadi Mawr was developed using traditional spate irrigation methods based on the natural flow characterstics of the wadi.

The rapidly increasing spate flow which lead to a sudden hight of the natural discharges and concequently its water levels was mostly destroying the the dykes & spares which distribute the irrigation water and affect the crop production, farmer income and level of living.

Considering the development of the water use system of the wadi, YAR. appointed Timpton & Kalaback Engineers in 1973 to carry out a study to evaluate the pheasibility of irrigated agriculture in the Wadi Mawr area.

In Jan. 1979 T&K submitted their final report which included their study and evaluation of the natural surface and ground water resources, crops and soils.

T&K plan based on dividing the wadi length into 3 reaches, each reach has a diverging check stracture on the wadi course and its own supply canals one on the North and other and other on the South side of the wadi, to feed the existing primay canals, such that each reach would take its share.

The plan also included the utilization of the ground water resources for the use of the existed wells and to drill 21 additional wells in the areas which will not be commended from the proposed scheme.

Concerning the proposed irrigation water distribution plan, it was based on the utilization of the capacity of the supply canals to insure equity distribution such that each canal takes its share using a control radial gates.

In 1980, Sir M. Macdonald and Partners were appointed for the detail designs and construction supervision of the Wadi Mawr Development Project.

MMP revised and updated the study of T&K. They also reconsidered the T&K distribution system and design procedures, while maintaining the over all project objectives.

The MMP final implemented project design was based on :-

- Having only one diversion stable concrete structure
- One principal canal controlled for the dicharge limit by using Nertic type single buffle gate.
- The supply canals to the North and South sides of the wadi course are branched from this principal canal.
- Supply the principal canals with weir type falls to flatten the Hydraulic gradient.
- The primary canals branch from the supply canals upstream the fall structures and can allow its maximum flow capacity to pass with minimum flow in the supply canals.
- Set a detailed water allocation and operation plan on calenders bases to be followed to insure the considered water sharing rules, in the project design.

The Wadi Mawr project has been implemented and put into operation in 1988.

2 The project Area

Wadi Mawr is of the largest of the seven major wadis that transverce Tihama plains and cross one of the best developed farming areas in it.

The wadi is originated from the central rugged high mountain region of the country which reaches an altitude of 3500 m. U.S.L. and flow west ward twards the red sea (F.g1.1)

The project area lies between two smaller wdis, wadi Jah to the North and wadi Ayan to the South,with Wadi Mawr cutting the area into two almost equal parts. The project area comprises about 72,000 hectars of land, of which 61,230 ha are classified as arable. It has an average width of 16km. and extends from the foothills to the salt marshes near the sea cost for a distance of about 46km. The region which is considered affected by the wadi and is regularly or periodically irrigated is of about 26,000 ha.

The project is situated at about 100 km. North of the costal main city of Hodeidah.

3 Climate

The climate in the Project area is hot and arid, it is extremly hot exacpt in the winter season where the temprature range from 26^{O}c to 34^{O}c. The mean monthly temprature range from 19^{O} to 29^{O}c while in July range from 32^{O}c to 40^{O}c. Anual mean temp is 23.8 for the minimum an 30^{O}c for the maximum.

The average annual precipitation is about 164 mm. it is mostly affected by the mansoon type rainfall distribution where 75% of it is in the period July thru October.

Table 1-1

Monthly Tempratures on Rainfall
at Al - Zuhra

Month	(1) Mean Temp. °C			Precipitation[2] m.m
	Min	Mean	Max	
January	20.9	26.1	31.7	5.2
February	19.6	26.0	32.4	4.7
March	20.8	27.8	34.1	.5
April	22.8	30.3	37.7	1.6
May	26.4	32.4	38.3	9.8
June	27.8	33.8	39.9	4.7
July	28.4	33.9	39.6	38.4
August	28.2	33.8	39.4	34.1
September	26.2	32.4	38.7	13.2
October	24.1	30.5	36.9	62.9
November	22.3	28.3	34.3	8.9
December	18.9	25.7	32.5	0.1
Annual	23.8	30.0	36.3	164.1

1 - Mean of the period 1972 - 1977 after T&K

2 - Mean of the period 1977 - 1981 after MMP.

The average monthly temprature and rainfall at Al-Zuhra station is shown in (table 1-1)

The average relative humidity is 50% to 60% and range from 80% in the early morning to 25% in the late afternoon.

The annual free surface evaporation is estimated to be 3,000 mms while the evapotranspiration was estimated for the reference evapotranspiration of Zuhra station to be as shown in table 1-2.

Table 1-2

Average Refference Crop Evapotranspiration

	in mm
January	119
February	129
March	186
April	218
May	237
June	221
July	223
August	217
September	194
October	190
November	162
December	138
Annual	2234

4 Land Resources

The Wadi Mawr is a gently sloping plain composed of deltaic material laid by the wadi flowing water from the upper lands. The total project area covers 72,000 ha.

It was classified and evaluated under potential irrigation developments, seperation between arable and non arable lands and classed into 4 classes from soil phisical and chemical point of view.

Class 1 of 23030 ha, represent lands that are highly suitable for irrigated farming and having a high sustained production capability.

Class 2 of 32,040 ha, similar to class 1 but have surface soil conditions from the physical and surface slope and land leveling point of view that may effect its productivity when irrigated.

Class 3 of 5,860 ha, have restricted suitability due to texture, morphology or drainage.

Class 6. of 10,420 ha, not arable for, topogrophical, chemical, phisical reasons or ocupied by raods, villiges and sand dunes.

Average slope from the east to the west of about gmt. in each kilometer.

The soils are alluvial sands, sandy silt and sandy clay. The surface soil deosnot have a well defined profile because of the aridity, water and wind erosion.

In general the soil is non sodic with low nitrogen, low humaus content and low soluble salts. The average water holding at field capacity is about 13% and at the wilting point 3.5.

The average available water is 9.5%
The readily available water at 75% is 7.1%

1.5 Surface Water Resources

The surface water in the project area, except for a small amount derived from storms in the area, originates from the Wadi Mawr catchment area. Surface run off of the Wadi Mawr catchment area is mounitored at Shat Al Erge guaging site which was stablished by T&K in 1975, at about 11.5 km to the upstream of the project newly constructed diversion works.

The type of flow is shown in (Fig 1-2) which is a typical spate flow hydraugraph ruled by mansoon type of stormy short durated showers where the flow increases rapidly for short duration.

The mean daily flow in the winter season, Nov. to Feb. is sourced from the emupehrial base flow and range from 2 to 3 $m^3/s.$, the first mansoon peak occurs in Apr. where the flow rises to about 10 $m^3/s.$ and decreases slightly in May and early June then get the main flow peak in the period June thru October where the mean daily flow reaches $73m^3/s.$

The daily flow rates are varying rapidlly, it my may increase about 50 or 60 $m^3/s.$ suddenly, and loose again 70% or even 80% of this increase in a day and then follow its normal recession.

The estimated runoff factor is 5.7% of the total rainfall on the watershed.

The annual runoffs calculated from the records collected at Shat Al Erge is shown in table (1-3)

and Table 1-3a show the propability of accurance for the monthly flow rates.

The wadi water has very low salinity of about 350 to 550 PPM and very suitable for irrigation.

Table 1 - 3a

Proportion Of Time Given Discharge Is Equalled or Exceeded

Qdischarge m^3/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep.	Oct	Nov	Dec	Year
1	0.995	0.999	0.982	0.864	0.983	0.801	0.946	0.999	0.962	0.908	0.999	0.999	0.954
2	0.715	0.839	0.939	0.697	0.854	0.713	0.911	0.998	0.882	0.730	0.801	0.857	0.828
3	0.478	0.839	0.701	0.553	0.700	0.678	0.751	0.917	0.805	0.652	0.522	0.457	0.670
4	0.183	0.129	0.461	0.434	0.582	0.588	0.577	0.832	0.748	0.583	0.521	0.434	0.555
5	0.173	0.437	0.336	0.368	0.496	0.395	0.501	0.776	0.713	0.212	0.417	0.419	0.437
10	0.022	0.028	0.205	0.161	0.171	0.055	0.225	0.393	0.259	0.058	0.058	0.012	0.138
20	0.006	0.010	0.189	0.098	0.080	0.013	0.052	0.111	0.073	0.039	0.008	-	0.057
50	0.003	0.002	0.136	0.18	0.23	0.002	0.006	0.022	0.007	0.013	-	-	0.020
100	-	-	0.035	-	0.006	-	-	0.005	-	0.003	-	-	0.004

1-6 Ground Water Resources

Shallow ground water occurs under phereatic water table condition throughout the project area.

It lies at a depth ranges from less than 5m to 30 m.

The known source of the aquifer recharge are the wadi and the deep perculation losses from the wadi and irrigated fields.

Natural discharge of the ground water occurs through out the year along the sea cost in the salty marshes.

The quality of the ground water is acceptable. It's electrical conductivity range from 600 to 4,400 micromohs.

30% of the dug wells are less than 2,000 mic. mohs and 15% of them is over 4,000 mic.mohs

The average tranmissivity of the aquifer was 400 m^2/day with anaverage specefic yield of 1.54 l/s/m. The annual ground water flow was estimated to be 19.1 Mm^3.

2. The Wadi Mawr Project Consideration

2-1 Agriculture

2.1.1 Cropping Pattern

In the Project assesment it was aimed that the Project which includes the improvement of all the activities that related to the agriculture production and markting will lead to :-

- An increase of 20% of the crop area to be 18,000 ha instead of 15,000

- Change the crop pattern towards better production

- Better water management will help changing the traditional crop pattern twards growing maize and high value crops such as melons and onions. Table (2-1) show the the past and projected crop area.

Table 2-1 Past and projected crop area (ha)

Crop	Spate Irrigation		Well Irrigated	
	Past	Projected	Past	Projected
Sorghum (white)	7400	8400	1400	1250
Sorghum (red)	4000	1100	650	-
Millet	1600	1200	-	-
Maize	150	2500	50	1200
Cotton	200	1600	20	200
Sesame	1500	1700	200	600
Tomatoes	-	-	40	150
Onion	-	500	20	150

Water Melons	80	450	60	200
Sweet melon	70	550	50	700
Papayas	-	-	10	50
Total cropped area	15000	18000	2500	4000

2.1.2 Crop Yield

Aplying the result of the researches, credit facilities, improved water distribution and an effective extension prgramme inaddition to the improvement of the crop distribution and better seeds, would increase the yield levels and return.

Table (2-2) show the past and future yield levels at a full development in year 2003

Table (2-2) Past and Future Yield Levels in Wadi Mawr (kg/ha)

Crop	Spate Irrigation		Well Irrigated	
	Past	Year 2003	Past	Year 2003
Sorghum (white)	973	1529	1112	1807
Ratoon Sorghum	487	765	556	904
Sorghum (red)	626	1390	834	-
Millet	584	1112	-	-

Maize	973	1691	1112	3197
Cotton	973	2363	1251	2710
Sesame	695	1168	695	1251
Tomatoes	-	-	11815	24742
Onions	-	15290	8340	18070
Water Melon	5560	13066	6950	14456
Sweet Melon	5004	12510	5560	13900
Papayas(1st year)	-	-	31970	44480

2 Irrigation

2.1 Past Irrigation Practices

2.1.1 General

The people in Wadi Mawr have gained their practices interacting with the nature of their wadi to develop their traditional spate irrigation.

Realizing the high level of variability in herent in the ephermial runoff, Upstream lands have higher probability of receiving spate irrigation in any particular year than those lying further downstream. The total area of land watered being dependent on both the distribution and amount of runoff. Complex arrangements of water rights are set.

They have also developed and perfected a system of spate irrigation by diverting the flood water which flow from the high wadi lands onto the coastal plains and direct it through a system of canals to their lands.

Diversions were made by constructing easthern suprs in the wadi, which usually are armoured by brush, to direct a portion of the wadi flow into the canals when a large flood occured or during periods of sustained flow, the spars were commonly destroyed and might be rebuilt. Floods might also erode the bank of the wadi and a section of the canal separating the diversion from the canal.

2.1.2 The Water Distribution System

The water distribution systems were premitive consit of primary canals taking directly from upstream of the diversion spur (okom). They had relativly high embankment to sustain the high fluctuations. The farmers keep maintaining these embankments to protect their lands from unexpected flows.

2.1.3 The Water Application System

The farmers take their water needs from the primary canals following the traditional rules, set and applied in centuries. It is the over riding principal of water rights on the wadi flows, where, the first to the upstream has the periority in getting all his need of water before letting it to the next, and so on.

Two methods were used to deliver water to the lands which are normally irrigated by flooding basins formed by embankments or bunds. In the first method the flow is diverted for the supply canal by constructing an earthern dike in the canal and cutting the canal bank water is diverted in the first basin, after the first basin is filled, the dike along the lowest side of the basin is cut and water flows to the next basin and in some cases to a third one, when the basins are filled, the dyke in the supply canal had to be removed to the down stream and so on.

In the second method which was prodominate in the area, flow is diverted from the supply canal into a secondary canal by constructing an earthern dike in the main canal and cutting the canal banks. A dike is constructed in the secondary canal and a basin on each side of the channel is

flooded. After that area is irrigated, the dike is breached, water then flow downstream in the secondary channnel to irrigate the next field.

2.1.4 Irrigation under the old system was also practiced in winter months. The upstream irrigation canals, Daraaniah Maadbaiah, Badriah, Mawasiah, Al Naseriah, Fath Al Bary, Hazamiah, and Basheeriah were considered to be pernial and winter flows were diverted to these canals. Flow was diverted in winter by constructing gravel and capple spurs. These are usually destroyed by the first substantial flood in the summer.

2.1.5 **Water Rights and Water Users' Organization**

a) Water Rights.

The farmers interacting with the wadi water capacity, with the type and sequence of its natural flow, had in centuries, developed, forced and agreed upon the rules that organize their relations concerning the individual water rights on the Wadi Mawr flow, and considered as a tradition by low, known and accepted by every body.

A1 The rules of water rights reflect the following :-

- The wadi is a typical arid ephermial water course fed by the runoff caused by a very short duration rain showers with differnt rain fall intencity.

- The wadi flow may suddenly increase by 30 or 50 times and drops sharply in hours, then following the natural recession.

- The wadi spate flow is not predictable either in timing, duration, size or its prequency of occurance

- The base flow of the wadi is available in the winter season when spates are rare and not expectable.

- That the water which couldnot be traped by the up-stream users will any how find its way naturally to the downstream ones.

- The type of soil which is a moderate water holding capacity but with deep profile.

- As the frequent irrigation couldnot be insured to replenish the continiously depleted water by the plant in the root zone.

- If they cultivate the crop they couldnot permit the rushing spate water to their lands before the plant have a certain growth range and tightly rooted to the soil, the fast spate flow may wash the seed and the surface soil with the young seedling

- Before cultivation they must have sufficient water stored in the deep soil profile to minimize the risk of loosing all thir crops.

- As the Wadi Mawr is a pernial water course, but have a limited natural base flow in the winter priod. Nov. thru Feb., then, cultivating a winter crop different of the traditional ones.

  They also can cultivate on the base water in this period some pernial fruit crops and also some short rooted vegetable crops.

A2 From these consideration and the nature and the traditional organization of the society, the people set rules of using the Wadi Mawr Water Resources which gives the water right periority to the upstream user. The upper most user have the periority to get his land sufficiency of water before letting it to the next to the down stream, and so on. (see fig. 2-1)

- On the main wadi water course the first periority (I) is to the most upstream offtake on either of the Wadi sides, the water in excase of their use or that couldnot be trapped by them will naturally flow and the periority of its use is to the next to the down stream (II).

- On the feeding canals, the periority is to the first upstream user on either of the canal sides (A1). This first periority user has the right to get his water sufficiency. After getting his sufficiency, the periority is still at the other users irrigating from the same intake, and the periority is shifted to the one next to him either through a cut in his field dike or on the same brach or ditch (A2) then, the periority is given to the next. When all the irrigators have had their sufficiency, the periority is returned to the feeding canal to the next Down stream user B1, and so on.

B. Organizations

To activate such a complicated vital subject, the rights need to be secured and the system has to function permenantly, that, need to be kept maintained, to over come imergency cases, to strenghthen and/or rebuild the destroyed spurs(aqum) dykes of the feeder canals (Feniah).

This couldnot be done without the co-operation, co-ordination of the farmers and the existance of a well organized and managed body to deel with this system.

Two organizations were managing and ruling the system

A) The Uqum Board

- The highest organization of the wadi course management.
- They formed of a commitee of 10 elected representatives of the water benifitures and land owners on the Wadi course. They usually are of the most respected and distinguished members of the society.
- After being elected they ere then appointed by the official government authorities.

B) The Water Masters (The Wakil)

Each spur diversion and offtake from the Wadi is controlled by a water master called the Wakil elected by the benificiaries for that diverstion. He carry on the runing and temporary maintance of the diversion works, strengthening and /or rebuilt it when destroyed or defected, organize the farmers to do some of running maintance by themselves, their hired labours, animals and in case of imergency. He also help in organizing them to get their water rights according to the adubted rules and help in settling some of the disputes.

The Wakil was charging the farmers for the works by assesing the cost and distribute the expences among the beneficiers in proportion to the area of the land he holds.

He was also paid for his services with about 5% of the grain crop yield.

2.3 The Project Scheme

The Project scheme is based on the diversion of upto 40m^3/s from the natural flow of the Wadi Mawr to the project area, through the implemented canal distribution system, and spilling the rest to the natural wadi courses to the down stream users.

The Main Component Of The Project Are :-

- A diversion weir on the wadi course
- An intake to the principal canal (Combined Head Reach) supplied with a desilting basin which clears the water from most of the silt sediment load and let it return to the wadi course.
- A combined canal reach has 40 m^3/s nominal capacity, is 4,200 km length and a total command of 16,760 ha. It feeds one primary canal 950ha. command, called Daraaniah canal.

At its end, it is divided into two main supply canals, each serves one of the sides of the Wadi Mawr.

- The North supply canal has 15.6 m^3/s, nominal flow capacity19.37km length, a total command of 5,170ha and has 17 primary canal off takes. It takes its root close to the wadi course at its' North side. (Table 2-3)

- The Southern supply canal has 22.5m^3/s nominal capacity, 24.5 km length, a total command of 10,740 ha and has 20 primary canal offtakes table (2-4) see Dr.(2-2)

Table 2 - 3

The North Primary Canal's Offtakes

Supply Canal	Primary canal	Design command ha	Chainage km	Design supply canal $l.s^3/s$	Discharge primary canal m^3/s
Combined reach			0.0	40	
	Daaraniah	950	1.15	38.1	1.9
End of combined reach			4.20		
Northy supply canal intake			0.0	15.6	
	Madbaiah	200	2.11	15.2	0.4
	Al-Mawasiah	490	2.43	14.1	1.0
	Al-Naseriah	240	5.38	13.5	0.6
	Hazamiah	200	6.89	13.0	0.5
	Fathelbary	280	8.39	12.3	0.7
	Barodiah	250	9.70	11.6	0.7
	Gule Figa	190	11.40	11.1	0.5
	Taheriah	720	12.20	9.5	1.5
	Bakkriah	150	13.25	8.9	0.6
	Adaa	660	14.10	7.4	1.5
	Labadah	150	15.25	7.1	0.3
	Hashadiah	330	16.75	6.3	0.8
	Bakhashiah	300	17.25	5.6	0.7
	Juniah	500	17.87	4.6	1.0
	Markozah	110	19.37	4.0	0.6
	Makiah	100	19.37	0.5	
	Masliah	300	19.37	0.6	

Table 2 - 4

The South Primary Canals offtakes

#	Supply Canal	Primary canal	Design command ha	Chainage km	Design supply canal m^3/s	Discharge primary canal m^3/s
	South Supply Canal intake			0.0	22.5	
1		Badriah A	460	4.6	21.5	1.0
2		Badriah B	430	6.65	20.5	0.9
3		Badriah C	1290	8.1	18.0	2.6
4		Basheriah	270	8.82	17.4	0.6
5		Hamodiah	310	9.17	16.8	0.6
6		Asmara	800	10.91	15.2	1.6
7		Sabakhiah	890	12.48	13.3	1.9
8		Bakryyah	200	14.35	12.9	0.4
9		Mastorah	860	15.93	11.0	1.9
10		Gazilyah	880	17.74	9.2	1.8
11		Jerba	550	17.74	8.1	1.1
12		Wadian	350	18.15	7.4	0.7
13		Khalifa	150	18.15	7.1	0.3
14		Haraji	290	20.11	6.5	0.6
15		Mariah	790	20.11	4.8	1.7
16		Jadidah	180	20.91	4.4	0.4
17		Gadyah	380	21.67	3.6	0.8
18		Masud	270	23.68	3.0	0.6
19		Jezan	470	24.5	2.0	1.0
20		Kidaid	920	24.5		1.9

- The canals are designed to be unlined, with stable cross section using tractive force design paramiters, and for a rate of flow of 2/1/s of each commended area

- Because of the natural ground slope is relatively high, the canal bed slope is flattered by drop weirs' regulating structure.

- The 38 primary canal offtakes are designed as gated drop weir intakes, it has a flap gate to be closed partially or totaly to control the required flow when needed.

- The offtakes are fed at the upstream side of the regulating drop structure weirs.

- The weir cill of the offtake is set at a level lower than the regulating structure weir in depths range from 0.23ml to 0.67m.

- The lower setting of the cill of the offtake weir is to insure that it traps all its design flow at Zero discharge in the supply canals.

- The design discharge of the primary canals is 2 l/s/ha of the design command.

- In addition to the primary canal offtakes, 40 slide gated pipe intakes are installed to feed the isolated reaches between the supply canals and the wadi channel, each of capacity 0.1 cms.

- The primary canals are considered comprising a section of a new channel and was redesigned and remodled.

- The scheme include a complete monotary set that include flood warning system, water level recording measuring flow meters, meteorlogical station.

- The scheme didnot consider offtakes to the secondary branches or ditches.

- The project activity did not go further in the system to lower levels of water use.

2.4 Water Allocation Plan

The water allocation plan of the prject was prepared by MMP to maximize the annual flow which can be abstracted from the wadi and to distribute it as equitable as possible.

Because of the wadi flow as a ephermal channel is variable and spate increase the flow very rapidly but for a few hours, there for the establishment of a water distribution system is deeply required.

The plan splitted the year into 3 seasons according to the diffrent hydrological seasons.

Winter	Nov. thru. Feb.
Early Rain	Mar. thru. June
Late Rain	July thru. Oct.

In the winter season the base flow is the main resource. Opportunity of spate flow is very little. The plan allocates all the base flow to the upper reach of the project area, to those canals which were traditionally receiving the winter flow, this will allow cultivation production all over the year and give chance for pernial fruit and vegetable crops.

In the early and late rain, the flow is allocated to the middle and lower reaches of the project which were traditionally receiving spate flow only, this, will allow

the cultivation of 2 crops in the middle and one crop only for the lower reach.

The plan is based of a target continious irrigation requirement of 0.8 l/s/ha. as an anual average, which allows an average annual depth of 2.mt. i.e 25,000 c.m/ha in the upper reach and decreased in proportion to the expected crops in the other two reaches.

2.4.1 Allocation To The Upper Reach.

This reach serves 10 primary canals with total command of 4810 ha and a design intake capacity of $9.62 m^3/s$ the target average continious flow rate is $3.84 m^3/s$ according to the requirement calculations.

Table 2.5 analyses the upper reach command and its requirements.

Table 2 - 5

Details of the upper reach primary canals command and the allocated water

Combined reach				North Supply canal				South Supply Canal			
Prim. Ca.	Area served ha	Discharch Design m^3/s	Target m^3/s	Prim Ca	Area served ha	Discharge Design m^3/s	Target m^3/s	Prim.	Area served ha	Discharge Design m^3/s	Targ m^3/s
Baraniah	950	1.9	0.76	Madbaiah	200	0.4	0.16	Badriah A	460	1.1	0.37
				Nawasiah	490	1.0	0.39	Badriah B	430	0.9	0.34
				Naseriah	240	0.6	0.19	Badriah C	1290	2.6	1.03
				Hazamiah	200	0.5	0.16	Basheriah	270	0.6	0.22
				Fath Albary	280	0.7	0.56				
Total	950	1.9	0.76		1410	3.2	1.46		2450	5.2	1.96

According to the plan, all the winter flow will be diverted to the upper reach offtakes only, no water will find its way to the middle reach unless the diverted flow is in surplus of the capacity of outlets on this reach.

As the design capacity of the intakes is 2 ls/ha. while the target requirement is only 0.8 l/s/ha, i.e, 40% of the design capacity, there for the allocation plan is based on the opening & closure of these intakes to be operating only for 40% of the time.

In general, the winter flow will be much less than the design flow, there for a callender operation plan is prepared as shown in section (2.5)

2.4.2 Allocation For Middle and Lower Reaches

The middle reach is considered to include the primary canals from Barodiah to Juniah on the North supply canal and from Hamodiah to Kalifa on the Southern one. The reach covers a command area of 8230ha with design flow capacity of 17.90m^3/s distributed on 18 primary canals and 14 gated pipe supply intake.

While the lower reach serves 10 primary canals and 5 gated pipe supply intakes. The last primary canal in each of the North and South supply canals is directly fed from the tail end.

This reach cover acommand area of 3810 ha. with a total intake capacties of 8.7 m^3/s.

Table (2-6) analysses the middle and lower reach command and requirement.

Table 2 - 6

Details of the Middle and Lower reaches Command and the allocated water

Middle Reach						Lower Reach					
North Supply Ca.			South Supply Ca.			North Supply Ca.			South Supply Ca.		
Prim. Ca	Area ha	Q m^3/s	Prim Ca	Area ha	Q m^3/s	Prim. Ca	Area ha	Q m^3/s	Prim. Ca	Area ha	Q $m^3/3$
Barodiah	250	0.70	Haaodiah	310	0.6	Markoza	110	0.6	Haraji	290	0.60
Gulaliga	190	0.50	Asmara	800	1.6	Makkiah	100	0.5	Moriah	790	1.70
Tahoriah	720	1.50	Sabakkiah	890	1.9	Maalyah	300	0.6	Jadidah	180	0.4
Bakoriah	150	0.60	Bakkryya	200	0.4				Gadyah	380	0.8
Mea	660	1.50	Mastorah	860	1.9				Masud	270	0.6
Labadah	150	0.30	Gozilyah	880	1.8				Jezan	470	1.0
Kashodiah	330	0.80	Jarba	550	1.1				Kidaid	920	1.9
Kalbash-	300	0.70	Wadian	350	0.7						
Jaalah	500	1.00	Khalifa	150	0.3						
Total	3240	7.60		4990	10.3		510	1.7		3300	7.0

2-5 The Operation Plan

MMP, prepared a detailed operation manual explaining in details the operational effort required to apply the water allocation plan sucessfully, it shows in step by step the different procedures with some examples.

The plan set strict procedures to measure, calculate and destribute the natural water supply to insure that each offtake have got its design target flow.

To follow this strict plan correctly, the project installed a series of continious measuring devices to follow up the actual flow that distributed on the whole project area. These devices are essential as a complementary tool to insure that each offtake had got its target share. With these devices, the engineer could follow easily with the least effort, the water distribution of the whole project area.

The plan is based on the operation of the gates and measuring continiously the flow codition at each distribution points and offtake on the following rules.

- To restrict any water flow to the natural wadi course, unless the natural flow exeeds 40 m^3/s. All the flow up to 40 m^3/s is automatically directed to the intake of the canal system.

- A discharge measurement site was fixed at shat Al Erg for periodical flow currentmeter measuremnt. A continious stage recorder was installed in the same site to detect the changes of the spate flow and an Allarm system installed at the diversion site to allarm when the flow gets to 40 m^3/s to activate the head work operations and a rating chart is prepared to calculate the actual flow at the combined reach intake.

- To divide the water flow in the canal system such that each of the North and South supply canals get its share.

- A weekly recording float stage recorders was installed to the downstream of each canal intake at a drop weir site, a rating chart for the weir was prepard to measure the actual flow in each supply canal and a procedure for gate operations to correct the shares is included the plan.

- To measure the actual flow to each intake, a flow meter was installed at each offtake to measure the accumulated flow to each offtake.

- To insure that each gate hasgot its allocated share two calender operation plans for opening and closing the offtake gates, one for the winter season while the other for early and late rain seasons were included. See fig (2-3) & (2-4).

- The calender operation could be also adubted with the flow meter readings if it is proved that any of the intake got more or less than the target flow.

- For the winter season, a flow operating chart was prepared to help gatting each of the upper reach canals its share fig (2-5).

3. Evaluation Of the Canal Distribution System

3.1 The project water allocation plan and the operational procedures and rules set in the project manual is to attain an equal distribution of the water abstracted from the wadi as possible; taking into account the existing local practices.

The plan is mainly based on instrumentation measurements and manual operational procedure for the closing and opening of the primary canals.

This short study is based on the information collected from:

- The exixting information available in TDA main library
- The Wadi Mawr Project, anual and quarterly reports in 1988 & 1989 for the operation and water sections
- The attained data from the project site
- Meetings with TDA, HQ Consultants and staff
- Meetings with Project Seniors, water, operation and maintainance field staff.
- Meetings with the farmers, canal Masters and the area leaders.
- Data and information attained from my field visits and calculations and justifications.

The study will focus on a breif review of the existing coditions from the technicals legal and organizational point of view, the defects in the systems, the possible solutions and the proposed consideration need to be taken for similar projects.

3-2 Data Acquisition

The project has several data collection sources and methods. In the data revision the intention was mainly to the continuity of the data with acceptable accuracy.

There are some difficulty in dealing with the existing data collected from the the continious recording devices. The flow meters for measuring, the accumulated discharge at the primary canals intakes didnot function.

- The stage recorders that measure the water stage to the down stream of the North and South supply canals' intakes seem to have accuracy problems due to the repeated clogging of the pipes that connect the canal channel to the recorder manhole which may give faulse readings. It also, some times give stage readings while the canal is supposed to be dry. Some times there are unlogic diffrences in the recorded charts.

The operation and maintainance technical staff covered these defects by getting;

- Several daily measurements at the intake weir of the head reach and use it in estimating the daily discharge using the formula from the operation manual.

- Daily measurement for the water head over the offtakes' weirs to the primary canals and estimate daily discharges of these offtakes using the operations manual for-

mulas, and also traces the rate of advance of the spate flow in the supply canals.

- These are the sustainable data which used in this evaluation. It give a good indication of the condition of the relative distribution of the system.

3 The Existing State Of The Water Distribution And The System Operation.

3.1 The system is designed in a way that facilitates the measurement needed to follow up the distribution condition and operate the system according to the operation manual choosing the weirs as check structures at the distribution points simplifies the discharge measurement with high acuracy level, with the possibility of sustaining on its manual readings if the instruments fail.

Concerning the main data collection and project operation

a) Shat Al Erge Site

This site is located to the upstream of the project diversion. It is the main hydrometric station on the Wadi Mawr for the estimation of the actual natural flow of Wadi Mawr entering the project area.

It consists of a discharge measuring site and a coninious water stage recorder.

The project staff continue measuring the natural base flow by direct discharge measurements.

In 1988, 89 flow measurement were done.

The measurements untill Sep. 1988,were done using the float method because of currentmeter problems, while in 1988, 89 discharge measurements were done.

Concerning the water stage recorder, it is not functioning in the time being and the specialists complain from the battery. default due to the high ambient temperature and from failure of the transducer.

b) The diversion weir and the head works.

- The electronic warning and controll system didnot function for technical problems.

The failier of this device overburden the operation staff to do it manually.

In the period of our visit the natural flow was minimal and was completely divertd to the project area. The settling basins seems to be functioning well in clearing the water from the silt deposits. The canal cross section is in a good condition and not to much silt deposits are observed.

c. The head regulation at the intake of the North and South supply canals.

These intakes are constructed such that a fixed sharing between the North and South supply canal of 1:2.1 according to their command areas. By gate operations, the sharing could be adubted in the winter season in the ratio of 1:1.7 up to a discharge of 10.3m^3/s.

weirs range from 23cm to 67cm see Dr.(3-1), this lead to :-

- If all the primary canal intake gates are open, then the water never gets to any branching of the supply canal unless the flow at the head reach intake exceeds the accumulated design flow of all the intakes getting to the upstream of the concerned branch.

- If the flow of the supply canal at the branching exeeds the primary canal design discharge(Qb).

The primary canal gets its design discharge (Q_a), the rest will be ($Q_b - Q_a$) passes over the drop weir and created a head (ah) over the cill, concequently, the head over the cill of the intake weir will increase by (aH) and will be (Ha + ah), the flow to the primary canal will be increased to (n Q_a) wher $n = (\underline{Ha-ha})^{1.5}/Ha^{1.5}$
n, will increase concequent within the design limited this increase to about 1.6 of the design discharge.

This means that if all the offtakes are open the required flow at the intake has to be increased continiously with sum of ($N_1Q^1 + N_2 Q_2 + \ldots\ldots N_nQ_n$)
with a maximum margin of {1.6(sum of Q)}

Table 3-1 show the minimum accumulated flow required to let water flow gets to a certain primary canals' intake (without considering the increasing factor, n.)

This means that unless the callender rotation plan for the gate closure

Table 3 - 1

Minimum Acumulated Flow Required For The Flow To Reach The Pr. Can.

Primary canal	Design discharge m^3/s	Accumulated discharge	Min. Head discharge for flow continuity	Primary canal	Discharge Design	Discharge accumulated
[illegible] canal			1.9			
[illegible]	.4	.4		Badria A	1.0	1.0
[illegible]	1.0	1.4		Badria B	0.9	1.9
[illegible]	0.6	2.0		Badria C	2.6	4.5
[illegible]	0.5	2.5		Al Nawasiah	0.6	5.1
[illegible] Al Bary	0.7	3.2	10.2			
[illegible]	0.7	3.9		Hamodiah	0.6	5.7
[illegible]	0.5	4.4		Asmera	1.6	7.3
[illegible]	1.5	5.9		Sabahliah	1.9	9.2
[illegible]	0.6	6.5		Bakryyah	0.4	9.6
[illegible]	1.5	8.0		Mastorah	1.9	11.5
[illegible]	0.3	8.3		Gazilyah	1.8	13.3
[illegible]	0.8	9.1		Jerba	1.1	14.4
[illegible]	0.7	9.8		Wadiain	0.7	15.1
[illegible]	1.0	10.8	28.1	Khalifah	0.3	15.4
[illegible]	0.6	11.4		Haraji	0.6	15.0
[illegible]	0.5	11.9		Mariah	1.7	17.7
[illegible]	0.6	12.5		Jadidah	0.4	18.1
				Gadyah	0.8	18.9
				Masud	0.6	19.5
				Jezan	1.0	20.5
			36.8	Kidaid	1.9	22.4

and opening is applied, proper water sharing according to the project goals could not be easily acheived.

The operation section of the project meat difficulties in forcing the activation of the calender operation schedule.

The farmers and land owners on the first primary canal on the combined head reach never allowed the closure of their intake gate, and continued getting their maximum possible flow all over the year, its' design discharge is 1.8 m^3/sec at zero discharge in the cobined head reach, the design margin for its capacity increase is 60%, i.e. there is a room to get a discharge up to 2.88 m^3/sec.

In a similar way many of the other primary canals benificiers acted, others in spate area donot like any closure of their canals unless all the comand is being irrigated adequatly.

Water Sharing Evaluation

Within this study, an analysis is done using the available data, from which the following findings are extracted for the different cropping seasons, and the results are stipulated in tables (3-2) to table (3-9).

The Winter Season

In the 4 winter season months, Nov. thru. Feb, the only expected water source is the winter base flow, expected effective spate is minimal, while the base flow is limited.

According to the water allocation plan of the project, all the water resources in this season is dectated to the upper canal reach which cover a total command area of 4810 ha., srved by 10 primary canals. In the season 1988 - 1989, the

total discharge to the system was 9.398Mm^3 which makes an average coverage of 20 cms. All the water was directed to one canal only, Daraaniah canal of 950 ha. command area, while the other 9 commands on this reach got nothing. From the analysis we can conclude :

- While Daraaniah ca. is 20% it get 100% of the flow. According to the target planned flow, its allocation is 6.5 Mm^3 with a water depth of 68cms but it got a depth of 79 cm. as an average distribution over the whole area.

- According to the actual water requirement, it requires a depth of 37cms, while it got 99 cms with a total efficiency of 37% which is very low.

- The natural flow of the winter season was much less than the target normals which was 32.5 Mm^3 it represents about 30% of the target which can irrigate an area of 1525ha with 60% irrigation efficiency as projected.

2.4.2 The Early Rain Season

The available data for the early rain season covers all the 4 months Mar. thru. June 1989, and only 3 months Apr. thru. June 1988.

The total discharge during the 3 month of 1988, was 37.3 Mm^3, of which 9.4 Mm^3 to Darrniah ca., 9.7 Mm^3 to the rest of the North supply canal of 5170 ha. and 18.2 to the south supply canal of 10740 command. In the 4 months of season 1989, the total discharge was, 54.8Mm^3, 11.8 to Daraaniah, 12.1 to the North ca., 23.9 to the South ca.

1.4.2.1 Distribution of the upper canal reach (4810ha)

- In 1988 season, Daraaniah inflow was 9.4Mm^3 for a duration of 88 days out of the total recorded period of 91 days. With a water depth of 98cm, getting 519% of its target flow. In the season of 1989 it got 11.8Mm^3 for 100% duration and a water coverage depth of 124cm. getting 655% of its target flow.

- In 1988, the rest of the reach got 10.1 Mm^3 with 158% of the target flow. The flow duration range from 38% to 14% of the period. The average water coverage, was 26cms. In 1989, it got 15.9 Mm^3 which is 194% of the target, and a duration range from 31% to 9%.

This reach as whole got 212% of the target in 1988 and 338% in 1989

1.4.2.2 Distribution Of The Middle Reach (8240ha)

- In 1988 it got 15.4Mm^3 represent 37% of the target with duration range from 23% to 5%.

- In 1989 it got 22.9 Mm^3 represent 45% of the target with duration range from 25% to 4%.

1.4.2.3 Distribution Of The Lower Reach (3850ha)

In 1988,, it received 2.3 Mm^3, 23% of the target for a duration 8 days for one, 7 days for 2/5 daysfor 2/2 days for 4 canals and one canal didnot get water.

In 1989, it received 4.16 Mm^3, 27% of the target for a duration of 13 days for 1/8 days for 3/6 days for 1/5 days for 3/3 days for 1/and one days for one canal only./

4.2.4 Average Distribution Of The System Command (16860ha)

In 1988 the total inflow to the system was 90.3/Mm^3 , which was 112% of the target flow with an average coverage of 54 cms over the whole command. distributted as 98cm. for Daraaniah, 26cm for the rest of the upper reach, 19cms for the middle, 6 cms for the lower reach.

In 1989, the total inflow was 54.8Mm^3 which was 44% of the target with an average coverage of 32cm distributed as 124 cms. for Daraaniah, 41cms. for the rest of the upper command, 28 cms for the middle and 11 cms for the lower reach.

4.3 The Late Rain Season (Jul. - Oct.)

During the late rain season, the total inflo was 90Mm^3 in 1988 and 38 Mm^3 in 1989 with an coverage depth of 53 cms and 23cm. respectivly, the share of the North and South canal were 57 and 44cms in 1988, 29 cm and 11 cm. in 1989. While the to share of the combined head reach abstracted by Darania canal was 144cm and 121cms in 1988 and 1989.

4.3.1 Distribution Of The Upper Reach (Jul. thru. Oct.)

- Daraaniah canal share was 13.7Mm^3 and 11.2Mm^3 in 1988 and 1989 respectivly represent 15% & 36% of the total re of the respective season's flow. The share of Daraania with respect to the natural flow increased to 240% in 1989 inspite of the decrease of the natural flow to 42% of 1988.

  With respect to the project target its actual flow was 5.7 times and 4.7 times the target flow in 1988 & 1989 with an average coverage of 144 and 99 cms.

- For the rest of the reach, the share was 14.6 Mm^3 and

7.8Mm^3 in 1988 and 1989, with a coverage of 38 & 20cms. This coverage was 148% and 79% of the target for 1988 and 1989. Splitted between the North and South canal in the ratio of 1:2.3 in 1988 and 1:0.75 in 1989 while the area ratio is 1:1.7.

3.4.3.2 Distribution Of The Middle Reach.

- This reach share was 52.6 Mm^3 and 13.3 Mm^3 in 1988 and 1989, with a coverage of 64 cm and 16 cm respectivly. The distribution beteen the North and South canals was 1:0.93 in 1988 and 1:1 in 1989 while the command area ratio is 1:1.5.

The average coverage with respect to target was 85% for the reach splitted as 98% to the North and 77% to the South supply canal in 1988.

In 1989, the average coverage was 24% of the target ; flow splitted as 30% to the North and 20% to the South supply canal.

3.4.3.3 Distribution Of The Lowere Reach.

This reach share in the season was 15.7 Mm^3 in 1988 and 1.8 Mm^3 in 1989 with coverage of 115% and 23% respectivly

The distribution between the North and South canals was 1:2.8 in 1988 and 1:12.1 in 1989 while the command area ratio is 1:6.6.

3.4.4. The Sum Of Water Dsitribution In The Two Rain Seasons. (Apr. - Oct. 1988) & (Mar. - Oct. 1989)

Due to the distribution differences, notable improvement in the uniformity of the distribution on the system appeared on

Summation of the two rain seasons (Apr.- Oct) in 1988 and (Mar.- Oct) in 1989.

The total inflow to the system was 128 Mm^3 in 1988and 83 Mm^3 in 1989. with a coverage of 92% and 66% of the target which represent 76cm. and 55 cm. respectivly.

The distribution for the North and South supply canals was in the ratio of 1:1.7 in 1988 and 1:1.6 in 1989, while the ratio of the command areas is 1:2.1.

3.4.4.1 The Distribution Of The Upper Reach.

- In 1988 and 1989 Daraaniah canal share during the period was 23Mm^3 and 23Mm^3 with a coverage depth of 2.6m, that represent 510% and 480% of the target. With respect to the whole command, its water share was 18% and 24% respectivly while its area is 5.6% of the total command.

For the rest of the reach, the respective water flow was 25Mm^3 and 23Mm^3 which represent 126% and 116% of the targeted flow, with a coverage of 65 cms and 61cms the share of the North and South canals was 1:2.1 and 1:1.8 while the area sharing in this command is 1:1.73

3.4.4.2 The Middle Reach

The respective total flow in 1988 and 1989 was; 62 Mm^3 and 36Mm^3, with a coverage of 75cms and 44cms, that represents 65% and 33% of the target flow.

The share of the North and South canals was in the rate 1:1.3 and 1:1.6 while area ratio is 1:1.5.

4.4.3 The Lower Reach

The total flow in 1988 and 1989 seasons was; 17.6 Mm^3 and 6 Mm^3 with a coverage of 46cm and 16cm, which is 76% and 23% of the target flow respectivly.

The share of the North and South canals was 1:2.8 in 1988 and 1:7 in 1989 while the area ratio is 1:6.5.

Discussion

From the previous analysis e can find that

- Daraaniah canal which has an allocated command of 950ha, has taken alone an estimated annual quantity of water of 35 Mm^3 in the period Mar. 1988 to Feb. 1989, that is 3.1 times it allocated water and represent an average water depth coverage of 3700 mm while the free water evaporation in the project area is estimated to be 3000 mm only.

The estimated annual allocated water depth for this reach by MMP is 1189mm only.

In this canal the cropping pattern is changing to cash crops, many farmers are growing fruit trees and Banana which is a high water consumptive crop, short rooted crops as vegetable which need to be frequently irrigated. The project helped in attaining better water stage conditions that could irrigate more lands than allocated beside having almost all the area reliably pernially irrigated which gave the chance to expand the cultivated area on this canal.

- Under these conditions, the allocated target flow to Daraaniah is under estimated.

The comparison shown in table (3-10) express the actual releases related to the Targeted, for the several canal reaches

When representing the water depth distribution versus the area comanded for the North and South supply canals, on Drawings (3.2) to (3.7) it is observed that there is lot of scattering in the distribution, mainly in the high flow depths (this is mostly due to the level of acuracy of the data). The drawings show average curve fittings to explain the general charactor of this distribution in the period of the 7 months (Apr. - Oct.) 1988 and of the 8 month (Mar. - Oct.) 1989, and an idea about the water sharing in the canal system.

In general the early and late rain seasons are complementory. The areas that has defecit in the early, substitute its need in the late one. If the water supply is sufficient, the upstream group of primary canals get only its need, and the water find its way easily to the down stream lower reaches

In the low flow years as in 1989, the upstream canal group, got about the same water depth as 1988 inspite of the notable decrease in the natural supply.

There is no distribution problems in the high yeild years as 1988, when almost all the lands had got its water sufficiency, the lower reaches had the chance to get, even more water depths than the upstream areas.

In the low yield years as in 1989, with Daraaniah canal getting about 39% of all the annual flow of the project area, attaining the required equaly in share distribution couldnot be attained unless the operation schedule is activated successfully.

Requirements To Attain Equity Of Water Distribution

The level of eqity of the distributed water in the project area is attained when :

- Each primary canal intake get its allocated target flow in the concerned cropping season.

- The Project area is divided into 3 reaches Upper, Middle and Lower. Each has a target flow.

- The water required to be distributed equally within each reach's offtakes. The increase or decrease in the flow quantities, is added or substracted from the allocated flow in ratio to the offtakes' command. The internal distribution within each primary canal is out of the project concern.

- The operation engineers has to have a water budjet to each primary canal and adubt the operation by closing or opening the gates to attain the required equity. (The program is based on getting the recorded quantities of ater by the flow meters at the offtakes), and make the required water budject calculations these devices, are not functioning and the case need to be considered. That project plan did not consider the internal equity of distribution within the primary canal commands. Do the farmers still have to follow their traditions of upstream periority ? or do the farmers have to distribute the water quantity equally on the land ?. These questions need to get an answer to define the equity levels required by the project.

Deeling with uncertainty and unpredictable flowes in Wadi Mawr, with rapidly chaning flow that causes sudden increase

in the water quantities and stages without commonication or acting warning system and with no storage capabilities or check structure to delay the instantanious peaks, some diviation in the equity of distribution could be allowed.

3.6.1 In Spate Irrigated Areas

Because of the uncertainly of flow with respect to the value, timing and duration, the farmer need certainty of a production crop by getting all his water sufficiency as early as he can. He can only cultivate when he has the crop water use already stored in his soil profile. So to cultivate his needs he has to be insured to irrigate. He diverts all the flow to his Basin bonds untill filled. The sufficient water depth according to the farmers practices is when the bond is filled to the top of the boundary ridge.

The extent of the spate irrigated areas depend on their land altitudes with respect to the water stages at the vicinity if their fields, which changes from year to year and with each spate wave

3.6.2 In Pernially Irrigated Areas

Each crop in the area need a certain water requirement that depend on the type, age, dencity and weather conditions, equity of distribution in this case means that each crop has to have its water requirement within the economy of water use:

Irrigation requirement in these areas is ruled by the physical codition of the soil, the land surface slope, the on-farm application systems, the irrigation rates and frequencies.

In our case, Daraaniah canal, is the only canal that has pernial irrigation in addition of other well irrigated areas distributed in the project command.

In Daraaniah, they are irrigating pernially but, using the irrigation practices gained from their tradition spate system. They still keeping their basins unleveled and flooding it with large water depths. They cultivate short rooted crops which couldnot get to the stored water in the deeper soil profile, the soil is of light and moderate texture with limited holding capacity and high intake rates. Therefore most of the water is lost in the deeper soil profile. They will certainly need to irrigate frequently when the water content of the surface profile is depleted and the crop begins to wilt. This canal uses an average water depth of 3700mm distributed on the project command i.e. 1.23 times the free water evaporation in the project area and about 2.7 times the actual requirement.

The estimated irrigation efficiency in this area range from 25% to 37%. If we compaire the used water depth with the farmer practices, the 3700 mm are needed for 6 to 8 irrigation only during the year which is appropriate assuming that there is no concern to develop the on farm practices. This very low water use efficiency has also a negative effecton the crop yield.

One of the farmers told us that he irrigates his tradition basins under pernial areas, once a month with an estimated average water depth of 50 to 60 cms because of his sloping land, and his banana and vegetable once a week as he is giving only about 15 to 20 cms water depths which will lead to the same result.

So, controll the following of Daraaniah canal could be attained in 3 cases :

a) To give the canal its share only with an anual wat coverage of 1284mm as targeted for the average year and let the farmers control the area by decreasing or increasing as the natural flow will be.

In this case, while irrigating with the existing practic will be sufficient for 350ha only. The same case will b repeated for the other 9 canals of the upper canal rea that planned to be as a pernial area. i.e. about 1700ha or will be cultivated instead of the total command of 4810 ha

This area will need also to be increased or decrea anually with the change in the natural flow.

b) To keep the case as it is but, accomplish a monatorin program to collect the correct basic data about the actual irrigated areas, cropping pattern, holdin actual on farm water use.

c) To work in developing the farm water practices and management with sample farms after having a proper identification and evaluation of the real farm pro- problems. Some practices need to be experimented such as land leveling in small basins, contour ditch and border strip flooding methods in the perni areas and water spreading methods for spate areas. Because of the relativly high land surface slopes, and of high intake families, it is recommended to experiment a simple drip irrigation system in Zuhra farm which will have much help in water saving and in geting high crop yields. This may attract th land lords in the pernial areas and the water well i gators, and use the saved water in solving a part of the existing problems.

3.3 The Project Reaction On The Water Distribution

Before the project, different water distribution conditions were existing. The wadi flow was not completely controlled. The cultivated areas were limited to the available water stage at the farm vicinity. T&K in his survey 1979, splitted the irrigated areas of the project in two categories.

a) Reliable irrigated lands, which gets its water and cultivated each year.

b) Intermittent irrigated lands, which couldnot be irrigated each year and its coverage depend on the flood conditions.

Table (3.11) show the Percentage of the previously reliable irrigated lands in the different reaches related to the total commands of the reach.

Table (3 - 11)

Percentage Of The Realiable Irrigation To The Command Areas

The Canal	Upper Reach %	Middle Reach &	Lower Reach %	Some of the Reach as %
Daraaniah	32			32
North S. Canal	86	88	80	86
South S. Canal	96	89	58	81
North + South Canals only	92	89	63	82
Total Project	80	89	63	78

Comparing the enalysis of this survey with the new condition

- Daraaniah canal was irrigating 32% reliablly, now it cultivates 100% penially with development the cropping pattern and adding new area.

- The rest of the upper reach on the North and South canals were having 92% of their commands reliablly irrigated and getting their winter water share from the base flow. now, they donot get any base flow, but they can insure irrigating 100% of their commands even, in the lowest possible flood conditions.

- The middle reach was irrigating 89% reliablly, now it insures irrigating 100% anually. The upper part of the reach can ensure the cultivation of two crops if the farmer desires. The lower area could be partially affected in low yield years.

- The lower reach was reliablly irrigating 78% of its command, now they can cultivate 100% of their lands in high yield years much lower in the low yield years.

These differences are expected, because in the past the cultivated areas were dependable on the flood stages, in the wadi itself. The cultivated areas were dependable on the different spate conditions and the cabpbilities of the farmers to capture the water. The wadi water stages were changing in a range of about 3.5 mt.

Now, they have more handble water levels. In the canals water level variations are very limited. Each offtake can capture all its requirement at the least water depth in the supply canals.

This raise the need for strict operational programme.

- Some of the areas that lie between the Wadi Mawr and supply canals are isolated. These areas were having the first periority on the old system. The project included supply gated pipe intakes to them. But, many of these areas did not get any water since the project accomplishment either because of neglecting the construction of the a ditch to lead the water to the whole elongated reach or because the intakes are constructed at high spots or the farmers does not allow the secondary water courses to path their lands.

Detailed survey maps are needed to identify the problem and get to the proper solution.

Some of the farmers prefare to get their water from the wadi, specially in the lower end of the middle reach where the surplus water could be available in the wadi but not available to them from the canal. The problem is that the reconstruction of the old spurs (ohm) is very expensive to them due to their small holdings.

7 Water Rights and Organizations

In general water rights is a legal subject. Water legislations usually fix the rights, responsibilties, legal powers and the relation between the organizations and water users. These legal aspect have to be followed in designing operating and managing the projects.

For the Wadi Mawr project, water legislations are not yet issued. In centuries, the people of the wadi have agreed and set their unwritten traditions which fix the water rights and their relations in using the wadi flows. Their rules is based on the upstream users' periority to get their water needs. These rules are respected and used in YAR and

also in the surrounding region where the weather and conditions of using spate flow in arid regions is similar.

Countries other than YAR and its neighbours are also using upstream user perioty such as "The riperian water rights in USA".

In setting water laws and legislations, the gained water rights is usually fixed, insured, respected and protected. These rights are usually limited to the actual water use within a certain period of time before issuing the low. Un-used water rights, could be failed and dropped. Legal organizations for the system management and for solving disputes is usually considered from the legal point of view.

In new project when the sequence and nature of flow and water availability is subject to major changes, it is recommended to measure and evaluate the existing water rights and insure it in space and time. Gained water due to the artificial alternation in the condition of the natural flow could be directed according to the project policy and objectives.

Before making major changes in the distribution of water, the identification of the actual distribution conditions is required to maintain the traditional rights (see Apr. - 1982, MMP inception report, chap. 4, item 19 Water Rights)

From the organizational point of view the past organizations that were managing for the water distribution, the wakil and his assistances were managing the old system, organizing the farmers' co-operation, solving disputes, and forcing the sharing of the maintainance costs and effort.
The new project is providing an assured better controled supply. The wakil and his assistance became with no responsibilities and the farmers feel that they became with no responsiblilty

TABLE 3.2
DURATION AND WATER FLOWS IN THE NORTH SUPPLY CANAL AND THE HEADREACH
1988

No.	Primary Canal	Total Area ha	April-June Days	April-June Q Mm3	April-June Water Depth cm	July-October Days	July-October Q Mm3	July-October Water Depth cm
Upper Reach								
1.	Daraaniah	950	88	9.350	98	104	13.690	144
2.	Madbaiah	200	13	0.332	17	9	0.186	10
3.	Nawasiah	490	27	1.381	28	23	1.254	26
4.	Naseriah	240	17	0.582	24	17	0.620	26
5.	Hazamiah	200	16	0.515	26	34	1.405	70
6.	Fath-El-Bary	280	17	0.704	25	17	0.943	34
	Sum	2360		12.864	54		18.098	76
Middle Reach								
7.	Barodiah	250	21	0.531	21	23	1.050	43
8.	Gula-Figa	190	20	0.615	32	20	0.621	33
9.	Taheriah	720	20	1.709	23	31	3.200	45
10.	Bakeriah	150	16	0.535	35	55	1.436	95
11.	Adam	660	17	1.227	19	65	4.051	62
12.	Labadah	150	12	0.207	14	45	4.800	(319)
13.	Hashediah	330	7	0.406	13	42	2.150	65
14.	Bakhashiah	300	5	0.242	8	36	1.780	59
15.	Juniah	500	5	0.371	7	35	2.220	45
	Sum	3250		5.843	18		21.307	66
Lower Reach								
16.	Marzuka	110	5	0.207	19	27	1.230	116
17.	Makkia	100	5	0.164	17	11	0.320	32
18.	Maslia	300	-	-	-	18	2.430	81
	Sum	510		0.371			3.980	
	Total:	6120		19.078	31		43.385	72

TABLE 3.3
DURATION AND WATER FLOWS IN THE SOUTH SUPPLY CANAL

1988

Primary Canal	Total Area ha	April-June Days	April-June Q Mm3	April-June Water Depth cm	July-October Days	July-October Q Mm3	July-October Water Depth cm
Upper Reach							
1. Badriah A	460	20	1.334	29	19	1.151	26
2. Badriah B	430	35	1.708	40	30	1.927	45
3. Badriah C	1290	31	3.113	24	48	5.717	45
4. Baseriah	270	13	0.499	19	29	1.370	51
Sum	2450		6.654	28		10.165	41
Middle Reach							
5. Hanodiah	310	17	0.987	31	30	1.610	52
6. Asmara	800	14	1.361	17	72	4.683	58
7. Sabakhia	890	14	1.620	18	44	3.096	35
8. Bakryya	200	16	0.500	25	26	1.000	50
9. Mastorah	860	14	1.854	21	59	5.356	63
10. Gazilyah	880	-13	1.624	19	31	3.460	39
11. Garba	550	13	0.950	17	31	3.870	70
12. Hadian	350	8	0.415	12	31	1.350	38
13. Khalifa	150	8	0.207	14	31	0.980	65
Sum	4990		9.518	19		25.405	51
Lower Reach							
14. Maraji	290	8	0.346	12	28	1.100	38
15. Moriah	790	2	0.294	4	24	2.140	26
16. Qudsiah	180	7	0.181	13	26	0.764	43
17. Gadyah	380	7	0.423	10	25	1.280	34
18. Masood	270	2	0.086	3	23	0.880	33
19. Jecan	470	2	0.155	3	21	1.370	29
20. Khaled	920	2	0.587	6	19	3.770	41
Sum	3300		2.072	6		11.300	34
Total:	10740		18.244	17		46.870	44

TABLE 3.4

DURATION AND QUANTITY OF WATER FLOWS IN THE NORTH SUPPLY CANAL AND THE HEADREACH IN 1988/1989

Primary Canal	Total Area ha	Nov.88-Feb.89 Days	Q Mm3	Water Depth cm	March-June 89 Days	Q Mm3	Water Depth cm	July-October 89 Days	Q Mm3	Water Depth cm
Upper Reach										
Sharaniah	950	120	9.398	99	96	11.847	124	N.A.	11.248	121
Madbaiah	200				7	0.242	13		0.360	18
Awasiah	490				25	0.984	20		1.710	35
Naseriah	240				16	0.429	18		0.750	31
Ramaniah	200				32	1.038	52		0.680	52
Fath-El-Bary	280				21	1.270	45		0.900	46
Sum	2360		9.398	40		15.810	67		15.648	66
Middle Reach										
Sharadiah	250				19	0.665	26		0.970	39
Bala-Figa	190				9	0.423	22		0.600	32
Taheriah	720				30	1.139	16		2.340	32
Bakeriah	150				26	1.348	(89)		0.750	50
Idda	660				21	2.124	33		0.820	13
Labadah	150				17	0.501	34		0.270	18
Mashediah	330				9	0.490	15		0.320	10
Barnashiah	300				5	0.362	12		0.240	9
Wardiah	500				6	0.432	8		0.270	5
Sum	3250					7.484	23		6.580	20
Lower Reach										
Bartuka	110				5	0.207	19		0.050	4
Bakia	100				5	0.172	17		0.040	4
Matia	300				5	0.207	7		0.050	2
Sum	510					0.586	12		0.140	3
Total:	6120					23.880	39		26.368	44

N.A. = Not available

TABLE 3.5

DURATION AND WATER FLOWS IN THE SOUTH SUPPLY CANAL

1988-1989

Primary Canal	Total Area ha	Nov.88-Feb.89 Days	Nov.88-Feb.89 Q Mm3	Nov.88-Feb.89 Water Depth cm	March-June 89 Days	March-June 89 Q Mm3	March-June 89 Water Depth cm	July-October 89 Days	July-October 89 Q* Mm3	July-October 89 Water Depth cm
[illegible] Reach										
[illegible]										
[illegible]eriah A	460				11	1.130	24	N.A.	0.90	19
[illegible]eriah B	430				19	1.711	40		0.80	19
[illegible]eriah C	1290				38	8.316	64		0.94	7
[illegible]asteriah	270				16	0.777	28		0.70	26
Sub	2450					11.934	48		3.34	14
[illegible] Reach										
[illegible]										
[illegible]eddiah	310				15	0.727	23		0.65	21
[illegible]eara	800				13	1.659	21		1.26	16
[illegible]abakia	890				19	3.118	35		1.44	16
[illegible]atryya	200				15	0.519	26		0.24	12
[illegible]astoriah	860				24	3.775	44		1.12	13
[illegible]astiyah	880				23	3.110	36		1.44	16
[illegible]arba	550				22	1.330	24		0.09	2
[illegible]adian	350				19	0.786	22		0.30	8
[illegible]alifa	150				18	0.337	22		0.12	8
Sub	4990					15.371	30		6.66	14
[illegible] Reach										
[illegible]										
[illegible]ajji	290				13	0.518	18		0.15	5
[illegible]ariah	790				8	1.469	19		0.75	10
[illegible]addah	180				8	0.346	19		0.06	3
[illegible]adyan	380				8	0.553	15		0.14	3
[illegible]asoot	270				6	0.259	9		0.10	3
[illegible]arah	470				3	0.259	5		0.18	4
[illegible]dait	920				1	0.164	2		0.32	3
Sub	3300					3.568	11		1.70	5
Total:	10740					30.873	28		11.70	11

* Estimated by TDA.

TABLE 3-6
WATER DISTRIBUTION ON NORTH SUPPLY CANAL REACHES
1988

	April-June	July-October	April-October
Upper Reach			
Total Discharge Mm3	12.864	18.098	30.962
Total Command Area Ha	2360	2360	2360
Unit share m3/ha	5449	7669	13119
Av. water depth cm	54.50	76.70	131.00
Av. rate l/s/ha	0.69	0.72	0.71
Middle Reach			
Total Discharge Mm3	5.84	21.307	27.150
Total Command Area Ha	3250.00	3250	3250
Unit share m3/ha	1798.00	6556	8354
Av. water depth cm	18.00	65.60	83.50
Av. rate l/s/ha	0.23	0.62	0.45
Lower Reach			
Total Discharge Mm3	0.371	3.980	4.351
Total Command Area Ha	510	510	510
Unit share m3/ha	727.00	7803	8531
Av. water depth cm	7.30	78.00	85.30
Av. rate l/s/ha	0.10	0.73	0.46
Total Canal Command			
Total Discharge Mm3	19.078	43.385	62.463
Total Command Area Ha	6120	6120	6120
Unit share m3/ha	3117	7089	10206
Av. water depth cm	31.2	70.90	102.10
Av. rate l/s/ha	0.4	0.67	0.55

TABLE 3-7
WATER DISTRIBUTION ON NORTH SUPPLY CANAL REACHES
1988-1989

	Nov.88-Feb.89	March-June	July-October	March-October
Upper Reach				
Total Discharge Mm3	9.398	15.810	15.648	31.458
Total Command Area Ha	2360	2360	2360	2360
Unit share m3/ha	3982	6699	6631	13330
Av. water depth cm	39.82	67.00	66.30	133.30
Av. rate l/s/ha	0.38	0.64	0.62	0.63
Middle Reach				
Total Discharge Mm3	0.00	7.484	6.580	14.064
Total Command Area Ha		3250	3250	3250
Unit share m3/ha		2302	2024	4327
Av. water depth cm		23.00	20.20	43.27
Av. rate l/s/ha		0.22	0.19	0.20
Lower Reach				
Total Discharge Mm3	0.00	0.586	0.140	0.726
Total Command Area Ha		510	510	510
Unit share m3/ha		1149	275	1424
Av. water depth cm		11.50	2.75	14.20
Av. rate l/s/ha		0.11	0.03	0.07
Total Canal Command				
Total Discharge Mm3	0.00	23.880	26.368	50.248
Total Command Area Ha		6120	6120	6120
Unit share m3/ha		3901	4308	8210
Av. water depth cm		39.00	43.10	82.10
Av. rate l/s/ha		0.37	0.41	0.39

TABLE 3-8
WATER DISTRIBUTION ON SOUTH SUPPLY CANAL REACHES
1988-1989

	Nov.88-Feb.89	March-June	July-October	March-October
Upper Reach				
Total Discharge Mm3	0.000	11.934	3.340	15.274
Total Command Area Ha	2450	2450	2450	2450
Unit share m3/ha		4875	1363	6234
Av. water depth cm		48.75	13.60	62.30
Av. rate l/s/ha		0.46	0.13	0.29
Middle Reach				
Total Discharge Mm3		15.371	6.660	22.031
Total Command Area Ha		4990	4990	4990
Unit share m3/ha		3080	1335	4415
Av. water depth cm		30.80	13.40	44.20
Av. rate l/s/ha		0.29	0.13	0.21
Lower Reach				
Total Discharge Mm3		3.568	1.700	5.268
Total Command Area Ha		3300	3300	3300
Unit share m3/ha		1081	515	1596
Av. water depth cm		10.80	5.20	16.00
Av. rate l/s/ha		0.10	0.05	0.07
Total Canal Command				
Total Discharge Mm3		30.873	11.700	42.573
Total Command Area Ha		10740	10740	10740
Unit share m3/ha		2875	1089	3964
Av. water depth cm		28.80	10.89	39.60
Av. rate l/s/ha		0.27	0.10	0.19

Relation Between Actual and Target Flow
Apr. 88 - Feb 89

Table 3-9

	Apr - June 88			Jul - Oct 88			Sum/Apr - Oct 88			winter Crop Nov88-Feb89		
	Target	Actual	Ratio	Target	Actual	Ration	Target	Actual	Ratio	Target	Actual	Ratio
Upper Reach												
Daraaniah (C.H.R)	1.80	9.35	5.19	2.4	13.69	5.70	4.20	23.04	5.49	6.50	9.4	1.45
North Canal	2.72	3.51	1.29	3.6	4.41	1.22	6.32	7.92	1.25	9.60	0.0	0.00
South Canal	4.70	6.65	1.41	6.3	10.17	1.61	11.00	16.82	1.53	16.60	0.0	0.00
Sum up Reach-CHR	6.42	10.16	1.58	9.9	14.58	1.47	16.32	24.74	1.52	26.20	0.0	0.00
Sum up reach incl CHR.	9.22	19.51	2.11	12.3	28.27	2.30	21.55	47.78	2.22	32.70	9.4	0.29
Middle Reach												
North Canal	16.29	5.84	0.36	21.7	21.31	0.98	37.99	27.15	0.71			
South Canal	24.74	9.52	0.38	33.0	25.41	0.77	57.74	34.93	0.60			
Sum of Reach	41.03	15.36	0.37	54.7	46.72	0.85	95.73	62.08	0.65			
Lower Reach												
North Canal	4.2	0.37	0.09	5.6	4.0	0.71	9.80	4.37	0.45			
South Canal	5.78	2.07	0.36	7.7	11.3	1.47	13.48	13.37	0.99			
Sum of Reach	9.98	2.34	0.23	13.3	15.3	1.15	23.28	17.64	0.76			
Total North Canal Command	23.21	9.73	0.41	30.9	29.72	0.96	54.11	39.44	0.73			
Total South Command	35.22	16.24	0.52	47.0	46.88	1.00	82.22	65.12	0.79			
Total System Command	60.23	37.32	0.62	80.3	90.29	1.12	140.53	127.60	0.91			

Relation Between Actual and Target Flow
Nov. 88 - Oct 89

Table 3.9a

	Nov 88 - Feb 89			Mar - Jun 89			Jul - Oct 89			Total Year 88/89		
	Target	Actual	Ratio	Target	Actual	Ratio	Target	Actual	Ratio	Target	Actual	Ratio
Upper Reach												
Daraaniah (C.H.R)	6.50	9.40	1.45	2.40	11.85	4.94	2.40	11.25	4.69	11.30	32.50	2.88
Norths Canal	9.60		0.0	3.60	3.85	1.10	3.60	4.30	1.19	16.80	8.25	0.49
South S. Canal	16.60		0.0	6.30	11.93	1.89	6.30	3.34	0.53	29.20	15.27	0.52
Sum.Up reach-C.H.R.	26.60		0.0	9.90	15.89	1.61	9.90	7.64	0.77	46.40	23.53	0.51
Total up Reach	32.70	9.40	0.29	12.30	27.74	2.23	12.30	8.89	1.54	57.30	57.03	0.98
Middle Reach												
North S. Canal				21.70	7.46	0.34	21.70	6.58	0.30	43.40	14.06	0.32
South S. Canal				33.00	15.37	0.47	33.00	6.66	0.20	66.00	22.03	0.33
Sum of Reach				54.70	22.85	0.42	54.70	3.24	0.24	109.40	36.09	0.33
Lower Reach												
N. S. Canal				5.60	0.59	0.11	5.60	0.14	0.03	11.20	0.73	0.07
South S. Canal				7.70	3.57	0.46	7.70	1.70	0.22	15.40	5.27	0.34
Sum of Reach				13.30	4.16	0.31	13.30	1.84	0.14	26.60	6.00	0.23
Total North Canal	9.60	0.0	0.0	30.90	12.03	0.39	30.90	15.12	0.49	71.40	27.15	0.38
Total South Canal	16.60	0.0	0.0	47.00	30.87	0.66	47.00	11.70	0.25	110.60	42.57	0.38
Total System	32.70	9.40	0.29	80.30	54.75	0.68	80.30	38.07	0.47	193,30	102.22	0.53

TABLE 3-10
APPLIED AND TRGET IRRIGATION DEPTHS

		April-June 88				July-October 88				November 88-February 89			
	Command Area	Applied Depth	Required Depth cm	Applied E%	Coverage Area with required 60% E	Applied Depth	Required Depth cm	Applied E%	Coverage Area with required 60% E	Applied Depth	Required Depth cm	Applied E%	Coverage Area with required 60% E
[illegible]	950	98	40	41 *	1434	144	42	29	1954	99	37	37	1525
[illegible]					1560**				1606**				
[illegible] Reaches	3860	26	(26x.75) = 19	73	2007	38	26	68	2938				
[illegible] Reaches	8240	19	(66x.75) = 50	263	3131	57	66	116	9994				
[illegible] Reaches	3810	6	35	583	457	40	35	88	3048				

[illegible] efficiency is considered
[illegible] canal pernial areas
[illegible] in upper and middle reaches for spate irr.
[illegible] in the lower
[illegible] area with coverage depth of 50 cm

Recommendations.

This short study recommendation foucs on the technical and organizational aspect to attain equity distribution.

a) For the new wadis' development programs
b) Requirements for attaining better distribution for Wadi Mawr Project.

Considering that attaining equity in water distribution may need major changes in the system and distrub the attained water rights.

Alternatives will be also recommended.

Considerations For The New Areas

The main objective of managing base and spate flow of the wadis from the irrigation point of view as :

- To maximize the water use efficiency
- To upgrade the water distribution and application system.
- To develop the farmer practices

In the project preparation stage, the adubted policies of distribution and the water rights need to be well defined and followed in the project design and operation.

1) In case of respecting the attained traditional water rights:

a) In the prefeasibily and feasibility stage's

- To measure and evaluate the used water rights and actual water sharing in each of the project components which may need some longer period of time but,will help in attaining a successful operative project.
- To have well identification of the gained water rights.

- To get reliable basic data for the cropping areas and croping patterns with detailed base maps.

- The base data and the reliable detailed maps has to be well documented and kept, that will help the future monotoring effort.

- To identify and measure the actual farmes water use, that has to be the basic data to consider in estimating the water budject, water shares and the project water requirements.

It is not recommended to use the developed consumptive use calculations and irrigation effciencies that donot reflect the actual use.

Upgrading the efficiencies need to change the irrigation traditions and practices which need a lot of interdisciplinary effort with the land and the farmer. This could be considered in the long term objectives of the project.

For the water allocations;

- To assure that each will get his traditionally measured shares.
- To consider that the water benifits gained from the project; is due to the artificial interference with the system and could be distributed between the beneficiers. This distribution could be done according

to the project feasibility and policies. It could be either shared equally on the offtakes level or to be directed to the lower beneficiers or allocated for new lands.

- The base water could be directed to the areas which are actually using it. It gives a good chance for pernial irrigation and introducing permenent fruit trees or short rooted vegetable cash crops. The areas allocated for pernial irrigation on the base flow need to be shown in the project map, to get special permission to insure their flow.

- In pernial irrigated areas, on-farm improvements prefered to be considered, because, adding more water with the traditional methods will destroy the crops beside loosing the precious water resources.

- To consider the ground water resources as a component of the water budjet and direct it conyuctivly with the surface water resources. Giving first periority to the excluded areas or that seen to be hurt by the project activity. Giving secound periority to use it as complementary source in areas seen to be pernially irrigated for cash crops. The expected changes in the ground water resources due to the project activity need also to be predicted and considered.

4.1.2 In Case Of Seeking Equitable Distribution.

In spate areas attaining equitability in the actual operation is difficult to be attained due to the high variability of the flow. It also need setting and forcing new legislations with new rules, other than the respected traditions, alternating, cancelling and deleting the existing water rights. If policies change towards equitable water sharing, then we have to define the required sharing, it could be

absolute faire equitable distribution with the land holdings or equitality according to the main offtakes holdings. Getting it according to the offtakes' holdings is recommended for practicality, but the upstream periority rule is still applicable at farms and holdings level.

In this case in the project preparation phase it is needed to :-

- Get basic detail maps for the cropping pattern and the cultivated areas before the project.

- Distribute the natural flow between the offtakes according to the actual holdings and actual water use values, measured, from the existing practices.

- For the pernially irrigated lands, to follow same recommendations as in 5.1.1.

- Still considering the ground water resources as supplementary to the over all water budject as in 5.1.1.

4.1.3 The Design Requirement

It is proved that substituting the numerous offtakes from the wadis by one canal intake will absolutly change the conditions, rights and periorities. Water distribution and management of very large water systems with numerious number of users is difficult to manage for attaining the fair allocations.

Using moderate canal commands within 3000 to 4000ha. holdings will be more reliable, disputes and disturbancies will be limited, equity of sharing on such reaches could be easily attained from the main diversions on the natural wadi course.

In this case equity on the level of the canal commands is recommended.

It is proved that using oversized offtakes can capture much more water than the allocated and mainly in the upper and middle reaches and lead to an uncontrolled full demand system.

It is recommended to chose offtakes of limited capacity types, according to the location, command and flow reliability.

In the upper reaches where flow is more reliable limited intake capacities is necessary. The limitation of the capacity could be attained either by using. Flumes; parchal, cutthroat, or trapeziodal.

Buffled weirs that could act freely in case of low flows and controled by the buffels or orifices at high stage.

No need to lower the offtake cills to capture all the flow.

As we approch to the down stream, the flow reliability and frequency decreases, the limitation of the offtakes could be decreased relativly to have demand system at the tails.

To Minimize the manual interference in the system to consider the required improvements on the distribution and the farm level.

Instrumentation

- To minimize suffistication as possible
- Chose the devices and instrument that proved seccessful in similar projects and condition.
- The technicians and engineers must be well trained to handle and maintain the instruments to continiously check

its accuracy and assure its riability.

- The montory and operation of the system has to be simply done manually when the instruments fail.

1.5 The Technicians and Engineers Must be activly trained on dealing with Hydrologic and Hydraulic data, check its acuracy and reliability, data interpretation techniques, make simple water flow, and water balance calculations.

The operation and water distribution activity must have its nominated staff without engaging them in other activity.

1.6 Basic detailed maps is the tool to design, operate and monitor the project successfully. Base maps and detailed maps has to get more attension and periority.

2. Consideration For Wadi Mawr Project

2.1 The problem of Wadi Mawr is mainly an operational, Sociological and legal problem, concentrated at the upper pernial reach, where one canal gets all the winter water flow and more than 30% of the anual flow of the project. This is due to :

- The continious availability of water with over sizing at the offtake capacity and having uncontroled demand system.

- The farmers keeping their basin spate flooding practices.

- The complete freedum in using the upstream periority and not allowing the offtakes closure rotations.

- Non formation of a legal organization to commonicate with the farmers.

- The drop in the natural base flow of the wadi in the last two years than expectations.

Some of these aspects were seen in the design while others not expected.

Considering that the areas allocated for pernial irrigation has to be mapped and fixed to insure its winter requirement from the base flow which is the limiting factor. Unfortunately, the winter base in the last to years was very low and lower than expected.

The recorded winter base flow in the last two winter seasons was about 30% of the expected. The water allocation to this area is based on optemistic estimations for the irrigation efficiencies while the farmers are still using their traditions. There for the recommended solusion will consider the possible alternatives and mainly focus on.

a) Monotoring of the wadi natural flow
b) Activation of the water plans
c) Farm water management
d) Legal and Management aspects

Monotores Of Wadi Mawr Natural Flow

The wadi natural flow in the last to winter seasons was very low it was about 30% of the expected normal flow considered in the study. Some farmers are pumping directly at the upstream reaches of the project intake there for it is recommended to :

- Give more intension to shat Al Erge discharge site by repairing or replacing the water stage recorder at Shat Al Erge to keep it working, it is the single source to

water budjet calculations. Check occasionally the accuracy and reliability of its readings with the staff guages.

- Survay the existing wells in the upper reach of Wadi Mawr, their commands, their abstractions and evaluate its respond on the flow to the project, especially in the winter period.

- Lay and certify the methodology for the water measurement rules, checing and verifying.

The currentmeters and its counters need to be calibrated occationaly to have confidence in its readings. Recalibration could be done in an authorized laboratory after a certain period of time or actual working hours. It also could be done by checking with a calibrated one. Therefor, more than one currentmeter is required to be available.

.3 Activation Of The Operation Plan

It is recommended to consider that the water rights are limited to the actually used rights before the Wadi Mawr Project. Unfortunately, these rights were not evaluated or measured during the project prepration.

The only available data is that survayed by T&K which estimate the reliable and intermittant areas, but didnot get to the actual winter cropped areas.

To solve the problem we have first to solve Daraaniah canal conditions. People gained more rights than before, and expanded the area. In some countries using the water course in a year gives them rights on that course. This lead to two alternatives :

i) To consider the pernially cultivated areas in Daraania as a fact and restrict any more expansion. This solution will disturb the fair equity in distribution but keeping the overall project objective, as the water is still used but directed to areas other than allocated. Applying this option will not annoy the people of the Wadi, Because all of them respect the rule of giving the upstream users, the periority of getting their water sufficiency

In this case the flow to the canal has to be limited to the target crop requirements seen in the project design according to the actual served area. It is not recommended to continue letting this cnal to take this high share of the project water.

The farmers have to be advised by the project to divide their lands into narrow stip boarders with minimal land leveling, this will help saving water and is in favour of encreased yeild.

Forcing the regulations doesnot always insure sucess, it may seriously retard, if not destory. Working with the farmers and their leaders, attaining better commonication and confidence may lead to success and better results. Eepecially untill the issuance of the water legislation which will fix the rights and relations.

ii) To divide the available flow between the 10 upper reach offtakes fairly according to their allocated command, and allow to change the winter crop areas anualy, according to the flow availability, to activate this, it is required to;

- Have a proper forecast to the winter base flow yield, and set an anual plan for the areas that could be cultivated on this yield and declaire it to the farmers

to be aware before cultivation.

- To issue the required regulations and legislations that give the power to the engineer to activate their operations.

- To activate the operation squedule to open and close offtakes to acheive the required level of equity in the water distribution. Periodical water sharing measurement and calculation is required occationally. In the absence of the flowmeter measurement of the actual offtake flows due to the reported defects, we have to rely on the manual reading and getting more frequent daily water level asurements and trace the spate stages it each offtakes. This will overburden the technical staff that need to be supported.

- To install staff guage at each offtake to simplity the measure of the operating head and the discharge.

- The 4 water stage recorders at the intakes and tail ends of the to suply canals are the only available tool to trace the flow changes. All the possible effort is needed to keep it working properly with reliable results.

A staff guage is required to be installed at each site to work as a bench mark for the periodical check and correct of the recorder readings. Th recorder, its well and connecting pipe to the canal need to be kept maintained.

- To continue activating the operation squedule for closure of the offtakes, as it proved to give positive results in getting an acceptable water sharing level.

After arriving to a solution to Daraania canal and put it under control, the level of equity in the distribution will be upgraded.

It is also recommended to oppoint a full time Engineer with irrigation and hydraulic background, assisted by 4 trained technicians at least, to collect and check the data, to make the required hydraulic calculations for the water discharges, allocation and budjet.

- The basic data are the only possible tool to measure, and monitor the changes and accomplishments. To attain success, the reliability of the data has to be insured.

- With the assistance of the TDA Consultants, it is required to prepare unified rules for the data collection, calculation, verifying and assesment. Using different data management methods or personal justifications and different source may lead to different results.

- Detailed and base maping is the main tool to monitor, manage and follow up. It required to set a 2 year plan to accomplish the detailed project maps, that can fit with the YAR maping system. It is required mainly to have base detailed topographical maps of scale 1:2500 showing the holdings, spot land levels and different topographical details.

- There are some changes in the cultivated boundery in the different seasons which need to be identified, sattelite alfared immigaries may help with adequate ground control for successful interpratation shots at Feb. - May and Aug.

4.3 The Farm Water Management

Wadi Mawr Project is for sure increasing the water

availability, both in time and space and specially for the upper and middle commands.

This availability led to the misuse of the water resources. Increasing the water availability means decreasing risks and the water has to be applied to the land in an efficient way. Misuse of the water resources retard the yield. Leaving the farmer to continue using his spate traditions in irrigating his land with big water depths will retard the project in acheiving its goals.

It is recommended to introduce to the farmers the proper irrigation practices on the farm level through an active implementation effort.

This program could be a 3 year program, the outline of this program could be as follows :

- Objective : It is to develop the on farm practices to maximize the water use efficiency and the land productivity and increasing the farmer income.

- To collect basic real data on the farm water crop and financial budjet.

- To work with the farmer, communicate with him, increase his confidence, develop efficient water user organization.

- Methodology; To chose 3 farms which represent the different reaches with respect to the water cource of Daraaniah, and also to be representative to the soil and cropping pattern on the canal.

- Action program.

1st year, to chose the fields, get the farmer agreement, collect the basic data on the water and land use. The required data about the crops and related production factors, the basic base data for the farm budjet and ingeneral a complete identification of the farm related problems.

2nd and 3rd years get to the solutions assess implent and evaluate. Test the formulation of the proper water user associations and give the proper recommendations.

- The results gained from this action effort will encourage the farmers to immitate and give proper chance for farmer training and technology transfer.

4.4 Legal and Managment Aspects.

4.4.1 The Legal Aspects.

The legal as well as the administrative structure under which irrigation is practiced will insure, success or retard the undertaking.

In Wadi Mawr, the rule of water use rights is based on an inhereted traditions act as by laws, of upstream periority. Due to artificial interference with the natural water cources by introducing improved water use projects. The gained water rights are mostly disturbed, that cause retardation in attaining the project goals. The water availability and assurance is in favour of the upstream benificieary, when trying to practice their upstream right and their gain by increasing more land, misuse of the avialable water, while the down stream beneficiars on the water course loose their rights.

It is recommended that the ligislation consider the following :

- That the water rights are limited to the actual use of the lands attaining water according to the previous conditions in last five years before the renovations.

- The attained water rights have to be measured documented and declaired before the renovations.

- The land owners who get's water from the low base flow in the winter seasons and cultivate pernially have to identify them selves and the actual really cultivated lands only have to be liecenced for pernial irrigation.

- In the renovation the declared rights have to be evaluated and considered in the new projects.

- The authorities have the freedom to distribute and direct the water which gained or saved due to the new projects' activity according to their feasibility study and policies.

- Not to allow getting pumps or new abstractions directly from the wadi course unless liecenced.

- To limit the freedom of using the water sufficiency by limiting the water depths on the irrigated lands, and the land owners have to divide their sloping lands in narrow strips such that the water depths doesnot increase the specified limits at the lowest point.

N.B." There is a general principle governing the irrigation rights in Islam. The upper land is irrigated before the lower, but the quantity of water retained should not reach above the ankle. These resrictions are applied when the sources is scarce, otherwise anyone can irrigate as he like.

Management Aspects.

The type of organization formed to deliver irrigation is vitally important. The legal powers and relations between the organization and the water users are governed by the type of organizations. The most successful is that operated by the co-operation of the farmers.

In the past, the system was successfully operated and mainaind with the farmers, having strong co-operative organization. Chosing the wakil as a leader to guide organize and lead them.

- It is recommended to strenghten the old organization of :

a) The wakile role, to be supported as the farmers' representative, strengthen the relation and commoni-cation with the farmers and help the engineers in activating the operation program.

b) The Wadi Mawr water users board to be formed from 12 members.

8 Elected from the primary canals wakils'

1 Wadi Mawr Project Director

1 Chairman of TDA.

1 Of the Local Leaders

1 From the Local Authorities

This commitee settling disputed and help in the over all project management.

6. REFERENCES

Tipton and Kalmbach inc, Denver, Clorodo, USA, May 1977, Wadi Mawr feasibility study working paper.

Brigitta Mitchel, Herman Escher, Martena Mundy, The World Bank Regional Development Unit, May 1978, A base line Socio-Economic Survay of the Wadi Mawr Region.

The World Bank, Project Dep. For Europe, Middle East and North Africa Regional Office, Feb. 1979, Staff Wadi Mawr.

Tipton and Kalmbach Inc. Engineers Denver. Glorads, USA, Jan. 1979, Development of Wadi Mawr;

Par. I	Report
Par. II	Vol. 2 - Appendix E
Par. II	Vol. 3 - Appendices F,G,I,J

Sir M. MaDonal & Parteners Limited, Consulting Engineers (MMP) Cambridge, United Kingdom, Apr. 1982 Wadi Mawr Project Inception study supporting papers.

MMP Oct., 1982, Wadi Mawr Water Distribution and Management.

MMP, Dec. 1982, Wadi Mar Project, report in Hydrological Field Investigations.

MMP, Apr. 1985, Distribution of Residual Wadi Mawr Flood waters to the Down Stream users.

MMP, Jun. 1987, Water Allocation Plan for Wadi Mawr Project.

MMP, Jun. 1987, Operation, and Maintainance Manual for Wadi Mawr Project.

DHV Consulting Engineers, Apr. 1988, Tihama Basin Water Resources Study, Technical Report 6, Water Resources Management

TDA, Quartery and annual reports, on Wadi Mawr Project Mar. 1988 thru. Dec. 1990.

NESPAK, Lahore, Pakistan, Apr. 1989, Project completion report, Tihama Development Project III, Wadi Mawr.

ANNEX A

TERMS OF REFERENCE

OF

SHORT STUDY ON WATER DISTRIBUTION

OF WADI MAWR

- TERMS OF REFERENCE
- ITENARY OF THE STUDY

ARAB REPUBLIC
OF AGRICULTURE
ERIES RESOURCES
ELOPMENT AUTHORITY
HODEIDAH

بسم الله الرحمن الرحيم

الجمهورية العربية اليمنية
وزارة الزراعة والثروة السمكية
الهيئة العامة لتطوير تهامة
الحديدة

22.04/189

الرقم :
التاريخ : November 21, 1989

Mr. Faruk Shahin
Ministry of Public Works & Water Resources
Al-Aini Street,
CAIRO-EGYPT

Subject: SHORT STUDY ON WATER DISTRIBUTION OF WADI MAWR
APPOINTMENT OF INDIVIDUAL CONSULTANT

Dear Sir,

Kindly find attached herewith Terms Of Reference (TOR) for the short study cited as subject. Tihama Development Authority, with the concurrence of the co-financing agencies i.e.. IDA and Kuwait Fund for Arab Economic Development (KFAED), and Govt. of Netherlands, intends to appoint an individual consultant to carry out the subject study which will also require a good knowledge of traditional and Islamic Laws on water allocation. Time is of essence for the study and therefore the Consultant's Draft Report of the study will be required by TDA on Ist February 1990 and the Final Report on February 25, 1990.

We request you please to send us your terms and conditions for working as an individual consultant for the subject short study.

Looking you and hoping for immediate response,

Yours faithfully,

YEMEN ARAB REPUBLIC
الجمهورية العربية اليمنية
الهيئة العامة لتطوير تهامة
Chairman, TDA
DEVELOPMENT AUTHORITY

Chairman, TDA

cc: 1. H.E. The Minister of Agriculture and Fisheries Resources Sana'a
2. Director General, TDA
3. Director Engg., TDA

A-2 TOR

A-2 SHORT STUDY ON WATER REGULATION OF WADI MAWR
TERMS OF REFERENCE

2.1. Background Objective of Study

Tihama Development Authority (TDA) implemented a surface water (spate) irrigation scheme on Wadi Mawr in April 1988. Water regulation system was designed to ensure equitable distribution of Wadi waters (both base flow and floods) to the farmers. TDA desires the Consultant to carryout a short study on the experience of water regulation in Wadi Mawr over the last one and a half year, who should evaluate the equity or otherwise of the Wadi water (both base flow and floods) distribution to farmers over that period. The recommendations of the Consultant shall be reviewed by the Government of Yemen Arab Republic (YAR) in Consultation with the co-financing Agencies i.e Kuwait Fund for Arab Economic Development (KFAED), the International Development Association (IDA) and the Dutch Government, and effective measures so determined and agreed, shall be applied to ensure equitable distribution of Wadi Waters.

2.2. Time Frame

Time is of essence for this study and therefore completion of the study in minimum possible time is required so that the study enables the Government of YAR to establish a policy frame work for implementation of Wadi Siham or other schemes of similar nature. Currently, implementation of Wadi Siham Surface Water Irrigation Scheme is under active consideration of the Government of YAR.

2.3. Focus of Study

Study should focus primarily on following points:

A) Areas surveyed with maps (Scale 1:5,000) prior and after project implementation, thus delineating areas excluded and added because of the Project.

B) Amount of water diverted by various beneficiaries with & prejudiced parties and without project.

C) Precise identification of representative sample areas for detailed socio-economic survey to include areas;

(i). New areas not serviced before implementation of the project.

(ii) Areas excluded after implementation.

(iii) Areas with benefits significantly declined after implementation.

(iv) Areas with significant improvement.

D) Sample areas should cover about five percent of total areas under (A) above.

E) Socio-economic survey should focus on the following aspects:

i) Agriculture production-with and without project-farm size, cropped areas, cropping pattern, cropping intensities, water requirement, yields, total production and net income.

ii) Water distributing aspect-with and without project-amount of water diverted, daily hours of irrigation, use of various control structures, TDA influence in distribution of water at various levels.

12. Carryout necessary field surveys and compile relevant data for the study including data on actual regulation and distribution of Wadi waters.

UNO
UN
E

07.01.90 13:08

/06/90 DATE: JAN.07, 1990.

HODEIDAH, YAR.

FAROUK SHAHIN,
SECRETARY OF STATE,
STRY OF PUBLIC WORKS AND WATER RESOURCES - CAIRO.

THE DEPUTY PRIME MINISTER, MINISTER OF DEVELOPMENT AND
HAN, CPO. - SANA'A.

THE MINISTER OF AGRICULTURE N FISHERIES RESOURCES - SANA'A.

WASHINGTON DC, USA,
MR. P.GARG, CHIEF, AGR/OPR, COUNTRY DEPT, ENENA III

- KUWAIT, ATTN: MR. H.ALWAGAYAN, DIRECTOR OF OPERATION.

RT STUDY ON WATER DISTRIBUTION OF WADI MAWR.

TO YR TLX OF 9 DEC 1989, TDA INTENDS TO APPOINT YOU AS
AL CONSULTANT FOR THE SHORT STUDY BUT BEFORE IT DOES SO,
CLARIFICATION ON ITEM 2 OF YOUR TLX.

E DESIRED TO BE ACCOMOPANIED WITH AT LEAST ONE OF THE
ISTS KNOWLEDGEABLE WITH THE PROJECT AREA.

AVE FOLLOWING DOCUMENTS PREPARED BY SIR M. MACDONALD AND
S, THE PROJECT CONSULTANTS FOR WADI MAWR PROJECT.
MAWR WATER ALLOCATION PLAN - JUNE 1987.
MAWR O AND M MANUAL - JUNE 1987.

HAVE A STUDY CARRIED OUT BY PROF. SARGENT OF MMP ON WATER
ENT AND REGULATION OF WADI MAWR WATER.

PRESENCE OF THESE DOCUMENTS, WE PRESUME THAT THE SPECIALIST
ED IN ITEM 2 OF YOUR TLX IS REQUIRED IN CONNECTION WITH
ECONOMIC SURVEY OF THE PROJECT AREA WHO HAS KNOWLEDGE OF THE
EA.

IS PURPOSE TDA WILL BE PLEASED TO ASSIGN SUCH PERSON OUT
AGRICULTURE DEPARTMENT.

CONFIRM IF SUCH ARRANGEMENT WILL BE ACCEPTABLE TO YOU THRU
TLX.

EGARDS.

NNIN HAZZA,
R GENERAL.

UNDP UN
ALHAIA YE

13 JAN 90 13:48

WRC UN*
WRC UN

673+
ALHAIA YE

WRC UN

IDAH DURIEHEMI ROAD
CTOR GENERAL, TIHAMA DEVELOPMENT AUTHORITY

ENG. ABDUL MOMIN HAZZA,
WITH REF TO YR TLX ON 7 JAN 1990, I CONFIRM THAT YOUR
NGEMENT IS ACCEPTABLE . I WILL NEED TO SPEND SOMETIMES
ND THE CONCERNED AREA TO HAVE SUFFICIENT KNOWLEDGE.

REGARDS
UK SHAHIN

ALHAIA YE

.2 MINS

ZHAP UNO
ZHAP UN
HAIA YE

PUTER MESSAGE - DO NOT INTERRUPT

NG/FNC/66/90
EB.10, 1990.

- HODEIDAH, YAR.

FAROUK SHAHIN, FIRST UNDER SECRETARY OF STATE'
STRY OF PUBLIC WORKS AND WATER RESOURCES, CAIRO.

THE DEPUTY PRIME MINISTER, MINISTER OF DEVELOPMENT AND
IRNAN, CPO - SANA'A.

THE MINISTER OF AGRICULTURE N FISHERIES RESOURCES - SANA'A.

- WASHINGTON DC, USA,
N: MR. P.GARG, CHIEF, AGR/OPR, COUNTRY DEPT, EMENA III

ED - KUWAIT, ATTN: MR. H.ALWOQAYAN, DIRECTOR OF OPERATION.

RT STUDY ON WATER DISTRIBUTION OF WADI MAWR.

PLEASED TO APPOINT YOU AS INDIVIDUAL CONSULTANT FOR THE
STUDY. PLEASE REACH TDA H.Q., HODEIDAH TO TAKE UP YOUR
ENT. ARRANGEMENT WILL BE MADE TO ADVANCE YOU LOCAL
ON YOUR ARRIVAL. FOREIGN EXPENDITURE WILL BE DRAWN
AED AND IDA AFTER THE AGREEMENT IS SIGNED BETWEEN TDA
RSELF. EXPECT YOUR ARRIVAL WITHIN THIS WEEK ON DIRECT FLIGHT
DIA FROM CAIRO TO HODEIDAH.

EGARDS.

LDOUNI,
H.

ZHAP UN
HAIA YE

Annex B - Mapping

The maps put available in TDA are':-

a) A General plan map for the old surface Irrigation system attached to their study of scal about 1:150,000

This map is showing, the areas of reliable spate irrigation and the area for intermittent spate irrigation from yar 197 survay.

b) Th map of the project of scale 1:50,000 showing the area included in Wadi Mawr development project, and showing also the boundary of the area commanded by each primary canal. This map is preapred by MMP and included in their operation plan.

c) A map of scale 1:25,000 based on a recent survay done by TDA for the South supply canal command, showing the boundaries of the area commanded by each primary canal. There are some change in the boundary of some primary canals.

This map doesnot have topgraphical or complete details, to be considered as base maps to trace the actual seasonal cultivated areas.

- The previous three maps are interpolated on map B1 and and show a comparison between the 3 maps

d) Because a similar survay is not available for the North canal command. An interplotation of the T&K and MMP maps is shown on the map B2.

- The areas that were previosly irrigated reliably and intermittent from T&K survay, 1975.

- The areas included according to the project design.

- The areas that are under Irrigation form the TDA latest survay.

- The included or exculded areas rated to any combination of the three sources.

3 Map B2 Shows Mainly :

The intermittent and reliable spate irrigated lands in, 1975 and the boundary of the area included in the project for all the project area.

The main notice on this map is that Daraaniah was irrigating only 300 ha. reliablly the design command is 950ha, while actual cultivated area has mostly been expanded.

4 Recommendations

1. It is recommended to wor in the preperation of a detailed topgraphic maps. It is preferable to be done by airial survays with contour maps. 5mt. intervals at least, with sufficient ground control points.

These maps has to done to simplify the monotoring effort for the survay of the seasonal cnanges in the cropping pattern of each command.

We recommend to set a 2 or 3 years plan to finalize the reliable detailed base maps and in the preperation phase

of this project, the YAR survay departement is prefered to participate in all the survay project stages to insure, the accuracy levels that the maps could fit in the general YAR, survay system and rules.

5 Getting landsat imigaries could be helpful in identifying the cultivated area in the 3 agriculture seasons if taken from shots in mid February, early June and late August.

Because of the project are has many grazing which may misslead in the estimation of the actual cropped areas, and to identify the crops, strict ground control is needed.

Annex - C

Field Visits to Wadi Mawr Project

General

The intension of the visits to the project site was to have more understanding to the project components, inspect some of the main and farm Irrigation systems of the project, to have more understanding of the farmers' organization in the socio-economic survey required by the terms of reference for the short study requested.

Meeting With The Field Project Staff

During this period I met :

- Eng Abdu Fareigh El-Romeih. The Wadi Mawr Project Director. He promised to give all the support and co-operation if requird either from himself or his project staff.

  He gave quidance to whom we has to meet and discuss from the local leader.

- Eng Ali Salem El-Awsagi Deputy Project Director and acting as the head of the Agriculture Division of the project who gave his support and co-operation and promised to help by him self and his staff in the choice of the farm represntative samples and in finalizing the socio-economic survey questionaire

- Eng. Khaled El-Ahattas Head of the Maintainance division who gave all co-operation and engaged his staff to prepare the available data and accopany .

my field visits and my meetings with the other personnell.

- Eng. Abdallah Aglan. From the maintaninance division He engaged 100% of his time in accompanying me all the time and helped in explanations, discussions and data preparation.

- Eng. Lotf Allah Saad from the Agri. Extension. He promised to give all the possible help in the finalization of the socio-economic survay.

- Eng. Mohamed Awad Head of the Water Division. He accompained us to one of the field visits to show us the Water Measurement Facilities in the Canal system.

3 The Main Supply System and Control Structure and the Principal Canals.

- The head works is functioning in good condition. The technicians were doing the normal maintainance for the electric operating system.

- The natural flow of the wadi at the visit timing was of about 650 lit/sec. 500 lit/sec. was going to the combined head reach canal freely flowing on the head work control structure while the rest was leaing to the Nation wadi course.

- The control structures are in good conditions and regular maintainance was going on.

- The principal canal section is well maintained and is in a good condition that an indication of the effectiveness of the maintainance effort.

- There are a lot of silt accumulated at the intake of the primary canals and at the sliding gate pipe offtakes. This mostly happens when the flood waves come during the closure of these gates. The maintainance crew of the project was doing big effort to clean the silt heaps hich were of about 1.0m. hight at some location

- The pipes leading from the canal to the water stage recorder wells are very small in diameter and not protected from the trash carried by the water flow and always clogged by the fine trash and it is difficult to clean, the maintainance crew is doing a continious cleaning effort.

- Lot of silt accumulate and stops the activity of the sensors which are not acting. The alarm control system need to be considered.

- At the vicinity of the water stage recorders these is not reference staff guage to use when setting the new recorder charts, this subject needs direct solution to insure the reability of the records taken from these instrements.

- The project staff try to activate the calender operation for the opening and the closure of the primary canal gates according to the MMP. operation plan manual, but the farmers in most of the times open the gates during their official closure. On Daraaniah canal, the first one on the combined head reach, the farmers never allow its closure. It mostly gets all the base flow during the winter months and getting the benefit of the flood waves in the same period.

- Some of the farmers on the upper and middle reaches of the South supply canal request the closure of the intakes during their official operation period if they find that they are satisfied.

The Farm Irrigation System

- The information stated below are based on our technical inspection, the farmers discussion, local leaders discussion and from Wadi Mawr officials'

- The Project could be divided in 4 reaches :-

  The Combined head reach
  The Upper reach of the supply canals
  The Middle reach of the supply canals
  The Lower reach of the supply canals

The Combind Head Reach

On this reach lies Maadbaiah primary canal.
From T&K survey 1979, the command area of this canal was 950 ha. of which 300 ha. were reliable and 650 were intermittent.

The design capacity of its' offtake done by MMP. is based on 2 l/sec. for all the asigned command area which is taken as 950 ha. for this canal. i.e. 1.8 m^3/s.

This canal is the source of distrubing the operation plan of the project. The farmers force keeping the gates open all the time while it has to be opened 40% of the time only in the winter period Nov-Feb. when the Wadi Mwar has the least base and spate flow. In the rest of the year it was planed to open it for 20% only of the time to insure the required level of equity in water shares.

Lot of our field visit time was spent in this canal to understand the case.

2. Dareaniah Canal

During our visit on Feb. 26.1990, the canal intake was fully open and the base flow was completely directed to its course.

Considering the farm irrigation practices.

- The fields are divided in to plots of about 60x60m.
- The fields are sloping considerably following the natural land slope from the East to the West.
- The farmers keep high dikes of about 1.0m hight or even more in some cases at the lower end of their land to keep the irrigation water in their field basin to insure the coverage of the high spates in the field with about 25 to 30 cm. depth.
- When irrigate, the farmer fills his basin field untill having a water depth of about 25 to 30 cm. at the highest and of the field, this means having 80 cms. or even more at the lower parts.
- In these fields as a general phenomena, the high spots have dance healthy plantation and growth while having dispursed and very weak, growth at the low spots. In a sesame field the hight and dence of the growth was gradually decreasing ith the land slope, such that the hight of the plant was 90 cms at the high spots and 30 cms. only at the low ones.

- In 0.5 Maad Bannana field, the farmers said that he irrigates it with about 25cm. water depth each other day.

The Banana yield was very poor, it seems that it subject to deseases. The farmers didnot report to the Project Adminstration because he was afraid of hurting the hunny bees which he breeds.

- In our visit there were several farmers Irrigating at the same time.

- Many of the farmers bleive that the silt carried by the spate flow give their lands the required fertility and that they donot need to use fertilizers.

- I spite of the base flow was during the visit less than the normal, the canal had a reasonable water flow close to end and all the lands which were having sufficient water content close to the soil surface.

- Almost all the canal command area was cultivated with sorghum, sesame, vegetables and fruit trees such as banana, citrus, mango and guafa.

- One of the farmers said that before the project he could not cultivate his land with one summer crop on spate flow and rainfall, that was because of the lower available water levels at that time, and the water levels after the project can cover more lands.

- New land out side the command area had been added, as an example a strip of about 100 to 200 mt. width along most of the canal right side is planted using the base flow

4.3 The Upper reach of the supply canal

This reeach cover nine primary canals command areas. 5 of them gets from the North supply canal. The area served by this reach is planed to be cultivated by summer and winter crops. In summer by using the base and spate flow by means of keeping the gates open for about 20% of the time for the period Mar. to Oct. to give the canal its chance to get its requirement.

While in Winter, the upper canals of the reach is kept open for about 80% of the time while the rest are kept open, because of the limited base flow and the low chance for getting spate.

On our visit to this reach it was observed that :-

- All the reach has very little chance to get base flow in the winter.
- The winter crop areas are decreasing as we go to the down stream.
- The land is not levelled and has considerable slope following the general land slops in the region.
- The farmer irrigates on the tradition By-Law the first in the reach has the periority to get what he needs first.
- Some of the farmers are using the ground water as supplementry irrigation by dug wells to cultivate cush crops. They get loan facility to get the pump.

- When pumping water the farmer is aware of saving water. They divide their lands in small basin with very primitve leveling.

One of those farmers cultivate Banana, Juafa, and Okra. He irrigates once a week and is satisfied with the yeild.

- The farmers of this reach said that they have great benefit from the project.

4.4 The middle and the Lower reaches of the supply canals

- In general these reaches donot have any chance to get the winter base flow.

- Some of the canals on the middle reach may get some water if the spate is reatively high

- There is no chance of the lower reach to have winter spate flow.

- Dug wells are increasing as we go lower in the canal

C-5 Farmer's Organization and Relations

From our discussion and meeting with the local leaders and the farmers we understood that

In the past, before the project implemintation, there was certain orgainizations governing the system such as :-

- The Okom board for Wadi Mawr it has 10 of the distinguished members of the society. They were mainly responsible to solve the problems of the dikes (Okom) set on the wadi to lead the water to the primary canals

- The Members are chosen by the farmers andappointed by the Authorities. Their decisions were obligary by law.

- The wakil of the primary canal. He was taking care of the maintainance of the dikes (09om) and the canal embankment. He also was helping in orgainizing the farmers getting their water rights. For the annual maintainace he was collecting each one's share according to his land holding. It was costing of about 20R/Mead a year

The other maintainance effort is done either by the farmers themselves or by their hired labours.

- The Wakil was mainly nomineted by the farmers and authorized by the local authorities.

- The Wakil was getting a fare of about 5% of the total land yeild for his survices.

- After the project implementation the farmers felt that they are not in need of the Wakil, they abundoned him and stopped paying the fare.

D - Socio Economic Survay

The TOR calls for a Socio-Economic Survay that covers a sample of 5% of the project area to be done within the requested short study.

The requirement of this study is to evaluate the effect of the redistribution of the system on the cultivated areas, productivity and water use efficiency.

The combination of the technical evaluations and this socio-economical survay are complementary to give a better picture about the project changes.

In such Arid spate areas, the range of veriability of the size of flood both in space and time, is very large.

Since the project implementation only two floods have passed, one of them was moderate, while the other was very low, the farmer are not aquainted with the changes, yet.

So, this evaluation could help only in highlighting the problem to try to overcome in the early stage.

D - 2 Presurvaying

Presurvay effort was done through ;

- Extracting the main questions needed to cover the TOR requirement from the project design components, the operational and maintainance problems, the project reports, our technical inspection, and investigations and the discussion with the project engineering agronomics and agri. extension officials.

- Interviews with the farmers, testing the equestions component, add, change and committ as needed

- The interviewed farmers represent a representative sample to the water course distribution problem.

It included higher intencity in the problem creating areas, representation of location on the secondary canal level, the supply canal level, size of farmers, cropping pattern, base spate flow, suplementary wells as well and those ho have direct benefit or loss.

- The final group of questions were 23 questions concerned on identifying.

- The farmer experiance, age and level of education.

- The distribution and size of his holding on the water cource.

- Extent of his use of the base flow before and after the project.

- Identification of the cultivated areas, crop pattern and the crop production in the three Agri. seasons after and before

- New crops that introduced after the project

- Test his irrigation practices concerning when and how much to irrigate.

- Irrigation traditions and his relation with his neighbouring farmers, before and after.

- The water course organizations, its' role, cupera-

tion, financial and management organization before after and getting the farmers future farmer's view.

- The farmers interection with project operation squedule concerning the open and closure of the offtake gates and equity of distribution.

- Changes in his cultivation related practices concerning farm mechanization.

- The communitation with the project and using their services.

- The change in the animal possesion before and after the project.

- The farmers were in general conservative in their answers. It was difficult to most of them to quantitave estimations as answering the questions.

- They still using their traditional irrigation methods while began to shift towards agriculture mechanization

- Their majority still are not yet concerned of using fertilizers.

All of them respect the upstream periority in getting their water sufficiency, even thôsé at the lower reaches who are monstly hurted.

Their majority donnot agree to apply the operational plan open and close the gates unless the benificiars on the water cources are satisfied on the upstream periority rule

In winter, the spate lands are not cultivated, except some lands have very poor sorghum crop grown on the traces of

the soil water content in the soil profile. There were almost no one on his field, and we have to trace them in the villages, except in Daraaniah canal which gets all the base flow and the farmers irrigate pernially.

-3 The detailed survey

It was agreed with the Wadi Mawr Project director and his deputy that the detailed survey has to be carried on by the trained agriculture extension engineers.

The sampling procedure was discussed and agreed upon to cover the requirement of the TOR and has to cover not less that 900ha. distributed as follows ;

Reach	Sample Area ha	The Interviewer
Daraaniah ca.	150	Eng. Mohammed Mousa
The North Supply canal	300	Eng. Lotfallah saad & Mokhtar Ali Othman
The South supply canal	450	Eng Nagieb Abdel Allem & Nabiel Morshed.

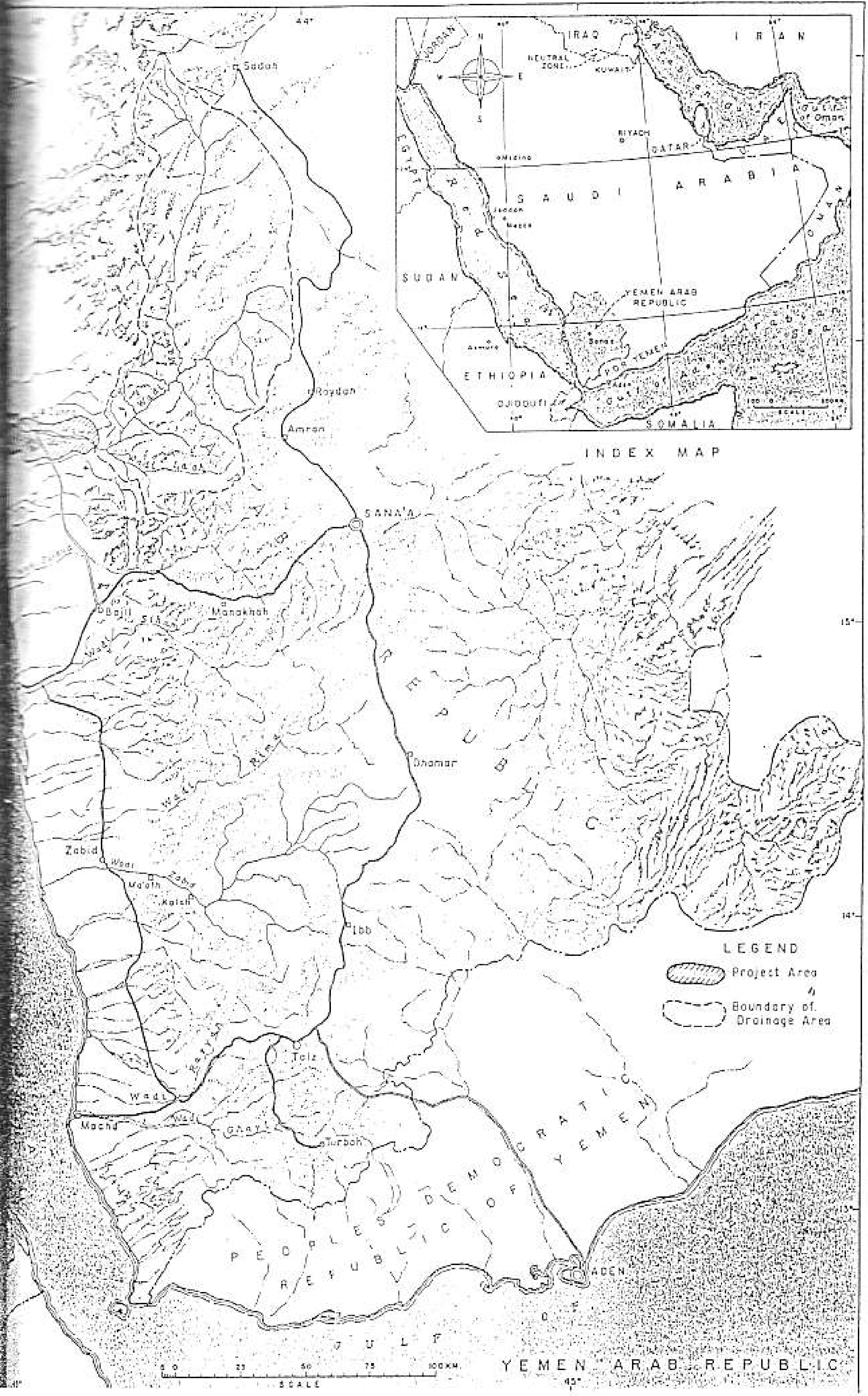
The number of the required farmers to interview was estimated to range from 90 to 100 farmer.

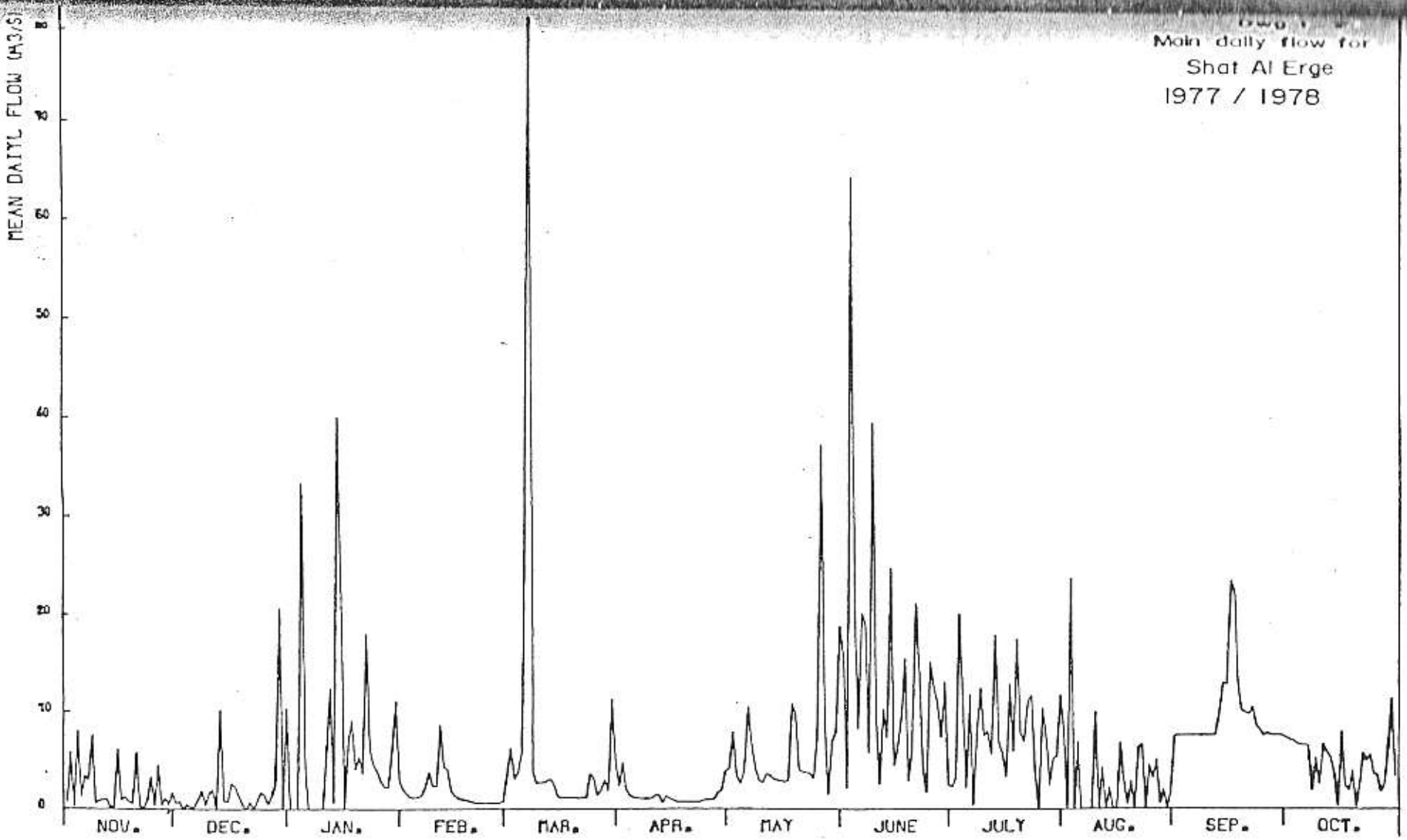
They began to get to the farmer interviews on Mar. 5, 1990.

Due to difficulty and the need of patience, sociological interaction with the farmer, impatiency of the farmer, tracing the farmers in the village because of most the lands are follow. All this take long period of time in

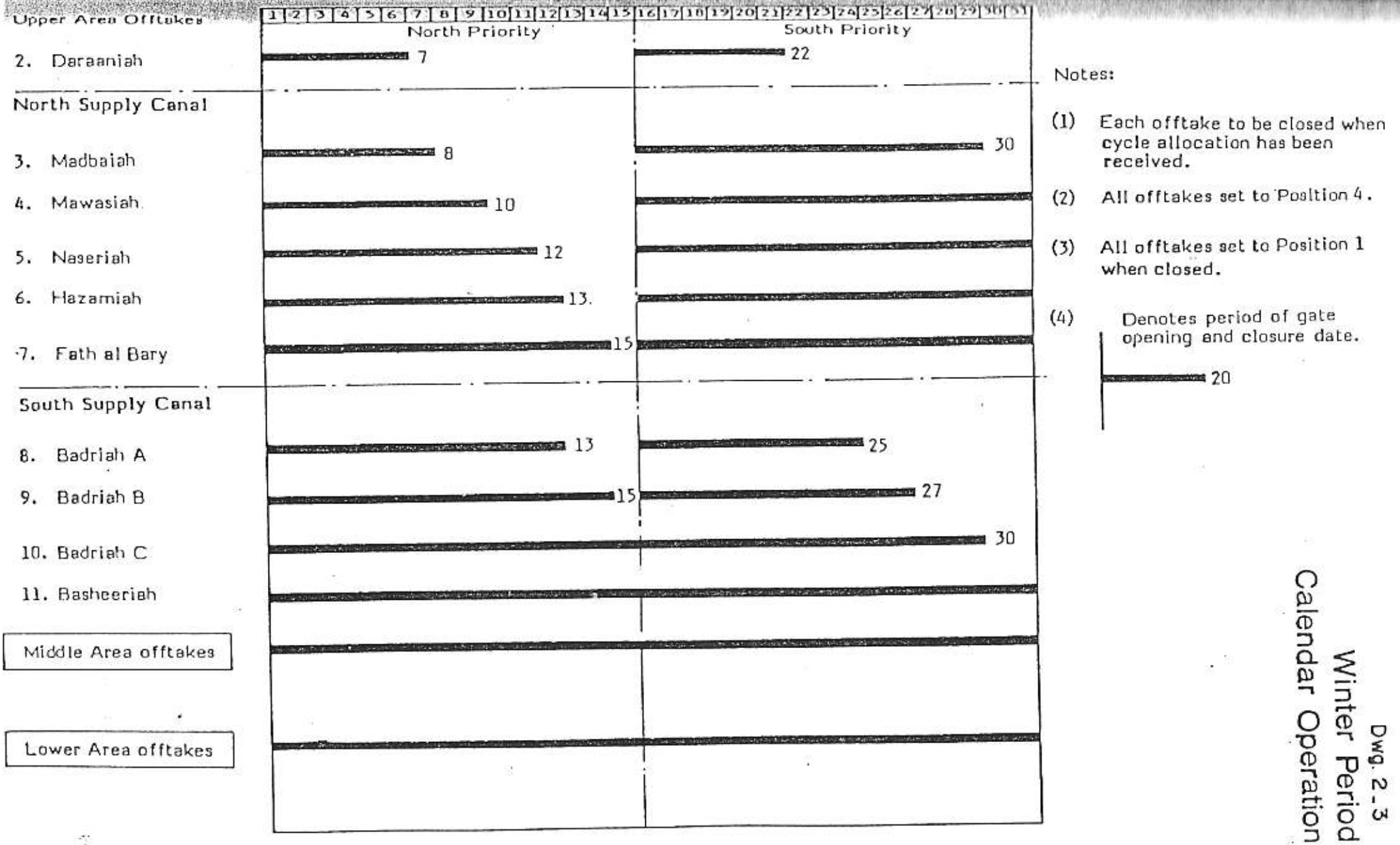
the interviewing and large size of the sample due to the large extension of the project with the time limitation requested for the study. And due to the time constraint the datailled analysis and findings as a result of this servay will be included in the final report after getting the rest of the interviws.

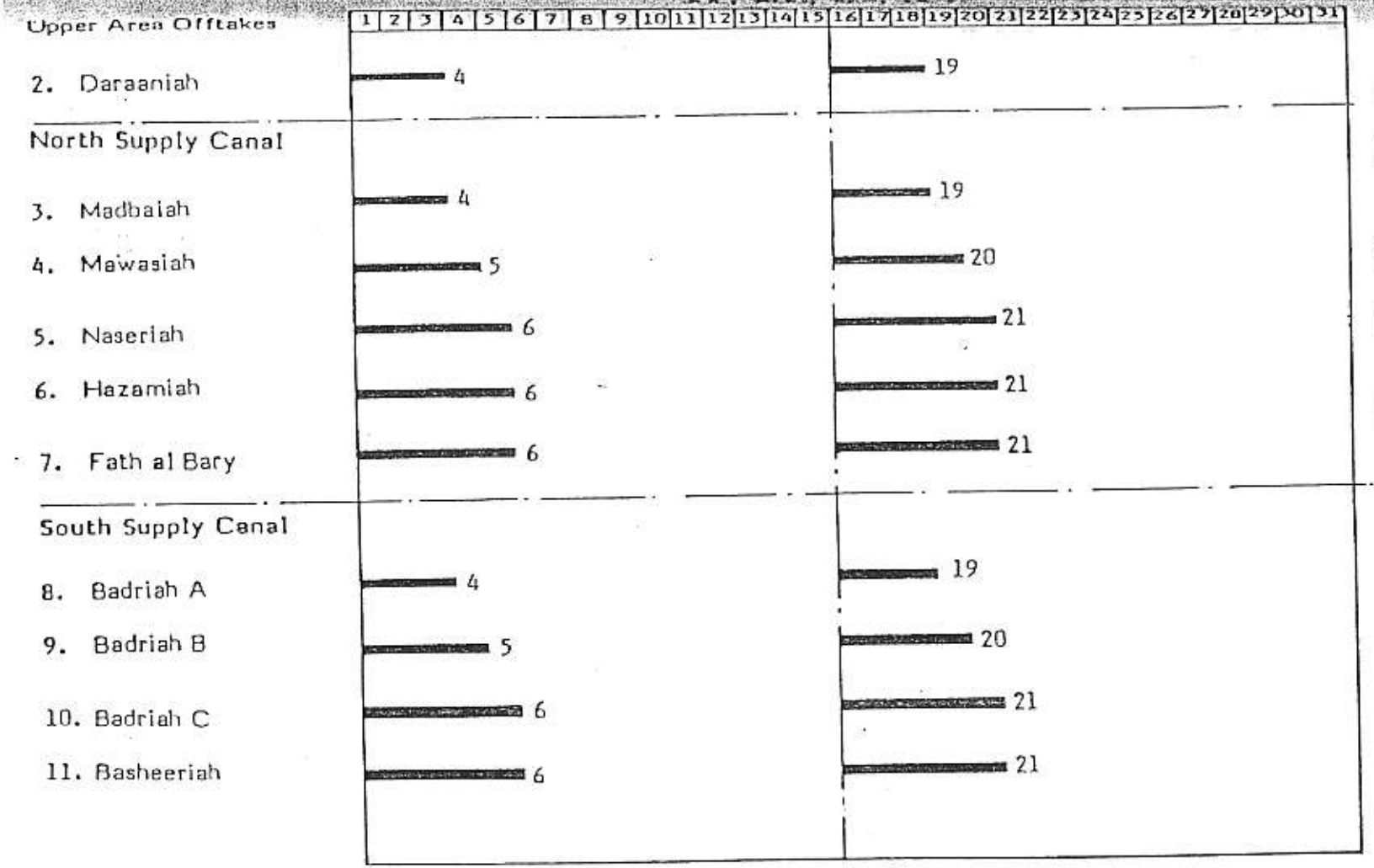
FIGURE I


INDEX MAP
IRAQ
IRAN
JORDAN
NEUTRAL ZONE
KUWAIT
RIYADH
QATAR
SAUDI ARABIA
EGYPT
SUDAN
YEMEN ARAB REPUBLIC
ETHIOPIA
DJIBOUTI
SOMALIA
OMAN
Sadah
Raydah
Amran
SANA'A
Bajil
Manakhah
Dhamar
Zabid
Ma'aih
Ibb
Taiz
Mocha
Turbah
ADEN
REPUBLIC
PEOPLES DEMOCRATIC REPUBLIC OF YEMEN
LEGEND
Project Area
Boundary of Drainage Area
SCALE
YEMEN ARAB REPUBLIC



Mean daily flow for Shat Al Erge m^3/s 1977 / 1978


Upper Area Offtakes
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 26 27 28 29 30 31
North Priority
South Priority
2. Daraaniah
7
22
North Supply Canal
3. Madbaiah
8
30
4. Mawasiah
10
5. Naseriah
12
6. Hazamiah
13.
7. Fath al Bary
15
South Supply Canal
8. Badriah A
13
25
9. Badriah B
15
27
10. Badriah C
30
11. Basheeriah
Middle Area offtakes
Lower Area offtakes
Notes:
(1) Each offtake to be closed when cycle allocation has been received.
(2) All offtakes set to Position 4.
(3) All offtakes set to Position 1 when closed.
(4) Denotes period of gate opening and closure date.
20
Dwg. 2-3
Winter Period
Calendar Operation



Notes:

(1) Each offtake to be closed when cycle allocation has been received.

(2) All offtakes set to Position 4.

(3) All offtakes set to Position 1 when closed.

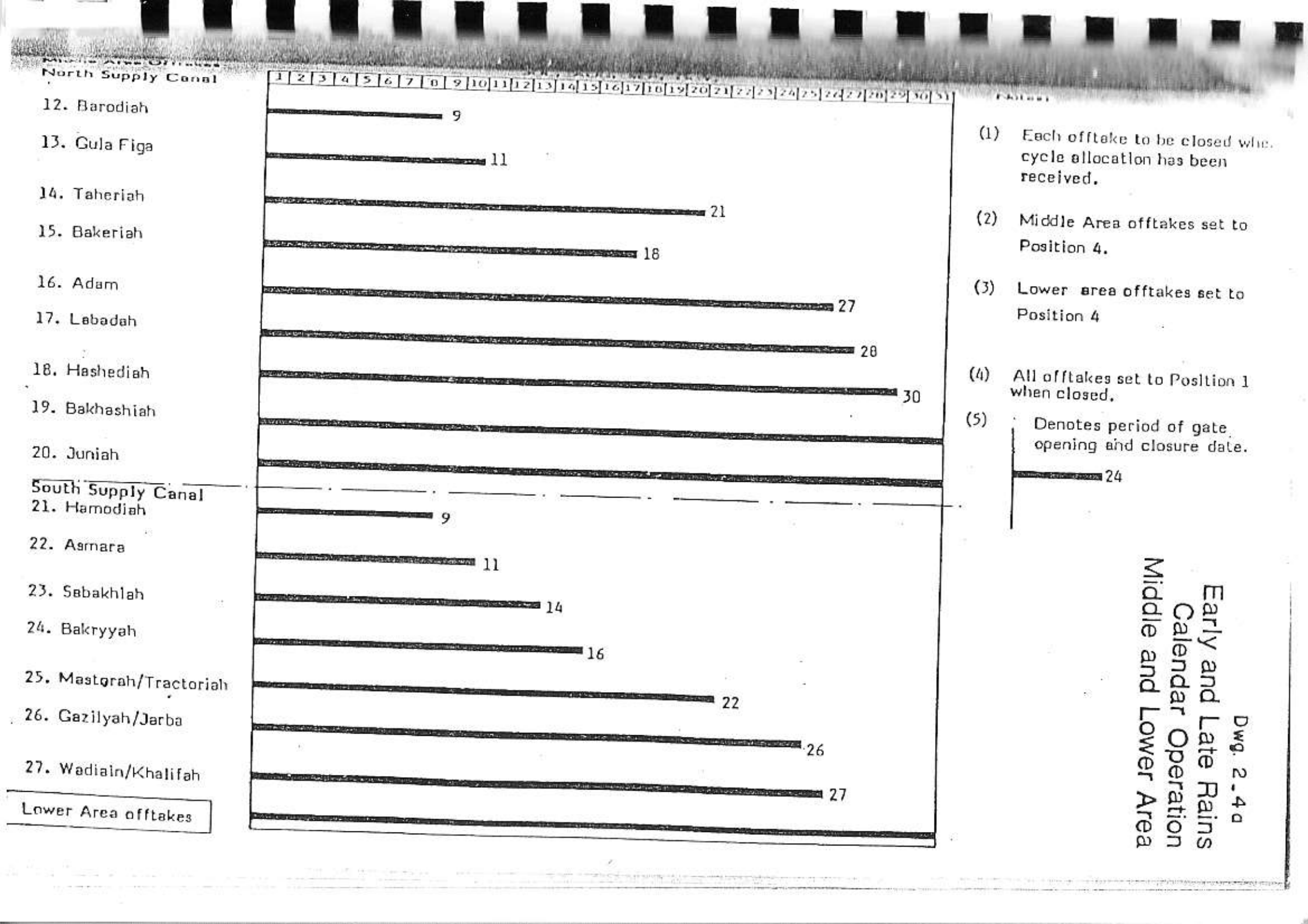
(4) Denotes period of gate opening and closure date.

23

See Figure 2.7 for Middle and Lower Area Offtakes

Dwg. 2.4

Early and Late Rains Calendar Operation Upper Area


North Supply Canal
12. Barodiah
13. Gula Figa
14. Taheriah
15. Bakeriah
16. Adam
17. Lebadah
18. Hashediah
19. Bakhashiah
20. Juniah
South Supply Canal
21. Hamodiah
22. Asmara
23. Sabakhlah
24. Bakryyah
25. Mastorah/Tractoriah
26. Gazilyah/Jarba
27. Wadiain/Khalifah
Lower Area offtakes
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 26 27 28 29 30 31
9
11
21
18
27
28
30
9
11
14
16
22
26
27
(1) Each offtake to be closed when cycle allocation has been received.
(2) Middle Area offtakes set to Position 4.
(3) Lower area offtakes set to Position 4
(4) All offtakes set to Position 1 when closed.
(5) Denotes period of gate opening and closure date.
24
Dwg. 2.4a
Early and Late Rains
Calendar Operation
Middle and Lower Area

Division
Operati
Wint

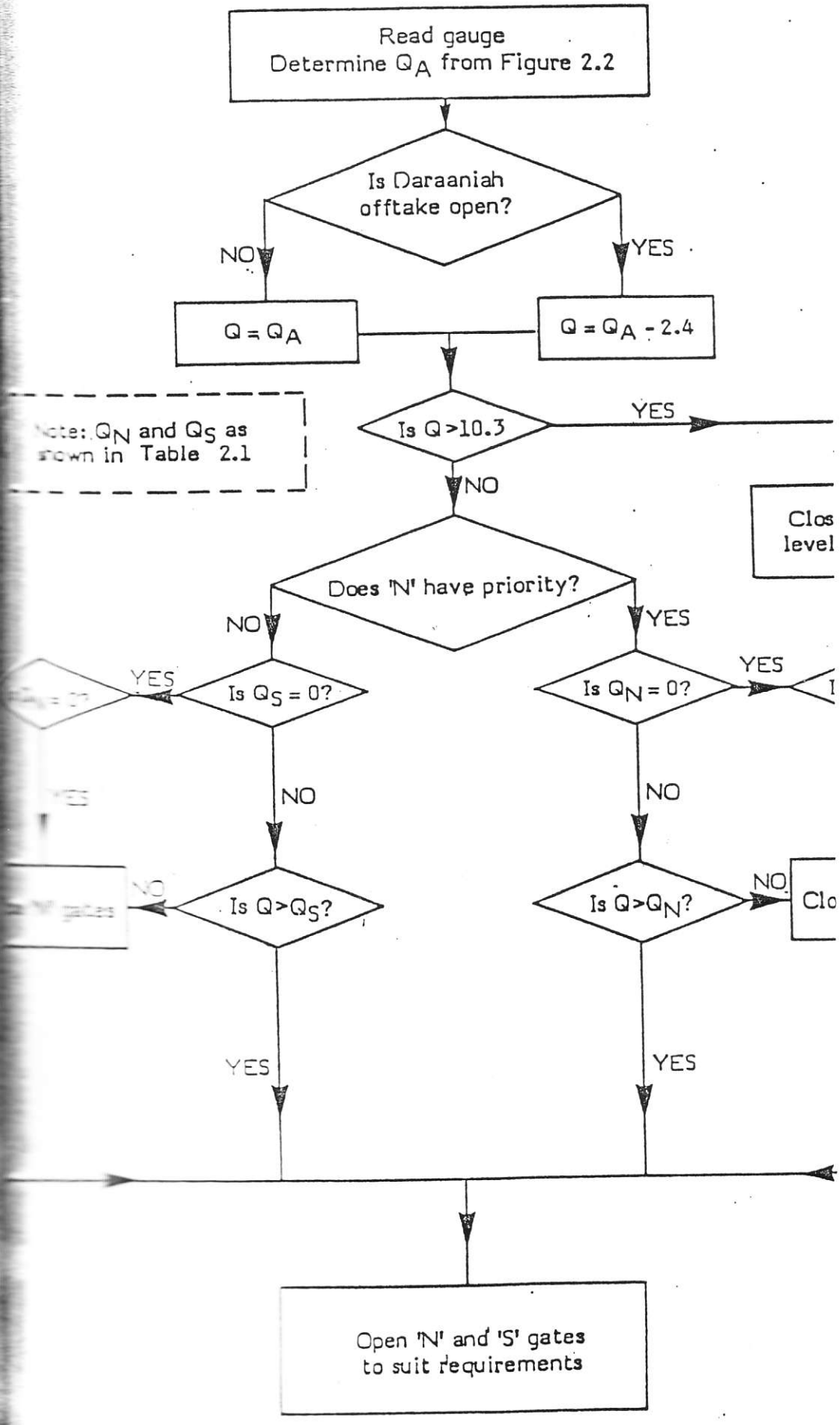
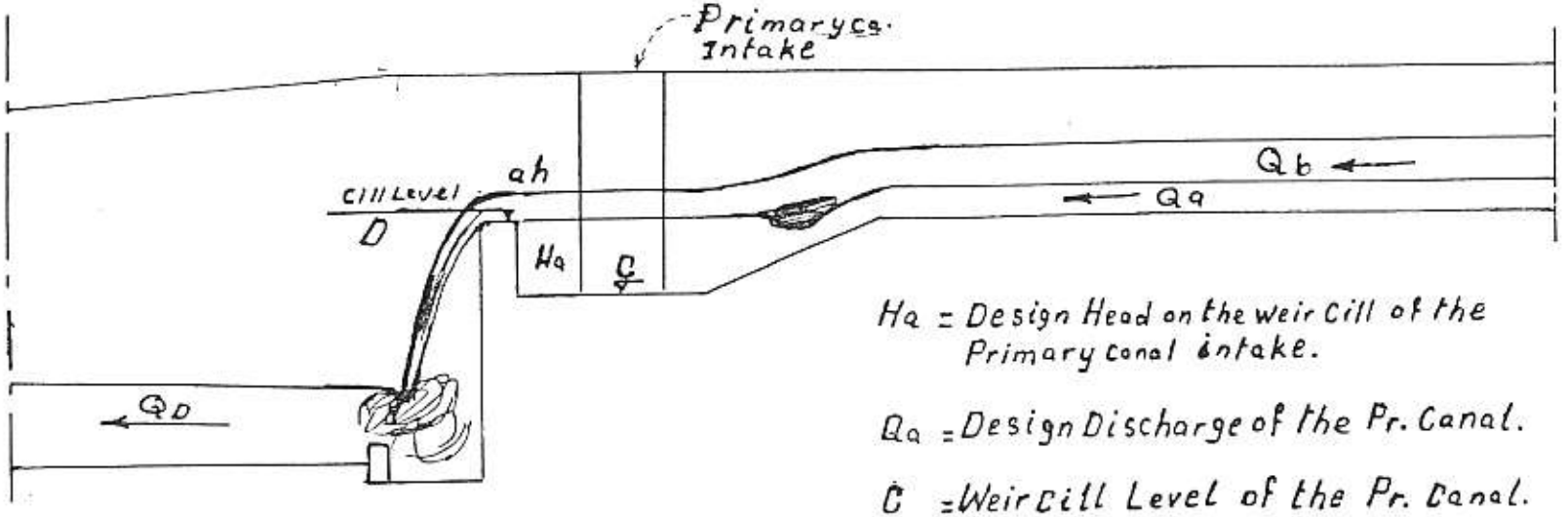


Diagram for the Setting of the Primary Weir Cill and the drop Structures on the Supply Canals.



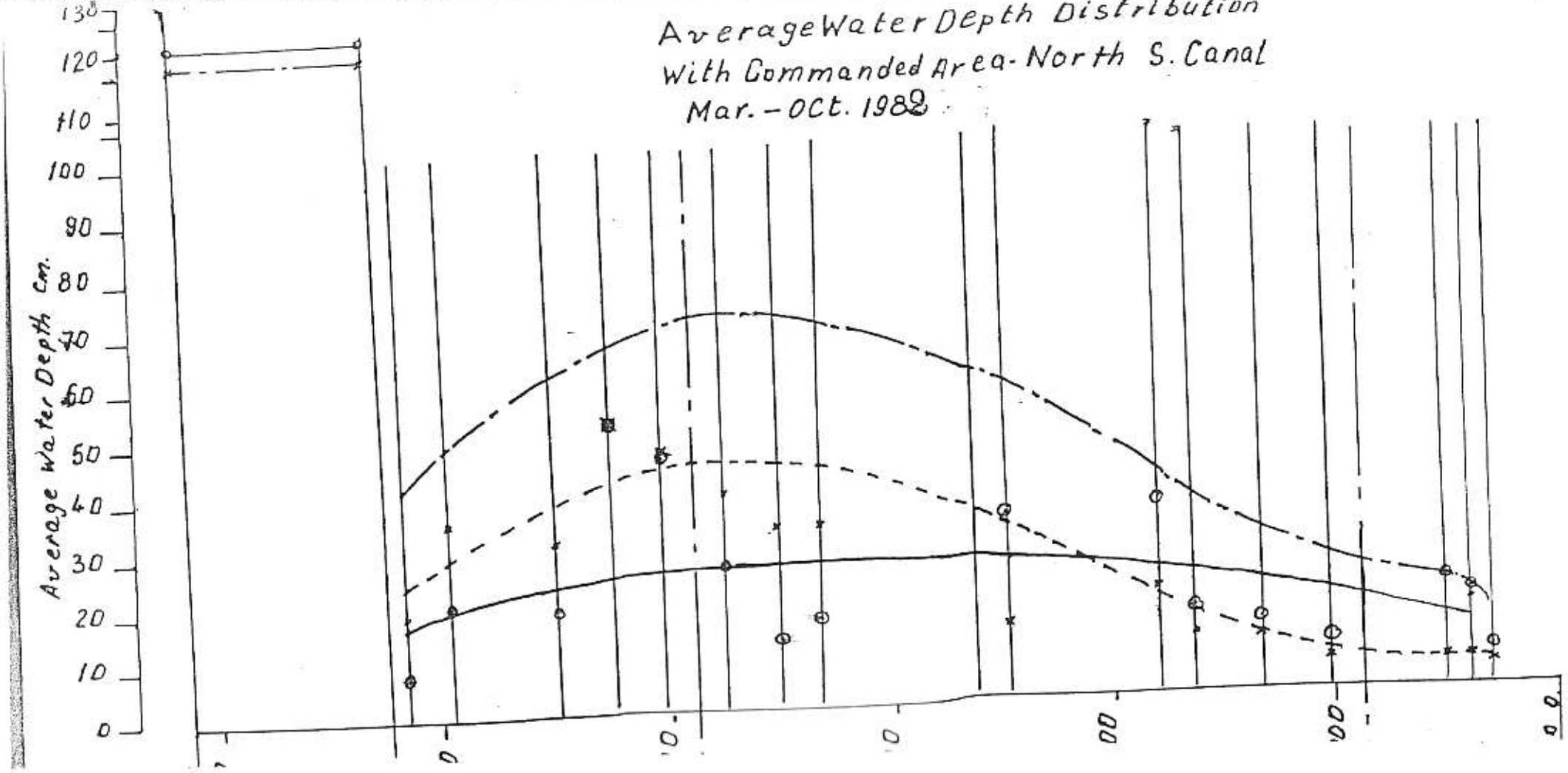
Ha = Design Head on the weir Cill of the Primary canal intake.

Qa = Design Discharge of the Pr. Canal.

C = Weir Cill Level of the Pr. Canal.

D = Cill Level of the Drop weir.

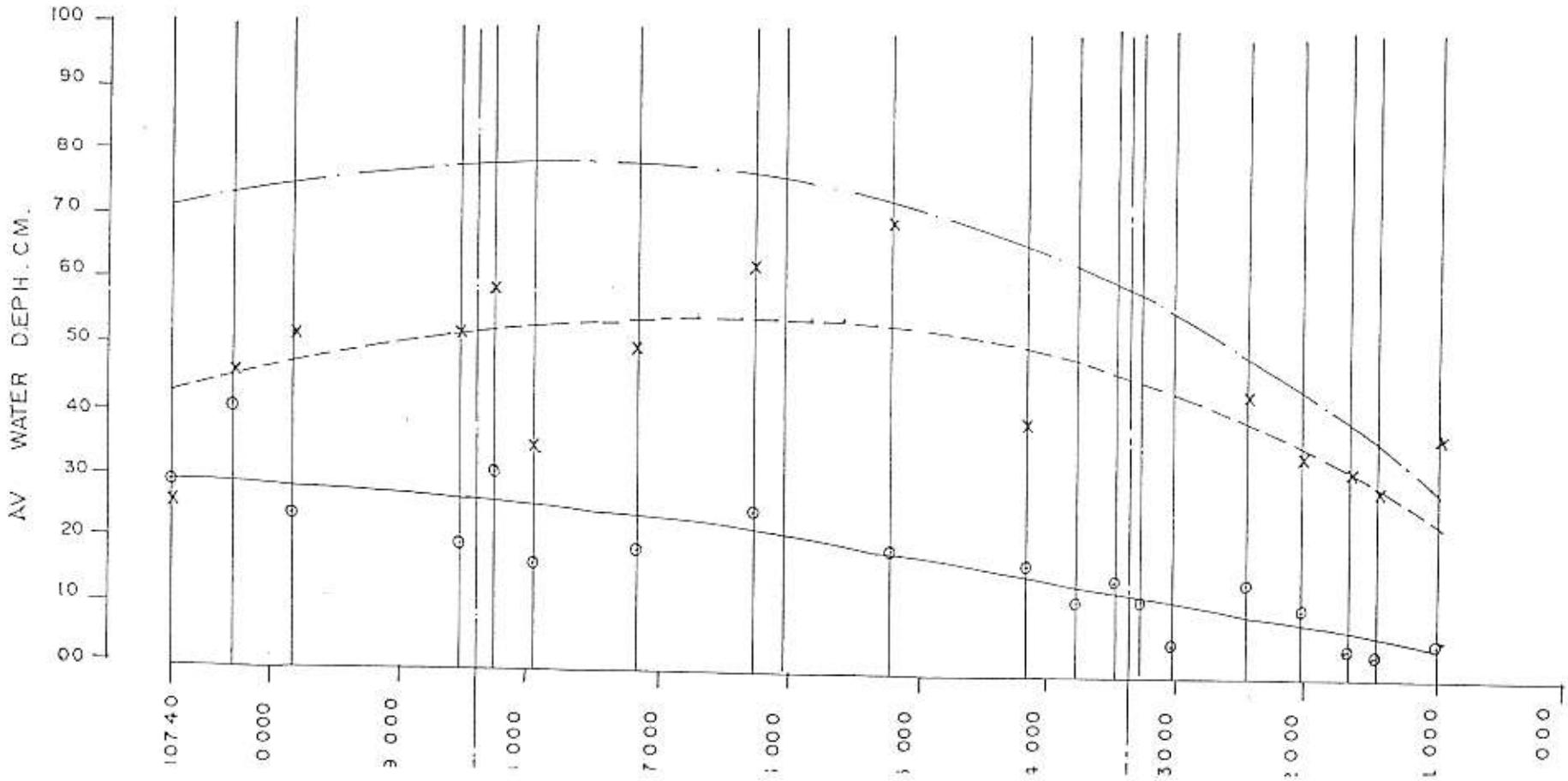
Average Water Depth Distribution With Commanded Area - North S. Canal Mar. – Oct. 1982



AVERAGE WATER DEPTH DISTRIBUTION

WITH COMMOND AREA SOUTH SUPPLY CANAL

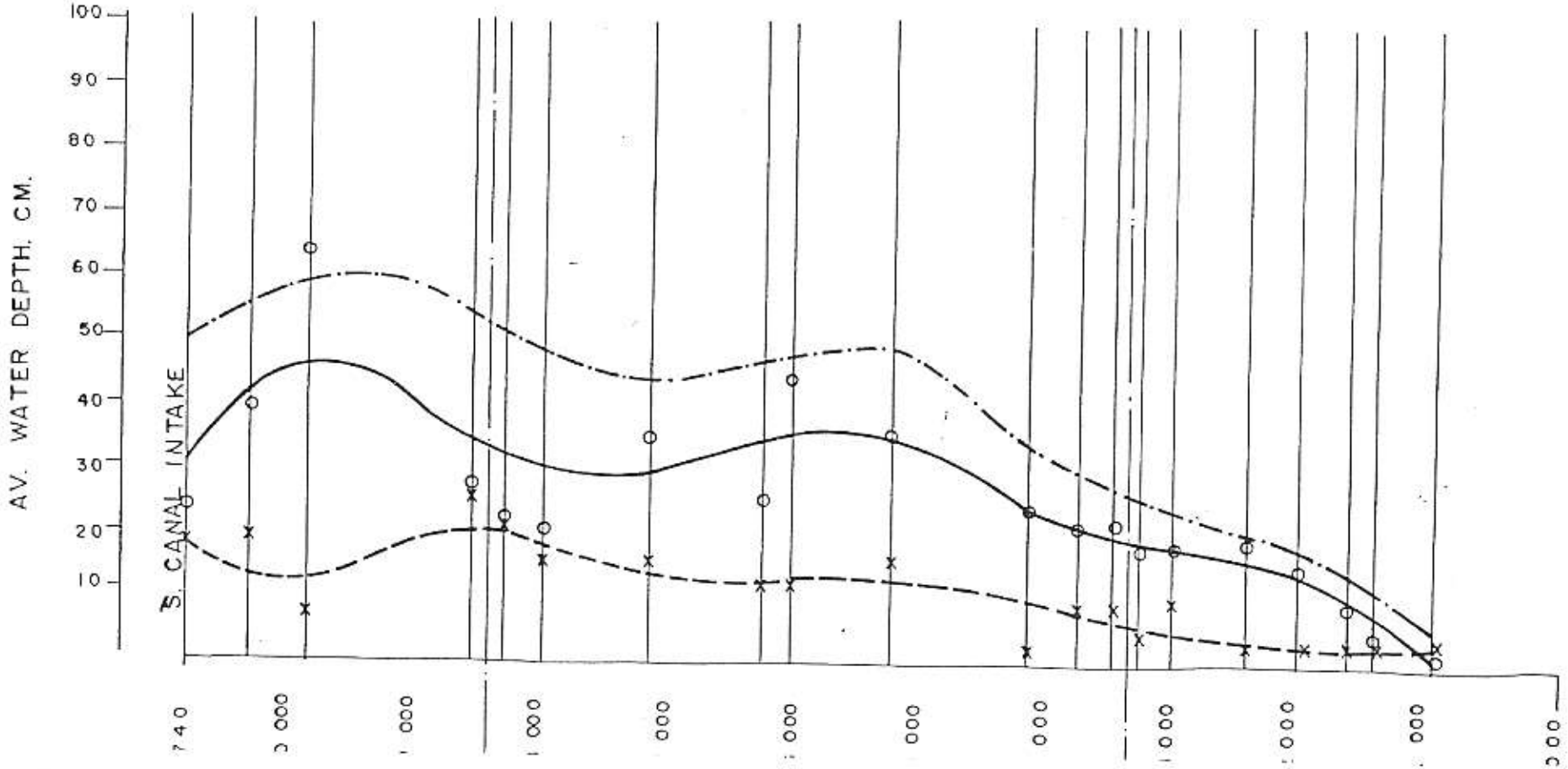
APR. _ OCT. 1988

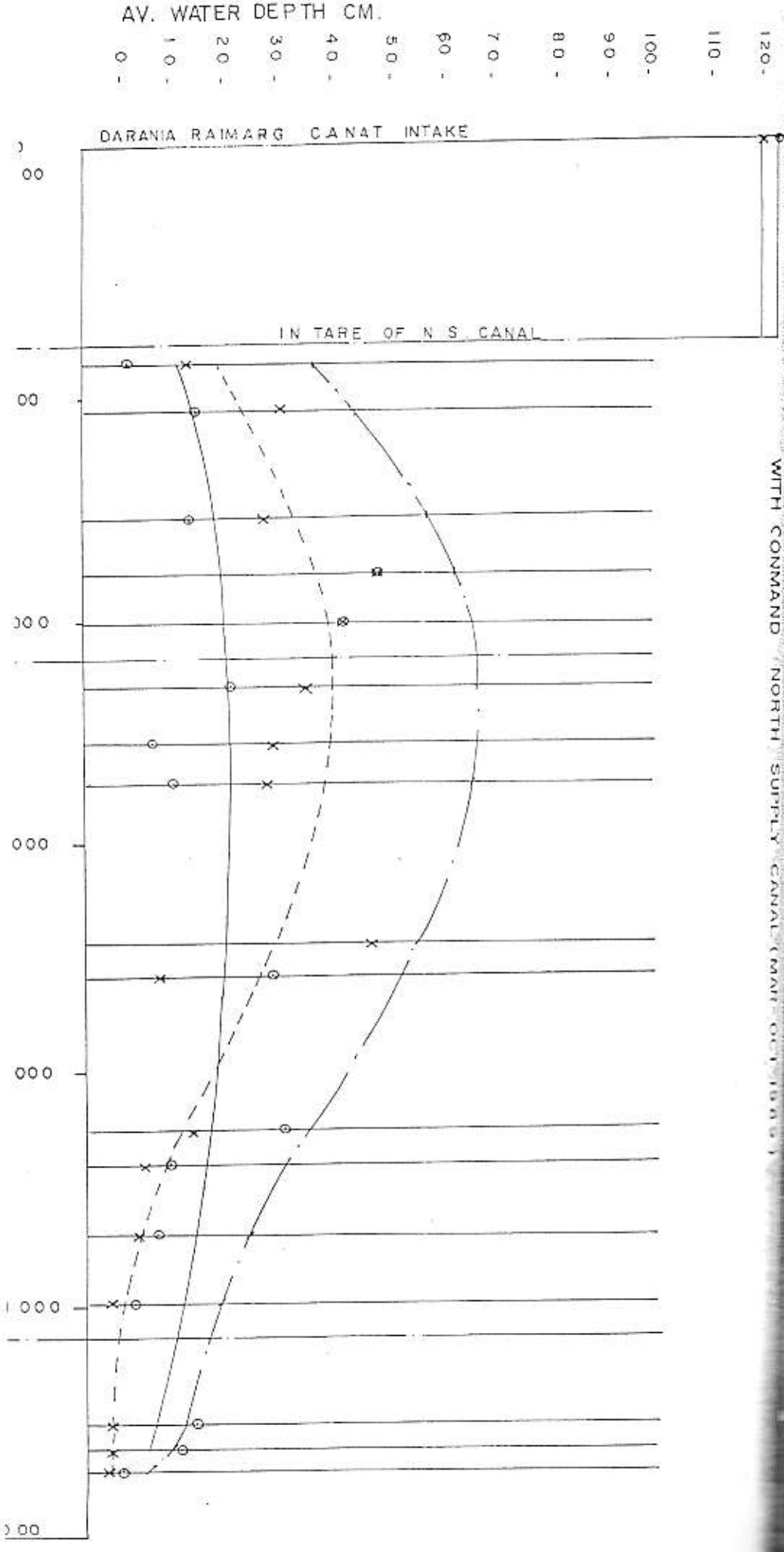


AVERAGE WATER DEPTH DISTRIBUTION

ALONG THE SOUTH SUPPLY CANAL.

MAR. - OCT. 1989

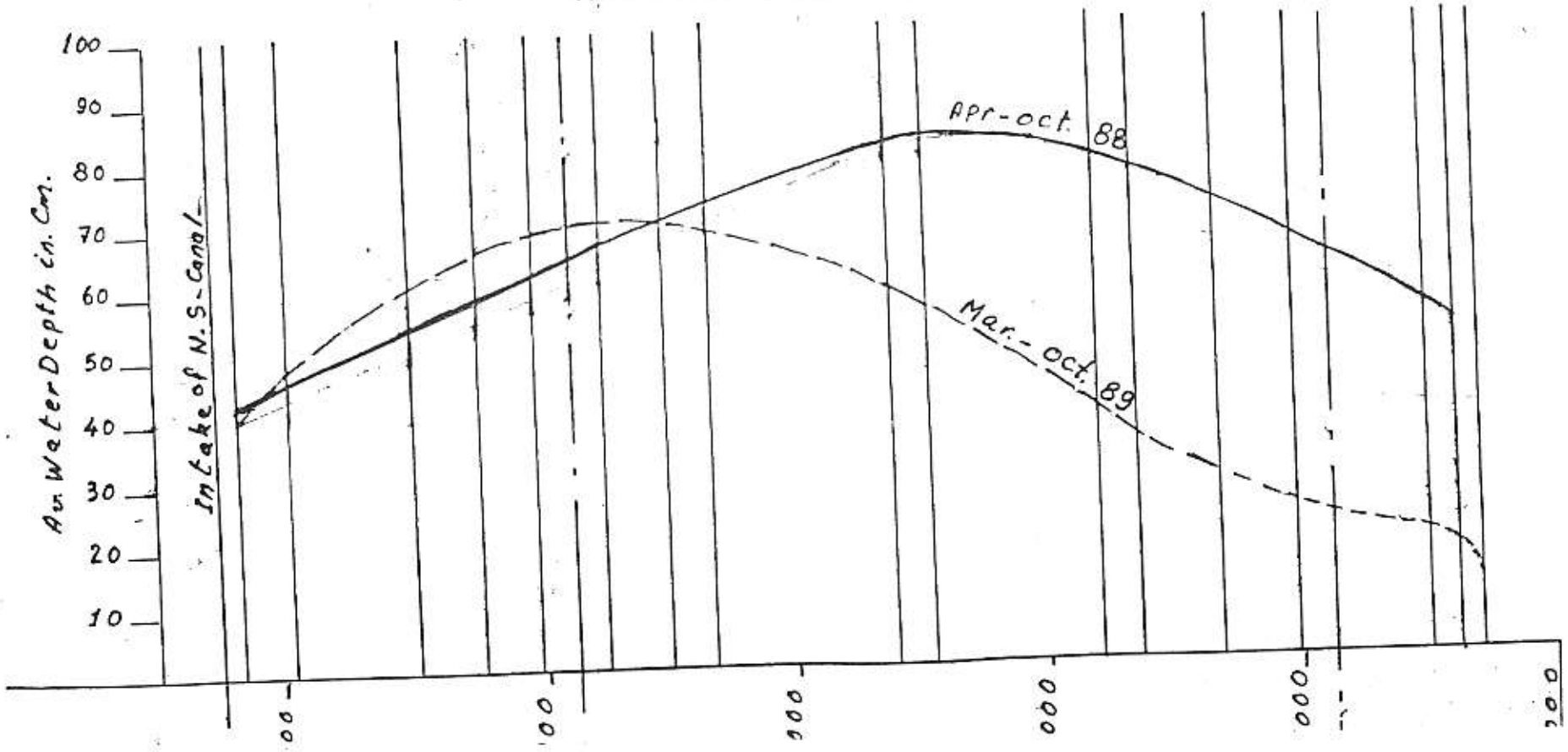



AV. WATER DEPTH CM.
0 -
10 -
20 -
30 -
40 -
50 -
60 -
70 -
80 -
90 -
100 -
110 -
120 -
DARANIA RAIMARG CANAT INTAKE
IN TARE OF N S CANAL
WITH CONMAND NORTH SUPPLY CANAL (MAI

Average Water Depth Distribution

With Commanded Area-North Supply Canal

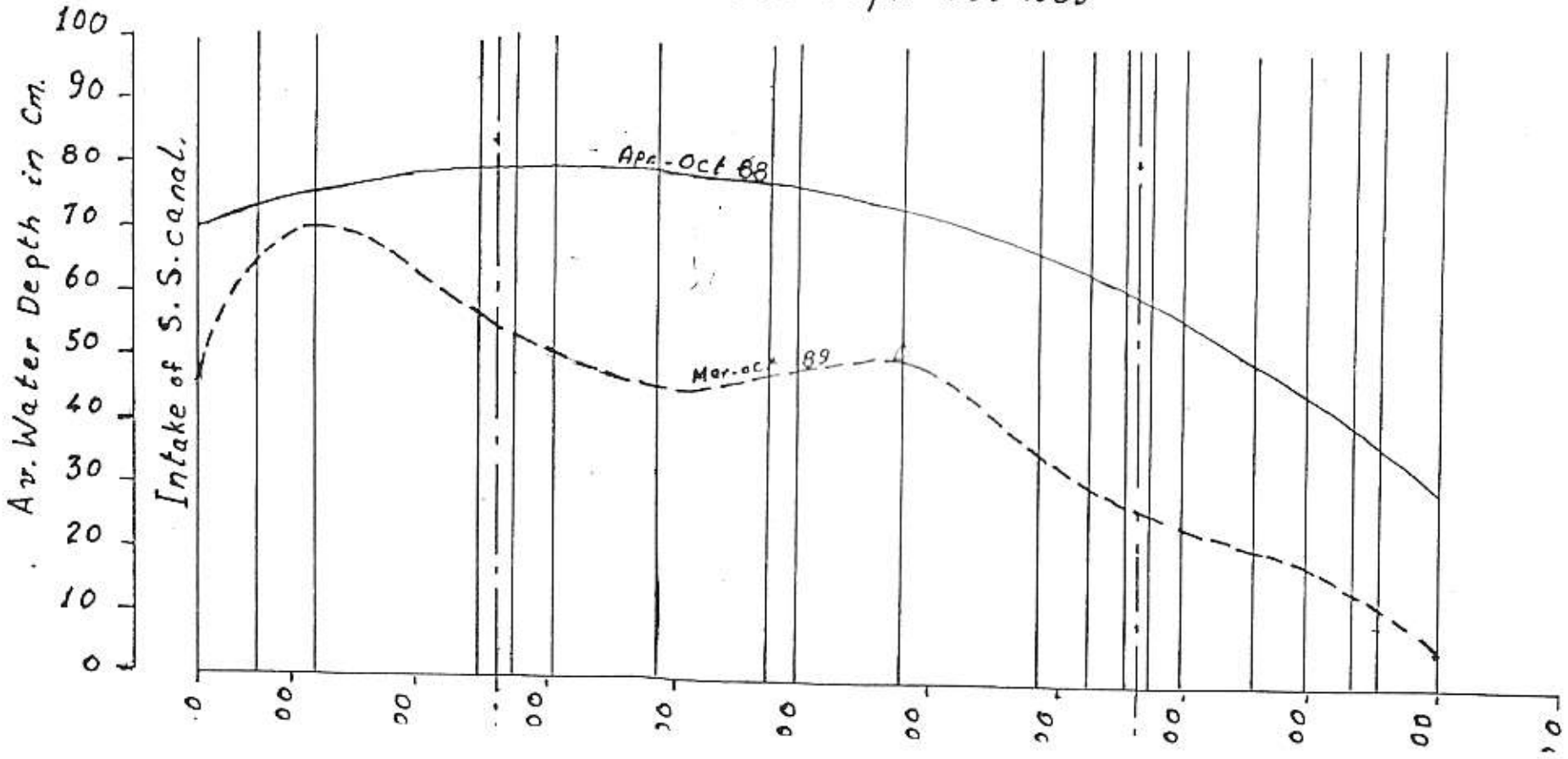
Mar.-Oct. 1988 & Apr.-Oct. 1989



Average Water Depth Distribution

With Commanded Area South Supply Canal

Mar. - Oct. 1988 & Apr. - Oct 1989

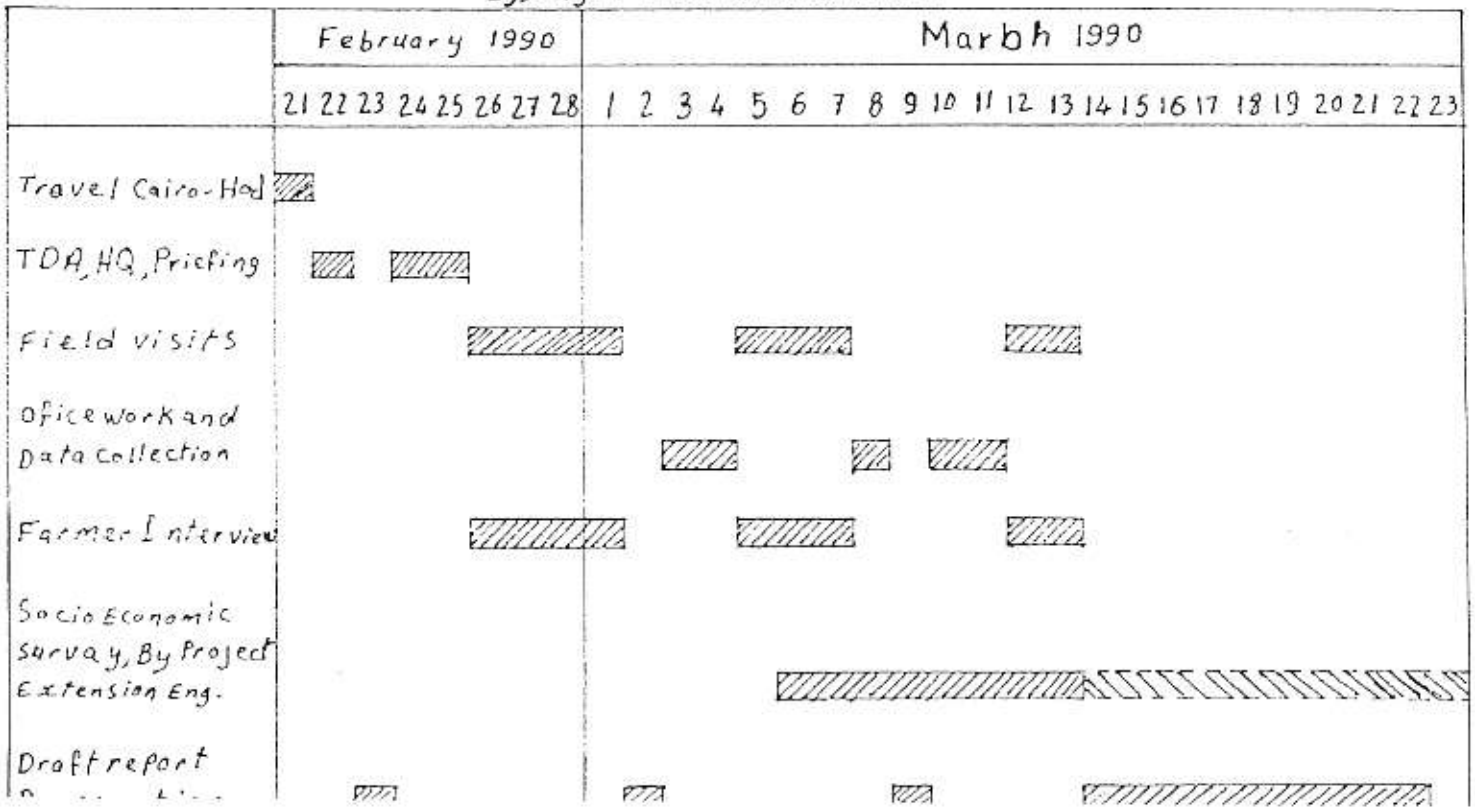


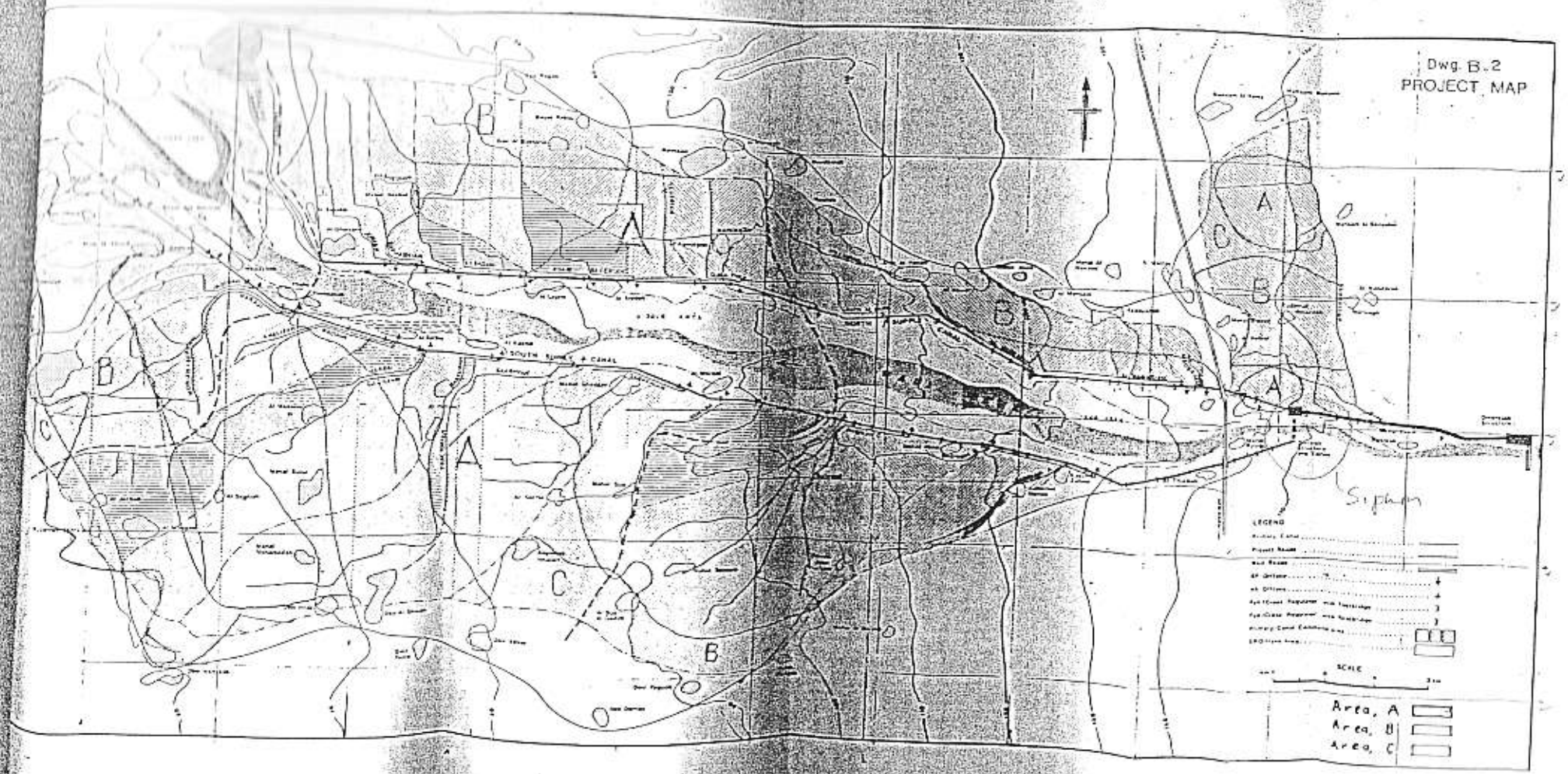
Itenary For

Short Study For Wadi Mawr Water Regulation

period, Feb. 21 to Mar. 23, 1990

By, Eng. Farouk. A.R. Shahin.




Dwg. B-2
PROJECT MAP
A
B
C
Siphon
LEGEND
SCALE
Area, A
Area, B
Area, C