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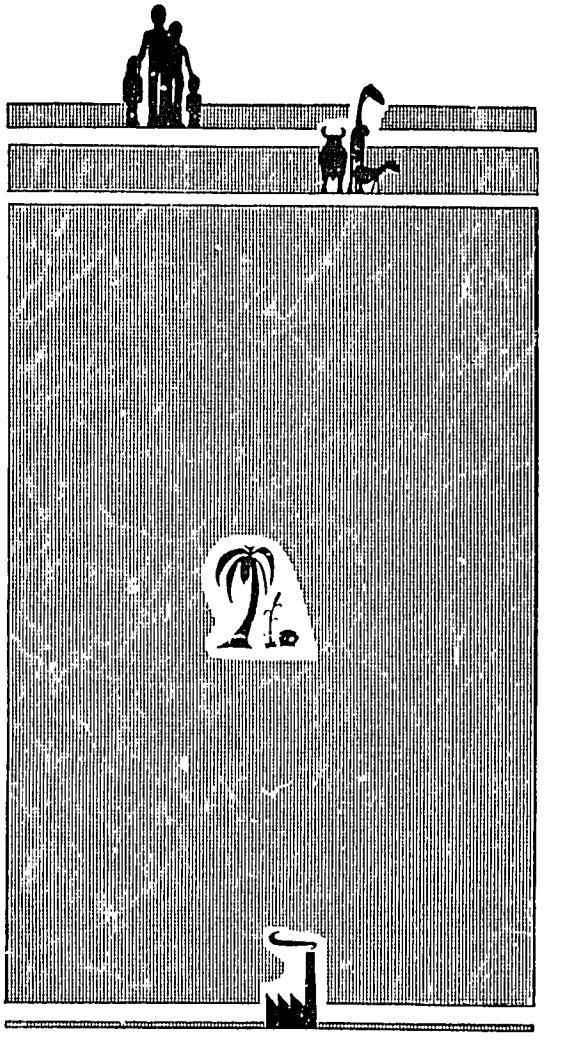
VOLUME I

STRUCTURE AND APPLICATIONS OF A WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

- 1984 Estimates
- 1990 Forecasts
- Constraint Analysis of National Water Supply Objectives



COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

SEPTEMBER, 1985

Louis Berger International, Inc.

Working File Copy

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MEMORANDUM

TO: Yussef Mohamed Elmi, WDA

FROM: Harvey Lerner, LBII

SUBJ: Water Resources Private Sector Study - Staff Working Paper on a Water Industry Systems Model for Somalia (WISyMS)

DATE: 12 September 1985

Attached is a copy of our Staff Working Paper on a Water Industry Systems Model for Somalia (WISyMS). This paper sets forth the data base used by LBII in the main body of the Study of Water Resource Development Industries in Somalia and in the Draft Executive Summary which you received in August.

This working paper provides documentation for the data base, and presents and explains the methodology used to:

1. Provide forecasts to 1990 of the water industry in Somalia;

2. Analyze national water supply objectives in light of resource constraints; and

3. Generate integrated estimates of the current water industry system in Somalia.

The paper has been submitted in advance of the series of seminars on the Study, scheduled to take place in October, in order for potential seminar participants to become familiar with data base generated by WISyMS. One of the seminars will focus primarily on WISyMS; other seminars will draw upon the data base generated by the model.

We also anticipate and welcome your comments (and those of your staff) on the model, and suggestions for refining or expanding it to better suit WDA's needs.

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

STUDY OF WATER RESOURCE DEVELOPMENT INDUSTRIES IN SOMALIA

STAFF WORKING PAPER

STRUCTURE AND APPLICATIONS OF A WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA (WISyMS)

- 1984 Estimates
- 1990 Forecasts
- Constraint Analysis of National Objectives

Prepared for:
The Water Development Agency
Somali Democratic Republic

Prepared by:
Louis Berger International, Inc.
September 10, 1985

Funded by:
United States Agency for
International Development

WATER RESOURCE DEVELOPMENT INDUSTRIES IN SOMALIA

STAFF WORKING PAPER

STRUCTURE AND APPLICATIONS OF A

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA (WISyMS)

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STAFF WORKING PAPER

STRUCTURE AND APPLICATIONS OF A WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA (WISyMS)

I. INTRODUCTION

This staff working paper sets forth the comprehensive data base used by Louis Berger International, Inc. (LBII) in its study of water resource development industries in Somalia. It also provides an explanation of and documentation for LBII's Water Industry Systems Model for Somalia (WISyMS) which was used to integrate available data, to make projections, and to perform other types of analysis.

In addition to presenting and providing documentation for a comprehensive data base, this working paper explains the methodology used to 1) provide forecasts for 1990 of the water industry in Somalia; 2) analyze national water supply objectives in light of resource constraints; and 3) generate integrated estimates of the characteristics of the water industry system in Somalia as it currently exists. Appendices present quantitative details.

This paper is composed of five sections and four appendices in addition to this introduction. Section II provides an overview of the Water Industry Systems Model for Somalia (WISyMS) and its uses. Section III provides an explanation of each of the three submodels of WISyMS. Section IV discusses the use of the model for the Consultant's 1990 forecasts. Section V discusses the use of the model for a constraint analysis of national water supply objectives. Section VI discusses LBII's methodology by which the model was used to generate 1984 integrated estimates of system parameters.

Definitions used in the model are contained in Appendix A; Appendix B presents the methodology and formulae employed by the model; Appendix C contains the detailed data generated by running the model under various assumptions; and Appendix D discusses the sources of data used in developing the model.

II. OVERVIEW OF THE STRUCTURE AND APPLICATIONS OF THE WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

The Water Industry Systems Model for Somalia, (WISyMS) has been designed to provide an integrated analysis of the relationships between water consumers, water supply structures, and inputs to the water industry. Exhibit 1 presents the symbols that will be used to represent the principal categories of water consumers throughout this paper in graphical explanations of the model. Exhibit 2 presents the symbols used to represent the water supply structures in Somalia considered in this report. Exhibit 3 presents the symbols used to represent the principal categories of inputs to the water industry in Somalia.

Water needs begin at the level of the consumer. The need for water leads to a need for water supply structures to serve the consumers' water needs efficiently. New wells must be drilled and new water supply structures must be constructed each year, and this drilling and construction activity in turn gives rise to a need for inputs of capital, labor, and materials. The physical flows, of course, move in the opposite direction: inputs (Level III) are supplied to serve drilling and construction activity (Level II); water supply structures provide water to consumers (Level I) (see Exhibit 4). Each of the three industry levels, and the submodels of WISyMS which analyze them, are explained below.

The Water Industry Systems Model for Somalia (WISyMS) serves the three basic functions of forecasting, constraint analysis, and integrated estimation. It is made up of three related sub-models which correspond to the three basic levels of the water industry structure in Somalia: Level I - water supply, Level II - well drilling and construction of water supply facilities, and Level III - provision of water industry inputs (See Exhibit 5).

A. THE LEVEL I SUBMODEL: WATER SUPPLY

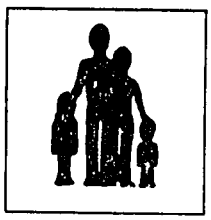
Level I, water supply, is the business or economic activity of providing water to consumers. Water supply "activities" include water resource ownership, operation and maintenance of physical water supplies, and revenue collection. The Level I submodel analyses water consumption requirements in a given year and translates these into the required complement of water supply structures that need to be in place in that year. Characteristics of the submodel are described below:

- **Purposes:** Forecasts the effects of changes in population and water consumption on the magnitudes of Level I water supply activities; projects the total complement of water supply structures that will be owned, operated and maintained by the public and private sectors in Somalia.

EXHIBIT 1

PRINCIPAL CATEGORIES OF CONSUMERS OF WATER

HUMANS

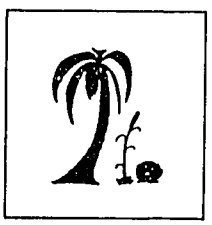


-URBAN
-RURAL SETTLED
-NOMADIC

ANIMALS

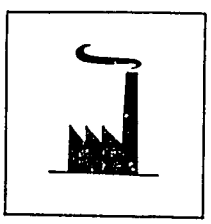
-CAMELS
-CATTLE
-SHEEP/GOATS
-OTHER

AGRICULTURE



-IRRIGATION FARMS
-RAIN FED FARMS
-FLOOD FED FARMS

GOVERNMENT/
INDUSTRY

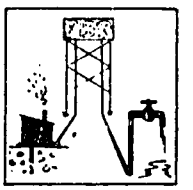


-GOVERNMENT
-INDUSTRY

EXHIBIT 2

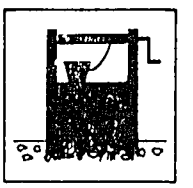
PRINCIPAL WATER SUPPLY STRUCTURES

DRILLED WELLS



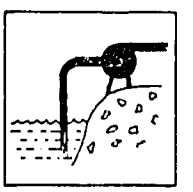
ALL WELLS DRILLED MECHANICALLY, EQUIPPED WITH DIESEL OR HAND PUMP

HAND DUG WELLS



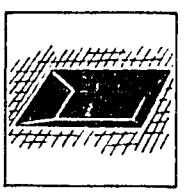
ALL WELLS DUG BY HAND, REGARDLESS OF DEPTH

INTAKES FROM RIVERS/STREAMS/ SPRINGS



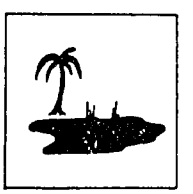
CONSISTING OF PIPES IMMERSED INTO WATER AND CONNECTED TO A DIESEL PUMP

UARS/ RESERVOIRS



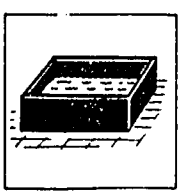
RESERVOIRS DUG IN RELATIVELY IMPERMEABLE GROUND TO CATCH RAIN-WATER AND SURFACE RUN-OFF

BALLEHS



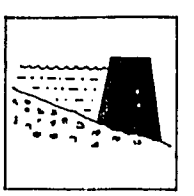
PONDS OR NATURAL DEPRESSIONS WHICH CATCH AND HOLD RAIN-WATER AND SURFACE RUN-OFF

BURKEDS/ CISTERNS



IN-GROUND MASONRY CIS-TERNS WHICH SERVE AS WATER STORAGE TANKS OR WHICH CATCH RAINWATER AND SURFACE RUN-OFF

DAMS/ DIVERSIONS

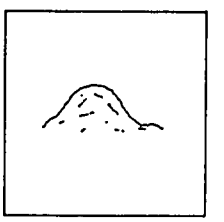


MAN-MADE STRUCTURES TO DIVERT OR HOLD BACK THE NATURAL FLOW OF A RIVER, STREAM, OR TUG

EXHIBIT 3

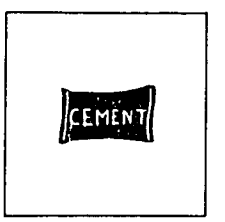
PRINCIPAL CATEGORIES OF INPUTS TO THE WATER INDUSTRY

RAW MATERIALS



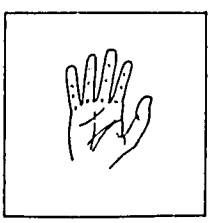
- SAND
- GRAVEL
- STONES
- OTHER

MANUFACTURED MATERIALS



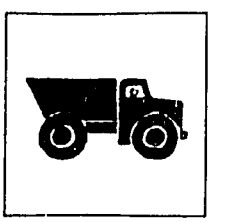
- CEMENT
- STEEL CASING
- STEEL SCREEN
- OTHER

LABOR



- SKILLED
- UNSKILLED

EQUIPMENT



- DRILL RIGS
- PUMP RIGS
- VEHICLES
- OTHER

EXHIBIT 4

OVERVIEW OF RELATIONSHIPS AMONG LEVELS OF THE WATER INDUSTRY

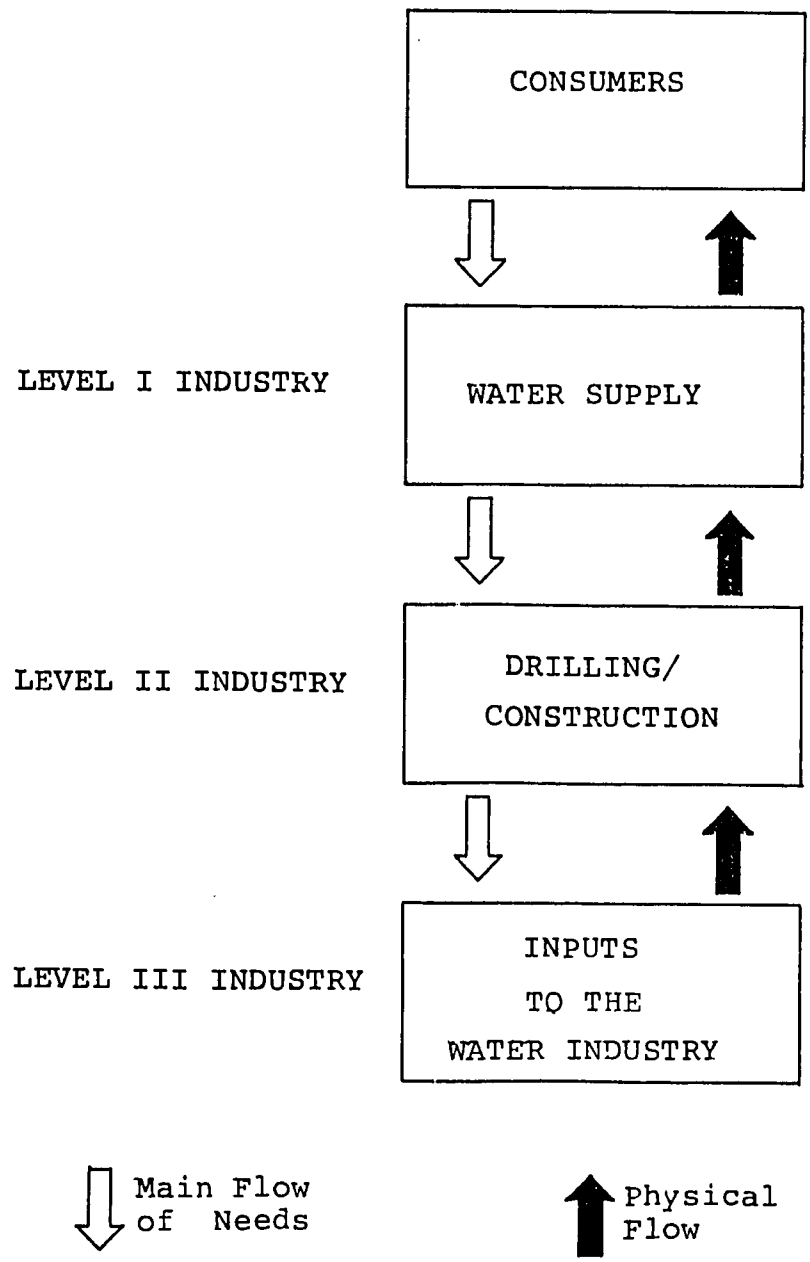


EXHIBIT 5

FUNCTIONS OF THE WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

	FORECASTING	CONSTRAINT ANALYSIS	INTEGRATED ESTIMATION
LEVEL I SUBMODEL Water Supply	✓	✓	✓
LEVEL II SUBMODEL Drilling/ Construction	✓	✓	✓
LEVEL III SUBMODEL Inputs to the Water Industry	✓	✓	✓

- **Data Inputs:** demographic data, water consumption data, data on agricultural, livestock, and industrial activity including water use, data on historical patterns of water use and reliance on water supply structures.

- **Data Outputs:** requirements for volumes of water to be provided by each type of water supply structure and associated total numbers of each type of water supply structure needed to provide that water in a given year.

- **Principal Uses of Data Outputs:** planning for water system capacity; analysis of public/private roles in water supply; data input for the Level II submodel. The Level I "activities" of water resource ownership, operation, maintenance, and revenue collection, including an analysis of market shares for the local public and private sectors and the foreign import sector, are discussed elsewhere in the main body of the report.

B. THE LEVEL II SUBMODEL: WELL DRILLING AND CONSTRUCTION OF WATER SUPPLY FACILITIES

Level II is the drilling of wells and construction of related civil works structures, and the planning, design, and administration of drilling and construction. The Level II submodel translates the annual needed stock of water supply structures into annual drilling and construction requirements, taking into account both the need for replacement of old, failing structures and the need for net addition to structural capacity. Elements of the Level II submodel are described below:

- **Purposes:** to forecast the effects of changes in water consumption on Level II requirements (well drilling and construction of other water supply facilities.)

- **Data Inputs:** Total numbers of each type of water supply structure needed to provide the water requirements for a given year (data output from the Level I Submodel).

- **Data Outputs:** Numbers of new water supply structures needed to be constructed both to replace old, failing structures and to provide for net increases in water consumption for a given year.

- **Principal Uses of Data Outputs:** A Level II market study identifying needs for water supply drilling and construction activity; data for Level III Submodel. An analysis of the market shares for Level II activity in Somalia is presented elsehwere in the main body of the report.

C. THE LEVEL III SUBMODEL: WATER INDUSTRY INPUTS

Level III is the production or provision of manufactured and raw material inputs, equipment, labor, and fuel for water supply, well drilling, and water supply construction activities. The Level III submodel translates Level II construction requirements into needed inputs for a given year. Elements of the submodel are described below:

- **Purposes:** Forecasts the effects of changes in needed water system capacity on Level III requirements (water industry inputs.)

- **Data Inputs:** Requirements for needed new drilling and construction (output from Level II Submodel).

- **Data Outputs:** Annual required quantities of raw material and manufactured material inputs, as well as labor and equipment inputs to the water industry for a given year.

- **Principal Uses for Data Outputs:** Level III market study identifying needs for expansion of facilities or new ventures which could supply inputs to the water industry; measuring the economic impacts of increased activity in the industry. An analysis of the market shares for Level III activity in Somalia is presented elsewhere in the main body of the report.

D. TYPES OF ANALYSES PERFORMED WITH WISyMS

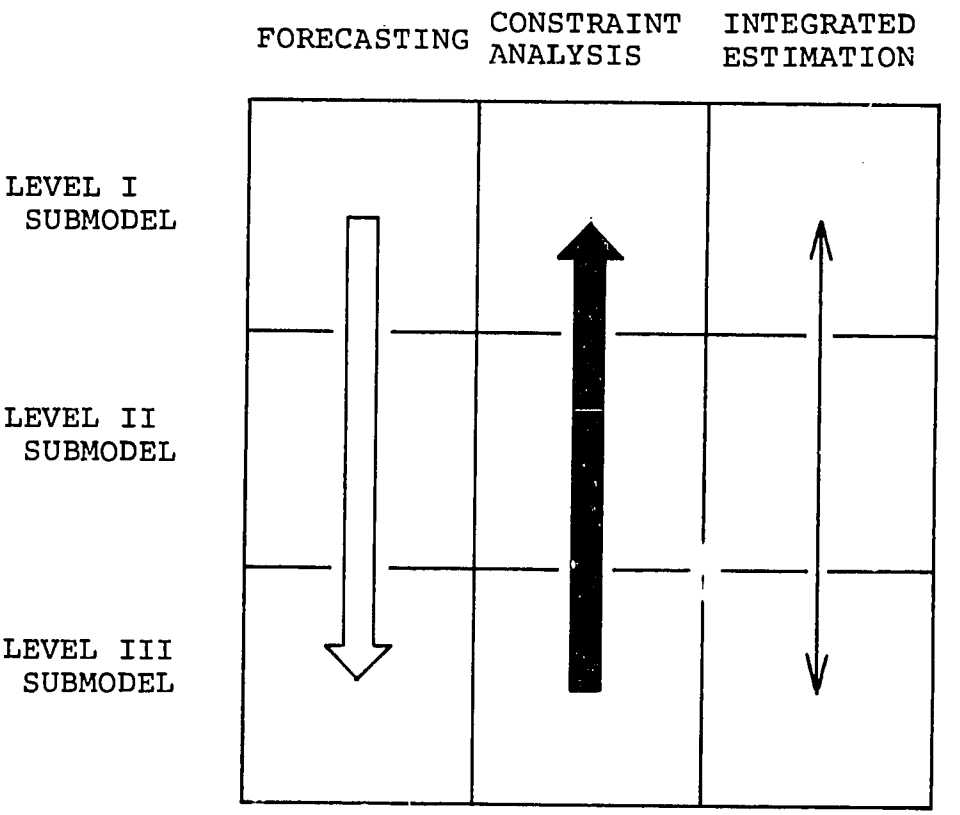
Three types of analyses can be performed using WISyMS: forecasting, constraint analysis, and integrated estimation. Exhibit 6 shows the direction of analysis among the three sub-models, depending on the purpose for which the model is used.

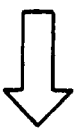
1. Forecasting

If used for forecasting, the analysis follows the flow of needs. First, demographic and economic data are gathered and used to forecast Level I demand for water for a given year and an associated stock of supply structures. This stock of structures is used to calculate Level II demand for the flow of drilling and construction activity needed to expand the existing stock. The flow of new drilling/construction activity in turn is used to calculate Level III input requirements. This forecasting procedure is explained in greater detail in Section IV of this paper. Appendix C contains the Consultant's 1990 forecasts generated by running WISyMS.

EXHIBIT 6

THE DIRECTION OF ANALYSIS IN WISyMS





Main Flow of Needs

Physical Flow

2. Constraint Analysis

Constraint analysis, on the other hand, is used most often to evaluate the realism of proposed goals, programs, or large projects. It asks the question: "Are there bottlenecks, resource shortages, or other constraints in the system which will prevent the attainment of stated objectives?" Constraint analysis proceeds by making forecasts over the relevant time period, including key assumptions of the program. The model is run first as a forecast, and the implications in terms of drilling/construction requirements are compared with resource availability. The major constraints are identified, and these constraints impose restrictions on the degree to which desired goals can be achieved: the availability of inputs constrains the numbers and types of structures that can be produced in a given time frame, and this in turn constrains the amounts of, say, groundwater resources that can be made available for use in the nation. The crucial part of the analysis starts at Level III and works back toward Level I. This type of analysis is examined in more detail in Section V, as part of the Consultant's constraint analysis of national water supply objectives in Somalia.

3. Integrated Estimation

Integrated estimation of system parameters, as presented in the Consultant's baseline (1984) estimates for the water industry system in Somalia (see Appendix C), is actually the first step involved in building the model. It seeks to identify the historical patterns of water consumption and reliance on water supply structures.

The most readily available information includes some demographic data and inventories/estimates of the stock of existing water supply structures in Somalia. Other data can be generated through the Delphi Method, whereby a consensus on a variable is established on the basis of opinions supplied by a variety of informed sources; and by eclectic methods which combine, sift, weight, average, and then incorporate estimates in the framework of the model. Further, reasoned analyses of broad behavioral patterns (e.g., seasonal reliance on surface water resources) and technical constraints (e.g., on volumes of water output per structure) are incorporated in the model. Together, available data, estimates, and logical reasoning can be used to infer the parameters of key relationships between water consumption and water provision, as well as to infer logical estimates for variables on which we lack reliable data. Thus, the analysis for integrated estimation of system parameters proceeds in both directions among the submodels. This type of analysis is explained in more detail in Section VI.

The overview of WISyMS provided above is expanded in Section III to describe the workings of each of the three submodels. Detailed explanations of the procedures followed for forecasting, constraint analysis and integrated estimation, including examples of WISyMS' data output, are presented respectively in Section IV, V, and VI.

III. EXPLANATION OF THE WISyMS SUBMODELS

This section explains how each of the three submodels of WISyMS works and how they fit together. A detailed methodology is presented in Appendix B.

A. WISyMS LEVEL I SUBMODEL WATER SUPPLY - WATER SUPPLY: An Integrated Analysis of Water Consumption and Delivery Systems (Exhibit 7).

This submodel analyzes water flow requirements in a given year, as determined by demographic, economic, and water consumption data, and translates these into the required complement or stock of water supply structures that need to be in place in that year. Actual data are presented in Appendix C; notes and sources are discussed in Appendix D.

There are four basic types of consumption examined in the model*:

- **Human** consumption of water for drinking, cooking, washing and cleaning;
- **Livestock** consumption of water primarily for drinking;
- **Agricultural Crops** consumption of water for crop production; and
- **Government and Industrial** consumption of water for all purposes.

Specific numbers for each type of consumption unit are estimated: human populations, livestock populations, hectares under cultivation, and numbers of government institutions and industrial or commercial establishments.

Next, per unit consumption factors are estimated for each type of consumption unit: for humans - average annual water consumption per capita; for livestock - average annual water consumption per head; for agriculture - average annual water consumption per hectare; and for government and industry - average annual water consumption per institution, office, or establishment.

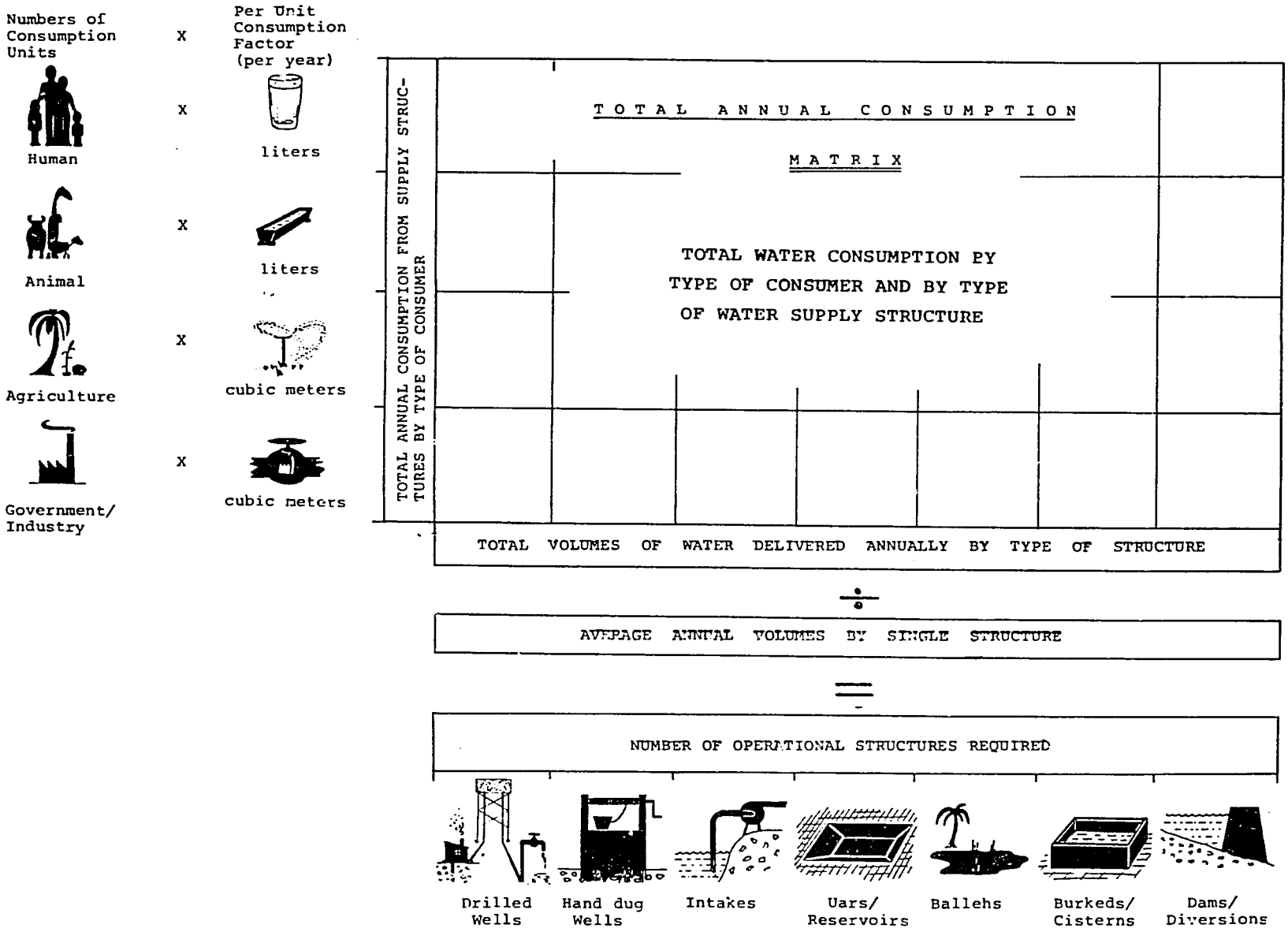
Multiplying numbers of consumption units (in each category) with the associated average per-unit consumption factor yields total estimated volume of consumption by type of consumption. The model focuses on water consumed through the use of man-made supply systems, as opposed to water consumed directly from nature.

* Detailed definitions are provided in Appendix A.

EXHIBIT 7

LEVEL I SUBMODEL

Integrated Analysis of Water Consumers and Delivery Systems



The next step is to analyze historical patterns of reliance, (for each type of consumption) on each type of man-made water supply structure:

- **Drilled Wells** - deep wells drilled by heavy equipment, specifically drill rigs;
- **Hand Dug Wells** - shallow wells dug with the use of hand tools;
- **Intakes from Rivers** - pumps delivering water from rivers for various purposes;
- **Uars** - man-made reservoirs dug or excavated in relatively impermeable ground to hold rainwater;
- **Ballehs** - natural ponds or depression which collect rainwater and are often deliberately enlarged;
- **Burkeds** - masonry cistens for holding rainwater;
- **Dams/Diversions** - structures to hold back or divert the flow of permanent or seasonal rivers.*

The model uses estimates of the historical percentage distribution of reliance, for each type of consumption, on each type of supply structure, and uses this to create a matrix of water consumption calculating the volume of water consumed for each type of consumption from each type of supply structure. This is shown in the rows of the matrix in Exhibit 7. Summing down each of the columns yields:

- **Structural Supply Volumes:** the total volume of water estimated to be supplied annually by each type of supply structure.

At this point, we have specific estimates of the annual flow requirements for water consumption. The next step is to translate water flow requirements into associated stock requirements for structures. To do this, the Structural Control Totals are divided by:

- **Output per Structure per Year:** estimated average annual volume of output per structure for each type of supply structure.

This yields specific requirements for total stock levels for each type of water supply structure, presented as:

- **Total Numbers of Water Supply Structures** needed to provide the amounts of water indicated in the calculation of the structural supply volumes, above.

* These structures are defined in more detail in Appendix A.

These stock totals are used in the second component of WISyMS, the Level II Submodel, to calculate the flow of annual construction requirements, as described below. This data output can also be used by planners at WDA to (a) forecast water consumption needs based on demographic trends or (b) to analyze objectives in terms of increased total consumption or increased use of particular types of structures.

B. WISyMS LEVEL II SUBMODEL - DRILLING AND CONSTRUCTION: Quantification of flow requirements for new water supply structures for replacement and expansion of existing capacity (Exhibit 8).

The Level II Submodel starts with the bottom line of the Level I Submodel: the total numbers of water supply structures needed to provide the amounts of water indicated in the calculation of the structural supply volumes. Each type of supply structure is examined separately in the manner outlined below.

For each type of supply structure, we have:

- **Total Numbers of Water Supply Structures** needed to provide the amounts of water indicated in the calculation of the structure supply volumes.

This is compared with:

- **Old Structures:** excising capacity on hand in a given year, which will be subject to a certain expected rate of deterioration/failure during the year.

Subtracting the numbers of old structures from the total numbers of needed water supply structures in a given year then yields:

- **Numbers of New Water Supply Structures** needed to be constructed to:

  a) replace old structures expected to fail during the course of the year, plus

  b) provide for expected net increases in consumption from all sources.

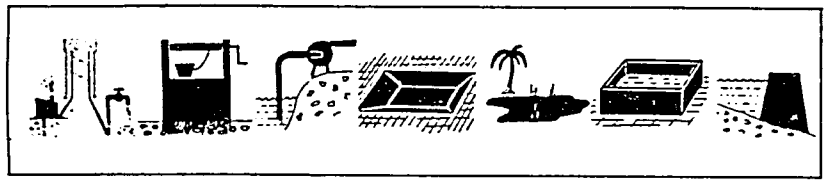
These numbers are used in the final component of WISyMS, the Inter-Industry Component, to calculate the input requirements for the water industry for a given year. These numbers can also be used for a market study for drilling and construction services.

EXHIBIT 8

LEVEL II SUBMODEL

Quantification of Requirements for New Water Supply Structures
for Replacement and for Expansion of Existing Supply Capacity

Total Stock at Beginning of Year 1

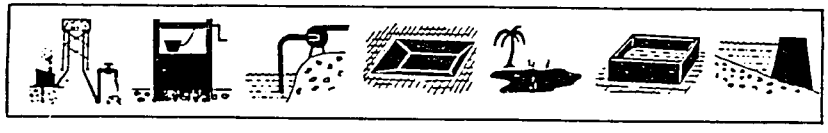


MINUS

Closure During Year 1

=

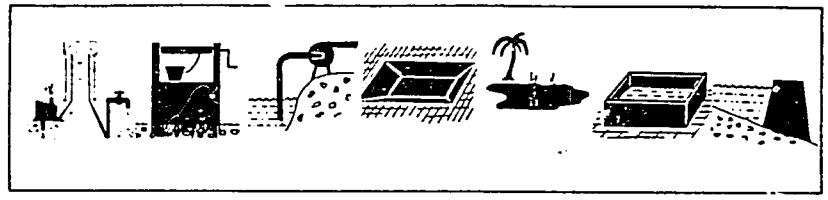
Remaining at End of Year 1



+%

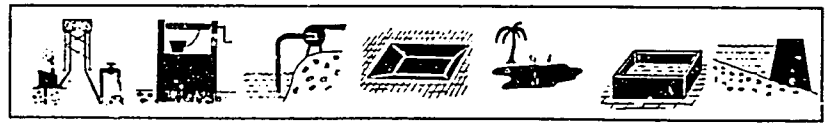
EXPANSION

Total Needed Stock Year 2



MINUS

Stock at Beginning of Year 2



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NEEDED NEW STRUCTURES IN YEAR 2

C. WISyMS LEVEL III SUBMODEL - WATER INDUSTRY INPUTS: Quantification of Inputs Required for Expansion of Water Supply Capacity. (Exhibit 9)

The top row of Exhibit 9 corresponds to the bottom line for each type of supply structure analyzed in the Level II submodel. The left hand column of Exhibit 9 lists the types of inputs required to construct each type of water supply structure. These include:

- **Raw Materials** such as sand, gravel, and stone;
- **Manufactured Inputs** such as well casing and screen, pumps, cement, reinforcement steel, plastic and iron fixtures, etc.
- **Labor Inputs** required in the construction processes; and
- **Equipment Inputs** required in the construction processes.

For each type of structure, there are technical input coefficients for production, rehabilitation, and maintenance which are used to calculate the specific physical quantities of each type of input required, based on current technology and practices. These are presented in terms of, e.g., cubic meters of cement, meters of well casing, man-days of masonry labor, or equipment days of bull-dozer utilization for the construction of one structure. These per-structure input requirements are multiplied by the numbers of each type of structure to be produced in a given year to yield total physical requirements for each type of input, for each type of structure. These can be assumed across each row to yield:

- **Total Input Requirements** for each type of input for all types of structures.

This forms an annual bill of materials of key inputs to the water industry. These numbers can be used for market studies for the various types of inputs to the water industry, although some of the inputs used in the water industry (such as reinforcement steel) are used much more heavily in other industries (such as basic construction), so that quantities used for the water industry form an insignificant portion of total demand for that input. A similar analytical procedure can, however, be applied to these industries as well.

Note that at present, the model considers only those water supply facilities which take water directly from natural sources. Municipal water distribution systems, irrigation systems, and water transport have not been examined, although they could be incorporated into the model in the future. In addition, future versions of the Level III submodel could analyze the input requirements for the Level I activities of water facility operation and revenue collection as well as maintenance.

EXHIBIT 9

LEVEL III SUBMODEL

Quantification of Inputs Required for Expansion of Total Capacity of Supply

NUMBERS OF NEEDED NEW WATER SUPPLY STRUCTURES

RAW MATERIALS							
MANUFACTURED INPUTS							
LABOR							
EQUIPMENT							

TOTAL INPUT REQUIREMENTS

RAW MATERIALS

MANUFACTURED INPUTS

LABOR

EQUIPMENT

+

In summary, the three submodels of WISyMS work together to illustrate the relationships between the most important variables of the water system. The practical applications of the model are discussed in the following sections.

IV. 1990 FORECASTS

LBII'S Water Industry Systems Model for Somalia has been designed to facilitate practical applications for a range of forecasting needs. This section explains WISyMS forecasting features and procedures and presents 1990 forecast data generated by the model.

A. FORECASTING FEATURES

Although the parameters of the model were estimated on the basis of information on historical patterns of water use and relationships between types of consumption and types of structures, WISyMS has been designed to facilitate parameter adjustments based on changes in data or assumptions including the following:

- Expected demographic or economic trends affecting water use patterns;
- Expected technological advancements affecting the performance of the physical water supply system;
- Expected technological advancements affecting the technical input co-efficients for drilling and construction;
- Proposed policy changes expected to affect water use patterns; and/or
- New information or data.

B. FORECASTING PROCEDURES

The procedures involved in each of the above listed WISyMS forecasting features is described below.

1. Expected Demographic or Economic Trends

Demographic and economic trends are the most obvious influences on total water consumption needs and associated requirements for supply system capacity and system inputs. Starting from any assumed baseline data on, e.g., human and livestock population, estimates of annual growth rates for these categories (or sub-categories), can be used to project population levels for future years. The model then translates these projected population figures into requirements for water consumption and associated requirements for supply system capacity and industry inputs.

Assumptions on e.g., growth in per capita water consumption and trends in patterns of reliance on different types of supply structures (such as wells vs surface catchments) can be similarly incorporated into the model's projections for a given year and translated into estimates of requirements for water, supply system capacity and industry inputs.

Actual 1990 forecast data generated by WISyMS and a discussion of the major assumptions involved are presented below in Section IV C.

2. Technological Advancements in Supply System Performance

The effects of technological advancements in supply system performance on the basic relationships analyzed in the WSyMS can be incorporated in parameter changes in the model. For instance, an improvement in maintenance and rehabilitation capabilities in the country can extend the useful life of supply structures and correspondingly reduce the need for new construction for replacement purposes. This can be translated into changes in the need for inputs - more inputs going into maintenance and rehabilitation and fewer inputs required for new construction.

3. Technological Advancements in Construction

Changes in drilling and construction procedures will affect the technical input co-efficients for specific water supply structures and will therefore affect the total quantities of associated inputs required to support drilling/construction. For example, over time, it can be expected that drilling/construction procedures will become gradually more capital intensive. This would tend to decrease the per-unit labor input requirements and increase the per-unit equipment and fuel requirements and thus alter the expected annual totals of employment and equipment units needed by the industry as a whole.

4. Future Policy, Program and Project Changes

The effects of possible future changes in government policies on various aspects of water use can be analyzed by WISyMS. For example, a change in the price of groundwater sold to the public relative to the price of surface water can be assumed to alter the pattern of reliance on groundwater vs. surface water sources of supply. This can be translated by the model into estimates of requirements for specific types of supply systems and related industry inputs. This element is examined in more detail in Section V, "Constraint Analysis".

5. New Information or Data:

As the relevant data base for use in WISyMS improves, adjustments can be made to any of the variables or parameters used in the model, and these adjustments will be translated into associated changes in downstream variables. For instance, if new data is available on the numbers of industrial establishments in the country, this adjustment may affect the total volume of water estimated to be consumed by industrial sources, which will in turn affect the estimates of the numbers of required supply structures, the numbers of new supply structures needed, and the quantities of each of the inputs involved. This element is discussed in greater detail in Section VI, "1984 Integrated Estimates".

C. 1990 FORECASTS

Exhibit 10 presents the key data generated by the Level I submodel (Water Supply) for the 1990 projections. The data incorporates official estimates of population and herd growth, urbanization trends, and increases in agricultural and industrial activity. The consultant made other additional assumptions, (e.g. that per capita human water consumption would exhibit a growth rate in the range of 6 - 13% per anum) and incorporated those into the model as well. Exhibit 11, which is drawn from the "Structural Control Volumes" column of Exhibit 10, provides a graphic representation of the distribution of water by type of consumer. Exhibit 12, which is drawn from the "Structural Supply Volumes", of Exhibit 10, shows the distribution of water by type of structure. A detailed presentation of the data is contained in Appendix C; notes and sources for the data are discussed in Appendix D.

Exhibit 13 presents the key data generated by the Level II submodel (drilling, construction and maintenance activities) for the 1990 projections. For each type of structure, the first row shows the stock of structures expected to be in place in a given year. The second row shows the existing stock of old structures available taking into account the rate of failure of each type of structure. The third row shows the numbers of new structures which need to be constructed in a given year to make up the difference between the needed stock of structures (including net expansion of capacity) and the existing stock of old structures (taking into account their rate of failure). A more detailed presentation of the data is contained in Appendix C.

Exhibit 14 presents the data generated by the Level III submodel (inputs to the water industry) for the 1990 projections. The top row shows the numbers of new structures which need to be constructed in the year 1990, and the fourth row shows the maintenance requirements for the stock of structures in the year 1990. The left hand column lists the major inputs required for all types of drilling, construction, maintenance, and rehabilitation while the far right hand column shows the total

EXHIBIT 10

Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN										
Urban	1741	persons	20300	15225	2030	2030	406	0	609	0
Rural Set	1853	persons	9638	1928	4337	1446	482	193	1253	0
Nomadic	2757	persons	9057	1359	3170	1811	906	906	906	0
SUBTOTAL1	6351	persons	38995	18511	9537	5287	1794	1098	2768	0
ANIMAL										
Camels	5308	Animals	31483	3148	6297	6297	6297	7871	1574	0
Cattle	4246	Animals	30996	4649	10849	4649	6199	3100	1550	0
SheepGoats	28661	Animals	23538	2354	8238	4001	3531	3766	1648	0
OtherAnim	10615	Animals	581	46	174	99	116	116	29	0
SUBTOTAL2	12292	LSU	86598	10198	25558	15046	16143	14853	4801	0
AGRICULTURE										
Irrigfarm	64	Hectares	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.										
Govt.	2	Estabs	7800	7176	390	234	0	0	0	0
Industry	.73	Estabs	1752	1524	175	53	0	0	0	0
SUBTOTAL4			9552	8700	565	287	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)			1560134	77916	49162	1235807	31438	29453	7568	128789
COMMERCIAL SCALE STRUCTURES				996	4634	6180	953	230	14166	156

EXHIBIT 11

1990 FORECASTS OF DISTRIBUTION OF
WATER FROM SUPPLY STRUCTURES BY TYPE OF CONSUMER

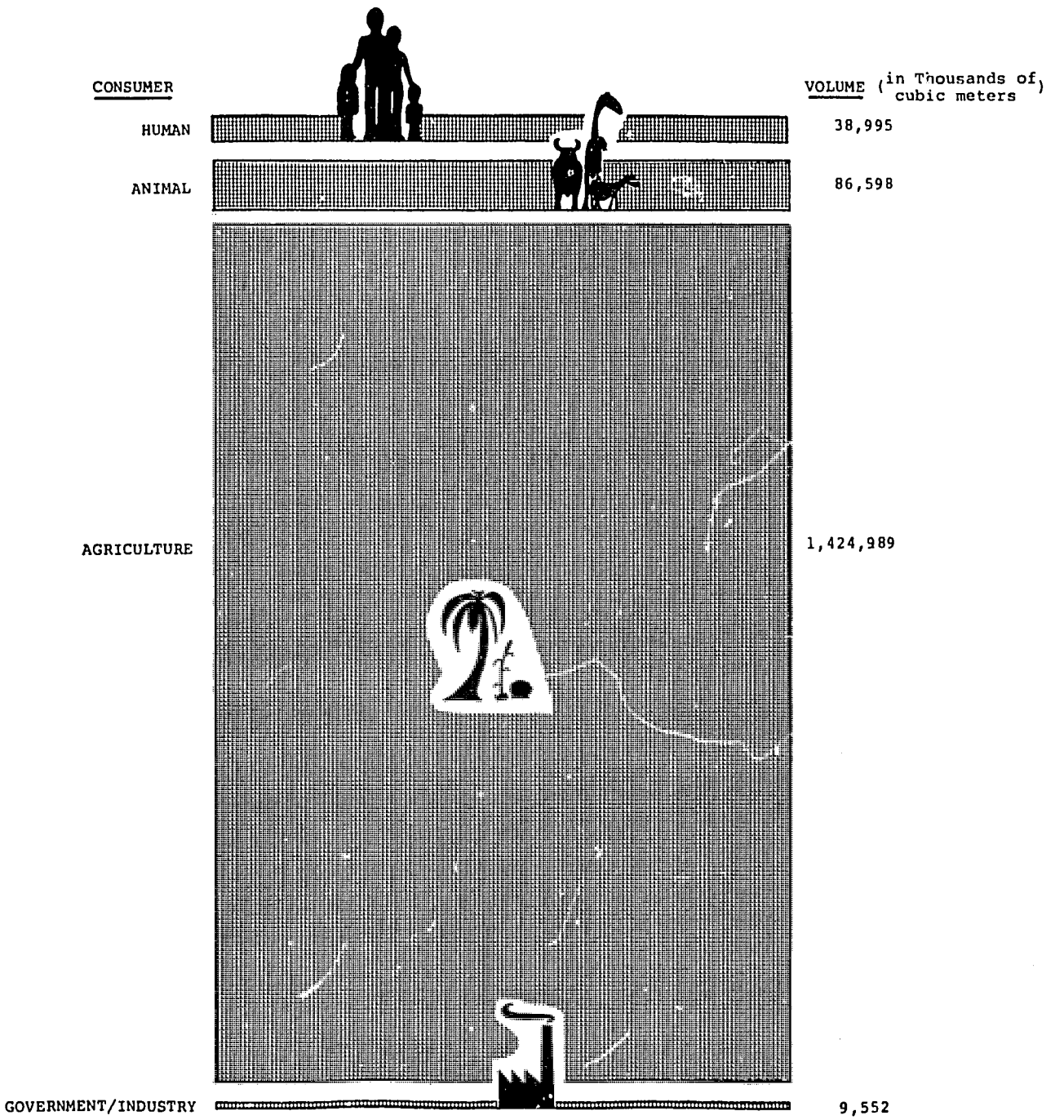

EXHIBIT 12

1990 FORECASTS OF DISTRIBUTION OF WATER BY TYPE OF SUPPLY STRUCTURE

Total 1,560,134 (in Thousands of Cubic Meters)

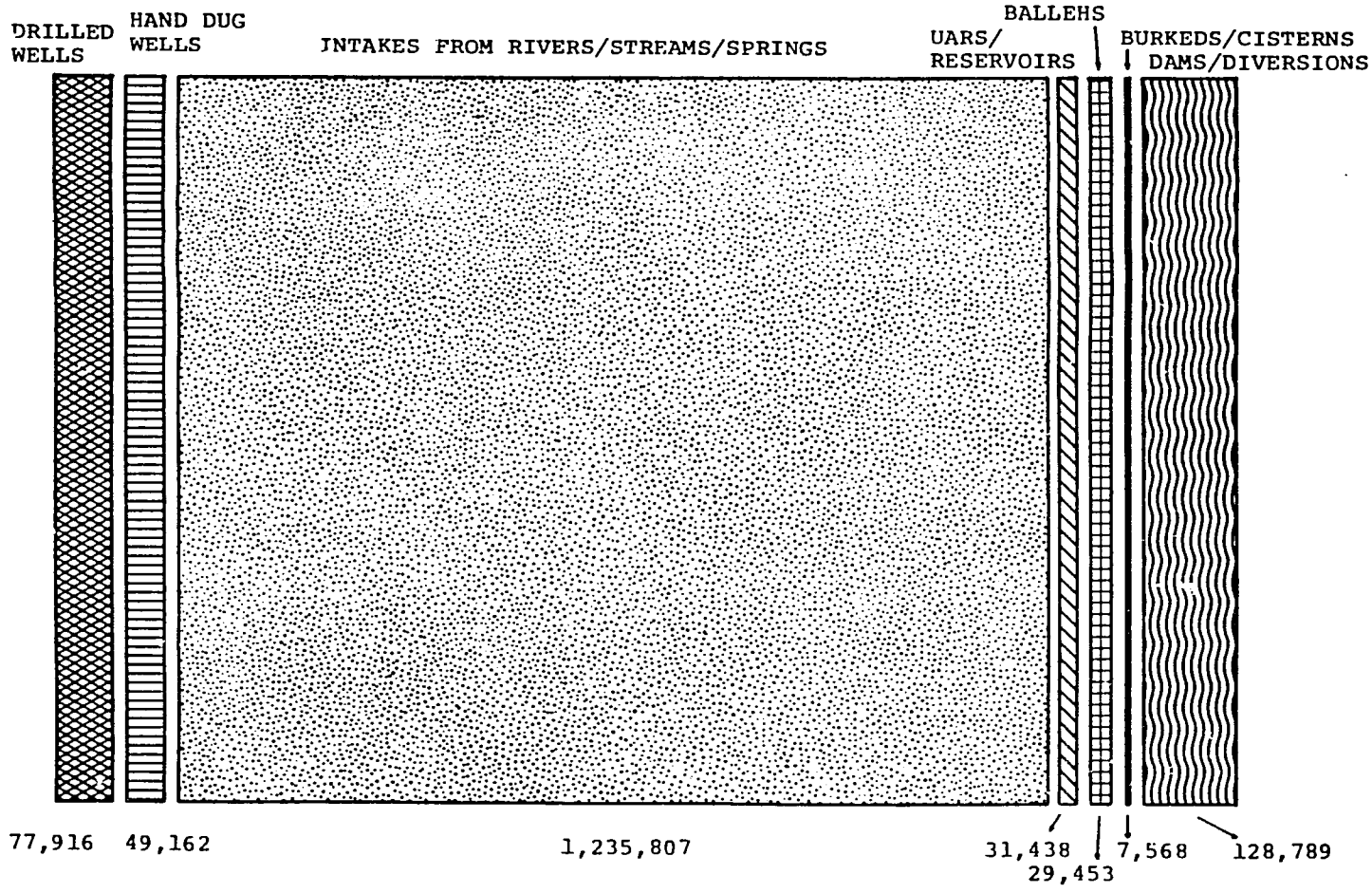

EXHIBIT 13

Projections of Requirements for New Water Supply Structures for 1985 - 1990

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	653	710	773	841	915	996
Old Wells	325	334	386	454	501	537	583	633	687	746	811
Needed New Wells	41	89	113	102	99	116	127	140	154	169	185
DUG WELLS											
Needed Total Dug Wells					2500	2771	3071	3404	3772	4181	4634
Old Dug Wells					2250	2275	2521	2774	3059	3377	3731
Needed New Dug Wells					250	496	550	630	714	805	903
INTAKES											
Needed Total Intakes					5000	5180	5366	5559	5759	5966	6180
Old Intakes					4500	4550	4680	4808	4943	5084	5232
Needed New Intakes					500	630	686	751	816	881	948
UARS											
Needed Total Uars					750	781	812	845	880	916	953
Old Uars					675	683	706	728	752	778	804
Needed New Uars					75	98	107	117	128	138	149
BALLEHS											
Needed Total Ballehs					200	205	210	214	220	225	230
Old Ballehs					180	182	185	187	190	193	196
Needed New Ballehs					20	23	25	27	29	31	34
BURKEDS											
Needed Total Burkeds					10000	10598	11231	11902	12613	13367	14166
Old Burkeds					9333	9378	9931	10486	11079	11709	12379
Needed New Burkeds					667	1220	1300	1416	1535	1658	1787
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	84	88	92	97	102	124
Needed New Dams					20	24	28	33	38	43	32

EXHIBIT 14

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL III SUBMODEL

(Please Turn Over)

WATER SYSTEM MATRIX:MIDDLE LEVEL
1990 PROJECTIONS

INPUTS	OUTPUTS Measure	CONSTRUCTION: WELLS H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES: Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION: WELLS HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	111	74	903	56	948	149	34	1787	32											
UL	Years	15	15	10		10	10	5	15	5											
MP	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											324	1622	3731	10464	804	196	12380	124		
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	777	14800	6321	280	3792	0	0	5361	0	31331	226.8	9732	2611.7		0	321.6	0	0	0	12892.	44223.1
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7	
Annual stones	cubic meters			14448		9480	0	0	12509	20480	56917			5969.6		0	804	0	0	86.8	6860.4	63777.4
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	555	2590								3145	162	1703.1								1866.6	5011.65
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	222	8880	1806					3574	0	14482	64.8	5839.2						0	24.8	5928.8	20410.8
8" Steel Casing per st	meters	75	75																		
Ann.8"Steel Casing	meters	8325	5550								13875										0	13875
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	4995	3330								8325										0	8325
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	666	444		0						1110										0	1110
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	22.2	74	90.3					893.5		1080										0	1080
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	14800	0		14220			17870		46890	0	9732	0		0			0		9740.5	56630.5
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	2775	1850		280						4905	0	0								0	4905
Hand Pump per st	units	1		0.2								0.2		0.4							
Annual Hand Pumps	units	111		180.6							291.6	64.8		1492.4							1557.8	1849.4
Diesel Pump per st	units		1			1							0.04			0.2					
Annual Diesel Pumps	units		74			948					1022		64.88			2092.8					2157.6	3179.68
Rebars & wood per st	meters		30						20										3		
Annual Rebars&wood	meters		2220						35740		37960								37140		37140	75100
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						28459	10000			38459						25400				25400	67859

LABOR

Skilled:

Drilling per St.	men-days	28	28	19								0	0										
Annual Drilling	men-days	3108	2072	1064							6244	0	0									0	6244
Excavation per st.	men-days			6.4			10	10	30	30							3	9					
Annual Excav.Wrks	men-days			5779.2			1490	340	53610	960	62179.2						2412	1764				4188	66367.2
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5			
Annual Civil Wrks.	men-days	1998	2664	4515	1137.6	74.5	51	26805	960	38205.1		583.2	1751.7	1865.5		0		9.8	1857	186		6253.2	44458.3
Mech.Wrks per st.	men-days	3	10	0.6	5			3				9.6	0.6	0.12	0	0							
Ann.Mechanic Wrks.	men-days	333	740	541.8	4740			5361			11715.8	194.4	973.2	147.72		0						1615.3	13331.1
Carp.Wrks per st.	men-days	2	2																				
Ann.Carpentry Wrks.	men-days	222	148								370											0	370

Unskilled:

Drilling per St.	men-days	240	240	150								0	0										
Annual Drilling	men-days	26640	17760	8400							52800	0	0									0	52800
Excavation per st.	men-days			6.4				3						0.64					0				
Annual Excav.Wrks	men-days			5779.2				5361			11140.2			2387.8					0			2387.8	13528.0
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5			
Ann.Civil Wrks.	men-days	3996	15984	4515	1896	74.5	51	26805	2880	56201.5		1166.	10510.	1865.5		0		9.8	1857	186		15595.	71796.7
Mech.Wrks. per st	men-days	12	12	3.6	12			6				2.4	0.72	0.72	0	0							
Ann.Mechanic Wrks.	men-days	1332	888	3250.8	11376			10722			27568.8	777.6	1167.8	2686.3		0						4631.7	32200.5

FUEL CONSUMPTION

Drill Rigs per st	Liters	3600	3600	1200								0	0										
Annual Drill Rigs Fuel	Liters	399600	266400	67200							733200											0	733200
Pump Rigs per st	Liters	336	336	0								0	0										
Annual Pump Rigs Fuel	Liters	37296	24864	0							62160											0	62160
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120			
Annual Heavy Vhcl Fuel	Liters	349650	449550	406350	88200	85320	67050	15300	643320	43200	2147940	25920	389280	298480		837120	96480	70560		14880		2E+06	3880660
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60			
Annual Light Vhcls Fuel	Liters	466200	349650	406350	78400	99540	26075	14280	250180	33600	1724275	51840	817488	596960		418560	48240	35280	742800	7440		3E+06	4442883

EQUIPMENT

Drill Rigs per st	Eq-days	24	24	10								0	0										
Annual Drill Rigs Use	Eq-days	2664	1776	560							5000	0	0									0	5000
Pump Rigs per st	Eq-days	3	3	0								0	0										
Annual Pump Rigs Use	Eq-days	333	222	0							555	0	0									0	555
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3			
Annual Heavy Vehcl Use	Eq-days	7770	9990	9030	1960	1896	1490	340	14296	960	47732	648	9732	7462		20928	2412	1764		372		43318	91050
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3			
Annual Light Vhcls Use	Eq-days	13320	17760	9030	2240	2844	745	408	7148	960	54455	2592	38928	29848		20928	2412	1764	37140	372		133984	188439
Other Light Eq per st	Eq-days																						

annual quantities required for each type of input. Detailed presentations of the methodology and the co-efficients are contained in Appendices B and D; data is contained in Appendix C.

The forecasting application of WISyMS can be used by private sector entrepreneurs in the water industry to provide the basis for market studies for both Level II and Level III. Although the model can not be expected to provide precise predictions of future activity in the water industry, it can provide useful information on the industry as a whole and its key elements. This is the type of information on which businessmen every where must rely for their decision-making.

V. CONSTRAINT ANALYSIS

Use of WISyMS for evaluating national objectives for standards of water consumption is another important application of the model, and can provide useful insights into the physical resource and financial implications of official goals, policies, and programs.

A. FEATURES OF CONSTRAINT ANALYSIS

Use of the model to evaluate national objectives can be regarded as a special forecasting application, in which the purpose of the forecast is to determine whether the objectives have been set at realistic levels. The objectives are translated into rates of build and/or investment requirements. An assessment of the realism of the objectives can be made by comparing the implied rates of build and/or investment to historical rates of build, funding availability, resource availability, or other measures.

While simple forecasting proceeds in a straight forward manner through the three submodels, the most important aspect of constraint analysis concentrates on submodel III, and the implications of constraints located at the industry input level on maximum achievable rates of construction at Level II and therefore on maximum achievable rates of water provision at Level I.

B. PROCEDURES FOR CONSTRAINT ANALYSIS

Generally, use of the WISyMS for this purpose proceeds as follows:

1. One or more runs of the model are made with standard projections assuming there is no change in policy (as discussed above in Section IV, Forecasting). The output, in terms of numbers of new structures needed and the associated input requirements provides a basis for comparison with the implications of the new policy.

2. Demographic data, some economic data (e.g., livestock population figures and growth rates), and some technological data (e.g., output per structure, average useful life of structures) are considered as "givens".

3. Explicit policy goals (e.g., specific levels of per capita water consumption) are inserted in place of standard projections or parameters as appropriate.

4. Where goals are announced in conjunction with the adoption of new policies or programs, assumptions associated with the implementation of the new policy are used to adjust certain parameters (e.g., new drilled well water systems installed in rural areas, although intended primarily for

human consumption, will also be used by livestock, so that the percentage reliance by livestock on drilled well water supplies would have to be adjusted upward).

5. The model is run using the variables and parameters associated with the proposed policy. The output of this run indicates the total numbers of new structures and associated inputs needed, taking into account policy goals.

6. Output from the "with policy" run of the model is compared with the output from the "without policy" run of the model to indicate the physical requirements, in terms of quantities of new structures and associated inputs, that are solely attributable to the policy being examined.

7. The data provided by steps 5 and 6 can be compared with funding and resource availability to determine first - whether the objectives can be considered reasonably attainable, and second - what, if any, effort can or must be made to alleviate or circumvent particular constraints. Here the model may be particularly useful in revealing unsuspected constraints and/or in showing that what was thought to be a constraint is not necessarily so.

C. CONSTRAINT ANALYSIS OF SOMALIA'S NATIONAL OBJECTIVES

Somalia's 1990 objectives with regard to water consumption have been outlined in the MMWR's document "Planning for the Drinking Water Supply and Sanitation Decade for Somalia". Generally, these are objectives with regard to the provision of safe, reliable, permanent water supplies for the Somali people. Specifically, they include targets for "water service" for 80% of the urban population and 50 - 60% of the rural population. Of those so served, there are targets for water consumption of 130 liters per capita per day (lcd) for urban dwellers with individual household connections (up to 40% of urban dwellers served by the system), 50 lcd for urban dwellers with access to public stand posts, 30 lcd for rural dwellers served by public watering systems and 20 lcd for all other rural dwellers.

A constraint analysis of these goals was undertaken by incorporating them into the WISyMS framework for evaluation. The model employs a global analysis taking into account the explicit goals plus:

- the water supply needs of populations who can not be served by publicly provided water supply systems before 1990,

- all other types of water supply needs, including livestock, industry and agriculture,

- water supply needs to be met by all types of potentially available water supply systems, both public and private, and

- the need for replacement of aging water supply structures.

The model further makes the following assumptions:

- That groundwater resource (from both drilled wells and hand-dug wells) are the major source of safe, reliable, and permanent water supplies,

- That water resources provided primarily for human consumption will also be used by industry in urban areas and by livestock in rural areas: and

- That each community will make use of a range of groundwater, surface water and catchment structures, depending on seasonal availability, cost, and convenience.

Examining the national goals in light of the above considerations and assumptions, data provided by the model indicate a needed rate of construction of drilled wells between 1985 and 1990 that is almost two and a half times the rate achieved during the previous four years. While the average annual rate of drilled well construction was about 101 between 1981 and 1984, realization of national goals would require an average rate of construction of 245 wells between 1985 and 1990. Assuming a construction program for the national goals was begun in 1985, this would start with a rate of 164 in 1985 and rise to 347 for 1990 (see Exhibits 15 and 16; detailed data are presented in Appendix C).

A second run of the model was made on the basis of a more modest set of goals presented in the MMWR's planning document. The second set of goals was more practically oriented, implying less of an attempt to develop groundwater resources and relying relatively more heavily on surface water resources and catchments to serve its target populations. Examining the second set of goals in light of the above outlined considerations and assumptions, data provided by the model indicate a needed rate of drilled well construction for the six years to 1990 which would be more than double the rate actually achieved during the previous four years. The needed construction program would require an average of 214 wells per year, starting with 150 in 1985 and rising to 291 in 1990 (see Exhibits 17 and 18; detailed data are presented in Appendix C).

In either case, a greatly expanded rate of well drilling is implied, and in all likelihood, a rate of well drilling that can not be achieved given existing resource and institutional limitations.

EXHIBIT 15

Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumption

	(000s)	MEASURE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN										
Urban	1741	persons	48021	38416	3842	4322	480	0	960	0
Rural Set	1853	persons	16706	5012	6682	2506	501	334	1671	0
Nomadic	2757	persons	23548	7064	7064	4710	1177	1177	2355	0
SUBTOTAL1	6351	persons	88274	50492	17588	11537	2159	1511	4986	0
ANIMAL										
Camels	5308	Animals	31483	6297	4722	4722	6297	7871	1574	0
Cattle	4246	Animals	30996	7749	9299	3100	6199	3100	1550	0
SheepGoats	28661	Animals	23538	4708	7061	2825	3531	3766	1648	0
OtherAnim	10615	Animals	581	87	145	87	116	116	29	0
SUBTOTAL2	12292	LSU	86598	18840	21228	10734	16143	14853	4801	0
AGRICULTURE										
Irrigfarm	64	Hectares	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.										
Govt.	2	Estabs	7800	7410	234	156	0	0	0	0
Industry	.73	Estabs	1752	1577	123	53	0	0	0	0
SUBTOTAL4			9552	8987	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)			1609413	118826	52675	1237667	31804	29866	9786	128789
VOLUME OUTPUT/STR (M^3*K/str'yr)				78.26272	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5008
NOS OF WATER SUPPLY STRUCTURES				1518	33762	6189	23126	13967	18318	7805
COMMERCIAL SCALE STRUCTURES				1518	4965	6189	964	233	18318	156

EXHIBIT 16

Projections of Requirements for New Water Supply Structures for 1985 - 1990

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	700	818	954	1114	1300	1518
Old Wells	325	334	386	454	501	537	630	735	858	1002	1171
Needed New Wells	41	89	113	102	99	164	187	219	256	298	347
DUG WELLS											
Needed Total Dug Wells					2500	2803	3142	3523	3950	4428	4965
Old Dug Wells					2250	2275	2553	2842	3171	3 13	3962
Needed New Dug Wells					250	528	590	681	779	886	1003
INTAKES											
Needed Total Intakes					5000	5181	5369	5563	5764	5973	6189
Old Intakes					4500	4550	4681	4810	4947	5089	5239
Needed New Intakes					500	631	688	752	817	883	950
UARS											
Needed Total Uars					750	782	813	850	887	925	964
Old Uars					675	683	707	731	757	784	812
Needed New Uars					75	100	108	119	130	141	152
BALLEHS											
Needed Total Ballehs					200	205	210	216	221	227	233
Old Ballehs					180	182	185	188	192	195	199
Needed New Ballehs					20	23	25	28	30	32	34
BURKEDS											
Needed Total Burkeds					10000	11061	12236	13534	14971	16560	18318
Old Burkeds					9333	9378	10395	11460	12646	13962	15422
Needed New Burkeds					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	84	88	92	97	102	124
Needed New Dams					20	24	28	33	38	43	32

EXHIBIT 17

Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumption

	(000s)	MEASURE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN										
Urban	1741	persons	48021	38416	3842	4322	480	0	960	0
Rural Set	1853	persons	16706	2506	5012	3341	1671	2506	1671	0
Nomadic	2757	persons	23548	3532	7064	4710	2355	3532	2355	0
SUBTOTAL1	6351	persons	88274	44454	15918	12373	4506	6038	4986	0
ANIMAL										
Camels	5308	Animals	31483	3778	6297	4722	7241	7871	1574	0
Cattle	4246	Animals	30996	4649	9299	3100	7749	4649	1550	0
SheepGoats	28661	Animals	23538	2825	7061	2825	5884	3295	1648	0
OtherAnim	10615	Animals	581	70	116	87	139	139	29	0
SUBTOTAL2	12292	LSU	86598	11322	22773	10734	21014	15955	4801	0
AGRICULTURE										
Irrigfarm	64	Hectares	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.										
Govt.	2	Estabs	7800	7410	234	156	0	0	0	0
Industry	.73	Estabs	1752	1577	123	53	0	0	0	0
SUBTOTAL4			9552	8987	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)			1609413	105269	52549	1238502	39022	35495	9786	128789
VOLUME OUTPUT/STR (M^3*K/str/yr)				78.26272	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5008
NOS OF WATER SUPPLY STRUCTURES				1345	33681	6194	28374	16600	18318	7805
COMMERCIAL SCALE STRUCTURES				1345	4953	6194	1182	277	18318	156

EXHIBIT 18

Projections of Requirements for New Water Supply Structures for 1985 - 1990

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	686	785	898	1028	1176	1345
Old Wells	325	334	386	454	501	537	616	704	805	921	1054
Needed New Wells	41	89	113	102	99	150	169	194	223	255	291
DUG WELLS											
Needed Total Dug Wells					2500	2802	3140	3519	3944	4420	4953
Old Dug Wells					2250	2275	2552	2840	3167	3537	3953
Needed New Dug Wells					250	527	588	679	776	883	1000
INTAKES											
Needed Total Intakes					5000	5182	5370	5565	5767	5977	6194
Old Intakes					4500	4550	4682	4812	4949	5092	5243
Needed New Intakes					500	632	688	753	818	884	951
UARS											
Needed Total Uars					750	809	873	942	1016	1096	1182
Old Uars					675	683	734	786	843	904	972
Needed New Uars					75	127	139	156	173	191	210
BALLEHS											
Needed Total Ballehs					200	211	223	235	249	262	277
Old Ballehs					180	182	191	200	210	220	231
Needed New Ballehs					20	29	32	35	39	42	46
BURKEDS											
Needed Total Burkeds					10000	11061	12236	13534	14971	16560	18318
Old Burkeds					9333	9378	10395	11460	12646	13962	15422
Needed New Burkeds					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	84	88	92	97	102	124
Needed New Dams					20	24	28	33	38	43	32

Interestingly, an examination of the resource requirements associated with implied drilling programs reveals that the traditional approach of foreign assistance in this industry does not necessarily address the most severe constraints. Many of the foreign aid projects in the drilling industry have involved the mobilization of a large ex-patriot drilling firm, complete with new drilling equipment. However, there are now 35 drilling rigs in Somalia judged by the Consultant to be in operation or capable of operation. Assuming each rig could drill eight production wells per year (and four non-production well), Somalia could theoretically sustain a production rate of 280 wells per year.

A more cost-effective approach for foreign assistance would be to target:

- the more immediate physical resource constraints, such as well drilling materials, consumables, and spares; and

- the institutional constraints such as administrative capabilities and market restrictions on private sector participation.

The Consultant's forecast of reasonably attainable water consumption standards and associated drilling and construction activity would include a rate of drilled well construction for 1985 - 1990 which would be about 50% higher than that achieved over the previous four years. (See Section IV, above). This program could be comfortably achieved with the existing stock of drilling rigs; although the constraints mentioned above would still require the concerted attention of both the Somali government and the donor community in order for the program to be achieved.

VI. USE OF WISyMS TO ESTIMATE CURRENT SYSTEM PARAMETERS

A. INTRODUCTION

This Section provides a description of the use of WISyMS to provide estimates of the current characteristics and parameters of the water system in Somalia. It gives an overview of the "Integrated Analysis of Conformed Estimates" (IACE) which was used to weave together a coherent and consistent profile of water consumption and facilities from a variety of data sources, technical estimates and informed opinions. It provides a summary of WISyMS quantitative estimates for 1984, which are presented in detail in Appendix C of this paper.

The forecasting and constraint analysis applications of WISyMS were introduced earlier in this paper (Section IV and Section V) because they are less complicated and are easier to understand than the estimating applications. However, analytically and chronologically, estimation of the characteristics of the existing system comes first. Integration of available information to define existing relationships between water consumption and facilities is prerequisite for making sound projections of future needs and for making realistic assessments of national water supply objectives.

B. IACE METHODOLOGY

Somalia's data base on water consumption and water supply systems is incomplete. Some information is very much out of date; other information is not reliable. Estimates of certain system parameters vary widely. In order to provide an improved data base and rational framework for market studies and an analysis of the distribution of functions between the public and private sectors, Louis Berger International, Inc. used its IACE methodology to:

- Determine current and historical relationships between types of water use and types of supply structures (i.e., what types of structures supply how much water for what types of uses); and

- Synthesize information and generate internally consistent estimates for variables on which we lack reliable data, but which form a logical and indentifiable part of the system being analyzed.

Prior to applying IACE procedures, the information requirements of the three submodels comprising WISyMS were defined. In the case of the Submodel for Level I, these information requirements included consumption units, per-unit consumption factors, a matrix of percentage distribution of water use across the range of supply structures, and the associated numbers of supply structures.

The first step in the IACE methodology was to gather as much relevant data as possible. Official estimates and/or estimates contained in well conceived studies were available on: human population (and its breakdown between urban, rural settled, and nomadic categories), livestock populations, and hectares of land under cultivation. Other estimates derived form aerial surveys were available on numbers of water supply structures such as hand-dug wells, uars, and ballehs. The Consultant conducted an investigation of well drilling activity over the past five years to estimate the number of operational drilled wells currently in the country.

Estimates on the average useful life of each type of structure were available from experts and technicians who were familiar with each type of structure, and were used in the Level II submodel to help translate stocks of structures into flows of needed new structures.

Estimates on the technical co-efficients of production inputs for each type of structure were provided by engineers who had designed or worked with the systems currently in use in Somalia.

Missing pieces of data, such as numbers of burkeds, diversion dams, and intake structures form rivers, were filled in with rough estimates.

The Delphi Method was used to obtain estimates on some variables: a variety of informed opinions were solicited; these opinions were sifted, weighted, averaged, compared with other data in the framework, and adjusted until a consensus was achieved. This process of comparative analysis was used in particular to approximate per-unit consumption factors and the percentage distribution of water consumption across the range of water supply structures.

All the above sources of information were incorporated into the model, and used to estimate the average volume of output per (single) supply structure per year. Knowledge of the reasonable range of annual volumes of output for each type of structure provided a basis for adjusting or "conforming" the rough estimates. For example, during the first run of the model, output per burked was calculated as several thousands of cubic meters per year. This appeared unreasonably high and was considered as evidence that the numbers of burkeds in the country had been under-estimated.

Since there is a fairly wide range of estimates on most of the variables examined in the model, three versions were made: one incorporating the low end of the range of estimates for each variable, one incorporating the high end of the range, and one incorporating the middle, average, or most commonly accepted estimate for each variable.

The above described process of gathering, estimating, integrating, and conforming information inputs is called "IACE" for Integrated Analysis of Conformed Estimates. Stated in another way, IACE is an orderly eclectic estimating procedure by means of which available data, opinions, and technical analyses are combined to provide consistent, reasonable approximations of the quantitative characteristics of water systems in Somalia.

C. 1984 SYSTEM ESTIMATES SUMMARIZED

Examples of data on the water system in Somalia as of end-1984 generated by WISyMS (middle estimates) are outlined below. A full presentation of data, including the range of high and low estimates as well as the middle-range estimates for the year are contained in Appendix C.

On the basis of estimates generated by the model, water consumption through the use of supply structures in Somalia in 1984 was about 1.2 billion cubic meters. Of this total, about 4% was supplied by drilled wells; 2% by hand-dug wells; 2% by uars, 2% by ballehs, 7% by diversion dams, less than 1% by burkeds and over 80% by intakes from rivers.

Of that same 1.2 billion cubic meters of water, use on agricultural cropland accounted for over 92% of the total; livestock consumption accounted for about 5%, human consumption accounted for less than 2%; and government institutions and industry accounted for less than 1%.

Of the 47 million cubic meters of water provided by drilled wells, 58% was consumed by agricultural crops, 16% was consumed by government institutions and industry, 14% by humans, and 12% by livestock.

As of end-year 1984, there was a stock of approximately 600 operational drilled wells in the country, 17,000 hand dug wells, 18,000 uars, 12,000 ballehs, at least 10,000 burkeds, perhaps 5000 intake structures from rivers, and 5000 earth diversion dams. Many of these are very small structures, built on an individual or community self-help basis. Others, however, are larger or more sophisticated structures requiring substantial capital input and at least the potential for provision on a commercial scale. These would include all the drilled wells, river intakes, and burkeds; it would also include perhaps 2500 hand dug wells, 750 uars, 200 improved ballehs, and 100 earth diversion dams.

The absolute minimum commercial scale construction needed during 1985, solely to replace failing or obsolete structures, includes at least 60 drilled wells, 250 hand dug wells, 75 uars, and 20 earth dams.

The replacement program implies a minimum need for locally produced or available inputs as follows: cement - 22 thousand cubic meters, stone - 31 thousand cubic meters, gravel - 3

thousand cubic meters, sand - 11 thousand cubic meters, skilled labor - 54 thousand man-days, unskilled labor - 71 thousand man-days, fuel - 5 million liters, and drill/pump rigs - 1800 equipment days.

The model, as used for integrated estimation of current system characteristics, presents the "big picture" of the water industry in Somalia as well as an indication of the orders of magnitude of each of its elements. The Consultant expects that the data base will be continuously updated to privde ever more accurate analyses, and that the framework will be expanded to provide more detail in the future.

APPENDIX A

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

DEFINITION OF TERMS, CATEGORIES AND CONCEPTS

APPENDIX A

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA DEFINITION OF TERMS, CATEGORIES, AND CONCEPTS

I. INTRODUCTION

This Appendix has three sections including this introduction. Section II contains an alphabetical listing of the principal terms, categories, and concepts used in the Water Industry Systems Model for Somalia (WISyMS) together with cross references to the definition of these terms in Section III. Section III organizes definitions under nine principal categories as follows:

A. Water Industry/WISyMS Structure

B. Consumption Units

C. Per Unit Water Consumption Factors

D. Water Consumption/Intake Structure Flow Relationships

E. Types of Water Supply Structures

F. Subset of Commercial-Scale Water Supply Structures

G. Volumes of Water Provided through Supply Structures

H. Numbers of Each Type of Water Structure

I. Inputs to Water Industry

II. ALPHABETICAL LISTING OF TERMS

	Defined on Page
Agriculture	A5
Agricultural Consumption	A5
Animal Consumption	A5
Animal Population	A4
Average Useful Life	A8
Ballehs	A7
Burkeds	A7
Capital Equipment	A9
Consumption Units	A4
Diversion Dams	A7
Drilled Wells	A6
Flood-fed Agriculture	A5
Government and Industry	A5
Government and Industry Consumption	A5
Hand Dug Wells	A6
Human Consumption	A5
Human Population	A4

Industry Structure A3
Inputs to the Water Industry A9
Intakes from Rivers A6
Irrigated Agriculture A5
Labor A9
Level I: Water Supply A3
Level II: Well Drilling and Construction of Water Supply Facilities A4
Level III: Water Industry Inputs A4
Manufactured Materials A9
Material Inputs A9
Needed New Structures A8
Nomadic A4
Numbers of Each Type of Water Supply Structure . . . A8
Old Structures A8
Output per Structure A8
Percentage Distribution Across Structures A6
Per-Unit Water Consumption Factors A5
Rainfed Agriculture A5
Raw Materials A9
Rural Settled A4
Structural Control Percentage A6
Structural Control Volume A6
Structural Supply Volumes A8
Subset of Commercial Scale Water Supply Structures . A7
Total Consumption of Water by Type of Consumption and by Type of Structure A8
Total Needed Numbers of Structures A8
Types of Water Supply Structures A6
Uars A7
Urban HC A4
Urban SP A4
Volumes of Water Provided Through Supply Structures . A8
Water Consumption/Supply Structure Flow Relationships A5

III. DEFINITIONS

A. INDUSTRY STRUCTURE

The Water Industry Systems Model for Somalia and its respective submodels provide outputs useful in analyzing water industry structure at three levels. These levels and the reflecting submodels are defined below.

1. **Level I: Water Supply** - The direct provision of water to the ultimate consumer, including water resource ownership, water supply operation maintenance and revenue collection. Water supply needs are analyzed by the Level I Submodel of WISyMS.

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2. **Level II: Well Drilling and Construction of Water Supply Facilities** - The drilling of wells and construction of related civil works structures; planning, design, and administration of drilling and construction. This is analyzed by the Level II Submodel of WISyMS.

3. **Level III: Water Industry Inputs** - The production or provision of manufactured or raw material inputs, equipment, labor, and fuel for water supply, well drilling, and water supply construction activities. These are analyzed by the Level III Submodel of WISyMS.

B. CONSUMPTION UNITS:

A consumption unit is defined as an individual consumer of water in Somalia. Consumption Units are classified into human populations, animal populations, agricultural land, and government and industry. Definitions of these categories are presented below.

1. **Human Population:** Measured in numbers of people. For the purpose of detailed analysis, the estimates of total human population in Somalia are divided into four categories:

   a. **Urban HC** - urban population with private Household Connections for provision of water,

   b. **Urban SP** - urban population with access to Standpipes for provision of water,

   c. **Rural Settled** - rural populations that tend to live year round in one location, and

   d. **Nomadic** - rural populations that tend to move from place to place during the year.

Total urban population for this study is defined as populations in and around cities and towns containing municipal water distribution systems. These are: Mogadishu, Hargeisa, Berbera, Burao, Johar, Balad, Merka, Afgoi, Kismayo, and Baidoa. The distinction between "rural settled" and "nomadic" (or even for "urban" vs "rural") is conceptually useful but arbitrary in practice. Many people move some years but not others; or move for only short periods of time in any given year. We used official estimates for the pecentage breakdown of these categories (See Appendix D).

2. **Animal Population:** measured in numbers of head. They are divided into four basic categories: a. **Camels**, b. **Cattle**, C. **Sheep and Goats** (one category) and d. **Other**, which is intended to include other household animals including poultry, donkeys, cats, and dogs.

3. **Agriculture:** Measured by Hectares under cultivation. it includes:

   a. **Irrigated Agriculture** - land under controlled channel irrigation;

   b. **Rainfed Agriculture** - land fed almost exclusively by natural rainfall; and

   c. **Flood-fed Agriculture** - land fed by rainfall plus flood water and tugs (small seasonal rivers) diverted by earth dams.

4. a. **Government** and b. **Industry:** Measured in numbers of establishments. They are primarily urban and include government offices or institutions and industrial or commerical establishments employing five or more people.

C. PER-UNIT WATER CONSUMPTION FACTORS:

A per-unit consumption factor is defined as the average volume of water consumed per day by an individual consumption unit in a particular category. Factors for each category of consumption are discussed in the following paragraphs.

1. **Human Consumption:** Daily per capita consumption of water varies drastically by area and by season. Rural dry season consumption may be no more than the minimum required for subsistence (3 - 5 liters), while urban consumption can easily exceed 100 liters per day.

2. **Animal Consumption:** Although the figures presented in WISyMS are for consumption per head per day, camels are actually watered once every one to three weeks, cattle are watered once every other day on average, and sheep and goats are watered once every two to six days.

3. **Agricultural Consumption:** Total amount of water used for growing crops on agricultural land, whether or not the water is actually absorbed by the plants (i.e., water applied to crops which evaporates directly or percolates through to lower strata is included here.)

4. **Government and Industrial Consumption:** Weighted average volume of water used in these categories.

D. WATER CONSUMPTION/SUPPLY STRUCTURE FLOW RELATIONSHIPS

At least three types of calculations/estimates are required to relate consumption flows to flow through particular types of supply structures. These are discussed below.

1. **Structural Control Percentage:** For each type of consumption, the percentage of water taken from nature with the use of man-made water supply structures or improvements to natural sources. <What is excluded ("**no structure**") is water consumed directly from natural sources, such as springs, ponds, or rivers, without the use of man-made supply structures.>

2. **Structural Control Volume:** For each type of consumption, the actual volume of water consumed through man-made water supply structures.

3. **Percentage Distribution Across Structures:** For each type of consumption, the percentage distribution of consumption across the range of types of water supply structures listed below.

E. TYPES OF WATER SUPPLY STRUCTURES

Seven types of water supply structures are covered by WISyMS. They are: drilled wells, hand-dug wells, intakes from rivers, uars, ballehs, burkeds, and diversion dams. Each of the seven types of structures is defined below. Note that wells are structures used to reach sources of groundwater and may be almost any depth from two meters to over 300 meters in Somalia. Although wells are sometimes classified as "shallow" vs "deep", in the context of WISyMS they are classified as "drilled" or "hand dug" in order clearly to reflect the type of input that goes into the structure (see below).

1. **Drilled Wells:** All wells drilled mechanically by cable, hydraulic, or rotary rig, regardless of depth. They may be equipped with either a **diesel pump** (DP) or a hand pump (HP). They may be **production wells**, which are completed, operational structures equipped with a pump and producing water, or **non-production wells**, which are test boreholes abandoned after it has been determined that quantity and/or quality is not suitable. Drilled wells provide most of the water consumed in urban areas and are of growing importance in rural areas for dry season water supply.

2. **Hand Dug Wells:** All wells dug by hand tools, regardless of depth. There are three basic types, depending on local geological conditions: i) wells dug in or near stream or river beds; ii) wells dug in sand dune areas; and iii) wells dug in gypsiferous, limestone, or sandstone formations. These are important sources of water during the dry season in rural areas.

3. **Intakes from Rivers:** Pipes immersed into a river and connected to a diesel powered pump. Water is then distributed to irrigation channels or, less frequently, to water purification facilities.

4. **Uars:** Reservoirs dug in relatively impermeable ground to catch rainwater and surface run-off and to serve as retention basins. They are usually intended for livestock watering, though they are also used by people.

5. **Ballehs:** Ponds or natural depressions which tend to catch and hold rainwater and surface run-off, which have been or could be deliberately improved, deepened, or enlarged. They are a traditional source of water during the rainy season for both human and livestock consumption.

6. **Burkeds:** In-ground masonry cisterns which serve as water storage tanks or which catch rainwater or surface run-off. They are primarily a wet season source of water, although water may be transported to them for storage and use during the dry season.

7. **Diversion Dams:** Man-made structures to divert or hold back the natural flow of a river, stream, or tug. They are used in all forms of agriculture, especially "flood-fed" agriculture.

F. SUBSET OF COMMERCIAL SCALE WATER SUPPLY STRUCTURES:

For each type of above-listed supply structure there is a subset of structures the construction of which involves some capital input and at least the potential for construction on a commercial basis. These supply structure subsets are important because they help identify potential markets for drilling and construction firms. The subsets include:

1. All **drilled wells,** because they require the use of a drill rig;

2. Only those **hand dug** wells with a cement or stone lining;

3. All **intakes** from rivers because of the need for diesel pumps;

4. Only those **uars** excavated with heavy equipment;

5. Only those **ballehs** improved with the use of heavy earth-moving equipment;

6. All **burkeds** because of the need for skilled masons and cement; and

7. Only those **diversion dams** built with the use of heavy earth-moving equipment.

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G. VOLUMES OF WATER PROVIDED THROUGH SUPPLY STRUCTURES

Three terms are important in understanding the process by which WISyMS calculates volumes of water provided through supply structures. These are discussed below.

1. **Total Consumption of Water by Type of Consumption and by Type of Structure:** A matrix in which the rows illustrate the amounts of water used for each type of consumption and its distribution across types of structures. The columns of the matrix illustrate the amounts of water provided by each type of structure and its distribution among different types of use. Therefore, the cells of the matrix specify the amount of water used for each particular use AND supplied by a particular type of structure (see Appendix B, Methodology for the concise mathematical formulae).

2. **Structural Supply Volumes:** The sums of the volume of water consumed for each type of structure for all uses.

3. **Output per Structure:** The weighted average volume of water provided per single supply structure per year for each type of supply structure.

H. NUMBERS OF EACH TYPE OF WATER SUPPLY STRUCTURE

This section presents definitions of terms used to describe the process by which numbers of water supply structures are calculated.

1. **Total Needed Numbers of Structures:** For the purposes of WISyMS analysis, defined as the numbers of each type of structure needed to keep up with growth in consumption from all sources, assuming the average volume of output per single operational structure is fixed and given as measured in 1984.

2. **Average Useful Life:** For each type of structure, the expected number of years it will be operational and providing water before it becomes worn out, fails, and needs to be replaced.

3. **Old Structures:** for the purposes of WISyMS analysis, defined as those operational structures which had been in existence before the year being analyzed in the model, and which will be subject to a certain expected rate of deterioration/failure during the year being analyzed. (See also "Previously Constructed" structures in Appendix B).

4. **Needed New Structures:** for the purposes of the WISyMS analysis, are defined as the numbers of each type of structure needed to be constructed to:

- Replace those old structures which are expected to fail during the course of the year being analyzed, plus
- Provide for expected net increases in consumption from all sources.

I. INPUTS TO THE WATER INDUSTRY

WISyMS deals with four categories of inputs to the water industry: raw materials, manufactured materials, labor and capital equipment. These are described below.

1. **Material Inputs:** presented in WISyMS include those of primary importance to the water resource development industry, and focus on those materials with a potentially significant impact on "Level III" industries and entrepreneurs' decision making. They include:

   a. **Raw Materials** available in Somalia - sand, gravel, stone, and some wood:

   b. **Manufactured Materials**, some of which are potentially available in Somalia - cement, metal and PVC pipes, spun-reinforced concrete pipes; plastic sheets, PVC storage tanks, and hand pumps; and other materials which must be imported - drilling fluid (bentonite), well casing and screen, diesel pumps, reinforcement steel, and fuel;

2. **Labor** - for drilling, excavation, construction, and mechanical services;

3. **Capital Equipment** - drill rigs, pump rigs, heavy vehicles such as flatbed trucks, dump trucks, water tankers, and fuel tankers; and light vehicles and equipment.

APPENDIX B

WATER INDUSTRY SYSTEMS MODEL FOR SOMLIA

METHODOLOGY

APPENDIX B

DETAILED METHODOLOGY FOR THE WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

I. INTRODUCTION

This presentation of the methodology employed by the Water Industry Systems Model for Somalia (WISyMS) contains three sections, corresponding to the three submodels for each of the levels of the water industry in Somalia. The Level I Submodel analyses water supply, the Level II submodel analyses well drilling and construction of water supply facilities, and the Level III submodel analyses water industry inputs. (Detailed definitions of terms used in this appendix are presented in Appendix A)

Actual data generated by WISyMS has been bound separately in Volume II, Appendix C. It is suggested that the Exhibit 4, "1990 Middle Level Projections" data be referred to throughout the following discussion for illustration. Familiarity with the general structure of the model, as presented in Sections II and III of the main body of this study, is assumed in the discussion that follows.

II. LEVEL I SUBMODEL

The Level I submodel is composed of three sections. The first section employs data on numbers of consumption units and per unit consumption factors to calculate total annual volumes of water consumed by type of use, and estimates the percentage and volumes of water consumed through the use of man-made water supply structures. The second section contains a matrix of estimates on

the percentage distribution of consumption across the range of types of water supply structures. The third section uses the estimates provided by the first and second sections to calculate a matrix of volumes of water by type of use and by type of supply structure. This section also contains estimates on numbers of each type of supply structure and average volume of output per single supply structure.

A. LEVEL I SUBMODEL, FIRST SECTION

The first column of figures represents consumption units in thousands: N.

The second column of figures represents average amounts of water consumed daily per unit in each consumption category, and is expressed in liters or cubic meters: c.

The third column of figures represents the relevent number of consumer-days per year: D.

The fourth column of figures represents the relevent conversion factor for each category of consumption to cubic meters (liters * 1000 or M^3 * 1): F.

The fifth column of figures represents the total annual volume of water consumed by each category in thousands of cubic meters per year: V.

Columns 1 - 5 relate to each other according to the following formula:

$$V = (N * c * D) / F$$

Of all water consumed, some is provided through the use of man-made supply structures and the rest is consumed directly from

nature, (e,g., Urban populations with private household connections for water have 99% of their water consumption needs provided through the use of man-made water supply structues; the other 1% is taken directly from nature without the use of such supply structures). In order to assess the volume of water consumed through water supply control structures V_c for each category of consumption, we multiply by the appropriate percentage of total annual consumption:

e.g.: $V_c = .99 * 6351 = 6287$

where V_c = Structural Control Volume by category of consumption (volume of consumption from supply structures).

Similarly, "No Structure" is the volume of water consumed directly from nature.

B. LEVEL I SUBMODEL, SECOND SECTION

The second section repeats the columns representing consumption units, total annual consumption, structural control percentage, and structural control volume, although in the Human category of consumption, Urban populations with household connections (HC) and those with access only to standpipes (SP) are combined. To the right of these columns is a matrix representing, for each category of consumption, the percentage distribution (% of V_c) of reliance on each of seven types of water supply structures. (e.g., Human Urban Consumption from drilled wells accounts for 75% of the total urban consumption from all types of supply structures). Each row of the matrix sums to 100%.

C. LEVEL I SUBMODEL, THIRD SECTION

The third section repeats the columns representing

consumption units, total annual consumption, structural control percentage, and structural control volume. To the right of these columns is a matrix representing the total consumption of water (V_c) by type of consumption and by type of structure (e.g., for the Human consumption category, urban consumption from drilled wells is : .75 * 20300 = 15255).

This produces the matrix: $[V_{cs}]$

or:

$$
\begin{array}{c|ccccc}
 & V_{s1} & V_{s2} & V_{s3} & \cdots & V_{sM} \\
\hline
V_{c1} & V_{c1s1} & V_{c1s2} & V_{c1s3} & \cdots & V_{c1sM} \\
V_{c2} & V_{c2s1} & V_{c2s2} & V_{c2s3} & \cdots & V_{c2sM} \\
V_{c3} & V_{c3s1} & V_{c3s2} & V_{c3s3} & \cdots & V_{c3sM} \\
\vdots & \vdots & \vdots & \vdots & & \\
V_{cN} & V_{cNs1} & V_{cNs2} & V_{cNs3} & \cdots & V_{cNsM}
\end{array}
$$

where: V_{ci} is the volume of water (V_c) consumed by consumption category i,

V_{sj} is the volume of water (V_s) consumed through type of supply structure j, and

V_{cisj} is the volume of water consumed by consumption category i and through type of structure j.

Knowing the volumes of water for each supply structure per category of consumption, we can calculate the total volumes of water for each type of supply structure (V_s) (in thousands of cubic meters per year) by summing down each column of the $[V_{cs}]$ matrix.

$$V_{sj} = \sum_{i=i}^{n} V_{cisj}$$

No comprehensive figures existed, in 1984, on average volumes of output per single supply structure for each type of structure. However, using the available estimates of numbers of each type of supply structure (S_j), it was possible to calculate an estimated output per single structure V_o:

$$V_{oj} = V_{sj}/S_j$$

These estimates were then taken as fixed and given for use in projections of needed water supply structures for each type of structure for 1990:

$$S_j = V_{sj}/V_{oj}$$

To provide an additional point of reference, the model includes two extra rows as follows:

- **DAYS/YEAR:** is the weighted average number of days per year each type of structure is in use: D_j
- **M^3/STR/DAY:** volume of output in cubic meters per single supply structure per day, calculated as "Output per Structure per Yeara" V_{oj} divided by "Days per Year" D_j.

For instance, of about 600 operational drilled wells in existence as of end 1984, approximately 240 of these are irrigation wells used 100 days per year and pumping about 1000 cubic meters per day: 60 are municipal wells operating 365 days per year and pumping 800 cubic meters per day; and 300 are rural boreholes used 200 days per year and pumping 80 cubic meters per day. This gives us a weighted average of about 180 days per year and 435 cubic meters per day per drilled well, although this describes no

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typical well in Somalia.

For each type of water supply structure, a fixed proportion is assumed to form the subset of commercial scale structures:

$$SC_j = S_j * P_j$$

where SC_j is the number of structures in the subset of Commercial Scale Structures for category j, and P_j is the proportion of commercial scale structures in category j.

Estimates of an average useful life U_j for each category of commercial scale structure can be used for a rough notion of replacement/rehabilitation requirements R_j (in the absence of detailed knowledge of the ages of the structures concerned):

$$R_j = SC_j/U_j$$

This would represent the bare minimum replacement rate without suffering a loss in crude supply capacity. For the 1984 middle-base estimates (Exhibit 1 in Appendix C), these replacement rates were introduced directly into the Level III submodel to illustrate the quantities of inputs required solely for replacement purposes at the drilling/construction level.

II. LEVEL II SUBMODEL

Section IV of the main body of this study discussed the procedures for using the Level I submodel for making water consumption forecasts for future years and presented estimates on, among other things, projections of the numbers of needed new structures in 1990. Section VI discussed the use of the model to make estimates of the current (end-1984) system. This provides the basis for comparison between two years, which is necessary to derive needed flows of drilling and construction from needed

stocks of structures.

The columns of the Level II submodel present numbers of commercial scale structures by year. The rows of the Level II submodel are grouped by type of structure. The first row in each group represents "Needed Total Structures" for each year: SC_{jt}. Numbers of operational commercial scale structures in existence as of end-year 1984 were taken as the basis of comparison. Projections of needed structures in 1990 ("needed" to keep pace with growth in consumption from all sources) were made assuming that the 1984 level of output per single structure V_{oj} was constant (see above).

Assuming there will be a constant growth rate (g) in the stock of structures between 1984 and 1990 the total needed structures for each year between 1984 and 1990 can be calcualted by expotential interpolation. For example:

1984 Total existing drilled wells = 600; and
1990 Total needed drilled wells = 996; then

$$996/600 = (1 + g)^6$$

$$g = (996/600)^{1/6} - 1 = 0.0881398 \text{ or } 8.81398\%$$

therefore 1985 Total needed drilled wells = 600 * 0.0881398 = 653

The second row of each grouping presents the stock of old structures, SO_{jo}, in existence at the beginning of the period of analysis (pre-1980 for drilled wells; pre-1984 for all other types of structures) and assumes a deterioration rate equal to the inverse of useful life for that type of structure: $(1/U_j)$. From those figures can be calculated the numbers of remaining old structures (SO_{jt}) for each type of structure j and for any succeeding year:

$$So_{jt} = SO_{jo} * [1 - (t/U_j)];$$

where t = the number of years after the beginning period of the analysis for a given type of structure.

The third row of each grouping, "Previous New Structures" (SP_{jt}) represents the status of structures built in succeeding years (post-1980 for drilled wells and post-1984 for all other types of structures). In each year, new structures are being built. It is assumed that each new structure remains functional for one year after construction (it gets one year grace), but deteriorates at a rate ($1/U_j$) each year after that. For example, for drilled wells, there were 99 new wells drilled in 1984, and 306 "Previous New Wells" in 1984. Therefore, there are [99 + (.9 * 306)] = 374 drilled wells in the "Previous" row for the 1985 column.

The fourth row of each grouping, "Needed New Structures", SN_{jt}, represents the numbers of structures which must be built in a given year to 1) keep pace with expanding consumption needs from all sources and 2) to replace deteriorated structures (as calculated above). Specifically, they are calculated as the number of structures needed to make up the difference between "Needed Total Structures" and "Old Structures" plus "Previous new Structures":

$$SC_{jt} - (SO_{jt} + SP_{jt}) = SN_{jt}$$

For each grouping, the 1990 numbers of "Needed New Structures" have been used in the Level III submodel to calculate needed inputs.

III. LEVEL III SUBMODEL

The primary objective of this submodel is to provide a system which estimates the inputs of raw materials, labour and equipment required to build and maintain a water supply system with a given

capacity. A major objective of this model is to serve as a basis for the development of a market study for Level III of the water industry to provide the private sector with a decision making tool.

This model can be regarded as a simplified Input/Output model based on current technology in Somalia. Inputs are the raw materials, labour and equipment involved in the construction and/or maintenance of the different water supply structures under consideration. Outputs are defined as numbers and types of water supply structures which need to be "produced", that is, either constructed or rehabilitated or maintainted. (e.g. number of drilled wells to be constructed or number of burkeds to be maintained).

Technical coefficients, establishing the quantity of Input i required in order to produce (either construct or maintain) one unit of Output (structure) j are determined. (e.g., quantity of cement required for the construction of one burked).

For purposes of the Level III Submodel, drilled wells are divided into three categories:

- Drilled Wells equipped with hand pumps;
- Drilled Wells equipped with diesel pump; and
- Non Production Wells.

The other structures are undivided.

Each of these structures is clearly defined in Appendix A sources and estimating procedures are discussed in Appendix D. The framework has been designed in a way that allows more structures to be considered. Estimates have been made of the following:

- Technical coefficients of construction

- Technical coefficients of maintenance
- Useful Life
- Maintenance Period.

The framework is designed in order to allow maximum flexibility in the estimates. Any of the values that have been assumed in the main framework can be easily modified.

Definitions:

APR_j = Annual Production Rate: indicates the number of new structures to be constructed in a given year for each type of structure j (= SN_j, Needed New Structures for Level II).

UL_j = Useful Life for structure j: represents the life expectancy of structure j, assuming that the structure is properly and regularly maintained.

MP_j = Maintenance Period: indicates the number of years between two consecutive maintenance services for structure j.

AMR_j = Annual Maintenance Rate for structure j: indicates the annual number of structures j to be maintained. AMR is defined as follows:

$$AMR_j = (SO_j + SP_j)/MP_j$$

WRP_j = Rehabilitation Period, indicates the number of years between two consecutive rehabilitations of drilled wells.

$AWRP_j$ = Annual Wells Rehabilitation Rate for structure j: indicates the annual numbers of wells to be rehabilitated. $AWRR_j$ is defined as:

$$AWRR_j = SP_j/WRP_j$$

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n = number of Inputs i (i=1, . . . n)
m = number of Outputs (structures) j (j=1, . . .m)

A_{ij} = Technical coefficient representing the quantity of Input i required to construct one unit of Output j.

B_{ij} = Technical coefficient representing the quantity of Input i required for one maintenance and rehabilitation service of one unit of j.

X_{ij} = Total annual quantity of Input i to be supplied in order to construct one unit of Output j.

Y_{ij} = Total quantity of Input i required for the construction of all the water supply structures.

Xi = Total annual quantity of input; required for the construction of all the supply structures.

Y_i = Total annual quantity of Input i required for the maintenance and rehabilitation of all water supply structures.

Relationships:

The following relationships can be established:

$$X_{ij} = A_{ij} * APR_j$$

$$Y_{ij} = B_{ij} * (AMR_j + AWRR_j)$$

$$X_i = \sum_{j=1}^{n} X_{ij}$$

$$Y_i = \sum_{j=1}^{m} Y_{ij}$$

Finally, $X_i + Y_i$ = Total annual quantity of Input i to be supplied to the water industry at Level II for all purposes.

WISyMS output is presented in Appendix C. Notes, sources and estimating procedures are discussed in Appendix D.

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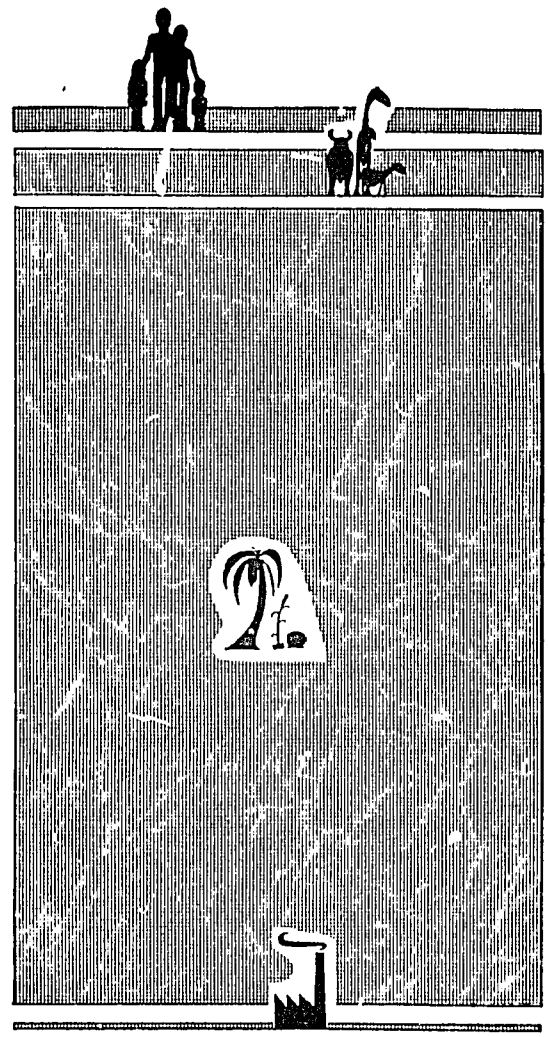
VOLUME II

STRUCTURE AND APPLICATIONS OF A WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

- 1984 Estimates
- 1990 Forecasts
- Constraint Analysis of National Water Supply Objectives



COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

SEPTEMBER, 1985 Louis Berger International, Inc.

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

STUDY OF WATER RESOURCE DEVELOPMENT INDUSTRIES IN SOMALIA

STAFF WORKING PAPER

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(Volume II)

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APPENDIX C

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

Data

I. 1984 Baseline Estimates

A. Exhibit 1: Middle Level Estimates
- Level I Submodel
- Level III Submodel

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 1: MIDDLE LEVEL 1984 ESTIMATES OF POPULATION, RATES OF CONSUMPTION, AND EXISTING STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	107	persons	60	liters	365	1000	2343	99	2320	1	23
Urban SP	1230	persons	12	liters	365	1000	5387	97	5226	3	162
Rural Set	1552	persons	10	liters	365	1000	5665	90	5098	10	566
Nomadic	2461	persons	7	liters	365	1000	6288	85	5345	15	943
SUBTOTAL1	5350	persons					19683		17989		1695
ANIMAL											
Camels	5000	Animals	20	liters	365	1000	36500	60	21900	40	14600
Cattle	4000	Animals	20	liters	365	1000	29200	75	21900	25	7300
SheepGoats	27000	Animals	3	liters	365	1000	29565	70	20696	30	8870
OtherAn	10000	Animals	3	liters	365	1000	10950	5	548	95	10403
SUBTOTAL2	11580	LSU					106215		65043		41172
AGRICULTURE											
Irrigfarm	55	Hectares	68	M^3	365	1	1365100	80	1092080	20	273020
Rainfarm	600	Hectares	35	M^3	120	1	2520000	1	25200	99	2494800
Floodfarm	120	Hectares	25	M^3	90	1	270000	1	2700	99	267300
SUBTOTAL3	775	Hectares					4155100		1119980		3035120
GOVT/IND											
Govt	2	Estabs	13	M^3	300	1	7800	100	7800	0	0
Industry	.5	Estabs	5	M^3	300	1	750	100	750	0	0
SUBTOTAL4							8550		8550		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1337	persons	7731	97	7546	70	10	10	5	0	5	0
Rural Set	1552	persons	5665	90	5098	15	40	15	10	5	15	0
Nomadic	2461	persons	6288	85	5345	10	30	20	15	15	10	0
SUBTOTAL1	5350	persons	19683		17989							
ANIMAL												
Camels	5000	Animals	36500	60	21900	7	15	25	20	28	5	0
Cattle	4000	Animals	29200	75	21900	10	30	20	20	15	5	0
SheepGoats	27000	Animals	29565	70	20696	9	30	20	15	20	7	0
OtherAnim	10000	Animals	10950	5	548	7	25	20	20	23	5	0
SUBTOTAL2	11580	LSU	106215		65043							
AGRICULTURE												
Irrigfarm	55	Hectares	1365100	80	1092080	2.5	.5	90	1	1	0	5
Rainfarm	600	Hectares	2520000	1	25200	0	0	0	0	0	0	100
Otherfarm	120	Hectares	270000	1	2700	0	0	0	0	0	0	100
SUBTOTAL3	775	Hectares	4155100		1119980							
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	90	5	3	2	0	0	0
Industry	.5	Estabs	750	100	750	85	10	3	2	0	0	0
SUBTOTAL4			8550		8550							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1337	persons	7731	97	7546	5282	755	755	377	0	377	0
Rural Set	1552	persons	5665	90	5098	765	2039	765	510	255	765	0
Nomadic	2461	persons	6288	85	5345	534	1603	1069	802	802	534	0
SUBTOTAL1	5350	persons	19683		17989	6581	4397	2588	1689	1057	1676	0
ANIMAL												
Camels	5000	Animals	36500	60	21900	1533	3285	5475	4380	6132	1095	0
Cattle	4000	Animals	29200	75	21900	2190	6570	4380	4380	3285	1095	0
SheepGoats	27000	Animals	29565	70	20696	1656	6209	4139	3104	4139	1449	0
OtherAnim	10000	Animals	10950	5	548	38	137	110	110	126	27	0
SUBTOTAL2	11580	LSU	106215		65043	5417	16201	14104	11974	13682	3666	0
AGRICULTURE												
Irrigfarm	55	Hectares	1365100	35	1092080	27302	5460	982872	10921	10921	0	54604
Rainfarm	600	Hectares	2520000	1	25200	0	0	0	0	0	0	25200
Floodfarm	120	Hectares	270000	1	2700	0	0	0	0	0	0	2700
SUBTOTAL3	775	Hectares	4155100		1119980	27302	5460	982872	10921	10921	0	82504
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	7020	390	234	156	0	0	0
Industry	.5	Estabs	750	100	750	638	75	23	15	0	0	0
SUBTOTAL4			8550		8550	7658	465	257	171	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/yr)					1211562	46958	26523	999820	24754	25659	5343	82504
VOLUME OUTPUT:		(M^3*K/str/yr)				78.262720	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5003
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				435	4	800	11	24	9	275
NOS OF WATER SUPPLY STRUCTURES						600	17000	5000	18000	12000	10000	5000
COMMERCIAL SCALE STRUCTURES						600	2500	5000	750	200	10000	100
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						60	250	500	75	20	667	20

LEVEL III SUBMODEL

Please Turn Over

WATER SYSTEM MATRIX:MIDDLE LEVEL
1984 PROJECTIONS

INPUTS	OUTPUTS Measure	CONSTRUCTION: WELLS: M.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES: Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION: WELLS: HP Drilled Wells	DP Drilled Wells	Hand Dug Wells		OTHER STRUCTURES: Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	24	36	250	18	500	75	20	667	20												
UL	Years	15	15	10		10	10	5	15	5												
MP	Years											1	0.3	1		0.5	1	1	1	1		
AMR	Number of struct.											216	1080	2250		9000	675	180	9333	80		
MATERIALS																						
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0		
Annual cement	cubic meters	168	7200	1750	90	2000	0	0	2001	0	13209	151.2	6480	1575		0	270	0	0	0	8476.2	21685.2
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7		
Annual stones	cubic meters			4000		5000	0	0	4669	12800	26469			3600		0	675	0	0	56	4331	30800
Gravel per st	cubic meters	5	35									0.5	1.05									
Annual gravel	cubic meters	120	1260								1380	108	1134								1243.5	2623.55
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2		
Annual Sand	cubic meters	48	4320	500					1334	0	6202	43.2	3888						0	16	3947.2	10149.2
8" Steel Casing per st	meters	75	75																			
Ann.8"Steel Casing	meters	1800	2700								4500										0	4500
8"Steel Screen per st	meters	45	45																			
Ann.Steel Screen	meters	1080	1620								2700										0	2700
Conduct.casing per st	meters	6	6		0																	
Ann.conduct.casing	meters	144	216		0						360										0	360
Shelter per st	units	0.2	1	0.1					0.5													
Annual Shelter	units	4.8	36	25					333.5		399.3										0	399.3
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1		
Annual Pipe&Fittings	meters	0	7200	0		7500			6670		21370	0	6480	0		0			0		6488.5	27858.5
Drilling Fluid per st	sacks	25	25		5							0	0									
Annual Drilling Fluid	sacks	600	900		90						1590	0	0								0	1590
Hand Pump per st	units	1		0.2								0.2		0.4								
Annual Hand Pumps	units	24		50							74	43.2		900							943.8	1017.8
Diesel Pump per st	units		1			1							0.04			0.2						
Annual Diesel Pumps	units		36			500					536		43.2			1800					1843.2	2379.2
Rebars & wood per st	meters		30						20										3			
Annual Rebars&Wood	meters		1080						13340		14420								27999		27999	42419
Plastic Sheet per st	sq.meters						191	3120										150				
Annual Plastic sheets	sq.meters						14325	10000			24325							27000			27000	51325

LABOR																									
Skilled:																									
Drilling per St.	men-days	28	28		19								0	0											
Annual Drilling	men-days	672	1008		342						2022		0	0										0	2022
Excavation per st.	men-days			6.4			10	10	30	30								3	9						
Annual Excav.Wrks	men-days			1600			750	200	20010	600	23160							2025	1620					3657	26817
Civil Wrks.per st.	men-days	18	36	5		1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5				
Annual Civil Wrks.	men-days	432	1296	1250		600	37.5	30	10005	600	14250.5		388.8	1166.4	1125		0		9	1399.9	120			4209.1	19459.6
Mech.Wrks per st.	men-days	3	10	0.6		5			3				0.6	0.6	0.12	0	0								
Ann.Mechanic wrks.	men-days	72	360	150		2500			2001		5083		129.6	648	270		0							1047.6	6130.6
Carp.Wrks per st.	men-days	2	2																						
Ann.Carpentry Wrks.	men-days	48	72								120													0	120
Unskilled:																									
Drilling per St.	men-days	240	240		150								0	0											
Annual Drilling	men-days	5760	8640		2700						17100		0	0										0	17100
Excavation per st.	men-days			6.4					3						0.64					0					
Annual Excav.Wrks	men-days			1600					2001		3601				1440					0				1440	5041
Civil.Wrks per st.	men-days	36	216	5		2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5				
Ann.Civil Wrks.	men-days	864	7776	1250		1000	37.5	30	10005	1800	22762.5		777.6	6996.4	1125		0		9	1399.9	120			10429.	33192.4
Mech.Wrks. per st	men-days	12	12	3.6		12			6				2.4	0.72	0.72	0	0								
Ann.Mechanic Wrks.	men-days	288	432	900		6000			4002		11622		518.4	777.6	1620		0							2916	14538
FUEL CONSUMPTION																									
Drill Rigs per st	Liters	3600	3600		1200								0	0											
Annual Drill Rigs Fuel	Liters	86400	129600		21600						237600													0	237600
Pump Rigs per st	Liters	336	336		0								0	0											
Annual Pump Rigs Fuel	Liters	8064	12096		0						20160													0	20160
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350			80	240	80	0	80	120	360	0	120				
Annual Heavy Vhcl Fuel	Liters	75600	218700	112500	28350	45000	33750	9000	240120	27000	790020		17280	259200	180000		720000	81000	64800		9600		1E+06		2121900
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050			160	480	160	0	40	60	180	60	60				
Annual Light Vhcls Fuel	Liters	100800	170100	112500	25200	52500	13125	8400	93380	21000	597005		34560	544320	360000		360000	40500	32400	559980	4800		2E+06		2533565
EQUIPMENT																									
Drill Rigs per st	Eq-days	24	24		10								0	0											
Annual Drill Rigs Use	Eq-days	576	864		180						1620		0	0										0	1620
Pump Rigs per st	Eq-days	3	3		0								0	0											
Annual Pump Rigs Use	Eq-days	72	108		0						180		0	0										0	180
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30			2	6	2		2	3	9		3				
Annual Heavy Vehcl Use	Eq-days	1680	4860	2500	630	1000	750	200	5336	600	17556		432	6480	4500		18000	2025	1620		240			33297	50853
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30			8	24	8		2	3	9	3	3				
Annual Light Vhcls Use	Eq-days	2880	8640	2500	720	1500	375	240	2668	600	20123		1728	25920	18000		18000	2025	1620	27999	240			95532	115655

I. 1984 Baseline Estimates

B. Exhibit 2: Low Estimates
- Level I Submodel

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 2: LOW ESTIMATES OF 1984 POPULATION, RATES OF CONSUMPTION, AND EXISTING STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	100	persons	40	liters	365	1000	1460	99	1445	1	15
Urban SP	1150	persons	10	liters	365	1000	4198	97	4072	3	126
Rural Set	1450	persons	8	liters	365	1000	4234	90	3811	10	423
Nomadic	2300	persons	5	liters	365	1000	4198	85	3568	15	630
SUBTOTAL1	5000	persons					14089		12895		1194
ANIMAL											
Camels	4000	Animals	18	liters	365	1000	26280	60	15768	40	10512
Cattle	3800	Animals	18	liters	365	1000	24966	75	18725	25	6242
SheepGoats	25000	Animals	2.5	liters	365	1000	22813	70	15969	30	6844
OtherAn	8000	Animals	2.5	liters	365	1000	7300	5	365	95	6935
SUBTOTAL2	10170	LSU					81359		50826		30532
AGRICULTURE											
Irrigfarm	45	Hectares	68	M^3	365	1	1116900	80	893520	20	223380
Rainfarm	540	Hectares	35	M^3	120	1	2268000	1	22680	99	2245320
Floodfarm	100	Hectares	25	M^3	90	1	225000	1	2250	99	222750
SUBTOTAL3	685	Hectares					3609900		918450		2691450
GOVT/IND											
Govt	2	Estabs	10	M^3	300	1	6000	100	6000	0	^
Industry	.3	Estabs	5	M^3	300	1	450	100	450	0	0
SUBTOTAL4							6450		6450		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1250	persons	5658	97	5517	70	10	10	5	0	5	0
Rural Set	1450	persons	4234	90	3811	15	40	15	10	5	15	0
Nomadic	2300	persons	4198	85	3568	10	30	20	15	15	10	0
SUBTOTAL1	5000	persons	14089		12895							
ANIMAL												
Camels	4000	Animals	26280	60	15768	7	15	25	20	28	5	0
Cattle	3800	Animals	24966	75	18725	10	30	20	20	15	5	0
SheepGoats	25000	Animals	22813	70	15969	8	30	20	15	20	7	0
OtherAnim	8000	Animals	7300	5	365	7	25	20	20	23	5	0
SUBTOTAL2	10170	LSU	81359		50826							
AGRICULTURE												
Irrigfarm	45	Hectares	1116900	80	893520	2.5	.5	90	1	1	0	5
Rainfarm	540	Hectares	2268000	1	22680	0	0	0	0	0	0	100
Otherfarm	100	Hectares	225000	1	2250	0	0	0	0	0	0	100
SUBTOTAL3	685	Hectares	3609900		918450							
GOVT/IND.												
Govt.	2	Estabs	6000	100	6000	90	5	3	2	0	0	0
Industry	.3	Estabs	450	100	450	85	10	3	2	0	0	0
SUBTOTAL4			6450		6450							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1250	persons	5658	97	5517	3862	552	552	276	0	276	0
Rural Set	1450	persons	4234	90	3811	572	1524	572	381	191	572	0
Nomadic	2300	persons	4198	85	3568	357	1070	714	535	535	357	0
SUBTOTAL1	5000	persons	14089		12895	4790	3146	1837	1192	726	1204	0
ANIMAL												
Camels	4000	Animals	26280	60	15768	1104	2365	3942	3154	4415	788	0
Cattle	3800	Animals	24966	75	18725	1872	5617	3745	3745	2809	936	0
SheepGoats	25000	Animals	22813	70	15969	1278	4791	3194	2395	3194	118	0
OtherAnim	8000	Animals	7300	5	365	26	91	73	73	84	18	0
SUBTOTAL2	10170	LSU	81359		50826	4279	12864	10954	9367	10501	2861	0
AGRICULTURE												
Irrigfarm	45	Hectares	1116900	35	893520	22338	4468	804168	8935	8935	0	44676
Rainfarm	540	Hectares	2268000	1	22680	0	0	0	0	0	0	22680
Floodfarm	100	Hectares	225000	1	2250	0	0	0	0	0	0	2250
SUBTOTAL3	685	Hectares	3609900		918450	22338	4468	804168	8935	8935	0	69606
GOVT/IND.												
Govt.	2	Estabs	6000	100	6000	5400	300	180	120	0	0	0
Industry	.3	Estabs	450	100	450	383	45	14	9	0	0	0
SUBTOTAL4			6450		6450	5783	345	194	129	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/yr)					988622	37190	20823	817152	19623	20162	4065	69606
VOLUME OUTPUT		(M^3*K/str/yr)				74.38004	2.0323325	326.86081	1.3082068	2.0162326	.5419885	27.8424
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				413	6	1307	11	22	9	464
NOS OF WATER SUPPLY STRUCTURES						500	10000	2500	15000	10000	7500	2500
COMMERCIAL SCALE STRUCTURES						500	1250	2500	500	100	7500	50
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						50	125	250	50	10	500	10

I. 1984 Baseline Estimates

C. Exhibit 3: High Estimates
- Level I Submodel

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 3: HIGH ESTIMATES OF 1984 POPULATION, RATES OF CONSUMPTION, AND EXISTING STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTPOL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	130	persons	80	liters	365	1000	3796	99	3758	1	38
Urban EP	1620	persons	15	liters	365	1000	8870	97	8603	3	266
Rural Set	2035	persons	12	liters	365	1000	8913	90	8022	10	891
Nomadic	3100	persons	8	liters	365	1000	9052	85	7694	15	1358
SUBTOTAL1	6885	persons					30631		28078		2553
ANIMAL											
Camels	6000	Animals	25	liters	365	1000	54750	60	32850	40	21900
Cattle	4200	Animals	25	liters	365	1000	38325	75	28744	25	9581
SheepGoats	30000	Animals	3	liters	365	1000	32850	70	22995	30	9855
OtherAn	10000	Animals	3	liters	365	1000	10950	5	548	95	10403
SUBTOTAL2	13115	LSU					136875		85136		51739
AGRICULTURE											
Irrigfarm	65	Hectares	68	M^3	365	1	1613300	80	1290640	20	322660
Rainfarm	978	Hectares	35	M^3	120	1	4107600	1	41076	99	4066524
Floodfarm	54	Hectares	25	M^3	90	1	121500	1	1215	99	120285
SUBTOTAL3	1097	Hectares					5842400		1332931		4509469
GOVT/IND											
Govt	2	Estabs	21	M^3	300	1	12600	100	12600	0	0
Industry	.5	Estabs	8	M^3	300	1	1200	100	1200	0	0
SUBTOTAL4							13800		13800		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1750	persons	12666	97	12361	70	10	10	5	0	5	0
Rural Set	2035	persons	8913	90	8022	15	40	15	10	5	15	0
Nomadic	3100	persons	9052	85	7694	10	30	20	15	15	10	0
SUBTOTAL1	6885	persons	30631		28078							
ANIMAL												
Camels	6000	Animals	54750	60	32850	7	15	25	20	28	5	0
Cattle	4200	Animals	38325	75	28744	10	30	20	20	15	5	0
SheepGoats	30000	Animals	32850	70	22995	8	30	20	15	20	7	0
OtherAnim	10000	Animals	10950	5	548	7	25	20	20	23	5	0
SUBTOTAL2	13115	LSU	136875		85136							
AGRICULTURE												
Irrigfarm	65	Hectares	1613300	80	1290640	2	.5	90	1	1	0	5.5
Rainfarm	978	Hectares	4107600	1	41076	0	0	0	0	0	0	100
Otherfarm	54	Hectares	121500	1	1215	0	0	0	0	0	0	100
SUBTOTAL3	1097	Hectares	5842400		1332931							
GOVT/IND.												
Govt.	2	Estabs	12600	100	12600	80	10	5	5	0	0	0
Industry	.5	Estabs	1200	100	1200	75	15	5	5	0	0	0
SUBTOTAL4			13800		13800							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1750	persons	12666	97	12361	8653	1236	1236	618	0	618	0
Rural Set	2035	persons	8913	90	8022	1203	3209	1203	802	401	1203	0
Nomadic	3100	persons	9052	85	7694	769	2308	1539	1154	1154	769	0
SUBTOTAL1	6885	persons	30631		28078	10626	6753	3978	2574	1555	2591	0
ANIMAL												
Camels	6000	Animals	54750	60	32850	2300	4928	8213	6570	9198	1643	0
Cattle	4200	Animals	38325	75	28744	2874	8623	5749	5749	4312	1437	0
SheepGoats	30000	Animals	32850	70	22995	1840	6899	4599	3449	4599	1610	0
OtherAnim	10000	Animals	10950	5	548	38	137	110	110	126	27	0
SUBTOTAL2	13115	LSU	136875		85136	7052	20586	18670	15878	18234	4717	0
AGRICULTURE												
Irrigfarm	65	Hectares	1613300	35	1290640	25813	6453	1161576	12906	12906	0	70985
Rainfarm	978	Hectares	4107600	1	41076	0	0	0	0	0	0	41076
Floodfarm	54	Hectares	121500	1	1215	0	0	0	0	0	0	1215
SUBTOTAL3	1097	Hectares	5842400		1332931	25813	6453	1161576	12906	12906	0	113276
GOVT/IND.												
Govt.	2	Estabs	12600	100	12600	10080	1260	630	630	0	0	0
Industry	.5	Estabs	1200	100	1200	900	180	60	60	0	0	0
SUBTOTAL4			13800		13800	10980	1440	690	690	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/yr)					1459945	54470	35232	1184914	32048	32696	7308	113276
VOLUME OUTPUT/STR		(M^3*K/str/yr)				77.814763	1.4680164	157.98854	1.5261095	2.3354369	.48716672	15.103493
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				432	4	632	13	26	8	252
NOS OF WATER SUPPLY STRUCTURES						700	24000	7500	21000	14000	15000	7500
COMMERCIAL SCALE STRUCTURES						700	4000	7500	1050	280	15000	150
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						70	400	750	105	28	1000	30

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II. 1990 Projections/Forecasts

A. Exhibit 4: Middle Level Projections
- Level I Submodel
- Level II Submodel
- Level III Submodel
- Level III Submodel with Rehabilitation

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 4: MIDDLE LEVEL PROJECTIONS OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	174	persons	100	liters	365	1000	6351	99	6287	1	64
Urban SP	1567	persons	25	liters	365	1000	14299	98	14013	2	286
Rural Set	1853	persons	15	liters	365	1000	10145	95	9638	5	507
Nomadic	2757	persons	10	liters	365	1000	10063	90	9057	10	1006
SUBTOTAL1	6351	persons					40858		38995		1863
ANIMAL											
Camels	5308	Animals	25	liters	365	1000	48436	65	31483	35	16952
Cattle	4246	Animals	25	liters	365	1000	38745	80	30996	20	7749
SheepGoats	28661	Animals	3	liters	365	1000	31384	75	23538	25	7846
OtherAn	10615	Animals	3	liters	365	1000	11623	5	581	95	11042
SUBTOTAL2	12292	LSU					130187		86598		43590
AGRICULTURE											
Irrigfarm	64	Hectares	68	M^3	365	1	1588480	85	1350208	15	238272
Rainfarm	804	Hectares	35	M^3	120	1	3376800	2	67536	98	3309264
Floodfarm	161	Hectares	25	M^3	90	1	362250	2	7245	98	355005
SUBTOTAL3	1029	Hectares					5327530		1424989		3902541
GOVT/IND.											
Govt	2	Estabs	13	M^3	300	1	7800	100	7800	0	0
Industry	.73	Estabs	8	M^3	300	1	1752	100	1752	0	0
SUBTOTAL4							9552		9552		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	DARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1741	persons	20650	98	20300	75	10	10	2	0	3	0
Rural Set	1853	persons	10145	95	9638	20	45	15	5	2	13	0
Nomadic	2757	persons	10063	90	9057	15	35	20	10	10	10	0
SUBTOTAL1	6351	persons	40858		38995							
ANIMAL												
Camels	5308	Animals	48436	65	31483	10	20	20	20	25	5	0
Cattle	4246	Animals	38745	80	30996	15	35	15	20	10	5	0
SheepGoats	28661	Animals	31384	75	23538	10	35	17	15	16	7	0
OtherAnim	10615	Animals	11623	5	581	8	30	17	20	20	5	0
SUBTOTAL2	12292	LSU	130187		86598							
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	3	1	90	1	1	0	4
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	100
Otherfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	100
SUBTOTAL3	1029	Hectares	5327530		1424989							
GOVT/IND.												
Govt.	2	Estabs	7800	100	7600	92	5	3	0	0	0	0
Industry	.73	Estabs	1752	100	1752	87	10	3	0	0	0	0
SUBTOTAL4			9552		9552							

Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1741	persons	20650	98	20300	15225	2030	2030	406	0	609	0
Rural Set	1853	persons	10145	95	9638	1928	4337	1446	482	193	1253	0
Nomadic	2757	persons	10063	90	9057	1359	3170	1811	906	906	906	0
SUBTOTAL1	6351	persons	40858		38995	18511	9537	5287	1794	1098	2768	0
ANIMAL												
Camels	5308	Animals	48436	65	31483	3148	6297	6297	6297	7871	1574	0
Cattle	4246	Animals	38745	80	30996	4649	10849	4649	6199	3100	1550	0
SheepGoats	28661	Animals	31384	75	23538	2354	8238	4001	3531	3766	1648	0
OtherAnim	10615	Animals	11623	5	581	46	174	99	116	116	29	0
SUBTOTAL2	12292	LSU	130187		86598	10198	25558	15046	16143	14853	4801	0
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	5327530		1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	7176	390	234	0	0	0	0
Industry	.73	Estabs	1752	100	1752	1524	175	53	0	0	0	0
SUBTOTAL4			9552		9552	8700	565	287	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1560134	77916	49162	1235807	31438	29453	7568	128789
VOLUME OUTPUT/STR		(M^3*K/str/yr)				78.26272	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5008
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				435	4	800	11	24	9	275
NOS OF WATER SUPPLY STRUCTURES						996	31510	6180	22860	13774	14166	7805
COMMERCIAL SCALE STRUCTURES						996	4634	6180	953	230	14166	156
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENTS						100	463	618	95	23	944	31

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

Projections of Requirements for New Water Supply Structures for Somalia 1985 - 1990, at Prevailing Useful Life..*.*.*

STRUCTURE YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	653	710	773	841	915	996
Old Wells	325	293	260	228	195	163	130	98	65	33	0
(Prev. New wells)	-	41	126	226	306	374	453	535	622	714	811
Needed New Wells	41	89	113	102	99	116	127	140	154	169	185
DUG WELLS											
Needed Total Dug Wells					2500	2771	3071	3404	3772	4181	4634
Old Dug Wells					2250	2025	1800	1575	1350	1125	900
(Prev. New Dug Wells)					-	250	721	1199	1709	2252	2831
Needed New Dug Wells					250	496	550	630	714	805	903
INTAKES											
Needed Total Intakes					5000	5180	5366	5559	5759	5966	6180
Old Intakes					4500	4050	3600	3150	2700	2250	1800
(Prev. New Intakes)					-	500	1080	1658	2243	2834	3432
Needed New Intakes					500	630	686	751	816	881	948
UARS											
Needed Total Uars					750	781	812	845	880	916	953
Old Uars					675	608	540	473	405	338	270
(Prev. New Uars)					-	75	166	256	347	440	534
Needed New Uars					75	98	107	117	128	138	149
BALLEHS											
Needed Total Ballehs					200	205	210	214	220	225	230
Old Ballehs					180	162	144	126	108	90	72
(Prev. New Ballehs)					-	20	41	61	82	103	124
Needed New Ballehs					20	23	25	27	29	31	34
BURKEDS											
Needed Total Burkeds					10000	10598	11231	11902	12613	13367	14166
Old Burkeds					9333	8711	8089	7466	6844	6222	5600
(Prev. New Burkeds)					-	667	1842	3020	4234	5487	6780
Needed New Burkeds					667	1220	1300	1416	1535	1658	1787
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	64	48	32	16	0	0
(Prev. New Dams)					-	20	40	60	81	102	124
Needed New Dams					20	24	28	33	38	43	32

*Projections of Requirements for New Drilled Wells for Somalia 1985 - 1990 if Enhanced Rehabilitation Efforts Enhance Useful Life.

DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	653	710	773	841	915	996
Old Wells	325	293	260	228	195	163	130	98	65	33	0
(Prev. New wells)	-	41	126	226	306	374	465	549	639	734	834
Needed New Wells	41	89	113	102	99	116	115	126	137	149	162

LEVEL III SUBMODEL

Please Turn Over

WATER SYSTEM MATRIX:MIDDLE LEVEL
1990 PROJECTIONS

INPUTS	OUTPUTS Measure	CONSTRUCTION: WELLS H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES: Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION: WELLS HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	111	74	903	56	948	149	34	1787	32											
UL	Years	15	15	10		10	10	5	15	5											
MP	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											324	1622	3731	10464	804	196	12380	124		
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	777	14800	6321	280	3792	0	0	5361	0	31331	226.8	9732	2611.7		0	321.6	0	0	0	12892.	44223.1
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7	
Annual stones	cubic meters			14448		9480	0	0	12509	20480	56917			5969.6		0	804	0	0	86.8	6860.4	63777.4
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	555	2590								3145	162	1703.1								1866.6	5011.65
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	222	8880	1806					3574	0	14482	64.8	5839.2						0	24.8	5928.8	20410.8
8" Steel Casing per st	meters	75	7[illegible]																		
Ann.8"Steel Casing	meters	8325	5550								13875										0	13875
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	4995	3330								8325										0	8325
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	666	444		0						1110										0	1110
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	22.2	74	90.3					893.5		1080										0	1080
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	14800	0		14220			17870		46890	0	9732	0		0			0		9740.5	56630.5
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	2775	1850		280						4905	0	0								0	4905
Hand Pump per st	units	1		0.2								0.2		0.4							
Annual Hand Pumps	units	111		180.6							291.6	64.8		1492.4							1557.8	1849.4
Diesel Pump per st	units		1			1							0.04			0.2					
Annual Diesel Pumps	units		74			948					1022		64.88			2092.8					2157.6	3179.68
Rebars & Wood per st	meters		30						20										3		
Annual Rebars&Wood	meters		2220						35740		37960								37140		37140	75100
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						28459	10000			38459						29400				29400	67859

LABOR

Skilled:

Drilling per St.	men-days	28	28	19								0	0										
Annual Drilling	men-days	3108	2072	1064						6244		0	0									0	6244
Excavation per st.	men-days			6.4		10	10	30	30							3	9						
Annual Excav.Wrks	men-days			5779.2		1490	340	53610	960	62179.2						2412	1764					4188	66367.2
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5			
Annual Civil Wrks.	men-days	1998	2664	4515	1137.6	74.5	51	26805	960	38205.1		583.2	1751.7	1865.5		0		9.8	1857	186		6253.2	44458.3
Mech.Wrks per st.	men-days	3	10	0.6	5			3				0.6	0.6	0.12	0	0							
Ann.Mechanic Wrks.	men-days	333	740	541.8	4740			5361		11715.8		194.4	973.2	447.72		0						1615.3	13331.1
Carp.Wrks per st.	men-days	2	2																				
Ann.Carpentry Wrks.	men-days	222	148							370												0	370

Unskilled:

Drilling per St.	men-days	240	240	150								0	0										
Annual Drilling	men-days	26640	17760	8400						52800		0	0									0	52800
Excavation per st.	men-days			6.4				3						0.34					0				
Annual Excav.Wrks	men-days			5779.2				5361		11140.2				2387.8					0			2387.8	13528.0
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5			
Ann.Civil Wrks.	men-days	3996	15984	4515	1896	74.5	51	26805	2880	56201.5		1166.	10510.	1865.5		0		9.8	1857	186		15595.	71796.7
Mech.Wrks. per st	men-days	12	12	3.6	12			6				2.4	0.72	0.72	0	0							
Ann.Mechanic Wrks.	men-days	1332	888	3250.8	11376			10722		27568.8		777.6	1167.8	2686.3		0						4631.7	32200.5

FUEL CONSUMPTION

Drill Rigs per st	Liters	3600	3600	1200								0	0										
Annual Drill Rigs Fuel	Liters	399600	266400	67200						733200												0	733200
Pump Rigs per st	Liters	336	336	0								0	0										
Annual Pump Rigs Fuel	Liters	37296	24864	0						62160												0	62160
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120			
Annual Heavy Vhcl Fuel	Liters	349650	449550	406350	88200	85320	67050	15300	643320	43200	2147940	25920	389280	298480		837120	96480	70560		14880		2E+06	3880660
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60			
Annual Light Vhcls Fuel	Liters	466200	349650	406350	78400	99540	26075	14280	250180	33600	1724275	51840	817498	596960		418560	48240	35280	742800	7440		3E+06	4442883

EQUIPMENT

Drill Rigs per st	Eq-days	24	24	10								0	0										
Annual Drill Rigs Use	Eq-days	2664	1776	560						5000		0	0									0	5000
Pump Rigs per st	Eq-days	3	3	0								0	0										
Annual Pump Rigs Use	Eq-days	333	222	0						555		0	0									0	555
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3			
Annual Heavy Vehcl Use	Eq-days	7770	9990	9030	1960	1896	1490	340	14296	960	47732	648	9732	7462		20928	2412	1764		372		43318	91050
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3			
Annual Light Vhcls Use	Eq-days	13320	17760	9030	2240	2844	745	408	7148	960	54455	2592	38928	29848		20928	2412	1764	37140	372		133984	188439
Other Light Eq per st	Eq-days																						

LEVEL III SUBMODEL

With Rehabilitation

Please Turn Over

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WATER SYSTEM MATRIX:MIDDLE LEVEL
1990 PROJECTIONS
WITH REHABILITATION

INPUTS	OUTPUTS Measure	CONSTRUCTION WELLS H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION WELLS HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	65	97	903	48	149	804	34	1787	32											
UL	Years	15	15	10		10	10	5	15	5											
MP	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											334	1668	3731	10464	804	196	12380	124		
WRP	Years											5	2								
AWRR	Number of struct.											67	250								
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	455	19400	6321	240	596	0	0	5361	0	32373	233.8	10008	2611.7		0	32[illegible].6	0	0	0	13175.	45548.1
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7	
Annual stones	cubic meters			14448		1490	0	0	12509	20480	48927			5969.6		0	804	0	0	86.8	6860.4	55787.4
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	325	3395								3720	167	1751.4								1919.9	5639.95
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	130	11640	1806					3574	0	17150	66.8	6004.8						0	24.8	6096.4	23246.4
8" Steel Casing per st	meters	75	75																		
Ann.8"Steel Casing	meters	4875	7275								12150										0	12150
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	2925	4355								7290										0	7290
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	390	582		0						972										0	972
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	13	97	90.3					893.5		1093.8										0	1093.8
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	19400	0		2235			17870		39505	0	10008	0		0			0		10916.	49521.5
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	1625	2425		240						4290	0	0								0	4290
Hand Pump per st	units	1		0.2								0.2		0.4							
Annual Hand Pumps	units	65		180.6							245.6	66.8		1492.4							1559.8	1805.4
Diesel Pump per st	units		1			1							0.04			0.2					
Annual Diesel Pumps	units		97			149					246		66.72			2092.8					2159.5	2405.52
Rebars & Wood per st	meters		30						20										3		
Annual Rebars&Wood	meters		2910						35740		38650								37140		37140	75790
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						153564	10000			163564						29400				29400	192964

LABOR																								
Skilled:																								
Drilling per St.	men-days	28	28	19								0	0											
Annual Drilling	men-days	1820	2716	912						5448		0	0										0	5448
Excavation per st.	men-days		6.4			10	10	30	30							3	9							
Annual Excav.Wrks	men-days		5779.2			8040	340	53610	960	68729.2						2412	1764						4188	72917.2
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30		1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5					
Annual Civil Wrks.	men-days	1170	3492	4515	178.8	402	51	26805	960	37573.8	601.2	1801.4	1865.5		0		9.8	1857	186	6320.9	43894.7			
Mech.Wrks per st.	men-days	3	10	0.6	5			3			0.6	0.6	0.12	0	0									
Ann.Mechanic Wrks.	men-days	195	970	541.8	745			5361		7812.8	200.4	1000.8	447.72		0					1648.9	9461.72			
Carp.Wrks per st.	men-days	2	2																					
Ann.Carpentry Wrks.	men-days	130	194							324										0	324			
Unskilled:																								
Drilling per St.	men-days	240	240	150								0	0											
Annual Drilling	men-days	15600	23280	7200						46080		0	0										0	46080
Excavation per st.	men-days		6.4					3					0.64					0						
Annual Excav.Wrks	men-days		5779.2					5361		11140.2			2387.8					0		2387.8	13528.0			
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90		3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5					
Ann.Civil Wrks.	men-days	2340	20952	4515	298	402	51	26805	2880	58243	1202.	10808.	1865.5		0		9.8	1857	186	15929.	74172.3			
Mech.Wrks. per st	men-days	12	12	3.6	12			6			2.4	0.72	0.72	0	0									
Ann.Mechanic Wrks.	men-days	780	1164	3250.8	1788			10722		17704.0	801.6	1200.9	2686.3		0					4688.8	22393.6			
FUEL CONSUMPTION																								
Drill Rigs per st	Liters	3600	3600	1200								0	0											
Annual Drill Rigs Fuel	Liters	234000	349200	57600						640800													0	640800
Pump Rigs per st	Liters	336	336	0								0	0											
Annual Pump Rigs Fuel	Liters	21840	32592	0						54432													0	54432
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120				
Annual Heavy Vhcl Fuel	Liters	204750	589275	406350	75600	13410	361800	15300	643320	43200	2353005	26720	400320	298480		837120	96480	70560		14880	2E+06	4097565		
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60				
Annual Light Vhcls Fuel	Liters	273000	458325	406350	67200	15645	140700	14280	250180	33600	1659280	53440	840672	596960		418560	48240	35280	742800	7440	3E+06	4402672		
EQUIPMENT																								
Drill Rigs per st	Eq-days	24	24	10								0	0											
Annual Drill Rigs Use	Eq-days	1560	2328	480						4368		0	0										0	4368
Pump Rigs per st	Eq-days	3	3	0								0	0											
Annual Pump Rigs Use	Eq-days	195	291	0						486		0	0										0	486
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3				
Annual Heavy Vehcl Use	Eq-days	4550	13095	9030	1680	298	8040	340	14296	960	52289	668	10008	7462		20928	2412	1764		372	43614	95903		
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3				
Annual Light Vhcls Use	Eq-days	7800	23280	9030	1920	447	4020	408	7148	960	55013	2672	40032	29848		20928	2412	1764	37140	372	135168	190181		
Other Light Eq per st	Eq-days																							

II. 1990 Projections/Forecasts

B. Exhibit 5: Low Projections
- Level I Submodel
- Level II Submodel
- Level III Submodel

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WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 5: LOW-LEVEL PROJECTIONS OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	142	persons	80	liters	365	1000	4146	99	4105	1	41
Urban SP	1440	persons	20	liters	365	1000	10512	98	10302	2	210
Rural Set	1731	persons	12	liters	365	1000	7582	91	6899	9	682
Nomadic	2485	persons	8	liters	365	1000	7256	86	6240	14	1016
SUBTOTAL1	5798	persons					29496		27546		1950
ANIMAL											
Camels	4122	Animals	20	liters	365	1000	30091	61	18355	39	11735
Cattle	3915	Animals	20	liters	365	1000	28580	76	21720	24	6859
SheepGoats	25759	Animals	3	liters	365	1000	28206	71	20026	29	8180
OtherAn	8243	Animals	3	liters	365	1000	9026	5	451	95	8575
SUBTOTAL2	10479	LSU					95902		60553		35349
AGRICULTURE											
Irrigfarm	48	Hectares	68	M^3	365	1	1191360	81	965002	19	226358
Rainfarm	626	Hectares	35	M^3	120	1	2629200	1	26292	99	2602908
Floodfarm	116	Hectares	25	M^3	90	1	261000	1	2610	99	258390
SUBTOTAL3	790	Hectares					4081560		993904		3087656
GOVT/IND.											
Govt	2	Estabs	10	M^3	300	1	6000	100	6000	0	0
Industry	.4	Estabs	6.7	M^3	300	1	804	100	804	0	0
SUBTOTAL4							6804		6804		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1582	persons	14658	98	14407	72	10	10	3	0	5	0
Rural Set	1731	persons	7582	91	6899	17	40	15	10	3	15	0
Nomadic	2485	persons	7256	86	6240	12	35	20	13	10	10	0
SUBTOTAL1	5798	persons	29496		27546							
ANIMAL												
Camels	4122	Animals	30091	61	18355	6	15	24	20	28	5	0
Cattle	3915	Animals	28580	81	21720	11	30	19	20	15	5	0
SheepGoats	25759	Animals	28206	71	20026	9	30	19	15	20	7	0
OtherAnim	8243	Animals	9026	5	451	8	25	19	20	23	5	0
SUBTOTAL2	10479	LSU	95902		60553							
AGRICULTURE												
Irrigfarm	48	Hectares	1191360	81	965002	3	.5	90	1	1	0	4.5
Rainfarm	626	Hectares	2629200	1	26292	0	0	0	0	0	0	100
Otherfarm	116	Hectares	261000	1	2610	0	0	0	0	0	0	100
SUBTOTAL3	790	Hectares	4081560		993904							
GOVT/IND.												
Govt.	2	Estabs	6000	100	6000	92	7	1	0	0	0	0
Industry	.4	Estabs	804	100	804	87	12	1	0	0	0	0
SUBTOTAL4			6804		6804							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1582	persons	14658	98	14407	10373	1441	1441	432	0	720	0
Rural Set	1731	persons	7582	91	6899	1173	2760	1035	690	207	1035	0
Nomadic	2485	persons	7256	86	6240	749	2184	1248	811	624	624	0
SUBTOTAL1	5798	persons	29496		27546	12295	6385	3724	1933	831	2379	0
ANIMAL												
Camels	4122	Animals	30091	61	18355	1468	2753	4405	3671	5139	918	0
Cattle	3915	Animals	28580	76	21720	2389	6516	4127	4344	3258	1086	0
SheepGoats	25759	Animals	28206	71	20026	1802	6008	3805	3004	4005	1402	0
OtherAnim	8243	Animals	9026	5	451	36	113	86	90	104	23	0
SUBTOTAL2	10479	LSU	95902		60553	5696	15370	12423	11109	12507	3428	0
AGRICULTURE												
Irrigfarm	48	Hectares	1191360	81	965002	28950	4825	868501	9650	9650	0	43425
Rainfarm	626	Hectares	2629200	1	26292	0	0	0	0	0	0	26292
Floodfarm	116	Hectares	261000	1	2610	0	0	0	0	0	0	2610
SUBTOTAL3	790	Hectares	4081560		993904	28950	4825	868501	9650	9650	0	72327
GOVT/IND.												
Govt.	2	Estabs	6000	100	6000	5520	420	60	0	0	0	0
Industry	.4	Estabs	804	100	804	699	96	8	0	0	0	0
SUBTOTAL4			6804		6804	6219	516	68	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1088807	53160	27116	884716	22693	22988	5807	72327
VOLUME OUTPUT/STR		(M^3*K/str/yr)				74.38004	2.0823325	326.86081	1.3082066	2.0162326	.5419885	27.8424
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				413	6	1307	11	22	9	464
NOS OF WATER SUPPLY STRUCTURES						715	13022	2707	17346.	11401	10715	2598
COMMERCIAL SCALE STRUCTURES						715	1628	2707	578	114	10715	52
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						71	163	271	58	11	714	10

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

Projections of Requirements for New Water Supply Structures for Somalia, 1985 - 1990, at Prevailing Useful Life..*.*.*

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	241	310	386	448	500	531	563	598	635	674	715
Old Wells	200	180	160	140	120	100	80	60	40	20	0
(Prev. New wells)	-	41	126	213	287	351	396	444	494	545	599
Needed New Wells	41	89	100	95	93	79	88	94	101	108	116
DUG WELLS											
Needed Total Dug Wells					1250	1306	1365	1427	1491	1558	1628
Old Dug Wells					1125	1013	900	788	675	563	450
(Prev. New Dug Wells)					-	125	281	437	595	756	920
Needed New Dug Wells					125	169	184	202	220	239	258
INTAKES											
Needed Total Intakes					2500	2533	2567	2601	2636	2671	2707
Old Intakes					2250	2025	1800	1575	1350	1125	900
(Prev. New Intakes)					-	250	483	719	955	1191	1427
Needed New Intakes					250	258	284	308	332	356	380
UARS											
Needed Total Uars					500	512	525	538	551	564	578
Old Uars					450	405	360	315	270	225	180
(Prev. New Uars)					-	50	102	155	207	260	313
Needed New Uars					50	57	63	68	74	79	85
BALLEHS											
Needed Total Ballehs					100	102	104	107	109	112	114
Old Ballehs					90	81	72	63	54	45	36
(Prev. New Ballehs)					-	10	20	30	41	51	61
Needed New Ballehs					10	11	12	13	14	15	17
BURKEDS											
Needed Total Burkeds					7500	7959	8447	8965	9514	10096	10715
Old Burkeds					7000	6533	6067	5600	5133	4667	4200
(Prev. New Burkeds)					-	500	1393	2288	3212	4166	5152
Needed New Burkeds					500	926	988	1077	1168	1264	1363
DAMS											
Needed Total Dams					50	50	51	51	51	52	52
Old Dams					40	32	24	16	8	0	0
(Prev. New Dams)					-	10	16	23	30	37	44
Needed New Dams					10	8	10	12	13	14	8

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LEVEL III SUBMODEL

Please Turn Over

WATER SYSTEM MATRIX:LOW LEVEL
1990 PROJECTIONS

INPUTS	OUTPUTS Measure	CONSTRUCTION: WELLS: H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES: Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION: WELLS: HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Uars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	46	70	258	35	380	85	17	1363	8											
UL	Years	15	15	10		10	10	5	15	5											
MP	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											240	1198	1370	4650	493	97	9352	44		
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	322	14000	1806	175	1520	0	0	4089	0	21912	168	7188	959		0	197.2	0	0	0	8512.2	30424.2
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7	
Annual stones	cubic meters			4128		3800	0	0	9541	5120	22589			2192		0	493	0	0	30.8	2715.8	25304.8
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	230	2450								2680	120	1257.9								1379.4	4059.45
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	92	8400	516					2726	0	11734	48	4312.8						0	8.8	4369.6	16103.6
8" Steel Casing per st	meters	75	75																		
Ann.8"Steel Casing	meters	3450	5250								8700										0	8700
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	2070	3150								5220										0	5220
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	276	420		0						696										0	696
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	9.2	70	25.8					681.5		786.5										0	786.5
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	14000	0		5700			13630		33330	0	7188	0		0			0		7196.5	40526.5
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	1150	1750		175						3075	0	0								0	3075
Hand Pump per st	units	1		0.2								0.3		0.4							
Annual Hand Pumps	units	46		51.6							97.6	48		548							596.6	694.2
Diesel Pump per st	units		1			1							0.04		0.2						
Annual Diesel Pumps	units		70			380					450		47.92		930						977.92	1427.92
Rebars & Wood per st	meters		30						20										3		
Annual Rebars&Wood	meters		2100						27260		29360								28056		28056	57416
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						16235	10000			26235						14550				14550	40785

LABOR

Skilled:

Drilling per St.	men-days	28	28	19								0	0											
Annual Drilling	men-days	1288	1960	665							3913	0	0										0	3913
Excavation per st.	men-days			6.4			10	10	30	30							3	9						
Annual Excav.Wrks	men-days			1651.2			850	170	40890	240	43801.2						1479	873					2364	46165.2
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5				
Annual Civil Wrks.	men-days	828	2520	1290	456	42.5	25.5	20445	240	25847		432	1293.8	685		0		4.85	1402.8	66		3884.4		29731.4
Mech.Wrks per st.	men-days	3	10	0.6	5			3				0.6	0.6	0.12	0	0								
Ann.Mechanic Wrks.	men-days	138	700	154.8	1900			4089			6981.8	144	718.8	164.4		0							1027.2	8009
Carp.Wrks per st.	men-days	2	2																					
Ann.Carpentry Wrks.	men-days	92	140								232												0	232

Unskilled:

Drilling per St.	men-days	240	240	150								0	0											
Annual Drilling	men-days	11040	16800	5250							33090	0	0										0	33090
Excavation per st.	men-days			6.4				3						0.64					0					
Annual Excav.Wrks	men-days			1651.2				4089			5740.2			876.8					0				876.8	6617
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5				
Ann.Civil Wrks.	men-days	1656	15120	1290	760	42.5	25.5	20445	720	40059		864	7763.0	685		0		4.85	1402.8	66		10785.		50844.6
Mech.Wrks. per st	men-days	12	12	3.6	12			6				2.4	0.72	0.72	0	0								
Ann.Mechanic Wrks.	men-days	552	840	928.8	4560			8178			15058.8	576	862.56	986.4		0							2424.9	17483.7

FUEL CONSUMPTION

Drill Rigs per st	Liters	3600	3600	1200								0	0											
Annual Drill Rigs Fuel	Liters	165600	252000	42000							459600												0	459600
Pump Rigs per st	Liters	336	336	0								0	0											
Annual Pump Rigs Fuel	Liters	15456	23520	0							38976												0	38976
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120				
Annual Heavy Vhcl Fuel	Liters	144900	425250	116100	55125	34200	38250	7650	490680	10800	1322955	19200	287520	109600		372000	59160	34920		5280		887680		2210635
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60				
Annual Light Vhcls Fuel	Liters	193200	330750	116100	49000	39900	14875	7140	150820	8400	950185	38400	603792	219200		186000	29580	17460	561120	2640		2E+06		2608377

EQUIPMENT

Drill Rigs per st	Eq-days	24	24	10								0	0											
Annual Drill Rigs Use	Eq-days	1104	1680	350							3134	0	0										0	3134
Pump Rigs per st	Eq-days	3	3	0								0	0											
Annual Pump Rigs Use	Eq-days	138	210	0							348	0	0										0	348
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3				
Annual Heavy Vehcl Use	Eq-days	3220	9450	2580	1225	760	850	170	10904	240	29399	480	7188	2740		9300	1479	873		132		22192		51591
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3				
Annual Light Vhcls Use	Eq-days	5520	16800	2580	1400	1140	425	204	5452	240	33761	1920	28752	10960		9300	1479	873	28056	132		81472		115233

II. 1990 Projections/Forecasts

C. Exhibit 6: High Projections
- Level I Submodel
- Level II Submodel
- Level III Submodel

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 6: HIGH PROJECTIONS OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	281	persons	120	liters	365	1000	12308	99	12185	1	123
Urban SP	2064	persons	30	liters	365	1000	22601	98	22149	2	452
Rural Set	2508	persons	20	liters	365	1000	18308	95	17393	5	915
Nomadic	3416	persons	12	liters	365	1000	14962	90	13466	10	1496
SUBTOTAL1	8269	persons					68179		65192		2987
ANIMAL											
Camels	6757	Animals	30	liters	365	1000	73989	65	48093	35	25896
Cattle	4730	Animals	30	liters	365	1000	51794	80	41435	20	10359
SheepGoats	33785	Animals	3	liters	365	1000	36995	75	27746	25	9249
OtherAn	11262	Animals	3	liters	365	1000	12332	5	617	95	11715
SUBTOTAL2	14769	LSU					175109		117890		57219
AGRICULTURE											
Irrigfarm	87	Hectares	68	M^3	365	1	2159340	85	1835439	15	323901
Rainfarm	1387	Hectares	35	M^3	120	1	5825400	2	116508	98	5708892
Floodfarm	77	Hectares	25	M^3	90	1	173250	2	3465	98	169785
SUBTOTAL3	1551	Hectares					8157990		1955412		6202578
GOVT/IND.											
Govt	2	Estabs	21	M^3	300	1	12600	100	12600	0	0
Industry	.77	Estabs	12	M^3	300	1	2772	100	2772	0	0
SUBTOTAL4							15372		15372		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	2345	persons	34909	98	34334	75	10	10	2	0	3	0
Rural Set	2508	persons	18308	95	17393	20	45	15	5	2	13	0
Nomadic	3416	persons	14962	90	13466	15	35	20	10	10	10	0
SUBTOTAL1	8269	persons	68179		65192							
ANIMAL												
Camels	6757	Animals	73989	65	48093	10	20	20	20	25	5	0
Cattle	4730	Animals	51794	80	41435	15	35	15	20	10	5	0
SheepGoats	33785	Animals	36995	75	27746	10	35	17	15	16	7	0
OtherAnim	11262	Animals	12332	5	617	8	30	17	20	20	5	0
SUBTOTAL2	14769	LSU	175109		117890							
AGRICULTURE												
Irrigfarm	87	Hectares	2159340	85	1835439	3	1	90	1	1	0	4
Rainfarm	1387	Hectares	5825400	2	116508	0	0	0	0	0	0	100
Otherfarm	77	Hectares	173250	2	3465	0	0	0	0	0	0	100
SUBTOTAL3	1551	Hectares	8157990		1955412							
GOVT/IND.												
Govt.	2	Estabs	12600	100	12600	92	5	3	0	0	0	0
Industry	.77	Estabs	2772	100	2772	87	10	3	0	0	0	0
SUBTOTAL4			15372		15372							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	2345	persons	34909	98	34334	25750	3433	3433	687	0	1030	0
Rural Set	2508	persons	18308	95	17393	3479	7827	2609	870	348	2261	0
Nomadic	3416	persons	14962	90	13466	2020	4713	2693	1347	1347	1347	0
SUBTOTAL1	8269	persons	68179		65192	31249	15973	8735	2903	1694	4638	0
ANIMAL												
Camels	6757	Animals	73989	65	48093	4809	9619	9619	9619	12023	2405	0
Cattle	4730	Animals	51794	80	41435	6215	14502	6215	8287	4143	2072	0
SheepGoats	33785	Animals	36995	75	27746	2775	9711	4717	4162	4439	1942	0
OtherAnim	11262	Animals	12332	5	617	49	185	105	123	123	31	0
SUBTOTAL2	14769	LSU	175109		117890	13848	34017	20655	22191	20729	6449	0
AGRICULTURE												
Irrigfarm	87	Hectares	2159340	85	1835439	55063	18354	1651895	18354	18354	0	73418
Rainfarm	1387	Hectares	5825400	2	116508	0	0	0	0	0	0	116508
Floodfarm	77	Hectares	173250	2	3465	0	0	0	0	0	0	3465
SUBTOTAL3	1551	Hectares	8157990		1955412	55063	18354	1651895	18354	18354	0	193391
GOVT/IND.												
Govt.	2	Estabs	12600	100	12600	11592	630	378	0	0	0	0
Industry	.77	Estabs	2772	100	2772	2412	277	83	0	0	0	0
SUBTOTAL4			15372		15372	14004	907	461	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					2153867	114164	69252	1681747	43448	40778	11087	193391
VOLUME OUTPUT/STR		(M^3*K/str/yr)				77.814763	1.4680164	157.98854	1.5261095	2.3354369	.48716672	15.103493
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				432	4	632	13	26	8	252
NOS OF WATER SUPPLY STRUCTURES						1467	47174	10645	28470	17461	22758	12804
COMMERCIAL SCALE STRUCTURES						1467	7862	10645	1423	349	22758	256
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						147	786	1064	142	35	1517	51

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WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

Projections of Requirements for New Water Supply Structures for Somalia 1985 - 1990, at Prevailing Useful Life..*.*.*.

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	521	568	631	673	700	792	896	1013	1146	1297	1467
Old Wells	480	432	384	336	288	240	192	144	96	48	0
(Prev. New wells)	-	41	132	234	313	381	514	652	804	970	1152
Needed New Wells	41	95	115	103	99	171	190	217	246	279	315
DUG WELLS											
Needed Total Dug Wells					4000	4477	5011	5608	6276	7025	7862
Old Dug Wells					3600	3240	2880	2520	2160	1800	1440
(Prev. New Dug Wells)					-	400	1197	2011	2887	3828	4842
Needed New Dug Wells					400	837	934	1077	1230	1397	1580
INTAKES											
Needed Total Intakes					7500	7951	8429	8935	9472	10041	10645
Old Intakes					6750	6075	5400	4725	4050	3375	2700
(Prev. New Intakes)					-	750	1801	2849	3925	5030	6164
Needed New Intakes					750	1126	1228	1362	1497	1637	1781
UARS											
Needed Total Uars					1050	1105	1162	1223	1286	1353	1424
Old Uars					945	851	756	662	567	473	378
(Prev. New Uars)					-	105	244	382	523	667	814
Needed New Uars					105	149	163	179	196	214	232
BALLEHS											
Needed Total Ballehs					280	290	301	313	324	336	349
Old Ballehs					252	227	202	176	151	126	101
(Prev. New Ballehs)					-	28	61	94	127	160	194
Needed New Ballehs					28	36	39	43	46	50	54
BURKEDS											
Needed Total Burkeds					15000	16079	17236	18476	19806	21231	22758
Old Burkeds					14000	13067	12133	11200	10266	9333	8400
(Prev. New Burkeds)					-	1000	2946	4906	6949	9076	11292
Needed New Burkeds					1000	2013	2157	2370	2590	2822	3066
DAMS											
Needed total Dams					150	164	179	196	214	234	256
Old Dams					120	96	72	48	24	0	0
(Prev. New Dams)					-	30	62	95	129	164	201
Needed New Dams					30	38	45	53	61	70	55

LEVEL III SUBMODEL

Please Turn Over

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WATER SYSTEM MATRIX:HIGH LEVEL
1990 PROJECTIONS

INPUTS	OUTPUTS Measure	CONSTRUCTION WELLS H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION WELLS HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	126	189	1580	95	1781	232	54	3066	55											
UL	Years	15	15	10		10	10	5	15	5											
MP	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											461	2304	6282	17728	1192	295	19692	201		
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	882	37800	11060	475	7124	0	0	9198	0	66539	322.7	13824	4397.4		0	476.8	0	0	0	19020.	85559.9
Stones per st	cubic meters			16		10	0	0	7	640				1.6		0	1	0	0	0.7	
Annual stones	cubic meters			25280		17810	0	0	21462	35200	99752			10051.		0	1192	0	0	140.7	11383.	111135.
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	630	6615								7245	230.5	2419.2								2651.2	9896.25
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	252	22680	3160					6132	0	32224	92.2	8294.4						0	40.2	8426.8	40650.8
8" Steel Casing per st	meters	75	75																		
Ann.8"Steel Casing	meters	9450	14175								23625										0	23625
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	5670	8505								14175										0	14175
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	756	1134		0						1890										0	1890
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	25.2	189	158					1533		1905.2										0	1905.2
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	37800	0		26715			30660		95175	0	13824	0		0			0		13832.	109007.
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	3150	4725		475						8350	0	0								0	8350
Hand Pump per st	units	1		0.2								0.2		0.4							
Annual Hand Pumps	units	126		316							442	92.2		2512.8							2605.6	3047.6
Diesel Pump per st	units		1			1							0.04			0.2					
Annual Diesel Pumps	units		189			1781					1970		92.16			3545.6					3637.7	5607.76
Rebars & Wood per st	meters		30						20										3		
Annual Rebars&Wood	meters		5670						61320		66990								59076		59076	126066
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						44312	10000			54312						44250				44250	98562

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LABOR

Skilled:

Drilling per St.	men-days	28	28	19								0	0										
Annual Drilling	men-days	3528	5292	1805							10625	0	0									0	10625
Excavation per st.	men-days			6.4		10	10	30	30								3	9					
Annual Excav.Wrks	men-days			10112		2320	540	91980	1650		106602						3576	2655				6243	112845
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5			
Annual Civil Wrks.	men-days	2268	6804	7900	2137.2	116	81	45990	1650		66946.2	829.8	2488.3	3141		0		14.75	2953.8	301.5		9729.1	76675.3
Mech.Wrks per st.	men-days	3	10	0.6	5			3				0.6	0.6	0.12	0	0							
Ann.Mechanic Wrks.	men-days	378	1890	948	8905			9198			21319	276.6	1382.4	753.84		0						2412.8	23731.8
Carp.Wrks per st.	men-days	2	2																				
Ann.Carpentry Wrks.	men-days	252	378								630											0	630

Unskilled:

Drilling per St.	men-days	240	240	150								0	0										
Annual Drilling	men-days	30240	45360	14250							89850	0	0									0	89850
Excavation per st.	men-days			6.4				3						0.64					0				
Annual Excav.Wrks	men-days			10112				9198			19310			4020.4					0			4020.4	23330.4
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5			
Ann.Civil Wrks.	men-days	4536	40824	7900	3562	116	81	45990	4950		107959	1659.	14929.	3141		0		14.75	2953.8	301.5		23000.	130959.
Mech.Wrks. per st	men-days	12	12	3.6	12			6				2.4	0.72	0.72	0	0							
Ann.Mechanic Wrks.	men-days	1512	2268	5688	21372			18396			49236	1106.	1658.8	4523.0		0						7288.3	56524.3

FUEL CONSUMPTION

Drill Rigs per st	Liters	3600	3600	1200								0	0										
Annual Drill Rigs Fuel	Liters	453600	680400	114000							1248000											0	1248000
Pump Rigs per st	Liters	336	336	0								0	0										
Annual Pump Rigs Fuel	Liters	42336	63504	0							105840											0	105840
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120			
Annual Heavy Vhcl Fuel	Liters	396900	1E+06	711000	149625	160290	104400	24300	1E+06	74250	3872700	36880	552960	502560		1418240	143040	106200		24120		3E+06	6656700
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60			
Annual Light Vhcls Fuel	Liters	529200	893025	711000	133000	187005	40600	22680	429240	57750	3003500	73760	1E+06	1E+06		709120	71520	53100	1E+06	12060		4E+06	7270916

EQUIPMENT

Drill Rigs per st	Eq-days	24	24	10								0	0										
Annual Drill Rigs Use	Eq-days	3024	4536	950							8510	0	0									0	8510
Pump Rigs per st	Eq-days	3	3	0								0	0										
Annual Pump Rigs Use	Eq-days	378	567	0							945	0	0									0	945
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3			
Annual Heavy Vehcl Use	Eq-days	8820	25515	15800	3325	3562	2320	540	24528	1650	86060	922	13024	12564		35456	3576	2655		603		69600	155660
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3			
Annual Light Vhcls Use	Eq-days	15120	45360	15800	3800	5343	1160	648	12264	1650	101145	3688	55296	50256		35456	3576	2655	59076	603		210606	311751
Other Light Eq per st	Eq-days																						

III. Constraint Analysis of 1990 National Objectives

A. Exhibit 7: National Consumption Goals (Full Standards)
- Level I Submodel
- Level II Submodel
- Level III Submodel

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 7: MIDDLE-LEVEL PROJECTIONS OF 1990 POPULATION, WITH NATIONAL CONSUMPTION GOALS: NEEDED STRUCTURES

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	696	persons	130	liters	365	1000	33025	99	32695	1	330
Urban SP	1045	persons	41	liters	365	1000	15638	98	15326	2	313
Rural Set	1853	persons	26	liters	365	1000	17585	95	16706	5	879
Nomadic	2757	persons	26	liters	365	1000	26164	90	23548	10	2616
SUBTOTAL1	6351	persons					92413		88274		4139
ANIMAL											
Camels	5308	Animals	25	liters	365	1000	48436	65	31483	35	16952
Cattle	4246	Animals	25	liters	365	1000	38745	80	30996	20	7749
SheepGoats	28661	Animals	3	liters	365	1000	31384	75	23538	25	7846
OtherAn	10615	Animals	3	liters	365	1000	11623	5	581	95	11042
SUBTOTAL2	12292	LSU					130187		86598		43590
AGRICULTURE											
Irrigfarm	64	Hectares	68	M^3	365	1	1588480	85	1350208	15	238272
Rainfarm	804	Hectares	35	M^3	120	1	3376800	2	67536	98	3309264
Floodfarm	161	Hectares	25	M^3	90	1	362250	2	7245	98	355005
SUBTOTAL3	1029	Hectares					5327530		1424989		3902541
GOVT/IND.											
Govt	2	Estabs	13	M^3	300	1	7800	100	7800	0	0
Industry	.73	Estabs	8	M^3	300	1	1752	100	1752	0	0
SUBTOTAL4							9552		9552		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1741	persons	48664	98	48021	90	8	9	1	0	2	0
Rural Set	1853	persons	17585	95	16706	30	40	15	3	2	10	0
Nomadic	2757	persons	26164	90	23548	30	30	20	5	5	10	0
SUBTOTAL1	6351	persons	92413		88274							
ANIMAL												
Camels	5308	Animals	48436	65	31483	20	15	15	20	25	5	0
Cattle	4246	Animals	38745	80	30996	25	30	10	20	10	5	0
SheepGoats	28661	Animals	31384	75	23538	20	30	12	15	16	7	0
OtherAnim	10615	Animals	11623	5	581	15	25	15	20	20	5	0
SUBTOTAL2	12292	LSU	130187		86598							
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	3	1	90	1	1	0	4
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	100
Otherfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	100
SUBTOTAL3	1029	Hectares	5327530		1424989							
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	95	3	2	0	0	0	0
Industry	.73	Estabs	1752	100	1752	90	7	3	0	0	0	0
SUBTOTAL4			9552		9552							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1741	persons	48664	98	48021	38416	3842	4322	480	0	960	0
Rural Set	1853	persons	17585	95	16706	5012	6682	2506	501	334	1671	0
Nomadic	2757	persons	26164	90	23548	7064	7064	4710	1177	1177	2355	0
SUBTOTAL1	6351	persons	92413		88274	50492	17588	11537	2159	1511	4986	0
ANIMAL												
Camels	5308	Animals	48436	65	31483	6297	4722	4722	6297	7871	1574	0
Cattle	4246	Animals	38745	80	30996	7749	9299	3100	6199	3100	1550	0
SheepGoats	28661	Animals	31384	75	23538	4708	7061	2825	3531	3766	1648	0
OtherAnim	10615	Animals	11623	5	581	87	145	87	116	116	29	0
SUBTOTAL2	12292	LSU	130187		86598	18840	21228	10734	16143	14853	4801	0
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	5327530		1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	7410	234	156	0	0	0	0
Industry	.73	Estabs	1752	100	1752	1577	123	53	0	0	0	0
SUBTOTAL4			9552		9552	8987	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1609413	118826	52675	1237667	31804	29866	9786	128789
VOLUME OUTPUT/STR		(M^3*K/str/yr)				78.26272	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5008
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				435	4	800	11	24	9	275
NOS OF WATER SUPPLY STRUCTURES						1518	33762	6189	23126	13967	18318	7805
COMMERCIAL SCALE STRUCTURES						1518	4965	6189	964	233	18318	156
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENTS						152	496	619	96	23	1221	31

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WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

Projections of Requirements for New Water Supply Structures to Meet National Goals 1985 - 1990, at Prevailing Useful Life..*.*.*

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	700	818	954	1114	1300	1518
Old Wells	325	293	260	228	195	163	130	98	65	33	0
(Prev. New wells)	-	41	126	226	306	374	500	638	793	970	1171
Needed New Wells	41	89	113	102	99	164	187	219	256	298	347
DUG WELLS											
Needed Total Dug Wells					2500	2803	3142	3523	3950	4428	4965
Old Dug Wells					2250	2025	1800	1575	1350	1125	900
(Prev. New Dug Wells)					-	250	753	1267	1821	2418	3062
Needed New Dug Wells					250	528	590	681	779	886	1003
INTAKES											
Needed Total Intakes					5000	5181	5369	5563	5764	5973	6189
Old Intakes					4500	4050	3600	3150	2700	2250	1800
(Prev. New Intakes)					-	500	1081	1660	2247	2839	3439
Needed New Intakes					500	631	688	752	817	883	950
UARS											
Needed Total Uars					750	782	815	850	887	925	964
Old Uars					675	608	540	473	405	338	270
(Prev. New Uars)					-	75	167	259	352	446	542
Needed New Uars					75	100	108	119	130	141	152
BALLEHS											
Needed Total Ballehs					200	205	210	216	221	227	233
Old Ballehs					180	162	144	126	108	90	72
(Prev. New Ballehs)					-	20	41	62	84	105	127
Needed New Ballehs					20	23	25	28	30	32	34
BURKEDS											
Needed Total Burkeds					10000	11061	12236	13534	14971	16560	18318
Old Burkeds					9333	8711	8089	7466	6844	6222	5600
(Prev. New Burkeds)					-	667	2306	3993	5802	7740	9822
Needed New Burkeds					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	64	48	32	16	0	0
(Prev. New Dams)					-	20	40	60	81	102	124
Needed New Dams					20	24	28	33	38	43	32

LEVEL III SUBMODEL

Please Turn Over

WATER SYSTEM MATRIX:NATIONAL GOALS
1990 PROJECTIONS

CONSTRUCTION

INPUTS	OUTPUTS Measure	WELLS H.P Drilled Wells	WELLS D.P Drilled Wells	WELLS Hand Dug Wells	WELLS Non Prod Wells	OTHER STRUCTURES Intks from Riv	OTHER STRUCTURES Uars	OTHER STRUCTURES Ballehs	OTHER STRUCTURES Berkeds	OTHER STRUCTURES Dams	ANNUAL CONSTR INPUTS
APR	Number of struct.	139	208	1003	104	950	152	34	2896	32	
UL	Years	15	15	10		10	10	5	15	5	
MP	Years										
AMR	Number of struct.										
MATERIALS											
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0	
Annual cement	cubic meters	973	41600	7021	520	3800	0	0	8688	0	62602
Stones per st	cubic meters			16		10	0	0	7	640	
Annual stones	cubic meters			16048		9500	0	0	20272	20480	66300
Gravel per st	cubic meters	5	35								
Annual gravel	cubic meters	695	7280								7975
Sand per st	cubic meters	2	120	2					2	0	
Annual Sand	cubic meters	278	24960	2006					5792	0	33036
8" Steel Casing per st	meters	75	75								
Ann.8"Steel Casing	meters	10425	15600								26025
8"Steel Screen per st	meters	45	45								
Ann.Steel Screen	meters	6255	9360								15615
Conduct.casing per st	meters	6	6		0						
Ann.conduct.casing	meters	834	1248		0						2082
Shelter per st	units	0.2	1	0.1					0.5		
Annual Shelter	units	27.8	208	100.3					1448		1784.1
Pipe&Fittings per st	meters	0	200	0		15			10		
Annual Pipe&Fittings	meters	0	41600	0		14250			28960		84810
Drilling Fluid per st	sacks	25	25		5						
Annual Drilling Fluid	sacks	3475	5200		520						9195
Hand Pump per st	units	1		0.2							
Annual Hand Pumps	units	139		200.6							339.6
Diesel Pump per st	units		1			1					
Annual Diesel Pumps	units		208			950					1158
Rebars & Wood per st	meters		30						20		
Annual Rebars&Wood	meters		6240						57920		64160
Plastic Sheet per st	sq.meters						191	3120			
Annual Plastic sheets	sq.meters						29032	10000			39032

MAINTENANCE AND REHABILITATION

INPUTS	OUTPUTS Measure	WELLS HP Drilled Wells	WELLS DP Drilled Wells	WELLS Hand Dug Wells	OTHER STRUCTURES Intks from Riv	OTHER STRUCTURES Uars	OTHER STRUCTURES Ballehs	OTHER STRUCTURES Berkeds	OTHER STRUCTURES Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.										
UL	Years										
MP	Years	1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.	468	2342	3962	10478	812	199	15422	124		
MATERIALS											
Cement per st	cubic meters	0.7	6	0.7	0	0	0.4	0	0	0	
Annual cement	cubic meters	327.6	14052	2773.4		0	324.8	0	0	0	17477.	80079.8
Stones per st	cubic meters			1.6		0	1	0	0	0.7	
Annual stones	cubic meters			6339.2		0	812	0	0	86.8	7238	73538
Gravel per st	cubic meters	0.5	1.05								
Annual gravel	cubic meters	234	2459.1								2694.6	10669.6
Sand per st	cubic meters	0.2	3.6	0.2	0	0	0	0	0	0.2	
Annual Sand	cubic meters	93.6	8431.2						0	24.8	8549.6	41585.6
8" Steel Casing per st	meters										
Ann.8"Steel Casing	meters										0	26025
8"Steel Screen per st	meters										
Ann.Steel Screen	meters										0	15615
Conduct.casing per st	meters										
Ann.conduct.casing	meters										0	2082
Shelter per st	units										
Annual Shelter	units										0	1784.1
Pipe&Fittings per st	meters	0	6	0	0	0	1.5	0	0	1	
Annual Pipe&Fittings	meters	0	14052	0		0			0		14060.	98870.5
Drilling Fluid per st	sacks	0	0								
Annual Drilling Fluid	sacks	0	0								0	9195
Hand Pump per st	units	0.2		0.4							
Annual Hand Pumps	units	93.6		1584.8							1679	2018.6
Diesel Pump per st	units		0.04			0.2					
Annual Diesel Pumps	units		93.68			2095.6					2189.2	3347.28
Rebars & Wood per st	meters								3		
Annual Rebars&Wood	meters								46266		46266	110426
Plastic Sheet per st	sq.meters						150				
Annual Plastic sheets	sq.meters						29850				29850	68882

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Skilled:																									

Drilling per St.	men-days	28	28	19								0	0												
Annual Drilling	men-days	3892	5824	1976							11692	0	0											0	11692
Excavation per st.	men-days			6.4			10	10	30	30								3	9						
Annual Excav.Wrks	men-days			6419.2			1520	340	86880	960	96119.2							2436	1791					4239	100358.
Civil Wrks.per st.	men-days	18	36	5		1.2	0.5	1.5	15	30		1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5					
Annual Civil Wrks.	men-days	2502	7488	5015		1140	76	51	43440	960	60672	842.4	2529.3	1981		0		9.95	2313.3	186		7862.0	68534.0		
Mech.Wrks per st.	men-days	3	10	0.6		5			3			0.6	0.6	0.12	0	0									
Ann.Mechanic Wrks.	men-days	417	2080	601.8		4750			8688		16536.8	280.8	1405.2	475.44		0						2161.4	18698.2		
Carp.Wrks per st.	men-days	2	2																						
Ann.Carpentry Wrks.	men-days	278	416								694											0	694		
Unskilled:																									

Drilling per St.	men-days	240	240	150								0	0												
Annual Drilling	men-days	33360	49920	15600							98880	0	0											0	98880
Excavation per st.	men-days			6.4					3					0.64						0					
Annual Excav.Wrks	men-days			6419.2					8688		15107.2			2535.6						0		2535.6	17642.8		
Civil.Wrks per st.	men-days	36	216	5		2	0.5	1.5	15	90		3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5					
Ann.Civil Wrks.	men-days	5004	44928	5015		1900	76	51	43440	2880	103294	1684.	15176.	1981		0		9.95	2313.3	186		21351.	124645.		
Mech.Wrks. per st	men-days	12	12	3.6		12			6			2.4	0.72	0.72	0	0									
Ann.Mechanic Wrks.	men-days	1668	2496	3610.8		11400			17376		36550.8	1123.	1686.2	2852.6		0						5662.0	42212.8		
FUEL CONSUMPTION																									

Drill Rigs per st	Liters	3600	3600	1200								0	0												
Annual Drill Rigs Fuel	Liters	500400	748800	124800							1374000											0	1374000		
Pump Rigs per st	Liters	336	336	0								0	0												
Annual Pump Rigs Fuel	Liters	46704	69868	0							116592											0	116592		
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120					
Annual Heavy Vhcl Fuel	Liters	437850	1E+06	451350	163800	85500	68400	15300	1E+06	43200	3571560	37440	562080	316960		838240	97440	71640		14880		2E+06	5510240		
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60					
Annual Light Vhcls Fuel	Liters	583800	982800	451350	145600	99750	26600	14280	405440	33600	2743220	74880	1E+06	633920		419120	48720	35820	925320	7440		3E+06	6068808		
EQUIPMENT																									

Drill Rigs per st	Eq-days	24	24	10								0	0												
Annual Drill Rigs Use	Eq-days	3336	4992	1040							9368	0	0									0	9368		
Pump Rigs per st	Eq-days	3	3	0								0	0												
Annual Pump Rigs Use	Eq-days	417	624	0							1041	0	0									0	1041		
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3					
Annual Heavy Vehcl Use	Eq-days	9730	28080	10030	3640	1900	1520	340	23168	960	79368	936	14052	7924		20956	2436	1791		372		48467	127835		
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3					
Annual Light Vhcls Use	Eq-days	16680	49920	10030	4160	2850	760	408	11584	960	97352	3744	56208	31696		20956	2436	1791	46266	372		163469	260821		
	Eq-days																								

III. Constraint Analysis of 1990 National Objectives

B. Exhibit 8: National Consumption Goals (Partial Standards)
- Level I Submodel
- Level II Submodel
- Level III Submodel

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WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

EXHIBIT 8: MIDDLE PROJECTIONS OF 1990 POPULATION WITH NATIONAL GOALS AND STRUCTURAL DISTRIBUTION ASSUMPTIONS

*Human Population, Livestock Population, Hectares under Agriculture and consumption rates for the nation as a whole.....

	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS/YR	CONV FACTOR	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUCTURE %AGE	NO STRUCTURE VOLUME
HUMAN											
Urban HC	696	persons	130	liters	365	1000	33025	99	32695	1	330
Urban SP	1045	persons	41	liters	365	1000	15638	98	15326	2	313
Rural Set	1853	persons	26	liters	365	1000	17585	95	16706	5	879
Nomadic	2757	persons	26	liters	365	1000	26164	90	23548	10	2616
SUBTOTAL1	6351	persons					92413		88274		4139
ANIMAL											
Camels	5308	Animals	25	liters	365	1000	48436	65	31483	35	16952
Cattle	4246	Animals	25	liters	365	1000	38745	80	30996	20	7749
SheepGoats	28661	Animals	3	liters	365	1000	31384	75	23538	25	7846
OtherAn	10615	Animals	3	liters	365	1000	11623	5	581	95	11042
SUBTOTAL2	12292	LSU					130187		86598		43590
AGRICULTURE											
Irrigfarm	64	Hectares	68	M^3	365	1	1588480	85	1350208	15	238272
Rainfarm	804	Hectares	35	M^3	120	1	3376800	2	67536	98	3309264
Floodfarm	161	Hectares	25	M^3	90	1	362250	2	7245	98	355005
SUBTOTAL3	1029	Hectares					5327530		1424989		3902541
GOVT/IND.											
Govt	2	Estabs	13	M^3	300	1	7800	100	7800	0	0
Industry	.73	Estabs	8	M^3	300	1	1752	100	1752	0	0
SUBTOTAL4							9552		9552		0

Percentage Distribution of Consumption across Human Control Structures.*.*.*. *Percentage Distribution of Consumption*.*.*.*.*.*

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS %AGE	HAND DUG WELLS %AGE	INTAKES FROM RIV/ STR/SPR %AGE	UARS/ RESER- VOIRS %AGE	BALLEHS/ PONDS %AGE	BURKEDS/ CISTERNS %AGE	DAMS/ DIVRSNS %AGE
HUMAN												
Urban	1741	persons	48664	98	48021	80	8	9	1	0	2	0
Rural Set	1853	persons	17585	95	16706	15	30	20	10	15	10	0
Nomadic	2757	persons	26164	90	23548	15	30	20	10	15	10	0
SUBTOTAL1	6351	persons	92413		88274							
ANIMAL												
Camels	5308	Animals	48436	65	31483	12	20	15	23	25	5	0
Cattle	4246	Animals	38745	80	30996	15	30	10	25	15	5	0
SheepGoats	28661	Animals	31384	75	23538	12	30	12	25	14	7	0
OtherAnim	10615	Animals	11623	5	581	12	20	15	24	24	5	0
SUBTOTAL2	12292	LSU	130187		86598							
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	3	1	90	1	1	0	4
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	100
Otherfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	100
SUBTOTAL3	1029	Hectares	5327530		1424989							
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	95	3	2	0	0	0	0
Industry	.73	Estabs	1752	100	1752	90	7	3	0	0	0	0
SUBTOTAL4			9552		9552							

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Total Consumption of Water by Types of Consumption and by Types of Structure..*Total Consumption of Water by Types of Consumptio

	(000s)	MEASURE	VOLUME CONSUMP'N M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FROM RIV/ STR/SPR M^3*K/YR	UARS/ RESER- VOIRS M^3*K/YR	BALIS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	DAMS/ DIVRSNS M^3*K/YR
HUMAN												
Urban	1741	persons	48664	98	48021	38416	3842	4322	480	0	960	0
Rural Set	1853	persons	17585	95	16706	2506	5012	3341	1671	2506	1671	0
Nomadic	2757	persons	26164	90	23548	3532	7064	4710	2355	3532	2355	0
SUBTOTAL1	6351	persons	92413		88274	44454	15918	12373	4506	6038	4986	0
ANIMAL												
Camels	5308	Animals	48436	65	31483	3778	6297	4722	7241	7871	1574	0
Cattle	4246	Animals	38745	80	30996	4649	9299	3100	7749	4649	1550	0
SheepGoats	28661	Animals	31384	75	23538	2825	7061	2825	5884	3295	1648	0
OtherAnim	10615	Animals	11623	5	581	70	116	87	139	139	29	0
SUBTOTAL2	12292	LSU	130187		86598	11322	22773	10734	21014	15955	4801	0
AGRICULTURE												
Irrigfarm	64	Hectares	1588480	85	1350208	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	Hectares	3376800	2	67536	0	0	0	0	0	0	67536
Floodfarm	161	Hectares	362250	2	7245	0	0	0	0	0	0	7245
SUBTOTAL3	1029	Hectares	5327530		1424989	40506	13502	1215187	13502	13502	0	128789
GOVT/IND.												
Govt.	2	Estabs	7800	100	7800	7410	234	156	0	0	0	0
Industry	.73	Estabs	1752	100	1752	1577	123	53	0	0	0	0
SUBTOTAL4			9552		9552	8987	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1609413	105269	52549	1238502	39022	35495	9786	128789
VOLUME OUTPUT/STR		(M^3*K/str/yr)				78.26272	1.5601894	199.96407	1.3752467	2.1382869	.53425579	16.5008
		(days/yr)				180	360	250	120	90	60	60
		(m^3/str/day)				435	4	800	11	24	9	275
NOS OF WATER SUPPLY STRUCTURES						1345	33681	6194	28374	16600	18318	7805
COMMERCIAL SCALE STRUCTURES						1345	4953	6194	1182	277	18318	156
USEFUL LIFE						10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENTS						135	495	619	118	28	1221	31

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WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

Projections of Requirements for New Water Supply Structures to Meet National Goals, 1985 1990, at Prevailing Useful Life..*.*.*

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DRILLED WELLS											
Needed Total Wells	366	423	499	556	600	686	785	898	1028	1176	1345
Old Wells	325	293	260	228	195	163	130	98	65	33	0
(Prev. New wells)	-	41	126	226	306	374	486	607	740	889	1054
Needed New Wells	41	89	113	102	99	150	169	194	223	255	291
DUG WELLS											
Needed Total Dug Wells					2500	2802	3140	3519	3944	4420	4953
Old Dug Wells					2250	2025	1800	1575	1350	1125	900
(Prev. New Dug Wells)					-	250	752	1265	1817	2412	3053
Needed New Dug Wells					250	527	588	679	776	883	1000
INTAKES											
Needed Total Intakes					5000	5182	5370	5565	5767	5977	6194
Old Intakes					4500	4050	3600	3150	2700	2250	1800
(Prev. New Intakes)					-	500	1082	1662	2249	2842	3443
Needed New Intakes					500	632	688	753	818	884	951
UARS											
Needed Total Uars					750	809	873	942	1016	1096	1182
Old Uars					675	608	540	473	405	338	270
(Prev. New Uars)					-	75	194	313	438	567	702
Needed New Uars					75	127	139	156	173	191	210
BALLEHS											
Needed Total Ballehs					200	211	223	235	249	262	277
Old Ballehs					180	162	144	126	108	90	72
(Prev. New Ballehs)					-	20	47	74	102	130	159
Needed New Ballehs					20	29	32	35	39	42	46
BURKEDS											
Needed Total Burkeds					10000	11061	12236	13534	14971	16560	18318
Old Burkeds					9333	8711	8089	7466	6844	6222	5600
(Prev. New Burkeds)					-	667	2306	3993	5802	7740	9822
Needed New Burkeds					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total Dams					100	108	116	125	135	145	156
Old Dams					80	64	48	32	16	0	0
(Prev. New Dams)					-	20	40	60	81	102	124
Needed New Dams					20	24	28	33	38	43	32

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LEVEL III SUBMODEL

Please Turn Over

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WATER SYSTEM MATRIX:NATIONAL GOALS
1990 PROJECTIONS (2)

INPUTS	OUTPUTS Measure	CONSTRUCTION WELLS H.P Drilled Wells	D.P Drilled Wells	Hand Dug Wells	Non Prod Wells	OTHER STRUCTURES Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL CONSTR INPUTS	MAINTENANCE AND REHABILITATION WELLS HP Drilled Wells	DP Drilled Wells	Hand Dug Wells	OTHER STRUCTURES Intks from Riv	Dars	Ballehs	Berkeds	Dams	ANNUAL MAINT INPUTS	TOTAL ANNUAL INPUTS
APR	Number of struct.	116	175	1000	87	951	210	46	2896	32											
UL	Years	15	15	10		10	10	5	15	5											
MF	Years											1	0.3	1	0.5	1	1	1	1		
AMR	Number of struct.											422	2108	3953	10486	972	231	15422	124		
MATERIALS																					
Cement per st	cubic meters	7	200	7	5	4	0	0	3	0		0.7	6	0.7	0 0	0.4	0	0	0		
Annual cement	cubic meters	812	35000	7000	435	3804	0	0	8688	0	55739	295.4	12648	2767.1	0	388.8	0	0	0	16099.	71838.3
Stones per st	cubic meters			16		10	0	0	7	640				1.6	0	1	0	0	0.7		
Annual stones	cubic meters			16000		9510	0	0	20272	20480	66262			6324.8	0	972	0	0	86.8	7383.6	73645.6
Gravel per st	cubic meters	5	35									0.5	1.05								
Annual gravel	cubic meters	580	6125								6705	211	2213.4							2425.9	9130.95
Sand per st	cubic meters	2	120	2					2	0		0.2	3.6	0.2	0 0	0	0	0	0.2		
Annual Sand	cubic meters	232	21000	2000					5792	0	29024	84.4	7588.8					0	24.8	7698	36722
8" Steel Casing per st	meters	75	75																		
Ann.8"Steel Casing	meters	8700	13125								21825									0	21825
8"Steel Screen per st	meters	45	45																		
Ann.Steel Screen	meters	5220	7875								13095									0	13095
Conduct.casing per st	meters	6	6		0																
Ann.conduct.casing	meters	696	1050		0						1746									0	1746
Shelter per st	units	0.2	1	0.1					0.5												
Annual Shelter	units	23.2	175	100					1448		1746.2									0	1746.2
Pipe&Fittings per st	meters	0	200	0		15			10			0	6	0	0 0	1.5	0	0	1		
Annual Pipe&Fittings	meters	0	35000	0		14265			28960		78225	0	12648	0	0			0		12656.	90881.5
Drilling Fluid per st	sacks	25	25		5							0	0								
Annual Drilling Fluid	sacks	2900	4375		435						7710	0	0							0	7710
Hand Pump per st	units	1		0.2								0.2		0.4							
Annual Hand Pumps	units	116		200							316	84.4		1581.2						1666.2	1982.2
Diesel Pump per st	units		1			1							0.04		0.2						
Annual Diesel Pumps	units		175			951					1126		84.32		2097.2					2181.5	3307.52
Rebars & Wood per st	meters		30						20									3			
Annual Rebars&Wood	meters		5250						57920		63170							46266		46266	109436
Plastic Sheet per st	sq.meters						191	3120									150				
Annual Plastic sheets	sq.meters						40110	10000			50110						34650			34650	84760

LABOR

Skilled:

Drilling per St.	men-days	28	28	19								0	0											
Annual Drilling	men-days	3248	4900	1653							9801	0	0										0	9801
Excavation per st.	men-days			6.4		10	10	30	30							3	9							
Annual Excav.Wrks	men-days			6400		2100	460	86880	960		96800					2916	2079						5007	101807
Civil Wrks.per st.	men-days	18	36	5	1.2	0.5	1.5	15	30			1.8	1.08	0.5	0	0	0.12	0.05	0.15	1.5				
Annual Civil Wrks.	men-days	2088	6300	5000	1141.2	105	69	43440	960		59103.2	759.6	2276.6	1976.5		0		11.55	2313.3	186		7523.5		66626.7
Mech.Wrks per st.	men-days	3	10	0.6	5			3				0.6	0.6	0.12	0	0								
Ann.Mechanic Wrks.	men-days	348	1750	600	4755			8688			16141	253.2	1264.8	474.36		0							1992.3	18133.3
Carp.wrks per st.	men-days	2	2																					
Ann.Carpentry Wrks.	men-days	232	350								582												0	582

Unskilled:

Drilling per St.	men-days	240	240	150								0	0											
Annual Drilling	men-days	27840	42000	13050							82890	0	0										0	82890
Excavation per st.	men-days			6.4				3						0.64					0					
Annual Excav.Wrks	men-days			6400				8688			15088			2529.9					0				2529.9	17617.9
Civil.Wrks per st.	men-days	36	216	5	2	0.5	1.5	15	90			3.6	6.48	0.5	0	0	0.2	0.05	0.15	1.5				
Ann.Civil Wrks.	men-days	4176	37800	5000	1902	105	69	43440	2880		95372	1519.	13659.	1976.5		0		11.55	2313.3	186		19666.		115038.
Mech.Wrks. per st	men-days	12	12	3.6	12			6				2.4	0.72	0.72	0	0								
Ann.Mechanic Wrks.	men-days	1392	2100	3600	11412			17376			35880	1012.	1517.7	2846.1		0							5376.7	41256.7

FUEL CONSUMPTION

Drill Rigs per st	Liters	3600	3600	1200								0	0											
Annual Drill Rigs Fuel	Liters	417600	630000	104400							1152000												0	1152000
Pump Rigs per st	Liters	336	336	0								0	0											
Annual Pump Rigs Fuel	Liters	38976	58800	0							97776												0	97776
Heavy Vehicles per st	Liters	3150	6075	450	1575	90	450	450	360	1350		80	240	80	0	80	120	360	0	120				
Annual Heavy Vhcl Fuel	Liters	365400	1E+06	450000	137025	85590	94500	20700	1E+06	43200	3302100	33760	505920	316240		838880	116640	83160		14880		2E+06		5211580
Light Vehicles per st	Liters	4200	4725	450	1400	105	175	420	140	1050		160	480	160	0	40	60	180	60	60				
Annual Light Vhcls Fuel	Liters	487200	826875	450000	121800	99855	36750	19320	405440	33600	2480840	67520	1E+06	632480		419440	58320	41580	925320	7440		3E+06		5695372

EQUIPMENT

Drill Rigs per st	Eq-days	24	24	10								0	0											
Annual Drill Rigs Use	Eq-days	2784	4200	870							7854	0	0										0	7854
Pump Rigs per st	Eq-days	3	3	0								0	0											
Annual Pump Rigs Use	Eq-days	348	525	0							873	0	0										0	873
Heavy Vehicles per st	Eq-days	70	135	10	35	2	10	10	8	30		2	6	2		2	3	9		3				
Annual Heavy Vehcl Use	Eq-days	8120	23625	10000	3045	1902	2100	460	23168	960	73380	844	12648	7906		20972	2916	2079		372		47737		121117
Light Vehicles per st	Eq-days	120	240	10	40	3	5	12	4	30		8	24	8		2	3	9	3	3				
Annual Light Vhcls Use	Eq-days	13920	42000	10000	3480	2853	1050	552	11584	960	86399	3376	50592	31624		20972	2916	2079	46266	372		158197		244596

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APPENDIX D

WISyMS' NOTES AND SOURCES

APPENDIX D: WISYMS NOTES AND SOURCES

I. INTRODUCTION

This appendix provides notes to accompany the presentation of WISyMS contained in Appendices B (Methodology) and C (Data). It discusses sources of data and estimates used in the various runs of the model which are presented in Appendix C, and also discusses some of the estimating procedures involved in building the model. This appendix is organized into three sets following the presentation of the data contained in Appendix C:

- **1984 BASELINE ESTIMATES**
  Exhibit 1. Middle Level Estimates
  Exhibit 2. Low Estimates
  Exhibit 3. High Estimates

- **1990 PROJECTIONS/FORECASTS**
  Exhibit 4. Middle Level Projections
  Exhibit 5. Low Projections
  Exhibit 6. High Projections

- **CONSTRAINT ANALYSIS 1990 OF NATIONAL OBJECTIVES**
  Exhibit 7. National Consumption Objectives (full standards)
  Exhibit 8. National Consumption Objectives (partial standards)

Each exhibit presents a run of some or all of WISyMS three inter-related submodels under different assumptions. The Baseline Estimates present 1984 estimates of current system parameters on the basis of three alternative sets of demographic and economic data and of inventory estimates as to the stock of existing water supply structures. The 1990 Projections/Forecasts extrapolate from the three baseline exhibits based on three alternative sets of growth rates applied to the demographic and economic data. One extra run of the Level III Submodel for the middle level 1990 projection is presented to illustrate the costs and benefits of rehabilitation on drilled wells. The 1990 Evaluations of National Objectives are based on Exhibit 4, the middle range projections, and include specific national goals for water consumption, standards, and service.

II. WISyMS 1984 BASELINE ESTIMATES

The data presented in the first model, Exhibit 1, "Middle Level 1984 Estimates of Population, Rates of Consumption, and Existing Structures" represent the Consultants' baseline estimates for year-end 1984. Exhibit 2 and Exhibit 3 present, respectively, lower and higher estimates for most variables used in the model, in order to illustrate the range of available estimates on each of the categories examined. Definitions and sources are described

below, organized as in Section III of the main body of this paper and in Appendix A, "Definitions". Sources indicated in <brackets> refer to the bibliography, attached. Figures for which a specific source is not mentioned are Consultant's estimates. All calculation are explained in Appendix B.

CONSUMPTION UNITS:

- **Total Human Population ("Subtotal 1"):** Ministry of National Planning (MNP) figures indicate a total population of around 5.35 million <1> as of end 1984. While these are the government's official estimates, many experts believe that the 1975 census on which those figures are based was not an accurate one and that there may have been significant double counting and/or missed areas. Exhibit 2 presents the Consultant's estimate of the likely lowest end of the possible range of population, and estimates presented in Exhibit 3 are from aerial reconnaissance and ground sampling techniques conducted by Resource Management and Research (RMR) of London, which estimated the total population at over 6,885,000 as of 1983/84 <2>.

- **Urban Population:** Urban population figures are based on MNP's estimate of 25% of total population. Surveys for the Mogadishu Second Water Supply Project <3> estimated that about 11 percent of Mogadishu households have private connections ("**HC**") and 89% have access only to standpipes ("**SP**"). Kismayo claims to have about 20% of its households connected. The figures presented represent the Consultant's estimate that about 8% of the total "urban population" has household connections.

- **Rural Settled And Nomadic:** The figures presented are in line with MNP and RMR estimates of the percentage of the total population in each category: approximately 29% and 46% respectively.

- **Livestock:** estimates for camels, cattle, sheep, and goats are from the MMWR <4>, RMR <2>, and MNP <1>, which are in close agreement. The estimate for "other animals" is strictly hypothetical. "LSU" is Livestock Unites, where the average camel is counted as one LSU, cattle are .3 LSU and Sheep and Goats are .125 LSU.

- **Agriculture, (Hectares):** for Figure 1 are from MNP <5> estimates for "current irrigated cropland", "current rainfed cropland" and "flood-fed cropland". Figure 3 estimates are from RMR <6 & 7>, adjusted to take into account different definitions for the categories.

- **Government And Industry:** The MNP <8> lists about 300 industries with five or more employees, but admits that probably many companies were missed.

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PER UNIT WATER CONSUMPTION FACTORS

- **Daily Use Factor:** is the estimated weighted average consumption of water per day for each type of consumption unit.

- **Human Consumption of Water:** The figures employed represent rough estimates of average consumption, based on a number of sources, including the Mogadishu Water Supply Project <3> for urban consumption and MMWR <4> and the National Range Agency (NRA) for rural consumption.

- **Livestock Consumption Estimates:** are based on a variety of sources, including MMWR <4>, and the National Range Agency (NRA).

- **Agricultural Water Consumption:** the 68 cubic meters per day for irrigated land was calculated from assumed absorption of rainfall plus information in MMWR <4> on agricultural demand for surface and groundwater, (however, these estimatesare based on an assumed 45% efficiency of water use in irrigation, instead of the more likely 20% efficiency estimated by most experts). The consumption figures for "rainfed" and "flood" agriculture are heuristic approximations offered for illustrative purposes only.

- **Government and Industry:** The Mogadishu Water Supply Project <3> estimates that government institutions use over half of the water consumed in Mogadishu, and that industry uses another 3%. The Consultant's estimates are based on an extrapolation to all urban areas. "Average Daily Consumption" was derived from these figures and from estimated numbers of establishments.

- **Days per Year:** is for use of water. This is 365 days/year for humans and livestock, the average potential growing season for agriculture, and working days/year for government and industry.

- **Conversion Factor:** translates liters into cubic meters of water for human and livestock water consumption.

- **Annual Consumption ("M^3K/YR"):** for each type of consumption unit is the calculated total annual volume of water consumed in thousands of cubic meters per year.

WATER CONSUMPTION/INTAKE STRUCTURE FLOW RELATIONSHIPS

- **Structural Control Percentages:** refer to the percentage of water taken from nature with the use of man-made water supply structures or improvements to natural sources. Figures presented are the Consultant's estimates.

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- **Structural Control Amount:** is then the calculated volume of water consumed through man-made water supply structures, in thousands of cubic meters per year.

- **No Structure Percentage:** percentage of water consumed directly from nature without the use of structures.

- **Percentage Distribution Across Structures:** A matrix illustrating the percentage distribution of consumption across the range of water supply structures, by type of consumption. Since there are no published data available on this subject, the figures employed represent the Consultant's estimates based on conversations at the Water Development Agency (WDA), NRA, and MNP. Further research will be conducted by the WDA Planning Department.

VOLUMES OF WATER PROVIDED THROUGH SUPPLY STRUCTURES

- **Total Consumption of Water by Type of Consumption and by Type of Structure:** A matrix calculated from the Structural Volumes for each type of consumption, and the Percentage Distribution Across Supply Structures: each cell of the matrix specifies the volume of water used for each particular use AND supplied by a particular type of structure.

- **Structural Supply Volumes:** are the volumes of water consumed for all uses for each type of structure, summed down each column of the above-described matrix.

- **Volume Output, M^3K/STR/YR:** is the weighted average volume, in thousands of cubic meters, of water consumed per single supply structure per year and is calculated in Figures 1 - 3 as "structural supply volumes" divided by the "numbers of water supply structures".

- **Days/Year:** is the weighted average number of days per year each type of structure is in use.

- **M^3/STR/DAY:** calculated volume of output in cubic meters per single supply structure per day.

For instance, of about 600 operational drilled wells in existence as of end 1984, approximately 240 of these are irrigation wells used 100 days per year and pumping about 1000 cubic meters per day; 60 are municipal wells operating 365 days per year and pumping 800 cubic meters per day; and 300 are rural boreholes used 200 days per year and pumping 80 cubic meters per day <9>. This gives us a weighted average of about 180 days per year and 435 cubic meters per day per drilled well, although this describes no typical well in Somalia.

- **Numbers of Water Supply Structures:** are estimates on the numbers of each type of water supply structure which were operational and in use as of end-1984. Numbers of drilled wells are Consultant's estimates based on known drilling activity over the past five years, and on the numbers of older wells assumed to be still operational. Estimates of the numbers of dug wells, uars, and ballehs are based on RMR data <7, 10 & 11>, along with standard errors, which were used for the numbers of supply structures presented in Exhibits 2 and 3. Figures presented on intakes from rivers and streams, burkeds, and dams are rough estimates, as there are no published comprehensive data on these structures.

- **Commercial Scale Structures:** are the subsets of operational supply structures the construction of which involve some capital input and at least the potential for construction on a commercial basis. In other words, they have been selected on the basis that their construction and/or maintenance require minimum inputs of raw materials, labor, fuel and equipment that can justify the involvement of "Level III" (water industry inputs) industries. Structures built on a self-help scheme and natural water sources are not included.

- **Drilled Wells:** All drilled wells are considered commercial scale structures. Drilled wells are either equipped with a hand-pump or a diesel pump. (Wind mill pumps are being seriously considered for the future but at this stage, their number is too marginal to be taken into account in the context of our framework).

  Both **hand-pump** and **diesel pump wells** have an average depth of 120 meters. Most wells are completed with a 12" or 14" diameter surface casing and 8" steel or plastic casing and screen.

  Hand pump wells are equipped with a lift pump which is manually operated and yields approximately 10 liters/minute. A sloped concrete pad is built around the well in order to drain spoil water. It is assumed that about 40% of all drilled wells are equipped with a hand pump.

  Diesel pumped wells serving rural areas are equipped with a diesel that is capable of yields from 8 cubic meters per hour. Water is stored in an above ground concrete storage tank with a capacity of 45,000 liters which supplies one human water point and two animal water points by gravitation. It is assumed that about 60% of all drilled wells are equipped with a diesel pump.

Drilled wells are further classified as **"production"** or **"non-production wells"**. **Production wells** are completed operational structures, equipped with a pump and "producing" water. **Non-production wells** are test boreholes abandoned after it has been determined that quantity and/or quality is not suitable. Non-production wells are also referred to as exploratory wells. It is assumed that the number of non-production wells in a given year equals 30% of the number of production wells.

- **Hand Dug Wells:** Less than 15% of hand dug wells are in the Commerical Scale category. Depending on the kind of layers encountered while digging the well, well depth and lining requirements will vary. Wells dug entirely through soft layers of unconsolidated materials will require lining over the full height of the well, wells dug partly through consolidated materials will only require lining in the portions of the well which are unconsolidated. Therefore, it is realistically impossible to give one clear definition of a hand dug well. For the purpose of our analysis, an average commercial scale well is defined, which is a combination of the three types of wells described above. This well has a depth of 15 meters, is lined over 55% of its height and is covered in 20% of the cases.

- **Intakes From Rivers:** All intakes are considered commercial scale. Intakes consist of a pipe immersed into a river and connected to a diesel powered pump with a generator. In some cases, a concrete pump house is built in order to protect the diesel engine from the rain. For irrigation, water is then distributed through hand dug distribution channels.

- **Uars:** The Consultant estimates that about 4% of all uars are commercial scale. The commerical scale uars considred in the model are defined as those mechanically excavated with bulldozer or draglines. Their average size is of 50 m x 25 m at the top X 4 m deep and of trapezoid vertical cross-section (this shape has been used by the National Range Agency in order to avoid degration). Their average volume is 2500 cubic meters. It is estimated that they are lined with plastic sheets in 10% of the cases.

- **Improved Ballehs:** The Consultant estimates that only about 2% of ballehs are commercial scale. For a commercial scale balleh, the natural balleh's shape is improved by earth moving with heavy equipment such as bulldozers. Then plastic sheets are installed in the bottom and on the sides in order to reduce seepage of the water. These balleh's holding capacity range from 10,000 to over 50,000 cubic meters, with an average of perhaps 30,000 cubic meters. The commercial scale ballehs considered in the model are assumed to be 1.5 meters deep, 300 meters long and 100 meters wide. They are also assumed to be lined with plastic sheet in 10% of the cases.

- **Burkeds:** All burkeds are considred to be commercial scale. The range of holding capacities is extremely wide, 10 to over 100 cubic meters in the Central Rangelands and South. In the North, where they originated, they may be as large as 600 meters. The average holding capacity is assumed to be 60 cubic meters. They are sometimes roofed with materials such as corrugated metal sheeting, concrete, plastic sheet or simply shaded with small bushes suspended over the tank in nets.

- **Diversion Dams:** The Consultant estimates that about 2% of diversion dams are commercial scale structures. The average commerical scale diversion dam is assumed to be 120 meters long, of trapezoid shape, up to 4 meters high above channel invert with a top width of 2 meters. The side slopes of the earth section are 3 to 1 (average). Diversion Dams are constructed across water channels and are made of earth, stones, (the stones may be contained in gabions - wire cages), or concrete.

- **Average Useful Life:** for each type of structure are consultant's estimates. Actual lifespans for each type of structure will vary widely. The figures presented take into account the conditions and levels of maintenance currently prevailing in Somalia.

- **Annual Replacement Rates:** calculation gives a rough indication of the number of new structures needed solely to replace the ones likely to fail in a given year. For the 1984 middle-level estimates (Exhibit 1 in Appendix C), these replacement rates were introduced directly into the Level III submodel to illustrate the quantities of inputs required solely for replacement purposes. Notes of the Level III submodel follow the discussion of the 1990 forecasts and the Level II submodel, below.

III. WISyMS 1990 PROJECTIONS/FORECASTS

The next step in the simulation, presented in Exhibits 4 through 6, was to make a set of projections by applying different possible growth rates to the three sets of baseline (1984) estimates. Exhibit 4 contains the middle-level projections for 1990, using middle-level growth rates applied to Exhibit 1's middle-level base line estimates for each of the key variables. Exhibit 5 contains the low-level projections for 1990, using low-level growth rates applied to Exhibit 2's low-level baseline estimates. Exhibit 6 contains the high-level projections for 1990, using high-level growth rates applied to Exhibit 3's high-level baseline estimates. This gives us the largest possible range of projections for 1990 for each of the variables.

A. LEVEL I SUBMODEL

- **Population Projections:** for Exhibit 4 assume a total annual average population growth of 2.9%. This figure is a weighted average of urban population growth (4.5% p.a.), rural settled growth (3.0% p.a.) and nomadic population growth (1.9% p.a.). The MNP calculates a net natural increase of 3.1% <2>, but indicates that net emmigration would bring the actual population growth rate to just below 3% p.a. We also assume that the percentage of urban households with private connections increases to 10%. Exhibit 5 assumes a total annual average growth rate of 2.5%; with a 4% p.a. increase in urban population, of which 9% will have household connections by 1990. Exhibit 6 assumes a total annual average population growth of 3.1%; with a 5% p.a. increase for urban population, of which 12% will have household connections by 1990.

- **Livestock Population Projections:** for Exhibit 4 employ the MNP's estimate of about 1% for annual average net increase <12>. Exhibit 5 uses 0.5% and Exhibit 6 uses 2% net increase per anum.

- **Agricultural Projections:** Exhibit 4 assumes a growth rate of 2.5% per anum for hectares under irrigated cultivation; and 5% per anum growth for hectares under rain-fed and flood-fed cultivation. Exhibit 5 assumes 1.1%, 2.5% and 2.5% growth rates p.a. respectively for the three categories; and Exhibit 6 assumes 5%, 6% and 6% growth rates p.a.

- **Government and Industry Projections:** All three 1990 forecast Exhibits assume no growth in water consumption for governmental institutions. Exhibit 4 assumes the number of private commercial establishments will increase by 6.5% per anum, and that per-establishment consumption will increase by 8% per anum. Exhibit 5 assumes the number of establishments will also increase by 5% per anum, and that per-establishment consumption will increase by 5% per anum. Exhibit 6 assumes the number of establishments will increase by 7.3 per anum, and that per-establishment consumption will increase by 9.8% per anum.

- **Human Consumption Projections:** are the Consultant's estimates which indicate the likely range of figures on per capita consumption as of 1990.

- **Livestock Consumption Projections:** assume some growth for cattle and camel, but not for sheep and goats (except for Exhibit 5, which assumes some growth from Exhibit 2).

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- **Agricultural Consumption Projections:** Per hectare consumption is assumed not to increase; for although crops could usefully consume more water, this should come about as a result of increased efficiency in water use, and not through greater quantities of water diverted to agriculture.

- **Structural Control Percentage Projections:** All three Exhibits assume that there will be increased reliance on water from structures in general, increasing "Structural Control Percentage" by up to five percentage points for each category of use.

- **Groundwater Percentage Projections:** All three Exhibits assume that there will be increased reliance on groundwater (water from drilled wells and hand dug wells) in particular, changing the percentage distribution in favor of drilled wells and hand dug wells by up to 5 percentage points, at the expense of surface water facilities.

The combined effects of human, livestock, agricultural, and industrial growth, plus growth of per-capita, per-head, per-hectare, and per-establishment consumption of water are significant. Exhibit 4 indicates an increase of 4.3% per anum for total water consumption through all structural control facilities. Exhibit 5 and Exhibit 6 indicate a possible range of 1.6 to 6.6% per anum.

- **Numbers of Water Supply Structures:** For the sake of projecting the numbers of water supply structures for 1990, the Consultant assumed that output per supply structure per year would remain constant; and calculated the number of supply structures needed in 1990 to satisfy the projected growth in water consumption.

- **Commercial Scale Structures:** are assumed to remain as a constant proportion of total water supply structures for each type of facilitiy.

- **Useful Life:** in the first instance is assumed to be unchanged. For Exhibit 4, a second calculation is offered for drilled wells, assuming that improved maintenance and rehabilitation efforts can extend useful life by 50%.

These projections, together with the baseline estimates of the numbers of each type of supply structure in existence as of end-1984, are used to project the numbers of NEW supply structures needed to (a) replace old deteriorated structures and (b) to keep pace with growing water consumption needs. The procedure used by the Consultant is described in more detail in Appendix B.

B. LEVEL II SUBMODEL

- **Needed Total Drilled Wells:** from 1980-1984, numbers of drilled wells are Consultant's estimates based on known drilling activity over the past five years, and on the numbers of older wells still assumed to be operational; from 1985 through 1990 they are the projected requirements of numbers of wells needed to maintain existing (end-1984) volume of output per operational drilled well, keeping pace with growth in consumption from all sources.

- **Old Wells:** are Consultants estimates on the number of operational drilled wells which had been in existence as of 1980. At that point, they would have had varied ages, and if their life expectancy is ten years, we can assume that about 10% of them would fail each year. By 1990, we could not expect any of them to be functional.

- **Previously Drilled "New" Wells:** are wells drilled since the beginning of 1980 but before the current year of the column. For the sake of analysis, the consultant assumes that all drilled production wells will last at least one year, and will fail at a rate of 10% per year.

- **Needed New Wells:** for years 198-1984 are estimates of the numbers of wells actually drilled each year, based on known drilling activity. (Figure 5 assumes we were double-counting or counting nonproduction wells, and Figure 6 assumes we missed some drilling activity.) For 1985 through 1990, they are calculated as the number of wells that need to be drilled to make up the difference between "needed total wells" and "old wells" plus "previously drilled new wells".

A similar procedure is used for each of the other types of structures, although data are not available for past rates of construction.

For Exhibit 4, a second set of figures is offered for drilled wells, assuming that increased levels of maintenance and rehabilitation effort enhance useful life by 50%. This would reduce the numbers of new wells needed to be drilled each year to replace deteriorated wells.

C. LEVEL III SUBMODEL

INPUT-OUTPUT TECHNICAL COEFFIECIENTS FOR CONSTRUCTION (A_{IJ})

Note that all "inputs" used in the input-output model represent averages currently prevailing in the country. These averages are heavily influenced by work taking place under foreign auspices which is relatively more capital intensive than average, and by work taking place under governmental force account, which involves larger payroll than is perhaps necessary. Work

undertaken by the private sector, (whose inputs are described in Chapter V of the main body of the report), may make more economical use of labor and capital, but are also restricted in their well depths and in the formations through which they can drill.

Raw Materials Inputs:

The list of raw materials inputs does not pretend to include every single item involved in water supply structures construction. The purpose of this exercise is not to give a detailed bill of materials for each structure, but rather to estimate the potential impact of an increase in the number of structures on the "Level III" industries. Hence, the raw materials inputs have been selected on the basis that they are likely to influence "Level 3" entrepreneurs' decision-making. More precisely, these are either raw materials used in substantive quantities or materials that are expensive.

- **Cement, stone, gravel and sand** are used for well construction and for civil works. Gravel for packing of wells is used on a limited basis, and is not included in calculations. In the context of this model, gravel refers to crushed stones, used to make aggregate. Input coefficients have been assumed to be 20% higher than standard civil engineering coefficients, to allow for lost and damaged materials. The relatively high coefficients associated with wells equipped with diesel pumps are due to the large storage tanks incorporated into the civil works. (See Definitions of the Structures in Appendix A).

- **Steel casing, screen and conductor casing** are used exclusively in drilled wells. Technical coefficient for production wells have been selected on the basis that the average well depth is of 120 meters. Coefficients estimates were provided by Roscoe Moss and CGDP experts.

- **Shelter:** The following structures are estimated to have a shelter:

  (i) All drilled well equipped with a diesel pump
  (ii) 20% of drilled wells equipped with a hand pump
  (iii) 10% of the Hand dug wells
  (iv) 50% of the burkeds

- **Pipes** includes plumbing and fittings in addition to the pipe itself. Technically, pipes are not part of the structures, but rather a link between different structures (e.g., from a well to a burked) or from a structure to the water end-user. (e..g., from a river intake to an irrigated field). Pipe requirements are substantial however and will increase as development of water distribution systems increases.

- **Hand Pumps and Diesel Pumps:** CGDP experts estimate that hand pumps are used in 20% of the hand dug wells and 40% of the drilled wells. In drilled wells, the choice between a hand pump versus a diesel pump is usually determined by the production rate of the well. Diesel pumps are generally utilised for needed production rates greater than 40 liters per minute. Clearly, other factors, when choosing between hand and diesel pumps, such as the location of the well, its accessibility to fuel and maintenance services, the identification of water users and the rate of utilisation of the well, are taken into account.

  In low population density areas, where wells are used primarily by the nomadic population as a source of water for human and animal consumption, wells are equipped with hand pumps. These areas are often remote areas, thus not easily accessible for maintenance and fuel services, another reason to decide for hand pump.

  In high population density areas, urban areas, or intensive agriculture areas, where substantive quantities of water are needed, wells are usually equipped with diesel pumps. These areas are also usually easily accessible for maintenance and fuel services, a necessary condition to meet when opting for diesel pump.

  Intakes from rivers are equipped with diesel pumps. Clearly intakes are to yield substantive quantities of water, mainly for irrigation purposes, thus must be equipped with diesel pumps.

- **Rebars and Wood:** Rebars (reinforced steel) are used in limited quantities in order to improve the tensile strength in masonry such as service tanks at well-heads and burkeds. Wood is used for concrete forms.

- **Plastic Sheets:** Plastic sheets are used to line some of the ballehs and uars to prevent seepage through the bottom and sides. The consultants estimate that around 10% of the ballehs and uars are lined with plastic sheets. Since uars average holding capacity is estimated to be about 2500 cubic meters (trapazoidal: 50 x 125 top x 4 depth), plastic sheet requirement per uar is 1,043 square meters. A similar estimate of plastic requirements per balleh (300 x 100 x 1.5) can be made and yields to approximately 15,000 square meters.

Labor Inputs

Labor inputs are measured in man-days and classified as skilled or unskilled. Note that these are current average labor inputs and reflect the large amount of WDA force-account labor and labor in foreign aided projects executed on behalf of the WDA.

- **Drilling Labour Inputs:** includes all labour involved in the borehole test drilling, log taking, hole reaming, well development, casing and screen installation. In the case of production wells, drilling is estimated to be performed by a team of 13 people. These include 3 skilled workers: chief driller, assistant driller, and hydrogeologist plus a crew of 10 unskilled workers. The team is assumed to spend 24 days on the well site. In the case of non production/exploratory wells, the same team will be present on the site but for a time period of 15 days.

- **Excavation Labour Inputs** relates to hand digging and/or earth moving with heavy equipment such as bulldozers. Diggers are unskilled whereas bulldozer operators are assumed to be skilled. Completion of hand dug wells are estimated at the rate of 3 men-hours per meter, 7 hours per day and an average well depth of 15 meters. Thus excavation labour input coefficients per hand dug well is:

  $$(3 \times 15)/7 = 6.43 \text{ men-days}$$

  Uars are assumed to be excavated with bulldozers and graders (uars hand dug on a self-help scheme by villagers are not included in this analysis since they are not commercial scale and do not require the involvement of "level 3" industries). It is estimated that an average uar with 2500 cubic meter capacity can be excavated with one bulldozer in 10 days. Ballehs are also excavated with bulldozers and graders. It is estimated that a balleh with a 30,000 cubic meter capacity will require 10 equipment-days. Burkeds are hand dug at the rate of 0.5 men-days per cubic meter of capacity, thus (0.5 x 60) = 30 men-days for the average burked of 60 cubic meters capacity. Diversion dams are dug with bulldozers and/or draglines. These are estimated to hold 7,500 cubic meters in average, hence will require approximately 15 equipment days.

- **Civil Works Labour Inputs:** CGDP experts estimate that a team of 9 people (1 skilled civil work supervisor assisted by 2 skilled workers and 6 unskilled crew members) will work for 6 days in the case of hand pumped wells and 36 days in the case of diesel pumped wells. The considerable amount of civil work associated with wells equipped with diesel pumps is due to the number and size of structures provided.

  In the case of hand dug wells, civil work consists principally in lining the well. The amount of work involved is directly related to the structure of the layers encountered. In soft layers, chances that soil will cave in the hole are high, thus lining is required over the full height of the well. Wells dug in hard layers may not

require any lining. On average, 55% of the wells need to be lined and 1.2 men-days are necessary per meter of well lining. Thus, total civil works labout input requirement amounts to: (15 meters x 55% x 1.2 men-days/meter)=10 men-days which are practically split between one skilled mason and his assistant (unskilled).

In most instances (80%), intakes from rivers do not involve civil works. Intakes usually consist of a bare pump and an intake pipe immersed into the river. There are however some intakes that involve the construction of a concrete block structure, such as a pump house. It is estimated that for those intakes that require some civil work, 1 mason and an unskilled assistant will be working for 5 days. Thus, technical coefficients for both skilled and unskilled labour are: (10 men-days x 20%) = 2 men-days.

Uars and ballehs involve minimal civil works such as masonry work, but in those uars and ballehs lined with plastic sheets, labour inputs are required. These are classified under civil work for practical purpose. It is estimated that the installation of pastic sheets takes 1 man-day per 100 square meters, thus input technical coefficients for uars and ballehs are respectively of 1.5 men-days and 15 men-days.

Dams, for the purpose of this study, are structures usually made of stones and earth, thus requiring civil works. It is estimated that 6 skilled men-days, and 10 unskilled men-days are sufficient for the construction of an average sized dam.

- **Mechanical Labour Inputs:** Under mechanical labour inputs are grouped all labour inputs that involve some mechanical, plumbing or electrical work, such as installation of the pumps, pipes and fittings, generators, etc.

  In drilled wells equipped with hand pump, mechanical works consist mainly in the pump installation. The pump crew is composed of one skilled supervisor and 4 unskilled crew members who will be working for 3 days. Note that the pump installation itself can be completed within 1 day but it is reasonable to add 2 other days for deployment to and from site.

  In drilled wells equipped with a diesel pump, pump installation labour requirements are comparable to those of hand pumped wells; but mechanical work also involves the installation of pipes and fittings between the various structures attached to the well. It is assumed that 7 men-days will be necessary to complete the additional mechanical (plumbing) works. Thus, the technical input coefficient for mechanical labour per drilled well with diesel pump are (a) skilled: (1 pump crew supervisor x

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3 days + 7 plumbers-days) = 10 men-days and (b) unskilled: (4 crew members x 3 days) = 12 men-days.

As for those hand dug wells equipped with a hand pump, mechanical labour inputs are similar to those required for drilled wells, technical coefficients are (a) skilled: (1 men x 3 days x 20%)= 0.6 men-days and (b) unskilled: (6 men x 3 days x 20%)= 3.6 men-days.

Intakes from rivers equipped with diesel pumps require mechanical labour inputs. As previously stated, in 80% of the cases intakes merely consist of piping from the river to the pump. Mechanical labour inputs are 3 skilled men-days and 12 unskilled men-days. In the remaining 20% more sophisticated structures, pipes and fittings are installed, requiring about 2 additional skilled men-days. Thus technical input coefficients are (a) skilled: (3 men-days + (2 men-days x 20%)) = 3.4 men-days, and (b) unskilled: 12 men-days.

Neither uars, nor ballehs require any kind of mechanical labour inputs, thus coefficients are nil.

Burkeds require a minimum of plumbing work which is assumed to take 3 men-days of skilled labour and 6 men-days of unskilled labour.

In the case of dams, technical mechanical labour coefficients are assumed to be nil.

Equipment Inputs

Equipment Inputs are measured in equipment-days of utilization of drill rigs, pump rigs, heavy vehicles and light vehicles. Minor equipment items such as chisels and trowels have been neglected in order to simplify this analysis. Note that these are current average equipment inputs and reflect the relatively high capital intensity of work on foreign aid projects and WDA force account work.

- **Drill Rigs:** Drill Rigs are used exclusively for the construction of drilled wells. Drilling is performed with a rotary rig using a hammer bit and various sized tricone bits. The drill rig input coefficient is estimated to be 24 equipment-days. This figure may appear a little high (under normal circumstances, this coefficient would be 7 equipment-days), but it reflects a real situation where drilling progress is slowed down because of logistics such as lack of fuel, and difficult site accessibility. These 24 days include 12 days of drilling and 12 days of down-time.

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In the case of non-producing exploratory wells, drilling is stopped as soon as it has been determined that the site is not appropriate for well completion. The input-output coefficient is assumed to be 10 equipment-days.

- **Pump Rigs:** Pump rigs are used for the installation of the pump in drilled wells. The pump installation should not take longer than one day. Two additional days are needed to move the pump rig to and from the site. Thus, the input coefficient is 3 equipment-days.

- **Heavy Vehicles:** include a wide range of vehicles, such as water tankers, fuel tankers, flatbed trucks, trailers and bulldozers.

  In the case of drilled wells equipped with hand pump, equipment requirements are as follows:

  1 Flatbed truck x 25 days
  1 Water truck x 20 days
  1 Fuel Tanker x 5 days
  1 Crane Truck x 20 days

  Thus the input coefficient is 70 equipment-days.

  In the case of drilled wells equipped with diesel pump, additional equipment inputs are needed to support the civil works involved in the construction of the water storage and distribution structures. These additional requirements are as follows:

  Flatbed truck x 30 days
  1 Water Tanker x 30 days
  1 Fuel Tanker x 8 days
  1 Dump truck x 30 days

  Thus additional requirements are for 98 equipment-days so the input coefficient is: (70 + 98) = 168 equipment-days.

  Hand dug wells require the use of two heavy vehicles for 5 days, thus the coefficient is 10 equipment-days.

  Non production wells require the following heavy vehicles:

  1 Flatbed x 12 days
  1 Water Truck x 10 days
  1 crane truck x 10 days
  1 Fuel tanker x 3 days

  The coefficient is 35 equipment-days of heavy vehicle per non-production well.

Intakes from rivers require heavy equipment inputs. It is estimated that 2 equipment days are sufficient for the pump installation and basic civil works.

As previously stated (see Excavation Labour Inputs), uars and ballehs require respectively 10 and 62 heavy earth moving equipment-days.

Burkeds can be completed with 2 heavy vehicles in four days.

As previously stated, diversion dams require 25 days of heavy earth moving equipment-days.

- **Light Equipment Inputs:** Light vehicles are used principally for passenger transportation; estimates of equipment-days are based on number of people and number of days on the site.

- **Fuel Inputs:** Fuel inputs are calculated as follows: (Estimated daily fuel consumption x Number of Equipment days).

  Estimates of Daily Fuel Consumption are as follows:

  Drill Riggs: 300 liters
  Pump Rig: 112 liters
  Heavy Equipment: 40 liters
  Light Vehicles: 20 liters

INPUT-OUTPUT TECHNICAL COEFFICIENTS FOR MAINTENANCE AND REHABILITATION (B_{ij})

Currently in Somalia, little attention is paid to maintenance of facilities and no attention to rehabilitation. It is often too late to repair a structure when a crisis occurs, thus facilities need to be replaced at a rate which can hardly be supported by the country. A maintenance program would reduce both construction and operating costs, would ensure a reliable water supply, would ensure that financial resources are directed to the construction of additional structures, (thus increasing the water supply) and would ensure regular demand for goods and services provided by "level 3" industries.

The following coefficients are estimates based on an empirical maintenance program which could be followed in the immediate future. This program involves only materials, skills and equipment which are either locally available or can be procured at resonable cost and within a reasonable delay. A brief description of the proposed maintenance program and the calculation of input coefficients is given for each of the structures considered in the framework.

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Maintenance and Rehabilitation of Drilled Wells Equipped with Hand Pumps

These wells should be serviced at least once a year and the following maintenance procedures should be followed:

- Remove, clean and make necessary repairs to hand pump,
- Pump the well with engine-driven pump to clean it, removing all dirt and organic materials,
- Disinfect the well with bleaching powder, and
- Repair cracks in cement base

It is estimated that the following inputs are required in order to carry out the operations described above:

Cement, sand and gravel: 10% of construction requirements
Spare Parts: 20% of original pump
Skilled mechanical labour: 20% of pump installation requirements
Civil work labour: 10% of construction requirements

These wells should be rehabilitated every 5 years. The rehabilitation procedures consist of drilling deeper and cleaining the well of the sand and other impurities that prevent the passage of water. At this stage, no rehabilitation procedures involving casing and screen repairs are envisaged. Such procedures require sophisticated equipment and skills which are not available in Somalia. Technical coefficients for rehabilitation are Roscoe Moss estimates.

Maintenance and Rehabilitation of Drilled Wells Equipped with Diesel Pumps

These wells should be serviced every 4 months for maintenance of the pump and every year for maintenance of the well and attached structures.

The maintenance procedures for the diesel driven pumps are as follows:

- Decarburize if the engine shows loss of compression or blow-by past the piston
- Adjust valve clearances
- Clean cylinder
- Check conditions of all belts and pulleys
- Clean the restrictor banjo union at the top end of the lubricating oil feed pipe to each cylinder head
- Renew fuel filter element.

The maintenance procedures for the well, storage tank, human and animal water points are as follows:

- Sample the well, conduct chemical and bacteriological analysis, and disinfect
- Clean thoroughly the human and animal water distribution points,
- Repair cracks in cement structures,

The following inputs are required:

Sand, cement and gravel: 10% of construction requirements
Spare Parts: 20% of pump
Civil works: 10% of construction requirements
Mechanical works; 20% of pump and fitting installation

These wells should be rehabilitated every two years. The rehabilitation procedures are the same as for hand-pumped drilled wells.

Maintenance of Hand Dug Wells:

Hand dug wells which are not equipped with a hand pump require less maintenance than drilled wells. The following items should be checked on hand dug well:

- Inspect well for signs of collapse in the walls,
- Inspect ground facilities for any unsafe conditions, unsanitary conditions, cracks in cement structure, and for a proper well cover.
- Disinfect well.
- Make checks of water depth and turbidity.

The following inputs are required:

Cement, stones, sand and gravel: 10% of construction requirements
Civil work labour: 10% of construction requirements

Hand dug well equipped with a hand pump are subject to the same maintenance requirements as drilled wells equipped with hand pumps.

Maintenance of Other Structures

Yearly Coefficients for maintenance of other structures are roughly estimated to be 10% of construction coefficient of these structures.

IV. WISyMS CONSTRAINT ANALYSIS OF NATIONAL OBJECTIVES TO 1990

Two final sets of projections for 1990 have been made on the basis of the national goals with regard to human water consumption: specifically, the goals established by the MMWR in the Plan for the Drinking Water Supply and Sanitation Decade <4>. These are presented in Exhibits 7 and 8. Most of these figures

are based on the demographic assumptions contained in Exhibit 4, the middle level projections to 1990, with the following significant changes:

- **Human Population:** The percentage breakdown between urban families with household connections (HC) and those with access only to Standpipes (SP) was made on the basis of the Plan's Service Level goals of 80% of the urban population "served" (i.e., having a private connection or being within 200 meters of a standpipe), of which 40-50% have a private connection and consume 130 lcd, and 50-60% are within 200 meters of a standpipe and consume 50 lcd, while the remainder (20% of the urban population, all of whom are served by standpipe) are at a distance of over 200 meters from a standpipe and consume about 25 lcd.

- **Rural Population:** Consumption estimates are based on the Plan's service level goals of 60% of the rural population being "served" (i.e., being within 500 meters of a public standpipe) and consuming 30 lcd, and the remaining 40% of the rural population being beyond 500 meters from a public standpipe and consuming 20 lcd. The Plan further assumes that rural settled and nomadic patterns of consumption will be "similar".

- **Percentage Distribution Across Supply Structures:** Implicit in the stated goals of the Plan is an increased reliance on "safe, permanent" groundwater resources and in drilled well water supplies in particular; although the Plan did not explicitly link the growth in consumption with the quantities of needed new drilled wells.

  For Exhibit 7, the Consultant assumes that reliance on drilled wells in urban areas increases to 80%, and in rural areas to 30% (60% served by groundwater resources; about half each by drilled wells and hand dug wells). Once new water supplies are in place, it must also be assumed that they will be used by industrial firms in urban areas, and by livestock in rural areas, increasing these categories' reliance on drilled well water supplies along with human consumption's.

  Exhibit 8 makes use of a more modest set of goals presented in planning document. The second set of goals implies less of an attempt to develope groundwater resources and a relatively heavier emphasis on surface water resources and catchments to serve its ta rget populations. The distribution for rural areas in this run is : 15% for drilled wells, 30% for hand dug wells, and the rest distributed across the range of surface/catchment supply structures.

- **Numbers of Water Supply Structures:** These numbers increase greatly, solely due to the increased per capita consumption of water assumed in the national goals. The Consultant allowed WISyMS to show other structures to be used as a source to make up the needed growth in consumption, (even though many of these are surface water and catchment structures and therefore not necessarily "permanent and safe").

The Consultant's interpretation of WISyMS data output from all 3 levels and for all 3 functions forms an important basis for the analyses contained in the main body of the report and in the Executive Summary.

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