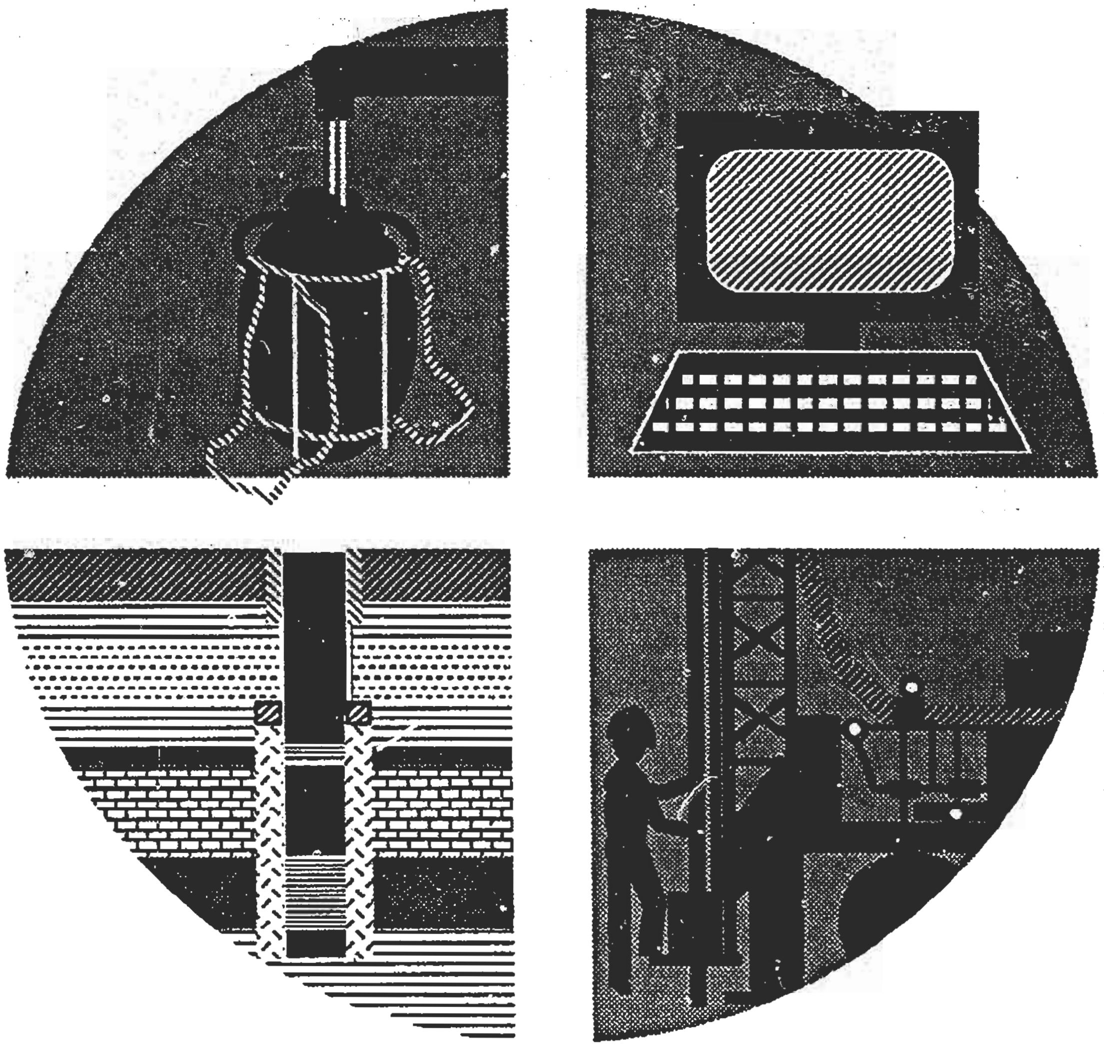
SOMALI DEMOCRATIC REPUBLIC

MINISTRY OF MINERALS AND WATER RESOURCES
WATER DEVELOPMENT AGENCY

Comprehensive Groundwater Development Project



Volume I

Executive Summary

End of Project Report

LOUIS BERGER INTERNATIONAL, Inc.

ROSCOE MOSS Co.

END OF PROJECT REPORT

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

VOLUME I

EXECUTIVE SUMMARY

PREPARED FOR: THE WATER DEVELOPMENT AGENCY
MINISTRY OF MINERALS AND WATER RESOURCES
SOMALI DEMOCRATIC REPUBLIC

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VOLUME I
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

VOLUME II
TABLE OF CONTENTS
GENERAL ACTIVITIES

VOLUME III
TABLE OF CONTENT
HYDROGEOLOGY

VOLUME IV
APPENDICES FOR VOLUME II

APPENDIX A

MONITORING AND EVALUATION FORMS

APPENDIX B

COST ANALYSES

VOLUME V
APPENDICES FOR VOLUME III

APPENDIX A

BASIC WELL DATA: BAY REGION
BASIC WELL DATA: CENTRAL RANGE

APPENDIX B

AS-BUILT DRAWINGS AND LOGS OF BOREHOLES: BAY REGION
AS-BUILT DRAWINGS AND LOGS OF BOREHOLES: CENTRAL RANGE

APPENDIX C

PUMPING TEST DATA: BAY REGION
PUMPING TEST DATA: CENTRAL RANGE

APPENDIX D

WATER QUALITY DATA: BAY REGION
WATER QUALITY DATA: CENTRAL RANGE

GENERAL ABBREVIATIONS

BRADP	Bay Region Agricultural Development Project.
BR	Bay Region
CAPP	Community Assessment and Participation Program
CGDP	Comprehensive Groundwater Development Project.
CRDP	Central Range Development Program.
CR	Central Rangelands.
EPR	End of Project Report.
FAO	Food and Agricultural Organization.
GDRS	Government of Democratic Republic, Somalia.
HTS	Hunting Technical Services, Ltd.
LBII	Louis Berger International, Inc.,
MES	Monitoring and Evaluation System
MMWR	Ministry of Minerals and Water Resources.
NRA	National Range Agency
NWC	National Water Committee
NWDC	National Water Data Center.
OJT	On the Job Training
PU	Planning Unit.
RLA	Range and Livestock Association
RMC	Roscoe Moss Company.
RMR	Resource Management and Research.
TVAPP	Tuulo Village Assessment and Participation Program
UNCHR	United Nations High Commission for Refugees.
UNDP	United Nations Development Program.
USAID	United States Agency for International Development.
USDA	United States Department of Agriculture.
WDA	Water Development Agency.

MATHEMATICAL/CHEMICAL ABBREVIATIONS

m	meters
cm	centimeters
mm	millimeters
m/s	meters per second
m^2/min	meters squared per minute
m^3/hr	cubic meters per hour
m^2/d	meters squared per day a reduction of meters cubed/day/meter.
m^3/min	meters cubed per minute
m/km	meters per kilometer
km^2	square kilometers
km/hr	kilometers per hour
mph	miles per hour
T	transmissivity (see Glossary of Terms)
Q	signifies discharge in m^3/d unless otherwise noted.
t	time in minutes
EC	electrical conductivity
pH	negative logarithm of hydrogen ion concentration.
mg/l	milligrams per liter
$^{\circ}$C	degree centigrade
TDS	total dissolved solids
PVC	polyvinyl cholride

ACKNOWLEDGEMENTS

No project of this magnitude can be accomplished without the cooperation and assistance of a large number of people. We would like to thank Engineer Yussuf Mohamed Elmi, Deputy Director of WDA, and his successor Abdullahi Hagi Rage, who struggled with us on a day to day basis to keep the project moving, and who, through many regional directors, provided logistical support. The cooperation and assistance from Mr. Mohamed Warsame, Director of the Bay Region Agricultural Development project, was especially appreciated, as was that from Mohamed Ayan, Project Manager of the Central Rangelands Development Project.

Mr. Louis Cohen, Director of USAID, Mr. W. Darkins, CGDP Project Officer, and the staff of the USAID mission are to be acknowledged for the assistance they provided to the LBII/RM team members during the course of the project. Their patience and understanding provided the moral support needed to presevere.

We would like to pay a special tribute to Mr. Ronald Kornell, Vice President of Louis Berger International, Inc., and to Mr. Robert Van Valer of Roscoe Moss Co. who were instrumental in project development, and to all the LBII/RMC support staff in Washington, East Orange, Los Angeles, and Mogadishu, without whose backup the project could not have succeeded.

Last, but not least, we would like to acknowledge those team members that were instrumental in this report preparation. They include:

L.A. Cerrillo	Project Manager
C.A. Sumsion	Sr. Hydrogeologist
D. Douglass	Hydrogeologist
J. Gillespie	Hydrogeologist
R.J. Lock	Economist/Planner
R.A. Schwarz	Anthropologist
M.A. Cullen	Agricultural Economist
G. Jones	Administrator

This report is dedicated to the rural people of Somalia with the hope that our contribution of water supplies will be of lasting value.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions presented are based on the results of the work completed and on the professional judgement of the consultant's staff. Recommendations are those viewed to be most important to the improvement of water resources development and/or to the operation of future water projects. These recommendations may not necessarily reflect the opinion or desires of USAID or WDA. Recommendations incorporated in Volumes II and III are not necessarily reiterated here. The interested reader is advised to review those volumes.

A clear distinction between a conclusion and a recommendation was not always possible because one evolves from the other. For purposes of discussion, however, conclusions and recommendations are identified. The numbers adjacent to major headings correspond to the section of the report where that subject is addressed.

2.0 INSTITUTIONAL SUPPORT

Institutional Support covered a number of activities aimed at strengthening the ability of WDA to construct, operate, and maintain rural water supply systems. Conclusions and recommendations are presented for each activity.

2.1 Equipment and Material Support Conclusion

In excess of 9 million dollars worth of equipment and materials that included 3 rotary drill rigs, two pump rigs and numerous heavy and light vehicle support equipment and spares were provided.

Recommendations:

1. Selected members of the proposed project team should be mobilized well in advance of project start to assist in equipment selection and procurement and to set up warehouse facilities and establish an inventory control system.

2. All equipment to be utilized on a project should be paid for and used only by that project, and should be under the total control of project personnel.

3. Existing cable-tool rigs should, where feasible, be rehabilitated, and additional rigs purchased.

4. Choice of vehicles for the project should be standardized to the greatest extent possible.

5. All vehicles planned for use in the Central Rangelands should be equipped with high chassis, flotation tires and four wheel drive.

6. Provisions should be made to enable WDA to procure parts for USA manufactured equipment.

2.2 Training Program Conclusion

Training was provided in the form of OJT, classroom instruction, and short term and university degree programs in the U.S. In excess of 120 individuals received one or more levels of training. Manuals covering 8 topics were prepared to support the training, six in both English and Somali.

Recommendations:

1. English language training should be made a continuous effort for all counterparts, and in particular for individuals required to report to consultant's staff.

2. Project team should have total, or equal, control to that of WDA over counterparts.

3. Salaries of WDA employees should be adjusted to encourage continued employment with the Agency. Field per diems, in particular, should be so structured as to create the necessary incentive for working outside of Mogadishu.

4. Training programs should continue to be developed within the Agency to encourage improvement and advancement. Training by expatriates on a periodic basis should be conducted in country . This training should involve all levels of personnel from drivers to managers.

5. Training for hydrogeologist should emphasize well design, well development, and testing.

6. Training for drillers should include rig mechanics, welding, well design, well development, and grouting procedures.

7. Training for pump installers should include welding, and pump troubleshooting and maintenance.

8. All employees should receive driver education with emphasis on safety and maintenance.

2.3 Planning Unit Development Conclusion

Establishment of a planning unit, pending approval of a planning department, proved to be marginally successful. The lack of qualified personnel available within WDA and the lack of incentives were the primary limiting factors.

Recommendation:

Efforts to recruit and retain an appropriate staff of sociologists, economists, and hydrogeologists should continue. A commitment should be made toward strengthening the Planning Unit and making it an integral part of WDA operations.

2.4 Well Site Maintenance Conclusion

Well site maintenance, maintenance of pump and distribution systems, is minimal to non-existent.

Recommendations:

1. A management Program should be developed for maintenance operations.

2. Well site operators should be given basic training in operation and maintenance, and provided with the necessary tools and materials to do the work.

3. WDA should upgrade regional office capabilities to more efficiently conduct maintenance efforts.

4. WDA should consider sub-contracting maintenance operations to private sector contractors wherever expedient.

5. Maintenance schedules should be prepared and implemented.

2.5 Community Participation Conclusion

Community participation and water committees are established in 12 communities. They prove very effective when developed prior to well construction, and when provided adequate support by WDA.

Recommendations:

1. Efforts should continue to establish and to support the community participation and water committee programs.

2. Additional staff should be hired and trained within the Planning Unit to support this effort.

3. The role and responsibility of the CAPP must be updated to reflect policy changes that occur within WDA.

2.6 Water Quality Laboratory Conclusion

The water quality laboratory was provided equipment and supplies, personnel were trained, and standards were established for proper analysis of water samples.

Recommendations:

1. A renovation contract should be let for the water quality laboratory. All plumbing and electrical systems should be upgraded. All electrical controls for laboratory equipment should be installed outside the laboratory. This work should be completed before additional new equipment is installed.

2. A supply/maintenance manager should be assigned to the laboratory to insure that adequate reagents are available and that the lab is kept in a clean and operative condition.

3. The laboratory should be organized to operate on a self-supporting basis. Charges for analyses should be established, and proper business practices instituted.

2.7 Electronics and Geophysical Lab Conclusion

An electronics and geophysical laboratory was established within the WDA compound to provide repair and maintenance service to mobile radios, geophysical equipment, hydrogeologic field equipment, and laboratory instruments. No full time counterpart staff were provided.

Recommendations:

1. A full time electronics/geophysics technician should be assigned to this lab with four field assistants.

2. An expatriate service contract should be let to provide training and repair of equipment, until the lab can operate independently.

3.0 MONITORING AND EVALUATION SYSTEM CONCLUSION

A monitoring and evaluation program was to have been established to integrate socioeconomic considerations with technological.

Because of the lack of qualified Somali manpower, a monitoring and evaluation program was not able to be initiated. A Monitoring and Evaluation System (MES) was developed and tested instead.

Recommendation:

Adequate qualified staff should be recruited and trained within the Planning Unit to fulfill the objectives of this system.

4.0 COST ANALYSIS CONCLUSION

Cost analysis models were developed, based on data from the project, and intended as a management tool for use by WDA.

Cost analysis models have been developed which indicate that the current price of water is adequate to cover all operation and maintenance costs. The price would have to be doubled to recover direct construction costs.

Recommendations:

1. Similar cost analyses must be carried out for all other WDA operations.

2. A "standard form of accounts" should be used throughout the WDA.

3. Drill rigs need to be more fully utilized, and downtime reduced, to reduce the cost of well construction.

4. Future drilling in the Central Rangelands should be conducted from regional offices to reduce cost of well construction in that area.

5. Water meters should be installed at all sites having motorized pumps, and pump operators should be trained in data collection procedures.

5.0 SOCIOECONOMIC CONDITIONS CONCLUSION

Background information was collected on the socioeconomic conditions prior to testing of the MES. Lack of sufficient water points during the dry season caused increases of morbidity and mortality of humans and animals that often resulted in mass migrations. Evidence exists that this situation has been considerably alleviated at sites where wells have been constructed. Populations at well site villages have substantially increased in most cases.

Recommendation:

The MES should become an active program to determine the changes that occur following the development of new water resources.

6.0 PRIVATE SECTOR CONCLUSION

A special study was conducted to evaluate the potential of the water development industry in Somalia.

An adequate number of private sector industries exist that are capable of making a significant contribution to the development of water resources in Somalia.

Recommendation:

Please refer to the original report as recommendations are too numerous to adequately describe in this volume.

7.0 WDA'S FUTURE ROLE IN WATER RESOURCE DEVELOPMENT CONCLUSION

Based on the experience of the CGDP, an evaluation was made of WDA's role as sole provider's of the nations deep groundwater resources.

The present water needs, and the increased water demands that are required to improve the socioeconomic conditions of Somalia, cannot be adequately provided solely by WDA.

Recommendations:

1. WDA must assume the role of administrator and regulator of the nations water supplies. It must gradually move into this role, and reduce its efforts as an organization engaged in production well-drilling.

2. The responsibility for well operation and maintenance should be given to communities, and the task subcontracted to the private sector.

3. WDA must establish itself as the planning and data collection agency for water development.

4. WDA's drilling capabilities should be utilized primarily for exploration purposes and for emergency production drilling.

VOLUME III
HYDROGEOLOGY

2.0 BAY REGION CONCLUSION

Exploration and exploitation throughout the Bay Region resulted in drilling of 94 boreholes, 53 percent of which were completed as production wells.

Only 23 percent of the Bay Region area is suitable for development of water resources by drilled wells. At present only one percent of estimated recharge is being discharged by wells.

Recommendations:

1. Other water development schemes for those areas not suitable for drilled wells should be investigated. Infiltration galleries, surface catchments, and springs should be considered.

2. Additional well construction should continue with attention to water quality and ecological effects.

3. Review of Section 2.8 Recommendations for Future Water Development in Volume III.

3.0 CENTRAL RANGELANDS CONCLUSION

Exploratory drilling was conducted over large areas of three regions in the Central Rangelands. The Trap Series Basalt, and the Jessoma sandstone were found to be most reliable aquifer.

Potential for water development by wells in the Central Rangelands is limited by quality of water. A more detailed investigative program needs to be developed in conjunction with the National Range Agency.

Recommendations:

1. Surface geophysical methods should be conducted to locate and define limits of the Trap Series Basalt.

2. Development of surface catchments, and infiltration galleries in drainages and along the coast should be considered.

3. Additional development of wells in the Jessoma sandstone should be investigated.

4. A review of Section 3.8 Recommendations for Future Water Development in Volume III.

VOLUME I
EXECUTIVE SUMMARY

1.0 INTRODUCTION

This End of Project Report (EPR) summarizes the results of five years of intensive effort to investigate and to develop the groundwater resource potential of two areas in Somalia. The scarcity of dependable water supplies for the rural population and for their livestock is one of the most serious constraints to the economic development of the country. The Government of the Democratic Republic of Somalia (GDRS), in recognition of this problem, and in cooperation with the United States Agency for International Development (USAID), established and funded the Comprehensive Groundwater Development Project (CGDP).

This project was administered through the Water Development Agency (WDA) of the Ministry of Minerals and Water Resources (MMWR), and was provided technical assistance by the firm of Louis Berger International, Inc. in association with the Roscoe Moss Company (hereinafter referred to as LBII/RM).

In addition to developing water supplies in the designated priority areas of the Bay, Hiran, Galgudud and Mudug Regions (Figure 1.1.1), the overall purpose of the CGDP was to strengthen the WDA's capability to construct, operate, and maintain rural water supply systems. The CGDP was designed to be integrated with two existing USAID projects, the Bay Region Agricultural Development Project (BRADP), and the Central Rangelands Development Project (CRDP).

Exploration and exploitation of the groundwater resources were made possible through the provision by USAID of required equipment and materials, and by the requirement for the training of WDA personnel in the use and maintenance of this equipment. In an effort to insure that water supply facilities would be properly received and maintained, a socioeconomic program was included in the project to monitor impacts and to foster community participation.

1.1 Organization of Report

This report has been prepared in five volumes with the intent of providing one set of documents that cover the main goals and accomplishments of the project. Volume I, this Executive Summary, was prepared to provide an overview of the project. Volume II, entitled General Activities, describes the accomplishments in the areas of institutional support, the monitoring and evaluation system, cost analyses, and private sector development. The results of the exploration and

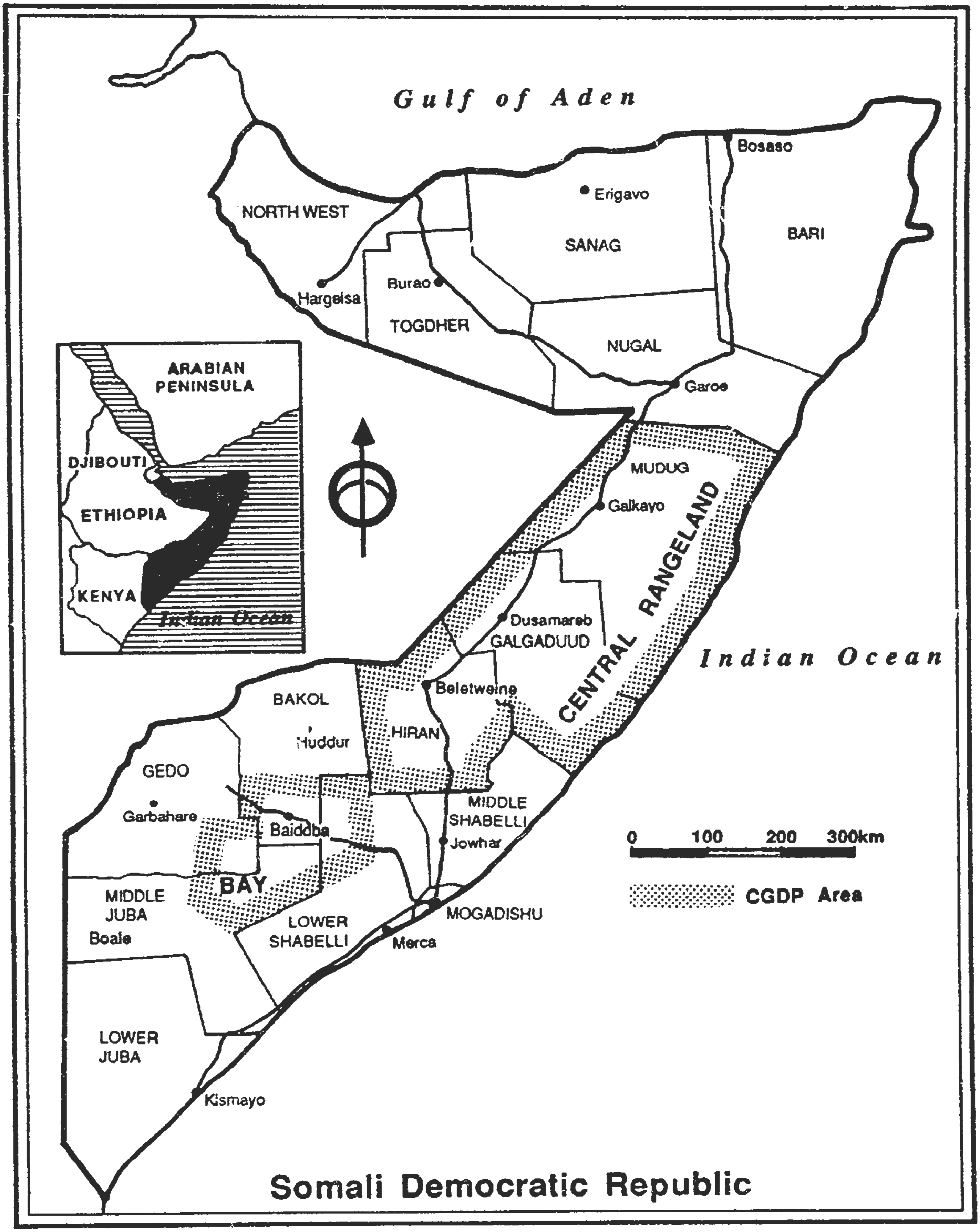


Figure 1.1.1 INDEX MAP OF PROJECT AREA.

exploitation work are presented in Volume III, entitled Hydrogeology. All basic data pertaining to Volume II are provided in Volume IV, and all of the basic data pertaining to Volume III are provided in Volume V.

1.2 Previous Reports

Ten reports, not including this End of Project Report, were prepared by the technical assistance team of LBII/RM during the life of the project. The interested reader is advised to refer to specific reports for a more comprehensive review of work completed. The objectives of these earlier works are briefly described here and the key findings are included in the appropriate volumes of this (EPR). All reports, although identified in some instances by major contributor, are reports of Louis Berger International, Inc..

One of the earliest reports completed pertained to the potential environmental impacts of the project (Pape, 1982). Other than potential rural road damage and possible well contamination, no negative impacts were cited. The next two reports addressed the economic and socioeconomic aspects of the project. These reports developed the basic methodologies for collecting and monitoring economic and socioeconomic data (Pape, 1982, & Roark, 1982).

After twenty-five wells had been completed during the exploratory drilling in the Bay Region, a report of findings was completed (LBII, 1983). This report provided the information necessary to plan the continuation of other drilling activities.

As the project moved into the second and third years, reports were completed that described the results of the monitoring and evaluation programs, and the economics of the drilling operation (Schwarz, 1983 and Brandon, 1984).

A final report, covering all phases of project activity, was completed in July of 1984. This report, although entitled Final Report, covered what was ultimately referred to as Phase One (Final Report Phase I, 1984). The project was extended for two additional years until July of 1986. The Final Report Phase I is a three volume report incorporating all basic data collected to that time. One of the recommendations of the report was to pursue involvement of the private sector in water resources development. As a result, a special study to evaluate this potential was made a part of the project extension.

After the first year of the extension period, an interim report was prepared to serve as an update of activities to that time. The basic data collected, and the progress and problems encountered were reported (LBII, 1985). The last two reports, prepared prior to this EPR, were related to the private sector study. The first was an executive summary of what was to be contained in the completion report. It described the status of the water development industries in Somalia and made recommendations for greater private sector involvement. The completed report, entitled Somalia Water Resource Development Industry, consisted of three volumes. Volume I contained the main body of the report, Volumes II and III contained appendices of all basic data, and recommended a phased program for long term development.

Other reports prepared included monthly reports, work plans and other administrative documents. These are not discussed in this report.

The eleven reports prepared by Louis Berger International, Inc., included in the Selected References, are:

1. Louis Berger International, Inc., 1981,
   Inception Report, Comprehensive Groundwater Development project: WDA, MMWR, Mogadiscio.

2. Louis Berger International, Inc., 1982,
   Exploratory Drilling Program for the Bay Region: WDA, MMWR, Mogadiscio.

3. Pape, M.B., 1982,
   Preliminary Analysis of the Potential Environmental Impacts of the Comprehensive Groundwater Development Project: Louis Berger International, Inc., Mogadishu, 45 p.

4. Pape, M.B., 1982,
   Preliminary Economic Analysis of the Comprehensive Groundwater Development Project: Louis Berger International, Inc., Mogadishu, 71 p.

5. Roark, Paula D., 1982
   Phase I Socioeconomic Report

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

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

8. Louis Berger International, Inc., 1985
Comprehensive Groundwater Development, Project 104, Final Report, Vol. 1-3: WDA, MMR, Mogadishu.

9. Louis Berger International, Inc., 1985,
Interim Report, Comprehensive Groundwater Development Project (Extension): WDA, MMWR, Mogadiscio, 115 p., annex.

10. Louis Berger International, Inc., 1985,
Specifications for Civil Works for Comprehensive Groundwater Development Project: WDA, MMWR, Mogadishu.

11. Lerner, H., and Coolidge J., 1986,
Study of Private Sector Participation in Somalia's Water Resource Development Industry. Four Volumes Comprehensive Groundwater Development Project, Louis Berger International, Inc.,

2.0 INSTITUTIONAL SUPPORT

Institutional support to the WDA and the MMWR has been provided throughout the life of the project. This support has been developed in response to particular needs and has consisted of equipment and material support, training programs, and the development of a planning unit.

The primary goal of this support has been to strengthen WDA's capability to deal with the growing demands for water resources while lessening their dependence on assistance from outside of Somalia. This goal has to a large extent been realized.

2.1 Equipment and Material Support

One of the major contributions to the institutional support effort has been the provision of equipment and materials to conduct an intensive drilling program. Over nine million dollars of USAID funds from three projects have contributed to this effort. Equipment includes everything from three rotary drilling rigs and a fleet of support trucks, to hydrogeologic and laboratory test equipment. Material support has included everything from acetylene to zinc oxide.

2.2 Training Program

In order to assure continued utilization of techniques and methods employed by LBI/RM staff in the development of groundwater resources, training of counterpart personnel was emphasized. Training was a part of the institutional support provided to WDA and MMWR staff in order to strengthen their overall capabilities. Training consisted of on-the-job instruction, intensive seminars, university degree programs in the USA, short-term training in the USA, and English language instruction.

On-the-job training (OJT) was provided to all WDA assigned staff regardless of whether specific consultant counterparts were assigned. OJT consisted of continuous demonstration and explanation of all project related activities that included, but was not limited to: drill rig operations, pumping operations, hydrogeologic investigations, water distribution systems construction, water quality analysis, data collection and socioeconomic analysis.

Although some training was provided to all staff, six main groups, namely hydrogeologists, chemists, drillers, pump installers, mechanics and planners received the most attention. Other project staff, such as truck drivers and laborers, received little training, although drivers were given periodic lectures in driving safety and maintenance. This training resulted in a cadre of counterpart personnel who are capable of undertaking the basic activities of a groundwater development program.

2.3 Planning Unit

Although a Planning Department was initially planned as part of the project extension program, the time required to get Department status sanctioned by the President was prohibitive. The WDA agreed to establish a Planning Unit (PU) as an interim group. Ten staff members were to have been assigned to the PU, however, a shortage of qualified staff within the WDA prevented this from being realized. Those assigned to the PU had varied educational and work backgrounds that only marginally prepared them for the tasks required.

LBII provided 12 manmonths of an economist, 5.5 of an anthropologist, and 2 of a water resource planner/computer instructor. All three individuals had previous African experience and were able to make a significant contribution to the PU effort.

The National Water Data Center (NWDC) which was to have been established in 1984, was only partially in place at the time of report preparation. Five staff members were to have been provided from UNDP, sponsors of this program, however, a project manager had not yet been selected and no personnel were assigned at the time of this writing.

The initial objective of the PU was to "...integrate technical, sociological, and maintenance plans...not only on the selection of well sites, but also on the use of WDA resources (financial,human,and material) in order to help improve overall WDA operations." This was categorized into four functions; planning, economic analysis, sociological evaluation and policy studies.

Specific objectives were established for each of these functions, however, because of the short fall of staff assigned to the PU effort, the initial objectives were considerably modified. The modified objectives in most cases were achieved. In addition, other tasks were undertaken by the PU. These included: preparation of a computerized stores inventory for all parts and equipment provided to WDA during the project, preparation of a budgetary procedures manual, technical assistance to other sections of the project and training to interested WDA staff.

Two micro computers, a COMPAQ and an IBM PC-XT were provided to the PU in addition to printers, electrical control components and an assortment of software packages. This equipment was indispensable for the storage and evaluation of data generated during the course of the project.

A proposed future strategy for the PU should include the following objectives:

(1) WDA Resource Management. This involves monitoring WDA activities, and planning the most efficient use of WDA resources, that include but are not limited to: manpower, vehicles, and drilling equipment. This requires the establishment of management information systems in all WDA regional operational units. It also involves the coordination of Planning Unit data collection and reporting functions with those of other agencies and programs with water development components.

(2) Economic Analysis of WDA Activities. A comprehensive economic analysis of water development includes the cost of drilling construction, and the operation and maintenance of water distribution systems. The objectives are to provide data for more efficient resource planning and to analyze the relative efficiency of pumping operations at different well sites.

(3) Technical Monitoring and Evaluation. The collection and analysis of data on: the design of water supply structures; pumping operations; water use; the management of community water systems and; WDA support services.

(4) Socioeconomic Monitoring and Evaluation. Community baseline data must be collected on a periodic basis to monitor and evaluate changes related to water development. Areas of study include water use patterns, population changes, including physical infrastructure, and crop and livestock production.

(5) Community Participation. This involves the organization and support of local institutions to participate in the development and management of WDA wells.

(6) Policy Studies. The Planning Unit should be in a position to advise the Government on all aspects of rural water development in Somalia. Information from the evaluations will be analyzed in relation to policy issues, such as the role of community groups in water

development, and the ownership and management of wells, pricing and revenue collection, fuel supply, and maintenance and repair services.

(7) Water Resource Data. In cooperation with the NWDC, the Planning Unit should have on-going groundwater data collection responsibilities, and should contribute to the national water resource database.

(8) Training. The Planning Unit should also be responsible for training members of other WDA departments, and the extension and evaluation staff of other agencies. Training in community participation strategies, and methods to monitor and evaluate water development programs will be emphasized.

In order to accomplish the objectives and carry out the functions listed above, the Planning Unit will need a five person professional staff, six to ten field staff, and administrative personnel that includes computer operators and drivers.

2.4 Well Site Maintenance

Well site maintenance addresses the most neglected aspect of all water development activity. Well site maintenance as related to the CGDP, refers to two distinct categories, well maintenance and distribution system maintenance. Well maintenance, regardless of how completed, hand pump or diesel pump, is of primary importance. Manuals in both English and Somali were prepared to deal with the problem in detail. A minimum requirement for well maintenance should include the keeping of monthly water level records and of monthly water quality analyses.

Distribution system maintenance is associated with those sites equipped with motorized pumps, and having completed civil works. The civil works completed during the course of this project included storage tanks, and animal and domestic water points. The structures and the piping between structures needs to be looked after on a continuing basis to insure that piping, cement work and sanitary conditions are properly maintained.

2.5 Community Participation

The original project paper (1979) did not propose a significant role for villagers nor did it allocate funds to develop and support local water management institutions. This oversight was corrected in the CGDP Inception Report (1981) which proposed a strategy to include villagers in the planning, construction and management of the water facilities. The process, initially called the Tuulo Village Assessment and Participation Process (TVAPP) was implemented in twelve villages. In spite of its apparent success, the community participation program did not receive adequate support from WDA, USAID and other agencies. After January 1984, few community meetings were organized.

The CGDP Supplement Project Paper (1984) gave considerable attention to the local participation program and its personnel needs. Responsibility for these activities was assigned to the new Planning Unit of WDA which was to hire a full time Somali sociologist and four sociological field assistants. WDA was not able to recruit qualified staff, however, and the limited consultant resources, were not able to adequately implement the community participation program components.

In spite of the failure to strengthen and expand local participation in 1985 and 1986, village committees established by the project continued to function and play an active role in the construction and maintenance of water systems constructed by the CGDP. In addition, the participation strategy was revised and integrated into other project activities. This approach is called the Community Assessment and Participation Program (CAPP).

2.5.1 The Community Assessment and Participation Program (CAPP)

The goal of the CAPP is to strengthen the capacity of WDA to install, operate and maintain rural water supply systems. The approach calls for close cooperation among technical personnel, communtiy participation specialists and villages leaders. The program and network plan presented identify the stages and principle events of a strategy to integrate community participation into a comprehensive technical and administrative framework for groundwater development. Although the program was developed and tested in the Bay Region, it can readily be adapted to water development projects in other regions.

The CAPP organizes water development into four stages each of which includes technical activities and village participation. The stages are:

1) Community Orientation and Assessment
2) Drilling of Boreholes
3) Construction of Civil Works and Pump Installation
4) Operations and Maintenance

The events and activities of each stage and their relationship to the MES are presented in Figure 1.2.1.

Water committees have been established in 12 project communities in the Bay Region. In spite of the limited attention they received from the project, the water committees effectively organized local contributions of labor and food. A comparison of communities in which the participation program was implemented with those in which it had not, revealed that contributions were more than three times higher from participation communities. In the CAPP communities, villagers contributed 1,803 person days of labor valued at approximately 325,000 Somali Shillings, or $4000 dollars.

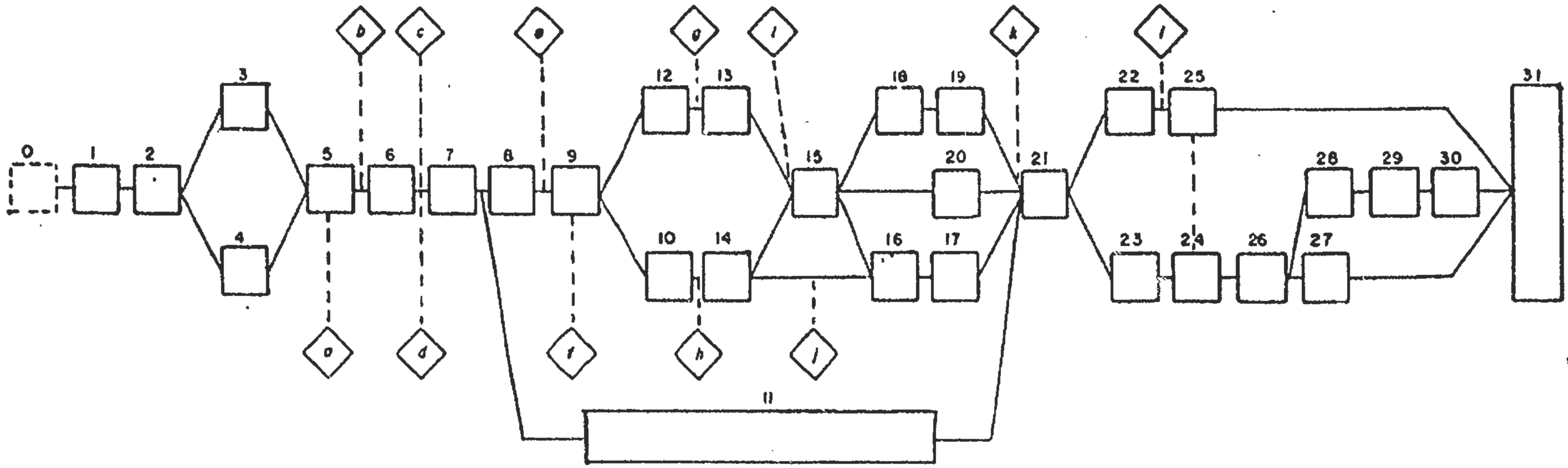
The participation of water committees in the management of operations, however, has not met the villagers expectations. In spite of frequent recommendations to increase their role in well management, little progress has been made during the past eighteen months. Some community leaders feel that WDA has not kept agreements made at the start of the project. They point specifically to issues, such as the setting of water fees, the procurement of fuel and other supplies, and maintenance and repair services; all of which remain fully under WDA control.

In general, village leaders in the Bay Region have demonstrated a high level of interest and ability to promote and manage water development. The concept of shared responsibility among residents of different villages is well established in the Bay region and the contributioin of goods and services has been relatively high. The social science activities supported by the CGDP demonstrated the viability of community participation and produced an integrated program (the CAPP) to guide this component. With adequate logistical and manpower support from WDA and the donors, the CAPP strategy could facilitate the expansion of water resource development and reduce capital and administrative expenditures.

2.5.2 CAPP in the Central Rangelands

The socioeconomic and development contexts in the Central Rangelands are significantly different from those found in the Bay Region. Population density is smaller, the number of animals per household is much larger (about ten times greater) and the principle mode of production is pastoral. The NRA and the CRDP have a strong informal education-extension program which focuses on the creation of Range and Livestock Associations (RLA's) at the <u>deegan</u> level.

The RLA's are still new organizations and while they are based on social and geographical conditions, they are composed of many groups spread out over a large area. Because the management of a diesel powered pump and civil works is complex and has a high potential for generating conflict, the appropriateness of local control of these systems by the embryonic RLA's cannot yet be determined. Additional long term



THE COMMUNITY ASSESSMENT AND PARTICIPATION PROGRAM (CAPP)*

COMMUNITY ORIENTATION AND ASSESSMENT STAGE	DRILLING STAGE	CONSTRUCTION STAGE	OPERATIONS AND MAINTENANCE STAGE	
Duration: 4-6 weeks	8-14 weeks	4-25 weeks	52-61 weeks	Continuous
0. Site Selection	7. Third Community Meeting (Select of Drilling Site)	15. Construction of Water distribution system begins	22. Well Operation and Maintenance	
1. Community Organization Meeting Organized	8. Drill Site Prepared	16. Pump Installed	23. Project Monitoring (First year)	28. Annual Joint Project Evaluation
2. Community Orientation Meeting	9. Well Drilled	17. Pump Operators Trained	24. Project Assessment Meetings	29. Preparation of Annual Work Plan
3. Socioeconomic Background Survey	10. Pump Test	18. Sixth Community Meeting (Water Management Plan)	25. Well Operations and Maintenance	30. Implementation of Annual Work Plan
4. Joint Village Assessments	11. Monitor Construction Activities (BL data)	19. KDA Approval of Community Management Plan	26. Evaluation Plans Developed	31. Periodic Impact Evaluations
5. Project Zone Baseline Profile	12. Fourth Community Meeting	20. Construction of Distribution System completed	27. End of Year Impact Evaluation	
6. Second Community Meeting	13. Fifth Community Meeting	21. Inauguration of Community Water System		
Waiting Period: 1-13 weeks	14. Preparation of Borehole			

* This Plan focuses on community participation and evaluation. It is NOT a detailed plan for all technical and construction activities.

COMPLEMENTARY EVENTS ◇

a) Share findings with KDA technical staff.
b) Advise village of visit.
c) Determine when drill rig is available.
d) Waiting period 1 - 13 weeks.
e) Drill rig to site.
f) Test water quality.
g) Well committee and community meeting.
h) Construction materials to site.
i) Construction materials to site.
j) Pump to site.
k) Inauguration ceremony organized.
l) Health, education and other development activities organized.

Figure 1.2.1 Major Components CAPP

research is needed to adapt the CAPP to extension activities in the CRL, particularly in regard to the role of RLA's in water management.

2.5.3 Recommendations

The WDA PU must be provided with adequate professional resources and field personnel if the potential benefits of the CAPP program are to be realized. They include a professional social scientist, preferably an applied anthropologist skilled in community development, field staff in each region, and a trainer. The CAPP needs to be integrated into future water development programming and adapted to villages where pumps have already been installed. Based on the evaluation of current well sites, policy changes to strengthen the role of the private sector would be welcomed by community water committees and would increase their role in well management.

3.0 MONITORING AND EVALUATION SYSTEM, MES.

In an effort to maximize the water resource development aspect and to integrate the socioeconomic considerations with technological, a monitoring and evaluation program was to have been established. Unfortunately, the manpower that was to have been provided by WDA, and the cooperation anticipated from the BRADP monitoring staff never materialized. As a result, the objective to fully develop and operationalize a monitoring and evaluation program was changed to prepare a monitoring and evaluation system. Data collection instruments were prepared, and a framework for data entry and analysis was developed. This system and the data collection instruments were ultimately field tested in ten Bay Region communities. Prior to a discussion of the MES and field test results, the socioeconomic conditions are reviewed.

3.1 Socieconomic Conditions, Bay Region

The socioeconomic conditions described relate to the conditions existing prior to the installation of the wells. Most of this data was taken from existing reports and/or from investigations made by the consultant's staff early in the project. These conditions are presented for both the Bay Region and the Central Rangelands.

The Bay Region has an arid to semi-arid climate with four seasons, two dry and two wet. The main dry season, Jilaal, occurs between January and April. It is often a time of severe climatic and ecologic stress when villages are forced to move for lack of water and pasture.

Of the estimated 40,000 square kilometer area, it is estimated that up to 65% has some agricultural potential. Some parts are heavily cropped at present. It reportedly has the highest number of livestock of any region in the country, and seasonal grazing patterns are therefore an important factor in local land use.

3.1.1 Population

The total population is estimated at over 720,000, of which the rural population is estimated at 490,000, and the nomadic population is 118,000. The population density is 18.6 people per square kilometer. There are 1500 villages ranging between 30 and 65 households per village, with an average village population estimated at 305 inhabitants.

3.1.2 Administration

The Bay Region is divided into four districts, which are divided into beels, the administrative centers for groups of villages (tuulos), and for hamlets (buulos). There are 55 beels in the region comprising 1500 villages.

3.1.3 Social Organization

The village is the central focus of social orgnization and it is where residents claim a common male ancestor. Although residents often consider themselves of the same heritage, most villages are composed of members of several lineages. Villages have a strong sense of autonomy and cohesion which finds expression in the traditional institutions, such as the water committees which manage and maintain water resources. These institutions are an important element in social relations and in resource management.

3.1.4 Water Resources

Rainfall is the most important source of water, and in addition to its direct effect on the wholly rainfed agriculture of the region, it replenishes groundwater resources. Rainfall fills reservoirs, (wars) which are hand-dug pits that are able to store up to 1500 cubic meters of water. Most average about 800 cubic meters. In the region there are an estimated 9000 wars, of which 40 to 50 are government built wars that hold from 5000 to 20,000 cubic meters of water.

One study has estimated that 94% of all villages in the region have access to at least one war, and 70% have access to two or more. In the dry season, only one village in four has a reservoir that provides a reliable supply of water throughout the year.

3.1.5 Agriculture and Livestock

The dominant system of agricultural production in the Bay Region is agro-pastoralism. Approximately 20% of the population is non-agricultural, 45% settled farmers, and 35% pure nomads. Of the settled farming population, most have some livestock. Only a small percentage of the sedentarized rural population has no livestock. Estimates of average family holdings are from 10 to 15 livestock units. A variety of crops are cultivated, including sorghum, peanuts, and beans, along with an assortment of garden vegetables.

3.2 Socioeconomic Conditions, Central Rangelands

The Central Rangelands is a sparsely settled dry region almost exclusively used for livestock production with little cultivated agriculture. Its three regions comprise an area of roughly 117,000 square kilometers.

The population of the region is estimated from the 1975 census figures to be about 900,000; growing at about 3% per year. At least 75% of the population is nomadic, 15% consists of sedentary pastoralists, and the remainder is urban-oriented. Population varies seasonally as changing climatic conditions compel nomads to move herds in search of water and pasture.

3.2.1 Social Organization and Livestock Production

The basic social unit of the area, the degaan, is the area inhabited by a given nomadic group. This area is the year-round residence for at least some members of the group. A degaan may be 1000 to 1500 square kilometers in size, and each will have at least one year-round water source. The social cohesion found within a degaan may or may not extend beyond its limits. Some neighboring degaans cooperate over such issues as water and grazing rights, while others do not. For this reason siting of wells is a delicate problem. Siting a well on the boundary between two or more degaans may result in conflicts over control and access.

A degaan may have less than 100 to over 1000 livestock owners who are considered as heads of households. Degaans may have populations from a few 100 to 5000. Populations of degaans fluctuate seasonally, and tend to concentrate around the few water points that contain water at the height of the dry season. Consequently, conflicts often arise over the use of water and grazing areas during this time.

The number of animals per family ranges from 20 to over 350 with roughly ten times the number of goats and sheep to cattle and camels. An average family owns nearly 300 goats and sheep, 25 camels and 14 cattle.

3.2.2 Impact of Well Drilling

A trend toward agro-pastoralism, due to recent well construction has emerged whereby families stake claims in a 6 kilometer radius around a well site. Fences are erected to protect these areas in which cowpeas are cultivated in the wet season, and animals are pastured in the dry season. Families with enslosed areas can ensure themselves incomes from cowpeas, and forage for their animals in times of stress. Those who have not made any claims are forced to walk their animals great distances through the fenced area to the well site, and then back out to pasture beyond the fenced land.

This system is a source of conflicts because it is the private appropriation of access to a public resource. These changes in land use have caused severe degradation around the well sites, and require that water management schemes be integrated with land use schemes. Long-term effects may result in the creation of sand dunes that are worse than no wells at all. Problems of managing these new conditions were recognized at the beginning of the CGDP, but are only just beginning to be investigated in any detail.

3.3 MES and Water Resource Planning

The MES focuses on four major areas which directly concern water development planning and the management of routine WDA activities to construct and operate wells. These are: the physical status and operating conditions of the pumps and civil works; patterns of water use by people and livestock; socio-economic conditions, including changes in population, physical infrastructure; economic activities and social services; community participation in well construction and management; and the effectiveness of villagers' participation in the management of water facilities.

The MES system was used to conduct a field assessment of ten villages. Although the lack of Somali staff limited the quantity of data which could be collected, enough information was obtained to produce a preliminary evaluation of CGDP activities and the impact of the new wells on water use, socio-economic conditions and community participation. As a result of this effort some policy issues are discussed.

Water use. In regard to questions pertaining to the design and operation of the water system, villagers pointed out several problems related to the storage and distribution systems. These were subsequently addressed by the project civil engineer in a set of specifications presented to the BRADP and CRDP staff.

On questions pertaining to maintenance, the major problem related to the unavailability of fuel at those sites equipped with diesel pumps. Additionally these sites were found to have a minimal supply of oil and oil and air filters.

The availability of water from wells has decreased collection time, both for people living near to the wells, and those living within the target zone. Estimates for water collection time ranged from 4.5 to 8 hours before well construction, and from 1.5 to 3 hours per day after well operations began. On a yearly basis the total savings ranged between 64 and 79 days. Water demands are at very high levels in the dry season with average daily pump use of 4 to 6 hours per day; between 8,000 to 11,000 liters being pumped per day.

Socio-economic Conditions. In all well site villages surveyed, the numbers of households increased, usually with permanent families moving from villages in the target zone to the well site village, or temporary families settling permanently in the well site villages. In some cases, where there was no village before the well was constructed, villages have literally sprung up in less than a year. The number of Koranic schools, tea shops, and stores have increased dramatically in most villages. No additional government services in the form of schools or health dispensaries have been built. Other unqualified changes noted were healthier livestock, increases in the price of agricultural land, and an increase in marriages.

Community Participation. In all villages surveyed, members of the community particpated in some form with the construction phase of the wells by donating their labor, food and/or cash to the work crews. Highest levels of success in participation came from villages which were involved at the earliest stages of site selection and construction. Most villagers expressed disappointment that they did not have full control of the wells, having believed that with their contribution of labor and money they would eventually own the well. Nonetheless, in nearly all cases, villagers have reacted positively to the well sites. An appreciation was expressed for the time saved, the improvement to animal health, and most of all, for the dependability of water during the dry season.

Policy Issues. Control of the well sites by WDA, particularly with regard to fuel sales and repairs should be reduced. Moreover, with pump operators being WDA employees, their allegiance is to WDA rather than to the village.

Privatization of services and supplies to the well sites should be encouraged wherever possible. A percentage of the tremendous revenue generated from water sales, estimated annually at over 150,000 Shillings at some well sites, should be placed in the control of villagers for operation and maintenance.

4.0 COST ANALYSES

One of the objectives of the CGDP was to determine the cost of water well drilling operations in Somalia. Project drilling and other day to day operations, were conducted under the supervision of the consultant's staff. Whether the WDA staff, operating independently, would perform in the same manner is not known. Projections and estimates, where possible were based on project experience.

Two earlier economic reports were prepared by LBII staff. The first developed a costing methodology and layed the foundation for subsequent economic evaluations (Pape 1982). This report was conducted early in the project when virtually no experience had yet been obtained. The second report was prepared after two years of project activity (Brandon, 1984). This report contained detailed costs of project activities and estimated program costs to cover the useful life of the drilling rigs.

The analysis presented in this report addresses well construction, well operation and maintenance, amortization of well costs and revenues, and concludes with a discussion of major findings.

4.1 Well Construction

Many variables were incorporated in the computer model to yield a realistic cost estimate of well construction under varying circumstances. The variables are not discussed in this summary because a thorough understanding of rationale and methodology associated with the variables is necessary to appreciate the results obtained. Variables where this is especially important include:

1. Currency exchange rates
2. Freight and insurance
3. Travel time to sites
4. Vehicle and equipment costs
5. Direct, indirect, and sunk capital costs
6. Labor costs

The model details well construction in six stages that are separately costed. These stages are:

1. Hydrogeology
2. Drilling
3. Well Testing
4. Well Logging
5. Civil works
6. Pump Installation

For a specific drilling program the model gives total costs split between local currency and foreign exchange costs. It also details the manpower and vehicle and equipment budgets necessary for the program. The various assumptions associated with each of these stages results in a number of conclusions regarding well construction costs. The most significant factor in varying the cost of a well was found to be the time taken to drill the well.

Direct costs vary little with time taken, the only increase being to labor costs which are a small part of the total. The major cost elements which increase significantly with increase in time taken are the capital replacement and repairs and maintenance provisions for vehicles and equipment. This would come as no surprise to a driller in developed countries. Within WDA, however, these indirect costs were never accounted for; much of the equipment having been fully depreciated or simply donated.

4.2 Well Operation and Maintenance

Well operation and maintenance costs were broken down into three main elements; pump operation, routine maintenance, and major overhauls. Pump operating costs relate only to wells equipped with diesel powered pumps.

In the Bay Region, annual operating costs were found to be 8%, and major overhauls 35% of the total annual costs. Proportionate costs in the Central Range were not significantly different, though the actual costs were higher.

4.3 Amortization of Total Well Costs and Revenues

The amortization of total costs and revenues were only prepared for wells equipped with diesel pumps; these are the only wells for which a charge for water is made. Because a typical cost-benefit analysis was not feasible for the type of well use, a costing statistic of cost per cubic meter of water produced over the life of the well was calculated. These calculations included the total well construction costs and the operation and maintenance costs. The amortized cost per cubic meter are as follows:

	Bay Region	"Average"	Central Range
NPV Total Costs	$114,948	$156,672	$198.396
NPV Total Water	156,987	156,987	156,987
Cost/cubic meter	$0.73	$1.00	$1.26
Cost So.Sh.@83:1	61	83	105

Costs are higher in the Central Range because of the greater distances involved. This affected the time to get to the site and the amount of additional support equipment required. The ratio of successfully completed wells was also lower in the CR.

4.4 Major Findings

The bottom line to all the costing exercises pointed to one major factor; well construction and water production costs could be reduced by increased efficiency in the use of equipment and supplies. In theory, the current price of water is adequate to cover all operation and maintenance costs. In order to recover the direct costs and construction costs, the price would need to be at least doubled. In practice, however, it was found that many of the wells in the Bay Region were not sufficiently utilized to recover these costs, that maintenance support at the level assumed in the costing model was not provided by WDA, and that irregularities in the final delivery and revenue collection system prevent the full recovery of these costs. A summary of the total costs is shown in Table 1.4.1.

Table 1.4.1. Summary Total Cost of Well Equipped with Diesel Pump

	Bay Region			"Average"	Central Range		
Direct Costs: So. Sh.		162,282	$2,003	$2,372		221,956	$2,740
F/Exch.	Materials		$29,730	$30,593	Materials		$31,455
	Fuel		$6,845	$9,607	Fuel		$12,368
	Total Direct Costs		$38,579	$42,571	Total Direct Costs		$46,563
Capital Replacement Charge			$8,587	$15,707			$22,826
Repairs and Maintenance Provision		10%	$6,865	$10,076		10%	$13,288
	Direct + Indirect		$54,030	$68,354	Direct + Indirect		$82,677
Exploratory Drilling Overhead		40%	$9,605	$22,311		50%	$35,016
	Total Program Cost		$63,636	$90,665	Total Program Cost		$117,693
Amortized Operation and Maintenance			$18,470	$21,244			$24,018
	Full life cost		$82,106	$111,909	Full life cost		$141,711
Agency Overhead Costs		40%	$32,842	$44,763		40%	$56,685
	Grand Total Cost		$114,948	$156,672	Grand Total Cost		$198,396

5.0 PRIVATE SECTOR

In recognition of the constraints that lack of water development has on the economic development of Somalia, USAID in granting the extension of the CGDP required that a special study be conducted to evaluate the existing and potential involvement of the private sector. This study, referred to as the private sector study, was divided into four phases. These four phases as set forth in the Inception Report were:

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

Phase I was essentially completed with the submittal of the Inception Report in January 1985. Phase II was initiated in the LBII Washington offices and continued with the arrival of the study team in Mogadishu. In Mogadishu, two sub-contractors, Geomatec and MAM Brothers, were retained to assist in the information gathering exercise.

Conceptual models of potential options were formulated during the information gathering period, and Phase III was formalized upon completion of Phase II. Policy options were developed and circulated to WDA, USAID and CGDP team members for comment.

Upon-completion of this effort an executive summary of recommendations was prepared in anticipation of a seminar to be held in Mogadishu prior to commencement of final recommendations and a final report. Unfortunately, the seminar was cancelled, but the study team met with key individuals of WDA, and USAID to review their initial recommendations.

A four volume final report entitled, "Study of Private Sector Participation in Somalia's Water Resource Development Industry" was completed in February of 1986. The report was organized in three sections. Section one provided an introduction and overview of the study, section two explained the three phases of the recommended program and section three discussed the need for private sector participation in the water resource development industry.

Section I is self explanatory. Section II of the report, the consultants' recommended program, contains the main thrust of the study. Each of the three phases described under Section II were presented in a logical sequence of steps that would be required to strengthen the water resource development capability of Somalia.

Phase one, Well Rehabilitation and Maintenance, outlines the steps required to upgrade the numerous existing, non-operating wells throughout Somalia by involvement of the private sector. The action components and technical assistance required are carefully detailed.

Phase two, Water Security Role for Somali Private Sector, discusses the role the private sector would take in water development during emergency situations. The action components of this phase employ Option F as discussed in an earlier report.

Phase III, Reoriented WDA Role, discusses the major reorientation of WDA's role as a rural water well drilling and parastatal agency. It recommends that WDA concentrate on five functions:

(1) Contracting with the Somali private sector for well operation and maintenance, drilling and construction, and provision of related inputs;

(2) Research and planning for rural water resources development in Somalia;

(3) Public utility regulation of water prices and service;

(4) Exploratory and emergency drilling; and

(5) Operation of selected wells and water systems.

Section III of the report provides the documentation that supports the need for greater private sector participation. The current and future water needs of Somalia are illustrated and capabilities and constraints of the private sector industry are described.

Because the material in this final report on private sector participation is too voluminous for inclusion in this report, the interested reader is strongly encouraged to review the original document. It is the consultant's opinion that implementation of the recommendations provided will go far to improve Somalia's self-sufficiency in water development activities.

6.0 HYDROGEOLOGY

During the course of the project, a total of 118 boreholes were drilled in the Bay Region and Central Rangelands, Ninety-four of these were in the Bay Region, one at Afgoi and 23 in the Central Rangelands. Fifty-three percent of those in the Bay Region and forty-one percent in the Central Rangelands were completed as production wells equipped or waiting to be equipped with either a motor pump or a hand pump. Table 1.6.1 Provides a compilation of wells completed during the project. These results are the culmination of the hydrogeologic effort that involved a number of tasks from well siting through drilling, testing, and completing. Volume III of this report presents, in separable sections, a comprehensive discussion of the hydrogeology in the BR and CR areas. For the sake of brevity these sections are combined in this summary volume.

6.1 Methods of Investigation

The basic methods of investigation for the two regions was not significantly different. Previous investigations were reviewed, maps and air photos studied and field inspections made prior to approving a potential site for drilling. These technical efforts were coordinated with the respective BRADP and CRDP staff prior to actual drilling. Both projects had sociologists and ecologists that selected sites based on need and in accordance with their project development plans. In a few instances, the hydrogeologist's recommendation against drilling in a particular area were overruled by the socio-ecological considerations. In all such instances the borehole was unsuccessful.

Drilling was conducted with Ingersol Rand TH-60 rotary drill rigs and with a Dando cable tool rig. In the Bay Region air-foam techniques were used and in the CR mud rotary techniques. The cable tool rig was initially used in the Bay Region and then transferred to the CR where it was utilized in the coastal area.

Whenever logistics, fuel and manpower allowed, boreholes were logged using one or more geophysical logging tools that included gamma/resistivity, caliper, temperature and flowmeter. While results of these efforts did not prove satisfactory for regional stratigraphic mapping, aquifer zones were able to be identified in the respective boreholes.

Upon completion of the well, development work consisting primarily of air jetting techniques was conducted. In some instances this was combined with bailing of the hole. No chemical development was attempted in any of the boreholes.

Table 1.6.1. List of All CGDP Boreholes

Refer. number	Location	Map Co-ord's Long. (hhmmss)	Map Co-ord's Latit. (hmmss)N	Elev-ation (m)	Date Completed	Well Depth (m)	Screen depth 1: Start/end 2: Start/end (m)	(m)	Static Water Level (m)	Specific conduct-ivity umhos/cm	Total dissolved solids mg/l	Yield CuM/hr	Specific capacity CuM/hr/M	Pump depth (m)	Pump type	Remarks	FT CD GL
CHO	Afgoi	450910	20625	95	15.04.85	158	96	114	70.2	1950		5.45	0.35		A	Awaiting Pump	PT CD GL
B 1	Boonkay 1	433900	30700	510	04.02.82	18									E	Aband. dry	
B 2	Bonkay 2	433900	30700	510	27.02.82	201	30	201	48.5	2300					E	Aband. observ. well	GL
B 3	Bonkay 3	433900	30700	510	13.04.82	160	74	160	30	2700	2216	6.6	0.33	114	M	In use	FT CD GL
B 4	Tugerew 1	434230	30701	390	10.06.82	42	6 26	12 32	3	1700	1348	3.7	0.21	29	M	In use	PT CD GL
B 5	Gasarta	434812	30736	350	21.03.82	42	6	42	12						E	Aband. low yield	GL
B 6	Waraji 1	433230	25448	475	28.03.82	80	6	80	67						E	Aband. low yield	GL
B 7	Waraji 2	433230	25312	430	29.03.82	39	1	39							E	Aband. dry	GL
B 8	Tugerew 2	434142	30654	400	29.03.82	48		48							E	Aband. dry	GL
B 9	Bur Halab	440612	30412	280	30.03.82	32		35							E	Aband. dry	GL
B 10	Sarman Dheere	432124	31636	450	10.04.82	85	30	50.4	12.9	3300	3000	26.6	140.2	50	M	In use	FT CD GL
B 11	Baidoa Aid Comp	433854	30718	460	02.06.82	137	48	140	7	1500	1360	13.3	28.9		E	Aband. surface seal	PT CD GL
B 12	Hareero Jiifo	432512	31354	478	09.07.82	166	51	73	29.5	3900	3544	11.4	0.53	77	M	In use	FT CD GL
B 13	Shabelle Dugsiil	431300	31712	420	14.07.82	172	44	172	11	24000	19772				E	Aband. exc. salinity	CD GL
B 14	Warta Jaffay	430830	31900	390	03.08.82	91	2	91	17.5	10000	9188				E	Aband. exc. salinity	CD GL
B 15	Qansax Omane	430224	31954	365	19.08.82	174		174	165	24000	16436				E	Aband. exc. salinity	CD GL

Table 1.6.1. List of All CGDP Boreholes

B 16	Taflow	431124	30354	435	16.08.82	154	72	153	35.4	1580	1528	11.4	1.69	67 M	In use	PT CD GL
B 17	Robay Gaduud	431864	24616	440	27.08.82	142	48	88	22.7	1280	1024	11.4	0.2	88 H	In use	PT CD GL
B 18	Gaduudo Dhuunte	431548	24730	430	29.09.82	73	16	64	23.5	3800	1932	11.4	0.9	50 M	In use	PT CD GL
B 19	Buulo Fuur 1	430500	25318	435	20.08.82	94		94						E	Aband. dry	GL
B 20	Duri Ali Galle	425554	24954	405	11.10.82	116	82	100	69.4	2000	1816	11.4	0.34	88 H	In use	PT CD GL
B 21	Baidoa Aid Compo	433942	30724	460	16.12.82	42	19.6	36.4	8.5	2500	1928	5.5		40 M	In use	CD GL
B 22	Buulo Gaduud	423824	20724	260	04.01.83	189		189						E	Aband. dry	GL
B 23	Kurman	425118	22854	350	10.01.83	148	30	54	20	2400	1068	3.6	0.12	48 H	In use	PT CD GL
B 24	Yaaq Baraawe	431406	15700	160	24.01.83	10	5	10	1					E	Aband. low yield	GL
B 25	Dodole	433354	21818	190	13.01.83	24	17	24	12	900	660			E	Aband. low yield	CD GL
B 26	Shidallow 1	441612	25336	195	20.01.83	67	3	67	36	33000	32042			E	Aband. exc. salinity	CD GL
B 27	Shidallow 2	441612	25336	195	22.01.83	80	2	80	37	34000	33376			E	Aband. exc. salinity	CD GL
B 28	Bur Akaba 1	441136	24836	200	25.01.83	54	1	54	22	14000				E	Aband. exc. salinity	GL
B 29	Bur Akaba 2	441136	24836	200	26.01.83	24	1.5	24	7	34000				E	Aband. exc. salinity	
B 30	Bur Akaba 3	441136	24836	200	01.02.83	30	1	30	22	42000				E	Aband. exc. salinity	GL
B 31	Bur Akaba 4	440506	24730	200	02.02.83	63	1	63	20	49000				E	Aband. exc. salinity	GL
B 32	Bur Akaba 5	440506	24730	200	15.02.83	89	6 31	31 89	17	1140	916			45 H	Low yield	CD GL
B 33	Bur Heibi 1	442954	25836	230	10.03.83	26			18					E	Aband. low yield	GL

Table 1.6.1. List of All CGDP Boreholes

B 34	Bur Heibi 2	442600	25848	230	23.02.83	73	8	20	16	1320	952	.		52 H	Low yield	CD GL
B 35	Bur Heibi 3	442654	25836	230	23.02.83	60	2	60						E	Aband. dry	GL
B 36	Bue Heibi 4	442654	25848	230	15.03.83	25	1	25						E	Aband. dry	
B 37	Bur Heibi 5	442654	25848	230	15.03.83	26	1	26						E	Aband. dry	
B 38	Bur Heibi 6	442654	25848	230	16.03.83	36	2	36						E	Aband. dry	GL
B 40	Limestone Depres	441524	31112	360	23.02.83	32	1.5	32						E	Aband. dry	GL
B 41	Dolondole	441412	31606	480	02.03.83	166	5.4 10.8	10.8 166	1.9	1040	564			E	Well destroyed	CD GL
B 42	Buulo fuur 2	430500	25348	435	03.05.83	130	64.5 98	98 130	56.2	2050	1640	11.4	1.73	92 M	In use	PT CD GL
CR43	Aborey 1	465112	35730	435	03.05.83	130	2	120						E	Not deep enough	GL
CR44	Afar Irdood	465124	35930	284	21.05.83	174	37.8	81						E	Not deep enough	GL
B 45	Baidoa AID Comp.	433854	30718	460	20.07.83	120	65	117	6.5	1770		10.9	0.22	E	Aband. defect. seal	PT GL
B 46	Quansaxdheere	425718	25530	405	11.05.83	103	60	103	30.2	1900	1772	11.4	0.87	92 M	In use	PT CD GL
B 47	Awshini	432330	31212	475	30.06.83	143	56 90	86 143	29.8	3100	2740	11.4	0.72	89 M	In use	PT CD GL
CR48	More Ari	463212	35130	180	23.06.83	102	60	96	36	3700				E	PVC casing rupt 45m	GL
CR49	Maxaas Jeejo 1	461006	44006	200	09.09.83	190	9	190						E	Dry, not deep enough	GL
CR49	Maxaas Jeejo 2	461036	44036	200	15.10.83	180	6	180						E	dry, not deep enough	GL
B 50	Bonkay seed farm	433636	31148	510	22.09.83	200			30.1	11400		11.4	0.21	E	Aband. high salinity	PT GL
B 51	Mintano	433312	32048	490	02.10.83	132	51 99	93 132	40.2	1400	1164	11.3	0.7	60 H	In use	PT CD GL

Table 1.6.1. List of All CBDP Boreholes

B 52	Maleel	433512	32612	495	07.12.83	130	51 99	93 130	48.5	670	608	25.2	23.77	92 M	In use	PT CD GL
CR53	Aboorey 2	455048	35054	285	11.12.83	133	3	133						E	Aband. dry	GL
B 54	Isgeed	433312	32648	490	19.12.83	150	90 120	114 150	37.1	1350	992	17	0.76	92 M	In use	PT CD GL
B 55	Martimoog	432848	33400	490	23.01.84	147	76 120	114 147	32.8	1150	964	22.7	0.83	91 M	In use	PT CD GL
B 56	Jimcada Dheen	442124	24542	175	03.03.84	41								E	Aband. dry	
B 57	Hagarkaa	431842	25342	470	09.03.84	154	54	114						E	Aband. dry	PT CD GL
B 58	Buur Hakaba 6	440848	24430	190	20.03.84	27			20	48000				E	Aband. saline	
B 59	Shawka	433148	30030	485	18.03.84	138	45.8 91.6	51.6 132	30	13500	10224	11.4	0.27	P	Awaits investigation	PT CD GL
B 60	Kannanax	432400	21224	200	27.03.84	15	9	15	8.6					E	Aband. low yield	GL
B 61	Hubay	425848	23818	405	05.04.84	152	60 108	108 152	17	2550	1348	3.56	0.1	E	Low yield	PT CD GL
B 62	War Caasha	433236	30236	485	29.04.84	201		201	120	1250	1200			E	Aband. low yield	CD GL
B 63	Bonkay extension	433636	31148	510	30.04.84	153	117	147	25.6	2200	1476	9.1	0.1	W	Experim. windmill	PT CD GL
B 64	Buulo Yuusuf	432748	30342	480	15.05.84	85	58.5	85	18.2	2900	2456	15.9	3.6	55 M	In use	PT CD GL
CR65	Aboorey 3	455048	35854	285	19.05.84	210	3	210						E	Aban.not deep enough	GL
B 66	Buulo Haawo	430636	30342	415	07.06.84	142	66.2 83	77.4 142	33.5	1825	1408	14.5	0.43	76 M	In use	PT CD GL
CR67	Wargaloh	473112	61548	205	25.07.84	252	165 178	177 252	100	3200	3156	11.4		134 M	In use	PT CD GL
B 68	Dhambaal AAlin	432654	30536	475	26.06.84	126	49 98.5	71 126	17.7	1675	1456	14.1	0.18	96 M	In use	PT CD GL
B 69	Togaal	435536	33124	625	18.07.84	92	37	64.5	18.7	970	576	15.3		E	Low yield	PT CD

Table 1.6.1. List of All CGDP Boreholes

B 70	Garilmay	435212	33854	600	16.09.84	135	60 90	72 114	60	1420	964				A		0 PT CD
B 71	Uusle	433006	32342	465	19.08.84	102	50	80	36	1420	1252				A		0 PT CD GL
CR72	Afgaduudle	435812	55730	125	17.11.84	204			17	12000	5245				E	Aband. exc. salinity	CD
B 73	Fajir-Lowger	435506	34148	605	12.09.84	4									E	Aband. as directed	
B 74	Bigdalow	435030	33624	605	13.10.84	130	58 70	64 88	74.7	1700	1088				A		0 PT CD
B 75	-1 Labaatan Jiro	435054	33136	595	18.10.84	132	60 90	72 108	40.1						E	Aband. low yield	PT CD
B 75	-2 Ufurow	425306	24536	395	28.12.84	85	49	73	49.5	2200	2068	4.7	0.24		H	Replac. well for WDA	PT CD
B 76	Dhuuboy	435300	24130	375	28.12.84	124	52 88	64 100	19.2	3500	2344	15.9	0.51	90	H		0 PT CD
B 77	Dhorhabay	425548	23354	390	28.12.84	200			46.5					50	H		0
CR78	Dajimaale	481300	61830	110	19.01.85	177	56.8 86.8	68.8 176	69.6	4800	6720	12.5	8.33	90	H	In use	PT CD
B 79	2. Buulo Caddey	424806	30030	315	11.02.85	50	3 18	26 50							E	Aban.	
B 79	1. Buulo Caddey	424806	25912	315	27.12.84	26									E	Aband. dry	
B 80	Tugere Hoosle	425436	23800	395	04.03.85	212			57	3900	2248			90	H		0 CD GL
CR81	Budbud	484042	61036	70	11.03.85	60	24	60	25.9	12000	10128	0.65	0.03	40	H	In use	PT CD
CR82	Saadaal	473048	40642	50	25.04.85	75	46	73	40.1	6100	4352	10.3	0.93	54	H	In use	PT CD
B 83	Misra	432418	23512	390	17.04.85	170	62 152	74 170	21.1	9400	6640	5.8	0.14	50	H	T = 3M³/day step	PT CD
CR84	Cagacadde	472260	42442	360	02.06.85	133									E	Aband.	GL
B 85	Buklaabow	432418	30112	490	30.05.85	130	88	106	14	2900	2232				P		0 CD

30

Table 1.6.1. List of All CGDP Boreholes

CR86	Xasan Afrax	470736	40742	290	30.05.85	200									E	Aband. dry	GL
CR87	Calyabaal	470560	35818	229	09.07.85	250	216	240	220						E	Low yield,obser.well	GL
B 88	Kooban Heegan	430400	24000	395	16.06.85	294			28	4800	3540	4.7			E	Aband. constr.supply	CD GL
CR89	Xarardheere	475118	43918	235	20.07.85	28	15	21	13.5	2800				21	H		CD GL
B 90	BRADP CMPD	433954	30718	460	27.06.85	30	6	18	5.6	790	639	23.2	34.8		A		0 PT CD GL
B 91	Xaarre	433348	33048	500	13.07.85	115	44 72	50 83	42	1100	876	18.2	1.57		P	Needs retest	PT CD GL
B 92	Caasha Fartow	433400	31560	505	18.07.85	120	54 84	72 102	46.4	1400	899	15.3	0.96		A		0 PT CD GL
CR93	Calytun	471842	44654	185	23.10.85	114	78	113	82.6	6600	3996	6	0.35	108	M	Backfilled from 122m	PT CD
B 94	Baqalley	431312	31418	470	18.07.85	66	48	66	18	1300	980	23.5	0.35		A		0 PT CD GL
B 95	Kurtin	431242	30100	470	05.08.85	130	76 100	100 130	34	2400		1.78	0.05	50	H	Low yield	PT CD GL
B 96	Qansaxdheere 2	425718	25530	405	08.08.85	136	82 124	100 130	48	1900	1260	4.1	0.05		A		0 PT CD GL
B 97	Toosilow	431112	30812	445	22.08.85	140	68 92	80 110	32	2250	1550	12.2	0.34	50	H		0 PT CD GL
B 98	Guralow	431605	30200	477	11.09.85	120	41.6	69.6	39	3320	2092	2.59	0.05		A	Low yield - handpump	PT CD GL
B 99	Hareero Jiifo-2	432512	31354	478	11.09.85	120	63.8 103	80.6 114	35						P		0 GL
CR100	Darr Shadoor	471512	35542	55	00.01.00	50				32000	23192				E	Aband. high salinity	CD
B 101	Hobishole	432100	25848	482	02.10.85	120	36	114	26.5	1520	1112	2	0.09		A	Aquifer 40-90m	PT CD GL
B 102	Caliyo Marayle	431954	25554	478	12.10.85	88	20.8 37.6	32 54.4	14.3	3500	2300	8.3	2.32		A	Screen 65.6 - 71.2	PT CD GL
B 103	Gras Mood	431624	25230	455	27.11.85	94	26.8 49.2	43.6 54.8	25.4	1500	912	18.2	0.69		A	Screen 60.4 - 66.0	PT CD GL

Table 1.6.1. List of All CBDP Boreholes

B 104	Ceel Jaalle	434900	30236	300	27.11.85	30			15.4	21800	14080		E	Aband. high salinity		CD	
B 105	Coorar	430754	31306	398	12.12.85	102	30	34	11.7	6900	4940		P		0	CD	
B 106	Asha Gab GE	433800	31518	510	07.01.86	96			36.4				E	Low yield			GL
B 107	Hartiqanle	433118	31724	525	30.12.85	84	40 60	52 72	24.2	910	740		P	Screen 78 - 84		CD	
CR108	Ouracley	471148	50342	160	18.01.86	230							E	Aband. dry			GL
CR109	More Arie 2	460236	35130	180	10.03.86	110	74	104	69			90	M		0		
B 110	Ohejiile	430800	30700	420	18.03.86	90	54 72	66 78	37				A		0		
CR111	Hobbio NRA	483130	52042	12	04.03.86	11	7	11	7				A	Saline water			
B 112	Bottis	432342	25142	462	22.03.86	96	34 62	46 74	35				P		0		
CR113	Hobbio 2	433106	52112	17	22.03.86	19	13	19	17				A		0		
B 114	Eeg	432712	30206	0	00.01.00	0							D		0		
CR115	Bulo Burde Nurse	453448	35000	140	00.01.00	54							D		0		

Total: 118

Key:			
M	Wells with diesel pump	20	17%
H	Wells with hand pump	16	14%
W	Wells with windmill	1	1%
A	Wells awaiting pump	15	13%
P	Wells awaiting pump test	7	6%
E	Exploratory boreholes	57	48%
D	Under construction	2	2%

PT - Pumptest Data Available
CD - Chemical Data Available
GL - Geophysical Log Available

During the development effort, a decision was made regarding the potential success of the well and the need to conduct aquifer pumping tests. Testing was done in most instances with a Grundfos submersible pump, and in a few cases with the Mono diesel pump earmarked for permanent installation. Where possible, 24 hour tests were conducted.

Water samples were collected during the testing period and sent to the MMWR laboratory for analysis. All of the major cations and anions were tested. In the Bay Region some wells were monitored for bacterial contamination. The logistics associated with this effort required that it be discontinued.

6.2 Geology

The geology of the Bay Region consists of three basic rock types, igneous and metamorphic rocks in what is known as the Bur area and sedimentary rocks in the plateau area (Figure 1.6.1). The igneous-metamorphic complex was found not to be very productive in terms of quantity and quality of water.

The sedimentary rocks, mainly the limestones of the Iscia Baidoa Formation were most productive. This formation contains sufficient joints and fractures enlarged by karstic development to yield developable supplies of water to wells. Table 1.6.2 provides a brief geologic description and the water-bearing characteristics of the rocks in the Bay Region.

In the Central Rangelands the geology is considerably more complex. Although only four basic rock types occur in this area, igneous, sedimentary, eolian and alluvial, the sedimentary sequence is highly varied. Limestones, siltstones, sandstones and evaporite deposits are interlayered beneath aeolian dune deposits. The evaporite sequences caused special problems with regard to quality of water, and the limestone formations caused lost circulation problems during drilling. The most productive formations were found to be the Trap Series basalts, and the Jessoma sandstone. Table 1.6.3 provides a brief geologic description and the water-bearing characteristics of the formations in the Central Rangelands.

6.3 Hydrogeology

A description of the hydrogeology of an area generally involves a discussion of the recharge, movement and discharge of water through geologic formations. In the Bay Region most recharge results from direct infiltration of precipitation through enlarged joints and fractures of the limestone exposed at the surface and through dessicated soil layers early in a precipitation event.

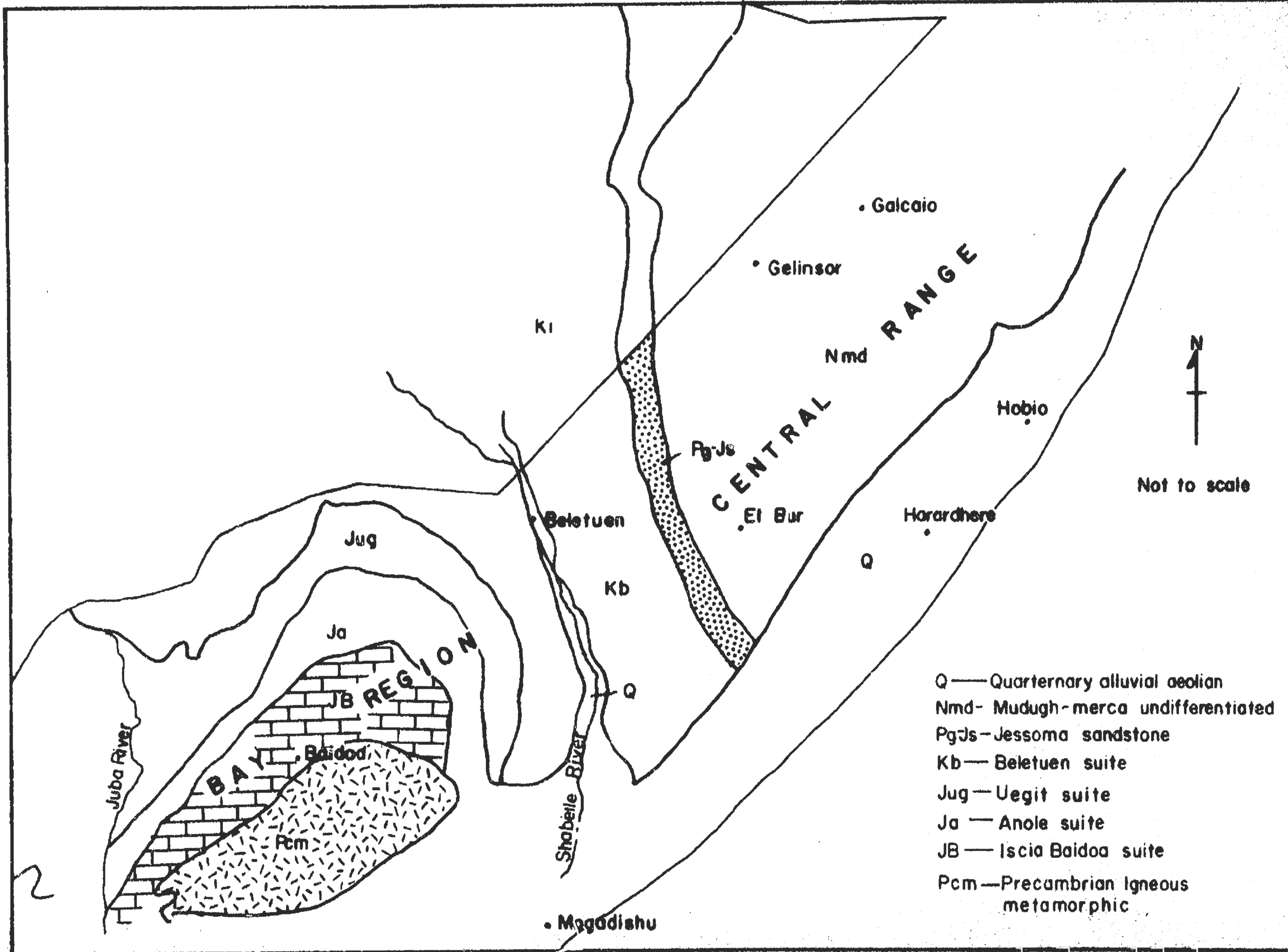


FIGURE 1.6.1 GENERALIZED GEOLOGIC MAP OF PROJECT AREA

TABLE 1.6.2. 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 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.

MIOCENE-PALEOCENE	Basalt; BPg-N_1	80	Near the rivers and in the north-western 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, anyhydrite, ± dolomite, marl, clay and siltstone, yields water of marginally useable quality to a few hand-dug wells.
	Busul Subsuite of Gabra Harre Suite; J_3bs	400	North of Bay Region between the Giuba and Shabelle Rivers; limestone, dolomite, marl, and sandstone yield water of marginally useable quality to hand-dug wells.
LATE JURASSIC	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, B:15, 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, limestone, marl and clay, project wells B14 and B15 yield unuseable saline water from this suite.

LATE JURASSIC	Iscia Baidoa Suite; J_3bd	870	Occupies part of the Bay Region adjacent to the northwest side of the Bur area; kastic 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	undetermined	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.

TABLE 1.6.3. CENTRAL RANGELANDS GEOLOGIC UNITS AND WATER BEARING CHARACTERISTICS

EPOCH	SUITE OR SERIES	APPROXIMATE MAXIMUM THICKNESS	OCCURENCE, LITHOLOGY, AND WATER BEARING CHARACTERISTICS
RECENT PLEISTOCEN	Stream Alluvium Qal	100 m	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, Qeolte	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	120 m	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	500 m	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 pore spaces, bedding planes, and karst formations water quality is variable with specific conductance from 3,000 to 30,000 umhos/cm, sulfate conccentrations are generally high; water with specific conductance of less than 3,000 umhos/cm is found in less than 15 percent of wells.

MIOCENE PALEOCENE	Trap Series; B P_e-Ni	80 m	Forms intraformational flow extending from Dhusamareeb to El-Bur and north to Wargaloh. Basalt and tuff, may be related to the existence of fesh water found during this project.
OLIGOCENE	Middle Daban series Pg_3 mdu	800 - 2000 m	Sandstone, siltstone, lenses of boulder conglomerate; generally contains highly mineralized
EOCENE	Lower Daban series Pg_2ld	245 m	Sandstone, siltstone, marl, lenses of gypsum and conglomerate; generally contains highly mineralized water.
	Karkar Suite Pg_2kr	230 m	Limestone, minor marl, clayey dolomite, siltstone; may contain small amounts of water but not an aquifer of regional importance.
	Taleh Suite Pg_2tl	350 m	Anhydrite, gypsum, interbedded dolomite and marl; generally contains highly mineralized water in karstified zones.
	Auradu series Pg_2ar	400 m	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.

PALEOCENE	Jessoma Suite	200 m	In a north-south section east of the Shabelle River and west of El-Bur. Inequigranular crossbedded sandstone, minor siltone, 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 due to low effective porosity.
UPPER CRETACEOUS	Beled Weine Suite Cr_2bl	200 m	East of the Shabelle River, limestone, marl, gypsiferous shaley clay. Generally contains highly mineralized water at depth.
CRETACEOUS	Mustahil Suite Cr_1	180 m	West of Shabelle River, gypsiferous siltstone, mudstone, interbedded limestone; karst formations supply water which is generally highly mineralized, specific contuctance is rarely below 3500 umhos/cm.
CRETACEOUS	Marehan Suite Cr_{1-2}-mr	300 m	Occurs only at southwestern border of Central Rangeland. Generally supplies small amounts of fresh water to wells.

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

Movement of groundwater is toward the Juba River to the west of the region and eastward toward the escarpment. Discharge occurs to the river and to springs along the escarpment.

In the Central Rangelands, recharge results from direct infiltration of precipitation to the dune deposits and to the shallow limestone aquifers. The Trap Series basalts and the deeper Jessoma sandstone are recharged in the outcrop areas of these formations in the highlands of Ethiopia.

Movement of groundwater is less well defined than in the Bay Region, but is assumed to be toward internal basin areas and toward the coast. In the areas adjacent to the Shebelle River, movement is assumed to be toward the river.

Discharge of groundwater is likewise less well defined. Some discharge from the shallow limestone aquifers occurs to internal basins where it is quickly evaporated. Discharge from the Jessoma is known to occur from springs located near the village of Jessoma. Other discharge is assumed to be to the ocean.

A minor amount of discharge in both areas occurs through wells. This will eventually be of significance in the Bay Region, but is not likely to reach significant quantities in the Central Rangelands.

6.4 Quality of Water

The quality of water in both areas was more often the reason for abandonment of a well than quantity. In the Bay Region this problem was less severe, especially from wells completed in the Iscia Baidoa formation. Waters in the Bay Region are of the calcium bicarbonate type, with a few areas containing calcium chloride waters. Total dissolved solids ranged from 640 mg/l to 6640 mg/l.

In the Central Rangelands the quality of water varied with location but was universally of high TDS. Total dissolved solids ranged from 272 mg/l to 23,192 mg/l. Two types of water were found in the CR that included calcium-chloride along the coast, and calcium-bicarbonate inland.

Because of the unusually high total dissolved solids in both areas, a standard for well acceptance was established on the basis of use. This standard was based on the electrical conductivity of the water and was as follows:

Camels $\leq$ 10,000 michromhos
Cattle, goats and sheep $\leq$ 7,500 michromhos
Domestic use $\leq$ 3,500 michromhos

Depending upon availability of water, even these standards were exceeded in some areas.

6.5 Civil Works

Civil works were designed and intended to be installed at those sites equipped with diesel-operated pumps. The civil works consist of a 45 m^3 storage tank, animal-watering troughs and domestic water points equipped with laundry basins and wash boards. The task of constructing the civil works was initially assigned to the BRADP and CRDP projects, however, it was taken on by the CGDP only to be reassigned to the respective projects after the first three years of the project.

Only 7 sites were completed with civil works in the Bay Region and none in the CR. Those in the Bay Region were evaluated approximately a year after installation and design modifications made. These modifications were presented to the BRADP and CRDP project staff in a set of specifications.

6.6 Pumping Systems

Three types of pumping systems were installed during the life of the project, hand pumps, motorized pumps, and wind pumps. The hand pumps were Robbins and Myers Moyno rotor/stator type pumps. These were received with a factory defect and had to be repaired after a relatively short time in operation.

The motorized pumps were the Mono/Lister pumps. These were also of the rotor/stator design, but were manufactured by the originator of the rotor/stator system. Both the hand pumps and the motorized pumps were capable of lifting water from depths of 90 m.

Only two wind pumps were ordered, and only one was installed. These were Wind Baron pumps manufactured in the USA, and ordered because of the ability to pump water at windspeeds of 8 km/hr. Conventional wind pumps generally require wind speeds of 15 km/hr.

The unit installed was in the Bay Region at the Agricultural Research Farm. It was installed at this location to enable the collection of data on the performance of windmills in the region. Sufficient data was collected to allow an evaluation, however, technical difficulties resulted in less data collection than originally planned.

6.7 Recommendations for Future Water Development

A small advance has been made in the water development effort in Somalia as a result of the CGDP. Considerably more water development is needed to meet the minimum needs of the people and satisfy livestock water requirements. In addition to having been an exploration, exploitation and training project, the CGDP can be regarded as a learning project for rural water development operations.

Drilling techniques utilized during the project were adequate to excellent. In the BR, cable tool techniques should be utilized more extensively. In most parts of the CR, the mud rotary technique is the only feasible way to complete wells of 200 to 250 m depth. The area just inland from the coast can be drilled using cable tool rig methods.

In both regions there are large areas where conventional wells are not feasible. Potential for successful wells in the Bur area of the Bay Region for example is minimal. There are, however, many wadis heading along the escarpment and disappearing in the alluvial and aeolian materials overlying the igneous-metamorphic rock. These wadis, if equipped with infiltration galleries and gabion structures, could be potential sources of water.

The coastal area of the CR presents a special problem for conventional wells, namely upconing of salt water. This problem is solvable to some degree by installation of infiltration galleries along the coast. These can be constructed so as to skim the fresh water off the salt water without causing upconing.

Two other recommendations regarding water development pertain to improvements in existing practices. These recommendations apply to both regions, and relate to improvements in the construction of surface catchments and wars. Two of the major problems with surface catchments are erosion of channels and/or loss of water through seepage. Erosion problems can be solved by the use of rip-rap and improved sloping and grading of the system.

Losses of water from seepage into sand can be solved by the use of synthetic liners or clay mixes that can be compacted in the field and covered with rock to reduce the potential for erosion. Based on average annual precipitation, sized catchments can be constructed where most needed. Invariably, these catchments are constructed in conjunction with berkeds.

Improvements to these structures are provided in Volume III, Figure 3.3.15 and 3.3.16.

War improvements consist of solving the problem of bank erosion and contamination of the water by people and animals entering the war for water. This problem is solvable by constructing a stilling well outside the war embankment and connecting it with 8 inch PVC pipe to the center of the war. Where the PVC pipe enters the war it is perforated and protected with gravel.

Additional recommendations for future water development concern monitoring programs and publication of basic data. All wells installed should be equipped with a one inch diameter PVC pipe to enable the measurement of water level in the well. This data should be maintained on a quarterly basis at minimum. Records of this data will enable better management of existing wells and allow for planning of future wells. This is especially important in the Bay Region where the density of wells in an area will ultimately be of concern.

7.0 WDA's Future Role

WDA's role as providers of water resources has been changing slowly since its inception in 1971. Many of these changes have been outside the control of WDA, yet they have radically altered WDA's ability to fulfill its original objectives. WDA can be described as a "service agency" providing water development to other agencies of government as required. In terms of creating new water sources, it is required only to advise on hydrogeological issues, and to carry out the actual construction and development of the resources. Site selection per se is out of WDA's hands. WDA still has a formidable role to fulfill in the construction and maintenance of water supply systems.

As a result of the work completed during this project, it has become obvious that WDA's role will need to change from what it was originally. The plan proposed for this change in roles has been discussed rather extensively in the special study report submitted as part of the CGDP (LBII, March 1986). This proposes that WDA's role be reoriented by curtailing production well drilling programs and civil works functions; and by focusing on exploration drilling, administration and regulation of water resources.

A methodology for transferring the production drilling, and operations and maintenance functions to others is detailed in the special studies report. In its role as administrator and regulator of water resources, WDA will be responsible for establishing construction standards and for managing water resource development.

8.0 RETROSPECT

This section is presented in an effort to aid those persons planning future water development projects. What has happened during the course of this project is now history, and cannot be changed, however, the experience must serve as a guide to what could be in the future.

A prerequisite for project success is the ability of those responsible for implemention to have the authority necessary to exercise control over all aspects of the project. When this function is divided, the chances of success in the project are greatly reduced. In the following sections, those aspects of the project that were affected by this lack of control are discussed.

8.1 Project Objectives

In retrospect the project was over ambitious in design. Greater successes may have been realized if the various components of the project were segregated. This would have likely resulted in slightly higher costs, but would have been more effective. The three components could have been institutional support, training, and exploration and development drilling.

Institutional support would have been more effective if counterparts were provided from the Deputy General Managers level on down to the director of drilling operations. These individuals should have shared offices with respective counterparts, and dealt with day to day operations of the over all project. This would have been especially effective in the accounting department.

Training was relatively successful, but would have been more effective with professional trainers. U.S. drillers are highly qualified in the work they do, but they are not professional trainers. This applies in all vocational disciplines, such as mechanics, pump installers, and civil constructors. The technical level disciplines were more adaptable to training by professionals in the respective disciplines.

Exploration and development work was fairly successful, but could have shown greater success if conducted as a turnkey project. This is not to say that some OJT could not have been combined with this effort, but it should have been under the control of the contractor.

8.2 Personnel Management

All members of the consultant's staff expressed the same feeling with regard to personnel - frustration at the lack of control experienced from not being able to hire and fire. On numerous occasions, certain individuals were reported to be not performing adequately, but were allowed to remain on the job, ostensibly because of the inability to find replacements.

The consultant was aware of the problems faced by WDA in not being able to offer adequate salaries to attract and retain competent staff. The consultant was also aware of the conflicts generated by paying higher salaries to those employed on the project. A serious question arises as to what is really demonstrated by a development project that pays staff more than they can expect to earn after the project is completed.

8.3 Supplies and Equipment

One of the difficulties in fulfilling the objectives of the project was the failure of appropriate supplies and equipment to be received in a timely manner. There are numerous reasons for this, not all of which are readily solvable. One potential solution to this problem is to have select members of the contractor's team mobilized in advance to procure equipment and to establish the infrastructure required to carryout the work. This team might consist of the project manager, and one or two key personnel of disciplines appropriate to the project being considered.

Means to reduce procurement time should also be sought. This might involve placing the consultant in direct contact with a procurement agent of the donor's choice. By reducing the number of people involved in procurement, the chances for error, as well as the times involved, are reduced. In addition, accountability for errors is more clearly defined. Fuel should also be under the control of the contractor or the donor. A reliable fuel procurement and distribution system is paramount to project efficiency.

8.4 Warehousing

As with procurement, warehouse space and warehouse procedures should be established prior to initiation of project activities, and should also be a task of the advance team. Attempting to establish a system when the project is already underway, leads to confusion and loss.

If accountability for supplies is placed with the contractor, then complete control over those supplies must also be given. It is virtually impossible to account for a warehouse of supplies and equipment where only token control is permitted.

8.5 Planning/Monitoring Evaluation

Key factors in the less than optimum success of the Planning Unit were the absence of qualified staff and the late establishment of the Unit. The objectives of planning, monitoring and evaluation were to track construction, and operation and maintenance of wells, and to monitor the impacts of the wells on village communities. Normal feedback of information on a day-to-day basis provided adequate monitoring of construction, and operation and maintenance activities. Monitoring the impacts of the wells on village communities, however, was handicapped by a shortage of qualified staff.

In retrospect, the Planning Unit should have been established at the beginning of the project rather than towards the end. All too often the Unit was regarded by WDA management as a resource for the project, rather than for WDA as a whole. As a result, the level of institutional support originally intended was not possible.

Site selection, with the exception of the hydrogeologic elements, was carried out by the BRADP and CRDP personnel. The establishment of a community participation program should be initiated and monitored by the Planning Unit as soon as possible after site selection has been made. This will be especially important if the WDA is to remain as the administrator of water resources in the country.

8.6 Well Site Selection

The selection of well sites must by necessity be a joint effort with the agency for whom the well is being drilled. Final approval of the site, however, must rest with the hydrogeology team selected for that purpose. Considerable time and expense was invested in sites which were known, on the basis of professional judgement, to be poor risk sites for drilling.

Acceptance of the well site by the village community should be insured prior to mobilization of equipment and personnel. The TVAPP process, described in Section 5 of the Phase One Final Report, should be implemented well in advance of the drilling team.

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