water currently consumed by type of use (e.g., urban households, livestock, irrigated agriculture, industry), and by type of supply structure (e.g., drilled wells, hand-dug wells). Also, it projected growth in total consumption needs from demographic trends, and assumed modest increases in standards of consumption. For Level II - Drilling and Construction of New Water Supply Structures, it projected the numbers of New Water Supply Structures which would need to be constructed or rehabilitated each year to 1990 in order 1) to replace failing facilities, and 2) to keep pace with growth in overall consumption needs. For Level III - Water Industry Inputs, it estimated the input requirements for activities at Levels I and II.

On the basis of WISyMS' analysis, it was determined that water consumption in Somalia in 1984 was about 1.2 billion cubic meters.[1] Of this total, about 4% was supplied by drilled wells; 2% by hand dug wells; 2% by uars (earth reservoirs); 2% by ballehs (pond catchments); 7% by dams; less than 1% by burkeds (masonry cistern catchments); and over 80% by intakes from rivers (see Exhibit 3-B).

Of the 1.2 billion cubic meters of water provided through the use of supply structures, agricultural crops accounted for over 92% of this total; livestock consumption accounted for about 5%; human consumption accounted for less than 2%; and government institutions and industry accounted for less than 1% (see Exhibit 3-C).

Of the 47 million cubic meters of water provided by drilled wells, approximately 58% was consumed by agricultural crops, 16% was consumed by government institutions and industry, 14% by humans, and 12% by livestock (see Exhibit 3-D).

There was a stock of approximately 600 operational drilled wells in the country as of end-year 1984. Construction of functioning drilled wells ("production wells") in the country has been about 100 per year for the past three years, of which about 28% were produced under government force account, 32% by the local private sector (mostly irrigation wells), and 40% by foreign firms.

As of end-year 1984, there were approximately 17,000 hand dug wells, 18,000 uars, 12,000 ballehs, at least 10,000 burkeds, perhaps 5,000 intake structures from rivers, and 5,000 dams and earth diversions in this country.

---

1 The estimate of 1.2 billion cubic meters represents only water provided through the use of man-made supply structures (such as wells, reservoirs, cisterns and intakes from rivers). The amount of water consumed directly from nature is about two and a half times the amount consumed through such man-made supply structures in Somalia.

EXHIBIT 3-B

1984 DISTRIBUTION OF WATER FROM SUPPLY STRUCTURES BY TYPE OF STRUCTURE

TOTAL 1,211,562 (in Thousands of Cubic Meters)

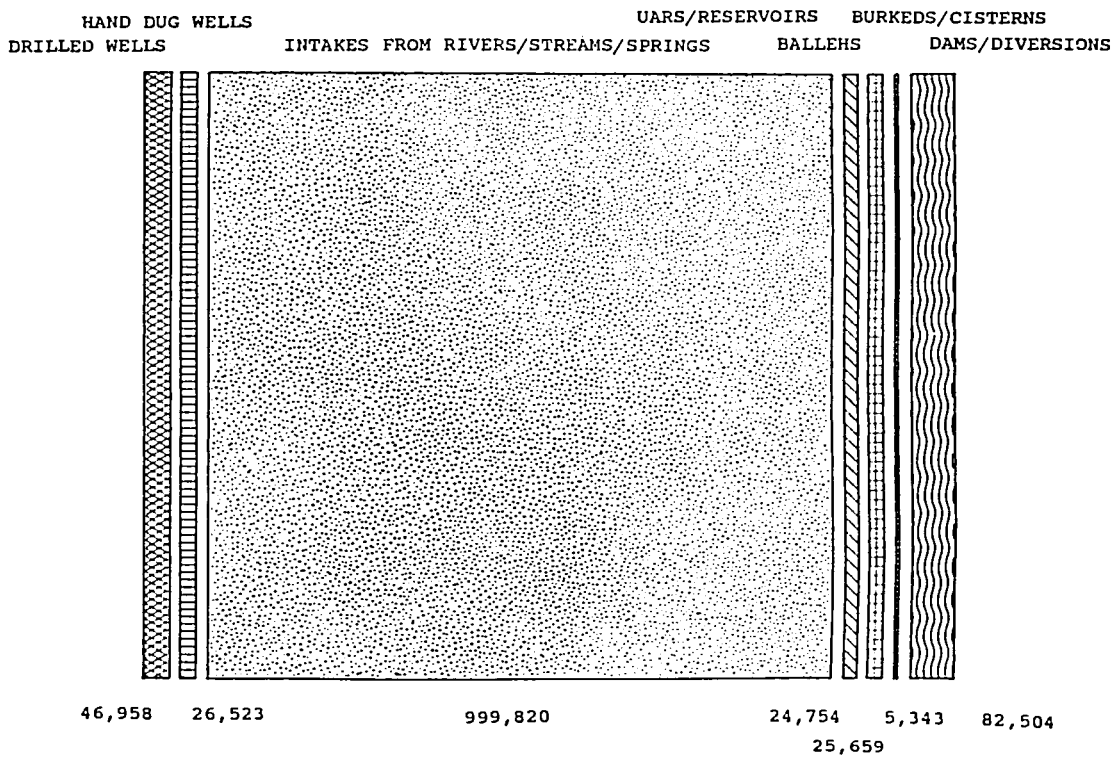


EXHIBIT 3-C

1984 DISTRIBUTION OF WATER FROM SUPPLY STRUCTURES

BY TYPE OF CONSUMER

TOTAL 1,211,562 (in Thousands of Cubic Meters)

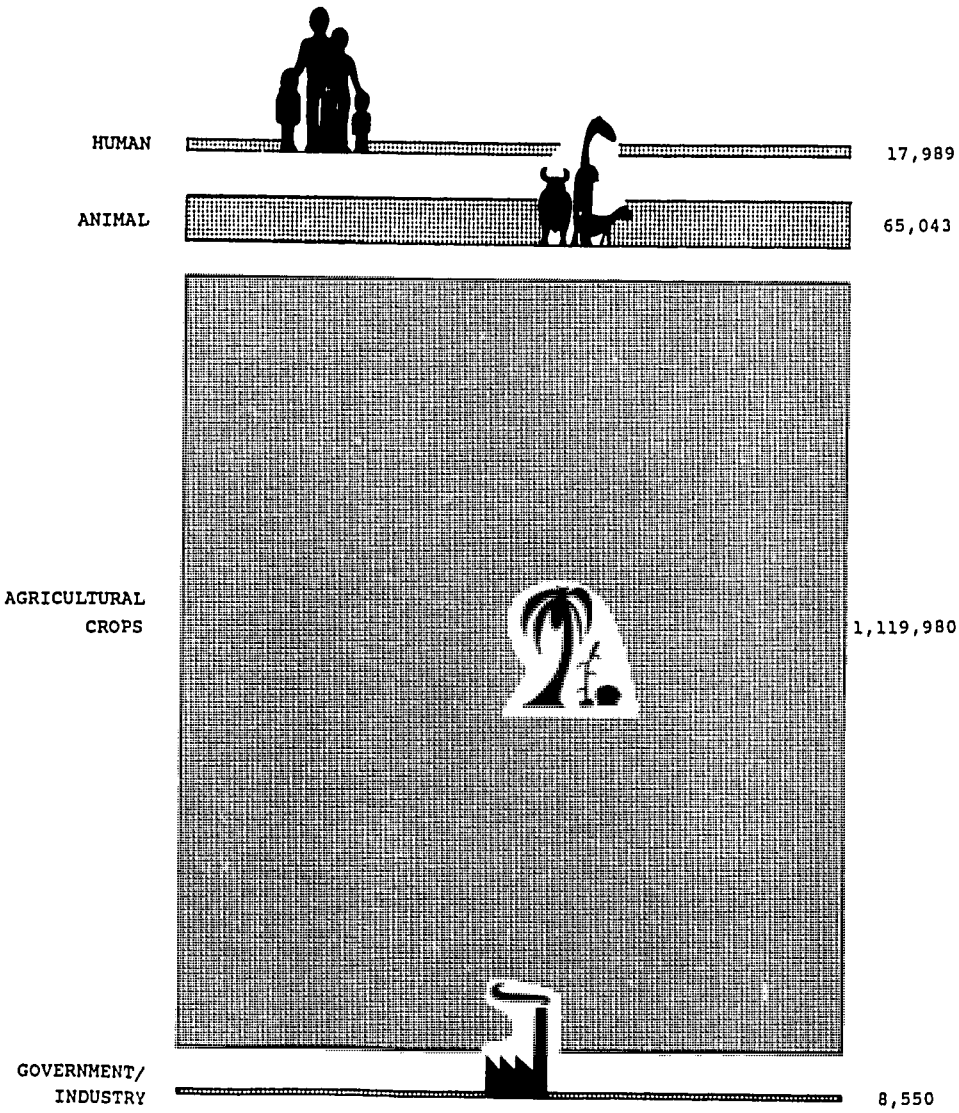
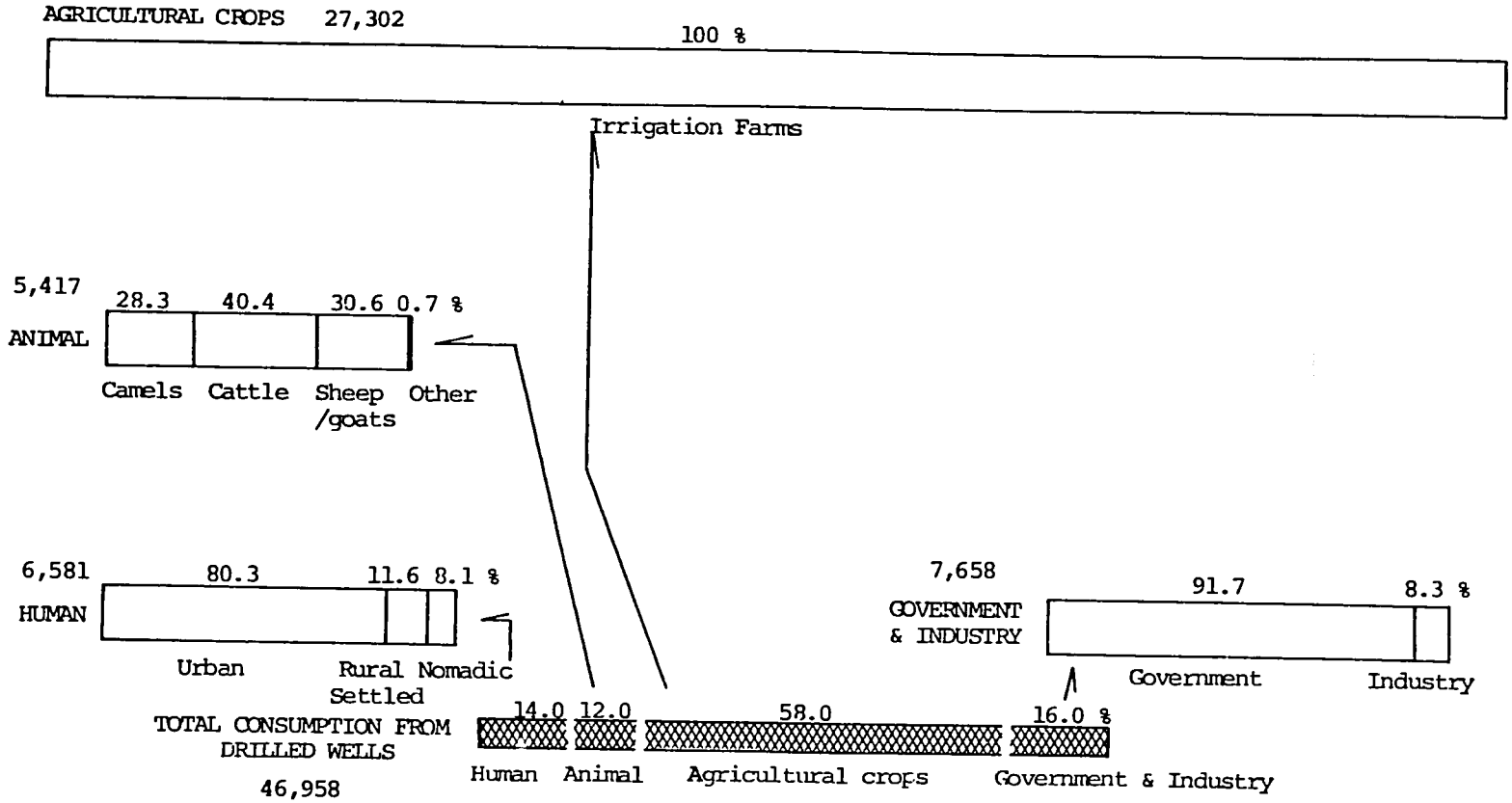


EXHIBIT 3-D

1984 DISTRIBUTION OF WATER FROM DRILLED WELLS

BY TYPE OF CONSUMER

TOTAL 46,958 (in Thousands of Cubic Meters)



1984

Maintenance work on water supply structures currently is sub-optimal, such that the useful life of pumps for drilled wells, for example, may be only three or four years. Improved maintenance activity could increase useful life for these facilities to about 10 years or more.

3.2.2 Projected Future Consumption

In a further refinement of WISyMS, LBII disaggregated the entire section pertaining to drilled wells, and split that category into four sub-categories:

1) urban wells (including municipal wells serving entire cities and private wells primarily for individual industrial/commercial or government facilities);

2) rural wells equipped with hand pumps;

3) rural wells equipped with diesel pumps; and

4) irrigation wells.

We then took into account the possibility of well rehabilitation and pump replacement as an alternative in some cases to drilling new wells. This involved no change in estimates of numbers of currently operational wells but led to revisions in the projected numbers of needed new wells.

The Consultants' WISyMS projections to 1990, based on trends in population growth and urbanization, and allowing for moderate increases in per capita water consumption and economic activity, indicate a growth in water consumption to over 1.5 billion cubic meters. Of this total, about 5% may be provided by drilled wells, 3.2% by hand-dug wells, 2% by uars, 2% by ballehs, 0.5% by burkeds, 8.2% by dams, and 79% by intakes from rivers (see Exhibit 3-E).

The same projections indicate that of the 1.5 billion cubic meters of water projected to be provided by water supply structures in 1990, human consumption will account for about 2.5%; livestock consumption, 5.6%; government and manufacturing, 0.6%; and agricultural crops, 91.3%. (See Exhibit 3-F.)

The WISyMS analysis indicates a need for a stock of over 1,000 drilled wells by 1990. Excluding irrigation wells, there will still be a need for a total stock of 819 wells to serve human, livestock and industrial needs by 1990. If a program of routine maintenance and timely pump replacement is in effect on the stock of wells, these requirements could be met by an annual drilling program of about 52 new wells in 1986 rising to 80 in 1990. This would provide for a total of 327 new wells over the five year period 1986-1990 (see Exhibit 3-G), some of which can be supplied by the rehabilitation of currently non-operational wells.

EXHIBIT 3-E

1990 DISTRIBUTION OF WATER CONSUMPTION FROM SUPPLY STRUCTURES

BY TYPE OF STRUCTURE

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

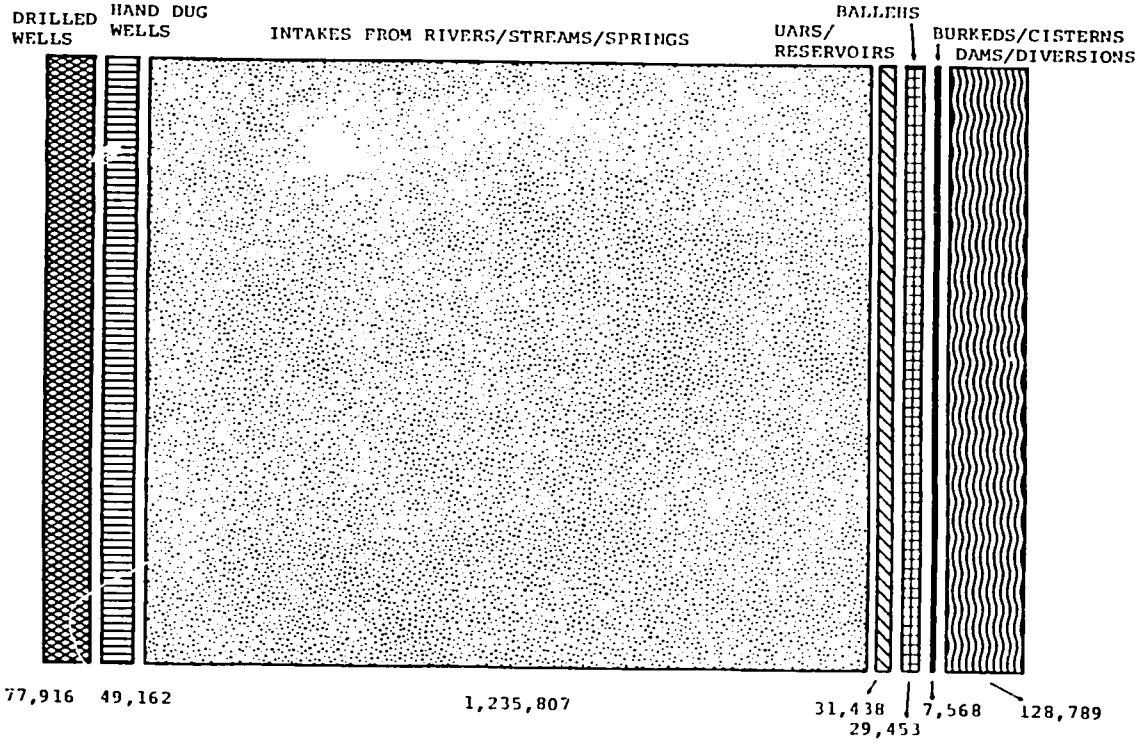


EXHIBIT 3-F

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

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

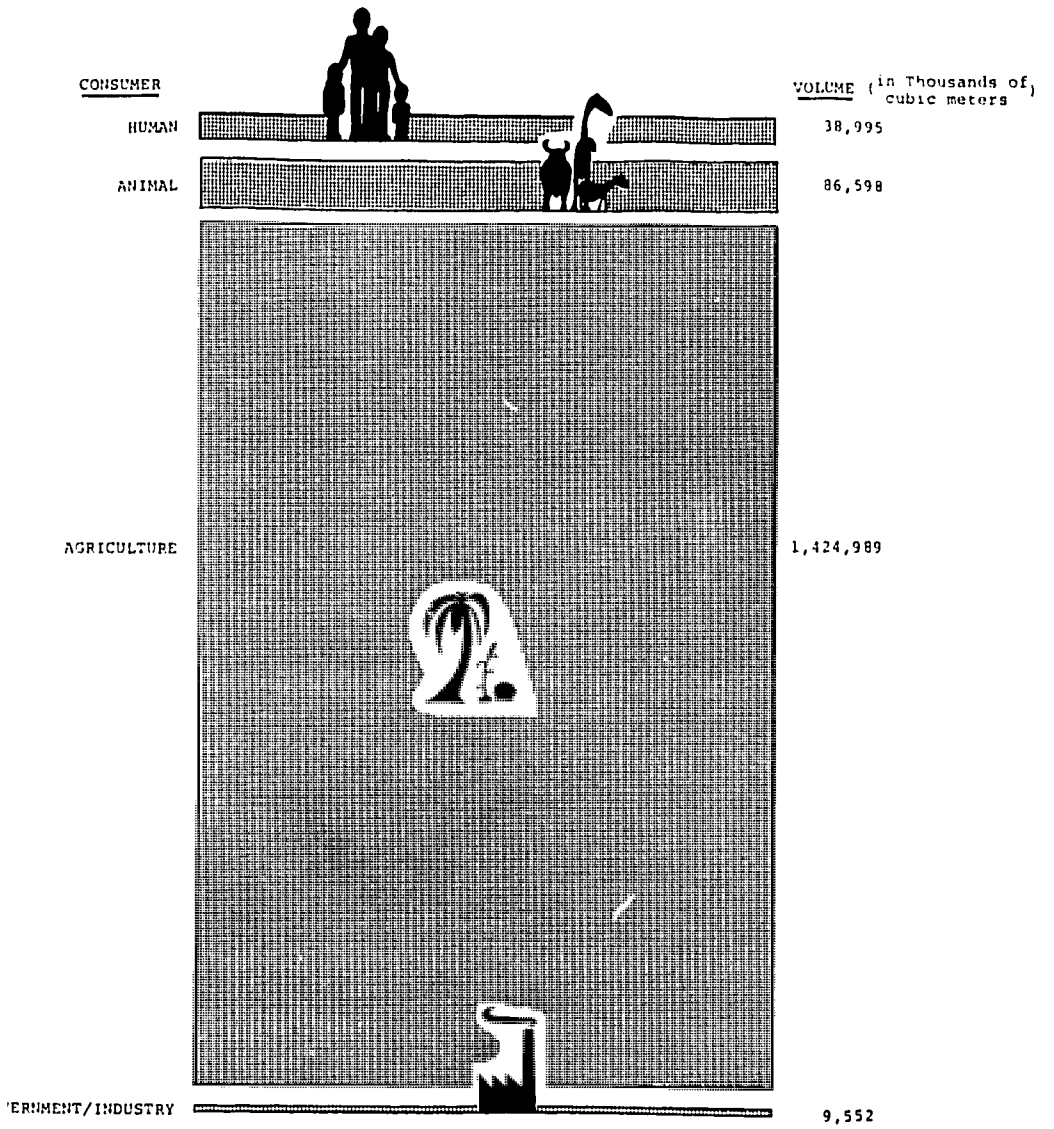


EXHIBIT 3-G

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL, MIDDLE-LEVEL PROJECTIONS

Past Achievements and Projections of Requirements for Well Drilling and Pump Replacement/Well Rehabilitation through 1990

UNITS/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total Stock	26	49	88	112	124	138	153	170	189	210	233
Needed Drilling	5	23	39	24	12	14	15	17	19	21	23
Needed Rehabilitation	3	5	9	12	13	14	16	17	19	21	24
DIESEL PUMP RURAL BOREWELLS											
Needed Total Stock	64	96	125	159	199	223	250	280	314	352	395
Needed Drilling	13	32	29	34	40	24	27	30	34	38	43
Needed Rehabilitation	7	10	13	16	20	23	25	28	32	36	40
HAND PUMP RURAL BOREWELLS											
Needed Total Stock	56	72	86	103	122	131	141	152	164	177	191
Needed Drilling	7	16	14	17	19	9	10	11	12	13	14
Needed Rehabilitation	6	8	9	11	13	14	15	16	17	18	20
ALL NON-IRRIGIGATION WELLS											
Needed Total Stock	146	217	299	374	445	492	544	602	667	739	819
Needed Drilling	25	71	82	75	71	47	52	58	65	72	80
Needed Rehabilitation	16	23	31	39	46	51	56	61	68	75	84

In addition, to support increased water consumption from all sources, annual construction for other types of structures will have to rise to the following levels by 1990: hand-dug wells - about 900, river intakes - almost 1,000, uars - 150, burkeds - 2,000, and dams - 30.

This construction program (along with maintenance and operations) in turn implies a need for certain inputs which are available or produced locally or have the potential to be produced locally. In 1990, these quantities could be as high as:

cement - 56 thousand cubic meters,
stone - 85 thousand cubic meters,
gravel - 6 thousand cubic meters,
sand - 27 thousand cubic meters,
hand pumps - 300 units,
skilled labor - 682 thousand person-days,
unskilled labor - 389 thousand person-days,
fuel - 10.7 million liters,
drill/pump rigs - 8 thousand equipment-days.

In all, the Somalia water industry could represent an $80 million industry by 1990, (in 1985 dollars), of which almost $3 million would be paid to local labor directly, and an additional $3.65 million might have the potential for local production.[2/] For further detail, refer to Appendix I - 4.

3.2.3 National Goals

The 1982-1986 Five Year Plan called for WDA to construct 50 drilled wells per year. In the 1984-1986 revision, this was adjusted downward to 30 per year. Actual achievements from 1982-1984 were in the range of 10-15 production wells per year, including wells drilled by WDA under contract to other government agencies for special purposes.

The Ministry of Mineral and Water Resources (MMWR) has produced "The Plan for the Drinking Water Supply and Sanitation Decade" that includes ambitious goals for 1990: urban consumption of 40-130 liters per capita per day (lcd) and rural consumption of 20-30 lcd. Using the WISyMS model and assumptions on demographic trends, this implies a 30% per annum growth rate in human water consumption from 1984, which would in turn imply a need for over 1,400 drilled wells by 1990, of which almost 1200 would be needed even excluding irrigation wells. Even if a program of routine maintenance and periodic pump replacement were in effect on the entire existing stock of wells, these goals would require a production program of a total of 673 non-irrigation wells between 1986-1990. (See Exhibit 3-H). For further detail, refer to Appendix I - 5.

2/ This assumes the local market provides all needed stone, gravel, sand and half the needed cement, pipes and fittings and handpumps by 1990. Source: LBII's Revised WISyMS, Appendix I.

EXHIBIT 3-H

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL, NATIONAL GOALS PROJECTIONS

Past Achievements and Projections of Requirements for Well Drilling and Pump Replacement/Well Rehabilitation through 1990

UNITS/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total Stock	26	49	88	112	124	153	189	234	289	358	448
Needed Drilling	5	23	39	24	12	29	36	45	55	69	90
Needed Rehabilitation	3	5	9	12	13	16	19	24	29	36	45
DIESEL PUMP RURAL BOREWELLS											
Needed Total Stock	64	96	125	159	199	233	273	320	375	439	516
Needed Drilling	13	32	29	34	40	34	40	47	55	64	77
Needed Rehabilitation	7	10	13	16	20	24	28	32	38	44	52
HAND PUMP RURAL BOREWELLS											
Needed Total Stock	56	72	86	103	122	135	150	166	184	204	230
Needed Drilling	7	16	14	17	19	13	15	16	18	20	26
Needed Rehabilitation	6	8	9	11	13	14	15	17	19	21	23
ALL NON-IRRIGIGATION WELLS											
Needed Total Stock	146	217	299	374	445	521	612	720	848	1001	1194
Needed Drilling	25	71	82	75	71	76	91	108	128	153	193
Needed Rehabilitation	16	23	31	39	46	54	62	73	86	101	120

3.2.4 Minimum Needs

In addition, the Consultants have used WISyMS to project "minimum needs" for Somalia to 1990. This minimum needs projection was based on growth trends for human and livestock population, and allowed for no increase in currently prevailing consumption standards (in terms of per capita water consumption). This projection establishes a minimum need for a total stock of 598 non-irrigation wells by 1990. If and only if a program of routine maintenance and timely pump replacement is in effect on the entire existing stock of wells, these minimum water consumption needs could be met by a construction program of 132 wells over the period 1986-1990, (see Exhibit 3-I). Any shortfall from this combined maintenance, rehabilitation, and construction program would imply an absolute reduction in currently prevailing consumption standards, measured in terms of per capita groundwater consumption volumes.

Exhibit 3-J displays the three alternative projections of annual needed well drilling (for non-irrigation wells) based on, respectively:

1) the Consultants' middle projections, (allowing for modest increases in per capita water consumption),

2) Somalia's national goals for the decade (involving more ambitious goals for per capita water consumption), and

3) the Consultants' projection of minimum needs (allowing for no increase in consumption standards).

Actual well-drilling achievements from 1981 through 1984 are presented for comparison.

3.3. SOMALIA'S WATER INDUSTRY - SUPPLY SIDE ANALYSIS

3.3.1 Maintenance Capabilities

Somalia's groundwater development needs include a combination of new drilling and construction, and a program of maintenance and repair on existing structures. There is currently no functioning program of maintenance for WDA's wells whatsoever, although some maintenance activities are being performed on an ad hoc basis, particularly under foreign aid drilling projects. It is for this reason that the Consultants have focused first on a program of contract well/pump maintenance.

As of the end of 1984, WDA was operating 359 borewells in rural areas, and had an additional 130 wells which were not operating due to a lack of operating pump/generator sets.[3/] Some of these wells were newly drilled, and had yet to receive a pumping unit. However, for the rest, had there been a program of

EXHIBIT 3-I

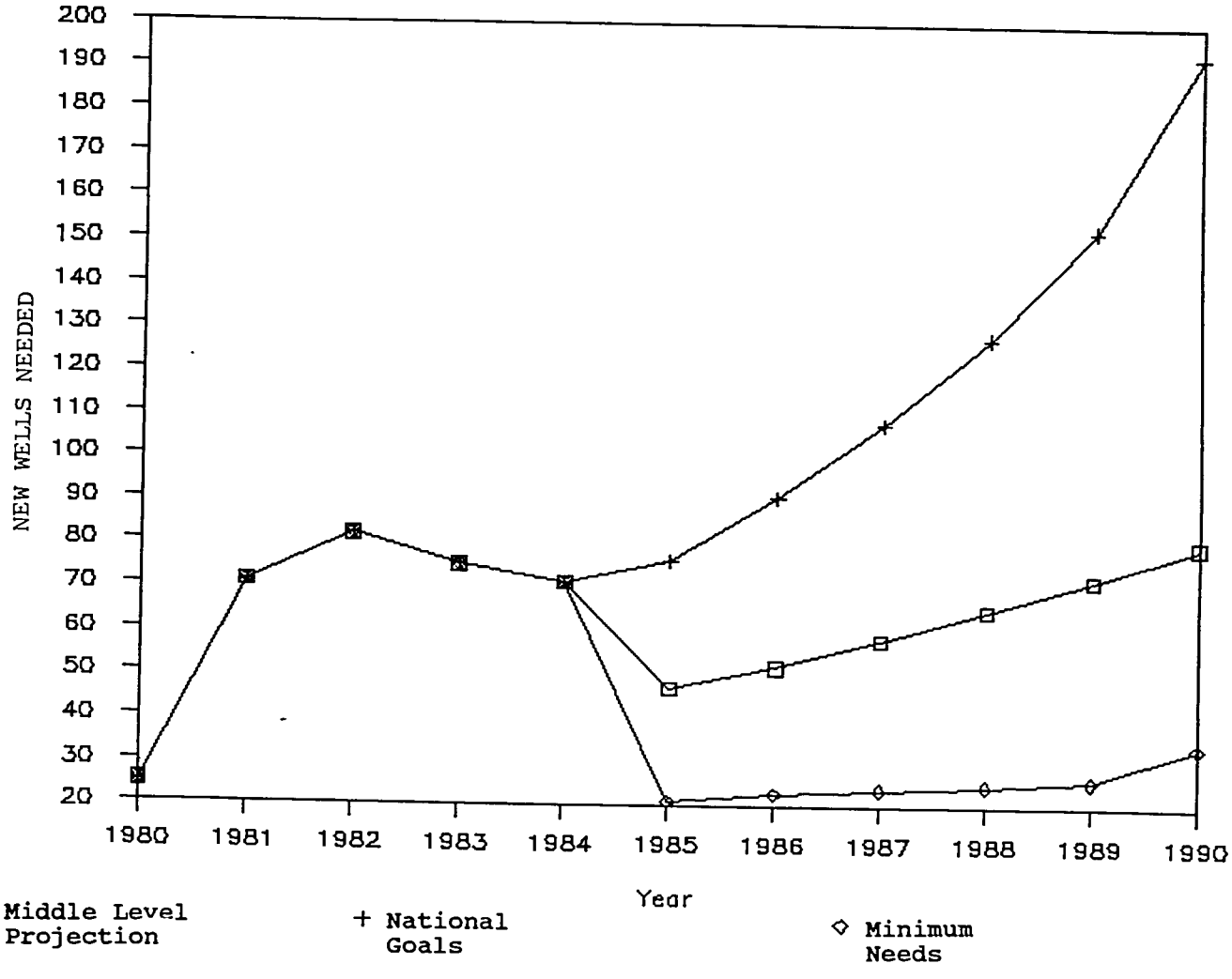
WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL, MINIMUM NEEDS PROJECTIONS

Past Achievements and Projections of Requirements for Well Drilling and Pump Replacement/Well Rehabilitation through 1990

UNITS/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total Stock	26	49	88	112	124	128	133	138	143	148	156
Needed Drilling	5	23	39	24	12	4	5	5	5	5	8
Needed Rehabilitation	3	5	9	12	13	13	14	14	15	15	16
DIESEL PUMP RURAL BOREWELLS											
Needed Total Stock	64	96	125	159	199	213	228	244	261	279	299
Needed Drilling	13	32	29	34	40	14	15	16	17	18	20
Needed Rehabilitation	7	10	13	16	20	22	23	25	27	28	30
HAND PUMP RURAL BOREWELLS											
Needed Total Stock	56	72	86	103	122	125	128	131	134	137	143
Needed Drilling	7	16	14	17	19	3	3	3	3	3	6
Needed Rehabilitation	6	8	9	11	13	13	13	14	14	14	15
ALL NON-IRRIGIGATION WELLS											
Needed Total Stock	146	217	299	374	.445	466	489	513	538	564	598
Needed Drilling	25	71	82	75	71	21	23	24	25	26	34
Needed Rehabilitation	16	23	31	39	46	48	50	53	56	57	61

EXHIBIT 3-J

DEMAND SIDE PROJECTIONS OF NEEDED WELL DRILLING THROUGH 1990



pump maintenance in place over the past several years, the Consultants estimate that approximately 70% of those wells would be in operation now.

In other words, there may be up to 90 wells in the country currently out of operation due to the lack of a program of routine maintenance and repair. In some cases, these wells are left in disuse for long periods of time. This represents an utter waste of what is usually a $50,000 to $70,000 investment. It forces the local community to resort to less reliable and sanitary surface water sources, or to undergo frequent long journeys to fetch safe water supplies from distant sources, or to uproot and move to communities that have functioning borewells.

In other cases, the whole pump and/or generator eventually may be replaced, at a cost of $20,000 or more for the new equipment alone (to which the costs of labor and transport would have to be added), when a simple repair could be made for a small fraction of the replacement cost.

More importantly, once in place, a program of routine pump monitoring and maintenance can often more than double the effective life-span of a pump/generator set. While unmaintained equipment may have a lifespan of as little as three or four years, a properly maintained pump should be able to last for ten years. Appendices A-1.3 and A-2.2 include preliminary estimates of the savings to the Somali economy of an effective program of routine pump maintenance and repair.

3.3.2 Drilling Capabilities

Somalia had a stock of approximately 600 operational drilled wells as of end-year 1984, of which about 445 were non-irrigation wells, with 359 operated by WDA. Construction of functioning drilled wells ("production wells") in the country averaged about 100 per year from 1981 through 1984, of which about 75, on average, were new non-irrigation wells. In the construction of non-irrigation wells, government production accounted for an average of 20 wells per year (including WDA, the Urban Water Agencies, and the Ministry of Defense) or about 27% of the total; production by foreign firms accounted for an average of 41 wells per year or about 54% of the total; and production by local private firms accounted for an average of 14 wells per year or about 19% of the total.

Simple linear correlation estimates of the data from 1981 through 1984 show that the trend in non-irrigation drilling activity has been only slightly positive and quite erratic. If

3/ Ministry of National Planning, "Performance of the Somali Economy in 1984", Mogadishu, June 1985.

construction of production wells between 1986 and 1990 could continue the trend established from 1981 to 1984, it might climb from about 95 in 1986 to 115 in 1990, for a total of about 525 over the five year period. This achievement, however, would require a sustained increase in foreign drilling, while current donor plans indicate a decline in their drilling assistance. (See exhibit 3-K.)

At this point in time, it appears that foreign drilling activity can only be expected to fall from the drilling levels attained over the past four years for the following reasons:

1. Of a total of 269 foreign-aid funded non-irrigation wells drilled or planned for 1981-1987, about 16% of those wells were drilled under the auspices of refugee relief and resettlement efforts, which are largely completed.

2. Almost 10% were undertaken by German aid for a number of medium sized towns. Two phases of that program have been completed, anu funding for the third has not yet been allocated as of this writing. There are no immediate plans to fund the third phase, and it is possible that the program will end as it stands now.

3. Almost 20% have been or will be undertaken by USAID's CGDP, which is scheduled for completion in the middle of 1986, with no further extention in sight.

4. About 15%, being funded by the Saudi's for rural water development, are scheduled for completion this year, and as of this writing, there were no plans for an extension.

Thus, unless and until foreign donors decide to fund more well drilling in the future, WDA must assume that foreign funded drilling will fall off to less than half the average achieved during the previous five years. (See Appendix C-3.2)

In addition, foreign drilling over the period 1981-1985 has shown itself to be highly erratic, with an upward trend of about 1.7 additional wells per year from 1981-1985 but very large variability (see Exhibit 3-L).

Meanwhile, the total number of wells produced under local efforts (i.e., by the Somali public and private sectors but excluding foreign firms) would more likely range from about 45 in 1986 to 58 in 1990, for a total of 260 over the five year period.

Government drilling has also been rather uneven. Although averaging 20 wells per year, with moderate variability, the overall trend has been slightly (but insignificantly) negative (see Exhibit 3-M). Local private drilling, growing from a very small base, has exhibited an upward trend of about 3.6 additional wells per year, with very low variability (see Exhibit 3-N).

EXHIBIT 3-K

PAST ACTUAL AND PROJECTED/PLANNED WELL DRILLING THROUGH 1990

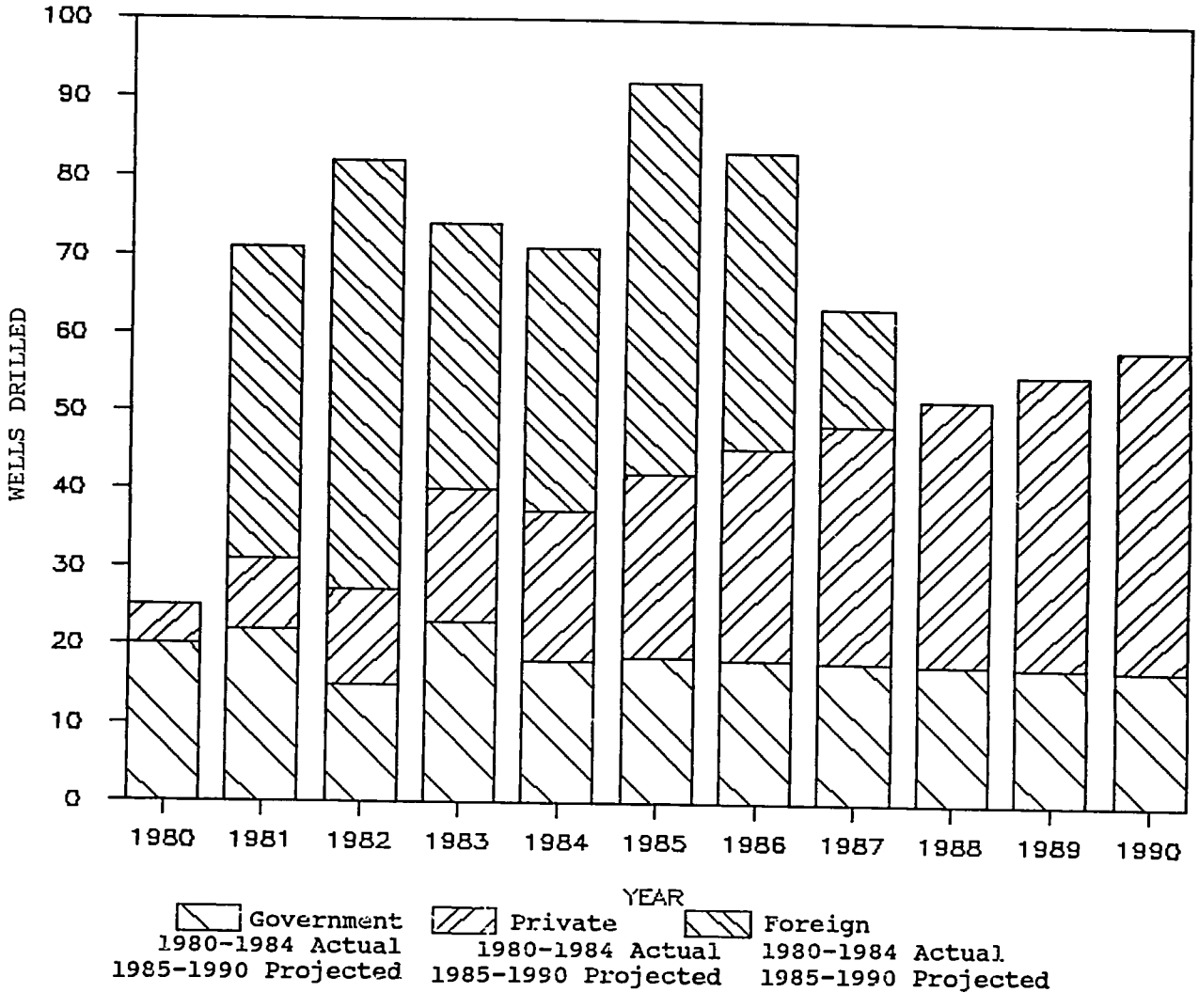
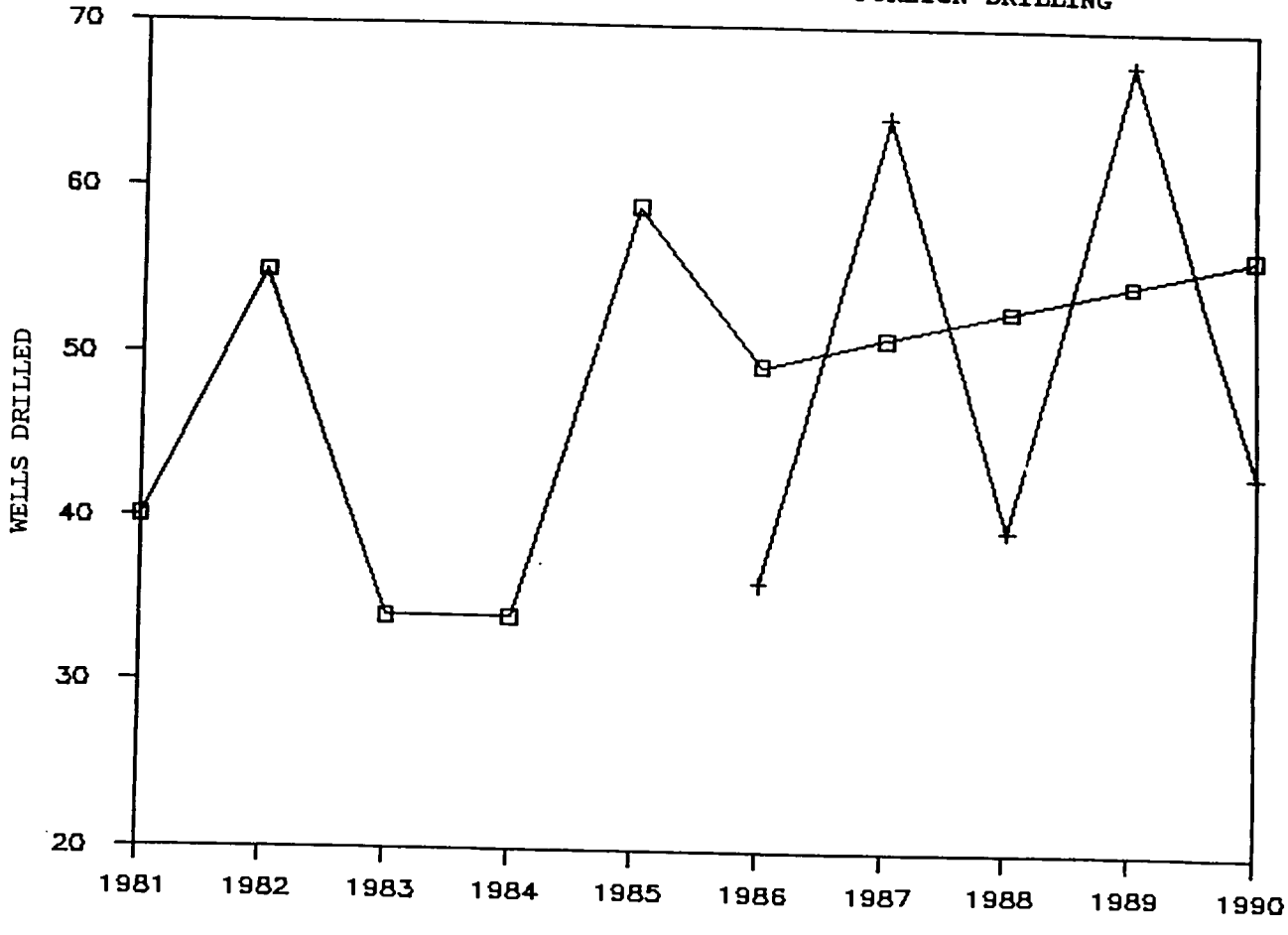


EXHIBIT 3-L

TRENDS AND VARIABILITY IN DRILLING - FOREIGN DRILLING

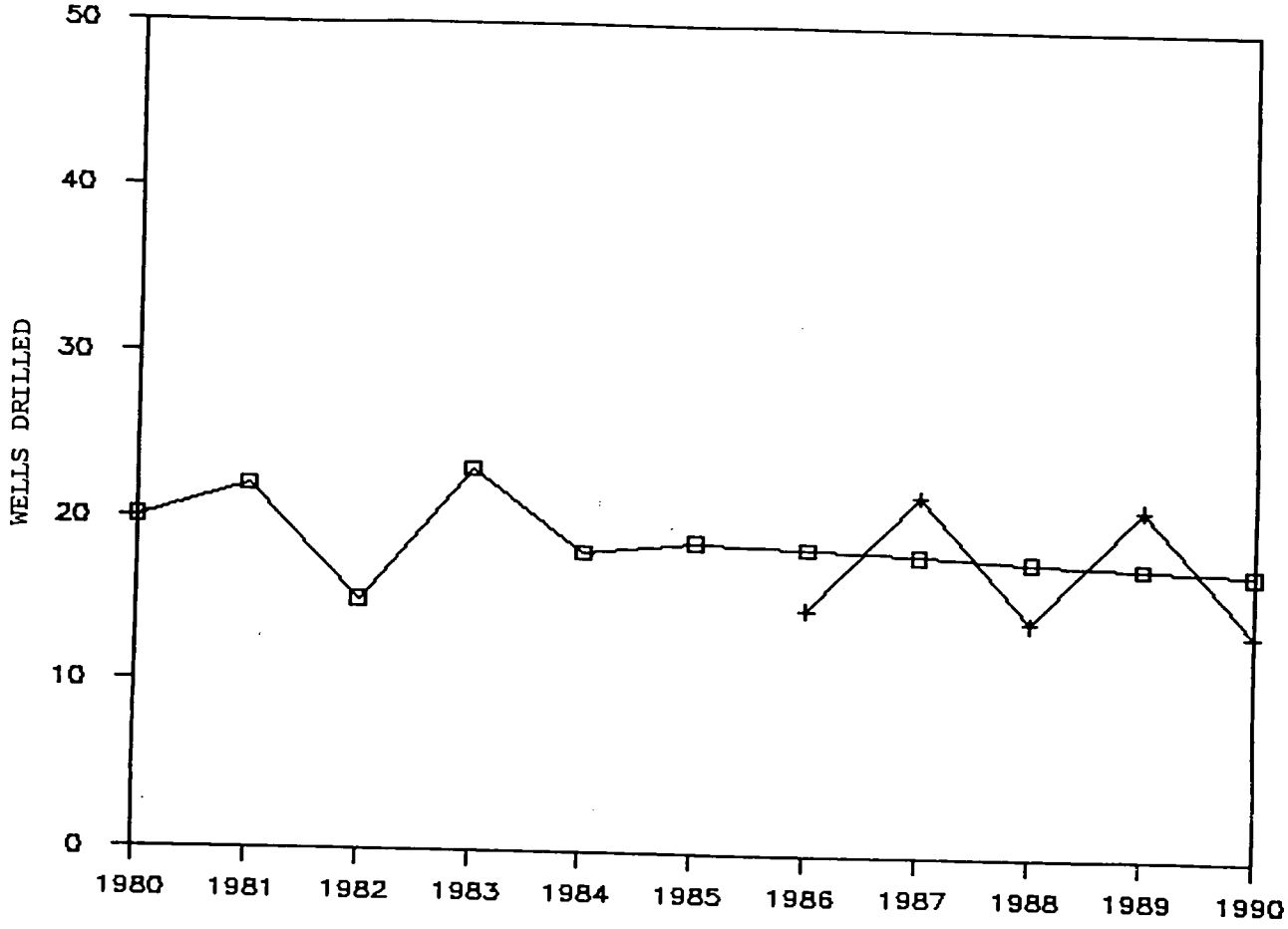


□ Foreign
1981-1985 Actual/Planned
1986-1990 Trend Line

+ Foreign
Variability
About Trend Line

EXHIBIT 3-M

TRENDS AND VARIABILITY IN DRILLING - GOVERNMENT DRILLING

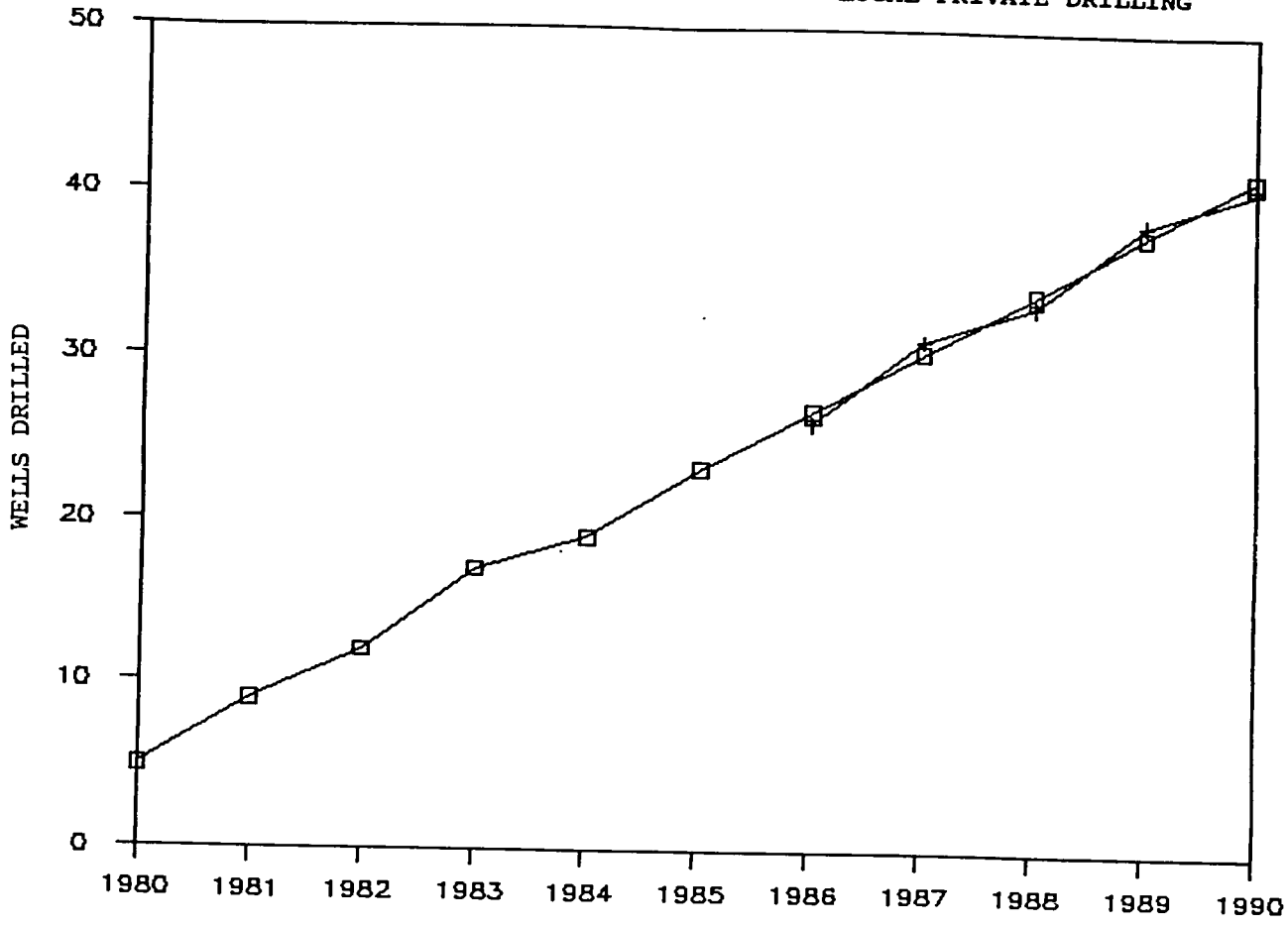


□ Government
1980-1985 Actual
1985-1990 Trend Line

+ Government
Variability
About Trend Line

EXHIBIT 3-N

TRENDS AND VARIABILITY IN DRILLING - LOCAL PRIVATE DRILLING



□ Private
1980-1984 Actual
1985-1990 Trend Line

+ Private
Variability
About Trend Line

A comparison of the supply-side projections of local drilling activity with the demand-side projection of the drilling needed to support forecasted consumption needs through 1990 (the Consultants' middle level projections) reveals a significant shortfall (see Exhibit 3-O). This comparison shows that under current policies and conditions, Somalia is not self-sufficient in water resource development, and could not significantly increase the water consumption standards of its population without either foreign assistance or a significant diversion of resources from other important activities to the water industry. In particular, the lack of a program of maintenance and repair, combined with unbalanced geographical patterns of local drilling activity, indicate that a fall-off in foreign assisted drilling may actually lead to an absolute decline in water consumption standards in many rural areas. (For more details as to the supply side of the Somali Water Development Industry, see Appendix C.)

Exhibit 3-P illustrates how the Consultants' recommended program (Phase One and Phase Two) compares with the demand side middle level projections of need. The recommended program will allow for modest but significant increases in per capita consumption of water from drilled wells of about 13% per capita per year), although falling short of the National Goals embodied in the Plan for the Drinking Water Supply and Sanitation Decade. (Somalia could conceivably meet its full goals, although it would probably require a considerable increase in donor assistance and/or rapid and substantial diversion of financial, material, and human resources from other national endeavors).

Exhibit 3-Q illustrates the breakdown of drilling and rehabilitation activity by source and by year through 1990 with the recommended program, and shows past performance for sake of comparison. Government drilling stays at approximately the same level as has been achieved in the past; foreign drilling is increasingly taken over by local private contractors, and the rehabilitation program considerably boosts output during the transition. For further detail, refer to Appendix I-5.5.

3.4 CURRENTLY EXISTING CONSTRAINTS TO THE EXPANSION OF SOMALI WATER RESOURCE DEVELOPMENT

Expansion of the supply of safe, reliable water facilities for Somalia depends crucially on the ability of the country to tap its groundwater resources. This in turn requires the appropriate human resources, materials, and equipment; and financial resources, organizational abilities, and a set of policies and incentives conducive to encouraging efforts in this industry. Somalia faces constraints in most of these areas, each of which is discussed below, first in a summary of the current situation at each level of the industry, and then in a more detailed presentation by type of constraint.

EXHIBIT 3-O

DEMAND SIDE VS SUPPLY SIDE PROJECTIONS OF DRILLING - PAST ACTUAL
TOTAL DRILLING AND PROJECTED LOCAL DRILLING
COMPARED TO PROJECTED NEEDED DRILLING

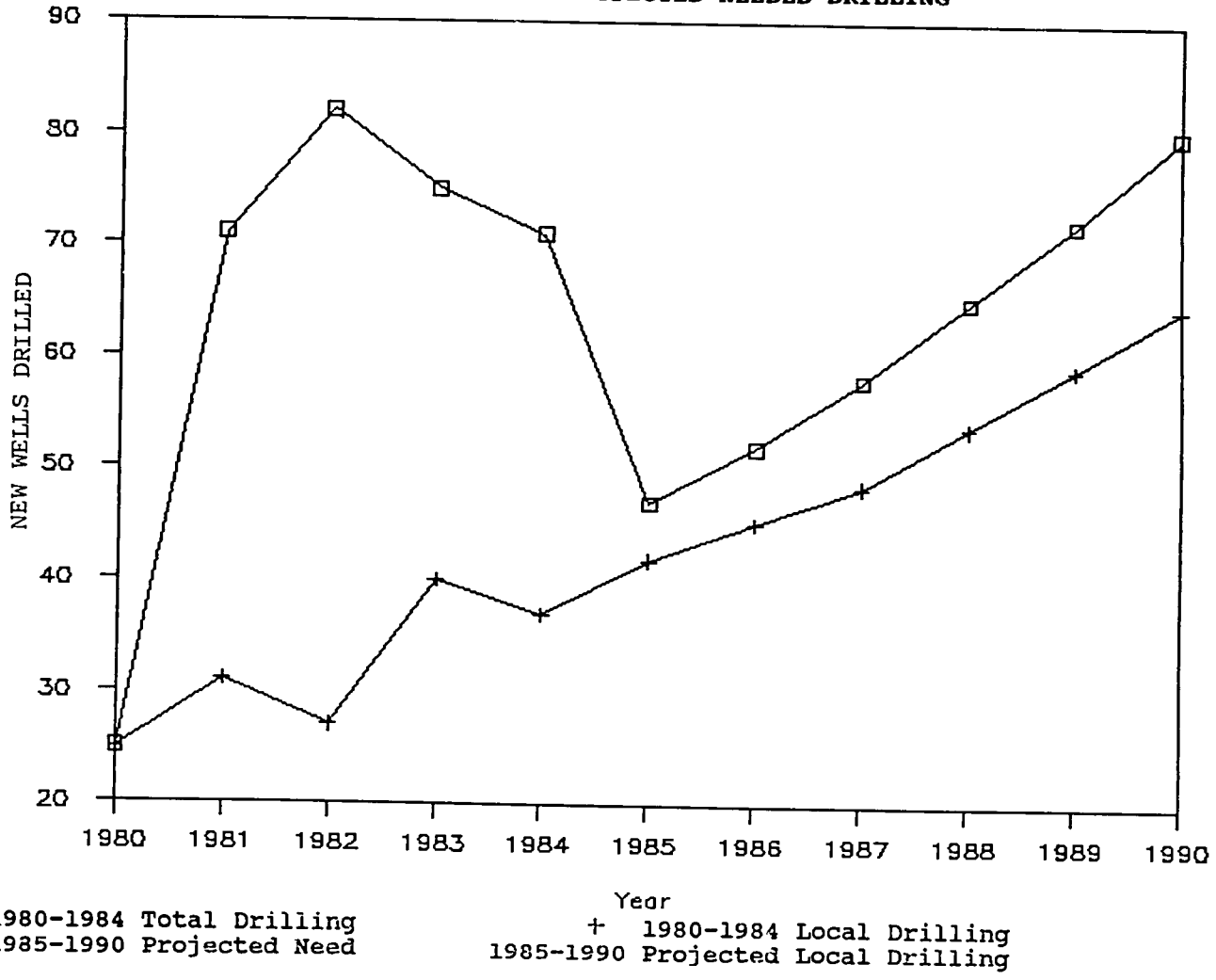


EXHIBIT 3-P

DEMAND SIDE VS SUPPLY SIDE PROJECTIONS OF STOCK OF WELLS - PAST ACTUAL TOTAL, PROJECTED NEED AND ACHIEVEMENTS WITH CONSULTANT'S RECOMMENDED PROGRAM

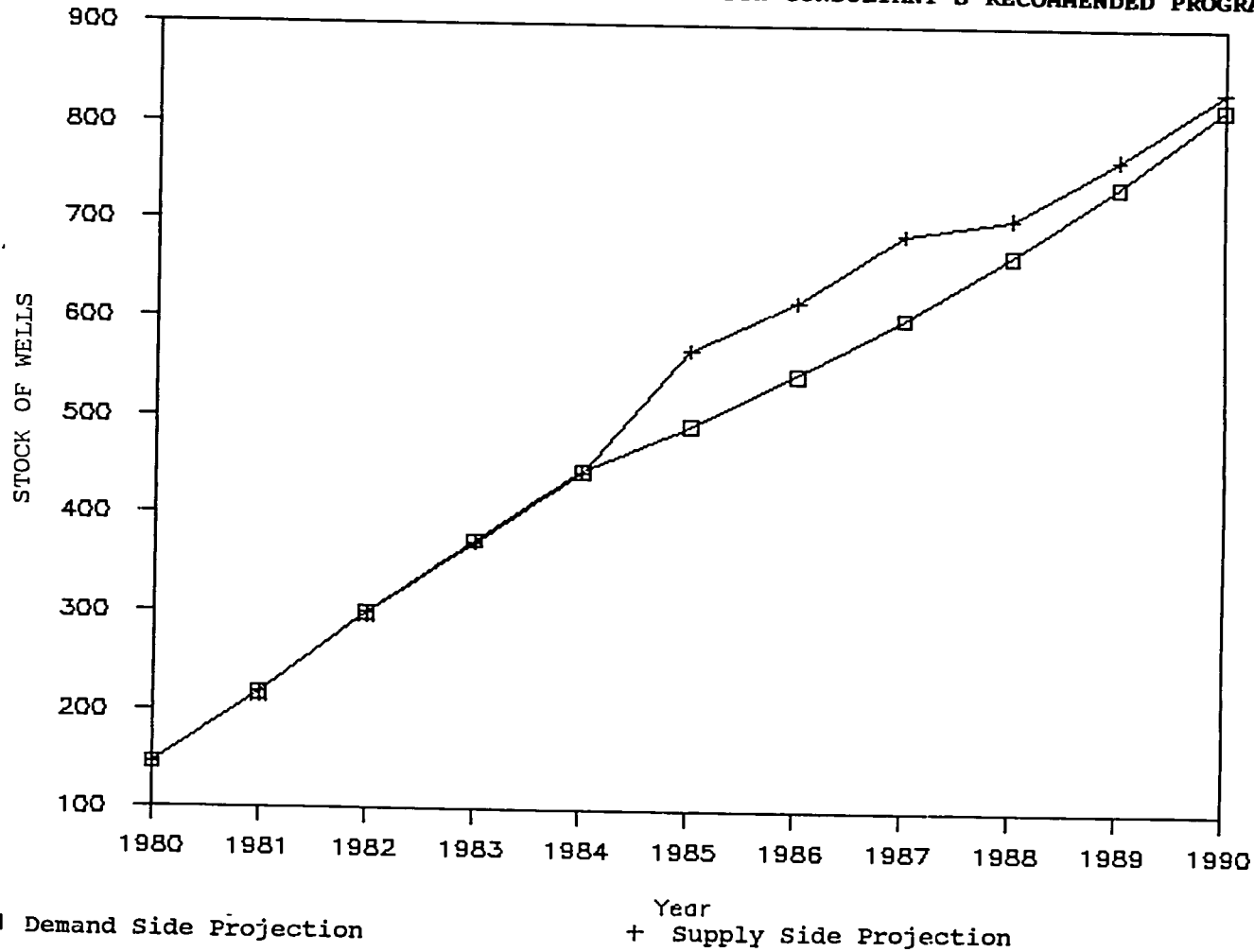
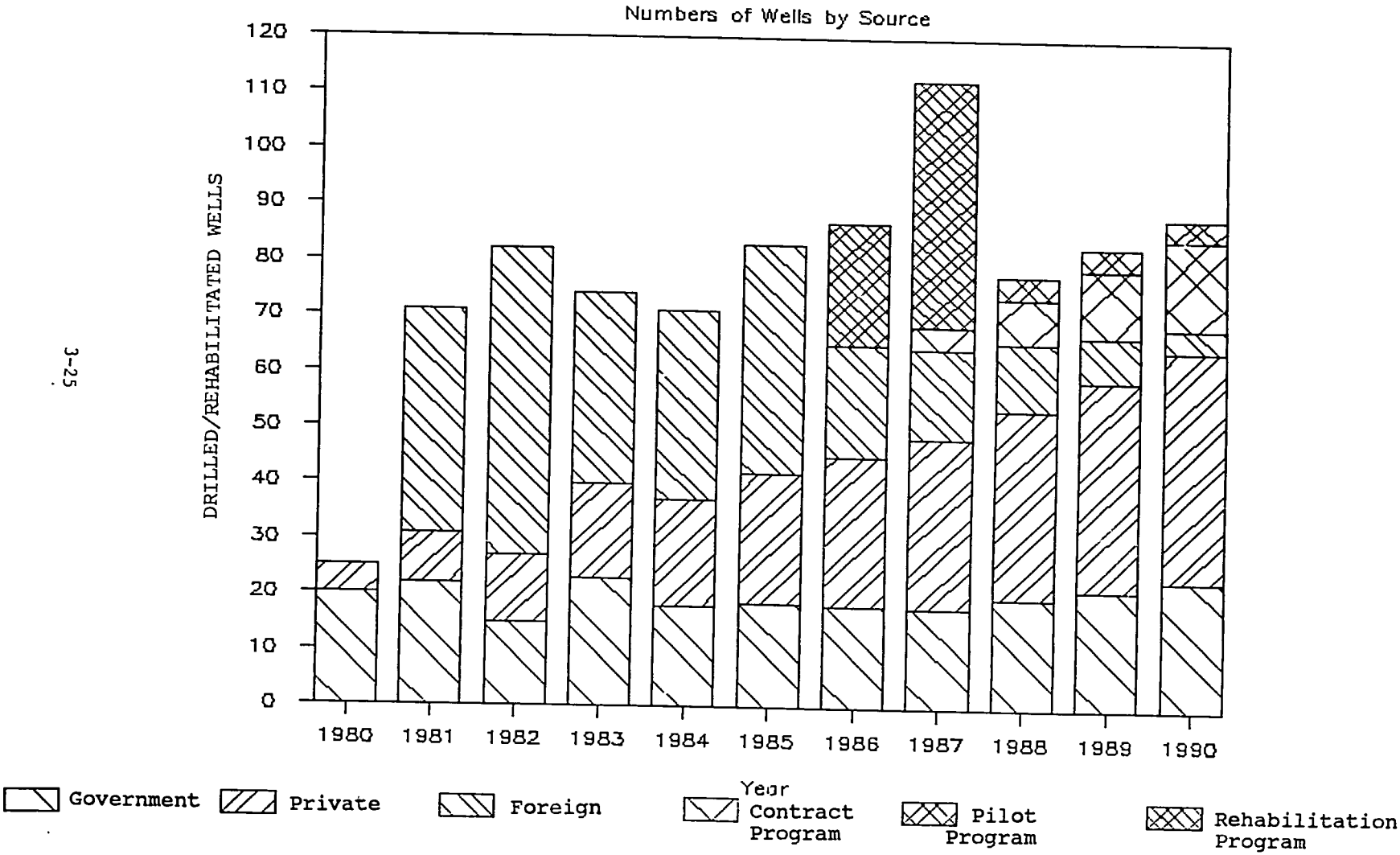


EXHIBIT 3-Q

PAST ACHIEVEMENTS AND RECOMMENDED PROGRAM



3.4.1. Summary of Constraints by Industry Level

In Somalia, Level I (water supply) is heavily dominated by the public sector, at least as far as groundwater is concerned. Private ownership of groundwater supply to serve the public is not recognized by the State, and water sales are subject to official price control. This situation has discouraged investment in groundwater resources. The current national price of water is set at 18 So.Sh. per cubic meter throughout the country, although dry season water prices are known to climb (unofficially) to 20 times that amount.

Level II activities (well drilling and construction of water supply facilities) in groundwater are under State control. Private drillers must be licensed by WDA and receive permission for each well drilled. Most drilling activities for public water supplies are carried out under foreign aid funding and work is often done by foreign firms.

Level III activities (production/provision of manufactured and raw material inputs) are carried out by a variety of public and private entities in Somalia:

- Locally available materials (gravel, sand, stone, and some PVC pipe, covers, and small tanks) are available from both the public and private sectors;
- Imported materials (drilling fluid, well casing and screen, diesel pumps, and fuel) are procured primarily by WDA or foreign donors; and
- Other materials are currently imported, but have the potential for local manufacture in the foreseeable future (cement, handpumps, rebars, steel pipe, and spun-reinforced concrete pipe).

3.4.2 Equipment

There are at least 35 drilling rigs (and probably more) in Somalia judged by the Consultants to be in operation or capable of operation. Of these, 14 belong to the public sector (WDA, Mogadishu Water Agency, and Ministry of Defense), 13 belong to the local private sector (including Somalfruit, a mixed-ownership company) and 8 are being used by expatriate firms primarily on foreign aid projects.

Some of these rigs are in need of major repairs. If all rigs were operational, and assuming each rig could drill eight production wells per year (and four non-production wells), Somalia could sustain a production rate of at least 280 wells per year - almost three times the current rate.

Much of the drilling and construction equipment is old, however, and even assuming adequate maintenance and repairs are performed, will need to be replaced eventually with new equipment.

3.4.3 Materials and Supplies for WDA Drilling and Civil Works Construction

In the past, WDA has undertaken to procure needed imports of drilling materials (drilling fluid, well casing and screen, etc.) for public sector wells (except foreign aid projects) and, if sufficient funds are available, for sale to the private sector. For internal budget calculations, for transfers to other public agencies and sales to the private sector, WDA estimates materials costs at CIF Mogadishu (at the official exchange rate) plus 45% to cover local transportation, storage, administration, and handling.

For the past year, however, WDA has been short of funds, and has been unable fully to meet public sector needs for well materials, much less maintain an inventory surplus for sales to the private sector. In addition, a lack of control over distribution of materials may have contributed to WDA's inability to complete fully its drilling responsibilities under the National Plans.

The shortage of materials is due primarily to the shortage of foreign exchange with which to purchase them. With respect to the public sector, WDA itself is constrained in its foreign currency purchases by the Central Bank and Ministry of Finance. Since budget estimates for approved public sector programs are calculated one to six years in advance of actual implementation, changes in costs due to inflation/devaluations are often not anticipated and are not corrected until the Ministries of Planning and Finance make an official revision.

With respect to the larger institutional setting, private sector alternatives for procurement of materials have so far failed to materialize for the following set of reasons:

A. There is a disincentive to potential private sector investment in inventories of water resource materials due to WDA's involvement in the market because:

- WDA has an exchange rate advantage over potential private sector importers;
- WDA mark-ups may not be adequate to cover all the costs involved in importing and maintaining an inventory that would be faced by a private sector firm; and
- a lack of effective control within WDA over public sector inventory may represent an unacceptable risk to private sector investment.

B. There are economies of scale in maintaining an inventory of relatively expensive, imported, specialized materials; with one large competitor (WDA) already established in the market.

C. Future exchange rate, import licensing, and tariff policies are uncertain.

D. There exist other possible sources of market failure facing potential private sector investors.

3.4.4 Summary Analysis of the Private Sector in Somalia's Water Industry

Private sector enterprise structure in the water industry falls into three basic patterns:

- Small, family run Somali firms capable of doing one or two types of work, and working on one or two projects at one time;
- Medium size Somali firms capable of handling a variety of types of work and having sufficient personnel, equipment, and managerial capacity to undertake a number of different projects at one time; though constrained somewhat by lack of finance, foreign exchange, and technical expertise; and
- Subsidiaries or affiliates of large expatriate firms engaged in large scale development projects with foreign aid funds.

From 1982 to 1984, the private sector has accounted for almost 30% of all the wells drilled in Somalia. Private sector firms have been involved, in particular, in well drilling for irrigated agriculture, livestock, and industry; primarily in the coastal plains and river valleys. Some of the larger domestic firms have done work for foreign aid projects, and at least two wells have been contracted out by WDA to smaller private firms. In addition, under the CGDP, four rural wells may be contracted out to private drillers this year.

The Consultants' overall analysis indicates that the local private sector firms have the technical and administrative capacity to expand immediately their role in providing water development services to the market - both to public and private customers. For a more detailed analysis of the private sector firms operating in the Somali water industry, please refer to Appendix D.

3.4.5 Administrative Constraints in the Water Industry

WDA drilling contracts to the private sector have been limited for two reasons:

- First, WDA only opts for contracting to the Somali private sector when: (a) it is overburdened with commitments relative to its equipment availability **and** (b) it has the funds to pay for private sector contracts **and** (c) it has the necessary materials for the well;

- Second, WDA bases its per-meter well cost estimates (and therefore the price it is willing to pay for contract well drilling services) on historical average nationwide costs, regardless of the geological formation through which drilling takes place or other logistical difficulties involved. Thus, the private sector has only been interested in contracts for wells where costs are substantially below average.

WDA contracts to private individuals for operation of public fountains are used on a few of WDA's wells. Generally speaking, however, WDA's limited contract administration capabilities have stifled the expansion of this option.

3.4.6 Financial Constraints

A shortage of investment funds has plagued the industry for many years. There are currently two banks in Somalia available to serve the private sector, and both are government owned and controlled. Officials at both institutions agree that there is a shortage of investment funds at the prevailing interest rates (14 - 17% fixed annual). They are obliged to ration loans on the basis of priorities (currently agriculture) established by the central Government and by foreign donors who support the institutions financially.

In addition, local bank officials indicate that they would be unwilling to lend to a private firm in this high-risk industry without guarantees of long term contracts to provide sufficient revenues to ensure repayment of the loan. This consideration apparently is not offset by the standard requirement for collateral of a value substantially in excess of the value of the loan.

3.4.7 Regulatory Constraints

Perhaps most important, the private sector is constrained by the lack of a free market. The public sector regulates and dominates all levels of the industry at the moment:

- At Level I (water supply), the lack of recognition and protection of property rights in groundwater resources, coupled with legal price controls on the sale of water, have discouraged private sector investment in water supply. This has in turn had a dampening effect on industries relying on adequate water supplies, such as the livestock industry.

- At Level II (well drilling and construction of water supply facilities), the requirement that the private sector must obtain permission from the State for each well drilled discourages long term financing of private sector drilling firms.

- At Level III (inputs of the water industry), WDA has long controlled the supply of the most important material inputs to the industry; while pervasive government control (through parastatals) of most industrial activity has slowed the potential development of local supplies of such materials as cement, pipe and handpumps.

A more in-depth analysis of the private sector in Somalia's water industry is contained in Appendix D-2. Profiles of individual firms are contained in Appendix D-4.

3.4.8 Foreign Exchange Markets for the Private Sector

Prior to 1985, USAID's Commodity Import Program (CIP) made hard currency available to private Somali businessmen for approved business investments, at the official exchange rate. Since the price of foreign currency at the official exchange rate was substantially lower than its shadow price, government agencies and individuals with access to foreign currency at the official exchange rate enjoyed a large subsidy. Thus, the CIP helped local businessmen compete with the public sector, and was for many the only legitimate source of foreign exchange in a country where supplies were short.

On January 1, 1985, Somalia devalued and moved to a dual exchange rate. The "official rate" went from 26 So.Sh. to the US dollar to 36; and a "market rate" was created which was set at 75 So.Sh. to the dollar. The official exchange rate was to rise at the rate of about half a shilling per dollar per month and the market rate, which was intended to float, rose slowly to just over 80 So.Sh. per dollar and stayed at that level. The latter is the exchange rate used at the local banks for changing dollars into shillings and for many quasi-official transactions, but it has been extremely difficult for private individuals to buy hard currency at that rate.

Since January 1, 1985, USAID policy with respect to CIP has been to price its foreign exchange for the private sector at the newly legalized "market exchange rate." For several months, there were no disbursements from the CIP: the Somali businessmen maintained that the market rate was "too expensive," and that if they wanted foreign exchange at that price, they could obtain it elsewhere more quickly and with fewer restrictions than were attached to CIP funds. Gradually, however, a third rate, known as the "auction rate," was allowed to develop between foreign exchange earners and potential importers, which rose to over 100 So.Sh. per dollar by the latter half of 1985.

Although the Commercial and Savings Bank can sometimes help bring buyers and sellers together, in most cases these arrangements are made informally within established extended-family or regional networks. In practice the flow of information within the auction market is sub-optimal, and it is particularly difficult for new entrepreneurs to break into old networks. The CIP, which uses the cheaper market rate, began to look more attractive to many businessmen than the alternatives. Over the summer and fall of 1985, imports through the CIP resumed, including two packages for drill rigs and related equipment, spares and tools, for two separate investors interested in drilling operations in northern Somalia.

The CIP must be considered an important avenue of assistance to private firms in the water industry. However, certain shortcomings must be noted. First, purchases are generally restricted to US products, whereas there is already a need for spare parts for equipment from a variety of other countries. Second, at the moment at least, local businessmen must usually obtain local currency financing from the Somali Development Bank, where loan funds are short and priorities are often skewed toward direct assistance to the agricultural industries.

3.4.9 Market Constraints and the Privatization Issue

The issue of privatization in Somalia's water industry has recently become current among much of the donor community. USAID, GTZ, the World Bank and several consulting firms involved in projects, have recommended, in general terms, the privatization of many of WDA's functions, including well operations, maintenance, drilling, and the construction of well head civil works.

The process of privatization has not until now been described in specific terms, in all probability because the issue is highly complex and would in practice require substantial donor support to alter long-standing methods of operation.

3.4.9.1 Water Prices

The primary issue underlying all others in Somalia's water industry is that of the price of water. Past Somali tradition strongly supported property rights in water: every membership group, along with its territory, had its water resources (which it controlled to the point of refusing access to outsiders or charging as stiff a fee as the buyer might be able to pay). Following the revolution, all groundwater resources were officially nationalized, and eventually a national water price was established, which became the single legal ceiling price which could be charged for water at any time and at any place.

Over the past several years, this national water price has risen from 4 So.Sh. per cubic meter to 10, 13, and most recently to 18 So.Sh. per cubic meter. This price reflected the average direct cost of supplying water to urban systems, at official prices. In a study conducted by the Consultants in the Bay Region in late 1983-early 1984, figuring at the (then) official exchange rate and official prices for fuel and wages, the price of 10 So.Sh. per cubic meter was found to cover the costs of operation and maintenance of a well pumping an average of 70 cubic meters per day, and to recover part (but not all) of the direct costs of constructing the well. It did not begin to recover either the indirect costs of constructing the well (WDA overhead, for instance) or the capital costs of the equipment purchased for well drilling and construction.[4/] If the shadow prices of foreign exchange, fuel, and labor were used in the calculations, it is unlikely that 10 So.Sh. per cubic meter would be found to cover the real costs even of the operation and maintenance of the rural wells.

The difference between the costs of providing water in rural Somalia and the price charged for that water is not subsidized by the urban dwellers (who also probably pay less than the full real cost of their water), nor by the State fully on its own resources, but largely by the resources of the foreign donor community. Over the past several years, more than half the drilling for public water supplies in Somalia has been under the auspices of foreign aid, and most of that work has been done by foreign firms. As well drilling projects have been completed, project equipment has been turned over to the local water agencies. Local currency project funds have supplemented the salaries of many of the agencies' personnel. Consequently, the unit costs of both drilled wells and of the water produced by them has been figured by the Government as a small fraction of the total real costs involved.

4/ "Economic Evaluation of the Comprehensive Groundwater Development Project," LBII, April 1984.

In addition, the fuel used to run the pumps of the drilled wells in Somalia comes, (in irregular supply), nearly free from Saudi Arabia or with subsidies from other foreign donors. While this fuel has been available in inexpensive, but rationed supply to some consumers, there are frequent shortages which often prevent the running of the water pumps on their full schedule.

The overall situation has greatly benefited a relatively small number of people in Somalia: those who live in communities that have received a drilled well, receive regular supplies of fuel to run the pumps, and have their repair needs taken care of on a timely basis. The Consultants estimate that almost 70% of the water consumed for human use in urban areas (those served with water distribution systems) comes from drilled wells; while at most only about 10-15% of the water consumed by rural people comes from drilled wells. The vast majority of rural people still must resort to hand-dug wells and (in the rainy season only) a variety of surface water resources for their water needs, which are much less reliable and sanitary than water from drilled wells. Dry season water prices in rural areas often climb many times higher than the official national price of water.

This situation bespeaks a chronic and perhaps a progressively deteriorating underinvestment in groundwater resources in Somalia. Nevertheless, a number of important donors seem reluctant to continue their assistance to public sector water development, citing their dissatisfaction with the past performance of the public sector. In particular, they make reference to shortcomings in the organizational efficiency, record keeping, and revenue collection functions of public sector agencies.[5/]

They have for this reason suggested the privatization of key functions of the water industry now performed within the public sector (local or foreign).

3.5 SUMMARY ASSESSMENT OF PRINCIPAL APPROACHES TO IMPROVING WATER RESOURCE DEVELOPMENT CAPABILITIES

There are at least three alternative strategies for Somalia to improve its own water resource development capabilities:

One would be to attempt to find foreign donors willing to continue to fund direct public investment in water resource development. This appears to be a high-risk strategy, judging from the current atmosphere within the donor community.

5/ "Management Appraisal of the Somali Water Development Agency," Coopers and Lybrand Associates, Sept. 1980.

A second alternative would be to rely entirely on domestic resources, either within the public sector or the private sector. If the public sector approach were chosen, the government would need to devote vastly more of its resources to the water development effort in order to increase the pace of expansion of water supply. If the private sector approach were chosen, a rapid deregulation of the industry (and related sectors of the economy) would be necessary before market forces could direct substantial private resources into the water industry. Either of these accelerated self-reliance approaches would also appear to carry high risks, as there are many other pressing complex and inter-related problems facing the nation.

A third alternative would be to seek to sustain foreign support for the water industry at levels similar to those prevailing in the past, by emphasizing an increasing role for the local private sector. This alternative has the advantage of drawing local private sector resources into the effort. Given the current atmosphere in the donor community in favor of private sector involvement in many economic development efforts, this approach should have the additional advantage of capturing donor interest and support, and thus increasing the resources available to devote to efforts in this field.

It is this third alternative that the Consultants judge to have the highest probability of success, and have thus developed into the full-scale program described in Section Two. This approach would require, during an intermediate period, foreign support to the public and private sector of approximately the same level as that received by the public sector in the past, until the currently prevailing subsidies to prices and production processes can be phased out and the system becomes self supporting with all prices covering all real costs involved.

The Consultants' recommended program would facilitate an efficient division of labor between the public and the private sectors. The program involves carefully targeted adjustments to policies and incentives along with direct technical and financial assistance to both the private sector (primarily to build up its productive capacities) and the public sector (primarily to build up its administrative capacities). In particular, the program is designed to release constraints that currently apply to private firms, to allow them more efficiently to utilize available resources and participate in serving the Somali public.

3.5.1 Privatization in Drilling

Local private sector drillers will have two sources of competition. One is WDA itself, which operates with the rigs given to it by donors, and which costs its well drilling services only in terms of marginal direct costs at official prices, leaving

out both depreciation of its capital assets and its overhead costs, and figuring only the subsidized price it pays for fuel. The other source of competition is from foreign firms, who are commonly allowed to write off all equipment costs to a particular project, who have firm contracts for a substantial number of wells, and who are skilled and experienced organizations both technically and in a business sense.

If the local private sector is to become more involved in drilling for public water supplies in the face of such competition, the donors must agree on a program of assistance. This program should include, first, some technical assistance for the private firms; but equally important will be a program of financial assistance and administrative support. The donors could, for example, agree to exclude the WDA from consideration for any contracts on foreign aid work so long as they fail to price their services to cover the full costs of the operation, including equipment depreciation, overhead, and the real cost of the fuel and foreign exchange involved. The donors should also agree to guarantee enough work for local firms so that they can safely invest in necessary equipment and materials, and pay off their investment on that work.

There already exist a number of small local drilling firms in Somalia. These firms, however, have very old equipment, often acquired as used equipment ten to twenty years ago. This equipment is maintained with parts fabricated in local machine shops, and is of limited use for drilling in many parts of Somalia. The prices charged by these firms, like the prices charged by WDA, bear no relation to the real current costs of investing in new and modern equipment. Drilling in certain areas, in particular, practically requires the use of relatively sophisticated and expensive rotary drilling rigs. The prices which need to be charged by local Somali firms for drilling services using these rigs cannot be much less than those charged by the foreign firms operating in Somalia in the recent past, because equipment costs in the form of depreciation and/or amortization, constitute a very significant proportion of total drilling costs.

3.5.2 Privatization in Maintenance

Similarly, related aspects of the water development industry in Somalia, such as well/pump maintenance, will require substantial (though less costly) donor commitment to the privatization process. Pump maintenance is a necessary and highly cost effective function which is currently neglected in Somalia. While donors are willing to fund high-profile well drilling and construction, they have failed to institute and enforce a program of well maintenance to protect the investment. Pump failure in rural areas, which often happens within three or four years of installation due to lack of proper maintenance, generally leaves an entire community or region without groundwater supplies. These areas remain without groundwater unless and until the WDA or

another donor comes in and drills a whole new well, or perhaps replaces the entire pump and generator unit, at almost half the entire cost of the original well.

Although a portion of the national water fees are officially earmarked for "maintenance and repair," no routine maintenance program is available. Repair requirements happen sporadically and unpredictably, and sufficient funds cannot be counted upon to pay for repairs when they occur, especially when general inflation in costs runs well ahead of the fee schedules for water and the actual revenues generated. Thus, maintenance and repair costs, if they are to be covered, must usually be subsidized by the State and/or the foreign donor community. Subsidies are required until water prices rise to the point where these functions can be covered by domestic revenues (along with all the other real costs of water provision which need to be covered by the same revenue source).

The Consultants therefore recommend that a program of routine pump maintenance and repair be made an integral part of a coordinated donor-funded well drilling program. Regional pump maintenance firms should be selected, fully equipped, and provided with medium term contract guarantees sufficient to ensure that their investment costs are covered. This is a substantial commitment in monetary terms, but is far less expensive than the alternative of periodic pump replacement or well replacement. The cost of a program of pump maintenance and repair has been estimated at a maximum of $1,200-2,400 per well, per year, including periodic repairs; while the cost of a pump replacement, which may be required after only three years, is in excess of $20,000.

3.5.3 How the Consultants' Recommended Program Meets the Need

The expansion of the water resource development industry has been shown to be limited by a complex web of material, equipment, financial, foreign exchange, and - more importantly - administrative, regulatory and market constraints. The Consultants' recommended program, as outlined in Section Two of this report, addresses these constraints as follows:

3.5.3.1. Materials, Spare Parts, Financial and Foreign Exchange Difficulties

The materials and equipment (more particularly, spare parts) constraints are primarily the result of financial and foreign exchange shortages. WDA itself faces a tight budget constraint for both shillings and foreign exchange, while the private sector's access to financing is hampered by an overall shortage of loan funds and a set of priorities at the two Somali

government banks which often relegates them to a low position on the waiting list. Its access to foreign exchange is limited to two sources: the "auction market," which is expensive, not well organized, and where information flows between potential buyers and sellers is inadequate; and USAID's CIP, which is limited in scope, governed by policy (as opposed to market) priorities, and must restrict its resources primarily to purchases made in the United States.

In its first phase, the Consultants' program would address the foreign exchange problem directly through donor funding of the project's prime contract. The contract would provide donor funding for needed equipment and technical assistance. In the second and third stages, the problem would be dealt with by the establishment of PRIfund, which would be dedicated to the water industry, involve the resources of a number of donors, assist in arranging seed capital for new water industry firms and would assure a minimum value of contracts between WDA and/or donors and local private firms. These contracts will make it easier for the private firms to obtain financing for their initial investments, and facilitate the maintenance of adequate private inventories of necessary materials and spare parts for contract maintenance, operations, and drilling activities.

3.5.3.2. Administrative and Regulatory Constraints

The private sector has also been hampered by the lack of a reliable market. Contracts between the public and private sectors have been sporadic and few, with fixed prices that are often inadequate to cover all relevant costs. Private sector contracts have been contingent on obtaining permission from WDA for each well drilled. Foreign contracts have usually gone either to foreign firms or to WDA itself, rather than to local private firms.

The Consultants' program addresses these constraints by building the WDA's ability to tender and administer contracts and encourage competitive bidding; by releasing some inefficient or unnecessary restrictions on private drilling; and by restricting WDA's ability to compete with private firms for foreign contracts by subsidizing its prices.

The program of assistance will both directly facilitate a transition to a situation of local self-sufficiency in water development and ensure that immediate and pressing water needs are addressed during the transition process.

3.6 CONCLUSIONS

Over the long run, in order to become self-sufficient in water production and to extend groundwater services to more of the rural areas, the price of water should be allowed to rise to cover

all relevent costs, including all overhead and capital recovery costs. If the Somali people wish to subsidize the price of their water to the poor, then this should eventually be accomplished with domestic revenues or cross-subsidies.

Private sector participation in the development of Somalia's groundwater resources should prove an effective and efficient complement to the State's exploratory, emergency, regulatory, and supervisory role. If the donor community wishes to promote movement in the Somali water industry in the direction of privatization, it should be prepared to devote substantial resources to building up the capabilities of the local private sector in the face of competition from both the local public sector and from foreign firms.

Study of

PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER RESOURCE DEVELOPMENT INDUSTRY

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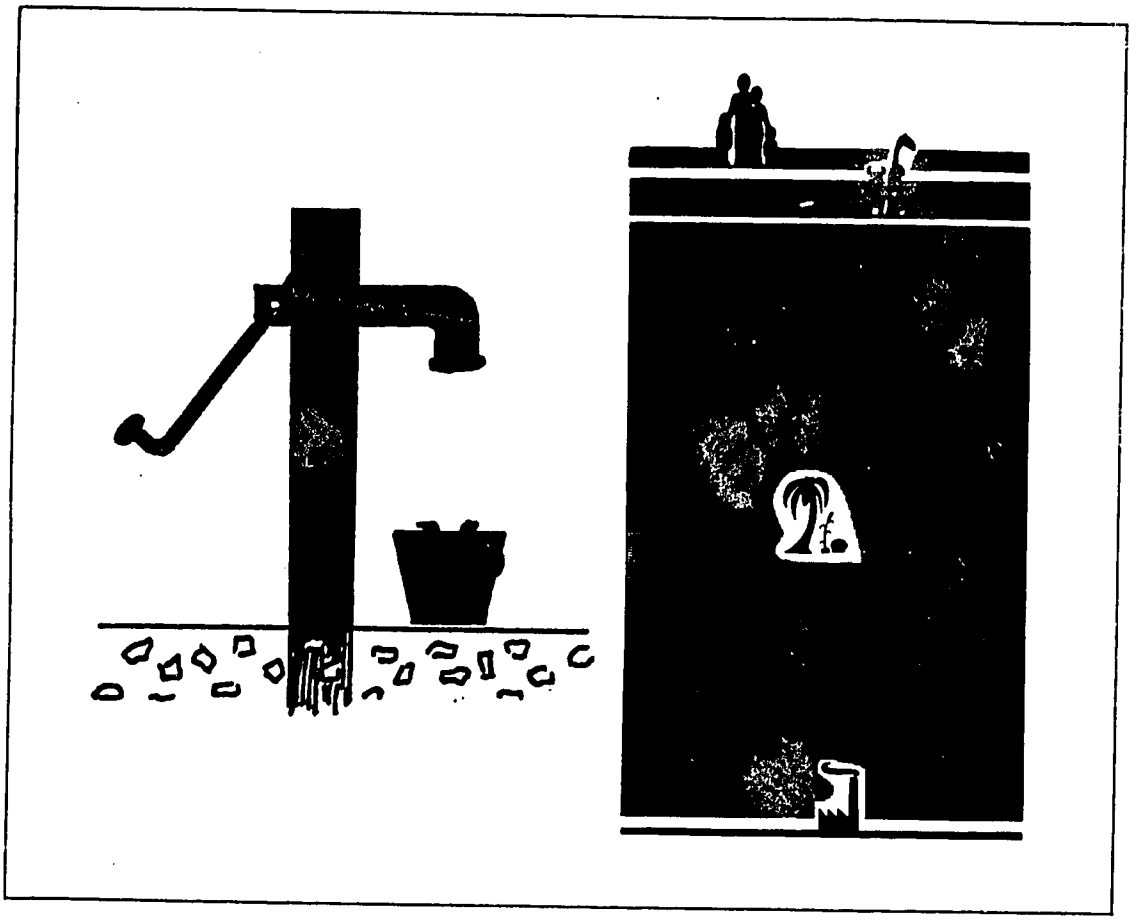

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

April, 1986

Louis Berger International, Inc.

STUDY OF PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER RESOURCE DEVELOPMENT INDUSTRY

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APPENDIX A

CONSULTANTS' RECOMMENDED PROGRAM DETAILS OF ESTIMATED FUNDING AND RESOURCE REQUIREMENTS

The Consultants' recommended Private Sector Water Resource Development Program is described in general terms in Section Two of the main body of the Final Report. This appendix explains the details of the project requirements in terms of funding, services, equipment, and materials. Exhibit A-1 provides an overview of project activities including numbers of wells affected by each activity during each quarter. Exhibit A-2 provides an overview of technical assistance, studies and institutions designed to support the program.

A-1 PHASE ONE PROGRAM

Exhibit A-3 outlines the project cost estimates by line item. The line items labeled "Other Costs" (which would include such items as R&R, mobilization, per diems, and office supplies) were based on rules-of-thumb, and were not actually costed out in detail. Other specific line items are treated in more detail immediately below.

Exhibit A-4 outlines the expatriate staffing requirements, duties, qualifications, and person-months of time for each position for the two year program. The sum total for expatriate staffing costs for Phase One is estimated at about $2.6 million. A more complete description of the duties for these personnel are contained in Section 2.2.2 of the main body of the Final Report.

Exhibit A-5 provides the quantity and cost estimates for the needed equipment for the project. Actual numbers of flatbed trucks, pickup trucks and construction equipment may depend on the existing equipment resources of the potential local subcontractors; the figures used are for the estimated maximum. Actual numbers of pumps will depend on the proportion of wells in the rehabilitation program that are suitable for operation. We assume that about half of the 130 wells involved in the rehabilitation program will be suitable (66 wells), and that the four wells to be drilled by local contractors will be equipped similarly. In addition, the project will supply 25 temporary replacement pumps to support the contract maintenance program. Unit costs are listed as F.O.B.; insurance and freight is assumed to add 40%.

Exhibit A-6 provides the quantity and cost estimates for the needed imported materials for the project. The unit costs for civil works consumables are based on the average costs for civil works for rural wells in Somalia under the Comprehensive Groundwater Development Project. Quantities for civil works

EXHIBIT A-1

PROGRAM TIME FRAME: KEY ACTIVITIES OF CONSULTANTS' RECOMMENDED PROGRAM

NUMBER OF WELLS AFFECTED PER QUARTER

YEAR	1986				1987				1988				1989				1990				1991				1992				1993				1994				1995			
QUARTER	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
ACTIVITY																																								
	First Phase								Second Phase												Third Phase																			
Well Survey (1)	32	32	34	34																																				
Well Rehabilitation (2)			11	11	11	11	11	11	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Well Abandonment (2)			11	11	11	11	10	10																																
Well Maintenance (3)			15	33	52	70	89	107	126	139	153	166	180	194	208	222	236	251	266	281	296	312	328	344	360	378	396	414	432	450	468	486	504	522	540	558	576	594	612	630
Well Operations (3)			15	33	52	70	89	107	126	136	147	157	168	179	190	201	212	224	236	248	260	273	286	299	312	327	342	357	372	387	402	417	432	447	462	477	492	507	522	537
Well Drilling (4)					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	6	6	6	6	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10
									ASSUMED EXTRA-PROGRAM ACTIVITIES																																
NGA Drilling (5)	2	3	2	3	2	3	2	3	2	3	2	3	3	3	3	3	4	4	4	4	3	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Foreign Drilling (6)	5	5	5	5	4	4	4	4	3	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PRINCIPAL FOREIGN ASSISTANCE MECHANISM:	USAID FINANCED CONTRACT								USAID FINANCED CONTRACT CREATES MULTI-DONOR Pool												MULTI-DONOR Pool																				
								Decision Point												Decision Point																				

Notes:

(1) Estimate of number of currently non-operational NGA bore- :s to be surveyed quarterly.

(2) Estimate based on assumed number of NGA wells to be l rd during survey and proportion of those wells assumed to be potential production wells.

(3) Estimate based on assumed number of rehabilitated wells and numbers of new public wells drilled by any driller.

(4) Wells in second year to be drilled under program; later years estimates based on assumptions concerning donor commitments.

(5) Estimate based on past activity.

EXHIBIT A-2

OVERVIEW OF TECHNICAL ASSISTANCE, INSTITUTIONS, AND STUDIES FOR CONSULTANT'S RECOMMENDED PROGRAM

PHASE ONE PROGRAM TWO YEARS	PHASE TWO PROGRAM THREE YEARS	PHASE THREE PROGRAM FIVE YEARS
1986 - 1988 FOCUS: Option D Contract Well Maintenance • Initiate well survey: 130 wells • Initiate high impact well rehabilitation: 66 wells • Begin routine contract maintenance program: all new and rehabilitated wells • Begin routine contract operations program: all new and rehabilitated wells • Begin contract well drilling: 4 wells	**1988 - 1991** FOCUS: Option F Water Security Role for Private Drillers • Continue well rehabilitation: 72 wells • Continue and expand routine contract maintenance: all new and rehabilitated wells o Continue and expand routine contract operations: all new wells • Expand contract well drilling: 8 + 12 + 16 new wells	**1991 - 1996** FOCUS: Option H Re-Oriented Role for WDA • Continue well rehabilitation: 72 wells • Continue and expand routine contract maintenance: all new and rehabilitated wells • Continue and expand routine contract operations: all new wells • Further expand contract well drilling: 20-30 new wells per year • WDA assume regulatory role
USAID BILATERAL FUNDING	TRANSITION FROM BILATERAL TO MULTILATERAL FUNDING	MULTILATERAL FUNDING

EXHIBIT A-3

BILATERAL AID COMPONENT OF THE PHASE ONE PROGRAM

(1986 - 1988: Two Years)

SCHEDULE	DESCRIPTION		COST
I.	FOREIGN EXCHANGE COSTS (U.S. DOLLARS)		
A.	Expatriat Staffing		$2,566,000
B.	Contractor Furnished Equipment		$3,046,000
C.	Imported Materials		$1,298,000
D.	Other Direct Costs		$488,000
	TOTAL FOREIGN EXCHANGE COSTS		$7,398,000
II.	LOCAL COSTS (SOMALI SHILLINGS)		
A.	Subcontract Activities		84,338,000
B.	Other Local Costs		23,543,000
	TOTAL SHILLING COSTS	So.Sh.	107,881,000

EXHIBIT A-4

PHASE ONE EXPATRIATE STAFFING REQUIREMENTS

POSITION	DUTIES	QUALIFICATIONS	MONTHS
1. Team Leader	Responsible for administration of proj. & subcontracts; coordinates data	Background in water industry; experience in project administration in dev'ing countries	24
2. Civil Engineer	Designs simple, standard civil works for wells; trains local contractors in design	Experience in civil works design and training for rural wells in developing countries	12
3. Light Duty Mechanic	Provides Tech. Asst. for & supervises repair of equipment, vehics, pumps & gen'tors	Experience in pump, gen'tor & equipment repair and in tech. training	18
4. Heavy Duty Mechanic	Provides Tech. Asst. for & supervises repair of heavy vehicles and rigs	Experience in heavy vehicle repair and tech. training	24
5. Inspector (south)	Provides tech. training in & supervises work of survey & rehab. subcontracts	Civil Engineer with experience in well rehab., repair, & pump installation	24
6. Inspector (north)	Provides tech. training in & supervises work of survey & rehab. subcontracts	Civil Engineer with experience in well rehab., repair, & pump installation	18
7. Driller	Provides tech. Asst. for drilling for local private contractors	Experience in drilling in diverse rural conditions, and in tech. training	6
8. Donor Water Policy Coordinator	Arranges donor commitments to private sector contracts in Somali water industry	Background in project design and finance; strong diplomatic skills	6
9. Gov't Contracting Expert	Designs appropriate contracting procedures and organization for WDA.	Businessperson with experience in gov't contracting	6
10. Sr. Pub. Util. Economist	Coordinates & undertakes overall analysis for Water Pricing Study	Economist with expertise in Public Utility Pricing Policy	12
11. Water Engineer/Cost Analyst	Provides all relevent cost data and analyses for Water Pricing Study	Water Industry Engineer with cost-analysis capabilities	10
12. Systems Analyst	Undertakes all data analysis for Water Pricing Study	Economist/statistician with experience in computer-aided systems analysis	9
13. Cost-Benefit Economist	Coordinates & undertakes overall analysis for Private Sector Well Ownership Study	Economist with expertise in Cost-Benefit Analysis & familiarity with water industry	12

14. Privatization Specialist	Provides analysis of economic benefits to private sector water resource investment	Businessperson with expertise in privatization processes	12
15. Livestock Ind. Expert	Provides analysis of benefits to livestock industry of improved water supply	Agricultural economist specializing in livestock industry	6
16. Groundwater Ind. Expert	Provides analysis of costs of water supply investment for livestock industry	Economist specializing in water industry analysis	6
17. Joint Venture/ Legal Expert	Develops guidelines for the formation of JVs in Somali water industry	Corporate law expert with experience in formation of Joint Ventures	2
18. Ind. Dev't Specialist - Hand Pumps	Feasibility study for manufacture of hand-pumps	Industrial Dev't Specialist with experience in manufacture of hand-pumps	6
19. Ind. Dev't Specialist - PVC products	Feasibility study for expansion of PVC production	Industrial Dev't Specialist with experience in manufacture & marketing of PVC products	4
20. Ind. Dev't Specialist - Cement	Feasibility study for expansion of cement production	Industrial Dev't Specialist with experience in manufacture & marketing of cement	4
21. Ind. Dev't Specialist - Steel Pipe	Prefeasibility study for manufacture of steel pipe	Industrial Dev't Specialist with experience in manufacture of steel pipes	2
22. Ind. Dev't Specialist - Concrete Pipe	Feasibility study for manufacture of spun-reinforced	Industrial Dev't Specialist with experience in manufacture	2
23. Procurement Officer	Responsible for procurement of all project equipment and materials	Experience in project procurement	4
24. Coordinator	Oversees project		4
SUBTOTAL PHASE ONE			233

EXHIBIT A-5

PHASE ONE CONTRACTOR FURNISHED EQUIPMENT AND COSTS

(Based on Estimated Maximum Requirements)

ITEM	DESCRIPTION	QTY	UNIT COST	TOTAL COST
A.	Cable Tool Rig	1	$90,000	$90,000
B.	Flat Bed Trucks	3	$50,000	$150,000
C.	Station Wagon, 4wd	1	$20,000	$20,000
D.	Pickup Trucks	8	$20,000	$160,000
E.	Satellite Nav. Locators	3	$6,500	$19,500
F.	Machine Shop Fac. & Tools	3	$50,000	$150,000
G.	Cement Mixer & Block Maker	2	$8,000	$16,000
H.	Contractor Required Spares	1	$100,000	$100,000
I.	Test Pumps	3	$15,000	$45,000
J.	Pumps	95	$15,000	$1,425,000
	Total F.O.B.			$2,175,500
	I.F. Mogadishu	40%		$870,200
	Total C.I.F. Mogadishu			$3,045,700

EXHIBIT A-6

PHASE ONE IMPORTED MATERIALS AND COSTS

	ITEM	UNITS	UNIT COST	TOTAL COST
A.	Civil Works Consumables (cement, etc.)	70	$15,000	$1,050,000
B.	Fuel - Diesel			
	3 Cable Tool Rigs 500 liters/month 18 months	27000	$0.35	$9,450
	3 Flat Bed Trucks 550 liters/month 18 months	29700	$0.35	$10,395
	9 Light Duty Vehicles 1050 liters/month 20 months	189000	$0.35	$66,150
C.	Pump Spares	28	$4,200	$117,600
D.	Drilling Consumables (cement, collars, casing, screen, gravel)	4	$11,000	$44,000
	TOTAL			$1,297,595

consumables will depend upon the proportion of wells in the rehabilitation program that are suitable for operation. Fuel consumption estimates are based on past averages in Somalia. Pumps spares for the well maintenance program are based on the assumption that about 30% of the pumps in the program will require some repairs each year, and that the spare parts costs for each repair will represent about 20% of the original cost of the pump/generator unit. Drilling consumables are for wells of about 100 meters in depth, drilled with a cable tool rig, and include the costs associated with a 25% probability of drilling a non-production well (i.e., four production wells plus one non-production well).

Exhibit A-7 summarizes the project activities and associated maximum shilling cost estimates for the Somali subcontracts for the well survey and well rehabilitation/ abandonment programs for 130 rural WDA boreholes, a two year maintenance program, and a four well drilling program. It is assumed that the expatriate project contractor will be responsible for tendering and administering the subcontracts, for procuring all needed equipment and materials for the project, including fuel, and for administering the subcontractor equipment leases and distribution of materials. These activities are described in greater detail below. The financial models refered to in the text are bound separately as an Annex to Appendix A. This should allow the interested reader to follow the discussion of the models with the data readily at hand.

A-1.1 Locating the Wells - Local Engineering/Survey Subcontract

The first step of the project will be to send a local engineering firm, as a subcontractor, into the field to locate the 130 non-operational WDA wells and to make a preliminary determination of each well's rehabilitation potential and the resource requirements for either fully rehabilitating and equipping or properly abandoning the well.

Annex A-1 presents a financial model of the needed engineering/survey operations, assuming the firm has neither the pickup trucks nor the satellite locators needed for the job (which will all be procured by the project and leased to the firm for the duration of the project).

Part A of the model outlines the assumptions with regard to equipment, labor and overhead costs. Part A.1 outlines equipment costs as follows: The unit cost of the satellite locators, CIF, is about US $9,100; the pickup trucks are about US $28,000 each. It is assumed that the firm will need to send out three crews in order to complete the entire survey in one year. Thus the firm needs three satellite locators and three pickup trucks. The lease payments will be made monthly, based on an imputed interest rate of 20% per annum and deposited into the PRIfund trust. In addition, the subcontractors will be given the option to purchase the equipment at a depreciated value at the end

EXHIBIT A-7

PHASE ONE LOCAL SUBCONTRACT ACTIVITIES AND COST

(Somali Shillings)

SUBCONTRACT TYPE	COST	SHILLING REPAYMENTS TO PRIfund HIGH	LOW
A. Engineering Firm (Locate wells)	5,850,000	4,375,350	1,105,650
B. Well Rehab. Contractors	42,525,000	21,558,600	10,168,200
C. Maintenance/Repair	24,712,500	13,176,000	10,395,000
D. Operations (funded from revenues collected)	0	0	0
E. Drilling	11,250,000	0	0
TOTAL	84,337,500	39,109,950	21,668,850

of the contract. In the case of the satellite locators, this should be set at 25% of the original value, or the market retail value, whichever is less. As explained in Section 2.1.1.1 of the main body of the report, this accelerated depreciation schedule is comparable to the contract terms commonly available to expatriate firms working on foreign aid projects, who generally are allowed to write off all their equipment costs to the project. Maintenance for leased equipment will be provided by the project.

Labor costs (Part A.2) are for one overall engineer/ supervisor (responsible for all three crews), and three survey crews each composed of a survey leader, a driver, and two assistants. Each crew spends an average of eight days per well, which includes transport time and time to be spent locating and assessing each well. Some wells can be located and assessed in a few days, others may take about ten days. If payment is per well located, the firm should not waste too much time searching for any single well.

Overhead costs (Part A.3) for an office, one clerk/ secretary, and one watchman for one year are included in the analysis.

A contract price (Part B) of about 25,000 to 40,000 So.Sh. per well located should suffice to cover costs, including equipment rental, and provide for a reasonable profit. The analysis works with the mid-point of 32,000 So.Sh. per well. The Preliminary Financial Analysis (Part C) examines the situation by quarters. It is assumed that the firm will be paid an advance each quarter equal to about half the estimated quarterly service payment (although actual payment should be made on a monthly basis, less the advance). This advance should nearly cover wages and equipment rental for each quarter.

The figures in the analysis assume that the firm exercises its option to purchase the used project equipment at its depreciated value at the end of the contract; this is shown in the line labelled "Purchase Equipment." However, the last line item is for the "Depreciated Value of the Equipment," which exactly offsets the end of project purchase price. If the firm decides not to exercise its option, the bottom line figures will remain the same, as the firm will not have made the purchase payment, but will not have received the equipment, either.

The analysis shows the Net Present Value (NPV) of the quarterly balances over the year long contract, discounted at a 35% nominal effective annual rate (which would include about a 15% real annual opportunity cost of capital if the inflation rate were 20% over the period). The analysis also shows the NPV discounted at 20% and at a zero discount rate. (A calculation of an "internal rate of return" is not relevant, as the firm will have made no substantial initial investment.)

Part D presents a simple sensitivity analysis on a few key variables. The first table shows how varying the number of wells located and the contract price affect the NPVs, if all other variables are held constant. This points out that if the number of wells to be located is reduced, the price per well located may have to be raised in order for fixed costs (such as equipment leases and overhead) to be adequately covered. The second and third tables simply demonstrate that, so long as the post-project purchase price of the equipment matches their depreciated value, the NPVs are unaffected.

The model presented in Annex A-2 is essentially the same as that in Annex A-1 except this model assumes that the engineering firm already has its own pickup trucks, and needs from the project only the satellite locators. As before, the firm will lease the satellite locators from the project, and will have the option to purchase them at the end, for a depreciated value. For pickup trucks, however, the analysis assumes that the firm must undertake its own maintenance and repairs and be reimbursed for depreciation and opportunity cost (equal to about 100% of the value of the used trucks over the life of the project).

A firm with its own trucks will nevertheless have the same labor and overhead costs as a firm leasing its equipment; these figures are the same as in Annex A-1.

The payment for the service of locating wells should be approximately the same whether the firm owns its own trucks or leases them from the project. In the former case, it earns an imputed rent for its equipment, which is fair reimbursement for maintenance, and depreciation and opportunity cost of its capital assets. In the latter case, it pays rent to the project for the equipment from its earnings. In the former case, a firm can earn more cash with which to invest in new (or used) equipment; in the latter case, it can acquire used but serviceable equipment largely written off by the project. To the extent that the model assumptions hold, a firm leasing project equipment, which reinvests its earnings wisely during the life of the project (at say a 15% real rate of return over and above inflation) may be able to use these proceeds to purchase the project equipment at the end. Otherwise, the firm would have to make use of some of its own (outside the project) financial resources even to meet the depreciated price of the equipment.

In either case, the engineering firm may in the future find a market for its services not only for locating existing non-functional wells, but for locating new wells, potential well sites, and other remote sites, such as springs, mineral deposits, archeological sites, or sites of agricultural interest.

A-1.2 Well Rehabilitation--Local Subcontract

The second step of the Well Rehabilitation Program is the physical work of either equipping or properly abandoning each well. It is assumed that this work can be performed by three separate, geographically based subcontractors over an eighteen month period, overlapping (and following) the ongoing work of the engineering firm locating the wells.

Annex A-3 presents a financial model of a single such firm, assuming that the firm has none of the essential equipment required for the work, and must lease all its equipment from the project. Part A of the model outlines assumptions with regard to equipment, labor and overhead costs.

Part A.1 of Annex A-3 outlines the assumptions with regard to equipment procurement and leasing. Each firm will need one cable tool rig (about US $126,000 CIF Mogadishu for a new rig), one flat bed and one pickup truck (about $70,000 and $28,000 CIF Mogadishu, respectively), and one cement mixer and block making machine (about $11,200 CIF Mogadishu). As in Annex A-1 above, the equipment lease payments will be made monthly, based on an imputed interest rate of 20% per annum and deposited into the PRIfund Trust. The pickup trucks, cement mixer and block machine may be purchased at the end of the project at a depreciated value of 10% of the original cost, or the market rate, whichever is less. However, the cable tool rig, having a longer useful life, should be sold for 25% of the original value, or the market retail value, whichever is less.

Labor costs per well (Part A.2) could be divided into three portions. For equipping a well, the borehole itself may have to be cleaned with the use of the cable tool rig, the old pump pulled, the new pump installed, and civil works constructed or repaired. This is estimated to take about fifteen days for pump replacement and for civil works construction, although the civil works construction can follow behind the pump installation and requires the use of a pickup truck, but not the drill rig. The time allotted allows for transportation and some down time, and represents an average time estimate per well while the actual time spent on any given well may vary from one to three weeks.

Abandoning the well involves filling the well with bentonite and capping it with cement. This procedure is necessary to prevent contamination of the aquifer with disease carrying organic matter (such as manure) or other poisonous chemicals (such as lead). The time estimated for this procedure is about five days, allowing for transportation time.

Annual overhead costs (Part A.3) for an office, a clerk/ secretary, and a watchman have been included. All fuel and materials will be provided by the project, including bentonite, cement, pumps and fixtures. Project equipment leased to the

subcontractor would be maintained under the auspices of the project.

Payment for services (Part B) should be in the vicinity of about 400,000-600,000 So.Sh. for each production well and 60,000 to 100,000 So.Sh. for each abandoned well. The analysis uses the mid-point prices of 500,000 shillings per production well and 80,000 shillings per abandoned well. It is assumed that among the 130 wells, about half will be production wells and half must be abandoned. Under this assumption, each firm will handle about 22 production wells and 21 non-production wells. Over an eighteen month period, this works out to about seven wells per quarter, of which there might be four production wells and three abandoned wells, or vice-versa.

Part C of Annex A-3 presents the financial analysis of the well rehabilitation/abandonment operations, if all the above assumptions hold. Lease payments and overhead costs are fixed, while labor costs and payments to each firm depend on the numbers of wells equipped and abandoned, respectively. It is assumed that an advance will be paid each quarter equal to about half the value of the estimated service payment for the quarter. This should approximately cover equipment lease and labor costs for each quarter.

At the end of the contract, the firm will have the option of purchasing the project equipment for its depreciated value. The financial analysis assumes that this option is exercised; this is shown in the line labeled "Purchase Equipment." Offsetting this is the last line item of the table, for "depreciated value of the equipment." If the firm chooses not to exercise its option, the bottom line figures will not change, as the equipment value and price are assumed to be equal.

The NPV of the balance of the firm's operations over the 18 month contract period is presented, using 35%, 20% and 0% nominal effective annual discount rates. (A calculation of the "internal rate of return" is meaningless, as the firm does not need to make any investments up front).

If a firm is able successfully to reinvest its quarterly earnings at a nominal effective annual rate of, say, 35% per annum (which would represent a real rate of 15% if the inflation rate were running at 20% per annum), then the firm could use its project-derived earnings to purchase all its project equipment at the prices set for their depreciated value. If it could not reinvest its earnings, it would have to rely on other resources to finance a purchase of the project equipment.

Part D presents a simple sensitivity analysis for a number of key variables. The first table shows how varying the number of total wells involved, and the contract price per production well, affect the NPVs, holding all other variables constant. This

indicates that if the number of wells involved in the rehabilitation operations must be reduced, then the price per well equipped may have to be increased in order for the firms to cover their fixed costs (such as equipment rental and overhead). The second table shows how varying the number of total wells involved and the price per non-production well affect the NPVs. The third table shows how varying the proportion of production wells to be equipped and the price per production well affect the NPVs, holding all other variables constant. The NPVs are highly sensitive to this proportion, so that per well prices for both production wells and abandoned wells may have to be adjusted, or minimum quarterly payments guaranteed, in order to ensure that the firms can adequately cover all their fixed costs. The fourth table shows how varying the proportion of production wells and the price per non-production well affects the NPVs.

The model presented in Annex A-4 is similar in most respects to that in Annex A-3 except that the firms in question are assumed to have all their own equipment, and would not need to lease any from the project. The value of their equipment is lower than those brought in by the project, because they are probably already used. These firms will be responsible for the maintenance of their own equipment and must be reimbursed for depreciation, assumed to be about 100% of the value of the used rolling stock per year, and 50% for other equipment.

Labor and overhead costs are as described for Annex A-3 above. Payments to these firms will be at approximately the same per well prices as for the firm described in Annex A-3. These prices are necessary to reimburse the firm for the depreciation of their capital equipment used on the project. At the end of the project, they may have enough cash on hand from their project earnings to purchase some new (or used) equipment.

It is assumed that there may be two firms in Somalia with all or most of the equipment needed to carry out the work of well rehabilitation; and that one new firm may have to be nearly completely outfitted. In either case, at the end of the project, (or even before) these firms should have the equipment they need to begin immediately contract well/pump maintenance work. This would involve the wells they had originally rehabilitated, in addition to all wells drilled after the start of the project and all newly rehabilitated wells in the future.

A-1.3 Well/Pump Maintenance Activities

Annex A-5 presents a financial model of a well/pump maintenance firm taking up the business as a primary and independent activity. It is assumed that such a firm would already have the cable tool rig sometimes necessary for well cleaning; would lease a fully equipped repair shop and a pickup truck from the project, and may perhaps make use of a used pickup truck in order to keep up with the expansion of activity.

Part A.1 of the model outlines the firm's equipment costs associated with this activity. Its cable tool rig will be used only rarely, and therefore the maintenance and depreciation costs associated with well maintenance activity are assumed to be only 10% per annum. The pickup truck and the repair shop would be leased on the same terms as the equipment involved in other project activities: based on an imputed 20% per annum interest cost, with the option of purchase at the end of the project at a price reflecting the depreciated value (25% of the original cost or the market value, whichever is less). At some point, as maintenance responsibilities expand (see Part B, below), the firm may need an additional pickup truck. We assume that the firm will resort to use of a used pickup truck already on hand, worth about $5,000, with maintenance/depreciation and opportunity costs representing about 100% of the value of the vehicle per annum.

Part A.2 outlines the unit prices for maintenance services for WDA wells, and the service price markup for private contracts. (Since the project subcontract for WDA wells is essentially riskless, it need not yield the firm a high return and therefore need not carry such a high price.) The subcontract service price should be about 40,000-70,000 So.Sh. per well per visit, if the length of the contract is limited to the life of the Phase One program. If the contract is guaranteed for Phase Two as well, this price could be substantially lower (see Appendix A-2.2). The repair fees are set on a time-and-materials basis, including a markup which is substantially higher for private contracts than for project contracts (again because project contracts involve less risk). The market exchange rate for mid-1986, the estimated start-up date, is projected to be about 90 Somali Shillings to the dollar. The estimated percent of the pumps needing repair in any given year is 30% of the total.

Part A.3 outlines direct costs for routine maintenance and for repairs, per pump per visit. (Each well should be visited at least once each quarter; repairs are made on an as-needed basis.) Labor will be hired on a as-needed basis, not as permanent staff. Fuel costs per unit are given in order to estimate costs for private well maintenance contracts--the WDA (project) well maintenance contracts will have fuel provided by the project.

Parts for pump repair (Part A.4) are figured on the assumption that the average repair will involve parts costs representing about 20% of the value of the original pump. For WDA wells, these parts will be provided by the project; for private contracts, the firms will probably want to maintain spare parts inventory equal to somewhat over 30% of the wells under those contracts. Overhead (Part A.5) is assumed to be about the same as for firms involved in the other activities.

Part B outlines quarterly variables: the number of WDA pumps under contract for each firm are one third of the total number of pumps involved in the maintenance program. (This

includes all new and all rehabilitated wells since the beginning of the program; see Section 2.1.1.3 of the main body of the Final Report.) Since 30%, on average, may need a repair each year, this is equal to about 7.5% per quarter. Multiplying the number of crew days per pump times the number of pumps for maintenance and repair, respectively, gives the number of crew days needed per quarter for the firm to accomplish its duties. Dividing the crew days by 90 gives the number of crews needed each quarter. Since each crew needs its own truck, this row also indicates when the firm must acquire a new truck.

The financial analysis contained in Part C itemizes the costs and the payments to the maintenance firm. The first line shows the lease payments to the project (deposited into the PRIfund Trust) for the repair shop and the truck. The second line shows the cost of purchasing the repair shop and the truck at the end of the project. The third line shows the maintenance and depreciation costs associated with the use of the rig and the extra, (used) pickup truck. The fourth line shows the quarterly overhead costs. The fifth line, since the project provides all parts and materials, is blank so long as only WDA wells are involved. The sixth line shows the direct costs of well maintenance activity. In the case of WDA wells, this will involve only labor, since fuel is provided by the project. The seventh line shows direct costs associated with repair activity. Again, for WDA wells, this involves only labor. The eighth line shows client's payments for parts; but this is only for private wells. The ninth line shows payments for routine maintenance activity, based on the fee per well shown in Part A.2. The tenth line shows payments for repairs, on a time and materials basis (in the case of WDA wells, this represents payment for time only). The last line shows the depreciated value of the repair shop and the project truck at the end of the project, at the time of purchase.

Under the income stream is shown the NPV of the quarterly balance discounted at an effective annual nominal rate of 35% per annum, 20% per annum, and 0% per annum, respectively. It is assumed that the firm may be able to purchase the repair shop and the project truck at the end of the project out of the earnings received for contract work, if those earnings were reinvested wisely during the course of the project.

Part D presents a sensitivity analysis for key variables in the model. The first table allows the number of WDA wells and the maintenance service price to vary. (In the model, varying the first value for numbers of WDA wells changes values for subsequent quarters proportionately). This demonstrates that if the number of wells involved in the contract were reduced, then the price per well may have to be raised in order for the firm to cover adequately all its indirect costs.

The second table varies the number of other, non-WDA wells for which the firm has maintenance contracts. It is this activity that allows the firm to show a significant profit. The third table varies the markup for repairs for WDA wells. This has little effect on the firm's bottom line.

Part E highlights the cost to the project of the contract maintenance program, if all the above-discussed assumptions hold. For each quarter of the program, the table shows the total amount paid to all three maintenance firms for routine maintenance service, and estimated average repair costs. It then shows the average cost per pump per quarter in shillings and in dollars; then the average cost per pump per year in dollars.

The table then compares the cost of the maintenance program with the alternative of pump replacement after each major breakdown in the absence of a program of routine maintenance. (Other alternatives are to leave wells without a workable pump after a breakdown or to drill a new well.) If a pump will break down an average of once every three years, then a policy of pump replacement will require a $21,000 expenditure every three years. The maintenance program will cost, at most, $3,700 per year, and $21,000 in the tenth year, when the pump will require its first replacment.

The Net Present Cost (NPC) of a ten year program of routine maintenance, under these assumptions (which involve the highest possible estimated costs for the maintenance program) is still less than the NPC of a policy of pump replacement, even at discount rates of 35%. As discussed below in A-2.2, the long term costs of the maintenance program are likely to be much less than those outlined in this model.

The model presented in Annex A-6 is similar in most respects to that in Annex A-5, except that the firm is assumed to have a growing number of non-WDA wells under maintenance contract. The firm would make use of the same equipment, except that they may have to resort to use of the old truck sooner than if they had only WDA wells under their responsibility. The basic service price charged to private customers for routine maintenance is assumed to be about 50% higher than that charged to WDA, in order to cover the higher risks associated with non-project contracts. The firms will have to keep a stock of spare parts on hand for needed repairs on non-WDA pumping units. Although about 30% of wells are assumed to require repair in any given year, the firm would be well advised to keep a somewhat larger inventory of parts on hand for this purpose. At the same time, it would be justified in charging a substantial markup over the parts costs to their private customers, to cover the opportunity cost of keeping capital tied up in inventory and ensuring the capability for prompt repairs.

The profitability for the maintenance firm which successfully markets its services beyond WDA will be substantial. NPVs may be three to four times higher than for firms which service only WDA wells.

A-1.4 Start-Up Operations

Responsibility for starting up operations following well rehabilitation will rest with WDA and will not be directly handled or funded by the project. This activity is described in Section 2.1.1.4 of the main body of the Final Report.

A-1.5 Contract Well Operations

Responsibility for contract operations of wells will rest with WDA and will not be handled directly or funded by the project, aside from some technical assistance or advice to WDA in contracting procedures. Contract costs will be recovered by the revenues generated by the sale of water, with a portion returned to WDA.

Annex A-7 presents a financial model for well operations and revenue collection. We assume that output per rural well is about 10 cubic meters per hour, and that initially, at least, pumps will run an average of 10 hours per day, 200 days per year. Fuel consumption for that level of operation would be about 1.5 liters of diesel per hour. The price of diesel fuel is a crucial variable in the calculation of the balance of operating costs and revenues (see below). The other major costs associated with well operation are those of annual maintenance/repair, figured at about 100,000 So.Sh. per year on average (including periodic repair needs) and daily operations labor. It is assumed that the well operations contractor will want to earn, at a minimum, the opportunity cost of foregone wages elsewhere in the private sector, which would probably be at least 200 So.Sh. per day.

The distribution of the balance between the above outlined costs, and the revenues generated from the sale of water at the official price, will be the issue under negotiation between the contractors and the WDA. The WDA will want to have as much revenue as possible returned in order to cover the direct and indirect costs of drilling and equipping the well, which amounts to about $10 - $20,000 (1.6 million So.Sh.) for the pump, which must be replaced once every ten yers or so and an additional $50,000 (4.0 million So.Sh.) for the well, which should last for many years.

At a price of 20 So.Sh. per cubic meter for water, and 30 So.Sh. per liter for fuel; and under the assumptions outlined above, WDA could receive 136,000 So.Sh. per year, net, from the sale of water from its wells. Over a ten year period, discounted at 20% per annum, this would show a net present value of 570,000 So. Sh.

The sensitivity analyses contained in Annex A-7 examine the following potential sources of variation:

Table 1 shows how the price of water and the price of fuel affect the average annual return to WDA per well. Table 2 shows how the price of water and the price of fuel affect the net present value of the revenues returned to WDA. Obviously, if the price of fuel rises, so must the price of water, in order to recover a given level of revenues per well. Table 3 shows how water price increases must match fuel price increases in order to recover a given level of revenues per well.

Tables 4 and 5 show how increasing the volume of water output per well affect the net present value of the revenues returned to WDA. Although the fuel costs increase with the volume of water output, the fixed costs (e.g., of maintenance) do not.

Table 6 illustrates how the annual percentage return to WDA (return as a percentage of total water revenues) is affected by the price of water and by the daily earnings of the operator.

Finally, Table 7 illustrates the effects of including straightline depreciation of the pump as a cost to be recovered by water revenues. All other variables held equal, attempting to recover the cost of a $17,500 pump over ten years (its expected useful life) would require water prices to be over 20 So.Sh. per cubic meter.

A-1.6 Well Drilling Program

Annex A-8 presents a model for a drilling firm which has invested in a new cable tool rig and ancillary equipment.

Part A.1 outlines equipment and other initial investment costs. If this were a purely commercial venture, undertaken primarily for the purpose of contracting for the drilling of public wells (through WDA and/or foreign donors), and if adequate guarantees were presented to a domestic lending institution (such as the Somali Development Bank), then financing may be obtained for about 65% to 75% of the total investment, for five years at 16% per annum.

We assume that about 25% of all wells drilled will be non-production wells. The firm may be paid about 20,000 So.Sh. per meter for a production well and half that rate for non-production wells. The average depth of the wells is assumed to be about 100 meters.

Direct costs per well are presented in Part A.2. Labor costs are shown in the first table. The second table itemizes materials costs for production and non-production wells. Note that a cable tool rig rarely uses bentonite or foam, and rarely

needs its bit replaced. Fuel costs for each vehicle are shown in the third table. It is assumed that the project will furnish all materials and fuel for wells drilled under its auspices, and that private customers will be charged a markup for the materials used by the firm and procured for the customer's well.

Part A.3 shows the overhead costs for the firm, in terms of vehicle spares, administration costs, and insurance.

Part B shows yearly variables. We assume that the firm might get a contract from WDA and/or foreign donors for drilling four rural, public wells per year for the next five years, (this assumes that Phase Two of the project is funded) and that an additional, non-production well might be drilled each year. We assume that the contract will increase to six wells per year for 1992-1996, with a 25% probability of drilling a dry hole.

Part C presents the financial analysis of such a venture. It is assumed that the loan would be paid off in five installments involving equal payments on the principal, plus accumulated interest on the balance (only the third, "payment" line enters into the calculations of the balance). The fourth line shows labor costs, based on the number of wells drilled (both production and non-production). The fifth and sixth lines, for materials and fuels, are blank because the project will furnish them and they therefore represent no cost to the contractor. The seventh line is for overhead. The eighth line shows revenues for services, based on the price per meter (for production and non-production wells, respectively), the number of wells (both production and non-production), and the number of meters per well. The ninth line, or payment for supplies, is not necessary for the WDA wells, as they are provided directly by the project.

The balance is discounted at 35%, 20% and 0% per annum for 1986-1991 and 1986-1996. If the WDA is the only source of business for such a driller, and if the price per meter is set at 20,000 shillings, then the firm would barely avoid a loss. Profitability would require that the driller acquire additional customers, as illustrated in Annex A-9.

Part D presents a simple sensitivity analysis for a few key variables. The first table demonstrates how varying the number of wells per year and the price per meter affect the NPVs. This shows that if the number of wells is reduced, then the price per meter may have to be increased in order for the firm to cover all its fixed costs adequately.

The second table shows how the proportion of non-production wells and the price per meter for non-production wells affect the NPVs. The third table shows how the price per meter for non-production wells and the price per meter for

production wells together affect the NPVs, holding all other variables constant.

The fourth table shows how increasing the number of other, non-WDA wells, and the markup in the price per meter for non-WDA wells, affect the NPVs. This shows that a driller can substantially increase his profitability by successfully marketing himself beyond WDA.

The model presented in Annex A-9 is similar in most respects that presented in Annex A-8, except that the firm is assumed to have a growing clientele aside from the contract activities.

We assume that a driller may initially have a contract for about one well per year in addition to the WDA wells, and that this may increase by one well every other year for the next ten years.

Non-WDA clients may be charged about a 50% higher price than WDA, as there is greater risk associated with their patronage. In addition, private clients will be required to pay the driller directly for the materials used in drilling and equipping the wells, or to provide those materials to the driller. (We assume that the driller will procure the materials and charge the client a markup to cover the logistical and inventory costs associated with procurement.)

Part D presents a simple sensitivity analysis, as in Annex A-8 above, except that the fourth table examines how varying the yearly increment to the number of non-WDA wells, and the price markup for non-WDA wells, affect the NPVs.

A-2 PHASE TWO OF THE CONSULTANT'S RECOMMENDED PROGRAM

The Consultants' recommended Phase Two program is described in general terms in Section 2.2 of the main body of the Final Report. This section explains the details of the project requirements in terms of funding, services, equipment and materials.

Exhibit A-8 outlines the Phase Two Foreign Aid budget estimates by line item. The lines labeled "other costs" (which include items such as mobilization, or office supplies) were based on rules-of-thumb, and were not actually costed out in detail. Other specific line items are treated in more detail immediately below.

Exhibit A-9 outlines the expatriate staffing requirements, duties, qualifications, and person-months of time for each

EXHIBIT A-8

PHASE TWO FOREIGN AID BUDGET ESTIMATES

(1988 - 1991: Three Years)

SCHEDULE	DESCRIPTION		COST
I.	FOREIGN EXCHANGE COSTS (U.S. DOLLARS)		
A.	Expatriat Staffing		$2,232,000
B.	Contractor Furnished Equipment		$3,059,000
C.	Imported Materials		$3,109,000
D.	Other Direct Costs		$467,000
	TOTAL FOREIGN EXCHANGE COSTS		$8,867,000
II.	LOCAL COSTS (SOMALI SHILLINGS)		
A.	Subcontract Activities		236,362,000
B.	Other Local Costs		23,000,000
	TOTAL SHILLING COSTS	So.Sh.	259,362,000

EXHIBIT A-9

PHASE TWO EXPATRIATE STAFFING REQUIREMENTS

POSITION	DUTIES	QUALIFICATIONS	MONTHS
1. PriFund Manager	Manages PriFund, Coordinates Donor policies aiding private sector contracting	Project manager with experience with multi-lateral institutions	36
2. Financial Coordinator	Responsible for PriFund's finance & accounting; including revolving fund	Senior accountant/financial expert w/ experience in revolving funds & mult. inst.	36
3. Business Extention/ Procurement Advisor	Advises private sector contractors, especially w/ import procurement	Water industry businessperson with experience in water ind. & in procurement	36
4. FinEquip Advisor	Starts up FinEquip, responsible for establishing leasing procedures & procurement	Financial manager with experience in financial leasing of equipment	9
5. Government Contracting Expert	Responsible for assisting WDA establishing & implementing contracting procedures	Businessperson or economist with experience in gov't contracting	24
6. Public Utility Expert	Assists WDA in establishing & implementing appropriate water pricing policy	Economist with expertise in Public Utility Pricing Policy	24
7. Procurement Officer	Responsible for procurement of all project equipment and materials	Experience in project procurement	6
8. Coordinator	Oversees project		6
SUBTOTAL PHASE II			177

position of the two year program. The sum total for expatriate staffing costs for Phase Two is estimated at about $2.2 million. A more complete description of the duties for these personnel are contained in Section 2.2.2 of the main body of the Final Report.

Exhibit A-10 provides the quantity and cost estimates for the contractor-furnished equipment for the project. Actual numbers of vehicles (particularly pickup trucks) may depend on the existing equipment resources of the potential subcontractors; the figures used are for the estimated maximum. The number of pumps corresponds with the numbers of wells to be drilled (36 wells) and rehabilitated (72 wells) during the three year program, plus 19 additional pumps to be used as temporary replacement pumps to support the maintenance program outlined in Exhibit A-1, above. Insurance and freight for shipment of goods from the U.S. to Mogadishu could be up to 40%.

Exhibit A-11 presents the quantity and cost estimates for imported materials for the Phase Two program. Civil works will be required for up to 108 wells, of which 36 will be newly drilled by local contractors and perhaps all 72 wells scheduled for rehabilitation. Fuel costs are based on an assumed monthly or daily consumption rate for each type of vehicle, given the level of project activities. It assumes that three cable tool rigs used for project activities will be nearly fully utilized. One or two rotary rigs may also be used to drill 15 of the wells during Phase Two. Drilling consumables are divided between those associated with the use of a cable tool rig (cement, collars, casing, screen, and gravel, including a 25% probability of drilling a dry hole), and those involved with the use of a rotary rig (all of the above materials plus bentonite and drill bits).

Exhibit A-12 presents shilling cost estimates for the local contracts for on-going well rehabilitation, maintenance, and drilling activities. These are each discussed in detail below.

A-2.1 Well Rehabilitation

Annex A-10 presents a financial model of the on-going well rehabilitation activities described in Section 2.2.1.2 of the Final Report. At this point in time, there will probably be only one firm needed for this activity, rehabilitating an average of six wells per quarter.

Part A.1 outlines assumptions concerning equipment costs, assuming all equipment is already on-hand and used. "Values" for each piece of equipment are current market values. The imputed maintenance and depreciation costs for the rig, cement mixer and block machine are set at 50% per annum; those costs for the rolling stock are set at 100% per annum. (Note, for sake of

EXHIBIT A-10

PHASE TWO CONTRACTOR FURNISHED EQUIPMENT AND COSTS

(Based on Estimated Maximum Requirements)

ITEM	DESCRIPTION	QTY	UNIT COST	TOTAL COST
A.	Station Wagon, 4wd	5	$20,000	$100,000
B.	Pickup Trucks	4	$20,000	$80,000
C.	Contractor Required Spares	1	$100,000	$100,000
D.	Pumps	127	$15,000	$1,905,000
	Total F.O.B.			$2,185,000
	I.F. Mogadishu	40%		$874,000
	Total C.I.F. Mogadishu			$3,059,000

EXHIBIT A-11

PHASE TWO IMPORTED MATERIALS AND COSTS

ITEM	UNITS	UNIT COST	TOTAL COST
A. Civil Works Consumables (cement, etc.)	108	$15,000	$1,620,000
B. Fuel - Diesel			
3 Cable Tool Rigs 700 liters/month 36 months	75600	$0.35	$26,460
3 Flat Bed Trucks 550 liters/month 36 months	59400	$0.35	$20,790
18 Light Duty Vehicles 1,050 liters/month 36 months	680400	$0.35	$238,140
2 Rotary Rig 250 liters/day 75 days	37500	$0.35	$13,125
C. Pump Spares	182	$4,200	$764,400
D. Drill Consumables (Cable Tool) (cement, collars, casing, screen, gravel)	21	$11,000	$231,000
E. Drill Consumable (Rotary) (all above plus drilling fluids and bits)	15	$13,000	$195,000
TOTAL			$3,108,915

EXHIBIT A-12

PHASE TWO LOCAL SUBCONTRACT ACTIVITIES AND COSTS

(Somali Shillings)

SUBCONTRACT TYPE	COST
A. Well Rehab. Contractors	31,500,000
B. Maintenance/Repair	77,049,875
C. Drilling (Cable Tool)	58,750,000
D. Drilling (Rotary)	69,062,500
TOTAL	236,362,375

comparison, that rental rates for rigs in the U.S. are commonly set at about 10% of the market value per month; the Somali market, however, is undoubtedly too weak to support such rates, and it can be assumed that the owner will be using his equipment with more care than would a rentee.)

Labor and overhead costs (Parts A.2 and A.3, respectively) are the same as those described in Appendix A-1.2 (Annex A-3) for Phase One, above. The payment schedule for Part B differs from that used for Phase One activities largely because there should not be any need for well abandonment: all wells rehabilitated after Phase I are assumed to be recently operational, with major breakdowns in the pumping equipment calling for replacement (with some well cleaning) rather than simple repair. Parts C and D (Financial Analysis and Sensitivity Analysis) function as in Annex A-3, above.

A-2.2 Well Maintenance

Annex A-11 models ongoing maintenance activities for a single well maintenance firm during Phase Two. The number of wells under maintenance contract for each of the three firms is assumed to be one third of the total number of wells involved in the maintenance program during each quarter, as presented in Exhibit A-1, above.

Part A.1 covers equipment costs. All equipment is assumed to be on-hand and used. The maintenance and depreciation costs associated with the use of the cable tool rig for maintenance activities are set at only 10% per annum, as the rig will be used only rarely. Rolling stock maintenance, depreciation and opportunity cost, as in earlier models, is set at 100% of market value per annum. The annual costs of the repair shop for maintenance and depreciation are set at 25% per annum of a market value of about $35,000.

Direct and overhead costs (Parts A.3 - A.5) are the same as described in Appendix A-1.3 (Annex A-5) above; but since the equipment costs are substantially lower, the per well price for routine maintenance activities can be cut approximately in half. Parts C, D, and E proceed as in Annex A-5. Note that per well costs to the project are also substantially reduced, making this activity extremely cost effective, compared to pump or well replacement.

The model in Annex A-12 is similar in most respects to that in Annex A-11, except that the firm is assumed to have a growing private clientele (10 wells at the beginning of the three year period, growing to 32 at the end). If the above assumptions hold, this additional market can increase a firm's NPVs threefold over those accruing solely from servicing WDA pumps.

A-2.3 Well Drilling (Cable Tool)

Over the course of the three year program it is anticipated that at least 21 wells will be drilled by cable tool rig. The financial analysis for the highest cost assumptions associated with the use of the cable tool rig were presented in Appendix A-1.6 (Annex A-8).

A-2.4 Well Drilling (Rotary)

Annex A-13 presents an analysis with the highest cost assumptions associated with the use of a rotary rig. It is assumed that at least 15 wells will be drilled by rotary rigs during the course of the three-year, Phase Two program.

Part A.1 outlines the equipment and other initial capital costs associated with the purchase of a rotary rig. As in Annex A-8, it is assumed that a local lending institution (probably the Somali Development Bank) would be the source of finance for about 70% of the initial investment. The loan would have a five year maturity, charge 16% per annum, and be paid off with annual installments for equal portions of the principal, plus annual accrued interest.

Direct costs for labor, materials, and fuel are outlined in Part A.2. For WDA wells, materials and fuel will be provided by the project. Annual overhead costs are described in Part A.3.

Yearly variables are set out in Part B. One firm with a rotary rig could drill five wells per year for WDA, and still have time to execute other contracts. We assume that the probability of drilling a dry hole is about 25%.

Part C presents the financial analysis of such a venture. It is assumed that the loan would be paid off in five installments involving equal payments on the principal, plus accumulated interest on the balance (only the third, "payment" line enters into the calculations of the balance). The fourth line shows labor costs, based on the number of wells drilled (both production and non-production). The fifth and sixth line, for materials and fuels, are blank because the project will furnish them and they, therefore, represent no cost to the contractor. The seventh line is for overhead. The eighth line shows revenues for services, based on the price per meter (for production and non-production wells, respectively), and the number of meters per well. The ninth line, or payment for supplies, is not necessary for the WDA contract wells, as they are provided directly by the project.

The balance is discounted at 35%, 20% and 0% per annum for both a five year and a ten year payback period. If the WDA is the only source of business for such a driller, and if the price per meter is set at 32,500 shillings, then a firm investing in a new rotary rig would barely avoid a loss. Profitability would require that the driller obtain additional customers, as illustrated by Annex A-14.

The model in Annex A-14 is similar in most respects to that in Annex A-13 except that the firm is assumed to have a growing clientele for well drilling services in addition to its WDA contract. The model shows the firm initially drilling one well per year for customers other than WDA, growing by one additional well every two years. This activity would allow the firm to achieve a rate of return in excess of 50% over a five year period, and almost 75% over a ten year period.

APPENDIX B

BACKGROUND INFORMATION ON DEMAND FOR WATER AND WATER SUPPLY FACILITIES IN SOMALIA

B-1. INTRODUCTION

In this appendix, the projected national consumption requirements for water, and the resulting requirements for water supply structures, civil works, services, manufactured inputs and raw materials are analyzed. The appendix will:

- Describe the determinants of demand for water;
- Describe current consumption;
- Estimate future consumption needs for water;
- Compare estimated current and future consumption needs with existing supply;
- Estimate consequent need for additional water supply structures, civil works, manufactured inputs, and raw materials.

B-2. DETERMINANTS OF DEMAND

Demand for water resource structures and related components rests fundamentally on the basic demand for water. This basic demand is in part determined by the level and growth of human population, animal herds, agricultural land area, and manufacturing and other activities which use water; by water consumption standards; and by responses to changes in the price of water.

"Demand" in the economic sense refers to the quantities of water consumed as a function of the price of water. Since there is a legal ceiling on the price of water in Somalia, there is insufficient data to determine demand in this sense. However, it is possible to estimate total current consumption of water by examining population figures and per unit consumption estimates for different types of water use.

The Consultant's Water Industry Systems Model for Somalia (WYSyMS) which appears in a separate volume, is designed to illustrate the major uses and sources of water throughout the country. In a number of cases, reliable data for many of the variables were not available, and in other cases, various sources of data and estimates conflicted. Therefore, three different scenarios are presented to illustrate the range within which the actual situation probably falls. The estimates discussed in this report are taken from the middle range of estimates for all variables, and middle-range projections to 1990.

B-2.1 Human Consumption of Water

As in all arid countries in the developing world, obtaining water is a major concern of the Somali people, especially in rural areas. The locations of water points and quantities of water available are the primary determinants of the

location and even the size of rural villages. In the nomadic lifestyle, which is followed by about half of Somalia's population, the availability of water and grazing land are the greatest influences on patterns of migration.

Much of the water consumed by people, especially in rural areas, is taken directly out of rivers, springs, and natural ponds (called "Ballehs" in Somalia). In the wet season, rainwater is collected in cisterns ("Burkeds") or earth reservoirs ("Uars"). In the dry season, people must rely more heavily on groundwater sources: both borewells and hand-dug wells.

Water use varies considerably throughout the year, between wet season and dry season; and also between years, depending on the strength of the rains and the water level in the rivers. While water is used for drinking, cooking and washing; the latter two forms of consumption may be sharply curtailed in the dry season to conserve limited water supplies for their most vital uses. Communities lacking groundwater resources may have no nearby sources of water at all during the dry season; necessitating daily journeys of six hours or more, roundtrip, to collect water and carry it home. Especially for poorer families who may not have donkeys or camels, the length of this journey limits the amount of water that practically can be provided.

By Somali tradition and law, drinking water for immediate consumption should always be available free of charge; but water for livestock and water carried away in containers carries a charge. The current legal national price of water is set at 18 So.Sh. per cubic meter (= 1000 liters), although dry season prices in arid areas can easily climb to 20 times the legal price. During the wet season when surface water is readily available, most people prefer to obtain their water free of charge from natural sources or simple catchments, even though the quality may be inferior to groundwater.

Rough calculations of average human consumption can be made on the basis of population figures and per capita consumption estimates. Estimates of human population in Somalia cover a wide range. There was a national population census in Somalia in 1975 (which was subject to some criticism for its coverage and methodology); it estimated a population of about 4.2 million, excluding refugees. The Ministry of National Planning (MNP) estimated a total population of 5.35 million as of end-1984, while an aerial reconnaissance survey estimated a population of almost 7 million.

Since per capita water consumption varies significantly between urban and rural dwellers, it is useful to divide the population along these lines to estimate total consumption. The MNP estimates that 25% of the population live in urban areas, approximately 29% are settled in rural areas and the rest are nomadic. Urban dwellers with individual household connections might consume up to 100 liters per capita per day (lcd) in cleaning, and cooking as well as direct consumption, while dry season nomads' consumption may be as low as 3 liters per day -

barely sufficient for survival. For purposes of simplicity, the Consultants' figures represent rough estimates of average consumption throughout the year. Actual consumption varies considerably between wet and dry seasons and from year to year depending largely on the amount of water readily available.

Most urban water is provided by deep drilled wells and an extensive distribution network leading to individual household connections or neighborhood standpipes. Rural communities and nomads rely more heavily on hand-dug wells, surface water from rivers and ponds, and from rainwater catchments. The Consultants estimate that total urban consumption of water for human use is currently about 8 million cubic meters per year; rural and nomadic consumption is about 12 million. For livestock consumption, also predominantly rural, see below.[1/]

Population growth rates for the country as a whole are estimated to be about 2.9% per annum. This is a weighted average of an urban population growth rate of 4.5%, rural settled growth of 3%, and nomadic population growth of 1.9%. This would give a total population of about 6.35 million in 1990, of which 1.74 million would be urban.

Growth in per capita consumption is harder to judge. Goals established under the United Nations' Drinking Water Supply and Sanitation Decade and formally endorsed by the Government of Somalia are to provide about 40% of the urban population with household connections and 60% of the urban population with nearby access to public stand posts. Consumption goals are set for a minimum of 30 lcd in urban areas (130 lcd for household connections) and 20 lcd in rural areas. This would require provision of almost 50 million cubic meters of water per year for human consumption in urban areas and 44 million cubic meters in rural areas for human consumption alone.[2/]

The Consultants estimate that achievements to 1990 will be more modest: 25 lcd in urban areas (100 lcd for household connections), 15 lcd in settled rural communities and 10 lcd for the nomadic population. This would lead to a total urban demand (for human consumption only) of about 21 million cubic meters of water, and rural human demand of about 20 million.[3/]

1/ Appendix I, Section I-6
2/ Appendix I, Section I-5
3/ Appendix I, Section I-4

B-2.2 Livestock Consumption of Water

Livestock production is the principal economic activity in Somalia, accounting for approximately half of GDP and up to 80% of export earnings. Almost half the Somali population is engaged in nomadic pastoralism, while four-fifths of the population are involved in livestock raising of one sort or another. Rural people derive about half their caloric intake for most of the year from milk and meat, and sell surplus animals, milk, hides and skins to purchase food staples. In urban areas, dietary preferences result in a high level of consumption of meat and milk.

The current basis of livestock production is an extensive and mobile system of grazing adapted to the natural characteristics of the country. Natural rangelands cover about 80% of the land area. Since large portions of the rangeland are unsuitable for any other use, it is expected that it will continue to serve as the nutritional base for the national herd. Utilization of arid rangelands can be improved by better distribution of watering facilities and by better management of grazing areas.

Livestock population estimates vary, but the MNP estimates a current population of about 4 million cattle, 5 million camels and 27 million sheep and goats. Growth rates for the national herds will depend on market conditions (especially export markets) as well as human population growth rates and climatic and range conditions. Over the past few years, the MNP estimates that livestock populations have increased by about 1% per annum (net after off-take). If this rate continues, 1990 populations can be expected of about 5.3 million camels, 4.2 million cattle, and 28.7 million sheep and goats.

Livestock water consumption varies with climatic and range conditions, and they can meet many of their water needs from the moisture content of their forage or browse. Cattle must be watered once every other day on average; whereas sheep and goats can be watered every two to six days, and camels are watered anywhere from one to three weeks. Volumes of water consumed at each watering can therefore vary significantly; but the Consultants work with the assumption of an average daily water need of 25 liters per head per day for camels and cattle, and 3 liters per head per day for sheep and goats. Per head consumption figures are not expected to increase significantly over the next five years. Thus livestock consumption, figured at about 100 million cubic meters for 1984, is projected to rise only to about 130 million by 1990.[4/]

Livestock watering fees are supposed to be based on the legal national price of water. In practice, the volume of water

4/ Appendix I, Section I-4

consumption per head per watering can only be estimated, and the fee set on the basis of that estimate. The table below presents typical livestock watering fees at a government controlled watering point as of 1983-84. Dry season watering prices in the more remote areas in Somalia, beyond effective government regulation, can be many times higher.

Livestock Watering Table5/

Type of Livestock	Est. Number of Head	Est. Volume per Watering	Frequency of Watering	Average Charge per Watering	So.Sh. per Cubic Meter
Camel	5,000,000	100-150 l.	1-3 wks.	0.7 So.Sh.	5 - 7
Cattle	4,000,000	40-60 l.	1-2 days	0.4 So.Sh.	6.7-10.0
Goats/ Sheep	27,000,000	6 l.	1-2 days	0.1 So.Sh.	16.7

B-2.3 Agricultural Water Consumption

About one-fifth of the Somali population are engaged in crop production activities, 80% of them on a subsistence basis. Agriculture is considered an especially important sector by virtue of its contribution to export revenues (mainly bananas); its role in import substitution, especially of food items; its function as a supplier of inputs to the manufacturing sector; and its potential to absorb some of the growing number of entrants to the labor force. The major crops include the staples maize (corn) and sorghum as well as bananas, sugarcane, cotton, rice, citrus fruits and some vegetables.

Agricultural production is from two sources: a relatively small commercial sector employing controlled irrigation, and traditional farms which produce the main staples. The largest segment of the population engaged in agriculture lives outside the monetary economy, producing primarily for its own consumption and marketing any excess beyond family needs. Agricultural practices have remained rather simple with minimal use of modern inputs or technologies.

The vast majority of crop land in Somalia is under purely rain-fed conditions; some agricultural land benefits from (semi-) controlled flood-irrigation in the rainy season, which makes use of small earth dams to divert run-off to the agricultural fields. About six percent of cultivated land, all of it near the Shabelle or Juba Rivers, is under controlled channel irrigation. This land is devoted primarily to production of export crops, particularly bananas and grapefruit. Since rainfall is beyond practical human

5/ MNP, "Five Year Development Plan (1982-1986)"

control, this study will examine only the portion of agricultural water use that is directed through water control structures. Further, since data are unavailable on the extent to which earth dams are used in flood-fed agriculture, we shall focus primarily on water used in controlled irrigation agriculture.

The MNP estimates that there are currently about 55,000 hectares under controlled irrigation. Estimates of water use per hectare are very rough, and heavily influenced by assumptions about the efficiency of water use. One figure used by the MMWR assumed a 45% water use efficiency and estimated annual per hectare water use at about 25,000 cubic meters. Most agricultural experts in Somalia, however, agree that water use efficiency is currently under 20%, implying that the MMWR's estimate of about one billion cubic meters per year for irrigation water consumption may be far too low.

Most irrigation water comes directly from the Shabelle River; but since the river runs dry at least once, usually twice, each year, irrigation wells have been drilled to enhance water availability. This groundwater probably provides less than three percent of water used in irrigation, yet irrigation accounts for over half of all groundwater consumption in Somalia.

The Ministry of Agriculture is anxious to increase irrigated crop production, and has plans both to extend the area under irrigated cultivation and to increase the intensity of irrigation. There is plenty of scope for introducing irrigation to the Juba River Valley, but the Shabelle River is considered by most experts to be over-exploited already. Since there are no laws governing water rights from the rivers, upstream plantations make heavy demands on the Shabelle's waters, leaving many downstream users dry shortly after the end of each rainy season. FAO and World Bank agricultural advisors insist that all future increases in irrigation intensity along the Shabelle will have to be accomplished through improvements in the level of irrigation efficiency. This can be achieved by replacing the current open-channel irrigation systems with closed-tube irrigation systems. (PVC pipe manufacturing facilities are available locally; preliminary specifications for such a system are presented in Section 2.1.2.4 of the main body of the Final Report).

The Consultants estimate that by 1990, there will be about 64,000 hectares under controlled irrigation, and consumption of irrigation water will be at least 1.35 billion cubic meters per year.[6/]

B-2.4 Institutional/Industrial Water Consumption

Little information is available on water consumption in

6/ Appendix I, Section I-4

industry and manufacturing in Somalia. The MNP has compiled a list of about 300 firms with five or more employees, but admits that many companies were probably missed. For Mogadishu, estimates made during the Second Water Supply Project suggest that government institutions accounted for over half of all water consumed in the city in 1981, and that private industry accounted for another 3%. The Consultants estimate that total institutional/industrial water consumption was about 8.5 million cubic meters in 1984.

Projections of industrial/institutional demand to 1990 depend crucially on assumptions about the economic environment, including economic policy. The Consultants assume that there will be little growth in water consumption in the public sector, but due to privatization policies and industrial growth, private industrial water use may grow by as much as 15% per annum. In this case, total water consumption for institutional/industrial use could climb to almost 10 million cubic meters per year.7/

Currently, many private firms prefer to dig or drill their own wells, rather than subscribe to metered city water. These wells may yield about 5 or 6 cubic meters per hour. As private commercial and industrial activity expands, this sector may form an important market for the local private sector drillers in Somalia.

B-2.5 Effects of Price on Demand for Water

Little information is available about the elasticity of demand for water with respect to price. Somalia currently has a fixed legal price for water of 18 So.Sh. per cubic meter; and although it is well known that people must often pay much higher prices during the dry season, there is no reliable data on this activity. It is also clear that in the wet season, rural populations usually prefer to obtain their water free from surface resources, including rivers, ponds, uars, and burkeds rather than pay for groundwater, even though it may be of better quality.

There is no indication that the current price is a barrier to water consumption in general. Water is provided as a utility good, not as a social service, and user charges are levied to help defray the cost of providing that good. The imposition of user charges has strong economic justification: not only does it help meet expenses involved in providing water, it also encourages water conservation (e.g., by encouraging livestock owners to sell non-productive animals in order to help pay their watering fees).

The uniform national price for water is based on the average delivery costs of several urban water systems, such as Mogadishu and Hargeisa, and does not reflect the varying cost of delivering water throughout the country. In one study of water

7/ ibid

prices carried out by the Consultants in 1984 in the Bay Region, the ten shilling price (using the official exchange rate) appeared to be sufficient to cover operation and maintenance costs and to make some contribution towards recovering the investment cost of the well, but it was figured to be far from sufficient to recover the full investment cost.[8/] Since the 1985 devaluation there has been some pressure from regional WDA offices to raise the official price. Although an official national price increase to 18 So.Sh. per cubic meter was recently approved, some urban offices earlier raised their fees to 25 So.Sh. per cubic meter.

B-3 ELEMENTS OF UP-STREAM DEMAND IN THE WATER INDUSTRY

Above the first-level provision of water to ultimate consumers, there extend second-level services and activities necessary for the production and distribution of water (e.g., drilling wells, constructing water lines and other civil works) and above these, third-level activities, which include the production of manufactured and raw-material inputs to the industry. Together they make up the industry structure:

Level I: Water Supply
- A. Well/reservoir ownership
- B. Well/reservoir operation and revenue collection

Level II: Construction and Related Services
- A. Drilling and construction services
- B. Planning and administration of well/reservoir operation and of drilling and construction
- C. Hydrogeological services
- D. Repair and maintenance of water supply facilities

Level III: Inputs
- A. Labor
- B. Materials
- C. Equipment

Thus demand for water gives rise to demand for the water facilities such as wells and uars. These must be designed, constructed, operated, and maintained. This in turn gives rise to demand for drillers, drivers, cement, pipe, pumps, fuel, equipment, and all that goes into the construction and maintenance of water facilities.

In the Water Industry Systems Model for Somalia, estimated current consumption for all uses has been compared to estimates of the numbers of all categories of water supply facilities, taking into account the likely percentage distribution of each type of use across the range of supply facilities. This establishes a

8/ Carter Brandon, LBII, "Economic Evaluation of the Comprehensive Groundwater Development Project", April 1984

quantifiable relationship between demand for water (which can be analyzed separately for each type of use of water) and the numbers of each type of water facility needed to meet that demand. In this way, projections of future water demand can help determine demand for water supply facilities. Knowing what goes into the production of each type of water supply facility can help in estimating the likely quantities of inputs required.

The WISyMS Level III submodel, which projects quantities of inputs for basic production as well as maintenance and repair are estimated for all types of water supply facilities.

B-4 IMPACT OF FOREIGN AID

A large proportion of water development projects in Somalia are funded through foreign assistance. Since 1981, more than forty percent of wells drilled in Somalia, including the major urban wells, were financed through foreign sources.

To meet water development requirements and objectives, continued foreign assistance will be required for the foreseeable future. The only other alternative, which should be considered as complementary to foreign aid programs, would be the mobilization of private domestic resources for water development.

A description of each of the recent major foreign-sponsored water resource development projects is contained in Appendix F-4.

APPENDIX C

OVERVIEW OF INDUSTRY AND SUPPLY STRUCTURE IN SOMALIA

C-1 INTRODUCTION

This appendix will examine the supply side of the water resources development industry in Somalia. The purpose is to present a picture of the industry as it currently exists. The appendix will:

- Define the industry;
- Examine the current supply of water and of water supply structures;
- Describe the administrative, regulatory, and legislative structure of the industry;
- Examine existing hydrogeological, design and other scientific and engineering services;
- Describe drilling and civil works construction resources existing in Somalia;
- Describe the methods of operation of water supply facilities and of collection of water related revenues; and
- Describe requirements for and existing capacities to maintain water supply structures.

C-2 DEFINITION OF INDUSTRY

The water resource development industry in Somalia is large and diverse and of crucial importance to other facets of the economy. While it is recognized that many of the components of the industry are inter-related, a detailed examination of private sector involvement in all aspects of water development (e.g., in irrigated agriculture) is clearly beyond the scope of this study.

Study boundaries have thus been established to permit an analysis of private sector opportunities generally felt to be closely related to drilling or construction, equipping, installing and maintaining water points; including storage and distribution systems. The primary emphasis of this appendix will be on groundwater development, particularly wells and boreholes, but some surface water development will also be examined. Particular consideration is given to the scope of activities carried out by individual entrepreneurs and establishments.

The water resource development industry is defined to include the activities of organizations and individuals engaged in:

- Drilling and digging wells and installing pumps in drilled wells;
- Constructing civil works related to water resource

development, including the construction of reservoirs, dams, cisterns, other water retention structures, and other water sources, as well as the operation, repair, and maintenance of these works;

- Planning, designing, and engineering wells and other structures described above;
- Manufacturing and assembling in Somalia inputs such as pumps, tanks, metal and PVC pipes, plastic liners and other material inputs used in drilling wells and constructing other water resource structures described above;
- Providing raw material inputs, such as gravel, stone, and wood, used in drilling wells and constructing other water resource structures.

C-3 WATER SUPPLY

This subsection will provide an overview of current water resources and water supply in Somalia. The sub section will describe the existing water resources, mechanisms of water supply, numbers of supply structures, and amounts of water supplied. Water in Somalia is obtained by several mechanisms and from several sources. These mechanisms and resources vary by geographic location, purpose of use, and season.

Somalia's water resources are generally sparse and are not evenly distributed because of the variation in rainfall distribution, topography and geology. Rainfall varies from a high of 450 - 780 mm per year in the inland highlands to a low of less than 50 mm per year along the Gulf of Aden's Coastal strip. Heavy individual rainfalls of 50 - 150 mm have occurred, and periods of prolonged drought, some lasting for years, are not uncommon. There are four distinct seasons in Somalia: Hagai, a dry season from December to March, Gu', an intense rainy season from April to June; Jilaal, a dry season from June to September/October; and Heyr, a short rainy season from October to December. Over the year, potential evapotranspiration greatly exceeds rainfall.

C-3.1 Existing Water Resources

Outside of the Shabelle and Juba River Valleys, surface water supplies in Somalia are scarce resources. Because of the arid climate, permeable soil, and high rate of evapotranspiration, surface water is seldom available year round in most areas.

The Juba and Shabelle Rivers are the main perennial sources of surface water in the country. The rivers provide a major source for irrigation in the southern part of the country. Other streams are intermittent, flowing only during monsoons.

The Shabelle River rises in Ethiopia and enters Somalia at Far-Far. It drains about 100,000 sq. km in Somalia and about 200,000 sq. km in Ethiopia. In Somalia, the river flows about 630 km, and terminates in a swamp about 30 km east of the Juba River.

The flow of the Shabelle at Jowhar averages 66 cubic meters per second and ranges from zero to 200 cubic meters per second. The southern reaches of the river generally run dry twice each year, and the quality of water varies greatly with the seasons.

The Juba, the other major river, is the only true continually flowing stream of Somalia. Like the Shabelle, the Juba flows from the Ethiopian plateau. The drainage basin of the Juba covers about 275,000 sq. km of which 98,000 sq. km is within Somalia and has a channel length of about 800 km. The volume flow of the Juba River is almost three times that of the Shabelle. In normal years it is an estimated 190 cubic meters per second with a range of about 20 to 700 cubic meters per second. The quality of Juba's water is less variable than the Shabelle and contains fewer dissolved solids, but the quality fluctuates with the seasons.

The mountainous area in the north contains many small streams which at times become torrents, but there is little information about the flow of these seasonal streams.

Surface water resources in Somalia are insufficient to satisfy consumption requirements. Use of groundwater resources is therefore a necessary complement to surface water.

Despite the drilling activities and the continuous search for groundwater during the past several years, the state of knowledge of the location, quantity and quality of groundwater resources is still very limited. There has been a lack of adequate systems for measuring, record keeping and monitoring. Efforts are being made to carry out proper hydrogeological investigation and data collection and interpretation.

Although Somalia has been experiencing frequent droughts, it is believed that the overall groundwater resources development of the country has not exceeded the (admittedly limited) capacity of these resources.

Groundwater is the predominate dry season source of water supply in many parts of the country, and is in most parts of the country the only perennial water source. However, the availability of groundwater varies across areas. Also, there are serious water quality problems, especially in the shallow aquifers, where hand dug wells may be constructed. Another serious problem is risk of over-development of groundwater in the Shabelle alluvium and in certain arid parts of the country. In some areas of the country, conditions may not favor the recharge of groundwater resources.

Hydrogeologists on the second Mogadishu Water Supply project estimated, for example, that the sustainable yield of groundwater bodies located within the Afgoi-Balad-Mogadishu triangle is about 25 million cubic meters per year. This region's groundwater is derived from recharge of the Shabelle River during high river stages. It is estimated that maximum use of this

resource will occur by the early 1990s and will require careful regulation of water production throughout the Basin. After this time Mogadishu may have to secure supplemental supplies directly from the Shabelle River and/or from more distant groundwater sources.

Mechanisms of water supply include water available without charge and water that is purchased. Where available, free surface water resources (i.e., without charge) are the preferred sources for most users, including water for human consumption, livestock consumption and irrigation. Such sources include river water, and during wet season, rainwater catchment resources, including uars, burkeds, and ballehs. The latter are all man-made or at least potentially man-improved water sources, designed to store surface water, especially rain and runoff water, for extended periods.

Wells, both deep and shallow, drilled and hand-dug, are commonly used to tap groundwater resources and to provide extended water availability. Many are designed to provide year-round water.

Other, less utilized and still uncertain sources include natural springs and desalinized seawater. In urban areas, piped water supply distribution systems are being extended. Ten communities are currently served by piped water systems.

C-3.1.1 Drilled Wells

The WDA operates approximately 360 public wells in rural and semi-urban areas, and has another 130 which are out of service.

WDA rural wells are estimated to produce approximately 70 cubic meters per day, on average. Municipal wells in the large towns and cities have much greater capacities and rates of consumption. Wells recently completed in Mogadishu each have an average daily capacity of about 1,375 cubic meters per day. In Hargeisa, the six wells recently completed by the Chinese have an average capacity of about 800 cubic meters per day.

Except in Kismayo, where water is obtained from the Juba River, all existing urban water supplies rely on groundwater from drilled wells, which is usually pumped into elevated reservoirs and distributed by gravity pipeline to the communities, through public standpipes and individual house connections.

In rural areas, well use is frequently seasonal because users prefer, when water is available, to obtain their water from sources that do not require payment. The traditional water sources for most inhabitants of the Bay Region, for example, are uars, waddies and shallow wells. When these sources dry up, as most do at least once if not twice a year, villages must seek water at the nearest available site, which often involves a roundtrip of up to one or two days. It is common for entire

villages to uproot and move nearer to a dry season water point if the round trip is longer than six to eight hours. Even if an entire village does not uproot, the young men will lead most of the family livestock away to other less dry regions. Thus, during the two set seasons, well water usage will drop virtually to zero, while during the two dry seasons, the user population per rural well could rise to over 5,000 people and their associated livestock.

The Consultants estimate that as of end-1984, there were in Somalia approximately 125 urban wells, 200 rural boreholes equipped with a diesel pump, 120 rural boreholes equipped with a handpump, and about 155 irrigation wells.

C-3.1.2 Hand Dug Wells

Available data on the number of dug wells is scarce and imprecise. Aerial reconnaissance data from the National Range Agency suggests that as of end-1984, there were about 17,000 hand-dug wells in the country.[1/] Traditional dug wells may be two to thirty meters in depth. There is, in fact, a great range among dug wells. The vast majority of wells are temporary (seasonal) or only moderately durable structures. The Consultants estimate that the average dug well can yield up to three to five cubic meters per day.

C-3.1.3 Uars

Uars, man-made surface water impoundments, are a traditional water source. They are usually dug in relatively impermeable clay soils and are occasionally lined with plastic sheets. The importance of construction of uars has been recognized by the Government of Somalia. This is reflected in the Five-Year Development Program, 1982 - 1986, which established the goal of construction of 500 new large uars, including ten per year by the NRA. It has been estimated that there are about 18,000 uars in Somalia, ranging in capacity from a few hundred cubic meters to 30,000 cubic meters or more; and yielding an average of perhaps 1,000-1,500 cubic meters of water per year for human and livestock consumption.

C-3.1.4 Burkeds

Burkeds are underground cisterns or containers lined with cement and/or stone, which store runoff water. Burkeds have long been common in the northern area of Somalia, and the technology has been adopted on a large scale elsewhere in the country. There has recently been a great increase in the rate of construction of burkeds.

1/ Resource Management and Research of London, Southern Rangelands Surveys, 1985

There are thought to be many thousands of burkeds in Somalia; the Consultants estimate that there are over 10,000 burkeds in the country, ranging in size from 10 to over 600 cubic meters, and yielding an average of perhaps 500 cubic meters per year per structure. During the dry season, burkeds may be filled with water trucked in from an outside source.

C-3.1.5 Springs

Natural springs exist, particularly in the three northeastern regions of Somalia. There are a few in the Upper Juba areas, but their number and potential are not well known.

The 1972 UNDP Mineral and Groundwater Survey estimated the number of springs in Somalia to be about 260. The report indicated that most have an insignificant discharge. Most springs were used for water supply of nearby habitations and livestock watering.

C-3.2 Planned Water Supply Development

A recent World Bank study of overall water resources and requirements concluded that Somalia is not seriously water deficient, and that adequate water supplies for its human and animal populations are available provided water development is carefully planned and implemented.

Reflecting this opportunity, a substantial portion of Somalia's development budget is devoted to projects associated with water exploration and the channeling and harnessing of water supplies. Ten percent of the Five Year Plan (1982-86) budget was planned for water resource development.2/

Because of the importance of the need, the Government of Somalia has identified the rural water supply subsector, which includes the nomadic population, as a major priority area. Fifty percent of the investment projected in the water sector in the Five Year Plan is ear-marked for this subsector, the remainder being equally shared between sanitation and urban water supply (see Exhibit C-1).

C-3.2.1 Human and Livestock Consumption

Rural Water Supply

One of the objectives adopted by the Government is to provide each rural and nomad inhabitant with 25 liters per capita per day (lcd) of safe drinking water by 1990. Service is

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2/ In the adjusted three-year Public Investment Program (1984-1986) the total share was increased to about 11.0% but annual expenditures in constant dollars are planned to be at least 50 percent higher during 1984-1986 than in 1982 and 1983.

EXHIBIT C-1

WATER SUPPLY FOR HUMAN CONSUMPTION[1/]
CURRENT WATER SUPPLY AND GOALS

Water Supply	Present Situation (1982)	Decade Targets (1990)
Urban Centers		
Percent of service coverage[2/]	60%	80%
Consumption in liters per capita per day (lcd, by:		
Private connections	40 lcd	130 lcd
Public fountain	15 lcd	30 lcd
Rural Areas		
Percent of service coverage[3/4/]	20%	50%
Consumption	10 lcd	25 lcd

1/ Source: Plan for the Drinking Water Supply and Sanitation Decade

2/ Accessibility criterion: Not more than 200 m from dwellings

3/ Design criteria for per capita allowances have been adopted on the assumption that water resources will be sufficient to meet the demand

4/ Accessibility criterion: Not more than 500 m from dwellings

considered adequate if the source is not more than 500 m from a village or dwelling of temporary nomads. According to Government estimates, this would imply an eight-fold increase in water supplied from 1982-1990, from 3 million cubic meters per year to 25 million cubic meters per year.[3/] The Consultants' estimates based on the Government's goals as well as the most recently available demographic data, indicate a need for 44 million cubic meters of water in rural areas. This in turn would imply a need for 746 rural boreholes in order to supply this quantity of water.[4/]

The Government target for the 1982-1986 Five Year Development Plan was to construct 250 deep wells in rural areas. In 1982, less than ten wells were completed. Objectives to 1986 have since been reduced to 30-35 wells per year. For financial as well as technical reasons, the WDA is currently operating at a level below that called for by the FYP. For example, in 1983, 10 rigs drilled 17 boreholes in eight regions. Eleven of these are production wells, the others have either found water in insufficient quantity, or the water has been too saline for use. Other government plans for the decade are illustrated in Exhibit C-2.

In addition to human consumption, rural water systems must serve the needs for the livestock populations. Livestock obtain their water requirements from a variety of surface and groundwater sources. During the wet season, pastoralists tend to water their herds at free, surface water catchments. During drier periods, the livestock are often brought to the uars and wells. There is, in practice, little difference between "animal" and "human" water resources.

In addition to the rural water supply projects discussed in the previous subsection, which will also serve livestock, there are several ongoing programs managed by the NRA to build uars and other waterpoints to serve livestock. The construction of 500 uars and 150 wells was planned for the Five Year Plan, although it seems unlikely that these targets will be fully realized.

The Consultants' middle-level projections to 1990, including more modest targets for per capita consumption, would provide a total of about 20 million cubic meters of water for rural consumption and require a stock of almost 600 rural boreholes. This would require the construction of about 232 wells from 1986 through 1990. (See Section Three of the main body of the Final Report).

3/ Source: Plan for the Drinking Water Supply and Sanitation Decade.

4/ Water Industry Systems Model for Somalia (WISyMS).

EXHIBIT C-2

INVESTMENT OBJECTIVES FOR RURAL WATER SUPPLY

Item	Quantity	Unit Cost So.Sh. (US$) million		Total Cost So.Sh. (US$) million	
Deep wells drilled	50	1.26	(0.084)	63.21	(4.20)
Deep well pumps	90	0.15	(0.010)	13.55	(0.90)
Pump houses	90	0.10	(0.007)	9.48	(0.63)
Houses for pump operation	90	0.30	(0.020)	27.10	(1.80)
Piping 2" diameter	1600	0.26	(0.017)	409.36	(27.20)
Standposts	550	0.12	(0.008)	66.22	(4.40)
Shallow wells dug	2000	0.037	(0.0025)	75.25	(5.00)
Shallow wells rehabilitated	1200	0.023	(0.0015)	27.09	(1.80)
Hand pumps	8000	0.011	(0.0075)	90.30	(6.00)
Clear water storage in thousands m^3	3600	0.226	(0.015)	812.70	(54.00)
Rain catchment area Km^2	30	45.15	(3.00)	1354.50	(90.00)
Rain catchment area in thousand m^3	500	0.10	(0.007)	526.75	(35.00)
Slow sand filters	$1000m^3$ 3	1.20	(0.080)	3.61	(0.24)
Infiltration galeries	Km 40	1.13	(0.075)	45.15	(3.00)
Fence	Km 750	0.075	(0.005)	56.44	(3.75)
Individual latrines	150	2.26	(0.15)	338.62	(22.50)
TOTAL				3919.33	(260.42)

1/ Source: Plan for the Drinking Water Supply and Sanitation Decade.
Note: Exchange rate used is 15 So.Sh. = 1 US$

Urban Water Supply

By early 1984, piped water supply systems served ten urban communities: the three major towns of Mogadishu, Hargeisa and Kismayo; and seven smaller towns of Berbera, Baidoa, Merca, Afgoi, Balad, and Jowhar. In addition, the WDA considers an additional 62 Regional and District Centers as "urban." It is estimated that 60 to 65% of the urban population has nearby access to drinking water.

In the city of Mogadishu, the population coverage is the highest, estimated to be 87% of the total city population. Most of the "excluded" urban population (those further than walking distance from an urban standpipe) are served by private transport and sale of water, either from water tanker trucks or from a vendor with a donkey cart carrying a 200 liter drum.

The Mogadishu water supply system is currently undergoing expansion through an IDA credit with co-financing by Arab funds. Most of the present water supply system for Mogadishu was commissioned in 1973 with the construction of 19 wells producing a total of about 24,000 cubic meters per day. By 1980, the number of production wells had dropped to 17 and production fell below 19,000 cubic meters per day.

Expansion was planned in two phases. Phase I of the Mogadishu Water Supply Expansion was completed in 1982 with the drilling of eight new production wells, and storage and distribution facilities. Phase II entails the construction of 47 production wells and associated works. Phase III, a river water extraction scheme, will begin late in the plan period. The objective is to meet by 1990 the target of 58,000 cubic meters per day.

The Hargeisa water supply system currently has six municipal wells, and has plans to double capacity with the construction of six additional wells with assistance from the People's Republic of China.

Other urban water programs to extend water supply in towns carried out with West German assistance have been planned, but are on hold. Italian aid is upgrading the Berbera city water system. See Appendix F-4 for more details on these and other foreign aid water supply projects.

The Government has adopted an objective of eighty percent coverage for urban areas by 1990, with 130 lcd for private connections and 30 lcd for public fountain service, with the levels of service differing according to the importance and stage of development of a particular town. Commercial and institutional water requirements are included in these per capita targets. Achievements of these targets will require the construction of about 25 new urban systems and expansion for three urban systems.

The WDA at present manages water supply systems in some towns and envisions extending its activities by 1990 to all towns with water supply systems not managed by separate entities (Mogadishu, Hargeisa, and Kismayo). By 1984, financing for expansion of new construction of water supplies for 17 centers was either assured or being negotiated with potential bilateral and multilateral donors.

The Consultants' projections to 1990, including more modest estimates of increases in per capita water consumption, would require a stock of about 230 urban wells by 1990 (including municipal, industrial, and other private wells), and would require drilling about 95 wells from 1986 through 1990. (See Section Three of the main body of the Final Report.)

C-3.2.2 Water for Agriculture

Water for agriculture is obtained through diverted flood irrigation, rainfall, or through controlled open channel irrigation. In some areas, notably the Shabelle River Valley, river water is supplemented by water from shallow drilled wells. Water used for agriculture in the Shabelle River basin was estimated in the 1982-1986 Five Year Plan to be 757 million cubic meters per year; in the Juba River basin, 209 million cubic meters per year.

On the basis of planned expansion of irrigated agriculture, the Consultants estimate a requirement of 1.35 billion cubic meters of irrigation water by 1990, if the currently prevailing technology and reliance on irrigation wells continues over the next five years. This would in turn require a stock of about 230 irrigation wells in 1990, and thus the construction of about 75 irrigation wells from 1986 to 1990.[5/]

C-4 PLANNING AND ADMINISTRATION OF WELL AND OTHER WATER SOURCE CONSTRUCTION AND OPERATIONS

Organizations and Their Responsibilities

Several ministries and agencies share responsibility for water resource development. The three autonomous municipal water agencies of the Ministry of Mineral and Water Resources are responsible for administration, operation, and maintenance of the larger urban systems in Mogadishu, Kismayo and Hargeisa, while the Water Development Agency (WDA) has the responsibility for all other towns and rural areas. Management often passes to local bodies once systems have been established. In addition, the Ministry of Agriculture, the National Range Agency, Ministry of the Interior and other agencies are responsible for some water projects.

5/ LBII, Water Industry Systems Model for Somalia, 1985.

Until now, there has not been a water law governing the development of water resources in Somalia. In cooperation with the FAO, the Hydrogeological Department of the Ministry of Mineral and Water Resources is undertaking the tasks of developing water legislation.

At the central government level, two organizations have key policy roles in water development: the National Water Committee and the Ministry of Minerals and Water Resources. The National Water Committee is reinforced by the National Technical Committee. The Ministry of Mineral and Water Resources is responsible for the Water Development Agency and municipal water utilities. The function of these agencies is discussed in greater detail in Appendix F-1.

C-5 HYDROGEOLOGICAL DESIGN AND OTHER PERTINENT SCIENTIFIC AND ENGINEERING SERVICES

There are relatively few domestic organizations or individuals capable of providing hydrogeological, design and other scientific and engineering services. The Government of Somalia recognizes this shortcoming and through technical assistance programs, and educational programs (abroad and at the National University), is attempting to increase the country's reservoir of trained personnel.

Currently, in Somalia, the sources of such services include:

a) **The Ministry of Mineral and Water Resources**, through its Hydrogeology Department, is responsible for research and hydrogeologial studies, the collection and assessment of hydrometeorological data, and the design and implementation of groundwater exploration projects.

b) **The WDA** has its own technical department and personnel. This department is capable of undertaking hydrogeological studies, design of wells, uars and other structures.

c) **Other Ministries:** The Ministry of Defense possesses its own technical capabilities. Other ministries, such as the Ministry of Agriculture, are able to design their own irrigation systems and certain water retention structures.

d) **Private Sector:** There are several individuals in the private sector, often ex-WDA employees, with the training and experience to undertake certain investigations and design. Geomatec and Aaron Construction and Consulting Company are two companies that have been identified with the technical capacity to undertake related work.

e) **University of Mogadishu:** A number of Somali students are receiving education in engineering, hydrogeology and similar disciplines. Other students are receiving advanced degrees

abroad and training from the WDA and other organizations. Thus a cadre of individuals educated in these disciplines, albeit lacking in experience, is becoming available.

None of the organizations in Somalia currently have the capability of undertaking major studies or designs without external assistance. The domestic ministries and agencies typically receive foreign technical assistance. For major programs of study, design, or construction, technical and supervisory work is normally tendered to foreign organizations.

C-6 DRILLING SERVICES

This section reviews the availability of drilling services in Somalia, the magnitude of drilling activities over the past five years, and the respective market shares in drilling activity of the government, foreign firms, and local private drilling firms. It presents a number of different forecasts of future drilling activities and compares these with forecasts of future consumption needs.

As discussed above and in Appendix F, the WDA and the urban water agencies share the legal responsibility for well drilling in Somalia. The WDA has primary responsibility for well drilling throughout the country outside of the urban areas of Mogadishu, Kismayo, and Hargeisa, which have their own autonomous water agencies. All other organizations and individuals are required to seek authorization from WDA for their drilling.

Rigs are owned by the WDA, the Mogadishu Water Agency, and the Ministry of Defense; by several private drilling companies including the parastatal Somalfruit, and by foreign firms. (See Exhibit C-3). The government agencies between them own 14 rigs deemed by the Consultants to be operational or capable of operation after some repair; local private firms own a total of 13 rigs; and foreign agencies and firms own another 8. Assuming each rig could drill up to 8 production wells per year (and 4-non production wells), these rigs could drill up to 280 production wells per year.

Figures on actual well drilling activity by drilling organizations over the past five years, and plans for 1985-1987 are presented in Exhibit C-4. A breakdown of this drilling activity by project/customer as well as by drilling organization is presented in Exhibit C-5. Between 1981 and 1984 average market shares for overall drilling activity break down as follows: Government agencies had about 29% of the entire market, the Somali private sector had about 31%, foreign firms working on foreign aid projects accounted for about 39% of the market, and foreign firm's other work accounted for about 1%.

Drilling activity can be divided into drilling for irrigation (about one quarter), and other drilling (including drilling for the public, livestock, mining, and unknown purposes -

EXHIBIT C-3

OPERABLE DRILLING RIGS IN SOMALIA

ORGANIZATION	RIG TYPE	QUANTITY 1/
WDA	Speedstar SS 20 rotary	4
WDA	IR TH60 rotary	3
WDA	Failing 1500 rotary	1
WDA	Dando 800 cable tool	2
Mogadishu Water Agency	Speedstar SS-22 rotary	1
Ministry of Defense	Russian URB-3AM rotary	3
SomalFruit	Italian Piacenza PRC 10 cable tool	1
SomalFruit	Failing 1500 rotary	2
National Drilling	Failing 1000 rotary	1
Horn of Africa Drilling	Mayhew 1000 rotary	1
Horn of Africa Drilling	Walkeneer cable tool	1
Murri	IR T4 rotary	1
Murri	Italian Mait cable tool	1
Murri	Failing 1500 rotary	1
Somali Drilling	British Rustom 22 cable	1
Somali-German Drilling	Homemade German rotary	1
Wild Drilling	German Bomag rotary	2
Chinese	Huanghe SPC-300H rotary	1
Chinese	Jiefang DPP-100 rotary	1
Juba Enterprises	Italian Pesina rotary	1
Juba Enterprises	Italian cable tool	1
USAID Project 104 2/	IR TH60 rotary	3
USAID Project 104 2/	Dando 800 cable tool	1

1/ In operation or capable of operation
2/ Comprehensive Groundwater Development Project

EXHIBIT C-4

AMOUNT OF DRILLING BY SOURCE IN SOMALIA 1980 - 1987

Production Wells

AGENCY/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	TOTAL
WDA	15	15	8	17	12	15			82
Mogadishu Water Agency	0	0	0	0	0				0
Ministry of Defense	13	17	17	14	14				75
National Drilling	3	3	3	3	4				16
Horn of Africa	0	3	8	6	2	2			21
Somali Drilling	0	0	0	3	3	4			10
Somali/German Drilling	0	0	0	0	6	1			7
Somalfruit	7	6	15	12	10	20			70
Juba Enterprises	1	2	2	3	4	4			16
Fratelli Murri	2	3	5	10	10				30
WILD		5	5		1	20	18		49
GKW (GTZ)		4	5	5					14
Kamphil		3	8	8	10	1			30
Roscoe Moss			9	10	17	20			56
Chinese			10	11	6	9	10		46
Unicef		24	14			5			43
Japanese						4	10	15	29
Mowlen		4	4						8
Other									0
TOTAL	41	89	113	102	99	105	38	15	602

MARKET SHARES (in percent)									AVERAGE '81 - '84
Government	68	36	22	30	26	14	0	0	29
Somali Private Sector	32	19	29	36	39	30	0	0	31
Foreign Aid	0	45	49	33	29	55	100	100	39
Foreign Imports	0	0	0	0	5	1	0	0	1
TOTAL	100	100	100	100	100	100	100	100	100

NOTES:

Figures for 1985 - 1987 include well drilling activity planned for those years as of mid 1985.

"Govt" includes WDA, Mogadishu Water Agency, and Ministry of Defence. It is unclear at this point how many production wells they have drilled in the past five years. It may be less than figures shown above.

"Somali Private Sector" includes National Drilling, Horn of Africa Drilling, Somali Drilling, Somali-German Drilling, Somalfruit, Pesina/Juba Enterpise, and Murri. They all seem to have drilled wells primarily for the private sector, especially irrigation wells.

"Foreign Aid" includes all other drillers listed, minus work done by foreign firms for the local private sector (Kampihl has drilled 6 wells for an Arab mining firm between '82 and '84.

"Foreign Imports" includes all wells drilled by foreign drillers for non-Aid purposes (see note above).

EXHIBIT C-5

AMOUNT OF DRILLING BY PROJECT IN SOMALIA 1980 - 1987

Production Wells

AGENCY/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	TOTAL
Rural Water Supply (WDA)	12	12	7	14	10	12			67
Other Drilling (WDA)	3	3	1	3	2	3			15
Ministry of Defence	13	17	17	14	14	0	0	0	75
Urban Water Supply (GKW)	0	4	5	5	0				14
Urban Water Supply (WILD)	0	5	5	0	0	0			10
Mogadishu Water Supply (Mowlen)	0	4	4	0	0	0			8
Mogadishu Water Supply (Kampihl)	0	3	8	8	5	0			24
CGDP (Roscoe Moss)	0	0	9	10	17	20			56
Hargeisa Water Supply (Chinese)	0	0	6	0	0	2	4		12
NE Water Supply (Chinese)	0	0	0	0	6	7	6		19
North Water Exploration (Chinese)	0	0	4	11	0	0			15
Refugee Water Supply (Unicef)	0	24	14	0	0	0			38
NW Water Supply (Unicef)	0	0	0	0	0	5			5
Rural Water Supply (WILD)	0	0	0	0	1	20	18		39
Banana Irrig. (Somalfruit)	7	6	15	12	10	20			70
Grapefruit Irrig. (Murri)	0	0	4	5	0	0			9
Mogadishu Water Supply (Japanese)	0	0	0	0	0	4	10	15	29
Govt. wells, Horn of Africa	0	0	8	6	0	0			14
Other wells, Horn of Africa	0	3	0	0	2	2			7
Foreign Financed (Murri)	0	0	1	2	5				8
Govt & Other (Murri)	2	3	0	3	5				13
Mining wells (Kampihl)	0	0	0	0	5	1			6
Berbera, (Somali Drilling)	0	0	0	0	2	0			2
Private, (Somali Drilling)	0	0	0	3	1	4			8
Govt, (Nat'l Drilling)	1	2	2	1	1				7
Other, (Nat'l Drilling)	2	1	1	2	3				9
Private Irrig. (Somali-German)	0	0	0	0	6	1			7
Aid Irrig. (Pesina/Juba)	1	2	2	3	4	4			16
TOTAL	41	89	113	102	99	105	38	15	602

about three quarters). Foreign firms drilling for foreign aid projects dominate drilling for public water supplies, and account for over three-quarters of all drilling in this category. Almost all the rest is undertaken by government agencies. In irrigation, local private firms account for almost two-thirds of the drilling activity, and the rest is done by government (including the Ministry of Defense for its farmland). Other drilling activity is also undertaken primarily by local firms, which have captured almost two-thirds of that market.

Overall drilling activity over the past five years has been somewhat erratic, especially drilling undertaken by foreign firms for foreign aid funded projects and by government. Drilling for irrigation by local private firms has exhibited growth with some variability; and drilling by local private firms for non-agricultural purposes has exhibited strong and steady growth, though admittedly from a low base. (See Section 3 of the main body of the Final Report).

The combined supply-side scenario can be compared with some of the demand-side scenarios generated by the Water Industry Systems Model for Somalia (WISyMS), as presented in Section Three of the main body of the Final Report.

C-7 CIVIL WORKS CONSTRUCTION

Civil works construction includes such well-related activities as the building of storage and distribution systems for wells. It also includes such non-well related but water-related activities as earthmoving for and lining of uars, and construction of burkeds, as well as construction of urban water distribution systems and irrigation systems.

Several Government agencies, including the WDA, NRA, and Mogadishu Water Agency, have in-house civil works capabilities. In the private sector, many domestic firms are capable of undertaking water-related civil works programs (see Appendix D-4 for a partial listing). These private firms range in size from small family operations to large organizations, and their capacities similarly vary considerably. Firms such as Juba Enterprises and Murri, for example are capable of undertaking both well-drilling and related civil works, and independent major civil works projects.

Communities have become greatly involved in the construction of civil works. Much of this has been through the lead of the WDA and the Ministry of the Interior. Much of the work is done through self-help programs. In the past lack of organization had prevented full community participation in such activities.

Private individuals also undertake civil works, either by themselves or through contractors. Burkeds, for example,

constructed by communities and by private individuals, have been springing up all over the Central Rangelands in recent years.

C-8 OPERATION AND REVENUE COLLECTION

Autonomous water agencies are responsible for the operation of water supply systems in Mogadishu, Hargeisa and Kismayo. In rural areas and other urban centers, the WDA is responsible for water supply. (The NRA also manages uars.) In addition, many individuals and industries operate their own systems.

Water may be sold at a single official price which applies throughout the country. This is a standard rate of 18 shillings per cubic meter.[6/7/] Private individuals may also sell water, but may not legally charge more than the official rate. Decisions on changes in the price of water are made by the Council of Ministers. Individual agencies may recommend changes to the Water Committee. Upon recommendation of the Committee, the Ministries of Mineral and Water Resources and of Finance then decide whether or not to recommend the change to the Council of Ministers.

According to long-standing community custom among the nomads, any family who digs a well or has a historical claim to a particular well has control over the distribution of water from that well, as "community custodian." In times of water shortage, distribution of water to the community follows set priorities: human needs first (which cannot be refused so long as there is water at all, and is distributed without fee), livestock next (for which fees may be charged), and other uses last (also for a fee).

6/ The uniform tariff was increased in 1983 from 4.5 So.Sh./m3 to 10 So.Sh./m^3, in 1985 to 13, and in 1986 to 18 So.Sh./m^3. The new rates were intended to be sufficiently above operating cost (before depreciation) so as to encourage the agencies in their search for greater cost recovery and financial autonomy. At the present time, however, the system of fee collecting and the fees imposed are far from ensuring that this is the case for at least CGDP wells. While the standard fee appeared to be sufficient in 1984 to cover operation and maintenance costs and to make some contribution to the cost of the well, it was not sufficient to cover total cost, particularly in high cost areas.

7/ Since the 1985 devaluation, despite the official price to which WDA generally adheres, water is officially sold in some locations at higher prices. For example, water is sold by Kismayo Water Agency at 25 So.Sh./m^3.

At WDA wells, drinking water is also free of charge, but water for livestock and water taken away in containers carries a fee of the standard rate of 18 So.Sh. per cubic meter (1000 liters). Standard containers include the 200 liter drum and 20 liter cans. In practice, it is impossible to be precise, and rural WDA employees must work with estimates and charge accordingly: for animals there are official estimates of water consumption by type of animal, and the owner is charged on this basis, for example, 0.7 So.Sh. per camel per watering (see Appendix B-2.2). Collection rates, particularly in rural areas, are poor and enforcement is not consistent. Also, water losses are high due to lack of, or defective water meters, leakages and the frequent absence of drinking troughs or basins for animals.

At all urban public fountains and some important rural pumped supplies, there are water tariff collectors who charge for water used. The "tap minders" are sometimes paid a fixed salary as direct agency employees and sometimes take a part of the return to cover their own remuneration.[8/] In most cases, WDA wells are operated by WDA employees. The Regional Director decides whether to contract out the operation of the standpipe.

In towns where WDA operates the water supply, the billing is frequently on a metered system. Most WDA urban standpipes are metered; most WDA rural standpipes are not. In some cases, the standpipe is operated by a WDA employee[9/]; in other cases, a private individual operates the standpipe. In the latter system, the private operator pays a reduced rate according to metered use, and sells the water at the official rate.

C-9 REPAIR AND MAINTENANCE

All water supply structures require routine and periodic maintenance. The maintenance requirements of each type of structure are described in Appendix I-9 bound separately.

8/ In Hargeisa, there was (as of 1983) neither a salary nor a fixed percentage deduction from revenues, but water minders charge more than the standard tariff with the agency being satisfied to receive the full fixed standard rate (10 So.Sh./ m^3).

9/ In the case of diesel pumps, 2 WDA employees, who come, if possible. from the local village are required - one as pump attendant and one as fee collector.

The frequency of periodic maintenance required for estimated useful life of each structure, given proper maintenance, is listed below for each type of structure.

	Useful Life (Years)	Periodic Maintenance (Years)
Drilled Wells	10	1 (handpump) 1/4 (diesel pump)
Dug Wells	10	2
Uars	10	1
Burkeds	15	3
Intakes from River	10	1/2
Ballehs	10	3
Small earth dams	5	1

One of the sector's key constraints is poor maintenance of water supply systems and equipment, especially in rural areas. Of the approximately 490 wells operated by WDA about 25% are out of service at any given time, and of the WDA's approximately 40 well-drilling rigs only ten are functioning. Water losses from production wells are estimated by WDA to be as high as 80% in some cases, as a result of leakage, wastage and improper metering. Recognizing these shortcomings, WDA has established an O & M Division which so far is, however, only poorly staffed.

The operation and maintenance costs of wells and most other man-made water supply structures are small compared with the initial investment costs, but are, of course, essential to the securing of benefits. The quality of the routine maintenance program will in a large way determine the functional life of the well and water distribution system.

As most of the deep wells in the country have not received adequate routine or even periodic maintenance, there will be an inordinate number of existing wells in need of rehabilitation or major repair, and the useful life of existing wells may be significantly reduced.

The WDA and the urban water agencies are responsible for the maintenance of structures under their responsibility. Similarly, the NRA is responsible for the rehabilitation of reservoirs under its authority.

The WDA often gives local community organizations and operators responsibility for routine maintenance. Major repairs are undertaken by WDA. This is also true of structures built with the assistance of the Ministry of the Interior and under projects such as those funded by Unicef. Urban water agencies (Hargeisa, Kismayo) often contract the operation and maintenance of their public fountains to individual entrepreneurs.

The WDA and urban water agencies, and Somalfruit, occasionally hire private drillers and private civil works contractors to undertake maintenance activities. As described in Sections C-7 and C-8, there are many private firms in Somalia capable of undertaking such work.

APPENDIX D

SOMALIA ENTERPRISE PROFILES

D-1 INTRODUCTION

This appendix will examine the Somali private firms currently active in the well drilling industry, and several firms interested in commencing well drilling operations. This appendix thus presents descriptions of these firms and an analysis of private participation in well drilling. Private involvement in water-related civil works construction is briefly described.

During the course of the study, the Consultants interviewed all identified Somali private sector firms engaged in water drilling operations, and several Somali firms which are actively attempting to begin drilling operations. The Consultants also interviewed foreign drilling firms such as Kampihl. The Somali firms identified and interviewed include:

- Juba Enterprises
- Fratelli Murri Company
- National Drilling
- Horn of Africa Drilling
- Somali Drilling Company
- Somali-German Drilling and Windmill Construction Company Ltd.
- Tiger
- Mr. Mohamed Ali Mohamoud
- Guleed Company

Profiles of these firms are presented in the following section, followed by general analysis of the private sector well drilling industry.

The Consultants held extensive interviews with several firms engaged in water-related civil works construction and held identification interviews with many other firms. Profiles are presented as well as a general description of private sector, water-related civil works companies.

D-2 SOMALI PRIVATE SECTOR DRILLING FIRMS - SUMMARY ASSESSMENT

D-2.1 Description of Firms

Private sector drilling operations in Somalia are undertaken by three categories of firms.

- Foreign firms, generally working under projects financed through foreign assistance.

- Large Somali firms, for which drilling operations are only a small part of total activities.

- Small Somali firms, for which drilling is the major company activity.

The foreign firms are essentially based in Mogadishu. Their presence in Somalia is due to foreign-financed drilling projects, and their continued involvement in Somali well drilling depends on their obtaining similar contracts. Their equipment and resources are largely foreign, and because of the foreign exchange component of payment and foreign sources of materials, they do not face the same constraints as most Somali firms.

Although there are only six Somali companies in the Somali private sector currently capable of well drilling activity, company size and structure ranges from Somali-owned sole proprietorship to large foreign-owned companies.

There are currently two large Somali firms engaged in well drilling: Juba Enterprises and Fratelli Murri Brothers. Both firms include a large component of foreign participation (Yemeni and Italian, respectively). These firms are primarily construction firms, and well drilling is a minor part of their activities, often a support activity for their work in other fields. Both firms, particularly Murri, have access to external resources.

The smaller drilling firms may be engaged in other, non-drilling activities, but drilling is the central focus of their business. Ownership and drilling are generally the responsibility of one individual, perhaps backed by local investors. Their approach to business and new investment tends to be less sophisticated than the larger companies.

Some firms perform their own civil works; other firms either do not do well-related civil works or contract such work to subcontractors.

A variety of equipment is owned and operated by the Somali firms. These firms have in the past purchased their equipment used. The companies have generally purchased their used rigs in-country from foreign drilling firms terminating their Somali operations. Several of the rigs operated by the drillers are quite old.

The larger Somali firms employ both expatriate and experienced Somali drillers. Murri Brothers have expatriate staff available "on call" from other countries. Several of the key personnel of the Somali firms are ex-WDA employees, and several others learned the trade by working with foreign firms both in and outside of Somalia. The larger firms hire employees on a permanent basis, assigning them to other activities when there is no drilling work. Smaller firms are more likely to hire part of

their personnel on an as-needed basis. Generally, drilling teams in the private sector are smaller than those in the public sector.

D-2.2 Risk-Taking Orientation

Private sector contractor in Somalia are subject to different types of risks in their operations. They must deal with the business and financial risks associated with a predominantly socialist government and deteriorating economic environment. Water well construction poses additional operational risks. Due to the high cost of well rigs and support equipment, contractors must determine if the outlook for well construction justifies high capital costs. Because the company structures in Somalia are so different, the risks are also different.

D-2.3 Business-Financial Risks

Foreign contractors, such as Kampihl and Wild, mobilized in Somalia to complete specific contracts funded by international donors. Kampihl was awarded a 40-well contract for the Mogadishu Water Agency, and Wild came to Somalia to drill 14 wells as part of an urban water supply program funded by the German government. Contracts received from foreign donors provide certain advantages over locally awarded contracts. Because the contracts are payable in hard currencies, contractors do not face the risks of accumulating sums of Somali Shillings or expatriating profits. They also have the ability to use the hard currency to procure required materials abroad and import them into Somalia. Foreign contractors generally write off equipment costs to a particular job. After completing their initial contracts firms such as Kampihl and Wild are in a better position to tender other international contracts. Wild recently tendered and was awarded a 40-well drilling contract funded by the Saudi government.

Rather than looking at a one-time contract, local drillers must consider ways to maintain ongoing operations with the limited contracts available in Somalia. Contracts, when available, have been limited primarily to Somali Shilling contracts from the Somali government, including the Water Development Agency, farmers, or private individuals. In two instances, Horn of Africa Drilling has been able to secure hard-currency contracts for work performed. Two water supply wells were completed in 1984 for OJS and 20 shallow seismic boreholes were drilled for ESSO in 1984 and 1985.

In order to complete contracts, local drillers, except Murri, depend on the WDA to supply casing, screen, drilling fluids and other well appurtances. In the last two years, private sector drillers have faced a serious shortage of these supplies. National Drilling has a one-well backlog and Somali Drilling has three. Both companies need casing to complete the wells. As of this writing, WDA is out of 8" casing and is unable to supply its own needs. Because of foreign exchange restrictions, WDA is not certain when more will be ordered. Thus, not only do contractors

face risks in their own operations, their risks are also due to the weakness of their prime supplier--the WDA.

The cost of the variability in drilling activity is hedged by the local firms' staffing policies. Whenever possible, drilling personnel are assigned other tasks when no drilling is going on; other staff are considered only temporary hires for the duration of the drilling assignment.

There are inherent risks in water well construction. Even in countries where geological data are readily available, drilling is unpredictable. In Somalia, the ratio of wells drilled to land area is relatively small. Little information is actually available on the approximately 1,500 wells drilled throughout Somalia. This lack of information enhances the risks of completing a successful well.

According to Brian Bowden of the Hargeisa Water Agency in Northern Somalia, Somalis find it hard to accept that a borehole will not produce water and usually will not pay a contractor for work performed on a dry hole. Somali Drilling confirmed this practice and indicated their drilling price per meter is higher to compensate for this factor.

Drillers in the south limit their area of operation to the softer formations of the coastal plains where well completions are more predictable. They charge on a per-meter basis, whether a particular hole yields water or not. Their price per meter can therefore be significantly lower than in the north. To reduce the risk of an unsuccessful well, local drillers occasionally request the hydrogeological services of the WDA to select well locations.

For[illegible] drillers on foreign aid projects have had more geological information available in Somalia than their local counterparts to help with tender preparation and equipment selection. For example, the engineering firm, Sir Alexander Gibbs & Son, completed a hydrogeological investigation before Kampihl drilled the wells for the Mogadishu Water Agency. Similar investigations were performed for the rural water supply wells drilled by Wild.

Probably the biggest risk for contractors is trying to predict the future in Somalia. Some local contractors are facing the problem of aging equipment and will have to make decisions in equipment replacement.

D-2.4 Management Orientation

Somali drilling firms are small family-owned businesses and tend to be staffed by family members and relatives. They correspond to most of the drilling companies in the United States which are considered "Mom and Pop" type companies. The chain of command goes directly form the owner-operator to the rig. Owner operators tend to be involved in every phase of the business

and drilling operations. Decisions are based on experience and "gut feeling" rather than ratio analysis, PERT charts or other more sophisticated business tools.

Even the larger companies like Murri operate similarly. Every evening Mr. Murri contacts each of his construction sites to review work progress.

The smaller companies seem to operate on a day-to-day basis. Although they are concerned with prospects for additional well contracts, they feel helpless to effect changes. Recurring problems with fuel and material supplies negate the value of future planning.

The foreign firms operate under a different set of circumstances. Management structures are more defined, as is the work to be performed. The foreign firms not only have the opportunity to plan, but must schedule activities and requirements in advance to insure proper supplies are imported and on hand when needed. For its construction activities, Kampihl even imports fuel to meet its requirements. Very little dependence is placed on the local economy for their operations.

The Somali drilling industry is opportunistic in that no marketing efforts are made by any of the local drilling firms to increase the number of wells drilled. The firms in the southern region believe that due to their longevity in the business, anyone interested in drilling will contact them. This lack of marketing also reflects the considerable supply constraints on investment in wells in both the public (availability of financial resources) and private (restrictions on water sale, foreign exchange) sectors.

Drilling firms are willing to undertake government contracts, but are wary of tardy payment. This is reflected in the general demand for a 50 percent mobilization payment, and additional progress payments.

Prices on government contracts are based on a standard per-meter basis. Other contracts are negotiated on the basis of the negotiated market rate. The smaller firms typically do no detailed cost analysis of their prices.

Private Somali firms rarely undertake drilling activities in distant or difficult areas. Standard prices on government contracts restrict private interest to low-cost areas where a profit can be made. Some firms have a regional preference (i.e., north or south), largely due to their generally small size and scope. Most firms indicated that, given the proper terms, they would be willing to drill in most areas of the country, including more difficult formations.

D-2.5 Marketing and Competition

Very little competition exists among the firms capable of private sector well construction. Geographical separation, rig capabilities, job preferences and the small number of firms all contribute to the limited competition.

The foreign firms concentrate on multi-well contracts sponsored by foreign governments or international organizations. For their first contracts in Somalia, new rigs and equipment were mobilized. Project management includes expatriate employees, and expatriate drillers manned the rigs. Even expatriate mechanics were mobilized to maintain the equipment.

Kampihl and Wild are headquartered in Mogadishu, but have experience drilling in other areas of Somalia. Drilling costs for an average 150-meter well completed by a foreign contractor reportedly range from US $70,000 to $75,000 per well (5.6 million So.Sh. to 6 million So.Sh. at the market exchange rate) or 37,000 So.Sh. to 40,000 So.Sh. per meter. This is six to ten times the price charged by Somali firms.

Both companies indicated they are not interested in contracts with Somali Shilling components of any significance.

Wells drilled by Juba Enterprises and Murri seem in part to be related to the firms' other construction activities. For example, Juba drilled twelve water supply wells during the construction of the Trans Juba project. No other wells were drilled until the award of a four-well contract funded by LIBSOMA. Juba's drilling prices range from So.Sh. 2,000 to So.Sh. 4,000 per meter. Juba Enterprises relies on the WDA for their materials. Murri is primarily interested in contracts paying foreign exchange which enable the company to import necessary materials. For this reason, Murri has constructed only a few wells for private individuals.

The smaller independent firms are separated by geographical boundaries and equipment capabilities. Somali Drilling and Somali-German Drilling have only drilled in the northern region while National and Horn of Africa Drilling have limited their operations to the south. The cable-tool rig operated by Somali Drilling is better suited to the consolidated formation found on the inland plateaus. Somali-German's homemade rig is basically designed for coring but has limited capability for shallow well construction. The small rotary rigs operated by National and Horn of Africa Drilling are better suited for well completions in the softer coastal formations.

There is a wide disparity between drilling prices charged by foreign firms and local firms. For cable tool wells, Somali Drilling charges So.Sh. 6,500 per meter. Drilling prices charged by National Drilling and Horn of Africa Drilling range from So.Sh. 2,000 to So.Sh. 4,000 per meter.

Competition is further limited by economic factors. Foreign contracts are generally awarded after an international tender. The financial, bonding and equipment requirements of these contracts are beyond the capabilities of smaller Somali contractors, resulting in awards to the international firms. The Somali contractors thus are limited to contracts with Somali government organizations or private sector farmers or developers.

Well drillers in Somalia rarely lose a drilling opportunity to another contractor. The deciding factor typically is the prospective well owner's ability to afford a well and the availability of materials.

D-2.6 Current Business Climate

Of approximately 100 wells constructed annually in Somalia over the past five years about 30 percent are constructed by Somali private sector drillers, including the parastatal SomalFruit. Of the average of 75 non-irrigation wells drilled annually over the past five years, the private sector has accounted for a 20% share of the market (compared to 27% for government and 54% for foreign firms).

In general, rig utilization tends to be well below theoretical capacity. This low utilization is, however, not due to lack of business or salesmanship - but is primarily due to the unavailability of materials for drilling and spare parts, caused by the difficulty of obtaining foreign currency.

Contractors and current (1985) projects, if any, include:

- Kampihl -- 2 rigs idle
- Murri -- 3 rigs idle
- Juba Enterprises -- 4-well contract
- National Drilling -- 1 private well
- Horn of Africa Drilling -- 2 rigs idle
- Somali Drilling -- 3 private wells
- Somali-German Drilling -- 1 rig idle

Local contractors confirm that few inquiries for well construction have been received since the devaluation of the Somali Shilling. As previously mentioned, the other limiting factor is the non-availability of fuel to operate the equipment, spare parts, well casing and screen, drilling fluids, and other well appurtenances to complete the wells.

Of the local companies, only National Drilling depends completely on drilling activities for company revenues. Murri and Juba have general construction contracts, Horn of Africa does mechanical work, Somali Drilling is part of an import business and Somali-German has agricultural interests.

Most local contractors believe the demand for water will require enough drilling this year to maintain their current level of operations, but not enough to permit growth or equipment purchases.

D-2.7 Private Sector Financing

Availability of local currency for investment or operation does not pose a problem for Somali firms (see below). The availability of foreign currency is, however, a major constraint, limiting new investment, purchase of spares to maintain or repair equipment, and purchase of materials needed to drill (e.g., casing, bentonite, fuel). As Somali firms are generally unable to obtain drilling materials, their contracts usually require the client to provide the materials (often obtained from the WDA).

Murri is the one firm that experiences relatively few foreign exchange difficulties; their contracts usually are with clients who are able to reimburse them in foreign currency.

Most firms must turn to the open market to obtain foreign currency. Self-financing has been the largest single source of funds in Somalia for private sector involvement in the water industry. However, the existing and prospective contractors in the industry advise that the high capital costs will require additional sources of financing for the industry to grow. The Somali Commercial Bank has not been a big contributor to the industry. Mr. Korfa Garane Ahmed, Manager of the bank's Hargeisa office, says the bank has been reluctant to consider large loans to private sector companies for capital equipment. He says it would be difficult for the bank to justify the loans under the present policies, because the responsibility for construction of water facilities belongs to the WDA. Mr. Korfa believes a loan would be considered only if a private sector company were awarded a drilling contract large enough to permit repayment of the loan during the course of the contract. He also advised that even if a Somali Shilling loan were approved, it would be difficult to provide the necessary foreign exchange to make the equipment purchase possible.

Most Somali drilling firms have not obtained financing from the Somali Development Bank although several potential investors have attempted to pursue this option. The priority of the Somali Development Bank is with the agricultural (including livestock) sector, and drillers are typically unable to obtain loans.

The role of USAID's Commodity Import Program (CIP) in water industry equipment purchases has changed over time. Prior to 1985, there was great interest on the part of the drilling firms in the program. Much of this interest was due to the possibility of obtaining US dollars at extremely favorable exchange rates. Two firms did obtain Development Bank loans, but

due to low CIP priority, where unable to participate in the program.

After January 1, 1985, the government of Somalia introduced a "market" exchange rate, which, at 75 So.Sh. to the US dollar, was more than twice as expensive as the official rate. The market rate was adopted by the CIP, and during the first half of 1985, Somali firms were unanimous in stating that they would not be interested in participating in the CIP at the new exchange rate.

Over the course of the year, however, the "market" exchange rate, even at 83 So.Sh. to the dollar, began to appear more attractive to inventors than the two alternatives: 1) to forego new equipment investments, and 2) to resort to the (legal) "auction market" for foreign exchange (at over 100 So.Sh. to the US dollar). Two requests for foreign exchange for rig purchases through the CIP were approved. One for Tiger, and one for Mohamed Mohamoud. Both requests were approved on the condition that the drillers would concentrate on the drilling market in northern Somalia.

Existing contractors routinely request contract advances that range from, 20% to 50% of the contract value, especially when dealing with the Somali government. It is questionable whether a Somali contractor could be awarded a contract large enough to permit equipment purchases through contract advances.

Several contractors expressed an interest in foreign investors and joint venture partners. Foreign investors, however, would have to consider the amount of private sector work available and competition for the existing work, economic and political stability, and the ability to expatriate profits. Unless guarantees were made from foreign sources along with firm guarantees from the Somali government as to the rights of foreign joint venture investors, these considerations make Somalia an unlikely place for investment.

D-2.8 Private Sector Assessments of the Future

Existing and prospective drilling contractors feel the future growth and prosperity of Somalia is dependent upon adequate supplies of potable water.

There is a great interest in expansion and further investment on the part of the Somali firms, and several companies and investors have expressed interest in commencing drilling activities. There appears to be a general recognition of the high potential for investment in water resources, and confidence that there will be a large demand for well-drilling.

Thus, despite current constraints and low rig utilization, there is great optimism in the long-term prospects for the drilling industry.

Kampihl and Wild Drilling plan to maintain operations in Somalia because they believe additional contracts will be tendered for well construction. Kampihl will keep its two rigs in Somalia, although the rigs are now idle. Wild Drilling has enough work to last until the end of 1986.

Local contractors do not foresee further increases in drilling until the economic situation improves or foreign assistance programs include private sector participation in well construction. The import constraints must be lifted and fuel must be available before the industry can experience any growth.

Contractors, however, do believe that the current problems will be resolved. When asked if they would be interested in local purchase of drilling equipment, all except one replied affirmatively.

Two Somali entrepreneurs planning to enter the drilling business believe they can compete with the international firms. The equipment packages selected total US $500,000 and $800,000.

D-3 SOMALI PRIVATE SECTOR CIVIL WORKS CONSTRUCTION FIRMS - SUMMARY ASSESSMENT

The nature of and problems faced by the Somali civil works and construction firms are in many ways similar to those of the drilling firms, described previously.

There are three categories of civil construction works in Somalia:

A) large building and civil engineering construction requiring expensive equipment and large capital investment, such as hydro-electric dams, highways, bridges, marine works, municipal water works and large reservoirs (uars),

B) medium sized construction such as office building and house construction; and

C) small construction work, generally in rural areas, such as the construction of well-head structures (pumphouses, service tanks, watering troughs and drinking water fountains) and burkeds, small uars, ballehs and small dams.

For executing the large works in category A funded by multi-lateral and bi-lateral donors, expatriate contractors are used almost exclusively. For projects in the private sector and for some locally funded public works in this category, the work is shared mainly among five large domestic contractors:

- Fratelli Murri (Murri Brothers)

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- Horn Contractors
- Juba Enterprises
- National Engineering and Construction Company (NATCO)
- Buralhess Construction Company Limited

All these large firms have their headquarters in Mogadishu. Some have branch offices in other parts of the country. All are prepared to work anywhere in the country. They all have earthmoving equipment, concrete mixers, trucks, road-making equipment, and maintenance shop facilities. They are physically able to perform all but the largest civil engineering works in Somalia which are at present being executed by foreign civil engineering contractors, albeit their management and technical skills could be improved by training to bring them up to the general standards of foreign contractors. There are no joint ventures between expatriate and Somali construction contractors at the present time.

In Somalia it is usual for skilled workmen (artisans) such as carpenters, masons, plumbers, electricians, bar-benders and fixers, concrete placers and steel workers to operate as intergrated teams under a team leader. The general contractors negotiate with the team leaders when they want to employ these categories of skilled workmen. Work is then subcontracted out on a piece-work basis or daily-pay basis, depending on the nature of the work. The teams will travel to projects anywhere in Somalia, sleeping in the nearest town or village to the project, or, if in the bush, the general contractor provides tents or other temporary accommodation. Most of the teams have their base in or around Mogadishu. The general contractors provide their own foremen and supervisors usually from their permanent staff, and they also have a skeleton staff of skilled workmen for emergencies.

Prior to the early 1970s the quality of workmanship in building and civil engineering was quite high, but with the construction boom in Saudi Arabia and the Gulf States, most of the best artisans were enticed by high wages to go overseas. While this has helped the economy of the country in providing foreign exchange through remittances, it has caused a severe decline in the quality of workmanship in Somalia. With the expected return of many of these artisans in the near future, due to the reduction of work in the oil-rich states, general contractors interviewed expect the quality of workmanship to improve. The return of these men is also likely to create disturbance and unrest in the labor market making it important for the country that more work should be found for the private construction industry.

With the exception of Fratelli Murri, all the large contractors interviewed said they had problems with obtaining foreign currency for the purchase of equipment, spare parts and off-shore material. They had no problems obtaining local currency for their investment or operating capital. Murri obtains its investment funds in foreign currency.

USAID, through CIP program, has assisted some (smaller) private sector entrepreneurs with the import of civil works equipment and supplies. A Somali from Hargeisa imported a Caterpillar loader, grader and dozer at a cost of US $650,000 under the CIP program. He has now had the equipment over a year and has not been able to put it to work.

The principal inhibition to using the services of the Somali Development bank and the CIP would appear to be the emphasis placed by these institutions on the agricultural sector, thereby relegating the application to a very low priority so that the loan is unlikely to be approved due to the inadequancy of funds. The merits of the financial and economic viability of the loan, or the credit of the applicant, therefore have little bearing on the outcome of the application.

In the absence of assistance from the Somali Development Bank the firms requiring foreign currency for the purchase of off-shore equipment and material must acquire the currency on the open market. The foreign currency funds on the open market come largely from the 65 percent that livestock exporters and other exporters are allowed to retain, and from remittances sent by overseas Somali workers. These sources are now shrinking due to the Saudi Arabian embargo on the importation of Somali cattle, and due to the return of Somali workers from the oil producing states.

A further complication faced by construction contractors requiring foreign currency lies ahead, due to the fact that they can no longer purchase off-shore items, even for public works purposes, at the official exchange rate (presently So.Sh. 54 to US dollars 1.00). Since their earnings are primarily in local currency they will have difficulty in amortizing the cost of items purchased in foreign currency until the present reimbursement rates for work have risen to match the rise in the exchange rate (presently over So.Sh. 80 to US $1.00). This applies where a contractor must purchase new equipment, spare parts, or consumable material off-shore. It could, therefore, have a profound effect on the expected expansion of the construction industry from the implementation of the "privatization" policy.

There are many small to medium sized contractors capable of executing works in category B. Some fifteen were interviewed by the Consultant. All had their headquarters in Mogadishu but they work throughout the country. Their equipment holdings consist mainly of concrete mixers, concrete block-making machines, carpentry machines and trucks. As with the large contractors, they negotiate with artisan team leaders for the provision of skilled labor. They also face the same problem as large contractors in obtaining foreign currency. The expansion of their business will be severely constrained until construction prices adjust to reflect the new price of equipment expressed in local currency. However, it would appear that, except for the foreign currency aspect, they would also have no difficulty in handling category C work such as the construction of pumphouses, tanks,

watering troughs and drinking fountains associated with the wells or intakes (work presently executed mainly by the WDA force account - with some local villager assistance). They could also construct burkeds.

With the exception of burkeds, which are constructed mainly by rural skilled and unskilled labor, category C works in the water resources sector are executed by WDA force account or by the foreign contractors who are drilling wells, or by their expatriate subcontractors (such as by Saarburg Interplan, executing civil construction works for GTZ on the "Rural Water Supply Project" funded by Saudi Arabia). All these works could be done by organizing the rural skilled and unskilled labor on the lines presently carried out for the construction of burkeds.

All construction contractors rely heavily on the present practice of receiving a 50 percent advance payment before commencing work. This is an important source of working capital. The requirement for this relatively high advance payment arises from the history of tardy progress payments and often the long time that contractors must wait to obtain final payment for their work. It is important for the construction industry that these advance payments should be made for government work. Where foreign donor funds are involved, contractors must put up performance bonds, 2 percent for EEC and 10 percent for IBRD projects, and must cover the advance payment with a 100 percent guarantee bond.

D-4 COMPANY PROFILES

D-4.1 Fratelli Murri Company

Company:

Fratelli Murri Company
P.O. Box 418, Mogadishu
Contact: Mr. Paolo Murri, Director
Mr. Garauldo Giorgio, General Manager
Telephone: 20293 Telex: 711

Description/History:

Fratelli Murri is a company owned by three Italian brothers, registered in Somalia, and with a permanent presence in Somalia. Murri is international in its operations, and Mr. Murri himself is involved in company operations in many places outside of Somalia.

Business Activities:

Murri is a large firm of general building contractors, working on roads, airports, dams, agricultural works, buildings, etc. Murri is currently working on the Baidoa airport (extension, surfacing, sheds) and the Juba Sugar Factory (dam, intakes, canals, roads, etc.). Drilling is of only minor importance.

Murri has an associate company representing Caterpillar, with large workshops. These workshops maintain other manufacturers' equipment as well as Caterpillar. Murri also repairs equipment for Government agencies, including the Army and also for other contractors.

Equipment:

Murri has 5 rigs in Somalia, and 3 smaller testing units. The company would have ready access to additional rigs from outside Somalia, if it were warranted by business volume.

Percussion - 3 Mait, which were purchased new. One is 7 years old, and is functioning. Another is older, and is not complete. These unit are used primarily for work connected with Murri's own activities.

Rotary - 1 Failing purchased new, and is now 10-12 years old. 1 Ingersoll Rand T4, purchased second hand in 1978-1979 from another company.

Murri also has considerable earth-moving, construction and workshop related equipment, including: Bulldozers (Caterpillar D8, D9, D4), Motograders (F.12, F.16 & F.14), Motoscrapers (D21),

Excavator (Fiat Allis), Tipper Trucks, Water Tank Trucks, Compactors, Marini Primix 70 (80 ton/hour), 3 crushing machines (Loro-Parisini), Telescopic Crane (Demag 18 tons/12m), and workshops in Mogadishu.

Personnel:

Murri uses both expatriates and Somalis on their drilling projects. A Somali is in charge of the Failing rig. Of three European drilling supervisors, one is in Somalia, one is on leave, and one is on call in Madagascar. This is indicative of the fact that the rigs are not fully utilized at the moment.

The company has a total staff in Somalia of about 700 local Somalis and 50 expatriates. Murri employees are all permanent employees. Their drilling teams are permanent staff (not temporary); when they are not drilling, they work elsewhere in the company. Most of the personnel have been with the company for a long time, and learned their skills with Murri. Murri estimates that the Failing has a team of 6 persons, the Ingersoll has 12 persons, and the percussion rigs 7-8 persons - plus supporting equipment and personnel such as bulldozers, water tanks, etc.

In addition to their permanent construction staff, Murri also makes use of local teams of artisans, with whom they sometimes negotiate piece work rates or sometimes daily rates.

There is a shortage of good skilled labor at present and Murri hopes that highly skilled Somalis working abroad would soon return.

Wells Drilled/Contracts:

During the past five years, Murri has drilled approximately 30 wells:

- 10-11 wells for the EEC Grapefruit Project (70 meters with water at 60 meters, yielding 25-30 liters per second)
- 3 under an Italian-financed project
- 1 financed by Kuwait
- 1 for the Fiat Workshop (Italy)
- 1 for the Common Market
- the remainder for the Government and others.

Murri drills few wells for private individuals. All the wells drilled by Murri have been in the "easier" areas between the rivers and the dunes. All Murri drilling contracts have a large foreign exchange component.

Current major civil works contracts include:

- Afgoi - Merca Road
- Afgoi - Baidoa Road - Joint Venture
- Mogadishu Airport Building
- Murri Workshop in Mogadishu
- Grapefruit Project in Lower Shabelli
- Paved Roads in Mogadishu
- Kismayo Airport

Sources of Materials:

Murri has no difficulty obtaining materials, as all its drilling projects have large foreign exchange components. They purchase their materials in connection with specific contracts, and maintain virtually no inventory. Typical sourcing is for PVC (Germany), pipes (Italy - Capari or Rotes), and submersible pumps (Italy - Marelli). Supply from Europe is very quick. Murri does not obtain materials from WDA and has very little work with WDA.

Maintenance of Equipment:

Maintains its owns equipment. Murri is currently building a new workshop outside of Mogadishu to repair Murri's own equipment.

Financing:

Murri indicates that the present Government system for paying contractors was not entirely satisfactory, leading to frequent delays in payment.

For Government contracts with mixed local and foreign currency, contractors must put up a performance bond in Somali Shillings. For IBRD sponsored projects, this amounts to 10 percent of the contract value; for EEC sponsored contracts, 2 percent.

The Government advances 50 percent of the contract value at the commencement of the contract to enable equipment to be mobilized and to provide working capital. This advance must be covered 100 percent with a bond or guarantee of repayment.

Murri would welcome the opportunity to acquire equipment through a Financial Hire Agency.

Murri has severe problems in obtaining foreign currency to import spare parts.

Interest in CIP Program as of Mid 1985:

Murri can use the CIP for a few items, but many items of American equipment and spare parts come from stocklists and are cheaper in countries such as Belgium. Anything financed by the CIP must come directly from the USA.

D-4.2 Juba Enterprises

Company: Juba Enterprises
P.O. Box 549, Mogadishu (Office is next to Stadium south of Fiat Circle, office also in Kismayo)
Telephone: 22238
also
P.O. Box 741, Kismayo
Telephone: 2050
Contact: Mr. Giafar M. Beder, Administrator

Business Activities:

Construction of all types (including water well construction) earthworks, trucking, trade, agricultural works.

Equipment:

Two drill rigs:

1 - Italian rotary, trailer mounted (purchased used in 1983 from Pesina Company)

1 - Italian cable-tool rig (purchased used in 1983 from Pesina Company)

The rigs are capable of a maximum depth of 150m and maximum diameter of 24 inches.

Other equipment includes: 12 Tipper trucks, Fiat 682 N3, 5 Mercedes 30 ton tipper trucks, trailer trucks, 3 water tanks, Caterpillar bulldozers D6, D8 and D9, Fiat Bulldozer B14, Caterpillar Scraper D21, Poclain excavators, Caterpillar Motograders G14, etc.

Personnel:

Total current employment is 800 on all projects. Of this total, only about 20 are involved in water well construction.

Each drilling team consists of 5-6 persons, all permanent employees. All personnel were trained with Pesina Company during Trans-Juba Project (1980-1984).

Wells Drilled/Contracts:

With Pesina Company, from 1980-1984, 12 wells were drilled for the Trans-Juba Project. Currently working on a four-well contract in Afgoi funded by LIBSOMA (a development program jointly funded by the Libyan and Somali Governments.)

In 1984, 7 wells were drilled with the rotary rig for the Agricultural Research Station of Afgoi.

Civil works contracts have included:

- Trans Juba project (IDA)
- Breakwater for Kismayo Harbor
- 80 kms of unpaved road (for Texaco)
- 400 kms road Genale Agricultural Extension Service
- 200 houses for Afgoi Agricultural Extension Service
- Secondary School in Kismayo (IDA)
- Muigarulo Irrigation Project

Marketing/Pricing:

No special marketing efforts are made for drilling services. Drilling prices are bid according to location. Prices are usually 2,000-4,000 So.Sh./meter.

Source of Materials:

Tries to locate available spare parts through WDA. WDA supplies most of Juba's casing, pump and generator requirements.

Maintenance of Equipment:

Performed by staff mechanics.

Constraints:

Difficult to obtain foreign exchange to import spare parts for equipment through the Somali Central Bank.

Future Plans and Strategies:

Would like to increase its volume of well construction. Would be interested in in-country purchase in Somali Shillings of drilling equipment.

Area of Operation:

Willing to mobilize any volume in Somalia.

Interest in CIP Program as of Mid-1985:

No plans to apply for CIP imports if the exchange is based on the floating market rate.

D-4.3 National Drilling

Company: National Drilling
P.O. Box 59, Mogadishu
Contact: Mr. Abdulahi Mohamed Ahmed, Owner
Telephone: Office - 20460
Home - 20982

Description/History:

In 1969, Independence Drilling completed its subcontract with Sinclair Oil for drilling shallow exploratory holes in Somalia. Before leaving, Independence placed an advertisement in the local paper for the sale of two used Failing 1000 drill rigs and other support equipment. Mr. Abdulahi bought one rig and water tanker. The other rig was sold to Mr. Murri. National started its drilling operations with the help of two engineers familiar with well construction. An Englishman worked with National until 1972 and a Somali until 1974. During that period Somali drillers were trained in well construction.

Business Activities:

Well drilling is the only activity - National will install well pumps, but does not perform civil works construction.

Equipment:

1 Failing 1000 drill rig; flatbed truck; water tanker

Personnel:

National uses a five-man crew on the rig. The driller and one assistant driller are considered permanent employees. Both started work when the rig was purchased and are related to Mr. Abdulahi.

Wells Drilled/Contracts:

Since 1980, National has completed 16 wells - 7 drilled for Government agencies and 9 for private individuals. National currently has a contract to drill 1 well in Afgoi. They plan to mobilize after installation of a new rig engine.

With the recent devaluation of the Somali Shi[illegible]g, National has raised drilling prices from about SS 1,20[illegible]meter to SS 2000/meter. The following is a listing of major cost items for drilling a 120m well in the Mogadishu area:

1. Drilling 120m @ So.Sh. 2,000/meter
2. Installation of casing
3. Well development
4. Pump installation
5. Well test -- 24 hours
6. Mobilization

The cost of item 1 is So.Sh. 240,000. The total cost of items 1 through 6 is So.Sh. 297,000 excluding the cost of casing and screen or other well appurtenances.

Drilling Capability:

National feels that if the company were properly supplied, its rig could complete a well every 15 days. The largest number of wells that national has completed in a year is eight. National feels that its rig is better suited to drilling the softer coastal formations and therefore limits its area of operation to agricultural wells in the Lower Shabelli region and domestic wells around Mogadishu. National is willing to mobilize its rig in the El Dheer region which the firm feels will provide suitable drilling conditions. Almost all of the wells completed by National are drilled to 120m although the rig is capable of well completions to 180m. Domestic wells are drilled with a 13 inch bit and completed with 8 inch casing and agricultural wells are drilled with a 15 inch bit to allow installation of 10 inch casing. Most of the domestic coastal wells yield from $10m^3$ to $30m^3$ per hour.

Financing:

National's new engine was ordered from International Harvester in 1983. At that time, the Somali Commercial Bank supplied the necessary foreign exchange at So.Sh.17/dollar. Abdulahi believes that the same transaction today would not be approved.

Abdulahi believes that the bank would only finance a new rig for a guaranteed contract which would enable the borrower to complete payments.

Sources of Materials:

Like other contractors, National experiences shortages of fuel and other supplies. National has a letter of priority from the Minister of Planning which makes it easier to get fuel, but Mr. Abdulahi says its still takes a least 3-5 days to process the paperwork. National relies completely on WDA for supplies of casing, screen and other drilling consumables. The year 1984 was particularly slow due to casing shortages at WDA.

Maintenance of Equipment:

Outside mechanics are working on the installation of the new engine. Drilling personnel perform routine maintenance, but repairs and major overhauls are contracted to private mechanics.

Area of Operation:

Coastal areas around Mogadishu.

Main Constraints:

Shortages of fuel and supplies. The year 1984 was particularly slow due to casing shortages at WDA. If National were properly supplied, it is felt that the rig could drill a well every 15 days.

Future Plans and Strategies:

National would be interested in purchasing an additional rig if it were available in Somalia.

National would like to form a joint venture with an American drilling firm. Mr. Abdulahi feels National could provide cheaper management and in-country experience while the American firm could provide technical assistance and supply of spare parts and drilling consumables. He realized this association would be difficult to arrange unless there were a foreign exchange component.

Interest in CIP Program as of Mid-1985:

No consideration has been given to a CIP purchase after the devaluation.

D-4.4 Horn Of Africa Drilling

Company: Horn of Africa Drilling
P.O. Box 931, Mogadishu
Contact: Mr. Ahmed Hashi Jama ("PeeWee"), Owner

Business Activities:

Horn of Africa is engaged in drilling, mechanical and electrical engineering. Seven brothers are in this variety of fields, working together. Through a subcontractor, Horn of Africa also does some construction and civil works, such as well structures.

Equipment:

Horn of Africa has 3 rigs, 20-25 years old. The company has one Mayhew 1000 rotary rig which they are using, originally purchased from IDC/Sinclair. The firm has one Franklin 1500 Speedstar Rotary, purchased from Rogers Drilling, which is not operable. The third rig is a Walkeneer cable-tool rig, purchased from Rogers Drilling, which requires a new cable. The Mayhew has an air compressor.

Personnel:

Horn of Africa Drilling has 15 permanent full-time employees, plus temporary employees hired when there is work. Several of the employees are family members to whom Mr. Ahmed (popularly known in the trade as "PeeWee") taught the trade. Mr. Ahmed himself has 30 years of experience, having started his career with Rogers Drilling in Somalia. Rig teams usually include 4 helpers and 2 drivers.

Wells Drilled/Contracts:

Horn of Africa has drilled approximately 20-25 wells since 1980. These include:

1984-1985	-	for ESSO, 20 20-meter dug wells (Seismic boreholes)
1984	-	for OJS, 2 wells at Afgoi
1983	-	6 wells of 100 meters near Mogadishu, for the Ministry of Local Government
1982	-	2 wells for the Ministry of Local Government
	-	4 wells at Afgoi for the Police
	-	2 wells for the college at Afgoi
1981	-	2 wells for factories in Afgoi
	-	1 well for a private individual
1980	-	no wells

Horn of Africa Drilling

Horn of Africa has drilled (in 1975) at Baidoa. They have worked for WDA - in 1972. In 1974-75 they drilled 27 wells for a private banana plantation at Afgoi.

Pricing/Marketing:

Current prices for Horn of Africa's drilling services are $777 per 10 hour day (ESSO contract), with the client providing tires, fuel, and all other supplies. On a per meter basis, the company currently receives 4,000 So.Sh. per meter, for drilling only. The company normally does no cost analysis to prepare bids, but negotiates on the basis of the "market rate."

Sources of Financing:

Primarily self-financed. Typically, the company receives a 50% mobilization advance at the beginning of a contract, 25% during the contract, and 25% at the end of the work. Mr. Ahmed will not deal with banks. To purchase a new rig, he says he would save enough from wells drilled with current rigs to finance the purchase.

Sources of Material:

Spare parts can be made locally at machine shops. The WDA, through the owner of the well, supplies mud, pumps, screen, casing and other materials. Drill pipe is obtained from the United States.

Maintenance of Equipment:

Horn of Africa maintains its own equipment.

Main Constraints:

The main constraint is the lack of materials, particularly casing and fuel. Mr. Ahmed believes the company could be working at capacity if these constraints were removed.

Future Plans and Strategies:

Would be interested in purchasing new rigs if available in Somali Shillings.

Area of Operation:

Interested in drilling anywhere in Somalia except in the north.

Risk Orientation/Payback:

Mr. Ahmed explained that in purchasing a new rig, he would do no particular benefit-cost calculation or other analysis, but would simply make a decision on his "feel of the situation."

D-4.5 Somali Drilling Company

Company:

Somali Drilling Company
P.O. Box 391, Hargeisa
Contact: Mr. Ahmed Yasir Omar Hashi, Manager
Telephone: 2573

Description/History:

The company is owned by Mr. Yusuf Mohamud Guma, and began drilling operations in 1983 with the arrival of a used British Rustom 22 cable tool rig from Qatar. The rig was originally purchased by a British drilling compan. for a project in Qatar.

Business Activities:

Well drilling, civil works, import.

Equipment:

1 British Rustom 22, an English production version of the Bucyrus - Erie 22W manufactured in the U.S.

Personnel:

The Somali Drilling Company's rig is staffed by a crew of seven--one foreman, two assistant foremen, and four helpers. The foreman, Mr. Ismail Diriye Madar, is a former WDA driller with more than 30 years of experience. The entire crew is considered to be part of the company's permanent work force, and when the rig is not in use, Mr. Ahmed admits their salaries are subsidized by the company's more profitable civil works and import operations.

Wells Drilled/Contracts:

The rig is now drilling its seventh well in Geriza, located between Hargeisa and the Djibouti border, for a livestock cooperative. Previously, six wells were completed, including two for the Berbera local government, drilled to 350 feet each, and four private farm wells drilled in the Gabiley District west of Hargeisa. Well depths for the farm wells range from 140 to 300 feet.

Somali Drilling has contracts for three additional wells--two for refugee camps and one for a private farm--but cannot drill the wells until a supply of 8" casing is found.

Pricing/Marketing:

The company charges 6,500 So.Sh. per meter drilled, which is what the market will permit.

Drilling Capability:

The Rustom 22 rig is capable of drilling a 12" (30cm) hole to 1,000 feet (300m), but Mr. Ahmed does not expect to complete wells deeper than 500 feet (150m). The cable rig is capable of 12 wells per year in northern Somalia.

Sources of Materials:

Somali Drilling relies on WDA for its screen, pumps and generators. The company also gets hydrogeological advice from WDA. Rig spare parts are purchased in Saudi Arabia by friends or relatives working there, and repayment is made in Somali Shillings.

Maintenance of Equipment:

The rig is maintained by a staff mechanic.

Main Constraints:

Availability of supplies - Somali Drilling has contracts for three wells, but cannot drill until a supply of 8" casing is found. The company made a down payment on a rotary rig in Qatar. The devaluation of the shilling and currency restrictions have prevented completion of the purchases.

Future Plans and Strategies:

So far, the drilling business has not been a major source of revenue for the company. Mr. Ahmed feels, however, Somali Drilling has a bright future if supply problems can be resolved. He believes the cable rig could complete 12 wells per year in northern Somalia and could be profitably used for well maintenance and rehabilitation.

Area of Operation:

Somali Drilling is willing to travel, but prefers to drill in the northern region.

D-4.6 Kampihl

Company:

Kampihl
P.O. Box 2993, Mogadishu
Contact: Mr. Per Wengler, Administration and Financial Manager
Telephone: 81983

Description/History:

Kampihl is a consortium of two Danish contractors, E. Pihl & Son Ltd. and Kampann, Kierulff & Saxild Ltd. Kampihl is primarily a civil works contractor, but has a division specializing in water supply and sewerage. The company came to Somalia about four years ago to drill 40 wells for Mogadishu Water Agency (MWA). Kampihl now maintains a regional base in Somalia and has been involved in construction at the Gesira generating station and with an office building in down town Mogadishu.

Business Activities:

Well drilling, construction.

Equipment:

Kampihl operates two rotary rigs. The larger rig is a Failing 2500 which can drill large diameter wells to 2000 feet (600m). The smaller rig, a Failing 1500, is capable of well completions to about 1,000 feet (300m).

Personnel:

An experienced expatriate driller is responsible for each rig. Expatriate mechanics also service Kampihl equipment. Somalia helpers and drivers assist in well construction. When the rigs are not in operation, drillers are used in other Kampihl locations in Mali and Guinea.

Wells Drilled/Contracts:

Kampihl came to Somalis in 1980 to drill 40 wells for the Mogadishu Water Agency. The project, known as Phase 2A, included well construction, pipelines, pumping stations and a reservoir. Funding was provided through the World Bank. The KKS company brochure lists the value of the contract at $14,200,000. The company also drilled 6 wells for the Arab Mining Company.

Last year the company drilled six wells in Dusa Mareb for the Arab Mining Company (AMICO) from Jordan. The wells are part of a planned uranium mining operation.

In addition to the turnkey water project in Somalia, Kampihl has completed the 55m high concrete chimney with steel core at the generating station in Gesira and is constructing a six story office building in downtown Mogadishu.

Sources of Materials:

The company imports all materials for well construction, primarily from Europe. Kampihl even imports all fuel required to supply its projects. It inventories the fuel in storage tanks at the port.

Future Plans and Strategies:

Kampihl intends to maintain its operation in Somalia. The company is very interested in future water-related projects and the possibility of water well construction.

D-4.7 Somali-German Drilling and Windmill

Company: Somali-German Drilling and Windmill Construction Company Ltd. (SGD)
P.O. Box 449, Hargeisa
Mr. Abdulkarin Ahmed Julaid, General Manager
Telephone: 2888

Description/History:

Mr. Abdulkarim owns about 100 hectares in the region known as Cell-La-Helay, where he has established the SGD operations. Although the company name is Somali-German Drilling, there are no German or other foreign partners, Mr. Abdulkarim does receive technical advice on different types of water-related equipment from the same German advisor who constructed his drill rig. Abdulkarim returned to his native northwestern region of Somalia from Germany after receiving his masters degree in business economics and working as a computer programmer for Siemens for nine years.

Business Activities:

Company activities include water well construction (the major activity); also core sampling, windmill construction and installation, water catchment and collection gallery construction, and the manufacture of building blocks. Future plans include the manufacture of PVC casing and installation of drip irrigation systems.

Mr. Abdulkarim plans to combine his company's activities to provide complete irrigation systems for farmers in the northwest region. To demonstrate SGD's capability, Mr. Abdulkarim is developing an impressive water supply system on his own property. His water system includes five drilled 20-meter wells and three collection galleries which feed into a central storage tank and a large water catchment reservoir.

Equipment:

1 - Homemade German coring rig imported from Germany by Mr. Abdulkarim. The rig was manufactured in 1980 and later mounted on a truck in Somalia.

Wells Drilled:

Five 20 meter wells.

Financing:

More than 2 million Somali Shillings have already been spent on the project. The construction has thus far been funded by a relative. Mr. Abdulkarim's request for bank development financing was denied.

D-4.8 Tiger/Tiger Workshops

Company: Tiger/Tiger Workshops
P.O. Box 1005, Mogadishu
Contacts: Mr. Jama A. Farah, General Manager
Mr. Musa Ainan Gele, Manager, Tiger Auto Parts and Accessories
Telephone: 80622 (office), 81023 (residence)

Business Activities:

Tiger's operations include equipment rental, some civil works construction, machine shop, auto-truck parts supply, port clearing agents. Tiger is the Somalia representative for Porclain excavators and Colchester lathes. Tiger also has a workshop which repairs and maintains other firms', equipment. The WDA and NRA use Tiger workshops, and use Tiger trailers to haul and erect windmills.

Equipment:

5 - trucks with 10 meter flatbed trailers
1 - 30-ton crane
2 - 3- to 5-ton forklifts
1 - water tank
1 - Fiat Allis bulldozer
1 - G12 Caterpillar Grader
compressors, heavy duty working tools.

Tiger also has a workshop which repairs and maintains the company's own equipment and those of other firms.

Personnel:

Tiger employs two equipment operators who trained as drillers in Saudi Arabia.

Sources of Financing:

Tiger could make a down-payment of 10 million Somali shillings on an equipment purchase.

Tiger has discussed financing the purchase of a rig with Somali Development Bank.

The company obtains foreign exchange by working for foreign firms and by buying foreign currency in the open market where foreign exchange is furnished by Somalis working overseas and by Somali experts.

Tiger would welcome the establishment by banks or others of facilities for hire-purchase for heavy equipment.

Future Plans and Strategies:

Tiger has teams available which are able to repair and rehabilitate existing wells.

In order to support the rig, Tiger indicates that water well contracts in Somalia funded by foreign governments would be their target. Ideally, the company would like to operate a rig in the northern and southern regions of the country. Both gentlemen are from the north and would like to set up a base of operations in Hargeisa. They feel an excellent opportunity exists in well and pump rehabilitation and maintenance. In addition to their machine shop in downtown Mogadishu, they have purchased equipment to set up a machine shop in Hargeisa which they say would be used to repair pump parts.

Interest in CIP Program as of Mid-1985:

Mr. Mussa Geelle said that their application for foreign funds to purchase a drilling rig (1500-55 Holemaster) (approx. cost before recent devaluation about US $500,000 when rate was 23 So.Sh. to US $1.00) had been approved by the Somali Development Bank, but was shelved by the CIP. Their 1983 application to the CIP program was however not approved, because the US $16 million available for Somalia had been spent.

Tiger indicated that if the market rate of the Somali Shilling is used, the company would not be able to meet the down-payment requirement.

Mr. Geelle indicated that there is now little difference between the legal "floating" rate and the open "black market" rate. CIP exchange rate is as high as the black market rate and few people want to use the CIP for procurement. There are also long waiting periods for CIP funds as compared with capital from other sources for foreign purchases. In the fall of 1985, the CIP funds were approved and the purchase is in process.

Risk Orientation/Payback:

Tiger could make a down-payment of ten million Somali shillings on an equipment purchase. They feel the return on investment for the rig would require eight to ten years. They estimate receipts for drilling only, excluding casing, pump and generator, to be 7.2 million shillings a year.
(4,000 So.Sh./meter X 150 m/well X 12 wells/year).

D-4.9 Mr. Mohamed Ali Mohamoud

Company: Mr. Mohamed Ali Mohamoud
P.O. Box 627, Mogadishu
Telephone: 20806

Description/History of Firm:

Mr. Mohamed is a licensed importer - exporter and marketing consultant to the water well industry. He wishes to start a drilling company.

Mr. Mohamed was in charge of purchasing for WDA for nine years. He left WDA in 1977 to form his own import-export company. He is the Somali distributor for Failing and Speedstar drill rigs, Gardner-Denver hand pumps and Hughes bits.

Equipment as of Mid-1985:

None.

Mr. Mohamed contemplated a tender offer for a water well construction project in Somalia during the last couple of years. Because his CIP application was still pending he requested and received approval from the Ministry of Minerals and Water Resources for the lease of a WDA rig for the project. Mr. Mohamed says the Ministry posed the question to the president and approval was granted. He decided not to tender the project when he inspected the rigs available from WDA.

Mr. Mohamed's CIP application includes the purchase of one Speedstar SS 15 truck-mounted rotary drill rig. The SS 15 is a medium weight rig for wells drilled to 600 meters. Included with the package are spare parts for two years, bits, 450 meters of drill pipe and all hoses, cables and fittings needed to begin drilling. The cost of this drill package is $500,000. In the fall of 1985, his application for CIP funds was approved, and the purchase is in process.

Pricing/Marketing:

With new equipment, Mr. Mohamed feels he can compete with expatriate firms operating in Somalia. Mr. Mohamed indicates there is a big difference in prices of wells constructed by expatriate firms and Somali firms. Per meter drilling prices charged by local contractors are about So.Sh. 4,000/meter while expatriate firms have received between $450-$500/meter (So.Sh. 36,000-So.Sh. 400,000 at current market exchange rates). At the higher prices, Mr. Mohamed feels he can recover his investment in two years. He also believes he can offer the same quality of construction as that provided by expatriate firms.

Financing:

Mr. Mohamed made a CIP application for a $500,000 drill package which was approved in mid 1985. Mr. Mohamed is willing to invest up to 15 million Somali shillings. He indicated that the Somali Development Bank supported the purchase of at least one rig, and has letters of confirmation.

Future Plans and Strategies:

See above, desires to establish a new enterprise.

Interest in CIP Program as of Mid-1985:

Mr. Mohamed has applied to the CIP program for the purchase of a Speedstar SS 15 rotary drill package. He was however, reluctant to complete the purchase while the CIP exchange rate was based on the "market" price of the Somali shilling. Over the year, however, the market exchange rate used by the CIP began to appear more attractive than the next best alternative, the "auction rate". The CIP package was approved in the latter half of 1985, and the purchase is now in progress.

D-4.10 Guleed Company

Company: Guleed Company
Hargeisa
Representative: Mr. Ahmed Omar Hassan

Description/History of Firm:

Mr. Ahmed represents a group of Hargeisa investors interested in establishing a drilling company.

Business Activities:

Not yet defined. Expecting delivery of a Caterpillar 950 loader. Mr. Ahmed currently operates a restaurant with his family in Hargeisa, and operates a Toyota parts store in Hargeisa.

Equipment:

Caterpillar 950 loader (delivery due in May, 1985).

Personnel:

No one in the group has any knowledge of drilling equipment or well construction. Mr. Ahmed was educated in Texas and worked for 7 years for Ramco as an Administrator in Dahran.

Financial Resources/Sources of Financing:

Group of investors.

Future Plans and Strategies:

Interested in well construction due to the water shortage in the northern region.

Interest in CIP Program as of Mid-1985:

Caterpillar loader was purchased under the CIP Program for US $12,0000 at an exchange rate of 17 So.Sh./dollar. The group can afford a further US $250,000 CIP investment if the official bank exchange rate of 36 So.Sh./dollar is applied.

Assistance Requested:

Technical assistance from USAID for equipment selection and all phases of well construction.

D.4.11 Warfa Trading and Construction Enterprise

Company: Warfa Trading and Construction Enterprise
P.O. Box 3200, Mogadishu
Contact: Mr. Warfa Jama Warfa, General Manager

Description/History:

Mr. Warfa received a degree in civil engineering in Czechoslovakia. From 1976 to 1979, he was site construction engineer and later project manager for a Belgian company, Sagres, in Saudi Arabia. Sagres constructed the National Metal Industry facility in the Saudi capital. From 1979-82, Warfa was employed in Jubail, Saudi Arabia by Fichtner Consulting Engineers, a German firm. Warfa was the civil engineer supervisor on a water distribution system which included a main pumping station and pipelines.

He returned to Somalia in 1982 to start a design and civil works construction company.

Business Activities:

Civil works design and construction.

Equipment:

4 - concrete mixers with capacities of 180, 250, 350 and 510 liters.
1 - 12-meter hoist platform.

Contracts:

Design of 10 houses.
Construction of 3 houses.

D-4.12 Buralhess Construction Company Limited

Company:

Buralhess Construction Company Limited
P.O. Box 1264, Mogadishu
Contact: Mr. Ahmed Burale Farah, Vice President
Mr. Alessandro Muchiro, Administrative Accountant
Telephone: 21234

Business Activities:

Civil Engineering contractors, import-export, some design work.

Equipment:

2 - Bulldozers
2 - shovels
1 - case loader
2 - mini-loaders
6 - heavy duty trucks
4 - heavy duty tipper trucks
3 - light duty tipper trucks
2 - excavators
4 - concrete mixers (400 liter)
6 - concrete mixers (160 liter)
5 - vibrators
6 - pickups and landrovers
7 - small cars
7 - block-making machines
4 - timber cutting saws
3 - water pumps
1 - air compressor
2 - 25KWA generators
1 - 175KWA generator

The company also owns a 700-ton coastal vessel with lifting gear for containers.

Personnel:

Employs artisan gangs for such items as cement block making, shuttering, fixing reinforcement and masonry. Headmen in charge of the gangs negotiate payment with the company. Payment is on a piecework of daily rate basis, depending on the nature of the work. The company has permanent Somali personnel of the foreman type, who supervise and direct the work of the gangs.

Contracts:

Currently completing Phase 1 (housing) of the Mogambo Irrigation Project. Looking for other medium sized projects.

Sources of Materials:

Most of the company's materials are ordered direct from overseas. The company occasionally purchases materials, such as cement, from the local market. However, the company finds the local market to be unreliable.

Delayed payments from the Government sometimes affect the company's ability to order materials in good time, resulting in their having to purchase items on the local market to avoid work stoppages.

Future Plans and Strategies:

Buralhess would be very interested in taking on additional concreting and earthworks if this should be divested by the Government.

D-4.13 National Engineering and Construction Company

Company: National Engineering and Construction Co. (NATCO)
P.O. Box 900, Mogadishu
Contact: Mr. Hassan Mohamed Ali, Burao Branch Manager
Telephone: 80886/80887/81522

Business Activities:

Construction of buildings, agricultural works, water works, and indirect constructions. The company also has its own quarry in Mogadishu and supplies stone and crushed aggregate to Government and private contractors.

Equipment:

Considerable earth-moving equipment, workshop equipment, construction yard equipment, trucks and cars, including:

Bulldozer (14B 150 HP Fiat/Allis), bulldozer (14B/Ripper 150 HP Fiat/Allis), motor grader (14D Caterpillar), shovel loader (955 Caterpillar), excavator (Same Drago - Smae), Austin Western crane (8 tons), crusher unit complete with granulator and screen, 2 concrete mixers (Winget 400 liters), 2 concrete mixers (350 liters), air compressor, welding machine (Portable), road roller (10 tons), bitumen boiler and sprayer, compactor (Lombardini), electric air compressor, joinery machinery, vibrator with pocker, block making machine (Rosa Cometta), construction tools, mechnical Workshop tools, 4 Tipper trucks (6 tons), truck w/lowbed trailer and Land Rover and Range Rover.

NATCO has their own quarry and crushing equipment in Mogadishu and supplies stone and crushed aggregate to Government and to private contractors. The company also has its own workshops to repair and maintain equipment and its own carpentry and joinery shop for making doors and windows.

Personnel:

NATCO hires local specialist gangs for shuttering, concrete placing, reinforcement fixing, carpenters, masons, electricians, plumbers, etc. The gangs are prepared to go anywhere in Somalia and sleep in the nearest town or village, or in the bush where NATCO will provide tents. The gangs work under and are represented by a headman who negotiates for them. The company has its own teams of artisans, living in Mogadishu, who travel to the regions to do the work.

NATCO

With the slowing down of construction in Saudi Arabia and the Gulf area, NATCO expects that many highy skilled artisans will be returing to Somalia. Mr. Hassan indicated that most of the excellent work done in the construction field in Somalia was executed before he early 1970s and that the company could no longer do such high quality work because of the exodus of the best artisans to the oil-rich states.

Contracts:	Contract Price	Year
Alowla Fish Factory	So.Sh. 8,000,000	1965
Abdillahi Omer BLDG KM 5	So.Sh. 6,000,000	1965
Balad Textile Factory	So.Sh. 7,800,000	1965
Mineral & Ground Water Survey BLDG. M.	So.Sh. 2,200,000	1967
Agricultural Research Center Afgoi	So.Sh. 4,100,000	1968
Consultants Camps for Hargeisa-Borama Rd.	So.Sh. 4,000,000	1978
Experimental Banana Farm (Jilib)	So.Sh. 11,400,000	1972
Break Water of Kismaio Port 2nd Phase	So.Sh. 4,500,000	1973
Water Houses for Textile Factory Balad	So.Sh. 3,800,000	1974
North-West Agricul. project 24 Houses	So.Sh. 4,500,000	1978
Fishery & marine Institute	So.Sh. 5,800,000	1978
Borama & Cebiley Secondary School	So.Sh. 2,500,000	1978
Burao Potable Water Connection	So.Sh. 4,250,000	1978
KM 4 Hotel in Mogadishu	So.Sh. 10,000,000	1981
8 Private Villas	So.Sh. 8,500,000	1980

National Agency for Electricity, Mogadishu (Buildings)
Culverts, Canals, Sluice gates and Concrete breaks, Jowhar

Location of Work:

They have done a lot of construction in the north as well as the south, and are prepared to work anywhere in Somalia.

Financing:

NATCO has never applied to the Somali Development Bank for a loan. Most of their equipment was purchased several years ago, when it was comparatively easy to obtain foreign exchange. In order to expand, NATCO would be interested in the possibility of time-purchase of equipment.

Future Plans:

NATCO wishes to expand and would be interested in the hire purchase of equipment to expand. They would be interested in both drilling and civil work.

APPENDIX E

REQUIREMENTS FOR PRIVATE SECTOR INVOLVEMENT IN WATER RESOURCES DEVELOPMENT

E-1 ENTREPRENEURS' EXPRESSED NEEDS

As discussed earlier in Appendix D, local firms in the water works/construction industries are widely varied, but fall into two broad categories:

- Large Somali firms with diversified capabilities and the ability to run several projects at once. These firms are fairly sophisticated in their technical and business skills. They have a large component of foreign participation, have access to external resources, and have little need for special assistance.

- Smaller Somali firms, which are usually equipped to handle only one or two types of activities, and able to handle only one or two projects at a time. The principals often are former MMWR or MPW officials or former employees of foreign firms. It is this group which could benefit from targeted assistance. This appendix focuses primarily on this group.

As a result of extensive interviews with each of the local, private sector drillers in Somalia, a number of commonly perceived needs have come to light. These include:

1. An improved investment climate and reduction of market risks faced by entrepreneurs, through changes in government policies;

2. An assured supply of the imported materials and spare parts required for well drilling; and

3. Reliable sources of credit and foreign exchange.

E-1.1 Markets for and Competition within Water Industry

Section 3.4.9 highlights the market constraints confronting private sector firms in the water industry; and Section 3.5.1 discusses the competition faced by local private firms from both the WDA and foreign firms. The latter problem has been of particular concern to local firms, who have on several occasions been undercut by WDA in competition for foreign-funded

drilling projects. The regulatory constraints, although probably a substantial impediment to private sector growth potential, were not specifically cited by many entrepreneurs.

E-1.2 Parts and Materials

As discussed previously, WDA is the primary source, and for most local drillers the only source, of imported well drilling materials (well casing, screen, bentonite, drill bits, etc.) for wells not financed by foreign aid. WDA orders these supplies for its force-account well drilling program in the rural areas, for wells it drills on contract for other public and private agencies, and, funds permitting, a surplus which it may sell to the private sector at CIF plus 45% to cover local transport, storage, administration and handling. The foreign exchange to make these purchases is supplied to WDA by the Central Bank on authority from the Ministry of Finance.

Over the past few years, however, the severe shortage of foreign exchange at the official exchange rate has forced drastic cutbacks in all government projects with large foreign exchange components. Although the currently operating Three Year Plan calls for WDA to drill 30 rural boreholes per year, foreign exchange budget cuts have left them with the ability to complete only one third to one half of their assignments, due primarily to the shortage of foreign exchange to buy needed materials. Availability of supplies for the local private sector have dwindled to nothing over the past year, leaving local drillers with backlogs of wells for which they await supplies of casing and screen.

E-1.3 Foreign Exchange and Credit Availability

During the early 1980s, some private businessmen could apply to purchase foreign exchange from the Central Bank or from USAID's Commodity Import Program at the official exchange rate. There was a large excess of requests over supplies, but at least two applications from aspiring local drillers were approved by the Somali Development Bank. Foreign exchange was also available, illegally, on the parallel market, but was up to three and a half times as expensive as the official rate. On January 1, 1985, the Government of Somalia announced a 40% devaluation of the official exchange rate, the creation of a "market rate" which was ostensibly a floating rate, and the legalization of private sales of foreign exchange at any rate negotiated between buyer and seller (called the "auction rate"). This, in effect, largely supplanted the parallel market. Importers are now allowed to arrange private purchases of foreign exporters or from individuals who received foreign exchange remittances from family members abroad. Foreign exchange, with few exceptions, is no longer available to the private sector at the official exchange rate. The livestock export industry, once a reliable source of foreign exchange, has lost one of its biggest markets, as Saudi Arabia has

closed its ports to all livestock from Africa for fear of rinderpest. Further, the economic recession in the Gulf has cost many Somalis their jobs there, sharply curtailing the flow of hard currency remittances into Somalia.

Somali businessmen thus need a reliable market from which to obtain foreign exchange, and improved facilities for ordering and importing materials and spare parts. The foreign exchange market, only recently freed from government control, is developing slowly and has not formally expanded its network into the larger business community. Importers must arrange their own sources of foreign exchange, and this seems largely restricted to intra-family or intra-community contacts. Over the immediate future, as more functions of the Somali government are privatized, the foreign exchange market will have to handle the requirements of a growing private sector, even as the best sources of supply are drying up.

The Commodity Import Program (CIP) has undergone an extreme fluctuation in demand for its supplies of foreign exchange. Following the foreign exchange reforms of January 1, 1984, it was in a state of limbo between the desires of the government of Somalia, the private sector of Somalia, and USAID policy. The view of USAID has been that all transactions concerning the private sector should take place at the market rate, and therefore that CIP funds for the private sector should use that rate. The view of the government of Somalia had been that all foreign assistance should come in at the official rate, and therefore that all CIP funds should be exchanged at that rate. Private Somali businessmen of course preferred the more favorable official exchange rate and noted that if CIP funds were only available at the market rate, they might prefer to go to the open market, where hard currency was available at the same rate, but with less time involved and without restrictions as to where the money could be spent.

The exchange rate issue represented an impass for the CIP for several months. Investment decisions were put off, and there were no purchases made through the CIP. Private sector businessmen said that market rate was "too expensive," and stayed away.

Eventually, however, the CIP funds, at the market rate, began to appear attractive when compared with the alternatives: the "market rate" has been virtually unobtainable by the private sector from the Commercial and Savings Bank or from any other official source. For truly private transactions, the auction rate, which is about 25-50% higher than the market rate is the only recourse. These funds can be obtained legally from foreign exchange earners with an "external account" at the Commerical and Savings Bank (such as livestock exporters and Somalis working overseas), at any rate negotiated between buyer and seller. Once

a price has been agreed, and payment in shillings made, the seller for foreign exchange transfers the funds to an "import account" opened by the buyer. The importer can then obtain a letter of credit from the Commerical and Savings Bank for an approved purchase.

Given the difference of price between the auction rate and the market rate available from the CIP, the restrictions on purchases from CIP began to appear insignificant compared to the advantages.

Somali businessmen typically rely on their own financial resources, from surplus built up over profitable periods. The next major source of finance is from members of their extended family who are working abroad and remitting their earnings. Operating capital requirements are met primarily by contract advances, although these should probably be evened out into more frequent but smaller performance payments. At the moment, some local contractors do not even bother to approach the Somali Development Bank or the Commercial and Savings Bank. Loan officers at both institutions said they have had to refuse sound loan applications due to lack of funds. Bank credit is in short supply at the prevailing interest rates, and policy directs them to assign priority to the agricultural sector, to such an extent that no loans were made for industry or commerce over several months in 1984-1985. Other financial markets in Somalia are similary underdeveloped: there are no markets for equity or bonds, and no financial hire facilities for equipment acquisition.

Thus an important unmet credit need of the private drillers is that for the finance of equipment acquisition. Even when local banks have funds available for industrial/construction purposes, they are usually unwilling to lend unless the borrower has both a guaranteed market, in the form of contracts sufficient to assure repayment of the loan, and collateral considerably more valuable than the loan itself. One manager of the Commerical and Savings Bank pointed out that it would be difficult for the bank to justify loans to private sector drillers.

These conditions have proved too onerous for most of the smaller contractors in Somalia; therefore, the Consultant has proposed that over the short run equipment should be procured by the project and leased to local contractors. For the long run, we have proposed the creation of an Equipment Finance Corporation in Somalia to purchase heavy equipment for use and eventual purchase by local firms. This is discussed in greater detail in Section Two of the main body of the Draft Final Report. Other private sector needs perceived by the Consultant include new equipment acquisition, personnel development, and finance; each of which is discussed in greater detail in separate sections below.

E-2 EQUIPMENT SELECTION

Somalia is a widespread and geologically diverse country. The organization, size and complexity of the WDA demonstrates the difficulty of countrywide water well construction. The agency's number of personnel, drill rigs, supplies, repair facilities, and other infrastructure, although perhaps inflated by a lax government bureaucracy and not restrained by the need for profit-making, nevertheless indicate the necessary scale of operation.

This scale makes it unrealistic to suppose that any private contractor could contemplate a countrywide operation. Yet without this scope, it is debatable if any area of Somalia can provide a sufficient and continuous volume of well construction to allow for other than a small, localized, private-sector contractor operation.

There is one primary negative aspect of water well contracting, as opposed to, say, oil well construction. Although both share the inherent risks of underground construction, in most circumstances for the water well there is the relative (or controlled) low value of the product produced. This low end-product value limits the affordable price of the equipped well. This restricts the amount a profit-motivated contractor can invest in equipment. For these reasons, most successful water well drilling requires firms headed by entrepreneurial and resourceful individuals. Water well contracting is rarely successful as a branch operation of a larger commercial firm.

E-2.1 Drill Rigs

Worldwide, most water wells are constructed with one of three types of drilling equipment; namely cable tool, rotary, or down-hole air hammers. Some specialized equipment utilizes variations of these basic rigs, and more or less interchanges their procedures, but one of these basic procedures is capable of penetrating all water-bearing formations of practical importance. The procedure and equipment selected depends upon the type of formation, well design, and well diameter depth.

The drilling experience in Somalia has indicated that all three types of rigs can be profitably utilized, depending both on the sub-surface conditions and remoteness of the drill site.

Cable tool or percussion drilling is the oldest of these methods, with wells having been drilled by some variation of this procedure for many hundreds of years. Portable cable rigs similar to those used today first appeared nearly a century ago, with the underground tools and drilling basics largely unchanged during this period.

The advantages of cable tool are the relative simplicity of the equipment and tools, and its flexibility to adapt to a variety of underground conditions. In spite of development of newer equipment, cable tool is still the method of choice in many formations such as cavernous basalts and limestone, or in construction of naturally developed wells completed in finely graded sands and coarser materials.

Cable tool drilling also requires less fuel, drilling water, and expendable supplies such as foam, mud, etc., than do the alternate methods, so that it is easier to support in remote locations. Another advantage is that the crew size is generally smaller, allowing smaller and less complex camp facilities. In many formations, cable tool drilling also better tolerates work interruptions, and can be performed on a single shift basis. However, since drill fluid is not ordinarily employed in the work, the borehole must be held open in incompetent formations by advancing the casing with the drilling, which can sometimes be complicated.

Hydraulic rotary drilling normally utilizes a drill fluid both to maintain the borehole and remove the drill cuttings as the hole progresses. The procedure permits relatively fast construction compared to percussion drilling, and also allows producing an oversize borehole to permit gravel packing of the well annulus. This makes it an ideal procedure for wells such as those drilled in the Somalia sand dunes.

The equipment is relatively more complex than cable tool, and the rig, mud pumps, drill pipe, etc., require considerably more transport. Crew size is larger, usually requiring more complex camp support facilities. Hydraulic rotary construction requires more fuel, drilling water, and expendable supplies than does cable tool, but as mentioned, is the ideal method for certain type wells.

Air rigs using down-hole hammers are best suited for the construction of relatively small diameter boreholes drilled into hard or semi-hard rock. Air-construction procedures are sensitive to the amount of water produced by the borehole, since it is necessary to remove the drill cuttings with the return air flow, sometimes aided by admixtures such as foamers. Too much water production can therefore stop the drilling. Air drilling also can be impeded if large fractures or crevices are encountered, since the increase in borehole diameter sometimes slows the return air flow velocity sufficiently to allow drill cuttings to drop out, sometimes forming a wall ring adjacent to the opening.

The primary advantage of air rigs is the high rate of penetration in hard formations difficult to drill with the other procedures. However, the rigs and air compressors are relatively complex and require more sophisticated maintenance than the other equipment. Fuel requirements are high, but relatively little

drilling water is needed, and few expendable supplies except foam are routinely required.

E-2.2 Drill Tools

Drill rig tooling can conveniently be divided into two categories, underground and aboveground. Underground tooling consists of those items such as drill bits, drill pipe, wire line, etc., which are required for construction of the borehole and which are expended more or less rapidly in the drilling operation. Aboveground tools are those items, ranging from hand tools to mud pumps and air compressors, needed to support the drilling operation. In the general range of water well construction, aboveground tools tend to be the same or similar regardless of well design, diameter, or depth. Underground tools, however, are a function of well design, so that a wide variety of these tools may be required by an individual contractor if differing designs and diameters of wells are to be undertaken.

However, wells in most parts of Somalia are relatively small producers, ranging from 50 to 150 gallons per minute (3 to 9.5 liters per second), so that a cased diameter larger than eight inch is seldom required. This simplifies underground tool inventory, since producing a borehole diameter adequate for eight inch casing will satisfy the requirement for most wells other than some found along the coastal strip.

E-2.3 Test Pumping

Underground tooling has been discussed above. An additional necessary item for proper well construction and completion is test pumps and engines. Both the pumps and experienced operators are in seemingly short supply, both in the public and private sectors. However, complete well development and testing is an essential part of well drilling.

E-2.4 Other Factors

There are a number of other factors involved in water well drilling, and as with any construction enterprise, final success depends upon every link.

The word infrastructure probably best describes the support components necessary to well construction. Unfortunately, the infrastructure of Somalia, as in many developing countries, is ill-suited to readily provide the degree of support needed by small, entrepreneurial enterprises. This lack of infrastructure then forces each firm to provide in-house nearly every facet of support needed for the endeavor.

These additional factors include such items as transport for men, equipment, drilling water, and supplies; and adequate inventory of construction materials such as casing, screen, and gravel where appropriate. Generally the contractor must insure

that he also has on hand a sufficient quantity of such items as fuel, drill mud or foam, and other expendables. He must also provide and support camp facilities for the drill crews often at remote construction sites.

Another major cost factor is the requirement to provide and maintain repair facilities for a number of diverse pieces of equipment, which for modern drill rigs, air compressors, and trucks often requires considerable sophistication in tools and skill of the mechanics. Also, any hope of expeditious operations also requires that the contractor maintain a large and costly spare parts inventory.

Elsewhere in this report, there is a proposal that a Water Industry Supply Corporation (WISC) be formed which would provide a number of these services jointly for the several members of the private sector contracting group, but lacking such a cooperative, each contractor must individually provide these items. At the current scale of drilling activity, and at the price structure currently imposed on private sector well construction, it is questionable if the total investment required can be justified for the individual contractor.

E-2.5 Drilling Equipment Life

Certainly one of the major initial expenditures for a potential private sector drilling contractor is the actual drill rig, equipped with the necessary above-ground and underground tools needed for the expected well construction. As mentioned, underground tools are considered an expendable supply in the drilling process and the value of each of these tools must be assigned as some pro-rata portion of operation costs.

However, the actual rig itself is a different matter: The CIF cost in Somalia may vary from less than $100,000 for used but serviceable cable tool equipment to many hundreds of thousands of dollars for rotary or air equipment. The expected life of this type of equipment is primarily a function of its degree of utilization or operating hours, and the effectiveness of its maintenance.

Even with a high degree of utilization, this type of equipment reasonably has a useful life of many years, with good maintenance probably easily 20 or more. Certainly many cable tool and rotary rigs in the United States have operated successfully for 30 or more years, and up to some point, keeping this equipment in operation for this number of years is economically sound. With the exception of the air drills, there have been relatively few equipment innovations which have made earlier equipment obsolete. Often, the decision to replace equipment is often made for public relation considerations rather than actual need.

Admittedly, it reasonably can be anticipated that the quality of maintenance necessary to insure this useful equipment life can be difficult in Somalia, and a persuasive argument can be made that periodic replacement of these expensive items is not only justified but necessary. However, it is doubtful that the Somali economy will have sufficient foreign exchange to permit these exchanges to be internally financed within the near future.

Therefore, there is also the valid observation that a decision to replace drilling equipment after relatively short periods of use make the Somali contractors constantly dependent on the largess of outsiders, which is in turn dependent on many vagaries. In fact, easy replacement of drilling equipment may not be a favor to the nation. Strong consideration should be given to the alternative of supplying ample stocks of spare parts, together with the necessary tools, equipment, and training to properly maintain aging equipment. Although the cost of this procedure may equal or even exceed that of new equipment, the eventual outcome should insure more self-reliance on the part of private sector contractors.

The negative aspect of this suggestion is that tools and spare parts of this nature have a tendency to disappear into the general economy without satisfying the needs for which they were furnished. Controls are difficult to establish and maintain, but nonetheless the prospects for long-term value received with this approach may exceed those for merely repeatedly furnishing expensive and sophisticated drilling equipment.

E-2.6 Equipment Costs

As previously stated, it is difficult to estimate the cost of complete drilling packages, particularly when a variety of different types of equipment is considered.

However, there is a general rule which Roscoe Moss Company and other U.S. drillers have found when pricing possible off-shore contracts. This precedent may have some value in establishing the required investment of a private sector contractor in Somalia. This general rule is that the total cost of a self-supporting drill team working off-shore will be about two to three times the price of the primary, fully equipped, drill rig or rigs. As already covered, it seems that any private sector contractor in Somalia essentially would be operating in this context, and that his total investment would probably be in this range. Obviously, the applicability of such a broad rule is debatable in many circumstances.

E-3 PERSONNEL DEVELOPMENT

Both public and private sector personnel in the water resource development industry could benefit from further training in both technical and business/financial skills. Many of the training needs are shared and could usefully be addressed jointly by providing training services for the public sector while welcoming private participation as well.

E-3.1 Technical Skills

Local contractors have proved themselves extremely resourceful and creative in improvising materials when short of supplies and dealing with other logistical difficulties. Their maintenance procedures are good and they can usually undertake their own minor repairs with spare parts fabricated, if necessary, at local machine shops. In general, skills at this level are beyond those obtainable solely in a classroom environment and are best acquired on the job or in a combined classroom - field setting program.

Local technical skills, while adequate for simple, routine, well drilling procedures, are often not sufficiently developed to cope with technical complications. For instance, if a loss of circulation is encountered while drilling a hole, local drillers must frequently resort to starting over on a new hole, instead of remedying the problem on the original hole.

Specific technical training needs include:

a) trouble-shooting complications encountered in the field; and

b) learning more efficient operational methods.

E-3.2 Business Skills

At the moment, the level business skills of the local private contractors are mixed. On the one hand, many Somali businessmen are well-known for their entrepreneurial skills: for seizing opportunities; for shrewd verbal, face-to-face negotiation with clients, suppliers, and employees; and for resourcefulness in the face of scarce supplies of finance, materials, and skilled workers. On the other hand, working as they do--primarily on a cash basis and avoiding financial resources which could increase their tax liability; they have not been in a position to familiarize themselves with the common analytical tools used in the business world. They work without the benefits from training in financial analysis, cash-flow management, or accounting. Consequently, most of the smaller scale entrepreneurs have been unable to fine-tune their business tactics or maximize their profit potential.

For the most part, the private Somali contractors bring to their business either a trading/commercial psychology or an artisan's psychology which tends to set limits to their ability to manage an expanding concern. The trading/commercial psychology strives for a rapid turnover and a big mark-up. There is a lack of emphasis on long-term planning and operational efficiency orientations which need to be well-developed in order to survive in a more complex business environment. The artisan psychology emphasizes quality workmanship and technical competence; sometimes to the detriment of cost control and the vigorous marketing effort required in an increasingly competitive industry.

As the private contracting industry grows in Somalia and becomes more intensely competitive, the types of business instruction most needed will include general management skills (including personnel and equipment management), accounting and costing procedures, (needed in particular for contracting), paying particular attention to such concepts as depreciation of equipment, amortization of loans, rates of return, and cash-flow management. Also needed will be instruction in business planning methods, cost and quality control, and marketing. As their businesses expand, they will need to acquire the skills of managing a large company: keeping control of diverse projects, delegating authority, and planning and coordinating activities.

As WDA begins to privatize its drilling and other functions, its administrative staff will require specific training in contracting procedures: defining projects, putting out tenders, evaluating bids, project supervision and quality control. At the upper levels of WDA, the Director General and the head of Planning should receive instruction in public utility pricing, regulation and alternative approaches to public utility policy. This instruction should relate to both well drilling services (with associated civil works construction) and to the direct provision of water to the public.

WDA employees also could benefit from technical, managerial, and financial instruction. Presently experienced rapid turnovers at the semi-skilled, skilled, and technical levels necessitate frequent training sessions for new personnel.

At the administrative/managerial level, WDA personnel need continuing assistance in establishing appropriate record keeping procedures for all activities, including force account, contract, and emergency drilling; operating expenses for water supply systems; and water tariff collection. GTZ has provided Technical Assistance in this field, but a failure to implement appropriate incentives has hampered implementation.

E-3.3 Potential Avenues of Assistance

Many of the above-discussed training needs relate to both the private contractors and to the civil servants in the water sector. Thus it would be beneficial to the water industry as a whole to invite the participation of private contractors when providing technical assistance to civil servants, and to recognize that skills learned by WDA personnel will be useful to them if and when they leave the agency to work in the private sector. WDA will also profit from being assured of a supply of well trained contractors in the private sector available to take on public sector contracts. A well-rounded technical assistance training program focused on private sector needs would be divided into three main categories:

1. Technical training covering, in particular, trouble-shooting common on-site complications, preventive maintenance, and minor repairs;

2. General management and business skills including accounting, finance, and personnel management and equipment utilization management; and

3. A series of contracting seminars, run in conjunction with foreign aid-financed projects containing components to be contracted out, covering project costing/bid evaluation, contract negotiation, and project supervision (including methods for settling disputes).

These training programs could perhaps best be offered within an (expatriate) contractor--local subcontractor relationship. The initial program would probably include specific technical assistance components, with training per-diems paid to all trainees, including those from the private sector.

Useful education and training programs already available in Somalia should be utilized to the fullest. These are available at the following institutions:

1. The University of Somalia, which offers degrees in both Geology and in Civil Engineering. Both are four year courses taught in Italian by, primarily, Somali and Italian professors. Curricula are presented in Exhibit E-1, immediately following this section. So far, the tuition has been covered 100% by the Government of Somalia, but there are plans to require students to pay for a portion of their education in the future. In the past, the Government of Somalia guaranteed government jobs to all graduates, and required them to accept such jobs. This policy has been abolished, and students are free to accept jobs in the private sector.

2. The Somali Institute of Development and Management (SIDAM), which offers classes in Business and Management at the collegiate and graduate levels. Tuition is free of charge to government employees if sponsored by their departments or agencies. Private entrepreneurs may find it more difficult to enroll unless they are involved in government-funded or foreign-funded projects and are sponsored under the auspices of the project.

3. The Industrial Vocational Training Center, which is being built by GTZ and is expected to be in operation in 1986. Programs will include auto mechanics, diesel mechanics, and auto electric. The center will also provide courses custom-tailored to a specific ministry's requirements.

4. Somalia Polytechnic Institute, which provides a post-secondary two-year diploma program in relevant technical fields of mechanical engineering and shop practices. The institute can provide after-school training in specialized subjects.

Another source of informal training could be available to local partners of joint ventures working on foreign aid funded projects. Practical, technical skills are readily transmitted in the project setting; in particular, local contractors would have an ideal opportunity to work with more modern technology. In return, local technicians would provide expertise on local geological and meteorological conditions of value to the joint venture. Expatriate joint venture administrators could transfer accounting and general business skills to their counterparts, while the latter provide knowledge of local markets and laws. Higher level management and financial skills, however, have a spottier record of transference in joint ventures, unless local partners have already attained a high degree of proficiency in these areas. It is recommended, therefore, that special attention be given to financial management training for the private sector in any technical assistance program in the water/construction industries.

EXHIBIT E-1

UNIVERSITY OF SOMALIA GEOLOGY CURRICULUM

The degree in Geology is completed after a four year program. There are four sections in the department, with the following courses offered:

I. Geology

- Introduction to Geology
- Structural Geology
- Regional Geology
- Photogeology
- Sedimentology
- Petrology of Sedimentary Rocks
- Mapping Geology
- Physical Geography
- Marine Geology

II. Applied Geology

- Engineering Geology I
- Engineering Geology II
- Geotechnics
- Raw Materials Geology
- Hydrogeology
- Applied Hydrogeology
- Prospection of Geophysics
- Cartography and Topography

III. Paleontology and Historiography

- Paleontology
- Micro-paleontology
- Stratigraphy
- Hydrocarbon Geology

IV. Petrography and Geochemistry

- Mineralogy I
- Mineralogy II
- Petrography
- Petrology
- Geochemistry
- Economic Geology
- Mineral Prospection
- Applied Petrography

Generally, the Department accepts about 45 - 50 entrants; but by the end of the program, the number graduated is down to about 15.

EXHIBIT E-2

UNIVERSITY OF SOMALIA

CIVIL ENGINEERING CURRICULUM

COURSE TITLE

1ST YEAR, 1ST SEMES.

1. Math I
2. General Chemistry
3. Analytic Geometry & Algebra
4. Italian Language

1ST YEAR, 2ND SEMES.

5. Math II
6. Physics I
7. Engineering Materials
8. Engineering Drawing I

2ND YEAR, 3RD SEMES.

9. Engineering Thermodynamics & Heat Transfer
10. Analytic Mechanics
11. Physics II
12. Engineering Drawing II

2ND YEAR, 4TH SEMES.

13. Mechanics of Materials I
14. Hydraulics
15. Topography
16. Electric Circuits & Electromagnets

3RD YEAR, 5TH SEMES.

17. Reinforced Concrete & Structural Steel Design I
18. Soil Mechanics
19. Technology of Construction Elements

3RD YEAR, 6TH SEMES.

21. Architectural Technology I
22. Mechanics of Materials II
23. Road and Airport Design

4TH YEAR, 7TH SEMES.

24. Town and Rural Design
25. Water Resources
26. Economic Estimation

4TH YEAR, 8TH SEMES.

27. Architectural Technology II
28. Technical Plants
29. Reinforced Concrete & Structural Design II

E-4 FINANCING PRIVATE SECTOR EXPANSION AND NEW VENTURES

Investment funds in general, and foreign exchange in particular, are in short supply in Somalia, and are among the greatest constraints to water resource development for both the private and public sectors. The supply of bank loans is considerably less than demand at prevailing interest rates. Loans are therefore rationed, and most Somali businessmen must rely primarily on their own resources and personal contacts, including members of their extended family, for investment funds. The shortage of foreign exchange is even more critical. Since there is no official supply of foreign exchange for the private sector, businessmen must make their own arrangements, which are again most likely to come from their own private network--members of which may be sending remittances from abroad or be involved in the livestock export business.

E-4.1 Funding Requirements

Most aspects of the water resource development industry require heavy capital investment. Drilling rigs, both rotary and cable tool, and heavy earth moving equipment represent a considerable investment by Somali standards. Many other material inputs (drilling consumables such as bentonite and foam, the casing and screen which go into drilled wells, and spare parts for heavy equipment) must all be imported on a regular basis, which requires regular access to foreign exchange.

Most of the private sector drillers currently in business in Somalia purchased their drilling equipment used from foreign firms which had been operating in Somalia or nearby countries. A new rig, plus a two year supply of spare parts, was quoted by one Somali businessman as costing at least $500,000. Drilling consumables and materials are acquired through WDA (when available), which charges its own CIF plus 45% to cover storage, transport and administrative costs. However, WDA has been unable to provide these materials to the private sector over the past year, as it has had insufficient supplies to cover its own force account well drilling program.

Fuel is in short and often erratic supply at official prices and is rationed. At a higher price, fuel can also be obtained on the parallel market. Wages in the private sector are considerably higher than in the public sector, but the private sector can take advantage of its ability to hire personnel on a temporary basis, thus reducing its payroll burden in times of low demand. Appendix A-1.6 and A-2.4 present direct labor, material, and fuel costs as well as overhead and capital costs associated with the well-drilling industry, and with the use of a drill rig and rotary rig, respectively.

Although it is not frequent, a fraction of well drilling activity takes place on the basis of contracts between the public and private sectors. This may go in either direction: Other

government agencies or private sector parties may request WDA well drilling services on a commercial basis; or a public sector agency may put out a contract to a private driller if WDA is too busy to perform the task itself. This would form the basis of a cooperative relationship between the public and private sectors. Under current policy, contracts between WDA and other parties follow a rigid format, with established fees set on the basis of WDA's historical average well drilling costs throughout the country and a 50% advance to the driller for mobilization. On the other hand, there may be some competition for funds and contracts between the public and private sectors. The Somali Development Bank makes abut 10% of its loans to the public sector, including parastatals. To the extent that WDA has access to foreign exchange at the official rate of about 39 So.Sh. to the dollar, they have an advantage over private sector contractors who would be lucky to finance imports at the market rate of about 85 So.Sh. to the dollar, unless they manage to obtain materials from WDA at the official rate plus 45%.

E-4.2 Sources of Funds

For the Somali private sector, the most important source of funds is from their own savings or from members of their extended families. Most successful Somali businessmen are members of families or private networks whose other members may be working abroad and sending remittances or may be involved in the livestock export business. According to current Somali law, 35% of export earnings must be changed at the official rate, but the other 65% may be kept in the exporter's foreign exchange account at the Commercial and Savings Bank of Somalia. The exporter may sell his hard currency without restriction at the "auction rate," (now over 100 So.Sh. per US dollar). The buyer, who must open a foreign exchange account and deposit his hard currency in it, can then obtain a letter of credit from the Commercial and Savings Bank for an import order. There are no longer licensing requirements for most imports. In general, the Commercial and Savings Bank would not be a source of financing for the capital requirements of the water development industry, as they provide only short-term loans of one to two years, which is too short a payback period for these investments to cover. Even for operating capital, current policy places priority on the agricultural sector, to the exclusion of industry and construction.

Medium and long-term loans (two to six years and seven to twenty years, respectively) are available at the Somali Development Bank. The Development Bank can finance up to 65% of a long-term investment at rates ranging from 14% to 16%. The money is lent in local currency, which can then be used to purchase the foreign currency needed for the actual purchase of imported equipment. The bank, in fact, approved two loans for private investment in well drilling equipment. These approvals were in support of applications for hard currency funds through USAID's Commodity Import Program. (For more on the CIP program, see Appendix E-1.3 above. The Development Bank may also finance the

drilling of individual wells, particularly irrigation wells. They may also be willing to finance wells in the livestock sector. In general, loans to the agricultural sector receive priority, both for availability of funds and in the terms of loan. Agricultural loans (including livestock) are 14% for two to six year maturity and 15% for seven to twenty year maturity loans. Loans for industry are harder to obtain, and the interest rates are 15% and 16% for medium and long term loans, respectively.

Contract advances are an important source of operating funds for private drillers. The most common arrangement is for the purchaser of well drilling services to pay 50% in advance and 50% due upon completion of the well. Prices are usually charged per meter drilled, with the purchaser bearing the risk of dry holes in southern Somalia; and the driller bearing the risk in northern Somalia. The customers usually also pay separately for the casing, screen (perforated casing), and collars for their wells. When they have their own sources, which is rare, they must obtain these from WDA.

There is considerable interest in Somalia, in both the public and private sectors, for subcontracts or joint ventures with expatriate firms as a source of finance, foreign exchange, and technical expertise. Although foreign investment in Somalia was discouraged in the past, the current climate is favorable, so long as the Somali partners are meaningful participants in the venture. Somali firms can contribute knowledge of local conditions, marketing, local currency and local expertise and labor. Specific proposals for local subcontracts in Somalia are contained in Section Two of the main body of the Draft Final Report.

Foreign aid has so far not been available for the private sector drillers, except through USAID's Commodity Import Program, and a special arrangement in the Comprehensive Groundwater Development Project (CGDP) to finance the drilling of four wells through contracts to the private sector.

Aside from the CGDP, at least two local drilling firms have obtained contracts to drill for foreign-financed agricultural development projects; and as the industry develops, may be in a position to take on more such contracts, reducing the need to bring in foreign drilling firms.

E-4.3 Framework for Economic and Financial Evaluation

Return on investment in this sector is highly variable. For investors who can obtain financing from, say the Somali Development Bank, a loan can cover 65% of the initial investment. Interest rates are 14% to 16% per annum, fixed, while WDA drilling prices have been rising at an average rate of 36% per annum since 1980 and the Consumer Price Index for Mogadishu has risen by an average of 39% per annum for the past seven years. Thus real interest rates are negative, and if private drillers can keep up

with inflation in their costs, their pre-tax return may range up to 25% to 60%, depending on availability of work and materials, market well drilling prices, and the exchange rate facing the businessmen. For examples of financial models for local well drilling firms, see Appendix A.

Current well drilling prices for most local drillers range from 2,000 to 4,000 So.Sh. per meter in the south and 4,000 to 6,500 So.Sh. per meter in the north (where geophysical and logistical difficulties are greater and where customers are unwilling to pay for dry holes). In general, most Somali businessmen are looking for a quick return on their investment, and a short payback period. Those in the water resources sector must, however, be prepared to accept longer payback periods, in the range of 5-10 years.

Although the private sector in Africa is often described as "risk averse," Somali entrepreneurs are known for their willingness to assume business risks of major proportions compared to the size of their firm or volume of activity. Well drilling is a particularly risky business in Somalia, with dry holes accounting for up to 60% of wells drilled in some parts of the country. The Somali businessman faces risks also of shortages of materials, spare parts and fuel. Transport and security add to his list of risks, so that the businessman who enters this line of work is a hearty and dauntless soul indeed. Few small businessmen bother to take out any kind of insurance and risks can only be spread or shared through individual contractual arrangement with clients or suppliers.

Most firms in Somalia cannot get credit on an unsecured basis. They are required to satisfy a lender's requirements for security before a loan is made. In the case of equipment purchase, lenders will consider the firm's expected cash flows to determine whether the company can meet a repayment schedule. To provide security for the loan, the lender will require the company to post the equipment purchased as collateral for the loan. In some cases the lender may even request additional collateral. To decide the amount of collateral, the lender will consider the marketability, life, and riskiness of the investment. Equipment used in the water industry is generally includes special purpose machines and tools and, in Somalia, may have no viable secondary market. In this instance, a lender will usually require security with a market value substantially above the amount of the loan, in the event they cannot sell the equipment for an amount to satisfy the value of the loan.

The manager of the Somali Commercial Bank in Hargeisa, Mr. Korfa, confirmed that due to a drill rig's limited marketability in Somalia, and the industry's recent performance, the bank most likely would only consider an equipment loan if a contractor were awarded a contract which would permit repayment. In addition, the successful loan applicant will have substantial expertise in his field, and an expected rate of return comfortably in excess of the

interest rate on the loan. The Somali Development Bank reports a good record from the Somali private sector.

Delinquent loans can be renegotiated if non-payment is the result of temporary circumstances beyond the borrower's control (e.g., natural disaster, drought, disease, war, etc.). Delinquency can also land the borrower in court, although it rarely goes so far. Members of the borrower's family or community, afraid that his performance will reflect poorly on them may, if they have the resources, come forward and cover his loan obligations. While such arrangements may result in the borrower repaying his loan to his new creditors, it is more likely that they will take an informal equity position in the venture, sharing in both the risks and rewards. There is no formal equity market in Somalia available to service businessmen's capital requirements.

Equity capital in the form of extended family participation is the most common among Somali businessmen. The consensus among contractors is that Somalis prefer investing their money in tangible objects such as livestock, capital assets or businesses rather than maintaining bank deposits or other paper assets. As a result, they turn to investments or investors they feel they can trust, namely, other family members.

In Somalia's cash society where tax avoidance is paramount, accurate figures of available equity capital are not available. Based on applications to the CIP program and conversations with Somali importers, equity capital is available to finance equipment purchases in the range of $100,000, figured at the market exchange rate. At the moment, very few Somali businessmen could provide equity capital in the $500,000 to $1,000,000 category needed for new equipment purchases in the drilling/construction business.

"Risk" is a major problem for the construction industry worldwide, and includes a number of types of risk, the first of which is the notoriously large fluctuation in demand faced by the industry. Other risks can broadly be grouped into three general categories as described in a 1984 publication on the Construction Industry by the World Bank. [1/]

a. **Inherent risks.** These arise from the assumptions made at the time of bidding; among them, work organization, labor and equipment productivity, procurement and expediting of materials, and weather conditions.

1/ The Construction Industry: Issues and Strategies in Developing Countries (IBRD 1984).

The ability to handle these risks depends on the experience of the manager and the estimator, the adequacy of cost control and feedback, and the quality of the information available on the site and other local conditions. The Somali drillers currently in business have many years of experience and are probably coping with these risks as well as can be expected. The two new drilling companies expected to begin operation in 1986 may have greater difficulty in assessing and adjusting to these types of risks and may therefore be at somewhat of a competitive disadvantage while they go through the learning process.

b. **Insurable risk.** Damage to property, health and life of employees, third party liability, and certain commercial risks are included in this category. Formal insurance markets in Somalia are available only through the State Insurance Company of Somalia. While the biggest of the Somali firms carry insurance, the vast majority of the smaller firms do not bother to cover themselves at all.

c. **Transferable risks.** These are conveyed to others by contractual arrangement. For instance, some production and consequential risks can be transferred to subcontractors, suppliers, and transporters. Since supply shortages are a major constraint to well completion, Somali drilling contractors routinely require the client to provide the necessary materials such as well casing, screen and pumps.

A specific transferable risk in the water industry is the risk of dry holes. In Somalia, under government contracts and in the south of the country in general, the client bears the risk of dry holes, and pays the contractor per meter drilled whether or not water is reached in a given hole. In the north of the country, however, private clients are unwilling to pay for dry holes; so the contractor bears the risk and must charge higher prices to cover it.

Insurance is available in Somalia from the State Insurance Company of Somalia (SICOS). Liability insurance is not required for contractors in Somalia for work on local contracts, nor for work on government contracts expressed in shillings. The smaller Somali firms rarely bother to insure themselves. Foreign aid funded contracts, however, require insurance and as Somali firms begin to work on such contracts, they will be introduced to the concept of buying insurance and the advantages involved.

In order to mitigate the severe fluctuations in demand and associated business risks faced by the local contractors, the WDA should attempt to contract out more to the private sector through long term contracts, planned specifically to distribute the work

more evenly across time, to fill in the valleys of private sector demand for drilling services (i.e., to provide work during or just after the rainy season when drilling demand is slack), and to distribute the work among the available drillers. However, the ability of WDA to honor long term contracts is limited by the availability of funds authorized for drilling by the Ministries of Finance and Planning. For long term WDA contracts to be considered reliable by Somali contractors and their potential financial backers, they may have to be guaranteed by a sound, external financial institution, and this guarantee in turn backed by the donor community.

More generally, the Government of Somalia can improve the business climate for the private sector by reducing distortions in factor prices (e.g., allowing interest rates to rise to positive real levels so that capital is not artificially cheap relative to labor) and decreasing control of such vital inputs as the supply of imported materials and spare parts. Foreign exchange rates and import tariffs have recently been liberalized in Somalia, and this should prove beneficial to the economy in general and the private construction industry in particular.

APPENDIX F

ACTIVITIES OF THE GOVERNMENT OF SOMALIA AFFECTING WATER RESOURCE DEVELOPMENT AND PRIVATE SECTOR PARTICIPATION

F-1 ORGANIZATIONS AND THEIR RESPONSIBILITIES

Several ministries and agencies share responsibility for water resource development. At the central government level, two organizations have key policy roles in water development: the National Water Committee and the Ministry of Mineral and Water Resources.

F-1.1 The National Water Committee

The National Water Committee, previously known as the Water Resources Development Committee, is the highest policy and decision making body in the water sector, and is the coordinating body with respect to all water resource projects. The committee is chaired by the Minister of Mineral and Water Resources.

The following ministers and heads of agencies comprise the membership of the National Water Committee:

- Minister of Mineral and Water Resources (Chairman);
- Minister of Livestock, Forestry and Range;
- Minister of the Interior;
- Minister of Agriculture;
- Minister of Health;
- General Manager, Water Development Agency; and
- National Range Agency.

This committee is responsible for national water policy, national water prices, and establishing priorities for actual water development projects. In particular, they determine, on an annual basis, WDA's rural borehole drilling program, choosing from a list of requests from rural communities, and fitting the program into the budgetary limits imposed by the Ministry of Finance.

The NWC is also responsible for setting national water prices, currently officially set at 18 So.Sh. per cubic meter throughout the country. For private individuals, there is no authorization required to sell water, but they cannot legally charge more than the established national price. It must be noted, however, that official and unofficial exceptions abound. In the dry season in rural areas, there is very little WDA can do to enforce the national policy, so actual prices paid can easily climb to 250 So.Sh. per cubic meter and above. Even some urban committees have begun to charge prices 50% higher than the official national price, although NWC has not sanctioned this.

The National Water Committee is served by an advisory National Technical Committee composed of key technical officers from the above agencies and ministries as well as expatriate advisors. This body is authorized to hold regular meetings to review information and options to be presented to the National Water Committee.

F-1.2 The Ministry of Mineral and Water Resources

The Ministry of Mineral and Water Resources (MMWR) is responsible for providing water for both human and livestock consumption. At the ministerial level of the MMWR, the primary task is to direct and monitor the activities of the WDA, Mogadishu Water Agency, the Hargeisa Water Agency and the Kismayo Water Agency. The Minister is closely involved in setting policy for utilizing water resources. The Ministry is also responsible for proposing legislation dealing with community water supply. The Ministry's Hydrology Department, which was established in 1978, is responsible for research and hydrogeological data, the design and implementation of groundwater exploration projects, and advising on water legislation and follow-up of policies. Shortages of staff, equipment and training have so far hampered the Department's effectiveness.

The three autonomous municipal water agencies of the MMWR are responsible for administration, operation and maintenance of the larger urban systems in Mogadishu, Kismayo and Hargeisa, while the Water Development Agency (WDA) has the responsibility for the other towns and rural areas under the WDA. Management often passes to local bodies once systems have been established. In addition, the Ministry of Agriculture, National Range Agency, Ministry of the Interior, and other agencies are responsible for some water projects.

F-1.3 The Water Development Agency

The WDA's original mandate included research into water resources, collection and evaluation of water resource data, preparation of comprehensive plans for the proper use of water resources, coordination of water use within Somalia through

project preparation, programming, and execution and construction of water supply facilities. This mandate was established under Law number 28 of February 28, 1971, "Governing the Water Development Agency," published in the BOLETTINO UFFICIALE on April 6, 1971. The full text of the law is presented immediately following this section.

The WDA's role was later expanded to include direct responsibility for the water supply including operation and maintenance areas and the urban centers excluding Mogadishu, Hargeisa and Kismayo. WDA's project work includes: the execution of development projects within targets laid down by the National Plan; provision of contract borehole drilling and other services on a cost reimbursable basis to third parties; and emergency programs carried out with little advance warning to meet national emergencies, such as those relating to refugees.

In addition, WDA has a mandate to regulate the activities of private sector drillers and other contractors working on private water development contracts.

The WDA is headed by a General Manager appointed by the President on the recommendation of the MMWR. The General manager is assisted by a Deputy General manager, three operational departments at Headquarters, and 16 Regional Managers located in their respective regions. The operations departments are (a) Drilling, Central Workshop and Operations and Maintenance for Rural Water Supply, (b) Engineering (for design and construction) and (c) Urban Water Supply including Operations and Maintenance. The support departments are administration, personnel and planning.[1/] The organizational chart is presented in Exhibit 1.

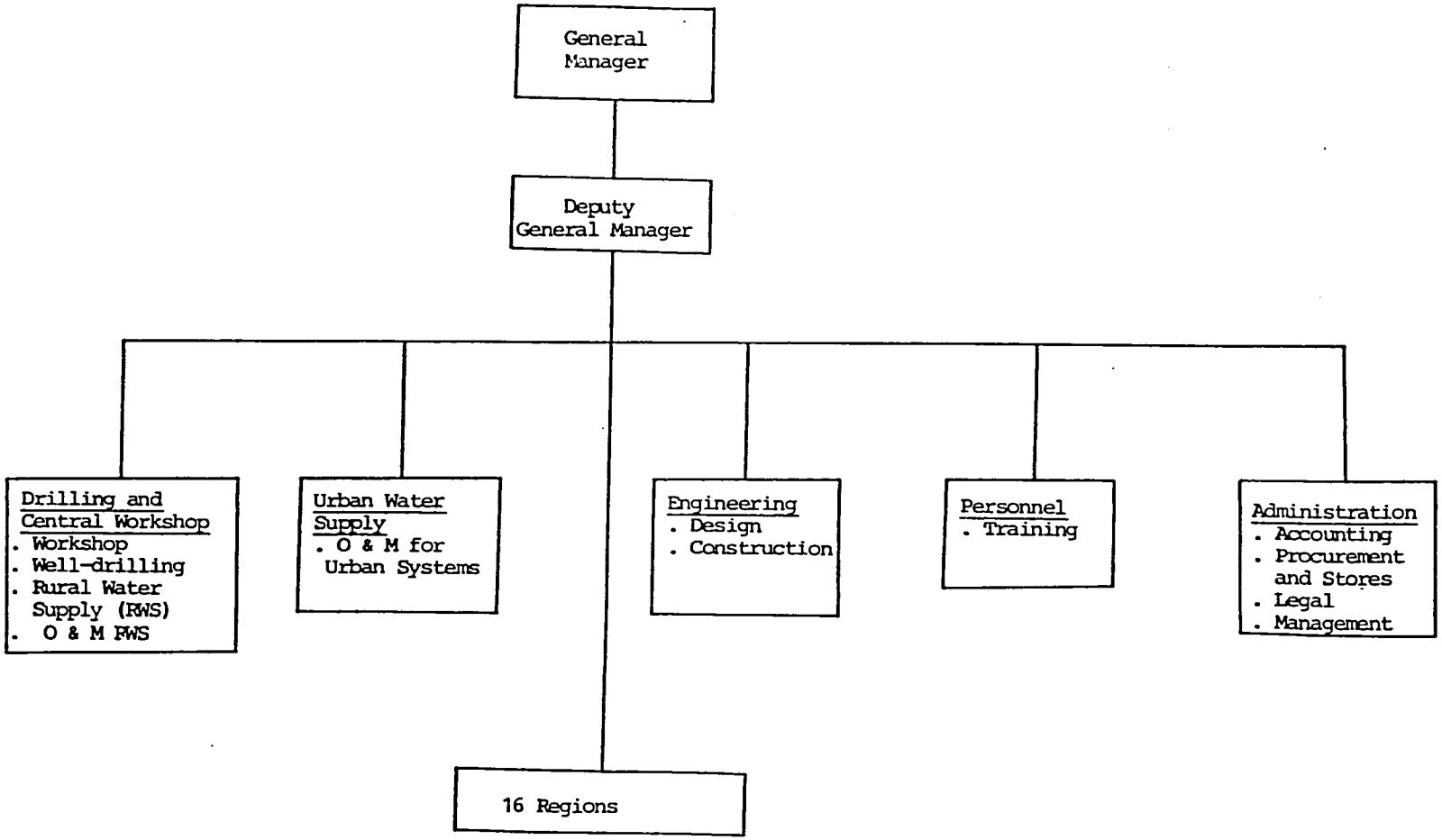
The technical and other departments are very short on personnel. WDA is partially funded through government budget and partially through revenue producing activities, such as the collection of water fees and well construction for other ministries.

WDA is affected by understaffing at the professional levels, and by factors such as its level of funding and the low pay of its staff. The Agency is supported by various external development agencies, and relies on expatriates in the planning and design of water systems.

1/ Not yet officially established

EXHIBIT F-1

ORGANIZATIONAL STRUCTURE OF THE WATER DEVELOPMENT AGENCY



1/ Plan for the Drinking Water Supply and Sanitation Decade, 1984

F-1.4 Other Agencies Involved in Water Resource Development

The **Ministry of the Interior** represents local communities' interests and itself promotes and initiates small scale water supply projects in the rural areas. Upon completion, the Ministry arranges locally for the operation and maintenance of the systems. The Ministry also performs coordinating functions, raises funds and organizes self-help labor for relevant activities, mainly at regional and district levels.

The responsibility for surface water (rivers and irrigation water) is largely with the **Ministry of Agriculture.** The **Ministry of Juba Valley Development** was recently established to regulate the development and utilization of the Juba River.

The **Ministry of Health's** responsibility is not yet well defined and its activities are constrained by a lack of trained staff. The Ministry's role includes control and surveillance over water quality, and advising on environmental and sanitation issues. The Ministry has overall responsibility for the qualitative monitoring of the sector. The Ministry is responsible for potable water quality standards. Currently, there is a lack of specific quality standards.

The **Ministry of Planning** has the responsibility of coordinating overall economic planning activities in all sectors, including water supply and sanitation. In this connection, the Ministry is responsible for coordinating donor participation and for arranging pledging conferences for external aid.

The **National Range Agency** has wide environmental protection powers. The NRA must approve the location of boreholes in rural areas and registers all rural water supplies. The NRA also takes a direct hand in constructing and maintaining rural water supply structures such as uars and ballehs, particularly for livestock watering.

Somali communities actively participate in water source development and management. Village locations are often based upon uars and other water points, and associations of users which cooperate in construction and maintenance. Individuals may be appointed to collect fees or perform minor maintenance.

Appointed local level water committees are responsible for coordinating the water related activites of several villages and hamlets. While the appointed committees may be involved in overseeing government or donor financed projects, the more localized, traditional committees have not, as a rule, considered government-controlled wells to be their responsibility, and users themselves tend to be unwilling to make contributions to maintain the government systems.

F-1.5 Laws and Regulations Governing Water Use and Development

There is still no comprehensive Water Law in Somalia defining rights to own or use water, buy or sell it, or invest in the development of water resources. An advisor from the Food and Agricultural Organization was sent to Somalia in 1982 and a draft Water Law was produced, but it has not yet been approved or put into effect. "Water Law" in Somalia is thus an unintegrated set of regulations, lacking a coherent structure and unifying purpose. Some important points of traditional custom and current law are as follows:

- The Government of Somalia does not officially recognize private ownership of wells, although by long-standing custom, a family which digs its own well or has a historical claim to a particular well can control the distribution of water from that well as community custodians. Drinking water for human consumption cannot be legally refused.

- Drinking water for immediate human consumption from any well should be free of charge; water for other purposes, including livestock watering, washing, and water carried away in containers may be sold at a price of 18 So.Sh. per cubic meter (= 1000 liters). Charges for livestock watering can be based on estimates of per-head consumption for each type of animal.

- Privately developed surface water facilities (including water intakes from rivers, reservoirs, cisterns, and ponds) are not controlled and may be privately owned. Water from these facilities may be sold, but is subject to the legal national price.

BOLLETINO OFFICIALE
LAW #28 OF FEBRUARY 20, 1971

THE PRESIDENT
OF THE SUPREME REVOLUTIONARY COUNCIL

HAVING SEEN the First Charter of the Revolution of 21st October 1969;

HAVING SEEN Law, of 1st August 1966, no. 13 concerning the Water Regulations;

HAVING SEEN Law No. 16 of 1st April 1970, Governing Autonomous Agencies and Audit of Industrial and Economical undertakings and Credit Institutions with State participation.

HAVING HEARD the Council of Secretaries;

TAKING NOTE of the approval of the Supreme Revolutionary Council;

HEREBY PROMULGATE

the following Law:

CHAPTER I

GENERAL PROVISIONS

Section 1 - Establishing Water Development Agency

Article 1
Water Development Agency

1. The Water Development Agency, hereinafter called "the Agency", is hereby established. It shall be an Autonomous Agency with juridical personality.

2. The Agency shall be subject to the provisions of the General Law governing Autonomous Agencies, Law No. 16 of 1 April 1970.

3. All moveable and immoveable properties, which at the time of coming into force of this Law belonged to the Mogadishu and Chismaio Water Agency established by Law No. 2 of 11 December 1967 and the moveable properties including equipment and vehicles, which on the aforesaid date belonged to the Water Department of the Ministry of Mineral and Water Resources are hereby transferred to the Agency.

4. The Agency shall succeed to all the rights and obligations of the Mogadishu, Chismaio, Water Agency and the Water Department in so far as they are compatible with this Law and any other provisions in force.

Article 2

Supervision of the Agency

1. The Agency shall function under the supervision of the Secretary of State for Mineral and Water Resources.

2. The Secretary of State for Mineral and Water Resources may give the Agency such directives as he may consider necessary from time to time in order to ensure that it acts in accordance with the best interest of the State.

Article 3

The Agency shall have its Head Office in Mogadishu and may establish branches in other places in the Republic.

Article 4

Purposes

1. The main purpose of the Agency shall be the development of water resources within the territory of the Republic.

2. In furthering said purpose, the Agency shall promote:

(a) the research of the necessary water resources;
(b) the construction of aqueducts, water networks and distribution facilities;
(c) the collection and the evaluation of all data relating to water resources and the potential thereof in the territory of the Somali Democratic Republic;
(d) the development of research and studies in the field of water resources;
(e) the preparation of comprehensive plans for the proper use of water resources;
(f) the preparation, programming and execution of projects relating to water resources, in order to coordinate the use of water within the territory of the Republic;
(g) the stipulation of contracts, conventions and agreements necessary to such end;
(h) the provision of spare parts necessary for water plants of the various Local Governments;

(i) the training of the subordinate technical and clerical personnel, in order to ensure the maximum efficiency of all service;
(j) the determination of the cost of water facilities realized for the single Administrations of the local governments and the charging thereof to said Administrations;
(k) the reimbursement of loans obtained from the State, the Public Agencies and national or foreign credit institutions.

Article 5

General Powers

1. The Agency shall have all the powers necessary for the achievement of its objectives under this Law or any other law.

2. Notwithstanding the generality of the above provision, the Agency may use public or private right of way or public utility easements for the purposes of research and construction operations.

3. The Agency may obtain permits required for research and construction referred to in paragraph 2 of this Article, from the respective local governments.

Article 6

Rights to expense reimbursement

The Agency, where deemed appropriate shall exact from the single Municipal Administrations the reimbursement of the expenses incurred in for the realization of the water facilities built, and also for services rendered in connection therewith.

Article 7

Power to hand over completed works to appropriate authorities

The Agency must hand over completed water works, water points and related facilities to the appropriate Municipal Administration for their operations and maintenance.

CHAPTER II

ORGANIZATION

Section 1 - General Manager

Article 8

Appointment

The General Manager of the Agency shall be appointed by decree of the President of the Supreme Revolutionary Council, on the proposal of the Secretary of State for Mineral and Water Resources having heard the Council of Secretaries.

Article 9

Emoluments

The emoluments of the General Manager of the Agency shall be established by decree of the President of the Supreme Revolutionary Council, on the proposal of the Secretary of State for Mineral and Water Resources having heard the Council of Secretaries.

Article 10

Functions

1. The General Manager shall be the executive head of the Agency and shall represent it.

2. He may conclude operating contracts on behalf of the Agency.

3. He shall be responsible for the funds of the Agency and for the maintenance of its accounts.

4. In case of temporary absence or impediment, his functions shall be performed by an official of the Agency designated by the Secretary of State for Mineral and Water Resources.

Section 2 - Staff

Article 11

Staff

1. The Agency may appoint the staff required by it, provided that while establishing the staff requirements the Agency shall absorb all suitable personnel currently employed by the Water Department of the Ministry and Water Resources.

2. No person, who has directly or indirectly any interest in a contract or contract of sale or lease with the Agency or in any work for the Agency, may become or remain a member of the Agency's staff.

3. The terms and conditions of services of the members of the staff of the Agency shall, subject to any general rules governing the terms and conditions of service of the staff of autonomous agencies issued by Government, be established in the Regulations.

CHAPTER III

FINANCIAL PROVISIONS

Article 12

Patrimony

The patrimony of the Agency shall be:

(a) an initial contribution made by the State;

(b) any other contribution made by the State, or public or private bodies;

(c) the income from realized water works and various services;

(d) the assets of the Mogadishu Water Agency and the Water Department of the Ministry of Mineral and Water Resources, which are transferred to the Agency under Article 1 of this Law.

Article 13

Reserves

1. The Agency may set aside reserves for its operations.

2. Except the Government disposes otherwise the reserves set aside for depreciation may be utilized only for the expansion or replacement of the Agency's plants and facilities.

3. The Regulations shall specify the use to which reserves other than those set apart for depreciation may be put.

4. Reserves may, without jeopardizing the Agency's ability to meet its cash requirements, be invested on a long term or short term basis only in Government credit institutions or Government securities.

Article 14

Authorized loans

The Agency may, for purposes of its activity, obtain loans from financial institutions within the Republic and abroad, with the prior approval of the Secretary of State for Mineral and Water Resources.

Article 15

Financial year

The financial year for the Agency shall begin on 1st January and end on 31st December.

Article 16

Budget

The General Manager shall, not later than 30th September in each year, prepare a statement to be called the Annual Budget Statement for the next financial year, showing the estimated receipts and expenditure of the Agency. The Annual Budget Statement shall be submitted to the Ministry of Mineral and Water Resources and the Ministry of Finance.

Article 17

Annual Accounts

1. Within 31st March in each year, the General Manager shall prepare the annual accounts, profit and loss statement of the Agency, and shall submit them to the Ministry of Mineral and Water Resources and the Ministry of Finance.

2. The Secretary of State for Mineral and Water Resources shall, in consultation with the Secretary of State for Finance, be competent to approve the annual accounts and shall give instructions for their publication at the expense of the Agency.

Article 18

Accounts

The accounts of the Agency shall be maintained in the manner prescribed by any general rules issued by Government for the purpose and by its Regulations.

Article 19

Audit

The accounts of the Agency shall be audited by the separate unit established in the Office of the Magistrate of Accounts for the purpose of auditing Autonomous Agencies.

Article 20

Exemption from taxation

Neither the Government nor any other entity within the Republic shall subject the Agency to any taxes, fees, charges or levies of any kind including any tax, fee, charge or levy for the removal of underground water for the Agency's system, on the Agency's properties or revenues, or on the purchase or use of water supplied to the Agency.

CHAPTER IV

FINAL DIVISIONS

Article 21

Regulations

The Regulations of the Agency shall be issued by decree of the President of the Supreme Revolutionary Council, on the proposal of the Secretary of State for Mineral and Water Resources.

Article 22

Internal rules

Internal rules of the Agency may, subject to this Law and Regulations, be issued by the General Manager. The said internal rules shall be transmitted to the Secretary of State for Mineral and Water Resources who may, if he deems it necessary, return them for reconsideration and modification.

Article 23

Repeal

Law No. 2 of 11 December 1967 on the establishment of the Mogadishu Water Agency and Water Law No. 13 of 7 August 1966 are hereby repealed.

Article 24

English text to prevail

Where there is any conflict between the English and Italian texts, the English text shall prevail.

Article 25

Entry into force

1. This Law will come into force on the 1st of May 1971 and will be published in the Official Bulletin of the Somali Democratic Republic.

2. All persons shall be obliged to observe it, and cause others to observe it, as a Law of the Republic.

Mogadiscio, 20 February, 1971.

Major General Mohamed Siad Barre

PRESIDENT

of the Supreme Revolutionary Council

F-2 GOVERNMENT CONTRACTING WITH THE PRIVATE SECTOR

This section discusses the current volume of activity, policies, and procedures for government contracting in the water industry and in related industries; and it discusses options for future development of government contracting to the private sector.

F-2.1 Volume of Activity

Aside from its force account well drilling program, which has an emphasis on boreholes in rural areas, WDA has established contracting procedures whereby the agency can either undertake work on behalf of public or private customers, or contract out work to private sector firms. Legally, as the agency responsible for all well drilling in the country, WDA has a practical right of first refusal on all well drilling (and related construction, operation and maintenance) in Somalia. In particular, WDA is expected to drill all wells required by other public agencies. Private drillers are licensed by WDA, and permission must be obtained from WDA for each well drilled.

WDA records show that at least eighteen wells were drilled under contract between WDA and other parties from 1978 through 1984, although the great majority have been contracts between WDA and other public sector agencies or parastatal corporations. A summary of each of the contracts, and full translations of two representative contracts are presented immediately following this section. In general, WDA only considers contracting out when it is too busy to complete all its assignments on schedule.

On two occasions in 1984, WDA concluded contracts with established local private drillers, engaging these drillers to complete work originally assigned to WDA. On at least one other occasion, WDA was prepared to rent one of its drill rigs to a private firm for use on a contract well construction project. This action required and received Presidential approval, but the firm declined the opportunity after inspecting the rig.

In addition, the WDA has arranged some contracts for well operation and revenue collection, one of which is in the town of Balad. The contractor must charge the official price of water, and share the revenues with WDA.

These contracts between WDA and private firms are of recent vintage and have been satisfactory to both parties; thus there is every chance that such relationships will continue to take place in the future. However, the WDA's use of a fixed price per meter in all its drilling contracts has limited the private sector's interest in them, as discussed in the section on "Policies," below.

For Civil Works, WDA sometimes does the work itself, but more often contracts the work out, particularly if the Agency is lacking in the necessary materials. The WDA's engineering department is responsible for designs and cost estimates. Civil works for a standard well are costed at 600,000 So.Sh., (though this may be under review soon) and each public fountain in urban systems is costed at 350,000 So.Sh.

F-2.2 Contracting Policies

For all government contracts over 50,000 So.Sh. in value, applications must go through the "Contracting and Control of Hard Currency Committee" (a government procurement agency which serves the entire central government). They publish the tenders in the domestic and/or international press, requesting submission of bids, which they then receive and evaluate.

For activities which fall exclusively and entirely under the responsibility of the WDA (e.g., rural well drilling services), WDA can undertake its own tendering, so long as it follows the same procedures.

WDA is most likely to contract out drilling of a well when it is for another government agency (rather than one of its force account rural wells) and when its own resources are fully committed. WDA can either (a) release the agency to make its own contract with a private firm and issue a license for that activity, or (b) subcontract the work to the private firm. WDA more frequently follows the former procedure.

Both for contracts in which WDA is the driller and in which WDA is the client, the agency has a fixed price per meter based on its historical average drilling and well development cost, regardless of the well site, logistical difficulties, or geological formation to be drilled. In 1978, this was set at about 400 So.Sh. per meter. The price was raised to 1,000 So.Sh. per meter in 1982 and to 2,000 So.Sh. per meter in late 1984; reflecting (but probably lagging behind) inflation and successive devaluations of the currency. Because of this, private drillers have been reluctant to respond to WDA tenders, unless the contract was for drilling a relatively low-cost well.

On the other hand, a compensating advantage to WDA's contract policies is that the price is paid per meter drilled whether or not the well yields water. The contract will set an agreed maximum depth; if at that depth, there is no water, the contractor will still be paid. If water is reached before the agreed maximum depth, the contractor is paid according to the actual depth. These policies place the burden of the risk of dry holes on WDA, which is a considerable advantage to the small

drilling firms. This practice, in turn, has set the industry standard, at least in the south of the country: private customers are also expected to bear the burden of risk. In northern Somalia, however, private clients are less willing to accept this provision, and will pay only for a productive well. Partly to cover the contractor's risks, therefore, per meter prices in the north are substantially higher than those in the south.

There is a time limit stipulated in each contract for well completion. WDA pays an advance of 50% of the contract value to the contractor to enable equipment to be mobilized and to provide working capital; and 50% upon completion of the well, although there have been complaints from the private drillers of tardy payments. Private contractors are subject to a 3% registration tax, a 2% stamp tax, and 11% income tax on their earnings.

WDA is the source of most necessary materials for drilling, including imported materials for both public projects and private wells. WDA, as a client in drilling contracts, directly supplies the materials for all wells contracted out to the private sector. Private clients are usually responsible for obtaining materials for their wells - frequently these are also purchased at WDA (if the agency has a surplus).

Contractor selection takes place among those private drillers who have responded to a WDA tender. There is little scope for price competition, although minor fees such as pump installation, testing, and cleaning may vary. Contracts are more likely to be awarded on the basis of established reputation. Realistically, WDA may have very few responses from which to choose.

The contractor is required to submit well logs containing information on well location (coordinates and elevation), well diameter, the screen diameter, length, depth, and type, the casing diameter, gravel packing (if any), geological/lithological strata encountered, aquifer type, and geophysical log.

At the Kismayo Water Agency, each of their twenty public fountains is operated by a private contractor. The operator is given a two year contract, renewable. The operator must charge for water at the rate of 25 So.Sh. per cubic meter. He keeps a percent, (about 35% on average) and gives the rest to KWA.

The contractor is responsible for cleaning, maintaining (including such duties as purchasing new valves and other small items), and painting the fountain and its enclosure. Contractors are free to subcontract their maintenance activities. The KWA is responsible for maintaining everything outside the enclosure.

KWA tenders these contracts and awards contracts on the basis of price (figured primarily on the basis of the lowest bid percentage of off-take, given the fixed price of water).

The government of Somalia currently has no bonding requirements associated with its own local currency contracts; but for government contracts involving foreign currency, such as those financed by foreign lending, Somali contractors must put up a performance bond in Somali Shillings. For World Bank-sponsored projects, this amounts to 10% of the contract value; the EEC sponsored contracts, 2%. Government advances 50% of the contract value at the commencement of the contract, which must be covered 100% with a bond or guarantee of repayment.

The unit price type contract favored by the WDA is a reasonable compromise between the need to share risk between contractor and client and the need to include incentives for cost reduction. Alternatives exist on both ends of the compromise. They include:

- Cost Plus Fixed Fee (CPFF), wherein the contractor is reimbursed for all costs associated with the project and receives a fixed fee for the service of carrying it out. This type of contract, however, builds in very few incentives for keeping costs down and requires reasonably high standards of record-keeping.

- Lump-Sum Contract, which provides a fixed sum for an agreed upon task, wherein the contractor bears the entire risk of cost-overruns and complications.

One possible improvement on the existing unit-price contract practice may be to allow the private drilling firms to compete explicitly on the basis of price per meter, assuming the location and probable geological formations involved are known. WDA would be obliged to award the contract to the firm with the lowest bid, unless there was evidence that the quality of work and/or time requirements of a particular firm were likely to be sub-standard. The contract would require the contractor to submit a well log for each well, reporting on the specifics of the well and materials used, as is currently the case; and WDA should make a habit of on-site inspections to verify the data.

WDA planning with regard to use of private contractor services is minimal. There is no official register of contractors, as there are very few drilling contractors in the country, and no pre-qualification process before tendering. Contracts are tendered on a well by well basis, and there have been no multiple well, long term contracts offered to the local private drillers.

This means that contracts may bunch up, and contractors may face a series of peaks and valleys in government contracting. This makes contractors' planning difficult and hampers their ability to gain the confidence of commercial lenders.

Multiple well contracts would be extremely valuable to private drillers, as they would remove some of the risk involved in investment decisions, and would assist the firms in obtaining finance for major investments.

It may be desirable first for WDA to establish a classified register of contractors, with firms categorized by the size of the contract they are capable of handling. A more important prerequisite would be guaranteed availability of funds and materials. Given the constraints WDA itself faces in this regard, such long term contracts might only be feasible in conjunction with foreign aid projects or direct foreign aid to support government contracting to the private sector. This could take place under a guarantee mechanism administered by an international financial institution, backed by foreign donors. While donor or counterpart funds would be used to pay local private drillers through WDA, WDA could receive technical assistance in contract administration and supervision. This is discussed further in Section Two of the main body of the Draft Final Report.

Such long term contracts would go well in conjunction with the establishment of an Equipment Finance Corporation (FinEquip) for heavy equipment. In fact, it can only be expected that any financial institution will be reluctant to extend financing to a small contractor in the absence of firm guarantees of long term contracts drilling contracts. In all probability, negotiations on long term contracts through WDA and negotiations on equipment finance services will have to proceed in step and be concluded together.

F-2.3 Contracting Procedures

Administration of contracts with WDA is quite simple, as are the contracts themselves. The complications of change orders and escalation are not included in the contracts, and may account, in part, for the lack of private sector interest in them. In the future as contracting takes place more frequently, with a greater degree of competition, and especially as they begin to cover long term agreements, these elements will have to be included. Escalation, in particular, will be a problem for long term contracts: It is needed in countries with high inflation rates, as contractors will otherwise be obliged to anticipate the risk of inflation and price their services to cover it. On the other hand, there is potential for abuse of escalation clauses

unless carefully monitored. Government contracts in many countries establish, for different aspects of the service contract (e.g., labor, fuel, imported materials, etc.), escalation formulas connected with the appropriate price indices.

Another problem which needs to be addressed in Somalia is how to provide compensation for delays in payment, a complaint which has already been heard from Somalia's private contractors. One possible model can be found in Peru's contracting procedures: contracts stipulate the accrual of commercial interest on delayed payment and have, since their incorporation in most government contracts, succeeded in discouraging tardy payment.

For contract supervision, assistance to the contractor, and to help avoid contract disputes, the World Bank has suggested that government clients appoint a trusted resident engineer with authority to resolve on-site construction problems. But beyond that, procedures for the settlement of contract disputes must be established. Currently, WDA can declare any of its contracting decisions "final". Alternatively, they can also conduct an investigation and either change their decision, or issue a report that would contain a written explanation of the basis of their decision. While there is not yet enough contracting activity in Somalia to warrant a special Claims Court, WDA will soon need a separate contract adjudication office to handle questions and disputes concerning its contracts; this office should be independent of any office which makes the contracts.

F-2.4 Potential for Public Utility Pricing in Somalia

In general, given the nature of the water and drilling markets in Somalia, coupled with the country's extreme sensitivity for national economic security, it will probably be necessary for Somalia to design an explicit Public Utility Pricing Policy.

For public supplies of groundwater, the fixed costs of drilling a well, installing a pump, and constructing civil works is extremely high compared to the marginal costs of providing water (mostly fuel and labor) once the well is in place. This situation gives rise to declining costs, with long run marginal costs below long run average costs. Marginal cost pricing under these circumstances brings about losses to the enterprise, as the initial investment costs cannot be covered. Uncontrolled, this could lead to a near monopoly situation: If one investor enters a market (in the water market, a geographic/demographic service area), other investors may not want to enter and begin competition with an established enterprise, for fear of a mutually destructive price war. The first (and perhaps only) investor may then be able to charge monopoly prices. Although undesirable in some respects, this may still be preferable to the alternative of no investment at all in a given market.

A roughly similar situation might be found in the drilling market. There are few Somali drilling firms (six to eight in the entire country, outside government agencies), most are small firms with one or two rigs. They face relatively high fixed costs in their initial investment in drilling rigs and other heavy equipment and relatively lower per-well costs in the form of labor, fuel, drilling fluid, and spares. If they have no guarantees of constant work for each of their rigs over the useful lives of those rigs, they will probably be subject to operation on the declining costs portion of their cost curve, where marginal costs are below average costs. If demand is strong enough to force marginal cost pricing, then some firms could face a loss, and be driven out of business. Small firms might find the high initial investment, with uncertain contracts in a field controlled by a government agency, a strong barrier to entry.

Government (and/or foreign) nurturing of such an industry could try to assure:

- an adequate return on investment, including depreciation of equipment, probably through long-term, multiple-well contracts;
- fair prices for consumers, through competition among firms for all contracts, both short and long term;
- protection from unregulated competitors, (including government agencies).

For the long run development of the industry, the situation in Somalia will probably require a generally cooperative relationship between WDA and at least some of the private drillers and other contractors. A climate of strong competition among all private drillers will probably have to await a considerable increase in the overall size of the market, sufficient to allow each firm to operate its equipment at close to capacity, a situation which seems unlikely to arise within the next five years.

EXHIBIT F-2

WDA CONTRACTS
(SUMMARY)

1. Contract between WDA and Local Government to drill a well for Local Government by WDA 10/3/85.

   2000 So.Sh. X 120m Total 811,000/=

2. Contract between WDA and China Jiangzu Int'l, to drill a well for China Jiangzu Int'l by WDA 22/11/84.

   2000 So.Sh. X 150m = Total 848,000/=

3. Contract between WDA and National Drilling to drill a well for WDA by National Drilling 1/3/84.

   1000 So.Sh. X 200m Total 254,000/=

4. Contract between WDA and Horn of Africa to drill a well for WDA by Horn of Africa 4/3/84.

   1000 So.Sh. X 130m Total 313,000/=

5. Contract between WDA and National Petroleum Agency to drill a well for National Petroleum Agency by WDA 27/2/84.

   1000 So.Sh. X 130m Total 701,000/=

6. Contract between WDA and Settlement Development Agency to drill a well for Settlement Development Agency by WDA 22/3/83.

   1000 So.Sh. X 80m Total 381,000/=

7. Contract between WDA and Custodial Corps to drill a well for Custodial Corps by WDA 22/2/83.

   1000 So.Sh. X 130m Total 243,000/=

8. Contract between WDA and Somali Socialist Party to drill a well for Somali Socialist Party by WDA 21/12/82.

   1000 So.Sh. X 150m Total 536,000/=

9. Contract between WDA and Italian Program for Refugees to drill a well for Italian Refugee Program by WDA 18/12/82.

   1000 So.Sh. X 20m Total 83,000/=

10. Contract between WDA and Somali construction Agency to drill two wells for Somali Construction Agency by WDA 24/11/82.

1000 SoSh. X 130m Total 972,000/=

11. Contract between WDA and Italian Program for refugees to drill a well for Italian Program for Refugees by WDA 13/8/82.

1000 So.Sh. X 20m Total 134,000/=

12. Contract between WDA and Ministry of Youth and Sports to drill a well for Ministry of Sports by WDA 13/3/82.

1000 So.Sh. X 120m Total 271,000/=

13. Contract between WDA and Somali Construction Agency to drill a well for Somalia Construction Agency by WDA 9/9/82.

1000 So.Sh. X 130m Total

14. Contract between WDA and Qadi Company to drill a well for the company by WDA 26/4/81.

430 So.Sh. X 140m Total 165,300/=

15. Contract between WDA and Ministry of Defense to drill a well for the Ministry by WDA 8/12/81.

300 So.Sh. X 360m Total 227,000/=

16. Contract between WDA and Ministry of Rural Development to drill a well for the Ministry by WDA 28/12/80.

430 So.Sh. X 130m Total 689,303/=

17. Contract between WDA Ban-Geele Project to drill a well for the Project by WDA 1/1/80.

430 So.Sh. X 130m Total 213,734/=

18. Contract between WDA and Ministry of Defense to drill a well for the Ministry by WDA 3/9/78.

400 So.Sh. X 300m Total 383,118/=

EXHIBIT F-3

SOMALI DEMOCRATIC REPUBLIC

WATER DEVELOPMENT AGENCY
(CONTRACT)

10/3/1985
Mogadishu

Water Development Agency, when abbreviated "the Agency" and "Mogadishu Local Government Industry and Commerce Department" made a contract for drilling one well for the New Mode factory of the Local Government, on 10/3/1985:

1. The Agency is requested to drill a well of 120m for the Local Government.

2. The two parties have agreed to the cost of the well as follows:

a)	Drilling meters	2,000 X 120m	= So.Sh.	240,000
b)	Casing Meters	2,000 X 100m	= " "	200,000
c)	Screen Meters	7,000 X 20m	= " "	140,000
d)	Gravel-Loads	12,000 X 2L	= " "	29,000
e)	Rig Installation & Transport		= " "	60,000
f)	Survey, cleaning, & testing		= " "	57,000
g)	Bentonite		= " "	40,000
h)	Pipes 2" (b meters)	2,500 X 20m	= " "	50,000
	T O T A L		So.Sh.	811,000

3. The Local Government promises payment as soon as this contract is signed.

4. The Agency's responsibility is to complete and finish this well's work in accordance with the measurement.

5. The Agency will start work after receiving 50% of this contract which is 405,000 So.Sh.

6. Those items which are not included in the contract but will be used for the execution of the well (such as the motor pump) will be brought by Local Government.

7. Any unforeseen natural disaster which hinders the smooth running of the operation is not the responsibility of the Agency and related expenses will be paid for by the Local Government.

8. Any poor workmanship or technical error will be the Agency's responsibility.

9. The Local Government will write a letter of its Agent and assume responsibility after the completion of the well.

10. If a dispute arises between the parties, a technical committee will be nominated to clarify the issue.

11. The well will be dug at the New Factory premises.

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EXHIBIT F-4

SOMALI DEMOCRATIC REPUBLIC
WATER DEVELOPMENT AGENCY CONTRACT

Water Development Agency, abbreviated "The Agency", and Company A signed a contract this date 6/2/84, the object of the contract is that Company A drills a well in which the Agency had a previous drilling contract with the Ministry of Post and Telecommunications, Hareeri Aadle station.

ARTICLE 1

The agreed depth of the well is 180 meters.

ARTICLE 2

The agreed amount for which the company will execute the work is 232,000 So.Sh., and is as follows:

1.	Drilling meters	1000 X 180m = So.Sh.	180,000
2.	Casing & Screen Instal.		
3.	Rig Movement/Install		
4.	Well Cleaning		
5.	Testing		
6.	Transport & Equipment		
7.	Pump Installations		
	T O T A L		So. Sh. 232,000

ARTICLE 3

The period for completing the well will be 20 days, starting the date on which the advance payment is made to the company drilling the well.

ARTICLE 4

If the company couldn't finish in the said period of time an amount of 5% will be deducted from the original amount unless there is a reasonable excuse such as a natural disaster.

ARTICLE 5

The agreed amount which is 232,000 So.Sh. (two hundred thirty-two thousand) will be paid as follows:

1. 50% advance

2. 50% after completion of the well and turnover stage.

ARTICLE 6

If the well doesn't function due to poor workmanship from the company side, it will be the responsibility of the company to drill another well, but if it is of natural cause the company will receive its full amount as agreed.

ARTICLE 7

As indicated in Article 6, if the Company does not reach the required depth of the well, appropriate payment will be paid to the Company.

ARTICLE 8

If water is reached before the said depth of 200m the Company will receive payment according to the meter where the water was reached.

ARTICLE 9

Equipment for the well such as casing and screen will be supplied by the Water Development Agency; the pump and, if needed, a motor will be supplied by Ministry of Post and Telecommunications; installation and organization will be carried out by the Company.

ARTICLE 10

The company is required to submit the following reports (conditions) regarding the well as soon as it is completed:

1. Location coordinates
2. Water analysis/chemical, conductivity, etc.
3. Elevation
4. Well diameter
5. Geological/Lithological
6. Screen diameter, length, depth & type
7. Aquifer type
8. Casing diameter
9. Geophysical Log
10. Gravel Packing, if any.

Also it is required from the Company to submit generally the hydrogeological data from the well for checking.

ARTICLE 11

Stamp duty relating to this contract will be paid by Company A's representative.

SIGNED BY

COMPANY A GENERAL MANAGER, WDA

F-3 SUMMARY OF FOREIGN AID PROJECTS CONCERNED WITH WATER RESOURCE DEVELOPMENT

This appendix offers a brief description of recent, on-going, and pending large-scale technical assistance projects related to water resource development in Somalia. The information provided concerns only the water development aspects of the projects, and should not be considered a comprehensive summary of any project. Nor should this list be considered exhaustive, as there are numerous small-scale self-help projects that deal with, among other concerns, local water supplies. Some of these project representatives could not be contacted by the consultants.

Urban Water Supply I funded by the Federal Republic of Germany, provided municipal water supply systems in Burao, Afgoi, Balad, Jowhar, and Merca. Drilling was executed by GKW and administered by GTZ from 1981-1983. They drilled two production wells in Balad and three in each of the other towns. The civil works (including water tanks, power stations, 25-40 public fountains in each town, and 250-360 new household connections in each town) were done by Saarburg Interplan under the design and supervision of GKW. That work was completed in 1983.

Urban Water Supply II wells were drilled by WILD in 1981 and 1982 under the design and supervision of GKW. One well was drilled in Dusa Mareb, two wells each in Galkayo, Garoe, and Gardo, and three wells in Erigavo. Civil Works construction will begin in late 1985 or early 1986. The plan is for 20-50 public taps in each town and 170-250 individual household connections.

Urban Water Supply III will provide municipal systems to the towns of Bardera, Lug, Brava, Hodua, Bulo Burti, El Bur, and Beletweine. Work is scheduled to begin in 1988.

Support to WDA/Urban Water Supply Project is provided by GTZ as a follow-up to the three urban Water Supply projects described above. The focus is on operation and maintenance of the municipal water systems. They plan to form a mobile workshop unit for maintenance and to provide training to WDA employees in maintenance procedures. They will also assist the WDA Chief Accountant in establishing efficient revenue collection, materials distribution, and operations control procedures using materials developed by Coopers and Lybrand Associates. Currently, this project is working with the towns involved in the Water Supply I project.

Mogadishu Second Water Supply Project funded by the World Bank, EEC, and Arab Development Fund, drilled eight new production wells in 1981 and 1982 to expand the Mogadishu water supply

system. The drilling was done by Mowlen. For the next phase of the project (1981-1984), Kampihl, a Danish consortium, drilled 40 wells (24 production wells). Their work also included construction of pipelines, pumping stations, and a reservoir.

The Comprehensive Groundwater Development Project funded by USAID and executed by Louis Berger International, Inc. and Roscoe Moss Co. develops groundwater resources for human and animal consumption in the Bay Region and the Central Rangelands of Somalia. It also aims to improve the hydrogeological, planning, and drilling capabilities of WDA. The project drilled 21 wells in 1982 (of which 9 were production wells and the rest exploratory in nature), 33 wells in 1983 (10 production wells), and 27 wells in 1984 (17 production wells). The project expects to drill 10 to 20 wells in 1985. Civil works are simple: 19 of the wells have diesel pumps, water tanks (45 cubic meter capacity), watering troughs, and a structure supporting 4 public taps. Seven of the wells have simple hand pumps, and one has a windmill driven pump.

Northwest Water Supply is funded by Unicef and will provide a variety of water supply systems. For 1985, the plans included 4 deep drilled wells (using a WDA rig), 24 new protected shallow hand dug wells, 16 improved shallow wells, 4 re-excavated ballehs, and 5 experimental burkeds of 100-300 cubic meter capacity. By the end of the project, there will be a total of 60 dug wells, 30 improved catchment facilities, 5 subsurface dams, 20 new solar pumps and 500 handpumps. Unicef will also provide a substantial amount of technical training in operation and maintenance of the water systems. The personnel will be recruited locally by WDA and become WDA employees. Unicef will also supply maintenance tools and spare parts.

Hargeisa Water Supply funded and executed by the People's Republic of China, is about to begin its second phase. In the first phase, they drilled 6 production wells, which supplied about 4000 cubic meters per day. The drilling was done with Chinese equipment and Chinese drillers. They are now planning to double the capacity with six more wells, which are scheduled to be drilled within the next two years. Civil works structures include a 150 cubic meter capacity water tank, two booster stations, and 20 kilometers of 300 mm diameter pipe.

Rural Water Supply in North East Somalia is also a project of the People's Republic of China. They are currently working in the Togdheer region, where they have drilled 12 wells (of which 8 are production wells). These wells are each producing 20-200 cubic meters per day. They plan to drill three wells in Nugal, two or three in Bari, and six in Sanag. The wells are intended

primarily for livestock watering, so the surface structures are rudimentary. Each well has a pump house and a generator, a water storage tank, and cement watering troughs. The Somali government is responsible for providing the pumps and generators, which they will import from the United Kingdom and Italy.

The **Rural Water Supply Project** funded by Saudi Arabia and executed by GTZ, will drill a total of 39 production wells in the regions of Gedo (8 wells), Bakol (10), Hiran (6), Mudug (8), and Galgadud (7). The water will probably be used for both human and livestock consumption. Drilling by WILD began in 1984 and is expected to be completed by the end of 1986. Civil works will be done by Saarburg Interplan. Major inputs include imported Italian turbine pumps with a capacity of 12 cubic meters per hour and plastic/fiberglass storage water storage tanks imported from Japan of 20 to 50 cubic meters capacity. Technical training for WDA employees in operation and maintenance is part of the project, with GTZ responsible for the maintenance for one year after the completion of each well.

Berbera Water System Expansion is an Italian aid project. They will not be drilling any new wells, but will expand the storage and distribution capacity of the system. They will build a new 4,000 cubic meter reservoir to supplement the existing 3,000 cubic meter one, and install 18 new public fountains and 21 emergency hydrants. Distribution capacity will increase from 20 liters per second to 50 liters per second. This should expand the numbers of people and livestock served from 40,000 people to 60,000 people and 80,000 livestock units. The work will be done by Edilter, of Italy; and most of the inputs will be imported from Italy.

Rehabilitation of Rural Water Reservoirs is an FAO project implemented through the National Range Agency. The 33 existing subsurface earth reservoirs (uars) involved have a range of 20,000-25,000 cubic meter capacity. Rehabilitation will include desilting the reservoirs, and building or replacing the above-ground water storage tanks. The water is pumped from the reservoirs into the tanks with diesel pumps (imported from Italy). From there, the water flows into water troughs for livestock watering. The project includes technical assistance in basic operation of the facilities, maintenance mechanics, and civil construction. The reservoirs are under the authority of the National Range Agency.

The Refugee Water Supply Project executed by Unicef in cooperation with WDA, drilled 24 production wells in 1981 and 14 production wells in 1982 for the refugee camps. In addition, they constructed 40 water tanks, and installed 800 public taps and 100 handpumps. Following the well drilling program, the rigs were turned over to WDA.

In addition to the completed and on-going projects described above, there are plans for the Japanese to drill four new wells and rehabilitate 25 others for the Mogadishu-area water supply system.

Other Foreign Aid projects which include water resource development components are the Central Rangelands Development Project, which is developing surface water catchment systems, and the various refugee relief and rural self-reliance projects sponsored by UNHCR, Unicef, WHO, bilteral agencies and associated private voluntary organizations: Ecumenical Relief and Development Group for Somalia, Trans Century, Oxfam, Care, Africare, Save the Children, the Belgian Survival Fund, the American Friends Service Committee, and others. These are implemented through the National Refugee Commission or the Ministry of the Interior.

Foreign assisted irrigation projects include Improvement of Grapefruit Production, the North West Region Agricultural Development project, Afgoi-Mordile Irrigation project, and the Jenali-Bulo Morerta Irrigation project.

F-4 GOVERNMENT SUPPORT OF THE PRIVATE SECTOR

Under past government policy in Somalia, the domestic private sector received very little support from government agencies. A Chamber of Commerce exists, but has been controlled by the government; the formal economy has been intended to run under the direction of central planning, and the government has been directly involved in the production and distribution of such diverse goods and services as spaghetti and cigarettes as well as drilling and civil works construction.

In 1982, Eliot Berg Associates produced a study on the private sector in Somalia, and recommended wide-ranging privatization of economic activities then in the hands of the government in order to achieve more efficient production of goods and services by taking advantage of typical private sector incentives. This was followed by a USAID study of the entire civil service in Somalia, which also recommended extensive privatization in order to reduce government expenditure by eliminating redundant workers from the government payroll. In principal, these recommendations have been approved by the government of Somalia, although practical steps toward implementation have been slow.

Plans have been made to encourage laid-off workers to go into private agriculture. The government has announced that it will grant land to former government employees, free of rent, to start farming in the fertile inter-river plains. They also hope to be able to provide farm implements, seed, and other inputs (or credit toward them), to the new farmers.

The extent to which privatization will take place is still not clear. There have been trade liberalization, a freeing of exchange controls, and other policy improvements, all of which look like benefiting the economy in general and the private sector in particular. The recommendations proposed by the Consultant in Section Two have been made on the assumption that policy will continue to move in the same direction: toward privatization and deregulation.

APPENDIX G-1

BIBLIOGRAPHY

1. Berg, Elliot, Encouraging the Private Sector in Somalia, USAID, 1982.

2. Bolletino Officiale, Law #28 of February 20, 1971, (Establishing WDA).

3. Brandon, Carter, Economic Evaluation of CGDP, LBII, 1984.

4. Cerrillo, L., Manual on Well Maintenance, LBII, 1985.

5. Committee Report on Plan for the Drinking Water Supply and Sanitation Decade, 1984.

6. Commodity Import Program Project Paper, Approval Document, USAID, 1982.

7. Comprehensive Groundwater Development Project Paper, USAID, 1984.

8. Draft Bill for the Creation of a National Water Committee and National Technical Committee, Mogadishu, 1984.

9. Financing Capital Formation Through Leasing - The IFC Experience, IFC, 1981.

10. Foreign Trade Returns 1982, Ministry of National Planning, Central Statistics Department, Mogadishu, 1983.

11. Freeman, Rossi and Wright, Evaluating Social Projects in Developing Countries, 1979.

12. Henriol, Ernesto, The Construction Industry - Issues and Strategies in Developing Countries, IBRD, 1984.

13. Holtzman, Review of Livestock Marketing and Livestock Marketing Facilities in Somalia, 1984.

14. Lal, Deepak, Wells and Welfare, 1973.

15. Livestock Marketing and Health Project Paper, USAID, 1984.

16. Management Appraisal of WDA for GTZ, Coopers and Lybrand, 1980.

17. Mineral and Groundwater Survey of Somalia, UNDP, 1973.

18. Notes of Mr. Sartana on Cost Pricing in WDA, Mogadishu, 1983.

19. Pape, Mark, Preliminary Analysis of Potential Environmental Impact of CGDP, LBII, 1982.

20. Pape, Mark, Preliminary Economic Analysis of CGDP, LBII, 1982.

21. Plan for the Drinking Water Supply and Sanitation Decade, Vol. I, MMWR, Mogadishu, Somalia, 1983.

22. Plan for the Drinking Water Supply and Sanitation Decade, Vol. II, MMWR, Mogadishu, Somalia, 1983.

23. Plan for the Drinking Water Supply and Sanitation Decade, Financial/Economic Analysis, MMWR, 1983.

24. Plan for the Drinking Water Supply and Sanitation Decade, Priority Projects, MMWR, 1983.

25. Policy Initiative and Privatization Project, 1983 - 1987, Project Paper, USAID, 1983.

26. Preliminary Estimates of Gross Domestic Product for Somalia, 1984, Ministry of National Planning, Mogadishu, 1985.

27. Private Sector Survey of Water Industry Firms in Somalia, Parts I and II, Geomatec, 1985.

28. Refugee Water Supply Project, Unicef Technical Report, 1980.

29. Refugee Water Supply Systems, UNHCR, 1985.

30. Report and Accounts for the Year(s) Ending 31 December 1977 - 1980, 1982, Commercial Savings Bank of Somalia.

31. Semida, John, Study of 50 Small-Scale Potential Industries in Somalia, USAID, 1984.

32. Somalia Commodity Import Program II, Program Approval Document, USAID, 1983.

33. Somalia in Figures, Ministry of National Planning, 1985.

34. Somali Civil Service Study, USAID for Ministry of Labor and Social Affairs, 1984.

35. Somali Democratic Republic Five Year Development Plan, 1982 - 1986, Ministry of National Planning, 1983.

36. Squire and Vander Tak, Economic Analysis of Projects, 1975.

37. Surface Water Resources in Somalia, FAO, 1973.

38. Van Valer, Robert, Private Sectore Drillers in Somalia, RMC/LBII, 1984.

39. Water Use in Irrigated Agriculture, Somalia, FAO, 1976.

40. Watson, Murray, Central Rangelands Survey, Resource Management and Research, London, 1981.

41. Watson, Murray, Northern Rangeland Survey, Resource Management and Research, London, 1985.

42. Watson, Murray, Southern Rangeland Survey, Resource Management and Research, London, 1985.

APPENDIX G-2

LIST OF PERSONS INTERVIEWED IN SOMALIA

JANUARY - MAY 1985

1. Mr. Daly, U.S. Embassy
2. Mr. Sartana, WDA Planning Unit
3. Mr. Oliver Montecastro, LBII, Road Maintenance Project
4. Mr. Ashkir, WDA Finance and Administration
5. Mr. Usmo, Mogadishu Water Agency
6. Mr. Awale, MMWR Hydrology
7. Mr. Savva, FAO Advisor to MNP
8. Mr. Ulf Olsen, MNP Central Statistic Department
9. Mr. Fred Witthans, USAID
10. Mr. Michael Houston, USAID Advisor to Ministry of Commerce
11. Mr. Gerry LaBomdard, USAID CIP
12. Mr. Tuijer, GTZ Advisor to WDA
13. Mr. Peter Conze, GTZ
14. Mr. Bill Fobaire, CRDP
15. Mr. Andy Sisson, USAID
16. Mr. Bill Keef, USAID
17. Mr. Hong Binwen, Second Secretary, Embassy of the People's Republic of China, Mogadishu
18. Mr. Stewart McNab, Unicef
19. Mr. Peter Bray, McDonalds Consultants
20. Mr. Jacob Strassler, Refugee Water Supply Division, NRC
21. Mr. Frank Procella, TransCentury
22. Mr. Joseph Ingari, BCI Geonetics
23. Mr. Roland (Skip) Hoag, BCI Geonetics
24. Mr. Kussner, IBRD
25. Mr. Hou Haixing, Economic Consul People's Republic of China

26. Mr. Erich Dede, GTZ
27. Mr. Fillacci, GTZ Advisor to WDA
28. Mr. John Pospisilik, WHO
29. Mr. William Darkins, USAID
30. Mr. Loren Wagonner, USAID
31. Mr. Heiko Brunken, GTZ Advisor to MJVD
32. Professor Arush, Head of Geology Dept. at University of Somalia
33. Mr. Murray Watson, Resource Management and Research
34. Mr. Abid, FAO Advisor at NRA
35. Mr. Jurgen Kraft, EEC
36. Mr. Guissepe Vitillo, EEC
37. Mr. Guidotti, SomalFruit
38. Mr. Hank Cawley, VITA
39. Mr. Schaefers, Embassy of the Federal Republic of Germany in Mogadishu
40. Mr. Richard Holt, NRA
41. Mr. Marco Vozzi, Italian Embassy
42. Mr. Olivetti, Somalfruit
43. Mr. Ahmed Hashi Jama ("Pee Wee"), Horn of Africa Drilling
44. Mr. Murri, Fratelli Murri Company
45. Mr. Per Wengler, Kampihl Company
46. Mr. Mohamed Ali Mohamoud
47. Mr. Ahmed Yasin Omar Hashi, Somalia Drilling Company
48. Mr. Brian Bowden, Hargeisa Water Agency
49. Mr. Ahmed Omer Hassan, Guleed Company
50. Mr. Jama A. Farah, Tiger Workshops
51. Mr. Musa Ainan Geele, Tiger Workshops
52. Mr. Abdulahi Mohamed Ahmed, National Drilling
53. Mr. Giafar M. Beder, Juba Enterprises
54. Mr. Mohamed Abdi Adam, Burao Livestock
55. Mr. Abdulkarin Ahmed Guleid, Somalia-German Drilling and Windmill Construction Co.
56. Mr. Warfa Jama Warfa, Civil Works Contractor
57. Mr. Soulemann Habane, Warshada Rootiga EE Tawakal

58. Mr. Jama, Kismayo Water Agency
59. Mr. Ayan, Central Rangelands Development Project
60. Mr. Sacid, Commercial & Savings Bank of Somalia
61. Mr. Ahmed Abdi, Commercial & Savings Bank of Somalia
62. Mr. Jama, Commercial & Savings Bank of Somalia
63. Mr. Nour, President, Somalia Development Bank
64. Mr. Abdul Kadir, Agricultural Division, Somali Development Bank
65. Engineer Yussef Mohamed Elmi, WDA
66. Assistant Manager, Somali Prefab
67. Mr. Yasin Haji Yussuf, Tubex
68. Mr. Hakan Widman, Somali GRP Products
69. Mr. Abbas Said Gibril, Aaron Construction and Consulting
70. Mr. Bula, Ministry of Industry
71. Mr. Lou Cohen, Director of USAID Mission, Mogadishu
72. Mr. Klaus Niemann, Acting Resident Representative, IBRD Mission, Mogadishu
73. Mr. Hassan Mohamed Ali, National Engineering & Construction Company (NATCO)
74. Mr. Alessandro Mucchino, Buralhess
75. Members of the Comprehensive Groundwater Development Project Team

APPENDIX H

REPRINT OF APRIL 1985 STAFF WORKING PAPER,

"PRELIMINARY ANALYSIS OF POLICY OPTIONS"

H-1. INTRODUCTION

This Staff Working Paper contains a preliminary analysis of policy options concerning drilled well public water supplies in Somalia. The Working Paper was prepared in March of 1985 in connection with the special private sector studies being conducted as part of the Comprehensive Groundwater Development Project.

The Comprehensive Groundwater Development Project (CGDP) is being implemented by the Water Development Agency of the Government of Somalia (WDA) with assistance from the United States Agency for International Development. The private sector special studies are being carried out by Louis Berger International, Inc. (LBII) with the assistance of Roscoe Moss Company of the the United States, and Geomatec Consultants and Mohamed Ali Mohamoud of Mogadishu.

It should be understood that this Working Paper was prepared in advance of the gathering and analysis of much information pertinent to the recommendations to be included in the final report. The quantitative analysis contained in this Working Paper is therefore necessarily heavily based on order of magnitude estimates and on simulations. Accordingly, very substantial revisions in market share and other estimates may be made as data gathering and analysis proceeds.

We solicit comments on any of the estimates contained in this paper and on sources of information relevant to these estimates, as well as suggestions concerning the scope and substantive content of our analysis of policy options.

There are currently about 600 operational drilled wells in Somalia supplying water for animal, human, agricultural and/or industrial consumption. About 100 new wells are drilled each year, most of them paid for by foreign aid or other foreign sources. This Working Paper is based on the premise that this annual drilling rated usefully could be expanded to 300 - 450 wells a year if sufficient financing were available and if institutional adjustments can produce a more efficient and self-sustaining structure for water resource development.

H-2. POLICY CHOICES

Drilled wells presently provide less than 4% of water brought under human control through intake and distribution structures in Somalia. However, because Somalia's deep groundwater resources are largely untapped and because properly maintained deep wells are generally less subject to seasonal and cyclical fluctuations in supply than are many other water sources in Somalia, there is considerable scope for the development of these groundwater resources.

This section describes ten policy options concerning private sector involvement in constructing, operating, maintaining or owning drilled well public water supplies in Somalia. It also examines the scope for private sector initiatives in industries which provide inputs of raw material, manufactured commodities, and distribution and other services for such activities in Somalia.

Subsection H-2.1 provides an overview of the ten options. Subsection H-2.2 discusses each of the ten options in detail. It is believed that these options represent a sufficiently wide range of choice to provide the basis for policy dialogue. Various combinations and variations of these options are of course possible, as are additions to and deletions from the list.

H-2.1 An Overview of Principal Policy Options

This subsection provides an overview of policy choices concerning the involvement of the Somali private sector in activities relating to water supplied to the public from drilled wells throughout the country. We set forth a series of ten policy options, ranging from no change in the current size and status of the private sector to pervasive privatization.

The ten policy options may be summarized as follows:

SUBSECTION REFERENCE	OPTION SUMMARY
H-2.2.1	**Option A:** No change No basic change in the roles or relative market shares of Somali private sector firms and individuals engaged in activities related to well drilling.
H-2.2.2	**Option B:** More community involvement Increased community involvement in planning, operation and maintenance of drilled wells for public water supply.

H-2.2.3 **Option C:** Private sector well operation

Government of Somalia contracts a substantial portion of the operation and revenue collection activities for its drilled well water supplies to the Somali private sector.

H-2.2.4 **Option D:** Private sector well maintenance

Government of Somalia contracts a substantial portion of the maintenance of its drilled well water supplies to the Somali private sector.

H-2.2.5 **Option E:** Private sector well ownership

Ownership of substantial numbers of drilled well public water supplies by the private sector.

H-2.2.6 **Option F:** Private sector water security role

Government of Somalia contracts a sufficient number of wells to private drillers to enable them to maintain capacity to render assistance in times of national water emergencies.

H-2.2.7 **Option G:** Public/private competition

Government of Somalia regularly contracts out wells for competitive bidding between government agencies and private firms and requires government drilling operations to show a fair rate of return on their use of equipment and other government owned assets.

H-2.2.8 **Option H:** Reprinted WDA role

WDA's role is reoriented by curtailing drilling and civil works functions and by focusing agency activity on exploration, private sector contracting, public utility regulation, and emergency operations.

H-2.2.9 **Option I:** Support activities privatized

Somali's private sector achieves substantial market shares of key industries supporting the development of drilled well water supplies.

H-2.2.10 **Option J:** Pervasive privatization

All three levels of industry structure relating to drilled well water supplies are substantially privatized.

In the discussion which follows, these options are examined in three ways, according to:

1. Main thrust or rationale of the option

2. Impacts on market shares of organizations and individuals providing relevant goods and services affected by the option:

   (a) Activities principally funded and carried out by Agencies, organizations and entities owned or controlled by the national government.

   (b) Activities principally funded and carried out by foreign aid agencies, with significant participation of expatriate technical assistance or operations personnel.

   (c) Community organizations and representatives providing funds, services, assistance in planning, and other forms of community involvement.

   (d) Individuals and firms in the Somali private sector.

   (e) Foreign sector including imports into Somalia and activities of foreign private sector firms

The five-fold classification of institutions holding market shares poses a few, but generally not difficult, problems of definition and classification. Some Government projects intermingle with government and foreign aid resources, and judgments must be made as to the heading under which such projects are shown. Where a project combines local and foreign resources, that project is classified under foreign aid if the foreign funding and in-country personnel presence is substantial, and if the foreign personnel are directly involved in providing service in the pertinent market. Thus the CGDP, which utilizes both government and foreign aid resources in drilling wells in Somalia is classified under foreign aid.

Community activities also often combine financial help and technical assistance with local contributions. Sometimes communities may receive assistance from the national government after water development activities are initiated by the community. In other cases, the national government may organize community participation. A similar range of relationships may exist in connection with foreign aid to communities. In general, we have classified any form of direct community initiative or participation as a market share for community involvement, even though such participation takes place under the aegis of the national or foreign organizations.

The Somali private sector consists principally of Somali individuals and business firms. Where companies are organized under Somali laws but are controlled in part by foreign nationals, some questions of classification may arise. In close cases, such companies are treated as being within the Somali private sector.

The foreign sector includes foreign private companies and the meeting of market demand through imports. If imports are financed by foreign aid, but brought in and sold without foreign aid or technical assistance, they are classified under imports as long as no processing or substantial value added through distribution activity takes place in Somalia.

3. Functional levels of activity at which the option has impact:

(a) Level I (ownership, operation, and maintenance of drilled wells).

(b) Level II (construction of wells and civil works).

(c) Level III (provision of raw material and manufactured inputs to Levels II and III).

The levels of industry structure at which each of the options has its primary impacts may be summarized as follows:

OPTION SUMMARY	PRIMARY LEVELS OF IMPACT
Option A: No change	I, II, III
Option B: More community involvement	I
Option C: Private sector well operation	I
Option D: Private sector well maintenance	I
Option E: Private sector well ownership	I
Option F: Private water security role	II
Option G: Public/private competition	II
Option H: Reoriented WDA role	II
Option I: Support activities privatized	III
Option J: Pervasive privatization	I, II, III

Each of the ten policy options is examined in detail in separate subsections below. The options are ordered to reflect the level of industry structure on which they have their primary impacts and, within each level, the extent to which they represent change from present arrangements. Exhibit H-1 on the following page summarizes the market shares of the private sector under each of the ten policy options.

EXHIBIT H-1

DRILLED WELLS FOR PUBLIC WATER SUPPLY SUMMARY OF PRIVATE SECTOR MARKET SHARES UNDER TEN POLICY OPTIONS

(Numbers Shown are Percentages)

	OPTION A	OPTION B	OPTION C	OPTION D	OPTION E	OPTION F	OPTION G	OPTION H	OPTION I	OPTION J
Level 1 Functions:										
Drilled Well Ownership	1	1	1	1	25	1	1	1	1	80
Well Operation/ Revenue Collection	2	2	50	2	27	2	2	2	2	85
Well Maintenance	1	3	6	48	24	1	1	1	1	78
Level 2 Functions:										
Well Drilling and Rehabilitation	15	15	15	15	40	25	35	45	15	60
Civil Works for Drilled Wells	36	36	36	36	61	47	56	65	36	65
Level 3 Functions:										
Gravel	35	37	35	36	58	40	50	60	75	75
Wood	15	17	15	16	26	20	25	30	30	30
Cement	10	12	11	11	26	15	20	26	30	35
Pipe	10	15	11	11	32	15	25	32	35	40
Storage Tanks	15	15	15	16	35	20	30	41	65	70
Pumps	8	8	9	9	15	8	15	15	15	18
Windmills	15	15	15	50	25	15	15	25	30	35
Petroleum Distribution	0	0	0	0	0	0	0	0	75	80
Machine Shops	35	35	36	50	42	35	35	35	65	90

H-2.2 Analysis of Individual Policy Options

This section presents our detailed discussion of ten policy options.

H-2.2.1 Option A: No basic change in roles or relative market shares of Somali private sector firms and individuals engaged in activities related to well drilling.

Main Thrust of Option A (No Basic Change)

Option A consists of the continuation of currently prevailing patterns of institutional responsibility. However, Option A does not consist of a rigid or detailed freezing of the status quo. It permits some specific changes as long as these changes do not alter the basic allocation of water resource activities among the national government, local communities, the private sector, and the foreign sector.

For example, under Option A, significant shifts in functions could occur among the various government agencies involved in water resource development without changing the fundamental balance between government and private sector activities. Likewise, under Option A, changes could take place in the identities and numbers of Somali firms engaged in drilling activities without changing the nature or magnitude of private sector participation in that activity. Similarly, the foreign donors can change in identity and in the relative shares of support which they provide for water resource development without necessarily altering the overall thrust of foreign assistance in this sector.

Changes in market shares which come about because of facilities which are about to come on stream or are now under construction in Somalia are not regarded as a departure from Option A.

Finally, it should be emphasized that the focus in defining options is on the relative market shares of each of the institutions involved. Thus the volume of activity of all institutions can increase or decrease as a result of factors such as population growth, weather conditions, or the effects of hostilities, but no real change may take place in the institutional balance. That is still Option A.

Market Shares Under Option A (No Basic Change)

Exhibit H-2 shows a 1990 projection of market shares under Option A (no basic change in the roles or relative market shares of Somali private sector firms and individuals engaged in activities related to well drilling).

EXHIBIT H-2

DRILLED WELLS FOR PUBLIC WATER SUPPLY

OPTION A NO FUNDAMENTAL CHANGE IN ROLE OR MARKET SHARE OF PRIVATE SECTOR

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total %
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Well Operation/ Revenue Collection	93		0		5		2		0		100
Well Maintenance	93		4		2		1		0		100
Level 2 Functions:											
Well Drilling and Rehabilitation	25		40		0		15		20		100
Civil Works for Drilled Wells	36		25		3		36		0		100
Level 3 Functions:											
Gravel	55		5		5		35		0		100
Wood	15		0		5		15		65		100
Cement	30		0		0		10		60		100
Pipe	5		0		0		10		85		100
Storage Tanks	60		0		0		15		25		100
Pumps	0		0		0		8		92		100
Windmills	25		0		0		15		60		100
Petroleum Distribution	85		15		0		0		0		100
Machine Shops	60		5		0		35		0		100

Exhibit H-2 shows that, under Option A, WDA and other agencies of the Government of Somalia would continue to dominate the ownership, operation, and maintenance of drilled wells, with market shares in excess of 90%. The private sector's shares of these markets is in the 1-2% range. The small shares reflect (1) the "grandfathering" of certain prerevolutionary arrangements with respect to private ownership of drilled wells from which water is sold to the public; (2) some incidental sales of water to the public from private wells (i.e, wells dedicated mainly to private uses such as irrigation), (3) some contractual arrangements which WDA makes for well operation/revenue collection by private individuals at certain of its wells, (4) and certain incidental maintenance spinoffs.

The foreign aid share of Level I activities is negligible. The 5% share shown in the case of maintenance represents the incidental result of participation in construction and technical assistance projects. The local community shares represent certain historical arrangements and the results of efforts under the Comprehensive Groundwater Development Project to encourage and support community involvement. See Section H-2.2.2. for further discussion of this subject.

It is interesting to note that foreign aid presently directly accounts for 40% of the wells drilled in Somalia. The Government's share (including wells drilled by urban water authorities and parastatal organizations with their own rigs is 25% while the Somali private sector accounts for only 15%. Taking into account foreign aid, wells privately drilled by and for foreign private companies, and government wells principally oriented toward foreign trade (e.g., in camels and bananas), it is clear that well drilling in Somalia has a very strong external orientation. The Level Three activities (raw materials and manufactured inputs) shown on Exhibit H-2 reflect market shares of those supply activities judged to have the highest potential for involvement of Somali entrepreneurs. Certain supplies (e.g. steel casing, screen, and Bentonite) have been excluded on the basis of preliminary analysis indicating that local production is not likely to be feasible.

It was noted in the previous section that imports financed by foreign aid are placed in the "imports" category if not accompanied by technical assistance or substantial operational involvement in the principal import/distribution functions. Thus, where foreign aid agencies regularly involve themselves in the business of supplying substantial quantities of petroleum products for a variety of their own projects, they are regarded as being in the petroleum distribution business, whereas the procurement of pumps for foreign aid financed drilled wells is regarded as importing of inputs and as an incidental attribute of having a market share of the well drilling business.

H-2.2.2 Option B: Increased community involvement in planning, operation and maintenance of drilled wells for public water supply.

Main Thrust of Option B (Community Involvement)

Option B gives its primary emphasis to creating community attitudes which are favorable to well installation and to actively involving local people in the location, operation and maintenance of their water supplies. Evaluation of rural water supply projects throughout Africa and other developing areas show repeated evidence of operation and maintenance failures after wells are installed in rural areas. These evaluations often attribute such failures to a lack of effort and attention devoted to community involvement during project design and execution. Option B is intended to provide such involvement.

Option B in fact represents one of the significant initial thrusts of the Comprehensive Groundwater Development Project, and of original version of the Project Paper Supplement on which the extension of CGDP from October 1984 through July 1987 was first based. (A subsequent project Paper Supplement rationale, one more directly related to private sector development than to community involvement, was incorporated later).

Option B lays considerable emphasis on committing the people and leadership of local communities to decisions to install wells in the community. It seeks to involve them in considering whether any well should be installed, in determining where it should be installed, and in planning how the wells will be operated and maintained. Members of the community are then employed to carry out the plans.

Although the persons who are selected to perform operation and revenue responsibilities actually become WDA employees, they are nominated by the community. While communities are required to turn over most of collected revenues to the national government, a small share of these revenues is retained at the community level to provide a source of funds for emergency repairs and other purchases required to keep the well operating. Thus while WDA is relied upon for major maintenance, routine work can be carried out or arranged for by the community itself. Some of the funds expended at the community level are used to purchase goods and services from the private sector.

We understand that at least one other foreign aid program has provided direct aid to communities, drilling wells in return for community commitments to use the revenues collected for operation and maintenance of the pumps. Apparently, assisted communities retain all revenue collection, and arrange for their own maintenance without the involvement of WDA.

Option B is expected to have the collateral effect of funneling additional business to the private sector, since

communities have some funds at their disposal which could be used to buy services and products from the private sector. This effect is not the primary purpose of Option B, nor is it expected to have any large immediate impact. However, the decentralization of responsibility and the placing of expenditure decisions in a multiplicity of locations is expected to create an atmosphere more conducive to private involvement in the long term.

It should be noted that "community involvement" is a concept which has its greatest application to small and medium sized communities with established leadership structures and a population with a significant degree of periodic if not permanent attachment to a particular location. Water authorities designated by the national government to look after the needs of major urban areas and drilling activities associated with the establishment and maintenance of refugee camps generally do not fit this description.

Market Shares Projected for Option B (Community Involvement)

Exhibit H-3 shows the market shares expected to be achieved under Option B by the end of 1990. As noted in the previous paragraph, the concept of community involvement appears to have its greatest application in settled small and medium-sized communities. Urban water authorities and refugee camps are largely excluded from the definition.

In addition to showing projected market shares, Exhibit H-3 shows the change in market shares expected to result from Option B. These changes are calculated by comparing each individual estimate in Option B with the corresponding estimate for Option A (see Exhibit H-2 above). Option A (no change) shows the respective market shares of the government, communities, the Somali private sector, and the external sector under current policies. For a discussion of Option A and definitions of key terms used in the Exhibit, see Section H-2.2.1 above.

It can be seen from Exhibit H-3 that there are projected major shifts from the National Government to communities in the areas of operations, revenue collection, and maintenance, resulting in additional market shares in excess of 40% for these Level I functions. A small increase in the maintenance share of the private sector is expected to result from purchasing decisions made at the community level. Well ownership will remain with the National Government and no change in the allocation of this activity among institutions is anticipated.

At Level II, there are modest shifts away from the National Government to communities in the area of well-related civil works. However, communities are not expected to undertake

EXHIBIT H-3

OPTION B

INCREASED COMMUNITY INVOLVEMENT

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	45		0		53		2		0		100
Change from Option A		-48		0		48		0		0	
Drilled Well Maintenance	39		4		54		3		0		100
Change from Option A		-54		0		52		2		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	25		40		0		15		20		100
Change from Option A		0		0		0		0		0	
Civil Works for Drilled Wells	36		25		3		36		0		100
Change from Option A		0		0		0		0		0	
Level 3 Functions:											
Gravel	46		5		12		37		0		100
Change from Option A		-9		0		7		2		0	
Wood	13		0		10		17		60		100
Change from Option A		-2		0		5		2		-5	
Cement	30		0		0		12		58		100
Change from Option A		0		0		0		2		-2	
Pipe	5		0		0		15		80		100
Change from Option A		0		0		0		5		-5	
Storage Tanks b/	60		0		0		15		25		100
Change from Option A		0		0		0		0		0	
Pumps	0		0		0		8		92		100
Change from Option A		0		0		0		0		0	
Windmills	25		0		0		15		60		100
Change from Option A		0		0		0		0		0	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	60		5		0		35		0		100
Change from Option A		0		0		0		0		0	

drilling or well rehabilitation activities, and no shift in the allocation of market shares is expected to result for this activity.

At Level III, modest shifts to communities are expected to take place in the provision of raw materials used in construction and maintenance. Some small shifts to the private sector at this level are also expected to result from the thrust toward community involvement.

H-2.2.3 Option C: Government of Somalia contracts a substantial portion of the operation and revenue collection activities for its drilled well water supplies to the Somali private sector.

Main Thrust of Option C (Substantial Private Sector Well Operation)

Option C would shift a substantial share of the responsibility for operating and collecting revenues at drilled wells from the public to the private sector. However, under Option C, the public sector also would retain a significant market share of well operation and revenue collection activity. Such activities would be contracted out by the Government of Somalia or communities at national, regional, or local levels, as appropriate.

The respective markets of the public and private sectors could be maintained by allocation of particular wells, areas, or regions to each type of institution; through open competition between the public and private sectors (which would require special organizational arrangements within the public sector) and/or through a combination of market allocation and competitive bidding. For additional discussion of such techniques, see Section H-2.2.7, Option G (Public/Private Competition).

The Government of Somalia could of course choose to shift all or nearly all well operation to the private sector. Such eventualities are covered in Option I (All Key Functions Privatized) and Option J (Complete Privatization) discussed respectively in Subsections H-2.2.9 and H-2.2.10 below. The present option, Option C, represents a significant amount of privatization, but not a full commitment in this direction.

Market Shares Projected for Option C (Substantial Private Sector Well Operation and Revenue Collection

Exhibit H-4 shows the market shares expected to be achieved under Option C by the end of 1990. In addition to showing projected market shares, Exhibit H-4 also shows the change in market shares expected to result from Option C. These changes are calculated by comparing each estimate for Option C with the corresponding estimate for Option A (See Exhibit H-2 above).

EXHIBIT H-4

OPTION C

PRIVATE WELL OPERATION AND REVENUE COLLECTION

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	45		0		5		50		0		100
Change from Option A		-48		0		0		48		0	
Drilled Well Maintenance	91		1		2		6		0		100
Change from Option A		-5		0		0		5		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	25		40		0		15		20		100
Change from Option A		0		0		0		0		0	
Civil Works for Drilled Wells	36		25		3		36		0		100
Change from Option A		0		0		0		0		0	
Level 3 Functions:											
Gravel	56		5		5		35		0		101
Change from Option A		1		0		0		0		0	
Wood	14		0		6		15		65		100
Change from Option A		-1		0		1		0		0	
Cement	29		0		0		11		60		100
Change from Option A		-1		0		0		1		0	
Pipe	5		0		0		11		84		100
Change from Option A		0		0		0		1		-1	
Storage Tanks b/	60		0		0		15		25		100
Change from Option A		0		0		0		0		0	
Pumps	0		0		0		9		91		100
Change from Option A		0		0		0		1		-1	
Windmills	25		0		0		15		60		100
Change from Option A		0		0		0		0		0	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	59		5		0		36		0		100
Change from Option A		-1		0		0		1		0	

Option A (No Change) shows the respective market shares of the government, communities, the Somali private sector, and the external sector under current policies. For a discussion of Option A and of definitions of key terms used in the Exhibit, see Section H-2.2.1 above.

Exhibit H-4 shows that approximately half of all drilled well operation and revenue collection activities will be shifted from the public to the private sector by 1990. There will be a modest increase in private sector shares of maintenance as a result of the shift of well operation activity to the private sector. The impact of Option C on Level III activities will be slight.

H-2.2.4 Option D: Government of Somalia contracts a substantial portion of the maintenance of its drilled well water supplies to the Somali Private Sector.

Main Thrust of Option D (Substantial Private Sector Well Maintenance

Option D is very similar in concept to Option C (private sector well operation and revenue collection), with the difference that some Option D maintenance functions can be conducted on a more centralized basis. Option C well operation and revenue collection activities are necessarily centered on the well site, whereas maintenance operations can be run in part from commonly used repair facilities. Option C and Option D easily could be combined. However, as discussed in Sections H-2.2.6 and H-2.2.8, well maintenance has a somewhat higher impact on regulation, industry structure, and water security.

Option D would shift a substantial share of the responsibility for maintaining drilled wells from the public to the private sector. However, as with the previous option, the public sector would retain a significant market share of this activity under Option D. Such maintenance would be contracted out by the government or communities at national, regional, or local levels, as appropriate.

The respective markets of the public and private sector could be maintained by allocation of particular wells, areas, or regions to each; through open competition among the organizations in the public and private sectors (which would require special organizational arrangements within the public sector) and/or through a combination of market allocation and competition. For an expanded discussion of these concepts, see Sect' H-2.2.7, Option G (Public/Private Competition).

The Government of Somalia could of course choose to shift all or nearly all well maintenance to the private sector. Such eventualities are covered in Option J (Complete Privatization) discussed respectively in Subsections H-2.2.9 and H-2.2.10 below.

The present option, Option D, represents a significant amount of privatization, but not a commitment to place all well maintenance activities in private hands.

Market Shares Projected for Option D (Substantial Private Sector Well Maintenance)

Exhibit H-5 shows the market shares expected to be achieved under Option D by the end of 1990. In addition to showing projected market shares, Exhibit H-5 also shows the change in market shares expected to result from Option D. These changes are calculated by comparing each estimate for Option D with the corresponding estimate for Option A (See Exhibit H-2 above).

Option A (No Change) shows the respective market shares of the government, communities, the Somali private sector, and the external sector under current policies. For a discussion of Option A and of definitions of key terms used in the Exhibit, see Section H-2.2.1 above.

Exhibit H-5 shows that approximately half of all drilled well maintenance activity will be shifted from the public to the private sector by 1990. No impacts on Level II or other Level I activities are expected. The impact of Option C on Level III activities will be slight.

H-2.2.5 Option E: Ownership of substantial numbers of drilled well public water supplies by the private sector.

Main Thrust of Option E (Private Ownership of Wells)

Private sector ownership of drilled well water supplies places the owner in the position of what is known in the United States as a "water company," a privately owned public utility, which is subject to government regulation of rates, service quality, health standards, environmental impacts, and other practices.

Subject to reasonable rules to protect the public, private ownership gives to the owner the right to select management and employees, control well operations, oversee revenue collection, and determine the arrangements by which maintenance responsibilities are met. Rates are designed to provide a reasonable return on investment, but the owner bears the risk of losses, and must provide service for a reasonable length of time even though losses are being incurred.

Option E (private ownership of wells) thus is a Level I activity which has a close relationship to Option C (well operation and revenue collection and Option D (well maintenance). However, unlike Options C and D, Option E represents a

EXHIBIT H-5

PRIVATE WELL MAINTENANCE

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Substantial Community Activity %	+/- %	Somali Private Sector %	+/- %	Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	93		0		5		2		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Maintenance	49		1		2		48		0		100
Change from Option A		-47		0		0		47		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	30 a/		45	0	0		25		0		100
Change from Option A		-5		-5		0		10		0	
Civil Works for Drilled Wells	26		21		3		50		0		100
Change from Option A		-10		-4		0		14		0	
Level 3 Functions:											
Gravel	59		10		5		26		0		100
Change from Option A		4		5		0		-9		0	
Sand	19		0		10		26		45		100
Change from Option A		4		0		5		11		-20	
Cement	29		0		0		11		60		100
Change from Option A		-1		0		0		1		0	
Pipe	4		0		0		11		85		100
Change from Option A		-1		0		0		1		0	
Storage Tanks b/	59		0		0		16		25		100
Change from Option A		-1		0		0		1		0	
Pumps	0		0		0		9		91		100
Change from Option A		0		0		0		1		-1	
Windmills	25		0		0		15		60		100
Change from Option A		0		0		0		0		0	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	45		5		0		50		0		100
Change from Option A		-15		0		0		15		0	

policy which would have very substantial secondary impacts throughout all three levels of the industry structure.

Government can require that well owners pay a fee for the right to sell water to the public and/or to collect a sales tax from purchasers of water. Government could also require owners to post security to assure performance of their commitments.

Option E involves a significant change in public and private roles in Somalia, requiring the Government to relinquish some direct control of water sources and to develop the capacity to regulate private sector ownership in a way that assures that reasonable standards of service can be sustained over an extended period of time. However, in the short run, the most practical and effective form of regulation could be the continued provision of water from a limited number of strategically located government-owned wells, such that people have some (if not very convenient) alternatives if private sector service at particular locations proves to be deficient.

Option E would also require foreign donors to re-examine the ways in which they provide assistance in water resource development. The private sector is not entitled to exemption from duties on imports and is generally not entitled to preferential exchange rates for purchases of equipment and spare parts abroad. Nor have most foreign aid programs, within the framework of their own rules and procedures, found practical and effective ways to assist the private sector. Given the fact that a substantial share of new investment in the development of Somalia's water resources comes from abroad, considerable readjustment and innovation in foreign aid practices would be required.

Option E also involves some rather specific changes in public/private relationships which are not present in the other Level I options. For example, Options C (private sector well operation and revenue collection) and D (private sector well maintenance) can be undertaken through Government contracts in which operation and/or maintenance of wells is treated as a service purchased by the owner of the well (the Government) from private contractors. In the case of Option E, a private person or company is the owner of the well and any contracts with government agencies for services (to drill a well, for example) would place the position the government agency in the position of contractor to the owner.

Option E would mean that the private sector would bear the risks of exploration for water, and of dry holes. However, a possible variation of Option E would be for the Government to bear

the costs of exploration, drilling and development of the well, and then auction it off to the private sector.

Market Shares Projected for Option E (Private ownership of wells)

Exhibit H-6 shows the market shares expected to be achieved under Option E by the end of 1990. In addition to showing projected market shares, Exhibit H-6 also shows the change in market shares expected to result from Option E. These changes are calculated by comparing each estimate for Option E with the corresponding estimate for Option A (See Exhibit H-2 above).

Exhibit H-6 assumes that private ownership of wells will occur for half of the new wells drilled in Somalia and that the Government of Somalia will continue to own and operate its present complement of wells until the end of their useful lives. It also assumes an average useful well life of ten years and a level of drilling activity during the period from 1985 through the close of 1990 that would result only in the replacement of the current complement. In other words, if ten percent of the current complement of drilled wells are replaced each year and half of these are privately owned, the share of wells owned by the private sector will be 25% at the end of five years. From the viewpoint of determining the extent to which Somalia will have turned to private ownership of wells by 1990, the 25% ownership share is significant. For purposes of determining the impact of private well ownership on other types of activity, the annual share of the private sector ownership of new wells is important.

Option E leads to substantially larger secondary effects on the various levels of the industry structure than any other of the five options we have discussed thus far. It is premised that, during the course of the period, the private owners of new wells will themselves turn increasingly to private sector sources for drilling and construction of civil works. Thus by the close of 1990, private sector well ownership could give a substantial boost to the private sector market shares of Level II drilling and construction, and have a widespread effect on Level III support activities. Accordingly, well ownership could become a powerful catalyst on privatization throughout the industry structure. The projected changes in the industry structure assume that returns to the private sector from drilled wells will be sufficient to support investment in new well drilling activity and that foreign exchange or other constraints will not inhibit or prevent such investment.

EXHIBIT H-6

OPTION E

PRIVATE OWNERSHIP OF PUBLIC DRILLED WELL WATER SUPPLIES

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Substantial Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	70		0		5		25		0		100
Change from Option A		-27		0		3		24		0	
Drilled Well Operation/ Revenue Collection	66		0		7		27		0		100
Change from Option A		-27		0		2		25		0	
Drilled Well Maintenance	73		1		2		24		0		100
Change from Option A		-23		0		0		23		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	5		35		0		40		20		100
Change from Option A		-20		-5		0		25		0	
Civil Works for Drilled Wells	16		20		3		61		0		100
Change from Option A		-20		-5		0		25		0	
Level 3 Functions:											
Gravel	35		2		5		58		0		100
Change from Option A		-20		-3		0		23		0	
Wood	4		0		5		26		65		100
Change from Option A		-11		0		0		11		0	
Cement	16		0		0		26		58		100
Change from Option A		-14		0		0		16		-2	
Pipe	3		0		0		32		65		100
Change from Option A		-2		0		0		22		-20	
Storage Tanks b/	40		0		0		35		25		100
Change from Option A		-20		0		0		20		0	
Pumps	0		0		0		15		85		100
Change from Option A		0		0		0		7		-7	
Windmills	20		0		0		25		55		100
Change from Option A		-5		0		0		10		-5	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	53		5		0		42		0		100
Change from Option A		-7		0		0		7		0	

H-2.2.6 Option F: Government of Somalia contracts a sufficient number of wells to private drillers to enable them to maintain capacity to deal with water emergencies.

Main Thrust of Option F (Private Sector Water Security Role)

Option F enables one or more firms in the Somali private sector to play a significant role in dealing with Somalia's periodic water emergencies. These emergencies, which result from weather cycles, hostilities, refugee problems, and other causes, occur with considerable frequency. The Government has difficulty in mobilizing its own resources in these crises. Often, too, the foreign aid community is unable to respond to urgent needs with assistance that is timely and properly targeted. Thus, Somalia periodically requires a drilling capability that can be mobilized quickly and used flexibly to deal with immediate problems.

As we have seen in Appendix E, private drillers own a relatively small number of the rigs used in Somalia. These rigs have, on the whole, longer useful lives, and are utilized for a higher percentage of the time during each year than those owned by agencies of the Government of Somalia, and the Somali drillers have shown considerable ingenuity in their use. They also have established reasonably effective arrangements for mobilizing drilling personnel with suitable skills on short notice, and for motivating and managing them in the field.

However, Somali private sector drillers' assignments are generally limited to those areas which have the highest concentration of water supply sources and fewest logistic problems. While they have demonstrated considerable adaptability, neither their equipment nor their current modes of operation are currently well suited to emergency operations. Government rigs are used for a variety of drilling assignments, ranging from the relatively simple to those which are quite difficult. The government has some equipment and logistic experience which is suited to difficult assignments, but it often has difficulty mobilizing them in emergencies because of maintenance, staffing and other problems.

Thus, in times of emergency, the best that can be done is for the Government to contract with the private sector to handle more routine and less difficult activities, while WDA and other Government agencies attempt to mobilize their resources to meet the emergency. All too often these agencies' full complement of equipment cannot be put into operating condition quickly and the Government experiences considerable difficulty in adjusting its customary mode of operation to the multiple requirements of emergency. The result is loss of property and human suffering until outside assistance can be mobilized.

The objective of Option F is to enhance the capabilities of the private sector such that it becomes both a supplementary resource and a realistic partial alternative to complete reliance on the well construction capabilities of the government and foreign aid community in times of recurring water emergencies.

This water security role of the private sector can be implemented in the following four ways.

First, the Government of Somalia could enter into long term contracts with one or more private sector drillers, (backed by foreign aid funds). These drillers would undertake to purchase and maintain equipment suitable for emergency drilling, and to give government needs priority in times of water emergency. The long term contracts would guarantee the drillers sufficient drilling activity to pay back their initial investment within the period of the contract. Equipment suitable for drilling in remote areas could be purchased new from abroad, or where appropriate, on a used/rehabilitated basis from agencies of the Government of Somalia. This subject is discussed in greater detail under Option G.

Second, the members of the foreign aid community could designate an agreed share of each future well drilling project over the next five years to the Somali private sector. This share could be provided by (1) direct contracts between a foreign aid agency and private drillers; (2) contract funds funneled through agencies of the Somali government; and/or through joint ventures and subcontracts with foreign drilling companies.

Third, private construction contractors could become the favored source for building civil works for wells undertaken as part of emergency programs.

Fourth, a pilot program could be undertaken to test the capacity of drillers to serve as prime contractors, undertaking responsibility for both drilling of wells and construction of civil works.

Overall, the objective is to provide equipment and experience that provide more rapid, more efficient, and less expensive responses to crises.

Market Shares Projected for Option F (Private Sector Water Security)

Exhibit H-7 shows the market shares expected to be achieved under Option F by the end of 1990. Exhibit H-7 also shows the change in market shares expected to result from Option F, by comparing Option F with Option A (Option A represents the respective market shares of the Government of Somalia, community activities, the Somali private sector, and the external sector at present.)

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EXHIBIT H-7

OPTION F

PRIVATE SECTOR NATIONAL WATER SECURITY ROLE

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	93		0		5		2		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Maintenance	96		1		2		1		0		100
Change from Option A		0		0		0		0		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	20		35		0		25		20		100
Change from Option A		-5		-5		0		10		0	
Civil Works for Drilled Wells	30		20		3		47		0		100
Change from Option A		-6		-5		0		11		0	
Level 3 Functions:											
Gravel	50		5		5		40		0		100
Change from Option A		-5		0		0		5		0	
Wood	10		0		5		20		65		100
Change from Option A		-5		0		0		5		0	
Cement	25		0		0		15		60		100
Change from Option A		-5		0		0		5		0	
Pipe	5		0		0		15		80		100
Change from Option A		0		0		0		5		-5	
Storage Tanks b/	55		0		0		20		25		100
Change from Option A		-5		0		0		5		0	
Pumps	0		0		0		8		92		100
Change from Option A		0		0		0		0		0	
Windmills	25		0		0		15		60		100
Change from Option A		0		0		0		0		0	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	60		5		0		35		0		100
Change from Option A		0		0		0		0		0	

Option F (private sector water security) does not involve any change in market shares for the Level I activities of well ownership, operation, maintenance, and revenue collection and only modest changes in support activities. The key changes envisioned by Option F are in the market shares for drilling and civil works construction.

Under Option F about ten percent of the drilling activity in the country would be shifted to the Somali private sector over a period of five years, five percent from Government of Somalia agencies and five percent from shares currently held by foreign organizations operating under foreign aid arrangements. Construction of civil works by the private sector would also increase by ten percent. Shifts of shares from the government and foreign organizations will make the private sector the leading provider of civil works for drilled wells.

A substantial amount of private contracting of civil works is presently carried out in the various regions of Somalia. Thus no major geographic reorientation is envisioned for this type of private sector activity, nor will major reorientations in equipment capabilities be required. As a result of increased private sector activity at Level II, private sector market shares would increase somewhat at Level III.

H-2.2.7 Option G: Government of Somalia regularly contracts out wells for competitive bidding between government agencies and private firms and requires its agencies which own rigs and other equipment used to construct wells and related civil works to show a return on their use of these assets.

Main Thrust of Option G (Public/Private Competition)

The objectives of Option G (Public/Private Sector competition) are to increase the efficiency of both public and private sector operations through competition, to enable at least a portion of the WDA to reward employees financially for efficient performance, to introduce techniques of management control and concepts of managerial responsibility for results into the organization in which some private sector drillers start their careers; and to turn WDA into a financially self-sustaining organization at the same it builds up the private sector through government contracting.

Under Option G, WDA would not only compete with private sector drillers for private sector business as it does now, but it would also be required to compete with them on assignments performed for other government agencies and for a portion of the work which it currently performs on its own account.

WDA is currently regarded as an exclusive contracting agency in the structure of the Government of Somalia. Other agencies of the government of Somalia may not enter into contracts

with private sector drillers without first receiving WDA approval. If WDA has equipment and manpower available, WDA has the right to exclude private drillers and take on the assignment, even though the purchasing agency believes it could obtain a better price and/or better service from a private driller. If WDA offers no objection to the engagement of the private driller, this engagement may take the form of a subcontract between WDA and the private driller, although a direct contractual relationship between the purchasing agency and the private driller is also possible.

Option G would eliminate WDA's right of first refusal on the drilling assignments of other government agencies. It would also require WDA to compete with the private sector for a portion of the drilling work which it now normally performs on its own behalf.

This approach would require WDA to separate its functions as a contractor (performing drilling and civil works construction under force account) from its functions as a government contracting agency -- awarding contracts following competition between private sector drillers and its own in-house (but separate) contracting organization. A certain amount of drilling activity -- perhaps that associated with emergencies at particular remote locations -- would not be offered for competitive bid, but could be awarded to the in-house contracting organization on a sole source basis.

The WDA in-house contracting organization would be subject to some special rules, not applicable to other government organizations. These include the following:

- A requirement that it recover sufficient funds in payment for the services which it renders to the private sector, including a return on an assigned value of the rigs, vehicles, and other assets which it uses;

- The right to pay bonuses to its employees and its management on the basis of productivity achievements, independently measured on the basis of work accomplished;

- The right to hire and discharge employees on the basis of productivity and efficiency;

- Loss of equipment, employment, and finally elimination of the organization itself if prescribed level of returns on assets are not achieved over a period of years.

Option G represents a significant departure in philosophy and practice from currently prevailing arrangements. It would require a reorganization of WDA and substantial addition to the contracting capabilities of the portion of the organization

which is designated to administer competitive contracting procedures.

As discussed below, the market share of the Government of Somalia is expected to decline appreciably under Option G. However, the resulting smaller share should remain relatively stable over time, reflecting a healthier and more viable organization.

Market Shares Projected for Option G (Public/Private Competition)

Exhibit H-8 shows the market shares expected to be achieved under Option G by the end of 1990. Exhibit H-8 also shows the change in market shares expected to result from Option G, by comparing it with Option A (Option A represents the respective market shares of the Government of Somalia, community activities, the Somali private sector, and the external sector at present.)

Option G (Public/Private sector competition) does not involve any change in market shares for the Level I activities of well ownership, operation, maintenance, and revenue collection but some changes in support activities. The key changes envisioned by Option G are in the market shares for drilling and civil works construction.

Under Option G about twenty percent of the drilling activity in the country would be shifted to the Somali private drillers over a period of five years, ten percent from Government of Somalia agencies and ten percent from shares currently held by foreign organizations operating under development assistance arrangements. Construction of civil works by the private sector would also increase by twenty percent. Shifts of shares from the government and foreign organizations will make the private sector the predominant provider of civil works for drilled wells.

H-2.2.8 <u>Option H: WDA role reoriented by curtailing drilling and civil works roles, and focusing agency activity on exploration, private sector contracting, public utility regulations and emergency operations</u>.

Main Thrust of Option H (Limited WDA production role)

Under Option H (Reoriented WDA role), WDA drilling of production wells and and construction of civil works would no longer be regarded as WDA's mission. The agency's drilling capabilities would be focused on a program of exploratory drilling designed substantially to improve knowledge of Somalia's groundwater resources. Such knowledge is very much needed, and would substantially reduce the risks of dry holes in the drilling of production wells by the private and foreign sectors.

EXHIBIT H-8

OPTION G

PUBLIC/PRIVATE COMPETITION FOR GOVERNMENT CONTRACTS

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Substantial Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	93		0		5		2		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Maintenance	96		1		2		1		0		100
Change from Option A		0		0		0		0		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	15		30		0		35		20		100
Change from Option A		-10		-10		0		20		0	
Civil Works for Drilled Wells	26		15		3		56		0		100
Change from Option A		-10		-10		0		20		0	
Level 3 Functions:											
Gravel	45		0		5		50		0		100
Change from Option A		-10		-5		0		15		0	
Wood	5		0		5		25		65		100
Change from Option A		-10		0		0		10		0	
Cement	20		0		0		20		60		100
Change from Option A		-10		0		0		10		0	
Pipe	3		0		0		25		72		100
Change from Option A		-2		0		0		15		-13	
Storage Tanks b/	45		0		0		30		25		100
Change from Option A		-15		0		0		15		0	
Pumps	0		0		0		15		85		100
Change from Option A		0		0		0		7		-7	
Windmills	25		0		0		15		60		100
Change from Option A		0		0		0		0		0	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	60		5		0		35		0		100
Change from Option A		0		0		0		0		0	

WDA's central role will be to serve as the principal government agency contracting with the private sector for the drilling of production wells. It would also provide technical services in locating suitable well sites, approve wells drilled by the private sector and perform certain planning and regulatory activities concerning the identification of high priority locations for drilled wells, assessment of drilling costs, and analysis of water rates.

As discussed in the previous subsection (Subsection H-2.2.7, Option G) WDA as currently regarded has an exclusive contracting role in the structure of the Government of Somalia. Other agencies of the government of Somalia may not enter into contracts with private sector drillers without first receiving WDA approval. If WDA has equipment and manpower available, WDA has the right to exclude the private driller and take on the assignment itself. WDA's decision to undertake an assignment prevails even though the purchasing agency believes it could obtain a better price and/or better service from the private driller.

If WDA offers no objection to the engagement of the private driller, this engagement may take the form of a subcontract between WDA and the private driller. A direct contractual relationship between the purchasing agency and the private driller is also possible. However, in such a case, WDA provides inspection and other technical services.

Under Option H, WDA would continue to provide inspection and technical services. However, it would lose the right to exclude the private sector from drilling production wells and could only drill such wells itself in times of water emergencies: that is, in situations where the private sector could not meet urgent national requirements in a timely or cost-effective way. Thus, in a certain sense, Option H is the public sector counterpart of Option F, which assigns an auxiliary water security role to the private sector. However, under Option H WDA would maintain its drilling capability through exploratory drilling, whereas under Option F the private sector would maintain its capabilities through long term contracts to drill production wells.

Market Shares Projected for Option H (Public/Private Competition)

Exhibit H-9 shows the market shares expected to be achieved under Option G by the end of 1990. Exhibit H-9 also shows the change in market shares expected to result from Option H, by comparing Option H with Option A (Option A represents the respective market shares of the Government of Somalia, community activities, the Somali private sector, and the external sector at present.)

EXHIBIT H-9

OPTION H

REORIENTATION OF WDA'S ROLE

POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	97		0		2		1		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Operation/ Revenue Collection	93		0		5		2		0		100
Change from Option A		0		0		0		0		0	
Drilled Well Maintenance	96		1		2		1		0		100
Change from Option A		0		0		0		0		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	5		30		0		45		20		100
Change from Option A		-20		-10		0		30		0	
Civil Works for Drilled Wells	16		16		3		65		0		100
Change from Option A		-20		-9		0		29		0	
Level 3 Functions:											
Gravel	30		5		5		60		0		100
Change from Option A		-25		0		0		25		0	
Wood	5		0		5		30		60		100
Change from Option A		-10		0		0		15		-5	
Cement	16		0		0		26		58		100
Change from Option A		-14		0		0		16		-2	
Pipe	3		0		0		32		65		100
Change from Option A		-2		0		0		22		-20	
Storage Tanks b/	34		0		0		41		25		100
Change from Option A		-26		0		0		26		0	
Pumps	0		0		0		15		85		100
Change from Option A		0		0		0		7		-7	
Windmills	20		0		0		25		55		100
Change from Option A		-5		0		0		10		-5	
Petroleum Distribution	85		15		0		0		0		100
Change from Option A		0		0		0		0		0	
Machine Shops	60		5		0		35		0		100
Change from Option A		0		0		0		0		0	

Option H (Public/Private sector competition) does not involve any change in market shares for the Level I activities of well ownership, operation, maintenance, and revenue collection. The key changes envisioned by Option H are in the market shares of drilling and civil works construction.

Under Option H about thirty percent of the drilling activity in the country would be shifted to the Somali private drillers over a period of five years, twenty percent from Government of Somalia agencies and ten percent from shares currently held by foreign organizations operating under development assistance arrangements. This would make the private sector the leading provider of drilling services in Somalia.

Construction of civil works by the private sector would also increase by thirty percent. Shifts of shares from the government and foreign organizations give the private sector about two thirds of the market of civil works for drilled wells.

H-2.2.9 Option I: Somali private sector achieves substantial market shares of key Level III support activities.

Main Thrust of Option I (Key support activities privatized)

In prior subsections (H-2.2.2 through H-2.2.8), we have dealt with options whose primary impacts were at Levels I and II. With the exception of Option E (discussed in Subsection H-2.2.5), the secondary impacts of these options on Level III activities would be relatively modest. In the case of Option I, the primary impact takes place only at Level III.

Under Option I, there would be no change in the present government and private shares of well ownership, operation and revenue collection, well maintenance, drilling, or construction of civil works. The government would continue to occupy its current position in these activities.

What would change under Option I is the structure of ownership and operation of key support industries such as the distribution of petroleum products, and provision of manufactures such as pipe and pumps, raw materials such as gravel and cement, and services such as those provided by a local machine shop. The premise of Option I is that the efficiency of Level I and Level II activities (public and private) is severely constrained by supply problems, and that changes in market structure at Level III might do more for water resource development in Somalia than changes in the structure of the industry at Level I and Level II together.

Option I differs from all of the previous options we have considered in that it implies significant changes in the market shares and institutional structure of important industries whose total markets dwarf the requirements on them generated by Level I and Level II drilled well activities. Thus petroleum products

represent critically important inputs to well operations, well drilling and well-related civil works, but such well-related requirements represent a relatively small share of the Somalia market for petroleum products.

Option I assumes that a strategy of privatization adopted in other sectors of the economy would result in substantial improvements in the efficiency with which inputs are provided to many industries and thus improve the functioning of the entire economy. If such a strategy were to succeed in overcoming presently existing bottlenecks, the impact on well related activity would be substantially to improve the productivity of drilled well construction and productivity at Level II and Level III without any institutional changes at these levels.

Market Shares Projected for Option I (Key support activities privatized)

Exhibit H-10 shows the market shares expected to be achieved under Option I by the end of 1990. Exhibit H-10 also shows the change in market shares expected to result from Option H, by comparing Option H with Option A (Option A represents the respective market shares of the Government of Somalia, community activities, the Somali private sector, and the external sector at present.)

As discussed above, Option I (Key support functions privatized) does not involve any change in market shares for the Level I activities of well ownership, operation, maintenance, and revenue collection, nor in the Level II activities of well drilling and related civil works construction. The key changes in market shares of drilling and civil works take place at Level III itself.

Exhibit H-10 shows very substantial shifts in market shares from the public sector to the private sector in Somalia in provision of cement, gravel, storage tanks, and petroleum products. Shifts of such magnitude could not be made without major reorientation of the internal structures of these industries in Somalia, divestiture of important parastatal organizations, and sale of their assets to the private sector.

H-2.2.10 <u>Option J: All three levels of industry structure relating to drilled well water supplies substantially privatized</u>.

Main Thrust of Option J (Pervasive privatization)

Option J would result in more extensive policy change in the direction of privatization than any other option analyzed in this Working Paper. Option J is based on the premise that the private sector could achieve a higher degree of efficiency than the public sector in each key industry related to drilled wells.

A correlary premise is that the Government can protect the public interest with respect to environmental and health regulation, reasonable charges for provision of an essential commodity, and continuity of water service without itself being directly engaged in any economic activity essential to the provision of water from drilled wells.

In order to achieve the market shares shown for Option J by the close of 1990, it is likely that the government will have to sell a substantial amount of property, equipment, and other assets to the private sector. While other options might require some such sales, the property transfers required by Option J would be pervasive and significant.

Option J is likely to generate requirements for the development of Government regulatory capacities. Since drilled wells in Somalia often represent natural monopolies at least in certain areas and seasons, and since water is a vital resource affecting the public welfare, effective public utility regulation is seen as a companion to privatization under Option J.

Option J clearly represents a fundamental policy change, with substantial shifts from public to private ownership. However, although large changes in market shares are shown throughout the industry structure, Option J does not constitute total privatization. In no case has a market share of zero been projected for an activity in which a public sector capability presently exists.

The reasons for retaining residual public sector market shares even in this polar option are as follows:

First, the analysis seeks to define and estimate changes in market structure which could occur by the end of 1990, a period of about five years from the time policy decisions would start to be implemented. To attempt to move to total privatization within so short a period could be beyond the the country's capacity to adapt to a radically changed institutional structure.

Second, concern for national water security indicates the advisability of retaining at least a bare minimum of established government productive capabilities.

Third, provision of general services by government agencies to other government agencies may in some instances represent the most cost-effective means of supply.

Nevertheless, while Option J gives these considerations weight at the margin, this policy option treats extensive privatization as an effective way to improve the functioning of the water resource sector within the structure of the economy of Somalia.

Market Shares Projected for Option J (Pervasive privatization)

Exhibit H-11 shows the market shares expected to be achieved under Option G by the end of 1990. Exhibit H-11 also shows the change in market shares expected to result from Option J, by comparing Option J with Option A (Option A represents the respective market shares of the Government of Somalia, community activities, the Somali private sector, and the external sector at present.)

In the case of Level I activities, the private sector would have a market share of 80 percent or more in each function. In the case of ownership, this would require that most new wells be private and that many existing wells be sold to the private sector by the government. Water from deep wells would in effect, be supplied by water companies throughout most of Somalia. These companies can be expected to operate and maintain the wells themselves or to secure these services elsewhere in the private sector, thus reinforcing privatization at Levels II and III.

EXHIBIT H-11

OPTION J

PERVASIVE PRIVATIZATION

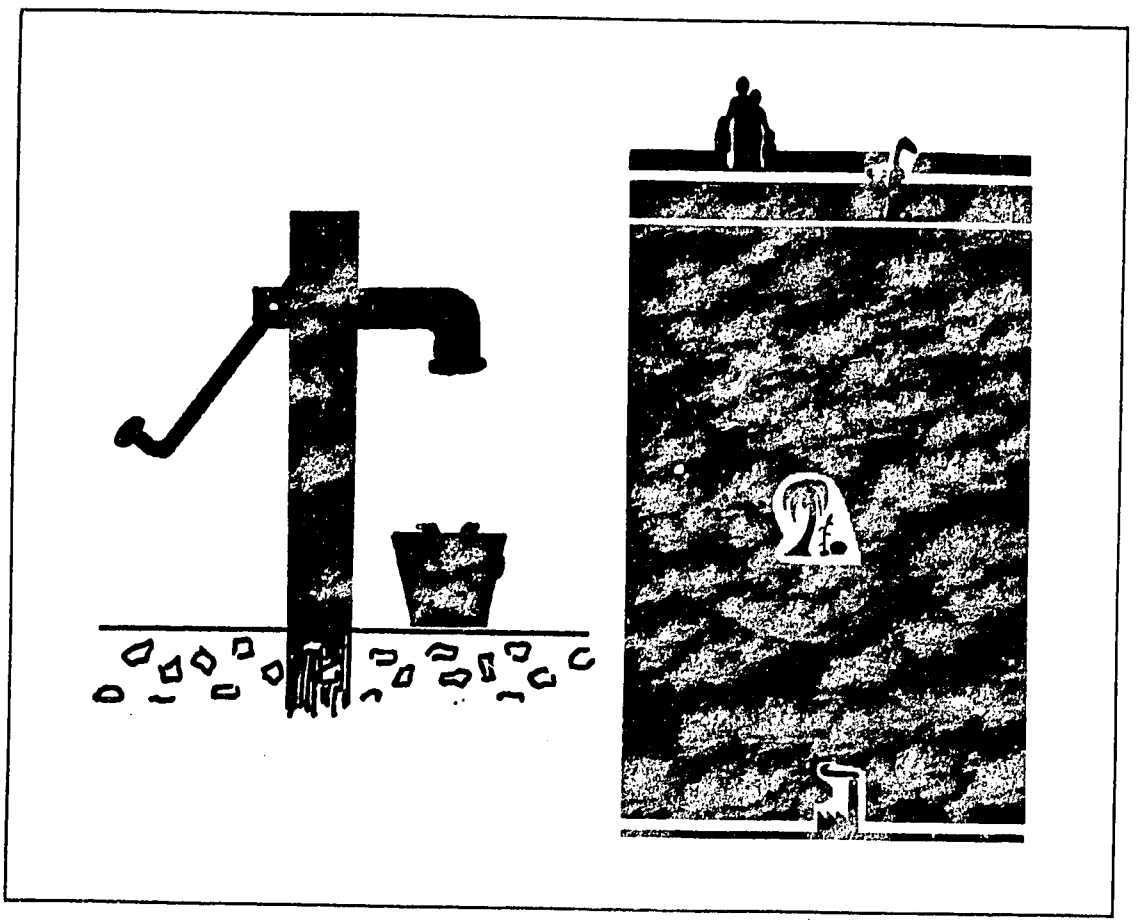
POLICY OPTION RELATED TO MARKET SHARES

Function/Organization:	Somalia Government Activity %	+/- %	Foreign Aid Activity %	+/- %	Substantial Community Activity %	+/- %	Somali Private Sector %	+/- %	Foreign Sector/ Imports %	+/- %	Total
Level 1 Functions:											
Drilled Well Ownership	10		0		10		80		0		100
Change from Option A		-87		0		0		79		0	
Drilled Well Operation/ Revenue Collection	5		0		10		65		0		100
Change from Option A		-88		0		5		83		0	
Drilled Well Maintenance	6		8		8		78		0		100
Change from Option A		-90		7		6		77		0	
Level 2 Functions:											
Well Drilling and Rehabilitation	3		17		0		60		20		100
Change from Option A		-22		-23		0		45		0	
Civil Works for Drilled Wells	5		20		10		65		0		100
Change from Option A		-31		-5		7		29		0	
Level 3 Functions:											
Gravel	5		5		15		75		0		100
Change from Option A		-50		0		10		40		0	
Wood	5		0		5		30		60		100
Change from Option A		-10		0		0		15		-5	
Cement	5		0		0		35		60		100
Change from Option A		-25		0		0		25		0	
Pipe	0		0		0		40		60		100
Change from Option A		-5		0		0		30		-25	
Storage Tanks b/	5		0		0		70		25		100
Change from Option A		-55		0		0		55		0	
Pumps	0		0		0		16		82		100
Change from Option A		0		0		0		16		-10	
Windmills	5		0		0		35		60		100
Change from Option A		-20		0		0		20		0	
Petroleum Distribution	5		15		0		80		0		100
Change from Option A		-80		0		0		80		0	
Machine Shops	5		5		0		30		0		100
Change from Option A		-55		0		0		55		0	

Study of

PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER RESOURCE DEVELOPMENT INDUSTRY

Appendix I



COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

April, 1986

Louis Berger International, Inc.

APPENDIX I

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

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APPENDIX I

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

I-1. INTRODUCTION

I-1.1 Scope and Organization of Working Paper

This appendix 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 the water industry in Somalia;

2) Analyze national water supply objectives in light of existing resource and market constraints;

3) Demonstrate the effects on water supply of the Consultants' Recommended Program; and

4) Generate integrated estimates of the characteristics of the water industry system in Somalia as it currently exists.

Annex I, bound separately, presents quantitative details.

This appendix is composed of eight sections and a set of annexes in addition to this introduction. Section I-2 provides an overview of the Water Industry Systems Model for Somalia (WISyMS) and its uses. Section I-3 provides an explanation of each of the three submodels of WISyMS. Section I-4 discusses the use of the model for the Consultants' 1990 forecasts. Section I-5 discusses the use of the model for a constraint analysis of national water supply objectives and discusses LBII's supply side analysis of the Consultants' recommended program. Section I-6 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 Section I-7; Section I-8 presents the methodology and formulae employed by the model; and Section I-9 discusses the sources of data and estimates used in developing the model. Annex I contains the detailed data generated by running the model under various assumptions.

I-1.2 WISyMS as an Integrated Data Base for a Private Sector Project

WISyMS is a tool for comprehensive sectoral analysis for a private sector project. It is believed that the concepts and methodology of WISyMS have general applicability for privatization or divestiture interventions throughout their respective project cycles. More specifically:

- WISyMS has been designed as a multi-purpose data base which can serve the needs of project identification, project monitoring, and project evaluation without requiring substantial structural modification.

- WISyMS can be presented in layman's terms, so it can be used by some of the primary beneficiaries of privatization projects: the local businessmen, to whom it presents an integrated analysis of an entire industry structure, including project complements and substitutes, as well as upstream and downstream markets;

- WISyMS can be presented in more detailed, technical terms, so it can be easily up-dated by local planning personnel, and kept available for reference by local government personnel, donors, and private individuals interested in or concerned with the market; and finally

- WISyMS can reduce the "market information risk", which businessmen in developing countries often face both by providing a tool for reconciling conflicting information, and by providing them with the results of sensitivity analyses on the points of conflict.

I-2 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 I-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 I-2 presents the symbols used to represent the water supply structures in Somalia considered in this report. Exhibit I-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

EXHIBIT I- 1

PRINCIPAL CATEGORIES OF CONSUMERS OF WATER

HUMANS

-URBAN
-RURAL SETTLED
-NOMADIC

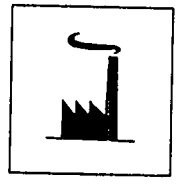
ANIMALS

-CAMELS
-CATTLE
-SHEEP/GOATS
-OTHER

AGRICULTURE

-IRRIGATION FARMS
-RAIN FED FARMS
-FLOOD FED FARMS

GOVERNMENT/
INDUSTRY



-GOVERNMENT
-INDUSTRY

EXHIBIT I- 2

PRINCIPAL WATER SUPPLY STRUCTURES

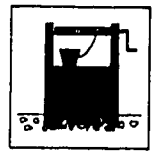
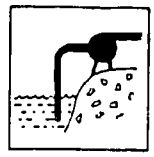
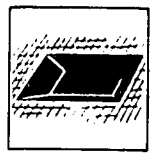
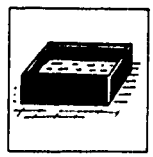
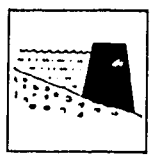
DRILLED WELLS		ALL WELLS DRILLED MECHANICALLY, EQUIPPED WITH DIESEL OR HAND PUMP
HAND DUG WELLS		ALL WELLS DUG BY HAND, REGARDLESS OF DEPTH
INTAKES FROM RIVERS/STREAMS/ SPRINGS		CONSISTING OF PIPES IMMERSED INTO WATER AND CONNECTED TO A DIESEL PUMP
UARS/ RESERVOIRS		RESERVOIRS DUG IN RELATIVELY IMPERMEABLE 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

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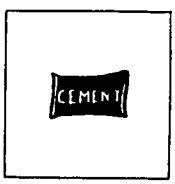
EXHIBIT I- 3

PRINCIPAL CATEGORIES OF INPUTS TO THE WATER INDUSTRY

RAW MATERIALS

- SAND
- GRAVEL
- STONES
- OTHER

MANUFACTURED MATERIALS

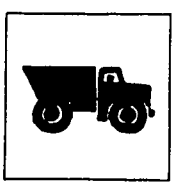


- CEMENT
- STEEL CASING
- STEEL SCREEN
- OTHER

LABOR

- SKILLED
- UNSKILLED

EQUIPMENT



- DRILL RIGS
- PUMP RIGS
- VEHICLES
- OTHER

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 I-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 I-5).

I-2.1 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.

- **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 in Section Three of the main body of the report.

EXHIBIT I- 4

OVERVIEW OF RELATIONSHIPS AMONG LEVELS OF THE WATER INDUSTRY

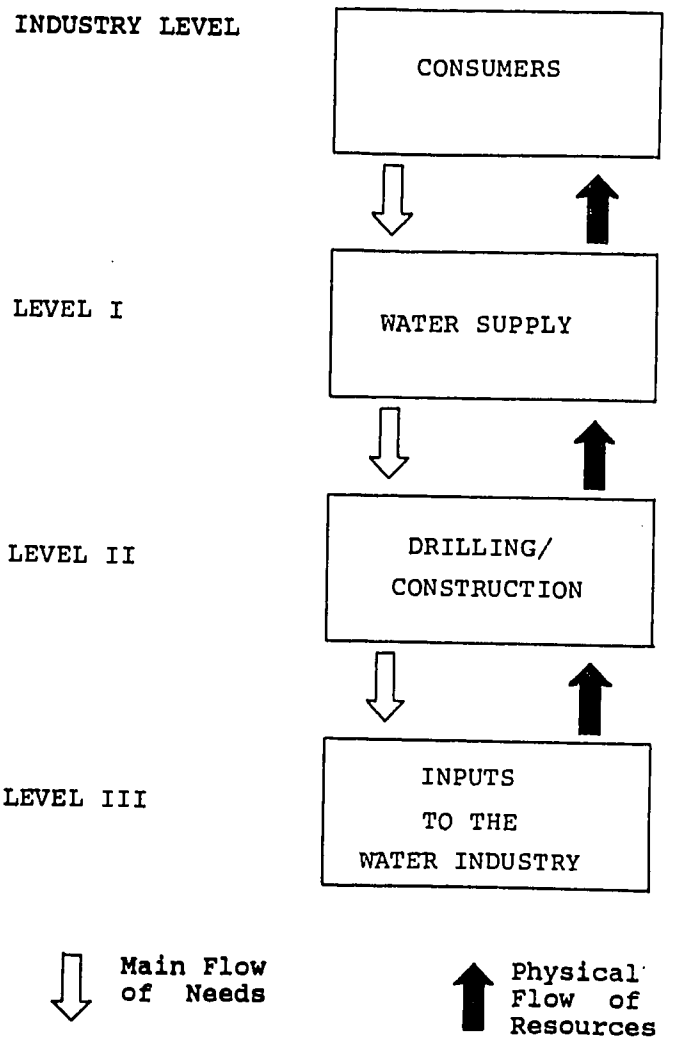


EXHIBIT I- 5

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	✓	✓	✓

I-2.2 The Level II Submodel: Well Drilling and Construction of Water Supply Facilities

Level II is the drilling and rehabilitation 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 (or rehabilitation) 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 old water supply structures to be rehabilitated and 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 in Section Three of the main body of the report.

I-2.3 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 new drilling, rehabilitation, and construction (output from Level II Submodel); requirements for operation and maintenance of structures (output from Level I 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.

I-2.4 Types of Analyses Performed with WISyMS

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

I-2.4.1 Forecasting

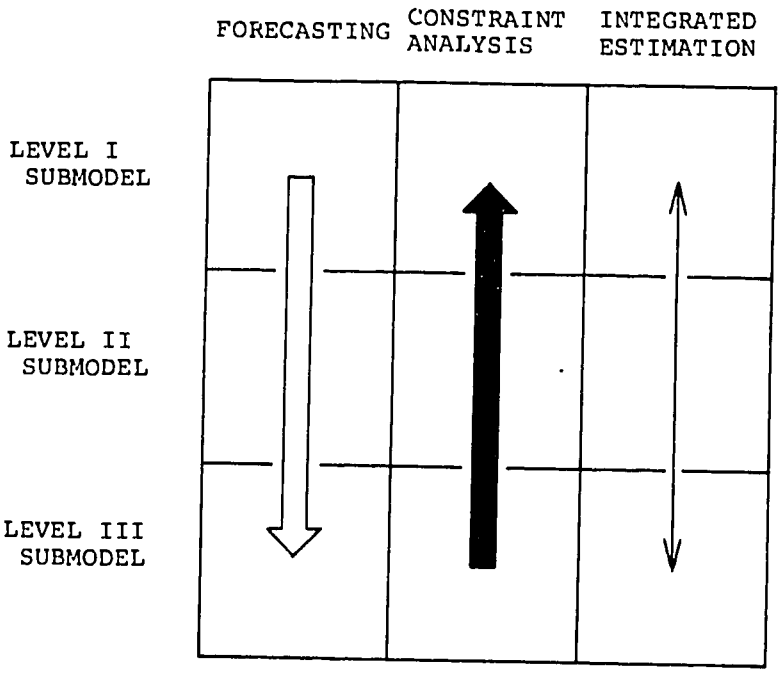
If used for forecasting, the analysis follows the flow of needs. First, demographic and economic data are gathered and used to forecast Level I demand for water for a given year and an associated stock of supply structures. This stock of structures is used to calculate Level II demand for the flow of drilling, rehabilitation 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 I-4 of this paper. Annexes I-4 through I-6 contain the Consultants' 1990 forecasts generated by running WISyMS.

I-2.4.2 Supply/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 specific goals and key assumptions of a particular program. The model is run first as a forecast, and the implications in terms of drilling/construction requirements are compared with past performance and resource availability. The major constraints are identified, and these constraints indicate 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 I-5, as part of the Consultants' supply side and constraint analysis of national water supply objectives in Somalia.

EXHIBIT I- 6

THE DIRECTION OF ANALYSIS IN WISyMS



Analysis Follows Main Flow of Needs

Analysis Follows Physical Flow

Analysis Proceeds in Both Directions

I-2.4.3 Integrated Estimation

Integrated estimation of system parameters, as presented in the Consultants' baseline (1984) estimates for the water industry system in Somalia (see Annexes I-1 through I-3) 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 I-6.

The overview of WISyMS provided above is expanded in Section I-3 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 Sections I-4, I-5, and I-6.

I-3 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 Section I-8.

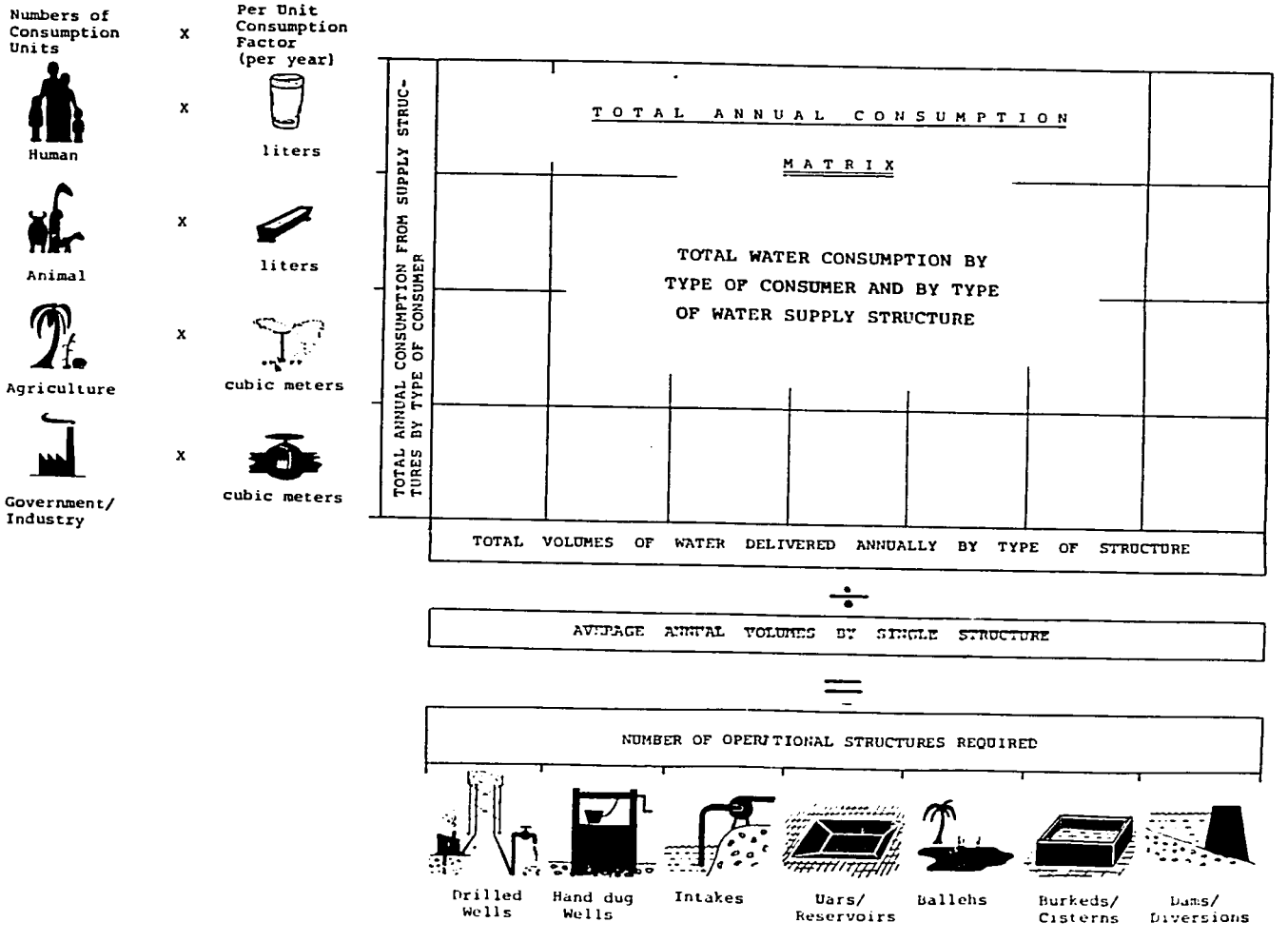
I-3.1 WISyMS Level I Submodel - Water Supply: An Integrated Analysis of Water Consumption and Delivery Systems (Exhibit I-7).

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 Annex I; notes and sources are discussed in Section I-9.

EXHIBIT I- 7

LEVEL I SUBMODEL

Integrated Analysis of Water Consumers and Delivery Systems



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;
- **Agriculture's** 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/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 factors 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.

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;

* Detailed definitions are provided in Section I-7.

- **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 I-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 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.

I-3.2 <u>WISyMS Level II Submodel - Drilling and Construction:</u> Quantification of flow requirements for new water supply structures for replacement and expansion of existing capacity (Exhibit I-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 in the manner outlined below.

* These structures are defined in more detail in Section I-7.

EXHIBIT I- 8

LEVEL II SUBMODEL

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

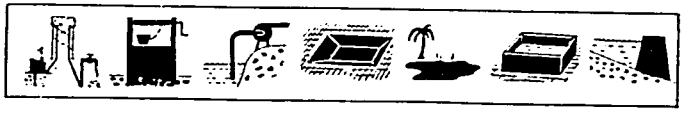
Total Stock at Beginning of Year 1

MINUS

Closure During Year 1

=

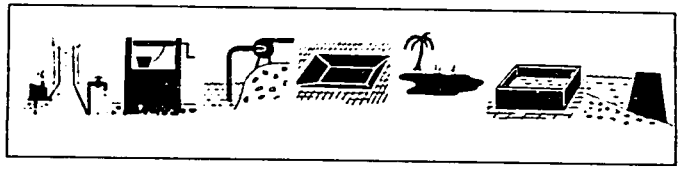
Remaining at End of Year 1



+%

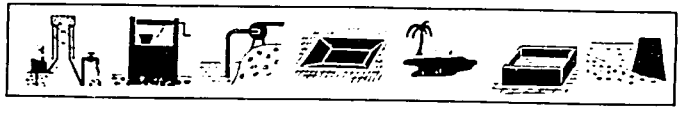
EXPANSION

Total Needed Stock Year 2



MINUS

Stock at Beginning of Year 2



=

NEEDED NEW/REHABILITED STRUCTURES IN YEAR 2

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 structural supply volumes.

This is compared with:

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

  Drilled wells and other water supply structures can be expected to fail at a certain rate, for a variety of reasons. Some of these failed structures can be rehabilitated by replacing worn parts, cleaning the structure, or redrilling the well. In other cases, rehabilitation may prove to be more expensive or complicated than drilling or constructing a new unit. Thus, of the total number of failed structures, some may be rehabilitated, while other mays have to be replaced by new structures. Net increases to the supply of structures, however, can only be undertaken by new drilling/construction.

  Over the past several years in Somalia, drilled wells which have ceased functioning (due primarily to pump/generator failure) have rarely been rehabilitated. Instead, they may lay idle for a considerable period of time, until the old well is replaced entirely by a new drilled well.

Subtracting the numbers of functioning 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 rehabilitated or constructed to:

  a) replace or rehabilitate old structures as they 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 Level III component of WISyMS, 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.

I-3.3 WISyMS Level III Submodel - Water Industry Inputs: Quantification of Inputs Required for Expansion of Water Supply Capacity. (Exhibit I-9)

The top row of Exhibit I-9 corresponds to the bottom line for each type of supply structure analyzed in the Level II submodel. The left hand column of Exhibit I-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;
- **Labor Inputs** such as supervisors, drillers, or carpenters; and
- **Equipment Inputs** such as drill rigs, bulldozers, and pickup trucks.

For each type of structure, there are technical input coefficients for production, rehabilitation, maintenance and operation 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 unit. These per-structure input requirements are multiplied by the numbers of each type of structure to be produced, rehabilitated, maintained, and operated in a given year to yield total physical requirements for each type of input, and for each type of structure. These can be summed 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.

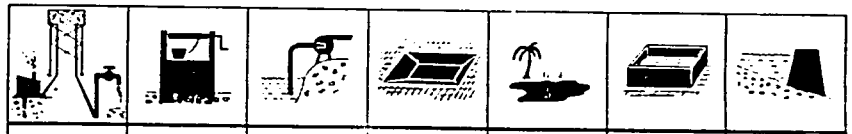
Note that at present, the model considers only those water supply facilities which take water directly from natural sources. Municipal water distribution systems, irrigation systems, and water transport have not been examined, although they could be incorporated into the model in the future.

EXHIBIT I- 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.

I-4 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.

I-4.1 Forecasting Features

The parameters of the model were estimated on the basis of the best available information on historical patterns of water use and relationships between types of consumption and types of structures; but WISyMS has also 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.

I-4.2 Forecasting Procedures

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

I-4.2.1. 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 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 I-4.3.

I-4.2.2 Technological Advancements in Supply System Performance

The effects of technological advancements in supply system performance on the basic relationships analyzed in the WISyMS can be incorporated in parameter changes in the model. For instance, an improvement in maintenance 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.

I-4.2.3 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.

I-4.2.4 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. Other such elements are examined in more detail in Section I-5, "Constraint Analysis".

I-4.2.5 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 I-6, "1984 Integrated Estimates".

I-4.3 1990 Forecasts

Exhibit I-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 consultants 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 I-11, which is drawn from the "Structural Control Volumes" column of Exhibit I-10, provides a graphic representation of the distribution of water by type of consumer. Exhibit I-12, which is drawn from the "Structural Supply Volumes" row of Exhibit I-10, shows the distribution of water by type of structure. A detailed presentation of the data is contained in Annex I-4; notes and sources for the data are discussed in Section I-9.

Exhibit I-13 presents the key data generated by the Level II submodel (drilling, construction and rehabilitation 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 or rehabilitated 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 Annex I-4.

Exhibit I-14 presents the data generated by the Level III submodel (inputs to the water industry) for the 1990 projections. The full model contains four parts, one analyzing inputs for drilling/construction, one analysing inputs for well rehabilitation, one analyzing inputs for maintenance, and one analyzing inputs for well operation and revenue collection. Here we present only the part analyzing new drilling/construction. The full level III sub-model is presented in Annex I-4.

EXHIBIT I-10

DATA FROM 1990 FORECAST, LEVEL I SUBMODEL

CONSUMPTION UNITS	(000s) MEASURE	PER UNIT CONS'N DAILY USE FACTOR MEASURE	TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE: STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	UARS/ RESER-VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN													
Urban HC	174 persons	100 liters	6287	4716	0	0	0	629	629	126	0	189	0
Urban SP	1567 persons	25 liters	14013	10510	0	0	0	1401	1401	280	0	420	0
Rural Set	1853 persons	15 liters	9638	193	1677	58	0	4337	1446	482	193	1253	0
Nomadic	2757 persons	10 liters	9057	109	1195	54	0	3170	1811	906	906	906	0
SUBTOTAL 1	6351 persons		38995	15527	2872	112	0	9537	5287	1794	1098	2768	0
ANIMAL													
Camels	5308 head	25 liters	31483	252	2771	126	0	6297	6297	6297	7871	1574	0
Cattle	4246 head	25 liters	30996	930	3534	186	0	10849	4649	6199	3100	1550	0
SheepGoats	28661 head	3 liters	23538	471	1789	94	0	8238	4001	3531	3766	1648	0
OtherAn	10615 head	3 liters	581	12	33	2	0	174	99	116	116	29	0
SUBTOTAL 2	13190 LSU		86598	1664	8126	408	0	25558	15046	16143	14853	4801	0
AGRICULTURE													
Irrigfarm	64 hectares	68 cu.meters	1350208	0	0	0	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804 hectares	35 cu.meters	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161 hectares	25 cu.meters	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029 hectares		1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS													
Govt	2 estabs	13 cu.meters	7800	7032	144	0	0	390	234	0	0	0	0
Industry	0.73 estabs	8 cu.meters	1752	1494	30	0	0	175	53	0	0	0	0
SUBTOTAL 4	2.73 estabs	9552	9552	8526	174	0	0	565	287	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)			1560134	25717	11172	520	40506	49162	1235807	31438	29453	7568	128789
COMMERCIAL SCALE STRUCTURES				232	398	189	230	4634	6180	953	230	14166	156

EXHIBIT I-11

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

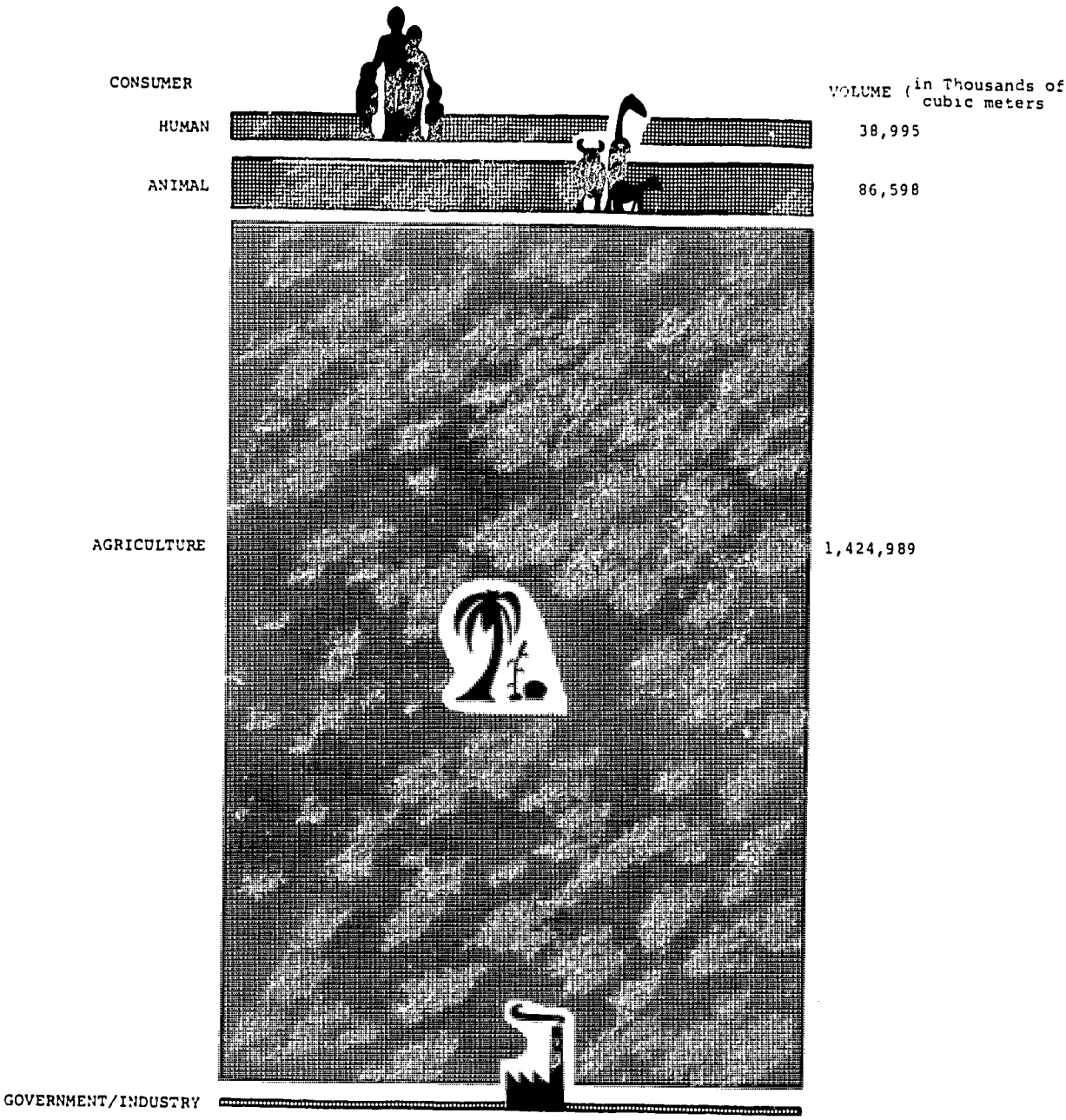


EXHIBIT I-12

1990 FORECASTS OF DISTRIBUTION OF WATER BY TYPE OF SUPPLY STRUCTURE

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

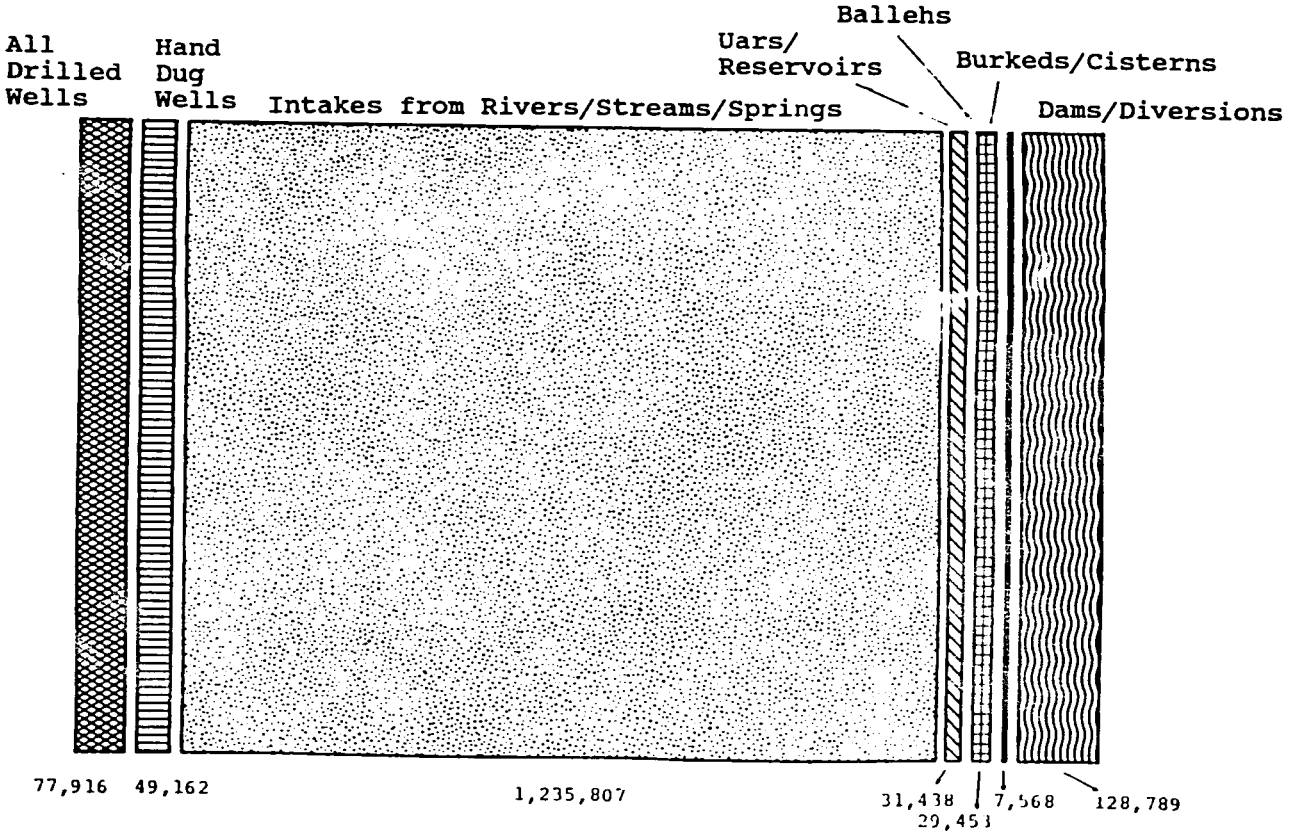


EXHIBIT I-13

PROJECTIONS OF REQUIREMENTS FOR NEW WATER SUPPLY STRUCTURES FOR 1985-1990

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total	56	74	107	123	124	138	153	170	188	209	232
Old	51	51	68	99	112	111	124	137	152	169	188
Needed New or Rehab	5	23	39	24	12	27	29	32	36	40	45
DP RURAL BOREHOLES											
Needed Total	120	142	159	177	199	223	251	281	316	354	398
Old	107	110	130	144	159	179	200	224	251	282	317
Needed New or Rehab	13	32	29	34	40	45	51	57	64	72	81
HP RURAL BOREHOLES											
Needed Total	99	105	110	115	122	131	141	152	163	176	189
Old	92	89	95	98	102	108	115	124	133	142	153
Needed New or Rehab	7	16	14	17	19	23	25	28	30	33	36
IRRIGATION WELLS											
Needed Total	91	102	123	141	155	166	177	189	202	215	230
Old	75	84	92	113	127	139	148	158	168	179	191
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39
HAND DUG WELLS											
Needed Total					2500	2771	3071	3404	3772	4181	4634
Old					2250	2275	2521	2774	3059	3376	3731
Needed New					250	496	550	630	714	805	903
INTAKES											
Needed Total					5000	5180	5366	5559	5759	5966	6180
Old					4500	4550	4680	4808	4943	5084	5232
Needed New					500	630	686	751	816	881	948
UARS/RESERVOIRS											
Needed Total					730	780	812	845	880	915	953
Old					675	683	705	728	752	777	804
Needed New					75	98	107	117	127	138	149
BALLEHS/PONDS											
Needed Total					200	205	209	214	219	224	230
Old					180	182	185	187	190	193	196
Needed New					20	23	25	27	29	31	34
BURKEDS/CISTERNS											
Needed Total					10000	10598	11231	11902	12613	13367	14166
Old					9333	9378	9931	10486	11079	11709	12379
Needed New					667	1220	1300	1416	1535	1658	1787
DAMS											
Needed Total					100	108	116	125	135	145	156
Old					80	84	88	92	97	102	124
Needed New					20	24	28	33	38	43	32

EXHIBIT I-14

1990 FORECASTS OF WISyMS LEVEL III SUBMODEL

(Please turn over)

LABOUR

Skilled:

Supervisory per St.	man-days	10	10	6	6		5						
Annual Supervisory	man-days	446	812	215	187		243						1903
Drilling per St.	man-days	25	26	17	17		14						
Annual Drilling	man-days	1114	1624	611	531		679						4559
Excavation per st.	man-days					6.4			10	10	30	30	
Annual Excav.Wrks	man-days					5780			1487	335	53605	949	62156
Civil Wrks.per st.	man-days	50	36	18	15	5		1.2	0.5	1.5	15	30	
Annual Civil Wrks.	man-days	2229	2922	646	469	4515		1137	74	50	26802	949	39796
Mech.Wrks per st.	man-days	20	12	6	6	0.6		5			3		
Ann.Mechanic Wrks.	man-days	891	974	215	187	542		4739			5360		12911
Carp.Wrks per st.	man-days	5	2	2	2								
Ann.Carpentry Wrks.	man-days	223	162	72	62								529

Unskilled:

Drilling per St.	man-days	300	240	200	200		150						
Annual Drilling	man-days	13371	19489	7183	6248		7276						53567
Excavation per st.	man-days					6.4					3		
Annual Excav.Wrks	man-days					5780					5360		11140
Civil.Wrks per st.	man-days	300	216	36	175	5		2	0.5	1.5	15	90	
Ann.Civil Wrks.	man-days	13371	17540	1293	5467	4515		1896	74	50	26802	2848	73857
Mech.Wrks. per st	man-days	20	12	3.6	8	3.6		12			6		
Ann.Mechanic Wrks.	man-days	891	974	129	250	3251		11375			10721		27592
Other Unskilled per st.	man-days												
Annual Other Unskilled	man-days												0

EQUIPMENT

Drill Rigs per st	Eq-days	30	24	20	18		10						
Annual Drill Rigs Use	Eq-days	1337	1949	718	562		485						5052
Pump Rigs per st	Eq-days	3	3	2	2		1						
Annual Pump Rigs Use	Eq-days	134	244	72	62		49						560
Heavy Vehicles per st	Eq-days	223	168	70	45	10	35	2	10	10	8	30	
Annual Heavy Vehcl Use	Eq-days	9939	13642	2514	1406	9030	1698	1896	1487	335	14295	949	57191
Light Vehicles per st	Eq-days	250	240	120	100	10	40	3	5	12	4	30	
Annual Light Vehcls Use	Eq-days	11143	19489	4310	3124	9030	1940	2844	743	402	7147	949	61122

FUEL CONSUMPTION

Drill Rigs per st	Liters	4500	1600	3000	2700		1200						
Annual Drill Rigs Fuel	Liters	200566	292334	107745			58208						658852
Pump Rigs per st	Liters	336	336	224	224		112						
Annual Pump Rigs Fuel	Liters	14976	27284	8045	6998		5433						62736
Heavy Vehicles per st	Liters	8920	6720	2800	1800	400	1400	80	400	400	320	1200	
Annual Heavy Vhcl Fuel	Liters	397566	545690	100562	56233	361219	67909	75832	59474	13408	571784	37971	2287648
Light Vehicles per st	Liters	6690	5040	2100	1350	300	1050	60	309	300	240	900	
Annual Light Vhcls Fuel	Liters	298174	409267	75421	47175	270914	50932	56874	44605	10056	429838	28478	[illegible]

The top row of the model for drilling and construction shows the number of new structures which need to be constructed in the year 1990. The left hand column lists the major inputs required for all types of drilling and construction, while the far right hand columns in the full model presented in Annex I-4 show:

1) the total annual quantities required for each type of input
2) the unit cost for each type of input
3) the total annual cost for each type of input

Detailed presentations of the methodology, the co-efficients, and the sources of data are contained in Sections I-8 and I-9 of this appendix.

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 everywhere must rely for their decision-making.

I-5 SUPPLY SIDE AND 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.

I-5.1 Features of Constraint Analysis

Use of the model to evaluate national objectives can be regarded as a special forecasting application focussing on the supply side of the industry, 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 Level III. Constraints affecting the water industry can be tangible and physical (e.g., a shortage of well casing) and explicitly analyzed by the submodel, or they can be more general (e.g., difficult licensing procedures), and may affect Level II activity indirectly.

Constraint analysis thus analyses 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.

I-5.2 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 I-4, 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 goals" run of the model is compared with the output from the "without goals" 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 goals can be considered reasonably attainable, and second - what, if any, efforts 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.

I-5.3 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". In brief, 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 or rehabilitation 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 283 wells between 1985 and 1990. Assuming a construction program for the national goals was begun in 1985, this would start with a rate of 168 in 1985 and rise to 440 for 1990 (see Exhibits I-15 and I-16; detailed data are presented in Annex I-7).

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 1985 through 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 224 wells per year, starting with 149 in 1985 and rising to 319 in 1990 (see Exhibits I-17 and I-18; detailed data are presented in Annex I-8).

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.

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 Consultants to be in operation or capable of operation. Assuming each rig could drill eight production wells per year (and four non-production wells), 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.

EXHIBIT I-15

DATA FROM 1990 CONSTRAINT ANALYSIS OF NATIONAL GOALS (FULL STANDARDS)

CONSUMPTION UNITS			PER UNIT CONS'N		TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE										
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER-VOIRS	BALLEHS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
					M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR	M^3*K/YR
HUMAN															
Urban HC	696	persons	130	liters	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045	persons	41	liters	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853	persons	26	liters	16706	501	4444	67	0	6682	2506	501	334	1671	0
Nomadic	2757	persons	26	liters	23548	353	3673	94	0	8242	4710	2002	2119	2355	0
SUBTOTAL 1	6351	persons			88274	39271	8117	161	0	18766	11537	2983	2453	4986	0
ANIMAL															
Camels	5308	head	25	liters	31483	315	5856	126	0	4722	4722	6297	7871	1574	0
Cattle	4246	head	25	liters	30996	1550	6075	124	0	9299	3100	6199	3100	1550	0
SheepGoats	28661	head	3	liters	23538	706	3907	94	0	7767	2825	3531	3060	1648	0
OtherAn	10615	head	3	liters	581	12	73	2	0	163	87	116	99	29	0
SUBTOTAL 2	13190	LSU			86598	2582	15912	346	0	21951	10734	16143	14129	4801	0
AGRICULTURE															
Irrigfarm	64	hectares	68	cu.meters	1350208	0	0	0	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	hectares	35	cu.meters	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161	hectares	25	cu.meters	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029	hectares			1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS															
Govt	2	estabs	13	cu.meters	7800	7176	156	0	0	312	156	0	0	0	0
Industry	0.73	estabs	8	cu.meters	1752	1524	53	0	0	123	53	0	0	0	0
SUBTOTAL 4	2.73	estabs	9552		9552	8700	209	0	0	435	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1609413	50553	24237	507	40506	54654	1237667	32628	30085	9786	128789
COMMERCIAL SCALE STRUCTURES						457	863	184	230	5151	6189	989	234	18318	156

EXHIBIT I-16

CONSTRAINT ANALYSIS PROJECTIONS OF REQUIREMENTS FOR NEW WATER SUPPLY STRUCTURES FOR 1985-1990 UNDER NATIONAL GOALS (FULL STANDARDS)

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total	56	74	107	123	124	154	191	238	296	367	457
Old	51	51	68	99	112	111	140	174	217	270	336
Needed New or Rehab	5	23	39	24	12	43	51	64	79	98	121
DP RURAL BOREHOLES											
Needed Total	120	142	159	177	199	254	324	414	529	676	863
Old	107	110	130	144	159	179	231	295	377	483	618
Needed New or Rehab	13	32	29	34	40	75	94	119	152	193	245
HP RURAL BOREHOLES											
Needed Total	99	105	110	115	122	130	140	150	160	172	184
Old	92	89	95	98	102	108	115	123	131	140	150
Needed New or Rehab	7	16	14	17	19	23	25	27	29	32	35
IRRIGATION WELLS											
Needed Total	91	102	123	139	155	166	177	189	202	215	230
Old	75	84	92	111	127	139	148	158	168	179	191
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39
HAND DUG WELLS											
Needed Total					2500	2820	3181	3589	4048	4567	5151
Old					2250	2275	2570	2879	3233	3635	4091
Needed New					250	545	611	709	815	932	1061
INTAKES											
Needed Total					5000	5181	5369	5563	5764	5973	6189
Old					4500	4550	4681	4811	4947	5090	5239
Needed New					500	631	688	752	817	883	950
DARS/RESERVOIRS											
Needed Total					750	785	822	861	902	944	989
Old					675	683	710	738	767	798	831
Needed New					75	103	112	123	135	146	158
BALLEHS/PONDS											
Needed Total					200	205	211	217	222	228	234
Old					180	182	185	189	192	196	200
Needed New					20	23	26	28	30	32	35
BURKEDS/CISTERNS											
Needed Total					10000	11061	12236	13534	14971	16560	18318
Old					9333	9378	10395	11460	12646	13962	15422
Needed New					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total					100	108	116	125	135	145	156
Old					80	84	88	92	97	102	124
Needed New					20	24	28	33	38	43	32

EXHIBIT I-17

DATA FROM 1990 CONSTRAINT ANALYSIS OF NATIONAL GOALS (PARTIAL STANDARDS)

CONSUMPTION UNITS			PER UNIT CONS'N		TOTAL DISTRIBUTION OF WATER					TOTAL DISTRIBUTION OF WATER BY STRUCTURE					
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	DRILLED WELLS IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	UARS/ RESER-VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN															
Urban HC	696	persons	130	liters	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045	persons	41	liters	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853	persons	26	liters	16706	334	2088	84	0	5012	3341	1671	2506	1671	0
Nomadic	2757	persons	26	liters	23548	471	2943	118	0	7064	4710	2355	3532	2355	0
SUBTOTAL 1	6351	persons			88274	39222	5032	201	0	15918	12373	4506	6038	4986	0
ANIMAL															
Camels	5308	head	25	liters	31483	315	3337	126	0	6297	4722	7241	7871	1574	0
Cattle	4246	head	25	liters	30996	775	3719	155	0	9299	3100	7749	4649	1550	0
SheepGoats	28661	head	3	liters	23538	471	2260	94	0	7061	2825	5884	3295	1648	0
OtherAn	10615	head	3	liters	581	12	56	2	0	116	87	139	139	29	0
SUBTOTAL 2	13190	LSU			86598	1572	9372	377	0	22773	10734	21014	15955	4801	0
AGRICULTURE															
Irrigfarm	64	hectares	68	cu.meters	135020B	0	0	0	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804	hectares	35	cu.meters	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161	hectares	25	cu.meters	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029	hectares			1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS															
Govt	2	estabs	13	cu.meters	7800	7254	156	0	0	234	156	0	0	0	0
Industry	0.73	estabs	8	cu.meters	1752	1524	53	0	0	123	53	0	0	0	0
SUBTOTAL 4	2.73	estabs			9552	8778	209	0	0	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES					1609413	49572	14612	579	40506	52549	1238502	39022	35495	9786	128789
COMMERCIAL SCALE STRUCTURES						448	520	210	230	4953	6194	1182	277	18318	156

EXHIBIT I-18

CONSTRAINT ANALYSIS PROJECTIONS OF REQUIREMENTS FOR NEW WATER SUPPLY STRUCTURES FOR 1985-1990 UNDER NATIONAL GOALS (PARTIAL STANDARDS)

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
URBAN WELLS											
Needed Total	56	74	107	123	124	154	190	236	292	361	448
Old	51	51	68	99	112	111	140	173	215	266	330
Needed New or Rehab	5	23	39	24	12	43	50	62	77	95	117
DP RURAL BOREHOLES											
Needed Total	120	142	159	177	199	234	274	322	378	443	520
Old	107	110	130	144	159	179	210	247	290	340	400
Needed New or Rehab	13	32	29	34	40	55	64	75	88	103	121
HP RURAL BOREHOLES											
Needed Total	99	105	110	115	122	133	146	160	175	192	210
Old	92	89	95	98	102	108	118	129	141	154	168
Needed New or Rehab	7	16	14	17	19	26	28	31	35	38	42
IRRIGATION WELLS											
Needed Total	91	102	123	141	155	166	177	189	202	215	230
Old	75	84	92	113	127	139	148	158	168	179	191
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39
HAND DUG WELLS											
Needed Total					2500	2802	3140	3519	3944	4420	4953
Old					2250	2275	2552	2840	3167	3537	3953
Needed New					250	527	588	679	776	883	1000
INTAKES											
Needed Total					5000	5182	5370	5565	5767	5977	6194
Old					4500	4550	4682	4812	4949	5092	5242
Needed New					500	632	688	753	818	884	951
DAMS/RESERVOIRS											
Needed Total					750	809	873	942	1016	1096	1182
Old					675	683	734	786	843	905	972
Needed New					75	127	139	156	173	191	211
BALLEHS/PONDS											
Needed Total					200	211	223	235	248	262	277
Old					180	182	191	200	210	220	231
Needed New					20	29	32	35	38	42	46
BURKEDS/CISTERNS											
Needed Total					10000	11061	12236	13534	14971	16560	18318
Old					9333	9378	10395	11460	12646	13962	15422
Needed New					667	1684	1841	2075	2325	2598	2896
DAMS											
Needed Total					100	108	116	125	135	145	156
Old					80	84	88	92	97	102	124
Needed New					20	24	28	33	38	43	32

The Consultants' 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 I-4, above). This middle-level program could be comfortably achieved with the existing stock of drilling rigs; the constraints mentioned above could be addressed by the Consultants' Recommended Phase One and Phase Two programs in order for the targets to be achieved.

The full goals contained in the MMWR's Plan for the Drinking Water Supply and Sanitation Decade could, however, reasonably be achieved by 1995, with the implementation of the Consultants' Recommended Program (Phases One through Three) as outlined in Section Two of the main body of the final report. This is discussed in greater detail in Section I-5.5, below.

I-5.4 WISyMS Supply Side Analysis

WISyMS has also been used for a straightforward supply side analysis of the water industry based on projections of Level II well drilling activities. This type of analysis begins directly with data, estimates, or projections of Level II drilling and construction activities, based on historical performance and/or known future plans. The impact of this activity on Level III (inputs to the industry) is analyzed in a straightforward manner, as discussed above. However, the impact of Level II activity on Level I variables, such as stocks of wells, volumes of water output, and per-capita water consumption, are of greater interest, and the analysis is a bit more involved.

For example, we obtained data on well drilling over a period of time, and used that to make projections into the future. We then translated the drilling projections (Level II data) into projections of stocks of wells (Level I data) by utilizing the estimated rate of old well deterioration. The stocks of wells are in turn translated into volumes of water by utilizing the estimated average output per well. Finally, total annual volumes of water are translated into average per-capita water consumption volumes by assuming that a certain proportion of water production will be consumed by humans (and/or livestock, agriculture, etc.) and dividing the resulting figure by the relevent population.

Exhibit I-19 illustrates how the analysis proceeds:

First, as with the standard Level II (drilling and construction) submodel described in previous sections, we assume a certain number of "old" structures as a given point in time, which will deteriorate at a fixed rate, and be added to by each previous year's drilling. This data is contained in the first row of the table.

EXHIBIT I-19

LEVEL II SUPPLY SIDE ANALYSIS

. ALL NON-IRRIGATION DRILLED WELLS

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total old + prev.	250	250	294	341	374	397	443	495	606	705	810	951	1106	1266	1428	1596
New Drilling	25	71	82	74	71	98	89	92	100	106	117	131	136	138	144	149
Total Stock	275	321	376	415	445	495	554	631	730	835	951	1106	1266	1428	1596	1769
Ave. Volume/Well	36	39	44	44	44	44	45	45	45	45	46	47	48	49	49	50
Volume of Water (M^3*k/yr)	9843	12471	16594	18914	19635	22005	24765	28357	32988	37932	43419	51783	60570	69587	78981	88665
Human cons (M^3*K/yr)					6574	7864	9446	11544	14333	17589	21485	26885	32983	39732	47273	55617
Proportion for human consumption:					33%	36%	38%	41%	43%	46%	49%	52%	54%	57%	60%	63%
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354
Ave. Human cons (M^3/capita/yr)					1.23	1.43	1.67	1.98	2.39	2.85	3.38	4.11	4.90	5.73	6.62	7.56

The second row contains the data and projections on annual drilling or construction activity. Adding the number of new structures to the number of old structures available in a given year gives us the number of total stock of structures available for use, as shown in row three.

The fourth row shows the average volume of output per structure per year, which is used to calculate the total volume of water available from the total stock of structures available in a given year; this is shown in row five.

We proceeded another step by making an assumption about the proportion of the total water available which would be consumed by humans. This is shown in row six. We present the total human population for each year in row seven, then calculate the average annual human consumption in cubic meters per capita per year in row eight.

I-5.5 Supply Side Analysis of Consultants' Recommended Program

The Consultants' supply side analysis for well drilling in Somalia began with a survey and inventory of all known well drilling activity in the country between 1980 and 1984, and planned drilling activity through 1987. Exhibit I-20 contains a comprehensive list of wells drilled by project (or type of client) and by year. The wells are categorized in two ways:

1. The drilling agencies are categorized as "Government" (Somali), "Foreign" and "Private" (Somali); and

2. The wells for each project are subdivided by type of well (urban, rural, and irrigation).

Any combination of the two categories and six classifications of characteristics could be analyzed. Exhibit I-21 contains a large selection of such combinations.

For the purposes of this study, we were particularly interested in the numbers of non-irrigation wells (i.e., rural and urban wells) drilled in Somalia, the market shares attained by each of the three types of drilling agencies, and the trends in non-irrigation drilling by each type of drilling agency.

The average number of non-irrigation wells drilled each year between 1981 and 1984 was about 75; of which an average of 20 (or 27%) were drilled by government agencies, 41 (or 55%) were drilled by foreign firms, and 14 (or 19%) were drilled by local private firms.

Of more importance than the averages, however, have been the trends in drilling activity. The number of wells drilled each year in Somalia has exhibited high variability, although the

EXHIBIT I-20

AMOUNT OF DRILLING BY PROJECT IN SOMALIA 1980-1987

PROJECT TITLE OR CLIENT	DRILLING AGENCY	TYPE OF WELL	Combo	NW80	NW81	NW82	NW83	NW84	NW85*	NW86**	NW87**	TOTAL WELLS
Rural Water Supply (WDA)	G-WDA	Rural	GR	12	12	7	14	10	12			67
Other Drilling (WDA)	G-WDA	U-Other	GU	3	3	1	3	2	3			15
Irrigation (Min. Defence)	G-MinDef	Irrig	GI	8	10	10	8	8				44
Other (Min. Defence)	G-MinDef	R-Other	GR	5	7	7	6	6				31
Urban Water Supply (GKW)	F-GKW	Urban	FU	0	4	5	5	0				14
Urban Water Supply (WILD)	F-WILD	Urban	FU	0	5	5	0	0				10
Mogadishu Water Supply (MOWLEN)	F-MOWLEN	Urban	FU	0	4	4	0	0				8
Mogadishu Water Supply (KAMPIHL)	F-KAMPIHL	Urban	FU	0	3	8	8	5				24
CGDP (L3ii/RMC)	F-ROSC MOS	Rural	FR	0	0	9	10	17	20			56
Hargeisa Water Supply (CHINA)	F-CHINESEf	Urban	FU	0	0	6	0	0	2	4		12
N.E. Water Supply (CHINA)	F-Chinese	Rural	FR	0	0	0	0	6	7	6		19
N. Water Exploration (CHINA)	F-Chinese	Rural	FR	0	0	4	11	0				15
Refugee Water Supply (UNICEF)	F-UNICEF	Rural	FR	0	24	14	0	0				38
N.W. Water Supply (UNICEF)	F-Unicef	Rural	FR	0	0	0	0	0	5			5
Rural Water Supply (WILD)	F-WILD	Rural	FR	0	0	0	0	1	20	18		39
Banana Irr. (SOMALFRUIT)	P-Somalfru	Irrig	PI	7	6	15	12	10	20			70
Grapefruit Irr. (MUURI)	P-MUURI	Irrig	PI	0	0	4	5	0				9
Mogadishu Water Supply (JAPAN)	F-Japanese	Urban	FU	0	0	0	0	0	4	10	15	29
Government (HORN OF AFRICA)	P-HOA	U-govt	PU	0	0	8	6	0				14
Other, (HORN OF AFRICA)	P-HOA	R-Other	PR	0	3	0	0	2	2			7
Foreign Financed (MURRI)	P-Muuri	R-Other	PR	0	0	1	2	5				8
Government, (MURRI)	P-Muuri	U-govt	PU	1	2	0	1	2				6
Other, (MURRI)	P-Muuri	R-Other	PR	1	1	0	2	3				7
Mine Well (KAMPIHL)	F-KAMPIHL	R-indus	FR	0	0	0	0	5	1			6
Berbera, (SOMALI DRILLING)	P-Som Dril	Urban	PU	0	0	0	0	2				2
Private, (SOMALI DRILLING)	P-Som Dril	R-Other	PR	0	0	0	3	1	4			8
Government, (NAT'L DRILLING)	P-Nat'l Dr	U-Govt	PU	1	2	2	1	1				7
Other, (NAT'L DRILLING)	P-Nat'l Dr	R-Other	PR	2	1	1	2	3				9
Private Irr. (SOMALI-GERMAN)	P-SOM DRIL	Irrig	PI	0	0	0	0	6	1			7
Aid Irrig. (PESINA-JUBA)	P-Pes-Juba	Irrig	PI	1	2	2	3	4	4			16
TOTAL				41	89	113	102	99	105	38	15	602

* Estimate
** Planned

G - Government
F - Foreign
P - Private

U - Urban
R - Rural
I - Irrigation

EXHIBIT I-21

CATEGORIES OF WELL DRILLING 1980 - 1985

YEAR			1980	1981	1982	1983	1984	1985	AVERAGE '81-'84	PERCENT '81-'84
TOTAL WELLS DRILLED			41	89	113	102	99	105	101	100%
DRILLING AGENCY	TYPE OF WELL									
Government	any	G*	28	32	25	31	26	15	29	28%
Government	rural	GR	17	19	14	20	16	12	17	17%
Government	urban	GU	3	3	1	3	2	3	2	2%
Government	irrig.	GI	8	10	10	8	8	0	9	9%
Government	non-irrig.	G*-GI	20	22	15	23	18	15	20	19%
Foreign agencies	any	F*	0	40	55	34	34	59	41	40%
Foreign agencies	rural	FR	0	24	27	21	29	53	25	25%
Foreign agencies	urban	FU	0	16	28	13	5	6	16	15%
Foreign agencies	irrig.	FI	0	0	0	0	0	0	0	0%
Foreign agencies	non-irrig.	F*-FI	0	40	55	34	34	59	41	40%
Private (local)	any	P*	13	17	33	37	39	31	32	31%
Private (local)	rural	PR	3	5	2	9	14	6	8	7%
Private (local)	urban	PU	2	4	10	8	5	0	7	7%
Private (local)	irrig.	PI	8	8	21	20	20	25	17	17%
Private (local)	non-irrig.	P*-PI	5	9	12	17	19	6	14	14%
any	rural	?R	20	48	43	50	59	71	50	50%
any	urban	?U	5	23	39	24	12	9	25	24%
any	irrig.	?I	16	18	31	28	28	25	26	26%
any	non-irrig.	?* - ?I	25	71	82	74	71	80	75	74%

overall trend has been positive. Simple linear correlation estimates were made on the number of wells drilled, by agency, over a five year period. These data, for all non-irrigation wells, are contained in Exhibit I-22.

For non-irrigation wells drilled by Somali government agencies, the overall trend has been slightly (and insignificantly) negative, with a variability of plus or minus 3 or 4 in any given year. For non-irrigation wells drilled by Foreign firms, the overall trend has been to expand production by about 2 wells per year, but this has been highly erratic: the variability has been plus or minus about 13 wells in any given year. For non-irrigation wells drilled by local private firms, the overall trend has been to expand production by between three and four wells each year, and the variability has been low: not even one full unit above or below the trend line.

These trends have been projected forward, on the assumption that past conditions affecting the market can continue into the future. These projections are shown in Exhibit I-23. Actual numbers of wells drilled, by agency and by year through 1984, are presented, along with projected numbers of wells to be drilled through 1990, on the basis of past established time trends. Along with the trend-line numbers, an illustration of the likely variability is presented for projections of non-irrigation wells.

Exhibit I-24 through I-26 present the same data in graphic form: for each category of drilling agency, the exhibits show the number of non-irrigation wells actually drilled through 1984 (or, in the case of foreign wells, 1985) and the trend line projected to 1990. The likely variability about the trend line is presented also, for illustrative purposes.

The assumptions on which these trend projections are based, however, are subject to change. Government drilling achievements are largely dependent on the overall budgets (and particularly foreign exchange budgets) authorized by the Ministries of Finance and Planning. Foreign drilling is similarly dependent on the foreign aid budgets of a few foreign donors, and by the foreign aid policies of those donors. Local private drilling activity is driven mainly by market forces (however severely constrained), on both the demand side (for drilled wells), and on the supply side (particularly concerning availability of finance and of foreign exchange with which to purchase imported materials, equipment, and spare parts).

In addition, overall drilling activity is dependent on hydrogeological conditions and past drilling activity in areas of likely demand for drilling: too many wells tapping a single, limited aquifer can cause the water table to fall, making required well depths progressively deeper and more expensive. Drilling supply is also limited by the country's existing stock (and quality) of drilling equipment, and by the number and expertise of its drillers.

EXHIBIT I-22

TREND EQUATIONS OF WELL DRILLING BY AGENCY

Government Drilled Non-Irrigation Wells

$Wt = 20.2 - 0.3\ (T) \pm 3.6651$ $(S^2 = 13.4333)$

Foreign Drilled Non-Irrigation Wells

$Wt = 41 + 1.7\ (T) \pm 13.3204$ $(S^2 = 177.4333)$

Privatly Drilled Non-Irrigation Wells

$Wt = 5.2 + 3.6\ (T) \pm 0.7303$ $(S^2 = 0.5333)$

Where:

Wt = Wells drilled in year "t"

T = Year T (1...n)

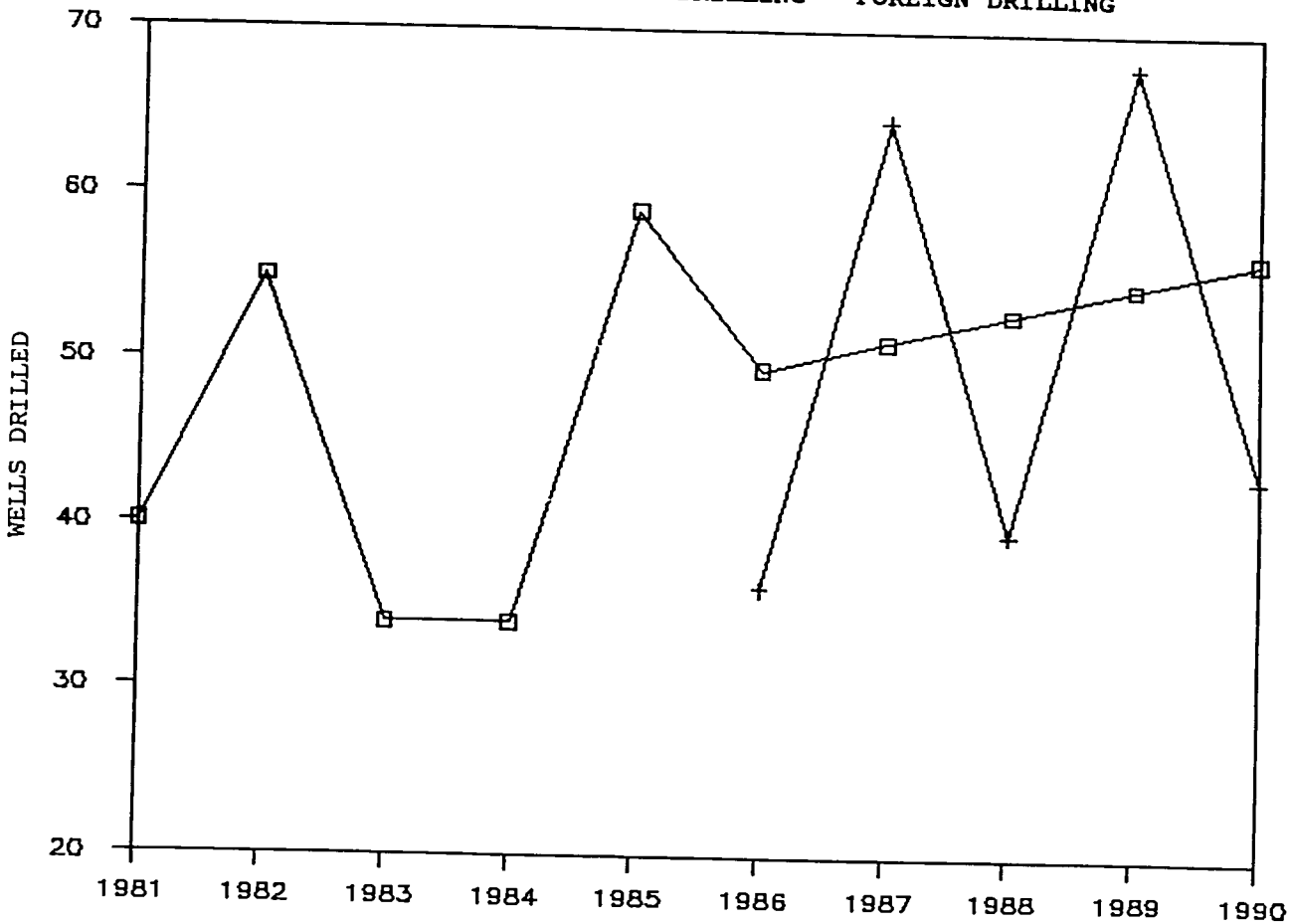
EXHIBIT I-23

WELL DRILLING SERVICES SUPPLY:
1980-1984 ACTUAL, 1985-1990
PROJECTIONS BASED ON PAST WORK

YEAR/CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Government Drilling	28	32	25	31	26	27	26	26	25	25	24
Foreign Drilling		40	55	34	34	59	50	51	53	55	56
Private Drilling	13	17	33	37	39	49	57	64	71	78	85
Total Drilling	41	89	113	102	99	135	133	141	149	158	166
Government non-irrigation	20	22	15	23	18	19	18	18	18	18	17
Government variability							15	22	14	21	14
Foreign non-irrigation		40	55	34	34	59	50	51	53	55	56
Foreign variability							36	65	40	68	43
Private non-irrigation	5	9	12	17	19	23	27	30	34	38	41
Private variability							26	31	33	38	40
Total non-irrigation	25	71	82	74	71	101	95	100	105	110	115
Total (variable model)							77	117	87	127	97

EXHIBIT I-24

TRENDS AND VARIABILITY IN DRILLING - FOREIGN DRILLING



□ Foreign
1981-1985 Actual/Planned
1986-1990 Trend Line

+ Foreign
Variability
About Trend Line

390

EXHIBIT I-25

TRENDS AND VARIABILITY IN DRILLING - GOVERNMENT DRILLING

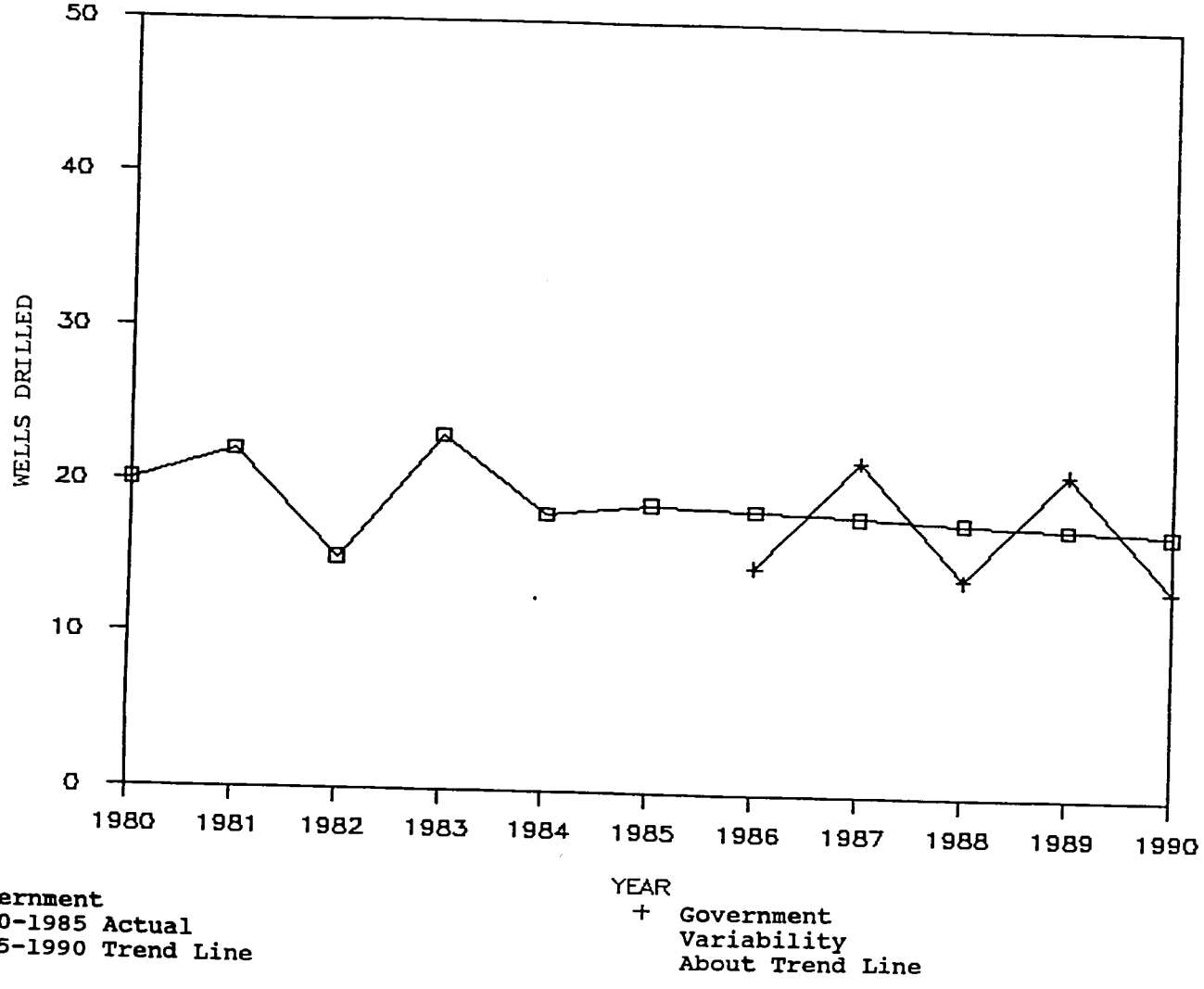
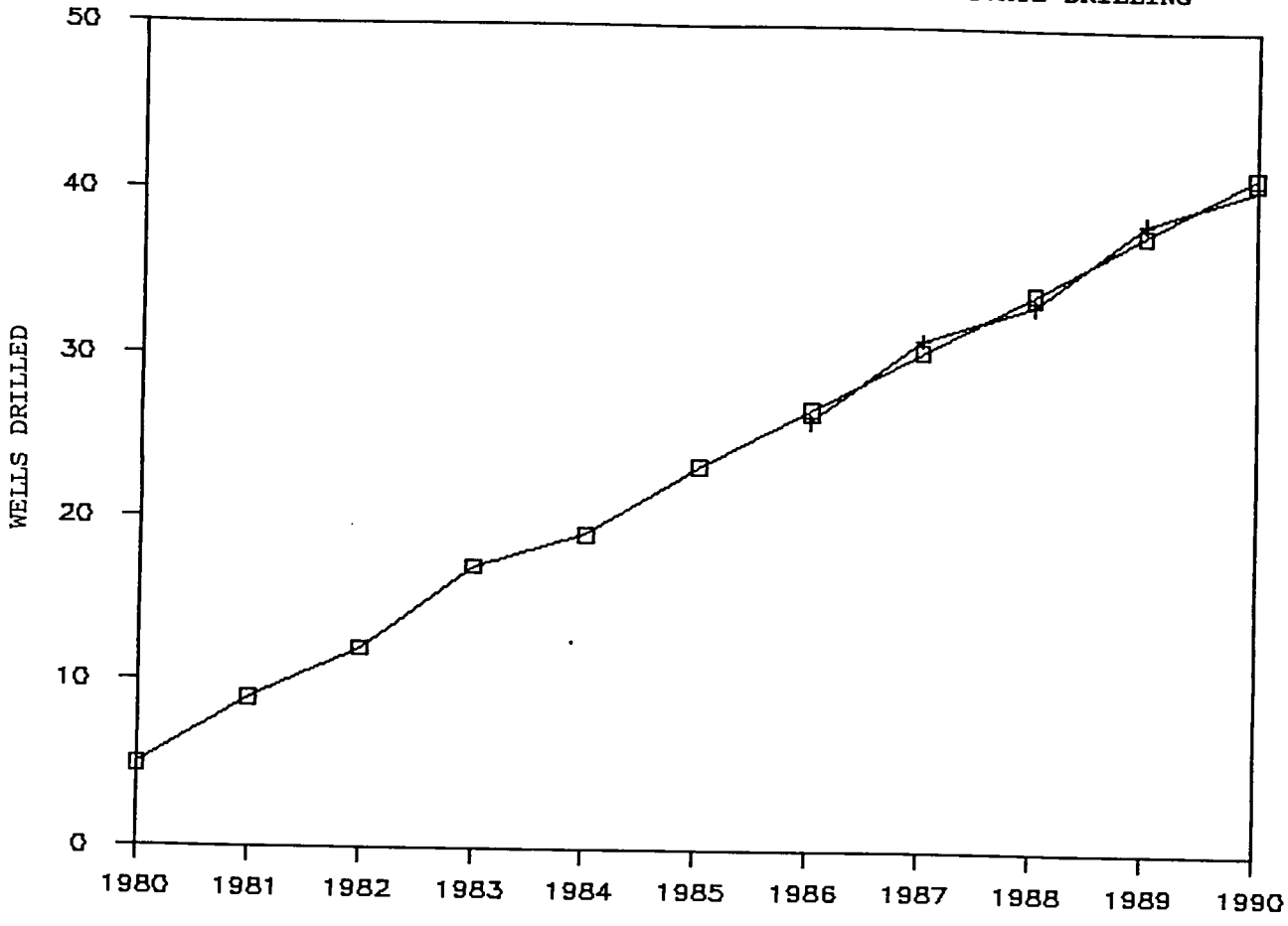


EXHIBIT I-26

TRENDS AND VARIABILITY IN DRILLING - LOCAL PRIVATE DRILLING



□ Private
1980-1984 Actual
1985-1990 Trend Line

+ Private
Variability
About Trend Line

Drilling demand may depend, among other things, on the average effective volume of output per well (e.g., the more water one can get from each well, the fewer wells are needed, given a certain overall level of demand for water).

Thus drilling activity in the future could be substantially different from (either higher or lower than) the trends projected and discussed above.

The supply side and demand side of well drilling are most appropriately compared using the WISyMS Level I and Level II submodels, highlighting in particular the volumes of water, averages of per-capita water consumption, and average volumes of output per well. On the demand side, as discussed in section I-4, above, WISyMS works with categories of wells broken down into urban, rural diesel pump, rural hand pump, and irrigation wells. These differ, in particular, by the volume of output of each type of well. However, the numbers of wells and volumes of water needed can each be summed to determine the total volumes of non-irrigation water needed and the total stock of non-irrigation wells needed in a given year. On the supply side, the principal analytical divisions used are those between the categories of drilling agencies (government, foreign, and local private).

I-5.5.1 The Consultants' 1995 Supply Side Projections (Without Program)

Exhibit I-27 compares demand side and supply side projections of drilling in Somalia. The demand side projections of the needed volumes of water and stock of wells each year through 1995 were made on the assumption that the national goals for water supply (as described in the MMWR's Plan for the Drinking Water Supply and Sanitation Decade) should be met by 1995. The full WISyMS data for these projections are contained in Annex I-9. The supply side projections are explained below.

In projecting local government drilling, we assumed it would follow its projected trend through 1995.

Local private drilling, we assumed, would follow its projected trend through 1990, and then flatten out, reaching a combination of market, equipment, and hydrogeological limits: The private drilling market has been largely confined to areas in or near urban centers, relatively simple geological formations, and relatively shallow wells. Unless market circumstances change, they may face growth limitations within five years.

Foreign drilling, according to current donor plans, may easily decrease to about 50% of the average levels achieved over the past five years by 1990, and sink to 30% or less by 1995. (See Section Three of the main body of the Final Report).

EXHIBIT I-27

1995 DEMAND SIDE PROJECTIONS FOR REQUIREMENTS FOR NEW/REHABILITATED WELLS; SUPPLY SIDE PROJECTIONS ASSUMING NO PROGRAM

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate P.A. '84-'90	Growth Rate P.A. '90-'95
TOTAL NON-IRRIGATION...																		
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Volume of Water (M^3*K/yr)	9843	12471	16616	18907	19656	21879	24255	27111	30182	33601	37409	44816	53769	64384	77203	92597	11.32%	19.87%
Human consumption (M^3*K/yr)					6581	7819	9290	11037	13113	15586	18511	23268	29247	36762	46209	58083	18.81%	25.70%
Ave. Ann. Human cons. (M^3/cap/yr)					1.23	1.42	1.64	1.89	2.19	2.52	2.91	3.56	4.34	5.30	6.47	7.90	15.46%	22.06%
Stock of Wells	275	321	376	415	445	492	545	603	668	739	819	957	1122	1321	1560	1847	10.70%	17.66%
Needed Rehabilitation	0	25	28	34	42	47	52	59	66	74	82	66	75	88	103	122		
Needed Drill//Rehabilitation	25	71	82	75	71	94	105	117	131	145	162	204	241	287	342	409		

WELL DRILLING SERVICES SUPPLY: 1980 - 1984 ACTUAL, 1985 - 1990 PROJECTIONS BASED ON PAST WORK, CURRENT PLANS AND MARKET CONDITIONS

YEAR/CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
GOVERNMENT NON-IRRIGATION DRILLING																
Consultants' projection w/o program	20	22	15	23	18	19	18	18	18	18	17	17	17	16	16	16
FOREIGN NON-IRRIGATION DRILLING																
Consultants' projection w/o program	0	49	55	34	34	56	40	35	30	25	20	19	18	17	16	15
PRIVATE NON-IRRIGATION DRILLING																
Consultants' projection w/o program	5	9	12	17	19	23	27	30	34	38	41	41	41	41	41	41
TOTAL NON-IRRIGATION DRILLING																
Consultants' projection w/o program	25	71	82	74	71	98	85	84	82	80	78	77	76	74	73	72

CONSULTANTS' SUPPLY SIDE PROJECTIONS, WITHOUT PROGRAM

ALL NON-IRRIGATION WELLS

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
Old	250	225	200	175	150	125	100	75	50	25	0	0	0	0	0	0		
(Previous)		25	94	166	224	272	343	394	438	476	508	536	559	579	595	609		
Total old + previous	250	250	294	341	374	397	443	469	488	501	508	536	559	579	595	609		
Need Rehabilitation	0	25	28	34	42	47	52	59	64	69	73	51	54	56	58	60		
Rehabilitated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
New Drilling	25	71	82	74	71	98	85	84	82	80	78	77	76	74	73	72		
Total Stock	275	321	376	415	445	495	528	552	570	581	587	613	635	653	668	681	4.74%	3.01%
Volume of Water (M^3*k/yr)	9843	12471	16594	18914	19635	22005	23611	24835	25759	26407	26804	27994	28999	29838	30528	31084	5.32%	3.01%
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Human consumption (M^3*K/yr)					6574	7864	9066	10111	11192	12245	13263	13852	14350	14765	15106	15381	12.41%	3.01%
Ave. Ann. Human cons. (M^3/cap/yr)					1.23	1.43	1.59	1.73	1.87	1.98	2.09	2.12	2.13	2.13	2.12	2.09	9.24%	0.03%

Following the normal WISyMS analysis in the opposite direction, we have summed all projected drilling activity, used this to calculate an estimated stock of wells for a given year (taking into account deterioration of old stock). We assumed that the proportions of types of wells projected to be drilled on the supply side are roughly the same as the proportion of wells projected as needed on the demand side, and that the volumes of output of each type of well will remain constant over time. From the above calculations and assumptions, we estimated a total volume of water output based on the supply side drilling projections.

Taking the analysis one step further, we used the same population projections used in the WISyMS demand side analysis to estimate average annual per capita water consumption based on the supply side projections.

The estimates contained in Exhibit I-27 are presented graphically below. Exhibit I-28 contains a bar chart of past actual and projected well drilling by source through 1995. Although this is expeced to exhibit a downward trend from 1985, under the assumptions outlined above, it would not decline below the levels achieved during the early 1980s.

Translating the annual drilling activity into annual stocks of wells and thence into overall volumes of water indicates that the projected supply of water will grow at a very slow rate, and fall far short of the national goals. (See Exhibit I-29).

Assuming that the proportion of water production going for human consumption remains constant, Exhibit I-30 shows per capita water consumption increasing slightly, and then falling off again, as the declining levels of drilling activity fail to keep pace with the need to increase the stock of wells for a growing population (and to replace failing structures in the absence of adequate well maintenance and rehabilitation programs). Human per capita water consumption could be maintained, of course, at the cost of decreasing water availability for livestock, government, industry, or other consumption needs.

I-5.5.2 Water Industry Downside Risk

The supply side projections described in the foregoing sections do not take into account certain downside risks. The following downside risks have been identified:

- Government drilling programs may face more severe budget cuts in the future than they have been subject to in the past, leading to a slightly steeper decline in well drilling activity.

- Foreign aid drilling may, under current donor plans, drop off to 38 wells in 1986, and 15 in 1987. This may signal the beginning of a serious dropoff in foreign aid

EXHIBIT I-28

PROJECTIONS OF DRILLING SUPPLY - WELLS BY SOURCE, NO PROGRAM

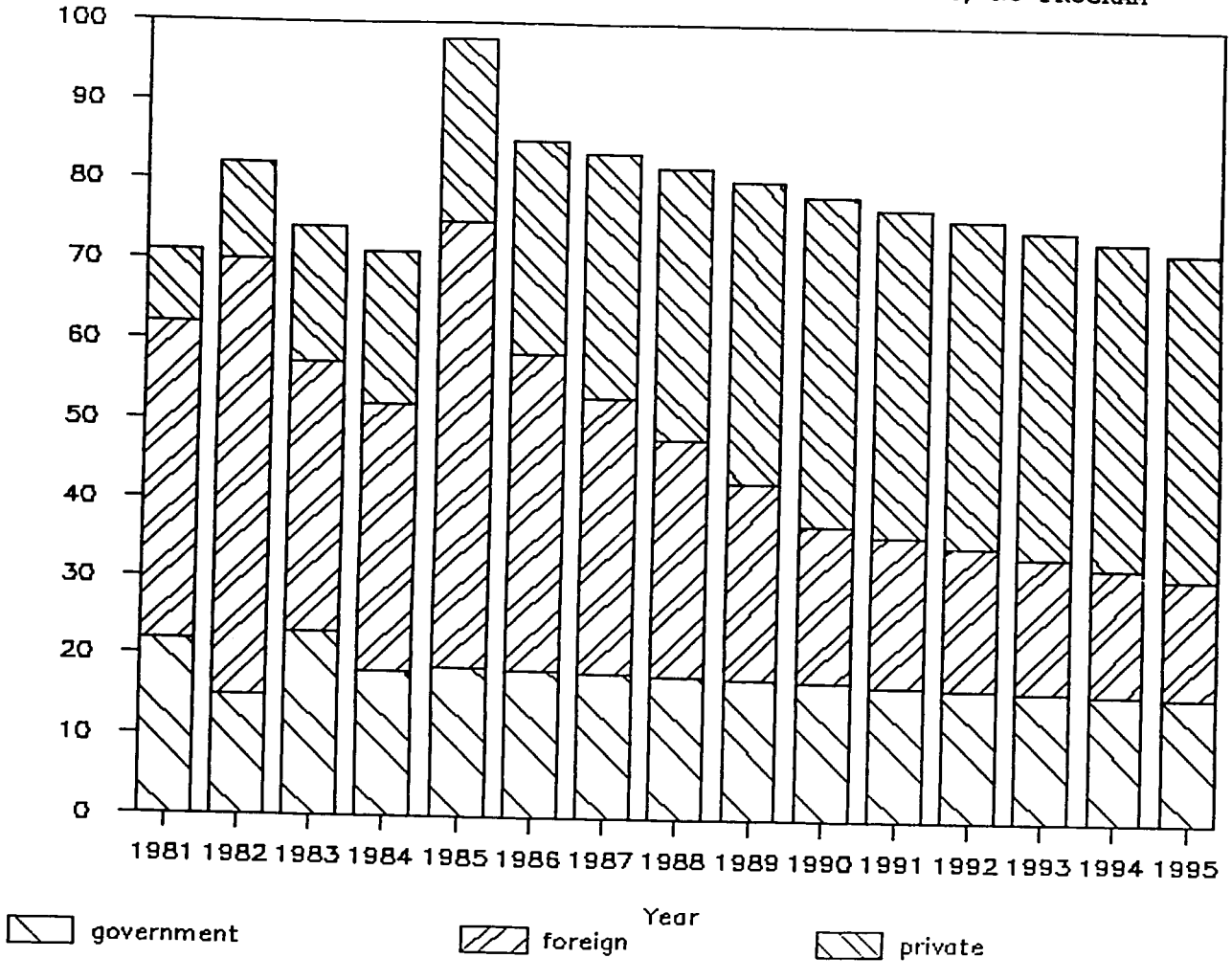


EXHIBIT I-29

PROJECTED VOLUME OF WATER CONSUMPTION - SUPPLY SIDE vs DEMAND SIDE, NO PROGRAM

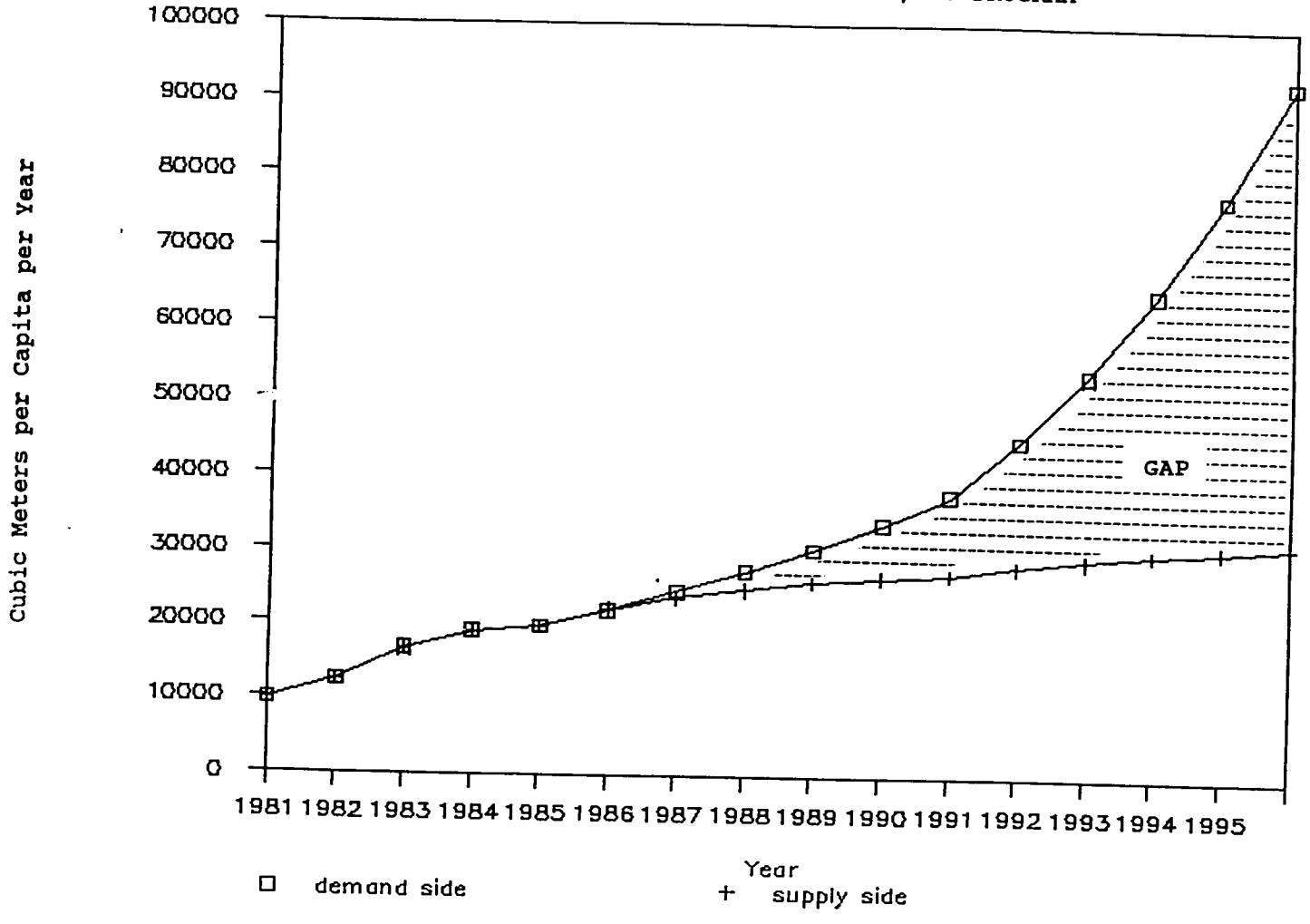
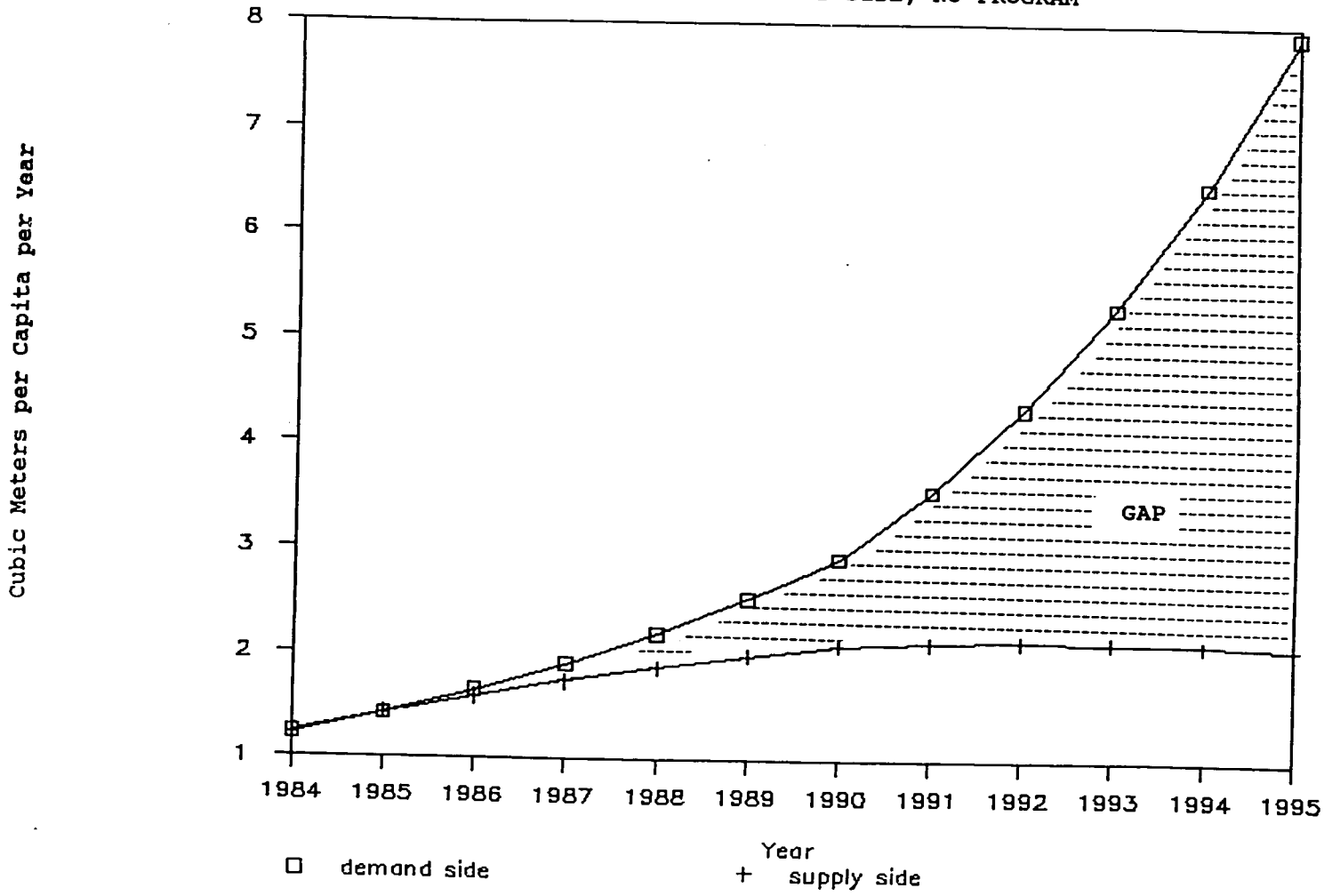


EXHIBIT I-30

PROJECTIONS OF HUMAN WATER CONSUMPTION -
SUPPLY SIDE vs DEMAND SIDE, NO PROGRAM



due to a discontinuation of major donor-funded drilling programs such as USAID's CGDP, GTZ's Urban wells project, and the Saudi's rural well drilling project.

- Private sector drilling activity may have recently peaked, and thus may start declining almost immediately due to a combination of severe input supply constraints (including supplies of credit and foreign exchange for needed imported inputs) and market constraints (including price and licensing constraints as discussed in section 3.4.9 of the main body of the Final report).

Thus overall drilling activity could conceivably suffer a serious decline even before 1990, falling significantly below levels achieved during the past five years.

Exhibit I-31 presents estimates concerning the possible downside risk facing the water industry in Somalia. Exhibit I-32 displays the estimates on drilling for this scenario graphically, through 1990. Although it is unlikely that the Somali government would let the situation deteriorate so drastically for too many years, if such a trend were to continue through, say, 1995, the stock of wells and output of water from that stock of wells could actually decline, as the rate of failure of wells could be even higher than the rate of new drilling.

If that were to occur, and assuming that human water consumption as a proportion of total water production remains constant, then the standards of water consumption of the nation as a whole could actually sink below currently prevailing levels estimated for the country. (See Exhibits I-33 and I-34). Under the circumstances outlined above, a decline in human water consumption standards could only be avoided by sacrificing other water consumption needs.

I-5.5.3 1995 Supply Side Projections (With Consultants' Recommended Drilling and Rehabilitation Programs)

The same procedure can be used to analyze the effects of the Consultants' Recommended Program of well drilling and rehabilitation (leaving aside, for the time being, the contract operations and maintenance programs, the effects of which will be analyzed below).

Exhibit I-35 involves the same demand side analysis presented above; but for the supply side, adds the drilling and rehabilitation portions of the Consultants' recommended program to the trend line data discussed above in Section I-5.5. This brings about a steady increase in new and rehabilitated wells each year through 1995 (See Exhibit I-36).

These portions of the Consultants' recommended program would keep the stock of wells and the volume of water above the demand side projections of needed volumes of water through 1994,

EXHIBIT I-31

CONSULTANTS' SUPPLY SIDE DRILLING PROJECTIONS, DOWNSIDE RISK

Demand Side Projections for Requirements for new/rehabilitated wells; Supply Side Projections Assuming Downside Risk

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate P.A. '84-'90	Growth Rate P.A. '90-'95
TOTAL NON-IRRIGATION...																		
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Volume of Water (M^3*K/yr)	9843	12471	16616	18907	19656	21879	24355	27111	30182	33601	37409	44816	53709	64384	77203	92597	11.32%	19.87%
Human consumption (M^3*K/yr)					6581	7819	9290	11037	13112	15580	18511	22268	29247	36762	46209	58083	18.81%	25.70%
Ave. Ann. Human cons. (M^3/cap/yr)					1.23	1.42	1.64	1.89	2.19	2.52	2.91	3.56	4.34	5.30	6.47	7.90	15.46%	22.06%
Stock of Wells	275	321	376	415	445	492	545	603	668	739	819	957	1122	1321	1560	1847	10.70%	17.66%
Needed Rehabilitation	0	25	28	34	42	47	52	59	66	74	82	66	75	88	103	122		
Needed Drill//Rehabilitation	25	71	82	75	71	94	105	117	131	145	162	204	241	287	342	409		

WELL DRILLING SERVICES SUPPLY: 1980 - 1984 ACTUAL, 1985 - 1990 PROJECTIONS BASED ON PAST WORK, AND POSSIBLE DOWNSIDE RISKS

GOVERNMENT NON-IRRIGATION DRILLING																
Downside Risk	20	22	15	23	18	19	18	18	18	17	17	17	16	16	16	15
FOREIGN NON-IRRIGATION DRILLING																
Downside Risk	0	40	55	34	34	56	38	15	14	13	12	11	10	9	8	7
PRIVATE NON-IRRIGATION DRILLING																
Downside Risk	5	9	12	17	19	23	23	22	21	20	19	18	17	16	15	14
TOTAL NON-IRRIGATION DRILLING																
Downside Risk							79	55	53	50	48	46	43	41	39	36

CONSULTANTS' SUPPLY SIDE PROJECTIONS, DOWNSIDE RISK

ALL NON-IRRIGATION WELLS

Old	250	225	200	175	150	125	100	75	50	25	0	0	0	0	0	0		
(Previous)		25	94	166	224	272	343	388	404	417	425	431	434	433	431	427		
Total old + previous	250	250	294	341	374	397	443	463	454	442	425	431	434	433	431	427		
Need Rehabilitation	0	25	28	34	42	47	52	59	64	65	67	42	43	43	43	43		
Rehabilitated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
New Drilling	25	71	82	74	71	98	79	55	53	50	48	46	43	41	39	36		
Total Stock	275	321	376	415	445	495	522	518	507	492	473	477	477	474	470	463	1.05%	-0.43%
Volume of Water (M^3*k/yr)	9843	12471	16594	18914	19635	22005	23352	23298	22928	22346	21613	21769	21766	21672	21475	21150	1.61%	-0.43%
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Human consumption (M^3*K/yr)					6574	7864	8907	9485	9962	10361	10695	10772	10770	10724	10626	10466	8.45%	-0.43%
Ave. Ann. Human cons. (M^3/cap/yr)					1.23	1.43	1.57	1.63	1.66	1.68	1.68	1.65	1.60	1.55	1.49	1.42	5.39%	-3.31%

EXHIBIT I-32

PROJECTIONS OF DRILLING SUPPLY -
WELLS DRILLED BY SOURCE, DOWNSIDE RISK

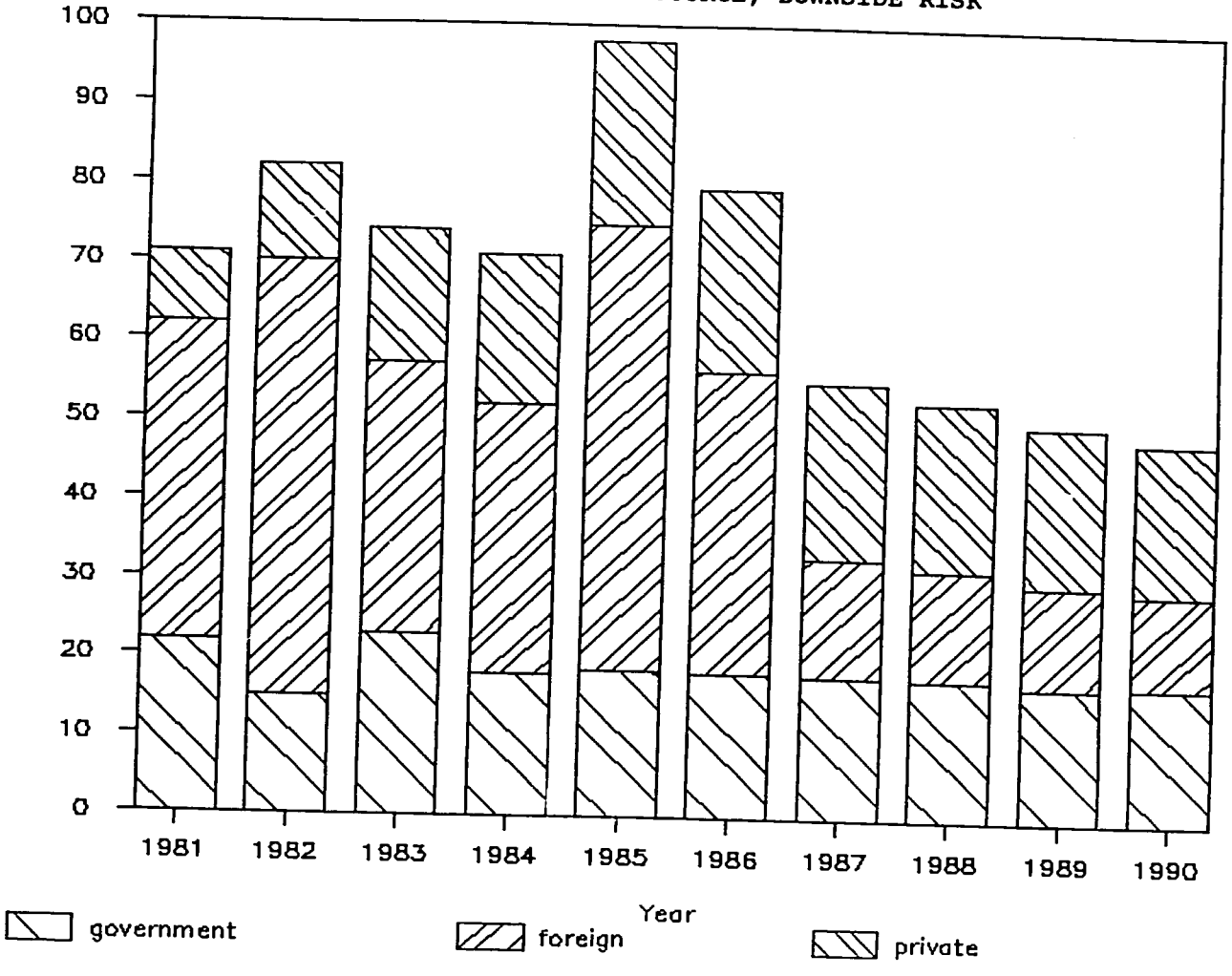


EXHIBIT I-33

PROJECTED VOLUME OF WATER CONSUMPTION -
DEMAND SIDE vs SUPPLY SIDE, DOWNSIDE RISK

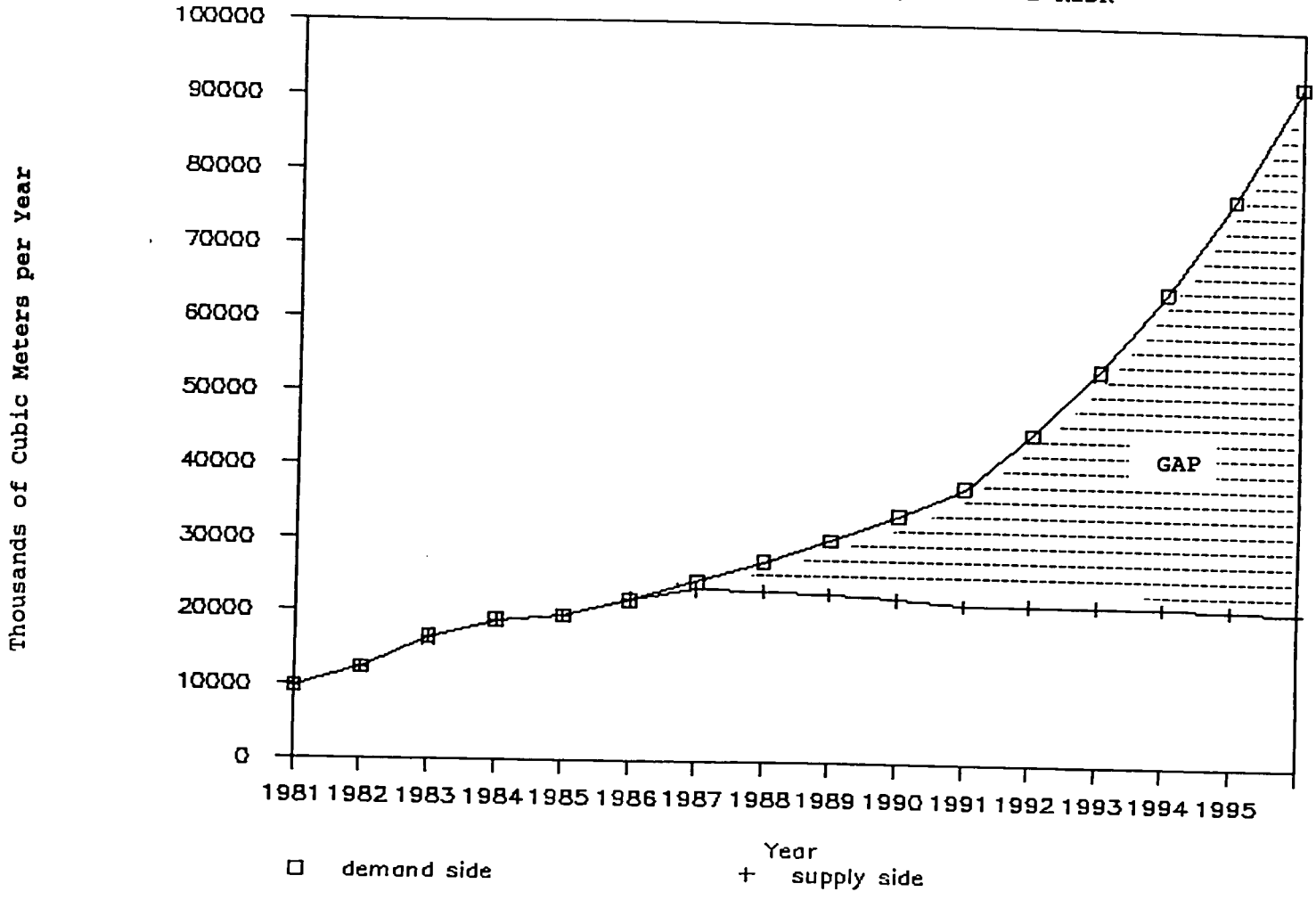


EXHIBIT I-34

PROJECTIONS OF HUMAN WATER CONSUMPTION -
DEMAND SIDE vs SUPPLY SIDE, DOWNSIDE RISK

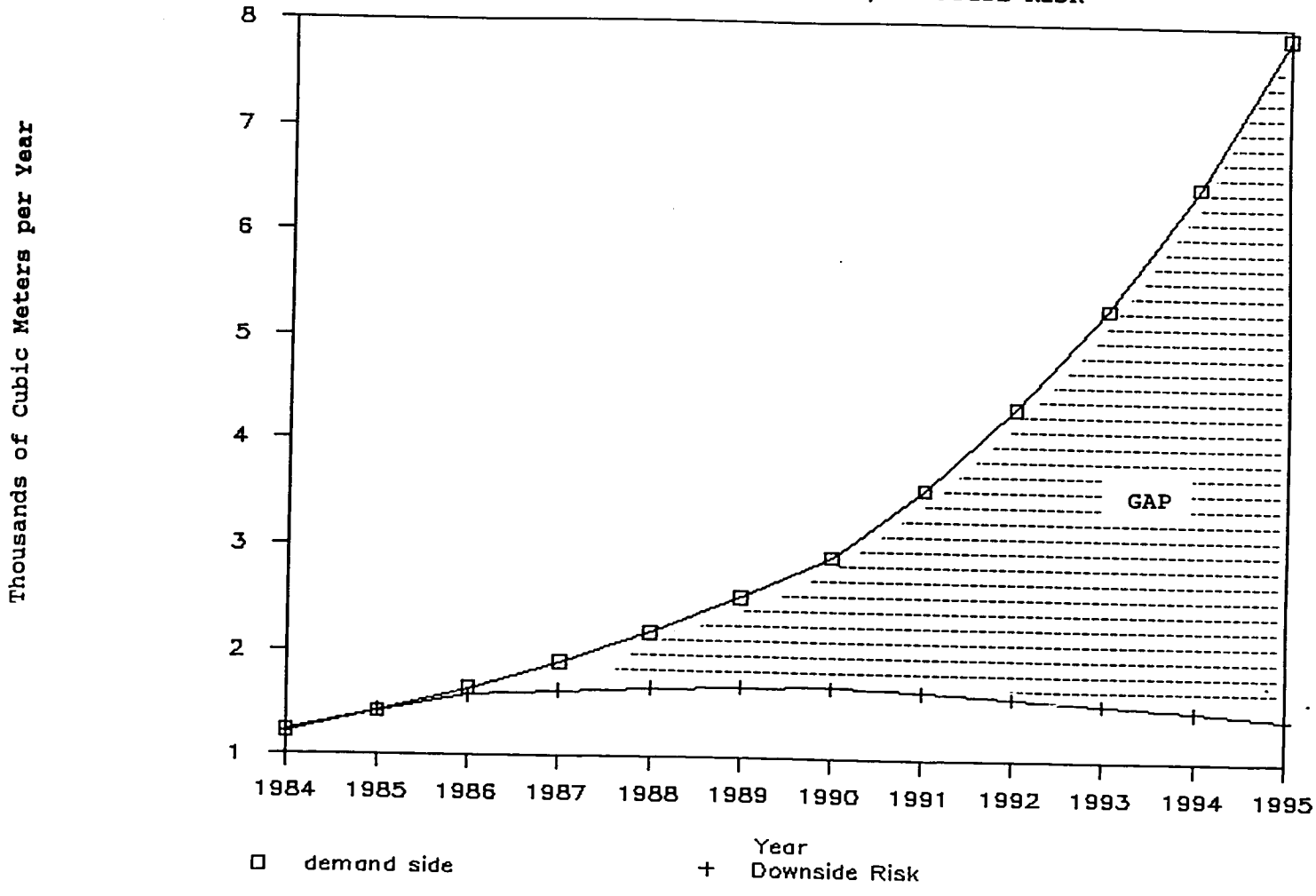


EXHIBIT I-35

DEMAND SIDE PROJECTIONS; SUPPLY SIDE PROJECTIONS ASSUMING CONSULTANTS' RECOMMENDED DRILLING AND REHABILITATION PROGRAM

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate P.A. '84-'90	'90-'95
TOTAL NON-IRRIGATION...																		
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Volume of Water (M^3*k/yr)	9843	12471	16616	18907	19656	21879	24755	27111	30182	33601	37409	44816	53709	64384	77203	92597	11.32%	19.87%
Human consumption (M^3*k/yr)					6581	7819	9290	11037	13113	15580	18511	22268	29247	36762	46209	58083	18.81%	25.70%
Ave. Human cons (M^3/capita/yr)					1.23	1.42	1.64	1.89	2.19	2.52	2.91	3.56	4.34	5.30	6.47	7.90	15.46%	22.06%
Stock of Wells	275	321	376	415	445	492	545	602	668	739	819	957	1122	1321	1560	1847	10.70%	17.66%
Rehabilitation	0	25	28	34	42	47	52	59	66	66	66	41	41	41	41	41		
Needed Drill or Rehabilitation	25	71	82	75	71	94	105	117	90	97	105	128	165	199	239	287		
Minimum Needed Drilling							52	58	24	31	39	97	124	158	198	246		

WELL DRILLING SERVICES SUPPLY: 1980 - 1984 ACTUAL, 1985 - 1990 PROJECTIONS BASED ON FAST WORK AND CONSULTANTS' RECOMMENDED DRILLING AND REHABILITATION PROGRAMS

YEAR/CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
GOVERNMENT NON-IRRIGATION DRILLING																
Consultants' Projections with Program	20	22	15	23	18	19	18	18	18	20	24	20	16	12	12	12
FOREIGN NON-IRRIGATION DRILLING																
Consultants' Projections with Program		40	55	34	34	56	40	36	32	28	24	24	24	24	24	24
PRIVATE NON-IRRIGATION DRILLING																
Consultants' Projections with Program	5	9	12	17	19	23	31	38	50	58	69	87	96	102	108	113
Contract Well Rehabilitation							22	44	24	24	24	24	24	24	24	24
TOTAL NON-IRRIGATION DRILLING																
Consultants' Projections with Program	25	71	82	74	71	98	89	92	100	106	117	131	136	138	144	149
Contract Well Rehabilitation							22	44	24	24	24	24	24	24	24	24

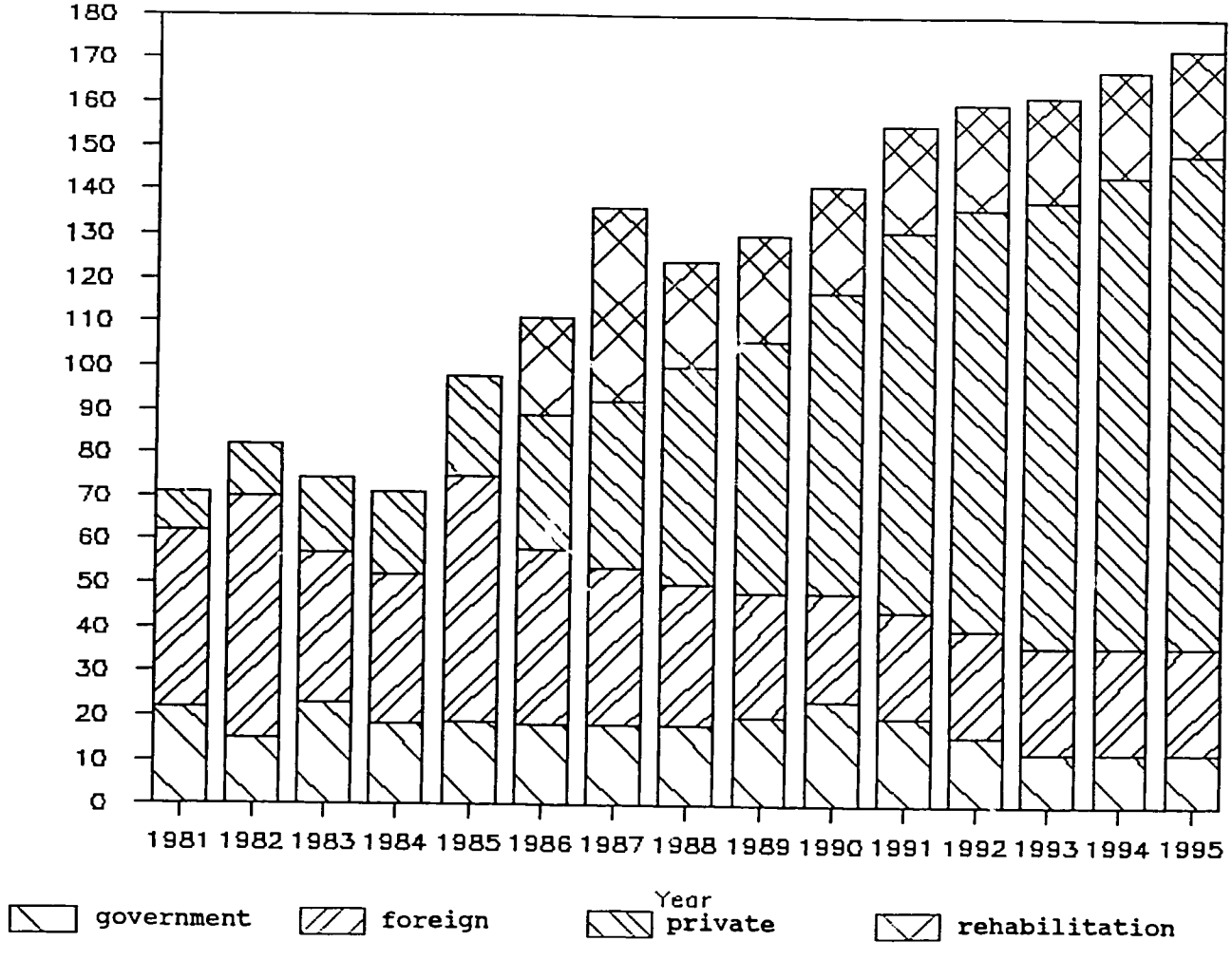
CONSULTANTS' SUPPLY SIDE PROJECTIONS, WITH DRILLING AND REHABILITATION PROGRAMS

ALL NON-IRRIGATION WELLS

Old	250	225	200	175	150	125	100	75	50	25	0	0	0	0	0	0		
(Previous)		25	94	166	224	272	343	420	556	680	810	951	1106	1266	1428	1596		
Total old + previous	250	250	294	341	374	397	443	495	606	705	810	951	1106	1266	1428	1596		
Need Rehabilitation	0	25	28	34	42	47	52	59	67	67	67	42	42	42	42	42		
Rehabilitated							22	44	24	24	24	24	24	24	24	24		
New Drilling	25	71	82	74	71	98	89	92	100	106	117	131	136	138	144	149		
Total Stock	275	321	376	415	445	495	554	631	730	835	951	1106	1266	1428	1596	1769	13.50%	13.22%
Volume of Water (M^3*k/yr)	9843	12471	16594	18914	19655	22005	24765	28357	32988	37932	42419	51783	60570	69587	78981	88665	14.14%	15.35%
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Human consumption (M^3*k/yr)					6574	7864	9446	11544	14323	17589	21485	26885	32982	39322	47273	55617	21.82%	20.95%
Ave. Human cons (M^3/capita/yr)					1.23	1.43	1.67	1.98	2.39	2.85	3.38	4.11	4.90	5.73	6.62	7.56	18.39%	17.46%

EXHIBIT I-36

PROJECTIONS OF DRILLING SUPPLY -
WELLS DRILLED BY SOURCE, WITH PROGRAM



but would fall behind in 1995 and fail to satisfy the national drinking water goals. (See Exhibit I-37). This same shortfall would be reflected in the ultimate target variable, per capita water consumption (See Exhibit I-38). Thus the drilling and rehabilitation portions of the Consultants' Recommended program, if implemented alone, would fail to achieve the nation's goals as outlined in the MMWR's Plan for the Drinking Water Supply and Sanitation Decade.

I-5.5.4 Supply Side Analysis of Consultants' Full Recommended Program

We have analyzed separately the effects of the contract maintenance and rehabilitation portions of the Consultants' recommended program in order to highlight their importance. In the past, in spite of carefully designed projects including provisions for ongoing maintenance of donor-funded facilities, host governments have often failed to implement, and donors have failed to enforce these maintenance programs in practice. This section illustrates the tangible water benefits of such a program.

A program of contract operations and routine maintenance should have the effect of increasing the annual volume of water output from each well by reducing the downtime, leakage and wastage of each well so served. By the end of 1995, we estimate that a minimum of 630 wells, out of a total national stock of about 1500 non-irrigation wells, will be under a program of routine maintenance (these are the WDA wells to be included in the recommended program. If other public and private wells receive routine maintenance, the benefits will be correspondingly higher).

The average annual output from un-maintained or irregularly maintained rural, diesel-pump borewells is about 28,000 cubic meters per well. We should expect that wells under contract operations and maintenance would yield about a 33% increase in annual production, or over 37,000 cubic meters per well. We assume that about 400 of the projected 929 rural diesel-pump borewells will be under contract operation and maintenance in 1995. Then the total output from all rural borewells would be about 14% higher than if no wells were in such a program.

Exhibit I-39 presents the data on the estimates of drilling, stocks of wells, and volumes of water assuming that the Consultants' full recommended program (including contract operation and maintenance as well as well drilling and rehabilitation) has been in effect through 1995. Increased output per well reduces the stock of wells needed to satisfy demand for a given amount of water. Thus, with the contract operation and maintenance program in effect, the drilling and rehabilitation programs as outlined in Section Two of the main body of the Final Report can comfortably achieve the national drinking water goals by 1995 (see Exhibits I-40 and I-41).

EXHIBIT I-37

PROJECTED WATER CONSUMPTION -
SUPPLY SIDE vs DEMAND SIDE, WITH PROGRAM

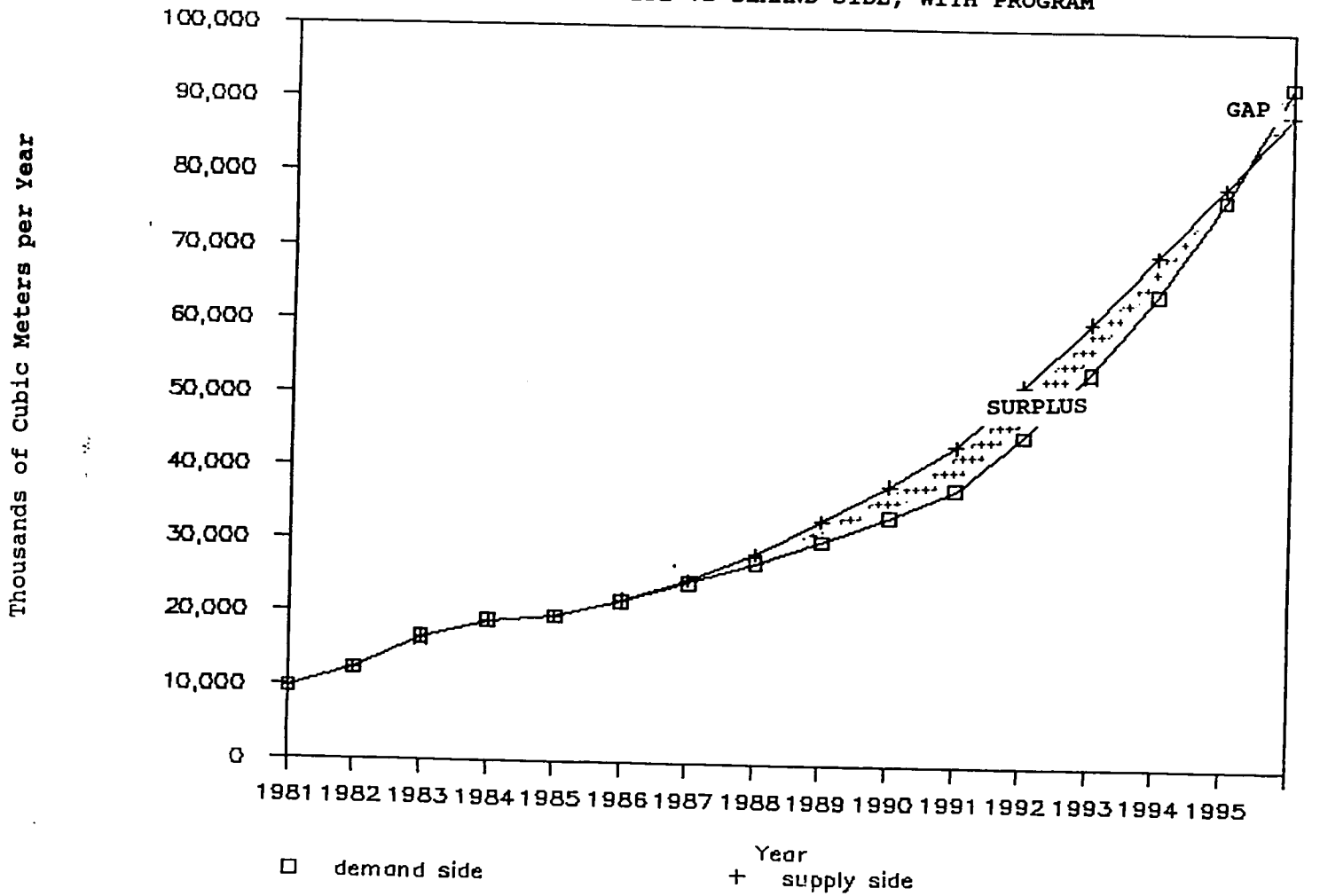


EXHIBIT I-38

PROJECTED PER CAPITA WATER CONSUMPTION -
SUPPLY SIDE vs DEMAND SIDE, WITH PROGRAM

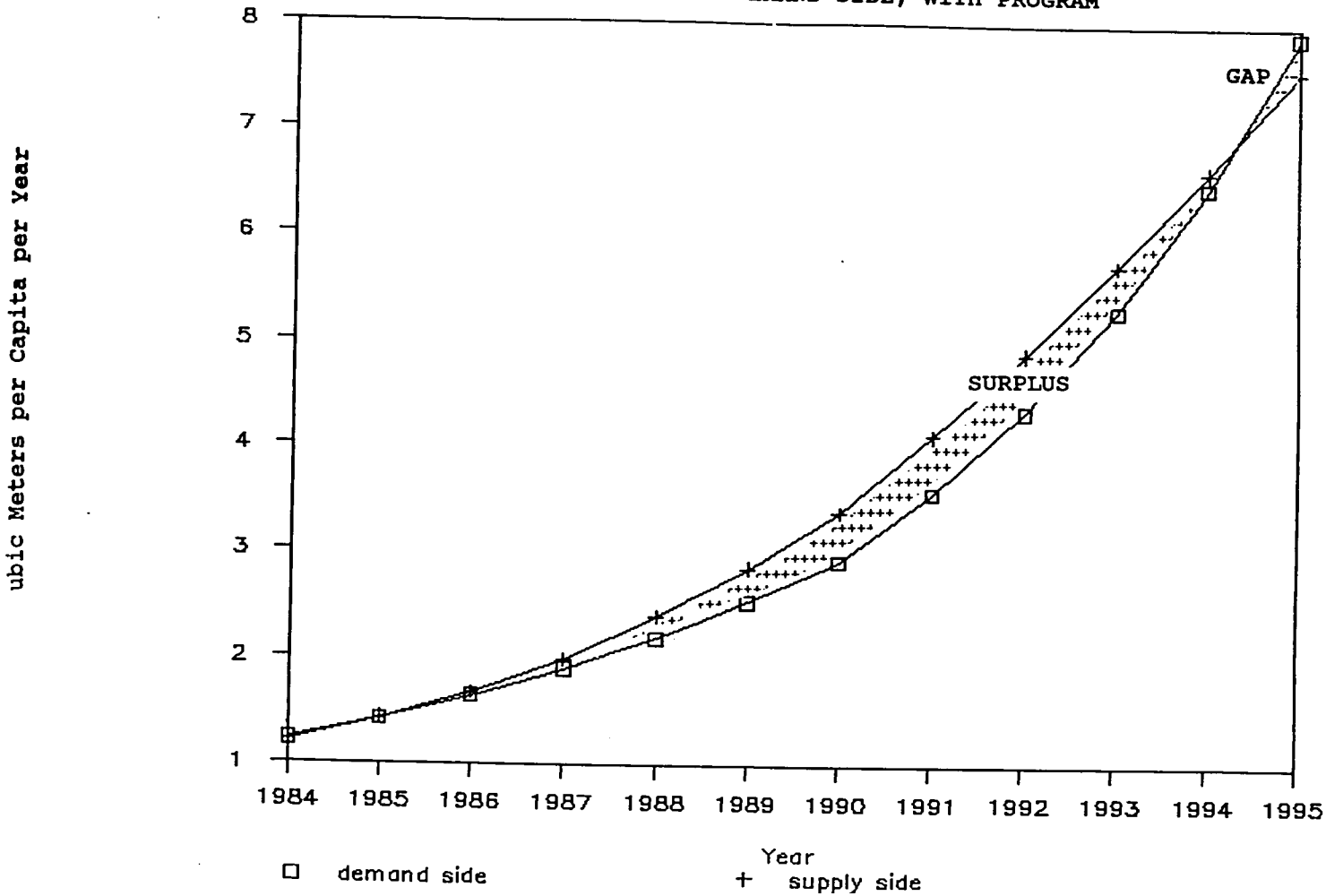


EXHIBIT I-39

DEMAND SIDE PROJECTIONS FOR REQUIREMENTS; SUPPLY SIDE PROJECTIONS ASSUMING CONSULTANTS' FULL RECOMMENDED PROGRAM

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate P.A. '84-'90	'90-'95
TOTAL NON-IRRIGATION...																		
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Volume of Water (M^3*k/yr)	9843	12471	16616	18707	19656	21879	24755	27111	30182	33601	37409	44816	53769	64384	77203	92597	11.32%	19.87%
Human consumption (M^3*k/yr)					6581	7813	9290	11037	13113	15580	18511	23268	29247	36762	46209	58083	18.81%	25.70%
Ave. Human cons (M 3/capita/yr)					1.23	1.42	1.64	1.89	2.19	2.52	2.91	3.56	4.34	5.30	6.47	7.90	15.46%	22.06%
Stock of Wells	275	321	376	415	445	490	540	595	656	723	797	913	1050	1212	1404	1631	10.20%	15.40%
Need Rehabilitation	0	25	28	34	42	47	52	59	66	66	66	41	41	41	41	41		
Needed Drill or Rehabilitation	25	71	82	75	71	92	102	114	86	92	99	116	137	162	192	227		
Minimum Needed Drilling							50	55	20	27	34	75	96	122	151	186		

WELL DRILLING SERVICES SUPPLY: 1980 - 1984 ACTUAL, 1985 - 1990 PROJECTIONS BASED ON FAST WORK AND CONSULTANTS RECOMMENDED FULL PROGRAM

YEAR/CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
GOVERNMENT NON-IRRIGIATION DRILLING																
Consultants' Projection with Program	20	22	15	23	18	19	18	18	18	20	24	20	16	12	12	12
FOREIGN NON-IRRIGATION DRILLING																
Consultants' Projection with Program		40	55	34	34	56	40	36	32	28	24	24	24	24	24	24
PRIVATE NON-IRRIGATION DRILLING																
Consultants' Projection with Program	5	9	12	17	19	23	31	38	50	58	69	87	96	100	108	113
Contract Well Rehabilitation							22	44	24	24	24	24	24	24	24	24
TOTAL NON-IRRIGATION DRILLING																
Consultants' Projection with Program	25	71	82	74	71	98	89	92	100	106	117	131	136	136	144	149
Contract Well Rehabilitation							22	44	24	24	24	24	24	24	24	24

SUPPLY SIDE PROJECTIONS, WITH CONSULTANTS' RECOMMENDED FULL PROGRAM

ALL NON-IRRIGATION WELLS

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
Old	250	225	200	175	150	125	100	75	50	25	0	0	0	0	0	0		
(Previous)		25	94	166	224	272	343	420	556	680	810	951	1106	1266	1426	1594		
Total old + previous	250	250	294	341	374	397	443	495	606	705	810	951	1106	1266	1426	1594		
Need Rehabilitation	0	25	28	34	42	47	52	59	67	67	67	42	42	42	42	42		
Rehabilitated							22	44	24	24	24	24	24	24	24	24		
New Drilling	25	71	82	74	71	98	89	92	100	106	117	131	136	136	144	149		
Total Stock	275	321	376	415	445	495	554	631	730	835	951	1106	1266	1426	1594	1767	13.50%	13.20%
Volume of Water (M^3*k/yr)	9843	12471	16594	18914	19635	22103	24987	28740	33587	38799	44617	54270	64730	75717	87628	100294	14.66%	17.59%
Human Population (000s)					5350	5505	5665	5829	5998	6172	6351	6540	6735	6935	7141	7354	2.90%	2.98%
Human consumption (M^3*k/yr)					6574	7899	9531	11700	14593	17991	22678	28176	35248	43233	52448	62911	22.37%	23.30%
Ave. Human cons (M^3/capita/yr)					1.23	1.43	1.68	2.01	2.43	2.91	3.48	4.31	5.23	6.23	7.34	8.55	18.92%	19.73%

EXHIBIT I-40

PROJECTED WATER CONSUMPTION -
SUPPLY SIDE vs DEMAND SIDE, WITH PROGRAM

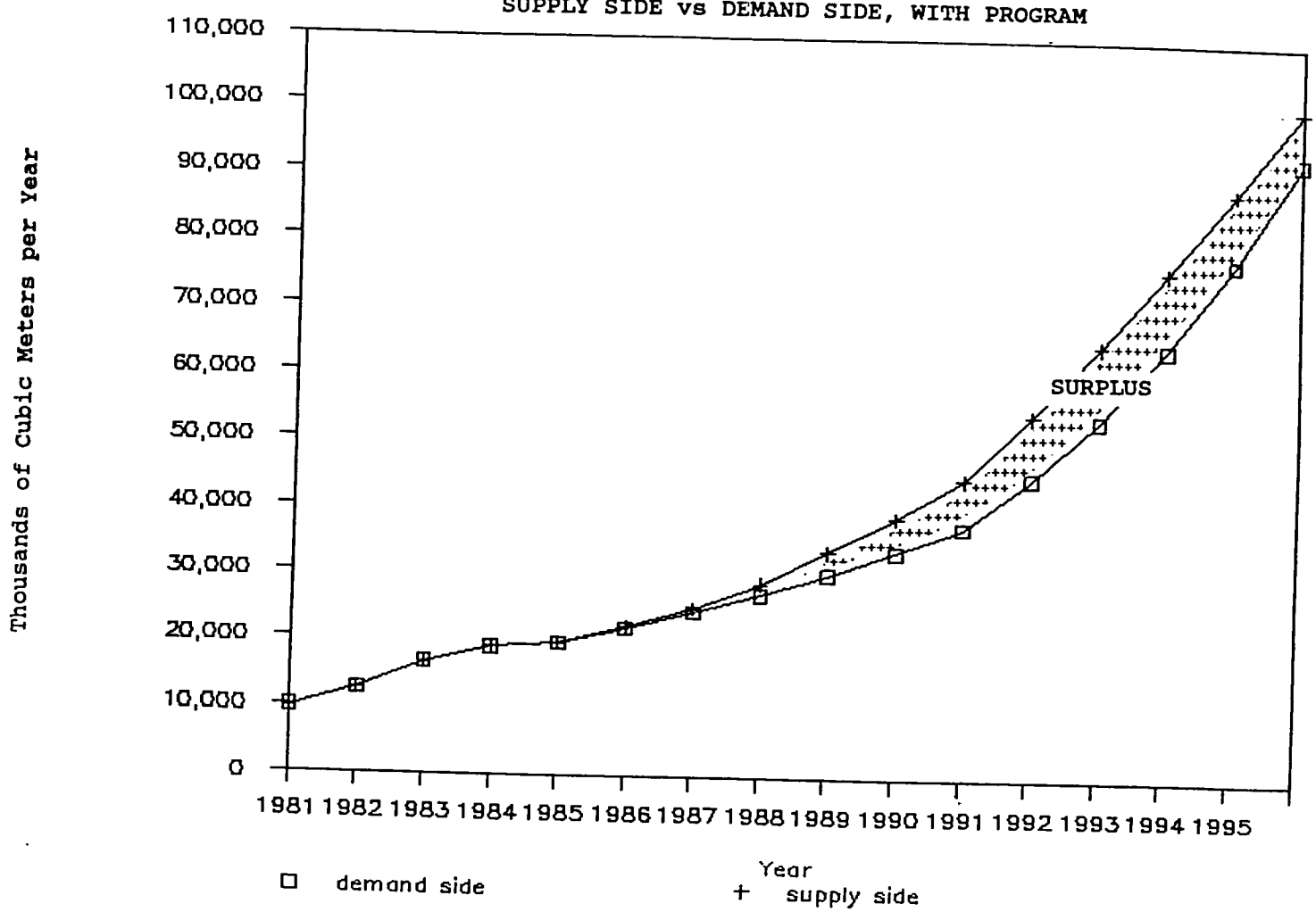
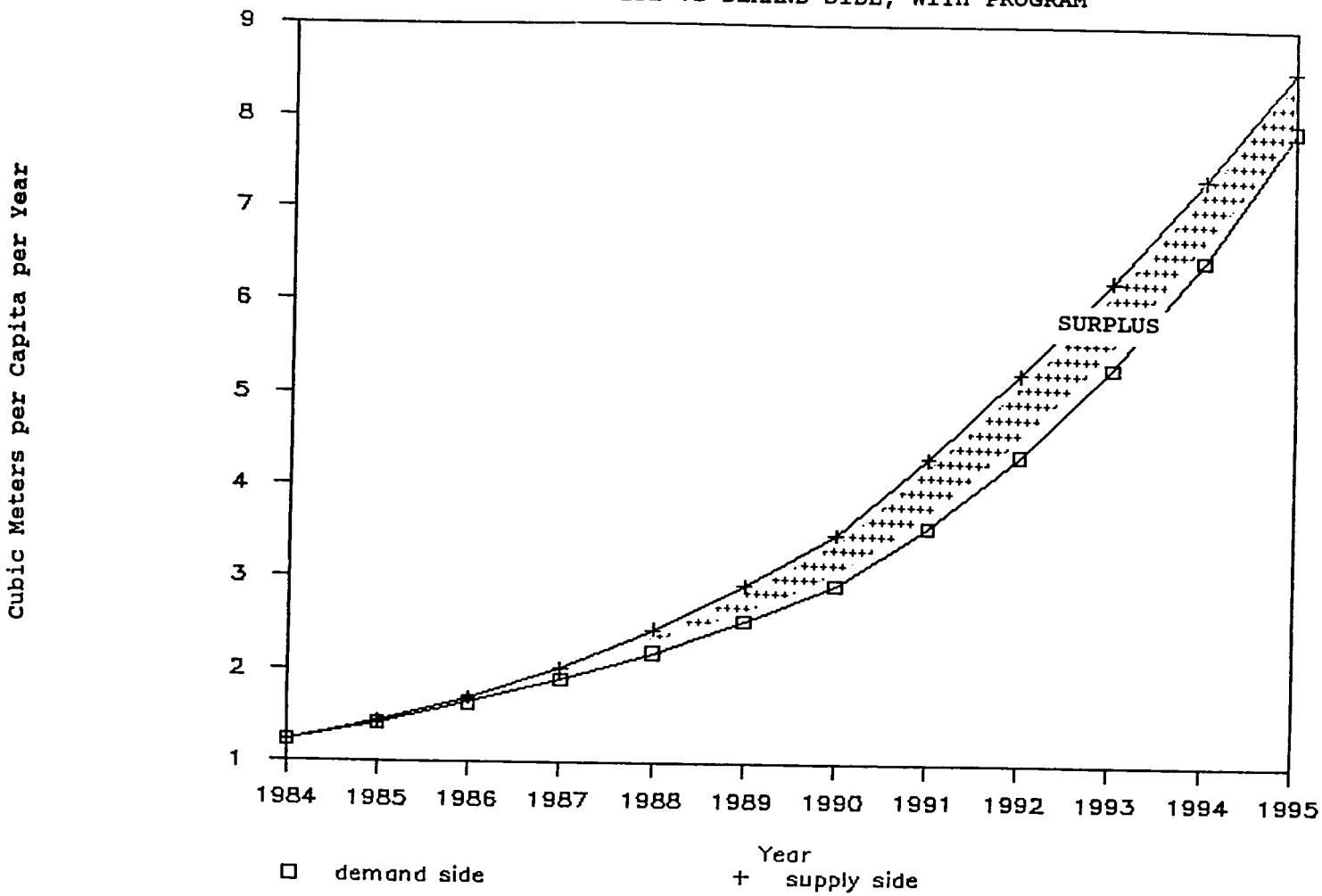


EXHIBIT I-41

PROJECTED PER CAPITA WATER CONSUMPTION -
SUPPLY SIDE vs DEMAND SIDE, WITH PROGRAM



I-6 USE OF WISyMS TO ESTIMATE CURRENT SYSTEM PARAMETERS

I-6.1 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 Annex I-1 through I-3.

The forecasting and constraint analysis applications of WISyMS were introduced earlier in this appendix (Sections I-4 and I-5) 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 a prerequisite for making sound projections of future needs and for making realistic assessments of national water supply objectives.

I-6.2 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 from 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 from 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.

I-6.3 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 Annex I.

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, included at least 60 drilled wells, 250 hand dug wells, 75 uars, and 20 earth dams.

The replacement program (along with needed maintenance and operations) implies a minimum need for locally produced or available inputs as follows: cement - 22 thousand cubic meters,

stone - 49 thousand cubic meters, gravel - 2 thousand cubic meters, sand - 10 thousand cubic meters, skilled labor - 551 thousand man-days, unskilled labor - 80 thousand man-days, fuel - 4 million liters, drill/pump rigs - 7 thousand equipment days, and other vehicles - 211 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 consultants expect that the data base will be continuously updated to provide ever more accurate analyses, and that the framework will be expanded to provide more detail in the future.

I-7 WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA DEFINITION OF TERMS, CATEGORIES, AND CONCEPTS

I-7.1 Introduction

This Appendix has three sections including this introduction. Section I-7.2 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 I-7.3. Section I-7.3 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

I-7.2 Alphabetical Listing of Terms

	Defined on Page
Agriculture	I-73
Agricultural Consumption	I-73
Animal Consumption	I-73
Animal Population	I-73
Average Useful Life	I-77
Ballehs	I-76
Burkeds	I-76
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I-7.3 Definitions

I-7.3.1 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 pro ion 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.

2. **Level II: Well Drilling and Construction of Water Supply Facilities** - The drilling and rehabilitation 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.

I-7.3.2 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 percentage breakdown of these categories (See Section I-9).

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.

I-7.3.3 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.

I-7.3.4 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.

I-7.3.5 Types Of Water Supply Structures

Ten types of water supply structures are covered by WISyMS. They are: drilled wells (including urban, rural diesel pumped, rural hand pumped, and irrigation), hand-dug wells, intakes from rivers, uars, ballehs, burkeds, and diversion dams. Each of the 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 **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. Production wells can be further classified into: **a) urban wells**, including both public, municipal wells serving the city as a whole, and private wells serving individual households or business establishments, **b) rural diesel pump wells**, including all rural drilled wells operated by diesel pumps, **c) rural hand pump wells**, including all drilled wells operated by handpumps, and **d) irrigation wells**, including all drilled wells serving irrigated agriculture.

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, if for drinking water, 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.

I-7.3.6 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.

I-7.3.7 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 Section I-8, 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.

I-7.3.8 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, depending upon the average volume of output per single operational structure.

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 or rehabilitated.

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 Section I-8).

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

   - Replace or rehabilitate 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-7.3.9 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, pipes, plastic sheets, storage tanks, and hand pumps; and other materials which must be imported - drilling fluid (bentonite), drill bit, well casing and screen, diesel pumps, reinforcement steel, and fuel;

2. **Labor** - for supervision, drilling, excavation, construction, mechanical and other 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.

I-8 DETAILED METHODOLOGY FOR THE WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA

I-8.1 Introduction

This presentation of the methodology employed by the Water Industry Systems Model for Somalia (WISyMS) contains three sections, corresponding to the t..ree 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 Section I-F).

Actual data generated by WISyMS has been bound separately in Annex I. It is suggested that Annex I-4, "1990 Middle Level Projections" data be referred to throughout the following discussion (unless otherwise noted) for illustration. Familiarity with the general structure of the model, as presented in Sections I-2 and I-3, above, is assumed in the discussion that follows.

I-8.2 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.

I-8.2.1 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.

I-8.2.2 Level I Submodel, Second Section

The second 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, for each category of consumption, the percentage distribution (% of V_c) of reliance on each of ten types of water supply structures. (e.g., Human Urban Consumption from urban drilled wells accounts for 75% of the total urban consumption from all types of supply structures). Each row of the matrix sums to 100%.

I-8.2.3 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_{cs}) by type of consumption and by type of structure (e.g., for the Human consumption category, urban (HC) consumption from urban drilled wells is : $.75 * 6287 = 4716$).

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

or:

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

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.

$$V_{sj} = \sum_{i=1}^{n} V_{cisj}$$

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 and 1995 for the "without program" projections:

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

For the "with program" projections (Annex I-10), V_{oj} was increased due to less down-time and wastage from drilled wells, assuming programs of contract operations and routine maintenance are functioning.

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 Year" V_{oj} divided by "Days per Year" D_j.

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 or rehabilitation requirements R_j (in the absence of

detailed knowledge of the ages and conditions of the structures concerned):

$$R_j = SC_j/U_j$$

This would represent the bare minimum replacement or rehabilitation rate without suffering a loss in crude supply capacity. For the 1984 middle-base estimates (Annex I-1), 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, (assuming no rehabilitation takes place).

I-8.3 Level II Submodel

Section I-4, above, 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 I-6 discussed the use of the model to make estimates of the current (end-1984) system. This provides the basis for comparison between 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 without the Consultants' recommended maintenance and rehabilitation program) were made assuming that the 1984 level of output per single structure V_{oj} was constant (see above). With-Program projections

for 1995 were made on the assumption that decreased downtime and waste would increase the effective annual output of drilled wells. (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 calculated by expotential interpolation. For example:

1984 Total existing urban drilled wells = 124; and
1990 Total needed urban drilled wells = 232; then

$$232/124 = (1 + g)^6$$

$$g = (232/124)^{1/6} - 1 = 0.11 \text{ or } 11\%$$

therefore 1985 Total needed urban wells = 124 * 1.11 = 138

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 in the absence of a routine maintenance program, deteriorates at a rate ($1/U_j$) each year after that. For example, for urban drilled wells, there were 12 new wells drilled in 1984, and 81 "Previous New Wells" in 1984. Therefore, there are [12 + (.9 * 81)] = 85 urban drilled wells in the "Previous" row for the 1985 column.

The fourth row of each grouping, "Needed New or Rehabilitated Structures", $SNjt$, represents the numbers of structures which must be built or rehabilitated in a given year to 1) keep pace with expanding consumption needs from all sources and 2) to replace or rehabilitate 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 or Rehabilitated Structures" have been used in the Level III submodel to calculate needed inputs.

I-8.4 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 drill/construct, rehabilitate, operate, 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 five categories:

- Urban Wells
- Rural Wells equipped with hand pumps;
- Rural Wells equipped with diesel pump;
- Irrigation Wells; and
- Non Production Wells, assumed to be in fixed proportion of rural wells.

The other structures are undivided.

Each of these structures is clearly defined in Section I-7; sources and estimating procedures are discussed in Section I-9. 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 drilling/construction
- Technical coefficients of rehabilitation (drilled wells only)
- Technical coefficients of maintenance
- Technical coefficients of operation (drilled wells only)
- Useful Life

- Rehabilitation Period
- 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 if there is no rehabilitation).

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:

$$AMR_j = (SC_j/MP_j)$$

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

$AWRR_j$ = Annual Wells Rehabilitation Rate for well j: indicates the annual numbers of wells to be rehabilitated. The maximum $AWRR_j$ would be estimated as:

$$AWRR_{jt} = (SO_{jt} + SP_{jt}) - (SO_{jt-1} + SP_{jt-1})$$

In practice, the rehabilitation rate will be defined according to the program (or lack thereof) in effect at time j.

$AWOR_j$ = Annual Wells Operation Rate for each well j: indicates the annual numbers of wells to be operated:

$$AWOR_j = SC_j$$

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 drill/construct one unit of Output j.

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

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

D_{ij} = Technical coefficient representing the quantity of Input i required for one year's operation of unit j.

W_{ij} = Total annual quantity of Input i to be supplied in order to drill/construct Output j.

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

Y_{ij} = Total annual quantity of Input i to be supplied in order to maintain Output j.

Z_{ij} = Total annual quantity of Input i to be supplied in order to operate Output j.

W_i = Total annual quantity of Input i required for the drilling/construction of all water supply structures in a given year.

X_i = Total annual quantity of Input i required for the rehabilitation of all wells in a given year.

Y_i = Total annual quantity of Input i required for the maintenance of all water supply structures in a given year.

Z_i = Total annual quantity of Input i required for the operation of all wells in a given year.

Relationships:

The following relationships can be established:

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

$$X_{ij} = B_{ij} * AWRR_j$$

$$Y_{ij} = C_{ij} * AMR_j$$

$$Z_{ij} = D_{ij} * AWOR_j$$

$$W_i = \sum_{j=1}^{m} W_{ij}$$

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

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

$$Z_i = \sum_{j=1}^{m} Z_{ij}$$

Finally, $W_i + X_i + Y_i + Z_i$ = the total annual quantity of nput i to be supplied to the water industry at Levels I and II or all purposes.

In addition, for the sake of calculating the direct costs of roduction in the well drilling industry, WISyMS provides unit osts (P_i, as CIF Mogadishu) for each type of input, in dollars. nen the total annual costs (PW_i) for each type of Input i for rilling/construction of drilled wells can be calculated as:

$$PW_i = P_i * W_i$$

(Similarly for rehabilitation - PX_i; maintenance - PY_i; and operations PZ_i)

The total costs for drilling/constrution for drilled wells (PW) is then:

$$PW = \sum_{i=1}^{n} PW_i$$

(Similarly for rehabilitation - PX, maintenance - PY, and operation PZ)

WISyMS data output is presented in Annex I. Notes, sources, and estimating procedures are discussed in Section I-9, below.

I-9 WISYMS NOTES AND SOURCES

I-9.1 Introduction

This appendix provides notes to accompany the presentation of WISyMS contained in Section I-8 (Methodology) and Annex I (Data). It discusses sources of data and estimates used in the various runs of the model which are presented in Annex I and also discusses some of the estimating procedures involved in building the model. This section is organized into four sets following the presentation of the data contained in Annex I:

- **1984 BASELINE ESTIMATES**
  Annex I-1 Middle Level Estimates
  Annex I-2 Low Estimates
  Annex I-3 High Estimates

- **1990 PROJECTIONS/FORECASTS**
  Annex I-4 Middle Level Projections
  Annex I-5 Low Projections
  Annex I-6 High Projections

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

- **1995 PROJECTIONS OF NATIONAL OBJECTIVES AND SUPPLY SIDE ANALYSIS OF CONSULTANTS' RECOMMENDED PROGRAM**
  Annex I-9 National Consumption Objectives without Consultants' Recommended Program (Demand Side Analysis)
  Annex I-10 National Consumption Objectives with Consultants' Recommended Program (Supply Side Analysis)

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. The 1990 Evaluations of National Objectives are based on Annex I-4, the middle range projections, and include specific national goals for per-capita water consumption, standards, and service. The 1995 projections are an extention of the middle range 1990 projections, with the national goals for per capita water consumption (full standards) included as a target for 1995. Annex I-9 examines these goals in the absence of the Consultants' Recommended Program; Annex I-10 uses a supply side analysis to show how the recommended program meets the need.

I-9.2 WISyMS 1984 Baseline Estimates

The data presented in the first model, Annex I-1, "Middle Level 1984 Estimates of Population, Rates of Consumption, and Existing Structures" represent the Consultants' baseline estimates for year-end 1984. Annex I-2 and Annex I-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 I-3 of this appendix and in Section I-7, "Definitions". Sources indicated in <brackets> refer to the bibliography, attached. Figures for which specific sources are not mentioned are Consultants' estimates. All calculations are explained in Section I-8.

I-9.2.1 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. Annex I-2 presents the Consultant's estimate of the likely lowest end of the possible range of population, and estimates presented in Annex I-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 Units, where the average camel is counted as one LSU, cattle are .8 LSU and Sheep and Goats are .125 LSU.

- **Agriculture, (Hectares):** for Annex I-1 are from MNP <5> estimates for "current irrigated cropland", "current rainfed cropland" and "flood-fed cropland". Annex I-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.

I-9.2.2 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 estimates are 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^3*K/YR"):** for each type of consumption unit is the calculated total annual volume of water consumed in thousands of cubic meters per year.

I-9.2.3 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.

- **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.

I-9.2.4 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^3*K/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.

I-9.2.5 Numbers of Water Supply Structures

- **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 Annex I-2 and I-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.

I-9.2.6 Detailed Descriptions of Water Supply Structures

- **Drilled Wells:** All drilled wells are considered commercial scale structures. Drilled wells are either urban, rural equipped with a hand-pump or a diesel pump, or irrigation wells. (Wind mill and solar 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 **urban** and **rural 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 and irrigation wells are assumed to be an average of 80 meters deep.

Diesel pumped wells serving rural areas are equipped with a diesel generator and pump unit 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 70% of all rural drilled wells are equipped with a diesel pump, as are all urban and irrigation wells.

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 30% of all rural drilled wells are equipped with a hand 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 water quantity and/or quality is not suitable. It is assumed that the number of non-production wells in a given year averages 30% of the number of rural 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 days 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 considered 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 cubic 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 (Annex I-1), 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.

I-9.3 WISyMS 1990 Projections/Forecasts

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

I-9.3.1 Level I Submodel

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

- **Agricultural Projections:** Annex I-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. Annex I-5

assumes 1.1%, 2.5% and 2.5% growth rates p.a. respectively for the three categories; and Annex I-6 assumes 5%, 6% and 6% growth rates p.a.

- **Government and Industry Projections:** All three 1990 forecast Annexes assume no growth in water consumption for governmental institutions. Annex I-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. Annex I-5 assumes the number of establishments will also increase by 5% per anum, and that per-establishment consumption will increase by 5% per anum. Annex I-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 Annex I-5, which assumes some growth from Annex I-2).

- **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 annexes 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 annexes 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. Annex I-4 indicates an increase of 4.3% per anum for total water consumption through all structural control facilities. Annex I-5 and Annex I-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:** is assumed to be unchanged.

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 Section I-8.

I-9.3.2 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 then begin to fail at a rate of 10% per year.

- **Needed New Wells:** for years 1980-1984 are estimates of the numbers of wells actually drilled each year, based on known drilling activity. (Annex I-5 assumes we were double-counting or counting nonproduction wells, and Annex I-6 assumes we missed some drilling activity.) For 1985 through 1990, they are calculated

as the number of wells that need to be drilled or rehabilitated 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.

I-9.3.3 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 Section Three of the main body of the report and in Appendix D), may make more economical use of labor and capital, but are also currently restricted in their well depths and in the formations through which they can drill. Unit costs are from the "Economic Evaluation of the C.G.D.P." (LBII, 1984) with updates from the consultants.

Raw Materials Inputs:

The list of raw materials inputs does not presume 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 III entrepreneurs' decision-making. More precisely, these are either raw materials used in substantive quantities or materials that are relatively 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 rural and urban wells equipped with diesel pumps are due to the large storage tanks incorporated into the civil works. (See Definitions of the Structures in Section I-7).

- **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 for urban and rural diesel pumped wells is of 120 meters. For irrigation and hand pumbed wells, the average depth is assumed to be 80 meters. Coefficients estimates were provided by CGDP experts.

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

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

- **Pipes** include 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 storage tank) 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. We exclude from this analysis the piped distribution systems of municipal and irrigation water works.

- **Drilling Fluid (Bentonite):** is used at the rate of 20 sacks per 100 meters drilled.

- **Drill Bits:** are used at the rate of one per 1000 meters.

- **Hand Pumps and Diesel Pumps:** CGDP experts estimate that hand pumps are used in 20% of the hand dug wells and 30% of the rural 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

sometimes equipped with hand pumps. These areas are often remote areas, thus not easily accessible for maintenance and fuel services, another reason to decide in favor of hand pumps. Solar or wind pumps are also alternatives.

In high population density areas, urban areas or intensive agriculture areas, where substantial 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 pumps.

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

- **Rebars and Wood:** Rebars (reinforcement steel bars) 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 a uar's 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 Labor Inputs:** includes all labor involved in the borehole test drilling, log taking, hole reaming, well development, casing and screen installation. In the case of rural diesel pump 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. Drilling labor for shallower irrigation and hand pump wells is correspondingly lower. In the case of non production/exploratory wells, the same size team will be present on the site but for a time period of 15 days.

- **Excavation Labor 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 labor input coefficients per hand dug well is:

  (3 x 15)/7 = 6.43 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 III" 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 Labor Inputs:** CGDP experts estimate that a team of 9 people (1 skilled civil works supervisor assisted by 2 skilled workers and 6 unskilled crew members) will work for 6 days in the case of rural hand pumped wells and 36 days in the case of rural diesel pumped wells. Urban wells require somewhat more time, and irrigation wells somewhat less. 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 works are involved 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 labor 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 labor 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, labor 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 Labor Inputs: under mechanical labor inputs are grouped all labor inputs that involve some mechanical, plumbing or electrical work, such as installation of the pumps, pipes and fittings, generators, etc.

In irrigation wells and rural drilled wells equipped with hand pumps, mechanical works are involved 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 more days for deployment to and from site.

In rural drilled wells equipped with a diesel pump, pump installation labor 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 coefficients for mechanical labor per drilled well with diesel pump are (a) skilled: (1 pump crew supervisor x 3 days + 7 plumbers-days) = 10 men-days and (b) unskilled: (4 crew members x 3 days) = 12 men-days. for urban wells, these co-efficients should be 67% higher.

As for those hand dug wells equipped with a hand pump, mechanical labor 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 labor inputs. As previously stated, in 80% of the cases intakes merely consist of piping from the river to the pump. Mechanical labor 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 labor inputs, thus coefficients are nil.

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

In the case of dams, technical mechanical labor 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 tricone drill bit; (or with a cable tool rig). The drill rig input coefficient is estimated to be 30 days for urban wells, 24 days for rural diesel pump wells, 20 days for rural hand pump

wells, and 18 days for irrigation wells. These figures may appear a little high (under normal circumstances, this coefficient would be about 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 amounts of time include 50% for drilling and 50% for down-time.

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. One or two additional days are needed to move the pump rig to and from the site. Thus, the input coefficient is 2-3 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.

  Coefficients for irrigation wells should be about 33% lower.

  In the case of drilled wells equipped with diesel pumps, 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.

Coefficients for urban wells should be about 33% higher.

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 labor 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: 30 liters

I-9.3.4 Level III Submodel, Input-Output Technical Coefficients for Rehabilitation (B_{ij})

Currently in Somalia, there are no functioning rehabilitation programs, and even simple pump replacements have not been performed. In the absence of a program of well/pump maintenance and repair (see below), well rehabilitation and/or

pump replacement may be called for as often as once every three years, instead of the ten years which should be available for a routinely maintained well and pump. In many cases in the past in Somalia, wells with a pump in need of simple repair have been abandoned, and a whole new well eventually drilled to replace the old. This alternative is usually three times as expensive as pump replacement (including the cost of the new pump) or six to ten times the cost of pump repair.

If a program of routine pump maintenance and repair is in place for a diesel pump well, it should be rehabilitated once every ten years. The rehabilitation procedure will involve cleaning the well of the sand and other impurities that prevent the passage of water. In some cases, it could involve drilling the well deeper. At this stage, no rehabilitation procedures involving casing or screen repairs are envisioned. Such procedures require sophisticated equipment and skills which are not available in Somalia, and wells in need of such extensive service should be replaced with a new well.

Technical coefficients for rehabilitation are LBII/RMC estimates, and since future rehabilitation is assumed to take place on a contract basis, the inputs match those contained in Annex A-10 (Finanical Model of Contract Well Rehabilitation Activities) for labor and equipment utilization in the rehabilitation of rural diesel pump wells. Material inputs per rehabilitation procedure are as follows:

Material Inputs

- **Cement, Gravel, Sand, Pipes and Fittings, and Rebars and Wood:** 30% of the original construction requirements for each type of drilled well.

- **Diesel and Hand Pumps:** one per rehabilitation.

Labor Inputs

- **Pump Rig Operator and Skilled Construction Labor:** 12 to 18 days each, depending on type of well.

- **Rig and Construction Assistants:** three and two workers, respectively, times 12 to 18 days.

- **Drivers (Other Unskilled):** two workers times 12 - 18 days.

Equipment Inputs

- **Cable Tool or Pump Rig, Flat Bed and Pickup Truck:** 12 to 18 days each.

Fuel Inputs

- **Cable Tool or Pump Rig:** 50 liters per day,
- **Flat Bed Truck:** 35 liters per day,
- **Pickup Truck:** 20 liters per day.

I-9.3.5 Level III Submodel, Input Output Technical Coefficients for Maintenance (C_{ij})

Currently in Somalia, little attention is paid to maintenance of water supply facilities; there are no functioning maintenance programs, so whatever maintenance there is takes place on an ad hoc basis if at all. Thus repairs are needed frequently. The repairs are also made only sporadically, so that communities may be without a functioning well for considerable periods of time.

A functioning, routine maintenance program would reduce the overall annual construction, rehabilitation, and repair costs, would ensure a reliable water supply, would ensure that financial resources are directed to the construction of net additions to stock (thus increasing the water supply), and would ensure regular demand for goods and services provided by "Level III" industries.

The following coefficients are estimates based on a contract maintenance program which could be followed in the immediate future, as described in Section Two of the main body of the Final Report. This program involves only materials, skills and equipment which are either locally available or can be procured at reasonable cost and within a reasonable period of time. A brief description of the proposed maintenance program and the calculation of input coefficients is given based on the finanical model of contract maintenance activities presented in Annex A-12 of the Final Report.

Maintenance of Drilled Wells Equipped with Diesel Pumps

These wells should be serviced at least once every three months for maintenance of the pump and every year for maintenance of the well and attached structures.

The routine 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 Cylinders

- Check conditions of all belts and pulleys
- Clean the restrictor banjo union at the top end of the lubricating oil feel pipe to each cylinder head;
- Renew fuel filter elements
- Make any necessary repairs to pump and/or generator.

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.

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.

The following inputs for drilled wells are required:

Material Inputs

- **Pipes and Fittings:** one half meter per maintenance service for all diesel pumped drilled wells.
- **Spare Parts for Diesel Pump:** about 30% of all pump/generator units will need repairs each year (or 7.5% per quarter); each repair is estimated to involve an average spare parts requirements equal to 20% of the value of the original pump/generator set.

Labor Inputs

- **Supervisor:** one day per maintenance and one day for each repair job

- **Mechanics:** two workers for three days for each maintenance and three days for each repair

- **Assistants:** two workers for three days for each maintenance and three days for each repair.

Equipment Inputs

- **Pump Rigs:** one day per pump repair,

- **Pickup Truck:** three days per maintenance service and three days per repair.

Fuel Inputs

- **Pump Rigs:** 50 liters per day.

- **Pickup Trucks:** 20 liters per day.

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 wells:

- 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 labor: 10% of construction requirements

Hand dug wells equipped with hand pumps are subject to the same maintenance requirements as drilled wells equipped with hand pumps. Diesel pumps for intakes from rivers require the same efforts as for diesel pumped wells.

Maintenance of Other Structures

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

I-9.3.6 Level III Submodel, Input-Output Technical Coefficients for Drilled Well Operation and Revenue Collection (D_{ij})

Operation of drilled wells is relatively simple, and requires a responsible individual, though not necessarily someone with extensive technical skills. For drilled wells providing drinking water to the public, the well operator may also function as a fee-collector. For other wells, it is not necessary for the "operator" to be present at the well at all times, but he or she would be responsible for the day-to-day functioning of the well, turning it on and off as needed, checking the meter and the fuel supply, and calling for the repair/maintenance service contractors if necessary.

The following inputs are involved in the operation of each drilled well:

- **Well Operator:** One person per well per day of operation for each type of well.
- **Diesel Pump:** Operating as many days as cited in the Level I submodel. Unit cost is calculated as the CIF price, amortized over the useful life, divided by the number of days in operation.
- **Fuel:** for urban wells, 36 liters per day (weighted average of municipal wells and private/industrial wells); for rural diesel pump wells, 15 liters per day; for irrigation wells, 25 liters per day.

I-9.4 WISyMS Constraint Analysis of National Objectives to 1990

Two 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 Annex I-7 and I-8. Most of these figures are based on the demographic assumptions contained in Annex I-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 this type of consumption with the quantities of needed new drilled wells.

  For Annex I-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.

  Annex I-8 makes use of a more modest set of goals found in the planning document. The second set of goals implies less of an attempt to develop groundwater resources and a relatively heavier emphasis on surface water resources and catchments to serve its target 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").

I-9.5 1995 Projections of National Objectives and Supply Side Analysis of Consultants' Recommended Program

Finally, we include two WISyMS projections through 1995, based in the middle level projections to 1990, continuing with the same growth rates for populations and economic activity (i.e., for consumption units), used for Annex I-4, and including the full national objectives for per capita consumption as targets for 1995, as described for Annex I-8, above.

Annex I-9 makes a straight forward WISyMS analysis as described above for Annexes I-4 and I-8. Annex I-10, on the other hand, assumes that the Consultants' Recommended Program with regard to well drilling, rehabilitation, maintenance, and operations has been in effect for the ten year period 1986 through 1995. The following assumptions are affected as described below:

I-9.5.1 Level I Submodel

- **Numbers of Water Supply Structures:** For the sake of projecting the numbers of water supply structures for 1995, the Consultants assumed that a program of contract operations and routine maintenance on 40% to 45% of about 1500 non-irrigation wells should have the effect of increasing the annual volume of water output from each well involved by about 33%; and thus increasing the average annual volume of water output from the entire stock of drilled wells by about 14%. This would correspondingly reduce the need for the number of wells needed to satisfy the projected volume of water required for 1995.

I-9.5.2 Level II Submodel

In place of the usual WISyMS demand side analysis for non-irrigation well drilling for Level II, Annex I-10 presents the Consultants' "with program" supply side projections of drilling and rehabilitation (as outlined above in Section I-5.5.4). These projections are summed for the section labled "TOTAL NON-IRRIGATION," described in further detail immediately below.

- **Old Wells:** deteriorate as described for Annex I-4, above.

- **Previously Drilled "New" Wells:** All new and newly rehabilitated wells, after the start of the Consultants' Recommended Program, are expected to be included in a program of contract routine maintenance and repair. These wells should not "fail" for ten years after their construction/rehabilitation. Thus the only deterioration in the stock of wells will be from the old (pre 1986) wells, which will continue to fail at a rate of 10% of the original (1986 stock) per annum.

- **Needed Rehabilitation:** This row highlights the numbers of wells which fail (as described immediately above) in a given year.

- **Rehabilitated Wells:** The well rehabilitation portion of the Consultants' Recommended Program covers some, but not all, failed structures each year.

- **New Drilling:** is the sum of all non-irrigation drilling projected by the consultants, assuming implementation of the Consultants' Recommended Program (see Section I-5.5.4, above).

- **New Stock:** For this supply side analysis is the sum, in any given year, of old plus "previous" plus rehabilitated plus newly drilled wells.

I-9.5.3 Level III Submodel, Input-Output Technical Coefficients for Constructon (A_{ij})

Inputs for the Level III submodel of Annex I-10 represent estimated averages of drilling to be undertaken by local government agencies, foreign firms, and local private firms, assuming implementation of the Consultants' Recommended Program. In 1995, about three quarters of all wells drilled are expected to be drilled by local private firms (90% of all rural wells, half of all urban wells, and 67% of irrigation wells) with a substantially smaller complement of labor and equipment, and taking much less time than has been required, on avaerage, in the past. Direct costs for rural diesel pump wells drilled by local private contractors would involve the following level of inputs, based on the financial models for contract well drilling presented in Annex A-14:

Material Inputs

Same as described for Annex I-4 above.

Non-production wells: assumed to be 25% of all rural production wells.

Labor Inputs

- **Supervisor/Chief Engineer:** 15 days per production well; 10 days per non-production well;

- **Chief Driller/Assistant Engineer:** 15 days per production well; 10 days per non-production well;

- **Civil Works Engineer:** 15 days per production well;

- **Mechanical Engineer:** 10 days per production well;

- **Carpenter:** 2 days per production well;
- **Drilling technicians and semi-skilled assistants:** 3 each for 10 days per production well and 5 days per non-production well;
- **Construction Laborers:** 5 laborers for 10 days;
- **Mechanic Assistants:** 1 person for eight days;
- **Other Unskilled:** 2 workers, each 10 days per production well and 5 days per non-production well.

Equipment Inputs

- **Drill Rig:** 15 days per production well and 10 per non-production well, of which 9 and 4 days respectively, actually spent drilling;
- **Pump Rig (pump tripod on pickup truck or cable tool rig):** 3 days per production well;
- **Pickup Truck:** 22 days per production well and 13 days per non-production well;
- **Other Light Vehicle:** 30 days per production well and 13 days per non-production well;

Fuel Consumption

- **Drill Rig:** 250 liters per day (50 if a cable tool rig is used, although time spent per well of given depth would be longer);
- **Flat Bed Truck:** 35 liters per day
- **Pick up Truck:** 20 liters per day (petrol)

I-9.6 Final Note

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

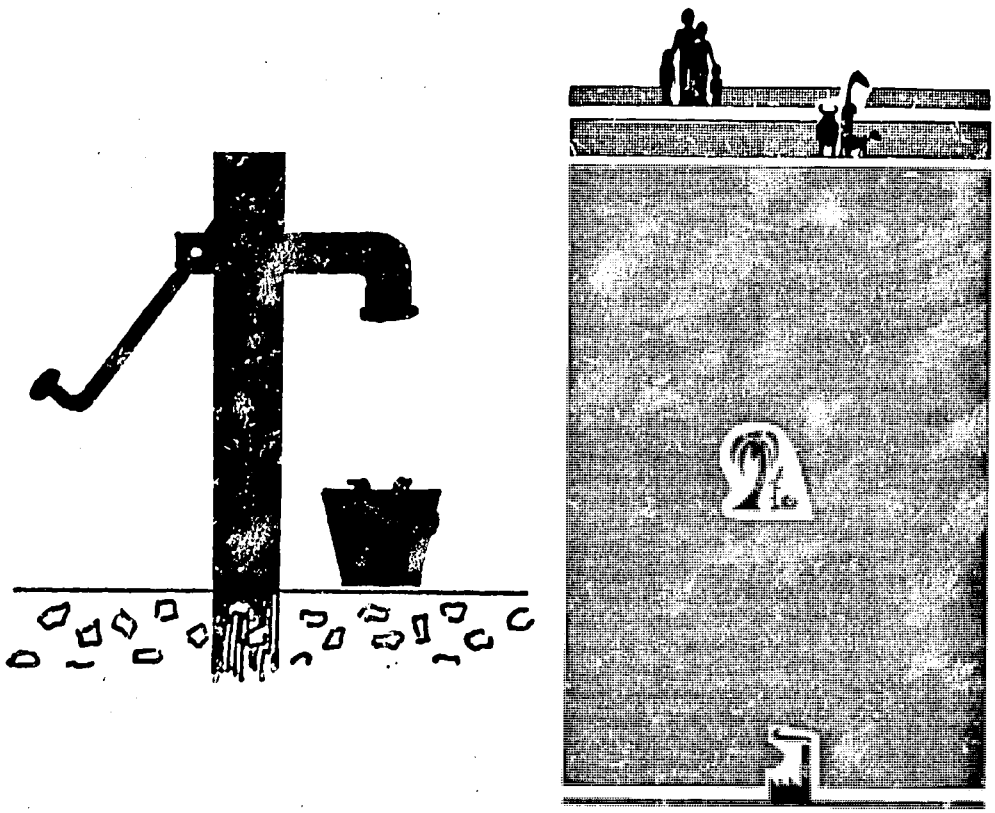
BIBLIOGRAPHY/SOURCES FOR WISyMS

1. Ministry of National Planning (MNP) 1985 pamphlet, "Somalia in Figures"
2. Resource Management and Research (RMR) 1985 "Southern Rangelands Survey," vol. 4, part 1
3. IBRD 1981 "Mogadishu Second Water Supply Project"
4. MMWR 1983 "Plan for the Drinking Water Supply and Sanitation Decade", Vol. II
5. MNP 1982 "Five Year Development Plan," 1982-1986
6. RMR 1985 "Southern Rangelands Survey" vol. 3 part 2
7. RMR 1985 "Southern Rangelands Survey" vol. 3 part 1
8. MNP 1984 "Data Base of Somali Industries"
9. LBII 1984 "Comprehensive Groundwater Development Project" (Project Paper).
10. RMR 1981 "Central Rangelands Survey" vol 1 part 1
11. RMR 1982 "Northern Rangelands Survey" vol 1 part 1/2
12. MNP 1985 "Preliminary Estimates of Gross Domestic Product 1984 for Somalia"
13. USAID 1984 "Livestock Marketing and Health" (Project Paper)
14. UNDP 1973 "Mineral and Groundwater Survey for the Republic of Somalia"
15. FAO 1973 "Surface Water Resources of the Republic of Somalia"
16. FAO 1974 "Water Use in Irrigated Agriculture"
17. IBRD 1977 "Central Rangelands Development Project"
18. Unicef, 1982 "Technical Report, Refugee Water Supply Project"
19. UNHCR 1985 "Refugee Water Supply Systems"
20. Mission of the People's Republic of China, 1984, logging data, North West Well Driling
21. Holtzman 1984, "Review of Livestock Marketing and Livestock Marketing Facilities in Somalia"
22. IBRD 1981 Somalia Agricultural Sector Review vols 1-3.
23. Ministry of the Interior, 1984, "Survey of Water Sources in Several Districts"

Study of

PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER RESOURCE DEVELOPMENT INDUSTRY

Annexes



COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

April, 1986

Louis Berger International, Inc.

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COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT

STUDY OF PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER RESOURCE DEVELOPMENT INDUSTRY

ANNEX I

WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA (DATA)

1984 Estimates

1990 Forecasts

1990 Constraint Analysis of National Objectives

1995 Projections

Prepared for:
The Water Development Agency
Somali Democratic Republic

Prepared by:
Louis Berger International, Inc.

Funded by:
United States Agency for
International Development

COMPREHENSIVE GROUNDWATER DEVELOPMENT PROJECT STUDY OF

PRIVATE SECTOR PARTICIPATION IN SOMALIA'S WATER

RESOURCE DEVELOPMENT INDUSTRY

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ANNEX A-1

FINANCIAL MODEL OF ENGINEERING/SURVEY OPERATIONS: PHASE ONE - STEP ONE

(Basis for calculation of appropriate contract price, equipment rental rate, and equipment purchase price)

A. MODEL ASSUMPTIONS (for firm lacking trucks and satellite locators)

A.1 Equipment Costs

3 Satellite Locators

Initial cost:	$27,300	US dollars CIF
Life Expectancy:	10	years
Interest:	20%	per annum
Term:	1	year
Monthly Payment	$455	40,950 So.Sh./mn
Depreciated Val:	25%	614,250 So.Sh.

3 Pickup Trucks

Initial cost:	$84,000	US dollars CIF
Life Expectancy:	5	years
Interest:	20%	per annum
Term:	1	year
Monthly Payment	$1,400	126,000 So.Sh./mn
Depreciated Val:	10%	756,000 So.Sh.

Market Exch Rate mid-'86: 90 So.Sh./$

Total Rent Payment: 3,005,100 So.Sh.
Purchase Equipment: 1,370,250 So.Sh.

4,375,350 So.Sh.

A.2 Labor Costs

Quant	Position	So.Sh./dy	days per well days	cost
1	Engineer/Supervisor	500	2	1,000 So.Sh./wl
1	Survey Crew Leaders	250	8	2,000 "
1	Drivers	130	8	1,040 "
2	Assistants	175	8	2,800 "
				6,840 So.Sh./wl

A.3 Annual Overhead

Quant	Item	So.Sh./mn	months	
1	Clerk/Secretary	5,000	12	60,000 So.Sh./yr
1	Watchman	4,000	12	48,000 "
1	Office/Yard	35,000	12	420,000 "
				528,000 So.Sh./yr

B. CONTRACT PRICE

	Price	Quant.	Total
Locate well:	36,000 So.Sh./wl	130	4,680,000 So.Sh.

C. FINANCIAL ANALYSIS

Somali Shillings

COMPONENT/QUARTER	I	II	III	IV
Number of Wells Located	30	32	34	34
Equipment Rental	(500,850)	(500,850)	(500,850)	(500,850)
Purchase Equipment				(1,370,250)
Labor Costs	(205,200)	(218,880)	(232,560)	(232,560)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)
Payment for Located Wells	1,080,000	1,152,000	1,224,000	1,224,000

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NPV of balance at 35% nominal opportunity cost of capital.	1,034,833
NPV of balance at 20% nominal opportunity cost of capital.	1,116,863
NPV of balance at 0% nominal opportunity cost of capital.	1,259,400

D. SENSITIVITY ANALYSIS

NPV at 20%		Contract Price: So.Sh. per well					
	1,116,863	20,000	25,000	30,000	35,000	40,000	45,000
	70	(1,442,425)	(1,131,147)	(819,869)	(508,592)	(197,314)	113,964
Number	80	(1,348,361)	(1,001,345)	(654,329)	(307,313)	39,703	386,719
of	90	(1,207,256)	(806,642)	(406,018)	(5,394)	395,229	795,853
wells	100	(1,115,202)	(676,840)	(240,478)	195,884	632,247	1,068,609
located	110	(972,107)	(482,137)	7,833	497,803	987,773	1,477,742
	120	(878,043)	(352,335)	173,373	699,082	1,224,790	1,750,498
	130	(736,948)	(157,632)	421,684	1,001,000	1,580,316	2,159,632
	140	(642,884)	(27,830)	587,225	1,202,279	1,817,333	2,432,388
	150	(501,789)	166,873	835,535	1,504,197	2,172,859	2,841,521

		NPV 35%	NPV 20%	NPV 0%
Depreciated				
Value,	0%	1,034,833	1,116,863	1,259,400
Satelite	10%	1,034,833	1,116,863	1,259,400
Locators	25%	1,034,833	1,116,863	1,259,400

		NPV 35%	NPV 20%	NPV 0%
Depreciated	0%	1,034,833	1,116,863	1,259,400
Value,	10%	1,034,833	1,116,863	1,259,400
Trucks	25%	1,034,833	1,116,863	1,259,400

FINANCIAL MODEL OF ENGINEERING/SURVEY OPERATIONS

A. MODEL ASSUMPTIONS (for firm having trucks but lacking satellite locators)

A.1 Equipment Costs

3 Satellite Locators			
initial cost:	$27,300	US Dollars CIF	
Life Expectancy:	10	years	
Interest:	20%	per annum	
Term:	1	year	
Monthly Payment	$455	40,950	So.Sh./mn
Depreciated Val:	25%	614,250	So.Sh.
3 Pickup Trucks			
value:	$15,000	US dollars	
Life Expectancy:	2	years	
Mnt, depr. cost p.a.	100%	per year	
Term:	1	year	
Mnt, depr. cost/mn:	$1,250	112,500	So.Sh./mn
Depreciated Val:	0%	0	So.Sh.

Market Exch Rate mid-'86: 90 So.Sh./$

Rental Payment:	491,400	So.Sh.
Purchase Equipment:	614,250	"
	1,105,650	So.Sh.

A.2 Unit Labor Costs - Direct

Quant	Position	So.Sh./dy	days per well days	cost	
1	Engineer/Supervisor	500	2	1,000	So.Sh./wl
1	Survey Crew Leaders	250	8	2,000	"
1	Drivers	130	8	1,040	"
2	Assistants	175	8	2,800	"
				6,840	So.Sh./wl

A.3 Annual Overhead

Quant	Item	So.Sh./mn	months		
1	Clerk/Secretary	5,000	12	60,000	So.Sh./yr
1	Watchman	4,000	12	48,000	"
1	Office/Yard	35,000	12	420,000	"
				528,000	So.Sh./yr

B. CONTRACT PRICE

	Price	Quant.	Total
Locate well:	36,000 So.Sh./wl	130	4,680,000 So.Sh.

C. FINANCIAL ANALYSIS

Somali Shillings

COMPONENT/QUARTER	I	II	III	IV
Number of Wells Located	30	32	34	34
Equip. rent, mnt & depreciation costs	(460,350)	(460,350)	(460,350)	(460,350)
Buy equipment				(614,250)
Labor Costs	(205,200)	(218,880)	(232,560)	(232,560)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)
Payment for Located Wells	1,080,000	1,152,000	1,224,000	1,224,000
Depreciated Value Equipment				614,250
BALANCE	282,450	340,770	399,090	799,090

NPV of balance at 35% nominal opportunity cost of capital	1,169,634
NPV of balance at 20% nominal opportunity cost of capital	1,261,604
NPV of balance at 30% nominal opportunity cost of capital	1,421,400

D. SENSITIVITY ANALYSIS

	NPV at 20%	Contract Price: So.Sh. per well					
	1,261,604	20,000	25,000	30,000	35,000	40,000	45,000
	70	(1,297,884)	(955,406)	(675,129)	(363,851)	(52,573)	259,704
Number	80	(1,203,620)	(856,604)	(509,588)	(162,572)	184,444	531,460
of	90	(1,062,525)	(661,901)	(261,277)	139,346	539,970	940,594
Wells	100	(968,461)	(532,099)	(95,737)	340,625	776,987	1,213,350
Located	110	(827,366)	(337,396)	152,574	642,544	1,132,513	1,622,483
	120	(733,202)	(207,594)	518,114	843,822	1,369,531	1,895,239
	130	(592,207)	(12,891)	566,425	1,145,741	1,725,057	2,304,373
	140	(498,113)	116,911	731,965	1,347,020	1,982,074	2,577,128
	150	(357,048)	311,614	980,276	1,649,938	2,317,600	2,986,262

Depreciated Value. Satellite Locator	NPV, 35%	NPV, 20%	NPV, 0%
25%	1,169,634	1,261,604	1,421,400
0%	1,169,634	1,261,604	1,421,400
10%	1,169,634	1,261,604	1,421,400

ANNEX A-3

FINANCIAL MODEL OF WELL REHABILITATION OPERATIONS: PHASE ONE, STEP TWO

(Basis for calculation of appropriate contract price, equipment rental rate, and equipment purchase price)

A. MODEL ASSUMPTIONS (for firm lacking equipment)

A.1 Equipment Costs

Cable Tool Rig

Initial cost:	$126,000	US Dollars CIF
Life Expectancy:	25	years
Interest:	20%	per annum
Term:	1.5	years
Monthly Payment:	$2,100	189,000 So.Sh./mo
Depreciated Val:	25%	2,835,000 So.Sh.

1 Pickup Truck, 1 Flat Bed Truck

Initial cost:	$98,000	US Dollars CIF
Life Expectancy:	5	years
Interest:	20%	per annum
Term:	1.5	years
Monthly Payment:	$1,633	147,000 So.Sh./mo
Depreciated Val:	10%	882,000 So.Sh.

1 Cement Mixer and Block Machine

Initial cost:	$11,200	US Dollars CIF
Life Expectancy:	10	years
Interest:	20%	per annum
Term:	1.5	years
Monthly Payment:	$187	16,800 So.Sh./mo
Depreciated Val:	10%	100,800 So.Sh.

Market Exch Rate mid-'86: 90 So.Sh./$

Total Equipment Payments:	6,350,400
Purchase Equipment:	3,817,800
	10,168,200 So.Sh.

A.2 Labor Costs

Quant	Position	So.Sh./dy	Production Well days	Production Well cost	Abandoned Well days	Abandoned Well cost
1	Rig Operator	500	15	7,500 So.Sh./wl	5	2,500 So.Sh./wl
1	Construction Leader	450	15	6,750 "	0	0 "
3	Rig Assistants	175	15	7,875 "	0	0 "
2	Construct n Assistants	175	15	5,250 "	5	1,750 "
2	Drivers	130	15	3,900 "	5	1,300 "
				31,275 So.Sh./wl		5,550 So.Sh./wl

A.3 Annual Overhead

Quant	Item	So.Sh./mo	months	
1	Clerk/Secretary	5,000	12	60,000 So.Sh./yr
1	Watchman	4,000	12	48,000 "
1	Office/Yard	35,000	12	420,000 "
				528,000 So.Sh./yr

B. PAYMENT SCHEDULE

	Price	Quant.	Total
TOTAL WELLS:		43	
Proportion Production Wells:		50%	
production well:	420,000 So.Sh./wl	22	9,240,000
abandoned well:	100,000 So.Sh./wl	21	2,100,000
			11,340,000

C. FINANCIAL ANALYSIS

(mid 1986 Somali Shillings)

Equipment Rental	(1,058,400)	(1,058,400)	(1,058,400)	(1,058,400)	(1,058,400)	(1,058,400)
Purchase Equipment						(3,817,800)
Labor Costs	(116,025)	(116,025)	(141,750)	(141,750)	(141,750)	(147,300)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Payment Prod'n Wells	1,260,000	1,260,000	1,680,000	1,680,000	1,680,000	1,680,000
Payment Aband. Wells	400,000	400,000	300,000	300,000	300,000	400,000
Depreciated Value Equipment						3,817,800
BALANCE	353,575	353,575	647,850	647,850	647,850	742,300

NPV of Balance at 35% nominal opportunity cost of capital	2,548,042
NPV of balance at 20% nominal opportunity cost of capital	2,846,023
NPV of balance at 0% nominal opportunity cost of capital	3,393,000

D. SENSITIVITY ANALYSIS (all tables show NPVs at 20%)

D.1 Price per Production Well

	2,846,023	200,000	300,000	400,000	450,000	500,000	600,000
Number	20	(3,958,608)	(3,119,286)	(2,279,963)	(1,860,301)	(1,440,640)	(601,317)
of	30	(2,608,318)	(1,255,918)	96,482	772,582	1,448,882	2,801,282
Wells	50	(1,258,027)	607,450	2,472,927	3,405,666	4,338,404	6,203,882
Total	60	92,264	2,470,818	4,849,372	6,038,649	7,227,926	9,606,481

D.2 Price per Non-Production Well

	2,846,023	50,000	75,000	100,000	125,000	150,000	200,000
Number	20	(2,500,085)	(2,306,093)	(2,112,098)	(1,918,103)	(1,724,108)	(1,336,117)
of	30	(277,567)	44,698	366,962	689,227	1,011,491	1,656,020
Wells	50	1,944,955	2,395,489	2,846,023	3,296,557	3,747,090	4,648,158
Total	60	4,167,477	4,746,280	5,325,083	5,903,886	6,482,689	7,640,296

D.3 Price per Production Well

	2,846,023	200,000	300,000	400,000	450,000	500,000	600,000
	20%	(2,020,203)	(1,180,880)	(341,557)	78,104	497,766	1,337,088
Proportion	30%	(2,504,804)	(1,665,482)	(826,159)	(406,497)	13,164	852,487
Production	40%	(2,123,716)	(771,316)	581,084	1,257,284	1,933,484	3,285,884
Wells	50%	(1,258,027)	607,450	2,472,927	3,405,666	4,338,404	6,203,882
	60%	(1,742,628)	122,849	1,988,326	2,921,064	3,853,803	5,719,280
	70%	(1,361,540)	1,017,014	3,395,568	4,584,845	5,774,122	8,152,677
	80%	(895,851)	2,395,780	5,267,412	6,733,228	8,179,043	11,070,675

D.4 Price per Non-Production Well

	2,846,023	50,000	75,000	100,000	125,000	150,000	200,000
	20%	(1,587,838)	(880,765)	(173,693)	533,380	1,240,452	2,654,597
Proportion	30%	(1,815,900)	(1,237,097)	(658,294)	(79,491)	499,312	2,656,918
Production	40%	(49,504)	401,030	851,564	1,302,097	1,752,631	2,653,699
Wells	50%	1,944,955	2,395,489	2,846,023	3,296,557	3,747,090	4,648,158
	60%	1,716,892	2,039,157	2,361,421	2,683,686	3,005,950	3,650,480
	70%	3,483,289	3,677,284	3,871,279	4,065,274	4,259,270	4,647,260
	80%	5,477,748	5,671,743	5,865,738	6,059,733	6,253,729	6,641,719

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ANNEX A-4

FINANCIAL MODEL OF WELL REHABILITATION OPERATIONS

A. MODEL ASSUMPTIONS (for firm with own equipment)

A.1 Equipment Costs

Cable Tool Rig

Value:	$50,000	US Dollars
Life Expectancy:	10	years
Maint.,dep %:	50%	per year
Term:	1.5	years
Maint,depr cost/mn:	$2,083	187,500 So.Sh./mn

1 Pickup Truck, 1 Flat Bed Truck

Value:	$20,000	US Dollars
Life Expectancy:	2	years
Maint.,dep %:	100%	per year
Term:	1.5	years
Maint cost/mn:	$1,667	150,000 So.Sh./mn

1 Cement Mixer and Block Machine

Value:	$2,500	US Dollars
Life Expectancy:	2	years
Maint.,dep %:	50%	per year
Term:	1.5	years
Maint cost/mn:	$104	9,375 So.Sh./mn

Market Exch Rate mid-'86: 90 So.Sh./$

A.2 Labor Costs

Quant	Position	So.Sh./dy	Production Well days	Production Well cost	Abandoned Well days	Abandoned Well cost
1	Rig Operator	500	15	7,500 So.Sh./wl	5	2,500 So.Sh./wl
1	Construction Leader	450	15	6,750 "	0	0 "
3	Rig Assistants	175	15	7,875 "	0	0 "
2	Construct'n Assistants	175	15	5,250 "	5	1,750 "
2	Drivers	130	15	3,900 "	5	1,300 "
				31,275 So.Sh./wl		5,550 So.Sh./wl

A.3 Annual Overhead

Quant	Item	So.Sh./mn	months	
1	Clerk/Secretary	5,000	12	60,000 So.Sh./yr
1	Watchman	4,000	12	48,000 "
1	Office/Yard	35,000	12	420,000 "
				528,000 So.Sh./yr

B. CONTRACT PRICE

	Price	Quant.	Total
TOTAL WELLS:		43	
Proportion Production Wells:		50%	
production well:	420,000 So.Sh./wl	22	9,240,000 So.Sh.
abandoned well:	100,000 So.Sh./wl	21	2,100,000 "
			11,340,000 So.Sh.

C. FINANCIAL ANALYSIS

(in mid-1986 Somali Shillings)

COMPONENT/QUARTER	III	IV	I	II	III	IV
No. Production Wells	3	3	4	4	4	4

Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Payment Prod'n Wells	1,260,000	1,260,000	1,680,000	1,680,000	1,680,000	1,680,000
Payment Aband. Wells	400,000	400,000	300,000	300,000	300,000	400,000
BALANCE	371,350	371,350	665,625	665,625	665,625	760,075

NPV of balance at 35% nominal opportunity cost of capital	2,630,740
NPV of balance at 20% nominal opportunity cost of capital	2,937,224
NPV of balance at 0% nominal opportunity cost of capital	3,499,650

D. SENSITIVITY ANALYSIS, (all tables show NPV @ 20%)

D.1

Price per Production Well

	2,937,224	200,000	300,000	400,000	450,000	500,000	600,000
Number of Wells Total	20	(3,867,411)	(3,029,087)	(2,188,764)	(1,769,102)	(1,349,441)	(510,117)
	30	(2,517,119)	(1,164,719)	187,682	863,882	1,540,083	2,892,483
	50	(1,166,828)	698,650	2,564,128	3,496,867	4,429,606	6,295,084
	60	183,463	2,582,019	4,940,574	6,129,852	7,319,129	9,697,684

D.2

Price per Non-Production Well

	2,937,224	50,000	75,000	100,000	125,000	150,000	200,000
Number of Wells Total	20	(2,408,890)	(2,214,995)	(2,020,899)	(1,826,904)	(1,632,909)	(1,244,918)
	30	(186,367)	135,897	458,162	780,427	1,102,691	1,747,221
	50	2,036,155	2,486,690	2,937,224	3,387,758	3,838,292	4,739,360
	60	4,258,678	4,837,482	5,416,285	5,995,088	6,573,892	7,731,498

D.3

Price per Production Well

	2,937,224	200,000	300,000	400,000	450,000	500,000	600,000
Proportion Production Wells	20%	(1,929,004)	(1,089,681)	(250,358)	169,304	588,965	1,428,289
	30%	(2,413,604)	(1,574,283)	(734,959)	(315,298)	104,364	943,687
	40%	(2,032,518)	(680,117)	672,284	1,348,484	2,024,684	3,377,085
	50%	(1,166,828)	698,650	2,564,128	3,496,867	4,429,606	6,295,084
	60%	(1,651,430)	214,048	2,079,526	3,012,265	3,945,004	5,810,482
	70%	(1,270,341)	1,108,214	3,486,769	4,676,047	5,865,325	8,243,880
	80%	(404,652)	2,484,981	5,378,614	6,924,430	8,270,246	11,161,879

D.4

Price per Non-Production Well

	2,937,224	50,000	75,000	100,000	125,000	150,000	200,000
Proportion Production Wells	20%	(1,496,639)	(789,566)	(82,493)	624,580	1,331,652	2,745,798
	30%	(1,724,701)	(1,145,898)	(567,095)	11,709	590,512	1,748,119
	40%	41,696	492,230	942,764	1,393,298	1,843,832	2,744,900
	50%	2,036,155	2,486,690	2,937,224	3,387,758	3,838,292	4,739,360
	60%	1,808,093	2,130,357	2,452,622	2,774,887	3,097,151	3,741,681
	70%	3,574,490	3,768,485	3,962,480	4,156,476	4,350,471	4,738,462
	80%	5,568,950	5,762,945	5,956,930	6,150,936	6,344,931	6,732,922

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SCHEDULE A 5

FINANCIAL MODEL FOR PUMP MAINTENANCE FIRMS - PHASE ONE

(Basis for calculation of appropriate contract price, equipment rental rates, and equipment purchase price)

A. MODEL ASSUMPTIONS

A.1 Equipment Costs

Cable tool rig

value:	450,000
life expectancy:	10
int. depr. % p.a.:	10%
Taxes:	0.5
maint & depr contracts:	37,500 Sa.Sh.

Pick-up truck,

	new (project)	old
value:	870,000	45,000
life expectancy:	5	2
interest, maint. & depr.	20%	100%
Taxes:	1.5	0.5
monthly payments:	42,000	37,500 Sa.Sh.
depreciated value:	100	0
	252,000	0 Sa.Sh.

Repair Shop, Trailer

initial costs	870,000	
life expectancy:	10	
% financed:	100%	
Interest %:	20%	
Taxes:	5	
Monthly Payments:	81,187	103,500 Sa.Sh.
depreciated value @ 25%:	817,500	1,375,000 Sa.Sh.

Total rent payments:	3,365,000 Sa.Sh.
Purchase Equipment:	1,027,000 "
	4,392,000 Sa.Sh.

A.2 Pump Maintenance Numbers & Revenues

	USA Contract	Private Contract
Sa.Sh./Pump (Revenue):	53,500	80,250
Sa.Sh./Pump (Rev.Ret.):	0	750,000
Sa.Sh./Pump (Rep.Times):	6,500	21,000
Percent Backup Service	0%	30%
Percent Backup Repair	100%	100%
Increment to contracts	0	0
Market Ex.Rate old 1984:	75	
Percent needing repair/yr	30%	

A.3 Pump Maintenance Costs (Direct)

Labor	Sa.Sh./day	d/pump maintenance	Sa.Sh./pm maintenance	d/pump repair	Sa.Sh./pm repair
1 Crew Leader:	450	1	450	1	450
2 Mechanics:	375	3	1,150	3	1,650
2 Assistants:	175	3	1,050	3	1,050
Total			3,150		3,150

Fuel	km.Sh./l	l/pump	Sa.Sh./pm		
50 l/trip	50	0	0	1	3,500
35 l/0/track	50	3	3,250	3	3,250
Total			3,250		7,750

A.4 Parts for pump repair

	MSH/unit	% parts cost	MSH/repair
1 Pump & Generator	820,000	20%	41,200

Annual Parts Inventory Needed

			MSH/yr
251 Pumps Spares (Inventory)	87,200	20%	8700
251 Gen. Spares (Inventory)	416,000	20%	83,176

A.5 Overhead

	Sa.Sh./pm	m/yr	Sa.Sh./yr
2 Clerk/Sec	5000	12	60,000
1 Watchman	4500	12	60,000
1 Office/yard	35000	12	420,000
Total			540,000

B. Quarterly Variables

Quarter	III	IV	I	II	III	IV
No. USA Pumps	5	11	17	23	30	36
No. Other Pumps	0	0	0	0	0	0
Number needing Repair (USA)	1	3	5	7	9	11
Number needing Repair (Oth)	0	0	0	0	0	0
Crew days/quarter	18	36	54	75	96	117
Crew man-years, trucks line needed	0.2	0.4	0.6	0.8	1.1	1.3

C. FINANCIAL ANALYSIS (1984 Small Shillings)

Component / quarter	III	IV	I	II	III	IV
Repair shop & new truck payments	(441,000)	(441,000)	(441,000)	(441,000)	(441,000)	(441,000)
Purchase Repair Shop, project truck						(1,027,000)
Maint & depr. new rig & old truck	(112,500)	(112,500)	(112,500)	(112,500)	(225,000)	(225,000)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Parts Stock	0	0	0	0	0	0
Other Direct Costs - Maint.	(13,750)	(34,650)	(52,250)	(72,450)	(94,500)	(113,400)
Other Direct Costs - Repair	(3,150)	(3,150)	(3,150)	(6,300)	(6,300)	(9,450)
Pump parts payments	0	0	0	0	0	0
Payments - Rent. Maint. Service	267,500	500,500	907,500	1,230,500	1,605,000	1,926,500
Payments - Repairs	6,500	6,500	6,500	13,000	13,000	19,500
Resid. value shop, project truck						1,027,000
BALANCE	(450,600)	(170,500)	173,600	570,250	710,000	1,924,950

Total Payments, Phase One

Maintenance:	6,527,000 Sa.Sh.
Repairs:	63,000 "
	6,590,000 Sa.Sh.

NPV of Balance at 25% nominal opportunity cost of capital	1,130,041 Sa.Sh.
NPV of Balance at 20% nominal opportunity cost of capital	1,373,070 "
NPV of Balance at 0% nominal opportunity cost of capital	1,836,200 "

D. SENSITIVITY ANALYSIS, PHASE ONE (All tables show NPV @ 20%)

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000
Number of USA Wells	2	(1,940,777)	(1,305,933)	(661,209)	(17,543)
	4	(1,325,754)	(452,070)	421,709	1,295,488
	6	(632,353)	495,619	1,673,991	2,751,362
	8	115,043	1,343,110	2,701,671	4,079,620

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000
Number of Other Wells	0	(970,929)	21,922	1,022,372	2,023,623
	1	(1,043,693)	77,119	1,109,931	2,107,743
	2	(1,112,457)	132,317	1,197,490	2,191,864
	3	(1,179,221)	187,516	1,284,249	2,315,985

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000

Probl. salvage, project level							1,027,000
BALANCE		(630,600)	(170,060)	173,600	670,850	710,000	1,026,950

NPV of Balance at 15% nominal opportunity cost of capital	1,130,064	Ba.Ch.
NPV of Balance at 20% nominal opportunity cost of capital	1,373,070	"
NPV of Balance at 0% nominal opportunity cost of capital	1,036,300	"

B. SENSITIVITY ANALYSIS, PHASE ONE Cell Tables when NPV @ 20%

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000
Number	2	(1,948,777)	(1,305,033)	(661,289)	(17,545)
of	4	(1,325,750)	(632,223)	121,709	1,295,438
4GA	6	(632,133)	995,619	1,623,391	2,251,162
Cells	8	(14,043)	1,345,114	2,701,071	4,059,028

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000
Number	0	(970,929)	21,922	1,072,772	2,027,623
of	1	(1,045,693)	32,119	1,109,931	2,187,743
Other	2	(1,112,437)	42,317	1,147,090	2,251,864
Cells	3	(1,179,221)	52,514	1,204,249	2,315,985

Maintenance Service Price

	1,373,070	30,000	40,000	50,000	60,000
	0%	(1,073,016)	(4,166)	996,625	1,997,535
Capair	25%	(999,991)	2,326	1,043,267	2,084,207
Cost	50%	(991,972)	8,878	1,089,779	3,018,579
Backup	75%	(985,151)	19,600	1,016,250	2,017,101
	100%	(970,929)	21,922	1,072,772	2,023,633

C. COST TO PROJECT FOR SERVICES

PARAMETER	III	IV	I	II	III	IV
Routine Maintenance Service	807,500	1,763,500	2,720,500	3,677,500	4,635,000	5,779,060
Pump Repairs	10,900	18,903	15,900	17,000	37,300	56,796
TOTAL	821,400	1,784,406	2,747,400	3,729,300	4,672,000	5,834,700
TOTAL ANNUAL COST PER PUMP	54,760	54,073	53,871	54,040	53,920	54,025
(IN 1981 DOLLARS)	6600	6601	6399	6601	6399	6600

Average Cost per year per cell, including cost of pump repairs 1/ 63,660

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Maintenance Costs	63,660	63,660	63,660	63,660	63,660	63,660	63,660	63,660	63,660	621,000
Replacement Costs	00	00	621,000	00	00	621,000	00	00	621,000	00

NPV Maint @ 15%:	410,022
NPV Replace @ 15%:	313,416
NPV Maint @ 20%:	318,179
NPV Replace @ 20%:	223,754
NPV Maint @ 0%:	954,015
NPV Replace @ 0%:	863,000

1/ Use Scenario II for lower long term costs estimates for maintenance.

ANNEX A-6

FINANCIAL MODEL FOR PUMP MAINTENANCE FIRMS - PHASE ONE

A. MODEL ASSUMPTIONS

A.1 Equipment Costs

Cable tool rig

value:	$50,000
life expectancy:	10
amt, depr % p.a.:	10%
Term:	1.5
maint & depr cost/month:	37,500 So.Sh.

Pick-up Truck.

	new (project)	old	
value:	$28,000	5000	
life expectancy:	5	2	
interest: maint. & depr.	20%	100%	
Term:	1.5	0.5	
monthly payment:	42,000	37,500	So.Sh.
depreciated value:	10%	0%	
	252,000	0	So.Sh.

Repair Shop, Tripod

initial cost:	$70,000		
life expectancy:	10		
% financed:	100%		
Interest I:	20%		
Term n:	5		
Monthly Payment:	$1,167	105,000	So.Sh.
resid. value 1991 @ 25%:	$17,500	1,575,000	"

A.2 Pump Maintenance Numbers & Receivables

	WDA Contract	Private Contract
So.Sh./Pump (Service):	53,500	80,250
So.Sh./Pump (Rep.Mat.):	0	756,000
So.Sh./Pump (Rep.Time):	6,300	21,800
Percent Markup Service	0%	50%
Percent Markup Repair	100%	100%
Increment to contracts	0	1
Market Ex. Rate mid 1986:	90	
Percent needing repair/yr	30%	

A.3 Pump Maintenance Costs (Direct)

Labor	So.Sh./dy	dy/pump maintenance	So.Sh./pm maintenance	dy/pump repair	So.Sh./pm repair
1 Inspector:	450	1	450	1	450
2 Mechanics:	275	3	1,650	3	1,650
2 Assistants:	175	3	1,050	3	1,050
Total			3,150		3,150

Fuel	So.Sh./l	dy/pump	So.Sh./pm		
50 l/d/rig	50	0	0	1	2,500
35 l/d/truck	50	3	5,250	3	5,250
Total			5,250		7,750

A.4 Parts for pump repair

	US$/unit	% parts cost	US$/repair
1 Pump & Generator	$21,000	20%	$4,200

Annual Parts Inventory Needed			US$/unit/yr
35% Pumps Spares (inventory)	$4,200	20%	$294
35% Gen. Spares (inventory)	$16,500	20%	$1,176

A.5 Overhead

	So.Sh./mo	mo./yr	So.Sh./yr
1 Clerk/Sec	5000	12	60,000
1 Watchman	4000	12	48,000
1 Office/yard	35000	12	420,000
Total			528,000

B. Yearly Variables

Year:	III	IV	I	II	III	IV
No. WDA Pumps	5	11	17	23	30	36
No. Other Pumps	3	4	5	6	7	8
Number Needing Repair (WDA)	1	1	1	2	2	3
Number Needing Repair (Oth)	0	1	0	1	0	1
Crew days/quarter	27	51	69	96	117	144
[illegible]	0.3	0.6	0.8	1.1	1.3	1.6

Repair shop & new truck payments	(441,000)	(441,000)	(441,000)	(441,000)	(441,000)	(441,000)	
Purchase Repair Shop, project truck						(1,827,000)	
Maint & depr. cost rip & old truck	(112,500)	(112,500)	(112,500)	(225,000)	(225,000)	(225,000)	
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	
Parts Stock	(99,225)	(132,300)	(165,375)	(198,450)	(231,525)	(264,600)	
Other Direct Costs - Maint.	(40,950)	(68,250)	(95,550)	(122,850)	(150,300)	(160,8[illegible])	
Other Direct Costs - Repair	(3,150)	7,750	(2,150)	4,600	(6,300)	1,45[illegible]	
Pump parts payments	0	756,000	0	756,000	0	756,000	Total Payments
Payments - Scut. Maint. Service	508,250	909,500	1,310,750	1,712,000	2,166,750	2,568,000	9,175,250
Payments - Repairs	6,300	28,100	6,300	34,400	12,600	40,700	128,400
Resid. value shop, project truck						1,827,000	9,303,65[illegible]
BALANCE	(314,275)	815,300	367,475	1,387,700	990,225	2,122,95[illegible]	

NPV of balance at 35% nominal opportunity cost of capital	3,765,400
NPV of balance at 20% nominal opportunity cost of capital	4,324,324
NPV of balance at 0% nominal opportunity cost of capital	5,369,375

D. SENSITIVITY ANALYSIS. PHASE ONE (all tables show NPV @ 20%)

D.1 Maintenance Service Price. WDA

	4,324,324	30,000	40,000	50,000	60,000
Number of WDA Wells	2	31,761	1,088,576	2,145,390	3,202,205
	4	654,789	1,941,588	3,228,388	4,515,188
	6	1,348,186	2,889,228	4,430,270	5,971,312
	8	1,965,695	3,736,723	5,507,750	7,278,777

D.2 Maintenance Service Price. Other

	4,324,324	40,000	50,000	60,000	70,000	80,000	90,00[illegible]
Number of Other Wells	0	1,861,390	1,982,847	2,104,304	2,225,761	2,347,218	2,468,67[illegible]
	1	2,511,072	2,683,827	2,856,602	3,029,287	3,202,132	3,374,86[illegible]
	2	2,503,504	2,727,577	2,951,650	3,175,722	3,399,795	3,623,8[illegible]
	3	3,215,918	3,491,298	3,766,679	4,042,059	4,317,439	4,592,8[illegible]
	4	3,298,350	3,525,026	3,861,726	4,188,414	4,515,102	4,841,7[illegible]
	5	3,200,782	3,578,778	3,956,774	4,334,770	4,712,765	5,090,76[illegible]
	6	3,821,180	4,250,483	4,679,787	5,109,090	5,538,394	5,967,69[illegible]

D.3 Maintenance Service Price. Other

	4,324,324	40,000	50,000	60,000	70,000	80,000	90,00[illegible]
Increment to Other Wells	0	1,256,616	1,410,539	1,564,463	1,718,386	1,872,309	2,026,23[illegible]
	1	3,215,918	3,491,298	3,766,679	4,042,059	4,317,439	4,592,81[illegible]
	2	3,825,968	4,222,806	4,619,643	5,016,480	5,413,318	5,810,15[illegible]
	3	4,408,038	4,926,333	5,444,627	5,962,922	6,481,216	6,999,51[illegible]
	[illegible]	[illegible]	5,717,774	6,357,528	6,997,279	7,637,031	8,276,782

ANNEX A-7

FINANCIAL MODEL FOR WELL OPERATIONS AND REVENUE COLLECTION

Increment to hours/day	0 hours/day	Water output/hour:	10 (m^3/hr)
Increment to days/year	0	Price of fuel:	30 So.Sh./l
Water Price increase % per annum:	0%	Price incr. fuel:	0% per year
Fuel consumption/hour:	1.5 liters/hr	Prevailing wages	200 So.Sh./day
Cost of Pump	$0 US$, CIF	Interest rate/yr	0%per annum
Expected life of pump	10 years	Market Exch. rate	90 So.Sh./US$

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Hours/day	10	10	10	10	10	10	10	10	10	10
Output (m^3/day)	100	100	100	100	100	100	100	100	100	100
Days/year	200	200	200	200	200	200	200	200	200	200
Output (m^3/yr)	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Fuel l/yr	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Cost of fuel/yr	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Cost of ent/yr	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)	(101,070)
Depr. Pump/yr	0	0	0	0	0	0	0	0	0	0
Price (1986 So.Sh.)	20	20	20	20	20	20	20	20	20	20
Revenue	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Balance at well	208,930	208,930	208,930	208,930	208,930	208,930	208,930	208,930	208,930	208,930
Min. Wages	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000
Max. return to WDA	135,930	135,930	135,930	135,930	135,930	135,930	135,930	135,930	135,930	135,930
As % of Rev.	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%
Ave. Ret. to WDA	135930									

NPV, 20%	569,883
NPV, 10%	835,231
NPV, 0%	1,359,300

SENSITIVITY ANALYSIS

Table 1: Average Annual Return to WDA per Well, 1987 - 1996

Price of Fuel (So.Sh./liter)

135,930	15	20	25	30	35	40	45	50	60	70	80	90
Price of Water (So.Sh./M^3) 15	80930	65930	50930	35930	20930	5930	-9070	-24070	-54070	-84070	-114070	-144070
18	140930	125930	110930	95930	80930	65930	50930	35930	5930	-24070	-54070	-84070
20	180930	165930	150930	135930	120930	105930	90930	75930	45930	15930	-14070	-44070
25	280930	265930	250930	235930	220930	205930	190930	175930	145930	115930	85930	55930
30	380930	365930	350930	335930	320930	305930	290930	275930	245930	215930	185930	155930
35	480930	465930	450930	435930	420930	405930	390930	375930	345930	315930	285930	255930
40	580930	565930	550930	535930	520930	505930	490930	475930	445930	415930	385930	355930
50	780930	765930	750930	735930	720930	705930	690930	675930	645930	615930	585930	555930
60	980930	965930	950930	935930	920930	905930	890930	875930	845930	815930	785930	755930

Table 2: NPV of Return to WDA, 1987 - 1996, @ 20%

Price of Fuel (So.Sh./liter)

569,883	15	20	25	30	35	40	45	50	60	70	80	90
Price of Water (So.Sh./M^3) 13	171598	108711	45824	-17063	-79950	-142838	-205725	-268612	-394386	-520160	-645934	-771708
15	339297	276410	213523	150636	87748	24861	-38026	-100913	-226687	-352461	-478235	-604009
20	758544	695657	632770	569883	506996	444109	381221	318334	192560	66786	-58988	-184762
25	1177791	1114904	1052017	989130	926243	863356	800469	737582	611807	486033	360259	234485
30	1597038	1534151	1471264	1408377	1345490	1282603	1219716	1156829	1031055	905280	779506	653732
35	2016286	1953399	1890511	1827624	1764737	1701850	1638963	1576076	1450302	1324528	1198754	1072979
40	2435533	2372646	2309759	2246872	2183984	2121097	2058210	1995323	1869549	1743775	1618001	1492227
50	3274027	3211140	3148253	3085366	3022479	2959592	2896705	2833818	2708043	2582269	2456495	2330721
60	4112522	4049635	3986747	3923860	3860973	3798086	3735199	3672312	3546538	3420764	3294990	3169215

Table 3: NPV of Return to WDA, 1987 - 1986, @ 20%

Yearly Increase in Price of fuel

569,883	0%	5%	10%	15%	20%	25%
Yearly Increase in price of water 0%	569883	505051	424219	323290	197205	39757
5%	827624	762792	681960	581031	454947	297499
10%	1203005	1138173	1057341	956412	830328	672879
15%	1651011	1586179	1505347	1404418	1278334	1120886
20%	2241106	2176274	2095442	1994513	1868428	1710980
25%	2919449	2854617	2773785	2672855	2546771	2389323

Table 4: NPV of Return to WDA, 1987 - 1986, @ 20%

Increment to Hours per day

Table 5: NPV of Return to WDA, 1987 - 1986, @ 20%

Increment to Days per Year

Price of Water (So.Sh./M^3)													
13	171592	108711	45824	-17063	-79950	-142838	-205725	-268612	-394386	-520160	-645934	-771708
15	339297	276410	213523	150636	87748	24861	-38026	-100913	-226687	-352461	-478235	-604009
20	758544	695657	632770	569883	506996	444109	381221	318334	192560	66786	-58908	-184762
25	1177791	1114904	1052017	989130	926243	863356	800469	737582	611807	486033	360259	234485
30	1597038	1534151	1471264	1408377	1345490	1282603	1219716	1156829	1031055	905280	779506	653732
35	2016286	1953399	1890511	1827624	1764737	1701850	1638963	1576076	1450302	1324528	1198754	1072979
40	2435533	2372646	2309759	2246872	2183984	2121097	2058210	1995323	1869549	1743775	1618001	1492227
50	3274027	3211140	3148253	3085366	3022479	2959592	2896705	2833818	2708043	2582269	2456495	2330721
60	4112522	4049635	3986747	3923860	3860973	3798086	3735199	3672312	3546538	3420764	3294990	3169215

Table 3: NPV of Return to MDA, 1987 - 1986, @ 20%

Yearly Increase in Price of fuel

Yearly Increase in price of water (569,883)	0%	5%	10%	15%	20%	25%
0%	569883	505051	424219	323290	197205	39757
5%	827624	762792	681960	581031	454947	297499
10%	1203005	1138173	1057341	956412	830328	672879
15%	1651011	1586179	1505347	1404418	1278334	1120886
20%	2241106	2176274	2095442	1994513	1868428	1710980
25%	2919449	2854617	2773785	2672855	2546771	2389323

Table 4: NPV of Return to MDA, 1987 - 1986, @ 20%

Increment to Hours per day

Price of Water (So.Sh./M^3) (569,883)	0.1	0.25	0.5	1
15	177698	218293	285950	421264
20	609833	669758	769632	969382
25	1041967	1121223	1253315	1517500
30	1474101	1572687	1736998	2065618
35	1906236	2024152	2220680	2613736
40	2338370	2475617	2704363	3161854
50	3202638	3378547	3671728	4238090

Table 5: NPV of Return to MDA, 1987 - 1986, @ 20%

Increment to Days per Year

Price of Water (So.Sh./M^3) (569,883)	5	10	15
15	218293	285950	353607
20	669758	769632	869507
25	1121223	1253315	1385408
30	1572687	1736998	1901308
35	2024152	2220680	2417208
40	2475617	2704363	2933109
50	3378547	3671728	3964909

Table 6: Percentage Return to MDA

Shillings per day for Operator

Price of Water (So.Sh./M^3) (34%)	50	100	150	200	250	300	350	400
15	30%	24%	18%	12%	6%	0%	-6%	-12%
20	48%	43%	37%	34%	29%	25%	22%	16%
25	58%	54%	51%	47%	44%	40%	36%	33%
30	65%	62%	59%	56%	53%	50%	47%	44%
35	70%	67%	65%	62%	60%	57%	54%	52%
40	74%	72%	69%	67%	65%	62%	60%	58%
50	79%	77%	75%	74%	72%	70%	68%	66%

Table 7: NPV of Return to MDA, 1987 - 1986, @ 20%

Total Cost of Pump (1/ Cost Depreciated over Ten Years)

Price of Water (So.Sh./M^3) (569,883)	7500	10000	12500	15000	17500	20000	22500
15	-132356	-226687	-321018	-415348	-509679	-604009	-698340
20	284891	192560	98230	3899	-90432	-184762	-279093
25	706138	611807	517477	423146	328816	234485	140154
30	1125385	1031055	936724	842393	748063	653732	559402
35	1544632	1450302	1355971	1261641	1167310	1072979	978649
40	1963880	1869549	1775218	1680888	1586557	1492227	1397896
50	2802374	2708043	2613713	2519382	2425052	2330721	2236390

MODEL 6-0

FINANCIAL MODEL 24 WELL DRILLING OPERATIONS (for firm drilling only USA wells)

A. MODEL ASSUMPTIONS

A.1 Capital Costs

Quantity	Item	Cost (US)	Cost (CA)
	1 Cable Tool Rig	8112,000	9,520,000
	1 Aux. Equip & Spares	614,000	1,190,000
	Sub-Total	8126,000	10,710,300
	1 Flat Bed Truck	870,000	5,950,000
	1 Pickup Truck	870,000	2,300,000
	Office Equip		750,000
	Pre-Operating Expenses		250,000
	Initial Working Capital		200,000
	Subtotal	8[illegible]	9,130,000
	Office and yard		2,300,000
	Contingency 10%		2,274,000
	GRAND TOTAL		24,444,000

1 Financed	70.0%
1 Principal	17124000
1 Interest	14%
Term	5
Annual payment	3,230,973 Co.Dr./yr

1 com prod.	1 working, other	Quantity	Item	Cost	Days/ prod well	Days/ n.p. well	L.Cost/ prod well	L.Cost/ n.p.well
75%	50%							
Increased business, other: 0 wells/year			**LABOR**					
			1 Chief Log/Rec.	600 Dollr/day	14	12 days	12,000	7,200
Price/o, prod USA: 30,000 Co.Dr.	Other: 20,000		1 Asst. Manager	450 "	15	10 "	6,750	4,500
			2 Technicians	800 "	15	10 "	12,000	8,000
Price, non-prod USA: 10,000 Co.Dr.	Other: 15,500		2 Semi-skilled labor	250 "	15	10 "	7,500	5,000
			3 Unskilled labor	150 "	15	10 "	4,500	3,000
Meters/well: 150 meters			Subtotal				42,750	27,700

Markup for materials: 25%

	MATERIALS	Unit cost	Production	non-production	Material Cost Prod. Well	Non-Prod
	casing	30.00 US$/m'3	0.5	0.5 m'3	375	375
	collar	160.00 US$/o	5	5 meters	4000	4000
	casing	53.00 US$/o	75	20 meters	4,375	11,664
	screen	115.00 US$/o	25	0 meters	17,875	00
	gravel	30.00 US$/m'3	5	0 m'3	5170	00
	pump	821,000 US$/unit	1	0 unit	821,000	00
	Subtotal				831,115	12,405

	FUEL				
34	Drill rig 11/dr	30 Dollr'3	13	15 days	37,300	23,000
45	Flat Bed Truck	30 Dollr/l	15	10 days	33,750	27,300
25	Pickup Truck	30 Dollr/l	16	13 days	12,500	22,750
	Subtotal				123,750	70,250

A.3 Overhead

		Annual	
10% Spares for rig/yr	8112,000 Orig.val.	311,200	1,073,200 Co.Dr.
10% Spares for F.B.T./yr	870,000 Orig.val.	37,000	172,000 "
10% Spares for P.U.T./yr	870,000 Orig.val.	62,300	263,000 "
Administration			75,000 "
Insurance			87,500 "
Subtotal			3,170,500 Co.Dr.

B. MODEL VARIABLES

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Market Exchange Rate	65	65									
No. Productive Wells USA		3	4	4	4	4	4	4	4	4	4
No. Non-Prod. Wells USA		1	1	1	1	1	2	1	2	1	2
No. Production Wells, Other		0	0	0	0	0	0	0	0	0	0
No. Non-Prod. Wells, Other		0	0	0	0	0	0	0	0	0	0

C. CASH FLOW ANALYSIS (in thousands of Canada Dollars)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Principal	24,444	17,173	12,900	10,275	6,850	3,425	0				
Interest	0	2,740	2,172	1,644	1,096	500	0				
Payment	(7,339)	(6,165)	(5,117)	(3,929)	(3,321)	(3,973)	0				
Labor Cost	0	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)
Materials	0	0	0	0	0	0	0	0	0	0	0
Fuel	0	0	0	0	0	0	0	0	0	0	0
Overhead	0	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)
Total Costs	(7,339)	(8,386)	(7,338)	(7,274)	(6,743)	(6,195)	(2,221)	(2,221)	(2,221)	(2,221)	(2,221)
Revenues for services	0	9,000	9,000	9,000	9,000	9,000	10,000	11,000	11,000	12,000	14,000
Payment for supplies	0	0	0	0	0	0	0	0	0	0	0
BALANCE	(7,339)	614	1,662	1,710	2,250	2,804	11,779	10,779	11,779	10,779	11,779

NPV 1986 - 1991, 25%	(3,146)	NPV 1986 - 1996, 25%	1,320
NPV 1986 - 1991, 30%	(2,346)	NPV 1986 - 1996, 30%	10,266
NPV 1986 - 1991, 0%	1,210	NPV 1986 - 1996, 0%	60,002
IRR 1986 - 1991:	4.3216711	IRR 1986 - 1996:	40.91501

D. SENSITIVITY ANALYSIS

Price per meter (gross)	Five Year Payback Period NPV 25%	NPV 30%	NPV 0%	Ten Year Payback Period NPV 25%	NPV 30%	NPV 0%
30,000	(3,146)	(2,346)	1,210	1,320	10,266	60,002
15,000	(6,046)	(7,953)	(10,040)	(3,799)	807	37,307
20,000	(3,146)	(2,346)	1,210	1,320	10,266	60,002
30,000	4,254	8,069	23,710	11,002	29,029	131,002
20,000	7,954	14,474	34,960	18,479	38,407	163,302

Price per meter (compared)	NPV.25%	NPV 30%	NPV 0%	NPV 25%	NPV 30%	NPV 0%
30,000	(3,146)	(2,346)	1,310	1,320	10,266	60,002
0	(6,790)	(8,020)	(3,799)	(973)	4,951	54,002
5,000	(5,040)	(3,597)	(1,799)	193	6,150	61,002
10,000	(3,146)	(2,346)	1,310	1,370	10,266	60,002
15,000	(2,323)	(1,151)	3,710	2,640	12,373	75,002

Five Year Payback Period, NPVs at 30%

Price per meter production well

		10,000	15,000	20,000	25,000	30,000	35,000
Number	3	(6,949)	(10,937)	(5,126)	(211)	4,792	10,520
of	3	(10,255)	(8,995)	(3,323)	[illegible]	[illegible]	[illegible]

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BALANCE											
	17,299	610	1,162	1,210	2,250	3,006	11,779	10,779	11,779	10,779	11,7[illegible]

NPV 10% - 1991, 33%	13,146	NPV 10% - 1990, 33%	1,320
NPV 10% - 1991, 20%	12,346	NPV 10% - 1990, 20%	10,266
NPV 10% - 1991, 0%	1,210	NPV 10% - 1990, 0%	60,002
IRR 10% - 1991	0.3210711	IRR 10% - 1990	60.01501

D. [illegible]

Five Year Payback Period

Price per meter 'proil	NPV 30%	NPV 20%	NPV 0%
35,000	13,146	12,346	1,210
15,000	10,046	17,931	10,[illegible]
20,000	12,146	12,346	1,210
30,000	6,754	8,869	23,710
30,000	7,954	10,076	34,960

Ten Year Payback Period

	NPV 33%	NPV 20%	NPV 0%
	1,320	10,266	60,002
	13,709	127	31,[illegible]02
	1,320	10,266	60,002
	11,002	29,624	131,002
	15,439	38,407	163,202

Price per meter (compared)	NPV 33%	NPV 20%	NPV 0%
10,000	12,146	12,346	1,210
0	10,906	16,8303	12,796
5,000	12,5693	12,7923	11,2909
10,000	15,146	12,346	1,210
15,000	12,3231	11,1001	3,710

	NPV 33%	NPV 20%	NPV 0%
	1,320	16,266	60,002
	19371	6,053	54,002
	193	8,129	61,002
	1,326	10,266	60,002
	2,460	12,373	75,002

Five Year Payback Period, NPVs at 20%

Price per meter production well

	12,346	10,000	15,000	20,000	25,000	30,000	40,000
Number of dry holes	2	(16,9993	(10,6371	(3,1291	(2114	4,792	14,329
	3	14,2253	(8,9953	(2,7253	1,329	6,786	17,204
	4	13,3611	17,9931	12,3443	3,753	8,869	20,004
	5	12,5663	16,9123	19371	5,990	10,952	22,363
	6	11,8243	15,3493	1,126	7,602	10,677	23,020

Price per meter, non-production wells

	12,346	5,000	10,000	15,000	20,000
Proportion of non-production wells	73%	(1,1001	2,639	6,372	10,115
	50%	12,3461	146	3,639	5,131
	25%	(3,3921	(2,3461	(1,1001	146
	0%	(6,0301	(4,0301	(6,0301	(6,0301

Price per meter production well

	12,346	10,000	15,000	20,000	25,000	30,000	40,000
Price per meter, non-production wells	0	(16,0071	(9,8229	(6,0301	146	5,131	13,099
	5,000	(13,3611	(8,3761	(3,3921	1,372	6,377	16,146
	10,000	(12,3131	(7,3301	(2,3461	2,639	7,633	17,392
	15,000	(11,2501	(6,0041	(1,1001	3,885	8,869	13,638
	20,000	(9,8229	(6,0301	146	5,131	10,115	20,004

Markup for Price per meter, other wells

	12,346	10%	25%	50%	75%	100%
Number of Other Wells	0	12,3461	12,3461	12,3461	12,3461	12,3461
	1	5,488	6,233	7,679	8,725	9,971
	2	12,109	13,644	16,136	18,630	21,121
	3	20,612	22,835	26,994	30,333	34,070
	4	27,276	30,266	33,252	40,215	49,219

MODEL 0-1

FINANCIAL MODEL OF WELL DRILLING OPERATIONS (for firm drilling 400 and other wells)

A. MODEL ASSUMPTIONS

A.1 Capital Costs

Quantity	Item	Cost (U)	Cost total
	1 Cable Tool Rig	812,000	9,324,000
	1 Aux. Equip & Spares	312,143	1,194,000
	Sub-Total	8126,000	10,718,000
	1 Flat Bed Truck	475,000	2,950,000
	1 Pickup Truck	420,000	2,100,000
	Office Equip		750,000
	Pre-Operating Expenses		750,000
	Initial Working Capitals		700,000
	Subtotal	890,000	9,030,000
	Office and yard		2,500,000
	Contingency 10%		2,274,000
	GRAND TOTAL		24,444,000

% financed	70 %
1 Principal	17,124,000
1 Interest	16%
Term	5
Annual Payment	5,734,375 Da.m./yr

251	1 non-prod	1 working, other
	251	501

Increment Incomes, other	
0.5 million/year	
Prices, prod 400	Other
20,000 Da.Dh.	30,000
Prs, non prod 400	Other
10,000 Da.Dh.	15,000
Meter/well	
100 meters	

A.2 Direct Costs

Quantity	Item	Cost	days/ prod well	days/ n.p. well	L.Cost/ prod well	L.Cost/ n.p. well
	LABOR					
	1 Chief Driller	600 Dzdh/day	30	12 days	12,150	7,250
	1 Asst. Driller	450 "	15	10 "	6,750	4,500
	2 Technicians	400 "	15	10 "	12,000	8,000
	2 Semi-skilled labor	250 "	15	10 "	7,500	5,000
	7 Unskilled labor	150 "	15	10 "	4,500	3,000
	Subtotal				42,750	27,750

Quantity	Materials	Unit cost	Production	non-production	Material Cost Prod. well	Non-Prod
	casing	50.00 Dzdh/m³	0.5	0.5 m³	425	425
	collar	160.00 Dzdh/m	5	5 meters	800	800
	casing	83.00 Dzdh/m	75	25 meters	6,225	2,075
	screen	115.00 Dzdh/m	25	0 meters	2,875	00
	gravel	30.00 Dzdh/m³	5	0 m³	150	00
	pump	121,000 Dzdh/unit	1	0 unit	121,000	00
	Subtotal				131,115	2,400
	FUEL					
30	drilling (l/d)	30 Dzdh/l	15	12 days	27,000	25,000
45	Flat Bed Truck	25 Dzdh/l	15	10 days	22,750	22,500
25	Pickup Truck	30 Dzdh/l	20	15 days	22,500	22,750
	Subtotal				122,750	70,750

A.3 Overhead

		Annual	
101	Wages for rig/yr	111,000 Orig.cal.	111,200 1,075,200 Da.Dh.
101	Wages for S.D.T./yr	470,000 Orig.cal.	17,000 472,000 "
101	Wages for P.U.T./yr	420,000 Orig.cal.	12,000 360,000 "
	Administration		75,000 "
	Insurance		87,500 "
	Subtotal		2,170,500 Da.Dh.

B. MONTHLY VARIABLES

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Partial Exchange Rate	85	96									
No. Production Wells 400		4	4	4	4	4	4	4	4	4	4
No. Non-Prod. Wells 400		1	1	1	1	1	2	1	2	1	2
No. Production Wells, Other		1	1	2	2	2	2	4	4	5	5
No. Non-Prod. Wells, Other		0	1	0	1	1	1	1	1	1	2

C. CASH FLOW ANALYSIS (in thousands of Dzmahi Dhillings)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Principal	24,444	17,122	11,700	10,273	6,850	3,425	0				
Interest	0	2,740	2,192	1,644	1,096	548	0				
Payment	(7,339)	46,163)	(5,617)	(5,069)	(4,521)	(3,973)	0				
Labor Cost	0	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)	(43)
Materials	0	(2,987)	(3,276)	(5,974)	(6,213)	(9,290)	(9,300)	(12,187)	(12,187)	(15,170)	(15,112)
Fuel	0	(1341)	(1341)	(2682)	(2010)	(4023)	(4025)	(5365)	(5365)	(6009)	(7509)
Overhead	0	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)	(2,179)
Total Costs	(7,339)	(11,197)	(11,250)	(13,513)	(13,273)	(19,025)	(15,547)	(19,773)	(19,773)	(19,8254)	(18,393)
Overhead for services	0	13,000	13,500	15,600	16,000	19,000	24,500	26,000	27,000	29,000	32,000
Payment for supplies	0	5,154	5,304	7,169	7,169	10,753	10,753	14,338	14,338	17,922	17,922
BALANCE	7,339)	6,087	5,827	8,637	10,896	14,610	23,301	25,063	26,065	29,328	34,329

NPV 1986 - 1991, 25%	6,081	NPV 1986 - 1996, 25%	17,000
NPV 1986 - 1991, 30%	13,276	NPV 1986 - 1996, 30%	42,400
NPV 1986 - 1991, 0%	36,046	NPV 1986 - 1996, 0%	205,046
IRR 1986 - 1991:	79.6066606	IRR 1986 - 1996:	91.5[illegible]27

D. SENSITIVITY ANALYSIS

Price per meter (grout)	Five Year Payback Period NPV 25%	NPV 30%	NPV 0%	Ten Year Payback Period NPV 25%	NPV 30%	NPV 0%
30,000	6,081	13,276	36,046	17,040	42,400	205,046
25,000	609	8,191	16,921	8,441	26,791	142,396
20,000	6,081	13,276	36,046	17,040	42,400	205,046
15,000	12,225	21,547	59,796	34,112	67,401	330,346
10,000	24,090	40,607	93,421	62,799	99,370	392,396

Price per meter (temporary)	NPV 25%	NPV 30%	NPV 0%	NPV 25%	NPV 30%	NPV 0%
10,000	6,081	13,276	36,046	17,040	42,400	205,046
0	3,645	8,011	20,546	12,903	25,679	176,546
5,000	9,363	11,643	31,296	14,936	29,630	191,346
10,000	6,081	13,276	36,046	17,040	42,400	205,046
15,000	7,099	15,509	40,796	19,009	47,717	220,346

Five Year Payback Period, NPV at 30%

Price per meter production well

	12,276	16,000	15,000	20,000	25,000	30,000	40,000
Number	2	16,921)	3,057	10,990	10,939	27,200	44,362

NPV 1986 - 1991, 25%	6,481	NPV 1986 - 1996, 25%	17,000
NPV 1986 - 1991, 20%	13,276	NPV 1986 - 1996, 20%	43,680
NPV 1986 - 1991, 0%	36,946	NPV 1986 - 1996, 0%	205,946
IRR 1986 - 1991:	29.6006681	IRR 1986 - 1996:	91.5[illegible]23

B. SENSITIVITY ANALYSIS

Five Year Payback Period

Price per meter (grad)	NPV 25%	NPV 20%	NPV 0%
30,000	6,481	13,276	36,946
15,000	609	6,191	16,921
20,000	6,481	13,276	36,946
30,000	18,225	31,547	76,296
35,000	24,090	40,182	93,121

Ten Year Payback Period

	NPV 25%	NPV 20%	NPV 0%
	17,000	43,680	205,946
	6,481	26,791	143,196
	17,000	43,680	205,946
	34,182	77,481	330,146
	42,709	94,378	397,396

Price per meter (unsorted)	NPV 25%	NPV 20%	NPV 0%
10,000	6,481	13,276	36,946
0	3,643	8,811	25,546
5,000	5,063	11,143	31,296
10,000	6,481	13,276	36,946
15,000	7,899	15,549	42,796

	NPV 25%	NPV 20%	NPV 0%
	17,000	43,680	205,946
	12,905	35,620	176,896
	14,956	39,650	191,346
	17,002	43,680	205,946
	19,051	47,710	220,546

Five Year Payback Period, NPV at 25%

Price per meter production well

Number of Dry Wells	13,276	10,000	15,000	20,000	25,000	30,000	40,000
	2	16,221	2,057	10,490	18,919	27,350	41,147
	3	15,604	2,499	11,087	20,675	29,463	47,039
	4	15,995	4,141	13,276	22,411	31,547	49,017
	5	16,300	5,182	14,663	24,147	33,630	52,575
	6	17,250	6,743	16,318	26,752	36,753	56,762

Price per meter, non-production wells

Proportion of non-production wells	13,276	5	5,000	10,000	15,000	20,000
	75%	8,279	11,300	29,546	26,700	32,068
	50%	8,663	12,302	16,343	20,162	24,024
	25%	8,811	11,013	13,276	15,509	17,741
	0%	9,217	9,217	9,217	9,217	9,217

Ranking for Price per meter, other wells

Number of Other Wells	13,276	10%	25%	50%	75%	100%
	0	3,200	2,754	3,531	4,308	5,085
	1	10,039	11,753	13,276	15,799	17,322
	2	17,277	19,230	22,527	25,777	29,046
	3	24,747	27,476	31,992	36,507	41,022
	4	31,909	35,366	41,117	46,870	52,630

Ranking for Price per meter, other wells

Yearly Increment in other wells	13,276	10%	25%	0%	75%	100%
	0	5,685	6,721	7,479	8,720	9,971
	0.25	10,039	11,753	13,276	15,299	17,322
	0.5	10,039	11,753	13,276	15,299	17,322
	0.75	17,390	19,364	22,654	25,945	29,235
	1	17,390	19,364	22,654	25,945	29,235

ANNEX A-10

FINANCIAL MODEL OF WELL REHABILITATION OPERATIONS - PHASE TWO PROGRAM

A. MODEL ASSUMPTIONS (for firm with own equipment)

A.1 Equipment Costs

Cable Tool Rig

Value:	$50,000	US Dollars
Life Expectancy:	10	years
Amt, depr. % p.a.:	50%	per annum
Term:	3	years
Monthly amt & depr:	$2,083	187,500 So.Sh./mn

1 Pickup Truck, 1 Flat Bed Truck

Value:	$20,000	US Dollars
Life Expectancy:	3	years
Amt, depr. % p.a.:	100%	per annum
Term:	3	years
Monthly amt & depr:	$1,667	150,000 So.Sh./mn

1 Cement Mixer and Block Machine

Value:	$2,500	US Dollars
Life Expectancy:	5	years
Amt, depr. % p.a.:	50%	per annum
Term:	3	years
Monthly amt & depr:	$104	9,375 So.Sh./mn

Market Exch Rate mid-'86: 90 So.Sh./$

A.2 Labor Costs

Quant	Position	So.Sh./dy	Production Well days	cost
1	Rig Operator	500	15	7,500 So.Sh./wl
1	Construction Leader	450	15	6,750 "
3	Rig Assistants	175	15	7,875 "
2	Construct'n Assistants	175	15	5,250 "
2	Drivers	130	15	3,900 "
				31,275 So.Sh./wl

A.3 Annual Overhead

Quant	Item	So.Sh./mn	months	
1	Clerk/Secretary	5,000	12	60,000 So.Sh./yr
1	Watchman	4,000	12	48,000 "
1	Office/Yard	35,000	12	420,000 "
				528,000 So.Sh./yr

B. CONTRACT PRICE

	Price	Quant.	Total
TOTAL WELLS:			
production well:	350,000 So.Sh./wl	72	25,200,000 So.Sh.

C. FINANCIAL ANALYSIS

(mid 1986 Somali Shillings)

QUARTERS	I	II	III	IV	I	II	III	IV	I	II	III	IV
No. Production Wells	6	6	6	6	6	6	6	6	6	6	6	6
Equip. amt & depr. Costs	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)	(1,040,625)
Labor Costs	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)	(187,650)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Payment Prod'n Wells	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000
BALANCE	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725

NPV of Balance at 35% nominal opportunity cost of capital	5,635,794
NPV of balance at 20% nominal opportunity cost of capital	6,682,588
NPV of balance at 0% nominal opportunity cost of capital	8,876,700

D. SENSITIVITY ANALYSIS (NPV at 20%)

Price per Well

Number of Wells	6,682,588	250,000	275,000	300,000	325,000	350,000	375,000	400,000	425,000	450,000	500,000
	40	(3,700,092)	(2,912,201)	(2,124,309)	(1,336,418)	(548,526)	239,365	1,027,257	1,815,148	2,603,040	4,178,823
	50	(2,689,612)	(1,786,224)	(882,836)	20,552	923,940	1,827,328	2,730,717	3,634,105	4,537,493	6,344,269
	55	(1,724,157)	(710,418)	303,321	1,317,059	2,330,798	3,344,536	4,358,275	5,372,013	6,385,752	8,413,229
	60	(713,677)	415,359	1,544,794	2,674,029	3,803,264	4,932,499	6,061,734	7,190,970	8,320,205	10,578,675
	65	251,779	1,491,365	2,730,950	3,970,536	5,210,122	6,449,707	7,689,293	8,928,878	10,168,464	12,647,632
	70	1,262,259	2,617,341	3,972,424	5,327,506	6,682,588	8,037,670	9,392,752	10,747,835	12,102,917	14,813,082
	80	2,227,715	3,693,147	5,158,580	6,624,013	8,089,445	9,554,878	11,020,311	12,485,743	13,951,176	16,882,041
	85	3,238,195	4,819,124	6,400,053	7,980,983	9,561,912	11,142,841	12,723,770	14,304,700	15,885,629	19,047,487
	90	4,203,651	5,894,930	7,586,210	9,277,490	10,968,769	12,660,049	14,351,329	16,042,608	17,733,888	21,116,447
	95	5,214,131	7,020,907	8,827,683	10,634,459	12,441,236	14,248,012	16,054,788	17,861,564	19,668,341	23,281,893

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Payment Prod'n Wells	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000
BALANCE	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725	739,725

NPV of Balance at 35% nominal opportunity cost of capital	5,635,794
NPV of balance at 20% nominal opportunity cost of capital	6,682,588
NPV of balance at 0% nominal opportunity cost of capital	8,876,700

D. SENSITIVITY ANALYSIS (NPV at 20%)

Price per Well

Number of Wells	6,682,588	250,000	275,000	300,000	325,000	350,000	375,000	400,000	425,000	450,000	500,000
	40	(3,700,092)	(2,912,201)	(2,124,309)	(1,336,418)	(548,526)	239,365	1,027,257	1,815,148	2,603,040	4,178,823
	50	(2,689,612)	(1,786,224)	(882,836)	20,552	923,940	1,827,328	2,730,717	3,634,105	4,537,493	6,344,269
	55	(1,724,157)	(710,418)	303,321	1,317,059	2,330,798	3,344,536	4,358,275	5,372,013	6,385,752	8,413,229
	60	(713,677)	415,559	1,544,794	2,674,029	3,803,264	4,932,499	6,061,734	7,190,970	8,320,205	10,578,675
	65	251,779	1,491,365	2,730,950	3,970,536	5,210,122	6,449,707	7,689,293	8,928,878	10,168,464	12,647,635
	70	1,262,259	2,617,341	3,972,424	5,327,506	6,682,588	8,037,670	9,392,752	10,747,835	12,102,917	14,813,082
	80	2,227,715	3,693,147	5,158,580	6,624,013	8,089,445	9,554,878	11,020,311	12,485,743	13,951,176	16,882,041
	85	3,238,195	4,819,124	6,400,053	7,980,983	9,561,912	11,142,841	12,723,770	14,304,700	15,885,629	19,047,487
	90	4,203,651	5,894,930	7,586,210	9,277,490	10,968,769	12,660,049	14,351,329	16,042,608	17,733,888	21,116,447
	95	5,214,131	7,020,907	8,827,683	10,634,459	12,441,236	14,248,012	16,054,788	17,861,564	19,668,341	23,281,893
	100	6,179,586	8,096,713	10,013,840	11,930,966	13,848,093	15,765,220	17,682,346	19,599,473	21,516,600	25,350,853

MODEL 6-11

FINANCIAL MODEL FOR PUMP MAINTENANCE FIRMS - PHASE IIB (for firms servicing only HPM pumps)

A. MODEL ASSUMPTIONS

A.1 Equipment Costs

Cable tool rig	
Value:	250,000
Life expectancy:	10
Maint, depr. % p.a.:	10%
Terms:	3
Maint, depr. contrac:	37,500 Ea Sh
Pick-up truck,	
Value:	45,000
Life expectancy:	3
Maint, depr. % p.a.:	100%
Terms:	3
Maint, depr. contrac:	37,500 Ea Sh.
Repair Shop, Tripod	
Value:	625,000
Life expectancy:	3
Maint, depr. % p.a.:	25%
Terms:	3
Maint, depr. contrac:	65,625 Ea Sh.

A.2 Pump Maintenance Numbers & Revenues

	HPM Contract	Private Contract
Rs.Sh./Pump (Services)	25,000	37,500
Rs.Sh./Pump (Dep.Maint.)	0	756,000
Rs.Sh./Pump (Dep.Trans)	6,300	21,000
Percent During Services	0%	30%
Percent During Repair	100%	100%
Increment to Contracts	0	0
Market Ex. Rate at 1-1986:	90	
Percent needing repair/yr	30%	

A.3 Pump Maintenance Costs (Direct)

Labor	Rs.Sh./Dy	Dy/pump maintenance	Rs.Sh./pm maintenance	Dy/pump repair	Rs.Sh./pm repair
1 Crew Leader:	150	1	150	1	150
2 Mechanics:	175	3	1,050	3	1,050
2 Assistants:	175	3	1,050	3	1,050
Total			3,150		3,150

Fuel	Ga.Sh./l	Dy/pump	Ga.Sh./pm		
50 l/dr/rig	50	0	0	1	2,500
25 l/dr/truck	50	3	3,750	3	3,750
Total			3,750		3,750

A.4 Parts for pump repair

	US$/unit	% parts cost	US$/repair
1 Pump & Generator	421,000	30%	14,700

Annual Parts Inventory Needed			US$/dy/yr
25% Pumps Spares (inventory)	44,700	25%	4,475
25% Gen. Spares (inventory)	416,000	25%	41,675

A.5 Overhead

	Rs.Sh./mo	months/yr	Ga Sh./yr
1 Clerk/Dr	5000	12	60,000
1 Watchman	4000	12	48,000
1 Office/yard	35000	12	420,000
Total			528,000

B. COMPUTED VARIABLES

QUARTER	I	II	III	IV	I	II	III	IV	I	II	III	IV
No. HPM Pumps	42	46	51	55	60	65	69	74	79	84	89	94
No. Other Pumps	0	0	0	0	0	0	0	0	0	0	0	0
Number needing Repair HPMs	3	3	4	4	5	5	5	5	6	6	7	7
Number needing Repair Others	0	0	0	0	0	0	0	0	0	0	0	0
Crew days/quarter	135	147	163	177	193	210	222	237	253	270	288	303
Crew quarters, front line needed	1.5	1.6	1.8	2.0	2.2	2.3	2.5	2.6	2.8	3.0	3.2	3.4

C. FINANCIAL ANALYSIS (US$ Small Dollars)

COMPONENT/QUARTER	I	II	III	IV	I	II	III	IV	I	II	III	IV
Cost. & Depr. cost rig, trucks, shop	(534,375)	(534,375)	(534,375)	(534,375)	(646,875)	(646,875)	(646,875)	(646,875)	(646,875)	(646,875)	(759,375)	(759,375)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Parts Stock	0	0	0	0	0	0	0	0	0	0	0	0
Other Direct Costs - Maint.	(132,500)	(154,500)	(160,630)	(173,250)	(189,000)	(204,750)	(217,530)	(231,100)	(245,850)	(264,600)	(280,750)	(296,100)
Other Direct Costs - Repair	(9,750)	(9,630)	(12,600)	(12,600)	(15,750)	(15,750)	(15,750)	(15,750)	(18,900)	(18,900)	(22,050)	(22,050)
Pump parts payments	0	0	0	0	0	0	0	0	0	0	0	0
Payments - Maint. Assist. Services	1,050,000	1,150,000	1,275,000	1,375,000	1,500,000	1,625,000	1,725,000	1,850,000	1,975,000	2,100,000	2,225,000	2,350,000
Payments - Repairs	10,500	10,500	25,200	25,200	31,500	31,500	31,500	31,500	37,800	37,800	44,100	44,100
BALANCE	360,775	340,175	460,575	547,975	547,875	637,125	744,525	853,175	966,175	1,075,125	1,075,125	1,184,375

NPV of balance at 12% annual opportunity cost of capital	4,972,143
NPV of balance at 20% annual opportunity cost of capital	4,132,157
NPV of balance at 0% annual opportunity cost of capital	8,722,000

D. SENSITIVITY ANALYSIS (all values show NPV @ 20%)

Maintenance Service Price

	4,132,157	10,000	15,000	20,000	25,000	30,000	35,000	40,000
	25	12,707,721	11,549,721	600,190	2,766,130	4,924,110	7,082,070	9,240,030
Number	30	13,392,000	11,809,600	1,374,207	2,758,013	6,141,827	8,525,630	10,909,437
of	35	13,864,001	12,021,146	2,152,309	4,763,153	7,371,010	9,981,473	12,591,137
HPM	40	12,746,136	99,372	2,929,074	5,760,176	8,595,079	11,431,284	14,264,082
Units	45	12,429,732	632,417	3,693,066	6,754,015	9,814,161	12,877,313	15,930,063
	50	12,107,071	1,179,710	4,444,906	7,754,102	11,041,298	14,330,493	17,615,691
	55	11,909,640	1,723,643	5,216,646	8,749,496	12,263,733	15,773,176	19,280,830
	60	11,667,660	2,247,273	6,000,113	9,737,004	13,483,493	17,229,788	20,963,676

Maintenance Service Price

	4,132,157	10,000	15,000	20,000	25,000	30,000	35,000	40,000
	0	13,677,363	303,475	3,279,316	6,132,157	9,000,998	12,004,838	14,932,679
Number	2	13,399,564	1330,197	2,733,193	5,709,243	8,843,091	11,907,246	14,960,389
of	4	973,191	4,176,097	7,466,984	10,563,764	13,760,631	16,957,470	20,154,316
Other	6	196,951	3,330,417	6,860,703	10,193,148	13,525,514	16,857,880	20,190,246
Units	8	1301,4091	3,086,723	6,254,634	9,822,533	13,394,467	16,738,791	20,226,133
	10	4,031,771	7,439,153	11,738,525	16,041,910	18,443,340	22,040,463	25,632,063
	12	3,754,631	6,993,521	10,132,412	14,471,302	18,210,193	21,949,084	25,687,973

Maintenance Service Price

	4,132,157	10,000	15,000	20,000	25,000	30,000	35,000	40,000
	0%	13,759,053	166,706	3,093,437	6,010,167	8,944,308	11,878,199	14,793,990
Repair	25%	13,724,003	300,956	3,126,799	6,052,646	8,978,400	11,908,121	14,838,162
Cost	50%	13,690,710	735,131	3,160,771	6,086,012	9,012,633	11,938,094	14,869,334
Markup	75%	13,636,330	369,363	3,195,144	6,120,004	9,046,975	11,972,666	14,898,307
	100%	13,627,363	303,475	3,279,316	6,132,157	9,000,998	12,004,838	14,932,679

E. CONFIG PROJECT FOR SERVICES

Number of Wells								
25	13,707,723	11,549,621	888,190	2,764,138	4,571,110	7,002,879	9,240,819	
30	13,793,000	11,000,1001	1,370,207	3,738,015	6,141,022	8,529,630	10,900,417	
35	13,866,001	1437,1461	2,152,305	4,763,163	7,371,010	9,901,673	12,291,137	
40	13,746,1361	99,172	2,926,076	5,760,176	8,393,070	11,231,200	13,366,007	
45	13,429,2271	632,117	3,693,444	6,754,010	9,816,163	12,077,313	13,930,063	
50	13,107,4071	1,179,710	4,466,901	7,754,107	11,041,290	14,329,197	17,413,693	
55	11,799,6411	1,723,641	5,236,444	8,749,679	12,267,733	15,775,776	19,200,030	
60	13,447,6601	2,267,223	6,000,113	9,747,604	13,485,093	17,224,755	20,941,676	

Maintenance Service Price

Number of Wells	6,155,157	10,000	15,000	20,000	25,000	30,000	35,000	40,000
0	13,427,363	303,475	3,229,316	6,155,157	9,000,990	12,066,830	14,932,679	
2	13,399,3661	1330,157	2,773,193	5,704,342	8,843,091	11,907,746	14,968,309	
4	973,191	4,170,099	7,366,904	10,563,724	13,760,621	16,957,470	20,151,136	
6	196,051	3,570,117	6,964,783	10,193,146	13,525,314	16,857,000	20,190,246	
8	1301,0091	2,006,795	6,254,654	9,822,533	13,799,447	16,758,201	20,226,155	
10	6,031,771	7,625,153	10,238,523	10,841,918	10,445,340	27,040,663	29,652,063	
12	2,254,631	6,993,321	10,732,612	11,071,361	10,310,193	21,949,004	25,687,973	

Maintenance Service Price

Repair Cost	6,155,157	10,000	15,000	20,000	25,000	30,000	35,000	40,000
0%	13,759,953	166,786	3,092,627	6,018,467	8,944,300	11,870,109	14,795,790	
25%	13,724,0831	298,958	3,026,799	5,952,640	8,878,480	11,804,321	14,730,162	
50%	13,690,7101	233,131	2,960,971	6,886,812	9,812,653	11,738,494	14,864,334	
75%	13,656,3381	367,303	2,895,144	6,820,984	9,846,825	11,672,666	14,998,507	
100%	13,427,3631	303,475	3,229,316	6,155,157	9,000,990	12,066,830	14,932,679	

I. COST TO PRODUCE PUMP SERVICES

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Routine Maintenance Service	3,150,000	3,250,000	3,025,000	4,125,000	4,300,000	4,075,000	5,175,000	5,250,000	5,975,000	6,300,000	6,475,000	7,050,000
Pump Repairs	56,700	56,700	75,600	75,600	94,500	94,500	94,500	94,500	113,400	113,400	132,300	132,300
TOTAL	3,206,700	3,306,700	3,000,600	4,200,600	4,394,500	4,169,500	5,269,500	5,344,500	6,088,400	6,413,400	6,607,300	7,182,300
TOTAL AVERAGE COST PER PUMP	25,650	25,411	23,994	23,650	23,173	23,025	23,457	23,476	23,470	23,430	23,194	23,447
FOR 1986 DOLLARS	$283	$282	$283	$283	$284	$283	$283	$283	$283	$283	$283	$283
Average Cost per Well per year, including pump parts	$1,123											

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Maintenance Costs	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123
Replacement Costs	$0	$0	$0	$21,000	$0	$0	$0	$21,000	$0	$0	$0	$21,000

OPC Maintenance @ 25%:	$4,109
OPC Repair @ 25%:	$0,799
OPC Maintenance @ 30%:	$0,175
OPC Repair @ 30%:	$17,367
OPC Maintenance @ 0%:	$23,283
OPC Repair @ 0%:	$63,000

ANNEX A 12

FINANCIAL MODEL FOR PUMP MAINTENANCE FIRMS - PUMPS PVD (for firms servicing VDH and other wells)

A. MODEL ASSUMPTIONS

A.1 Equipment Costs

Cable tool rig	
Value:	450,000
Life expectancy:	10
Maint, depr. $ p.a.:	10%
Term:	3
Maint, depr cost/mo:	37,500 Sa.Sh.
Pickup truck,	
Value:	25,000
Life expectancy:	3
Maint, depr. $ p.a.:	100%
Term:	3
Maint, depr cost/mo:	37,500 Sa.Sh.
Repair Shop, Tripod	
Value:	125,000
Life expectancy:	5
Maint, depr. $ p.a.:	25%
Term:	3
Maint, depr cost/mo:	13,125 Sa.Sh.

A.2 Pump Maintenance Manpower & Overheads

	VDH Contract	Private Contract
Sa.Sh./Pump (Services)	25,000	37,500
Sa.Sh./Pump (Pump.Maint.)	0	750,000
Sa.Sh./Pump (Other.Costs)	6,300	21,000
Percent Backup Service	0%	50%
Percent Backup Repair	100%	100%
Overpayment to contracts	0	3
Market Ex. Rate end-1986:	90	
Percent needing repair/yr	20%	

A.3 Pump Maintenance Costs (Direct)

Labor	Sa.Sh./dy	dy/pump maintenance	Sa.Sh./pm maintenance	dy/pump repair	Sa.Sh./pm repair
1 Crew Leaders	450	1	450	1	450
2 Mechanics	275	3	1,650	3	1,650
2 Assistants	175	3	1,050	3	1,050
Total			3,150		3,150

Fuel	Sa.Sh./l	dy/pump	Sa.Sh./pm	dy/pump	Sa.Sh./pm
30 l/dr/rig	30	6	6	1	2,500
25 l/dr/truck	50	3	3,750	3	3,750
Total			5,250		7,750

A.4 Parts for pump repair

	US$/unit	% parts cost	US$/repair
1 Pump & Generator	675,000	20%	135,000

Annual Parts Inventory Needed

			US$/yr
25% Pumps Spares (inventory)	33,750	20%	6,750
25% Gen. Spares (inventory)	175,000	20%	35,175

A.5 Overhead

	Sa.Sh./mo	months/yr	Sa.Sh./yr
1 Clerk/Mec	5000	12	60,000
1 Watchman	4000	12	48,000
1 Driver/yard	35000	12	420,000
Total			528,000

B. QUARTERLY VARIABLES

QUARTER	I	II	III	IV	I	II	III	IV	I	II	III	IV
No. VDH Pumps	42	46	51	53	60	63	69	74	79	84	89	94
No. Other Pumps	10	12	14	16	18	20	22	24	26	28	30	32
Number Needing Repair (VDH)	3	3	4	4	5	5	5	5	6	6	7	7
Number Needing Repair (Other)	1	1	1	1	1	2	1	2	1	2	1	2
Crew days/quarter	160	186	210	230	252	276	291	315	339	360	384	408
Crew quarters, truck time needed	1.9	2.1	2.3	2.5	2.8	3.1	3.2	3.5	3.8	4.0	4.3	4.5

C. FINANCIAL ANALYSIS (US$ Small Shillings)

COMPONENT/QUARTER	I	II	III	IV	I	II	III	IV	I	II	III	IV
Amt. & depr. cost rig, trucks, shop	(834,375)	(846,875)	(846,875)	(846,875)	(846,875)	(759,375)	(759,375)	(759,375)	(759,375)	(759,375)	(871,875)	(871,875)
Overhead	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
Parts Stock	(130,750)	(190,000)	(463,750)	(529,200)	(595,250)	(661,000)	(727,650)	(793,000)	(859,750)	(926,100)	(992,750)	(1,058,400)
Other Direct Costs - Maint.	(256,000)	(293,700)	(330,750)	(367,650)	(340,700)	(377,750)	(407,150)	(434,700)	(467,250)	(499,800)	(532,250)	(564,800)
Other Direct Costs - Repair	1,950	1,950	11,700	11,700	14,250	6,950	14,250	6,950	2,000	2,000	17250	10,650
Pump parts payments	750,000	750,000	750,000	750,000	750,000	1,512,000	750,000	1,512,000	1,512,000	1,512,000	1,512,000	2,260,000
Payments - Cont. Maint. Service	1,475,000	1,600,000	1,800,000	1,975,000	2,175,000	2,375,000	2,550,000	2,750,000	2,950,000	3,150,000	3,350,000	3,550,000
Payments - Repairs	48,700	48,700	47,000	47,000	53,300	75,100	53,300	75,100	81,000	81,000	87,700	109,300
BALANCE	1,009,725	976,675	1,081,125	1,140,575	1,263,025	2,043,525	1,135,275	2,227,275	2,227,725	2,429,025	2,630,975	3,310,975

NPV of balance at 25% annual opportunity cost of capital	17,419,542
NPV of balance at 30% annual opportunity cost of capital	15,387,100
NPV of balance at 0% annual opportunity cost of capital	21,800,900

D. SENSITIVITY ANALYSIS (all figures show NPV @ 30%)

D.1

Maintenance Service Price, VDH

Number of VDH Wells	15,387,100	10,000	15,000	20,000	25,000	30,000	35,000	40,000
	25	1,995,066	4,987,667	8,010,630	11,918,109	15,425,751	18,933,393	22,440,973
	30	1,709,021	3,443,729	5,176,437	12,918,044	16,643,054	20,370,063	24,110,376
	35	2,636,170	5,995,163	9,354,839	13,914,179	17,873,130	21,832,706	25,793,963
	40	2,257,099	6,347,293	10,727,204	14,917,987	19,087,313	23,302,613	27,467,716
	45	2,673,916	7,004,946	11,995,096	15,906,046	20,317,796	24,728,146	29,139,196
	50	2,995,742	7,632,539	12,769,336	16,906,133	21,543,721	26,179,730	30,816,529
	55	3,313,987	8,176,412	13,635,076	17,901,721	22,764,363	27,627,010	32,489,634
	60	3,633,360	8,722,952	13,810,544	18,899,032	23,987,527	29,036,107	34,164,310

D.2

Maintenance Service Price, Other

Number of Other Wells	15,387,100	25,000	30,000	35,000	40,000	45,000	50,000	60,000
	4	10,929,600	11,920,797	12,102,113	12,811,832	13,440,549	14,073,267	15,330,701
	6	11,319,913	12,020,971	12,750,027	13,477,742	14,196,146	14,913,146	16,253,800
	8	12,115,530	12,994,922	13,764,320	14,573,722	15,383,110	16,177,311	17,013,301
	10	12,957,051	13,957,507	14,857,321	15,757,920	16,656,709	17,554,327	19,229,901
	12	13,990,600	14,900,741	15,970,036	16,964,967	17,954,906	18,941,053	20,921,190
	14	15,170,999	16,091,720	18,067,000	19,233,751	20,404,042	21,574,732	23,916,293
	20	16,804,501	18,236,004	19,387,417	20,538,066	22,290,294	23,641,722	26,344,579

D.3

Maintenance Service Price, Other

Number of Other Wells	15,387,100	25,000	30,000	35,000	40,000	45,000	50,000	60,000
	0	10,972,399	11,424,293	11,873,900	12,327,602	12,779,171	13,231,071	14,134,460
Nearly	1	11,190,066	11,866,200	12,542,294	13,218,000	13,893,723	14,569,437	15,920,063
Equipment	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

0.1

Maintenance Service Price, 000

Number of 000 Units	15,387,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000
	25	1,993,346	4,901,067	8,610,670	11,910,109	15,425,751	18,933,312	22,440,873
	30	1,709,021	5,043,229	9,176,637	13,910,046	16,643,454	20,176,863	24,110,271
	35	2,836,170	5,995,603	9,954,939	13,910,195	17,873,450	21,832,706	25,791,962
	40	3,237,099	6,542,263	10,727,204	14,917,067	19,097,310	23,282,613	27,467,916
	45	2,473,996	7,084,946	11,499,896	15,906,066	20,317,796	24,728,744	29,139,694
	50	2,999,712	7,632,529	12,269,534	16,906,133	21,543,931	26,179,728	30,816,529
	55	3,313,787	8,176,132	13,039,676	17,901,721	22,764,365	27,627,010	32,489,654
	60	3,633,260	8,727,953	13,810,944	18,899,735	23,987,527	29,074,079	34,164,310

0.2

Maintenance Service Price, Other

Number of Other Units	15,387,100	75,000	30,000	35,000	40,000	45,000	50,000	60,000
	4	10,979,600	11,330,797	12,187,113	13,011,032	13,444,549	14,473,267	15,130,701
	6	11,319,915	12,038,971	12,790,027	13,672,063	14,196,146	14,913,196	16,253,300
	8	12,145,530	12,954,432	13,744,230	14,573,773	15,383,110	16,172,313	17,011,303
	10	13,057,053	13,957,307	14,857,321	15,757,975	16,656,709	17,356,523	19,233,991
	12	13,990,600	14,900,761	15,970,654	16,968,987	17,958,900	18,941,053	20,931,190
	14	15,720,999	16,091,790	18,067,300	19,233,751	20,464,042	21,534,752	23,916,253
	20	16,894,301	18,736,009	19,387,437	20,930,044	22,290,794	23,641,722	26,344,579

0.3

Maintenance Service Price, Other

Yearly Increment Other Units	15,387,100	25,000	30,000	35,000	40,000	45,000	50,000	60,000
	0	10,972,399	11,426,293	11,979,900	12,377,602	12,779,177	13,231,071	14,154,660
	2	11,190,044	11,844,300	12,547,994	13,210,000	13,993,721	14,847,137	15,930,063
	3	12,057,053	12,957,307	14,057,321	15,757,975	16,656,709	17,356,523	19,233,991
	5	13,075,616	14,199,370	17,323,123	18,646,077	19,570,131	20,694,305	22,941,097
	6	14,722,063	16,270,636	19,610,009	20,966,183	22,313,956	23,447,730	26,237,777
	8	16,805,291	20,457,104	23,670,970	25,600,771	22,172,363	26,744,238	29,887,044
	6	19,301,360	21,377,101	23,172,994	24,960,007	26,744,630	28,566,131	32,152,060

0.4

Maintenance Service Price, Other

Repair Cost Varies, Other	15,387,100	25,000	30,000	35,000	40,000	45,000	50,000	60,000
	0%	7,980,012	8,488,140	9,387,000	10,087,610	10,387,340	12,387,002	11,006,350
	30%	10,423,133	11,522,067	12,272,601	13,122,132	14,072,069	15,921,063	16,721,271
	100%	13,057,053	13,957,307	14,057,321	15,757,975	16,656,709	17,356,523	19,233,991
	150%	15,692,373	16,992,367	17,992,541	18,791,775	19,791,309	20,191,313	21,990,711
	200%	18,327,394	19,221,030	20,136,763	21,026,996	21,926,250	22,825,964	24,670,432

[illegible] 0.13

FINANCIAL MODEL OF WELL DRILLING OPERATIONS - Dollar Sh (for Fore drilling [illegible] wells only)

A. [illegible] ASSUMPTIONS

A.1 Capital Costs

Quantity	Item	Cost (US$)	Cost (Sh)
	1 Rotary Drill Rig	8000,000	14,200,000
	1 Aux. Comp & Spares	8115,000	9,775,000
	Sub-Total	8515,000	23,975,000
	1 Pickup truck	775,000	1,175,000
	1 Light Vehicle	815,000	1,275,000
	Office Comp		1,000,000
	Pre-Operating Expenses:		1,000,000
	Initial working Capital:		967,000
	Subtotal	640,000	6,367,000
	Office and yard		2,000,000
	Contingency 10%:		3,716,700
	GRAND TOTAL		42,056,700

% financed	71.4%
Principal	43495639.2
Interest	14%
Term	5

% Non-prod.	% Rotary, other
25%	30%

Increment business, other
0 well/3 years

Price/m, prod. HDA	Other
17,500 Sh/m.	40,750

Price/m, N.P., HDA	Other
16,750 Sh/m.	24,375

Meters/well
100 meters

Markup for materials
30%

A.2 Annual Costs

Quantity	Item	Cost	Days/ prod well	Days/ n.p.well	L.Cost/ prod well	L.Cost/ n.p. well
	LABOUR					
	1 Chief Eng/Mec.	1,000 Sh.Sh./day	13	10	13,000	10,000 Sh.Sh.
	1 Asst. Manager	800 "	15	10	12,000	8,000 "
	3 Technicians	800 "	10	8	12,000	9,600 "
	3 Semi-skilled labor	150 "	10	8	5,400	3,704 "
	2 Unskilled labor	130 "	20	5	5,000	1,300 "
	Subtotal				47,000	30,300 Sh.Sh.

MATERIALS	Unit cost	Production non-production		Material Cost Prod. Well	Non-Prod
Drilling fluid (a)	0.00 US$/m	100	100 meters	0400	0400
Drilling fluid (c)	0.00 US$/m	100	0 meters	0000	00
Bits	3 50 US$/m	100	100 meters	0750	0750
Cement	50 00 US$/m^3	0.5	0.5 m^3	775	775
Casing	140 00 US$/m	6	6 meters	0960	0960
Casing	87 00 US$/m	75	30 meters	06,225	01,600
screen	115 00 US$/m	25	0 meters	07,875	00
gravel	30 00 US$/m^3	5	0 m^3	0150	00
Pump	621,000 US$/well	1	0 well	621,000	00
Subtotal				632,425	03,375

FUEL					
250 Drill rig (lrs)	30 Sh/l	9	6 days	112,500	00,000
25 Pickup truck	30 Sh/l	25	13 days	03,750	23,750
20 L. Vehicle (lrs)	60 Sh/l	16	13 days	16,000	15,600
Subtotal				192,250	00,350

Overhead	Annual	
101 Spares for rig/yr	1000,000 Drlg.vol.	3,000,000 Sh.Sh/yr
100 Spares for D.T./yr	475,000 Drlg vol.	300,000 "
101 Spares for L.V./yr	815,000 Drlg.vol.	164,000 "
Administration		300,000 "
Insurance		350,000 "
		4,079,000 Sh.Sh./yr

B. MACRO VARIABLES

YEAR	0	I	II	III	IV	V	VI	VII	VIII	IX	X
Market Exchange Rate	15	16									
No. Prod. Wells, HDA		4	6	6	6	6	8	8	8	8	8
No. N.P. Wells, HDA		2	3	3	3	3	2	2	2	2	2
No. Prod. Wells, Other		4	6	8	8	8	8	8	8	8	8
No. N.P. Wells, Other		0	0	0	0	0	0	0	0	0	0

C. CASH FLOW ANALYSIS (in thousands of Kenyan Shillings)

Principal	42,056	43,005	36,004	27,003	18,002	9,001	0				
Interest	0	7,791	5,761	4,129	2,000	1,440	0				
Payment	(17,001)	(16,292)	(15,762)	(13,221)	(12,001)	(10,441)	0				
Labor Cost	0	(241)	(313)	(341)	(372)	(341)	(436)	(436)	(436)	(436)	(436)
Materials	0	0	0	0	0	0	0	0	0	0	0
Fuel	0	0	0	0	0	0	0	0	0	0	0
Overhead	0	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)	(4,076)
Total Costs	(17,051)	(21,017)	(19,000)	(18,534)	(17,048)	(15,154)	(5,310)	(5,310)	(5,310)	(5,310)	(5,310)
Revenues for services	0	22,750	31,175	22,750	31,175	22,750	39,750	39,750	39,750	39,750	39,750
Payment for supplies	0	0	0	0	0	0	0	0	0	0	0
BALANCE	(17,051)	1,333	2,177	4,216	4,027	7,596	33,940	33,940	33,940	33,940	33,940

NPV 10% - 1991, 25%	48,668
NPV 10% - 1991, 30%	17,231
NPV 20% - 1991, 0%	46,240
IRR 10% - 1991:	0.63491%

NPV 10% - 1996, 25%	112
NPV 10% - 1996, 30%	16,747
NPV 10% - 1996, 0%	119,726
IRR 10% - 1996:	25.1092%

D. SENSITIVITY ANALYSIS (NPVs expressed in thousands of Kenyan Shillings)

Price per meter (prod)	Five Year Payback Period NPV 25%	NPV 30%	NPV 0%	Ten Year Payback Period NPV 25%	NPV 30%	NPV 0%
12,500	48,668	17,231	46,240	112	16,747	119,726
25,000	117,063	119,963	121,110	110,741	73,720	82,170
30,000	111,467	111,669	111,294	12,512	10,252	99,074
40,000	1211	2,405	8,423	10,904	36,773	179,976
48,000	5,777	13,963	18,516	16,211	49,900	310,676

Price per meter (nonprod)	NPV 25%	NPV 30%	NPV 0%	NPV 25%	NPV 30%	NPV 0%
15,750	48,668	17,231	46,240	112	16,747	119,726
0	117,959	113,337	113,043	15,041	6,906	90,676
5,000	111,664	111,725	111,567	12,905	9,900	99,676
10,000	119,326	19,113	19,170	12,009	12,992	100,676
15,000	19,000	17,231	16,833	1311	15,996	117,676
20,000	17,671	15,329	16,993	1,204	19,000	126,676

Five Year Payback Period, NPVs at 25%, thousands of Kenyan Shillings

Price per meter, production well

	17,231	20,000	25,000	30,000	35,000	40,000	45,000	50,000
Number of HDA Wells	2	134,323	127,668	120,693	113,770	16,063	52	6,943
	3	113,167	129,905	110,643	111,301	10,110	3,164	10,906
	4	114,011	129,292	116,992	10,903	11,174	6,736	13,043
	5	129,700	131,430	113,320	15,390	3,761	10,871	19,001
	6	120,424	119,563	111,669	12,992	3,905	13,963	22,540
	7	127,060	110,244	19,419	1961	9,730	17,975	25,000
	8	125,712	116,543	17,369	1,003	10,973	20,117	29,219

Price per meter, production well

	17,231	0	5,000	10,000	15,000	20,000	25,000	30,000
Proportion of non-production	25%	113,900	10,300	12,467	3,273	9,013	14,753	20,493
	30%	111,833	110,993	16,250	12,620	1,110	8,257	6,993
	35%	113,733	111,730	19,733	11,733	13,720	13,727	11,730

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30,000	(11,667)	(11,669)	(11,300)	(3,512)	10,755	99,976
40,000	(271)	9,485	8,623	10,904	36,721	170,976
45,000	5,737	13,963	19,536	30,211	49,300	218,076

Price per meter temporari	NPV 251	NPV 301	NPV 41	NPV 51	NPV 101	NPV 151
16,750	(8,668)	(7,231)	(6,240)	117	36,717	119,776
0	(12,909)	(13,737)	(13,063)	(5,042)	6,906	90,476
5,000	(11,668)	(13,735)	(11,507)	(1,709)	9,909	99,476
10,000	(10,356)	(9,731)	(9,179)	(2,009)	12,972	108,076
15,000	(9,000)	(7,731)	(6,832)	(121)	15,996	117,076
20,000	(7,671)	(5,729)	(4,491)	1,304	18,999	126,176

Five Year Payment Period, NPVs at 30%, thousands of Somali shillings

Price per meter, production well

Number of SDH Wells	(7,231)	20,000	25,000	30,000	35,000	40,000	45,000	50,000
	2	(24,523)	(27,668)	(28,693)	(13,178)	(6,063)	32	6,967
	3	(22,167)	(25,905)	(18,643)	(11,261)	(8,110)	3,164	10,466
	4	(21,011)	(24,302)	(16,977)	(8,983)	(1,276)	6,736	15,945
	5	(29,700)	(27,630)	(13,520)	(5,396)	2,741	10,871	19,001
	6	(28,024)	(19,917)	(13,616)	(2,992)	5,405	13,963	22,440
	7	(27,068)	(18,244)	(9,819)	(991)	8,236	17,925	25,000
	8	(25,717)	(16,541)	(7,561)	1,261	10,973	20,117	29,319

Price per meter, production well

Proportion of non-production wells	(7,231)	0	5,000	10,000	15,000	20,000	25,000	30,000
	75%	(13,940)	(8,200)	(2,467)	3,373	9,013	14,751	20,497
	50%	(13,633)	(10,097)	(6,250)	(2,620)	1,110	5,857	9,975
	25%	(13,737)	(11,725)	(9,723)	(7,731)	(5,739)	(3,737)	(1,756)
	0%	(13,624)	(13,624)	(13,624)	(13,624)	(13,624)	(13,624)	(13,624)

Sorting for Price per meter, other wells

Number of Other Wells	(7,231)	101	251	301	751	1001
	0	(7,231)	(7,231)	(7,231)	(7,231)	(7,231)
	1	5,309	6,743	9,144	11,300	14,013
	2	16,047	18,716	23,164	27,613	32,060
	3	29,521	32,573	40,060	47,987	55,014
	4	40,270	43,746	54,030	63,970	73,023

ANNEX A-10

FINANCIAL MODEL OF WELL DRILLING OPERATIONS - ROTARY RIG (for five drilling RDA and other wells)

A. MODEL ASSUMPTIONS

A.1 Capital Costs

Quantity	Item	Cost (US)	Cost (Sh)
1	Rotary Drill Rig	6400,000	16,000,000
1	Aux.Equip & spares	815,000	9,775,000
	Sub-Total	6215,000	43,775,000
1	Pickup Truck	475,000	2,375,000
1	Light Vehicle	815,000	1,275,000
	Office Equip		1,000,000
	Pre-Operating Expenses		1,000,000
	Initial working Capital		967,000
	Subtotal	740,000	6,567,000
	Office and yard		7,000,000
	Contingency 10%		5,714,700
	GRAND TOTAL		62,056,700
	$ Financed	71.61	
	Principal	43005629.2	
	Interest	163	
	Term	5	

% Non-prod.	% Savings, other
25%	30%

Increment Business, other
1 well/ 2 years

Price/m, prod, RDA	Other
37,500 Sh.Sh.	40,750

Price/m, N.P., RDA	Other
16,750 Sh.Sh.	24,375

Meters/well
100 meters

Mud/m for meters
30%

A.2 Direct Costs

Quantity	Item	Cost	Days/ prod well	days/ n.p.well	L.Cost/ prod well	L.Cost/ n.p. well	
LABOR							
1	Chief Engrkeep.	1,250 Sh/day	13	10	13,000	10,000	Sh.Sh.
1	Asst. Driller	800 "	13	10	12,000	8,000	"
3	Technicians	800 "	10	5	17,000	6,000	"
3	Semi-skilled labor	150 "	10	5	5,400	2,700	"
3	Unskilled labor	150 "	10	5	5,400	2,700	"
	Subtotal				47,800	30,700	Sh.Sh.

MATERIALS	Unit cost	Production non-production		Material Cost Prod. Well	Non-Prod
Drilling fluid (A)	0.00 US$/m	100	100 meters	0400	0400
Drilling fluid (B)	4.00 US$/m	100	0 meters	0800	00
Bits	3.50 US$/m	100	100 meters	0350	0350
casing	50.00 US$/m^3	0.5	0.5 m^3	075	075
collar	160.00 US$/m	6	6 meters	0960	0960
tubing	37.00 US$/m	75	30 meters	04,225	01,660
screen	115.00 US$/m	25	0 meters	02,875	00
gravel	30.00 US$/m^3	3	0 m^3	0190	00
pump	673,000 US$/well	1	0 well	673,000	00
Subtotal				832,025	03,375
FUEL					
750 Drill rig (l/d)	30 Sh/l	9	6 days	112,500	30,000
25 Pickup Truck	30 Sh/l	25	13 days	02,750	22,750
30 L. Vehicle (l/d)	60 Sh/l	30	13 days	36,000	15,600
Subtotal				172,250	88,350

A.3 Overhead

		Annual	
10% Spares for rig/yr	6400,000 Orig.val.	0,640,000	Sh.Sh./yr
10% Spares for A.E./yr	475,000 Orig.val.	240,000	"
10% Spares for L.V./yr	815,000 Orig.val.	140,000	"
Administration		500,000	"
Insurance		250,000	"
		4,870,000	Sh.Sh./yr

B. MODEL VARIABLES

YEAR	0	I	II	III	IV	V	VI	VII	VIII	II	I
Market Exchange Rate	85	90									
No. Prod. Wells, RDA		6	6	6	6	6	0	0	0	0	0
No. N.P. Wells, RDA		7	1	2	3	3	2	2	2	2	2
No. Prod. Wells, Other		1	1	2	2	3	3	4	4	5	5
No. N.P. Wells, Other		0	1	0	1	1	1	1	1	1	2

C. CASH FLOW ANALYSIS (in thousands of Kenyan Shillings)

Principal	63,056	45,005	36,004	27,003	18,002	9,001	0				
Interest	0	7,701	5,761	9,320	2,880	1,440	0				
Payment	(17,051)	(16,202)	(16,762)	(12,323)	(11,001)	(10,441)	0	0	0	0	0
Labor Cost	0	(341)	(313)	(341)	(313)	(341)	(136)	(136)	(136)	(136)	(136)
Materials	0	(3,113)	(3,479)	(6,226)	(6,352)	(9,664)	(9,664)	(12,777)	(12,777)	(15,890)	(16,216)
Fuel	0	(172)	(201)	(385)	(473)	(663)	(663)	(857)	(857)	(1,050)	(1,138)
Overhead	0	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)	(4,870)
Total Costs	(17,051)	(24,723)	(23,660)	(25,146)	(24,093)	(25,903)	(15,329)	(18,940)	(18,940)	(22,949)	(22,653)
Revenues for services	0	27,425	30,430	32,000	33,313	39,013	46,313	51,100	51,700	56,063	58,500
Payment for supplies	0	8,047	6,470	6,853	8,517	13,364	12,364	16,618	16,618	20,657	21,001
BALANCE	(17,051)	8,750	9,240	13,647	17,737	26,391	43,237	48,854	48,854	54,170	56,913

NPV (90% - 1991, 25%)	7,317	NPV (90% - 1994, 25%)	23,117
NPV (90% - 1991, 30%)	10,715	NPV (90% - 1994, 30%)	40,000
NPV (90% - 1991, 0%)	24,060	NPV (90% - 1994, 0%)	310,246
IRR (90% - 1991)	57.0294931	IRR (90% - 1994)	72.32575

D. SENSITIVITY ANALYSIS

Price per meter (prod)	Five Year Payback Period NPV 25%	NPV 30%	NPV 0%	Ten Year Payback Period NPV 0%	NPV 10%	NPV 15%
32,500	7,317	10,715	24,060	23,117	40,000	310,246
35,000	10,341	903	3,130	9,199	25,134	212,183
30,000	3,427	12,711	17,795	19,794	30,090	277,930
40,000	19,967	36,721	46,007	41,005	90,001	300,300
45,000	36,727	60,727	60,730	52,730	117,957	473,463

Price per meter (nonprod)	NPV 25%	NPV 30%	NPV 0%	NPV 0%	NPV 10%	NPV 15%
16,750	7,317	10,715	24,060	23,117	40,060	310,246
0	1,053	9,001	13,002	14,001	32,131	299,930
5,000	2,079	11,909	16,930	17,170	37,173	271,000
10,000	4,903	10,970	20,930	21,073	47,013	290,930
15,000	6,030	17,966	23,906	24,460	66,057	300,300
20,000	8,756	20,922	27,510	27,063	71,699	372,050

Five Year Payback Period, NPVs at 30%, thousands of Kenyan shillings

Price per meter, productive well

		10,715	20,000	25,000	30,000	35,000	40,000	45,000	50,000
Number of RDA Wells	2	(17,399)	(6,956)	3,487	13,930	24,373	34,816	45,258
	3	(16,063)	(5,253)	5,517	16,329	27,110	37,900	48,690
	4	(14,687)	(3,549)	7,580	18,729	29,862	41,000	52,137
	5	(13,354)	(950)	10,660	22,319	33,977	45,635	57,293
	6	(11,300)	909	13,711	26,516	36,721	48,727	60,722
	7	(9,946)	2,609	16,761	27,114	39,466	51,819	64,172
	8	(8,000)	4,412	16,812	29,311	42,311	54,931	67,111

Price per meter, non-production well

		10,715	0	5,000	10,000	15,000	20,000	25,000	30,000
Proportion of non-production wells	75%		8,000	16,970	25,132	33,290	41,954	49,617	57,279
	50%		8,907	12,994	19,001	24,167	29,254	34,100	39,427
	25%		9,001	11,909	14,970	17,964	20,920	23,943	26,972
	0%		9,101	9,101	9,101	9,101	9,101	9,101	9,101

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Five Year Payback Period

Price per meter (yen)	NPV 25%	NPV 30%	NPV 0%
25,000	7,312	10,713	24,068
20,000	10,341	705	3,650
40,000	2,427	12,711	17,795
45,000	15,067	34,721	46,302
	26,737	48,727	60,130

Price per meter transported	NPV 25%	NPV 30%	NPV 0%
10,250			
0	7,312	10,713	24,068
3,000	1,021	9,001	12,463
10,000	2,979	11,909	16,936
17,000	4,903	14,970	20,150
20,000	6,834	17,966	23,906
	8,756	20,923	27,314

Ten Year Payback Period

NPV 25	NPV 30%	NPV 15%
25,117	40,068	310,244
9,109	30,114	217,183
19,796	38,090	277,130
41,085	48,001	000,300
34,730	117,957	672,483

NPV 25	NPV 30%	NPV 15%
25,117	40,068	310,244
16,483	52,331	295,958
1' 270	57,173	274,000
31,073	67,013	290,350
34,660	66,257	306,345
37,063	71,699	322,050

Five Year Payback Period, NPV at 20%, thousands of Rmeli shillings

Price per meter, production well

Number of Dry Wells	10,713	20,000	25,000	30,000	35,000	40,000	45,000	50,000
	2	(17,299)	16,956)	3,487	15,190	24,373	34,016	43,750
	3	(16,043)	15,251)	5,537	16,230	27,118	37,900	48,690
	4	111,671)	13,549)	7,500	18,725	29,862	41,000	52,137
	5	112,436)	1998)	10,660	22,319	33,977	45,125	57,291
	6	111,200)	395	12,711	24,716	36,721	48,727	60,712
	7	19,944)	2,609	14,761	27,114	39,466	51,819	64,172
	8	18,200)	4,112	16,812	29,511	42,211	54,911	67,611

Price per meter, non-production well

Proportion of non-production wells	10,713	0	5,000	10,000	15,000	20,000	25,000	30,000
	75%	8,000	16,970	25,132	33,294	41,456	49,617	57,779
	50%	8,987	13,994	19,001	24,167	29,254	34,346	39,437
	25%	9,001	11,009	14,970	17,964	20,925	23,943	26,922
	0%	9,101	9,101	9,101	9,101	9,101	9,101	9,101

Markup for price per meter, other wells

Number of Other Wells	10,713	10%	25%	50%	75%	100%
	0	199	1,003	2,400	3,906	5,322
	1	17,390	14,097	10,713	22,525	26,257
	2	24,222	27,040	32,991	39,934	45,976
	3	36,270	41,230	49,300	57,930	66,207
	4	47,700	54,031	64,569	75,187	85,444

Markup for price per meter, other wells

Increment to other wells	10,713	10%	25%	50%	75%	100%
	0	5,309	6,741	9,164	11,589	14,013
	1	17,390	14,097	10,713	22,525	26,257
	2	30,172	33,541	38,621	33,902	39,182
	3	27,482	31,490	38,164	44,947	54,326

I. 1984 Baseline Estimates

Annex I-1: Middle Level Estimates
- Level I Submodel
- Level II Submodel

ANNEX I-1: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

MIDDLE-LEVEL ESTIMATES OF 1984 POPULATION, RATES OF CONSUMPTION, AND NUMBERS OF WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS			PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION				
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL 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
SUBTOTAL 1	5350	persons					19683		17989		1695
ANIMAL											
Camels	5000	head	20	liters	365	1000	36500	60%	21900	40%	14600
Cattle	4000	head	20	liters	365	1000	29200	75%	21900	25%	7300
SheepGoats	27000	head	3	liters	365	1000	29565	70%	20696	30%	8870
OtherAn	10000	head	3	liters	365	1000	10950	5%	548	95%	10402
SUBTOTAL 2	12425	LSU					106215		65043		41172
AGRICULTURE											
Irrigfarm	55	hectares	68	cu.meters	365	1	1365100	80%	1092080	20%	273020
Rainfarm	600	hectares	35	cu.meters	120	1	2520000	1%	25200	99%	2494800
Floodfarm	120	hectares	25	cu.meters	90	1	270000	1%	2700	99%	267300
SUBTOTAL 3	775	hectares					4155100		1119980		3035120
GOVT/INDUS											
Govt	2	estabs	13	cu.meters	300	1	7800	100%	7800	0%	0
Industry	0.5	estabs	5	cu.meters	300	1	750	100%	750	0%	0
SUBTOTAL 4	2.5	estabs					8550		8550		0

Percentage Distribution of Consumption across the Range of Types of Water Control Structures

CONSUMPTION UNITS			VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER- VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN																
Urban HC	107	persons	2343	99%	2320	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%	100.00%
Urban SP	1230	persons	5387	97%	5226	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%	100.00%
Rural Set	1552	persons	5665	90%	5098	1.50%	12.75%	0.75%	0.00%	40.00%	15.00%	10.00%	5.00%	15.00%	0.00%	100.00%
Nomadic	2461	persons	6288	85%	5345	0.80%	8.70%	0.50%	0.00%	30.00%	20.00%	15.00%	15.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	5350	persons	19683		17989											
ANIMAL																
Camels	5000	head	36500	60%	21900	0.56%	6.09%	0.35%	0.00%	15.00%	25.00%	20.00%	28.00%	5.00%	0.00%	100.00%
Cattle	4000	head	29200	75%	21900	2.00%	7.50%	0.50%	0.00%	30.00%	20.00%	20.00%	15.00%	5.00%	0.00%	100.00%
SheepGoats	27000	head	29565	70%	20696	1.60%	6.00%	0.40%	0.00%	30.00%	20.00%	15.00%	20.00%	7.00%	0.00%	100.00%
OtherAn	10000	head	10950	5%	548	1.75%	4.90%	0.35%	0.00%	25.00%	20.00%	20.00%	23.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	12425	LSU	106215		65043											
AGRICULTURE																
Irrigfarm	55	hectares	1365100	80%	1092080	0.00%	0.00%	0.00%	2.50%	0.50%	90.00%	1.00%	1.00%	0.00%	5.00%	100.00%
Rainfarm	600	hectares	2520000	1%	25200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	120	hectares	270000	1%	2700	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	775	hectares	4155100		1119980											
GOVT/INDUS																
Govt	2	estabs	7800	100%	7800	87.30%	2.70%	0.00%	0.00%	5.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.5	estabs	750	100%	750	82.45%	2.55%	0.00%	0.00%	10.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.5	estabs	8550		8550											

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

CONSUMPTION UNITS			VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.*									
	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER- VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
HUMAN															
Urban HC	107	persons	2343	99%	2320	1624	0	0	0	232	232	116	0	116	0
Urban SP	1230	persons	5387	97%	5226	3658	0	0	0	523	523	261	0	261	0
Rural Set	1552	persons	5665	90%	5098	76	650	38	0	2039	765	510	255	765	0
Nomadic	2461	persons	6288	85%	5345	43	465	27	0	1603	1069	802	802	534	0
SUBTOTAL 1	5350	persons	19683		17989	5401	1115	65	0	4397	2588	1689	1057	1676	0
ANIMAL															
Camels	5000	head	36500	60%	21900	123	1334	77	0	3285	5475	4380	6132	1095	0
Cattle	4000	head	29200	75%	21900	438	1643	110	0	6570	4380	4380	3285	1095	0

AGRICULTURE																
Irrigfarm	55 hectares	1365100	80%	1092080	0.00%	0.00%	0.00%	2.50%	0.50%	90.00%	1.00%	1.00%	0.00%	5.00%	100.00%	
Rainfarm	600 hectares	2520000	1%	25200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	
Floodfarm	120 hectares	270000	1%	2700	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	
SUBTOTAL 3	775 hectares	4155100		1119980												
GOVT/INDUS																
Govt	2 estabs	7800	100%	7800	87.30%	2.70%	0.00%	0.00%	5.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%	
Industry	0.5 estabs	750	100%	750	82.45%	2.55%	0.00%	0.00%	10.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%	
SUBTOTAL 4	2.5 estabs	8550		8550												

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

CONSUMPTION UNITS — VOLUME CONSUMPTION — TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE

	(000s)	MEASURE	TOTAL M^3K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER-VOIRS	BALLEHS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
HUMAN															
Urban HC	107	persons	2343	99%	2320	1174	0	0	0	232	232	116	0	116	0
Urban SP	1230	persons	5387	97%	5226	3658	0	0	0	523	523	261	0	261	0
Rural Set	1552	persons	5665	90%	5098	76	650	36	0	2039	765	510	255	765	0
Nomadic	2461	persons	6288	85%	5345	43	465	27	0	1603	1069	802	802	534	0
SUBTOTAL 1	5350	persons	19683		17989	5401	1115	65	0	4397	2588	1689	1057	1676	0
ANIMAL															
Camels	5000	head	36500	60%	21900	123	1334	77	0	3285	5475	4380	6132	1095	0
Cattle	4000	head	29200	75%	21900	438	1643	110	0	6570	4380	4380	3285	1095	0
SheepGoats	27000	head	29565	70%	20696	331	1242	83	0	6209	4139	3104	4139	1449	0
OtherAn	10000	head	10950	5%	548	10	27	2	0	137	110	110	126	27	0
SUBTOTAL 2	12425	LSU	106215		65043	901	4245	271	0	16201	14104	11974	13682	3666	0
AGRICULTURE															
Irrigfarm	55	hectares	1365100	80%	1092080	0	0	0	27302	5460	982872	10921	10921	0	54604
Rainfarm	600	hectares	2520000	1%	25200	0	0	0	0	0	0	0	0	0	25200
Floodfarm	120	hectares	270000	1%	2700	0	0	0	0	0	0	0	0	0	2700
SUBTOTAL 3	775	hectares	4155100		1119980	0	0	0	27302	5460	982872	10921	10921	0	82504
GOVT/INDUS															
Govt	2	estabs	7800	100%	7800	6809	211	0	0	390	234	156	0	0	0
Industry	0.5	estabs	750	100%	750	618	19	0	0	75	23	15	0	0	0
SUBTOTAL 4	2.5	estabs	8550		8550	7428	230	0	0	465	257	171	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3K/YR)					1211562	13730	5590	336	27302	26523	999820	24754	25659	5343	82504
VOLUME OUTPUT:		(M^3K/str/yr)				110.7282	28.08801	2.752533	176.1419	1.560189	199.9640	1.375246	2.138286	0.534255	16.5058
		(days/yr)				365	280	365	120	365	250	120	90	60	60
		(M^3/str/day)				303	100	8	1468	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES						124	199	122	155	17000	5000	18000	12000	10000	5000
COMMERCIAL SCALE STRUCTURES						124	199	122	155	2500	5000	750	200	10000	100
USEFUL LIFE						10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						12	20	12	16	250	500	75	20	667	20

OTS-MD LEVEL III SUPPORT
MODEL 1-3
1984 WORLD PROJECTIONS

INPUTS	Measure	INPUTS: CONSTRUCTION — WELLS: Drilled Wells	D.P. Rural Bore-Wells	D.P. Rural Bore-Wells	Irrigation Wells	Hand Dug Wells	Hand Prod Wells	Tanks from Pro	OTHER STRUCTURES: Dams	Gullies	Bar-Rows	Roads	ANNUAL CONSTR INPUTS	REHABILITATION — WELLS: Drilled Wells	D.P. Rural Bore-Wells	DP Rural Bore-Wells	Irrigation wells	ANNUAL REHAB INPUTS	OF DRILLED WELLS: COST PER UNIT	D.P. RURAL BORE-WELLS	D.P. RURAL BORE-WELLS	TOTAL PHYSICAL OUTPUT.
GPD	Number of strc.	12	30	13	16	250	16	500	75	20	667	20										
GL	Years	10	10	15	10	10		15	10	10	15	5							EXCHANGE RATE USE IN $			FOR ALL TYPES OF ACTIVITIES
GDP	Years													10	10	10	10					
AGRI	Number of strc.													0	0	0	0					
MATERIALS																						
Cement per st	cubic meters	200	200	2	200	7	0.5	4	0	0	3	0		60	60	2.1	60		444.00			
Annual cement	cubic meters	2400	1900	02	3100	1750	8	2000	0	0	3000	0	15403	0	0	0	0	0		0177	00	22153
Stones per st	cubic meters					16		10	0	0	7	640							25.98			
Annual stones	cubic meters					8000		5000	0	0	4667	12800	26467									40067
Gravel per st	cubic meters	25	25	5	25									16.5	16.5	1.5	16.5		434.30			
Annual gravel	cubic meters	434	647	61	543								1734	0	0	0	0	0		024	00	1734
Sand per st	cubic meters	120	120	2	120	3					2	0		36	36	0.6	36		42.90			
Annual Sand	cubic meters	1400	1300	24	1060	500					1333	0	7594	0	0	0	0	0		07	00	7594
8" Steel Casing per st	meters	75	75	30	30		20												475.60			
Ann.8"Steel Casing	meters	930	1093	610	373		317						4130							0121	00	4130
8"Steel Screen per st	meters	43	45	30	30														1163.60			
Ann.Steel Screen	meters	520	096	344	443								2205							015	00	2205
Concrete casing per st	meters	6	6	6	6		6												1144.00			
Ann.concrete casing	meters	74	119	73	93		94						434							022	00	434
Shelter per st	units	1	1	0.2	0.2	0.1					0.5											
Annual Shelter	units	12	30	2	3	25					333		396									
Pipefittings per st	meters	200	200	0	200	0		15			10			60	60	0	60		130.00			
Annual Pipefittings	meters	2400	2900	0	3100	0		7500			6667		31277	0	0	0	0	0		0119	00	42186
Drilling Fluid per st	units	24	24	16	16		3							0	0	0	0		417.10			
Annual Drilling Fluid	units	296	470	175	240		70						1296	0	0	0	0	0		09	00	1296
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.08							0	0	0	0		12,200			
Annual Drill Bits	units	1.5	2.4	1.0	1.3		1.3						7	0	0	0	0	0		09	00	7
Hand Pump per st	units			1		0.2										1			47,400			
Annual Hand Pumps	units			12		30							63			0		0		00	00	110
Diesel Pump per st	units	1	1		1			1						1	1		1		121,400			
Annual Diesel Pumps	units	12	20		16			200					348	0	0		0	0		1110	00	548
Rotary & Hand per st	meters	30	30		15						20			9	9	0	3.0		425.71			
Annual Rotar&Hand	meters	372	597		202						13333		14504	0	0	0	0	0		221	00	14504
Plastic Sheet per st	sq.meters								104	1300												
Annual Plastic sheets	sq.meters								7800	10000			17800									25600
LABOUR																						
Skilled																						
Supervisory per St.	man-days	10	10	4	4		5												25.98			
Annual Supervisory	man-days	124	199	73	93		70						567					0		01	00	24287
Drilling per St.	man-days	75	30	17	17		14							18	13	12	12		25.95			
Annual Drilling	man-days	310	298	707	264		210						1277	0	0	0	0	0		03	00	1277
Excavation per st.	man-days					0.4			18	18	30	30							23.06			
Annual Exca.Dri	man-days					1600			750	300	20000	600	23130					0		90	00	70123
Civil Dri.per st.	man-days	50	36	10	10	5		1.2	0.5	1.5	15	30		18	13	12	12		27.36			
Annual Civil Dri.	man-days	620	716	220	273	1250		600	30	30	10000	600	11546	0	0	0	0	0		04	00	11524
Mech.Dri per st.	man-days	70	13	6	6	0.6		3			3								23.27			
Ann.Mechanic Dri.	man-days	248	239	73	93	150		2500			2000		5343					0		11	00	125007
Carp.Dri per st.	man-days	5	2	2	2														12.90			
Ann.Carpentry Dri.	man-days	62	40	24	31								157					0		00	00	157
Unskilled																						
Drilling per St.	man-days	140	240	200	200		150							54	45	36	36		12.00			
Annual Drilling	man-days	1730	4776	2400	3100		2100						16376	0	0	0	0	0		012	00	16376
Excavation per st.	man-days					0.4					3								12.00			
Annual Exca.Dri	man-days					1600					2000		3600					0		00	00	3200
Civil.Dri per st.	man-days	300	216	36	173	5		2	0.5	1.5	15	90		36	30	24	24		12.00			
Ann.Civil Dri.	man-days	3720	4290	439	2713	1250		1000	30	30	10000	1800	21260	0	0	0	0	0		09	00	21260
Mech.Dri. per st	man-days	30	12	3.6	3	3.6		12			6								12.00			
Ann.Mechanic Dri.	man-days	248	239	44	124	900		6000			4000		11755					0		00	00	11755
Other Unskilled per st.	man-days													36	30	24	24		11.30			
Annual Other Unskilled	man-days												0	0	0	0	0	0		00	00	0
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	24	20	18		10							18	12	12	12		7750			
Annual Drill Rigs Use	Eq-days	372	570	204	279		156						1529	0	0	0	0	0		0125	00	1529
Pump Rigs per st	Eq-days	1	1	2	2		1												973			
Annual Pump Rigs use	Eq-days	12	40	24	31		16						140					0		06	00	4400
Heavy Vehicles per st	Eq-days	223	140	70	95	10	25	1	10	10	8	30		18	13	12	12		900			
Annual Heavy Vehcl Use	Eq-days	2765	3343	854	490	2500	546	1000	750	300	5333	600	18509	0	0	0	0	0		0106	00	67979
Light Vehicles per st	Eq-days	790	240	130	100	10	30	1	5	12	4	30		18	13	12	12		130			
Annual Light Vhcls Use	Eq-days	3100	4776	1464	1530	2500	624	1200	375	240	2667	600	17796	0	0	0	0	0		0170	00	154000
FUEL CONSUMPTION																						
Drill Rigs per st	Litere	7500	3600	3000	2700		1200							900	750	600	600		00.60			
Annual Drill Rigs Fuel	Litere	25000	71400	36000			18720						152760	0	0	0	0	0		047	00	152760
Pump Rigs per st	Litere	336	336	276	276		112												00.60			
Annual Pump Rigs Fuel	Litere	4166	6686	2712	3472		1747						18005					0		04	00	18005
Heavy Vehicles per st	Litere	9720	6720	3000	1800	600	1000	80	600	600	320	1200		630	525	420	420		00.60			
Annual Heavy Vhcl Fuel	Litere	118800	112728	36360	27900	100000	21000	40000	30000	8000	213333	24000	712260	0	0	0	0	0		000	00	742260
Light Vehicles per st	Litere	6490	3840	2100	1300	200	1050	60	300	300	200	900		300	300	240	240		00.71			
Annual Light Vhcl Fuel	Litere	82906	104976	25620	30925	25000	16320	30000	12500	6000	160000	18000	557677	0	0	0	0	0		070	00	557677
																		TOTAL 1000cl		11,073	00	
																		3 WELL		0,322		

MISWS LEVEL III SUBMODEL
SHEET I-1
1984 MIDDLE PROJECTIONS

INPUTS	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Dams	Ballehs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.F Rural Bore-dells	H.P Rural Bore-Wells	Irrig-atica Wells	ANNUAL OPER. INPUTS	COST PER UNIT	D.P. RURAL WELLS TOTAL: MAINT. COST US$(000s)	OPER. COST US$(000s)	PHYSICAL QUANT.
MP	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1							EXCHANGE RATE SDSM/US$ 34			FOR ALL ACTI-VITIES
NWR	Number of struc.	496	796	122	620	2500	20000	750	200	10000	100										
NWOR	Number of Struc.												124	199	122	155					
MATERIALS																					
Cement per st	cubic meters					0.7	0.1	0	0	0.3	0							$44.40			
Annual cement	cubic meters					1750	2000	0	0	3000	0	6750							$0	$0	
Stones per st	cubic meters					1.6	0.25	0	0	0.7	64							$5.95			
Annual stones	cubic meters					4000	5000	0	0	7000	6400	22400							$0	$0	
Sand per st	cubic meters					0.2	0	0	0	0.2	0							$2.98			
Annual Sand	cubic meters									2000	0	2000							$0	$0	
Pipe&Fittings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0							$30.00			
Annual Pipe&Fittings	meters	248	398	0	310	0	7500			10000		18459							$12	$0	
Hand Pump per st	units			0.09		0.018												$2,000			
Annual Hand Pumps	units			11		45						56							$0	$0	
Diesel Pump per st	units	0.015	0.015		0.015		0.015		0	0	0							$21,000			
Annual Diesel Pumps	units	7	12		9		300					329							$251	$0	
Rebars & Wood per st	meters						0	0	0	2	0							$35.71			
Annual Rebars&Wood	meters									20000		20000							$0	$0	
Plastic Sheet per st	sq.meters						0	10.4	150	0	0										
Annual Plastic sheets	sq.meters							7800	30000			37800									
LABOUR																					
Skilled:																					
Supervisory per St.	man-days	1.075	1.075	1.3	1.075		1.075											$5.95			
Annual Supervisory	man-days	533	856	159	667		21500					23720							$5	$0	
Excavation per st.	man-days						0	1	1	3	3							$5.95			
Annual Excav.Wrks	man-days							750	200	30000	300	54972							$0	$0	
Civil Wrks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3							$5.06			
Annual Civil Wrks.	man-days					1250	600	38	30	15000	300	17218							$0	$0	
Mech.Wrks per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36			
Ana.Mechanic Wrks.	man-days	3199	5134	952	3999	5300	129000			3000		150584							$28	$0	504
Other Skilled per st	man-days												745	799	745	170		$2.38			

Ann.Mechanic Wrks.	man-days	3199	5134	952	3999	5300	129000			3000		150584							$28	$0	504
Other Skilled per st.	man-days												365	280	365	120		$2.38			
Annual Other Skilled	man-days											0	45260	55720	44530	18400	164110		$0	$133	164110
Unskilled:																					
Excavation per st.	man-days					0.64	0	0	0	0.3	0							$2.08			
Annual Excav.Wrks	man-days					1600				3000		4600							$0	$0	
Civil.Wrks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9							$2.08			
Ann.Civil Wrks.	man-days					1250	1000	38	30	15000	900	18218							$0	$0	
Mech.Wrks. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							$2.08			
Ann.Mechanic Wrks.	man-days	3199	5134	952	3999	1800	129000			6000		150084							$11	$0	
EQUIPMENT																					
Drill Rigs per st	Eq-days																	$256			
Annual Drill Rigs Use	Eq-days											0							$0	$0	
Pump Rigs per st	Eq-days	0.075	0.075	0.3	0.075		0.225											$92			
Annual Pump Rigs Use	Eq-days	37	60	37	47		4500					4680							$5	$0	
Heavy Vehicles per st	Eq-days					2	2	3	9		3							$81			
Annual Heavy Vehcl Use	Eq-days					5000	40000	2250	1800		300	49350							$0	$0	
Light Vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3							$39			
Annual Light Vhcls Use	Eq-days	1600	2567	476	2000	20000	64500	2250	1800	30000	300	125492							$98	$0	
Diesel Pump per st.	Eq-days												365	280		120		$14			
Annual Diesel Pumps	Eq-days											0	45260	55720		18400	119580		$0	$807	119580
Hand Pump per st.	Eq-days														365			$1.18			
Annual Hand Pumps	Eq-days											0			44530		44530		$0	$0	44530
FUEL CONSUMPTION																					
Drill Rigs per st	Liters																	$0.60			
Annual Drill Rigs Fuel	Liters											234038							$0	$0	
Pump Rigs per st	Liters	3.75	3.75	15	3.75		11.25											$0.60			
Annual Pump Rigs Fuel	Liters	1860	2985	1830	2325		225000					234000							$2	$0	
Heavy Vehicles per st	Liters					80	80	120	360	0	120							$0.60			
Annual Heavy Vhcl Fuel	Liters					200000	1600000	90000	72000		12000	1974000							$0	$0	
Light Vehicles per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60							$0.71			
Annual Light Vhcls Fuel	Liters	31992	51342	9516	39990	40000	1290000	45000	36000	600000	6000	2509840							$36	$0	
Diesel per Pump	Liters												13140	4200	0	3000		$0.60			
Annual Diesel	Liters											0	1629360	835800	0	465000	2930160		$0	$501	2930160
																	TOTAL (000s)		$448	$1,441	
																	PER WELL/YEAR		$2,249	$7,242	
																	TOTAL O & M (000s)			$1,889	
																	O&M PER M^3 WATER			28.38367	

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I. 1984 Baseline Estimates

Annex I-2: Low Estimates
- Level I Submodel

ANNEX I-2: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

LOW ESTIMATES OF 1984 POPULATION, RATES OF CONSUMPTION, AND NUMBERS OF WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS		PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION				
	(000s) MEASURE	DAILY USE FACTOR MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL 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
SUBTOTAL 1	5000 persons				14089		12895		1194
ANIMAL									
Camels	4000 head	18 liters	365	1000	26280	60%	15768	40%	10512
Cattle	3800 head	18 liters	365	1000	24966	75%	18725	25%	6242
SheepGoats	25000 head	2.5 liters	365	1000	22813	70%	15969	30%	6844
OtherAn	8000 head	2.5 liters	365	1000	7300	5%	365	95%	6935
SUBTOTAL 2	10785 LSU				81359		50826		30532
AGRICULTURE									
Irrigfarm	45 hectares	68 cu.meters	365	1	1116900	80%	893520	20%	223380
Rainfarm	540 hectares	35 cu.meters	120	1	2268000	1%	22680	99%	2245320
Floodfarm	100 hectares	25 cu.meters	90	1	225000	1%	2250	99%	222750
SUBTOTAL 3	685 hectares				3609900		918450		2691450
GOVT/INDUS									
Govt	2 estabs	10 cu.meters	300	1	6000	100%	6000	0%	0
Industry	0.3 estabs	5 cu.meters	300	1	450	100%	450	0%	0
SUBTOTAL 4	2.3 estabs				6450		6450		0

Percentage Distribution of Consumption across the Range of Types of Water Control Structures

CONSUMPTION UNITS		VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN															
Urban HC	100 persons	1460	99%	1445	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%	100.00%
Urban SP	1150 persons	4198	97%	4072	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%	100.00%
Rural Set	1450 persons	4234	90%	3811	1.50%	12.75%	0.75%	0.00%	40.00%	15.00%	10.00%	5.00%	15.00%	0.00%	100.00%
Nomadic	2300 persons	4198	85%	3568	0.80%	8.70%	0.50%	0.00%	30.00%	20.00%	15.00%	15.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	5000 persons	14089		12895											
ANIMAL															
Camels	4000 head	26280	60%	15768	0.56%	6.09%	0.35%	0.00%	15.00%	25.00%	20.00%	28.00%	5.00%	0.00%	100.00%
Cattle	3800 head	24966	75%	18725	2.00%	7.50%	0.50%	0.00%	30.00%	20.00%	20.00%	15.00%	5.00%	0.00%	100.00%
SheepGoats	25000 head	22813	70%	15969	1.60%	6.00%	0.40%	0.00%	30.00%	20.00%	15.00%	20.00%	7.00%	0.00%	100.00%
OtherAn	8000 head	7300	5%	365	1.75%	4.90%	0.35%	0.00%	25.00%	20.00%	20.00%	23.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	10785 LSU	81359		50826											
AGRICULTURE															
Irrigfarm	45 hectares	1116900	80%	893520	0.00%	0.00%	0.00%	2.50%	0.50%	90.00%	1.00%	1.00%	[illegible] 00%	5.00%	100.00%
Rainfarm	540 hectares	2268000	1%	22680	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	[illegible] 00%	100.00%	100.00%
Floodfarm	100 hectares	225000	1%	2250	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	685 hectares	3609900		918450											
GOVT/INDUS															
Govt	2 estabs	6000	100%	6000	87.30%	2.70%	0.00%	0.00%	5.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.3 estabs	450	100%	450	82.45%	2.55%	0.00%	0.00%	10.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.3 estabs	6450		6450											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
HUMAN														
Urban HC	100 persons	1460	99%	1445	1012	0	0	0	145	145	72	0	72	0
Urban SP	1150 persons	4198	97%	4072	2850	0	0	0	407	407	204	0	204	0
Rural Set	1450 persons	4234	90%	3811	57	486	29	0	1524	572	381	191	572	0
Nomadic	2300 persons	4198	85%	3568	29	310	18	0	1070	714	535	535	357	0
SUBTOTAL 1	5000 persons	14089		12895	3948	796	46	0	3146	1837	1192	726	1204	0

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AGRICULTURE															
Irrigfarm	45 hectares	1116900	80%	893520	0.00%	0.00%	0.00%	2.50%	0.50%	90.00%	1.00%	1.00%	0.00%	5.00%	100.00%
Rainfarm	540 hectares	2268000	1%	22680	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	100 hectares	225000	1%	2250	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	685 hectares	3609900		918450											
GOVT/INDUS															
Govt	2 estabs	6000	100%	6000	87.30%	2.70%	0.00%	0.00%	5.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.3 estabs	450	100%	450	82.45%	2.55%	0.00%	0.00%	10.00%	3.00%	2.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.3 estabs	6450		6450											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.*				TOTAL DISTRIBUTION OF WATER BY STRUCTURE					
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS OP RURAL BOREWELL	DRILLED WELLS MP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER- VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIK
HUMAN														
Urban HC	100 persons	1460	99%	1445	1012	0	0	0	145	145	72	0	72	0
Urban SP	1150 persons	4198	97%	4072	2850	0	0	0	407	407	204	0	204	0
Rural Set	1450 persons	4234	90%	3811	57	486	29	0	1524	572	381	191	572	0
Nomadic	2300 persons	4198	85%	3568	29	310	18	0	1070	714	535	535	357	0
SUBTOTAL 1	5000 persons	14089		12895	3948	796	46	0	3146	1837	1192	726	1204	0
ANIMAL														
Camels	4000 head	26280	60%	15768	88	960	55	0	2365	3942	3154	4415	788	0
Cattle	3800 head	24966	75%	18725	374	1404	94	0	5617	3745	3745	2809	936	0
SheepGoats	25000 head	22813	70%	15969	256	956	64	0	4791	3194	2395	3194	1116	0
OtherAn	8000 head	7300	5%	365	6	18	1	0	91	73	73	84	16	0
SUBTOTAL 2	10785 LSU	81359		50826	725	3341	214	0	12864	10954	9367	10501	2861	0
AGRICULTURE														
Irrigfarm	45 hectares	1116900	80%	893520	0	0	0	22338	4468	80416B	8935	8935	0	44670
Rainfarm	540 hectares	2268000	1%	22680	0	0	0	0	0	0	0	0	0	22680
Floodfarm	100 hectares	225000	1%	2250	0	0	0	0	0	0	0	0	0	2250
SUBTOTAL 3	685 hectares	3609900		918450	0	0	0	22338	4468	80416B	8935	8935	0	69600
GOVT/INDUS														
Govt	2 estabs	6000	100%	6000	5238	162	0	0	300	180	120	0	0	0
Industry	0.3 estabs	450	100%	450	371	11	0	0	45	14	9	0	0	0
SUBTOTAL 4	2.3 estabs	6450		6450	5609	173	0	0	345	194	129	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)				988622	10281	4310	260	22338	20823	817152	19623	20162	4065	69600
VOLUME OUTPUT:	(M^3*K/str/yr)				99.81832	25.96596	2.552763	173.1627	2.082332	326.8608	1.308206	2.016232	0.541988	27.8424
	(days/yr)				365	280	365	120	365	250	120	90	60	60
	(M^3/str/day)				273	93	7	1443	6	1307	11	22	9	464
NUMBERS OF WATER SUPPLY STRUCTURES					103	166	102	129	10000	2500	15000	10000	7500	2500
COMMERCIAL SCALE STRUCTURES					103	166	102	129	1250	2500	500	100	7500	50
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					10	17	10	13	125	250	50	10	500	10

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I. 1984 Baseline Estimates

Annex I-3: High Estimates
- Level I Submodel

ANNEX I-3: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

HIGH ESTIMATES OF 1984 POPULATION, RATES OF CONSUMPTION, AND NUMBERS OF WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS		PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION				
	(000s) MEASURE	DAILY USE FACTOR MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL VOLUME
HUMAN									
Urban HC	130 persons	80 liters	365	1000	3796	99%	3758	1%	38
Urban SP	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
SUBTOTAL 1	6885 persons				30631		28078		2553
ANIMAL									
Camels	6000 head	25 liters	365	1000	54750	60%	32850	40%	21900
Cattle	4200 head	25 liters	365	1000	38325	75%	28744	25%	9581
SheepGoats	30000 head	3 liters	365	1000	32850	70%	22995	30%	9855
OtherAn	10000 head	3 liters	365	1000	10950	5%	548	95%	10403
SUBTOTAL 2	13940 LSU				136875		85136		51739
AGRICULTURE									
Irrigfarm	65 hectares	68 cu.meters	365	1	1613300	80%	1290640	20%	322660
Rainfarm	978 hectares	35 cu.meters	120	1	4107600	1%	41076	99%	4066524
Floodfarm	54 hectares	25 cu.meters	90	1	121500	1%	1215	99%	120285
SUBTOTAL 3	1097 hectares				5842400		1332931		4509469
GOVT/INDUS									
Govt	2 estabs	21 cu.meters	300	1	12600	100%	12600	0%	0
Industry	0.5 estabs	8 cu.meters	300	1	1200	100%	1200	0%	0
SUBTOTAL 4	2.5 estabs				13800		13800		0

Percentage Distribution of Consumption across the Range of Types of Water Control Structures

CONSUMPTION UNITS		VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION									
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLEHS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
HUMAN														
Urban HC	130 persons	3796	99%	3758	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%
Urban SP	1620 persons	8870	97%	8603	70.00%	0.00%	0.00%	0.00%	10.00%	10.00%	5.00%	0.00%	5.00%	0.00%
Rural Set	2035 persons	8913	90%	8022	1.50%	12.75%	0.75%	0.00%	40.00%	15.00%	10.00%	5.00%	15.00%	0.00%
Nomadic	3100 persons	9052	85%	7694	0.80%	8.70%	0.50%	0.00%	30.00%	20.00%	15.00%	15.00%	10.00%	0.00%
SUBTOTAL 1	6885 persons	30631		28078										
ANIMAL														
Camels	6000 head	54750	60%	32850	0.56%	6.09%	0.35%	0.00%	15.00%	25.00%	20.00%	20.00%	5.00%	0.00%
Cattle	4200 head	38325	75%	28744	2.00%	7.50%	0.50%	0.00%	30.00%	20.00%	20.00%	15.00%	5.00%	0.00%
SheepGoats	30000 head	32850	70%	22995	1.60%	6.00%	0.40%	0.00%	30.00%	20.00%	15.00%	20.00%	7.00%	0.00%
OtherAn	10000 head	10950	5%	548	1.75%	4.90%	0.35%	0.00%	25.00%	20.00%	20.00%	23.00%	5.00%	0.00%
SUBTOTAL 2	13940 LSU	136875		85136										
AGRICULTURE														
Irrigfarm	65 hectares	1613300	80%	1290640	0.00%	0.00%	0.00%	2.00%	0.50%	90.00%	1.00%	1.00%	0.00%	5.50%
Rainfarm	978 hectares	4107600	1%	41076	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Floodfarm	54 hectares	121500	1%	1215	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 3	1097 hectares	5842400		1332931										
GOVT/INDUS														
Govt	2 estabs	12600	100%	12600	77.30%	2.70%	0.00%	0.00%	10.00%	5.00%	5.00%	0.00%	0.00%	0.00
Industry	0.5 estabs	1200	100%	1200	72.45%	2.55%	0.00%	0.00%	15.00%	5.00%	5.00%	0.00%	0.00%	0.00
SUBTOTAL 4	2.5 estabs	13800		13800										

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLEHS/ PONDS	BURKEDS/ CISTERNS	EAR DAMS/I
HUMAN														
Urban HC	130 persons	3796	99%	3758	2631	0	0	0	376	376	188	0	188	
Urban SP	1620 persons	8870	97%	8603	6022	0	0	0	860	860	430	0	430	
Rural Set	2035 persons	8913	90%	8022	120	1023	60	0	3209	1203	802	401	1203	
Nomadic	3100 persons	9052	85%	7694	62	669	38	0	2308	1539	1154	1154	769	
SUBTOTAL 1	6885 persons	30631		28078	8835	1692	99	0	6753	3978	2574	1555	2591	

SUBTOTAL 3	1097 hectares	5842400		1332931											
GOVT/INDUS															
Govt	2 estabs	12600	100%	12600	77.30%	2.70%	0.00%	0.00%	10.00%	5.00%	5.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.5 estabs	1200	100%	1200	72.45%	2.55%	0.00%	0.00%	15.00%	5.00%	5.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.5 estabs	13800		13800											

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

CONSUMPTION UNITS — VOLUME CONSUMPTION — TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE

	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG * WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV
HUMAN															
Urban MC	130	persons	3796	99%	3758	2631	0	0	0	376	376	188	0	188	0
Urban SP	1620	persons	8870	97%	8603	6022	0	0	0	860	860	430	0	430	0
Rural Set	2035	persons	8913	90%	8022	120	1023	60	0	3209	1203	802	401	1203	0
Nomadic	3100	persons	9052	85%	7694	62	669	38	0	2308	1539	1154	1154	769	0
SUBTOTAL 1	6885	persons	30631		28078	8835	1692	99	0	6753	3978	2574	1555	2591	0
ANIMAL															
Camels	6000	head	54750	60%	32850	184	2001	115	0	4928	8213	6570	9198	1643	0
Cattle	4200	head	38325	75%	28744	575	2156	144	0	8623	5749	5749	4312	1437	0
SheepGoats	30000	head	32850	70%	22995	368	1380	92	0	6899	4599	3449	4599	1610	0
OtherAn	10000	head	10950	5%	548	10	27	2	0	137	110	110	126	27	0
SUBTOTAL 2	13940	LSU	136875		85136	1136	5563	353	0	20586	18670	15878	18234	4717	0
AGRICULTURE															
Irrigfarm	65	hectares	1613300	80%	1290640	0	0	0	25813	6453	1161576	12906	12906	0	70985
Rainfarm	978	hectares	4107600	1%	41076	0	0	0	0	0	0	0	0	0	4107[illegible]
Floodfarm	54	hectares	121500	1%	1215	0	0	0	0	0	0	0	0	0	1215
SUBTOTAL 3	1097	hectares	5842400		1332931	0	0	0	25813	6453	1161576	12906	12906	0	[illegible]1327[illegible]
GOVT/INDUS															
Govt	2	estabs	12600	100%	12600	9740	340	0	0	1260	630	630	0	0	0
Industry	0.5	estabs	1200	100%	1200	869	31	0	0	180	60	60	0	0	0
SUBTOTAL 4	2.5	estabs	13800		13800	10609	371	0	0	1440	690	690	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1459945	20580	7626	451	25813	35232	1184914	32048	32696	7308	11327[illegible]
VOLUME OUTPUT:		(M^3*K/str/yr)				142.9197	32.87013	3.155425	142.6121	1.468016	157.9885	1.526109	2.335436	0.487166	15.10349
		(days/yr)				365	280	365	120	365	250	120	90	60	60
		(M^3/str/day)				392	117	9	1188	4	632	13	26	8	252
NUMBERS OF WATER SUPPLY STRUCTURES						144	232	143	181	24000	7500	21000	14000	15000	7500
COMMERCIAL SCALE STRUCTURES						144	232	143	181	4000	7500	1050	280	15000	150
USEFUL LIFE						10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						14	23	14	18	400	750	105	28	1000	30

51W

- 1990 Projections/Forecasts

  Annex I-4: Middle Level Projections
  - Level I Submodel
  - Level II Submodel
  - Level III Submodel

ANNEX I-4: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

MIDDLE-LEVEL PROJECTION OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS			PER UNIT CONS'N FACTORS				VOLUME CONSUMPTION				
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL 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
SUBTOTAL 1	6351	persons					40858		38995		1863
ANIMAL											
Camels	5308	head	25	liters	365	1000	48436	65%	31483	35%	16952
Cattle	4246	head	25	liters	365	1000	38745	80%	30996	20%	7749
SheepGoats	28661	head	3	liters	365	1000	31384	75%	23538	25%	7846
OtherAn	10615	head	3	liters	365	1000	11623	5%	581	95%	11042
SUBTOTAL 2	13190	LSU					130187		86598		43590
AGRICULTURE											
Irrigfarm	64	hectares	68	cu.meters	365	1	1588480	85%	1350208	15%	238272
Rainfarm	804	hectares	35	cu.meters	120	1	3376800	2%	67536	98%	3309264
Floodfarm	161	hectares	25	cu.meters	90	1	362250	2%	7245	98%	355005
SUBTOTAL 3	1029	hectares					5327530		1424989		3902541
GOVT/INDUS											
Govt	2	estabs	13	cu.meters	300	1	7800	100%	7800	0%	0
Industry	0.73	estabs	8	cu.meters	300	1	1752	100%	1752	0%	0
SUBTOTAL 4	2.73	estabs					9552		9552		0

* * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * *

CONSUMPTION UNITS			VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * * PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT	DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN																
Urban HC	174	persons	6351	99%	6287	75.00%	0.00%	0.00%	0.00%	10.00%	10.00%	2.00%	0.00%	3.00%	0.00%	100.00%
Urban SP	1567	persons	14299	98%	14013	75.00%	0.00%	0.00%	0.00%	10.00%	10.00%	2.00%	0.00%	3.00%	0.00%	100.00%
Rural Set	1853	persons	10145	95%	9638	2.00%	17.40%	0.60%	0.00%	45.00%	15.00%	5.00%	2.00%	13.00%	0.00%	100.00%
Nomadic	2757	persons	10063	90%	9057	1.20%	13.20%	0.60%	0.00%	35.00%	20.00%	10.00%	10.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	6351	persons	40858		38995											
ANIMAL																
Camels	5308	head	48436	65%	31483	0.80%	8.80%	0.40%	0.00%	20.00%	20.00%	20.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4246	head	38745	80%	30996	3.00%	11.40%	0.60%	0.00%	35.00%	15.00%	20.00%	10.00%	5.00%	0.00%	100.00%
SheepGoats	28661	head	31384	75%	23538	2.00%	7.60%	0.40%	0.00%	35.00%	17.00%	15.00%	16.00%	7.00%	0.00%	100.00%
OtherAn	10615	head	11623	5%	581	2.00%	5.68%	0.32%	0.00%	30.00%	17.00%	20.00%	20.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	13190	LSU	130187		86598											
AGRICULTURE																
Irrigfarm	64	hectares	1588480	85%	1350208	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%
Rainfarm	804	hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	106.00%	100.00%
Floodfarm	161	hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1029	hectares	5327530		1424989											
GOVT/INDUS																
Govt	2	estabs	7800	100%	7800	90.16%	1.84%	0.00%	0.00%	5.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.73	estabs	1752	100%	1752	85.26%	1.74%	0.00%	0.00%	10.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.73	estabs	9552		9552											

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

CONSUMPTION UNITS			VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DAMS/ RESER-VOIRS M^3*K/YR	BALLENS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN															
Urban HC	174	persons	6351	99%	6287	4716	0	0	0	629	629	126	0	189	0
Urban SP	1567	persons	14299	98%	14013	10510	0	0	0	1401	1401	280	0	420	0
Rural Set	1853	persons	10145	95%	9638	193	1677	58	0	4337	1446	482	193	1253	0
Nomadic	2757	persons	10063	90%	9057	109	1195	54	0	3170	1811	906	906	906	0
SUBTOTAL 1	6351	persons	40858		38995	15527	2872	112	0	9537	5287	1794	1098	2768	0
ANIMAL															

Irrigfarm	64 hectares	1588480	85%	1350208	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%
Rainfarm	804 hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	161 hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1029 hectares	5327530		1424989											
GOVT/INDUS															
Govt	2 estabs	7800	100%	7800	90.16%	1.84%	0.00%	0.00%	5.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.73 estabs	1752	100%	1752	85.26%	1.74%	0.00%	0.00%	10.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.73 estabs	9552		9552											

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

CONSUMPTION UNITS	(000s) MEASURE	VOLUME CONSUMPTION TOTAL M^3*K/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3*K/YR	TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE: DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DAMS/ RESER-VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEOS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	174 persons	6351	99%	6287	4716	0	0	0	629	629	126	0	189	0
Urban SP	1567 persons	14299	98%	14013	10510	0	0	0	1401	1401	280	0	420	0
Rural Set	1853 persons	10145	95%	9638	193	1677	58	0	4337	1446	482	193	1253	0
Nomadic	2757 persons	10063	90%	9057	109	1195	54	0	3170	1811	906	906	906	0
SUBTOTAL 1	6351 persons	40858		38995	15527	2872	112	0	9537	5287	1794	1098	2768	0
ANIMAL														
Camels	5308 head	48436	65%	31483	252	2771	126	0	4297	6297	6297	7871	1574	0
Cattle	4246 head	38745	80%	30996	930	3534	186	0	10649	4649	6199	3100	1550	0
SheepGoats	28661 head	31384	75%	23538	471	1789	94	0	8238	4001	3531	3766	1648	0
OtherAn	10615 head	11623	5%	581	12	33	2	0	174	99	116	116	29	0
SUBTOTAL 2	13190 LSU	130187		86598	1664	8126	406	0	25558	15046	16143	14853	4801	0
AGRICULTURE														
Irrigfarm	64 hectares	1588480	85%	1350208	0	0	0	40506	13502	1215187	13502	13502	0	54006
Rainfarm	804 hectares	3376800	2%	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161 hectares	362250	2%	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029 hectares	5327530		1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS														
Govt	2 estabs	7800	100%	7800	7032	144	0	0	390	234	0	0	0	0
Industry	0.73 estabs	1752	100%	1752	1494	30	0	0	175	53	0	0	0	0
SUBTOTAL 4	2.73 estabs	9552		9552	8526	174	0	0	565	287	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)				1560134	25717	11172	520	40506	49162	1235867	31438	29453	7566	128789
VOLUME OUTPUT:	(M^3*K/str/yr)				110.7282	28.08801	2.752533	176.1419	1.560189	199.9640	1.375246	2.138286	0.534255	16.5006
	(days/yr)				365	280	365	120	365	250	120	90	60	60
	(M^3/str/day)				303	100	8	1466	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES					232	398	189	230	31510	6180	22860	13774	14166	7825
COMMERCIAL SCALE STRUCTURES					232	398	189	230	4634	6180	953	230	14166	156
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					23	40	19	23	463	618	95	23	944	31

ANNEX I-4 WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

* * * Projections of Requirements for New Water Supply Structures for Somalia 1980 - 1990, at Prevailing Useful Life * * *

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Growth Rate F.A. 84-90
URBAN WELLS												
Needed Total	56	74	107	123	124	138	153	170	188	209	232	11.0295%
Old	51	46	41	36	31	25	20	15	10	5	0	
(Previous)		5	28	64	81	85	104	122	142	164	188	
Needed New or Rehab	5	23	39	24	12	27	29	32	36	40	45	
DP RURAL BOREHOLES												
Needed Total	120	142	159	177	199	223	251	281	316	354	398	12.2373%
Old	107	96	86	75	64	53	43	32	21	11	0	
(Previous)		13	44	69	95	125	157	192	230	271	317	
Needed New or Rehab	13	32	29	34	40	45	51	57	64	72	81	
HP RURAL BOREHOLES												
Needed Total	99	105	110	115	122	131	141	152	163	176	189	7.6247%
Old	92	83	74	64	55	46	37	28	18	9	0	
(Previous)		7	22	34	47	62	79	96	114	133	153	
Needed New or Rehab	7	16	14	17	19	23	25	28	30	33	36	
IRRIGATION WELLS												
Needed Total	91	102	123	141	155	166	177	189	202	215	230	6.7794%
Old	75	68	60	53	45	38	30	23	15	8	0	
(Previous)		16	32	60	82	102	118	135	153	171	191	
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39	
HAND DUG WELLS												
Needed Total					2500	2771	3071	3404	3772	4181	4634	10.8325%
Old					2250	2025	1800	1575	1350	1125	900	
(Previous)						250	271	1199	1709	2251	2831	
Needed New					250	496	550	630	714	805	903	
INTAKES												
Needed Total					5000	5180	5366	5559	5759	5966	6180	3.5946%
Old					4500	4050	3600	3150	2700	2250	1800	
(Previous)						500	1080	1658	2243	2834	3432	
Needed New					500	630	686	751	816	881	948	
DAMS/RESERVOIRS												
Needed Total					750	760	812	845	880	915	953	4.0641%
Old					675	608	540	473	405	338	270	
(Previous)						75	165	256	347	440	534	
Needed New					75	98	107	117	127	138	149	
BALLENS/PONDS												
Needed Total					200	205	209	214	219	224	230	2.3248%
Old					180	162	144	126	108	90	72	
(Previous)						20	41	61	82	103	124	
Needed New					20	23	25	27	29	31	34	
BURKEDS/CISTERNS												
Needed Total					10000	10598	11231	11902	12613	13367	14166	5.9761%
Old					9333	8711	8089	7466	6844	6222	5600	
(Previous)						667	1842	3020	4234	5487	6779	
Needed New					667	1220	1300	1416	1535	1658	1787	
DAMS												
Needed Total					100	108	116	125	135	145	156	7.7046%
Old					80	64	48	32	16	0	0	
(Previous)						20	40	60	81	102	124	
Needed New					20	24	28	33	38	43	32	

DISPOSAL LEVEL III SCENARIO
BASE 1-6
1990 ANNUAL PROJECTIONS

INPUTS	Remarks	OUTPUTS: CONSTRUCTION — WELLS: Urban Drilled Wells	R.P. Rural Bore-Wells	G.P. Rural Bore-Wells	Irrig-ation Wells	Hand Dug Wells	Hand Pump Wells	Tube Wells Fire Wells	OTHER STRUCTURES: Dams	Bullocks	Bar-rows	Boats	ANNUAL COUNTRY INPUTS	REHABILITATION — WELLS: Urban Drilled Wells	R.P. Rural Bore-Wells	GP Rural Bore-Wells	Irri-gation wells	ANNUAL REHAB INPUTS	COSTS — R.P. RURAL WELLS: COST PER UNIT	COST COST (US$1000s)	REHAB COST (US$1000s)	TOTAL PROJECTED COUNT.
NPU	Number of strus.	45	61	56	31	963	19	940	149	14	1757	12							EXCHANGE RATE 1000s/US$			FOR ALL INPUTS OF ACTI-VITIES
BL	Years	10	10	10	10	10		10	10	10	13	5							84			
DEP	Years													10	10	10	10					
AMRD	Number of strus.													0	0	0	0					
MATERIALS																						
Cement per st	cubic meters	264	200	7	200	7	0.5	6	0	0	3	0		60	60	2.1	60		144.10			
Annual cement	cubic meters	9910	12241	251	6240	6321	24	3792	0	0	5360	0	47132	0	0	0	480	480		0722	00	56429
Stones per st	cubic meters					18		18	0	0	7	140							45.90			
Annual stones	cubic meters					16449		9479	0	0	12500	70251	56687									00687
Gravel per st	cubic meters	22	22	5	22									10.5	10.5	1.3	10.5		134.30			
Annual gravel	cubic meters	1360	2042	180	1093								3675	0	0	0	84	84		490	00	5759
Sand per st	cubic meters	170	120	2	120	2					2	0		36	36	0.6	36		12.90			
Annual Sand	cubic meters	5340	9744	72	1749	1006					2576	0	21793	0	0	0	288	288		029	00	21957
8" Steel Casing per st	meters	75	75	30	50		70												175.60			
Ann.8"Steel Casing	meters	1343	6090	1796	1562		990						13761							1491	00	15761
8"Steel Screen per st	meters	42	45	30	30														1163.60			
Ann.Steel Screen	meters	7006	3654	1077	937								7674							0379	00	7674
Conduct.casing per st	meters	6	6	6	6		6												1104.00			
Ann.Conduct.casing	meters	267	487	213	187		293						1409							008	00	1409
Shelter per st	units	1	1	0.3	0.3	0.1					0.5											
Annual Shelter	units	48	81	7	6	90					893		1123									
Pipe&Fittings per st	meters	200	200	0	200	0		10			10			60	60	0	60		130.00			
Annual Pipe&Fittings	meters	9910	16241	0	6240	0		10210			17960		63490	0	0	0	480	480		1407	00	67543
Drilling Fluid per st	units	70	70	10	10		5							0	0	0	0		017.10			
Annual Drilling Fluid	units	1070	1999	573	300		243						4136	0	0	0	0	0		135	00	4236
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.30							0	0	0	0		01,200			
Annual Drill Bits	units	2.3	9.7	2.9	2.5		2.9						24	0	0	0	0	0		036	00	24
Hand Pump per st	units			1		0.3										1			12,000			
Annual Hand Pumps	units			36		101							217			0		0		00	00	301
Diesel Pump per st	units	1	1		1			1						1	1		1		021,000			
Annual Diesel Pumps	units	45	81		31			940					1100	0	0		0	0		01,700	00	1320
Nature & Hand per st	meters	30	30		12						70			9	9	0	3.9		023.73			
Annual Nature&Hand	meters	1337	2136		446						13737		19916	0	0	0	31	31		187	00	16700
Plastic Sheet per st	sq.meters								194	1500												
Annual Plastic sheets	sq.meters								15463	10000			25463									62230
LABOUR																						
Drillers																						
Supervisory per Dt.	man-days	10	10	6	6		0												15.72			
Annual Supervisory	man-days	346	812	213	187		243						1981					0		93	00	32127
Drilling per Dt.	man-days	25	20	17	17		19							10	15	12	12		05.95			
Annual Drilling	man-days	1114	1624	611	531		679						4539	0	0	0	96	96		111	00	4630
Excavation per st.	man-days					6.4													03.06			
Annual Excav.Dris	man-days					3700			10	10	30	30						0		00	00	18193
Civil Dris per st.	man-days	30	36	10	15	3		1.2	0.5	1.3	15	30		10	15	12	12		05.36			
Annual Civil Dris.	man-days	2729	5973	646	469	4515		1132	74	30	21602	919	31796	0	0	0	96	96		115	00	6311
Mech.Dris per st.	man-days	20	12	6	6	0.6		3			3								03.27			
Ann.Mechanic Dris.	man-days	891	976	213	187	542		4729			5360		17911					0		02	00	20643
Carp.Dris per st.	man-days	3	3	2	2														02.95			
Ann.Carpentry Dris.	man-days	223	162	72	62								520					0		00	00	520
Unskilled																						
Drilling per Dt.	man-days	300	240	204	200		130							54	45	36	36		12.40			
Annual Drilling	man-days	13371	19489	7103	6240		7276						53267	0	0	0	288	288		147	00	53555
Excavation per st.	man-days					6.4													12.00			
Annual Excav.Dris	man-days					3700					3360		11100					0		00	00	17394
Civil.Dris per st.	man-days	300	216	36	175	3		2	0.5	1.3	15	90		36	30	24	24		12.00			
Ann.Civil Dris.	man-days	13371	17540	1773	5467	4515		1096	74	30	21602	2040	73537	0	0	0	192	192		137	00	96909
Mech.Dris. per st	man-days	30	12	3.6	6	3.6		12			6								12.00			
Ann.Mechanic Dris.	man-days	891	976	179	220	5251		11373			10721		27993					0		02	00	230013
Other Unskilled per st.	man-days													36	30	24	24		11.20			
Annual Other Unskilled	man-days												0	0	0	0	192	192		00	00	192
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	24	30	10		10							10	15	12	12		0234			
Annual Drill Rigs Use	Eq-days	1337	1949	710	367		402						3952	0	0	0	96	96		1361	00	5400
Pump Rigs per st	Eq-days	3	3	2	2		1												192			
Annual Pump Rigs Use	Eq-days	134	244	72	62		99						560					0		175	00	2729
Heavy Vehicles per st	Eq-days	273	168	70	45	10	35	2	10	10	0	30		18	13	12	12		001			
Annual Heavy Veh1 Use	Eq-days	9939	13642	2511	1406	9630	1692	1096	1487	325	14175	909	57191	0	0	0	96	96		11,164	00	118729
Light Vehicles per st	Eq-days	720	240	120	100	10	60	3	5	12	0	30		10	15	12	12		334			
Annual Light Veh1s Use	Eq-days	11142	19488	4310	3124	9630	1940	3044	743	402	7142	909	61122	0	0	0	96	96		3606	00	224306
FUEL CONSUMPTION																						
Drill Rigs per st	Litres	4500	3600	1000	2700		1300							900	720	600	600		00.60			
Annual Drill Rigs Fuel	Litres	200586	292334	10745			36300						630063	0	0	0	4800	4800		0189	00	779619
Pump Rigs per st	Litres	336	336	229	270		112												00.60			
Annual Pump Rigs Fuel	Litres	14976	27384	8040	6948		3438						62776					0		140	00	171172
Heavy Vehicles per st	Litres	9720	1728	3000	1000	600	1400	30	600	600	320	1700		630	528	420	420		00.60			
Annual Heavy Veh1 Fuel	Litres	397386	545090	100562	36233	361219	67900	73032	29479	13000	571904	17911	2387640	0	0	0	2360	2360		1342	00	1740091
Light Vehicles per st	Litres	6600	3840	2100	1320	300	1950	60	300	300	700	900		360	300	240	240		00.73			
Annual Light Veh1 Fuel	Litres	290170	609767	75421	47175	270914	30933	36479	14400	10056	42028	20470	1715736	0	0	0	1728	1728		[illegible]	00	[illegible]
																		TOTAL (US$M) per one well		17,360 / 100	00	

WISyMS LEVEL III SUBMODEL
ANNEX I-4
1990 MIDDLE PROJECTIONS

INPUTS	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irrigation wells	OTHER STRUCTURES: Hand Dug Wells	Intks from Riv	Uars	Ballehs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P Rural Bore-Wells	Irrigation Wells	ANNUAL OPER. INPUTS	D.P. RURAL WELLS: COST PER UNIT	MAINT COST US$(000s)	OPER COST $(000s)	TOTAL PHYSICAL QUANT.
MP	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1										
AMR	Number of struc.	929	1591	189	920	3731	24721	804	196	12379	124							EXCHANGE RATE SOSH/US$ 84			FOR ALL TYPES ACTI-VITIES
AMOR	Number of Struc.												232	398	189	230					
MATERIALS																					
Cement per st	cubic meters					0.7	0.1	0	0	0.3	0							$44.40			
Annual cement	cubic meters					2612	2472	0	0	3714	0	8797							$0	$0	
Stones per st	cubic meters					1.6	0.25	0	0	0.7	64							$5.95			
Annual stones	cubic meters					5969	6180	0	0	8665	7965	28780							$0	$0	
Sand per st	cubic meters					0.2	0	0	0	0.2	0							$2.98			
Annual Sand	cubic meters									2476	0	2476							$0	$0	
Pipe&Fittings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0							$30.00			
Annual Pipe&Fittings	meters	465	796	0	460	0	9270			12379		23372							$24	$0	
Hand Pump per st	units			0.09		0.018												$2,000			
Annual Hand Pumps	units			17		67						84							$0	$0	
Diesel Pump per st	units	0.015	0.015		0.015		0.015	0	0	0	0							$21,000			
Annual Diesel Pumps	units	14	24		14		371					422							$501	$0	
Rebars & Wood per st	meters						0	0	0	2	0							$35.71			
Annual Rebars&Wood	meters									24758		24758							$0	$0	
Plastic Sheet per st	sq.meters						0	10.4	150	0	0										
Annual Plastic sheets	sq.meters							8360	29407			37767									
LABOUR																					
Skilled:																					
Supervisory per St.	man-days	1.075	1.075	1.3	1.075		1.075											$5.95			
Annual Supervisory	man-days	999	1710	246	989		26575					30524							$10	$0	
Excavation per st.	man-days						0	1	1	3	3							$5.95			
Annual Excav.Wrks	man-days							804	196	37138	373	69037							$0	$0	
Civil Wrks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3							$5.06			
Annual Civil Wrks.	man-days					1865	742	40	29	18569	373	21619							$0	$0	
Mech.Wrks per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36			
Ann.Mechanic Wrks.	man-days	5992	10262	1474	5933	7909	15944B			3714		194732							$55	$0	
Other Skilled per st.	man-days												365	280	365	120		$2.38			
Annual Other Skilled	man-days											0	84773	111374	68966	27596	292709		$0	$265	292709
Unskilled:																					
Excavation per st.	man-days					0.64	0	0	0	0.3	0							$2.08			
Annual Excav.Wrks	man-days					2388				3714		5101							$0	$0	

517

Excavation per st.	man-days									3714		8101										
Annual Excav.Wrks	man-days					2388																
Civil.Wrks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9							$2.08		$0	$0	
Ann.Civil Wrks.	man-days					1865	1236	40	29	18569	1120	22860										
Mech.Wrks. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							$2.08		$21	$0	
Ann.Mechanic Wrks.	man-days	5992	10262	1474	5933	2686	159446			7428		193223										
EQUIPMENT																						
Drill Rigs per st	Eq-days																	$256		$0	$0	
Annual Drill Rigs Use	Eq-days											0										
Pump Rigs per st	Eq-days	0.075	0.075	0.3	0.075		0.075											$92		$11	$0	
Annual Pump Rigs Use	Eq-days	70	119	57	69		1854					2169										
Heavy Vehicles per st	Eq-days					2	2	3	9		3							$81		$0	$0	
Annual Heavy Vehcl Use	Eq-days					7462	49441	2411	1764		373	61452										
Light Vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3							$34		$173	$0	
Annual Light Vhcls Use	Eq-days	2996	5131	737	2967	29847	79724	2411	1764	37138	373	163088										
Diesel Pump per st.	Eq-days												365	280		120		$14		$0	$1,613	223742
Annual Diesel Pumps	Eq-days											0	84773	111374		27596	223742					
Hand Pump per st.	Eq-days														365			$1.1E		$0	$0	68966
Annual Hand Pumps	Eq-days											0			68966		68966					
FUEL CONSUMPTION																						
Drill Rigs per st	Liters																	$0.60		$0	$0	
Annual Drill Rigs Fuel	Liters											108466										
Pump Rigs per st	Liters	3.75	3.75	15	3.75		3.75											$0.60		$4	$0	
Annual Pump Rigs Fuel	Liters	3484	5966	2834	3449		92702					108436										
Heavy Vehicles per st	Liters					80	80	120	360	0	120							$0.60		$0	$0	
Annual Heavy Vhcl Fuel	Liters					298465	1977647	96459	70576		14935	2458083										
Light Vehicles per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60							$0.71		$73	$0	
Annual Light Vhcls Fuel	Liters	59922	102623	14738	59331	596930	1594478	48229	35289	742750	7467	3261757										
Diesel per Pump	Liters												13140	4200	0	3000		$0.60		$0	$994	5412321
Annual Diesel	Liters												3051820	1670611	0	689891	5412321					

TOTAL (000s)	$873	$2,873
PER WELL/YEAR	$2,194	$7,222
TOTAL O & M (000s)		$3,745
O&M PER M^3 WATER		28.15996

II. 1990 Projections/Forecasts

Annex I-5: Low Projections
- Level I Submodel
- Level II Submodel
- Level III Submodel

ANNEX I-3: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

LOW-LEVEL PROJECTIONS OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS			PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION				
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL 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
SUBTOTAL 1	5798	persons					29496		27546		1950
ANIMAL											
Camels	4122	head	20	liters	365	1000	30091	61%	18355	39%	11735
Cattle	3915	head	20	liters	365	1000	28580	76%	21720	24%	6859
SheepGoats	25759	head	3	liters	365	1000	28206	71%	20026	29%	8180
OtherAn	8243	head	3	liters	365	1000	9026	5%	451	95%	8575
SUBTOTAL 2	11113	LSU					95902		60553		35349
AGRICULTURE											
Irrigfarm	48	hectares	68	cu.meters	365	1	1191360	81%	965002	19%	226358
Rainfarm	626	hectares	35	cu.meters	120	1	2629200	1%	26292	99%	2602908
Floodfarm	116	hectares	25	cu.meters	90	1	261000	1%	2610	99%	258390
SUBTOTAL 3	790	hectares					4081560		993904		3087656
GOVT/INDUS											
Govt	2	estabs	10	cu.meters	300	1	6000	100%	6000	0%	0
Industry	0.4	estabs	6.7	cu.meters	300	1	804	100%	804	0%	0
SUBTOTAL 4	2.4	estabs					6804		6804		0

* * * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * *

CONSUMPTION UNITS			VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * * PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN																
Urban HC	142	persons	4146	99%	4105	72.00%	0.00%	0.00%	0.00%	10.00%	10.00%	3.00%	0.00%	5.00%	0.00%	100.00%
Urban SP	1440	persons	10512	98%	10302	72.00%	0.00%	0.00%	0.00%	10.00%	10.00%	3.00%	0.00%	5.00%	0.00%	100.00%
Rural Set	1731	persons	7582	91%	6899	1.50%	15.00%	0.50%	0.00%	40.00%	15.00%	10.00%	3.00%	15.00%	0.00%	100.00%
Nomadic	2485	persons	7256	86%	6240	1.10%	10.50%	0.40%	0.00%	33.00%	20.00%	13.00%	10.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	5798	persons	29496		27546											
ANIMAL																
Camels	4122	head	30091	61%	18355	0.50%	7.00%	0.50%	0.00%	15.00%	24.00%	20.00%	28.00%	5.00%	0.00%	100.00%
Cattle	3915	head	28580	76%	21720	1.50%	9.00%	0.50%	0.00%	30.00%	19.00%	20.00%	15.00%	5.00%	0.00%	100.00%
SheepGoats	25759	head	28206	71%	20026	2.00%	6.60%	0.40%	0.00%	30.00%	19.00%	15.00%	20.00%	7.00%	0.00%	100.00%
OtherAn	8243	head	9026	5%	451	2.00%	5.68%	0.32%	0.00%	25.00%	19.00%	20.00%	23.00%	5.00%	0.00%	100.00%

AGRICULTURE																
Irrigfarm	48 hectares	1191360	81%	965002	0.00%	0.00%	0.00%	3.00%	0.50%	90.00%	1.00%	1.00%	0.00%	4.50%	100.0
Rainfarm	626 hectares	2629200	1%	26292	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.0
Floodfarm	116 hectares	261000	1%	2610	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.0
SUBTOTAL 3	790 hectares	4081560		993904											
GOVT/INDUS															
Govt	2 estabs	6000	100%	6000	90.16%	1.84%	0.00%	0.00%	7.00%	1.00%	0.00%	0.00%	0.00%	0.00%	100.0
Industry	0.4 estabs	804	100%	804	85.26%	1.74%	0.00%	0.00%	12.00%	1.00%	0.00%	0.00%	0.00%	0.00%	100.0
SUBTOTAL 4	2.4 estabs	6804		6804											

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

CONSUMPTION UNITS	(000s) MEASURE	VOLUME CONSUMPTION TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE: DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	DRILLED WELLS IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DARS/ RESER-VOIRS M^3*K/YR	BALLENS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	142 persons	4146	99%	4105	2956	0	0	0	410	410	123	0	205	0
Urban SP	1440 persons	10512	98%	10302	7417	0	0	0	1030	1030	309	0	515	0
Rural Set	1731 persons	7582	91%	6899	103	1035	34	0	2760	1035	690	207	1035	0
Nomadic	2485 persons	7256	86%	6240	69	655	25	0	2184	1248	811	624	624	0
SUBTOTAL 1	5798 persons	29496		27546	10545	1690	59	0	6385	3724	1933	831	2379	0
ANIMAL														
Camels	4122 head	30091	61%	18355	92	1285	92	0	2753	4405	3671	5139	918	0
Cattle	3915 head	28580	76%	21720	326	1955	109	0	6516	4127	4344	3258	1086	0
Sheep&Goats	25759 head	28206	71%	20026	401	1322	80	0	6008	3805	3004	4005	1402	0
OtherAn	8243 head	9026	5%	451	9	26	1	0	113	86	90	104	23	0
SUBTOTAL 2	11113 LSU	95902		60553	827	4587	282	0	15390	12423	11109	12507	3428	0
AGRICULTURE														
Irrigfarm	48 hectares	1191360	81%	965002	0	0	0	28950	4825	868501	9650	9650	0	43425
Rainfarm	626 hectares	2629200	1%	26292	0	0	0	0	0	0	0	0	0	26292
Floodfarm	116 hectares	261000	1%	2610	0	0	0	0	0	0	0	0	0	2610
SUBTOTAL 3	790 hectares	4081560		993904	0	0	0	28950	4825	868501	9650	9650	0	72327
GOVT/INDUS														
Govt	2 estabs	6000	100%	6000	5410	110	0	0	420	60	0	0	0	0
Industry	0.4 estabs	804	100%	804	685	14	0	0	96	8	0	0	0	0
SUBTOTAL 4	2.4 estabs	6804		6804	6095	124	0	0	516	68	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)				1088807	17467	6402	341	28950	27116	884716	22693	22988	5807	72327
VOLUME OUTPUT:	(M^3*K/str/yr)				99.81832	25.96596	2.552763	173.1627	2.082332	326.8608	1.308206	2.016232	0.541988	27.8424
	(days/yr)				365	280	365	120	365	250	120	90	60	60
	(M^3/str/day)				273	93	7	1443	6	1307	11	22	9	464
NUMBERS OF WATER SUPPLY STRUCTURES					175	247	134	167	13022	2707	17346	11401	10715	2598
COMMERCIAL SCALE STRUCTURES					175	247	134	167	1628	2707	578	114	10715	52
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					17	25	13	17	163	271	58	11	[illegible]	[illegible]

ANNEX I-5 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	Growth Rate P.A. '84-'90
URBAN WELLS												
Needed Total	47	62	89	103	103	113	123	134	147	160	175	9.1600%
Old	43	38	34	30	26	21	17	13	9	4	0	
(Previous)		4	23	53	66	71	84	98	112	127	143	
Needed New or Rehab	4	19	33	20	10	21	22	24	26	29	32	
DP RURAL BOREHOLES												
Needed Total	100	118	132	148	166	177	189	202	216	231	247	6.8343%
Old	89	80	71	62	54	45	36	27	18	9	0	
(Previous)		11	37	57	79	104	122	141	161	182	204	
Needed New or Rehab	11	27	24	28	33	28	31	34	37	40	43	
HP RURAL BOREHOLES												
Needed Total	84	89	92	97	102	107	112	117	122	128	134	4.5976%
Old	78	70	62	55	47	39	31	23	16	8	0	
(Previous)		6	18	28	39	51	63	74	86	98	110	
Needed New or Rehab	6	13	12	14	16	16	18	19	21	22	23	
IRRIGATION WELLS												
Needed Total	76	85	103	117	129	135	141	147	153	160	167	4.3775%
Old	63	56	50	44	38	31	25	19	13	6	0	
(Previous)		13	27	50	68	85	95	106	118	129	141	
Needed New or Rehab	13	15	26	23	23	19	21	22	23	25	26	
HAND DUG WELLS												
Needed Total					1250	1306	1365	1426	1491	1558	1628	4.4992%
Old					1125	1013	900	788	675	563	450	
(Previous)						125	281	437	595	756	920	
Needed New					125	169	184	202	220	239	258	
INTAKES												
Needed Total					2500	2533	2567	2601	2636	2671	2707	1.3328%
Old					2250	2025	1800	1575	1350	1125	900	
(Previous)						250	483	719	954	1191	1427	
Needed New					250	258	284	308	332	356	380	
DAMS/RESERVOIRS												
Needed Total					500	512	525	538	551	564	578	2.4519%
Old					450	405	360	315	270	225	180	
(Previous)						50	102	155	207	260	313	
Needed New					50	57	63	68	74	79	85	
BALLENS/PONDS												
Needed Total					100	102	104	107	109	112	114	2.2097%
Old					90	81	72	63	54	45	36	
(Previous)						10	20	30	41	51	61	
Needed New					10	11	12	13	14	15	17	
BURKEDS/CISTERNS												
Needed Total					7500	7959	8447	8965	9514	10097	10715	6.1262%
Old					7000	6533	6067	5600	5133	4667	4200	
(Previous)						500	1393	2288	3212	4166	5152	
Needed New					500	926	988	1077	1168	1264	1363	
DAMS												
Needed Total					50	50	51	51	51	52	52	0.6412%
Old					40	32	24	16	8	0	0	
(Previous)						10	16	23	30	37	44	
Needed New					10	8	10	12	13	14	8	

GTZ/PE LEVEL III SEMINAR
ANNEX 1-5
1990 LOA PROJECTIONS

INPUTS	Units	CONSTRUCTION: WELLS: Urban Drilled Wells	D.P. Rural Bore-Wells	D.P. Rural Bore-Wells	Irrigation Wells	Hand Dug Wells	Non Prod Wells	Intake Free Air	SPACE STRUCTURES: Sore	Bathpm	Bur-Ieds	Bunc	ANNUAL CONSTR INPUTS	REHABILITATION: WELLS: Urban Drilled Wells	D.P. Rural Bore-Wells	DP Rural Bore-Wells	Irri-gation wells	ANNUAL REHAB INPUTS	COSTS: D.P. RURAL WELLS: COST PER UNIT	COST COST (US$000)	RURAL COST (US$000)	TOTAL PHYSICAL QUANT.
DPO	Number of stran.	32	43	23	30	250	79	300	85	17	1363	0										
DL	Years	10	10	10	10	10		10	10	10	15	5										
DRP	Years																					
ANNC	Number of stran.													10	10	10	10					
														0	0	0	0					
MATERIALS																						
Cement per st	cubic meters	300	300	2	300	2	0.5	6	0	0	3	0		60	60	2.1	60		644.00			
Annual cement	cubic meters	6325	8570	164	6436	1007	13	1519	0	0	6609	0	26343	0	0	0	360	360		6301	00	31750
Stones per st	cubic meters					10		10	0	0	7	600							05.95			
Annual stones	cubic meters					4131		3797	0	0	9541	2973	29146									36710
Gravel per st	cubic meters	23	30	5	23									10.3	10.3	1.5	17.1		431.30			
Annual gravel	cubic meters	1100	1501	117	706								3434	0	0	0	43	43		952	00	3447
Sand per st	cubic meters	120	130	2	130	2					2	0		36	36	0.6	36		02.90			
Annual Sand	cubic meters	3001	3147	67	2422	514					7720	0	14639	0	0	0	216	216		413	00	16792
6" Steel Casing per st	meters	72	73	30	30			30											975.60			
Ann.6"Steel Casing	meters	2276	3217	1174	1009			300					8364							8299	00	8364
6"Steel Screen per st	meters	42	43	30	30														3103.00			
Ann.Steel Screen	meters	1429	1930	704	605								4663							3700	00	4663
Conduct.casing per st	meters	6	6	6	6			6											1111.00			
Ann.conduct.casing	meters	190	257	141	121			176					884							946	00	884
Shelter per st	units	1	1	0.2	0.2	0.1					0.5											
Annual Shelter	units	32	43	5	4	36					681		791									
Pipefittings per st	meters	300	300	0	300	0		15			10			60	60	0	60		130.00			
Annual Pipefittings	meters	6325	8570	0	6436	0		3473			13630		30274	0	0	0	360	360		8757	00	33276
Drilling Fluid per st	units	24	24	16	16		5							6	6	0	0		017.10			
Annual Drilling Fluid	units	760	1029	376	223		167						2625	0	0	0	0	0		019	00	2635
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.08							0	0	0	0		03,200			
Annual Drill Bits	units	3.8	5.1	1.9	1.4		2.6						15	0	0	0	0	0		019	00	15
Hand Pump per st	units			1		0.2										1			77,000			
Annual Hand Pumps	units			23		32							75			0		0		00	00	112
Diesel Pump per st	units	1	1		1			1						1	1		1		011,000			
Annual Diesel Pumps	units	32	43		30			300					474	0	0		0	4		4991	00	478
Rubber & Hand per st	meters	20	20		15						30			9	9	0	3.9		023.71			
Annual Rubber&Hand	meters	920	1207		362						21759		29739	0	0	0	23	23		046	00	4040
Plastic Sheet per st	sq.meters								300	1200												
Annual Plastic sheets	sq.meters								8075	14000			18075									30572
LABOUR																						
Skilled:																						
Supervisory per st.	man-days	10	10	6	6		3												05.95			
Annual Supervisory	man-days	317	429	101	121		167						1135					0		13	00	13304
Drilling per st.	man-days	25	30	17	17		10							10	13	12	12		05.95			
Annual Drilling	man-days	792	858	399	343		612						2804	0	0	0	72	72		46	00	2876
Excavation per st.	man-days					0.8			10	10	30	30							15.06			
Annual Excav.Orts	man-days					1632			849	144	46009	233	43709					0		00	00	46921
Civil Orts.per st.	man-days	30	36	18	13	3		1.3	0.5	1.5	13	30		10	13	12	12		05.36			
Annual Civil Orts.	man-days	1304	1544	423	263	1791		456	42	73	30444	233	36345	0	0	0	72	72		00	00	41426
Mech.Orts per st.	man-days	30	12	6	6	0.6		5			3								03.37			
Ann.Mechanic Orts.	man-days	632	515	141	121	125		1898			6609		7252					0		57	00	99136
Carp.Orts per st.	man-days	3	2	2	2														03.90			
Ann.Carpentry Orts.	man-days	130	86	47	40								331					0		00	00	331
Unskilled:																						
Drilling per st.	man-days	300	300	300	300		150							54	75	36	36		07.00			
Annual Drilling	man-days	9502	10294	6696	6436		6412						32941	0	0	0	216	216		023	00	33157
Excavation per st.	man-days					6.6					3								03.00			
Annual Excav.Orts	man-days					1632					6009		7741					0		00	00	9423
Civil.Orts per st.	man-days	300	216	36	173	5		7	0.5	1.5	15	90		36	30	24	24		07.00			
Ann.Civil Orts.	man-days	9502	7263	845	3032	1791		799	42	73	30444	700	46486	0	0	0	144	144		019	00	42741
Mech.Orts. per st	man-days	30	12	3.6	8	3.6		12			6								02.00			
Ann.Mechanic Orts.	man-days	632	515	85	161	929		4254			8190		13957					0		01	00	107770
Other Unskilled per st.	man-days													36	30	24	24		01.00			
Annual Other Unskilled	man-days												0	0	0	0	144	144		00	00	144
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	24	30	18		30							18	15	12	12					
Annual Drill Rigs Ann	Eq-days	950	1029	670	362		299						3107	0	0	0	72	72		0291	00	3179
Pump Rigs per st	Eq-days	3	3	2	2		1												972			
Annual Pump Rigs Ann	Eq-days	95	129	67	60		29						380					0		013	00	1369
Heavy Vehicles per st	Eq-days	221	168	70	45	10	35	2	10	10	8	30		18	15	12	12		401			
Annual Heavy Veh1 Ann	Eq-days	7063	7206	1644	908	2582	1029	799	849	146	19966	233	33343	0	0	0	72	72		6413	00	46397
Light Vehicles per st	Eq-days	250	240	120	100	10	60	3	5	12	6	30		18	15	12	12		030			
Annual Light Vehic Ann	Eq-days	7919	10294	2010	2040	2582	1177	1139	424	199	9452	233	34294	0	0	0	72	72		0409	00	113001
FUEL CONSUMPTION																						
Drill Rigs per st	Litres	4200	3600	3000	2700		1700							900	720	600	600		00.60			
Annual Drill Rigs Fuel	Litres	142533	154412	79444			25297						403686	0	0	0	3600	3600		0100	00	437752
Pump Rigs per st	Litres	336	336	274	274		112												00.60			
Annual Pump Rigs Fuel	Litres	10642	14412	3260	4520		2794						30179					0		99	00	39366
Heavy Vehicles per st	Litres	8970	6720	2800	1800	400	1400	80	400	400	320	1200		630	525	420	420		00.60			
Annual Heavy Veh1 Fuel	Litres	282933	300720	65747	36225	103277	41100	20172	33941	6620	436117	9334	1332720	0	0	0	7529	7529		0100	00	2411534
Light Vehicles per st	Litres	6600	3000	3100	1250	300	2450	60	300	300	240	900		360	300	240	240		00.71			
Annual Light Vehic Fuel	Litres	311990	216176	49111	27244	77457	30085	23779	25456	4971	327110	7000	1080390	0	0	0	1440	1440		7162	00	2692931
																			TOTAL (000s)	44,520	00	
																			ONE PER WELL	994,150		

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WISyRS LEVEL III SUBMODEL
ANNEX I-5
1990 LOW PROJECTIONS

INPUTS	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Uars	Ballehs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P Rural Bore-Wells	Irrig-ation Wells	ANNUAL OPER. INPUTS	COSTS: D.P. RURAL WELLS: COST PER UNIT	MAINT COST US$(000s)	OPER COST US$(000s)	TOTAL PHYSICAL QUANT.
MP	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1										
AMR	Number of struc.	700	986	134	669	1370	10827	493	97	9352	44							EXCHANGE RATE SOSH/US$ 84			FOR ALL TYPES ACTI-VITIES
AMOR	Number of Struc.												175	247	134	167					
MATERIALS																					
Cement per st	cubic meters					0.7	0.1	0	0	0.3	0							$44.40			
Annual cement	cubic meters					959	1083	0	0	2806	0	4847							$0	$0	
Stones per st	cubic meters					1.6	0.25	0	0	0.7	44							$5.95			
Annual stones	cubic meters					2191	2707	0	0	6547	2827	14272							$0	$0	
Sand per st	cubic meters					0.2	0	0	0	0.2	0							$2.98			
Annual Sand	cubic meters									1870	0	1870							$0	$0	
Pipe&Fittings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0							$30.00			
Annual Pipe&Fittings	meters	350	493	0	334	0	4060			9352		14593							$15	$0	
Hand Pump per st	units			0.09		0.018												$2,000			
Annual Hand Pumps	units			12		25						37							$0	$0	
Diesel Pump per st	units	0.015	0.015		0.015		0.015	0	0	0	0							$21,000			
Annual Diesel Pumps	units	10	15		10		162					198							$311	$0	
Rebars & Wood per st	meters						0	0	0	2	0							$35.71			
Annual Rebars&Wood	meters									18704		18704							$0	$0	
Plastic Sheet per st	sq.meters						0	10.4	150	0	0										
Annual Plastic sheets	sq.meters							5131	14616			19747									
LABOUR																					
Skilled:																					
Supervisory per St.	man-days	1.075	1.075	1.3	1.075		1.075											$5.95			
Annual Supervisory	man-days	752	1060	174	719		11639					14350							$6	$0	
Excavation per st.	man-days						0	1	1	3	3							$5.95			
Annual Excav.Wrks	man-days							493	97	28057	133	43132							$0	$0	
Civil Wrks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3							$5.06			
Annual Civil Wrks.	man-days					685	325	25	15	14028	133	15210							$0	$0	
Mech.Wrks per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36			
Ann.Mechanic Wrks.	man-days	4515	6361	1043	4313	2903	69833			2806		91774							$34	$0	
Other Skilled per st.	man-days												365	280	365	170		$2.38			
Annual Other Skilled	man-days											0	63871	69031	48812	29062	201776		$0	$164	201776
Unskilled:																					

Excavation per st.	man-days					0.64	0	0	0	0.3	0								$2.08			
Annual Excav.Wrks	man-days					877				2806		3682								$0	$0	
Civil.Wrks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								$2.08			
Ann.Civil Wrks.	man-days					685	541	25	15	14028	398	15691								$0	$0	
Mech.Wrks. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0								$2.08			
Ann.Mechanic Wrks.	man-days	4515	6361	1043	4313	986	69833			5611		92662								$12	$0	
EQUIPMENT																						
Drill Rigs per st	Eq-days																		$256			
Annual Drill Rigs Use	Eq-days											0								$0	$0	
Pump Rigs per st	Eq-days	0.075	0.075	0.3	0.075		0.075												$92			
Annual Pump Rigs Use	Eq-days	52	74	40	50		812					1029								$7	$0	
Heavy Vehicles per st	Eq-days					2	2	3	9		3								$81			
Annual Heavy Vehcl Use	Eq-days					2739	21654	1480	877		133	26882								$0	$0	
Light Vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								$38			
Annual Light Vhcls Use	Eq-days	2257	3180	522	2157	10956	34917	1480	877	28057	133	84535								$121	$0	
Diesel Pump per st.	Eq-days												365	280		120			$14			
Annual Diesel Pumps	Eq-days											0	63871	69031		20062	152964			$0	$1,000	152964
Hand Pump per st.	Eq-days														365				$1.18			
Annual Hand Pumps	Eq-days											0			48812		48812			$0	$0	48812
FUEL CONSUMPTION																						
Drill Rigs per st	Liters																		$0.60			
Annual Drill Rigs Fuel	Liters											51467								$0	$0	
Pump Rigs per st	Liters	3.75	3.75	15	3.75		3.75												$0.60			
Annual Pump Rigs Fuel	Liters	2625	3698	2006	2508		40601					51437								$2	$0	
Heavy Vehicles per st	Liters					80	80	120	360	0	120								$0.60			
Annual Heavy Vhcl Fuel	Liters					109565	866146	59204	35079		5301	1075295								$0	$0	
Light Vehicles per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60								$0.71			
Annual Light Vhcls Fuel	Liters	45147	63407	10431	43133	219130	698330	29602	17539	561130	2651	1690701								$45	$0	
Diesel per Pump	Liters												13140	4200	0	3000			$0.60			
Annual Diesel	Liters											0	2299365	1035463	0	501552	3836380			$0	$616	3836380
																	TOTAL (000s)			$555	$1,780	
																	PER WELL/YEAR			$2,250	$7,222	
																	TOTAL O & M (000s)				$2,335	
																	O&M PER M^3 WATER				30.64196	

ANNEX 1-6: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

HIGH-LEVEL PROJECTION OF 1990 POPULATION, RATES OF CONSUMPTION, AND NEEDED WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS		PER UNIT CONS'N FACTORS				VOLUME CONSUMPTION				
	(000s) MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3x1/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL IAGE	NO STRUC CONTROL 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
SUBTOTAL 1	8269 persons					68179		65192		2987
ANIMAL										
Camels	6757 head	30	liters	365	1000	73989	65%	48093	35%	25896
Cattle	4730 head	30	liters	365	1000	51794	80%	41435	20%	10359
SheepGoats	33785 head	3	liters	365	1000	36995	75%	27746	25%	9249
OtherAn	11262 head	3	liters	365	1000	12332	5%	617	95%	11715
SUBTOTAL 2	15699 LSU					175109		117890		57219
AGRICULTURE										
Irrigfarm	87 hectares	68	cu.meters	365	1	2159340	85%	1835439	15%	323901
Rainfarm	1387 hectares	35	cu.meters	120	1	5825400	2%	116508	98%	5708892
Floodfarm	77 hectares	25	cu.meters	90	1	173250	2%	3465	98%	169785
SUBTOTAL 3	1551 hectares					8157990		1955412		6202578
GOVT/INDUS										
Govt	2 estabs	21	cu.meters	300	1	12600	100%	12600	0%	0
Industry	0.77 estabs	12	cu.meters	300	1	2772	100%	2772	0%	0
SUBTOTAL 4	2.77 estabs					15372		15372		0

* * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * *

CONSUMPTION UNITS		VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * * PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s) MEASURE	TOTAL M^3x1/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3x1/YR	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN															
Urban HC	281 persons	12308	99%	12185	75.00%	0.00%	0.00%	0.00%	10.00%	10.00%	2.00%	0.00%	3.00%	0.00%	100.00%
Urban SP	2064 persons	22601	98%	22149	75.00%	0.00%	0.00%	0.00%	10.00%	10.00%	2.00%	0.00%	3.00%	0.00%	100.00%
Rural Set	2508 persons	18308	95%	17393	2.00%	17.40%	0.60%	0.00%	45.00%	15.00%	5.00%	2.00%	13.00%	0.00%	100.00%
Nomadic	3416 persons	14962	90%	13466	1.20%	13.20%	0.60%	0.00%	35.00%	20.00%	10.00%	10.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	8269 persons	68179		65192											
ANIMAL															
Camels	6757 head	73989	65%	48093	0.80%	8.80%	0.40%	0.00%	20.00%	20.00%	20.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4730 head	51794	80%	41435	3.00%	11.40%	0.60%	0.00%	35.00%	15.00%	20.00%	10.00%	5.00%	0.00%	100.00%
SheepGoats	33785 head	36995	75%	27746	2.00%	7.60%	0.40%	0.00%	35.00%	17.00%	15.00%	16.00%	7.00%	0.00%	100.00%
OtherAn	11262 head	12332	5%	617	2.00%	5.68%	0.32%	0.00%	30.00%	17.00%	20.00%	20.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	15699 LSU	175109		117890											
AGRICULTURE															
Irrigfarm	87 hectares	2159340	85%	1835439	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%
Rainfarm	1387 hectares	5825400	2%	116508	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	77 hectares	173250	2%	3465	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1551 hectares	8157990		1955412											
GOVT/INDUS															
Govt	2 estabs	12600	100%	12600	90.16%	1.84%	0.00%	0.00%	5.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.77 estabs	2772	100%	2772	85.26%	1.74%	0.00%	0.00%	10.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.77 estabs	15372		15372											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s) MEASURE	TOTAL M^3x1/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3x1/YR	DRILLED WELLS URBAN/ IND/GOVT M^3x1/YR	DRILLED WELLS DP RURAL BOREWELL M^3x1/YR	DRILLED WELLS HP RURAL BOREWELL M^3x1/YR	DRILLED WELLS IRRIG'N WELLS M^3x1/YR	HAND DUG WELLS M^3x1/YR	INTAKES FOR RIV/ STREAMS M^3x1/YR	DAMS/ RESER-VOIRS M^3x1/YR	BALLENS/ PONDS M^3x1/YR	BURKEDS/ CISTERNS M^3x1/YR	EARTH DAMS/D.V M^3x1/YR
HUMAN														
Urban HC	281 persons	12308	99%	12185	9139	0	0	0	1218	1218	244	0	366	0
Urban SP	2064 persons	22601	98%	22149	16612	0	0	0	2215	2215	443	0	664	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

AGRICULTURE																
Irrigfarm	87 hectares	2159340	85%	1835439	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%	
Rainfarm	1387 hectares	5825400	2%	116508	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	
Floodfarm	77 hectares	173250	2%	3465	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	
SUBTOTAL 3	1551 hectares	8157990		1955412												
GOVT/INDUS																
Govt	2 estabs	12600	100%	12600	90.16%	1.84%	0.00%	0.00%	5.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%	
Industry	0.77 estabs	2772	100%	2772	85.26%	1.74%	0.00%	0.00%	10.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%	
SUBTOTAL 4	2.77 estabs	15372		15372												

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

CONSUMPTION UNITS	(000s) MEASURE	VOLUME CONSUMPTION TOTAL M^3*K/YR	STRUCT'L CONTROL AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE: DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	DRILLED WELLS IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DAMS/ RESER- VOIRS M^3*K/YR	BALLENS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	281 persons	12308	99%	12185	9139	0	0	0	1218	1218	244	[illegible]	366	0
Urban SP	2064 persons	22601	98%	22149	16612	0	0	0	2215	2215	443	0	664	0
Rural Set	2508 persons	18308	95%	17393	348	3026	104	0	7827	2609	870	348	2261	0
Nomadic	3416 persons	14962	90%	13466	162	1777	81	0	4713	2693	1347	1347	1347	0
SUBTOTAL 1	8269 persons	68179		65192	26260	4804	185	0	15973	8735	2903	1694	4638	0
ANIMAL														
Camels	6757 head	73989	65%	48093	385	4232	192	0	9619	9619	9619	12023	2405	0
Cattle	4730 head	51794	80%	41435	1243	4724	249	0	14502	6215	8287	4143	2072	0
SheepGoats	33785 head	36995	75%	27746	555	2109	111	0	9711	4717	4162	4439	1942	0
OtherAn	11262 head	12332	5%	617	12	35	2	0	185	105	123	123	31	0
SUBTOTAL 2	15699 LSU	175109		117890	2195	11099	554	0	34017	20655	22191	20729	6449	0
AGRICULTURE														
Irrigfarm	87 hectares	2159340	85%	1835439	0	0	0	55063	18354	1651895	18354	18354	0	73416
Rainfarm	1387 hectares	5825400	2%	116508	0	0	0	0	0	0	0	0	0	116508
Floodfarm	77 hectares	173250	2%	3465	0	0	0	0	0	0	0	0	0	3465
SUBTOTAL 3	1551 hectares	8157990		1955412	0	0	0	55063	18354	1651895	18354	18354	0	193391
GOVT/INDUS														
Govt	2 estabs	12600	100%	12600	11360	232	0	0	630	378	0	0	0	0
Industry	0.77 estabs	2772	100%	2772	2363	48	0	0	277	83	0	0	0	0
SUBTOTAL 4	2.77 estabs	15372		15372	13724	280	0	0	907	461	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)				2153867	42178	16183	739	55063	69252	1681747	43448	40778	11087	193391
VOLUME OUTPUT:	(M^3*K/str/yr)				142.9197	32.87013	3.155425	142.6121	1.468016	157.9885	1.526109	2.335436	0.487166	15.10349
	(days/yr)				345	280	345	120	345	250	120	90	60	60
	(M^3/str/day)				392	117	9	1188	4	632	13	26	8	252
NUMBERS OF WATER SUPPLY STRUCTURES					295	492	234	386	47174	10445	28470	17461	22758	12804
COMMERCIAL SCALE STRUCTURES					295	492	234	386	7842	10445	1423	349	22758	256
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					30	49	23	39	786	1044	142	35	1517	51

ANNEX I-6 WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

* * * Projections of Requirements for New Water Supply Structures for Somalia 1980 - 1990, at Prevailing Useful Life * * *

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Growth Rate F.A. '84-'90
URBAN WELLS												
Needed Total	65	86	125	144	144	163	183	206	233	262	295	12.65591
Old	59	53	47	41	35	30	24	18	12	6	0	
(Previous)		6	32	74	95	99	123	147	174	203	236	
Needed New or Rehab	6	27	46	28	14	34	36	41	47	53	59	
DF RURAL BOREHOLES												
Needed Total	140	166	185	207	232	263	298	338	383	434	492	13.34951
Old	125	112	100	87	75	62	50	37	25	12	0	
(Previous)		16	52	80	111	146	186	230	278	330	389	
Needed New or Rehab	16	38	34	39	46	55	62	71	81	91	104	
HP RURAL BOREHOLES												
Needed Total	117	124	129	135	142	155	168	183	199	216	234	8.59131
Old	109	98	87	76	65	54	44	33	22	11	0	
(Previous)		8	25	39	55	72	93	116	139	163	189	
Needed New or Rehab	8	18	17	19	23	29	31	35	38	42	46	
IRRIGATION WELLS												
Needed Total	106	118	144	164	181	205	232	264	300	340	386	13.45651
Old	88	79	70	61	53	44	35	26	18	9	0	
(Previous)		19	38	70	96	119	150	183	220	260	306	
Needed New or Rehab	19	21	36	33	33	43	48	55	63	71	81	
HAND DUG WELLS												
Needed Total					4000	4477	5011	5608	6277	7025	7862	11.92161
Old					3600	3240	2880	2520	2160	1800	1440	
(Previous)						400	1197	2011	2887	3828	4842	
Needed New					400	837	934	1077	1230	1397	1580	
INTAKES												
Needed Total					7500	7951	8429	8935	9472	10041	10645	6.00971
Old					6750	6075	5400	4725	4050	3375	2700	
(Previous)						750	1801	2648	3925	5030	6163	
Needed New					750	1126	1228	1362	1497	1637	1781	
DAMS/RESERVOIRS												
Needed Total					1050	1105	1162	1223	1286	1353	1423	5.20291
Old					945	851	756	662	567	473	378	
(Previous)						105	244	382	523	667	814	
Needed New					105	149	162	179	196	214	232	
BALLENS/PONDS												
Needed Total					280	291	301	313	324	337	349	3.75011
Old					252	227	202	176	151	126	101	
(Previous)						28	61	94	127	161	195	
Needed New					28	36	39	43	46	50	54	
BURKEDS/CISTERNS												
Needed Total					15000	16079	17236	18476	19806	21231	22758	7.19511
Old					14000	13067	12133	11200	10267	9333	8400	
(Previous)						1000	2946	4906	6949	9076	11292	
Needed New					1000	2013	2157	2370	2590	2822	3066	
DAMS												
Needed Total					150	164	179	196	214	234	256	9.32421
Old					120	96	72	48	24	0	0	
(Previous)						30	67	95	129	164	201	
Needed New					30	38	45	53	61	70	55	

INPUTS	CONSTRUCTION	REHABILITATION	COSTS
WELLS / OTHER STRUCTURES	[illegible]	[illegible]	[illegible]

MATERIALS

[illegible]

LABOUR

Skilled

[illegible]

Unskilled

[illegible]

EQUIPMENT

[illegible]

FUEL CONSUMPTION

[illegible]

AWS LEVEL III SUBMODEL EX 1-6) HIGH PROJECTIONS	Measure	MAINTENANCE WELLS Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES Intks from Riv	Dars	Ballehs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS WELLS Urban Drilled Wells	D.P Rural Bore-Wells	H.P Rural Bore-Wells	Irrig-ation Wells	ANNUAL OPER. INPUTS	COSTS D.P. RURAL WE COST PER UNIT	MAIN COST US
	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1							EXCHANGE RATE	
	Number of struc.	1180	1969	234	1544	6282	42579	1192	295	19692	201							SOSH/US$ 84	
	Number of Struc.												295	492	234	386			
$																			
er st	cubic meters					0.7	0.1	0	0	0.3	0							$44.40	
ment	cubic meters					4397	4258	0	0	5908	0	14563							
er st	cubic meters					1.6	0.25	0	0	0.7	64							$5.95	
tones	cubic meters					10051	10645	0	0	13785	12887	47367							
st	cubic meters					0.2	0	0	0	0.2	0							.$2.98	
and	cubic meters									3938	0	3938							
tings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0							$30.00	
ipeFittings	meters	590	985	0	772	0	15967			19692		38010							
p per st	units			0.09		0.018												$2,000	
and Pumps	units			21		113						134							
mp per st	units	0.015	0.015		0.015		0.015	0	0	0	0							$21,000	
iesel Pumps	units	18	30		23		639					709							
Wood per st	meters						0	0	0	2	0							$35.71	
mbarskWood	meters									39385		39385							
Sheet per st	sq.meters						0	10.4	150	0	0								
lastic sheets	sq.meters							12396	44301			56696							
—																			
—																			
ory per St.	man-days	1.075	1.075	1.3	1.075		1.075											$5.95	
upervisory	man-days	1269	2117	304	1660		45772					51129							
on per st.	man-days						0	1	1	3	3							$5 95	
xcav.Wrks	man-days							1192	295	59077	604	112300							
ks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3							$5.06	
Civil Wrks.	man-days					3141	1277	60	44	29539	604	34665							
rs per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36	
hanic Wrks.	man-days	7614	12702	1827	9961	13318	274634			5908		325965							
illed per st.	man-days												365	280	365	120		$2.38	
Other Skilled	man-days											0	107718	137856	85493	46333	377400		
ed:																			
—																			
ion per st.	man-days					0.64	0	0	0	0.3	0							$2.08	
Excav.Wrks	man-days					4020				5908		9928							
rks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9							$2.06	
il Wrks.	man-days					3141	2129	60	44	29539	1812	34725							
ks. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							$2.08	
hanic Wrks.	man-days	7614	12702	1827	9961	4523	274634			11815		323078							
NT																			
—																			
igs per st	Eq-days																	$256	
Drill Rigs Use	Eq-days											0							
gs per st	Eq-days	0.075	0.075	0.3	0.075		0.075											$92	
Pump Rigs Use	Eq-days	89	148	70	116		3193					3616							
Vehicles per st	Eq-days					2	2	3	9		3							$81	
Heavy Vehcl Use	Eq-days					12564	85158	3576	2658		604	104560							

530

per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36	
ic Wrks.	man-days	7614	12702	1827	9961	13318	274634			5908		325965							$
led per st.	man-days												365	280	365	120		$2.38	
er Skilled	man-days											0	107718	137856	85493	46333	377400		
per st.	man-days					0.64	0	0	0	0.3	0							$2.08	
av.Wrks	man-days					4020				5908		9928							
per st.	man-days					0.5	0.05	0.05	0.15	1.5	9							$2.06	
Wrks.	man-days					3141	2129	60	44	29539	1812	36725							
per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							$2.08	
ic Wrks.	man-days	7614	12702	1827	9961	4523	274634			11815		323078							$
per st	Eq-days																	$256	
il Rigs Use	Eq-days											0							:
per st	Eq-days	0.075	0.075	0.3	0.075		0.075											$92	
Rigs Use	Eq-days	89	148	70	116		3193					3616							$
les per st	Eq-days					2	2	3	9		3							$81	
y Vehcl Use	Eq-days					12564	85158	3576	2658		604	104560							:
les per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3							$34	
t Vhcls Use	Eq-days	3807	6351	913	4981	50256	137317	3576	2658	59077	604	269541							$2
per st.	Eq-days												365	280		120		$14	
el Pumps	Eq-days											0	107718	137856		46333	291907		:
per st.	Eq-days														365			$1.18	
Pumps	Eq-days											0			85493		85493		:
PTION																			
per st	Liters																	$0.60	
l Rigs Fuel	Liters											180818							:
per st	Liters	3.75	3.75	15	3.75		3.75											$0.60	
Rigs Fuel	Liters	4427	7385	3513	5792		159671					180788							:
les per st	Liters					80	80	120	360	0	120							$0.60	
y Vhcl Fuel	Liters					502561	3406318	143028	106321		24162	4182391							:
les per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60							$0.71	
t Vhcls Fuel	Liters	76140	127025	18270	99615	1005121	2746344	71514	53161	1181545	12081	5390816							$
Pump	Liters												13140	4200	0	3000		$0.60	
el	Liters											0	3877851	2047844	0	1158313	7104009		:

TOTAL (000s) $1,0

PER WELL/YEAR $2,1

TOTAL O & M (000s)

O&M PER M^3 WATER

III. Constraint Analysis of 1990 National Objectives

Annex I-7: National Consumption Goals
(Full Standards)
- Level I Submodel
- Level II Submodel
- Level III Submodel

ANNEX 1-7: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

MIDDLE-LEVEL PROJECTION OF 1990 POPULATION, WITH NATIONAL CONSUMPTION GOALS: NEEDED WATER SUPPLY STRUCTURES

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

CONSUMPTION UNITS		PER UNIT CONS'N FACTORS				VOLUME CONSUMPTION				
	(000s) MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL 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
SUBTOTAL 1	6351 persons					92413		88274		4139
ANIMAL										
Camels	5308 head	25	liters	365	1000	48436	65%	31483	35%	16952
Cattle	4246 head	25	liters	365	1000	38745	80%	30996	20%	7749
SheepGoats	28661 head	3	liters	365	1000	31384	75%	23538	25%	7846
OtherAn	10615 head	3	liters	365	1000	11623	5%	581	95%	11042
SUBTOTAL 2	13190 LSU					130187		86598		43590
AGRICULTURE										
Irrigfarm	64 hectares	68	cu.meters	365	1	1588480	85%	1350208	15%	238272
Rainfarm	804 hectares	35	cu.meters	120	1	3376800	2%	67536	98%	3309264
Floodfarm	161 hectares	25	cu.meters	90	1	362250	2%	7245	98%	355005
SUBTOTAL 3	1029 hectares					5327530		1424989		3902541
GOVT/INDUS										
Govt	2 estabs	13	cu.meters	300	1	7800	100%	7800	0%	0
Industry	0.73 estabs	8	cu.meters	300	1	1752	100%	1752	0%	0
SUBTOTAL 4	2.73 estabs					9552		9552		0

* * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * *

CONSUMPTION UNITS		VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * * PERCENTAGE DISTRIBUTION OF CONSUMPTION											
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER- VOIRS	BALLEHS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN															
Urban HC	696 persons	33025	99%	32695	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Urban SP	1045 persons	15638	98%	15326	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Rural Set	1853 persons	17585	95%	16706	3.00%	26.60%	0.40%	0.00%	40.00%	15.00%	3.00%	2.00%	10.00%	0.00%	100.00%
Nomadic	2757 persons	26164	90%	23548	1.50%	15.60%	0.40%	0.00%	35.00%	20.00%	8.50%	9.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	6351 persons	92413		88274											
ANIMAL															
Camels	5308 head	48436	65%	31483	1.00%	18.60%	0.40%	0.00%	15.00%	15.00%	20.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4246 head	38745	80%	30996	5.00%	19.60%	0.40%	0.00%	30.00%	10.00%	20.00%	10.00%	5.00%	0.00%	100.00%
SheepGoats	28661 head	31384	75%	23538	3.00%	16.60%	0.40%	0.00%	33.00%	12.00%	15.00%	13.00%	7.00%	0.00%	100.00%
OtherAn	10615 head	11623	5%	581	2.00%	12.60%	0.40%	0.00%	28.00%	15.00%	20.00%	17.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	13190 LSU	130187		86598											
AGRICULTURE															
Irrigfarm	64 hectares	1588480	85%	1350208	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%
Rainfarm	804 hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	161 hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1029 hectares	5327530		1424989											
GOVT/INDUS															
Govt	2 estabs	7800	100%	7800	92.00%	2.00%	0.00%	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.73 estabs	1752	100%	1752	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.73 estabs	9552		9552											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	DRILLED WELLS IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DARS/ RESER- VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	696 persons	33025	99%	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045 persons	15638	98%	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853 persons	17585	95%	16706	501	4444	67	0	6682	2506	501	334	1671	0
Nomadic	2757 persons	26164	90%	23548	353	3673	94	0	8242	4710	2002	2119	2355	0
SUBTOTAL 1	6351 persons	92413		88274	39271	8117	161	0	18766	11537	2983	2453	4986	0

533

ANIMAL															
Camels	5308 head	48436	65%	31483	1.00%	18.60%	0.40%	0.00%	15.00%	15.00%	20.00%	25.00%	5.00%	0.00%	100.0
Cattle	4246 head	38745	80%	30996	5.00%	19.60%	0.40%	0.00%	30.00%	10.00%	20.00%	10.00%	5.00%	0.00%	100.0
SheepGoats	28661 head	31384	75%	23538	3.00%	16.60%	0.40%	0.00%	33.00%	12.00%	15.00%	13.00%	7.00%	0.00%	100.0
OtherAn	10615 head	11623	5%	581	2.00%	12.60%	0.40%	0.00%	28.00%	15.00%	20.00%	17.00%	5.00%	0.00%	100.0
SUBTOTAL 2	13190 LSU	130187		86598											
AGRICULTURE															
Irrigfarm	64 hectares	1588480	85%	1350208	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.0
Rainfarm	804 hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.0
Floodfarm	161 hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.0
SUBTOTAL 3	1029 hectares	5327530		1424989											
GOVT/INDUS															
Govt	2 estabs	7800	100%	7800	92.00%	2.00%	0.00%	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.0
Industry	0.73 estabs	1752	100%	1752	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.0
SUBTOTAL 4	2.73 estabs	9552		9552											

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

CONSUMPTION UNITS	(000s) MEASURE	VOLUME CONSUMPTION TOTAL M^3*K/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3*K/YR	TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE: DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	DRILLED WELLS IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DARS/ RESER-VOIRS M^3*K/YR	BALLEHS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	696 persons	33025	99%	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045 persons	15638	98%	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853 persons	17585	95%	16706	501	4444	67	0	6682	2506	501	334	1671	0
Nomadic	2757 persons	26164	90%	23548	353	3673	94	0	8242	4710	2002	2119	2355	0
SUBTOTAL 1	6351 persons	92413		88274	39271	8117	161	0	18766	11537	2983	2453	4986	0
ANIMAL														
Camels	5308 head	48436	65%	31483	315	5856	126	0	4722	4722	6297	7871	1574	0
Cattle	4246 head	38745	80%	30996	1550	6075	124	0	9299	3100	6199	3100	1550	0
SheepGoats	28661 head	31384	75%	23538	706	3907	94	0	7767	2825	3531	3060	1648	0
OtherAn	10615 head	11623	5%	581	12	73	2	0	163	87	116	99	29	0
SUBTOTAL 2	13190 LSU	130187		86598	2582	15912	346	0	21951	10734	16143	14129	4801	0
AGRICULTURE														
Irrigfarm	64 hectares	1588480	85%	1350208	0	0	0	40506	13502	1215187	13502	13502	0	54008
Rainfarm	804 hectares	3376800	2%	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161 hectares	362250	2%	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029 hectares	5327530		1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS														
Govt	2 estabs	7800	100%	7800	7176	156	0	0	312	156	0	0	0	0
Industry	0.73 estabs	1752	100%	1752	1524	53	0	0	123	53	0	0	0	0
SUBTOTAL 4	2.73 estabs	9552		9552	8700	209	0	0	435	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)				1609413	50553	24237	507	40506	54654	1237667	32628	30085	9786	128789
VOLUME OUTPUT:	(M^3*K/str/yr)				110.7282	28.08801	2.752533	176.1419	1.560189	199.9640	1.375246	2.138286	0.534255	16.5096
	(days/yr)				345	280	365	120	365	250	120	90	60	60
	(M^3/str/day)				303	100	8	1468	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES					457	863	184	230	35030	6189	23725	14049	18318	7805
COMMERCIAL SCALE STRUCTURES					457	863	184	230	5151	6189	999	234	18318	156
USEFUL LIFE					.10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					46	86	18	23	515	619	99	23	1221	31

ANNEX 1-7 WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

* * * Projections of Requirements for New Water Supply Structures for Somalia 1980 - 1990, at Prevailing Useful Life * * *

STRUCTURE/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Growth Rate F.A. '84-'90
URBAN WELLS												
Needed Total	56	74	107	123	124	154	191	238	296	367	457	24.2681%
Old	51	46	41	36	31	25	20	15	10	5	0	
(Previous)		5	28	64	81	85	120	159	207	265	336	
Needed New or Rehab	5	23	39	24	12	43	51	64	79	98	121	
RF RURAL BOREHOLES												
Needed Total	120	142	159	177	199	254	324	414	529	676	863	27.7067%
Old	107	96	86	75	64	53	43	32	21	11	0	
(Previous)		13	44	69	95	125	188	263	356	472	618	
Needed New or Rehab	13	32	29	34	40	75	94	119	152	193	245	
HP RURAL BOREHOLES												
Needed Total	99	105	110	115	122	130	140	150	160	172	184	7.1828%
Old	92	83	74	64	55	46	37	28	18	9	0	
(Previous)		7	22	34	47	62	78	95	113	131	150	
Needed New or Rehab	7	16	14	17	19	23	25	27	29	32	35	
IRRIGATION WELLS												
Needed Total	91	102	123	141	155	166	177	189	202	215	230	6.7794%
Old	75	68	60	53	45	38	30	23	15	8	0	
(Previous)		16	32	60	82	102	118	135	153	171	191	
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39	
HAND DUG WELLS												
Needed Total					2500	2820	3181	3589	4048	4567	5151	12.8686%
Old					2250	2025	1800	1575	1350	1125	900	
(Previous)						250	770	1304	1883	2510	3191	
Needed New					250	545	611	709	815	932	1061	
INTAKES												
Needed Total					5000	5181	5369	5563	5764	5973	6189	3.6208%
Old					4500	4050	3600	3150	2700	2250	1800	
(Previous)						500	1081	1661	2247	2840	3439	
Needed New					500	631	688	752	817	883	950	
DAMS/RESERVOIRS												
Needed Total					750	785	822	861	902	944	989	4.7102%
Old					675	608	540	473	405	338	270	
(Previous)						75	170	265	362	460	561	
Needed New					75	103	112	123	135	146	158	
BALLENS/PONDS												
Needed Total					200	205	211	217	222	228	234	2.6871%
Old					180	162	144	126	108	90	72	
(Previous)						20	41	63	84	106	128	
Needed New					20	23	26	28	30	32	35	
BURKEDS/CISTERNS												
Needed Total					10000	11061	12236	13534	14971	16560	18318	10.6145%
Old					9333	8711	8089	7466	6844	6222	5600	
(Previous)						667	2306	3993	5802	7740	9822	
Needed New					667	1684	1841	2075	2325	2598	2896	
DAMS												
Needed Total					100	108	116	125	135	145	156	7.7046%
Old					80	64	48	32	16	0	0	
(Previous)						20	40	60	81	102	124	
Needed New					20	24	28	33	38	43	32	

OUTPUTS CONSTRUCTION REHABILITATION COSTS

[illegible] LEVEL III [illegible]
ANNEX [illegible]
1990 FULL [illegible] PROJECTIONS

INPUTS	Measure	Urban Drilled Wells	D.P. Rural Bore-Wells	D.P. Rural Bore-Wells	Irrigation Wells	Hand Dug Wells	[illegible] Wells	Wells from [illegible]	Dams	Buildings	Bur-[illegible]	[illegible]	TOTAL CONSTR. INPUTS	Rehab. Urban Drilled Wells	D.P. Rural Bore-Wells	Rural Bore-Wells	Irrigation wells	ANNUAL REHAB INPUTS	COST PER UNIT	CONST COST	REHAB COST	TOTAL PHYSICAL [illegible]
[illegible]	Number of struc.	171	295	33	34	1061	130	950	130	33	7096	32							EXCHANGE RATE [illegible]			FOR ALL TYPES OF ACTIVITIES
[illegible]	Years	10	10	10	10	10		10	10	10	15	5										
[illegible]	Years													10	10	10	10					
[illegible]	Number of struc.													0	0	0	0					
MATERIALS																						
Cement per st	cubic meters	200	200	7	200	7	0.3	4	0	0	3	0		60	60	2.1	60		141.40			
Annual cement	cubic meters	34100	59019	212	6300	7626	60	3801	0	0	[illegible]	0	[illegible]	0	0	0	400	400		12,170	00	110077
Stones per st	cubic meters					16		10	0	0	7	640							45.95			
Annual stones	cubic meters					16973		9503	0	0	30272	20254	[illegible]									[illegible]
Gravel per st	cubic meters	25	25	5	25									10.5	10.5	1.5	10.5		134.20			
Annual gravel	cubic meters	4276	[illegible]	175	1075								[illegible]	0	0	0	00	00		[illegible]	00	[illegible]
Sand per st	cubic meters	130	130	2	130	2					2	0		36	36	0.6	36		12.00			
Annual Sand	cubic meters	[illegible]	[illegible]	60	3799	2122					[illegible]	0	[illegible]	0	0	0	300	300		[illegible]	00	[illegible]
[illegible] Casing per st	meters	75	75	50	50		20												175.00			
Ann. [illegible] Casing	meters	[illegible]	[illegible]	1732	1563		2465						33134							[illegible]	00	33134
[illegible] Screen per st	meters	40	45	30	30														1165.00			
Ann. [illegible] Screen	meters	3433	[illegible]	1039	912								[illegible]							[illegible]	00	[illegible]
Conduct. casing per st	meters	6	6	6	6		6												1106.00			
Ann. conduct. casing	meters	720	1171	300	187		721						3311							[illegible]	00	3311
Shelter per st	units	1	1	0.3	0.2	0.1					0.3											
Annual Shelter	units	171	245	7	6	106					1440		[illegible]									
Pipe&Fittings per st	meters	200	200	0	200	0		15			10			60	60	0	60		130.00			
Annual Pipe&Fittings	meters	34100	59019	0	6200	0		14250			70960		[illegible]	0	0	0	600	600		[illegible]	00	[illegible]
Drilling Fluid per st	sacks	21	21	16	16		3							0	0	0	0		117.10			
Annual Drilling Fluid	sacks	3590	3603	320	300		601						[illegible]	0	0	0	0	0		[illegible]	00	[illegible]
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.08							0	0	0	0		[illegible]			
Annual Drill Bits	units	14.3	21.0	2.0	2.3		9.6						50	0	0	0	0	0		[illegible]	00	50
Hand Pump per st	units			1		0.2										1			[illegible]			
Annual Hand Pumps	units			33		213							247			0		0		00	00	[illegible]
[illegible] Pump per st	units	1	1		1			1						1	1		1		[illegible]			
Annual [illegible] Pumps	units	171	245		31			950					1397	0	0		0	0		[illegible]	00	[illegible]
[illegible] per st	meters	30	30		13						20			0	0	0	3.1		[illegible]			
Annual [illegible]	meters	[illegible]	7353		406						57919		67300	0	0	0	31	31		[illegible]	00	[illegible]
Plastic Sheet per st	sq. meters								104	1500												
Annual Plastic sheets	sq. meters								16433	10000			26433									[illegible]
LABOUR																						
Skilled																						
Supervisory per st.	man-days	10	10	6	6		3												[illegible]			
Annual Supervisory	man-days	1307	3451	200	187		601						[illegible]					0		[illegible]	00	[illegible]
Drilling per st.	man-days	73	30	17	17		14							10	12	12	12		[illegible]			
Annual Drilling	man-days	5010	[illegible]	309	534		1682						[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Excavation per st.	man-days					6.4		10	10	30	15								[illegible]			
Annual Excav. Wrks	man-days					6700		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]					0		[illegible]	00	[illegible]
Civil Wrks. per st.	man-days	30	36	10	15	5	1.2	0.5	1.3	13	30			10	12	12	12		[illegible]			
Annual Civil Wrks.	man-days	[illegible]	[illegible]	[illegible]	[illegible]	5304	[illegible]	[illegible]	52	[illegible]	[illegible]		[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Mech. Wrks per st.	man-days	20	12	6	6	6.6	5			2									[illegible]			
Ann. Mechanic Wrks.	man-days	2113	2941	200	187	[illegible]	4751			[illegible]			[illegible]					0		[illegible]	00	[illegible]
Carp. Wrks per st.	man-days	3	2	2	2														[illegible]			
Ann. Carpentry Wrks.	man-days	[illegible]	[illegible]	[illegible]	[illegible]								[illegible]					0		[illegible]	00	[illegible]
Unskilled																						
Drilling per st.	man-days	200	200	200	200		130							36	48	36	36		[illegible]			
Annual Drilling	man-days	34271	[illegible]	[illegible]	[illegible]		[illegible]						[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Excavation per st.	man-days					6.4					5								[illegible]			
Annual Excav. Wrks	man-days					6700					[illegible]		[illegible]					0		00	00	[illegible]
Civil Wrks per st.	man-days	200	216	36	175	5	2	0.5	1.3	13	90			36	36	36	36		[illegible]			
Ann. Civil Wrks.	man-days	34271	53940	1297	5467	5304	[illegible]	[illegible]	52	[illegible]	[illegible]		[illegible]	0	0	0	172	172		[illegible]	00	[illegible]
Mech. Wrks. per st	man-days	20	12	3.6	8	3.6	12			6									[illegible]			
Ann. Mechanic Wrks.	man-days	2113	2941	123	250	[illegible]	[illegible]			[illegible]			[illegible]					0		00	00	[illegible]
Other Unskilled per st.	man-days													36	36	36	36		[illegible]			
Annual Other Unskilled	man-days												0	0	0	0	172	172		00	00	172
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	34	20	10		20							10	12	12	12		[illegible]			
Annual Drill Rigs Use	Eq-days	5622	[illegible]	[illegible]	[illegible]		[illegible]						[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Pump Rigs per st	Eq-days	3	3	2	2		1												[illegible]			
Annual Pump Rigs Use	Eq-days	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]						[illegible]					0		[illegible]	00	[illegible]
Heavy Vehicles per st	Eq-days	223	140	70	45	10	[illegible]	2	10	10	0	30		10	12	12	12		[illegible]			
Annual Heavy Vehicl Use	Eq-days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
Light vehicles per st	Eq-days	230	240	120	100	10	[illegible]	3	3	12	4	[illegible]		10	15	12	12		[illegible]			
Annual Light Vhcls Use	Eq-days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
FUEL CONSUMPTION																						
Drill Rigs per st	liters	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]							[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			
Annual Drill Rigs Fuel	liters	[illegible]	[illegible]	[illegible]			[illegible]						[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Pump Rigs per st	liters	[illegible]	[illegible]	[illegible]	[illegible]		112												[illegible]			
Annual Pump Rigs Fuel	liters	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]						[illegible]					0		[illegible]	00	[illegible]
Heavy Vehicles per st	liters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			
Annual Heavy Vhcl Fuel	liters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
Light Vehicles per st	liters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			
Annual Light Vhcls Fuel	liters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	[illegible]	[illegible]		[illegible]	00	[illegible]
																	TOTAL [illegible]	[illegible]	00	
																	[illegible] PER WELL	[illegible]		

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MS LEVEL III SUBMODEL
I I-7
FULL NAT'L GOALS PROJECTIONS

	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Dars	Ballohs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P Rural Bore-Wells	Irrig-ation Wells	ANNUAL OPER. INPUTS	COSTS: D.P. RURAL WE: COST PER UNIT	MAINT COST US$IC
	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1							EXCHANGE RATE SOSH/US$ 84	
	Number of struc.	1826	3452	184	920	4091	24758	831	200	15422	129								
	Number of Struc.												457	863	184	230			
w st	cubic meters					0.7	0.1	0	0	0.3	0								$44.40
ment	cubic meters					2863	2476	0	0	4627	0	996							
w st	cubic meters					1.6	0.25	0	0	0.7	64								$5.95
tones	cubic meters					6545	6189	0	0	10795	7965	31495							
st	cubic meters					0.2	0	0	0	0.2	0								$2.98
and	cubic meters									3084	0	3084							
tings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0								$30.00
ipesFittings	meters	913	1726	0	460	0	9284			15422		2780							
s per st	units			0.09		0.018													$2,000
and Pumps	units			17		74						90							
mp per st	units	0.015	0.015		0.015		0.015	0	0	0	0								$21,000
iesel Pumps	units	27	52		14		371					464							81
Wood per st	meters						0	0	0	2	0								$35.71
ebars&Wood	meters									30844		30844							
Sheet per st	sq.meters						0	10.4	150	0	0								
lastic sheets	sq.meters							8638	29964			38601							
ry per St.	man-days	1.075	1.075	1.3	1.075		1.075												$5.95
upervisory	man-days	1963	3710	240	989		26615					33522							
on per st.	man-days						0	1	1	3	3								$5.95
xcav.Wrks	man-days							831	200	46265	373	81194							
ks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3								$5.06
ivil Wrks.	man-days					2045	743	42	30	23133	373	26366							
s per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0								$5.36
anic Wrks.	man-days	11779	22263	1438	5933	8672	159688			4627		214399							
illed per st.	man-days												365	280	365	120			$2.38
ther Skilled	man-days											0	166642	241613	67284	27596	503136		
ion per st.	man-days					0.64	0	0	0	0.3	0								$2.08
Excav.Wrks	man-days					2618				4627		7245							
ks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								$2.08
l Wrks.	man-days					2045	1238	42	30	23133	1120	27608							
s. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0								$2.08
anic Wrks.	man-days	11779	22263	1438	5933	2945	159688			9253		213299							
gs per st	Eq-days																		$25
Drill Rigs Use	Eq-days											0							
gs per st	Eq-days	0.075	0.075	0.3	0.075		0.075												$9
Pump Rigs Use	Eq-days	137	259	55	69		1857					237							
vhicles per st	Eq-days					2	2	3	9		3								$8
Heavy Vehcl Use	Eq-days					8181	49516	2492	1798		373	62361							
vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								$3
Light Vhcls Use	Eq-days	5890	11131	719	2967	32726	79844	2492	1798	46265	373	184204							
Pump per st.	Eq-days												365	280		120			$14
Diesel Pumps	Eq-days											0	166642	241613		27596	435851		
mp per st.	Eq-days														365				$1.18
Hand Pumps	Eq-days											0			67284		67284		
ESUMPTION																			
ion per st	Liters																		$0.3

rks.	man-days					2045	1238	42	30	23133	1120	27608										.....
per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	6.6	0											$
c Wrks.	man-days	11779	22263	1438	5933	2945	15968			9253		213296										87.0
																						$4
per st	Eq-days																					
l Rigs Use	Eq-days											0										025
																						$
er st	Eq-days	0.075	0.075	0.2	0.075		0.075															
Rigs Use	Eq-days	137	259	55	69		185					237										95
																						9
les per st	Eq-days					2	2	3	9		2											
Vehcl Use	Eq-days					8161	49516	2492	1798		373	62363										8
																						$
les per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	2											
Vhcls Use	Eq-days	5690	11131	719	2967	32726	79844	2492	1798	46265	373	184204										93
																						042
per st.	Eq-days																					
l Pumps	Eq-days											0	365	280		120						014
													166642	241613		27596	435851					$
r st.	Eq-days														365							
Pumps	Eq-days											0			67284		67294				81.1	
																						$
TION																						
---																						
er st	Liters																					
Rigs Fuel	Liters											118878									80.1	
																						$
r st	Liters	3.75	3.75	15	3.75		3.75															
Rigs Fuel	Liters	6848	12944	2765	3449		9284					118838									80.6	
																						8
es per st	Liters					80	80	120	360	0	120											
Vhcl Fuel	Liters					327255	1980623	99664	71913		14935	2494391									80.80	
																						$
es per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	6											
Vhcls Fuel	Liters	117791	222629	14379	59331	654511	1596877	49832	35957	925310	7467	3684097									80.7	
																						815
ms	Liters																					
l	Liters											0	13140	4260	0	3000					80.8	
													5999130	3624194	0	689891	10313215					0

TOTAL (1000s)	81,94
PER WELL/YEAR	82,25
TOTAL O & M (1000s)	
O&M PER M^3 WATER	

III. Constraint Analysis of 1990 National Objectives

Annex I-8: National Consumption Goals
(Partial Standards)
- Level I Submodel
- Level II Submodel
- Level III Submodel

ANNEX I-B: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA, LEVEL I SUBMODEL

MIDDLE-LEVEL PROJECTION OF 1990 POPULATION, WITH NATIONAL CONSUMPTION GOALS (PARTIAL STANDARDS)

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

CONSUMPTION UNITS			PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION				
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3xK/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL IAGE	NO STRUC CONTRO. 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%	312
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
SUBTOTAL 1	6351	persons					92413		88274		4139
ANIMAL											
Camels	5308	head	25	liters	365	1000	48436	65%	31483	35%	16953
Cattle	4246	head	25	liters	365	1000	38745	80%	30996	20%	7749
SheepGoats	28661	head	3	liters	365	1000	31384	75%	23538	25%	7846
OtherAn	10615	head	3	liters	365	1000	11623	5%	581	95%	11042
SUBTOTAL 2	13190	LSU					130187		86598		43590
AGRICULTURE											
Irrigfarm	64	hectares	68	cu.meters	365	1	1588480	85%	1350208	15%	238272
Rainfarm	804	hectares	35	cu.meters	120	1	3376800	2%	67536	98%	3309264
Floodfarm	161	hectares	25	cu.meters	90	1	362250	2%	7245	98%	355005
SUBTOTAL 3	1029	hectares					5327530		1424989		3902541
GOVT/INDUS											
Govt	2	estabs	13	cu.meters	300	1	7800	100%	7800	0%	0
Industry	0.73	estabs	8	cu.meters	300	1	1752	100%	1752	0%	0
SUBTOTAL 4	2.73	estabs					9552		9552		0

* * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * *

CONSUMPTION UNITS			VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * * PERCENTAGE DISTRIBUTION OF CONSUMPTION										
	(000s)	MEASURE	TOTAL M^3xK/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3xK/YR	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DARS/ RESER- VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN																
Urban HC	696	persons	33025	99%	32695	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Urban SP	1045	persons	15638	98%	15326	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Rural Set	1853	persons	17585	95%	16706	2.00%	12.50%	0.50%	0.00%	30.00%	20.00%	10.00%	15.00%	10.00%	0.00%	100.00%
Nomadic	2757	persons	26164	90%	23548	2.00%	12.50%	0.50%	0.00%	30.00%	20.00%	10.00%	15.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	6351	persons	92413		88274											
ANIMAL																
Camels	5308	head	48436	65%	31483	1.00%	10.60%	0.40%	0.00%	20.00%	15.00%	23.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4246	head	38745	80%	30996	2.50%	12.00%	0.50%	0.00%	30.00%	10.00%	25.00%	15.00%	5.00%	0.00%	100.00%
SheepGoats	28661	head	31384	75%	23538	2.00%	9.60%	0.40%	0.00%	30.00%	12.00%	25.00%	14.00%	7.00%	0.00%	100.00%
OtherAn	10615	head	11623	5%	581	2.00%	9.60%	0.40%	0.00%	20.00%	15.00%	24.00%	24.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	13190	LSU	130187		86598											
AGRICULTURE																
Irrigfarm	64	hectares	1588480	85%	1350208	0.00%	0.00%	0.00%	3.00%	1.00%	90.00%	1.00%	1.00%	0.00%	4.00%	100.00%
Rainfarm	804	hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	161	hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1029	hectares	5327530		1424989											
GOVT/INDUS																
Govt	2	estabs	7800	100%	7800	93.00%	2.00%	0.00%	0.00%	3.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.73	estabs	1752	100%	1752	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.73	estabs	9552		9552											

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

CONSUMPTION UNITS			VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s)	MEASURE	TOTAL M^3xK/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3xK/YR	DRILLED WELLS URBAN/ IND/GOVT M^3xK/YR	DRILLED WELLS DP RURAL BOREWELL M^3xK/YR	DRILLED WELLS HP RURAL BOREWELL M^3xK/YR	DRILLED WELLS IRRIG'N WELLS M^3xK/YR	HAND DUG WELLS M^3xK/YR	INTAKES FOR RIV/ STREAMS M^3xK/YR	DARS/ RESER- VOIRS M^3xK/YR	BALLENS/ PONDS M^3xK/YR	BURKEDS/ CISTERNS M^3xK/YR	EARTH DAMS/DIV M^3xK/YR
HUMAN															
Urban HC	696	persons	33025	99%	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045	persons	15638	98%	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853	persons	17585	95%	16706	334	2088	84	0	5012	3341	1671	2506	1671	0
Nomadic	2757	persons	26164	90%	23548	471	2943	118	0	7064	4710	2355	3532	2355	0
SUBTOTAL 1	6351	persons	92413		88274	39222	5032	201	0	15918	12373	4506	6038	4986	0

Rainfarm	804 hectares	3376800	2%	67536	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	161 hectares	362250	2%	7245	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1029 hectares	5327530		1424989											
GOVT/INDUS															
Govt	2 estabs	7800	100%	7800	93.00%	2.00%	0.00%	0.00%	3.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	0.73 estabs	1752	100%	1752	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	2.73 estabs	9552		9552											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE										
	(000s) MEASURE	TOTAL M^3sK/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3sK/YR	DRILLED WELLS URBAN/ IND/GOVT M^3sK/YR	DRILLED WELLS DP RURAL BOREWELL M^3sK/YR	DRILLED WELLS HP RURAL BOREWELL M^3sK/YR	IPRIG'N WELLS M^3sK/YR	HAND DUG WELLS M^3sK/YR	INTAKES FOR RIV/ STREAMS M^3sK/YR	DARS/ RESER-VOIRS M^3sK/YR	BALLENS/ PONDS M^3sK/YR	BURKEES/ CISTERNS M^3sK/YR	EARTH DAMS/DIV M^3sK/YR
HUMAN															
Urban HC	696 persons	32025	99%	32695	26156	0	0	0	2616	2943	327	0	654	0
Urban SP	1045 persons	15638	98%	15326	12261	0	0	0	1226	1379	153	0	307	0
Rural Set	1853 persons	17585	95%	16706	334	2088	84	0	5012	3341	1671	2506	1671	0
Nomadic	2757 persons	26164	90%	23548	471	2943	118	0	7064	4710	2355	3532	2355	0
SUBTOTAL 1	6351 persons	92413		88274	39222	5032	201	0	15918	12373	4506	6038	4986	0
ANIMAL														
Camels	5308 head	48436	65%	31483	315	3337	126	0	6297	4722	7241	7871	1574	0
Cattle	4246 head	38745	80%	30996	775	3719	155	0	9299	3100	7749	4649	1550	0
SheepGoats	26661 head	31384	75%	23538	471	2260	94	0	7061	2825	5884	3295	1648	0
OtherAn	10615 head	11622	5%	581	12	56	2	0	116	67	139	139	29	0
SUBTOTAL 2	13190 LSU	130187		86598	1573	9372	377	0	22773	10734	21014	15955	4801	0
AGRICULTURE														
Irrigfarm	64 hectares	1588480	85%	1350208	0	0	0	40506	13502	1215187	13502	13502	0	540[illegible]
Rainfarm	804 hectares	3376800	2%	67536	0	0	0	0	0	0	0	0	0	67536
Floodfarm	161 hectares	362250	2%	7245	0	0	0	0	0	0	0	0	0	7245
SUBTOTAL 3	1029 hectares	5327530		1424989	0	0	0	40506	13502	1215187	13502	13502	0	128789
GOVT/INDUS														
Govt	2 estabs	7800	100%	7800	7254	156	0	0	234	156	0	0	0	0
Industry	0.73 estabs	1752	100%	1752	1524	53	0	0	123	53	0	0	0	0
SUBTOTAL 4	2.73 estabs	9552		9552	8778	209	0	0	357	209	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3sK/YR)				1609413	49572	14612	579	40506	52549	1238502	39022	35495	9786	128789
VOLUME OUTPUT:	(M^3sK/str/yr)				110.7282	28.08801	2.752533	176.1419	1.560189	199.9640	1.375246	2.138284	0.534255	16.5008
	(days/yr)				365	280	365	120	365	250	120	90	60	60
	(M^3/str/day)				303	100	8	1468	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES					448	520	210	230	33681	6194	28374	16600	18318	7805
COMMERCIAL SCALE STRUCTURES					448	520	210	230	4953	6194	1182	277	18318	156
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					45	52	21	23	495	619	118	28	1221	31

ANNEX I-B 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	Growth Rate F.G. '84- 90
URBAN WELLS												
Needed Total	54	74	107	123	124	154	190	236	292	361	448	23.8627%
Old	51	46	41	36	31	25	20	15	10	5	0	
(Previous)		5	28	64	81	85	120	158	205	261	330	
Needed New or Rehab	5	23	39	24	12	43	50	62	77	95	117	
DP RURAL BOREHOLES												
Needed Total	120	142	159	177	199	234	274	322	378	443	520	17.3724%
Old	107	96	86	75	64	53	43	32	21	11	0	
(Previous)		13	44	69	95	125	168	215	268	329	400	
Needed New or Rehab	13	32	29	34	40	55	64	75	88	103	121	
HP RURAL BOREHOLES												
Needed Total	99	105	110	115	122	133	146	160	175	192	210	9.5259%
Old	92	83	74	64	55	46	37	28	18	9	0	
(Previous)		7	22	34	47	62	81	101	122	145	168	
Needed New or Rehab	7	16	14	17	19	26	28	31	35	38	42	
IRRIGATION WELLS												
Needed Total	91	102	123	141	155	166	177	189	202	215	230	6.7794%
Old	75	68	60	53	45	38	30	23	15	8	0	
(Previous)		16	32	60	82	102	118	135	152	171	191	
Needed New or Rehab	16	18	31	28	28	26	29	31	34	36	39	
HAND DUG WELLS												
Needed Total					2500	2807	3140	3519	3944	4420	4953	12.0702%
Old					2250	2025	1800	1575	1350	1125	900	
(Previous)						250	752	1265	1817	2412	3053	
Needed New					250	527	588	679	776	883	1000	
INTAKES												
Needed Total					5000	5182	5370	5565	5767	5977	6194	3.6325%
Old					4500	4050	3600	3150	2700	2250	1800	
(Previous)						500	1682	1662	2249	2842	3442	
Needed New					500	632	688	753	818	884	951	
DAMS/RESERVOIRS												
Needed Total					750	809	873	942	1016	1096	1182	7.8803%
Old					675	608	540	473	405	338	270	
(Previous)						75	194	313	438	567	702	
Needed New					75	127	139	156	173	191	211	
BALLENS/PONDS												
Needed Total					200	211	223	235	248	262	277	5.5569%
Old					180	162	144	126	108	90	72	
(Previous)						20	47	74	102	130	159	
Needed New					20	29	32	35	38	42	46	
BURKEDS/CISTERNS												
Needed Total					10000	11061	12236	13534	14971	*16560	18318	10.6145%
Old					9333	8711	8089	7466	6844	6222	5600	
(Previous)						667	2306	3993	5802	7740	9822	
Needed New					667	1684	1841	2075	2325	2598	2896	
DAMS												
Needed Total					100	108	116	125	135	145	156	7.7046%
Old					80	64	48	32	16	0	0	
(Previous)						20	40	60	81	107	124	
Needed New					20	24	28	33	38	43	32	

[illegible] LEVEL III LANDFILL
[illegible]
1990 PARTIAL COST & ZONES PROJECTIONS

INPUTS	Measure	Drilled Wells	D.P. Rural Bore-Wells	D.P. Rural Bore-Wells	Irrig-ation Wells	Hand Dug Wells	Non Prod Wells	Inlets from Ocs	Weirs	Bulkhds	Bar-kers	Dams	ANNUAL COSTS 1990$
		WELLS							STREAM STRUCTURES				
NPV	Number of strms.	117	121	42	21	1000	80	951	241	46	2946	22	
CR	Years	10	10	10	10	10		10	10	10	15	3	
NRP	Years												
AWRD	Number of strms.												
MATERIALS													
Cement per st	cubic meters	200	200	7	200	7	0.5	4	0	0	3	0	
Annual Cement	cubic meters	23493	24120	294	6240	6990	42	1089	0	0	8680	0	73696
Stones per st	cubic meters					15		10	0	0	7	140	
Annual Stones	cubic meters					13994		9112	0	0	20272	20251	66631
Gravel per st	cubic meters	22	22	5	25								
Annual Gravel	cubic meters	4111	4272	210	1993								9633
Sand per st	cubic meters	120	120	7	120	7					2	0	
Annual Sand	cubic meters	13896	14437	84	3749	1999					5972	0	36137
8" Steel Casing per st	meters	75	75	30	30		20						
Ann. 8"Steel Casing	meters	8810	9040	2160	1562		1601						23290
6"Steel Screen per st	meters	45	45	30	30								
Ann. Steel Screen	meters	5286	5429	1260	937								12912
Conduct.Casing per st	meters	6	6	6	6		6						
Ann.conduct.casing	meters	708	724	252	187		504						2372
Shelter per st	units	1	1	0.2	0.2	0.1					0.5		
Annual Shelter	units	117	121	8	6	100					1440		1894
Pipe&Fittings per st	meters	200	200	0	200	0		15			10		
Annual Pipe&Fittings	meters	23493	24120	0	6240	0		14190			29040		97099
Drilling Fluid per st	units	24	24	16	16		5						
Annual Drilling Fluid	units	2819	2895	672	500		420						7306
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.08						
Annual Drill Bits	units	14.1	14.5	3.4	2.5		6.7						41
Hand Pump per st	units			1		0.3							
Annual Hand Pumps	units			42		300							342
Diesel Pump per st	units	1	1		1			1					
Annual Diesel Pumps	units	117	121		31			951					1221
Rotary & Hand per st	meters	30	30		13						70		
Annual Rotary&Hand	meters	3524	3619		406						17919		25468
Plastic Sheet per st	sq.meters								194	1500			
Annual Plastic sheets	sq.meters								21899	18000			31899
LABORS													
Drillers													
Supervisory per DL	man-days	10	10	6	6		5						
Annual Supervisory	man-days	1173	1206	252	187		420						3241
Drilling per DL	man-days	23	30	17	17		10						
Annual Drilling	man days	2932	2413	714	531		1176						7771
Excavation per st.	man-days					0.5			10	10	30	30	
Annual Excav.Drls	man-days					1590			2106	750	8679	900	14025
Civil Drls per st.	man-days	30	36	18	15	5		1.2	0.5	1.5	15	30	
Annual Civil Drls.	man-days	3873	4343	756	469	1990		1142	105	60	43440	900	62143
Carp.Drls per st.	man-days	30	12	6	6	0.6		5			3		
Ann.Carpentry Drls.	man-days	3549	1448	252	187	600		4757			8680		18701
Carp.Drls per st.	man-days	5	2	2	2								
Ann.Carpentry Drls.	man-days	587	241	84	62								975
Unskilled													
Drilling per DL	man days	300	240	200	200		150						
Annual Drilling	man days	35240	28954	8400	6240		12604						91444
Excavation per st.	man-days					0.5					3		
Annual Excav.Drls	man-days					1590					8680		10006
Civil.Drls per st.	man-days	360	216	36	175	3		2	0.5	1.5	15	90	
Ann.Civil Drls.	man days	42240	26059	1512	5462	1990		1903	105	60	43440	2940	121659
Carp.Drls. per st	man-days	30	12	3.6	8	3.6		12			6		
Ann.Carpentry Drls.	man-days	3549	1448	151	250	2399		11816			17376		36989
Other Unskilled per st.	man-days												
Annual Other Unskilled	man days												0
EQUIPMENT													
Drill Rigs per st	Eq-days	30	24	30	10		10						
Annual Drill Rigs Ope	Eq-days	3524	2895	840	562		840						8662
Pump Rigs per st	Eq-days	3	3	2	2		1						
Annual Pump Rigs Ope	Eq-days	352	362	84	62		84						940
Heavy Vehicles per st	Eq-days	225	160	90	40	10	33	2	10	10	8	30	
Annual Heavy Veh.I Ope	Eq days	26190	19264	7559	1406	9997	2941	1903	2106	750	23160	990	97220
Light Vehicles per st	Eq-days	750	240	120	100	10	30	8	8	12	4	30	
Annual Light Veh.I Ope	Eq days	29166	28934	5039	3124	9997	1261	7614	1052	547	11580	990	94230
FUEL CONSUMPTION													
Drill Rigs per st	Liters	4500	3600	3000	2700		1500						
Annual Drill Rigs Fuel	Liters	1.00393	134210	125970			1260.00						1107700
Pump Rigs per st	Liters	336	336	224	224		112						
Annual Pump Rigs Fuel	Liters	39466	40536	9408	6950		9414						103777
Heavy Vehicles per st	Liters	8000	5750	2000	1000	400	1000	30	400	400	320	1200	
Annual Heavy Veh.I Fuel	Liters	1047760	692711	119272	56223	399863	117600	76140	84227	30254	926799	37771	3473820
Light Vehicles per st	Liters	6400	2040	2100	1500	300	6000	60	300	300	240	900	
Annual Light Veh.I Fuel	Liters	748940	246032	88170	47175	299997	88236	22419	63270	12673	695852	28878	2164750

INPUTS	Measure	Drilled Wells	D.P. Rural Bore-Wells	D.P. Rural Bore-Wells	Irri-gation wells	ANNUAL COSTS 1990$
		WELLS				
NPV	Number of strms.					
CR	Years	10	10	10	10	
NRP	Years					
AWRD	Number of strms.	0	0	0	0	

INPUTS	Measure	COST PER UNIT	COST COST 1990$/1000m³	ANNUAL COST 1990$/1000m³	TOTAL PARTIAL Annual.
		D.P. RURAL WELLS			
NPV	Number of strms.	EXCHANGE RATE 1990$/USD			FOR ALL TYPES OF ACTI-VITIES
CR	Years	84			
NRP	Years				
AWRD	Number of strms.				
MATERIALS					
Cement per st	cubic meters	444.00			
Annual Cement	cubic meters		11,173	30	84040
Stones per st	cubic meters	23.75			
Annual Stones	cubic meters				97311
Gravel per st	cubic meters	234.50			
Annual Gravel	cubic meters		1146	30	1721
Sand per st	cubic meters	12.00			
Annual Sand	cubic meters		441	30	13269
8" Steel Casing per st	meters	475.60			
Ann. 8"Steel Casing	meters		4733	30	21300
6"Steel Screen per st	meters	1103.60			
Ann. Steel Screen	meters		1362	30	12912
Conduct.Casing per st	meters	1164.00			
Ann.conduct.casing	meters		1133	30	2372
Shelter per st	units				
Annual Shelter	units				1894
Pipe&Fittings per st	meters	150.00			
Annual Pipe&Fittings	meters		1720	30	174690
Drilling Fluid per st	units	117.10			
Annual Drilling Fluid	units		852	30	7306
Drill Bits per st	units	43,200			
Annual Drill Bits	units		425	30	41
Hand Pump per st	units	12,000			
Annual Hand Pumps	units		30	30	123
Diesel Pump per st	units	121,000			
Annual Diesel Pumps	units		12,322	30	1472
Rotary & Hand per st	meters	125.71			
Annual Rotary&Hand	meters		8129	30	96344
Plastic Sheet per st	sq.meters				
Annual Plastic sheets	sq.meters				76667
LABORS					
Drillers					
Supervisory per DL	man-days	25.92			
Annual Supervisory	man-days		30	30	25362
Drilling per DL	man-days	25.92			
Annual Drilling	man days		117	30	7867
Excavation per st.	man-days	25.86			
Annual Excav.Drls	man-days		30	30	176694
Civil Drls per st.	man-days	25.86			
Annual Civil Drls.	man-days		223	30	80540
Carp.Drls per st.	man-days	23.27			
Ann.Carpentry Drls.	man-days		15	30	223629
Carp.Drls per st.	man-days	12.98			
Ann.Carpentry Drls.	man-days		11	30	975
Unskilled					
Drilling per DL	man days	12.00			
Annual Drilling	man days		370	30	91732
Excavation per st.	man-days	12.00			
Annual Excav.Drls	man-days		30	30	33242
Civil.Drls per st.	man-days	12.00			
Ann.Civil Drls.	man days		154	30	119382
Carp.Drls. per st	man-days	12.00			
Ann.Carpentry Drls.	man-days		12	30	241079
Other Unskilled per st.	man-days	11.30			
Annual Other Unskilled	man days		30	30	192
EQUIPMENT					
Drill Rigs per st	Eq-days	1256			
Annual Drill Rigs Ope	Eq-days		1074	30	8750
Pump Rigs per st	Eq-days	292			
Annual Pump Rigs Ope	Eq-days		136	30	3223
Heavy Vehicles per st	Eq-days	804			
Annual Heavy Veh.I Ope	Eq days		81,736	30	1182346
Light Vehicles per st	Eq-days	838			
Annual Light Veh.I Ope	Eq days		81,132	30	276386
FUEL CONSUMPTION					
Drill Rigs per st	Liters	14.60			
Annual Drill Rigs Fuel	Liters		1302	30	1300264
Pump Rigs per st	Liters	30.60			
Annual Pump Rigs Fuel	Liters		220	30	219903
Heavy Vehicles per st	Liters	30.60			
Annual Heavy Veh.I Fuel	Liters		1060	30	6304329
Light Vehicles per st	Liters	30.71			
Annual Light Veh.I Fuel	Liters		1430	30	6366540
		TOTAL 1000m³	811,390	30	
		COST PER UNIT	999,610		

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SyRS LEVEL III SUBMODEL
MEI I-B
'90 PARTIAL NAT'L GOALS PROJECTIONS

	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P. Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES: Intks from Riv	Dars	Ballchs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	H.P Rural Bore-Wells	Irrig-ation Wells	ANNUAL OPER. INPUTS	COS D.P. RURAL: COST PER UNIT	MAI COS US$
	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1							EXCHANGE RATE SDSH/US$	
	Number of struc.	1791	2081	210	920	3953	24774	972	231	15422	124								
	Number of Struc.												448	520	210	230			
ALS																			
per st	cubic meters					0.7	0.1	0	0	0.3	0								$44.4
cement	cubic meters					2767	2477	0	0	4627	0	9871							
per st	cubic meters					1.6	0.25	0	0	0.7	64								$5.95
stones	cubic meters					6326	6194	0	0	10795	7965	31280							
er st	cubic meters					0.2	0	0	0	0.2	0								$2.98
Sand	cubic meters									3084	0	3084							
ittings per st	meters	0.5	0.5	0	0.5	0	0.275	0	0	1	0								$30.00
PipesFittings	meters	895	1040	0	460	0	9296			15422		27111							
ump per st	units			0.09		0.018													$2,000
Hand Pumps	units			19		71						90							
. Pump per st	units	0.015	0.015		0.015		0.015	0	0	0	0								$21,000
Diesel Pumps	units	27	31		14		372					443							
s & Wood per st	meters						0	0	0	2	0								$35.71
Rebars&Wood	meters									30844		30844							
ic Sheet per st	sq.meters						0	10.4	150	0	0								
Plastic sheets	sq.meters							10106	34663			44768							
R																			
ed:																			
visory per St.	man-days	1.075	1.075	1.3	1.075		1.075												$5.95
Supervisory	man-days	1925	2237	273	989		26633					32062							
ation per st.	man-days						0	1	1	3	3								$5.95
Excav.Wrks	man-days							972	231	46265	373	79906							
Wrks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3								$5.06
Civil Wrks.	man-days					1977	743	49	35	23133	373	26309							
Wrks per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0								$5.36
Mechanic Wrks.	man-days	11550	13422	1640	5933	8381	159795			4627		205349							
Skilled per st.	man-days												365	280	365	120			$2.38
Other Skilled	man-days											0	163407	145666	76732	27596	413400		
illed:																			
vation per st.	man-days					0.64	0	0	0	0.3	0								$2.08
Excav.Wrks	man-days					2530				4627		7157							
l.Wrks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								$2.08
Civil Wrks.	man-days					1977	1239	49	35	23133	1120	27552							
.Wrks. per st	man-days	6.45	6.45	7.6	6.45	0.72	6.45	0	0	0.6	0								$2.08
Mechanic Wrks.	man-days	11550	13422	1640	5933	2847	159795			9253		204440							
PMENT																			
Rigs per st	Eq-days																		$255.75
al Drill Rigs Use	Eq-days											0							
Rigs per st	Eq-days	0.075	0.075	0.3	0.075		0.075												$92..
al Pump Rigs Use	Eq-days	134	156	63	69		1858					2281							
y Vehicles per st	Eq-days					2	2	3	9		3								$81.11
al Heavy Vehcl Use	Eq-days					7907	49549	2915	2080		373	62824							
t Vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								$36.11
al Light Vhcls Use	Eq-days	5775	6711	820	2967	31628	79895	2915	2080	46265	373	179432							
sel Pump per st.	Eq-days												365	280		120			$14.48
al Dipsel Pumps	Eq-days											0	163407	145666		27596	336668		
d Pump per st.	Eq-days														365				$1.18
al Hand Pumps	Eq-days											0			76732		76732		
L CONSUMPTION																			
ll Rigs per st	Liters																		$0.6
ual Drill Rigs Fuel	Liters											114056							
p Rigs per st	Liters	3.75	3.75	15	3.75		3.75												$0.6
ual Pump Rigs Fuel	Liters	4715	7804	3153	3449		92904					114026							

[illegible]	man-days					2530				4627		7157							
[illegible]s per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								$2.0E
[illegible] Wrks.	man-days					1977	1239	49	35	23133	1120	27552							
[illegible]s. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0								$2.0E
[illegible]anic Wrks.	man-days	11550	13422	1640	5933	2847	159795			9252		204440							
T																			
--																			
[illegible]gs per st	Eq-days																		$255.75
[illegible]rill Rigs Use	Eq-days											0							
[illegible]s per st	Eq-days	0.075	0.075	0.3	0.075		0.075												$92.[illegible]
[illegible]mp Rigs Use	Eq-days	134	156	63	69		1858					2281							
[illegible]hicles per st	Eq-days					2	2	3	9		3								$81.1[illegible]
[illegible]eavy Vehcl Use	Eq-days					7907	49549	2915	2080		373	62824							
[illegible]hicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								$3E.[illegible]
[illegible]ight Vhcls Use	Eq-days	5775	6711	820	2967	31628	79898	2915	2080	46265	373	179432							
[illegible]mp per st.	Eq-days												365	280		120			$14.4E
[illegible]iesel Pumps	Eq-days											0	163407	145666		27596	336668		
[illegible]p per st.	Eq-days														365				$1.1E
[illegible]and Pumps	Eq-days											0			76732		76732		
[illegible]SUMPTION																			

[illegible]igs per st	Liters																		$[illegible]
[illegible]rill Rigs Fuel	Liters											11405[illegible]							
[illegible]gs per st	Liters	3.75	3.75	15	3.75		3.75												$0.[illegible]
[illegible]ump Rigs Fuel	Liters	6715	7804	3153	3449		92904					11402[illegible]							
[illegible]hicles per st	Liters					80	80	120	360	0	120								$0.[illegible]
[illegible]Heavy Vhcl Fuel	Liters					316279	1981959	116603	83191		14935	2512967							
[illegible]hicles per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60								$0.[illegible]
Light Vhcls Fuel	Liters	115504	134220	16398	59331	632558	1597955	58302	41595	925310	7467	3588639							
per Pump	Liters												13140	4200	0	3000			$0.0[illegible]
Diesel	Liters											0	5882645	2184984	0	689891	8757570		
																		TOTAL (000s) PER WELL/YEAR	
																		TOTAL O & M (000s)	
																		O&M PER M^3 WATER	

IV: 1995 Projections

Annex I-9: Demand Side Projections with National Goals

- Level I Submodel
- Level II Submodel
- Level III Submodel

ANNEX 1-9: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

MIDDLE LEVEL PROJECTIONS OF 1995 POPULATION, USING NATIONAL GOALS AS PER-UNIT CONSUMPTION TARGETS, W/OUT PROGRAM

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

CONSUMPTION UNITS		PER UNIT CONS'N FACTORS			VOLUME CONSUMPTION					
	(000s) MEASURE	DAILY USE FACTOR MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL VOLUME
HUMAN									
Urban HC	865 persons	130 liters	365	1000	41044	99%	40634	1%	410
Urban SP	1297 persons	41 liters	365	1000	19410	98%	19021	2%	388
Rural Set	2148 persons	26 liters	365	1000	20385	95%	19365	5%	1019
Nomadic	3044 persons	26 liters	365	1000	28888	90%	25999	10%	2889
SUBTOTAL 1	7354 persons				109726		105019		4707
ANIMAL									
Camels	5379 head	30 liters	365	1000	61090	70%	42763	30%	18327
Cattle	4463 head	30 liters	365	1000	48870	82%	40073	18%	8797
SheepGoats	30123 head	3 liters	365	1000	32985	80%	26388	20%	6597
OtherAn	11156 head	3 liters	365	1000	12216	5%	611	95%	11605
SUBTOTAL 2	13863 LSU				155160		109835		45326
AGRICULTURE									
Irrigfarm	72 hectares	68 cu.meters	365	1	1787040	85%	1518984	15%	268056
Rainfarm	1026 hectares	35 cu.meters	120	1	4309200	2%	86184	98%	4223016
Floodfarm	205 hectares	25 cu.meters	90	1	461250	2%	9225	98%	452025
SUBTOTAL 3	1303 hectares				6557490		1614393		4943097
GOVT/INDUS									
Government	2.000 estabs	13 cu.meters	300	1	7800	100%	7800	0%	0
Industry	1.000 estabs	12 cu.meters	300	1	3601	100%	3601	0%	0
SUBTOTAL 4	3.000 estabs				11401		11401		0

* * * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * * *

CONSUMPTION UNITS		VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * *				PERCENTAGE DISTRIBUTION OF CONSUMPTION * *						
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT	DP RURAL BOREWELL	DRILLED WELLS HP RURAL BOREWELL	IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN															
Urban HC	865 persons	41044	99%	40634	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Urban SP	1297 persons	19410	98%	19021	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Rural Set	2148 persons	20385	95%	19365	3.00%	26.60%	0.40%	0.00%	40.00%	15.00%	3.00%	2.00%	10.00%	0.00%	100.00%
Nomadic	3044 persons	28888	90%	25999	1.50%	15.60%	0.40%	0.00%	35.00%	20.00%	8.50%	9.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	7354 persons	109726		105019											
ANIMAL															
Camels	5379 head	61090	70%	42763	1.00%	18.60%	0.40%	0.00%	15.00%	15.00%	20.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4463 head	48870	82%	40073	5.00%	19.60%	0.40%	0.00%	30.00%	10.00%	20.00%	10.00%	5.00%	0.00%	100.00%
SheepGoats	30123 head	32985	80%	26388	3.00%	16.60%	0.40%	0.00%	33.00%	12.00%	15.00%	13.00%	7.00%	0.00%	100.00%
OtherAn	11156 head	12216	5%	611	2.00%	12.60%	0.40%	0.00%	28.00%	15.00%	20.00%	17.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	13863 LSU	155160		109835											
AGRICULTURE															
Irrigfarm	72 hectares	1787040	85%	1518984	0.00%	0.00%	0.00%	4.00%	1.00%	88.00%	1.00%	1.00%	0.00%	5.00%	100.00%
Rainfarm	1026 hectares	4309200	2%	86184	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	205 hectares	461250	2%	9225	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1303 hectares	6557490		1614393											
GOVT/INDUS															
Govt	2.000 estabs	7800	100%	7800	92.00%	2.00%	0.00%	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	1.000 estabs	3601	100%	3601	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	3.000 estabs	11401		11401											

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

CONSUMPTION UNITS		VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE									
	(000s) MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DP RURAL BOREWELL M^3*K/YR	DRILLED WELLS HP RURAL BOREWELL M^3*K/YR	IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DAMS/ RESER-VOIRS M^3*K/YR	BALLENS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN														
Urban HC	865 persons	41044	99%	40634	32507	0	0	0	3251	3657	406	0	813	0
Urban SP	1297 persons	19410	98%	19021	15217	0	0	0	1522	1712	190	0	380	0
Rural Set	2148 persons	20385	95%	19365	581	5151	77	0	7746	2905	581	387	1937	0
Nomadic	3044 persons	28888	90%	25999	390	4056	104	0	9100	5200	2210	2340	2600	0
SUBTOTAL 1	7354 persons	109726		105019	48695	9207	181	0	21618	13474	3387	2727	5730	0
ANIMAL														
Camels	5379 head	61090	70%	42763	428	3854	131	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0

Irrigfarm	72 hectares	1787040	85%	1518984	0.00%	0.00%	0.00%	4.00%	1.00%	88.00%	1.00%	1.00%	0.00%	5.00%	100.00%
Rainfarm	1026 hectares	4309200	2%	86184	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	205 hectares	461250	2%	9225	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1303 hectares	6557490		1614393											
GOVT/INDUS															
Govt	2.000 estabs	7800	100%	7800	92.00%	2.00%	0.00%	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	1.000 estabs	3601	100%	3601	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	3.000 estabs	11401		11401											

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

CONSUMPTION UNITS — VOLUME CONSUMPTION — TOTAL DISTRIBUTION OF WATER BY STRUCTURE.*.* TOTAL DISTRIBUTION OF WATER BY STRUCTURE

	(000s) MEASURE	TOTAL M^3K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3K/YR	DP RURAL BOREWELL M^3K/YR	DRILLED WELLS HP RURAL BOREWELL M^3K/YR	IRRIG'N WELLS M^3K/YR	HAND DUG WELLS M^3K/YR	INTAKES FOR RIV/ STREAMS M^3K/YR	DAMS/ RESER-VOIRS M^3K/YR	BALLENS/ PONDS M^3K/YR	BURKEDS/ CISTERNS M^3K/YR	EARTH DAMS/DIV M^3K/YR
HUMAN														
Urban HC	865 persons	41044	99%	40634	32507	0	0	0	3251	3657	406	0	812	0
Urban SP	1297 persons	19410	98%	19021	15217	0	0	0	1522	1712	190	0	380	0
Rural Set	2148 persons	20385	95%	19365	581	5151	77	0	7746	2905	581	387	1937	0
Nomadic	3044 persons	28868	90%	25999	390	4056	104	0	9100	5200	2210	2340	2600	0
SUBTOTAL 1	7354 persons	109726		105019	48695	9207	181	0	21618	13474	3387	2727	5730	0
ANIMAL														
Camels	5579 head	61590	70%	42763	428	7954	171	0	6414	6414	8553	10691	2138	0
Cattle	4463 head	48870	82%	40573	2004	7854	160	0	12022	4007	8015	4007	2004	0
Sheep&Goats	30123 head	329E5	80%	2e3E8	792	4380	106	0	8706	3167	3958	3430	1847	0
OtherAn	11156 head	12216	5%	611	12	77	2	0	171	92	122	104	31	0
SUBTOTAL 2	13863 LSU	155163		149835	3235	20266	439	0	27315	13680	20648	18232	6019	0
AGRICULTURE														
Irrigfarm	72 hectares	1787040	85%	1518984	0	0	0	60759	15190	1336706	15190	15190	0	75947
Rainfarm	1026 hectares	4309200	2%	86184	0	0	0	0	0	0	0	0	0	86184
Floodfarm	205 hectares	461250	2%	9225	0	0	0	0	0	0	0	0	0	9225
SUBTOTAL 3	1303 hectares	6557490		1614393	0	0	0	60759	15190	1336706	15190	15190	0	171356
GOVT/INDUS														
Govt	2 estabs	7800	100%	7800	7176	156	0	0	312	156	0	0	0	
Industry	1.000 estabs	3601	100%	3601	3133	108	0	0	252	108	0	0	0	
SUBTOTAL 4	3.000 estabs	11401		11401	10309	264	0	0	564	264	0			
STRUCT'L SUPPLY VOLUMES (M^3K/YR)				1614393	62235	29727	621	60759	64683	1364122	39225	36149	11745	171356
VOLUME OUTPUT:	(M^3K/str/yr)				110.7252	28.08251	2.752533	176.1419	1.560189	199.9643	1.375246	2.138286	0.534255	16.5025
	(days/yr)				365	280	365	120	365	250	120	50	0	0
	(M^3/str/day				303	100	8	1469	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES					562	1059	226	345	41461	6822	28522	16906	21991	10285
COMMERCIAL SCALE STRUCTURES					562	1059	226	345	6097	6822	1188	282	21991	208
USEFUL LIFE					10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT					56	106	23	34	610	682	119	28	1466	42

ANNEX I-9 WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL II SUBMODEL

* * * * * * Projections of Requirements for New Water Supply Structures for Somalia 1985 - 1995, at Prevailing Useful Life * * * * * *

CTURE/YEAR	1981	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate P.A. '84-'90	Growth Rate P.A. '90-'95
L WELLS																		
ed Total	56	74	107	123	124	138	153	170	188	209	232	272	331	395	471	562	11.0092%	19.2611%
	51	46	41	36	31	25	20	15	10	5	0	0	0	0	0	0		
vious)		5	28	44	81	85	104	122	142	164	188	213	256	305	364	435		
ed New or Rehab	5	23	39	24	12	27	29	32	36	40	44	64	75	90	107	128		
RAL BOREHOLES																		
ed Total	120	142	159	177	199	223	251	281	316	355	398	464	569	716	871	1059	12.2483%	21.6123%
	107	96	86	75	64	53	43	32	21	11	0	0	0	0	0	0		
vious)		13	44	69	95	125	157	192	230	271	317	366	447	544	661	804		
ed New or Rehab	13	32	29	34	40	45	51	57	64	72	81	118	141	172	209	254		
RAL BOREHOLES																		
ed Total	99	105	110	115	122	131	141	152	163	176	189	196	202	210	218	226	7.6296%	3.5979%
	92	83	74	64	55	46	37	28	18	9	0	0	0	0	0	0		
vious)		7	22	34	47	62	79	96	114	133	153	174	178	185	192	199		
ed New or Rehab	7	16	14	17	19	23	25	28	30	33	36	22	24	25	26	27		
ATION WELLS																		
ed Total	91	102	123	141	155	166	177	189	202	215	230	249	270	293	318	345	6.7822%	6.4428%
	75	68	60	52	45	38	30	23	15	8	0	0	0	0	0	0		
vious)		16	32	60	82	102	118	135	153	171	191	211	228	248	269	291		
ed New or Rehab	16	18	31	28	28	26	29	31	34	36	39	38	42	46	50	54		
DUG WELLS																		
ed Total					2500	2771	3071	3404	3772	4181	4634	4895	5172	5463	5772	6097	10.8331%	5.6417%
					2250	2025	1800	1575	1350	1125	900	675	450	225	0	0		
vious)						250	721	1199	1709	2252	2831	3451	3875	4334	4805	5291		
ed New or Rehab					250	496	550	630	714	805	903	770	846	904	967	806		
KES																		
ed Total					5000	5180	5366	5559	5759	5966	6180	6303	6439	6557	6688	6822	3.5944%	1.9956%
					4500	4050	3600	3150	2700	2250	1800	1350	900	450	0	0		
vious)						500	1080	1658	2243	2834	3432	4037	4550	5074	5600	6128		
ed New					500	630	686	751	816	881	948	917	979	1033	1088	693		
RESERVOIRS																		
ed Total					750	781	812	845	880	916	953	996	1041	1088	1137	1188	4.0731%	4.5142%
					675	608	540	473	405	338	270	203	135	68	0	0		
vious)						75	166	256	347	440	534	630	731	833	937	1043		
ed New					75	98	107	117	128	138	149	164	175	188	200	145		
EMS/PONDS																		
ed Total					200	205	210	214	220	225	230	240	249	260	271	282	2.3567%	4.1432%
					180	162	144	126	108	90	72	54	36	18	0	0		
vious)						20	41	61	82	103	124	146	171	196	222	248		
ed New					20	23	25	27	29	31	34	40	42	45	48	33		
DS/CISTERNS																		
ed Total					10000	10598	11231	11902	12613	13367	14166	15469	16891	18444	20140	21991	5.9761%	9.1946%
					9333	8711	8089	7466	6844	6222	5600	4978	4355	3733	3111	2489		
vious)						667	1842	3020	4234	5487	6779	8114	9950	11872	13919	16101		
ed New					667	1220	1300	1416	1535	1658	1787	2377	2585	2839	3109	3402		
ed Total					100	108	116	125	135	145	156	165	175	185	196	208	7.6930%	5.8915%
					80	64	48	32	16	0	0	0	0	0	0	0		
vious)						20	40	60	81	102	124	131	139	147	156	165		
ed New					20	24	28	33	38	43	32	34	36	38	40	43		

DISPOSAL LEVEL III SCENARIO
SHEET 1-9
1995 PROJECTIONS

INPUTS	Units	Drilled Wells	D.P. Rural Bore-holes	G.P. Rural Bore-holes	Drilling slime Wells	Hand Dug Wells	Hand Pump Wells	Intake from Riv	Dams	Buildings	Bore-hole	Dams	ANNUAL COSTS 1995
		CONSTRUCTION											
		WELLS						OTHER STRUCTURES					
GPD	Number of serv.	130	254	31	46	206	115	672	115	33	3463	13	
OL	Years	10	10	10	10	10		10	10	10	15	2	
DRP	Years												
RHD	Number of serv.												

INPUTS	Units	Drilled Wells	D.P. Rural Bore-holes	GP Rural Bore-holes	Dris-pation wells	ANNUAL COSTS 1995	COST PER WELL	COST PER SERV.	COST PER SERV.	TOTAL PHYSICAL COST.
		REHABILITATION								
		WELLS								
GPD	Number of serv.									
OL	Years									
DRP	Years	10	10	10	10					
RHD	Number of serv.	0	0	0	0					

INPUTS	Units	Drilled Wells	D.P. Rural Bore-holes	GP Rural Bore-holes	Dris-pation wells	ANNUAL COSTS 1995	COST PER WELL	COST PER SERV.	COST PER SERV.	TOTAL PHYSICAL COST.
							EXCHANGE RATE 2500=1USD			
MATERIALS										
Cement per st	cubic meters	200	200	7	200	7	0.5	4	0	0	3	0		60	60	2.1	60		444.00			
Annual cement	cubic meters	25313	50000	199	9143	3642	64	2770	0	0	10304	0	104399	0	0	0	400	400		47,260	00	146670
Stones per st	cubic meters					16		10	0	0	7	640							25.00			
Annual stones	cubic meters					12940		6125	0	0	23015	21330	30900									104463
Gravel per st	cubic meters	35	35	3	35									10.5	10.5	1.3	10.5		154.50			
Annual gravel	cubic meters	8463	8900	175	1600								15100	0	0	0	56	56		1367	00	15100
Sand per st	cubic meters	130	130	7	130	3					2	0		36	36	0.6	36		62.00			
Annual Sand	cubic meters	15209	30815	34	5406	1613					6004	0	59700	0	0	0	200	200		991	00	61706
6" Steel Casing per st	meters	75	75	20	20		20												475.00			
Ann.6"Steel Casing	meters	9260	15675	1500	2300		2453						34779							11,566	00	34779
6"Steel Screen per st	meters	45	45	20	20														1163.00			
Ann.Steel Screen	meters	5741	11145	840	1371								19365							11,106	00	19365
Conduct.casing per st	meters	5	5	5	5		5												1164.00			
Ann.conduct.casing	meters	760	1526	142	371		736						3463							1379	00	3463
Shelter per st	units	1	1	0.1	0.1	0.1					0.5											
Annual Shelter	units	130	254	3	9	81					1706		2170									2170
Pipedrillings per st	meters	200	200	0	200	0		13			13			60	60	0	60		130.00			
Annual Pipedrillings	meters	25315	50000	0	9143	0		10442			34019		129918	0	0	0	400	400		41,326	00	163315
Drilling Fluid per st	units	24	24	16	16		5							0	0	0	0		417.50			
Annual Drilling Fluid	units	3042	6143	422	731		615						10941	0	0	0	0	0		1110	00	10941
Drill Bits per st	units	0.12	0.12	0.00	0.00		0.00							0	0	0	0		12,200			
Annual Drill Bits	units	15	31	0	0		10						61	0	0	0	0	0		1115	00	61
Hand Pump per st	units			1		0.2										1			12,000			
Annual Hand Pumps	units			27		161							188			0		0		30	00	204
Diesel Pump per st	units	1	1		1			1						1	1		1		121,000			
Annual Diesel Pumps	units	130	254		46			693					1125	0	0		0	0		15,340	00	1126
Reburs & Bend per st	meters	30	30		13						20			9	9	0	5.9		123.71			
Annual Reburs&bend	meters	3823	7629		594						40038		50480	0	0	0	31	31		1373	00	117790
Plastic Sheet per st	sq.meters								104	1300												
Annual Plastic sheets	sq.meters								13000	10000			23000									73187
LABOUR																						
Skilled:																						
Supervisory per St.	man-days	10	10	6	6		3												15.90			
Annual Supervisory	man-days	1276	2543	142	274		613						4848					0		817	00	42928
Drilling per St.	man-days	25	20	17	17		10							10	13	12	12		15.90			
Annual Drilling	man-days	3189	5086	420	777		1717						11229	0	0	0	96	96		436	00	11325
Excavation per st.	man-days					6.4			10	10	30	30							63.00			
Annual Excav.Orts	man-days					3139			1450	134	102857	1381	110203					0		00	00	300922
Civil Orts.per st.	man-days	30	16	13	13	3		1.2	0.5	1.3	13	30		10	13	12	12		63.36			
Annual Civil Orts.	man-days	3791	4134	406	608	4631		832	73	30	51030	1381	74000	0	0	0	96	96		640	00	166029
Mech.Orts per st.	man-days	20	12	5	6	0.6		5			5								63.27			
Ann.Mechanic Orts.	man-days	2553	3051	142	274	400		3467			18790		28190					0		110	00	36360
Carp.Orts per st.	man-days	5	3	2	2														62.40			
Ann.Carpentry Orts.	man-days	638	909	56	91								1292					0		13	00	1292
Unskilled:																						
Drilling per St.	man-days	300	240	200	200		130							54	42	36	36		12.00			
Annual Drilling	man-days	38273	61020	3399	9143		13399						122294	0	0	0	200	200		8199	00	112533
Excavation per st.	man-days					6.4					3								12.00			
Annual Excav.Orts	man-days					3139					18206		15346					0		00	00	24320
Civil Orts per st.	man-days	300	216	36	173	3		3	0.5	1.3	13	90		36	30	30	24		12.00			
Ann.Civil Orts.	man-days	38273	54977	972	5480	4631		1387	73	30	51020	3044	147208	0	0	0	172	172		8115	00	196240
Mech.Orts. per st	man-days	12	12	1.6	0	1.6		12			6								12.00			
Ann.Mechanic Orts.	man-days	1531	3054	47	366	2962		8322			30411		36681					0		06	00	30122
Other Unskilled per st.	man-days													36	30	30	24		11.30			
Annual Other Unskilled	man-days												0	0	0	0	172	172		30	00	172
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	24	20	10		10							10	12	12	12		1256			
Annual Drill Rigs Use	Eq-days	3827	6103	340	823		1277						17520	0	0	0	96	96		21,736	00	13644
Pump Rigs per st	Eq-days	2	2	2	2		1												992			
Annual Pump Rigs Use	Eq-days	255	763	34	91		173						1386					0		677	00	3990
Heavy Vehicles per st	Eq-days	225	160	70	40	10	20	3	10	10	8	30		10	12	12	12		800			
Annual Heavy Veh.Use	Eq-days	28680	42771	1890	3652	8063	4295	1387	1459	134	27215	1381	119140	0	0	0	96	96		13,160	00	198833
Light Vehicles per st	Eq-days	250	240	130	140	10	40	3	5	12	4	30		10	12	12	12		930			
Annual Light Veh.Use	Eq-days	31894	61920	2240	4571	8062	8590	2080	723	604	13608	1381	131790	0	0	0	96	96		42,132	00	220491
FUEL CONSUMPTION																						
Drill Rigs per st	Litres	9300	5100	3000	9700		1300							900	750	600	600		90.00			
Annual Drill Rigs Fuel	Litres	1186000	913440	60991			147199						1711720	0	0	0	4800	4800		4399	00	1857751
Pump Rigs per st	Litres	224	136	224	224		112												90.00			
Annual Pump Rigs Fuel	Litres	28577	45642	6667	10240		12730						104000					0		406	00	279394
Heavy Vehicles per st	Litres	8950	5730	2800	1600	400	1600	20	400	400	320	1200		630	525	420	420		90.00			
Annual Heavy Veh.Fuel	Litres	1137406	1708833	75092	87200	322947	171772	15400	58919	11276	1088640	54259	4700000	0	0	0	1200	1200		54,000	00	7600400
Light Vehicles per st	Litres	6400	8000	7200	1200	300	1000	60	300	300	240	900		360	300	240	240		90.75			
Annual Light Veh.Fuel	Litres	813440	1280430	36699	61710	24000	120792	41640	43800	4000	544000	20400	2574190	0	0	0	1920	1920		4963	00	7540000
																	TOTAL ANNUAL			274,066	00	
																	PER WELL			999,340		

SyMS LEVEL III SUBMODEL
NET 1-9
95 MIDDLE PROJECTIONS

	Measure	MAINTENANCE: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	HP Rural Bore-Wells	Irri-gation wells	Hand Dug Wells	OTHER STRUCTURES: Inlks from Riv	Uars	Dallahs	Bur-keds	Dams	ANNUAL MAINT INPUTS	OPERATIONS: WELLS: Urban Drilled Wells	D.P Rural Bore-Wells	N.P Rural Bore-Wells	Irrig-ation Wells	ANNUAL OPER. INPUTS	COST PER UNIT	DP R MAIN COST US$
	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1								
Number of struc.		2248	4235	226	1380	5291	27287	1043	248	18589	165							EXCHANGE RATE SOSH/US$ 84	
Number of Struc.													562	1059	226	345			
ILS																			
per st	cubic meters					0.7	0.1	0	0	0.3	0								$44.40
cement	cubic meters					3704	2729	0	0	5577	0	12009							
per st	cubic meters					1.6	0.25	0	0	0.7	64								$5.95
stones	cubic meters					8466	6822	0	0	13013	10559	38859							
er st	cubic meters					0.2	0	0	0	0.2	0								$2.98
Sand	cubic meters									3718	0	3718							
fittings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0								$30.00
Pipes&Fittings	meters	1124	2117	0	690	0	10233			18589		32757							
mp per st	units			0.09		0.018													$2,000
Hand Pumps	units			20		95						116							
Pump per st	units	0.015	0.015		0.015		0.015	0	0	0	0								$21,000
Diesel Pumps	units	34	64		21		409					527							
& Wood per st	meters						0	0	0	2	0								$35.71
Rebars&Wood	meters									37179		37179							
c Sheet per st	sq.meters						0	10.4	150	0	0								
Plastic sheets	sq.meters							10851	37251			48102							
----																			
di																			
----																			
isory per St.	man-days	1.075	1.075	1.3	1.075		1.075												$5.95
Supervisory	man-days	2417	4557	293	1483		29334					38085							
tion per st.	man-days						0	1	1	3	3								$5.95
Excav.Wrks	man-days							1043	248	55768	495	95643							
Wrks.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3								$5.06
Civil Wrks.	man-days					2646	819	52	37	27884	495	31933							
Wrks per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0								$5.36
echanic Wrks.	man-days	14502	27314	1759	8900	11217	176004			5577		245272							
Skilled per st.	man-days												345	280	345	120			$2.38
Other Skilled	man-days											0	205161	296434	82321	41393	625310		
lled:																			
-----																			
ation per st.	man-days					0.64	0	0	0	0.3	0								$2.08
Excav.Wrks	man-days					3386				5577		8963							
Wrks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								$2.08
Civil Wrks.	man-days					2646	1364	52	37	27884	1485	33468							
Wrks. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0								$2.08
echanic Wrks.	man-days	14502	27314	1759	8900	3810	176004			11154		243442							
MENT																			

Rigs per st	Eq-days																		$256
Drill Rigs Use	Eq-days											0							
Rigs per st	Eq-days	0.075	0.075	0.3	0.075		0.075												$92
Pump Rigs Use	Eq-days	169	318	68	103		2047					2704							
Vehicles per st	Eq-days					2	2	3	9		3								$81
Heavy Vehcl Use	Eq-days					10582	54575	3130	2235		495	71017							
Vehicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								$38
Light Vhcls Use	Eq-days	7251	13657	880	4450	42379	88002	3130	2235	55768	495	218197							
Pump per st.	Eq-days												345	280		120			$14
Diesel Pumps	Eq-days											0	205161	296434		41393	542989		

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	man-days												365	280	365	120		82.38				
ed	man-days										0		205161	296434	82321	41393	625310		80	$		
	man-days					0.64	0	0	0	0.3	0							82.08				
	man-days					3386				5577		8963							80			
	man-days					0.5	0.05	0.05	0.15	1.5	9							82.08				
	man-days					2646	1364	52	37	27884	1485	33468							80			
	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							82.08				
	man-days	14502	27314	1759	8900	3810	176004			11154		243442							857			
	Eq-days																					
/ne	Eq-days										0							8256	80			
	Eq-days	0.075	0.075	0.3	0.075		0.075															
:e	Eq-days	169	318	68	103		2047					2704						892	829			
st	Eq-days					2	2	3	9		3							881				
Use	Eq-days					10582	54575	3130	2235		495	71017							80			
st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3							838				
Use	Eq-days	7251	13657	880	4450	42329	88002	3130	2235	55768	495	218197							8521			
	Eq-days																					
	Eq-days											0	365	280		120		814				
													205161	296434		41393	542989		80	84,2		
	Eq-days																					
	Eq-days											0			365			81.18				
															82321		82321		80			
	Liters																					
eel	Liters											135227						80.60				
																			80			
	Liters	3.75	3.75	15	3.75		3.75											80.60				
el	Liters	8431	15890	3383	5174		102328					135197							810			
st	Liters					80	80	120	360	0	120							80.60				
eel	Liters					423290	2182990	175204	89402		19798	2840683							80			
st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60							80.71				
Fuel	Liters	145018	273143	17592	88996	846580	1760035	62602	44701	1115368	9899	4363935							8194			
	Liters																					
	Liters											0	13140	8200	0	3000		80.60				
													7385810	4446515	0	1034837	12867162		80	92,6		

TOTAL (000s)	82,381	87,6
PER WELL/YEAR	82,249	87,2
TOTAL U & M/YEAR		810,0
O&M PER M^3 WATER		29.383

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IV. 1995 Projections

Annex I-10: Supply Side Analysis of Consultants' Recommended Program
- Level I Submodel
- Level II Submodel
- Level III Submodel

ANNEX I-10: WATER INDUSTRY SYSTEMS MODEL FOR SOMALIA: LEVEL I SUBMODEL

MIDDLE LEVEL PROJECTIONS OF 1995 POPULATION, SUPPLY-SIDE ANALYSIS, WITH CONSULTANTS' RECOMMENDED PROGRAM

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

CONSUMPTION UNITS			PER UNIT CONS'N FACTORS				VOLUME CONSUMPTION				
	(000s)	MEASURE	DAILY USE FACTOR	MEASURE	DAYS PER YEAR	CONV FACTOR	TOTAL M^3K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME	NO STRUC CONTROL %AGE	NO STRUC CONTROL VOLUME
HUMAN											
Urban HC	865	persons	130	liters	365	1000	41044	99%	40634	1%	410
Urban SP	1297	persons	41	liters	365	1000	19410	98%	19021	2%	388
Rural Set	2148	persons	26	liters	365	1000	20385	95%	19365	5%	1019
Nomadic	3044	persons	26	liters	365	1000	28888	90%	25999	10%	2889
SUBTOTAL 1	7354	persons					109726		105019		4707
ANIMAL											
Camels	5579	head	30	liters	365	1000	61090	70%	42763	30%	18327
Cattle	4463	head	30	liters	365	1000	48870	82%	40073	18%	8797
SheepGoats	30123	head	3	liters	365	1000	32985	80%	26388	20%	6597
OtherAn	11156	head	3	liters	365	1000	12216	5%	611	95%	11605
SUBTOTAL 2	13863	LSU					155160		109835		45326
AGRICULTURE											
Irrigfarm	72	hectares	68	cu.meters	365	1	1787040	85%	1518984	15%	268056
Rainfarm	1026	hectares	35	cu.meters	120	1	4309200	2%	86184	98%	4223016
Floodfarm	205	hectares	25	cu.meters	90	1	461250	2%	9225	98%	452025
SUBTOTAL 3	1303	hectares					6557490		1614393		4943097
GOVT/INDUS											
Government	2.000	estabs	13	cu.meters	300	1	7800	100%	7800	0%	0
Industry	1.000	estabs	12	cu.meters	300	1	3601	100%	3601	0%	0
SUBTOTAL 4	3.000	estabs					11401		11401		0

* * * * * * * * Percentage Distribution of Consumption across the Range of Types of Water Control Structures * * * * * * * *

CONSUMPTION UNITS			VOLUME CONSUMPTION			PERCENTAGE DISTRIBUTION OF CONSUMPTION * *						PERCENTAGE DISTRIBUTION OF CONSUMPTION * *				
	(000s)	MEASURE	TOTAL M^3K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3K/YR	DRILLED WELLS URBAN/ IND/GOVT	DRILLED WELLS DP RURAL BOREHOLE	DRILLED WELLS HP RURAL BOREHOLE	DRILLED WELLS IRRIG'N WELLS	HAND DUG WELLS	INTAKES FOR RIV/ STREAMS	DAMS/ RESER-VOIRS	BALLENS/ PONDS	BURKEDS/ CISTERNS	EARTH DAMS/DIV	TOTAL
HUMAN																
Urban HC	865	persons	41044	99%	40634	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Urban SP	1297	persons	19410	98%	19021	80.00%	0.00%	0.00%	0.00%	8.00%	9.00%	1.00%	0.00%	2.00%	0.00%	100.00%
Rural Set	2148	persons	20385	95%	19365	3.00%	26.60%	0.40%	0.00%	40.00%	15.00%	3.00%	2.00%	10.00%	0.00%	100.00%
Nomadic	3044	persons	28888	90%	25999	1.50%	15.60%	0.40%	0.00%	35.00%	20.00%	8.50%	9.00%	10.00%	0.00%	100.00%
SUBTOTAL 1	7354	persons	109726		105019											
ANIMAL																
Camels	5579	head	61090	70%	42763	1.00%	18.60%	0.40%	0.00%	15.00%	15.00%	20.00%	25.00%	5.00%	0.00%	100.00%
Cattle	4463	head	48870	82%	40073	5.00%	19.60%	0.40%	0.00%	30.00%	10.00%	20.00%	10.00%	5.00%	0.00%	100.00%
SheepGoats	30123	head	32985	80%	26388	3.00%	16.60%	0.40%	0.00%	33.00%	12.00%	15.00%	13.00%	7.00%	0.00%	100.00%
OtherAn	11156	head	12216	5%	611	2.00%	12.60%	0.40%	0.00%	28.00%	15.00%	20.00%	17.00%	5.00%	0.00%	100.00%
SUBTOTAL 2	13863	LSU	155160		109835											
AGRICULTURE																
Irrigfarm	72	hectares	1787040	85%	1518984	0.00%	0.00%	0.00%	4.00%	1.00%	80.00%	1.00%	1.00%	0.00%	5.00%	100.00%
Rainfarm	1026	hectares	4309200	2%	86184	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	205	hectares	461250	2%	9225	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1303	hectares	6557490		1614393											
GOVT/INDUS																
Govt	2.000	estabs	7800	100%	7800	92.00%	2.00%	0.00%	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	1.000	estabs	3601	100%	3601	87.00%	3.00%	0.00%	0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	3.000	estabs	11401		11401											

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

CONSUMPTION UNITS			VOLUME CONSUMPTION			TOTAL DISTRIBUTION OF WATER BY STRUCTURE * *						TOTAL DISTRIBUTION OF WATER BY STRUCTURE * *			
	(000s)	MEASURE	TOTAL M^3K/YR	STRUCT'L CONTROL %AGE	STRUCT'L CONTROL VOLUME M^3K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3K/YR	DRILLED WELLS DP RURAL BOREHOLE M^3K/YR	DRILLED WELLS HP RURAL BOREHOLE M^3K/YR	DRILLED WELLS IRRIG'N WELLS M^3K/YR	HAND DUG WELLS M^3K/YR	INTAKES FOR RIV/ STREAMS M^3K/YR	DAMS/ RESER-VOIRS M^3K/YR	BALLENS/ PONDS M^3K/YR	BURKEDS/ CISTERNS M^3K/YR	EARTH DAMS/DIV M^3K/YR
HUMAN															
Urban HC	865	persons	41044	99%	40634	32507	0	0	0	3251	3657	406	0	813	0
Urban SP	1297	persons	19410	98%	19021	15217	0	0	0	1522	1712	190	0	380	0
Rural Set	2148	persons	20385	95%	19365	581	5151	77	0	7746	2905	581	387	1937	0
Nomadic	3044	persons	28888	90%	25999	390	4056	104	0	9100	5200	2210	2340	2600	0

Rainfarm	1026 hectares	4309200	2%	86184	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Floodfarm	205 hectares	461250	2%	9225	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SUBTOTAL 3	1303 hectares	6557490		1614393											
GOVT/INDUS															
Govt	2.000 estabs	7800	100%	7800	92.00%	2.00%	[illegible]	0.00%	4.00%	2.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Industry	1.000 estabs	3601	100%	3601	87.00%	3.00%		0.00%	7.00%	3.00%	0.00%	0.00%	0.00%	0.00%	100.00%
SUBTOTAL 4	3.000 estabs	11401		11401											

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

CONSUMPTION UNITS — VOLUME CONSUMPTION — TOTAL DISTRIBUTION OF WATER BY STRUCTURE * * TOTAL DISTRIBUTION OF WATER BY STRUCTURE * *

	(000s)	MEASURE	TOTAL M^3*K/YR	STRUCT'L CONTROL IAGE	STRUCT'L CONTROL VOLUME M^3*K/YR	DRILLED WELLS URBAN/ IND/GOVT M^3*K/YR	DRILLED WELLS DP RURAL BOREHOLE M^3*K/YR	DRILLED WELLS HP RURAL BOREHOLE M^3*K/YR	IRRIG'N WELLS M^3*K/YR	HAND DUG WELLS M^3*K/YR	INTAKES FOR RIV/ STREAMS M^3*K/YR	DAMS/ RESER- VOIRS M^3*K/YR	BALLENS/ PONDS M^3*K/YR	BURKEDS/ CISTERNS M^3*K/YR	EARTH DAMS/DIV M^3*K/YR
HUMAN															
Urban MC	865	persons	41044	99%	40634	32507	0	0	0	3251	3657	406	0	813	0
Urban SP	1297	persons	19410	98%	19021	15217	0	0	0	1522	1712	190	0	380	0
Rural Set	2148	persons	20385	95%	19365	581	5151	77	0	7746	2905	581	387	1937	0
Nomadic	3044	persons	28898	90%	25999	390	4056	104	0	9100	5200	2210	2340	2600	0
SUBTOTAL 1	7354	persons	109726		105019	48695	9207	181	0	21618	13474	3387	2727	5730	0
ANIMAL															
Camels	5579	head	61090	70%	42763	428	7954	171	0	6414	6414	8553	10691	2138	0
Cattle	4463	head	48870	82%	40073	2004	7854	160	0	12022	4007	8015	4007	2004	0
SheepGoats	30123	head	32985	80%	26388	792	4380	106	0	8708	3167	3958	3430	1847	0
OtherAn	11156	head	12216	5%	611	12	77	2	0	171	92	122	104	31	0
SUBTOTAL 2	13863	LSU	155160		109835	3235	20266	439	0	27315	13680	20648	18232	6019	0
AGRICULTURE															
Irrigfarm	72	hectares	1787040	85%	1518984	0	0	0	60759	15190	1336706	15190	15190	0	75949
Rainfarm	1026	hectares	4309200	2%	86184	0	0	0	0	0	0	0	0	0	86184
Floodfarm	205	hectares	461250	2%	9225	0	0	0	0	0	0	0	0	0	9225
SUBTOTAL 3	1303	hectares	6557490		1614393	0	0	0	60759	15190	1336706	15190	15190	0	171358
GOVT/INDUS															
Govt	2	estabs	7800	100%	7800	7176	156	0	0	312	156	0	0	0	0
Industry	1.000	estabs	3601	100%	3601	3133	108	0	0	252	108	0	0	0	0
SUBTOTAL 4	3.000	estabs	11401		11401	10309	264	0	0	564	264	0	0	0	0
STRUCT'L SUPPLY VOLUMES (M^3*K/YR)					1840648	62239	29737	621	60759	64687	1364123	39225	34149	11749	171358
VOLUME OUTPUT:		(M^3*K/str/yr)				124	32	3.1	200	1.560189	199.9640	1.375246	2.138286	0.534255	16.5008
		(days/yr)				345	300	345	130	345	250	120	90	60	60
		(M^3/str/day)				340	107	8	1538	4	800	11	24	9	275
NUMBERS OF WATER SUPPLY STRUCTURES						502	929	200	304	41461	6822	28522	16906	21991	10385
COMMERCIAL SCALE STRUCTURES						502	929	200	304	6097	6822	1180	282	21991	208
USEFUL LIFE						10	10	10	10	10	10	10	10	15	5
CRUDE REPLACEMENT REQUIREMENT						50	93	20	30	610	682	119	28	1466	42

* * Projections of Requirements for New Water Supply Structures for Somalia 1985 - 1995, with Consultants' Recommended Program * * * * *

/YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Growth Rate '84- 90	Growth Rate '90- 95
Program	20	22	15	23	18	19	18	18	18	20	24	20	16	12	12	12		
Program		40	55	34	34	56	40	36	32	28	24	24	24	24	24	24		
Program	5	9	12	17	19	23	31	38	50	58	69	87	96	100	108	113		
Rehab.							22	44	24	24	24	24	24	24	24	24		
IRRIGATION WELLS																		
	250	225	200	175	150	125	100	75	50	25	0	0	0	0	0	0		
		25	94	166	224	272	343	420	556	680	810	951	1106	1266	1426	1594		
+ prev.	250	250	294	341	374	397	443	495	606	705	810	951	1106	1266	1426	1594		
	0	25	28	34	42	47	52	59	67	67	67	42	42	42	42	42		
							22	44	24	24	24	24	24	24	24	24		
	25	71	82	74	71	98	89	92	100	106	117	131	136	136	144	149		
	275	321	376	415	445	495	554	631	730	825	951	1106	1266	1426	1594	1767	13.5062%	13.1555%
WELLS																		
	91	102	123	141	155	166	177	189	202	215	230	243	257	272	287	304	6.7822%	5.7234%
	75	68	60	53	45	38	30	23	15	8	0	0	0	0	0	0		
		16	32	60	82	102	118	135	153	171	191	211	222	235	248	263		
	16	18	31	28	28	26	29	31	34	36	39	32	35	37	39	41		
WELLS																		
					2500	2771	3071	3404	3772	4181	4634	4895	5172	5463	5772	6097	10.8331%	5.6417%
					2250	2025	1800	1575	1350	1125	900	675	450	225	0	0		
						250	721	1199	1709	2252	2831	3451	3875	4334	4805	5291		
					250	496	550	630	714	805	903	770	846	904	967	806		
					5000	5180	5366	5559	5759	5966	6180	6303	6429	6557	6688	6822	3.5944%	1.9959%
					4500	4050	3600	3150	2700	2250	1800	1350	900	450	0	0		
						500	1080	1658	2243	2834	3432	4037	4550	5074	5600	6128		
					500	630	686	751	816	801	948	917	979	1033	1088	693		
VOIRS																		
					750	781	812	845	880	916	953	996	1041	1088	1137	1188	4.0731%	4.5142%
					675	608	540	473	405	338	270	203	135	68	0	0		
						75	166	256	347	440	534	630	731	833	937	1043		
					75	98	107	117	128	138	149	164	175	188	200	145		
WDS																		
					200	205	210	214	220	225	230	240	249	260	271	282	2.3567%	4.1432%
					180	162	144	126	108	90	72	54	36	18	0	0		
						20	41	61	82	103	124	146	171	196	222	248		
					20	23	25	27	29	31	34	40	42	45	48	33		
STERNS																		
					10000	10598	11231	11902	12613	13367	14166	15469	16891	18444	20140	21991	5.9761%	9.1946%
					9333	8711	8089	7466	6844	6222	5600	4978	4355	3733	3111	2489		
						667	1842	3020	4234	5487	6779	8114	9950	11872	13919	16101		
					667	1220	1300	1416	1535	1658	1787	2377	2585	2839	3109	3402		
					100	108	116	125	135	145	156	165	175	185	196	208	7.6930%	5.8915%
					80	64	48	32	16	0	0	0	0	0	0	0		
						20	40	60	81	102	124	131	139	147	156	165		
					20	24	28	33	38	43	32	34	36	38	40	43		

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DIFFERENTIAL III BUDGETS
BOREI I-10
IPPS DEMOPPY, RIVE PROJECTIONS
CONSULTANTS RECONNAISSANCE PROGRAM

INPUTS	Measure	OUTPUTS: WELLS: Drawn Drilled Wells	O.P. Drilled Wells	O.P. Drilled Wells	Irrigation Wells	Hand Dug Wells	Hand Prod Wells	CONSTRUCTION: Wells from Div	OTHER STRUCTURES: Dors	Bulkhds	Dwr-Lands	Dams	ANNUAL CONSTR INPUTS	REHABILITATION: WELLS: Drawn Drilled Wells	O.P. Drilled Wells	OP Drilled Wells	Irrigation Wells	ANNUAL REHAB INPUTS	COSTS: COST PER UNIT	COST COST (000s)	REHAB COST (000s)	TOTAL ANNUAL PHYSICAL INPUTS
EPU	Number of struc.	40	90	7	33	206	25	693	115	33	3462	63							EXCHANGE RATE (US$/LCU)			ALL PURPOSES
EL	Years	10	10	10	10	10		10	10	10	15	5							84			
EDP	Years													10	10	10	10					
EHRD	Number of struc.													6	12	6	0					
MATERIALS																						
Cement per st	cubic meters	200	200	7	200	7	0.5	4	0	0	3	0		60	60	2.1	60		644.00			
Annual cement	cubic meters	9536	18774	32	6633	5643	13	2774	0	0	10794	0	53413	360	720	12	480	1573		0014	132	67238
Stones per st	cubic meters					16		10	0	0	7	640							95.95			
Annual stones	cubic meters					12990		6925	0	0	23013	27130	70054									109043
Gravel per st	cubic meters	15	32	3	75									10.5	10.5	1.5	10.5		634.50			
Annual gravel	cubic meters	1649	3205	37	1163								6156	63	126	9	84	282		0113	04	6438
Sand per st	cubic meters	130	130	2	130	2					2	0		36	36	0.6	36		62.90			
Annual Sand	cubic meters	5772	11264	15	2993	1612					6004	0	29410	216	432	4	288	940		034	01	34060
8" Steel Casing per st	meters	75	75	30	30														975.60			
Ann.8"Steel Casing	meters	3376	3040	375	1064								12853							0532	00	13053
8"Steel Screen per st	meters	40	40	30	30														-0165.60			
Ann.Steel Screen	meters	2146	4224	224	990								7992							0430	00	7992
Cement.casing per st	meters	6	6	6	6		0												0145.00			
Ann.cement.casing	meters	204	543	45	300		0						1094							001	00	1094
Shelter per st	units	1	1	0.2	0.2	0.1					0.3											
Annual Shelter	units	40	94	1	7	21					1791		1931									1931
Pipefittings per st	meters	200	200	0	200	0		15			10			60	60	0	60		034.00			
Annual Pipefittings	meters	9536	18774	0	6633	0		10442			34019		79387	360	720	0	480	1560		0563	132	113409
Drilling Field per st	units	24	24	16	16		3							0	0	0	0		017.10			
Annual Drilling Field	units	1144	2253	119	532		177						4175	0	0	0	0	0		040	00	4175
Drill Bits per st	units	0.12	0.12	0.08	0.08		0.08							0	0	0	0		01,290			
Annual Drill Bits	units	5.7	11.3	0.6	2.7		2.0						22	0	0	0	0	0		039	00	22
Hand Pump per st	units			1		0.2										1			07,000			
Annual Hand Pumps	units			7		143							149			6		6		00	00	209
Diesel Pump per st	units	1	1		1			1						1	1		1		021,000			
Annual Diesel Pumps	units	40	94		33			693					860	6	12		8	26		01,971	0252	1103
Rubber & Hand per st	meters	30	30		13						30			9	9	0	3.9		035.71			
Annual Rubber&Hand	meters	1430	2816		433						60030		72717	54	108	0	31	193		0101	04	110009
Plastic Sheet per st	sq.meters								104	1300												
Annual Plastic sheets	sq.meters								12002	10000			22002									73187
LABOUR																						
Drillers																						
Supervisory per St.	man-days	10	13	6	6		10												05.v3			
Annual Supervisory	man-days	677	1400	45	399		253						2303					0		05	00	39909
Drilling per St.	man-days	25	15	12	12		10							10	15	12	12		03.95			
Annual Drilling	man-days	1692	1400	89	399		253						3342	100	180	72	96	456		05	01	3798
Excavation per st.	man-days					6.6			10	10	30	30							05.06			
Annual Excav.Drlr	man-days					5199			1150	334	112057	1281	118252					0		00	00	305406
Civil Drlr.per st.	man-days	30	15	10	15	5		1.2	0.3	1.5	15	30		10	15	12	12		05.36			
Annual Civil Drlr.	man-days	2304	1400	75	499	4031		832	73	50	51030	1281	61161	100	180	72	96	456		00	01	94000
Mech.Drlr per st.	man-days	20	10	3	3	0.6		3			3								03.27			
Ann.Mechanic Drlr.	man-days	954	939	22	100	484		2447			10296		16171					0		03	00	298569
Carp.Drlr per st.	man-days	5	2	2	2														05.90			
Ann.Carpentry Drlr.	man-days	230	188	15	67								500					0		01	00	500
Hand/Unskilled																						
Drilling per St.	man-days	200	60	30	30		30							54	65	36	36		02.00			
Annual Drilling	man-days	9536	5632	375	998		760						17299	324	540	216	288	1360		013	01	18667
Excavation per st.	man-days					6.6					3								02.00			
Annual Excav.Drlr	man-days					5199					10296		15463					0		00	00	24329
Civil.Drlr per st.	man-days	300	50	30	30	5		2	0.5	1.5	15	90		36	30	30	30		02.00			
Ann.Civil Drlr.	man-days	14304	6494	224	666	4031		1887	73	50	51030	3844	80300	216	360	144	192	912		010	01	116600
Mech.Drlr. per st	man-days	12	0	6	6	3.6		12			6								02.00			
Ann.Mechanic Drlr.	man-days	573	751	30	132	2902		8322			20411		33121					0		02	00	373600
Other Unskilled per st.	man-days	100	30	15	15									36	30	30	30		01.33			
Annual Other Unskilled	man-days	4763	1877	112	499								7256	216	360	144	192	912		03	01	8160
EQUIPMENT																						
Drill Rigs per st	Eq-days	30	13	15	12		10							10	15	12	12		0236			
Annual Drill Rigs Use	Eq-days	1430	1400	112	399		253						3603	100	180	72	96	456		0393	046	4009
Pump Rigs per st	Eq-days	3	3	3	3		0												092			
Annual Pump Rigs Use	Eq-days	90	202	23	67		0						430					0		026	00	2130
Heavy Vehicles per st	Eq-days	150	30	35	30	10	15	3	10	10	0	30		50	25	12	12		004			
Annual Heavy Vehic Use	Eq-days	7150	2347	406	666	2061	379	1887	1450	334	37213	1281	50409	900	600	72	96	456		0204	015	170002
Light Vehicles per st	Eq-days	800	30	30	30	60	60	3	5	12	0	30		60	25	12	12		020			
Annual Light Vehic Use	Eq-days	14920	2056	204	832	2061	1663	2000	720	604	13660	1280	42963	900	600	72	96	456		0127	07	260177
FUEL CONSUMPTION																						
Drill Rigs per st	Liters	4000	2250	2250	4500		6450							900	750	600	600		00.60			
Annual Drill Rigs Fuel	Liters	172000	211500	16743			25320						6.7064	5400	9000	3600	4800	22800		0.13	00	670573
Pump Rigs per st	Liters	800	800	900	900		0												00.60			
Annual Pump Rigs Fuel	Liters	8800	1000	940	3220		0						20736					0		00	00	260419
Heavy Vehicles per st	Liters	3000	875	875	700	300	600	50	400	400	320	1200		420	500	300	420		00.60			
Annual Heavy Vhcl Fuel	Liters	330000	82126	8849	12994	303907	15525	10400	80019	13379	1400004	54139	1993234	3900	6000	3600	3360	19860		002	04	4000227
Light Vehicles per st	Liters	1200	300	300	300	300	600	90	120	240	120	300		240	300	240	300		00.75			
Annual Light Vehic Fuel	Liters	132000	46920	4470	14630	340800	20004	13913	21757	13003	400227	30040	1066000	2600	3000	2400	3900	9120		001	01	1266263
																			TOTAL (000s) PER WELL	00,700 064.600	1300 033.000	

		MAINTENANCE											OPERATIONS					COST
9S LEVEL III SUBMODEL																		
E I-10																		
SUPPLY SIDE PROJECTIONS		WELLS					OTHER STRUCTURES						WELLS					D.P. RURAL WE
ULTANTS' RECOMMENDED PROGRAM																		
	Measure	Urban Drilled Wells	D.P Drilled Wells	HP Drilled Wells	Irrigation wells	Hand Dug Wells	Intks from Riv	Dars	Gallehs	Burkeds	Dams	ANNUAL MAINT INPUTS	Urban Drilled Wells	D.P Drilled wells	H.P Drilled wells	Irrigation Wells	ANNUAL OPER. INPUTS	COST PER UNIT / OF W MAIN COST USE
	Years	0.25	0.25	1	0.25	1	0.25	1	1	1	1							EXCHANGE RATE SOSH/US$ 34
	Number of struc.	2191	4028	212	1215	5291	27287	1043	248	18589	165							
	Number of Struc.												548	1007	212	304		
r st	cubic meters					0.7	0.1	0	0	0.3	0							$44.40
ment	cubic meters					3704	2729	0	0	5577	0	12009						
r st	cubic meters					1.6	0.25	0	0	0.7	64							$5.95
mes	cubic meters					8466	6822	0	0	13013	10559	38859						
it	cubic meters					0.2	0	0	0	0.2	0							$2.98
d	cubic meters									3718	0	3718						
ings per st	meters	0.5	0.5	0	0.5	0	0.375	0	0	1	0							$30.00
pe&Fittings	meters	1095	2014	0	608	0	10233			18589		32542						
per st	units			0.09		0.018												$2,000
d Pumps	units			19		95						114						
p per st	units	0.015	0.015		0.015		0.015	0	0	0	0							$21,000
esel Pumps	units	33	60		18		409					521						$1
Wood per st	meters						0	0	0	2	0							$35.71
bars&Wood	meters									37179		37179						
heet per st	sq.meters						0	10.4	150	0	0							
astic sheets	sq.meters							10851	37251			48102						
ry per St.	man-days	1.075	1.075	1.3	1.075		1.075											$5.95
pervisory	man-days	2555	4330	276	1306		29334					37606						
n per st.	man-days						0	1	1	3	3							$5.95
cav.Wrks	man-days							1043	248	55768	495	95164						
s.per st.	man-days					0.5	0.03	0.05	0.15	1.5	3							$5.06
vil Wrks.	man-days					2646	819	52	37	27884	495	31933						
per st.	man-days	6.45	6.45	7.8	6.45	2.12	6.45	0	0	0.3	0							$5.36
nic Wrks.	man-days	14129	25979	1654	7838	11217	176004			5577		242397						
lled per st.	man-days												365	300	365	130		$2.38
her Skilled	man-days											0	199888	302085	77376	39494	618843	
illed:																		
a per st.	man-days					0.64	0	0	0	0.3	0							$2.08
cav.Wrks	man-days					3386				5577		8963						
s per st.	man-days					0.5	0.05	0.05	0.15	1.5	9							$2.08
Wrks.	man-days					2646	1364	52	37	27884	1485	33468						
. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0							$2.08
nic Wrks.	man-days	14129	25979	1654	7838	3810	176004			11154		240567						
n per st	Eq-days																	$256
ill Rigs Use	Eq-days											0						
per st	Eq-days	0.075	0.075	0.3	0.075		0.075											$92
mp Rigs Use	Eq-days	164	302	64	91		2047					2668						
icles per st	Eq-days					2	2	3	9		3							$81
avy Vehcl Use	Eq-days					10582	54575	3130	2235		495	71017						
icles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3							$38
ght Vhcls Use	Eq-days	7065	12990	827	3919	42329	88002	3130	2235	55768	495	216759						
mp per st.	Eq-days												365	300		130		$14
esel Pumps	Eq-days											0	199888	302085		39494	541466	
per st.	Eq-days														365			$1.18
nd Pumps	Eq-days											0			77376		77376	

illed per st.	man-days												365	300	365	130			
Other Skilled	man-days											0	199888	302085	77376	39494	618843		$2.36
killed:																			
.on per st.	man-days					0.64	0	0	0	0.3	0								
Excav.Wrks	man-days					3386				5577		8963							$2.08
ks per st.	man-days					0.5	0.05	0.05	0.15	1.5	9								
l Wrks.	man-days					2646	1364	52	37	27884	1485	33468							$2.08
s. per st	man-days	6.45	6.45	7.8	6.45	0.72	6.45	0	0	0.6	0								
anic Wrks.	man-days	14129	25979	1654	7838	3810	176004			11154		240567							$2.08
T																			
gs per st	Eq-days																		
rill Rigs Use	Eq-days											0							$256
s per st	Eq-days	0.075	0.075	0.2	0.075		0.075												
mp Rigs Use	Eq-days	164	302	64	91		2047					2668							$92
hicles per st	Eq-days					2	2	3	9		3								
avy Vehcl Use	Eq-days					10582	54575	3130	2235		495	71017							$81
hicles per st	Eq-days	3.225	3.225	3.9	3.225	8	3.225	3	9	3	3								
ight Vhcls Use	Eq-days	7065	12990	827	3919	42329	88002	3130	2235	55768	495	216759							$38
mp per st.	Eq-days												365	300		130			
essel Pumps	Eq-days											0	199888	302085		39494	541466		$14
per st.	Eq-days														365				
and Pumps	Eq-days											0			77376		77376		$1.18
SUMPTION																			
gs per st	Liters																		
rill Rigs Fuel	Liters											133413							$0.60
s per st	Liters	3.75	3.75	15	3.75		3.75												
mp Rigs Fuel	Liters	8215	15104	3180	4557		102328					133383							$0.60
hicles per st	Liters					80	80	120	360	0	120								
avy Vhcl Fuel	Liters					423290	2182990	125204	89402		19798	2840683							$0.60
hicles per st	Liters	64.5	64.5	78	64.5	160	64.5	60	180	60	60								
ght Vhcls Fuel	Liters	141291	259793	16535	78380	846580	1760033	62602	44701	1115368	9899	4335184							$0.71
r Pump	Liters												13140	4500	0	3250			
essel	Liters											0	7195975	4531270	0	987340	12714584		$0.60

TOTAL (000s)

PER WELL/YEAR

TOTAL O & M/YEAR

O&M PER M^3 WATER