SOMALI DEMOCRATIC REPUBLIC

INTERIM REPORT

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT FOR WATER DEVELOPMENT AGENCY MINISTRY OF MINERALS AND WATER RESOURCES

Submitted by

LOUIS BERGER INT'L INC

ROSCOE MOSS COMPANY

INTERIM REPORT
COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT
AUGUST, 1985

FOR

WATER DEVELOPMENT AGENCY
MINISTRY OF MINERALS AND WATER RESOURCES
SOMALI DEMOCRATIC REPUBLIC

LOUIS BERGER INTERNATIONAL, INC.
ROSCOE MOSS INC.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LISTS OF PLATES

EXECUTIVE SUMMARY

The Comprehensive Groundwater Development Project , CGDP has been in progress since July, 1981. Originally scheduled to end in 1984, the project was extended until July, 1986. A final report was prepared in August, 1984 that summarized work completed from July, 1981 to July,1984. This interim report provides an update of project activities from July, 1984 to July, 1985.

Drilling Program.

As in Phase I, lack of fuel continued to hamper progress in drilling and other project activities. Some slowdown in drilling was experienced in the Bay Region during the rainy seasons, however, emphasis in the Central Range and classroom training activities were given at this time. Logistics in the Central Rangelands continued to be difficult, but progress was made.

There have been 26 boreholes drilled since July 1984; 18 in the Bay Region and 8 in the Central Range. Of the holes drilled, 15 wells were completed in the Bay Region and 4 wells were completed in the Central Rangelands. Of the wells completed, 6 have motor powered pumps, 4 are with hand pumps and 1 is equipped with a windmill. Thirty-nine water samples from wells have been analyzed for chemical and/or bacterial constituents.

Hydrogeology.

A considerable amount of hydrogeologic data have been collected. In the Bay Region it has now become clear that most well-drilling activity should be on the limestone plateau. Landsat or other high-altitude photography should be obtained for analysis of geologic structure prior to any additional drilling in the Bur area. In addition, the use of surface-water catchments and infiltration galleries should be considered in this area as an alternative to bored wells.

In the Central Rangelands a variety of conditions exist which make water development by drilled wells difficult. Along the coastal area water tends to be saline at shallow depths.

Inland, elevations are too high above potential aquifers in some areas to drill with available equipment. There are shallow wells of ± 70 m. in the Xaradhere area. The best aquifer encountered has been the Trap Series basalt in the El Bur-Dhusamareeb area. A surface geophysical survey should be conducted in a grid pattern over those areas known to have basalt at depth. If the extent of the basalt can be defined, future drilling can be planned more effectively.

Institutional Support.

Approximately eighty-two counterparts including professional and skilled personnel have been receiving continuous on-the-job and/or classroom training. Drillers and pump installers are able to perform relatively independently. The chemical lab staff is performing without supervision, and are providing analytical results. Mechanics are able to make a significant contribution, but are not yet able to independently diagnosis mechanical problems.

Hydrogeologists and assistant hydrogeologists are contributing to the data collection program by sampling well cuttings, and by conducting pumping tests. Those conducting pumping tests are working independently. Five of the hydrogeologists assigned are receiving additional training at the U.S. Geological Survey Center in Colorado.

Individuals assigned to the Planning Unit have been receiving microcomputer training and planning and management training from a socio-economic view point. They are capable of storing and retrieving basic data, and of conducting spread-sheet analyses.

Additional training is recommended for all counterparts in several areas that include; hydrogeologic report preparation, driver education, welding, pump repair and maintenance, and English language. These programs are recommended to be taught in-country.

One outstanding problem of variable degree with all counterparts has been the lack of incentive for continuous active participation. This is not a readily solvable problem, but one which will take time and considerable cooperation from management. Incentives must include a reasonable salary scale for the level of effort expected.

The Planning Unit got off to a slow start, but picked up considerable momentum with the arrival of the consultant's economist. A Compaq microcomputer and subsequently an IBM microcomputer were put into operation within the Unit. The arrival of the consultant's sociologist provided additional support to the Unit. Forms for baseline information gathering, project operations, and socio-economic impacts were developed. During this period, the Planning Unit personnel received training in the basic concepts for monitoring and collection of village baseline data.

The warehouse operations have been functioning almost entirely with WDA personnel, although the chief driller and chief mechanic have been providing some technical assistance toward this effort. All procurement specified in the extension, with the exception of needed parts, has been ordered and has either been received or is in transit.

The water-quality laboratory has been functioning under the direction of a Somali chemist. Chemical and bacterial analyses are being completed for water samples collected at new wells. Although some data have appeared suspect, the majority of analyses have been adequate for purposes intended.

Private Sector Study.

A three-phase private sector study of the water resource sector/industry was initiated in December of 1984. Short-term expertise was brought in to conduct evaluations of existing infrastructure, policies, demands, capabilities and constraints. Local consultants were sub-contracted to collect data on local contractors and suppliers in areas outside of Mogadishu that were or could potentially provide services and/or materials for water-resource development. This effort resulted in several reports that will be evaluated and the pertinent points incorporated in a final report on the private sector.

Several additional programs have been recommended for consideration. These include further exploration in both the Bay Region and in the Central Rangeland utilizing air photos and surface geophysical techniques prior to any additional drilling; evaluation of the potential for surface-catchment structures and for spring-site development; rehabilitation and maintenance on existing systems; concerted effort to evaluate and prepare a program for private sector drilling and civil works contractors; and review and evaluation of incentives that can be implemented within the existing system.

Demobilization.

A tentative demobilization schedule for the consultant's team has been proposed that should provide a smooth transition to WDA operations from current project level activity. This includes a number of items, from transfer of equipment and materials to preparation of a final report.

Project Manager's Note

In the period prior to July, 1984 the average drilling rate was 237 m/month. From July, 1984 to July, 1985 the average rate has been 330 m/month; an increase of approximately 30%. As of July, 1985 it is estimated that there are 2624 m^3 /day of available water production. This amount of water is able to serve 12,800 people and 200,000 animals. These statistics are added here to provide an update as to where the project is as of 31 July, 1985. These numbers are not discussed elsewhere in the text of the report, but are derived from data contained herein and compared with data from the 1984 Phase I Final Report.

1.0 INTRODUCTION

The Comprehensive Groundwater Development Project (CGDP) was begun in July of 1981. An Inception Report was submitted in August of 1981 that defined the objectives to be:

1. to conduct preliminary data collection.
2. to undertake an exploration and production program.
3. to provide institutional support to WDA and the MMWR.
4. to establish an ongoing data collection system.

In July of 1984 a three-volume Final Report, was prepared that provided a summary of activities in well production, data collection, institutional support, and hydrogeology. Several reports relating to specific aspects of the project were compiled during the interim between the Inception Report and the Final Report. These included an environmental report, a sociological report, and an economic report. Pertinent information from these reports was incorporated in the Phase I Final Report.

In August of 1984 a work plan for the period from July of 1984 to July of 1986 was prepared. The purpose of this Interim Report is to provide a summary of activities and accomplishments related to the work plan that took place from July, 1984 through July, 1985. It is not intended as a scientific report, although findings are discussed and basic data are presented in Annex A. The report covers six of the project components concerned; drilling program, hydrogeology or data collected, institutional support, private sector study, recommended programs, and demobilization.

2.0 DRILLING PROGRAM

The drilling program of the CGDP continued to be concentrated in the Bay Region and in the Central Rangelands Region. The objectives of the drilling program during the past year have been oriented more toward completion of production wells than toward completion of exploratory wells. These objectives have not been realized given the lack of data in some areas, such as in the Central Rangelands.

The selection of potentially successful well-site locations has been aided by the availability of information acquired during the initial phases of the project. The Bur area of the Bay Region is, for example, excluded as a potential area of development for bored wells, whereas most of the Bay Region north and west of the Bur area is considered to be favorable for groundwater development.

In the Central Rangelands, however, exploratory wells are as yet too few and too widely separated to establish a trend or to define a specific area as favorable for the concentration of production well drilling efforts. Where areas unfavorable for obtaining water from bored wells have been recognized, alternative means of water development have been considered. A discussion of these alternatives is provided in subsequent sections of the report.

2.0.1 Problems and Solutions

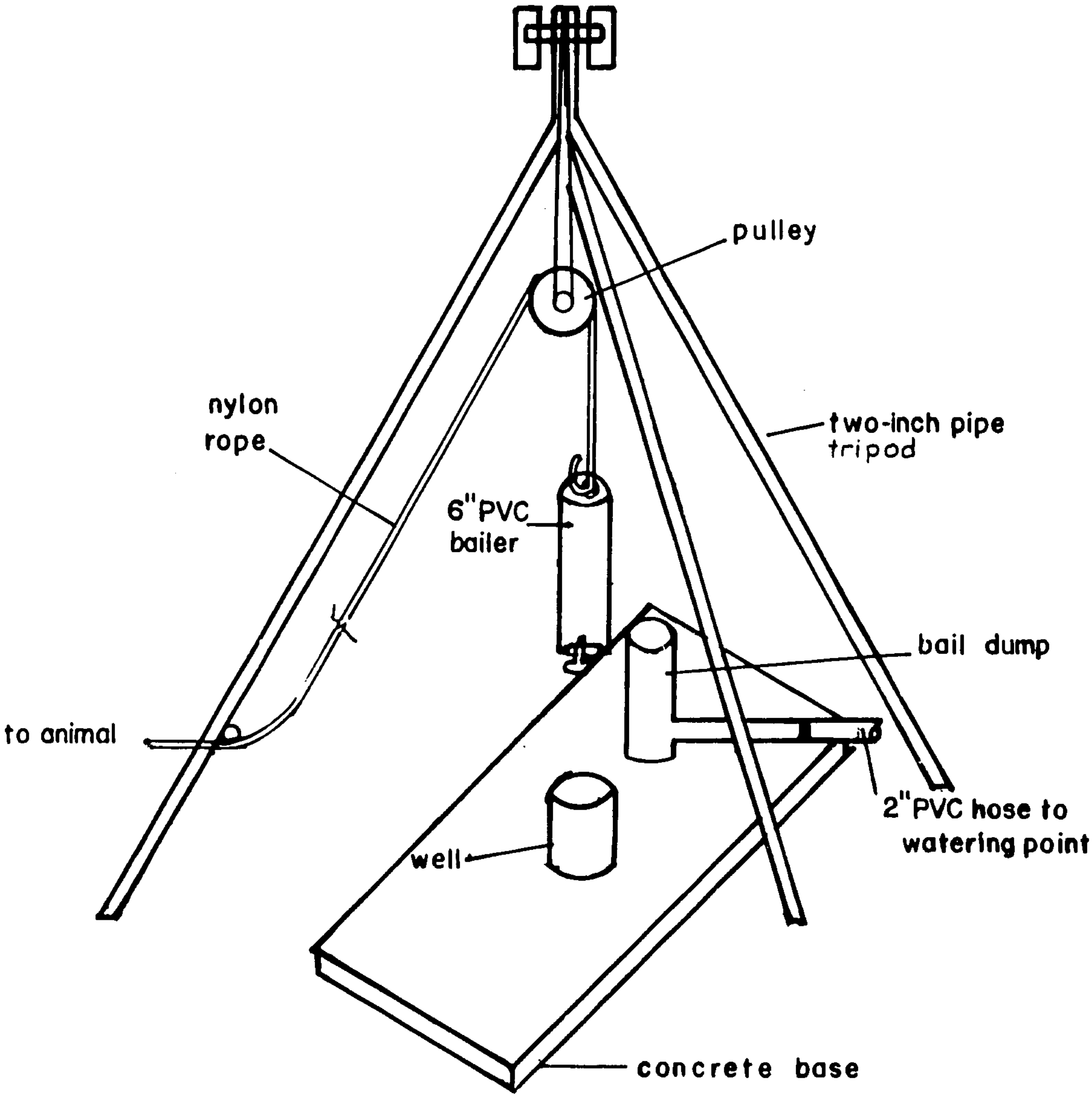
Problems associated with the drilling program during the extension phase of the project were similar to those in the initial phase. The most outstanding problem was the unavailability of diesel and petrol. The productive capacity of the project was reduced by nearly half because of the lack of fuel. Lack of fuel caused delays in drilling, in field maintenance, and in supply of materials to the field. An alternative source of fuel was obtained by USAID from Djibouti, but this was not until May of 1985 and it was only intended to provide a portion of total requirement.

Shortage of well casing created some logistical problems early in the year, however, a casing order from Nairobi that arrived in July averted any serious problems. Supplies of cement had to be purchased on the local market on an as-needed basis from July of 1984 through June of 1985. A fifty-ton cement order placed by USAID was never consumated, and ultimately the Consultant was requested to purchase the fifty tons through Nairobi. This arrived in mid July of 1985.

Lack of pumps in the Bay Region prevented the completion of some well sites. The pumps were ordered by the Bay Region Agricultural Development Project (BRADP) in April, but had not yet been received at the time of this report. The supply of Robbins and Myers hand-powered pumps were being installed, but proved to be unsatisfactory because of structural problems in the pump shaft. Attempts were made to get corrective measures from the manufacturer, however, it was learned they were no longer doing business in the U.S. Mono hand pumps were selected as replacements and an order was being prepared. In an effort to provide some means of obtaining water from drilled wells, a tripod equipped with a PVC bailer was being built for testing, Figure 1. It is hoped that if successful, this set-up would be utilized by the people until replacement pumps arrive. In some areas these systems may be left as a permanent set-up.

Training problems were primarily amongst professional counterparts who lacked incentive to particpate. Long term incentives, such as salary increases and promotions essential for effective training to succeed, were not able to be provided. In spite of this problem, several hydrogeologists and most skilled counterparts persisted in the necessary skills to work independently. Language differences occurred throughout all levels of the program to varying degrees and contributed to the problem. English language capability of most of the counterparts ranged from good to a very limited facility of the language. In this regard, the counterparts tried very hard to learn.

Operations and maintenance manuals, dealing with almost every aspect of project activities were prepared to assist in the training effort, and to provide guidelines in the absence of consultant supervision. Three of the manuals have been translated and it is planned to translate the remaining manuals into the Somali language. The manuals currently completed in English include:



not to scale

MANUAL OR ANIMAL BAILER FOR EXTRACTION OF WATER
FROM DEEP DRILLED WELLS

Figure 1

1. Light Duty Vehicle Preventive Maintenance.
2. Pump Rig Operation and Well Maintenance.
3. Manual for Pump Testing.
4. Well Drilling Operations and Preventive Maintenance.
5. Manual for Hydrogeologists.
6. Downhole Geophysical Logging.
7. Water Analysis at MMWR Laboratory.
8. Evaluation, Rehabilitation and Abandonment of Water Source Points.
9. A Manual of Warehouse Procedure.

Well site locations in the Central Rangelands created some logistical problems, however, these were generally resolved by persistent interaction with the Central Range field personnel. Most problems resulted from the difficulty of simultaneously satisfying political, ecological and hydrogeological considerations.

2.0.2 Recommendations

Drilling in the Bay Region should continue within the limits of the area defined in Plate 1. The uppermost limestone aquifer should be the objective of bored wells in the Bay Region. Deep drilling, greater than 200 meters, should be avoided as deeper boreholes in that region are seldom successful. Contours on the top of the uppermost limestone aquifer show its configuration in Plate 2. Geologic units of the Bay Region and their water-bearing characteristics area listed in Table 1 ; the geology of the area is shown in Plate 3.

The Bur area of the Bay Region should not be considered as favorable for bored wells. Experience in that area, although limited to the Bur Hakaba and Bur Heibe areas, indicates absence of sufficient quantities of groundwater , and the presence locally of highly saline groundwater. Limited additional exploration will be done to insure that these conditions are truly representative. It is recommended that water resource development in the Bur are be accomplished by the use of runoff retention structures, such as wars, berkeds, gabions, paved catchments, and small earthen dams. Water resource development utilizing these systems must be considered a continuous process.

TABLE 1 -BAY REGION GEOLOGIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS

EPOCH	SUITE OR SERIES AND SYMBOL	APPROXIMATE MAXIMUM THICKNESS, M	OCCURRENCE, LITHOLOGY AND WATER-BEARING CHARACTERISTICS
RECENT - PLIOCENE	Giuba and Shabelle Rivers alluvium, also alluvium of the Bur area; Qal	100	in the valleys or flood plains of the Giuba and Shabelle Rivers, the wadis of the Bur area; clay, silt, sand and coarser alluvium yield water to shallow (less than 30 m) wells. Water of less than 3500 micromhos/cm specific conductivity is found in about 10 percent of the wells.
	Aeolian sand, sandstone, and reef deposits of the eastern coastal zone; N_2-Qpl+al	120	Active and inactive dunes on the eastern coast, of well-sorted aeolian sand; yields water of useable quality to shallow (less than 7 m) wells. Bored wells in this zone yield saline water
	Proluvium, alluvium; clay, silt, sand, and gravel in flood deposits of the lower Giuba River, N_2-Qpl+al	120	Fluvial sediments of the lower Giuba River Flood plain mostly of clay, silt, and sand with lenticular gravel near the river; yields water of useable quality to shallow (less than 20 m) wells. There are no bored wells of record in this unit east of the Giuba River.
MIOCENE	Mudug-Merca Suite; N_1 md	500	Mostly in the Central Rangeland, but extends westward to the near-vicinity of the Bay Region; limestone, marl, gypsum, clay, sandstone, calcrete and related rocks. Not important to the Bay Region as an aquifer, but yields water to shallow (less than 10 m) wells.

EPOCH	SUITE OR SERIES AND SYMBOL	APPROXIMATE MAXIMUM THICKNESS,M	OCCURRENCE,LITHOLOGY AND WATER-BEARING CHARACTERISTICS
MIOCENE-PALEOCENE	Basalt; $BPg\text{-}N_1$	80	Near the rivers and in the northwestern Giuba-Shabelle interfluve; olivine basalt with layers of scoria and with columnar jointing. Yields water to a few small springs.
LATE CRETACEOUS	Main Gypsum and Mao Subsuite of Gabra Harre Suite; Cr_1 mg	450	North of the Bay Region between the Giuba and Shabelle Rivers; gypsum, anhydrite,dolomite,marl,clay, and silt-stone,yields water of marginally use-able quality to a few hand-dug wells.
LATE JURASSIC	Busul Subsuite of Gabra Harre Suite; J_3bs	400	North of the Bay Region between the Giuba and Shabelle Rivers; limestone, dolomite,marl,and sandstone yield water of marginally useable quality to hand-dug wells.
	Uegit Suite; J_3ug	350	In the northwest part of the Bay Region also northern and eastern part of the interfluve of the Giuba and Shabelle Rivers; limestone, dolomite, and marl, hand-dug and bored wells yield water of useable quality. One project well, B15, penetrates but does not yield water from the Uegit Suite.
	Anole Suite; J_3an	450	Extends through the northwestern part of the Bay Region, also the northern and eastern part of the interfluve of the Giuba and Shabelle Rivers; limes-tone,marl and clay, project wells B14 and B15 yield unuseable saline water from this suite.

EPOCH	SUITE OR SERIES AND SYMBOL	APPROXIMATE MAXIMUM THICKNESS,M	OCCURRENCE,LITHOLOGY AND WATER-BEARING CHARACTERISTICS
LATE JURASSIC	Iscia Baidoa Suite; J_3 bd	870	Occupies part of the Bay Region adjacent to the northwest side of the Bur area; karstic limestone, marl,clay, and sandstone yield water of generally good chemical quality to most project wells in the Bay Region. Average depth of the wells is 123 m.
PRECAMBRIAN, UNDIFFEREN-TIATED	Metamorphic and igneous massif, undifferentiated; Pcm	Undeter-mined	Occupies a large part of the central Bay Region forming the Bur area; granitic gneiss, schist, amphibolite gneiss and schist, quartzite,marble, and related siliceous metamorphic complex with intrusive stocks and dikes of granitoid to gabbroid composition and pegmatites. Fractured areas of the massif yield water of useable quality but also some highly saline water in other places, not all defined.

Repair or replacement of older structures, and construction of new ones following or prior to each rainfall season will likely be required.

Drilling in the Central Rangelands will continue to be semi-exploratory in nature. Boreholes there are too widely spaced to permit correlation or definition of hydrogeologic systems. Drilling of deep holes near the coast generally results in the interception of the salt-water interface and should be avoided. Wells should not be deeper than sea level when drilled within 20 km of the coast. Boreholes located at higher elevations may have to exceed 200 to 250m to reach groundwater.

Drilling records available from boreholes near larger communities, and from a few oil-exploration boreholes, must be evaluated carefully prior to selecting groundwater borehole sites. Water bearing formations in the Central Rangelands consist mainly of unconsolidated dune sands along the coast, Mudug Beds inland, fractured basalt locally, Karkar Limestone in the northeast, Auradu Limestone in the west and the Jesomma Sandstone in the southwest.

There are many hand-dug wells in use year-round in the Central Rangelands. Development of hand-dug wells must be considered for those areas where bored wells are not feasible. Improvement of existing hand-dug wells may increase seasonal use of the wells and eliminate much of the ever-present contamination. Hand-dug wells will continue to supply a large amount of the water used in Somalia, and the improvement of these wells must be a considered option for future water-resource development.

2.1 Bay Region

The Bay Region is located in the south-central part of Somalia, Figure 2. It covers an area of 40,000 square kilometers. Topographically the area is generally flat with minor undulations. An escarpment trending northeast-southwest across the region separates limestone from Precambrian metamorphic rocks. Some steep-sided washes are cut into the limestone, whereas gentle-sloping alluvial filled channels occur over the metamorphic sequence.

The Bay Region is divided into four political sub-divisions, the Baidoa, Qansaxdheere, Dinsoor, and Bur Akaba Districts. Within the districts, commissioners meet with the villagers to determine the need for wells, and to decide the list of proposed sites. This list of proposed sites is then submitted to the Bay Region Agricultural Development Project (BRADP) for their consideration. After review, BRADP submits a priority list to the CGDP hydrogeologist. The hydrogeologist evaluates the proposed sites on the basis of potential to develop sufficient water of useable quality.

As a result of the early stages of the CGDP, the potential for proper well siting has been increased. This is not to say, however, that these early efforts provide all the necessary data. Some drilling will continue to be exploratory.

Emphasis of drilling activities has therefore been concentrated in the more favorable karstic horizons of the limestone area in the northeastern part of the region. Sixteen wells have been drilled in this region during the period July, 1984 through July 1985. Only two of these wells have failed to intercept water of sufficient quantity and quality for the use intended. A summary of the wells completed, and the pertinent data is shown in Table 2.

Unfortunately, not all wells completed were immediately put into production. Nine wells, drilled prior to July, 1984, were

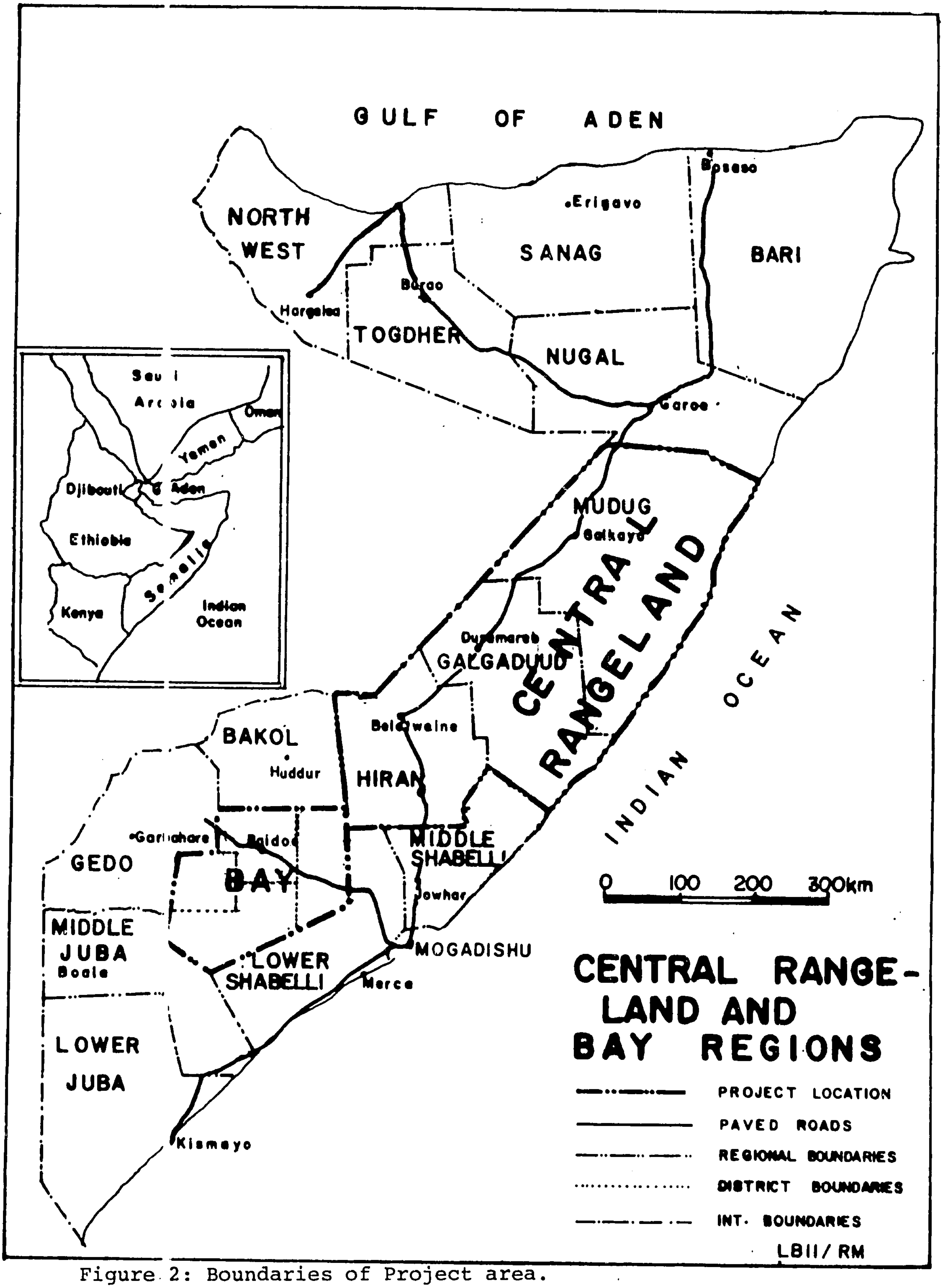


Figure 2: Boundaries of Project area.

Table 2: List of all CGDP Boreholes

Ref. no.	Location	Map Co-ord's Long. (hhmmss)	Map Co-ord's Latit. (hmmss)N	Elevation (m)	Date Completed	Well Depth (m)	Screen depth 1: Start/end 2: Start/end (m)	(m)	Static Water Level (m)	Specific conductivity umhos/cm	Total dissolved solids mg/l	Yield CuM/hr	Specific capacity CuM/hr/M	Pump type	Remarks
B1	Boonkay 1	433900	30700	510	04.02.82	18	0 0	0 0	0	0	0	0	0	0	Abandoned Dry
B2	Bonkay 2	433900	30700	510	27.02.82	231	30 0	201 0	48.5	2300	0	0	0	0	Aband. Observ. Well
B3	Bonkay 3	433900	30700	510	13.04.82	160	74 0	160 0	30	2700	2216	6.6	0.33	m	In Use
B4	Tugerew 1	434230	30701	390	10.06.82	42	6 26	12 32	3	1700	1348	3.7	0.21	h	In Use
B5	Gasarta	434812	30736	350	21.03.82	42	6 0	42 0	12	0	0	0	0	0	Aban. Low Yield
B6	Waraji 1	433230	25448	475	28.03.82	80	6 0	80 0	67	0	0	0	0	0	Aban. Low Yield
B7	Waraji 2	433230	25312	430	29.03.82	39	1 0	39 0	0	0	0	0	0	0	Aband Dry
B8	Tugerew 2	434142	30654	400	29.03.82	48	0 0	48 0	0	0	0	0	0	0	Aband Dry
B9	Bur Halab	440612	30412	280	30.03.82	32	0 0	35 0	0	0	0	0	0	0	Dry
B10	Sarman Dheere	432124	31636	450	10.04.82	85	30 0	50.4 0	12.9	3300	3000	26.6	140.2	m	In Use
B11	Baidoa Aid Comp	433854	30710	460	02.06.82	137	48 0	140 0	7	1500	1360	13.3	28.9	0	Aban - Surface seal
B12	HAREERO JIIFO	432512	31354	478	09.07.82	166	51 0	73 0	29.5	3900	3544	11.4	0.53	M	In use
B13	SHABELLE DUGSILL	4313	31712	420	14.07.82	172	44 0	172 0	11	24000	19772	0	0	0	Aban.Excess.Sal.
B14	Warta Jaffay	430830	319	390	03.08.82	91	2 0	91 0	17.5	10000	9188	0	0	0	Aban.Excess.Sal.
B15	Dansax Dmane	430224	31954	365	19.08.82	174	0 0	174 0	165	24000	16436	0	0	0	Aband. Exc. salinity
B16	Taflow	431124	30354	435	16.08.82	154	72 0	153 0	35.4	1580	1528	11.4	1.69	M	In use
B17	Robay gaduud	431864	24616	440	27.08.82	142	48	88	22.7	1280	1024	11.4	0.2	H	In use

Table 2: List of all CGDP Boreholes

							0	0							
B18	Gaduudo DHuunte	431548	24730	430	29.09.82	73	16	64	23.5	3800	1932	11.4	0.9 M		In use
							0	0							
B19	Buulo fuur 1	4305	25318	435	20.08.82	94	0	94	0	0	0	0	0	0	Aban. Dry
							0	0							
B20	Duri Ali Galle	425554	24954	405	11.10.82	116	82	100	69.4	2000	1816	11.4	0.34 H		In use
							0	0							
B21	Baidoa Aid Compo	433942	30724	460	16.12.82	42	19.6	36.4	8.5	2500	1928	5.5	0 H		In use
							0	0							
B22	Buulo Gaduud	423824	20724	260	04.01.83	189	0	189	0	0	0	0	0	0	Aban.Dry
							0	0							
B23	Kurman	425118	22854	350	10.01.83	148	30	54	20	2400	1868	3.6	0.12 H		In use
							0	0							
B24	Yaaq Baraawe	43146	157	160	24.01.83	10	5	10	1	0	0	0	0	0	Aban.Low yield
							0	0							
B25	Dodole	433354	21818	190	13.01.83	24	17	24	12	900	660	0	0	0	Aban. low yield
							0	0							
B26	SHidallow 1	441612	25336	195	20.01.83	67	3	67	36	33000	32042	0	0	0	Aband. Exc. salinity
							0	0							
B27	Shidallow 2	441612	25336	195	22.01.83	80	2	80	37	34000	33376	0	0	0	Aband. Exc. salinity
							0	0							
B28	Bur Akaba 1	441136	24836	200	25.01.83	54	1	54	22	14000	0	0	0	0	Aband. Exc, salinity
							0	0							
B29	Bur Akaba 2	441136	24836	200	26.01.83	24	1.5	24	7	34000	0	0	0	0	Aband. Exc. salinity
							0	0							
B30	Bur Akaba 3	441136	24836	200	01.02.83	30	1	30	22	42000	0	0	0	0	Aband. Exc. salinity
							0	0							
B31	Bur Akaba 4	44056	24730	200	02.02.83	63	1	63	20	49000	0	0	0	0	Aband. Exc. salinity
							0	0							
B32	Bur Akaba 5	44056	24730	200	15.02.83	89	6	31	17	1140	916	0	0 H		Low yield
							31	89							
B33	Bur Heibi 1	442954	25836	230	10.03.83	26	0	0	18	0	0	0	0	0	ABAN.Low yield
							0	0							
B34	Bur Heibi 2	442600	25848	230	23.02.83	73	8	20	16	1320	952	0	0 H		Low yield
							0	0							
B35	Bur Heibi 3	44260	25836	230	23.02.83	60	2	60	0	0	0	0	0	0	Dry, Abandoned

Table 2: List of all CGDP Boreholes

							0	0							
B36	BUR HEIBI 4	442654	25848	230	15.03.83	25	1 0	25 0	0	0	0	0	0	0	Aban.Dry
B37	BUR HEIBI 5	442654	25848	230	15.03.83	26	1 0	26 0	0	0	0	0	0	0	Abandoned, dry
B39	BUR HEIBI 6	442654	25848	230	16.03.83	36	2 0	36 0	0	0	0	0	0	0	Abandoned, dry
B40	LIMESTONE DEPRES	441524	31112	360	23.02.83	32	1.5 0	32 0	0	0	0	0	0	0	Aban. Dry
B41	DOLONDOLE	441412	3166	480	02.03.83	166	5.4 10.8	10.8 166	1.9	1040	564	0	0	0	Well destroyed
B42	BUULO FUUR 2	4305	25348	435	03.05.83	130	64.5 98	98 130	56.2	2050	1640	11.4	1.73 M		IN USE
CR43	ABOREY 1	465112	35730	435	03.05.83	130	2 0	120 0	0	0	0	0	0	0	Aban.Not deep enough
CR44	AFAR IRDOOD	465124	35930	284	21.05.83	174	37.8 0	81 0	0	0	0	0	0	0	Not deep enough
B45	BAIDOA AID COMP.	433854	30718	460	20.07.83	120	65 0	117 0	6.5	1770	0	10.9	0.22	0	Aban.seal defective
B46	DANSAXDHEERE	425718	25530	405	11.05.83	103	60 0	103 0	30.2	1900	1772	11.4	0.87 M		IN USE
B47	AWSHINI	432330	31212	475	30.06.83	143	56 90	86 143	29.8	3100	2740	11.4	0.72 M		IN USE
CR48	MORE ARI	460212	35130	180	23.06.83	102	60 0	96 0	36	3700	0	0	0	0	PVC casing rupt 45m
CR49	Maxaas Jeejo 1	46106	4406	200	09.09.83	190	9 0	190 0	0	0	0	0	0	0	Dry, not deep enough
CR49	Maxaas Jeejo 2	46106	4406	200	15.10.83	180	6 0	180 0	0	0	0	0	0	0	dry,not deep enough
B50	Bonkay seed farm	433636	31148	510	22.09.83	200	0 0	0 0	30.1	11400	0	11.4	0.21	0	Aband. High salinity
B51	Mintano	433312	32048	490	02.10.83	132	51 99	93 132	40.2	1400	1164	11.3	0.7 H		In use
B52	Maleel	433512	32612	495	07.12.83	130	51 99	93 130	48.5	678	608	25.2	23.77 H		In use
CR53	Aboorey 2	455048	35054	285	11.12.83	133	3	133	0	0	0	0	0	0	Dry,abandoned

Table 2: List of all CGDP Boreholes

							0	0								
B54	Isgeed	433312	32640	490	19.12.83	150	90 120	114 150	37.1	1350	992	17	0.76 M		In use	
B55	Martimoog	432848	33400	490	23.01.84	147	76 120	114 147	32.8	1150	964	22.7	0.03 M		In use	
B56	Jimcada Dheen	442124	24542	175	03.03.84	41	0 0	0 0	0	0	0	0	0	0	Dry Abandoned	
B57	Hagarkaa	431842	25342	470	09.03.84	154	54 0	114 0	0	0	0	0	0	0	Dry Abandoned	
B58	Buur Hakaba 6	440848	24430	190	20.03.84	27	0 0	0 0	20	46000	0	0	0	0	Abandoned saline.	
B59	Shawka	433148	30030	485	18.03.84	138	45.8 91.6	51.6 132	30	13500	10224	11.4	0.27		Awaits investigation	
B60	Kannanax	432460	21224	200	27.03.84	15	9 0	15 0	8.6	0	0	0	0	0	Abandoned low yield	
B61	Hubay	425848	23818	405	05.04.84	152	60 108	108 152	17	2550	1348	3.56	0.1	0	Low yield	
B62	War Caasha	433236	30236	485	29.04.84	201	0 0	201 0	120	1250	1200	0	0	0		0
B63	Bonkay extension	433636	31148	510	30.04.84	153	117 0	147 0	25.6	2200	1476	9.1	0.1 W		Experim. Windmill	
B64	Buulo Yuusuf	432748	30342	480	15.05.84	85	58.5 0	85 0	18.2	2900	2456	15.9	3.6 M		In use	
CR65	Aboorey 3	455048	35954	285	19.05.84	210	3 0	210 0	0	0	0	0	0	0	aban.not deep enough	
B66	Buulo Haawo	430636	30342	415	07.06.84	142	66.2 83	77.4 142	33.5	1825	1408	14.5	0.43 M		In use	
CR67	Wargaloh	473112	61548	205	25.07.84	252	165 178	177 252	100	3200	3156	11.4	0 M		In use	
B68	Dhambaal AAlin	432654	30536	475	26.06.84	126	49 98.5	71 126	17.7	1675	1456	14.1	0.16 M		In use	
B69	Togaal	435536	33124	625	18.07.84	92	37 0	64.5 0	18.7	970	576	15.3	0	0	Low yield	
B70	gariimay	435212	33854	600	16.09.84	135	60 90	72 114	60	0	0	0	0	0		0
B71	Uusle	43306	32342	465	19.08.84	102	50	80	36	0	0	0	0	0		0

Table 2: List of all CGDP Boreholes

							0	0										
CR72	Afgaduudle	435812	55730	125	17.11.84	204	0 0	0 0	17	12000	5245	0	0		0	Aband. Exc. salinity	
B73	Fajir-Lowger	435506	34148	605	12.09.84	4	0 0	0 0	0	0	0	0	0		0	Aband. as directed	
B74	Migdalow	435030	33624	605	13.10.84	130	58 70	64 88	74.7	0	0	0	0		0		0
B75	Labaatan jirow	435054	33136	595	18.10.84	132	60 90	72 108	40.1	0	0	0	0		0		0
B75	Ufurow	425306	24536	395	28.12.84	85	49 0	73 0	49.5	2200	2068	4.7	0.24	H		Replac.Well for WDA.	
B76	Dhuuboy	435300	24130	375	28.12.84	124	52 88	64 100	19.2	3500	2344	15.9	0.51	H			0
B77	Dhorhabay	425548	23354	390	28.12.84	200	0 0	0 0	46.5	0	0	0	0		0		0
CR78	Dajimaale	481300	61830	110	19.01.85	177	56.8 86.8	68.8 176	69.6	4800	6720	12.5	0.33	H		In use	
B79a	Buulo Caddey	424806	25912	315	27.12.84	26	0 0	0 0	0	0	0	0	0		0	Abandoned dry hole	
B79b	Buulo Caddey	424806	30030	315	11.02.85	50	3 18	26 50	0	0	0	0	0		0	Aban. holes	
B80	Tugere Hoosle	425436	23800	395	04.03.85	212	0 0	0 0	57	3900	2248	0	0	H			0
CR81	Budbud	484042	61036	70	11.03.85	60	24 0	60 0	25.9	12000	10128	0.65	0.03	H		In use	
CR82	Saadaal	473048	40642	50	25.04.85	75	46 0	73 0	40.1	6100	4352	10.3	0.93	H		In use	
B83	Misra	432418	23512	390	17.04.85	170	0 0	0 0	21.1	9400	6640	0	0		0		0
CR84	Cagacadde	472260	42442	360	02.06.85	133	0 0	0 0	0	0	0	0	0		0	Abandoned	
B85	Buklaabow	432418	30112	490	30.05.85	130	89 0	106 0	14	2900	2232	0	0		0		0
CR86	Xasan Afrax	470736	40742	290	30.05.85	200	0 0	0 0	0	0	0	0	0		0	Abandoned	
CR87	Cliyabaal	470560	35818	229	09.07.85	250	216	240	220	0	0	0	0		0	Low yield,obser.well	

Table 2: List of all CGDP Boreholes

							0	0								
D88	Koohan Heegan	430400	24000	395	16.06.85	294	0	0	28	4800	3540	0	0	0		0
							0	0								
CR89	Xarardheere	475118	43918	235	20.07.85	28	15	21	13.5	2800	0	0	0	0	Awaiting pump	
							0	0								
B90	BRADP CMPD	433954	38718	460	27.06.85	30	6	18	5.6	790	639	0	0	0		0
							0	0								
B91	Xaarre	433348	33048	500	13.07.85	115	44	50	42	0	0	0	0	0		0
							72	83								
B92	Caasha Fartow	433400	31560	505	18.07.85	120	54	72	46.4	0	0	0	0	0		0
							84	102								
CR93	Calytun	471842	44654	185	00.01.00	0	0	0	0	0	0	0	0	0		0
							0	0								
B94	Baqalley	431312	31418	470	19.07.85	66	48	66	18	1300	980	0	0	0		0
							0	0								
B95	Kurtun	431242	30100	470	00.01.00	0	0	0	0	0	0	0	0	0		0
							0	0								
B96	Qansaxdheere 2	425718	25515	405	00.01.00	0	0	0	0	0	0	0	0	0		0
							0	0								
B97	Toosilow	0	0	0	00.01.00	0	0	0	0	0	0	0	0	0		0
							0	0								
CR	Afgoi	0	0	0	15.04.85	158	96	114	70.2	1958	0	5.45	0.35	0	Awaiting Pump	
							0	0								

Total: 98

put into production with either a hand pump or a diesel driven pump. One well, No. 63 completed during the previous period, was equipped with a Wind Baron, high-performance experimental windmill.

2.1.1 Wells Completed

Data from the 17 wells completed in the Bay Region since July of 1984 are shown in Table 2. With the exception of the well at Ufurow, which was drilled with a cable-tool rig, all were drilled with an Ingersoll-Rand TH-60 rotary rig. The rotary rigs are equipped with a 600 cfm (cubic feet per minute) Gardner Denver compressor, and with an eight-inch stroke Gardner Denver mud pump.

The drilling method employed to depths of 200m, has been to use a 10-inch air-driven percussion hammer bit combined with a very thick foam-transport medium to lift cuttings out of the hole. The hole thus constructed accepts either 8-inch steel or PVC casing and avoids additional time and expense that would be required if the practice of reaming from a 6-inch to a 10-inch hole were continued.

Geologic conditions encountered since July, 1984, have generally been favorable for drilling the hard limestone with a 10-inch air hammer assisted by a foam medium to lift cuttings from the hole. In only one hole was karstifiction found to be sufficiently advanced to cause significant lost-circulation problems. At Usle, No. 69, circulation was lost at about 50 m, but the hole was deepened without return of cuttings to about 102 m. The cuttings lost to the secondary porosity presented no problems to completing the drilling and casing of the hole.

2.1.2 Civil Works

Civil works for those wells equipped with diesel operated pumps consisted of the construction of a storage tank, animal watering troughs, and domestic watering facilities. All of these structures are of concrete cement or combinations of concrete and dressed stone, Figure 3.

Civil works activities in the Bay Region by the CGDP have been curtailed since the beginning of January, 1985, when the responsibility for construction was transferred from the CGDP to BRADP. Civil works activities from July, 1984, to January, 1985, consisted of the completion of facilities at Awshini, No. 47, and partial completion at Isgeed, No. 54, Maleel, No. 52, Dhumbal Aalin, No. 68, Buulo Yuusuf, No. 64, and Marti Moog, No. 55.

In preparation for assuming civil works activities, BRADP has engaged a consulting firm to design civil works for the Bay Region that will utilize local materials as much as possible, and that can be constructed by local contractors. BRADP intends to distribute a tender document shortly after the plans have been received, and reviewed.

2.2 Central Rangelands

The Central Rangelands (CR) area includes the central portion of Somalia from Beled Weine to north of Galcaio, Figure 2. Topographically the area is comprised of undulating dunes along the coast and broad flat plains interspersed with large basins. Rainfall in the CR is sparse ranging from 150 to 300 mm, Figure 4.

The CR encompasses three regions; Mudug, Galguduud and Hiran. Each region is divided into districts that generally include major population centers. Within the Central Rangelands Development Project (CRDP) a district range officer is assigned to each district. This officer works with the local villagers to determine potential well site locations. The primary criteria utilized in well site selection have been the demonstrated need for livestock watering points, and the sociological and ecological suitability. After extensive research by CR personnel in these areas, prioritized sites are submitted to the CGDP hydrogeologist for further consideration. Unfortunately, hydrogeologic data pertaining to the sites are frequently sparse, inadequate, or non-existent.

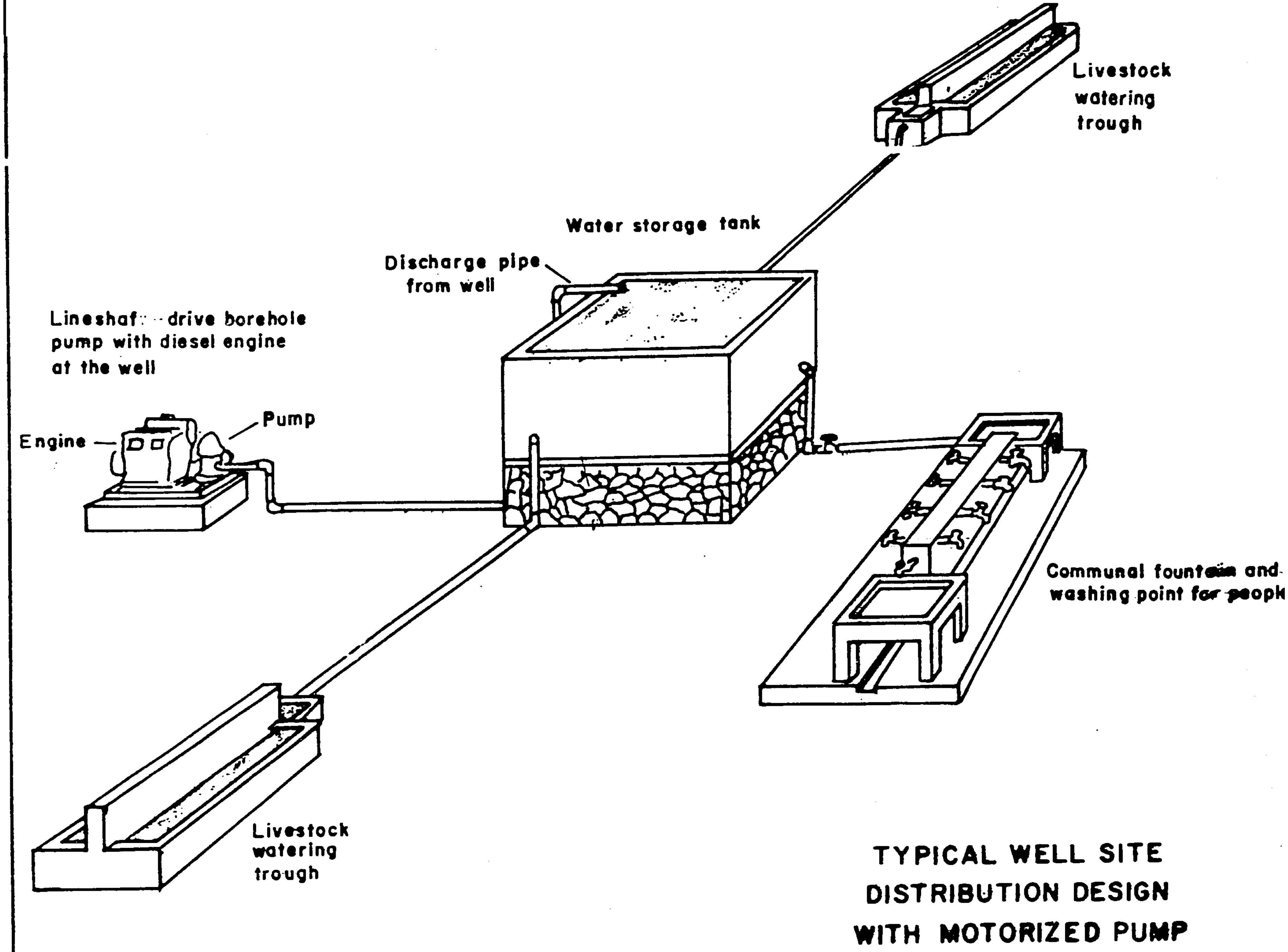


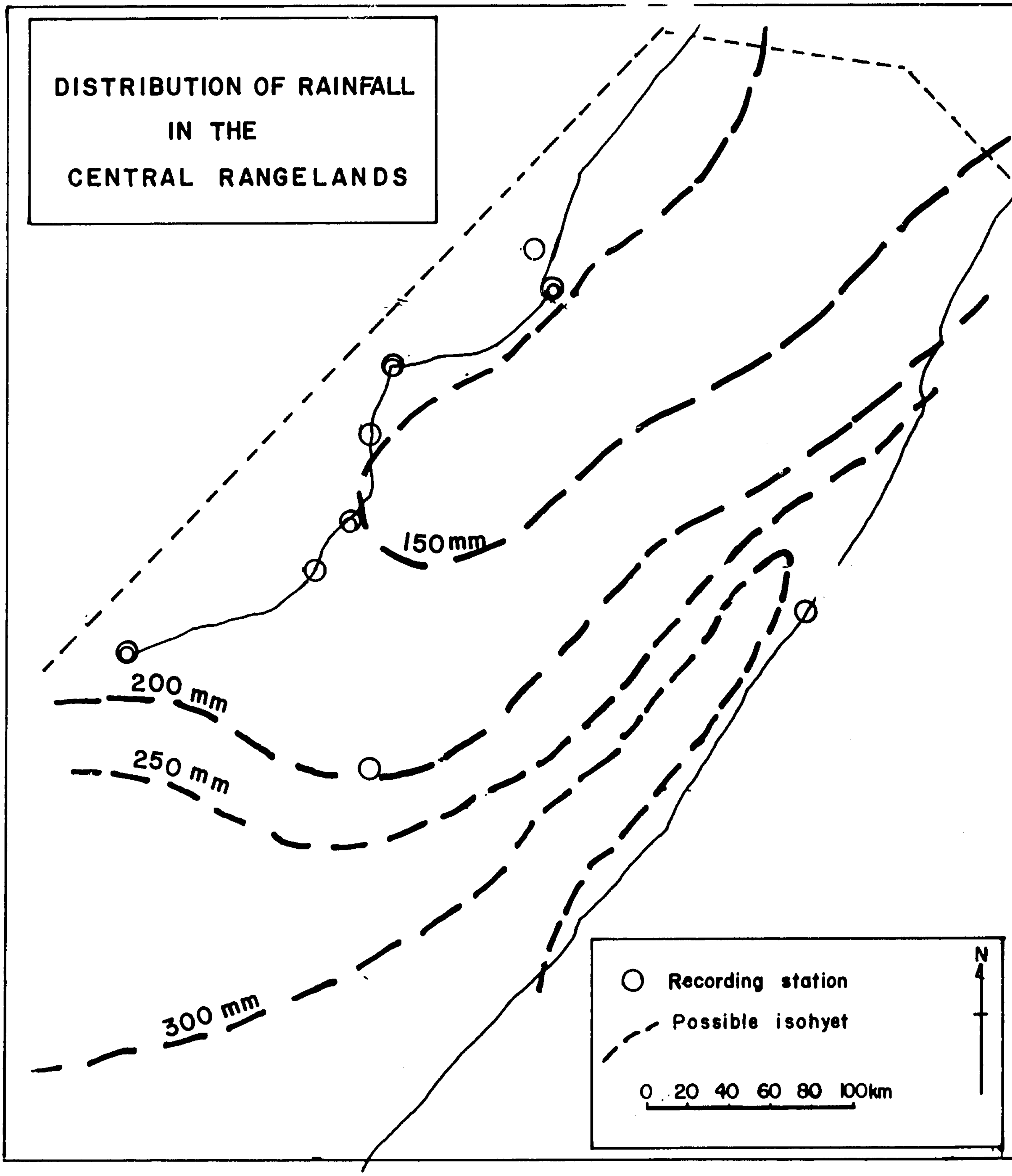
Figure 3: Typical well site distribution system with motorized pumps.

As a result, hydrogeologic suitability including the anticipated depth, quality, and quantity of water has often been considered by the CRDP personnel to be subordinate to socio-logical and ecological considerations. Consequently, boreholes have been attempted in hydrogeologically doubtful areas.

2.2.1 Wells Completed

A total of nine boreholes were drilled in the Central Rangelands between July, 1984 and July, 1985, four in the Hobyo District and five in the El-Dhere district, Table 3. All boreholes were drilled in coordination with the Central Rangelands Development Project (CRDP). A well completed at the Faculty of Agriculture College in Afgoi was also drilled under the CRDP. During drilling operations, an equal emphasis was placed on completing wells for water supply, training of counterpart personnel, and on data collection for future planning purposes. Four of the boreholes are currently in use, one is awaiting pump installation, one was abandoned due to excessive salinity, three were dry, and two are soon to be completed. The drilling and testing results are summarized in Table 3. With the exception of borehole No. 82 at Saddal and borehole No.89 at Xaradheere which were drilled with a cable tool rig, all boreholes were completed with Ingersoll-Rand TH-60 drilling rigs using a combination of air and mud rotary techniques.

Geologic conditions in the Central Rangelands generally are of two types; coastal dune sands, or alternating sedimentary beds of limestone, siltstone and sandstone. Boreholes completed in dune sands were drilled with a cable tool rig because of the shallow depths anticipated. Boreholes completed through the sedimentary rock sequence were drilled using mud rotary techniques. Lost circulation problems in some holes required the use of mud additives. These methods, however did not always prove successful.



From Resource Management and Research
Central Rangelands Survey Vol I, Part 3

Figure 4

2.2.2 Civil Works

Completion of civil works in the CR has been delegated to the CRDP. Unfortunately, only two wells of sufficient quantity and quality were drilled in the CR to warrant construction of civil works. These were at Wargaloh and Dhajimale. Civil works at these sites were not started during the period covered by this report. Materials required for this construction were ordered but not received before July of 1985.

In an effort to expedite completion of the civil works in the CR, the CRDP reportedly ordered prefabricated metal storage tanks and prefabricated animal watering troughs. The logistics of site accessibility and the shortage of native materials for concrete structures supports this decision.

2.3 Drilling Problems

The term drilling problems, as used here, refers to any problems that caused a delay in borehole completion. Some problems such as lack of fuel, lack of oxygen, and counterpart delays were common to both the Bay Region and the CR.

Lack of fuel during the period July, 1984 to July, 1985 has accounted for drilling rig down time ranging between 30 and 60 percent. This only accounts for the time the drill rigs were not working. Additional delays were caused by the necessity of having to redrill those holes that caved during the time the rigs were without fuel. More down time resulted from delays in the delivery of needed materials, such as bentonite, casing, and cement.

Lack of oxygen was an intermittent problem, but one that cumulatively was significatnt. A well cannot be cased unless there is sufficient oxygen to cut the casing to size. In addition, rig repairs and other work requiring bending, and cutting of steel were delayed.

Table 3: Boreholes Completed in the Central Rangelands, July 1984 - July 1985

Ref. no.	Location	Map Co-ord's Long. (hhmmss)	Map Co-ord's Latit. (hmmss)N	Elevation (m)	Date Completed	Well Depth (m)	Screen depth 1: Start/end 2: Start/end (m)	(m)	Static Water Level (m)	Specific conductivity umhos/cm	Total dissolved solids mg/l	Yield CuM/hr	Specific capacity CuM/hr/M	Pump type	Remarks
CR43	ABOREY 1	465112	35730	435	03.05.83	130	2 0	120 0	0	0	0	0	0	0	Aban.Not deep enough
CR44	AFAR IRDOOD	465124	35930	284	21.05.83	174	37.8 0	81 0	0	0	0	0	0	0	Not deep enough
CR48	MORE ARI	460212	35130	180	23.06.83	102	60 0	96 0	36	3700	0	0	0	0	PVC casing rupt 45m
CR49	Maxaas Jeejo 1	46106	4406	200	09.09.83	190	9 0	190 0	0	0	0	0	0	0	Dry, not deep enough
CR49	Maxaas Jeejo 2	46106	4406	200	15.10.83	180	6 0	180 0	0	0	0	0	0	0	dry,not deep enough
CR53	Aboorey 2	455848	35054	285	11.12.83	133	3 0	133 0	0	0	0	0	0	0	Dry,abandoned
CR65	Aboorey 3	455048	35854	285	19.05.84	210	3 0	210 0	0	0	0	0	0	0	aban.not deep enough
CR67	Wargaloh	473112	61548	205	25.07.84	252	165 178	177 252	100	3200	3156	11.4	.0	M	In use
CR72	Afgaduudle	435812	55730	125	17.11.84	204	0 0	0 0	17	12000	5245	0	0	0	Aband. Exc. salinity
CR78	Dajimaale	481300	61830	110	19.01.85	177	56.8 66.8	68.8 176	69.6	4600	6720	12.5	8.33	M	In use
CR81	Budbud	484042	61036	70	11.03.85	60	24 0	60 0	25.9	12000	10128	0.65	0.03	H	In use
CR82	Saadaal	473049	40642	50	25.04.85	75	46 0	73 0	40.1	6100	4352	10.3	0.93	H	In use
CR84	Cagacadde	472260	42442	360	02.06.85	133	0 0	0 0	0	0	0	0	0	0	Abandoned
CR86	Xasan Afrax	470736	40742	290	30.05.85	200	0 0	0 0	0	0	0	0	0	0	Abandoned
CR87	Cliyabaal	470560	35818	229	09.07.85	250	216 0	240 0	220	0	0	0	0	0	Low yield,obser.well
CR89	Xarardheere	475118	43918	235	20.07.85	28	15 0	21 0	13.5	2800	0	0	0	0	Awaiting pump
CR93	Calytun	471842	44654	185	00.01.00	0	0 0	0 0	0	0	0	0	0	0	
CR	Afgoi	0	0	0	15.04.85	158	96 0	114 0	70.2	1950	0	5.45	0.35	0	Awaiting Pump

Other drilling problems were peculiar to the respective areas, and these are described below. Detailed daily records of the delays attributable to these problems were not always available.

2.3.1 Bay Region

Drilling problems associated with the Bay Region, other than lack of fuel, included logistics during the rainy season, lost circulation in highly karstic areas, and lack of adequate utilities in the expatriate compound. Solutions to these problems were found and implemented, but not without resulting delays in operations.

All present drilling in the Bay Region is in limestone, and all holes encounter a certain degree of karst development. Karstification is the term used to describe the development of solution cavities in limestone. In some boreholes the development of solution cavities is so great that rock cuttings resulting from the drilling operation were not returned to the surface. This caused some delay in continuing the hole as cuttings resulting from the drilling operation either fell into the area being drilled or were washed back into the cavities. A potentially serious problem results if these cuttings wash back over the drill bit and prevent removal of the drill rod. Operations were generally stopped and the holes cased to avoid loss of equipment and to allow for completion of such holes.

The rainy season during the months of April, May, and June was anticipated, and all but one rig was moved out of the area. The one rig allowed to remain was moved to a site felt to be more accessible during the rainy season, however, this also became inaccessible. As a result, one month of drilling time was lost, and other related work had to be abandoned.

Lack of adequate power and water in the expatriate compound in Baidoa forced those individuals living there to return to Mogadishu. Although the drilling crews are trained well enough to carry on drilling activities without expatriate supervision, they have not yet attained efficiency in management of operations. It was estimated that a month of productive activity was lost as a result of these problems. Efforts to resolve these problems did not begin to occur until March of 1985, and results were not realized until June of 1985. Problems in the compound persist.

2.3.2 Central Rangelands

Drilling problems associated with the CR other than those previously described were and continue to be logistics, site selection, and to some degree security. Neither of these are readily solvable by efforts on the part of the CGDP staff.

Logistics with respect to the CR sites refers to distance and access conditions. Most CR sites to date have required one and a half to two days to mobilize equipment and supplies. The roads are mostly sand that creates traction problems for support vehicles, such as fuel trucks, water trucks, and flat bed trucks. Breakdowns and delays from getting stuck in the sand were frequent. Once a breakdown occurred, it required as long as a week to get another vehicle with the required parts and expatriate expertise to recover. The time lost to these problems was considerable. Solutions to the logistics problems involved searching for better routes, changing drivers, and concentrating work effort during the rainy season when the sand becomes firm.

Site selection was a problem in the El-Dhere area where ecological and sociological considerations had to be addressed. Two weeks were lost in the selection of the Sadal site and one week was lost in resolving the locations of three other sites. The problem was solved by continual interaction wtih the CRDP staff. A selection process was initiated that resolves the location of a site before a rig completes the hole on which it is drilling.

Security problems were not as critical as during previous years, however, five days were lost because of potential problems in areas through which the crews must travel. Travel advisories were provided by the U.S. Embassy and the consultants staff were and are required to get travel permits to the Central Rangelands area. This was a problem for which no solution on the part of the CGDP could be offered. All drilling in the CR is staffed with two full time military guards to ward off any potential problems after mobilization.

3.0 HYDROGEOLOGY

An extensive discussion of the hydrogeology was originally presented in the CGDP Phase I Final Report that summarized activities for the first three years of the project. During the past year, additional data have been collected and reviewed. As a result, conclusions based on early data have either been confirmed, rejected, or modified. It is not the intent of this interim report to present an in-depth discussion of hydrogeologic conditions in the two project areas, however because additional data have been collected, and it is the intent of this report to relate the activities of the project over the past year, data collected and interpreted will be briefly discussed. A more comprehensive treatment of the hydrogeology will be presented in a project termination report.

The establishment of a hydrogeologic data collection, storage and retrieval system is one of the major objectives of the CGDP. The initial program of data collection dealt mainly with the Bay Region. Hydrogeologic data from all available sources were collected, and filed for reference in planning hydrogeologic exploration for CGDP in the Bay Region. These data were useful but not definitive as the distance between locations of data points was too great for correlation, and the quality of some older data was judged to be not suitable. Published documents, mainly technical papers in scientific bulletins and investigative reports by governmental and international agencies, have been prime sources of hydrogeologic data and other related information. Most of these sources are listed in the report under selected references. As the exploratory phase of the CGDP progressed, hydrogeologic data from boreholes in the Bay Region and the Central Rangeland were accumulated, analyzed and appropriately filed.

All hydrogeologic data were filed in order of acquisition, boreholes were numbered consecutively with a B-prefix for the Bay Region holes and a CR-prefix for holes in the Central Rangeland. These data were extracted from the files and assembled in tabular form as a preliminary step in preparation of hydrogeologic data for computer processing, storage, and retrieval, Table 2. The bored wells are numbered consecutively in order of operational priority with appropriate designation for location. The completion dates indicate that the boreholes are not finished in order of well number. The borehole locations are shown in Plates 4 and 5.

The well name is generally the name of the nearest community or it may represent a small geographical or grazing locality. Where more than one borehole is located near a community, the name is followed by a number in suffix in order of operational priority.

Map coordinates were to be determined by satellite location methods which are accurate but time-consuming and subject to equipment malfunction or failure. Map coordinates alternatively are determined from 1:250000 - scale and 1:1000000 - scale base maps of the Bay Region and Central Rangelands. Coordinates are given by degrees, minutes and tenths of minutes north latitude and east longitude, Greenwich reference. One minute of longitude and one minute of latitude are about 1.85 kilometers.

Elevation of borehole sites are given in meters above mean sea level. In the absence of physical surveys for elevations, these have been determined from 1:100000 - scale series topographic maps of Somalia. Elevations of borehole sites are approximated to the nearest 5 meters. Completion date of the borehole is the date when the well is ready for pump testing.

Total depth of the bored well is given in meters and is determined by the number of drill rods of known length used to reach the total depth. Total depth is accurate to plus or minus 1 meter.

Intervals screened or perforated refers to the borehole well casing open to that interval of the formation where an aquifer will yield water. Well screen or perforated casing may be used. Where there is no screen or casing, the interval is designated as open hole. All depths and intervals are given in meters.

Static water level in the bored well is determined by measurement with an electrical-contact sounder or with a steel survey tape, and is usually accurate to $\pm$ 0.005 meter. The measurements recorded are made after the well has been developed and or prior to a pump test.

Specific conductivity is a determination of the electrical conductivity of water expressed as the reciprocal of resistance in micromhos per centimeter at 25 degree Centigrade. This measurement is an indication of the dissolved mineral content of water. Limits of specific conductance recommended during this study for use by people and by animals are:

To 3500 micromhos; limit for use by people.
To 7500 micromhos; limit for cattle, goats, and sheep.
To 10000 micromhos; limit for camels.

Well yields are determined by pump testing the well at a constant rate while measuring the decline or drawdown of water level in the well. The yield of a well is the rate at which it was pumped for a 24-hour period without drawing the water level down to the intake level of the pump. The yield is expressed in cubic meters per hour (m^3/hr).

Specific capacity of a bored well is an expression of the yield of the well per meter of drawdown. It is expressed as cubic meters per hour per meter ($m^3/hr/m$) or, simplified as square meters per hour (m^2/hr). It is obtained by the ratio of well yield to drawdown.

The types of pumps used for the bored wells are determined by the well yields. Generally, those bored wells that yield 10 m^3/hr, or more are equipped with motor powered Mono pumps. The depth of the pump in the well is expressed in meters and is predetermined by the pumping test.

The remarks column of Table 2 indicates the use or abandonment of the well and any other information that may contribute to the basic data. Abbreviated notations indicate additional data or information available with respect to that well:

PT - Pump-test data available. These data include pumping rates, water-level drawdown with time, recovery of water level with time after pumping, and plots of water level versus time for determination of aquifer characteristics.

CD - Chemical analysis available. Laboratory analysis of water includes:

PH	Sodium ion
Specific conductivity	Potassium ion
Total dissolved solids	Calcium ion
Total hardness	Magnesium ion
Alkalinity (as mg/l HCO_3)	Chloride ion
	Sulfate ion

These are minimal data that will determine the usefulness of the water; more detailed analyses are not practicable at this time.

GL - Geophysical log available. Whenever possible, downhole geophysical logs consisting of gamma ray, single-point resistivity, caliper and flowmeter were taken. These data are useful in the determination of relative permeability of rock types, presence of potential aquifers, and relative quality of formation water.

3.1 Bay Region

Groundwater development activities in the Bay Region since July, 1984, have been confined to the "Limestone Plateau" area described in LBII RMC Final Report, March, 1985. Data collected over this period confirm the heterogeneous character of the moderately karstified limestone described in the above report. Most of the wells drilled in the limestone have been located where karst features, are expressed at the surface. A few have been located as much as one kilometer from such known features to test the lateral extent of secondary porosity. All such attempts have resulted in wells of low yield. Wells drilled in obvious recharge areas have invariably been the better producers, but are also more susceptible to contamination. The data indicate greater karst development where jointing is more prevalent or where the rock chemistry is more favorable for solution. Karstification does not appear to have progressed sufficiently to provide a pervasive aquifer throughout the limestone plateau area. Additional drilling should help in the evaluation of this condition.

Recharge in the limestone plateau area is directly through the surface exposures of karst features. Although some areas are known to have soils developed as much as 6 meters deep, much of the plateau is covered by a soil mantle of only 0.5 to 4 meters thick. Some recharge occurs through this material from deep percolation. The amount of recharge over the area has not been quantified at this time.

Groundwater movement on the limestone plateau is indicated to be from a northeast-southwest groundwater divide that roughly parallels, but is offset 2-4 km. northwest of the escarpment that separates limestone rocks to the northwest from the basement complex to the southeast, Plate 3 and 6. Along the escarpment this flow is evidenced as intermittent springs at several levels along the face of the escarpment. Flow from these springs forms small streams that disappear over short distances of their course onto the alluvial cover of the basement complex. Flow to the north-western direction is not known to discharge at the surface within the Bay Region.

Since July, 1984 a basal conglomerate overlying the basement complex has been explored for developing water in the Dinsoor District. Four holes have penetrated the conglomerate. Buulo Caddey No. 79 A and B, Tugere Hoosle No. 80, Misra No. 83, and Copen Hegan No. 88. Holes 79A and 79B, both dry holes, encountered the basement complex at 25 meters and 50 meters respectively. Hole No. 83 intercepted the basement at 170 meters. Hole No. 80 has a low yield, and hole No. 83 produced moderate quantities of poor-quality water. Hole No. 88 was stopped at 294 meters, estimated to be within ten meters of the basement complex. Yield was low and the water conductivity was approximately 5100 umhos/cm.

3.1.1 Observation Wells.

An attempt to firmly establish an observation well network to begin collecting long-term data on the response of the aquifer to seasonal changes was initiated in February, 1985. Water levels and quality samples were to be collected from selected wells four times per year; at the beginning and end of the two wet seasons. Table 4 shows the wells and data collected. Data collected from these wells must be continued over a longer period of time to permit recognition of significant hydrologic trends.

Counterpart hydrogeologists were trained in the proper method of measuring and recording this data, and are able, when fuel is available, to proceed with the data collection.

3.1.2 Water Quality

Conductivity values of water developed in the upper karstified limestone of the Bay Region ranged between 970 and 2900 umho/cm. Total dissolved solids ranged from 575 to 2500 mg/l. Reports of analyses on the quality of water collected from the conglomeratic aquifer overlying the basement complex had conductivities ranging from 3900 to 11,000 umho/cm, equivalent to total dissolved solids of 2200 to 6000 mg/l. All analyses indicate sodium is the dominant cation and chloride the dominant anion.

Analytical results should be regarded with caution. Analyses of some samples from the same well have shown wide variations in results without any known changes in aquifer conditions. Cation and anion balances were in many instances greater than normal analytical error would permit.

Groundwater having less than 500 mg/l total dissolved solids is virtually absent in the Bay Region. Better quality water is found localized near the well developed karst recharge areas. There is little chance, however, of finding water of less than 3500 umhos/cm, within the basal conglomerate underlying the limestone plateau. Until the laboratory techniques are brought to a much higher level of accuracy, a definitive assessment cannot be made.

TABLE 4 . WATER LEVELS IN SELECTED MONITORING WELLS
(DEPTH BELOW LAND SURFACE IN METERS)

DATE / LS ELEV.	No.3 Bon-kay	No.16 Taflow	No.18 Gadu-udo Dhunte	No.21 Cmp'd	No.27 Shid-low	No.34 Bur Haibe	No.41 Dolon-dool	No.42 Buula Fuur	No.46 Qansax Dheere	No.47 Aw Shini	No.52 Maleel	No.54 Isgeed	No.56 Bam-basal	No.63 Ext.-Farm	No.64 Beled Xawa	No.68 Dumbal Aalin	No.76 Duboi	No.77 Doreybi
6/5/84														25.18				
23/9/84				8.06														
17/10/84	31.57			7.20														
27/10/84														23.48				
7/11/84	31.00																	
19/11/84				4.58														
2/12/84				4.86														
3/12/84	30.33																	
2/1/85				6.61														
3/1/85	32.19																	
9/1/85																		
10/1/85								57.04								23.27		
31/1/85	33.57																	
2/2/85				7.80														
5/2/85						36.30	3.07											
7/2/85															33.92			
8/2/85																		
9/2/85			25.43						30.28								19.13	26.15
19/3/85		34.65	26.40		32.50													
20/3/85										33.10								
4/4/85	34.30																	26.09
12/4/85									30.49									
20/5/85											49.14							

3.1.3 Geophysical Data

Geophysical data have been collected from four holes since July, 1984. One logging unit was repaired in late February, 1985, and field tested on holes at Dhorhaby No. 77 and Togeere Hoosle No. 80 in early March. The objectives of the test were to field test the equipment, and to train expatriates and Somali counterparts in its effective use. All probes were field tested in the two holes. Repeat logs were run with selected probes at different scales to examine methods of log enhancement and to check reproducibility. Training was focused on two Somali counterparts, Abdullahi Mohamed Jama and Saleh Farah Mohamed, each of whom has had previous experience with the equipment.

Logs from the two holes, 4 km. apart, failed to reveal marker beds sufficiently clear to correlate stratigraphy. Neither hole was in material sufficiently karstified to define porous or permeable zones with the logging tools available; gamma-ray, spontaneous potential resistivity, flowmeter, caliper, and temperature differential. Togeere Hoosle, No. 80, provided a well-defined contrast in stratigraphy on the gamma-ray, resistivity, and spontaneous potential logs.

When Misra, No. 83 was completed, the untested logging unit was dispatched to run a series of logs. The operator, trained on holes No. 77 and No. 80, could record on Misra No. 83 only a single value response with the runs attempted, and the unit was returned to Mogadishu to determine if the failure was due to malfunction of equipment or to operational error.

The geophysical logging equipment was returned to the Bay Region 22 June 1985, and Copan Hagan, No. 88, was logged the following day. Gamma-ray, resistivity and spontaneous potential probes and modules were operable and produced a log of which resistivity displayed the better definition. The gamma-ray and spontaneous potential responses were discernible, although they could have been improved by magnifying the scale.

3.2 Central Rangelands

Several publications, particularly the monographs "Groundwater Resources in Central Somalia", (Pozzi, Benvenuti, Mohamed, and Shuriye, 1983), and "Groundwater Resources in the Hobyo Area", (Pozzi and Mohamed, 1984), have contributed significantly to the understanding of the hydrogeology of the Central Rangelands. Revisions have been made in the conceptual model of groundwater resources in the Central Rangelands based on these publications, and on data from the drilling program.

The Central Rangelands consists of a broad central plateau, a narrow coastal plain, and the Shabelle River drainage. The central plateau ranges in elevation from 50 meters to 700 meters above sea level and is covered with lateritic soils and caliche. The coastal plain is covered by recent aeolian sediments and ranges in elevation from sea level to 50 meters. The Shabelle floodplain, in the southern portion of the Central Rangelands is covered with recent alluvium and ranges in elevation from 100 to 200 meters above mean sea level.

The Central Rangelands has an arid to semi-arid climate with a range in mean annual rainfall from approximately 100 mm in the north to 300 mm in the south (Resource Management and Research, 1984). The potential evapotranspiration for the Central Rangelands is approximately 2225 mm/year, (McGowan etal, 1979). This relatively high potential evapotranspiration rate is the result of the high winds, high temperatures, and extensive thorn-bush cover over much of the Central Rangelands, and of the phreatophytes which occur in the wadis. A potential annual water deficit of approximately 2000 mm/year exists throughout the Central Rangelands.

The Central Rangelands extends northeast of the Shabelle River to the Nugal Valley in northeastern Somalia. Marine sediments of mostly Tertiary age, and continental sediments of sub-Recent age cover the surface as part of a large basin. The basin extends through the Ogaden region, east of Beled Weine to Jowhar. The deepest part of the basin, the Hobyo Embayment, is located near Hobyo on the coast of the Indian Ocean, (Barnes, 1976). There have been several transgressive and regressive phases of the sea over the Horn of Africa and sedimentation thicknesses generally decrease inland.

The main structural feature is the long coastal fault, defined by geophysical surveys, which may affect the underflow regimes of the regional aquifers in the Central Rangelands (Johnson, J. 1978). A second fault system, also defined by geophysical surveys located in the strip of Jessoma Sandstone appears to be related to the occurrence of fresh water, (UNDP, 1972, Pozzi and Mohamed 1984). The areal distribution of the geologic formations in the Central Rangelands is shown on Plate 7. Table 5 provides a brief description of the geologic units and the waterbearing characteristics.

Groundwater recharge probably occurs predominately from surface runoff into karst areas, and from direct infiltration through coarse alluvium in the wadis, and through the sand dunes. No direct measurements of soil infiltration capacity, rainfall intensity or rainfall duration are available. Some researchers (Wilson, 1958; Pozzi and Mohamed, 1984; and Parson 1970), estimate that as much as 5 to 10 percent of the annual rainfll infiltrates the groundwater system. A conservative estimate of 5 per cent is used in the central plateau and 10 per cent in the dune areas for purposes of this study. The total land area of the Central Rangelands is 149,000 km^2 (World Bank, 1975). Utilizing an average annual rainfall of 200 mm/year, and a conservative estimate of 5 per cent infiltration, the annual groundwater recharge from direct infiltration is estimated to be 1.5×10^9 m^3/year.

The deep groundwater aquifers in the Central Rangelands, including the Auradu and Jessoma Formations, and the Trap Series basalts, extend into the Ogaden region and into the Ethiopian highlands (Johnson, 1978). These aquifers probably receive significant recharge in their western outcrop areas. Groundwater flow through these units is laterally toward the Indian Ocean. Geologic structure, including the coastal fault and the intraformational basalts may affect the underflow regimes, but the nature of this influence is unknown (Johnson, 1978).

TABLE 5 . CENTRAL RANGELANDS GEOLOGIC UNITS AND WATER BEARING CHARACTERISTICS

EPOCH	SUITE OR SERIES	APPROXIMATE MAXIMUM THICKNESS	OCCURENCE, LITHOLOGY, AND WATER BEARING CHARACTERISTICS
RECENT - PLEISTOCENE	Stream Alluvium Qal	100m	In the flood plain of the Shebelle River and along wadis throughout the Central Rangelands; clay, silt, sand, and coarse alluvium; yields water to shallow (less than 35 m) wells; water specific conductance of less than 3500 umhos/cm found in approximately 10 percent of wells.
	Aeolian sand, sandstone and reef deposits, Qeoltm	120 m	Active and inactive dunes on the eastern coast consisting of well-sorted aeolion sand. Yields small amounts of fresh water to shallow (less than 10 m) wells
PLIOCENE-MIOCENE	Upper Daban Series, N_1-N_2 md	125m	Possible in the eastern portions of Central Rangelands; sandstone, and conglomerate; yields water of variable quality from pore spaces and along bedding planes.
MIOCENE	Mudugh-Merca Suite, N_1 md	500m	Continental sediments covering much of the northern Central Rangelands; limestone, marl, sand, sandstone, gypsum, clay, calcrete, and related Rocks. Yields varying quantities of water from pure spaces, bedding planes, and karst formations Water quality is variable with specific conductance from 3,000 to 30,000 umhos/cm, sulfate concentrations are generally high water;with specific conductance of less than 3000 umhos/cm is found in less than 15 percent of wells

Table 5 (Continued)

MIOCENE PALEOCENE	Trap Series; B P_g-Ni	80m	Forms intraformational flow extending from Dhusamareeb to El-Bur and north to Wargaloh. Basalt and tuff. may be related to the existence of fresh water found during this project.
OLIGOCENE	Middle Daban Series Pg_{3mdu}	800-2000m	Sandstone, siltstone, lenses of boulder conglomerate; generally contains highly mineralized waters.
EOCENE	Lower Daban series Pg_2Id	245m	Sandstone, siltstone, marl, lenses of gypsum and conglomerate; generally contains highly mineralized water.
	Karkar Suite Pg_2Kr	230m	Limestone, minor marl, clayey dolomite, siltstone may contain small amounts of water but not an aquifer of regional importance
	Taleh Suite Pg_2tl	350m	Anhydrite, gypsum, interbedded dolomite and marl; generally contains highly mineralized water in karstified zones.
	Auradu Series Pg_2ar	400m	Outcrops in a band extending through the western part of Galgudud region; massive limestone, dolomitic limestone, dolomite, marl, siltstone; limestone beds are commonly fractured and offer good potential for groundwater storage and development; frequently yields large quantities of fresh water

Table 5 (Continued)

PALEOCENE	Jessoma Suite	200m	In a north-south section east of the Shabelle River and west of El-Bur. Inequigranular cross-bedded sandstone, minor siltstone, and compacted clay; supplies water with specific conductance of less than 3500 umhos/cm to wells and springs but frequently yields only small amounts of water of water due to low effective porosity.
UPPER CRETACEOUS	Beled Weine Suite Cr_2bl	200m	East of the Shabelle River, limestone, marl, gypsiferous shaley clay. Generally contains highly minaralized water at depth.
CRETACEOUS	Mustahil Suite Cr_1ms	180m	West of Shabelle River,gypsiferous siltstone, mudstone, interbedded limestone; karst formations supply water which is genrally highly mineralized, specific contuctance is rarely below 3500 umhos/cm
CRETACEOUS	Marehan Suite Cr_{1-2}-mr	300m	Occurs only at southwestern border of Central Rangelan Generally supplies small amounts of fresh water to wells.

From: UNDP, 1971, Pozzi etal, 1983, Pozzi etal, 1984.

Drilling activities were conducted in two districts of the Central Rangelands; the Hobyo District, which covers the central portion of the Mudug Region, and the El-Dhere District which covers the eastern portion of the Galgadud Region, Plate 5.

The Hobyo district lies mainly within the Hobyo structural basin. Wells were drilled at Wargaloh, No. 67, Afgaduudle, No. 72, Dhajimale, No. 78, and Bud Bud, No. 81. With the exception of the well drilled at Wargaloh, which penetrated Miocene-Paleocene Trap Series Basalts, all of the drilling encountered continental sediments tentatively ascribed to the Miocene Mudugh, Merca or Upper Daban Suites. The presence of gypsum was noted in all wells, and the groundwater in 11 cases indicated that degradation by contact with calcium sulfate had occurred.

Piezometric levels in the wells located in this area do not indicate a gradient towards the Indian Ocean, so it must be assumed that the groundwater occurring at exploitable depths in this region is perched within a surficial basin, and that recharge occurs locally within the basin. The regional groundwater flow system, which presumably involves the Jessoma and Auradu Formations, must lie at depths below the 250 meter capability of project drilling equipment.

All of the four wells attempted in the Hobyo district produced in excess of 375 lpm (liters per minute) at depths of less than 200 meters. Only the well at Wargaloh, however, contained water of suitable quality for human consumption. This well penetrated the Trap Series basalts. Within the sedimentary aquifers of the Hobyo Region, the Upper Duban and Mudugh-Merca, there is no indication that deeper drilling will yield fresh water. Groundwater in the Hobyo district of useable quality and at exploitable depths was found to be negligible.

The volume of groundwater resources in the Hobyo district may be considerable at depth, out unless the equipment is available for very deep drilling into the Auradu, Jessoma Formations, or the Trap Series basalts, the possibilities of developing large quantities of potable water in this area are limited. No water was encountered in the Hobyo district which could be classified as good irrigation water. Water produced at Wargaloh and Dhajimale can be "... used for tolerant plants on permeable soils with careful management practices." (NTAC, 1968). Water of adequate quality for livestock watering was encountered in three of the four wells attempted.

Given the rainfall and recharge conditions in the area there is no assurance that mining of groundwater from bored wells will not occur. Groundwater levels can be expected to decline locally as pumpage increases. Based on the present groundwater data in the district, development of water resources in the Hobyo district should be concentrated on surface-water catchments.

Four boreholes were drilled in the El-Dhere District at Saddal, No. 82, Cagacade, No. 84, Hassan Afrah, No. 86 and Ali Yabaal, No. 87. Only the borehole drilled at Saddal through the coastal dune deposits yields enough water to warrant completion as a producing well. This well, now equipped with a hand pump, was tested at 10.3 m^3/hr. Unfortunately, the quality of water from the well was poor; conductivity was 6100 umho/cm. This quality of water is only suitable for watering camels and cattle.

The borehole drilled at Cagacade lost circulation at 139 m, and was therefore not completed. Pre-drilling hydrogeologic data indicated that even if water were encountered, it would be of unuseable quality. This was one of the well sites drilled at the request of the CRDP for ecological and sociological reasons.

The borehole at Hassan Afrah, No. 86, was drilled to 200 m through sediments of the Daban Series. No indication of water was found in this hole, and estimated depths of potential water producing beds were beyond the capabilities of the drilling equipment. The hole was plugged and abandoned.

The borehole at Aliyabaal was drilled to 250 m, and although potentially deep enough to encounter water producing beds, only minor indications of a water producing zone were found. The well was cased with six-inch diameter steel casing and extensive development was conducted prior to concluding that the hole would not be a production well. The well was capped and left as a potential monitoring well should enough seepage occur with time to provide an indication of depth to water.

3.2.1 Observation Wells

Each of the production wells completed in the CentralRangelands may serve as an observation well. A formal monitoring program for the measurement of water levels and the collection of water samples has not as yet been established in this area. The logistics of accessing these sites is too great to include during the present program. Upon assignment of a WDA hydrogeologist to the respective areas a program will be initiated.

3.2.2 Water Quality

The assessment of the water quality in the Central Rangelands is based on results published in the UNDP Technical Report No.3 (1973), and on data obtained from analyses conducted during this study. The water quality data supplied from the UNDP report were utilized with caution. The ion balances reported indicate that sodium and potassium concentrations were computed by cation and anion differences instead of by analysis. Many of the boreholes sampled for the UNDP report were resampled during this study, however, the accuracy of well identification was suspect in some cases. Recognizing these constraints, an effort was made to characterize water quality conditions in the CR.

The analytical results of the Central Range water sampling are presented in the Annex A. Preliminary maps of Stiff diagrams for boreholes and for hand dug wells were prepared from these data, Plates 8 and 9. These data will be continually revised and assessed throughout the remainder of the project.

The water quality throughout the Hobyo District is poor. Hand dug wells along the coastal plain generally tap fresh water in the discharge area which overlies more saline water. These wells will frequently produce small quantities of relatively fresh water (EC values from 1000 to over 5000 umhos/cm) but, are not able to sustain continuous withdrawal of fresh water (Pozzi, Mohamed 1984). The groundwater along the coastal plain, as indicated on Plate 8, is predominantly sodium chloride water. This trend is evident in both hand dug wells and in boreholes.

Groundwater occurring in a closed basin within the Galcaio area rarely has a specific conductance of less than 3500 umhos/cm. This applies to the shallow hand dug wells and to boreholes extending to depths of 200 meters. The groundwater in this area is characteristic of gypsum; generally dominated by calcium and sulfate. The potential for developing groundwater with specific conductance values below 3500 umhos/cm in this area is poor. The Eocene deposits, which may lie at depths in excess of 300 meters, may contain water with conductivities below 3500 umhos/cm. (UNDP, 1973).

Groundwater quality in both hand dug wells and in boreholes from Dusamareeb southward appears to be a mixture of the two dominant water types. This area has not been as well explored to date as the other districts in the CR.

3.2.3 Geophysical Data

Following the repair work completed on the geophysical logging units in March, 1985, one logging truck was stationed in the Central Rangelands. The boreholes completed at Cagacade, Hassan Afrah, and Aliyabaal were all logged. The Central Rangelands geophysical logging unit was also utilized for the well completed at the Afgoi Agricultural College. Gamma-ray, resistivity and spontaneous potential logs were made and will continue to be routinely performed as additional wells are completed.

The geophysical data collected during the extension phase of the CGDP have been useful for the identification of potential aquifer zones and thus for well design. The available geophysical data were insufficient, however, for correlations of regional stratigraphy. As additional data are collected, it is hopeful that they will also be useful for this purpose.

4.0 INSTITUTIONAL SUPPORT

Institutional support for WDA in an advisory and instructional capacity has been one of the prime objectives of the CGDP. Technical assistance has been provided for the training of professional and technical personnel, for the improvement of planning and financial management, supply and warehouse management, and for chemical laboratory supervision and management. The level of effort for each of these areas was variable and largely dependent upon counterpart participation. The following sections describe the accomplishments in these areas during the period July 1984 to July 1985.

4.1 Training of Technical and Professional Personnel.

The purpose of training by the CGDP has been to provide supervised experience for the development of technical skills necessary to master the technology of modern drilling and support equipment. In addition, training through experience has been provided for improvement of the skills and capabilities of WDA professional, administrative, and management personnel.

The scope of training for WDA personnel has ranged from one-on-one experience through direct supervision, to classroom participation. Participants were not only involved in routine tasks, but in those activities that deviated from the ordinary. Personnel trained have gained experience in handling unusual or changing circumstances in drilling procedures, in equipment and vehicle maintenance, and in administrative and planning procedures.

The educational and experience background of individuals assigned as counterparts to the project are highly varied. This situation, combined with language difficulties of counterparts with expatriate personnel, and lack of counterpart incentives, has made the free flow of information extremely difficult. These conditions apply to mechanics and drillers as well as to professional staff.

Specific training provided since July of 1984 for the various disciplines follow. Training given prior to July of 1984 has been extensively discussed in the Phase I Final Report dated March, 1985.

4.1.1 Hydrogeologist

Twenty hydrogeologists, including chemists and geophysicists, have received training during the project. All have received on-the-job training and classroom training either in-country, in the US or both.

Of the twenty, eight remain in the employ of WDA or the MMWR. Four are enrolled in graduate studies at University of Arizona, others have taken jobs with other donor agencies or have left the country. In addition to the professional level personnel, several young men with technical school training have been brought into the project as assistants to the hydrogeologists. These individuals provide help in the collection and logging of drill cuttings and in the collection of aquifer test data.

During the past year, the eight remaining hydrogeologists and the technicians have received on-the-job training in the collection and identification of drill cuttings; record keeping; well design; well development; pump testing; aquifer analysis; drilling equipment operations; pumping tests and pump installation; hydrogeologic investigations and borehole analyses; water-quality analyses and relation to hydrogeology; borehole geophysical logging methods and analyses; and use of microcomputers.

Formal classroom seminars were planned for the rainfall seasons when access to potential and existing drilling sites became inaccessible due to impassable roads. In the Central Rangeland, however, the cover of wind-blown sand makes access difficult except during the rainfall seasons. Formal classroom seminars were therefore deferred for those drilling crews, support personnel and hydrogeologists assigned to work in the Central Rangelands during the Gu' rainfall season. Classroom seminars were conducted in Mogadishu for drilling crews and support personnel that had been working in the Bay Region where heavy rainfall made existing and proposed drilling sites inaccessible.

In June of 1985, five hydrogeologists were sent to the U.S. Geological Survey training program in Colorado. Attendance at this program served as an incentive for those individuals, and it will allow them to obtain additional intensive training in all aspects of groundwater investigations. This program, and similar programs, will need to be provided to elevate the interest and the level of participation of hydrogeologists. Consideration will need to be given to organizational structure, personnel management, and various compensation schemes to continually improve on-the-job participation. Field experience is essential to an effective application of hydrogeological theory. Somalia has a growing need for developing an internal hydrogeological capability to evaluate and manage its limited water resources.

4.1.2 Drillers

The drilling crew personnel assigned to the CGDP includes 40 to 50 people. A discussion of each individuals duties and progress over the period July 84 to July 85 would be too extensive for this report. There are at present at least six drillers that are able to operate the TH-60 rotary rigs essentially independent of expatriate supervision. Another six individuals are very close to being at this level.

The major weakness of the training program has been the training in planning and decision making capability. Two drillers have been receiving one-on-one experience in this phase of drilling operations, however, they are still reluctant to make a decision without first checking with a member of the consultant's staff. The extent to which they will be able to function totally independent of outside assistance is still an unknown.

During the course of the year, the drilling foreman from each of the rigs has been rotated to a different function or to a different drilling environment. Those that had been trained in air-drilling techniques were moved to rigs employing mud-rotary techniques. One drilling foreman was moved into the Baidoa compound to learn more of the logistics and equipment control, one was placed with the heavy vehicle mechanic for training of rig repair, and one was moved to a driving position with the ultimate objective of training him to drive a drilling rig.

Most of the drillers who have attained a comfortable proficiency with rig operation have been teaching younger men how to operate. All those drillers and crew that were not able to operate during the rainy season were brought to Mogadishu for classroom training. Unfortunately, once in Mogadishu, it was not always possible to bring them all together for such training.

Field conditions in the CR allowed for training of techniques with drilling mud additives and with the use of local materials, such as sawdust, to solve lost circulation problems. Other field problems presented opportunities for training in a variety of well drilling procedures, such as well development techniques, downhole retrieval of drilling tools, pulling casing, setting screen, gravel packing, and well abandonment procedures.

4.1.3 Pump Installers

The pump installation personnel were divided into two groups of seven people; one group to work in the Bay Region and the other to work in the CR. When work conditions require, however, both groups work in the same area. This condition existed during the part of the year when the windmill in Baidoa was being erected. One of the two pump rigs has been modified to allow for independence of operation from other vehicles and equipment, and the other is being prepared for similar modification.

Considerable emphasis was placed on the installation of submersible pumps for testing purposes. The crews were not only instructed in the installation of pumps, but also in the collection of aquifer data. As a result of this experience, one of the operators occasionally serving as assistant hydrogeologist was sent to the U.S. Geological Survey in the United States for additional training. Hopefully, other programs and other incentives can be developed to insure the continuity of a qualified staff. Training programs that can be brought to Somalia to improve the installation, repair and maintenance capabilities of the pump crews are now being sought.

4.1.4 Mechanics

From the inception of the project there have been two groups of mechanic trainees, one group to service light-duty vehicles and one to service heavy-duty vehicles including drill rigs and pump rigs. Although entirely on-the-job training, individuals participating in the program have received a broad range of experience.

Light-duty vehicle mechanics during the period covered by this report have received training in the following repair procedures:

- Routine preventive maintenance.
- Electrical problem troubleshooting.
- Camshaft/timing chains.
- Brake/clutch repair.
- Parts warehousing procedures and use of cardex system.
- Transmission trouble-shooting and repair.

At present there are four counterpart mechanics working on light-duty vehicles; Mohamed Osman Absuge, Abdullahi Ahmed Omar, Suleiman Mohamoud Warsame and Hassan Mire Mohamoud. All are considered assistant mechanics, as they came to the project with little or no previous mechanical experience. The project has been without a counterpart light-vehicle mechanic since March of 1985. The work required has been accomplished very efficiently with the consultant's mechanic and these four assistant mechanics.

Obtaining counterpart heavy-vehicle mechanics has also been a problem. There have been from two to five working with the consultant's mechanic over the duration of the project. During the past year there have been two assigned on a full-time basis and a third for short periods. The third is actually a driller who is being given rig-repair experience with the consultant's mechanic. If this procedure of providing drillers rig-repair experience proves successful, other drillers will be brought in for short periods of training.

The heavy-vehicle counterparts have been receiving a broad range of mechanical experience including but not limited to:

Preventive maintenance.
Transmission repair.
Valve repair and assembly.
Hydraulic systems trouble-shooting and repair.
Brazing and welding.
Mud-pump repair.
Ball-joint and suspension repair.
Injector repair and replacement.

The main difficulties in the training of mechanics has been:

1. They are trained primarily on those systems that break down.
2. They are under pressure to get a particular piece of equipment back into operation, and are often prevented from getting full hands-on experience.
3. They do not have sufficient understanding of English to allow them to use the manufacturers manuals and the parts catalogues.

It is strongly recommended that an English-language training program be provided to all skilled labor counterparts and that a diesel-mechanic and a hydraulics-mechanic training school be established for those attaining a proficiency in English.

The counterpart mechanics have attained a fair level of competence, however, the ability to independently trouble-shoot problems has not been attained. Attainment of this level of expertise will require more time to develop than the remaining project life.

4.1.5 Operation and Maintenance Manuals

In an effort to provide the Somali counterparts with guidelines for continuation of operations upon completion of the CGDP, nine manuals have been prepared. These nine manuals are:

1. Hydrogeologist Manual
2. Pump Testing
3. Water Quality
4. Downhole Geophysical Logging
5. Well Drilling Operations and Preventive Maintenance
6. Evaluation, Rehabilitation and Abandonment of Water Source Points.
7. Pump Rig Operation and Well Maintenance
8. Light Duty Vehicle Preventive Maintenance
9. Warehouse Procedure

All manuals were prepared in English, with Somali translations being provided for most. Some manuals, those prepared by manufacturers and those intended for the professional staff were not translated. The contents of the manuals are self explanatory and need no further discussion. The manuals will be made a part of the WDA library, and will hopefully be utilized by existing and future personnel.

4.2 Recommended Future Training

It is hoped that upon termination of the CGDP, those individuals who received training will be sufficiently motivated and provided enough incentives to continue their learning, and will assist those employees who have not been exposed to the project. In the interest of insuring continuity of effort, appropriate training programs for the various disciplines should be developed. These programs should be short term and preferably be given in Somalia. The problems and conditions existing in-country should serve as the basis for any additional training. All too often, training received in other countries has limited application to the trainees when they return. Conditions in-country are different, and the availability of high-technology equipment is often lacking.

Areas in which additional training for current employees should be considered include; hydrogeologic report preparation, driver education, welding, pump maintenance and repair, and English language. Hydrogeologic report preparation should be taught to those hydrogeologists that have a good grasp of the overall task performed in groundwater investigations. Nearly all publications in Somalia pertaining to groundwater have been prepared by outside consultants. Personnel of WDA should learn how to conduct regional hydrogeologic investigations and how to prepare meaningful reports. With the current available database, regional reports, or other divisional unit reports, should be prepared. These reports should be made available to other agencies and to the general public when large water-using projects are under consideration.

Driver education courses, both classroom and practical, are especially important for those individuals driving heavy duty trucks and the drilling rigs. The large number of vehicle repairs could be significantly reduced by improved driving standards. Transmissions, brakes, tires, etc. could be saved from excessive wear and failure if trained drivers were assigned to the vehicles. This training should extend to preventive maintenance.

Welding techniques should be provided to all drillers and to the mechanics. Some training in welding techniques has been given during the CGDP, however, lack of time and other difficulties prevented a more intensive program. Welding, and associated cutting and bending techniques are an integral part of most drilling operations and of many mechanical repair tasks.

If welding is provided in the curriculum of the local trade or technical school programs, arrangements should be made for drillers and mechanics to attend. Drillers with good welding techniques will save many hours of lost time that result from casing failures and related problems.

Because most of the pump work associated with the CGDP involved installation of new pumps, there were limited opportunities to provide training in the maintenance and repair of pumps. An in-country training program that deals with practical problems and with troubleshooting techniques would be most beneficial.

English-language training should be made a continuous program for all project counterparts. All equipment and vehicles provided are American-made, and all operations and maintenance manuals are written in English. Unfortunately, not all counterparts provided have sufficient working knowledge of English to allow them to research parts and supplies in manufacturers' manuals. Nearly all counterparts, however, express a desire to learn English.

4.3 Planning and Financial Management

Technical assistance in the development of planning and financial management techniques was formally initiated with the arrival of the consultant's economist in March, 1985. Prior to the arrival of this expert, planning and financial management assistance was provided on a limited basis through weekly meetings and periodic discussions. These meetings and discussions, generally between the Team Leader and the Deputy Director of WDA, have been continued, but emphasis on planning and financial management was shifted to a newly created planning unit within WDA.

4.3.1 WDA Planning Unit

As part of the institution building task, a Planning Department was to be established within WDA. Because Presidential approval was needed, the establishment of a Department was delayed. As a compromise, a Planning Unit within WDA was formed, consisting of a Head of Planning and five staff members. In March of 1985, the consultant's economist was assigned to work with the Planning Unit in the use of microcomputer techniques applicable to planning, financial management, and data base storage and retrieval. The computer generated data would then be used for policy decisions.

A Compaq, IBM-compatible microcomputer, and an IBM microcomputer have been installed with requisite software. The economist, with subsequent assistance from a water-resources planner and computer specialist, initiated training in computer operations and in the use of applicable software. All training utilized data available in-country in the development of useable programs for the Planning Unit. Tasks defined for the Planning Unit were set out as projects and prioritized for implementation. These projects included development of computer data bases, cost-analysis models, and technical applications.

Computer data bases: Several types of data have been or are being considered for inclusion in a computer data base program. Five of these were started between March and July, 1985 and include a drilled-wells inventory, a hydrogeological data inventory, a water publications inventory and a human and animal population data base for the Bay Region, Tables 6 and 7.

The drilled-wells inventory will consist of data on all known wells in Somalia. Inquiries from the database will allow lists of wells to be produced according to any characteristics including age and geologic location. In addition, the country has been divided into 26 areas that correspond to two degrees of latitude and two degrees of longitude. This system will enable the Planning Unit to quickly identify drilled wells by areas which correspond to the water publications inventory. The source of the available information was from the files established within WDA. When this data entry has been completed, data from other sources will be added. In addition, a system will be established whereby the data held is routinely verified and updated by WDA regional staff.

The exercise of updating the inventory will be a continuous process, and it is planned to establish formal procedures for supplying this data whenever any borehole is drilled in Somalia. This data will enable WDA to schedule its maintenance and replacement programs, it will facilitate studies of the availability of groundwater in any area relative to the population and demand in those areas, and it will provide the basis of a hydrogeological data base described below.

Bay Region Data Request Location (long. hrs: 45 long. min: 21 long. sec: 24) UTM location East: **** 8 316 + 0.5 Data from Hunting Technical Services Ltd
Name: Sarmaan dhere (lat. hrs: 3 lat. mins: 16 lat. secs: 36) North: 361 361 + 0.5 Survey taken in February/March 1992

	NW East 318 North 365 Strata 3 per sq km.	per 5 km grid	N East 315 North 365 Strata 2 per sq km.	per 5 km grid	NE East 328 North 365 Strata 1 per sq km.	per 5 km grid	Estimated totals per 225 sq km (approx. 8 km radius)	
Estimated numbers of....Cattle	2.1	53	6.3	158	27.	688	Cattle	4968
Goats	12.	313	13.	346	37.	946	Goats	7283
Sheep	0.1	4	1.6	42	1.3	35	Sheep	288
Camels	11.	297	11.	283	12.	307	Camels	2728
Donkeys	0	0	0.0	0	0.0	2	Donkeys	14
Horses	0	0	0	0	0	0	Horses	0
Permanent Houses	0	0	1.3	33	3.9	100	Permanent No.	731
Impermanent Houses	0	0	0.5	15	3.4	87	Impermanent No.	624
% Cropland		0%		6%		72%	% Cropland	57%
Estimated water demand..Low (CM per day)	0.3	10	0.5	14	1.3	34	Low demand	264
High	0.7	20	1.4	36	3.8	96	High demand	724
Estimated Wet wars:	0	0	0.0	0	0.3	9	Wet wars:	62
Dry wars:	0	0	0.0	2	0.6	15	Dry wars:	189
Wells:	0.0	0	0.3	2	0.0	1	Wells:	7

	W East 318 North 360 Strata 1 per sq km.	per 5 km grid	Selected East 315 North 360 Strata 1 per sq km.	per 5 km grid	E East 328 North 360 Strata 1 per sq km.	per 5 km grid	Estimated totals per 5 km radius based on central grid only:	
Estimated numbers of....Cattle	27.	688	27.	688	27.	688	Cattle	2135
Goats	37.	946	37.	946	37.	946	Goats	2973
Sheep	1.3	35	1.3	35	1.3	35	Sheep	108
Camels	12.	307	12.	307	12.	307	Camels	954
Donkeys	0.0	2	0.0	2	0.0	2	Donkeys	6
Horses	0	0	0	0	0	0	Horses	0
Permanent Houses	3.9	100	3.9	100	3.9	100	Permanent No.	313
Impermanent Houses	3.4	87	3.4	87	3.4	87	Impermanent No.	273
% Cropland		72%		72%		72%	% Cropland	72%
Estimated water demand..Low (CM per day)	1.3	34	1.3	34	1.3	34	Low demand	106
High	3.8	96	3.8	96	3.8	96	High demand	302
Estimated Wet wars:	0.3	9	0.3	9	0.3	9	Wet wars:	27
Dry wars:	0.6	15	0.6	15	0.6	15	Dry wars:	46
Wells:	0.0	1	0.0	1	0.0	1	Wells:	2

	SW East 318 North 355 Strata 1 per sq km.	per 5 km grid	S East 315 North 355 Strata 1 per sq km.	per 5 km grid	SE East 328 North 355 Strata 1 per sq km.	per 5 km grid	Estimated totals per 12km radius based on 9 grids shown:	
Estimated numbers of....Cattle	27.	688	27.	688	27.	688	Cattle	5929
Goats	37.	946	37.	946	37.	946	Goats	14643
Sheep	1.3	35	1.3	35	1.3	35	Sheep	579
Camels	12.	307	12.	307	12.	307	Camels	5496
Donkeys	0.0	2	0.0	2	0.0	2	Donkeys	26
Horses	0	0	0	0	0	0	Horses	0
Permanent Houses	3.9	100	3.9	100	3.9	100	Permanent No.	1472
Impermanent Houses	3.4	87	3.4	87	3.4	87	Impermanent No.	1254
% Cropland		72%		72%		72%	% Cropland	57%
Estimated water demand..Low (CM per day)	1.3	34	1.3	34	1.3	34	Low demand	531
High	3.8	96	3.8	96	3.8	96	High demand	1456
Estimated Wet wars:	0.3	9	0.3	9	0.3	9	Wet wars:	124
Dry wars:	0.6	15	0.6	15	0.6	15	Dry wars:	328
Wells:	0.0	1	0.0	1	0.0	1	Wells:	15

Table 7: Sample from Data Base Program.

Map of BAIGOA Population Strata Codes on 5 km UTM Grid (derived from Huntings ERADP Vol. I)

N\E	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375	380	385	390	395	400	405	410	415	420	425	430	435	440	445	450	455	460
395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	20	20	20	0
385	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	26	26	20	0
380	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	20	26	26	20	0
375	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	2	3	3	3	3	3	3	3	2	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	20	20	20	20	0
370	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	2	2	2	2	2	3	2	2	2	2	1	4	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	20	20	20	20	0
365	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	2	2	2	2	2	3	2	1	1	1	4	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	20	20	26	20	20	0
360	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	2	2	2	2	2	1	####	1	1	1	1	1	1	1	4	4	4	4	4	24	26	26	24	4	4	4	4	4	4	4	20	20	20	20	20	0
355	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	4	4	4	23	23	26	24	24	24	24	26	26	4	4	4	20	20	20	26	20	20	0
350	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	4	4	-23	23	24	10	16	26	24	25	26	26	26	26	20	26	26	20	20	20	20	20	0
345	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	24	23	23	24	24	16	10	16	26	26	26	26	26	26	26	26	20	20	20	20	26	20	0
340	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	1	1	2	2	2	2	1	1	1	1	1	1	24	23	23	10	24	16	16	10	26	26	26	26	26	16	16	26	26	20	20	26	26	20	0
335	0	0	0	0	6	6	6	6	6	5	5	2	2	2	2	2	1	1	2	2	2	2	2	1	1	1	7	7	7	24	16	16	10	10	16	10	26	26	10	26	16	16	16	16	16	20	20	26	26	20	0
330	0	0	0	0	6	6	6	5	5	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	7	7	7	7	10	10	10	16	10	10	10	10	12	12	10	16	10	10	16	16	16	16	29	26	20	0
325	0	0	0	0	6	6	6	6	6	5	2	2	2	1	2	2	2	2	2	2	2	1	1	1	7	7	7	7	10	10	10	10	10	10	16	10	10	10	10	10	16	10	17	17	16	16	16	20	20	20	0
320	0	0	0	0	6	6	6	6	5	5	2	2	2	1	2	2	2	2	2	2	2	1	1	1	7	7	7	7	10	10	10	10	12	10	16	10	10	10	10	10	12	12	12	17	17	16	16	16	26	20	0
315	0	0	0	0	6	6	6	5	5	2	2	2	1	1	1	1	2	2	2	2	1	1	1	7	7	7	7	9	9	10	10	16	10	10	16	10	10	12	10	10	10	10	10	17	17	16	16	20	25	20	0
310	0	0	0	6	6	5	5	5	2	1	1	2	1	1	1	1	2	2	1	1	1	1	7	7	9	9	9	9	9	9	9	10	16	10	16	10	10	10	10	10	10	10	17	17	17	27	16	20	20	26	0
305	0	0	0	6	6	5	5	5	5	1	1	1	1	2	1	2	2	1	1	1	7	7	7	7	9	9	9	9	9	9	10	16	10	16	10	10	10	12	12	10	12	17	17	27	27	27	16	16	20	26	0
300	0	0	0	6	5	5	2	2	1	1	1	2	2	2	2	2	1	1	1	7	7	7	7	9	9	9	9	9	9	9	10	10	16	16	16	16	10	10	10	10	17	27	17	27	27	27	27	27	27	27	0
295	0	0	0	5	5	2	2	1	1	2	2	2	2	2	2	0	1	1	7	7	7	9	9	9	9	9	9	10	9	9	9	9	9	9	10	10	10	10	10	10	17	27	27	16	27	17	27	27	27	27	0
290	0	0	0	5	2	2	2	2	1	2	2	2	2	0	0	0	0	7	7	9	9	9	9	9	9	12	9	9	9	9	9	9	9	9	10	10	10	10	16	16	10	27	27	27	17	17	17	17	27	27	0
285	0	0	0	2	2	2	2	2	2	2	2	2	0	0	6	7	7	7	9	9	9	9	9	9	9	9	12	9	9	9	9	9	9	9	9	10	10	10	10	27	10	17	27	27	17	10	10	16	17	17	0
280	0	0	0	2	2	2	2	2	2	2	2	2	0	0	7	7	7	9	9	9	9	9	9	12	9	9	12	9	9	9	9	9	9	27	9	10	10	27	27	27	27	29	17	17	17	17	16	10	10	10	0
275	0	0	0	2	2	2	2	2	2	2	0	0	0	7	7	7	9	9	9	9	9	9	9	12	9	9	12	9	9	9	9	9	9	27	27	27	27	27	27	27	27	29	29	17	17	17	17	16	10	10	0
270	0	0	2	2	2	2	2	2	2	0	0	0	0	7	7	9	9	9	9	9	9	9	9	12	9	9	9	12	9	9	12	9	9	9	27	27	27	27	27	27	25	29	29	10	10	17	17	17	17	19	0
265	0	0	2	2	2	0	2	0	0	0	0	0	0	7	9	9	9	9	9	9	9	9	9	9	12	9	9	12	9	9	12	12	27	27	27	27	27	25	27	27	25	29	29	10	10	10	10	10	19	19	0
260	0	0	2	2	0	2	6	0	0	7	7	7	7	7	9	9	9	9	9	9	9	9	9	9	9	12	9	9	12	9	9	12	12	27	27	27	25	25	25	25	25	29	29	17	17	17	10	19	19	19	0
255	0	0	2	0	2	2	6	6	6	7	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	12	9	9	12	9	9	9	12	27	27	27	25	25	25	25	25	29	29	17	17	17	19	19	0	0	0
250	0	0	6	2	2	6	6	13	13	13	13	9	9	13	9	9	9	9	9	9	9	13	9	13	12	9	9	9	12	9	9	9	12	25	25	27	25	25	25	25	25	29	29	17	17	10	0	0	0	0	0
245	0	0	2	2	2	2	0	13	13	13	13	13	13	13	13	9	9	13	13	13	9	13	13	13	12	12	12	9	12	12	9	12	12	25	25	25	25	25	25	25	25	25	29	29	0	0	0	0	0	0	0
240		0	2	2	2	2	9	0	6	15	13	13	13	13	13	9	9	9	13	13	13	13	13	12	12	12	12	12	12	12	12	12	12	25	25	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0
235	0	0	2	2	2	2	9	15	15	13	13	13	13	13	13	13	9	9	13	13	13	12	13	12	12	12	12	12	12	12	12	25	25	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0
230	0	0	20	2	15	0	0	15	15	13	13	13	13	13	13	13	9	9	15	13	13	13	13	12	12	12	12	25	25	25	25	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0
225	0	20	20	20	15	0	15	15	15	13	13	13	13	13	13	13	9	9	15	15	11	11	13	12	12	14	14	14	25	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	20	20	0	20	15	15	15	15	13	13	13	13	13	13	9	9	15	11	11	11	11	11	11	11	11	14	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	6	20	15	15	15	15	20	13	13	13	13	15	15	15	15	11	11	11	11	11	11	11	11	11	14	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	2	20	20	20	15	15	15	20	15	13	15	15	20	20	15	15	15	15	11	11	11	11	11	14	14	14	14	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205	0	20	20	15	15	20	20	22	20	15	15	20	20	15	15	15	15	15	20	11	14	14	14	14	14	14	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	15	15	20	20	20	20	15	20	20	22	22	20	20	20	20	20	14	14	14	14	14	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	20	20	22	20	22	20	20	22	22	22	22	21	21	21	21	22	22	14	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	22	20	22	22	22	20	22	20	22	22	21	21	21	21	22	22	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	22	22	22	22	20	20	20	22	22	21	21	21	21	21	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	22	22	22	20	20	20	20	22	21	21	21	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	22	22	20	20	20	22	21	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	22	20	22	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0

A hydrogeological data base was developed from existing WDA data and from data generated during the CGDP. This data will provide information on a number of parameters as shown in Table 2. This information will be vital to the planning of any new drilling in the country.

A water publications inventory will be developed on the same grid base as the well inventory. It will allow the Planning Unit to identify what studies, and thus what water information, are available for any area. This inventory will include the last known location of the available publication.

Human and animal population census data presently available from the BRADP and NRA studies will provide information needed for the estimation of water requirements in various areas of the country. As additional and revised information becomes available the data base will be updated.

Cost analysis models: Two cost analysis models have been prepared to date, a drilling and well-installation model, and a well-maintenance and amortization model. The drilling and well installation model has been set up on the computer, incorporates over 120 variables, giving detailed costs of the installation of wells by WDA, Table 8. The model provides vehicle use and manpower budgets required for any given program of well installation; it provides for the distinction between Somali Shilling costs and foreign currency requirements for a program covering a number of years; and it allows for an anticipated inflation rate. The model has been used to support WDA's submission of project plans for 1986-88 to the Ministry of National Planning. This model would also be useful in determining contract prices for well installations undertaken by the private sector on behalf of WDA.

The well-maintenance and amortization model is being set up to give details of the recurrent costs of operating and maintaining a WDA well. Besides the ability to schedule and accurately assess the cost of operation and maintenance in future years, this model also gives the NPV (Net Present Value) and IRR (Internal Rate of Return) of well installation projects.

TABLE 8: Sample of cost Analysis Program Results.

Table 9: Summary Cost of Installing Production Well

Note	# Cost (So.Sh.)	Cost (US$)	US$ equiv.
1 Hydrogeology	16,605	500	705
2 Drilling	118,973	24,010	25,479
3 Logging	6,412	233	312
4 Well testing	24,749	740	1,046
5 Civil Works	73,224	6,000	6,904
6 Pump Installation	29,840	16,760	17,128
Grand Totals	269,803	48,243	51,574

Note	Labour	Materials	Transport
Hydrogeology	43		662
Drilling	221	13,100	12,158
Logging	6		307
Well testing	25		1,020
Civil Works	115	5,023	1,766
Pump Installation	25	15,500	1,603
Grand Totals	435	33,623	17,516
			51,574

Table 10: Production Well Vehicle Cost Analysis

	Drill Rig	Pump Rig	Fuel Truck	Water Truck	Heavy Veh.	Light Veh.	Logging Veh.
Hydrogeology	0	0	0	0	0	250	0
	0	0	0	0	0	250	0
	0	0	0	0	0	162	0
Drilling	3,750	0	320	750	260	375	0
	3,750	0	320	750	260	375	0
	643	0	63	236	63	243	0
Logging	0	0	0	0	0	0	117
	0	0	0	0	0	0	117
	0	0	0	0	0	0	73
Well testing	0	270	0	0	0	·100	0
	0	270	0	0	0	100	0
	0	215	0	0	0	65	0
Civil Works	0	0	0	0	542	208	0
	0	0	0	0	542	208	0
	0	0	0	0	131	135	0
Pump Installation	0	270	0	0	260	100	0
	0	270	0	0	260	100	0
	0	215	0	0	63	65	0
Total	3,750	540	320	750	1,062	1,033	117
	3,750	540	320	750	1,062	1,033	117
	643	431	63	236	257	678	73
Capital recovery	7,572						
Spares/maint.	7,572						
Fuel	2,372	17,516					

Table 11: Summary Cost of Installing Exploratory Well

Note	# Cost (So.Sh.)	Cost (US$)	US$ equiv.
Hydrogeology	16,605	500	705
Drilling	92,135	14,700	15,837
Logging	6,412	233	312
Grand Totals	115,152	15,433	16,855

Note	Labour	Materials	Transport
Hydrogeology	43	0	662
Drilling	153	7,040	8,644
Logging	6	0	307
Grand Totals	202	7,040	9,613
			16,855

Table 12: Exploratory Well Vehicle Cost Analysis

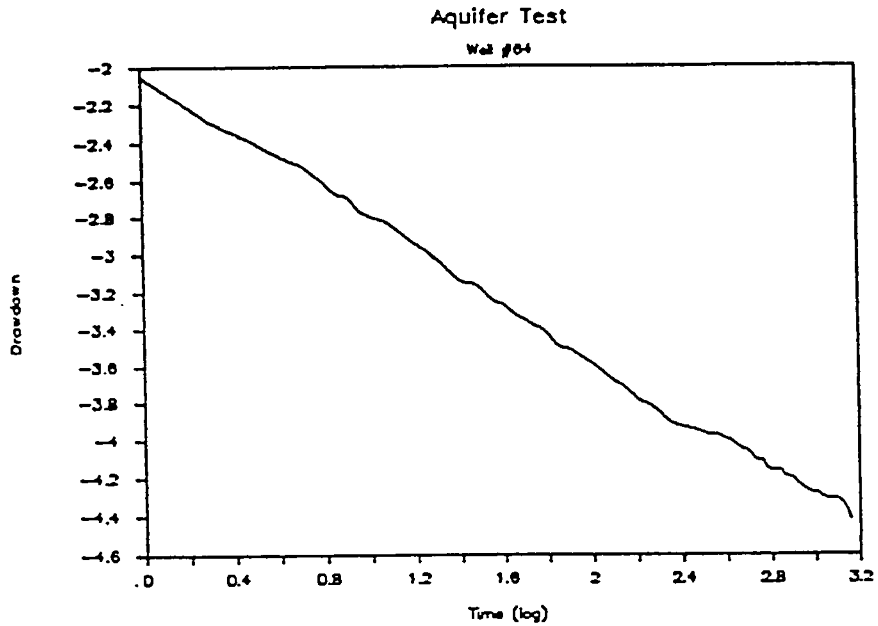
	Drill Rig	Pump Rig	Fuel Truck	Water Truck	Heavy Veh.	Light Veh.	Logging Veh.
Hydrogeology	0	0	0	0	0	250	0
	0	0	0	0	0	250	0
	0	0	0	0	0	162	0
Drilling	2,500	0	320	500	260	250	0
	2,500	0	320	500	260	250	0
	539	0	63	157	63	162	0
Logging	0	0	0	0	0	0	117
	0	0	0	0	0	0	117
	0	0	0	0	0	0	73
Total	2,500	0	320	500	260	500	117
	2,500	0	320	500	260	500	117
	539	0	63	157	63	324	73
Capital recovery	4,197						
Spares/maint.	4,197						
Fuel	1,220	9,613					

Technical applications. In addition to the many planning functions that will be facilitated by data generated from the microcomputer programs, many technical applications will also be possible. Two computer systems that have already been utilized are a program that plots and calculates aquifer-test data and one that plots Stiff diagrams of chemical data, Figures 5 and 6. Several related programs are planned for the computer that will be implemented as time permits.

A second microcomputer is due to be installed in September 1985, thereby doubling the data-processing capability of the Planning Unit. At that time, it is planned to hold a further training course on the operation of the computer for additional WDA staff yet to be identified. The present staff of the Planning Unit are expected to be competent to conduct this training course.

Socio-economic Studies. Valuable socio-economic data were collected from villages in the Bay Region where wells were installed in the early years of the CGDP. Unfortunately, both the data collection, and the Tuulo Village Assessment and Participation Process, TVAPP system, ceased to function by early 1984. The project extension provides for a 3-month visit by an LBII consultant sociologist to train members of the Planning Unit and to establish procedures for the on-going collection of data. Dependent upon the availability of staff from the Bay Region poroject, it is also hoped to resume a more modest form of the TVAPP system. This work is planned for the start of the second half of the extension period.

For the foreseeable future, this effort will concentrate on the Bay Region, with additional data gathered from the well-sites in the Central Range area. In the future, if resources become available and more staff are trained, the data collection can be extended to other regions of the country.



1200	3.0791812	22.48	-4.3!	-13.27127	9.4813571	18.5761
1260	3.1003705	22.48	-4.31	-13.36259	9.6122975	18.5761
1320	3.1205739	22.50	-4.33	-13.51208	9.7379816	18.7489
1380	3.1398790	22.54	-4.37	-13.72127	9.8588406	19.0969
1440	3.1583624	22.59	-4.42	-13.95996	9.9752536	19.5364

EXY,EXX,EYY = 512.27028 319.22001 859.9244

n = 64

X' = 2.0717444 Y' = 3.6115625

Exx = EXX - nX'X' = 44.524001

Eyy = EYY - nY'Y' = 25.147843

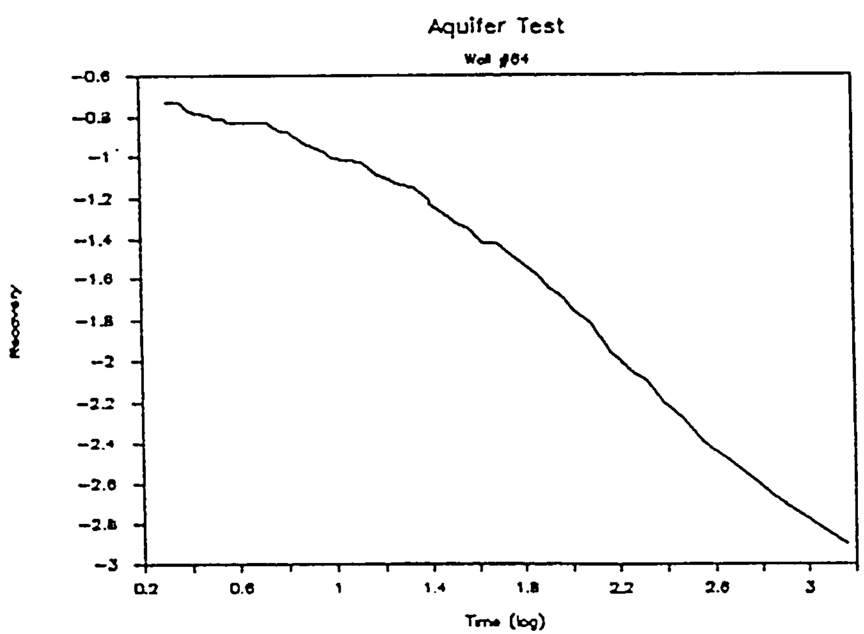
Exy = EXY - nX'Y' = 33.407269

Q = 4.5 x10(-3) = 0.0045

Slope = Exy/Exx = 0.7503204

Correlation coefficient = Exy/sqrt(ExxEyy) = 0.9983745

T = 2.3*Q/4*pie*slope - 1.0977000 x 10(-3)



1140	2.2631578	0.3547148	0.73	-0.73	-0.258941	0.1258226	0.5329
1200	2.2	0.3424226	0.73	-0.73	-0.249958	0.1172532	0.5329
1260	2.1428571	0.3309932	0.73	-0.73	-0.241625	0.1095565	0.5329
1320	2.0909090	0.3203351	0.73	-0.73	-0.233844	0.1026146	0.5329
1380	2.0434782	0.3103700	0.73	-0.73	-0.226570	0.0963295	0.5329
1440	2	0.3010299	0.73	-0.73	-0.219751	0.0906190	0.5329

EXY,EXX,EYY = 116.27090 123.10238 113.3019

n = 63

X' = 1.1715902 Y' = 1.2201587

Exx = EXX - nX'X' = 36.627093

Figure 5 : Sample of Aquifer Data Plot.

Eyy = EYY - nY'Y' = 19.508298

Exy = EXY - nX'Y' = 26.210760

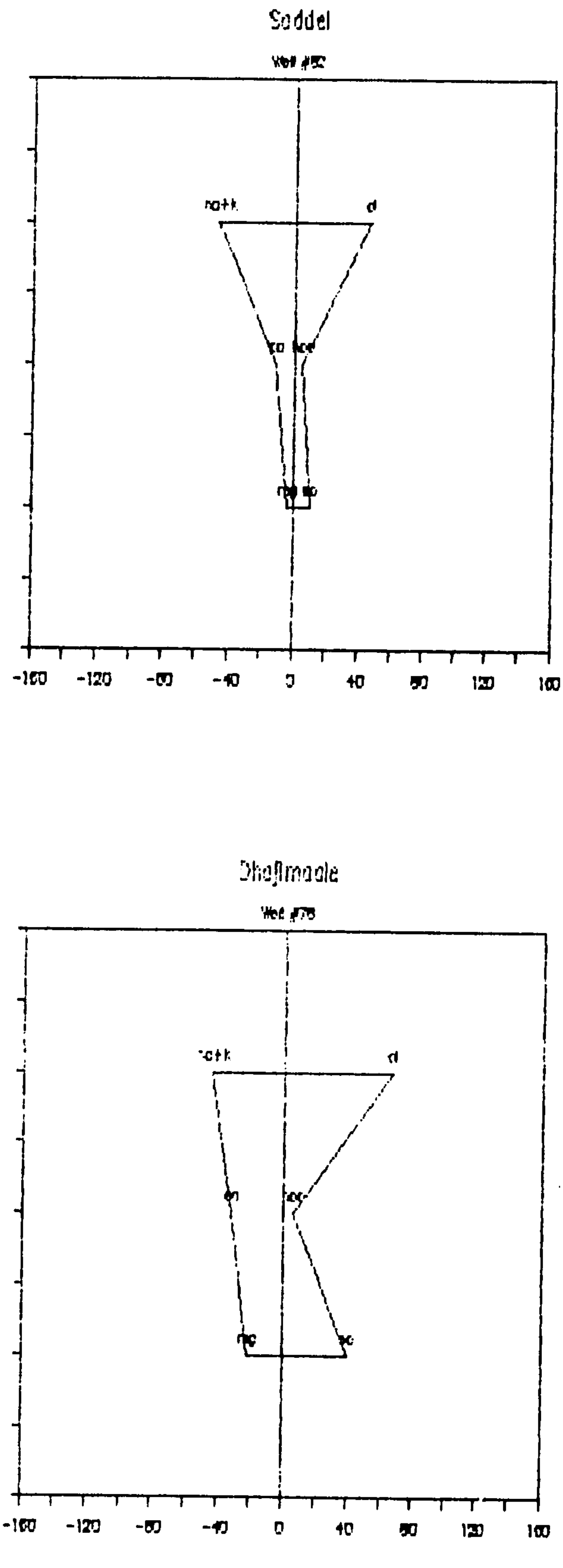


Figure 6: Sample of Chemical Data Plot, Stiff Diagrams.

The initial effort will be to gather basic demographic and socio-economic data from a representative sample of the wells installed under the CGDP. This effort will contribute to the knowledge of the positive and negative impacts of the well, such as changes in population; increased sedentarization, reduced travel for water, improved health, productivity, etc,. This study is expected to illustrate the usefulness of the TVAPP visits in terms of more successful management of the well by the villagers.

A pilot system has been established in three regions to gather data on an on-going basis from the well sites. Pump operators are required to record the numbers of people and animals using the well each day, and the regional headquarters staff are required to record the income received from each well and the fuel issued each month. From these data, it will be possible to gauge the demand for water as it varies over the seasons, to evaluate the efficiency of revenue collection, and to determine the demand for and adequacy of fuel supplied to the pumps. If the system proves successful, and the data appear reliable, it will be extended to all regions over the second half of the extension period.

WDA Overall Planning and Financial Management: It is expected that, by the end of the project extension period, the Planning Unit will be sufficiently trained to enable the WDA to better plan its future operations. The Planning Unit, through the Director of WDA, has instructed all department heads and regional directors to begin submitting monthly report. The first of these, due the first of August, required regional directors to provide a manpower and a supplies and equipment inventory. Thereafter, monthly reports will detail changes to these inventories, and the plans and accomplishments for the month.

This information, combined with information generated from the models described above will allow for more realistic estimation of the capabilities and resource requirements of the various departments and regions. WDA will also be able to prepare, and to justify, its annual budget submission to the Ministry of Finance, and if necessary, to adjust its plans to the level of budget support given.

A major objective of the Planning Unit will be to create an awareness among all development agencies in Somalia, of the need to keep WDA informed of water resource development plans.

4.4 Supply and Warehouse Management

The warehouse being utilised during the course of this project has been a leased building in the K-4 area. During the past year, employees of the WDA have been managing the warehouse facility. The chief driller and the chief mechanic have assisted with the cataloging and card-indexing of drill-rig and heavy equipment parts. It is anticipated that the same staff will move with the inventory to the WDA warehouse facilities upon termination of the project.

4.4.1 Procurement

With the approval of the extension program, a procurement package was prepared whereby USAID, LBI and RMC shared in the procurement responsibilities. USAID was to procure casing and screen under budgets for the Bay Region Agricultural Development Project and for the Central Rangelands Project. In addition, they were to make a sizeable procurement of General Motors spares, parts, and vehicles. These procurements are reportedly on line.

LBI was responsible for procurement of a number of GSD items, laboratory equipment, and eight-inch well casing. With the arrival of the casing in the first week of July, all procurement-package items to which the consultant was responsible have been received in country.

4.4.2 Other Procurement

During the period July 1984 to July 1985 it became apparent that there were a number of items, not previously included in the procurement package, that would be highly beneficial to the project. These were presented in a memo to the project officer and are currently under consideration. Listed below are some of the items requested.

A. Oxygen generator to use for filling of oxygen bottles; must be adaptable to BOC British Oxygen Company fittings and must be 220V - 50-60 HZ.

B. Miscellaneous construction steel

8	-	sheet plate steel	1/4" X 4' X 8'
5	-	do	1/2" X 4' X 8'
20	-	do	1/8" X 4' X 8'

C. Pipe threading equipment from McMaster CARR Supply Co., Elmhurst, Illinois, required to operate equipment no in-country and to include:

a) 1 set 2587A999 BSPT dies for Rigid model 141 geared pipe threader, die NBR 66625, HSS RH 11 TPI.

b) 1 each 2660A999 NBR 46 pipe support NBR 42505.

c) 1 each 2660A999 NBR 753 loop NBR 42410.

d) 1 each 2660A999 NBR 844 drive, BAR NBR 42405.

e) 1 each 2660A999 model 300 power drive NBR 75435, 230V 25-60 HZ 38 RPM spindle speed 1/8" - 2" pipe cap 1/2" - 2" rod capacity.

D. 4 each Aluminum landing MATS 2 X 10 ft.

E. 30 each monolift handpumps capable of drawing water from 90m depth.

The monolift handpumps were requested as replacement units for Robbins and Myers hand pumps that broke down shortly after installation. The problem was called to the attention of the manufacturer, however, they were not able, at least to date, to make any adjustments. This matter is being pursued.

Because the majority of vehicles and equipment are into the fourth year of operation, the number of breakdowns and repairs are expected to increase in the remaining contract period. Unfortunately, many of the items that will be needed are not known in advance. An upward adjustment to the line item, contractor furnished equipment, is being made in Amendment 13 to allow for such purchases.

Other potential items allowed for purchase were; personnel field-support equipment, miscellaneous construction materials, and laboratory equipment. A large photocopier and a memory typewriter were ordered in preparation for final report work and as support equipment for the WDA in the preparation of regional hydrogeologic reports.

4.5 Water Quality Laboratory

One of the major functions of the CGDP, in addition to exploration and exploitation of wells, has been the training of chemists and the upgrading of the water quality laboratory located within the MMWR compound. The need for an efficient, and qualified laboratory to function in conjunction with a water resource development program is crucial, not only during the development stages, but also for the maintenance and operation of safe-water supply systems.

The personnel, facilities and operations of the laboratory must be maintained to insure a successful water resource program. Weaknesses in any one of these factors should be cause for concern.

4.5.1 Laboratory Personnel

The chemical laboratory located in the MMWR facilities initially had a staff of twenty-five persons. Only one of the staff was a professional chemist. The remainder of the staff consisted of laboratory technicians and cleaners. Attendance of personnel at the lab experiences the same problems as discussed with respect to other professional and technical staff; low wages and lack of incentives. The few who maintained an interest were trained in basic analytical work and were able to perform various analyses under supervision.

Five professional chemists and two laboratory technicians were recruited during the early stages of the project. All the professional chemists and one laboratory technician have received or are receiving training in the U.S. Two are still in the U.S., two have been dismissed, one has transferred to the hydrogeology staff, one has transferred to the Planning Unit, and one provides intermittent service to the lab.

All those participating received on-the-job training in-country in water chemistry, microbiological field tests, interpretation of water-quality data, and in report writing. Seminars have been given in water chemistry and microbiology.

4.5.2 Laboratory Facilities

The MMWR laboratories are the only major laboratory facility outside of those associated with the National University of Somalia. The potential exists therefore of making the lab a self- sustaining unit. Prior to establishing this level of operation, considerable work must be done on the building and work areas; electrical and plumbing repairs are most important. A reliable source of water to the laboratory for preparation of distilled water and for the cleaning of glassware must be installed.

Power will be a continual problem, and the laboratory should have back-up power generation equipment to insure that analyses once started, can be completed uninterrupted. Voltage-regulator equipment to prevent electrical spikes or voltage drops is also essential, as analytical instrumentation will not produce valid results if not able to function properly. Unfortunately, some lab data are of questionable accuracy because of these problems.

During the past year some chemical lab equipment has been ordered, and a request for laboratory furniture, including industry exhaust hoods, has been requested. Pending further review by a laboratory specialist, the orders for the lab furniture have been postponed.

In addition to the infrastructure improvements cited above, the laboratory must have a qualified stores manager. Many of the analytical chemicals and reagents in stock are old and of questionable value, and other reagents are lacking. A proper inventory and control program needs to be implemented, and maintained.

4.5.3 Laboratory Operations

Three different laboratory data forms were introduced. One form to acknowledge receipt of the sample, another for listing the analytical results, and the third for the well file at the LBI office.

Forms for water-sample registration and analytical results were introduced together with chemical routines. Before an analytical method was used it was standardized, i.e. the method was modified to local conditions (available chemicals and glassware), and tested for analytical interferences. The standardization was done by the consultant's professional chemist. When the method was satisfactory, the laboratory attendants were instructed in its use and the method established as part of the chemical routine for water analysis.

During the past year the laboratory, has analyzed 39 samples; 19 are samples collected from newly constructed wells, 13 are from wells set up for continual monitoring, and 7 are from other wells or springs. Lack of power, lack of analytical chemicals, and absence of laboratory attendants, have caused periodic delays and interruptions of results, however, the lab continues to function.

5.0 PRIVATE SECTOR STUDY

The Private Sector study was made a part of the CGDP with submittal of Amendment 12 to the contract. The terms of reference for the study were included in that amendment and in the Inception Report submitted in January 1985. Basically, the objective of the private sector study is to collect and evaluate data concerning the potential for the private sector to make a contribution to water resource development in Somalia. The study was divided into four phases. The four phases as set forth in the Inception Report are:

Phase I. Planning and Reconnaissance
Phase II. Information Gathering
Phase III. Analysis
Phase IV. Recommendations and Report

The work accomplished to date and the status of each phase are described in the following sections:

5.1 Phase I. Planning and Reconnaissance.

The planning and reconnaissance phase of the private sector study was completed with the submittal of the Inception Report in January of 1985. Work on Phase I was initiated in December 1984 in the Washington offices of LBII and was completed in Mogadishu in January. The work conducted during Phase I consisted of reviewing the literature and files of LBII to evaluate what has been done in other countries; conducting meetings and interviews in Somalia with over 30 persons; and outlining the data, the tasks, and the manpower that would be needed to thoroughly evaluate the private sector status. The results of the work accomplished during Phase I and the tasks to be completed in remaining phases were presented in the Inception Report dated January 22, 1985.

5.2 Phase II. Information Gathering

Information gathering actually started in the LBII Washington offices prior to the submittal of the Inception Report and continued with the arrival of the study team in Mogadishu. Four investigators met with officials of various agencies, and conducted interviews with private sector contractors and with businessmen supplying materials to these contractors. The experience gained by the consultants team during this early effort was used to prepare terms of reference for a Somali sub-contractor, Geomatec, to continue the information gathering in Mogadishu and subsequently in Baidoa, Kismaio and Merca.

Similar surveys were conducted by MAM Brothers Consultants for Beled Wein, Dhusamareeb and Galcaio. This same firm is currently evaluating contractors and industries in Hargeisa, Berbera and Burao. All data will being analyzed in Phase III.

5.3 Phase III. Analysis

From data collected, a preliminary analysis was made, and a staff working paper on policy options was prepared. These options were circulated to WDA, AID, and team members of the LBII, CGDP for comments. An analysis of the status of the civil works construction industry in the private sector as it relates to water resources development was also completed. This effort included a financial analyses or recommended basic construction units. These analyses will be reviewed and preliminary recommendations will be presented in an executive summary in late August. Following review of the recommendations and conduct of briefing workshops, the Final Report will be presented.

6.0 RECOMMENDED PROGRAMS

The CGDP has the benefit of four years of exploration and exploitation experience in two relatively large areas of the country, the Central Rangelands and the Bay Region. The data collected and the experience gained have provided insights to water resource development. Areas where additional development could occur have been previously described, Section 2.0.2. Areas where additional exploration is needed, or where alternative methods may be required, need to be addressed. Other recommended programs include: surface catchments, spring development, rehabilitation and maintenance, private sector, and incentives.

6.1 Exploration

From the drilling experience thus far in the project, it has become obvious that more sophisticated exploration techniques could be utilized. These techniques would include greater use of aerial photos and surface geophysical techniques.

The area in the Bay Region recommended for further development by bored wells coincides generally with exposures of the Iscia Baidoa Suite, Plate 3. The stage of karst permeability in the Iscia Baidoa Suite, the recharge from rainfall in the area, and the generally good or useable quality of water from the aquifer in this unit, combine to produce conditions favorable for development of bored wells. The aquifer, however, is not uniform and locally may yield less water than required or may yield water of inferior chemical quality. Fortunately, these unsatisfactory results are the exception rather than the rule.

Three bored wells in the Anole Suite, in the northwest corner of the Bay Region, produce water too saline for use,10,000 mg/l or more total dissolved solids, Plate 10. The Anole Suite overlies the Iscia Baidoa Suite and the regional dip of both geologic units is northwestward at 2 to 3 degrees from horizontal. The Anole Suite contains evaporite deposits locally. Most of the successful bored wells in the Bay Region are aligned northeastward from the vicinity of Ufurow to Baidoa and thence northward. An area in the northeast corner of the Bay Region, more than 200 km² of Iscia Baidoa Suite, remains untested by borehole drilling, Plate 1. A similar area, about 100 km² of the Iscia Baidoa Suite southwest of the Bur complex also remains unexplored by borehole drilling. These areas should be investigated for degree of karst development and for borehole exploration potential.

The southern-most part of the Bay Region lies under a cover of older alluvium unexplored by borehole drilling. Hand-dug wells in the area indicate that the alluvium is thin, 3 to 4 m, where it overlies the granitic Bur complex. This area is not recommended for exploratory boreholes. Where alluvium overlies limestone, there is no apparent karst development, and fracture zones if present, cannot be defined beneath the alluvium, Plate 3.

In the southeastern part of the Bay Region, alluvium overlies limestone and older indurated clastic sediments that are separated from the granitic complex by a northeast-trending fault. The fault is concealed but has been defined by seismic surveys, Plate 3. The few scattered bored wells in this material generally do not exceed 130 m in depth (UNDP, 1973). The chemical quality of the groundwater is variable, and it may have as much as 9 g/l (9000 milligrams per liter) of total dissolved solids locally. This area of about 600 km² merits further borehole exploration of groundwater to define those localities where useable water may be obtained from bored wells.

Boreholes by the CGDP in the Bur area of the Bay Region have intercepted granitic intrusive rock or a metamorphic complex at relatively shallow depths with little or no groundwater, Table 2. Linear features expressed on satellite imagery of the Bur area may be zones of fractures where there may be sufficient permeability to yield water to bored wells. No exploratory drilling has taken place over these linear features.

During the initial phase of exploratory borehole drilling, 15 test boreholes were drilled to shallow depths at random locations in the Bur Akaba-Bur Heibe area. In most boreholes there was no groundwater, but in a few places concentrated brine was found. The presence of brine indicates the probability of groundwater being ponded within small basins on the granite that are covered by shallow alluvium. Capillary rise and evapotranspiration from the ponded groundwater results in high concentration of dissolved solids. Additional borehole exploration is recommended in the Bur areas if aerial photos or landsat imagery are used to define the presence of any fracture systems through which groundwater may flow.

In the Central Rangelands 15 boreholes have been drilled by CGDP through June, 1985, and six of these are productive. The chief limiting factors for successful boreholes have been the chemical quality of the groundwater, the depths to aquifers and the depth to water. Estimates can be made by interpolations of depths to groundwater from records of the few wells previously drilled. Drilling sites must be avoided where estimated depths to groundwater are greater than the capability of the drilling equipment, where depths to water are expected to exceed the pumping lift capacity of available pumping equipment, and where water is known to be saline. These exclusions are for those well sites 30 to 50 km inland of the coast, where land surface elevatons are near or above 200 m, and along the coastal area where the groundwater interface of fresh and salt water is near land surface.

A basalt aquifer has been penetrated by boreholes at Dhusamareeb, El-Bur, and Wargaloh. This aquifer yields water of relatively good chemical quality and of sufficient quantity to warrant additional development. A basalt aquifer is found also in a few places near the Uebi Shabelle at El-Bilal and El-Uarre (Pozzi, etal 1983).

The extent of the basalt aquifer is not known, but it may occur as volcanic flows through older topographically low areas; valleys or drainageways now covered by more recent sedimentary geologic units. Exploration for groundwater in the Central Rangelands must include the basalt aquifer. Surface geophysical methods should be used to locate the limits of the basalt, and then the locations should be drilled.

In the coastal area of the Central Rangelands there are many hand-dug wells where the depth to groundwater does not exceed 6 m.

These wells, dug in coastal sand dunes, are usually dug less than 2 m below the water table. The chemical quality of water from these wells is variable depending upon proximity to the coast, elevation above sea level, and relative activity of the dune. A program should be initiated to investigate the feasibility of horizontal well systems along the coastal area in the more stabilized dune areas and in those areas where dune stabilization may be effective.

Ideally, all of the exploration activities described above could be conducted by the personnel trained during the CGDP. Realistically, it is highly possible with periodic guidance from a qualified expatriate hydrogeologist. This work would be best suited for the WDA to carry out cover a five year plan.

6.2 Surface Catchments

The use of surface catchments is practiced throughout a large part of Somalia. With few exceptions most catchments, are natural or moderately improved depressions. The few exceptions are the privately owned or village constructed and maintained berkeds and wars. Improvements in the siting and construction of surface catchments any solve water availability problems in many areas. Because the CGDP has met with limited success in developing groundwater of useable quality by drilling in the basement complex and in the Anole Suite of the Bay Region,the BRADP initiated a study to explore the potential of improving existing catchments and in designing new ones in this area. The study effort was coordinated to a limited extent with the CGDP, and several sites were jointly inspected to evaluate the method of greatest potential. Engineering properties of the soils at selected sites were superficially assessed, and improvements to inlets for existing catchments were evaluated. The main objectives were improvement of potential to increase quantity of run-off and of reducing sedimentation in water storage.

In the Central Rangelands surface catchments are the most important sources of water for many people. The CGDP has provided technical assistance in the construction of surface water catchments and will continue on a limited basis. The local population in the CR have a relatively sophisticated understanding of catchments, but improvements in the areas of sedimentation, erosion, evaporation, infiltration, and pollution control are badly needed. The development of surface water catchment facilities is especially important in the area between El-Dhere and Xaradhere where the depth to groundwater is beyond exploitable limits. Figure 7 shows the locations of areas favorable for catchment development.

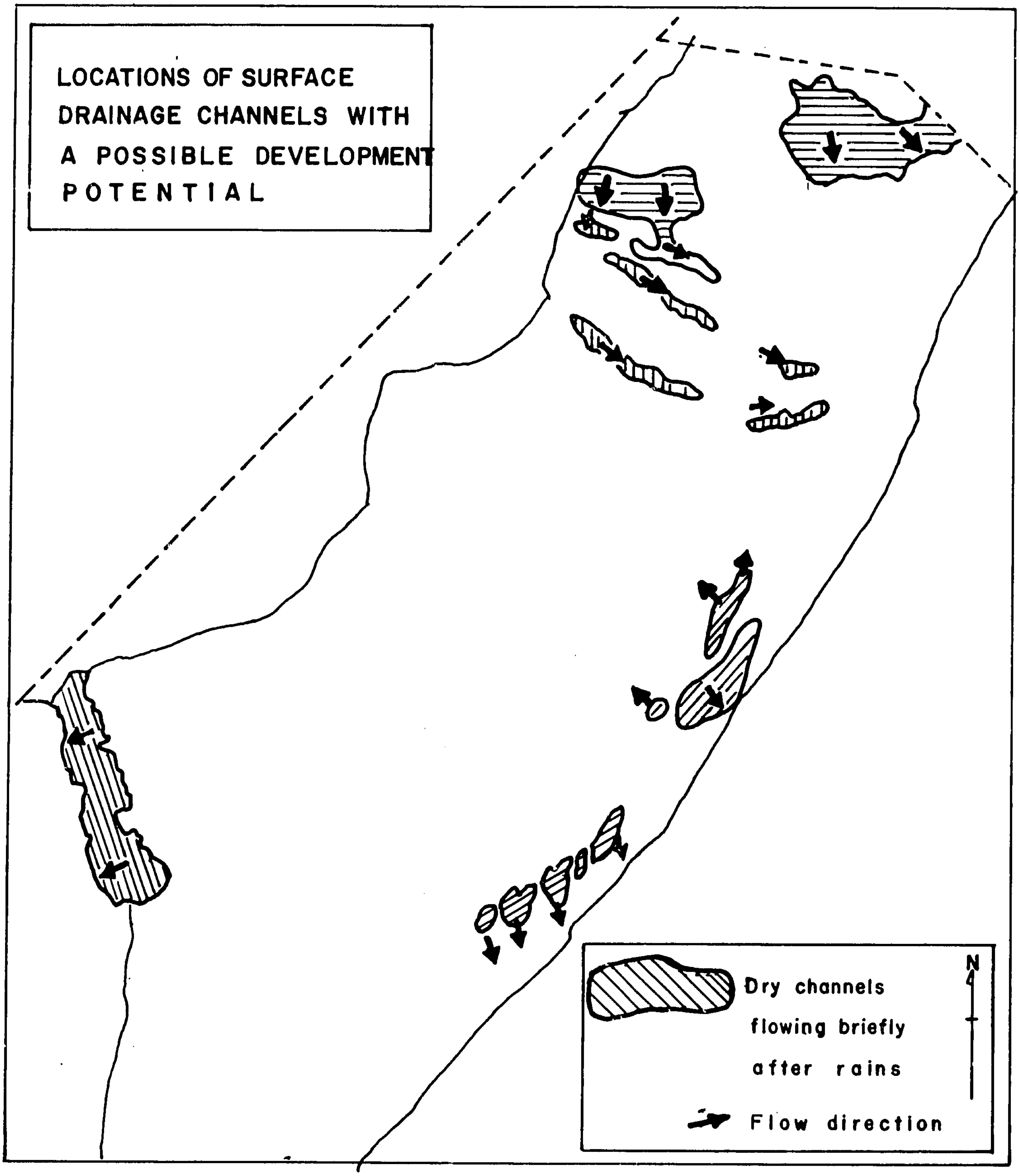
6.3 Spring Development

Although not widespread in Somalia, springs are numerous in some areas, such as the Bay Region. At present most springs become contaminated with animal waste and human refuse. A program should be initiated for the proper development of the springs to improve sanitation and to prolong the available use of water.

In most, instances, improvements could be effected utilizing local labor and local materials. Cement, cement blocks and, if needed, a pump would be the only materials required. A small tire mounted backhoe, similar to the WDA John Deere, would be the only major equipment needed. The springs should be evaluated during the rainy season and construction done during the dry season.

6.4 Rehabilitation and Maintenance

One of the programs highly recommended for implementation is a rehabilitation and maintenance program. WDA, through its own and numerous donor agency efforts, has numerous well and pump installations throughout the country that have fallen into disrepair and abandonment. An assessment program should be conducted to evaluate the potential for developing, rehabilitating and repairing these existing systems. An effort must be made to replace worn and broken pumps with those makes and models that are



From Resource Management and Research
Central Rangelands Survey Vol-I, Part 3

Figure 7

most abundant in the system. This effort toward standardization must be accompanied with a maintenance and repair program. This program should involve the private sector, and should be coordinated in such a manner that the physical apparatus is in-place for continued maintenance.

Although initially oriented toward those systems containing motorized pumps, a rehabilitation and maintenance program could be oriented toward the numerous hand dug wells that occur throughout the country. Indeed, both programs could be initiated simultaneously.

Hand dug well rehabilitation could be conducted with local labor and materials. A survey of existing construction methods in various sections of the country should be made in conjunction with a tabulation of locally, site-specific, available materials. Armed with this information, designs can be prepared for the various conditions, and training teams sent to priority areas.

6.5 Private Sector

Perhaps the most highly recommended program of all is one to increase the participation of the private sector in the water resource development effort. The private sector study has shown that there are several contractors, including a few highly enthusiastic entrepreneurial firms that have expressed interest in water development resource activities. Presently there are policy and contractural constraints that limit or make difficult widespread private sector involvement. Serious constraints concern the ability of the private sector to import, at reasonable cost, the equipment and materials needed to perform efficiently. Even with these constraints, however, there are those that have managed. Two areas where private sector involvement can be initiated rather quickly are well drilling and civil works construction.

6.5.1 Well Drilling

Because there are areas in the country where drilled wells represent the only potential source for water, well drillers have a definite role to play. Their efforts should be directed in areas of known groundwater development potential. The WDA should be reponsible for the research and exploration necessary to define these areas, and then the private drillers contracted to construct the needed production wells. These contracts could be with WDA, with villages or with private concerns.

6.5.2 Civil Works

There are more contractors equipped to do civil works construction than there are for well drilling. Although civil works construction is not always an extensive undertaking, it can be extremely important. The construction of animal water troughs is especially important to keep animals far enough removed from the well site to minimize the potential for contamination. Domestic water points are important to larger villages where greater demands are placed on the system. Water storage faciliti- es, in those villages where large numbers of animals are watered, are badly needed.

Each of these structures can be designed and constructed to utilize local building materials and local labor. In the case of village owned systems, the timing and payment of construction can be coordinated to coincide with the available revenue. One component could be added each year over a period of a few years. For example a storage facility could be done one year, a watering trough one year and a domestic tap the third year.

6.6 Incentive Programs

Because WDA will continue to be the key agency in the development of water resources in the country, a program to evaluate employee incentives should be initiated. It is not reasonable to expect that professional and skilled labor personnel will perform at an efficient level without adequate compensation. Lack of incentives was and is probably the greatest single deterrent to effective technology transfer during the CGDP. This is especially true amongst professional staff and to some degree amongst skilled labor. The direction such a program takes will require an evaluation of the agency and the rules and regulations under which it must operate. It is a program that would not be expected to produce immediate results, but that would begin slowly and go through many changes before yielding results.

7.0 DEMOBILIZATION

The Comprehensive Groundwater Development Project, is scheduled to be completed by July 1986. In an effort to conduct a systematic withdrawal of consultant's support, and to effect a smooth transfer of equipment and materials to appropriate entities, the proposed project phase-out is discussed. It is not cast in concrete, but should fairly closely represent the sequence of events as presently envisaged. Included in the phaseout program are tasks that are part of the work plan, such as this interim report and the final report. Likewise, there will be certain activities occurring simultaneously, such as various inventories to be taken and preparation of reports, while overseeing operations by WDA staff. The following sections briefly describe the rationale for the sequence of events that are proposed.

7.1 Transfer of Parts, Tools and Supplies

Throughout the course of the project a large volume of parts, tools and supplies have been purchased. A large share of these have been consumable items, such as drilling mud and foam, cement, oxygen and acetylene, welding rods, fuel, and lubricants. Other than the above mentioned consumables, the tools and parts will need to be accounted for and moved to a new location for use by WDA staff.

At present most of the parts, tools and supplies that are needed for drill rig support are stored at leased facilities near K-4. During phase-out, these items will be moved to WDA warehouse facilities and to storage containers to be located within the WDA compound. The WDA warehouse manager will then take charge of issuing all items on a requisition basis for the remainder of the project.

It is highly likely that there will be many ordered items still outstanding during the phase-out period. These will be cataloged and provided to the warehouse manager as received.

When all items except cement and drilling mud have been properly inventoried, they will be transferred to storage facilities in the WDA compound. Cement and drilling mud will remain in storage at K-4 until May of 1986 to avoid excess handling.

7.2 Establish WDA Team Operations

Although WDA counterparts are in established positions, the withdrawal of consultant's staff is likely to cause a vacuum and an interruption of operations unless a structured system is left in place. Organizational charts have been prepared to assist in the orderly transfer of responsibility.

7.2.1 Drilling Crew Organization

At present there are four drilling crews responding to two consultant's drillers. During the phase-out, a drilling supervisor will be appointed to oversee the operations of all four crews, Figure 8. Each of the crews will consist of a chief driller, an assistant driller, a mechanic/welder, a sample collector and a number of laborers. In addition to the drilling crews there will be support personnel, such as truck drivers assigned to each rig. By having a formalized organizational system, it is hoped the total assumption of operations by WDA staff will proceed smoothly.

7.2.2 Pump Crew Organization

The pump rig personnel have been divided into two crews; one crew to work in the Bay Region and one crew to work in the Central Rangelands. A supervisor and coordinator for both crews must still be selected.

It is not intended that each of these crews be assigned exclusively to one region or another. They will be expected to work in whatever area of the country they are needed. The division between the Bay Region and the Central Rangelands is soley for identification and administration for the remainder of the CGDP.

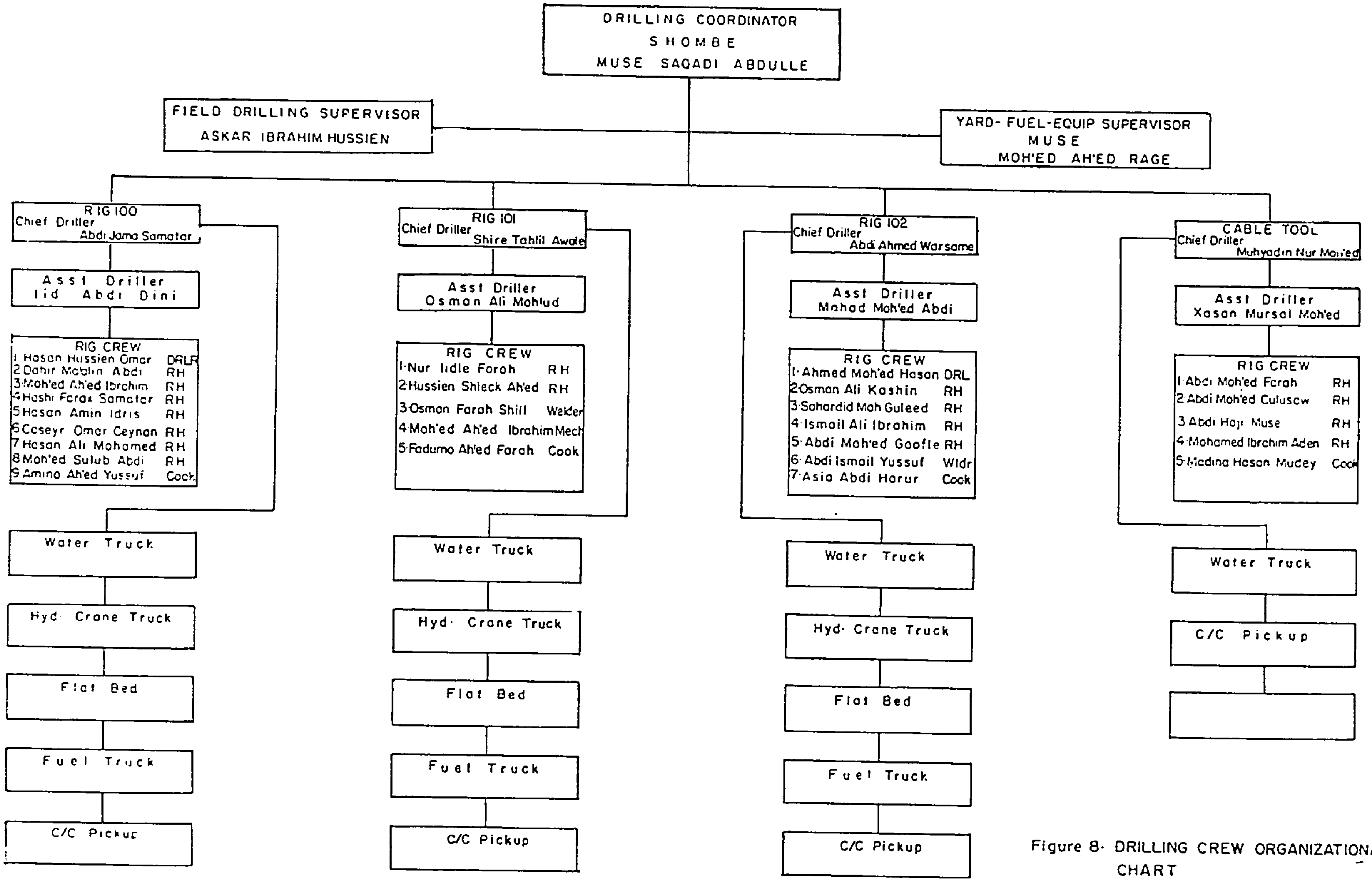


Figure 8. DRILLING CREW ORGANIZATIONAL CHART

7.2.3 Hydrogeology Team

During the project period, the hydrogeologists have been assigned to various aspects of work operations. During the phase-out period, an organizational chart will be prepared to provide each hydrogeologist with a geographic region of responsibility. This will not be to preclude mutual cooperation in a particular area, but to insure that attention is given to the water needs throughout the country. This effort will require the approval and coordination of Engineer Yussuf.

7.3 Transfer of Equipment and Vehicles

After the various drilling, pumping and hydrogeology crews have been organized, rig assignments and vehicle responsibilities can be made. This will occur in conjunction with expatriate departures and subsequent to a thorough inventory of equipment.

All equipment, welders, oxygen-acetylene bottles and appurtenances, tools, spares, etc., that are normally part of a particular vehicle will be inventoried and assigned with the vehicle to individuals. At present, no one person feels responsible for all items assigned to his rig or vehicle. This situation will need to be corrected early in the transition period.

Physical transfer of equipment and vehicles will begin taking place in October and November, 1985. This will afford the remaining expatriate staff an opportunity to view the operation as it will be under the direction of their former counterparts. Operational responsibility and decision making will be transferred to the Somali staff at this time, and expatriate staff will assume an advisory role with less hands-on involvment.

7.4 Consultant Team Phase Out

Consultant's staff will begin leaving Somalia in October, 1985. The proposed schedule of departures is shown in Figure 9 and 10. Specific departure dates may vary pending utilization of vacation time and the necessity for emergency leave. Some of the professional staff have been given extended schedules to assist in the preparation of the final report, and to assist in the turnover of documents and household furnishings.

Figure 9: Schedule of Man-months.

```
LBII Staff
==== =====
                                                1984                        1985                                1986
Name            Position                    O   N   D   J   F   M   A   M   J   J   A   S   O   N   D   J   F   M   A   M   J   J

Cerrillo, J.    Project Manager             ************************************************************************============

Sumsion, C      Database/Training           ************************************************************============

Douglass, D.    Hydrogeologist/CR           ****************************************************================

Gillespie, J.   Hydrogeologist/BR           ****************************************************================

Chambers, B.    Mechanic                    ************************************************************================

Jones, G.       GSO/Admin.                          ************************************************************================

Lock, R.        Economist                                       ************************************************

Schwarz, R.     Sociologist                                                 ******          ++++      ******

Templar, P.     Civil Engineer                                                  ****

Roark, P.       Water Resource Planner                  *   *   ***

Pape, M.        Computer Training                                           ***                     ***

Bukoski, J.     Procurement                         ********************        ****    ****

OPEN            Report Finalization                                                                                     **

Edgren, M.      Chemist                     ********++++++++++++++++++++++++++++

OPEN            Lab. Specialist                                                                 ********

Daveys, F.      Logger/Radio Technician                     *   *                                       *   *

Kornell, R.     Coordinator

Lerner, H.      Coordinator
```

Figure 10: Schedule of Man-months.

```
Roscoe Moss Staff
====== ==== =====                        1984                         1985                                1986
Name           Position               O   N   D   J   F   M   A   M   J   J   A   S   O   N   D   J   F   M   A   M   J   J

Woerner, J.    Chief Driller          ************************************************************************

Glessner, W.   Driller/BR             ************************************************

Williams, W.   Driller/CR                         ************************************************============

Hall, F.       Field Technician       ********************************************************

Steele, R.     Heavy Mechanic         ****************************************************++++

Van Valer, R.  Procurement                *                           *

Van Valer, R.  Coordinator                                **  **

Trans. to LBII Logger/Radio Technician
```

7.5 Water Resource Conference

Prior to the termination of the project a two to three day conference or workshop will be held at one of the local hotels to present the work completed to date, and to solicit papers on work other donors have been doing. The objective of this conference will be to fulfill the requirement of presenting a comprehensive groundwater picture of Somalia. We suggest this conference be sponsored by MMWR/WDA with invitations to all donors supporting groundwater projects, and to all ministries whose activities are water dependent. The private sector should also be encouraged to attend.

LBII, WDA and the Ministry of Minerals and Water Development would provide staff for organization and planning of the conference. The conference should be held about the 20th of November.

7.6 Preparation of Final Report

A draft final report summarizing all data and the status of the project work will be submitted in March of 1986. April will provide AID and WDA an opportunity for review, May will be utilized for corrections and revisions, and the final report ready for printing in June.

SELECTED REFERENCES

1. Abbate, E., Bruni, P., Fazzuoli, M., and Sagri, M., 1983. Le Facies di Transizione e Continentali nel Bacino Terzairio dal Daban, Somalia Settentrionle, Dati Preliminari: Universita' Nazionale Somala, Quaderni di Geologia della Somalia, Vol. 7, P. 7-38.

2. Abdisamad Sheikh Osman, Hilal Abdallah Farah, and Mohamed Said Abdi 1976. Geology of Somalia: MMWR, Mogadiscio, 22 P.

3. Abdullahi Hayder, M., 1983. Contributo alla Conoscenza delle Masse Granitoide dei Buur (Somalia Meridionale): Universita' Nazionale Somala, Quaderni di Geologia della Somalia, Vol. 7, P. 39-54.

4. Ahren, T.P., 1951. A Reconnaissance Groundwater Survey of Somalia, East Africa: Comitato Interministeriale per la Ricostruzione, Roma.

5. Ali-Salad Haydar, 1984. Il Quaternario Costiero della Zona di Chismaio: Universita' Nazionale della Somalia, Tesi Sprimentale di Laurea, 24 Pg.

6. Altichieri, L., Angelucci, A., Boccaletti, M., Abdulqadir, M.M., 1982. Preliminary Study on the Paleogene Formations of Central Somalia (Hiiraan, Galgaduud, Mudug, and Nugaal Regions): Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 6, P. 183-204.

7. Angelucci, A., Abdulkadir Mohamed, M., and Robba, E., 1983. A Preliminary Report on the Quaternary Sequence in the Coastal area of Benadir (Central Somalia): Universita' Nazionale Somala, Quaderni di Geologia della Somalia, Vol. 7, P. 69-74.

8. Angelucci, A., Barbieri, F., Maxamed, C.M., Caruush, M.C., Piccoli, G., 1982.
Preliminary Report on the Jurassic Sequence in the Gedo and Bay Regions (Southwestern Somalia): Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 6, P. 127-154.

9. Barbieri, F., (and others), 1982.
Il Cretaceo della Regione di Hiraan in Somalia (Valle dello Webi Scebeli) con Appendice sulla Foresta Fossile di Sheekh Guure: Universita' Nazionale Somala, Quaderno Geologia della Somalia, Vol. 6, P.155-182.

10. Bear, J., 1979.
Hydraulics of Groundwater: McGraw-Hill Inc., New York, 567 P.

11. Barnes, S.U., 1976.
Geology and Oil Prospects of Somalia, East Africa: American Assoc. of Petroleum Geologists Bull. Vol. 60, No. 3, P.390-413.

12. Beltrandi, M.D., and Pyre, A., 1973.
Geological Evolution of Southwest Somalia, in Bassins Sedimentaires du Littoral Africain, Part 2, Littoral Austral et Oriental: Paris Assoc. Serv. Geol. Afr., P.159-178.

13. Benvenuti, G. Abdulkadir S. Dorre, De Florentis, N., and Rapolla, A., 1983.
Risultati Preliminari di un'Indagine Geoelectrica nella zona Costiera nei Dintorni di Gesira (Mogadiscio): Universita' Nazionale della Somalia, Vol. 7, P.75-84

14. Biagi, P.F., 1982.
Sismisata' della Somalia: Universita' Nazionale Somalia, Quaderni Geologia della Somalia, Vol. 6, P.33-327.

15. Brandon, C., 1984.
Economic Evaluation of the Comprehensive Groundwater Development Project: Louis Berger International, Inc., Mogadishu, 99 p.

16. Campbell, M.D., and Lehr, J.H., 1973.
Water Well Technology: McGraw-Hill, New York, 681 P.

17. Carmignani, L., Ali Kassim M., and Fantozzi, P.L., 1983.
Nota Preliminare sul Rilevamento della Regione di Gedo (Alta Valle del Giuba, Somalia Meridionale): Universita' Nazionle della Somala, Quaderni Geologia della Somalia, Vol. 7, P.85-110.

18. Chinese Well-Drilling Team, 1983.
Report on Geological Exploration of Exploratory Boreholes and Test Wells in the Northwest Region of Somali Democratic Republic: China National Complete Plant Export Corporation, 28 P. annex.

19. Dal Pra', A., Benvenuti, G., Omar Shire Y., Osman Mohamed A., Mumin M. God, and Ahmed Yusuf I., 1983.
Indagine Idrogeologica nel Territorio Circostante la Citta' di Qorioley sul Fiume Scebeli (Somalia), per la Ricerca di Aque Sotterranee ad Uso Potabile: Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 7,P.111-128.

20. Dal Pra', A., De Florentis, N., Hussen Salaad M., and Mumin M.God, 1983.
Oscillazioni della Superficie Piezometrica della Falda Costiera Provocate dalla Escursioni di Marea Lungo il Litorale di Mogadiscio (Somalia): Universita' Nazionale della Somala, Vol. 7, P.141-152.

21. Dal Pra', A., Hussen Salaad M., and Mumin M. God, 1983.
Situazione Idrogeologica della Zona di Balad in Relazione al Rifornemento Idrico dell' Azienda Agricola dell' Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 7, P.129-140.

22. Dijon, R., 1971.
The Search for Groundwater in the Crystalline Regions of Africa: United Nations, New York, Dept. of Economic and Social Affairs, Natural Resources Forum, Vol. 1,No.1, P.32-38.

23. Eagleson, P.S., 1970.
Dynamic Hydrology: McGraw-Hill, New York, 462 P.

24. Faillace, C., 1960.
Stato della Altuali Conoscenze Sulla Geoidrologia della Somalia: Revista di Agricoltura Subtropicale e Tropicale, Firenze,

25. Faillace, C., 1962.
Linee Programmatiche per la Volorizzazione della Risorse Idriche in Somalia: Ministerio L. P. e Comunicazioni, Mogadiscio.

26. Faillace, C., 1964.
Surface and Underground Water Resources of the Shebeli Valley: Ministry of Public Works and Communication, Mogadiscio.

27. Faillace, C., 1983.
A Brief View of the Surface and Groundwater Resources of the Northwest Region of Somalia: Universita' Nazionale Somala, Quaderni Geologia della Somali, Vol. 7, P.171-188.

28. Faillace, C., 1983.
Groundwater Conditions of Belet Weyne Area and Potential Water Sources for the Town Water Supply: WDA, MMWR, Mogadiscio, 28 P., annex 1, 2 and 3.

29. Faillace, C., 1983.
Possibilities of Developing Water Resources for Irrigated Agriculture in Erigavo Area: Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 7, P.153-170.

30. Franceschetti, B., and Abdulkdir S. Dorre, 1983
Indagine Preliminare sulla Potenziolita' Idrica dei Bacini Torrentizi Situati sulla Sinistra dell' Uebi Scebeli, Tra Halgan e il Pozzo di Ceel Gal, e sulle Possibilita' d'Acqua: Universita' Nationale Somala, Quaderni Geologia della Somalia, Vol. 7,P.189-212.

31. Geomatec Consultants, 1985.
Private Sector Study FP-201A: Louis Berger International, Inc., Mogadishu, 60 P.

32. German Planning and Economic Advisory Group Dr. Hendrikson, 1973.
A Programme for the Allocation of Deep Wells to the Rural Areas: Ministry of Planning and Coordination, Mogadiscio, 249 P.

33. GTZ (Deutsche Gesellschaft Fur Technische Zusammenarbeit) 1981.
Dhusamareeb Technical Report: WDA, MMWR, Mogadiscio, 7 P. annex 1-4.

34. Hilal, C.F., Paran, G., and Robba, E., 1982.
Geologia Stratigrafica della Somalia: Universita' Nazionale Somala, Quaderni Geologi della Somalia, Vol. 6, P.99-126.

35. Horta, J.C. de O.S., 1980.
Calcrete, Gypcrete, and Soil Classification in Algeria: Engineering Geology, Vol. 15, P.15-52. Elsevier, Amsterdam.

36. Hunting Technical Services Ltd., 1982.
Bay Region Agricultural Development Project, Vol. 1-4: Ministry of Agriculture, Mogadiscio.

37. IDROTECNECO, 1976.
Hydrogeological Study in the Bur Region: WDA, MMWR, Mogadiscio, 190 P.

38. Johnson Division, UOP Inc., 1975.
Groundwater and Wells: Saint Paul, Minnesota, 440 P.

39. Louis Berger International, Inc., 1985.
Comprehensive Groundwater Development, Project 104, Final Report, Vol. 1-3: WDA, MMWR, Mogadiscio.

40. MacFayden, W.A, 1933.
The Geology of British Somaliland, Part 1: Govt. of the Somaliland Protectorate, 87 P.

41. McFayden, W.S., 1949, Water Supply and Geology of Parts of British Somaliland: Hargeisa (Unpublished), 184 P.

42. Pape, M. B., 1982.
Preliminary Analysis of the Potential Environmental Impacts of the Comprehensive Groundwater Development Project: Louis Berger International, Inc., Mogadishu.

43. Pape, M.B., 1982.
Preliminary Economic Analysis of the Comprehensive Groundwater Development Project: Louis Berger International, Inc., Mogadishu.

44. Piccoli, G., and Hilal, C.F., 1982.
Quaderno di Paleontologia della Somalia: Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 6, P. 67-98.

45. Piccoli, G. Robba, E., and Angelucci, A., 1983.
Gli Orizzonti Gessiferi in Somalia: Universita Nazionale Somala, Quaderni Geologia della Somalia, Vol. 7, P.233-238.

46. Pozzi, R., 1982.
Lineamenti della Idrogeologia della Somalia: Universita' Nazionale Somala, Quaderni Geologia della Somalia, Vol. 6, P.281-322.

47. Pozzi, R., Benvenuti, G., Mohamed, C.X., Shuriye, C.I., 1982.
Groundwater Resources in Central Somalia: Universita' Nazionale Somala, Quadderni Geologia della Somalia, Vol.6, P.257-280.

48. Pozzi, G.Benvenuti, G., Gatti,G., and Ibrahim Mohamed F., 1983.
A Proposal for the Adoption of Subsurface Dams in Somalia: Universita' Nazionale Somalia, Quaderni Geologia della Somalia, Vol.7, P.239-262.

49. Pozzi, R., and others, 1983.
Groundwater Resources in Central Somalia:
Memorie di Scienze Geologiche, Vol.35, P.397-409, Univ. di Padova.

50. Pozzi, R., and Mohamed, X.S., 1984.
Groundwater Resources in Hobyo Area:
Memorie di Scienza Geologiche, Vol.36, P.443-451. Univ. di Padova.

51. Sassi, F.P., and Ibrahim H.A., 1982.
Tentativo di Schematizzazione dei Problemi Litostratigrafici e di Correlazione del Basamento della Somalia Settenrionale: Universita' Nazionale Somala, Quaderni Geologia della Somala, Vol.6, P.59-66.

52. Schwarz, R.A., 1983.
The Somalia Groundwater Project: The Community Participation Process, Monitoring, Evaluation and Training:
Lc s Berger International, Inc., Mogadishu.

53. Stefanini, G., and Paoli, G., 1913.
Ricerche Geoidrologiche, Botaniche, Entomologiche fatte nella Somalia Italiana Meridionale: Instituto Agr. Coloniale, Firenze.

54. Stefanini, G., 1925.
Sur la Constitution Geologique de la Somalie Italienne Meridinale: 13th Internatl. Geol. Cong., Brussels, Comptes Rendus, P.1059.

55. Sommavilla, E., 1977.
Geologia Strutturale della Somalia:
Universita' Nazionale Somala, Quaderni di Geologia della
Somalia, Vol.1, P.60-93.

56. UNDP, 1973.
Technical Report 3, Mineral and Groundwater Survey, Phase 2,
Somalia: United Nations Development Programme, United
Nations, New York, 410 P.

57. UNICEF, 1982.
Technical Report, Refugee Water Supply Project, Somali
Democratic Republic: United Nations Childern's Fund,
Mogadishu, 20 P., Appendix 1 and 2.

58. U.S. Department of the Interior, 1968.
Water Quality Criteria: National Technical Advisory
Committee to the Secretary of the Interior, U.S. Govt.
Printing Office, Washington, D.C.

59. Usoni, L., and Parisini, G., 1951.
Studio Sulle Possibilitia Idriche del Sottosuolo della
Somalia: A.F.I.S., Mogadishu.

60. Water and Power Resources Service, 1981.
Groundwater Manual: U.S. Dept. of the Interior, U.S.
Govt. Printing Office, Denver, 480 P.

61. World Bank, 1979.
Central Rangelands Development Project, Somalia:
Staff Appraisal Report, No.2163-Somalia, Eastern Africa
Region, Northern Agriculture Division, Annex 6, P.80-85.

(A N N E X A)

TABLE OF CONTENTS
FOR
A N N E X A

SECTION 1.

As Built Drawings and Log of Borehole

Region CENTRAL RANGELAND

Well Location WARGALOH Coord 6°15.8'N 47°31.2'E

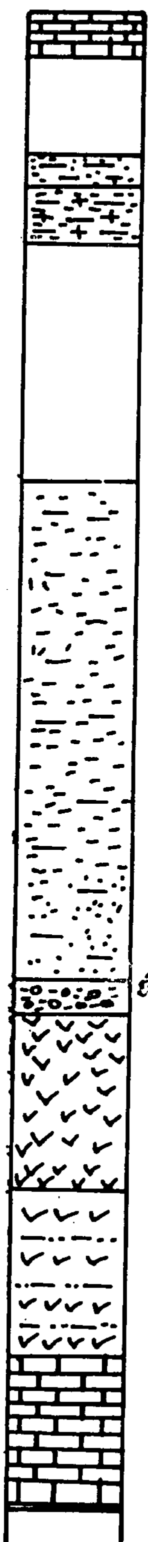
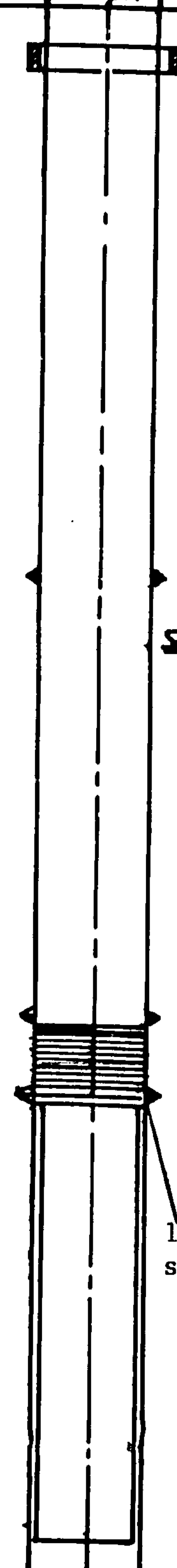
Well Number CR 67

Completion Date 25.7.84

Rig No 100 Page 1 of 1

Hydrogeologist L.A.Cerillo Drilling Method ROTARY-MUD

Driller HASSAN HUSSEIN OMER Bit Size 17½-12¼-7⅞

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Limestone; white, soft		14-inch surface casing to 3 m with cement seal
10				
20		No sample		8⅝ inch steel casing
30		Sand; fine to medium, with clay		
40		Sand, as above with interbedded Gypsum		
50				11.5 inch centering guides
60		No sample		17½ inch hole to 3m 12¼ inch hole to 176.9 m 7⅞ inch hole to 252m
70				
80				
90		Clay with sand, subrounded to rounded, medium to coarse grained, with fine gravel and hematite pebbles		
100				
110				Static water level 98.4 m, 19.9.84 Drawdown 0.2' m after 2:30 Hrs at 11.4 m³/hr
120				
130				
140				
150				Mono pump installed at 134 m
160		Sand, medium to coarse, with clay and fine gravel		
170		Basalt		20 slot Johnson screen screen 164.9 to 170.9 m, all 8 inch 10 slot Johnson screen 170.9 to 176.9 m, all 8 inch
180				
190				
200		Basalt with sand, fine to medium, with clay hematite, and gypsum fragments		1 m Blank casing steel, 8 inch
210				
220				7⅞ inch open hole to 252 m, Total Depth
230		Limestone, yellow, soft, with clay		
240				
250				
		252 m, Total Depth		252 m

Region BAY REGION

Well Location GARIMAY Coord 3°38.9'N 43°52.2'E

Rig Nº ____ Page 1 of 1

Hydrogeologist J.D.G Drilling Method ROTARY

Well Number B70

Driller ____ Bit Size 10

Completion Date 16.9.84

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil, Red		No surface casing.
10				8-inch steel casing to 126 m
20		Limestone (No lithologic log)		
30				
40				
50				
60		Karstic limestone (driller) — Static water level 60 m 16.9.84		Perforated casing, 1/8x2 inch slots, 216 per 6 m length of casing
70				
80		Limestone		
90				
100				Perforated casing, 1/8x2 inch slots
110		Karstic limestone(driller)		
120				
130		Limestone		Open hole 126-135 m
140		135 m Total Depth		135 m Total Depth

Region BAY REGION

Well Location USLE

Coord 3°23.7'N 43°30.1'E

Rig Nº

Page 1 of 1

Hydrogeologist J.D.G

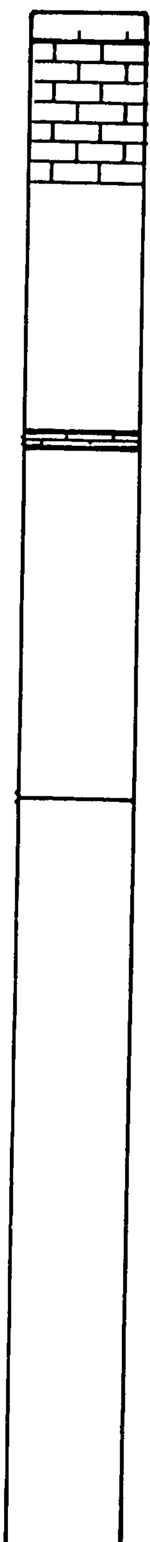
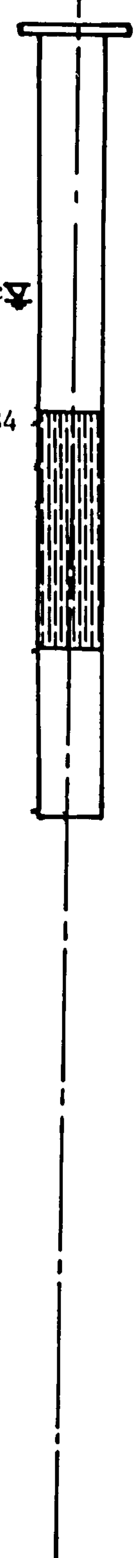
Drilling Method ROTARY

Well Number B 71

Driller

Bit Size 16-10

Completion Date 19.8.84

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil and weathered limestone,red		14-inch surface casing to 1 m
		Limestone,gray to olive -gray		8-inch PVC casing to 80 m
		Lost circulation , No returns (Karstic limestone)	Static water level 36 m 28.8.84	
		Limestone,light-gray		Perforated PVC casing 50-80 m
		Lost circulation, No returns (Karstic limestone)		
				Open Hole 80-102 m
		102 m Total Depth		102 m Total Depth

Region CENTRAL RANGELAND

Rig Nº 100 Page 1 of 1

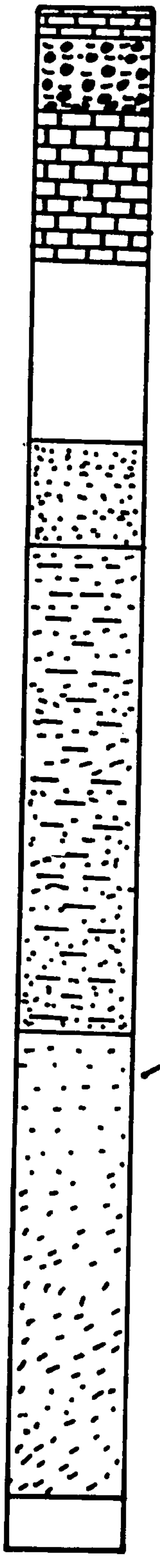
Well Location AFGAGUUDLE Coord 5°57.5'N 47°58.2'E Hydrogeologist MARSHALE Drilling Method ROTARY-MUD

Well Number CR 72 Driller HASSAN HUSSEIN OMAR Bit Size 17½-12¼-7⅞-6

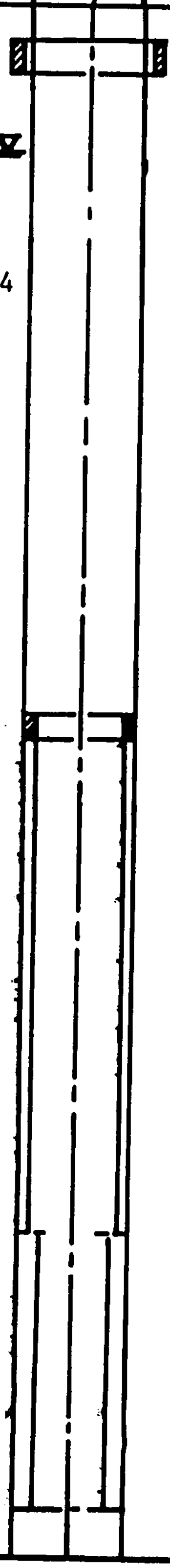
Completion Date 1.12.84

Depth (m)	Lithologic Description	Remarks
0	Limestone, gray	14-inch surface casing to 6 m, with cement seal
10	Conglomerate, brown-red	
20	Static water level 17m, 18.11.84	
30	Limestone, gray	8⅝ inch blank steel casing to 97 m
40	Water at 40 m, 26000 micromhos	17½ inch to 6 m 12¼ inch to 94 m 1⅞ inch to 164 m 6 inch to 204 m
50	No sample	
60		
70	Sand, very fine, brown Lost circulation at 66 m	
80		
90	Clay, sandy with Gypsum crystals	
100		97 m, end of blank steel casing driven 3 m in clay to seal off water at 40 m
110		
120		
130		
140	Sand, fine, with some clay	
150		
160	Water at 164 m, 12000 micromhos, well abandoned for excessive salinity	
170		7⅞ inch open hole to 164 m 6 inch open hole to 204 m
180		
190		
200	204 m, Total Depth	204 m, Total Depth

Graphic Log



Well Complt.



Region BAY REGION

Well Location MIGDALOO

Coord 3°36.4'N 43°50.5'E

Well Number B 74

Completion Date 13.10.84

Rig Nº ______

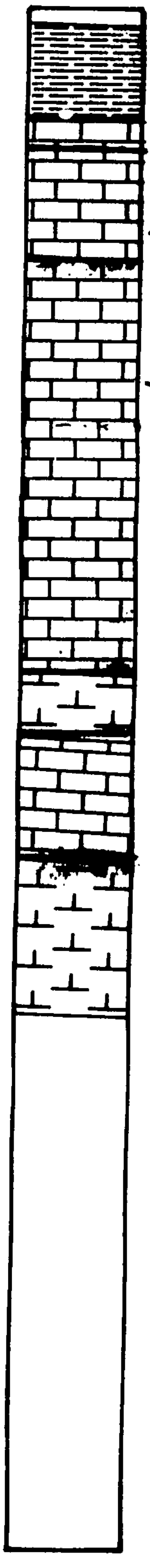
Hydrogeologist ______

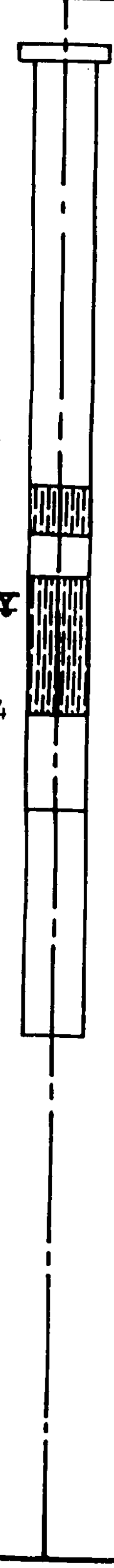
Driller ______

Page 1 of 1

Drilling Method ROTARY

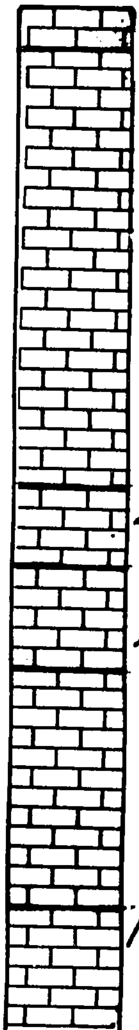
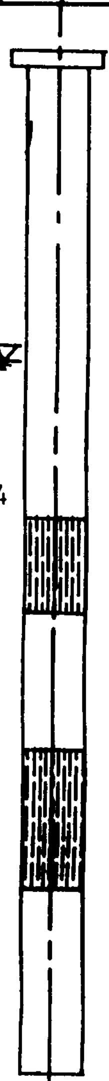
Bit Size 14 - 10





Depth (m)	Lithologic Description	Remarks
0	Soil, red	12-inch surface casing to 2 m
10	Clay, yellow	
20	Limestone, weathered sparse chert, and interbedded yellow clay	8-inch PVC casing to 100 m
30	Limestone, olive-gray sparse chert and clay, some weathering	
40		
50	Limestone, olive-gray iron-stained, with chert and secondary calcite	Perforated casing 58-64 m
60		
70		Perforated casing 70-88 m
80	Static water level 74.7 m 3.10.84	
90	Karstic limestone	
100	Limestone, weathered iron stained	Open hole 100-130 m.
110		
120	Karstic limestone	
130	130 m Total Depth	130 m Total Depth

Region: BAY REGION / LABATAN
Well Location: JIROW Coord: $3^{o}31.6'N$ / $43^{o}50.9'E$
Rig Nº: 102 Page: 1 of: 1
Hydrogeologist: J.D.G. Drilling Method: ROTARY
Well Number: B 75 Driller: MUSSE Bit Size: 15 - 10
Completion Date: 18.10.84

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Limestone, red weathered		12-inch surface casing to 2 m
10				
20		Limestone, yellow to olive-gray		8-inch PVC casing to 132 m
30				
40			Static water level 40.1 m 18.10.84	
50				
60		Limestone, weathered, karstic zone		Perforated casing 60-72
70		Limestone, gray with red and yellow stains, sparse yellow clay and chert		
80				
90		Limestone, gray, karstic		Perforated casing 90-108
100				
110		Limestone, gray		
120				
130		132 m TD		132 m Total Depth
140				

Region BAY REGION **Rig Nº** 102 **Page** 1 **of** 1

Well Location DHORHABY **Coord** 2°33.9'N 42°55.7'E **Hydrogeologist** J.D.G. **Drilling Method** ROTARY

Well Number B 77 **Driller** M.M. Rage **Bit Size** 14-10-8

Completion Date 28.12.84

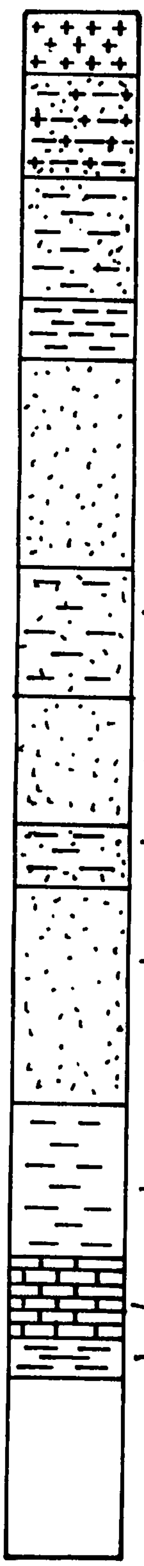
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil		12 inch casing to 2 m
10		Limestone, light to medium-gray, slightly weathered		
20		Lost circulation, no sample (Karst zone)		8 inch casing to 24 m
30		Water cascades from 26 m		8 inch open hole to 200 m
40		Limestone, light-gray, oolitic, iron-stained fractures		
50		Limestone, medium-gray, slight weathering		Static water level 46.51 m
60				
70				
80		Limestone, light to medium-gray, karst 126-128 m		
90				
100				
110				
120				
130				
140		Limestone, medium-gray partly oolitic		
150		Limestone, light-gray, oolitic		
160		Limestone, dark-gray, pyritic		
170		Limestone, light-gray, oolitic		
180		Limestone, medium-gray, foliated		
190		Limestone, gray oolitic		
200		No sample		200 m total depth

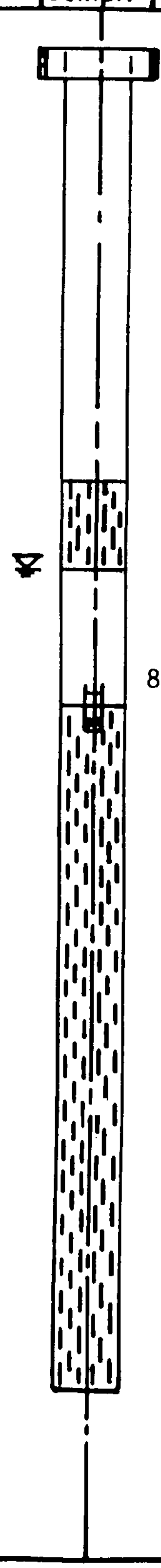
Region CENTRAL RANGELAND **Rig Nº** 101 **Page** 1 **of** 1

Well Location DHAIIMALE **Coord** 6°18.5'N 48°13.0'E **Hydrogeologist** D.DOUGLAS **Drilling Method** ROTARY-MUD

Well Number CR 78 **Driller** SHIRE TAHLIL **Bit Size** 15-12½

Completion Date 19.1.85





Depth (m)	Lithologic Description	Remarks
0	Gypsum	14-inch casing to 3 m
10	Sand with clay, Gypsiferous	8-inch blank casing to 56.8 m
20		
30	Sand with clay	
40	Clay, sandy, gypŝiferous	
50	Sand, medium to coarse, well-rounded, well sorted	
60		8-inch perforated casing 56.8 to 68.8 m, 1/8-inch slots, used in lieu of blank casing
70	Static water level 69.65 m 19.1.85	
80	Sand, medium, with clay — 4800 micromhos, drawdown 1.5 m after 11 hrs at 16.4 m^3/hr	8-inch blank casing
90		8-inch perforated casing 86.8 to 176.8m, 1/8 inch slots
100	Sand, medium to coarse, well-rounded	Mono pump installed at 90 m.
110	Sand, fine to medium, with clay and gypsum	
120	Sand, coarse, moderately well sorted and rounded	
130		
140		
150	Sand, fine to medium, with clay and gypsum	
160		
170	Limestone	
	Clay 176.8 m	176.8 m
180		

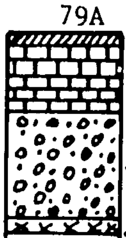
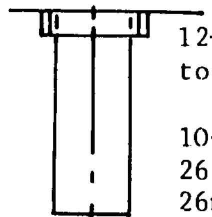
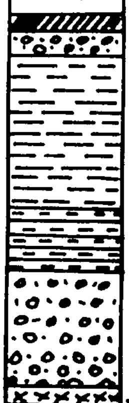
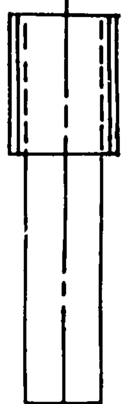
Region BAY REGION | Coord A $2^{o}59.2'N$ $42^{o}48.1'E$ | Rig № 100 | Page 1 of 1

Well Location BUULO CADDAY | Hydrogeologist J.D.G. | Drilling Method ROTARY

Well Number B 79A&B | Coord B $2^{o}59.5'N$ $42^{o}48.1'N$ | Driller TALL ABDI | Bit Size 44-10

Completion Date A. 27.12.84 B. 11.2.85

BOREHOLES ABOU. 2Km APART

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0, 10, 20, 30	79A 	Soil Limestone, medium gray, oolitic fragments at top, dendrites throughout conglomerate derived from granitic complex Granitic rock 26m, Total Depth, No water, Abandoned	79A 	12-inch surface casing to 3 m, no seal 10-inch open hole to 26 m 26m, Total Depth, no water
0, 10, 20, 30, 40, 50	79B 	Soil and clay, medium gray alluvium, sand-pebble conglomerate, weathered feldspar and clay matrix Shale, red, silty Limestone, dark gray, argillaceous Conglomerate, with siltstone, sparse quartz grains, becomes finer toward top Granitic complex, meta-sediments, ferro-magnesian minerals, some quartz and feldspar 50 m, Total Depth, No water, abandoned	79B 	12-inch surface casing to 18 m 10-inch open hole to 50 m, No seal 50 m, Total Depth No water

Region BAY REGION

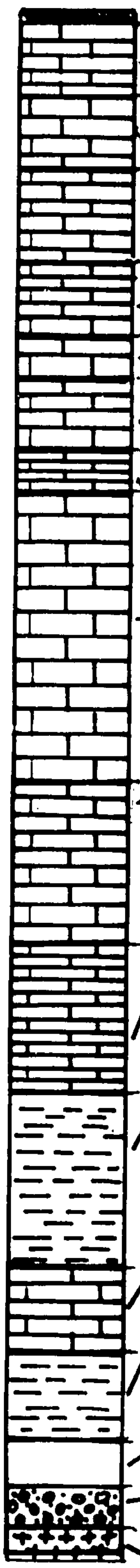
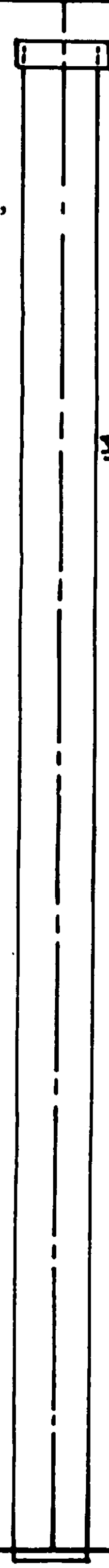
Well Location TOGERE HOOSLE   Coord $2^{o}38.0'N$ $42^{o}54.6'E$

Rig Nº ______ Page 1 of 1

Hydrogeologist J.D.G   Drilling Method ROTARY

Well Number B 80   Driller ______   Bit Size 14-10

Completion Date 4.3.85

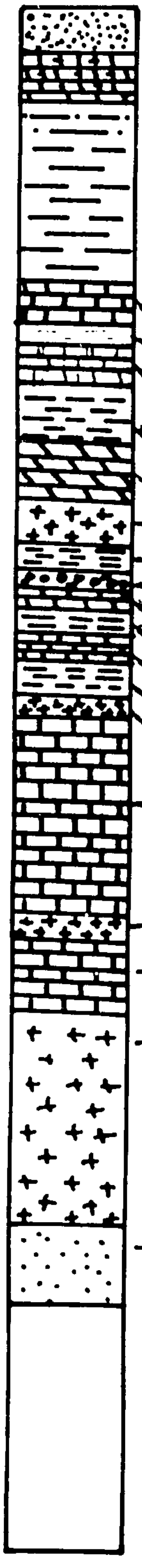
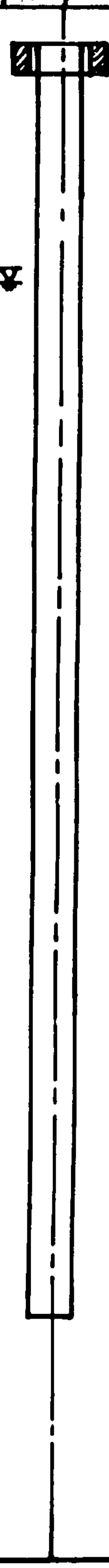
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0 – 200 (scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200)		Soil & limestone, light olive-gray, weathered Limestone, Medium greenish-gray argillaceous, slightly weathere Limestone, medium-gray, argillaceious, Oolitic Limestone, light-gray, oolitic Limestone, white to light-gray, oolitic Limestone, medium-gray, argillaceous, pyritic, very fine Limestone, white to light greenish-gray, oolitic Limestone, light-gray, very fine Limestone, white to light-gray, oolitic, with thin medium gray limestone, oxidized 88-90 m, water at 80-90 m Limestone, medium-gray, oolitic & very fine Limestone, white to light-gray very five, slightly oxidized 130-134 m Shale, red-brown to dark-gray, slightly fissile, silty, limy Limestone, dark-gray, argillaceous, shaley Siltstone, red-brown to green gray, some sand, grantic conglomerate No sample Conglomerate of granitic & Metasedimentary material Granitic complex		12-inch casing to 3 m. 10 inch open hole to 212 m Static water level 57.08 m Total depth 212 m

Region CENTRAL RANGELAND **Rig №** 101 **Page** 1 **of** 2

Well Location BUDBUD **Coord** 6°10.6'N 48°40.7'E **Hydrogeologist** D.DOUGLAS **Drilling Method** ROT.AIR/MUD

Well Number CR 81 Test **Driller** SHIRE TAHLIL **Bit Size** 12½-6½

Completion Date 2.3.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0 – 140				

Depth (m): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140

Lithologic Description

- Aeolian sand, loose
- Calcrete with Gypsum
- Water
- Clay,red,sandy,soft,expansive
- Water
- Water
- Limestone,Karstic
- Shale,red,hard,gypsiferous
- Limestone
- Shale,red,hard,gypsiferous
- Dolomite
- Gypsum
- Shale,gray-white,soft,calcareous
- Conglomerate,well cemented
- Limestone
- Shale,gray-white,soft gypsiferous
- Limestone
- Shale,gray-white,gypsiferous
- Gypsum
- Limestone with seams of red gypsiferous shale
- Gypsum
- Limestone
- Gypsum,karstic,much water, 11000 micromnos
- Sand,very fine,well-sorted, weakly cemented

133.5m, Total Depth

Static water level 17.65 m 2.3.85

Remarks

8-inch surface casing to 4 m.

6½-inch open hole To 133.5 m

12½-inch to 4 m
6½-inch to 133.5 m
Pilot Bore hole

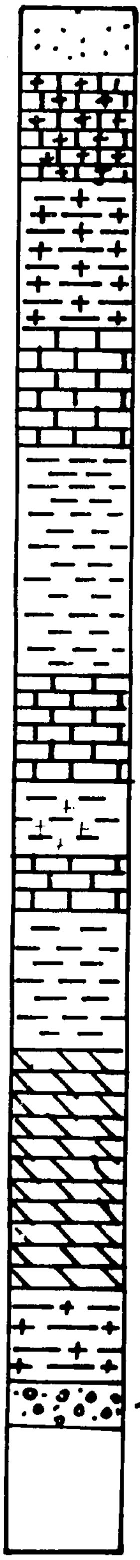
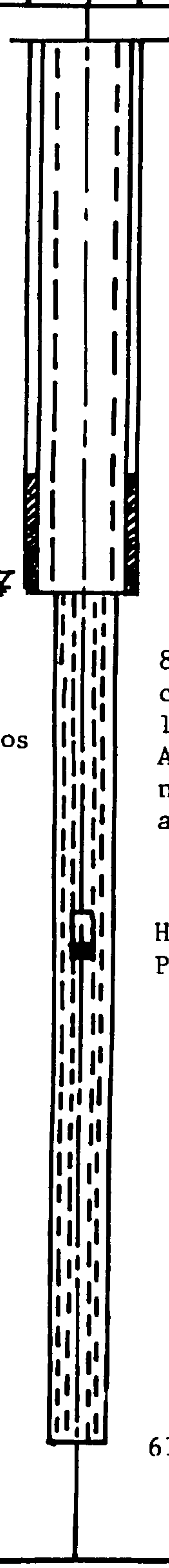
133.5m, Total Depth, Open hole

Region CENTRAL RANGELAND Rig № 101 Page 2 of 2

Well Location BUDBUD Coord 6°10.6'N 48°40.7'E Hydrogeologist D.DOUGLAS Drilling Method ROTARY-AIR

Well Number CR 81 Completion Driller SHIRE TAHLIL Bit Size 15½-10

Completion Date 11.3.85

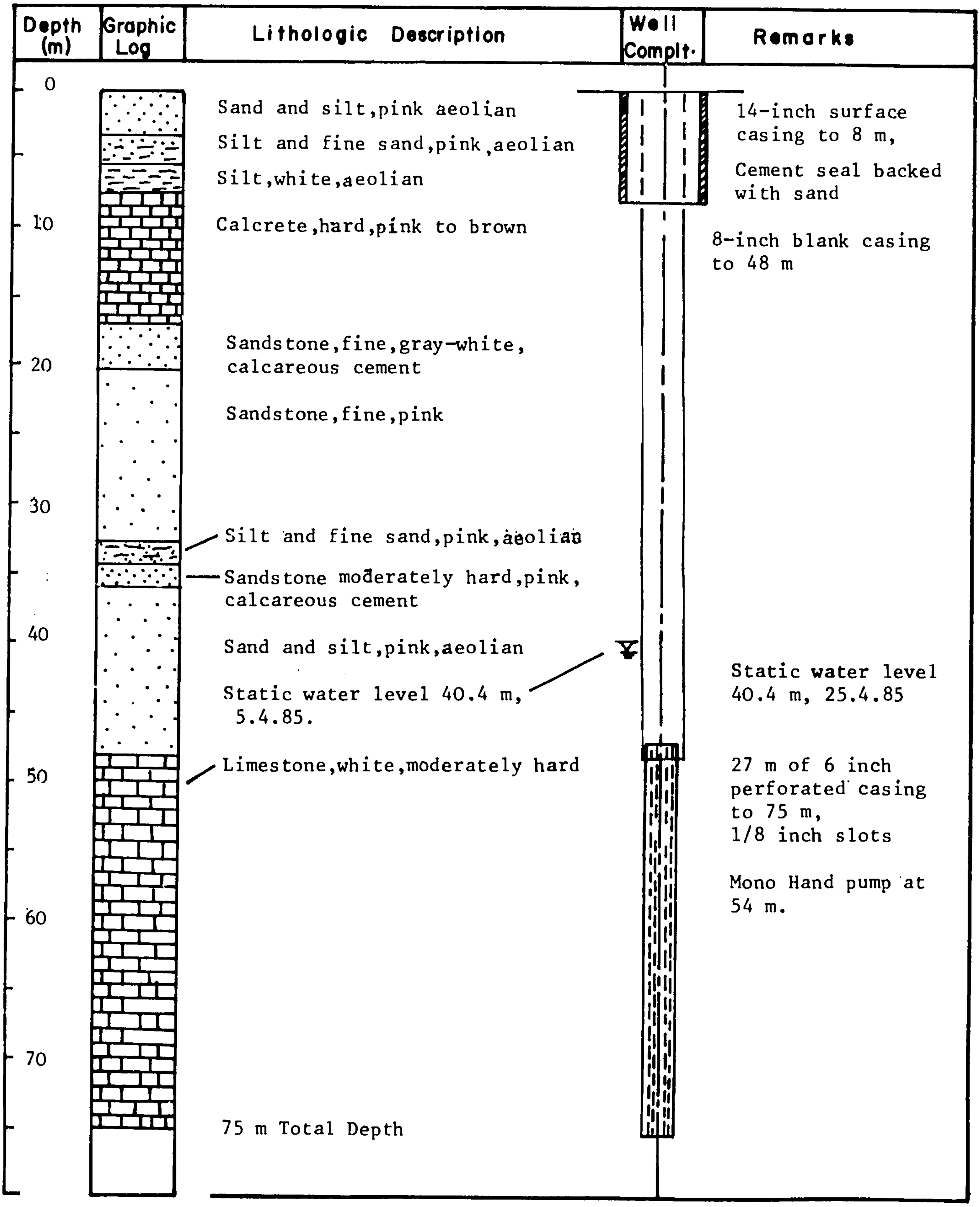
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Aeolian sand, loose		12-inch blank casing to 24 m
		Calcrete, gypsiferous		
10		Clay, sandy expansive, soft		
		Limestone		
20		Clay, sandy, expansive, soft		Cement seal, with 5 percent Bentonite, 19 to 24m, and sand fill to 19 m
		Static water level 23.5 m 11.3.85		
30		Limestone, karstic — 7400 micromhos 23.1 m draw-dawn after 2:10 hrs at 1 m^3/hr		8-inch slotted steel casing to 61 m 1/8-inch slots, All slotted casing, no blank casing available
		Shale, red, hard, gypsiferous		
		Limestone		
40		Shale, red, hard		Hand-powered Mono Pump at 40 m
		Dolomite, karstic		
50				
		Shale, Gypsiferous		
60		Conglomerate, well cemented		
		61 m, Total Depth		61 m, Total Depth

Region CENTRAL RANGELAND Coord 4°06.4'N 47°30.8'E Rig Nº CABLE TOOL Page 1 of 1

Well Location SADDEL Hydrogeologist D.DOUGLAS Drilling Method CABLE TOOL

Well Number CR 82 Driller MUHYADIN NUR Bit Size 16-12-7

Completion Date 25.4.85

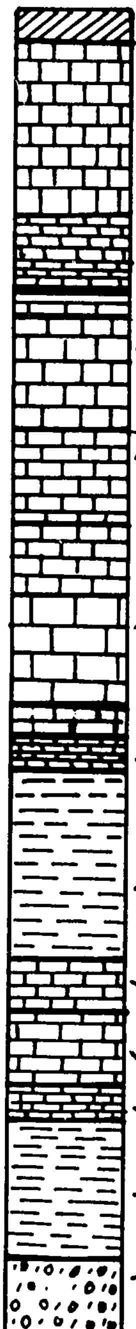
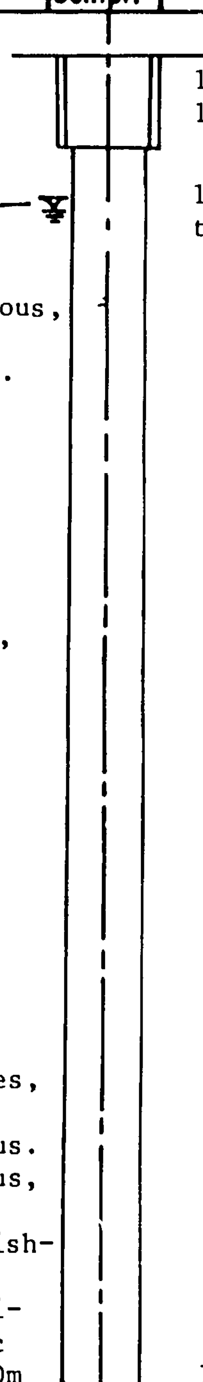


Region Bay Region | Rig Nº 102 | Page 1 of 1

Well Location Misra | Coord ______ | Hydrogeologist Gilicspie | Drilling Method ______

Well Number B 83 | Driller Abdi Warsame | Bit Size 14,10

Completion Date 17.4.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Clay soil, brown		12-inch casing to 12m, cement seal
10		Limestone, white to light-gray, oolitic, moderately weathered		
20		Static Water level 21.18m 17.4.85		10-inch open hole to 170 m
30		Limestone, white to light-gray, oolitic, some dark-gray, argillaceous, and purple siltstone		
40		Limestone, dark-gray, argillaceous.		
50		Limestone, white to light-gray, oolitic, weathered surfaces iron-stained		
60		Limestone, medium to dark-gray, oolitic, partly lithographic.		
70				
80		Limestone medium-gray very dense, sparse dark-gray fragments water		
90		Limestone, light to medium-gray, oolitic, sparse Bioclasts		
100		Limestone, white to medium-gray, very fine, argillaceous, sparse fine pyrite		
110		Limestone, medium greenish gray, argillaceous, pyrtic		
120		Shale, redish-brown, silty, fissile		
130		Limestone, medium to dark gray argillaceious calcite in fractures, pyrite traces		
140		Limestone, medium-gray, argillaceous. Limestone, medium-gray, argillaceous, sandy		
150		Siltstone, greenish-gray, some redish-brown, sparse sandstone, fine		
160		Conglomerate, granitic and metasedimentary components, fresh granitic rock in final sample, water at 170m		
170		170 m, Total Depth		170 m, Total Depth

Region CENTRAL RANGELAND

Rig Nº 101 Page 1 of 1

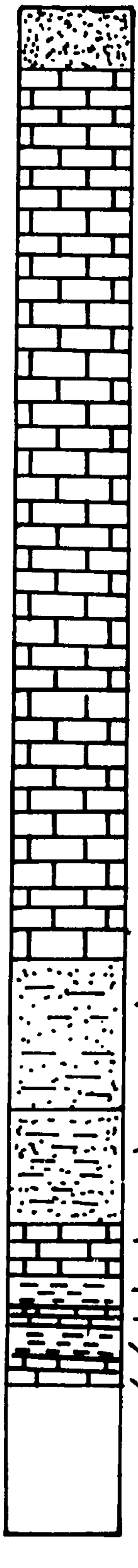
Well Location CAGACADE Coord ____

Hydrogeologist D.DOUGLAS Drilling Method ROTARY-MUD

Well Number CR 84

Driller SHIRE TAHLIL Bit Size 6"

Completion Date 1.6.1985

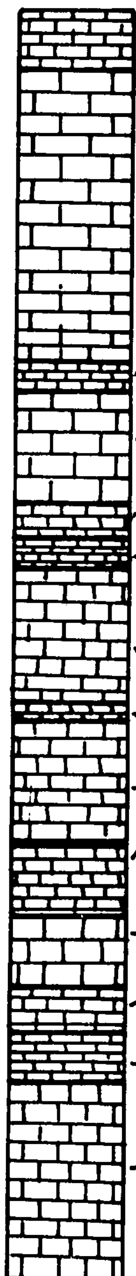
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Sand, medium to fine grained, well sorted, lateritic, red		
10		Limestone, sandy, moderately hard, white		
20				
30				
40				
50				
60				
70				
80				
90				
100		Sandstone, very five grained, slightly clayed, moderately well cemented, calcareous, white-red		
110		Sandstone, very fine grained, clayey, weakly cemented, calcareous, white-red		
120		Limestone, hard, with chert modules, fractured, white		Minor loss of circulation
		Clay, soft, expansive red		
130		Limestone, hard, with chert modules, fractured, white		Lost circulation 132.5 m 18.5.85
134.5		Clay, soft, expansive, red		Lost circulation 134.5 m 1.6.85
		Limestone hard, with chert modules, fractured, white		Bore hole abandoned
		TD= 134.5		No water encountered

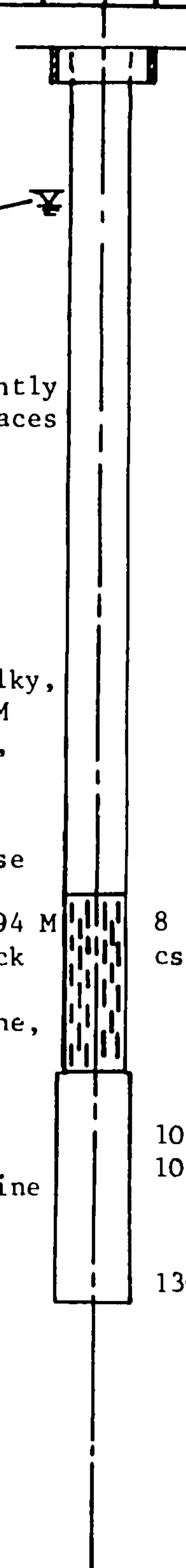
Region BAY REGION   Rig Nº 102   Page 1 of 1

Well Location Buklaabow   Coord 3°01.2'N 43°24.3'E   Hydrogeologist J.D.Gillespie   Drilling Method Rotary

Well Number B 85   Driller Abdi Warsame   Bit Size 14 - 10

Completion Date 30.5.85





Depth (m)	Lithologic Description	Remarks
0	Limestone, Weathered, iron stain decreases downward	12 Inch surface casing to 3.5m, cement seal
10	Limestone, light-gray to light-buff, fine, slight to moderate weathering	8 Inch PVC casing to 106, perforated from 88 to 106 M.
20	Static water level 14.0 M 30.5.85	
30		
40	Limestone, medium-gray, fine, slightly argillaceous sparse weathered surfaces	
	Limestone, light to medium-gray, oolitic	
50	Limestone, white to medium-gray, chalky, platy	
	Limestone, medium-gray, fine, argillaceous	
60		
	Limestone, white to light-gray chalky, platy, oxidized surfaces 64 to 68 M	
70	Limestone, medium gray, fine dense, argillaceous	
80	Limestone, light gray, oolitic	
	Limestone, light-medium-gray, sparse oolites, slightly argillaceous, slightly oxidized surfaces 88' to 94 M	
90	Limestone, medium-gray, sparse black fossil fragments, very fine.	8 Inch PVC perforated csing 88 to 106 M
100	Limestone light to medium-gray, fine, sparse fossils	
110	Limestone, light-gray, fine, platy cuttings	10 Inch open hole 106 to 130 M
120	Limestone, light to medium gray, fine sparse fossils.	
130	130 M Total depth	130 M Total depth

Region CENTRAL RANGE HASSAN

Rig Nº 101 Page 1 of 1

Well Location AFRAH Coord 4°07.7'N 47°07.6'E Hydrogeologist D.DOUGLAS Drilling Method ROTARY

Well Number CR 86 Driller ABDI DHEERE Bit Size 6

Completion Date 29.5.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0–10		Sand, red, fine to medium, lateritic, and calcrete		6-inch open hole to 201.3 m
10–100		Limestone, white, with stringers of fine, well-cemented sandstone		
100–160		Sand with clay, red-brown fine to medium		
160–175		Sand, Brown, fine, well sorted, well rounded		Minor circulation loss from 163 m to total depth, no water found, dry hole, Abandoned
175–178		Sand fine, with clay, brown		
178–193		Sand, Brown, fine, well sorted, well rounded		
193–201.3		Sand fine with clay, brown 201.3 Total depth		201.3 m Total depth

Depth scale (m): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200

Region CENTRAL RANGELAND　Rig Nº 101　Page 1 of 1

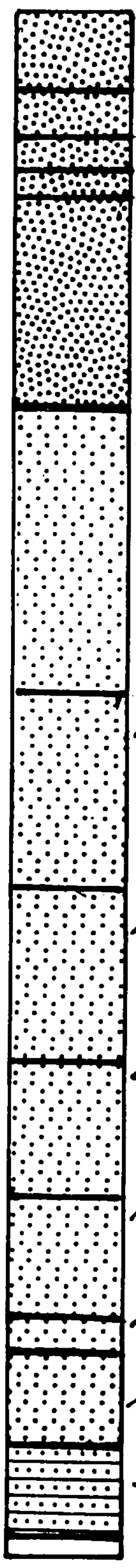
Well Location ALYCABAL　Coord 3°58.3'N 47°05.1'E　Hydrogeologist D.DOUGLAS　Drilling Method ~~CABLE TOOL~~ ROTARY

Well Number CR 87　Driller ABDI DHEERE　Bit Size 16-12

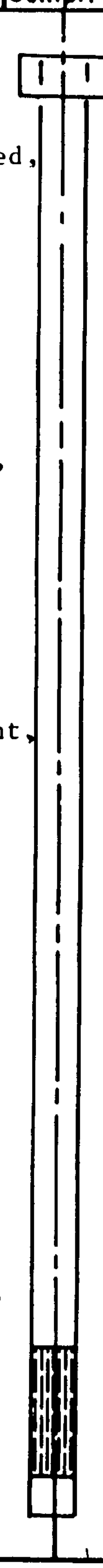
Completion Date 6.7.85

Depth (m)	Lithologic Description	Remarks
0	Sand red,fine,well-sorted, lateritic	14-inch surface casing to 6 m
10		
20	Sand,white,medium to fine,well-sorted, calcareous	6-inch steel casing to 245.5 m.
30	Sand,white,fine,well sorted	
	Sand,brown,fine to gravel,poorly sorted(to 1 cm diameter)	Perforated casing from 0-132 m in lieu of blank casing
40		
50	Sand,tan,fine to medium,well-sorted	
60		
70	Sandstone,red-brown,silty to medium, poorly sorted,calcareous cement	
80	Clay traces at 76-78 m,85-89 m, 100-103 m	
90		
100		
110	Sandstone, red-brown silty to very-fine, poorly sorted,calcareous cement, some clay	
120		
130		
140	Sandstone,white,silty to very-fine poorly sorted,calcareous cement	
150		
160		
170	Sandstone,red-brown,silty to very-fine,poorly sorted,calcareous cement	
180		
190	Sandstone with clay,red-brown,silty to very-fine,poorly sorted, calcareous cement	
200		1/8x2-inch slot perforated casing 216-240 m
210	Sandstone,red-brown,silty to medium, calcareous cement	
220		Static water level 220 m 6.7.85
230	Sandstone,red-brown,fine to medium well rounded	
240	Sand with clay,red-brown,silty to fine	
250	250 Total Depth	245.5 m cased, 45 m caved

Graphic Log



Well Complt.



Region BAY REGION

Well Location COPAN HAGAN

Coord 2°40.0'N 43°04.0'E

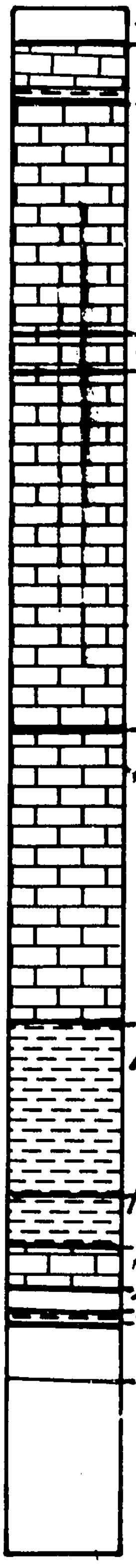
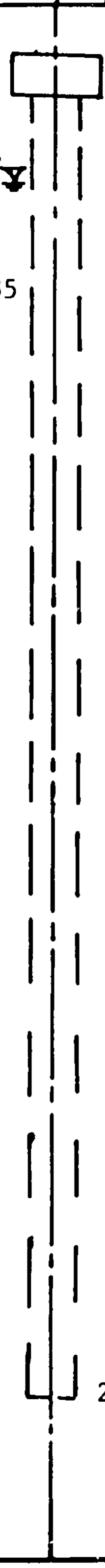
Rig Nº 102 Page 1 of 1

Hydrogeologist I.D.G. Drilling Method ROTARY

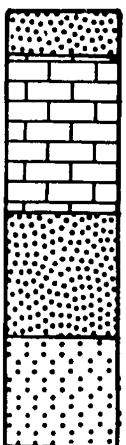
Well Number B 88

Driller ABDI WARSA Bit Size 14-6

Completion Date 16.6.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0–300 (scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300)		Soil,clay,dark-brown to gray Limestone,light-brown to gray weathered Limestone,light-brown to gray, Fine,Oolitic 50-52 m, weathered Limestone,light-gray,Fine weathered,secondary calcite vugs 76.78m. Limestone,light to dark-gray, Fine and Oolitic in part Limestone,light to medium-gray, Fine Shale,red-brown Shale,dark-gray,limy and marl Limestone,medium-gray,argillaceous No sample Shale,dark-gray with sand and metamorphic rock No sample 294m Total Depth	 Static water level 28m 26.6.85	12-inch surface 6-inch pilot hole to 294m, uncased 294 Total Depth

Region CENTRAL RANGELAND
Well Location XARADHEERE Coord 4°39.3'N 47°51.3'E
Rig Nº C.T Page 1 of 1
Hydrogeologist DAVID D. Drilling Method CABLETOOL
Well Number Ck 89
Driller Mohudin Bit Size 28-12
Completion Date 20.7.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Sand, medium, lateritic with silt, red		14-inch surface casing to 4m
		Calcrete, white, hard		8-inch PVC casing to 21m
		Sand, ill-sorted Fine to gravel, red	Static water level 13.5m 20.7.85	Perforated casing 15-21m
		Sandstone, white, calcareous, hard		Open hole 21-28m, with lost drill bit 21-28m
		28m Total Depth		28m Total Depth

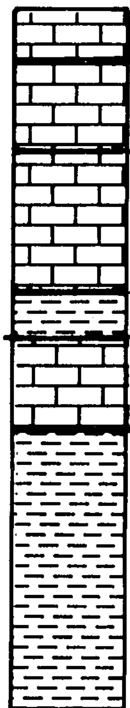
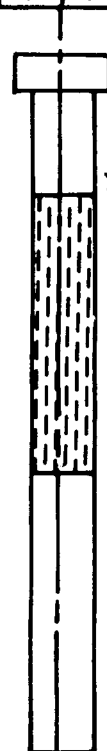
Region BAY REGION Rig Nº 101 Page 1 of 1

Well Location BRADP COMPOUND Coord 3°07.3'N 43°38.9'E Hydrogeologist J.D.G. Drilling Method ROTARY

Well Number B90 Driller Shire Bit Size 14-10

Completion Date 27.6.85

"Chinese Well"

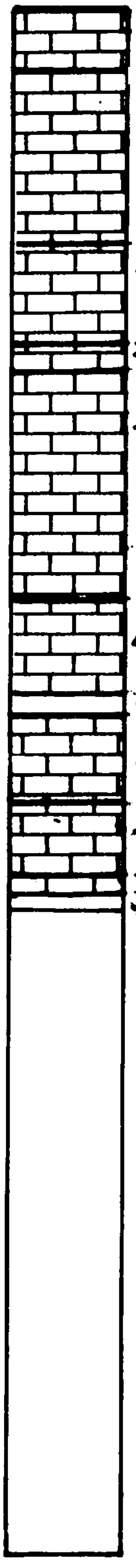
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Limestone, Buff, weathered		12-inch surface casing to 1.5m 8-inch PVC casing to 18m
10		Limestone,white to light-gray light-gray, moderately weathered		Static water level 5.6m, 27.6.85
20		Limestone,white to light-gray		
30		Shale,medium-gray,limy		Perforated PVC casing 6-18m
		Limestone,light-gray,platy, argillaceous,limy		
40		Shale,medium to dark-gray,limy		Open hole 18-30m
50				
60		30m Total Depth		30m Total Depth

Region BAY REGION Rig Nº 101 Page 1 of 1

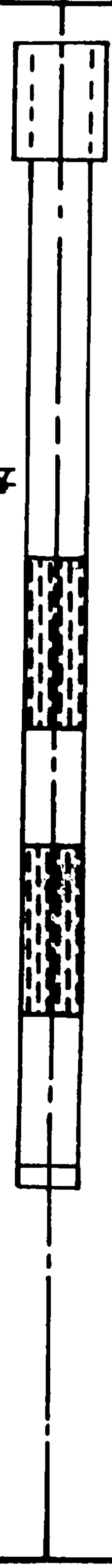
Well Location HARE Coord 3°30.8'N 43°33.8'E Hydrogeologist J.D.G. Drilling Method ROTARY

Well Number B91 Driller Shire Bit Size 16-10

Completion Date 13.7.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Limestone, red, highly weathered		14-inch surface casing to 1.5m
10				
20		Limestone, light-brown to gray moderately weathered		8-inch PVC casing to 116m
30		Limestone, light-gray sparse iron stain, medium-grained		
40		Limestone, white to light-gray, oolitic, oxidized, water		Static water level 44.2m 9.7.85; Perforated casing 44-50m
50		Limestone, medium-gray, argillaceous		
60				
70		Limestone, medium-gray, oxidized, water		Perforated casing 72-84m
80				
90		No sample		
100		Limestone, medium-gray, fine		
		Limestone light-brown to medium gray, oxidized, water		Perforated casing 104-116m
110		Limestone, medium-gray, fine		116m Total Depth
120		No sample 116m Total Depth		

Region BAY REGION
Well Location ASHA FARTOW
Coord 3°15.1'N 43°34.0'E
Rig № 102 Page 1 of 1
Hydrogeologist J.D.G.
Drilling Method ROTARY-AIR
Well Number B92
Driller ABDI WARSAME
Bit Size 14-10
Completion Date 18.7.85

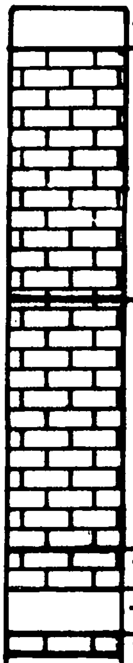
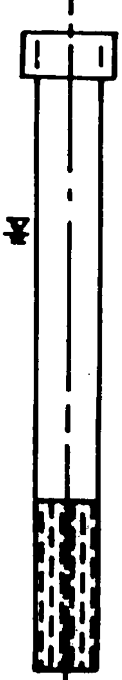
Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil and brown-to-yellow clay		12-inch casing to 24m
10				
20		Limestone, white to light-yellow, weathered, some clay		8-inch PVC casing to 118m
30		Limestone, white to light-brown, deeply weathered, fractures with clay fillings. Water at 58m		
40				
50		Static water level 46.48m 16.7.85		
60		Limestone, medium to dark brownish-gray, argillaceous		1/8-inch perforations in 8-inch PVC casing
70		Limestone, white to light-yellow calcite vuglinings, water		
80		Limestone, light-gray, weathers chalky, water		
90		Limestone, light-gray, soft with much clay		
100		Limestone, light to medium-gray		
		Limestone, dark-gray, very fine		
110		Limestone, medium-gray, Fossiliferous		
120		Limestone, white to light-gray weathered		120 total depth open hole 118-120m
		120m Total Depth		

Region BAY REGION　Rig Nº 101　Page 1 of 1

Well Location BAQALLEY　Coord $3^{o}14.3'N$ $43^{o}13.2'E$　Hydrogeologist J.D.G.　Drilling Method ROTARY-AIR

Well Number B 94　Driller SHIRE　Bit Size 14-10

Completion Date 20.7.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil and clay, red		12-inch casing to 4.5 m
10		Limestone, light-gray weathered, vuggy 12-14 m, 28-30 m		
20		Static water level 20.5 m 18.7.85		8-inch steel casing to 66 m
30				Specific conductivity
40		Limestone, medium-gray iron stains on fracture surfaces		
50				
60		Limestone, medium gray to brown, water 56-58 m		1/8-inch slots in 8 inch perforated casing
		No sample		
70		Limestone, medium-gray, water 66 m, total depth		66 m, total depth

Region BAY REGION

Well Location KURTÍN Coord 3°01.0'N 43°12,7'E

Well Number B95

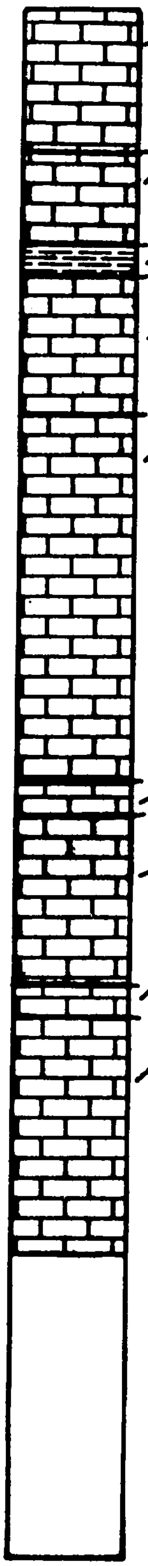
Completion Date 5.8.85

Rig Nº 101

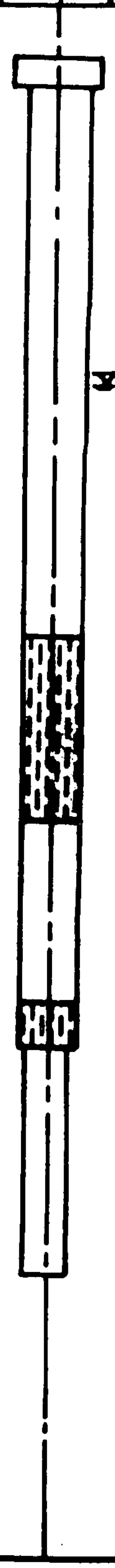
Hydrogeologist J.D.G. Drilling Method ROTARY

Driller ABDI WARSAME Bit Size 14-10-6

Graphic Log:



Well Compl'n:



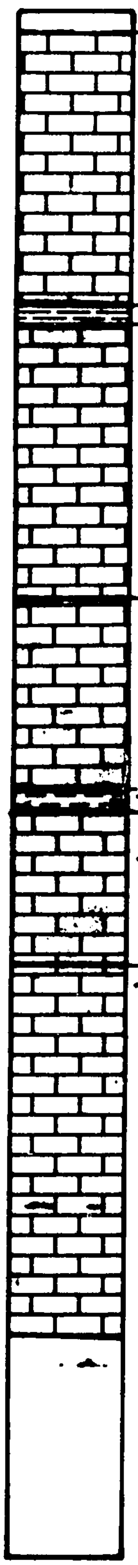
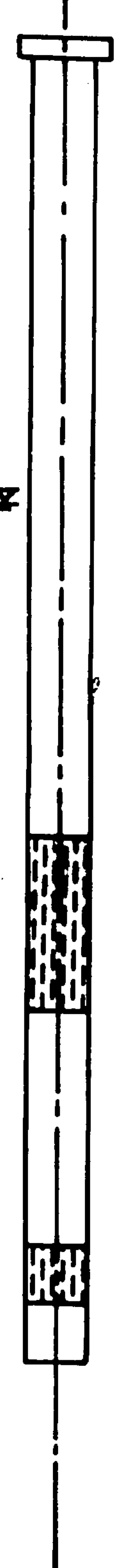
Depth (m)	Lithologic Description	Remarks
0	Limestone, light yellow to dark red, weathered	12 inch surface casing to 3.5 m
10		
20	Limestone, light-gray, oolitic, weathered with clay	8 inch steel casing to 130 m
30	Clay, yellow and gray oolitic limestone	
40	Limestone olive-gray to gray fine moderately weathered	Static water level 43 m 3.8.85
50	Limestone, gray, argillaceous, partly oolitic, some oxidized strata with clay	
60		
70		
80		Perforated casing, 1/8x2-inch slots, 216 per 6 m length, 76-100 m
90		
100	Limestone, dark-gray, with chert	
110	Limestone, gray, argillaceous some oxidized strata with clay	
120	Limestone, gray, oxidized	
130		Perforated casing 1/8x2-inch slots, 124-130 m
140	Limestone, gray, argillaceous, with sparse interbeds of dark-gray shale	6 inch open hole, 130-160 m
150		
160	160 m total depth	160 m total depth

Region Bay Region **Rig №** 101 **Page** 1 **of** 1

Well Location Qansax Dheere 2 **Coord** 2°55.5'N 42°57.3'E **Hydrogeologist** J.D.G. **Drilling Method** Rotary

Well Number B96 **Driller** Shire **Bit Size** 14-10

Completion Date 8.8.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Soil, clay and weathered limestone, red		12-inch surface casing to 2 m
10		Limestone, yellow-brown, weathered		8-inch steel casing to 136 m
20				
30		Clay and limestone, yellow		
40		Limestone, white to brown weathered, oxidized with clay.		
50		Static water level 48.04 m 8.8.85		
60		Limestone, light to dark-gray weathered to clay, limonitic vugs in some intervals.		
70				
80		Shale, dark gray, with some yellow-brown limestone		Perforated casing, 1/8 x 2 inch slots, 216 per 6 m length, 82-100 m
90		Limestone, light-brown moderately weathered		
100		Limestone, light-gray to dark-brown, argillaceous		
110				
120				Perforated casing 124-130 m
130		136 m total depth		136 m total depth
140				

Region: Bay Region

Well Location: Toosilow

Coord: 3°08.6'N 43°11.6'E

Rig Nº: 102

Page 1 of 1

Hydrogeologist: J.D.G.

Drilling Method: Rotary

Well Number: B97

Driller: Abdi Warsame

Bit Size: 14-10

Completion Date: 22.8.85

Depth (m)	Graphic Log	Lithologic Description	Well Complt.	Remarks
0		Limestone, white to light-gray, highly weathered		12-inch surface casing to 2 m 8-inch steel casing to 140 m
28		Limestone, light-gray, weathered		Static water level 32 m 23.8.85
52		Limestone, light-green to medium gray, weathered		
54		Limestone, gray and brown, weathered, water at 60 m		
62		Clay, green-gray to dark gray		
66		Limestone, light-gray to light-brown, weathered, iron-staubed fractures.	68–80	Perforated casing, 1/8 x 2" slots 216 slots per 6m length, 68-80 m.
82		Limestone light green-gray to gray		
94		Limestone light-gray to gray, argillaceous	92–110	Perforated casing, 92-110 m.
		Limestone, light-gray to gray, oxidized fragments		
124		Limestone, green-gray, argillaceous		
140		140 m total depth		140 m total depth

SECTION 2.

Basic Well Data

TABLE NO. BASIC WELL DATA. CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B1	Bonkay 1	S 3^o 07.0' N 43^o 39.0' E	510	4.2.82	18		Dry						Abandoned Dr
B2	Bonkay 2	S 3^o 07.0' N 43^o 39.0' E	510	27.2.82	201	Open hole 30-201'M	48.5 27.2.82	2300 27.2.82					Abandoned observation GL
B3	Bonkay 3	S 3^o 07.0' N 43^o 39.0' E	510	13.4.82	160	Open hole 74-160 M	30 19.7.84	2700 19.7.84	2216/ 533/12 10.9.83	6.6	0.33	Motor 114 M	In use PT,CD,GL
B4	Tugerew 1	S 3^o 07.1' N 43^o 42.5' E	390	10.6.82	42	6-12 26-32	3 31.1.84	1700 2.2.84	1348/ 461/55 2.2.84	3.7	0.21	Hand 29 M	In use PT,CD,GL

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

127

BASIC WELL DATA. CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B5	Gasarta	M 3° 07.6' N 43° 49.2' E	350	21.3.82	42	open hole 6-42	12 21.3.82						Abandoned low yield, GL
B6	Waraji 1	M 2° 54.8' N 43° 32.5' E	475	28.3.82	80	open hole 6-80	67 23.3.82						Abandoned low yield, G'
B7	Waraji 2	M 2° 53.2' N 43° 32.5' E	430	29.3.82	39	open hole 1-39	Dry						Abandoned Dry
B8	Tugerew 2	S 3° 06.9' N 43° 41.7' E	400	29.3.82	48	open hole 0-48	Dry						Abandoned Dry
B9	Burhalab	M 3° 4.2' N 44° 6.2' E	280	30.3.82	32	open hole 0-35	Dry						Abandoned Dry

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M3/hour/M	Type of Pump installed, Depth, M	REMARKS
B10	Sarman Dheere	S 3° 16.6' N 43° 21.4' E	450	10.4.82	85	30-50.4	12.9 28.6.82	3300 29.6.82	3000/ 649/47 29.6.82	26.6	140.2	Motor 50 M	In use,PT,CD,G
B11	Baidoa AID Compound 1	S 3° 07.3' N 43° 38.9' E	460	2.6.82	137	open hole 48-140	7 4.5.82	1500 14.10.82	1360/ 343/125 14.10.82	13.3	28.9		Abandoned surface seal Defective,PT,C
B12	Hareero Jiifo	S 3° 13.9' N 43° 25.2' E	478	9.7.82	166	51.6-73.2	29.5 10.7.82	3900 26.1.84	3544/ 1312/257 26.1.84	11.4	0.53	Motor 77 M	In use,PT,CD,G
B13	Shabelle Dugsilow	S 3° 17.2' N 43° 13.0' E	420	14.7.82	172	open hole 44-172	11 13.7.82	24000 26.6.82	19772/ 9618/284 26.6.82				Abandoned Excessive Salinity, CD

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	N a m e	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth. M	R E M A R K S
B14	Warta Jaffay	S 3^o 19.0' N 43^o 08.5' E	390	3.8.82	91	open hole 2-91	17.5 22.8.82	10,000 10.9.83	9188/ 3024/105 10.9.83				Abandoned Excessive Salinity, CD
B15	Qansax Oomane	S 3^o 19.9' N 43^o 02.4' E	365	19.8.82	174	open hole 0-174	165 22.8.82	24000 16.6.82	16436/ 874/362 16.6.82				Abandoned Excessive Salinity,CD,
B16	Taflow	S 3^o 03.9' N 43^o 11.4' E	435	16.8.82	153	open hole 72-153	35.4 5.1.84	1580 10.9.83	1528/ 265/130 10.9.83	11.4	1.69	Motor 67 M	In use,PT,CD,
B17	Robay Gaduud	S 2^o 46.3' N 43^o 18.8' E	440	27.8.82	142	48-88	22.7 27.3.84	1280 4.4.84	1024/ 355/89 4.4.84	11.4	0.20	Hand 88	In use,PT,CD,

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M3/hour/M	Type of Pump installed, Depth, M	REMARKS
B18	Gaduuda Dhunte	S 2° 47.5' N 43° 15.8' E	430	29.9.82	73	16-64	23.5 13.3.84	3800 13.3.84	1932/ 1148/204 13.3.84	11.4	0.90	Motor 50	In use,PT,CD,
B19	Buulo Fuur 1	S 2° 53.8' N 43° 05.0' E	435	20.8.82	94	open hole 0-94	Dry						Abandoned dry
B20	Duri Ali Galle	S 2° 49.9' N 42° 55.9' E	405	11.10.82	116	82-100	59.4 29.4.84	2000 29.4.84	1816/ 448/100 29.4.84	11.4	0.34	Hand 88	In use,PT,CD,
B21	Baidoa AID-Compound 2	S 3° 07.4' N 43° 39.7' E	460	16.12.82	42	19.6-36.4	8.5 18.9.84	2500 15.1.83	1928/ 341/64 15.1.83	5.5		Motor 40	In use,CD,GL

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available.
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B22	Buulo Gaduud	M 2° 07.9' N 42° 38.4' E	260	4.1.83	189	open hole 0-189	Dry						Abandoned dry,C
B23	Kurman	S 2° 28.9' N 42° 51.3' E	350	10.1.83	148	30-54	20 25.1.83	2400 29.2.83	1868/ 756/132 29.2.83	3.6	0.12	Hand 48	In use,CD,GL
B24	Yaaq Baraawe	M 1° 57.0' N 43° 14.1' E	160	24.1.83	10	5-10	1 26.1.83						Abandoned low yield,GL
B25	Dodole	S 2° 18.3' N 43° 33.9' E	190	13.1.83	24	open hole 17-24	12 12.1.83	900 19.1.83	660/32/ 36 19.1.83				Abandoned low yield,CD,GL

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B26	Shidaalow 1	S 2° 53.6' N 44° 16.2' E	195	20.1.83	67	open hole 3-67	36 27.1.83	33000 20.1.83	32042/10000 /1250 20.1.83				Abandoned Excessive Salinity ,CD,GL
B27	Shidaalow 2	S 2° 53.6' N 44° 16.2' E	195	25.1.83	80	open hole 2-80	37 27.1.83	34000 34000 25.1.83	33376/21300 /873 25.1.83				Abandoned Excessive Salinity,GL,CD
B28	Bur Akaba 1	M 2° 48.6' N 44° 11.6' E	200	25.1.83	54	open hole 1-54	22 25.1.83	14000 25.1.83					Abandoned Excessive Salinity, GL
B29	Bur Akaba 2	M 2° 48.6' N 44° 11.6' E	200	26.1.83	24	open hole 1.5-24	7 1.2.83	34000 1.2.83					Abandoned Excessive Salinity

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available.
3. [illegible]
4. [illegible]

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B30	Bur Akaba 3	M 2° 48.6' N 44° 11.6' E	200	1.2.83	30	open hole 1-30	22 1.2.83	42000 1.2.83					Abandoned Excessive Salinity
B31	Bur Akaba 4	S 2° 47.5' N 44° 05.1' E	200	2.2.83	63	open hole 1-63	20 2.2.83	49000 2.2.83					Abandoned Excessive Salinity
B32	Bur Akaba 5	S 2° 47.5' N 44° 05.1' E	200	15.2.83	89	6-31 open hole 31-89	17 24.3.84	1140 7.5.84	916/168/81 7.5.84			Hand 45	Low Yield, CD, GL
B33	Bur Heibe 1	M 2° 58.6' N 44° 29.9' E	230	10.3.83	26	open hole 2-26	18 10.3.83						Abandoned Low yield, GL

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT - Pump test data available [illegible]
3. [illegible]
4. [illegible]

134

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B34	Bur Heibe 2	M 2° 58.8' N 44° 26.0' E	230	23.2.83	73	8-20 open hole 26-73	16 1.4.84	1320 29.8.84	952/ 231/47 29.8.84			Hand 52	Low yield, CD
B35	Bur Heibe 3	M 2° 58.6' N 44° 26.9' E	230	15.3.83	60	open hole 2-60	Dry						Abandoned dry, C
B36	Bur Heibe 4	M 2° 58.6' N 44° 26.9' E	230	15.3.83	25	open hole 1-25	Dry						Abandoned dry
B37	Bur Heibe 5	M 2° 58.6' N 44° 26.9' E	230	15.3.83	26	open hole 1-26	Dry						Abandoned dry
B38	Bur Heibe 6	M 2° 58.6' N 44° 26.9' E	230	16.3.83	36	open hole 2-36	Dry						Abandoned dry

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available.
3. [illegible]
4. [illegible]

13

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	N a m e	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	R E M A R K S
B39													Site abandond not drilled
B40	Limestone Depression	M 3° 11.2' N 44° 15.4' E	360	23.2.83	32	Open hole 1.5-32	Dry						Abandoned, dry
B41	Dolondole	M 3° 16.1' N 44° 14.2' E	480	2.3.83	166	5.4-10.8 Open hole 10.8.-166	1.9 14.3.84	1040 10.9.83	564/71/72 10.9.83				Well destroye filledwith ro
B42	Buulo Fuur 2	S 2° 53.8' N 43° 05.0' E	435	3,5.83	130	64.5-98 Open hole 98-130	56.2 16.4.84	2050 20.6.84	1640/320/ 309 20.6.84	11.4	1.73	Motor 92	In use
CR 43	Aborey 1	M 3° 57.5' N 46° 51.2' E	281	3.5.83	120	Openhole 2-120	Dry						Abandoned, no deep enough
CR 44	Afar Irdood	M 3° 59.5' N 46° 53.4' E	284	21.5.83	174	37.8-81	Dry						Not deep enou
B45	Baidoa AID Compound 3	S 3° 07.3' N 43° 38.9' E	460	20.7.83	120	65-117	6.5	1770 20.7.83		10.9	0.22		Abandoned,sea defective&low yield

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	REMARKS
B46	Qansax Dheere	S 2° 55.5' N 42° 57.3' E	405	11.5.83	103	Open hole 60-103	30.2	1900 17.5.84	1772/391/62 17.5.85	11.4	0.87	Motor 92	In use PT, CD GL
B47	Awshini	S 3° 12.2' N 43° 23.5' E	475	30.6.83	143	56-86 Open hole 90-143	29.8 10.4.84	3100 10.4.84	2740/851/371 10.4.85	11.4	0.72	Motor 92	In use PT, CD GL
CR48	More Ari	S 3° 51.5' N 46° 02.6 E	180	23.6.83	102	60-96	36 9.12.83	3700 30.6.83	-/488/249 30.6.83				PVC casing ruptured at 4 CD, GL
CR49-1	Maxaas Jeejo	M 4° 40.1' N 46° 10.1' E	200	9.9.83	190	Open hole 9-190	Dry						Abandoned, GL Dry not deep enough.
CR49-2	Maxaas Jeejo	M 4° 40.1' N 46° 10.1' E	200	15.10.83	180	Open hole 6-180	Dry						Abandoned, GL Dry, not deep enough

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	Name	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed Depth, M	REMARK
B50	Bonkay Seed Farm	S 3° 11.8' N 43° 36.6' E	510	22.9.83	200	Open hole	30.1 29.11.83	11400 20.11.83		11.4	0.21		Abandoned,PT, excessive salinity
B51	Mintaan	S 3° 20.8' N 43° 33.2' E	490	2.10.83	132	51-93 Open hole 99-132	40.2 8.12.85	1400 8.2.84	1164/248/40 8.2.84	11.3	0.70	Hand 60	In use,PT,CD,
B52	Maleel	S 3° 26.2' N 43° 35.2' E	495	7.12.83	130	51-93 Open hole 99-130	48.5 21.12.83	670 1.-.84	608/112/67 1.-.84	25.2	23.77	Motor 92	In use,PT,CD,
CP53	Aborey 2	M 3° 58.9' N 45° 50.8' E	285	11.12.83	133	Open hole 3-133	Dry						Abandoned, GI
B54	Isgeed	S 3° 26.8' N 43° 33.2' E	490	19.12.83	150	90-114 Open hole 120-150	37.1 25.1.84	1350 26.1.84	992/283/40 26.1.84	17.0	0.76	Motor 92	In use,PT,CD

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	N a m e	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	R E M A R K S
B55	Marti Moog	S 3° 34.0' N 43° 28.8' E	490	23.1.84	147	76-114 Open hole 120-147	32.8 21.2.84	1150 22.2.84	964/142/ 21 22.2.84	22.7	0.83	Motor 91	In use,PT,CD
B56	Jimcada Dheen	M 2° 45.7' N 44° 21.4' E	175	3.3.84	41	Open hole 3-41	Dry						Abandoned,dr
B57	Hagarka	S 2° 53.7' N 43° 18.7' E	470	9.3.84	154	54-114.5 Open hole 120-154	19.3 21.3.84	2000 5.4.84	1656/560/ 187 5.4.84	11.4	0.2	Hand 88	In use,PT,CD
B58	Bur Akaba 6	S 2° 44.5' N 44° 06.8' E	190	20.3.84	27	Open hole 0-27	20 20.3.84	48000 20.3.84	---/22700/ --- 20.3.84				Abandoned, C excessive salinity
B59	Shawka	S 3° 00.5' N 43° 31.8' E	485	18.3.84	138	45.8.51.6 91.6-132.2	30 22.3.84	13500 3.4.84	10224 / 4760/782 3.4.84	11.4	0.2		Awaits furth investigatio PT,CD,GL.

1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA, CGDP

Well Number B, Bay Region Cr, Central Range	N a m e	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M[1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	R E M A R K S
B60	Kannana	M 2° 12.4' N 43° 24.0' E	200	27.3.84	15	9-15	8.6 2.4.84						Abandoned, low yield,GL
B61	Huubay	M 2° 38.3' N 42° 58.8' S	405	5.4.84	152	60-108 Open hole 108-152	17 5.4.84	2550 5.4.84	1348/497 /33 8.7.85	3.6	0.1		Low yield ,GL
B62	War Caasha	S 3° 02.6' N 43° 32.6' E	485	29.4.84	201	Open hole 0-201	120 22.4.84	1250 28.4.84	1200/252 /41 28.4.84				Abandoned, Low yield,CD,
B63	Bonkay Extension	S 3° 11.8' N 43° 36.6' E	510	30.4.84	153	117-147	25.6 6.5.84	2200 6.5.84	1476/420 324 6.5.85	9.1	0.1		Experimental windmill pump PT,CD,GL
B64	Buulo Yuusuf	M 3° 03.7' N 43° 27.8' E	480	15.5.84	85	Open hole 58.5-85	18.2 10.8.84	2900 11.8.84	2456/746 /128 11.8.84	15.9	3.60	Motor 55	In use,PT,CD

1. Elevation taken from 1:100,000 National Topographic Maps
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

BASIC WELL DATA. CGDP

W ll Number B, Bay Region Cr, Central Range	N a m e	Map coordinates S, satellite location M, Map location	Elevation above means sea level, M [1]	Date completed Day, Month, Year	Total Depth, M	Intervals screened or Perforated, M	Static water level, M Date, Day, Month, Year	Specific conductivity, Micromhos/cm, Date, Day, Month, Year	Total dissolved solids/Cl/SO_4 Date, Day, Month, Year	Yield, M^3/hour	Specific capacity M^3/hour/M	Type of Pump installed, Depth, M	R E M A R K S
CR65	Aborey 3	M 3° 58.9' N 45° 50.8' E	285	19.5.84	210	Open hole 3-210	Dry						Abandoned, not deep enough, GL
B66	Buulo Hawo	S 3° 03.7' N 43° 06.6' E	415	7.6.84	142	66.2-77.4 Open hole 83-142	33.5 28.8.84	1825 29.8.84	1408/302/ 161 29.8.84	14.5	0.43	Motor 76	In use,PT,CD,
CR67	Wargaloh	M 6° 15.8' N 47° 31.2' E	205	25.7.84	252	164.9- 176.4 Open hole 177.9- 252	100 22.1.85	3200 21.9.84	3156/418/ 1352 21.9.84	11.4		Motor 134	In use,PT,CD,
B68	Dambal Aalan	M 3° 05.6' N 43° 26.9' E	475	26.6.84	126	49-71 Open hole 98.5-126	17.1 22.8.84	1675 23.8.84	1456/391/ 55 23.8.84	14.1	0.18	Motor 96	In use,PT,CD
B69	Togaal	M 3° 31.4' N 43° 57.6' E	625	18,7.84	92	37-64.5	18.7 11.12.84	970 24.12.84	576/104/3 24.12.84	15.3			Low yield,PT,

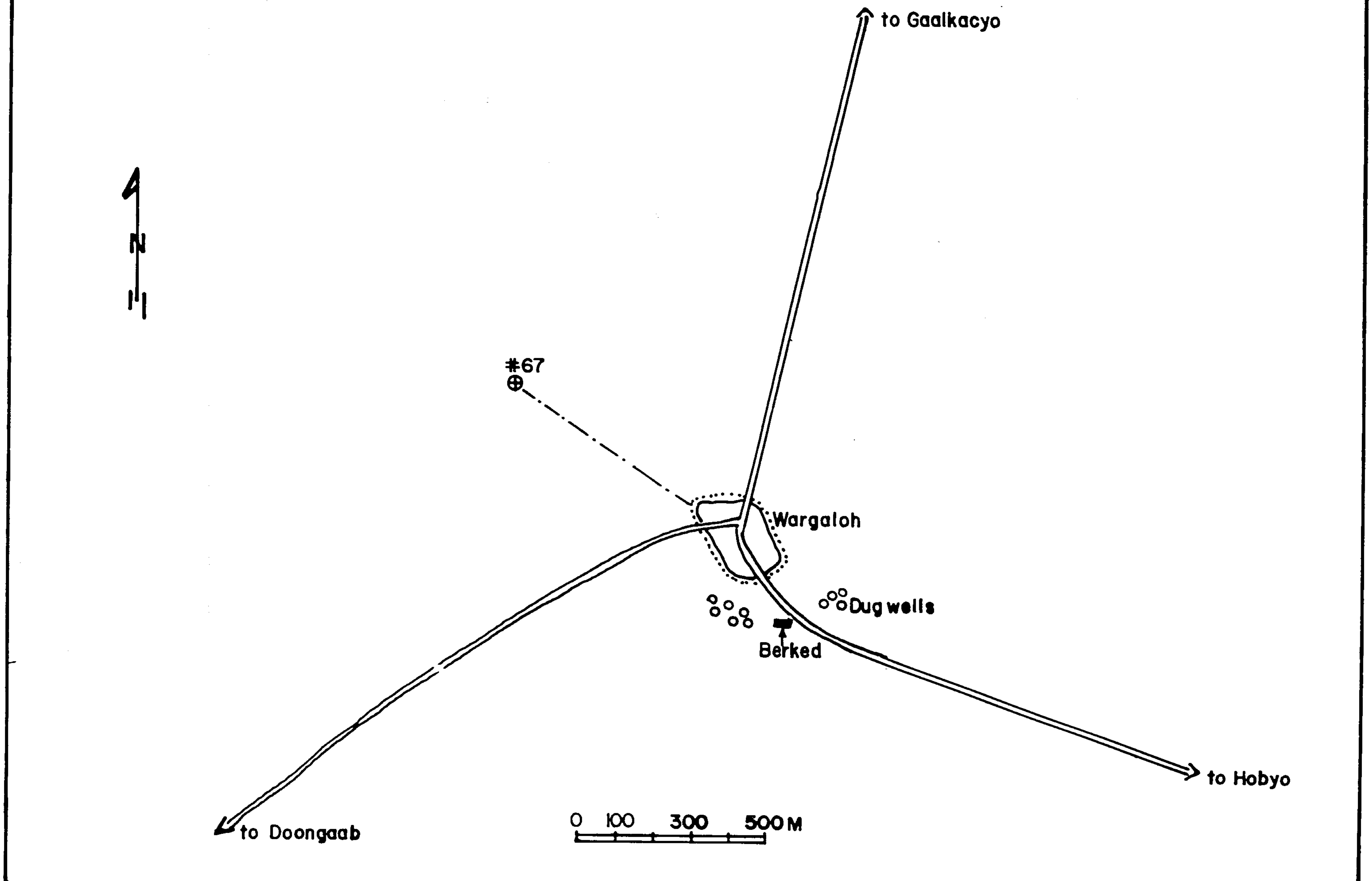
1. Elevation taken from 1:100,000 National Topographic Maps.
2. PT- Pump test data available .
3. CD- Chemical quality data available.
4. GL- Geophysical log available.

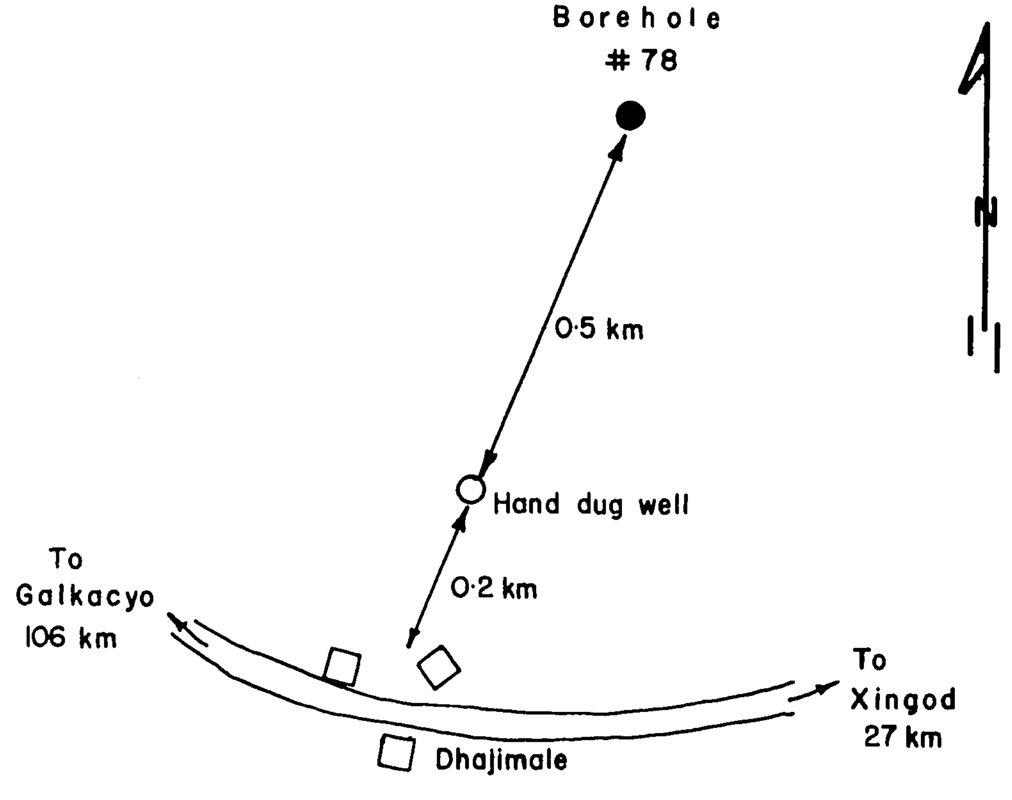
SECTION 3.

Site Location Maps, Stiff Diagrams and Pump Test Curves.

WARGALOH LOCATION MAP

WELL # 67





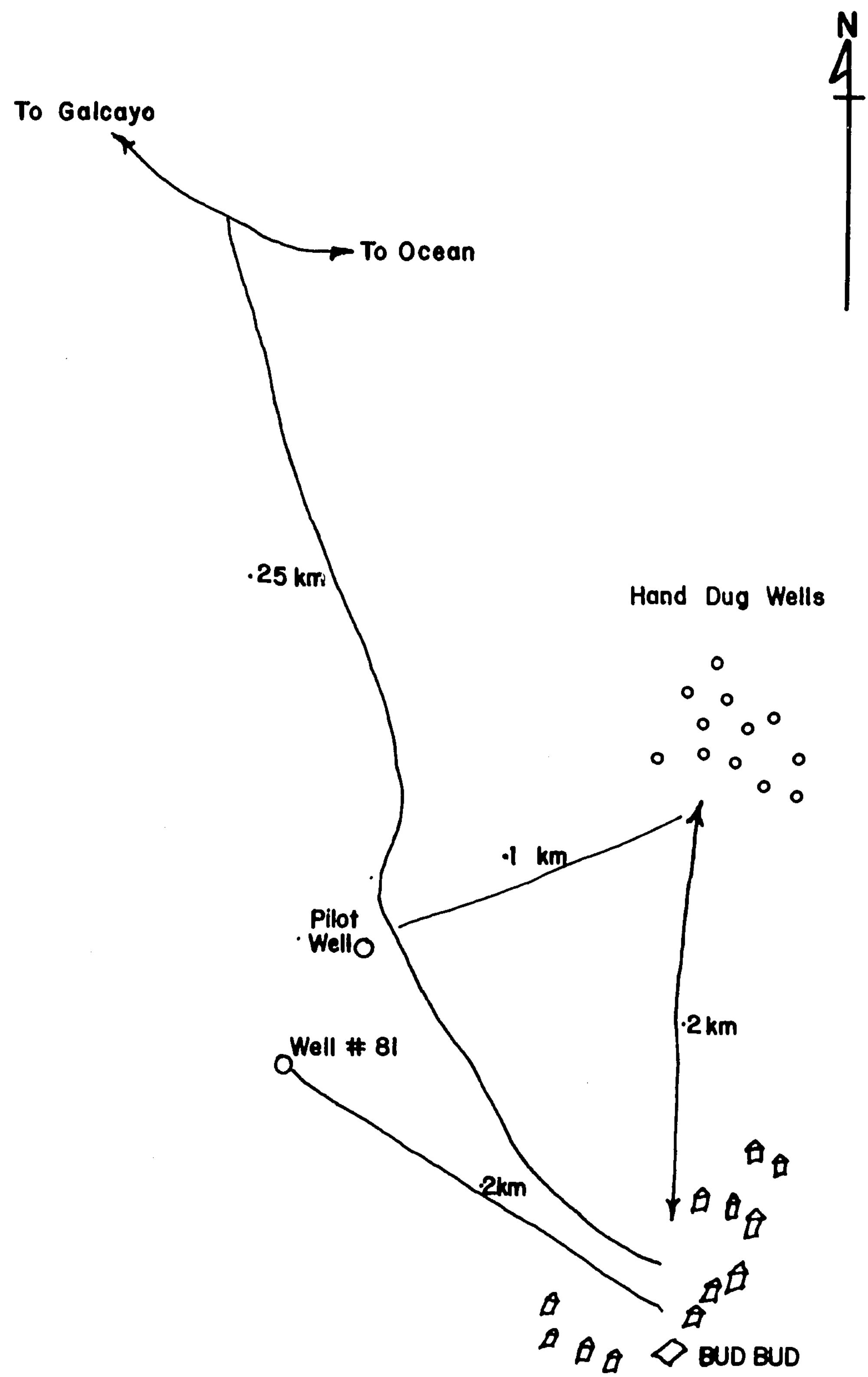
DHAJIMALE WELL # 78

SITE LOCATION MAP

Scale 1cm = 100m

SITE LOCATION MAP, BUDBUD

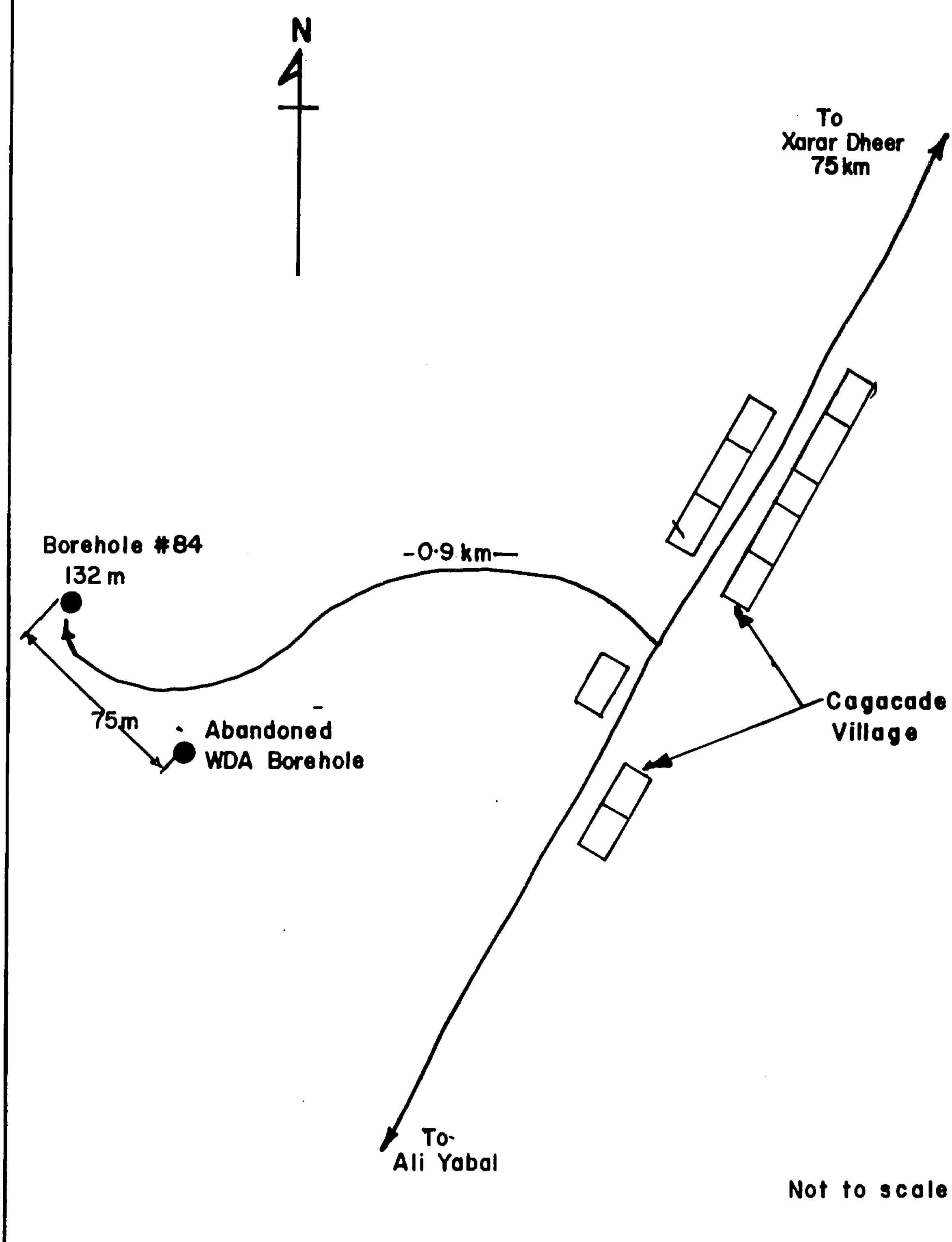
WELL # 81

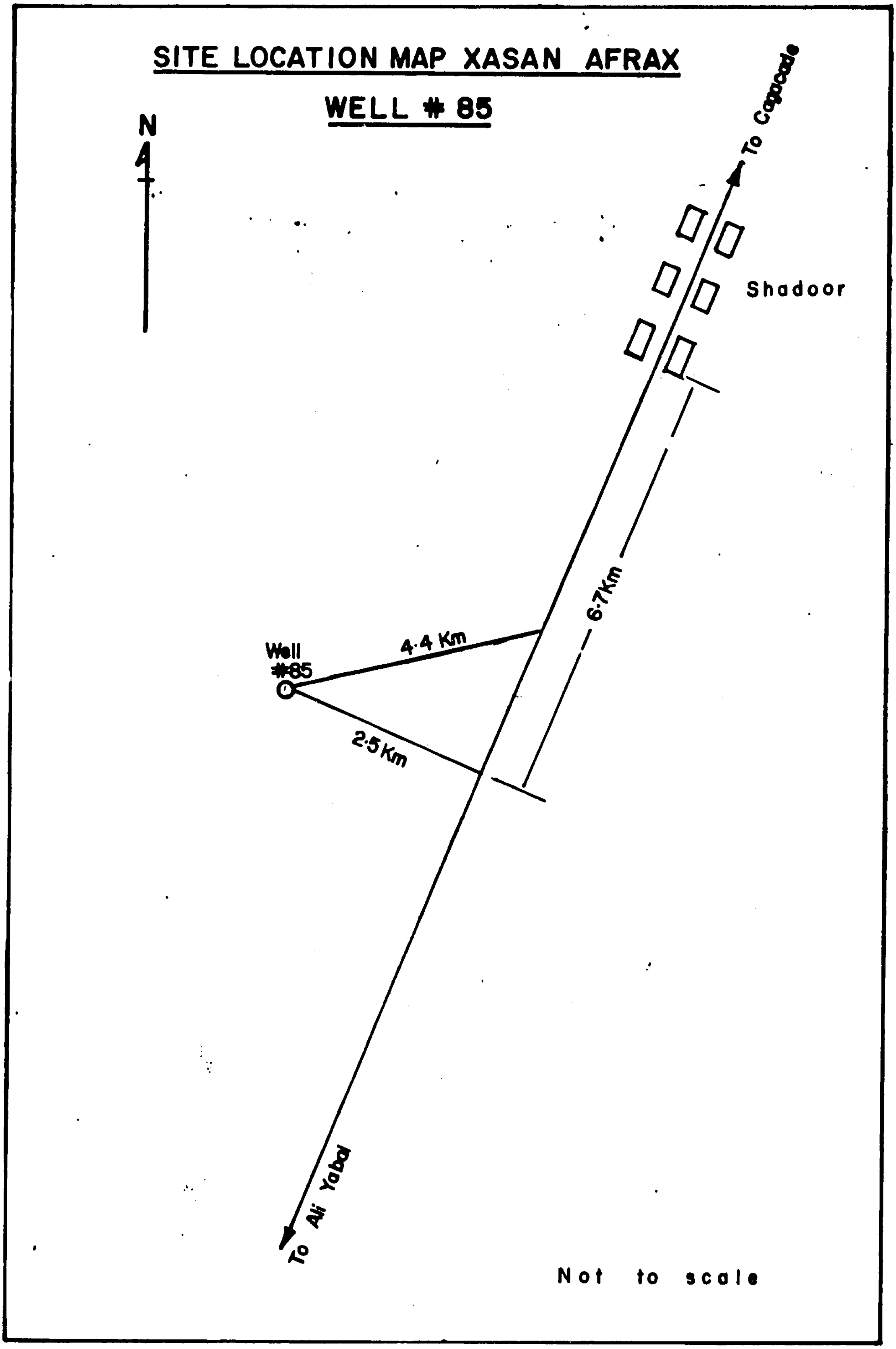


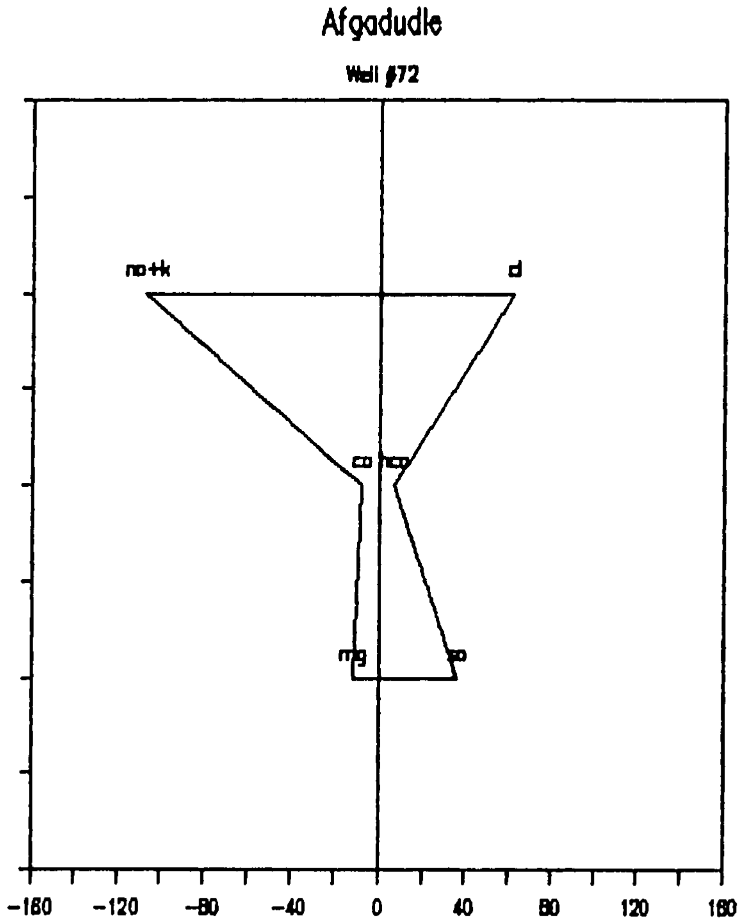
Not to scale

SITE LOCATION MAP CAGACADE

WELL # 84




SITE LOCATION MAP XASAN AFRAX
WELL # 85
N
To Cagacade
Shadoor
6·7Km
4·4 Km
Well
#85
2·5 Km
To Ali Yabal
Not to scale



Id: CR72 Long: 475812 E UTM-East 8831.506
Location:AFGADUDLE Lat: 55730 N UTM-North 658.823

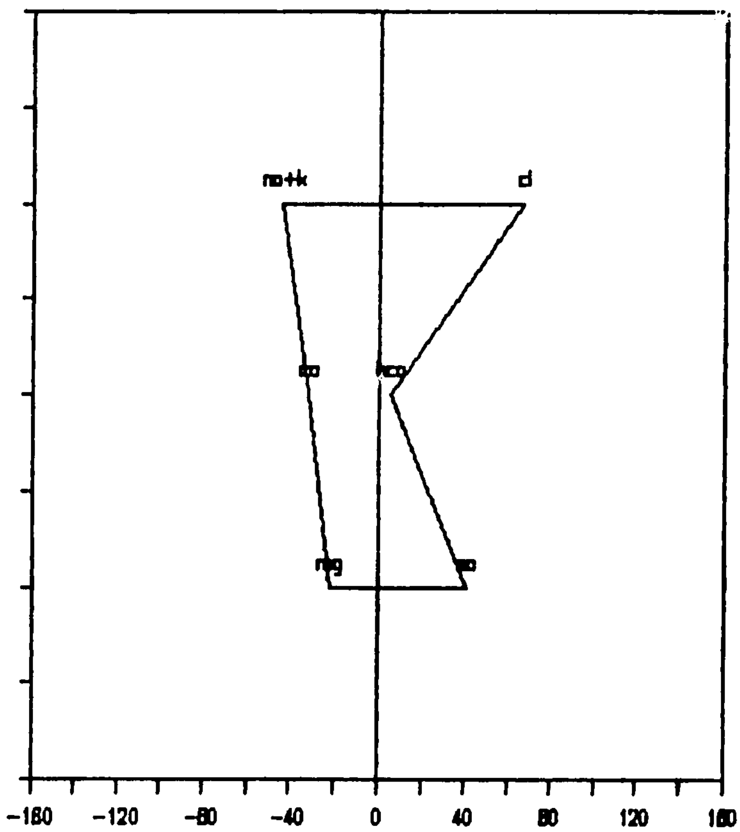
ph 8.2 Type of well: dw

	mg/l	meq/l	I	mg/l	meq/l	
	====	=====	I	====	=====	
* na+k	2408	106.9874	I	2192	61.83632	cl
ca	163	8.1337	I	387	6.34293	hco3
mg	148	12.17448	I	1711	35.62302	so4
			I			
* na	2334	101.529	I			
* k	74	1.89216	I			

Total Dissolved Solids: 5245 mg/l
Electrical Conductivity: 12000 umhos/cm
Total Depth: 204 m
Static Water Level 17 m Date sample taken:11/01/84

Dhajimaale

Well #78



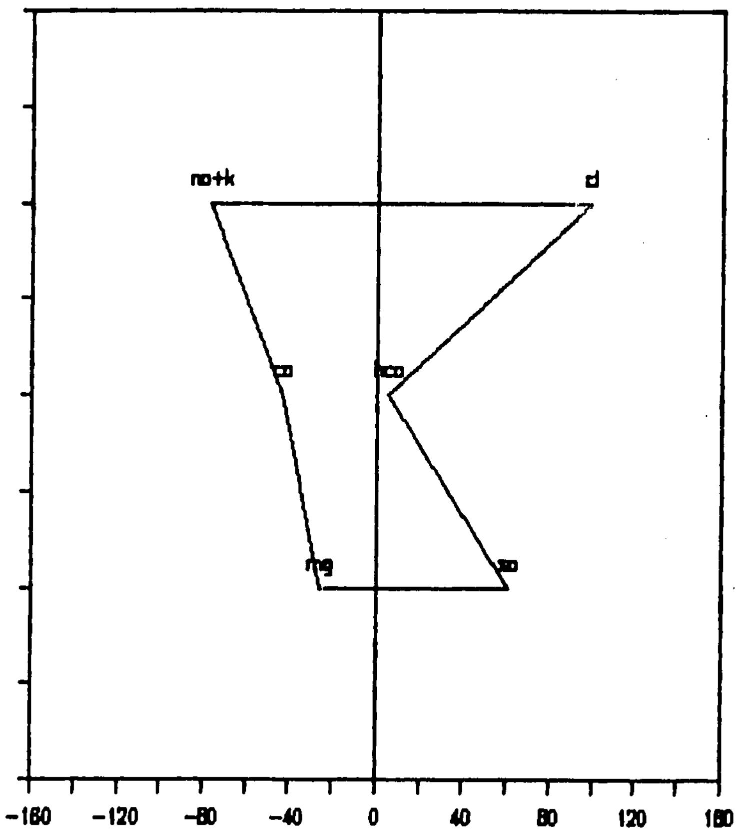
Id: CR78	Long:	481300 E		UTM-East 8859.158	
Location:DHAJIMAAL	Lat:	61830 N		UTM-North 697.533	

ph 7.6 Type of well: dw

	mg/l	meq/l	I	mg/l	meq/l	
	====	=====	I	====	=====	
* na+k	990	43.9857	I	2367	66.77307	cl
ca	640	31.936	I	316	5.17924	hco3
mg	274	22.53924	I	1929	40.16178	so4
			I			
* na	938	40.803	I			
* k	52	1.32964	I			

Total Dissolved Solids: 7924 mg/l
Electrical Conductivity: 9500 umhos/cm
Total Depth: 177 m
Static Water Level 69.65 m Date sample taken:03/20/85

Budbud



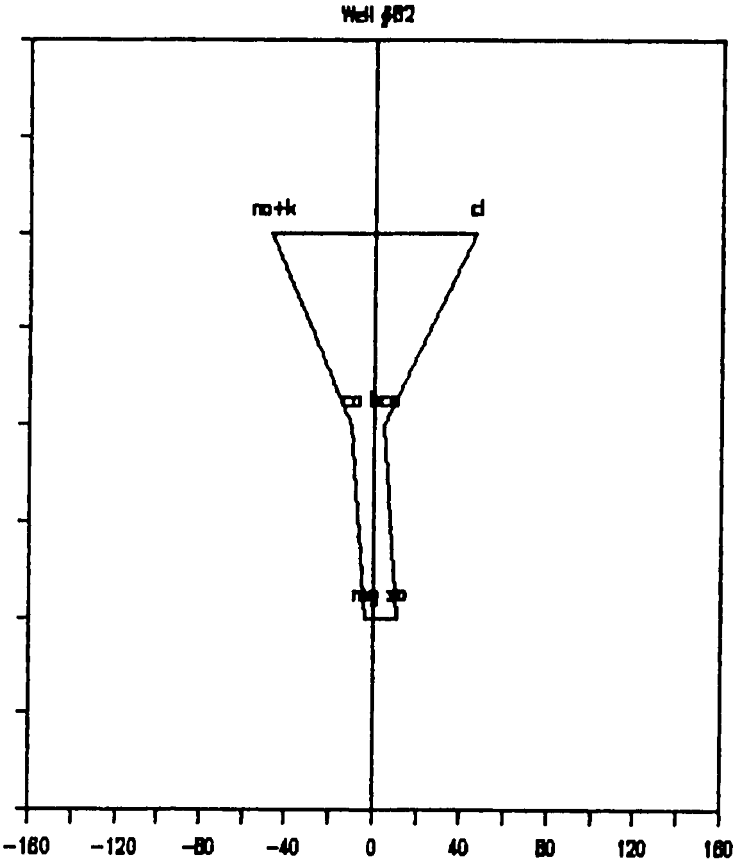
Id: CR81 Long: 484042 E UTM-East 8910.113
Location:BUDBUD Lat: 61036 N UTM-North682.8969

ph 7.2 Type of well: dw

	mg/l	meq/l	I	mg/l	meq/l	
	====	=====	I	====	=====	
* na+k	1727	76.73061	I	3508	98.96068	cl
ca	872	43.5128	I	336	5.50704	hco3
mg	317	26.07642	I	2916	60.71112	so4
			I			
* na	1614	70.209	I			
* k	113	2.88941	I			

Total Dissolved Solids: 10128 mg/l
Electrical Conductivity: 12000 umhos/cm
Total Depth: 110m
Static Water Level 25.93 m Date sample taken:03/12/85

Saddel



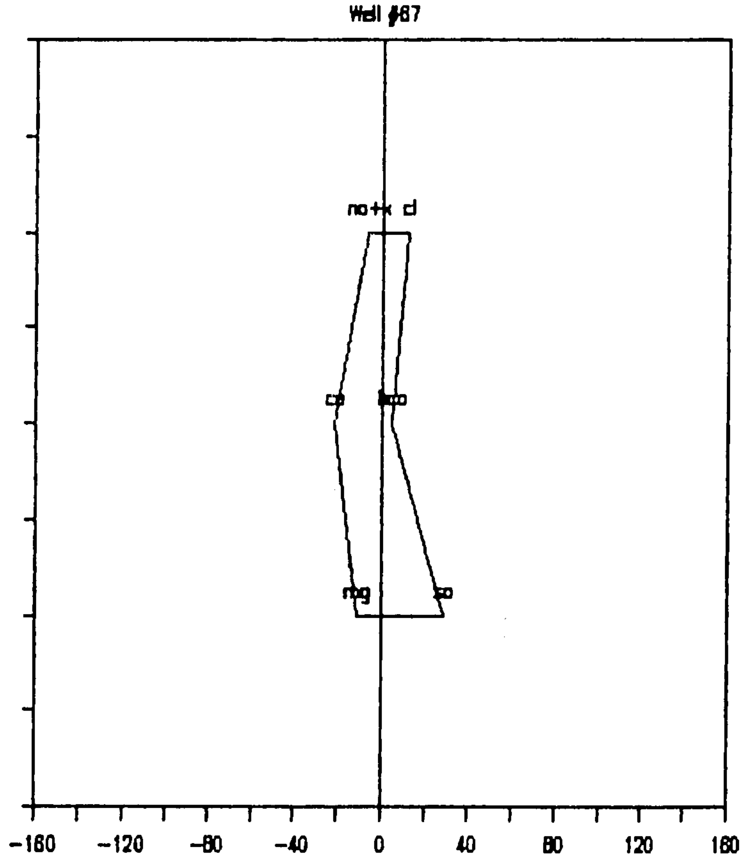
Id: CR82 Long: 473048 E UTM-East 8780.142
Location:SADDEL Lat: 40642 N UTM-North454.4342

ph 7.8 Type of well: dw

	mg/l	meq/l	I	mg/l	meq/l	
	====	=====	I	====	=====	
* na+k	1064	47.27352	I	1633	46.06693	cl
ca	211	10.5289	I	287	4.70393	hco3
mg	42	3.45492	I	515	10.7223	so4
* na	1044	45.414	I			
* k	20	0.5114	I			

Total Dissolved Solids: 4352 mg/l
Electrical Conductivity: 6100 umhos/cm
Total Depth: 75 m
Static Water Level 40.11 m Date sample taken:04/22/85

Wargaloh

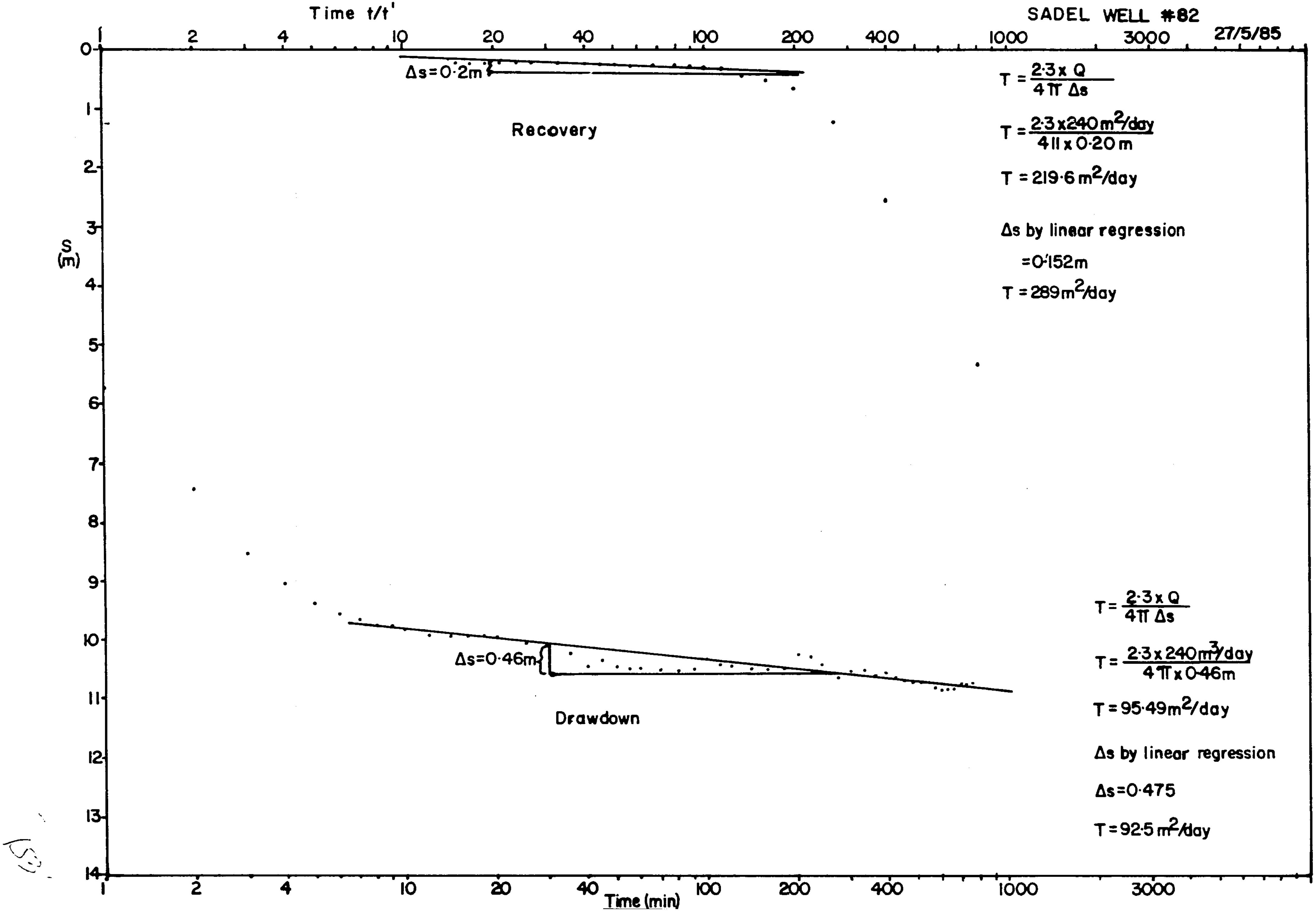


Id: CR67 Long: 473200 E UTM-East 8782.966
Location:WARGALOH Lat: 61600 N UTM-North693.2933

ph 7.2 Type of well: dw

	mg/l	meq/l	I	mg/l	meq/l	
	====	=====	I	====	=====	
* na+k	159	7.06437	I	418	11.79178	cl
ca	438	21.8562	I	290	4.7531	hco3
mg	133	10.94058	I	1352	28.14864	so4
			I			
* na	146	6.351	I			
* k	13	0.33241	I			

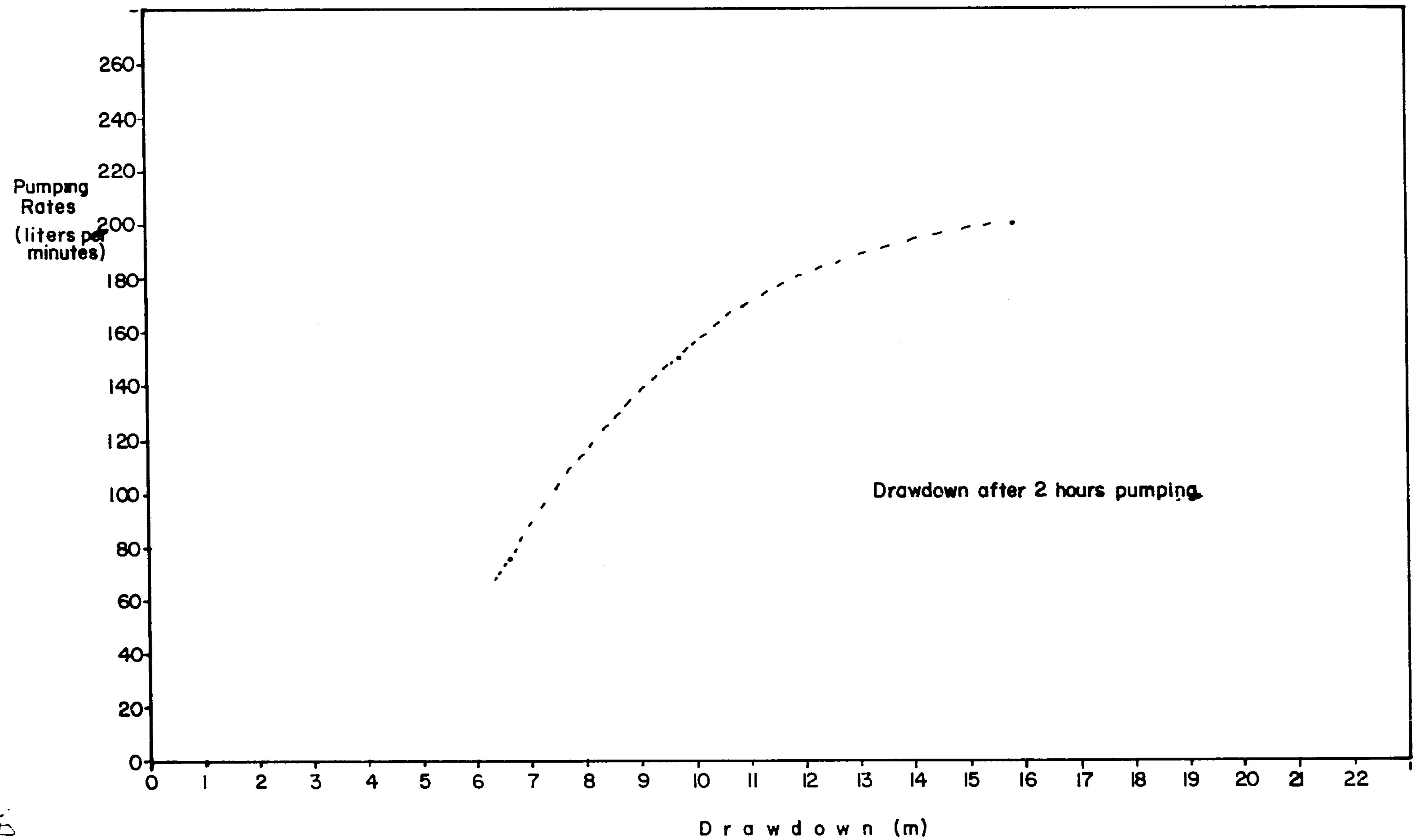
Total Dissolved Solids: 3156 mg/l
Electrical Conductivity: 3200 umhos/cm
Total Depth: 252 m
Static Water Level 110 m Date sample taken:09/27/84

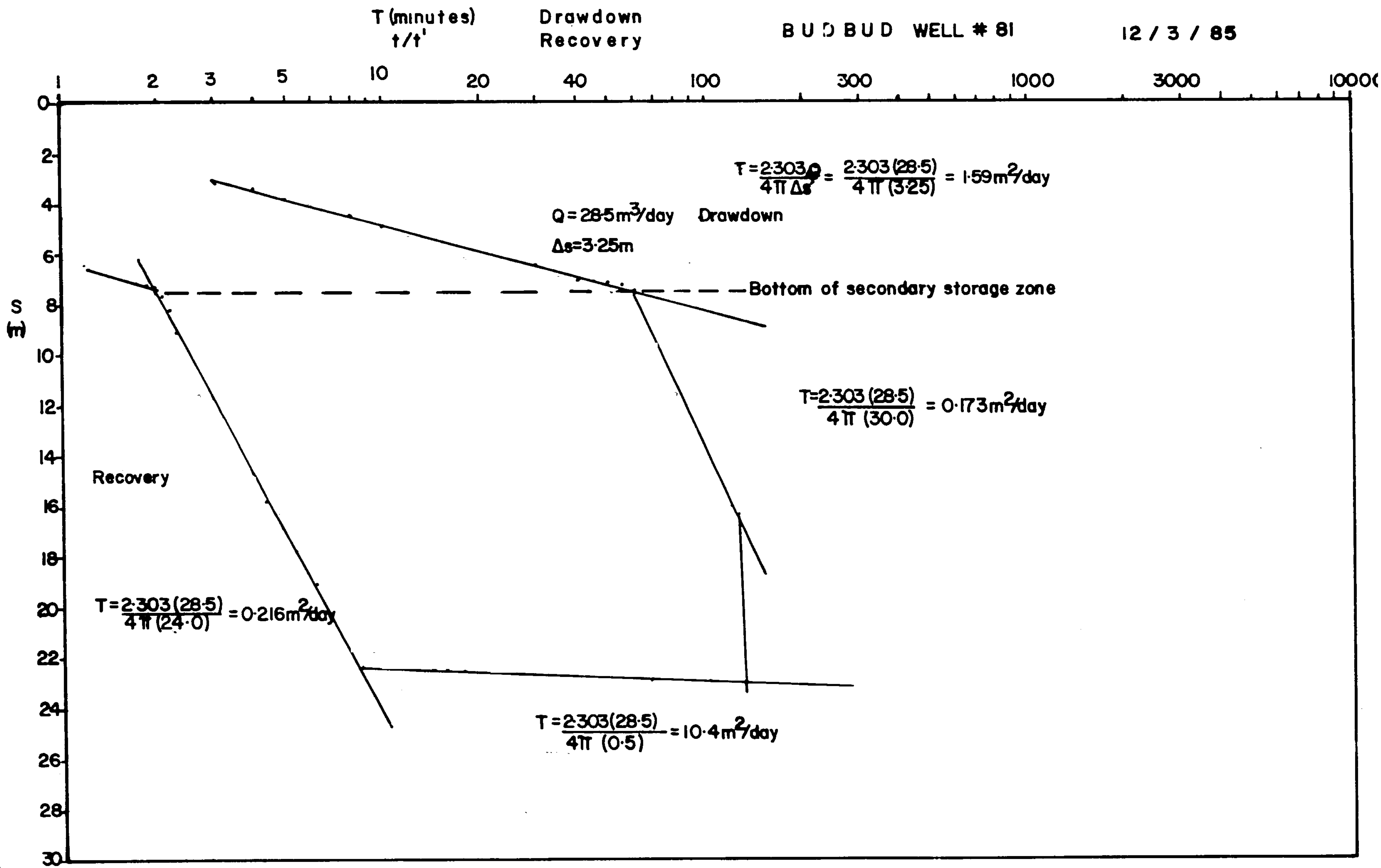


SADEL WELL #82
27/5/85
Time t/t'
Recovery
Δs=0·2m
T = 2·3 x Q / 4 π Δs
T = 2·3 x 240 m²/day / 4 π x 0·20 m
T = 219·6 m²/day
Δs by linear regression
=0·152m
T = 289m²/day
Drawdown
Δs=0·46m
T = 2·3 x Q / 4 π Δs
T = 2·3 x 240 m³/day / 4 π x 0·46m
T = 95·49m²/day
Δs by linear regression
Δs=0·475
T = 92·5 m²/day
S (m)
Time (min)

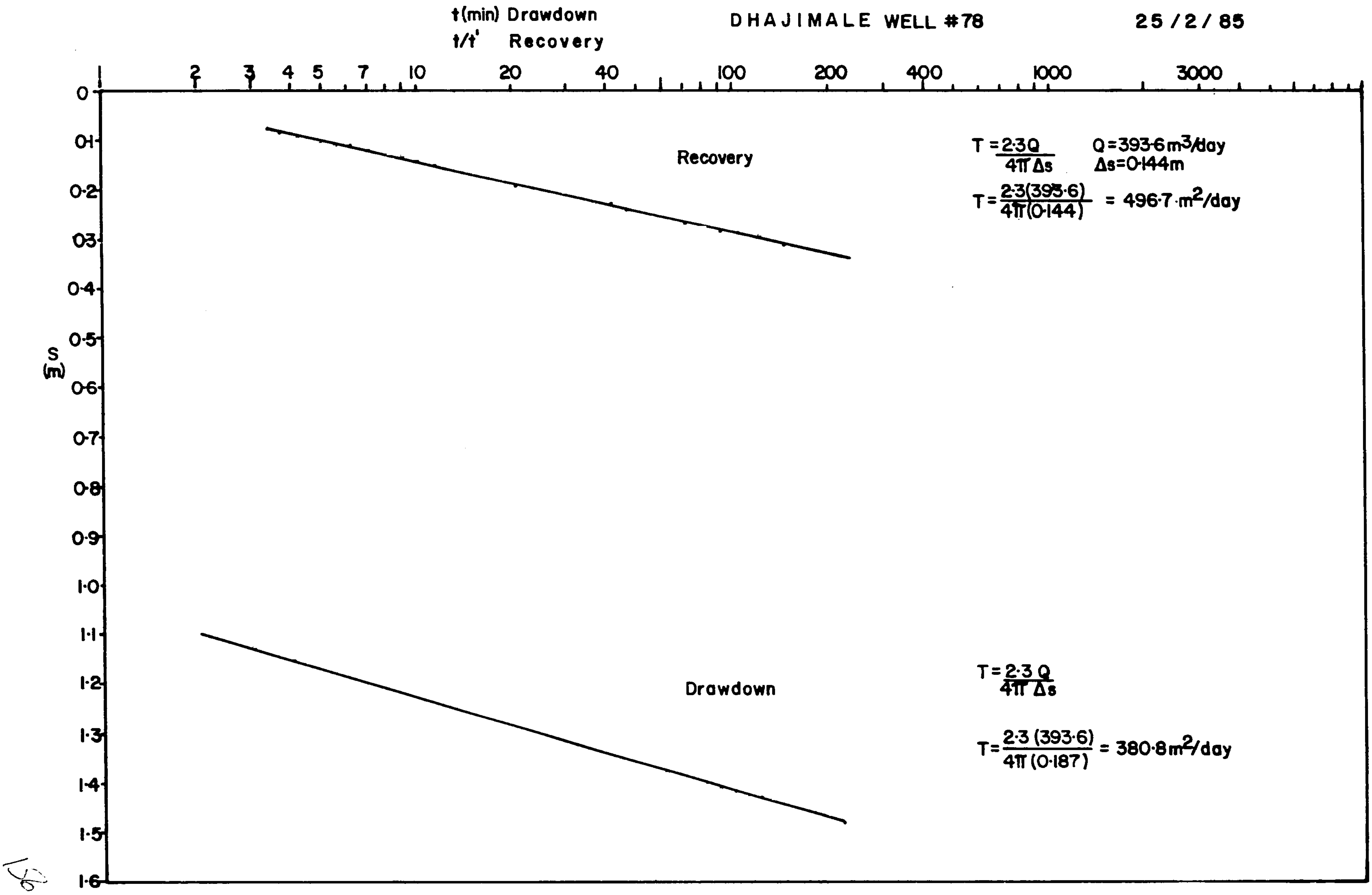
SADEL WELL # 82

Step Drawdown 26/5/85





T (minutes)
t/t'
Drawdown
Recovery
BUDBUD WELL # 81
12 / 3 / 85
1
2
3
5
10
20
40
100
300
1000
3000
10000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
S (m)
T = 2·303 Q / 4π Δs = 2·303 (28·5) / 4π (3·25) = 1·59 m²/day
Q = 28·5 m³/day
Drawdown
Δs = 3·25 m
Bottom of secondary storage zone
T = 2·303 (28·5) / 4π (30·0) = 0·173 m²/day
Recovery
T = 2·303 (28·5) / 4π (24·0) = 0·216 m²/day
T = 2·303 (28·5) / 4π (0·5) = 10·4 m²/day



t(min) Drawdown
t/t' Recovery
DHAJIMALE WELL #78
25/2/85
2
3
4
5
7
10
20
40
100
200
400
1000
3000
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
S (m)
Recovery
T = 2·3Q / 4π Δs
Q = 393·6 m³/day
Δs = 0·144m
T = 2·3(393·6) / 4π(0·144) = 496·7 m²/day
Drawdown
T = 2·3 Q / 4π Δs
T = 2·3 (393·6) / 4π (0·187) = 380·8 m²/day