HMR
CONSULTANTS

ACADEMY FOR EDUCATIONAL DEVELOPMENT
GreenCOM
BEST DOMESTIC WATER CONSERVATION PRACTICES IN SULTANATE OF OMAN

FINAL REPORT

REVISED January 1998

بسم الله الرحمن الرحيم

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A REPORT ON
BEST DOMESTIC WATER CONSERVATION PRACTICES IN SULTANATE OF OMAN
(Revised)

on behalf of

ACADEMY FOR EDUCATIONAL DEVELOPMENT
GreenCOM

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1.0 Executive Summary

A comprehensive evaluation of best practices for water conservation in the Sultanate has been documented. A total of eleven best practices have been reported, primarily driven and directed by the Public sector. Every effort was made to report the practices in the most objective and concise manner supported by empirical data wherever possible.

In reviewing the practices, it is clear to see that a concerted effort is being made to promote water conservation in all areas of consumption. The focal point for these efforts is the Ministry of Water Resources, with comprehensive public awareness programs that are formulated in a united effort with other governmental agencies, notably the Ministry of Agriculture and Fisheries, Ministry of Electricity and Water and Muscat (Regional) Municipalities.

Although documented results of conservation efforts have not been included in the report, it is evident that follow up programs and accurate evaluation and analysis of the results is an on going process. Initial priority in the Ministry of Water resources was to implement a strategy that would define and quantify the available water resources of the Nation, this included aggressive exploration drilling programs, setting up of a Nation wide ground water monitoring program, and a National Well inventory. These efforts have resulted in the collection of a vast amount of data that the Ministry is collating and formatting to support rationale water management strategies that will service current and future water resource needs.

In general, a holistic approach to best practice can be concluded as the currently preferred strategy towards water resources conservation in the Sultanate. This strategy, if viewed in light of the realities of urgent needs for water to support national economic development plans and effectively meet the quantum increases of domestic demands, is in itself an appropriate plan that reflects the Nation's development needs. As users and water markets develop in line with evolving institutional and economic framework, so would the need to implement more innovative and stringent water conservation plans. Furthermore, natural market forces, supply and demand, would force all sectors to adopt the most practicable and cost effective conservation strategy.

In the final analysis, any conservation effort and practice should be applauded and supported. It is clear that the Sultanate is making every effort to implement programs that will support sustainable economic development while promoting rationale water use among all sectors of the community.

2.0 Background on the Sultanate of Oman

2.1 Physiography

The Sultanate of Oman is located on the eastern coast of the Arabian peninsula. Oman has a desert climate, with exceptionally hot and humid weather along the northern, or Batinah, coast and hot and dry weather in the interior. The Southern region, Dhofar, experiences light annual monsoons during the summer months.

Muscat is the capital city, and the other major city is Salalah, located in the Dhofar Province in the south of the Sultanate. Among other towns are Sur, Nizwa, Rostaq, Ibri, and Sohar. Oman is bordered in the south by the People's Republic of Yemen, on the west of Saudi Arabia, and on the north by the United Arab Emirates. The Musandam Province of Oman, located on the Strait of Hormuz, is separated from the main part of the Sultanate by the United Arab Emirates (Fig.1). The eastern coast of Oman on the Gulf of Oman and the Arabian sea is 1056 mile (1700 km) long.

The country is divided into eight administrative regions- Muscat, Al Batinah, Musandam, Al Dhahirah, Al Dakhliyah, Al Sharqiyah, Al Wusta and the Dhofar region. (Fig.2)

The northern part of the country is dominated by the mountain chain (Al Hajar mountain which stretches in the form of an arc from Ras Musandam in the north to Ras Al Had) rising to 3000 metres and running for 700 kms from Musandam to near Sur. To the north east of these mountains lie the narrow coastal plain, Batinah which is the most populous part of the country. The capital Muscat is located at the eastern end of this plain. To the south of the mountains wadis *(Wadi's are dry river beds, "ephemeral" which flows only after heavy rain storm events)* drain to an arid interior plain with areas of sand dunes and sabkha (*salt basins*). In the south of the country the coast is bordered by the Jebel al Qara (Al Qara mountain range situated in the far side of south west of Oman). This slopes steeply to the south but to the north forms a gently sloping plain draining to the interior and known as the Nejd. And Salalah lies on the southern coast. The land is a contrast of jagged mountains, green grasslands, and the sands of the Rub al Khali, empty quarter.(Fig.3)

2.2 Population

The total population of Oman is 2, 018,074 with 286,748 households and a projected population growth rate of 3.5% every year. The most populated regions being Batinah with about 564,6477, followed by Muscat region with about 549,150.*(Results of the General census of Population, Housing & Establishment, 1993).*

2.3 Geology

The geological formations in Oman range from Pre- Permian *(Pre-Cambrian to Permian i.e 800 to 300 million years)* to recent in age, with rock types including granites, volcanics, sedimentary, gneisses, and alluvials. Outcrop ranging in age from 800 million years to

recent formations and varying in character from metamorphic and igneous to sedimentary as a result of experiencing different tectonic movements in the geological time scale. The major sources of water are the alluvium in Northern Oman (with recent potential findings even in the ophiolite in Semail) and the Tertiary limestones in the south.

2.4 Climate

Oman is an arid country in the tropics, characterised by low and erratic rainfall and high temperatures, which can reach over 50° C (122° F) in the summer months in the interior. The average annual rainfall varies from less than 50mm (2 inches) in parts of the central plains to 300mm (12 inches)over the mountains. Two distinct seasons occur, winter (November to April) and summer (May to October).

Table 2.1 A Comparison of Temperature and Precipitation Data of Sultanate of Oman with other World Wide Stations

Country & Station	Average Extreme Temperatures & Precipitation				
Country Station	Length of Record	Average Extreme Temperatures		Length of Record	Average Annual Precipitation
	Years	Max ° F	Min °F	Years	Inches
Oman ***Muscat***	**23**	**116**	**51**	**38**	**3.9**
USA *Washington D.C*	14	106	-15	30	40.8
UK *London*	30	99	9	30	22.9
Libya *Tripoli*	47	114	33	56	15.1
Saudi Arabia *Dhahran*	10	120	40	10	3.5
Iran *Abadan*	12	127	24	10	7.6
Pakistan *Karachi*	43	118	39	59	7.8
Australia *Adelaide*	86	118	32	104	21.1

Source:Environmental Science Services Administration, Climates of the World, 1969. Geographic names revised by editors in accordance with 1987 usuage.

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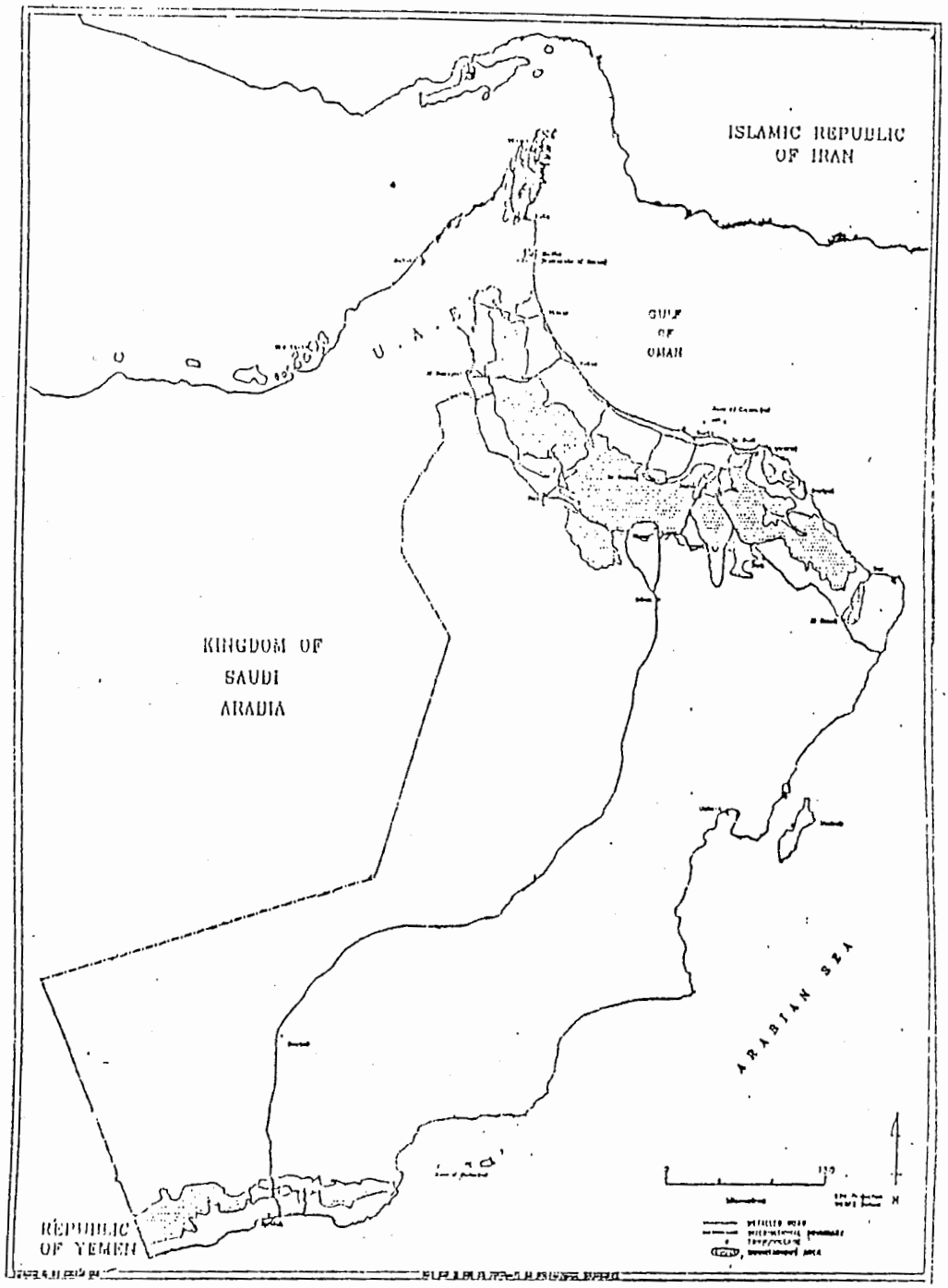
Figure 1: Map - Sultanate of Oman



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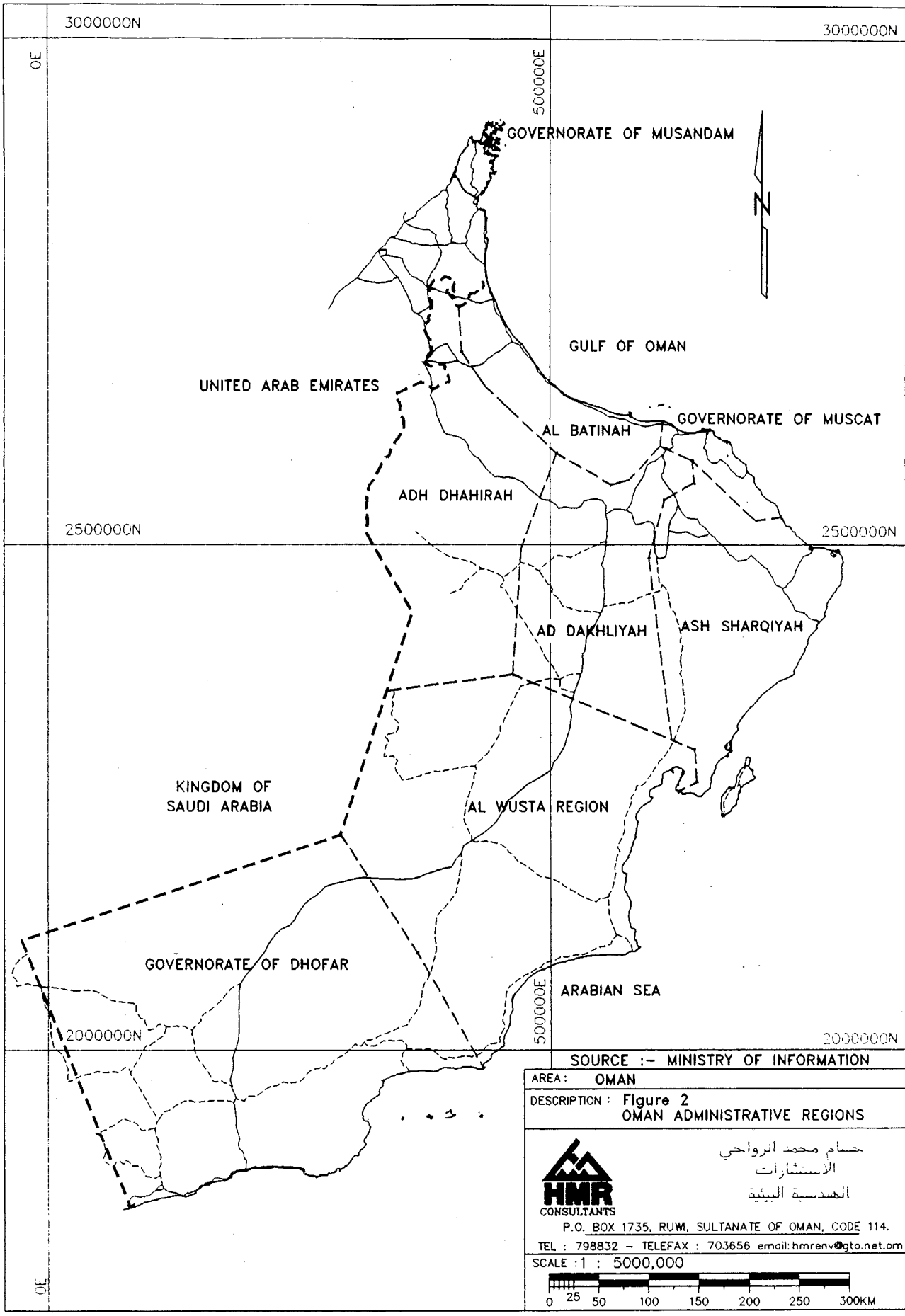

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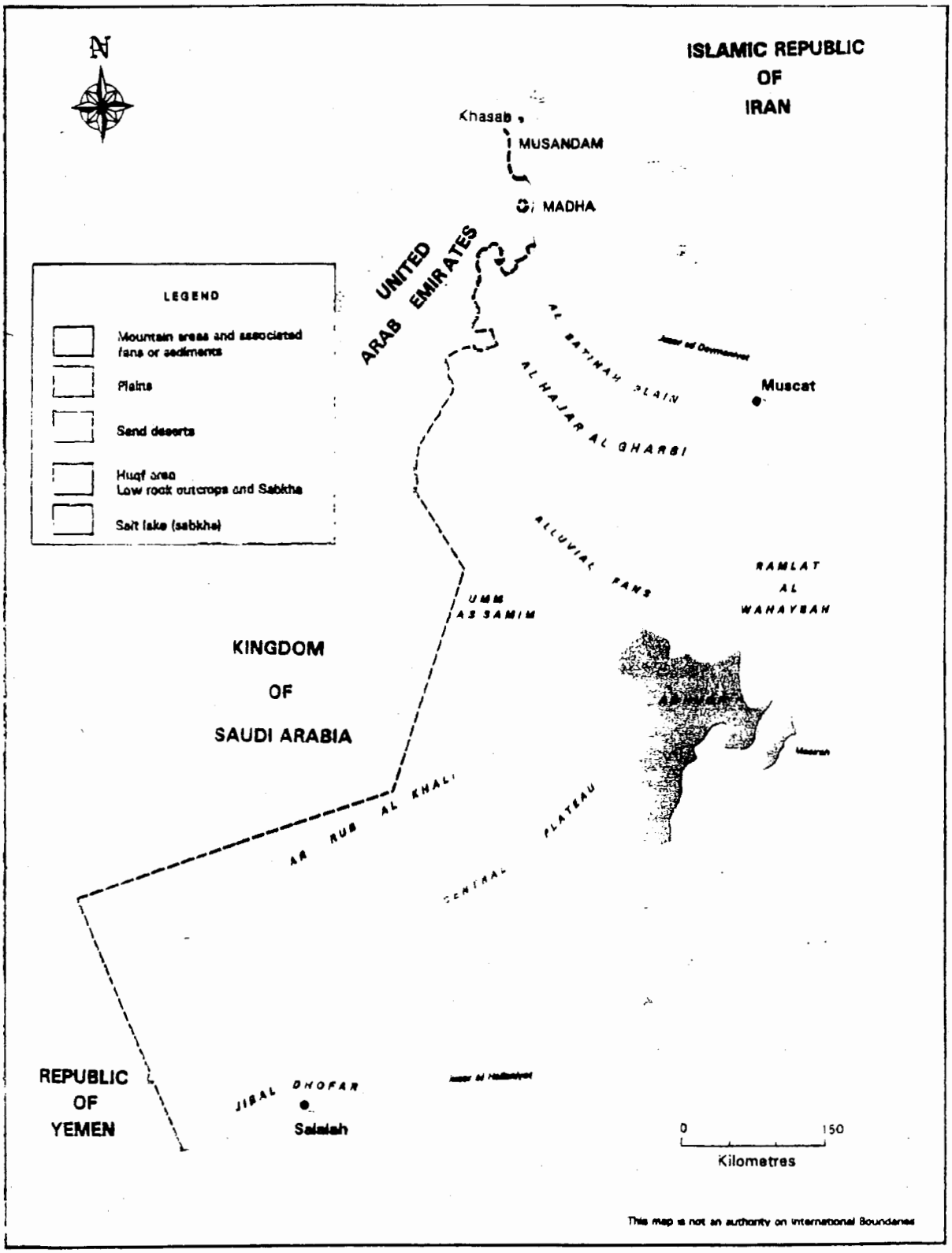
Figure 3: Oman - Physiography



Source: Ministry of Water Resources

2.5 Cultural and Sociological place of Water in Oman Society

Traditionally water is greatly valued by the community, and it's equitable appropriation amongst the community is controlled by the highest level of institutional hierarchy. There is no doubt that the community understands and respects the need to conserve water and control it's use under a strict order of priority. First and foremost the highest priority is given to the right to fulfill thirst. By this, it is perceived to be wrong to deny any man the right to of water to fulfill his thirst. Following this is the right of water for animals, irrigation and domestic use. This tradition is unanimously accepted and revered, especially in light of the teachings of the Quran with respect to water, for it is written that:

" We made from water every living thing " (The Holy Quran XXI, Verse 30)

The traditional lifestyle of all Omani communities adhere to this teaching and continue to place water as the most precious resource for their survival. In light of this, Government legislation, water management framework and implementation strategy continues to be influenced by this teaching. Once this fundamental principal is accepted, and understood, it is clear to recognize that traditional societal value for water support conservation and sustainable development of water resources of the Nation. This tradition continues to hold true for the most part of Omani society.

Evolving legislation, however, does consider the changing needs for water with growing urbanization, industrialization and societal expectations. There is a clear dichotomy between traditional needs and modern needs for water in the Sultanate. This is to be expected, given the rapid development and vast geographic distribution of communities within the Sultanate. The Government continues to make every effort to conform to traditional demands, mainly in the interior regions, for the right to potable water, while maintaining realistic water resources development strategies to meet urban and industrial demands.

3.0 History of Water Supply System

Prior to the succession of His Majesty Sultan Qaboos in 1970, Muscat was a separated walled city, with the palace and other government buildings located inside the walls. Nearby villages were Muttrah, which was a one-hour walk over the mountain from Muscat, Ruwi, Wattayah, Qurum, Ghubrah, Hamriya, Riyam, Al Kwai, and Wadi Aday. Now these names designate districts within the greater Muscat area. In 1970, each of these villages was served by a series of water wells located in a nearby "wadi", a dry valley or drainage channel. The water distribution system in each of these villages provided water to mosques, the "wali" (governor's) house and office, and the residences of a few high government officials. The network in Muscat served the hospital and palaces as well.

The forerunner of today's water distribution system was commissioned in April 1970 (Dawood et al., 1986). It consisted of three water wells located in Wadi Al Khawd that pumped to a 10, 000- Imperial gallons (Igal), (45,460-Litres), reservoir from which it was repumped through a 12-in. (cement-mortar lined) ductile iron pipeline to Muttrah and Muscat, a distance of about 22mi (35 km).

As new areas were developed in Muttrah, Ruwi, and Wadi Aday, the demand for water increased, so the system was expanded to meet those demands. By 1974, demand for water had increased dramatically as the capital area expanded. To meet the growing demand for water and electricity, the government made a decision to construct a combined power generating station and desalination plant (a combined cycle plant), using the waste heat from power generation to assist in desalting seawater. The Ghubarah Power and Desalination plant is comprised of steam turbines and a multistage flash (MSF) seawater evaporator providing electricity and freshwater to the Muscat capital area. The plant, since its commissioning in early 1976, has been operated and maintained by Sogex, which was the successful bidder for the repeated operation and maintenance contracts. The evaporator was built by Demag using the basic design of Envirogenics Systems Company, U.S.A., a member of the Sogex group (Chalchal, 1979).

The sources of water for the greater Muttrah area are Ghubrah desalination plant, the Wadi Aday (eastern well field), the western wellfield, and Oman Refinery Corporation (ORC). However MEW had stopped buying water from ORC since 1/1/1995. The original Ghubrah desalination plant consisted of one unit that produced 4 to 6 Imperial Million gallons/day (Imgd) (18 to 28 Million Litres/day(ML/day). Multistage flash distillation (MSF), which is common in most Arabian Gulf countries (Dawood et al., 1986), was used. A second MSF distillation unit, similar to the first, with a capacity of 6 Imgd (27 ML/d) was added to the plant in 1982.

The intake for the seawater extends into the Gulf of Oman a distance of 2,953 ft (900 m). Seawater is drawn by vacuum through four 8-in. (200mm) pipes to a seawater pump pit located adjacent to the beach and on the plant site. Eight vertical centrifugal pumps, each

with a capacity of 1.5 Imperial million gallons per hour (Imgph) (7,000m3/h), pump the water into the plant to commence the distillation process. The distillate from the plant is passed through a limestone bed and is chemically adjusted to lower the hardness of the water. The final product water fully meets the Omani drinking standards (Dawood et al., 1986). As the demand for water increases, the load control center calls for additional water by activating water wells in the eastern and western well fields. As the demand decreases, the wells are turned off.

In April 1986, two additional MSF units, similar to the existing units, were completed and put into service at the Ghubrah plant. The total capacity of the Ghubrah desalination plant as of April 1986, was 23 Imgd (104 ML/D).

The Wadi Aday, or eastern well field, consists of 29 wells located throughout the length of the wadi, a distance of about 5 miles (8 Km). The optimum rechargeable abstraction of the field is 2.2 Imgd (10 ML/d), but the maximum pumping capacity for short periods is 10 Imgd (45ML/d). The average electrical conductivity of these wells is 2500 **micromhos/cm or *microsiemens***. (Electrical Conductivity of sea water approximately 50,000 micromhos/cm. *Electrical conductivity is the ability of a substance to conduct an electrical current, electrical conductance when referred to groundwater is normally reported as reciprocal milliohms or reciprocal microhms, known as millimhos and micromhos.* ***In SI system, 1 millimho is denoted as 1 millisiemen (mS) and 1 micromho as 1 microsiemen (µS).*** *(Source:Groundwater by Freeze/Cherry,Page 139).* The wells range from 144 to 442ft (44 to 135 m) in depth. The use of this well field is closely monitored since over pumping will cause saltwater upconing. Once the upconing has occurred, the well is lost as a sweet water well. Six wells in the lower end of the Wadi Aday have already turned brackish (Dawood et al., 1986). the brackish water from these wells is pumped to a 1.1 mil Igal (5000 m3) reservoir. From there the water is pumped to Ghubrah for blending with the distilled water. Thus if any wells become brackish, they are not lost but are used for blending (Dawood et al., 1986). The conductance of the blended water is 500 micromhos/cm. The ratio of blending Groundwater with desalinated water is 20:80 respectively, which improves the taste of water and also lowers electrical conductance of groundwater supplied from the Government Well Fields. The groundwater available from the well fields are used in blending, reduces the cost of of the water when compared to cost of producing the same amount of desalinated water.

The western field, situated west of the Seeb International Airport, is located in Wadi Al Khawd. It consists of three sections: the Old Government section (20 wells), the Al Khawd section (14 wells), and the Seeb section (12 wells). Total no of wells in the western wellfield is 46. The recommendable abstraction rate for the three sections at this field is 2.2 Imgd (10ML/d) and the maximum pumping capacity for short periods can be raised to 10 Imgd for both the western and eastern wellfields.

The old government section has 20 wells ranging in depth from 213 to 312 ft (65 to 95 m). The well casings are 8 and 10 in. (200 and 250 mm) in diameter. All wells are screened.

The optimum capacity of this section is 0.8 Imgd (3.6 ML/d) with a maximum capacity if 1.2 Imgd 95.4 ML/d). The electrical conductivity averages about 1,350 micro mhos/cm.

The Al Khawd section is downstream of the Old Government section and below the new Al Khawd recharge dam. it consists of 14 wells, spaced at minimum intervals of 1312 ft. (400m). The wells are about 230 ft (70m) deep. All the wells are cased and screened with 10-in (250 mm) casings. By agreement with the Ministry of Agriculture and Fisheries, which built the recharge dam, water is pumped from only 12 wells at any one time, keeping two in reserve. All wells are pumped using rotating schedule. If an emergency occurs and additional water is needed, all 14 wells can be activated. The optimum capacity of the 12 wells is 3 Imgd (13.6ML/d) with a maximum capacity of 4 mgd (18.1 ML/d). The average electrical conductivity is 1300 micromhos/cm.

The Seeb section of the western well field is downstream from the Al Khawd section and recharge dam. It consists of 12 wells ranging from 8 to 10 in(200 to 250 mm) in diameter. All wells are cased and screened. Their depths range from 189 to 361 ft (88 to 110m). The optimum capacity of this section is 3 Imgd (13.6 ML/d) with a maximum capacity of 4 Imgd (18 ML/d). The average electrical conductivity is 1200 microhoms/cm. Six additional wells are located outside the physical boundaries of the western well field, but because of their proximity to the area, they are considered part of the well field.

The total groundwater resources for the capital water system is 75 water wells with an overall optimum capacity of 13.8 Imgd (62.7 ML/d) and a maximum capacity of 19.2 Imgd (87 ML/d). The average temperature of the groundwater at the discharge head of the wells is 93° to 95°F (34° to35°C).

The last source of water is the excess distilled water produced by the water produced by the Oman refinery Corporation (ORC), which has two MSF distillation units to produce water for the refinery. In October 1984, Ministry of Electricity and Water signed a contract with ORC to purchase excess distilled water. The treated water is pumped into the greater Muscat water distribution system in the Qurum Heights area. The contract calls for a maximum quantity not to exceed 0.5 Imgd (2,200 m^3/d). However since January 1995, MEW had stopped buying water form ORC. The water sources and characteristics for the capital area are summarized in Table 3.1.

The Ministry of Electricity and Water, established by Royal Decree in 1978, is responsible for the supply of potable water for all the Sultanate except for Dhofar Province and Sohar Town which are under the jurisdiction of Directorate General of Water and Transport of Dofar Governorate and Sohar Development Office of the Diwan of the Royal Court.

Table 3.1 Desalination Plant Sources for the capital Area.

Source	Quantity (Imgd)	Number of MSF Units
Ghubrah Desalination Plant	35	6
Oman Refinery Corporation*	0.5	2

* MEW had stopped buying water from ORC since January, 1995.

(Source:Paper on Experience with the three different cogeneration arrangements at Al hubarab Power & Desalination Station by A.R.Abu Dayyeh, Ribhi Hamdan, Wasfi F.Zaki, Salah Abunayib & Joshua Mathew of Sogex-Oman,1997). Revised by MEW, January 1998

Table 3.2 Groundwater Sources for the Capital Area

Source	Number of Wells	Depth (ft)	Output (Imgd)	Conductivity (umho/cm)
Eastern Well Field: Wadi Aday	29	144-442	2.2	2500
Western Well Field:				
1.Old Govt.	20	213-312		1350
2.Al Khawd	14	230	2.2	1300
3.Seeb	12	189-361		1200
Total	75		4.4	

(Source: Water Resource Management and Planning Decision Support System for the Sultanate of Oman, Dissertation by Dr.Hussam M.Al Rawahy, 1992). Revised by MEW, January 1998.

Table 3.3 Water Production & Consumption data for the year 1995

Regions	Production Mn.Gallon	Consumption Mn.Gallon	Produced from Well (Mn.Gallon)	Produced by Desalination (Mn.Gallon)
Muscat	11841.8	11826.2	2677	9164.8
Dhofar	2599.4	2563.3	NA	NA
Other Regions	2313.8	2297.3	NA	NA
Total	16755	16686.8		

Source:Statistical Year Book, 24th Issue, August,1996.

Of the total produced water about 55% is met through desalination processes mainly in the capital region.

4.0 Water Resources of Oman

The Middle East has been confronted with water resources crisis and with five percent of world's population, it has less than one percent of world's renewable fresh water. The Middle East region has one of the lowest water availability rate in the world, it is one third of Asia's levels, 15 percent of Africa's and a mere five percent of Latin America's. *(Excerpts from the speech of Frances D.Cook US Ambassador to Sultanate of Oman calling on better water management while speaking at a function to launch a water resources project in Salalah on 11th June, 1996).*

Throughout Oman surface water run off is generally a short lived phenomenon, occurring only for a few days or even a few hours after a storm, hence there are no perennial streams except for Wadi Dayqah. And the available water resources in Oman is severely limited by climatic conditions- the low and erratic rainfall, the high temperatures and high potential evapotranspiration.

Water is obtained mainly from the wells, boreholes, springs and aflaj. Groundwater occurs in the alluvial deposits in the wadi beds. Recharge to the alluvium occurs directly from floods , from rainfall and by transfer from hard rock aquifers. The permeability of the saturated alluvium is usually high and the quality of water good. The fractured bedrock units provides open hydraulic connection with alluvial aquifers which supports extensive storage and discharges to the alluvial aquifers. The extreme relief of the Northern Oman Mountains and the scarps behind the southern coastal plains of the Salalah and Marbat give rise to many springs in the valley. The limestones and dolomites of Hajar Super Group are also other significant sources of groundwater. The falaj system as a source is explained in detail below.

4.1 Falaj

Falaj (plural Aflaj) as used in Oman, is a generic term for a complete irrigation system or organisation for distributing water amongst those who have rights to it. It is the main source of water supply for domestic as well as irrigation purposes from historical times. Utilisation of groundwater resources in Oman was centred around the traditional falaj system. Falaj formed the life line not only for an individual but also for the community as a whole. A falaj (plural aflaj) is surface or /and sub-surface channel fed by wells, springs or surface/near surface wadi flows (Baseflows). Based on their sources of origin, these have been classified into three broad types; the **'Ghaily' type, the 'Daudi' type and 'Ayni' Type**. (Fig. 4)

4.1.1 A Ghaily falaj, which derives its flow from wadi baseflow, often at resurgences brought about by geologic factors *(like falling water table arised from pecularities of limestone hydrology, lithological variations, possible changes in the hydrology of the region through variation in the base levels of drainage and others)* and are seasonal in nature. They flow immediately after wadi flow or for some time after cessation of flow in wadi and then dry up. Water is diverted directly from the channel, or after impounding the flow behind a low earth or boulder bund. These are "run-of-the-wadi" aflaj. Such aflaj

are basically fed by surface water or recirculated (Return irrigation water) water and depend upon the rainfall and resulting wadi flows. Large scale fluctuations in their discharges are normally observed. The dependent population or agriculture plantations experiences an unreliable water supply and constantly remain vulnerable to the vagaries of climatic conditions. The agriculture experiences moisture stress due to the shortage of water supply, as such wells and boreholes are much sought for as "support well/borehole" for the falaj itself or by private individuals to support their private agriculture or to obtain domestic supply.

4.1.2 A daudi or iddi falaj or qanat falaj. This originates from a "mother well" which intercepts the groundwater table. They draw their water from permanent saturated zone (below fluctuation zone of water table) and are perennial in nature. Very rarely, they dry up. They are groundwater fed and a source of reliable water supply. They, generally, originate from a well which pierces through the saturated thickness of an alluvial aquifer or the productive fracture/fractured zone in the basement rocks. Fluctuations (of lower magnitude) in their discharges are experienced. The Sub-surface (underground) falaj channel starts from the permanently saturated zone in the mother well and continues underground in down gradient direction till it cuts the ground surface (the Sharia). From here onwards, the usage starts in the surface channel or with the help of a network of distribution channels in the users areas. The Daudi falaj may be equated to 24 hours pumping well having "steady state or equilibrium conditions". The surplus water form this falaj at the tail end or the return irrigation flow from the cultivated area, may create a "Perched Water pocket" and become a source for Ghaily type of falaj in the downstream direction or another "Daudi " falaj sourced from the perched water table. In such cases, the flow in the downstream falaj depends on the applied irrigation water in the cultivated area of upper falaj.

4.1.3 An Ayni falaj, which is fed directly from a spring (ayn). Many such springs are hot. The discharge in such aflaj depends on the nature of the source spring. If the spring is "ephemeral", the falaj will be seasonal and if the spring is "perennial", the falaj will also be perennial. The fluctuations of the discharges of the source spring and the falaj originating from it, are directly proportional to each other. The perennial springs can have any type of water showing a wide variation in physical, chemical or isotopic characteristics depending on their host rock characteristics, the depth of the origin of water and the source of water. These springs, generally represent ground water and may acquire additional importance from groundwater resources viewpoint if they are located on the major lineaments.
(Source:Main Report-Hydrogeology of Wadi Samail Upper Catchment, Directorate General of Water Resources Assessment, Ministry of Water Resources, 1997).

Most of the water for irrigation and domestic use in rural communities is still supplied by afalj. A falaj is normally owned and managed by the lcoal community and its members enjoy rights to water. Priorities for use may be set locally and differ between different communities, but drinking water for humans and animals is always accorded a higher priority than other uses.

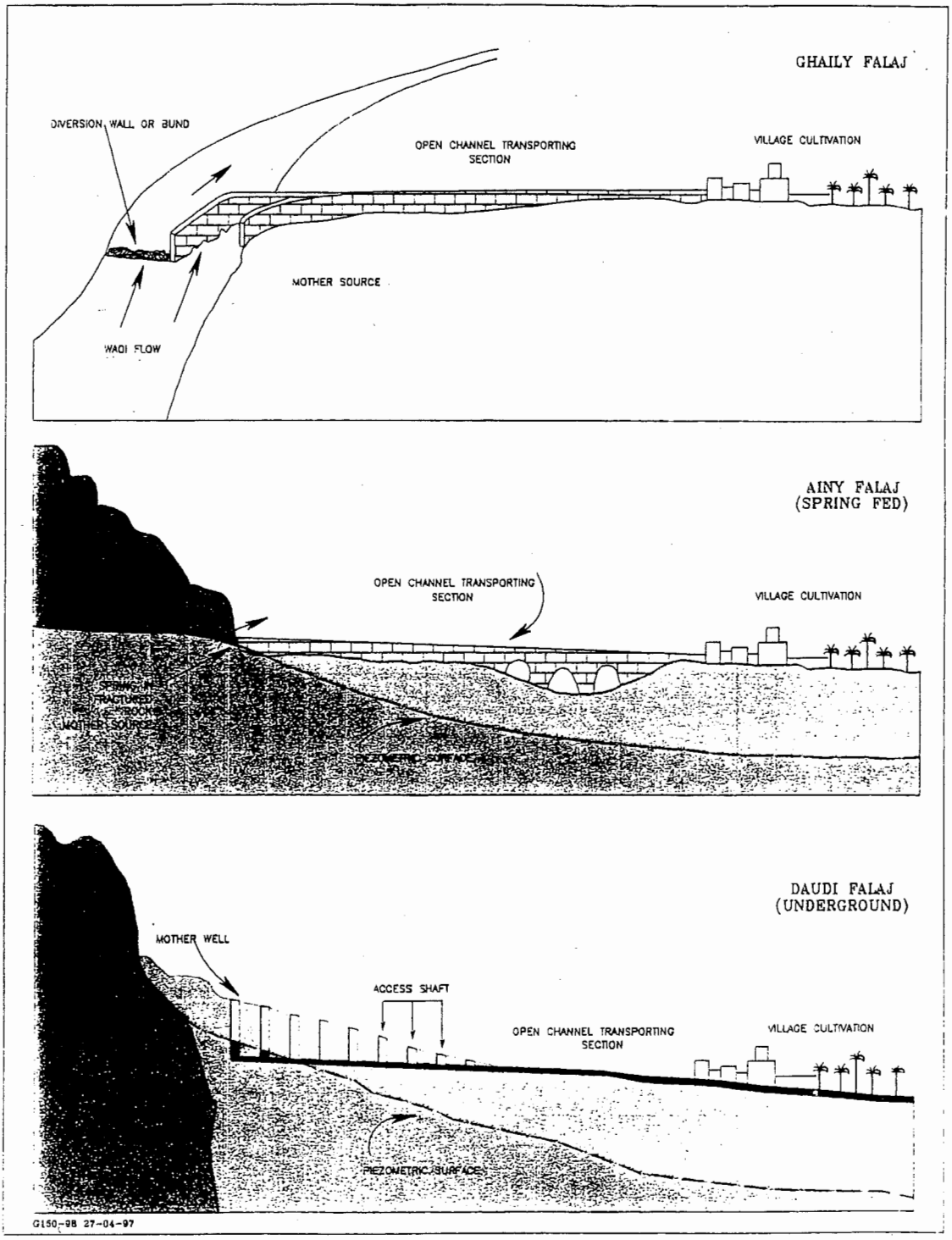
The discharge from the falaj is uncontrolled and continuous. It is distributed to the gardens on a rotation basis, individuals having established rights to water for a given period. Thus the voulme of irrigation water received by each farmer depends on the flow in the falaj and he must adjust his cropping to the availability of water. Most of the rights are owned in perpetuity and inherited or transferred with the land to which they are attached, but part of the supply, that is certain periods during the rotation, may be owned by the community, rather than individuals, and rights to this leased for six months or a year at a time.

The falaj system is self regulating insofar as the flow is governed by the volume of storage in the aquifers upstream and cannot in the short term be increased by artificail means. Falaj communities have generally adjusted well to the variations in the availability of water. However it does have the following disadvantages:

- The irrigation network above ground is often inefficient with very high channel losses.
- The long period between receiving water on any given plot restricts the crops which can be grown and in particular precludes the cultivation of high value vegetables which need regular watering.

Source: (National Water Resources Master Plan Draft Final Report -Volume2-Main Report, December, 1990).

Figure 4: Aflaj Systems in Oman



Source: Ministry of Water Resources

4.2 Water Resources Utilisation

4.2.1 Agricultural Utilisation

The main user of water in Oman is Agriculture. Agricultural water use accounts for approximately 90% of the total water use in the Sultanate, it is therefore essential that agricultural users fully participate in conservation and management measures.

Table 4.1 Water Demand for Agriculture

Demand(MCM/year)	1990	2010
Agricultural	1278	To match supply

Source (National Water Resources Master Plan Draft Final Report -Volume 1-summary Report, December, 1990).

Table 4.2 Agricultural Lands Distributed each five year

Year	% of Land Cultivated	Area in Fiddan under cultivation (Fiddan=0.4hectares)	Total Area in Fiddan (Fiddan=0.4hectares
1981-1985	83%	2337	2799
1986-1990	80.65%	8995	11153
1991-1995	70.89%	7035	9923
Total	76.9%	18,367	23,875

Source:Statistical Year Book, 24th Issue,Section by Ministry of Agriculture, August,1996.

Total agricultural land distributed since 1981- 1995 was 23,875 fiddans and cultivated area was about 18, 367 fiddans. **(nearly 77% of the distributed agricultural land is cultivated)**

This distribution of agricultural land has permitted a very large expansion of the area of irrigated agriculture due to pumps, borewells, better transport infrastructure and marketing opportunities.

Likewise water abstraction for irrigation has increased many fold with the introduction of improved irrigation, which includes the following,

- *expansion of Al Batinah Plain agriculture, with drilled wells inland of the traditional, dugwell reliant, coastal agricultural belt.*
  expansion of Salalah Plain agriculture.
- *development of farms in the Nejd, using deep, drilled wells.*
- *dug and drilled wells in Interior basins, competing with aflaj.*

4.2.2 Domestic Demand

Potable water supply in Muscat is from desalination to supplement groundwater resources. And few other places the major source of supply is groundwater.

Table 4.3 Domestic Demand

WATER PRODUCTION AND CONSUMPTION IN THE SULTANATE OF OMAN. (Million Gallons)								
ITEM	1995	1994	1993	1992	1991	1990	1989	1988
Production	16,755.0	16,184.6	15,535.4	14,677.2	13,354.1	13,214.3	12,186.2	11,728.3
Consumption	16,686.8	16,107.1	15,473.6	14,275.8	13,287.4	13,183.7	12,171.1	11,708.7

Source:Statistical Year Book, 24th Issue, August,1996, Section by Ministry of Electricity and Water.

Table 4.4 Number of Water Connections by Region

Regions	1995	1994	1993
Muscat	52,956	49947	47475
Dhofar	18241	17521	16882
Other Regions	16902	16902	15983
Total	88099*	84370*	80340*

* The numbers refer to the no. of water supply connections

Source:Statistical Year Book, 24th Issue, August,1996 Section by Ministry of Electricity and Water.

Table 4.5 Distribution of Occupied traditional dwellings with source of water supply

Source of Water Supply									
	Total Dwelling	Not Stated	Other	Stream	Falaj	Public Well	Private Well	Public network	
								Un-connected	Connected
Dwelling	242851	1041	6136	1400	7978	41256	49611	48747	86682
Percentage	100%	0.4%	2.5%	0.6%	3.3%	17%	20.4%	20.1%	35.7%
Households-	247437	1053	6212	1420	8104	42049	50566	49775	88258
Persons	1752844	5767	38166	9278	54141	315078	408937	358319	563158

Source:Statistical Year Book, 24th Issue, August,1996 Section by Ministry of Housing.

About 9% increase in water connections from 1993 to 1995 which is almost proportional to the increase of 8% in water consumption for the same period. Only about 35.7% of the "dwellings" *(Dwellings are classified into Villas, apartments, Arabic houses, Rural Houses, Box houses and Tents)* are connected to public water supply in Oman, the rest are supplied by tankered (20.1%)-*(Tankered means water source from the public network which is not piped into the house instead, taken to the dwellings by means of tanker vehicles),* private well (20.4%), Public well (17%), Falaj (3.3%) and rest by other sources.

Table 4.6 Occupied Traditional Dwellings, Households, And Occupants by Nationality of Head of Household and Number of Living Rooms in Dwelling.

No. of Occupants	Households by nationality of Head of Household.			Number of occupied dwellings	Number of Living Room in Dwellings
	Total	Non-Omani	Omani		
71375	21919	13090	8829	21505	1
216462	43114	19218	23896	42414	2
386915	61908	22760	39148	60879	3
395484	51509	11112	40397	50703	4
288336	32648	5013	27635	32086	5
155890	15339	1702	13637	14966	6
83574	7483	736	6747	7263	7
51983	4349	454	3895	4188	8
30162	2651	427	2224	2559	9
52351	3678	312	3366	3530	10+
20312	2839	1111	1728	2758	Not stated
1752844	**247437**	**75935**	**171502**	**242851**	**Grand Total**

(Source:General Census of Population, Housing and Establishments 1993)

Table 4.7 Total occupied dwellings with availability and type of bathroom / toilet / kitchen facilities in Oman with access to water

Number of Dwellings	242851	242851	242851
Bathroom/ Toilet/Kitchen	**Toilet**	**Bathroom**	**Kitchen**
Not stated	2918 (1.2%)	2555 (1%)	3173 (1.3%)
Toilet facility not available	28249 (11.6%)		
Toilet facility available Without Flush **With Flush**	 29146 (12%) **182538 (75.2%)**		
Bathing facility not available		26111 (10.8%)	
Bathing facility available Without piped water **With piped water**		 22988 (9.5%) **191197 (78.7%)**	
Kitchen facility not available			13788 (5.7%)
Kitchen facility available Without running water **With running water**			 56148 (23.1%) **169742 (69.9%)**

(Source:General Census of Population, Housing and Establishments 1993)

4.2.3 Water Demand for Domestic & Industrial purposes

Table 4.8 Water Demand for Domestic & Industrial purposes

Demand(MCM/year)	1990	2010
Domestic-	77	264
(Population Projections)	**1,500,000**	**2,984,000)**

Population demand is 109 MCM/year in 2010.
Projected population growth rate is 3.5%/year.
Domestic includes industrial, social and commercial demands, losses from distribution systems and the requirements of MoD, mineral and oil installations.

The estimates of water demand are based on the projected total national population on the data from the Supreme Committee for Town Planning. The pressure of improved living standards (affluence, washing machines, gardens swimming pools etc), the emphasis placed on the health of the increasing population and commercial and industrial development will impose increasing demands for a potable water supply. The estimates for domestic consumption are based on

- Present overall production and consumption data for the capital area.
- Per capita water consumption data from other countries. (Per Capita demand in Sultanate of Oman, as per Ministry of Electricity and Water standards is 200 litres/day excluding garden watering).
- Generalised information on the possible influences on demand of charging policies and public awareness campaigns.

Source (National Water Resources Master Plan Draft Final Report -Volume 1-summary Report, December, 1990).

4.2.4 Summary of certain facts on Water Resources in Oman

Table 4.9 Renewable water resources in Oman, Mm^3/y

Surface Water	GroundwaterRecharge	Present Exploitation	Present Deficit
1450	475	728	253

(Source:Ismail, 1995; Al Murad, 1994; Al Alawi and Abdul Razzak, 1992; Al Noami, 1993;Al Hajj., 1995, Kuwait Ministry of Electricity and Water, 1995)

Table 4.10 Treated Water, Reused Water, Treatment Facilities and Type of Utilization in Sultanate of Oman

Treated Wastewater m^3/d	Reused Water		Number of plants	Total Capacity m^3/d	Treatment Level	Type of Utilization
	m^3/d	%				
20,300	10,850 to 17,350	54 to 86	2 (large) 53 (small)	25,000 50-5,000	Tertiary	Irrigating landscape areas and parks, recreational activities and fountains.

(Source: Al-Saati, 1995; Al Muzaini and Ismail, 1994; Al Shaqsi, 1994; Al Assam and Abdul Rahim, 1994; Al Hajj, 1995)

Table4.11 Exploited Water Resources in Sultanate of Oman

Groundwater		Desalinated		Recycled		Total
Mm^3/y	%	Mm^3/y	%	Mm^3/y	%	Mm^3/y
645	93.8	32	4.7	10.5	1.5	687

Source:(Modified after Al-Alawi and Abdul Razzak, 1993)

5.0 History of Water Resources Institutions in Oman

Several major studies of the country's water resources were undertaken since 1970, after His Majesty Sultan Qaboos Bin Said ascended to the throne to become the Sultan of Oman. Since 1970, there has been development in all walks of life, especially in the social and physical infrastructure of a modern state.

An outline of the history of water resources institutions which formulated legislations, management , conservation and Utilisation of water resources in Oman is listed below,

- 1970-1975-Formulation of key government institutions. Water resources activities undertaken to support development in specific areas by different government organisations.

- 1975-Water Resources Council (WRC) formed. The council had the responsibility of monitoring and advising upon all water-related projects. Individual government institutions continued to conduct projects relevant to their needs.

  1979-Public Authority for Water Resources (PAWR) formed from the Technical Secretariat of the Water resources Council (which consisted of Public Authority of Water Resources for other regions except Buraimi and Musandam, Regional Development Committee (RDC) for Buraimi and Musandam Development Committee (MDC) for Musandam), to which it reported. The PAWR was charged with the country wide identification and assessment of water resources. PAWR was the first agency with national responsibility for investigating water resources.

- 1979-86- The PAWR installed a national network of rain, wadi and groundwater monitoring points. Systematic exploration for groundwater began, followed by resource assessment on selected priority areas throughout the Sultanate. A number of reports were issued, including a preliminary assessment of the Sultanate's hydrology and reports on saline intrusion into Al Batinah Coastal Aquifer.

Two important developments in this period were:
Introduction of a system of well permits and prohibition of wells near a falaj *under the auspices of WRC and administered by Ministry of Agriculture and Fisheries .*

Introduction of a system of well permits
A system of requiring well permits for new wells and for deepening existing wells was intorduced which was later by MD.No.2/90 was strictly enforced with penalty.

Prohibition of wells near a falaj
In 1983, The Water Resources Council (WRC) issued a decision on protection of "motherwells" of aflaj-Protection of Aflaj-That no wells should be constructed within 3.5kms of the mother well of a falaj. This decision was prompted by complaints about newly dug and drilled wells affecting aflaj. The 3.5 km radius adopted was a pragmatic, somewhat arbitary, value.

1986-1989 During this period, a series of important organisational and legislative changes occurred. The responsibilities for water resources and environment were under the umbrella of one organisation.

* *transfer of well permit responsibilities from MAF to the water resources agencies.*
* *transfer of some regional hydrologic networks to the water resources agencies.*
* *establishment of wellfield protection zones round major municipal wellfields.*
* *establishments of groundwater resources as a national asset, thus giving the government the right to allocate resources in the national interest.*
* *start of a national programme to delineate flood prone areas.*
* *start of public awareness programmes in water conservation*

1989-date-In October 1989 Ministry of Water Resources was formed with five regional offices. Highlighted programmes under Ministry of Water Resources include

* *transfer of responsibilities for recharge dams and aflaj from MAF to MWR, thus continuing the move towards centralisation of water resources functions.*
* *registration of all wells (167,000)*
* *initiation of National Well Inventory Programme*
* *expansion, upgrading and rationalisation of hydrometric networks.*
* *planning and implementation of water resources assessment projects.*

(Source: -An Introductory Guide - Water Resources of Sultanate of Oman, 1995)

6.0 Ministry Water Resource's Water Management and Conservation Programmes

The extensive economic development, which has taken place in Oman over the past 25 years, has placed a severe strain on the groundwater resources. The water demand has exceeded resource availability in Sultanate of Oman under increased demand conditions and over-exploitation of the resource due to insatiable pressure of rapid population growth and the accompanying demands of urbanization and irrigated agriculture.

Among the measures taken to preserve water resources in Oman was limiting withdrawals from freshwater aquifers, reusing treated wastewater and minimizing unaccounted-for water in urban water supply systems.

The construction of recharge dams, are deemed to be integral measures in Oman's water management strategy. To date there are about 17 major recharge dams built around northern Oman which help retain a portion of surface water flows during heavy rains.

Using brackish water in combination with suitable soil and proper irrigation techniques is another vital aspect of MWR's strategy to optimize the available water resources.

Another significant measure is to relocate large scale agricultural enterprises to areas with under utilized water resources. Grass and fodder farms on the Batinah and Salalah plains are planned for relocation, thus easing the water demand in area of over development. Certain uneconomic agricultural production should be moved away from current stressed aquifer and wastewater be treated to a tertiary level and reused to recharge the aquifer or for direct irrigation of cash crops.

A strategic approach was adopted by the Ministry of Water Resources since 1989 through improved definition of resource availability and water demands throughout Sultanate of Oman. Government regulations and policies were formulated to address the strategic requirements concerning water.

The Ministry of Water Resources, together with other government organizations undertook a series of steps to define water demands through Regional Well Inventories, Well Registration, National Well Inventory, Metering , Resource Protection, Wellfield Protection Zones, Augmentation, Substitution, Re use of Treated Effluent, Use of Brackish Water, Relocation of Users, Water Conservation and Public Awareness.

A national well inventory was completed at the end of 1995. This has yield a large amount of data on wells, nationally, including yields and water use, which will be used for planning future management programmes.

(Source: -An Introductory Guide - Water Resources of Sultanate of Oman,1995)

6.1 Royal Decrees and Ministerial Decisions on Water Law

Table 6.1 Royal Decrees and Ministerial Decisions on Water Law

Royal/ Ministerial Decision No.	Royal/Ministerial Decision.	Remarks.
RD 47/75	Established the Water Resources Council	(Later supplemented by RD76/77 and RD 105/85)
RD. 76/77	Law on the Development of Water Resources	Defines the duties of the Water Resources Council
RD.No.11/82	MEW are responsible for potable water supplies to most of the country.	
In 1983	The Water Resources Council (WRC) issued a decision on protection of "motherwells" of aflaj.	Protection of Aflaj- That no wells should be constructed within 3.5km of the mother well of a falaj. This decision was prompted by complaints about newly dug and drilled wells affecting aflaj. The 3.5 km radius adopted was a pragmatic, somewhat arbitrary, value.
	Another most important decision the Water Resources Council was the establishment of Well field Protection Zones, which prohibit any activity that will affect the wellfield. Well field Protection Zones under Action Plans established by the CCEWR in 1986 and 1987	Lead in monitoring abstractions, water levels, and groundwater quality
RD.105/85	Changes the name of the Council for Conservation of the Environment and Prevention of Pollution to the Council for Conservation of the Environment and Water Resources	
RD.No.92/86	Ministry of Environment given responsibility under this decree for implementation of controls for all aspects of environmental protection and for the protection of water resources.	Transferred to Ministry of Water Resources (MWR), but Ministry of Regional Municipalities and Environment (MRME) retains overall control of environmental legislation and has responsibility for the issue of "No Environmental Objection" certificates to all new projects, including those related to the MWR.

RD.No.93/86	Ministry of Agriculture and Fisheries (MAF) has been given specific responsibilities for maintenance of aflaj, wells, construction of dams, protection of agricultural land against flooding, collection of survey data from aflaj, wells and dams.	
RD 83/88	The Sultanate's groundwater reservoir was declared to be a part of the public national wealth, the exploitation of which will be manage by the Government in the interest of agricultural and development plans.	This law: • authorizes any necessary action to protect and conserve underground water. • authorizes the development of the existing water supply • vests water rights to the state
MD. 11/89	Western Water Supply Well Field Protection Zones and Action Plan	
RD. 100/89	Ministry of Water Resources created under this Royal Decree.	
MD. No.2/90	It states that requirement of registration of all existing wells and the issuing of new well permits. The well permitting policy seeks to control the growth of water demand and to direct the allocation of water by controlling the construction of water wells. If these regulations are not observed, a penalty is payable.	***Well Permits-*** • Well permit legislation has been refined and strengthened several times. Permits are required for new wells, for deepening existing wells, for change of use and for installing a pump. ***Contractor's Registration and Regulation*** • All drilling and well digging contractors are now required to register with MWR on a yearly basis. Contractors are required to satisfy themselves that the work they undertake is covered by the proper permits, otherwise they can incur penalties. ***Violations and Enforcement*** • The introduction of well permit regulation has been achieved by a combination of publicity, persuasion and frequent checking and follow-up. Inevitably there have been violations and MWR has enjoyed the cooperation of other government agencies such as the Ministry of Interior and the Royal Oman Police in dealing with offenders. Illegally-constructed

--		wells have been backfilled, contractors' equipment impounded and other measures have been taken to penalize violations and enforce the regulations. It would be naive to suggest either that there is 100% compliance, or that 100% of violations are detected; nevertheless the persistent application of the well permit policy is achieving results.
M.D.374/92	This was issued to set up The National Well Inventory (NWI) project to manage the Sultanate's water resources. Its primary aims are to assess the distribution and quality of the groundwater resources and to evaluate the present use of groundwater in terms of quantity and type of demand.	
MD. 145/93	Regulations for Wastewater Re-use and Discharge	
R.D.No.3/94	Transferring of Aflaj/Dams from MAF to MWR	

7.0 Best Practices for Water Conservation in Sultanate of Oman

The emergence of modern political theory and ideas concerning the obligations of the State, the view that the State, as the guardian and promoter of the public good, should have the ultimate responsibility for ensuring that water is distributed, allocated and used in an efficient and equitable manner has been widely accepted.

In this regard Sultanate of Oman has been supported effectively by all the Government organizations particularly Ministry of Water Resources, Ministry of Agriculture and fisheries, Ministry of Regional Municipalities and Environment, Muscat Municipality and Sultan Qaboos University to conserve Sultanate's limited water resources and use them judiciously for the people of Oman.

To safeguard Oman's limited Water Resources, several legislation have been formulated. In this context the best practices for water conservation in Sultanate of Oman are identified as:

1. **Participatory efforts with residents prior to installing water and sanitation systems.**
2. **Municipal planning initiatives that impact consumption and re-use of water**
3. **NGO and Government educational efforts in the schools**
4. **Programs with households (women) to change behavior**
5. **Technological improvements (e.g. improved water meters)**
6. **National Policies that impact domestic water consumption**
7. **National community water conservation program**
8. **Treatment and recycling of gray water**
9. **Efficient agricultural/irrigation practices (e.g. irrigating at night)**
10. **National Desalinization program**
11. **National Hotline.`**

7.1 Participatory efforts with residents prior to installing water and sanitation systems

Ministry of Regional Municipalities and Environment, Muscat Municipality, Ministry of Housing, Ministry of Electricity and Water insist the citizens through their public awareness program to follow some of the measures laid below.

Domestic household users- Modern water saving systems, reducing pressure at discharge points etc.

- Encouraging water conserving appliances and plumbing, and by rigorous loss-controlled programs.

- Household items like washing machine, dish washer etc should have the latest technologies to minimize the use of water.

- Toilet flushing -Encourage use of toilet flushes with a 4 liter flush cycle instead of 10-12 liters which are in common use.

- Low quality sanitary and plumbing fittings are more prone to leak, hence one time investment on quality fittings will prove to save money and conserve water. In other words the money spend on quality plumbing and sanitary items is quickly paid back, which otherwise would have spend more on maintenance and more water.

- Overhead tanks are installed with float devices which control overflow loss and to maintain pressure in the delivery line.

- Overhead tanks are covered to reduce loss by evaporation by direct contact with atmosphere.

- Metallic and concrete water tanks are replaced by Fiber Reinforced Plastic (FRP) to reduce loss by evaporation.

It should be noted that the use of water saving devices is not mandatory. Rather, the advice and information is made available to all home owners, and it is in the interest of homeowners to employ these methods given the potential savings on their water bills.

7.2 Municipal planning initiatives that impact consumption and re-use of water-

Use of wastewater

The Sultanate has recognized treated wastewater as an additional source of water, and would enable the country to reserve fresh water resources for potable supply and other priority uses. However presently it limits the use of treated wastewater to amenity irrigation and in some industries.

The use of treated effluent in irrigation for beautification/landscaping/public parks by means of sprinkler, drip and trickle methods, controlling irrigation time to reduce evaporation and limiting irrigation to the requirements of the trees, plants and lawns, are all actively practiced and promoted by the Municipality. Irrigation cycles are computer programmed and controlled, with an emphasis on maintaining irrigation to minimize evaporation.

Using reclaimed wastewater is highlighted as the most attractive alternative to supplement water supplies in the region. Wastewater reuse free from environmental and health hazards is a viable method to supplement the demand for agricultural use, landscape development, and aquifer recharge. The recharge section of MWR has presented a paper on the ground water recharge using reclaimed wastewater which could result in reducing sea water intrusion and improving ground water supplies even after irrigation uses. *(Source Paper on Ground Water Recharge Using Reclaimed Wastewater in Oman. Proceedings of the National Seminar on Wastewater reuses Muscat, 26-29 April 1992).*

It is recognized that recharging of groundwater aquifers by the unused volumes of wastewater may be considered for a number of purposes, provided it does do not cause pollution to the recharged groundwater. These are : 1) it may be employed to supplementing groundwater capacity to reduce declining levels of groundwater; 2) groundwater recharge may well be practiced in forming a barrier against sea water intrusion and, 3) Effluent may best be stored underground during off-season or when not used for irrigation as part of a drought management program. *(Source: Paper on Towards the Establishment of a Total Water Cycle Management and Re-Use Program in the GCC Countries By Waleed K. Al Zubari)*

The benefits for recharging reclaimed water are a steady water supply (even in drought years), additional soil filtering treatment of the water, relatively low cost, and the advantages of underground storage and transmissions not requiring pie lines.

Production of wastewater is about 20,000 to 25,000 m^3/day in the Capital Area from 10 STP's. The major ones being Darseit and Lansab. About 70 to 80km stretch of land from Al Bustan to Bait Al Barkah is irrigated by Muscat Municipality. They have a main pipeline with about 30 outlet points to local areas which has about 20 storage tanks from where it is irrigated through sprinkler and drip. And areas not reached by main sewage pipe line are irrigated through tankers which irrigates about 3000 to 4000m3/day (nearly 50% of this volume is fed by potable water).

See **Plate No. 1 through Plate No. 6** illustrating parks, gardens and lawns irrigated by treated effluent through modern irrigation systems.

(Source:Interview with Mr.Lars Paulsson Chief Sanitary Engineer and Mr.Patel Engineer of Darseit Sewage Treatment Plant, Muscat Municipality)

Water Reclamation in Salalah, Sultanate of Oman - Construction of the US$32 million water reclamation plant - funded jointly by the United States Agency for International Development (USAID) and the Government of Oman-will began operation in August, 1998. The Dhofar Municipality is implementing an innovative wastewater management program that that will provide beneficial to the community in terms of resource conservation by use of treated wastewater in the city of Salalah.

This Water Reclamation Plant will ultimately provide the local community with two valued commodities-

- usable water and
- a high quality fertilizer product through innovative application of advanced treatment technologies.

(Source: Paper on Water Reclamation in Salalah,Sultnate of Oman by Michael J. Walsh and Mohammed Alamin Ahmed Younis, 1997)

Reuse of water from Oil Industry

Ministry of Water Resources advocates the recycling of water, paved the way for the scientists at Sultan Qaboos University for the research project in collaboration with Japanese Scientists at recycling the huge quantities of water produced along with oil during the production of crude oil.

According to Dr.Mohammed Hammed Al Rumhy, Assistant Professor of Petroleum Engineering at SQU's College of Engineering, this pioneering study has vital significance to the oil industry and the cause of environmental and water conservation. The produced waste water is otherwise re-injected deeper into the ground which may find its way into sweetwater aquifers posing potential environmental risk.

This study aided by the Japanese government's Petroleum Energy Centre, will help determine ways to purify the produced water and render it safe for various applications. A study of the feasibility of reusing water from drilling operations in the oil industry in 1995 showed that it was both technically and economically viable.

(Source: Excerpts from the Article Research under way for recycling huge quantities of water published in the Oman Daily Observer dated 15th February, 1997 Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre)

Recharge Dams in Sultanate of Oman

Seventeen recharge dams have been built to date in the Sultanate. A monitorirng network was set up for each dam at the time of construction and readings are taken regularly from monitoring wells and also after each recharge event. The results of this monitoring show that recharge dams make a significant impact on groundwater storage and are certainly cheaper than building desalination plants. A number of specific studies have also been undertaken by the Dams Department of MWR.

(Source: Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre).

7.3 NGO and Government educational efforts in the schools-

MWR has been working to raise - Public Awareness of the need to conserve and protect water resources. to educate the citizens on the importance of water as a limited national

resources. Individuals are educated about the scarcity and decide to give up extravagance in water use.

Activities have included:

- working with the Ministry of Education to incorporate more water resources information in the school curriculum and school text books. The Information and Awareness Centre of the Ministry of Water Resources coordinates the Department of Educational Activities in the Ministry of Education. Educational boodklets have been provided to the Ministry of Education for primary and intermediate age groups and for women attending school in the evening. The school children's booklet emphasize the Water cycle, problems with water in the Sultanate and how to save water. It is assumed that the information that the children learn at school is transferred back to the family.
- delivering lectures to citizens groups, Women's Association meetings, students at colleges
- briefing senior government staff in various agencies
- publishing calendars with water conservation messages etc, for distribution to schools, government offices
- producing television announcements (commercials)
- participating in television and radio discussions
- arranging for water conservation messages to accompany all electricity and water bills
- encouraging private sector participation in campaigns (slogans printed on envelopes used by banks, on car sunscreens, on timetable cards provided to school children)
- advertising in newspapers.
- Public awareness and knowledge regarding utilization of treated wastewater as an additional resource for irrigation to replace depleting groundwater.

The Information and Awareness Centre of MWR carries out awareness activities through the media of lectures, exhibitions, TV and radio programmes and announcement , news and features in the Press, cooperation with the Ministry of Education, publication of pamphlets, cooperative activities with other organisations and youth camps. Lectures are the major activity representing 27% of the effort of the Awareness Department in Information and Awareness Centre.

Following programmes were conducted under the Information and Awareness Centre of MWR on water conservation.

- Lectures to schools, often illustrated with video and slides.
- In 1993, a competition was organised in cooperation with schools to ask children to make posters about water in the Sultanate and how to save it.
- In the summer of 1997, the Information and Awareness Centre organized a field visit for school children to make them aware of MWR activities.
- Coordinates competition in conjunction with women's organisations to find the best water-saving household in each region. A random selection was made of volunteer households who were supplied either by wells or tanker. Teams went to each of the randomly selected houses to identify water saving practices.

- Holds talks to groups of farmers often by showing videos and slides to demonstrate best practice in water saving in agriculture.
- In August, 1996 a Youth Camp was run in Dakhliyah for one week to teach young men how to mend broken aflaj and how to clear rubbish and silt from aflaj and dams. Volunteers from the Youth camp cleared the Tanuf Recharge Dam, Aflaj and Dams Department of MWR coordinated the work with the local Wakeels in this Youth camp, where about four hundred members participated.
- Other activities include regular coumns in Arabic newspaper, interviews with MWR staff on radio, TV and the press, posters ans so on. Water saving slogans are advertised on buses of the National Bus Company.

In addition to the above, the Information and Awareness Centre keeps statistics on the number of activities it undertakes, and has written a report which rates staff assessments of activities it has done, and which have been most successful. There are plans to introduce evaluation of attitudes of target groups of the population. Visits are repeated to various groups to obtain anecdotal evidence of changes in awareness. The information and Awareness Centre has carried out an in house survey of its activities to identify those which it feels are most successful. Telephone talk shows on the radio in which senior management of the Ministry participate, also generate valuable feedback form the public.
(Source: -An Introductory Guide - Water Resources of Sultanate of Oman, 1995 and Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre.)

Oman has taken steps to conserve water and has announced the preparation of MSc program in water resources and water technology studies aimed to begin in 1998, to be offered at the Sultan Qaboos Universtity.

Adopt plans and legislation to limit waste, especially in agriculture.

Adopt human resources programs for people involved in the management of water facilities and support establishments working towards conservation.

Meetings and seminars are held at local bodies (Wali Offices) stressing on the water conservation involving the active participation of the citizens.
(Source: -An Introductory Guide - Water Resources of Sultanate of Oman, 1995)

Ministry of Electricity and Water has a Public Awareness and Conservation Department attached to the Under Secretary's Office. They release advertisements in Oman Arabic Daily and some television programs stressing on conservation of water on domestic use.

The local media available for Public awareness are :
- There are five Newspapers and twenty three magazines issued locally in 1995.
- About 12, 803 hrs of radio broadcasting and 6,392 hours of television transmission has been recorded in 1995. (Programs include News, Religious, Development, Cultural, Educational & Guidance, Children, Youth & Sports, Family , Recreational & Art Programme, Advertisements, Program Announcement).

Table 7.1 Omani Households having Television in Urban/Rural Areas

Total Television	Total TV in Rural Areas	Total TV in Urban Areas
141087	34581	106506

(Source:General Census of Population, Housing and Establishments 1993)

7.4 Programs with households (women) to change behavior-

MWR - Public Awareness-to educate women to reduce water consumption in the household- Social commitment to rationalize water use-through women associations, girl's schools and colleges. Information Centre of MWR conducts lectures on public awareness on water conservation by women lecturers to women's group. The women's publications concentrate on how to save water. Lectures to women emphasize water saving

Gender roles in collecting water are not so clearly defined within the urban areas such as Muscat Municipality where water is piped or delivered in tankers to houses other than that women are invariably responsible for household tasks. Elsewhere usually in rural areas where water has to be fetched from wells or aflaj, domestic water has to be fetched by women. Water is collected from falaj at the shariah point (the point where the falaj becomes uncovered and accessbile to community use).

There are 16 Omani Women's Association with about 2406 members and there are about 14 Women's Training Centres with about 553 participants in the Sultanate of Oman as per records in 1995.(*Source:Statistical Year Book, 24th Issue, August,1996, Section By Ministry of Social Affairs & Labour).*

7.5 Technological improvements (e.g. improved water meters)

Ministry of Water Resources and Ministry of Electricity and Water

Water metering

Water metering is one of a number of conservation strategies being evaluated by the MWR. Metering the wells will definitely cause the owners aware of being monitored so that it can be assumed that this plan will caution the owners to use less water and at the same time it provides a more rigorous monitoring program that could potentially have future benefits, e.g. better insight in water use patterns and quantity consumed. It is considered that this would result in a 25% reduction of the total water used. Metering are done on few private and all the public water supply wells.

While meters are used on municipal water supplies, to date only a few meters have been installed on farm wells. It is estimated that agriculture accounts for 90% of annual water consumption, conservation of this water use is a key factor in any strategy for water resources management.

Therefore, in 1993, the MWR initiated a pilot project on southern Al Batinah to:

- evaluate different meter types under the climatic, water quality and pumping conditions
- monitor current levels of water use and irrigation efficiency
- identify the potential for water conservation on farms in the region.

The water metering project begun on southern Al Batinah in 1993 continues on an experimental basis, and is still at an early stage. Figures for water abstraction are monitored on a monthly basis, comparing the performance of helical vane and proportional water meters. The readings for water abstraction for each farm in the study are compared with estimates made by the Ministry for crop water requirements. The project is providing valuable information on the potential for water conservation and will support MWR's effort to develop an integrated water management program.
(Source: An Introductory Guide - Water Resources of Sultanate of Oman, 1995)

Meters are widely used by municipalities on wells and on demand points to households and at points of sale. MEW has instructed Oman Investment And Finance Company OIFC, its meter reading contractor, to place blue cards along with the consumer meter connection. The meter reader should register the monthly consumption on the card to enable the consumer to check his consumption. This will ensure all consumers water usage will be metered. Surprise meter checks for any irregularities would be undertaken by officials from MEW .
(Source: Interview with Mr.Said Mohammed Nabhani, Director of Muscat Water Department, Ministry of Electricity and Water, Sultanate of Oman)

Unaccounted Water

Based on 1983 production/consumption records Sir M MacDonald and Partners (MMP) has estimated unaccounted water system leakage in report 3 to Ministry of Electricity and Water as shown in Table below.

Table 7.2 1983 Unaccounted Water

Source	Quantity (m^3/d)	% of Production
Source Meter Error	200	nil
Consumer Meter Error	3865	7
System Leakage	11,555	23
Miscellaneous other	200	nil
Total	**15,820**	**30**

The operating pressures in the transmission and distribution systems coupled with corrosion of the galvanized mild steel service connections contribute significantly to leakage. In 1986, Sir Mott Macdonald and Partners began a leakage control program for the Ministry of Electricity and Water which was aimed at reducing unaccounted-water loss.

This program included repair and testing of source and revenue meters, site and flow surveys to identify locations for district meters and pressure reducing valves, and training MEW personnel in leakage location techniques.
(Source: Feasibility Studies for Third Five Year - Plan System Improvements For Capital Area Water Distribution, Sultanate Of Oman, July 1986 by WASH)

In order to reduce unaccounted-for water and leak detection, the Ministry of Electricity and Water (MEW) , implemented two programs for leak detection and unaccounted for water in 1984. Under Phase I of these programs, three district offices (Bausher, Seeb and Muttrah) in the Muscat Governorate were started. Proposals for extending this service to the interior regional offices of MEW is currently being considered.

Leakage control in municipal water supply schemes.

In each MEW district office, there is a leak detection engineer and supporting staff. Their main duties are leak detection, rectification and reduction of the unaccounted water. Each District is divided into waste zones. The flow entering and consumption (the flow leaving) each waste zone is metered. The difference between the volume of water entering the waste zone and the metered volume leaving the waste zone by consumption in each of the waste zones gives the unaccounted for water. This is due to inaccurate meter registrations, distribution system leakage and other unmetered consumption. The officials with their leak detection equipment detect the leaks of the underground pipes. In some places loggers are installed to detect irregularities in flow of water especially night flow, which may be caused due to some leak. The irregularities in night flow will be detected and immediate rectification is done.
(Source: Interview with Mr.Said Mohammed Nabhani, Director of Muscat Water Department, Ministry of Electricity and Water, Sultanate of Oman)

7.6 National Policies that impact domestic water consumption-

Ministry of Electricity and Water

Current production rates are 850 baizas/m3 (approximately US $2.19 for one cubic meter of desalinated water) and selling subsidized rates are about 440 baizas/m3 (approximately US $1.13 per one cubic meter of desalinated water) . If prices are increased for water then there will be a reduction on the consumption of water.

(Omani Currency Value: One Omani Riyal (R.O.1)= 1000 baizas (bzas): R.O.1 = US $2.58 or US $1=387 Baizas)

7.7 National community water conservation program-

Ministry of Water Resources, Ministry of Agriculture and Fisheries

Several augmentation alternatives, such as artificial recharge schemes, desalination, utilization of brackish water, urban waste water reuse, runoff harvesting and monsoon

precipitation harvesting have been adopted as a measure for conservation of water in Sultanate of Oman by the Government bodies.

There is little rain generally, hence direct, domestic rainwater harvesting is not an effective, reliable means of constant overall water supply for the whole country. As part of the run off harvesting programmes, thirty small retention dams have been built by the MWR on the northern Oman mountains to provide water supply to communities.

Studies of monsoon rain water harvesting on Jabal al Qara in Dhofar have shown that vegetation is very effective at collecting precipitation. Fog interception represented ten to fifteen percent of total precipitation in the foothills of the Jabal and was as much as fifty to eighty percent of precipitation on the summit.
(Source:Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre)

Falaj is one of ancient systems still practiced in Oman and is considered one of the best ways of utilization of water by community since first priority is taken for drinking purpose, secondly for domestic use such as washing and cleaning utensils, and then the water is allowed to settle in settling tank and lastly it is used for irrigation. Thus maximum utilization of water by the community.

MWR- Surface water Section had promulgated flood risk assessment and management programs to utilize surface run off to the ocean and provide flood protection to minimize flood disasters. MWR. Recharge Section initiated water conservation schemes by constructing recharge dams and reservoirs to utilize surface run off. The recharge dams have proved to replenish the underground aquifers thus boosting ground reserves.

The Public Awareness Department of MWR stresses on profligate use of water would wipe out the water reserve and as a finite resource the importance of using water prudently cannot be understated. The department undertakes all round the year campaign advocating water conservation measures through public awareness. Farmers for instance, are urged not use drinkable sweet water to irrigate their farms, recommending instead slightly brackish water which is unfit for drinking but just suitable for irrigation.

7.8 Treatment and recycling of gray water-

Muscat Municipality and Regional Municipalities

Government Organizations like Muscat Municipality and Regional Municipalities has taken up the large scale treatment of sewage to be recycled for irrigating ornamental plants, beautification of the towns and cities in the Sultanate of Oman..
Domestic-Encourage using reclaimed wastewater from kitchen and laundry for house gardens and lawns-Some citizens installed their own treatment units to recycle the wastewater for gardening their lawns.

7.9 Efficient agricultural/irrigation practices (e.g. irrigating at night)-

Muscat Municipality, Ministry of Agriculture and Fisheries & Ministry of Water Resources

With agriculture's present use of 80%-90% of the nation's fresh water, water conservation in the agricultural sector has now become a priority for the government of Oman. Ministry of Agriculture and Fisheries has taken up measures in the five year plans to improve efficient use of irrigation water with advanced irrigation technology it becomes possible to control, manage and distribute irrigation water to plants without any waste, especially on high water losses inherent in surface irrigation. Factors affecting irrigation efficiency include irrigation technology, environmental conditions and soil characteristics.

Research carried out for irrigated cops in the Batinah region of Oman under modern irrigation methods show that efforts should concentrate on controlling water applications in terms of number and period of irrigations as a step for conservation. *(Source: Paper on a Comparison of Economic and Engineering Efficiencies in Modern Irrigation in Oman, Lokman Zaibet and Abdullah Omezzine, Sultan Qaboos University, 1997)*

Ministry of Agriculture and Fisheries in the five year plan, has introduced **Modern Irrigation Systems at Farm levels** at all regions since 1991. They have formulated strategies to improve irrigation efficiency after recognition of the resources limitation and marginal conditions (Soil,water & climate) prevailing in Sultanate of Oman.

1. Improve irrigation efficiency from source to end- Irrigation improvements - through Ministry of Agriculture and Fisheries to encourage more efficient and productive water use.

2. Subsidising infrastructure for modern irrigation system for the farmers- Modern irrigation methods such as drip, bubble and sprinkler systems, have been introduced under Government incentive schemes, with up to 75% of the capital cost being subsidised.

3. Public awareness programme (through communication (training farmers), illustration, interface between officials and farmers) from the Ministry of Agriculture and Fisheries for operation and management of irrigation to use water efficiently so as to increase the production with lesser inputs more effectively to the farmers of small holdings.

4. Modern irrigation system is introduced only to cultivated areas -indirectly conserving water -since no expansion of land is permited.

5. Encourage utilisation of wastewater that are compliance to the standards specified by Ministry of Regional Municipalities and Environment.

6. Encourage crop rotation for improving soil fertility, quality of water to the right crop.

بسم الله الرحمن الرحيم

Oman Daily Observer
10th March, 1997

Call to rationalise the use of water resources

By A Staff Reporter

MUSCAT — A Gulf water conference and a companion Watertech exhibition that opened here yesterday has stressed on the need to rationalise use of water resources through management, involve scientific organisations in the search for efficient technologies and have legislation introduced that will help conserve the scarce resource.

The conference, organised by the Water Sciences and Technology Association (WSTA), Bahrain, in association with Sultan Qaboos University (SQU) and the GCC Secretariat-General, formally opened at the SQU and moved to Al Bustan Palace Hotel in the afternoon for the presentation of scientific papers.

Chief guest at the conference opening was His Highness Sayyid Haitham bin Tareq al Said, Secretary-General of the Foreign Ministry. The Watertech exhibition, organised by Oman International Trade and Exhibitions, was opened by Mohammed bin Abdulkarim al Sufi, WSTA chairman, at the Majan Ballroom of Al Bustan Palace Hotel.

In his speech at the conference, Al Sufi drew attention to the pressure on groundwater resources from large-scale development, saying overuse and extravagance posed a threat to future supplies. He called for urgent steps to avert what could be a disastrous situation for the region.

Speaking on the occasion, Al Maskari, highlighted steps Oman had taken to conserve water and announced that preparations were being made for an MSc programme in water resources and water technology studies aimed to begin in the next academic year.

The five-day conference has the theme, "Towards Efficient Utilisation of Water Resources in the Gulf."

Abdullatif al Migrin, Director of the GCC Secretariat-General's Trade and Agriculture Department,

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Water conference

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said GCC ministerial committees were keeping a close watch on the water situation. There were also a number of technical committees involved in water-related matters.

Al Sufi said the rise in oil prices in the 1970s and the demand for water in urban areas had created a real shortage that was being felt even now and could escalate in the years to come.

He said individual water use in the Gulf had surpassed all international levels in urban areas while in remote places it was much below international levels.

Turkey which he said was interested in selling water to the Middle East could think of doing so because consumption was much below international levels.

Industry was emerging as an important water user, Al Sufi noted and estimated that a fourth of a tenth of all water used was consumed by that sector.

Describing public awareness as a crucial factor, Al Sufi said individuals should be concerned about the scarcity and decide to give up extravagance in water use.

Sounding a note of warning, he said the water reserve for urban needs in GCC states could last only one century. Underground water reserves usable for agriculture could run out by the next generation unless serious steps were taken to limit water waste on ambitious agricultural projects.

He stressed that there should be a social commitment to rationalise water use.

About what should be done to rationalise water resources, Al Sufi suggested the following:

- Create public awareness about water as a scare resource
- Develop agriculture that will use water efficiently and cut wastage and also develop brackish supplies
- Use treated sewage water for ornamental trees and landscaping
- Create a scientific and technical research base that will help introduce technologies for cutting down the cost of water
- Adopt plans and legislation to limit waste, especially in agriculture
- Adopt human resources programmes for people involved in the management of water facilities and support establishments working towards conservation.

Salim bin Nasser al Maskari said scientists, experts and bureaucrats had gathered for the conference to discuss one of the most pressing issues in the Gulf.

Since long ago, Al Maskari said, human habitations concentrated in areas where fresh water existed and communities found ways to rationalise water use by developing collection systems, means of using groundwater and ways of transporting water from mountains to wadis. They had also introduced an administrative structure to guarantee distribution of water and the maintenance of water facilities such as aflaj and wells.

Al Maskari told the gathering that his university and many Omani government departments had been playing a leading role in raising awareness of citizens on the importance of water conservation.

Staff had been mobilised for research and several water-related studies had been conducted while new specialities had been introduced at the university.

The newest one would be an MSc programme in water resources and water technology studies and preparations were under way to start it in the next academic year.

Al Maskari also said that Joint Gulf action in such a vital field as water would need intensive efforts for the achievement of water rationalisation goals.

In Oman, he said, His Majesty's Government had focused on the importance of water conservation and management. It had set up an administrative apparatus, drafted laws including a Royal Decree that designated water as national wealth that had to be protected.

Anthony Milburn of the International Association on Water Quality, London, identified in his paper three challenges facing the global freshwater sector: The need to educate public opinion to recognise water issues as a high priority, the importance of filling the vacuum in initiative in the freshwater sector at national, regional and international levels and the need to increase productivity hugely to meet the growing demands on the world's freshwater.

Thirty odd companies are taking part in the Watertech exhibition including those involved in water desalination in the GCC states. The Ministry of Water Resources has a pavilion which highlights sources of water and the steps it is taking to manage them in the national interest.

The exhibition is the first of its type to be held exclusively in the Gulf and not as part of a general trade exhibition, Oman International Trade and Exhibitions General Manager Ali Habaj said.

Among organisations taking part in the exhibition are the Middle East Desalination Research Centre and the Omani Centre for Investment Promotion and Export Development.

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بسم الله الرحمن الرحيم

Oman Daily Observer
10th March, 1997

SQU will play significant role in desalination research

By S T Almeida

MUSCAT — Sultan Qaboos University (SQU) will have a significant role in research work of the newly set up Middle East Desalination Research Centre, its director said. The university, meanwhile, will be the venue in June of a meeting of scientists from other universities and research institutes brought together by the Centre as a first step towards the creation of an academic network.

"We expect to have researchers coming to Oman and working right here in co-operation with SQU which has excellent laboratory facilities," said the Centre's Director Eric R Jankel. The Centre is now assessing research needs in preparation for drafting a Research Plan.

Discussing research opportunities, Jankel said the Centre would invite proposals from people interested in doing desalination studies and enter into joint ventures with research organisations. Also, depending on the progress of its research programmes, the Centre could set up its own facilities in Oman incorporating equipment for testing desalination techniques.

Commenting on the presence of many desalination plants in the Middle East and technologies developed over the years, Jankel told the *Observer* that the centre could look into the possibility of establishing a demonstration hybrid plant to incorporate the best of the available technologies in the field.

The Middle East Desalination Research Centre, an offshoot of the Middle East Peace Process, has as its founding members Oman, Japan, Korea, the United States and Israel. The European Commission is a sponsor and hopes to

To page 2

Desalination research

From page 1

become a member soon.

In May the Centre will hold a two-week programme in Eilat, Israel, on water desalination technology. "This will be important in terms of bringing together Arab experts to learn about Israeli desalination techniques and operations," said Jankel. He added that invitations would be sent to all Middle East countries from Oman to Morocco.

About the June meeting at SQU, Jankel said: "We're interested in creating an academic network. The first meeting will be a brainstorming session to know how a network of the type we have in mind will work," he said. The Centre would eventually like to have an exchange of students and faculty and institute fellowships and scholarships.

The Centre hopes to complete its research needs assessment in a few weeks and make the first draft of the Research Plan in April. According to the Centre's establishment agreement, it will have to consult with the Water Resources Works Group of the Middle East Peace Process. The Centre is also in the process of forming a Research Advisory Council and will appoint a Research Director.

"If everything goes according to plan, the Research Plan will be ready for approval by the Executive Council by 1 July, 1997," said Jankel. "Then we will implement the Plan which will actually be the research projects the Centre will carry out."

An international team consisting of a representative from the European Commission and one official each from Oman, Israel, and the United States as well as Jankel himself began its work of assessing needs last October, touring, Oman, Kuwait, the UAE, Qatar, Egypt, Israel, Jordan and the Palestinian Authority area. It is expected to visit Tunisia and Morocco this month.

HMR

Oman Daily Observer
13th March, 1997

3rd Gulf Water Conference ends

Steps urged to conserve and recharge groundwater stocks

MUSCAT — Yahya bin Mahfoudh al Mantheri, Minister of Higher Education and President of Sultan Qaboos University, presided at the closing ceremony of the Third Gulf Water Conference at Al Bustan Palace Hotel yesterday.

The conference, which began on 8 March, discussed water problems in the region and studied the recommendations of the second conference, which was held in Bahrain in November 1994.

Yesterday's final session approved the principle of co-ordinating national water policies at regional level and recommended support for studies on the management of water resources.

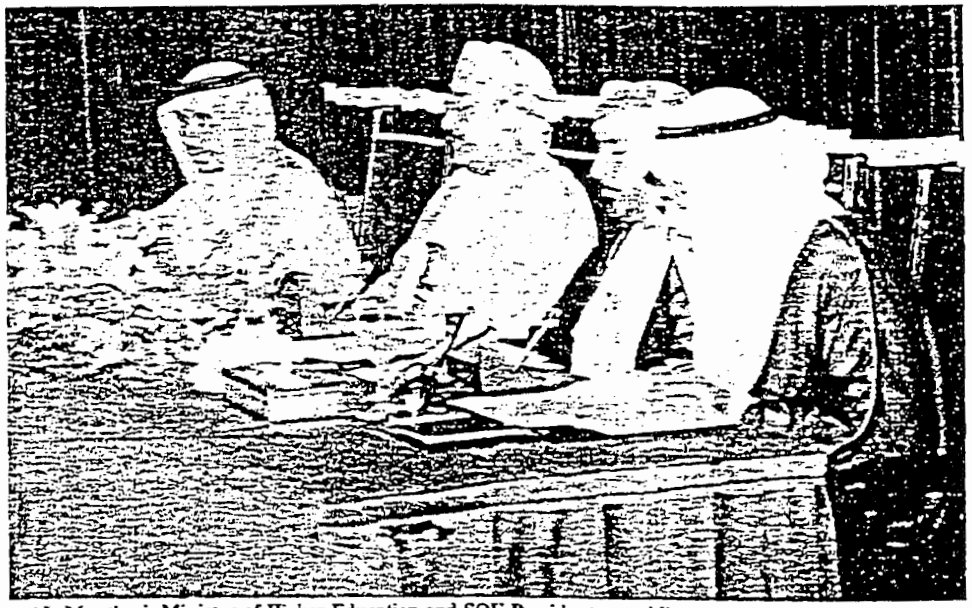
The conference recommended the use of information technology and invited the Water Science and Technology Association to establish a regional water information centre. It appealed to the Gulf Co-operation Council (GCC) states to provide the association with all necessary material and moral support.

The conference stressed the importance of training nationals to work in the water sector. It also called for studies to be carried out on transferring water utilities and services to the private sector.

It urged the GCC states to take urgent steps to conserve and recharge groundwater stocks and utilise them efficiently. It also stressed the need to encourage research into desalination technology.

The conference recommended that the GCC states place greater emphasis on the treatment and recycling of sewage water. At the same time, it urged that steps should be taken to reduce waste and increase efficiency, particularly in agriculture and irrigation. It recommended that the different qualities of natural water resources should be earmarked for specific agricultural uses.

The closing session was attended by ministry under-secretaries and water technology specialists.



AL Mantheri, Minister of Higher Education and SQU President, presiding over the closing session of the Third Gulf Water Conference at Al Bustan Palace Hotel. — *Picture by Fadhil Abdulwahid.*

بسم الله الرحمن الرحيم

Oman Observer Daily
26th March, 1997

Sultanate of Oman

MINISTRY OF AGRICULTURE AND FISHERIES
TENDER NOTICE

TENDER NO. 21/97

Date: 26.3.1997

Supply, Installation & Commissioning of Pumps Engines and Boosters forModern Irrigation Systems at Farm Lands in the Batina Region (Subsidy Programme)

Specialised companies Registered with the Tender board may obtain tender documents from The Legal Department, Second floor of The Ministry against payment of R.O. 25/- (Rials Omani Twenty Five only) per set, non-refundable on any working day.

Completed Tenders are to be submitted **before 10.00 A.M. on Wednesday 30/4/1997** in the Tender Box at The Legal Department of the Ministry.

Priority of awarding contracts shall be to the tenders including highest percentage of national products purchases.

The Ministry has the right to accept or reject any tender without assigning any reason.

TENDER COMMITTEE - MINISTRY OF AGRICULTURE AND FISHERIES

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بسم الله الرحمن الرحيم

Oman Daily Observer
28th April, 1997

Water stocks in dams put at 18m cubic metres

MUSCAT — Several wadis overflowed following three days of continuous rain last week, bringing the total volume of water stored in the Sultanate's recharge dam reservoirs to around 18 million cubic metres.

Wadi Al Jizzi dam reservoir in the Wilayat of Sohar overflowed into the Wadi al Hawasnah and Wadi Bani Omar dam reservoir in the Wilayat of Al Khabourah.

Water in the Wadi Ahen dam reservoir in the Wilayat of Saham reached a height of around 3 metres, adding an estimated 68,000 cubic metres to the reservoir's stocks.

The water in the Wadi Al Taw dam reservoir in the Wilayat of Barka rose to a height of around 2.1 metres, bringing the total volume stored in the reservoir up to around 1.28 million cubic metres.

The water level in the Wadi Al Fulaij dam in the Wilayat of Bárka reached a height of around 1.11 metres. The dam reservoir now holds an estimated 383,000 cubic metres.

In the Dakhiliyah region, Wadi Tanuf dam in the Wilayat of Nizwa overflowed, as well as Wadi Ghoul dam in the Wilayat of Al Hamra and Wadi Quriyat dam in the Wilayat of Bahla.

In the Dhahirah region the water in the Wadi al Kabir dam reservoir in the Wilayat of Ibri rose to 0.6 metres above the overflow level, adding around 421,000 cubic metres to the dam's stocks.

بسم الله الرحمن الرحيم

Oman Observer Daily
30th April, 1997

Sultanate's conservation of water resources outlined

CAIRO — Minister of Agriculture and Fisheries Shaikh Mohammed bin Abdullah al Hinai told Arab agriculture and water resources ministers here yesterday that Oman gave high priority to the conservation and management of its water resources.

He said a Royal Decree, No 82/88, had stressed that groundwater was national wealth which had to be protected used rationally.

Shaikh Mohamuned also said public awareness on water resources had been spreading in Oman thanks to the holding of seminars, exhibitions and other meetings and to instructional programmes on modern irrigation systems and other water management topics.

Oman considered it very important that every effort should be made to find new water sources and to conduct registration and inspection of sources of water supply, the minister said. He added that Oman wanted agricultural development to proceed in a balanced manner in the Arab world and achieve the objective of Arab food security.

That could be facilitated by access to information so it could be applied to every situation in the region.

Shaikh Mohammed called for the cultivation of crops that could adapt to salinity in areas where salinity levels had risen.

In other remarks, he stressed the importance of a scientific approach towards utilisation of waste water and the development of desalination techniques.

Shaikh Mohammed called upon the ministers to study issues concerning water resources in arid areas with the aim of balancing agricultural development with scarce water resources.

— ONA

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بسم الله الرحمن الرحيم

Oman Observer Daily
5th April, 1997

Women's role in water conservation

MUSCAT — Nasra bint Khalfan al Maamari, Awareness Specialist at the Ministry of Water Resources, highlighted the importance of water conservation in a lecture at the Oman Women's Association at Sohar yesterday.

The speaker noted in her address that women had a particular responsibility in the water rationalisation effort, given their role in households and as mothers. Educating children on the judicious use of water was also an important task in this regard she said.

The lecture was part of a programme organised by the ministry's Information and Awareness Centre focusing on women through the Oman Women's Association (OWA) chapters.

Oman Observer Daily
7th April, 1997

Lecture on water

SAHAM — A lecture on water was held at the Omani Women's Association in Saham yesterday.

The speaker, a water awareness specialist from the Ministry of Water Resources, pointed out that water was essential for all living creatures and played a vital role in national development.

She added that it was important to utilise the water from the recent rains in the best possible way, and ensure that not a drop was wasted.

She said women had a major role to play in ensuring that water was used rationally in the home, and were also called upon to propogate the message of prudent water use.

The lecture was one of a series of talks being held at the Omani women's associations in the regions this week. —ONA

HMR

Key aspects of achieving an overall reduction in agricultural water use will be:

- adoption of improved irrigation techniques
- optimum use of selected irrigation techniques
- selection of crops that have lower water requirements
- movements of cropping to areas of brackish water, away from areas where the resources are over committed.

Develop agriculture that will use water efficiently and cut wastage and also develop brackish supplies. Water flooding irrigation was practiced earlier, by now it is replaced by drip and sprinkler method which is more efficient and water conserving. Piped distribution system is now introduced for irrigating farmlands.

Ministry of Agriculture and Fisheries introduced two types of Pilot Projects. This program is a pay off program (benefiting) for the Government as well as for the farmers. By developing these programs both farmers and the government are benefited. Farmers started producing more by these methods thereby increasing the revenue of the country.

Small Pilot Project

- ***Falaj Keed Project at Bahla, Nizwa***

As a pilot project in 1992, a 45 acres of barren land near the tail end of Falaj Keed in Bahla, was converted to a very fertile productive agricultural land bearing vegetables and fodder grass. Falaj Keed with feeble flow was ending into a barren land and the water however less was wasted into this barren land. Ministry of Agriculture and Fisheries extended a lined canal from the tail end of the falaj which led into a tank. This stored water from the feeble flow of the falaj Keed was pumped to irrigate the barren land through modern irrigation sprinkler systems and virtually converted this to a productive agricultural land. This is an excellent example demonstrated by Ministry of Agriculture and Fisheries.

Pilot Projects for rotational irrigation at different regions-1995

- ***Rafa'a Farm Project, Nizwa***

Rafa'a Farm in Nizwa was selected for this project to educate the farmers on best irrigation practices and schemes subsidized by the Government to attain irrigation efficiency by proper management and operation of modern irrigation technologies. With advanced irrigation technology, it becomes possible to control, manage and distribute irrigation water to plants without any waste.

To introduce modern technology to manage the irrigated agriculture fed by big falaj-Mainly associated with date farms who sought traditional flood irrigation practices which are replaced by modern irrigation systems (delivery/distribution system through pipes from source to end, drip,bubbler etc) to conserve water after studying to the soil and crop requirements.

The bubbler irrigation system has been proved as a suitable and successful technology, since it can provide water to the trees as required and consequently high productivity with lesser agricultural inputs can also be achieved ever for trees of different ages. Similar project would be extended to all regions of the country.

(Source:Interview with Mr. Emad Abdul Majeed Al Lawatia, Director General of Irrigation and Dr.Hassan Wahibi, Irrigation Affairs Expert, Ministry of Agricultureand Fisheries on 18th March, 1997). Dr.Hassan Wahibi was formerly working as Director,EWUP USAID in Egypt (1978-1985).

Use of wastewater

Use of wastewater as a source of irrigation, with conservation measures like priority irrigation systems, moisture sensing devices and native vegetation etc.

Master plan to do complete night irrigation by 1998 is being considered by Muscat Municipality by facilitating storage facilities at the STP sites which will save about 500m^3/day of treated wastewater from evaporation and annually about R.O.18,500 is saved by this since cost of producing 1m3 of treated wastewater is about 100 baiza . **The unit cost of production of treated wastewater per m3 is 100 bzs (compared to 388 bzs/ m3 in U.S.A)** *(Source:Interview with Mr.Lars Paulsson,Chief Sanitary Engineer, Darseit Sewage Treatment Plant, Muscat Municipality)*

Efficient use of falaj water -The Ministry of Water Resources has initiated a programme to improve on farm irrigation systems within the area supplied by a falaj. A pilot scheme was set up at Falaj Halban with the cooperation of the farmers, tanks were installed on three plots to hold water taken from the falaj. So while water continued to be taken from the falaj at normal times, the farmers could release the water from the tanks more frequently to irrigate vegetables. The farmers were also able to use drip irrigation rather than the traditional flooding technique. Water meters monitored the amount of water used. This scheme has also enabled the farmers to grow crops at seasons when land would normally be left fallow.

The programme at Falaj Halban focussed on using agricultural water more efficiently, so farmers continued to collect the same amount of water from the falaj at allotted times while storing it in tanks to release at more frequent intervals to water higher value crops and vegetables. The project proved very successful and more farmers asked to be included.

The concept has now been expanded so that studies are now ongoing at two aflaj, Falaj Sibaa, near Bausher, and Falaj Hajir in Wadi Bani Kharus, to improve the use of irrigation water. The entire falaj in each location is being studied with all properties asociated with the aflaj being included. Aspects under investigations include channel efficiency, crop water requirements, does the falaj meet the requirements of the water users and how efficient is the community in managing the falaj.

(Source: -An Introductory Guide - Water Resources of Sultanate of Oman,1995and Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre)

Mist collection experiments

A number of mist collection experiments have been conducted by Ministry of Water Resources which includes:

- Using a variety of mesh screens to catch air borne moisture and to channel the drops into a central container.
- Siting tanks round the base of trees to catch and measure interception by the tree's canopy.

In parts of Dhofar, the Khareef (monsoon) produces several months of heavy cloud and mist, sometimes accompanied by drizzle. Occult precipitation is important on the jabal, especially on trees and other vegetation.

Moisture collection from individual trees depend on the unique characteristics of each tree, its canopy and its location. In 1989 one tree yielded 67,750 liters but in 1990 just 48, 164 litters. This gives strong empirical support to the importance of interception of occult precipitation by vegetation as a major contributory factor in overall recharge to the mountains.

(Source: -An Introductory Guide - Water Resources of Sultanate of Oman, 1995)

7.10 National Desalinisation program-

Ministry of Electricity and Water

Increased demand for potable water in the region and the shortage of potable ground and surface water resources have made desalination a viable water resources alternative. Although it involves high cost, modern technology has shown tremendous improvement in the performance of these plants and decrease in unit cost.

Research on producing desalinated water from brackish water

MWR is conducting experimental research into producing desalinated water from brackish water by reverse osmosis using solar energy as a power source at its camp at Hailat al Rakaa in the desert. This experimental research project may be successful to provide enough water to assist development of isolated communities in rural areas.
(Source: Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre).

Table 7.3 Total production of desalinated water by various desalination processes in Oman

Desalination Methods		Total Capacity (1995)		Produced in 1992 Mm^3
MSF (Multi Stage Flash)	RO & Others (Reverse Osmosis)	m^3/d	Mm^3/y	
105,000 m^3/d	2000 m^3/d	107,000	39.1	32

(Source Ismail, 1995;Al Alawi and Abdul Razzak, 1992)

Currently desalinated water amounts to 52MCM/year with 48 MCM/year in the Capital area, and is expected to reach 140 MCM/year in 2010.(MCM/year-Million Cubic Meter/year)

Nearly 55% of potable water produced in Sultanate is through desalination, major share is from Muscat region which constitutes nearly 77% of the total production by desalination process.
(Source: Statistical Year Book).

The newly set up Middle East Desalination Research Centre with base in Oman will in cooperation from the Sultan Qaboos University will play a significant role in desalination research.

7.11 National Hotline

Ministry of Electricity and Water (MEW) has a hotline **153** which is available to all the regions in Sultanate of Oman to attend to emergencies like water leakage from pipe burst . MEW has established emergency sections all over the regions to attend to water leakage. Similarly **Muscat Municipalities** has a hotline **150** to attend to sewage pipe leak. These hotlines are to assist citizens and government to save water from being wasted, thus conserving water.

An engineer is on duty up to 9.30 pm and a clerk on 24 hrs duty to attend to the hotline. Immediate measures are taken to rectify the leaks and resume the supply. A register is maintained to attend the complaints passed on hotline. An average of about 11 calls/day comes through the hotline which is paid immediate attention. Complaints such leak, pressure low, water block, and pipe burst are registered through hotline. A thorough evaluation of the hotline complaints is carried out by the Senior Officials of the Ministry of Electricity and Water.
(Source: Interview with Mr.Said Mohammed Nabhani, Director of Muscat Water Department, Ministry of Electricity and Water, Sultanate of Oman)

Thereis no national telephone hotline for MWR, but telephone talk shows on the radio, in which Ministry officials participate, have taken many calls from all over the Sultanate of Oman which have provided valuable feedback.
(Source:Letter dated 11th June, 1997 from Ministry of Water Resources Information and Awareness Centre)

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9.0 Acknowledgments

1. Mr. Ahmed Al Ghafry, Supervisor General, Public Awareness & Information Centre, Ministry of Water Resources, Sultanate of Oman
2. Mr.Saif Bin Rashid Al Sheksy, Director General of Water Resources Management, Ministry of Water Resources, Sultanate of Oman.
3. Mr.Ahmed Al Adwi, Director of Conservation, Ministry of Water Resources, Sultanate of Oman.
4. Mr.Abdulla Al Yahyayi, Director of Management, Ministry of Water Resources, Sultanate of Oman.
5. Mr.Saleh Shoukry, Director of Well Protection, Ministry of Water Resources, Sultanate of Oman.
6. Mr.Lars Paulsson, Chief Sanitary Engineer and Mr.Patel of Darseit Sewage Treatment Plant, Muscat Municipality, Sultanate of Oman.
7. Dr.Hassan Wahiby, Irrigation Affairs Expert, Ministry of Agriculture and Fisheries, Sultanate of Oman.
8. Mrs.Sue Hutton, Information Centre, Ministry of Water Resources, Sultanate of Oman.
9. Mr.Said Mohammed Nabhani, Director of Water Department of Muscat Governorate, Ministry of Electricity and Water, Sulatnate of Oman.
10. Mr.Emad Abdul Majeed Al Lawatia, Director General of Irrigation, Ministry of Agriculture and Fisheries, Sultanate of Oman.
11. Mr.Suleiman Al Harthy, Director of Public Awareness, Ministry of Water Resources, Sultanate of Oman.
12. Mr. Hassan Mohammed Moosa, Supervisor General of Planning & Training, Muscat Municipality, Sultanate of Oman

بسم الله الرحمن الرحيم

APPENDIX A

PLATES PERTAINING TO PARKS AND GARDENS

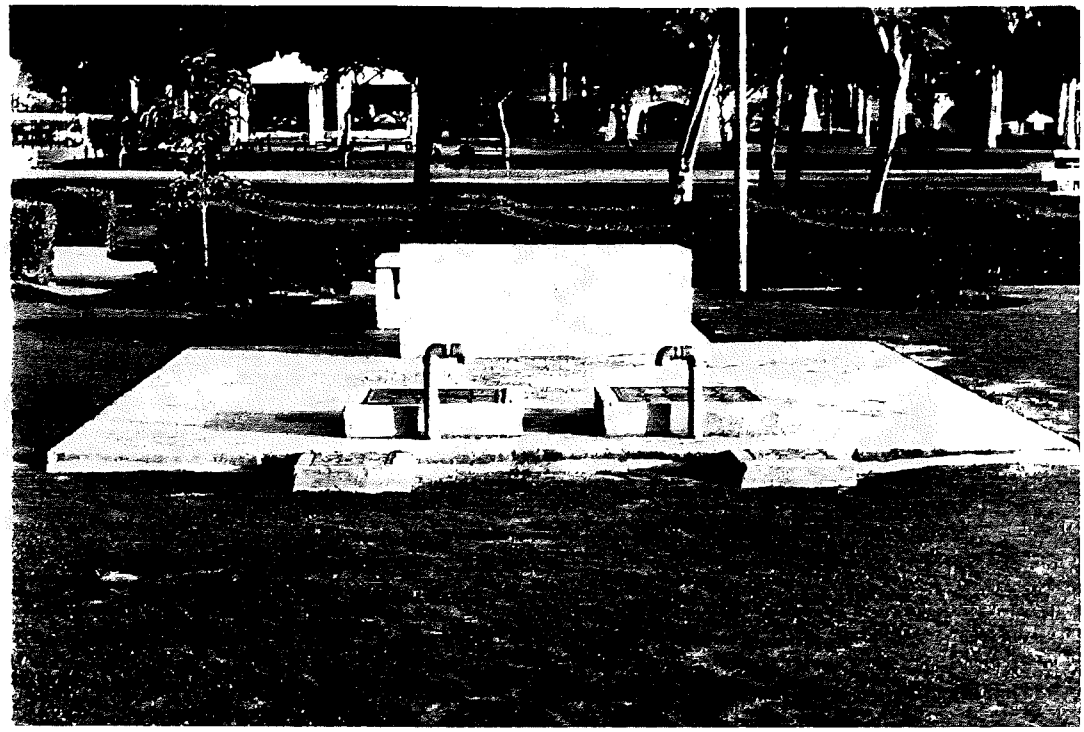
Entrance to Wadi Kabir Park

Shady Trees in Wadi Kabir Park

Lawns in the Park

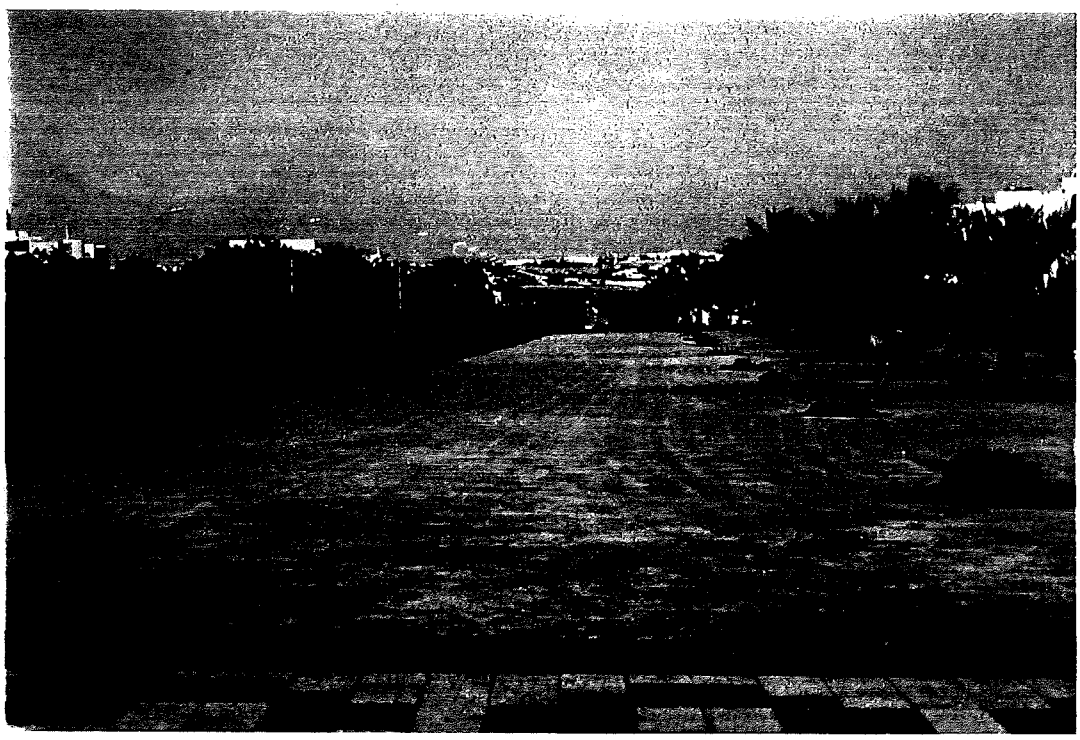
Gardens in Wadi Kabir Park

Plate No. 2

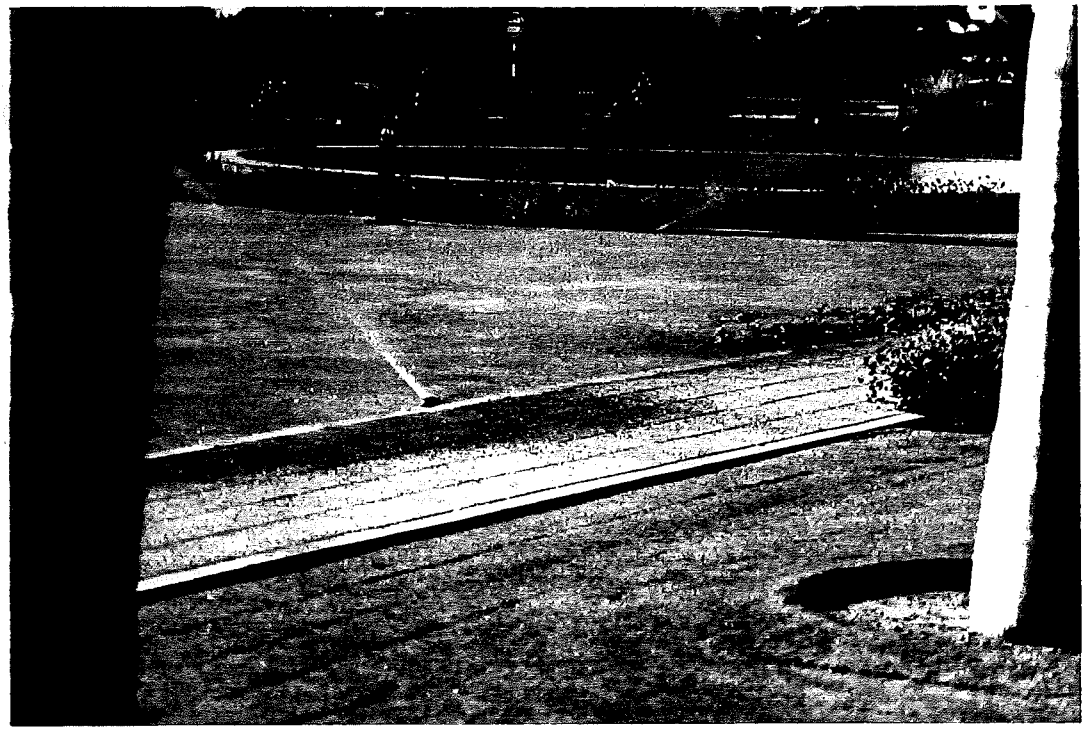


Treated Effluent Storage Tanks in the Park

Drip Irrigation System in the Park



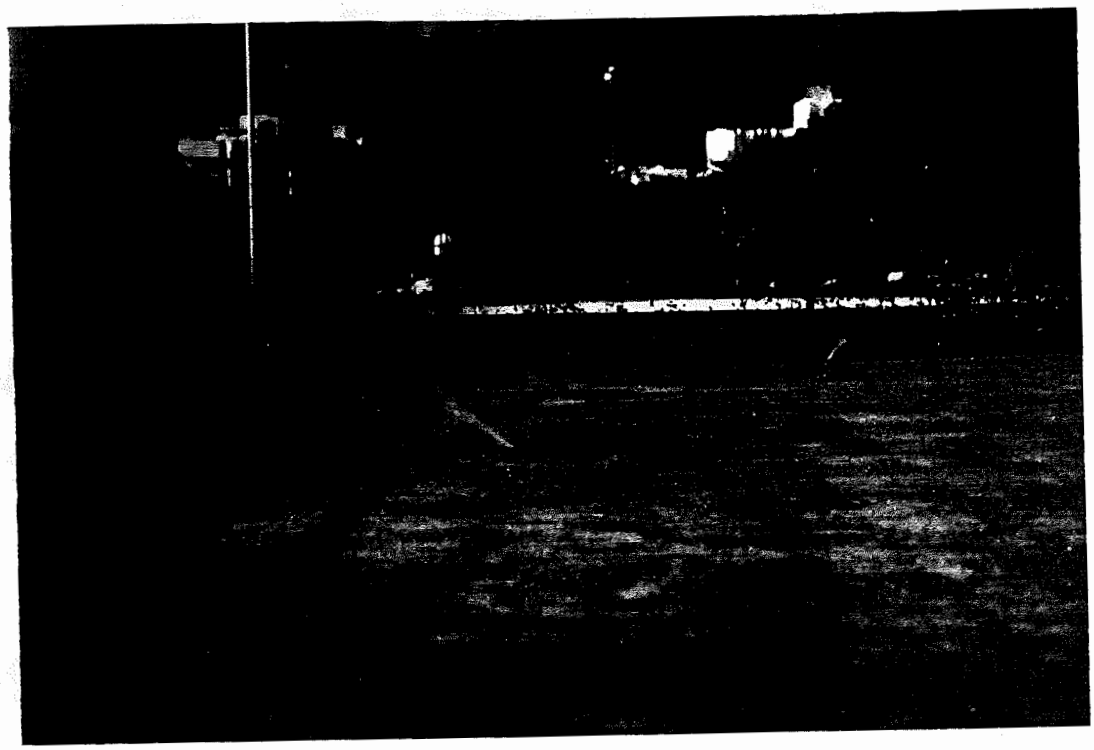
Sprinkler Irrigated Lawns



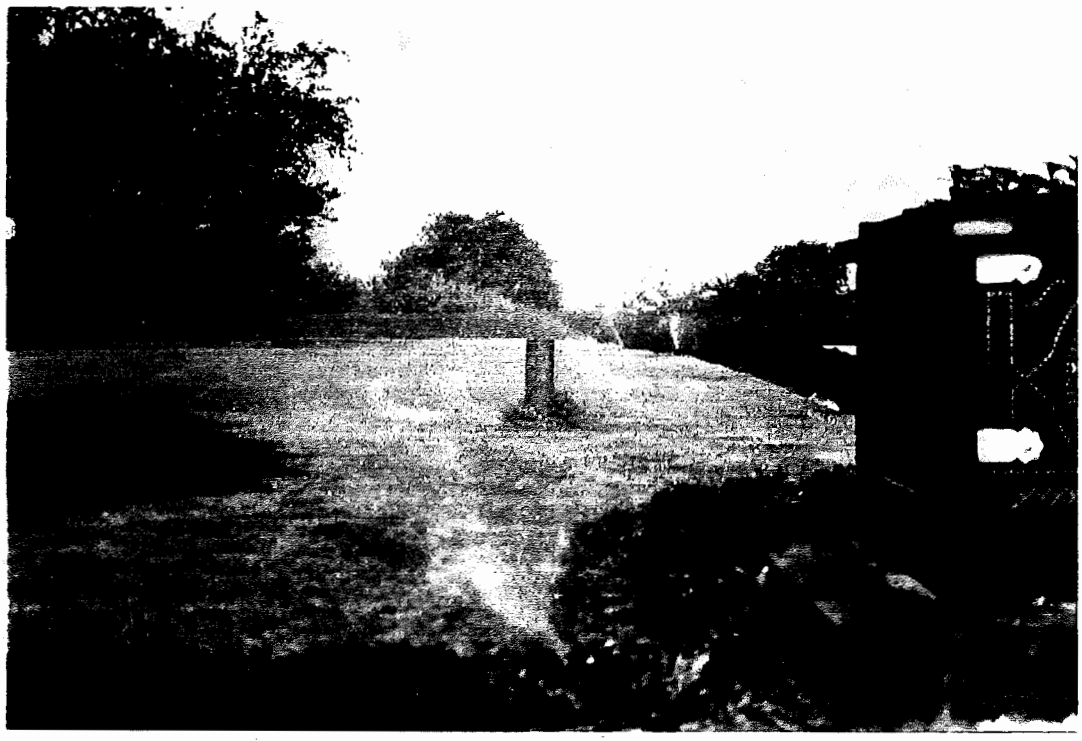
45 ^{0} Sprinkler system

Plate No.4

360 ^{0} Sprinkler system



Parks Irrigated by the Sprinkler systems



بسم الله الرحمن الرحيم

APPENDIX B

NEWSPAPER CLIPPINGS

بسم الله الرحمن الرحيم

Times of Oman
12th September, 1994

Progress in research and exploration for new water resources in Oman

MUSCAT — Dams are among the most important types of water projects in the Sultanate. Special studies have been made to select locations for new dams and evaluate their contribution to the country's water resources.

The basic aim of the dams is to make use of flood water which would otherwise be lost in the sea or in the desert. This is done by trapping the water so that it can seep into the ground and boost ground water stocks.

Around 150 million cubic metres of water have been stored by dams during the past four years. Most of it has seeped into the aquifers and recharged them.

It may be difficult to determine exactly the volume of water recharged so far. However the Ministry of Water Resources has a policy based on the rational use of water in order to reach a balance between supply and demand.

Despite the fact that the Ministry of Water Resources is relatively new, it has made good progress in the fields of research and exploration for new water resources, in addition to preserving the existing water resources from waste and attrition by making people more aware of modern methods of rationalising the use of water. The Ministry carries out studies in the Sultanate's regions and uses the most modern methods and scientific equipment in its search for water.

Royal Decree 3/94 on conducting hydrotechnical studies for dams and monitoring falajes brought falajes and dams under the Ministry's responsibility. Then the competent authorities at the ministry prepared plans for new dam projects in the Sultanate's regions. Programmes are aimed at upgrading their efficiency, improving sources and digging wells for the preservation of arable areas in the Sultanate.

Since 1985 16 recharged underground water dams have been built in the governorate of Muscat and the Batinah, Dakhiliyah, Dhahirah and Sharqiyah regions and the Governorate of Dhofar to store the maximum possible volume of Wadi of flood water which would otherwise be wasted.

Among the other dams built is Al Khoudh Dam in the Governorate of Muscat in Al Seeb which has an estimated capacity of around 11.55 million cubic metres. There are also eight dams in Al Batinah region. They are Al Faleej, Halban, Al Marbakhah and Ma'awal, Wadi Al Abyadh, Al Fara, Al Rustaq, Al Khizi and Al Hilti, Al Salahi and Al Hawasnah, Al-Khabourah.

Three dams have been constructed in Al Dhakhiliah region. They are Wadi Tanuf, Wadi Quriyat and Wadi Ghool. In Al Sharqiyah two dams have been constructed. They are Al Faleej and Khour Rasa'agh, and Wadi Al Kabir. There is also a dam in Wadi Sahanut in the Governorate of Dhofar.

After the transfer of the falajes and dams departments to the Ministry of Water Resources, the Ministry continues to plan for the construction of new dams in other areas of the Sultanate.

Three dams are currently being constructed in Wadi A'Abin in Wilayat of Sahum with a storage capacity of 6.8 million cubic metres. The project is due to be completed at the end of this year. Wadi Bani Umar and Al Hawasnah in Wilayat of Khabourah will store flood water estimated at around 3.7 million cubic metres. The project was started early this year. Work is also underway in implementing the first phase of a water systems project which will serve 29 villages in Al Jabal Al Akhdar, in Saiq, Wadi Mvaydin Basin and Wadi Tanuf. These projects will provide drinking water for the region.

The Ministry of Water Resources is currently completing detailed studies for the construction of seven small dams in Al Jabal Al Akhdar. Among them are two recharge dams on Wadi Al A'Ala to serve the wells and falajes of Sint village and the neighbouring regions. There will also be five similar surface storage dams to serve villages on the top of Jabal Al Kour. The total cost of the construction of the seven dams is around RO 1.25 million.

Ministry sources indicate that there are six projects for the construction of recharge water dams, which are currently under economical feasibility studies. They are Wadi Al Munaydin in Wilayat Nizwa, Wadi Halfain in Wilayat Izki, Wadi Dhank in Wilayat Yanqul, Wadi Al A'Arid in Wilayat Ibri and Wadi Ghalaji in Wilayat Al Qabil.

Dams and water systems in the Governorate of Musandam include 8 recharge dams, 20 small surface storage dams and 20 basins. These will give the local population access to water supplies near their homes. — *ONA*

HMR

بسم الله الرحمن الرحيم

Intense rains boost ground water levels

Oman Daily Observer
28th February, 1996

By Conrad Prabhu

MUSCAT — Last December's bountiful rains over much of Northern Oman have been described by officials of the Ministry of Water Resources as "the heaviest in more than a decade." The downpour in some areas was especially heavy, with an intensity observed once in 50 years or so.

Ground water levels have surged in many areas in the wake of the rains, but not to a point where water conservation measures can be in any way relaxed. Data is now being collated to determine the overall impact on ground reserves in the aftermath of the showers.

"The December rains have indeed been the heaviest spell in the last 10 years," observed Aley al Marjebi, Director of Ground Water Department, in the Ministry of Water Resources. Against an annual average of 100mm of rainfall in Northern Oman, up to 180mm of rainfall was recorded in December — an occurrence reported once in 10 to 20 years, he said.

Between 7 December and 20 December, the Batinah coast was lashed by unusually heavy rains, with a spell of intense showers on 25 and 26 December. The heaviest rainfall was recorded at Khasab in the Musandam, notching 245 mm. Such heavy downpours are recorded once in about 50 years in this region, Al Marjebi noted. In comparison, the annual average in Khasab is 150-200 mm.

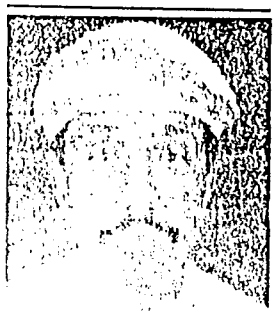
Three areas in the Batinah region — Aswadi, Shinas and Liwa — received particularly intense showers, recording 120-180mm — again an infrequent occurrence observed once in about 20 years, the official said. In the southern Batinah region, many areas recorded 100mm of rainfall, which was described as exceptionally heavy.

Al Mazara in Quriyat recorded about 130mm of rain during December, described as a rare occurrence observed once in 50 years. Some parts of the Interior region received 75 per cent of the annual rainfall in just two days of showers, on 25 and 26 December, Al Marjebi said.

Wadi flows have been heavy during the December period, but much of the water lost to runoffs into the sea. At Al Mazara in Wadi Dayqah, 56 million cubic metres (cu. m.) of water flowed through the wadi. Water levels in the 15 major recharge dams around Northern Oman have also been heartening. Underground aquifers will gradually be replenished thus boosting ground reserves.

According to ministry officials, some four million cu. m. of water collected in the Al Khoud recharge dam. Water levels in wells located in the area rose by at least two metres indicating a substantial replenishment of the water table.

At the end of December, the Al Ma'awil dam in Barka held some three million cu. m. of water, while 2.5 million cu. m. collected in the Al Hawasinah dam in Al Khabourah. The volume in the Wadi Ahin and Wadi Jizzi dams in Sohar were 1.2 million cu. m. and 1.1 million cu. m. respectively. Levels in many recharge dams rose to heights not seen in many years, officials said.



Aley al Marjebi, Director of Ground Water Department

Although December's rains have brought much cheer to the water resources ministry, the record downpours do not automatically translate into a proportionate rise in ground water reserves. According to Al Marjebi, a good deal of water is lost in runoffs and evaporation.

"This is the disadvantage of having heavy rains over a short period of time. Rather, if the same amount of rains was distributed over a longer period of time, it would have been a more welcome situation," he said.

To the agricultural sector, the showes have been something of a windfall. With levels in wells having increased, permits for deepening of wells have consequently dropped, it is learnt.

Ministry officials are however cautioning against overuse and misuse of water, saying the December rains were something of a one-off occurrence. In the Batinah area, for instance, against an annual abstraction of 688 million cu. m. of water, the volume of recharge is only 440 million cu. m.

According to Suleiman al Harthy, Director of Public Awareness (Ministry of Water Resources), profligate use of water would wipe away the gains to water reserves in the wake of the December rains. As a finite resource, the importance of using water prudently cannot be understated, he said.

The department undertakes a year-round campaign advocating water conservation measures. Farmers, for instance, are urged not to use drinkable sweet water to irrigate their farms, recommending instead slightly brackish water which is unfit for drinking but just suitable for irrigation.

Oman Daily Observe
3rd March, 1996

Water conservation workshop opens in Amman tomorrow

By Conrad Prabhu

MUSCAT — Oman's acclaimed water resources management strategy will be the highlight of a paper to be presented at this week's international workshop on water conservation, jointly organised by the World Health Organisation's Regional Centre for Environmental Health Activities, and the Islamic Development Bank.

Twenty member states of the Eastern Mediterranean region will be taking part in this four-day workshop, which opens in the Jordanian capital Amman tomorrow.

Representing the Sultanate will be the Ministry of Water Resources' Director of Groundwater Department, Aley al Marjebi. He told the *Observer* that his paper will focus on the Ministry's water management, conservation and protection programmes.

The workshop's theme, "Water Conservation and Reuse: Practical Approaches & Strategies", is expected to offer member participants a wealth of conservation experience and knowledge garnered in the region and worldwide.

Experts will review the current water resources situation in the Eastern Mediterranean region, and assess the future needs for fresh water resources in order to meet the developmental requirements of these countries.

The GCC states apart, countries taking part are Afghanistan, Djibouti, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Sudan, Syria, Tunisia and Yemen. Turkey and Bangladesh which fall outside the eastern Mediterranean region will also be sending representatives.

Classified as an arid country with an overall average rainfall of 100mm, the Sultanate's experience in the area of water management will be of considerable interest at the workshop, according to al Marjebi.

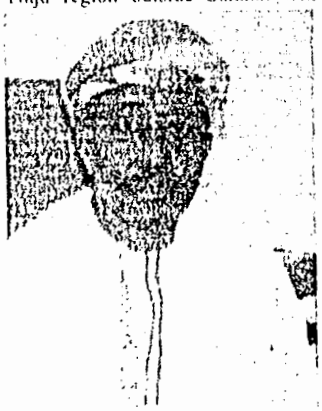
Some elements of Oman's water management strategy — the construction of recharge dams, for instance — are said to be path-breaking measures. To date, 15 major recharge dams have been built around northern Oman, which help retain a portion of surface water flows during heavy rains. Wadi Al Khoudh dam outside Muscat is the largest recharge dam with a capacity of 11.5 million cubic metres.

Al Marjebi's paper will outline the groundwater situation in Oman, and the peculiar factors that facilitate the natural recharge of underground aquifers. In the northern parts of the Sultanate, major groundwater sources occur in the alluvial deposits in wadi beds from where it is exploited by aflaj and wells. But the complex structure of the jebels limits the continuity of these aquifers, restricting their use to the vicinity of the aquifers only.

Limestones and dolomites are also significant sources of groundwater in these mountains, but their yield depends on locating open joints and fissures, according to al Marjebi.

The paper cites the Samayil ophiolite as a locally important aquifer which feeds aflaj and stores large quantities of water. Water from this aquifer is released slowly into the wadi alluvium and thus maintains supplies to wells and aflaj in small alluvial basins.

Recent groundwater finds in the Najd region outside Salalah will also figure in al Marjebi's talk. Four aquifers have been found this far. In fact there is water to be found under much of the Najd, but of a quality suitable for agriculture.



Aley al-Marjebi

The paper's main thrust will be the government's resource protection and conservation programmes. This includes the establishment of Wellfield Protection Zones, which aim to protect groundwater from contamination, over-extraction, saline intrusion and adverse development.

Using brackish water for irrigation purposes is also a vital aspect of the ministry's strategy, the paper notes. Certain areas of Oman has large brackish water resources. Suitable soils and proper irrigation techniques will enhance the utilisation of these resources.

Another significant measure concerns plans to relocate large-scale agricultural enterprises to areas with under-utilised water resources. Grass and fodder farms on the Batinah and Salalah plains are planned for relocation, thus easing the water demand in areas of over-development.

Treating effluents and sewage has been a successful outcome of the government's conservation efforts, according to the paper. Sewer systems and sewage treatment plants now make treated effluent available as a resource.

At present, the bulk of the treated effluent water of roughly 25,000 cubic metres/day, generated by all the major treatment plants, is being used for irrigation. The irrigation network is controlled by a central computer network to maximise the use of the water available, according to the paper.

HMR

بسم الله الرحمن الرحيم

Times of Oman
11th June, 1996

US ambassador calls for better water resources management

By A Staff Reporter

MUSCAT — The Middle East has been confronted with water resources crisis and with five per cent of world's population, it has less than one per cent of world's renewable fresh water, said US Ambassador to the Sultanate Frances D. Cook quoting a report by the World Bank. She was speaking at a function to launch a water resources project in Salalah.

The function was attended by Margaret Carpenter, head of the Asia and Near East Bureau of America's Agency for International Development, which provides personnel and contributions to the Omani-American Joint Commission.

In her remarks carried by a United States Information Service (USIS) press report, the ambassador commended the cooperation between the US and Oman in the field of water resources.

"The United States has a rich and varied partnership with Oman in the critical area of water," she said, adding that "Oman's leadership in this field was acknowledged when your nation was selected to host the future Middle East Desalination Centre, sponsored by Oman's and America's partners in the search for peace in the Middle East. And today we are here to launch another project which symbolises our close collaboration in water resources."

The ambassador pointed out that, given the rapid population growth in the Middle East, even the current exceedingly low water availability levels will fall by another 50 per cent in the next 30 years.

She added that the region has already the lowest water availability rate in the world. It is about one-third of Asia's levels, 15 per cent of Africa's and a mere five per cent of Latin America's.

The ambassador said that the extensive economic development, which has taken place in Oman over the past 25 years, has placed a severe strain on groundwater resources.

In Salalah, projections indicate that in the year 2020 there would be a water deficit of some 20 million cubic metres per year without planned interventions. More effective management of Oman's limited water resources will continue to be crucial to the development process that His Majesty Sultan Qaboos bin Said has launched, she added.

Among the measures to be taken to preserve water resources in Oman, she mentioned limiting withdrawals from freshwater aquifers, reusing treated wastewater and minimising unaccounted — for water in urban water supply systems which come to show the importance of the Salalah Wastewater Project.

The relationship between the US Agency for International Development, represented in Oman by the Omani-American Joint Commission and the Dhofar governorate began in 1989 when the OAJC agreed to finance preparation of a water and wastewater master plan for the city of Salalah and construction of wastewater treatment ponds intended to provide an interim solution to the wastewater disposal problem. The treatment ponds became operational in 1992. The master plan, completed in 1992, identified the water/wastewater infrastructure improvements required to meet the needs of Salalah's population through the year 2020. The OAJC's contribution for the treatment ponds, including training and laboratory equipment, and the master plan total RO4.3 million.

The ambassador noted that the Dhofar Municipality and OAJC consultant are aware that increasing demands on the freshwater aquifer were causing the groundwater to deteriorate and to avoid major capital investments in desalination facilities, any solution should include those steps needed to restore the water balance.

According to recommendations made by the consultant, certain uneconomic agricultural production should be moved away from the aquifer and that the wastewater should be treated to a tertiary level and reused to recharge the aquifer or for direct irrigation of cash crops.

بسم الله الرحمن الرحيم

Oman Daily Observer
16th June, 1996

Seminar on ground water resources

MUSCAT — The Sultanate represented by the Ministry of Water Resources will take part in a seminar on managing ground water resources by using advanced technical and mathematical models, organised by the Arab Centre for Studies of Arid Regions and Poor Lands, which begins today in Damascus.

The seminar will discuss several issues such as the basic principles to manage water resources and the importance of using geographical information and mathematical models in managing ground water resources.

The seminar will also study a model for mathematical practice and geographical information system in managing water resources at arid regions. —ONA

HMR

بسم الله الرحمن الرحيم

Oman Daily Observer
12th August, 1996

American expert aims strategic plan for water research centre

By Ebby Chacko George

MUSCAT — Eric R Jankel of the United States, who is an international expert in water resources management, will assume office as the first director of the Middle East Desalination Research Centre here in September, a diplomatic source at the US embassy told the *Observer* yesterday.

According to Jankel, his first priority will be to establish the centre on a secure, long-term financial basis. The strategic plan is to make the centre a fully independent and self-financing institution.

Jankel is all set to capitalise on an excellent start as the centre has already received $15.5 million in pledged financial contributions.

In a congratulatory note to the newly appointed director, US Vice-President Al Gore said the centre would make significant contribution to co operative efforts to improve water supply in the Middle East. The 1994 decision to establish the centre was bold and far-sighted, Al Gore added.

The centre is an early sign of what the new Middle East could be like. It is an institution of the future, part of a region at peace, Al Gore said. Everyone involved in making this centre a reality are making a real and tangible contribution to the peace process in the Middle East, Al Gore added.

Jankel brings a unique blend of practical and theoretical experience to the centre and he has a keen understanding of the role the centre is to play in the Middle East peace process, Ambassador Sayyid Badr bin Hamad al Busaidi, Chief of the Foreign Minister's Office and Chairman of the interim board of governors of the centre, pointed out.

Jankel will provide the leadership to establish the centre as an institution dedicated to assisting the Middle East peace process by means of contributing practical solutions to problems of water scarcity in the region, Ambassador Sayyid Badr added.

When Oman hosted the first meeting of the Working Group on Water Resources, set up as part of the Middle East multilateral peace process, in April 1994, not many could then fathom the diplomatic initiative.

The farsighted step, however, was not confined to contributing to the peace process alone, but a visionary step resulting from an assessment of the most precious of resources — water — which called for urgent measures to avert a graver crisis in the region.

The message hardly had to wait and the working group endorsed Oman's proposal to establish a regional desalination research centre in Muscat. The overall aim of the centre was to help identify, refine and develop economically viable and technically feasible methods and systems for desalting water.

The World Bank in a 1993 report warned that the average water availability in the Arab region, characterised by arid and semi-arid belts, was only 1700 m³ per capita compared to the world average of 13,000 m³ per capita.

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Desalination Research Centre

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As a result of the soaring population growth rate in the region of about three per cent per annum, the average per capita availability of renewable water resources was bound to decline to 667 m3 by the year 2025, the report added.

In recent history, the Arab region witnessed vast expansions in irrigation development and rainfed farming in the arid and semi-arid zones where agricultural water use consumed almost 80 to 90 per cent of the water resources, according to a study by Yahia Abdel Mageed, former minister of irrigation in Sudan and former Secretary-General of UN Water Conference.

In the case of Oman, domestic and industrial water requirement stood at three per cent each while the remaining 94 per cent of water resources was accounted by agricultural use, Yahia said.

Domestic water use is still very low in many parts of the region. It is estimated that one-third of the total population of the Arab region have no access to safe water, according to a report by the Arab Fund.

At current population growth rate and assuming a per capita consumption of about 200 litres a day, it is estimated that by the year 2030 the domestic water demand would reach 35 billion m3. Industrial demand, assuming three per cent annual growth, would touch 22 billion m3.

In contrast to this, the agricultural demand, taking into consideration its envisaged role to realise food security through self-sufficiency, would reach 377 billion m3 a year or about 86 per cent of the total water demand.

The stark reality is that by the year 2030, the water gap in the Arab region will be about 100 billion m3.

An outcry has been reverberating in the Middle East for sometime over the dwindling water resources and the subsequent threat to growth. At the Amman Economic Summit Conference last year, the World Bank warned that seven Mideast countries were already withdrawing 100 per cent or sometimes substantially more of their renewable water resources each year. Egypt and Israel were also already at or above the 90 per cent withdrawal, the World Bank said.

Very few projects in the Middle East region have found such ready acceptance and quick response globally as the desalination research centre. The centre has already brought together the US, the European Union, the UK, Japan, South Korea, Italy etc, besides the Middle East countries.

The co-operation reflects the need to accord priority to desalination which currently accounts for only 5.75 per cent of the water resources in the Arab region, but has unlimited potential provided the operational costs are within manageable limits.

The Middle East Desalination Research Centre will precisely be targeting at the advancement of technology to bring desalination costs down.

HMR

Oman Daily Observe
13th July, 1996

Groundwater search to be intensified

By Conrad Prabhu

MUSCAT — The quest for groundwater reserves in the Sultanate will now be mounted from space. Under a three-year-long programme, satellite imaging will be employed to probe Oman's substrata for aquifers and water-bearing structures.

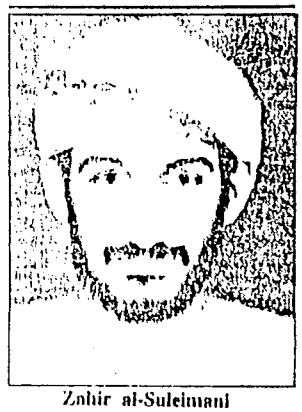
Launched by the Ministry of Water Resources in association with Boston University, the project is one of the most decisive in the government's concerted effort to augment the Sultanate's water resources. It will cover the entire length and breadth of the Sultanate, the Ministry's Research Director Zahir Khalid al-Suleimani told the *Observer*.

Dr Farouk el Baz, director of Boston University's Centre for Remote Sensing, who is well-regarded in the Middle East as an expert on groundwater exploration, will be leading the Boston University team.

The approximately $1.5 million project will help map geological and geomorphological structures and patterns of water flow, which offer vital clues to possible hidden water reserves.

The whole of Oman will be covered in three phases, according to Al-Suleimani, who heads the project's operational committee of the Ministry of Water Resources.

Initially, the northern regions of the Sultanate including the Jebel Akhdar and the Batinah Coast will be scanned. The Sharqiya region will be probed in the second phase, while the Al Wusta and Dhofar regions will be covered in the third phase.



Zahir al-Suleimani

Stage 1 of the project has now got under way, it is learnt. A Landsat satellite will be swung into position over the Sultanate to beam pictures and data on Oman's geological features.

Simultaneously an Omani expert panel will co-ordinate the collection of data on such aspects like borewells, rainfall levels and wadi flows.

In the next stage Boston University will study the satellite images and create a structural map showing the faults, fractures, joints and lineations that together define the shape of rock formations, which hold clues to underground reserves.

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Groundwater search

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The study will also map natural drainage patterns, directions of wadi flows, types of rocks they cut through and so on. A sample area will then be identified for further intensive studies. Using French SPOT imagery, 3-dimensional stereoscopic models will be produced at this stage, Al Suleimani said.

In Stage 3, experts will begin investigations to fine tune their Landsat and SPOT imagery findings.

A Geographical Information System (GIS) database will be created to compute the information garnered. From this data, computer models of groundwater flows will be designed to simulate the location of aquifers.

Finally, the project team will identify sites for drilling. Reports will be submitted to the ministry at the end of every working year, extensively detailing the Sultanate's groundwater resources.

Satellite and radar imaging is known to be a high-tech and sure-fire tool in the hunt for water especially in inaccessible areas like mountains and deserts.

In the Jebel Akhdar for instance, the discovery of limestone fractures are a promising indication that these mountains may be a repository of large water reserves, which can be confirmed only by satellite imaging, followed by drilling.

Likewise, radar imaging may help uncover potential areas for drilling beneath the dunes in the Sharqiya and Al Wusta regions.

Under a training programme proposed by the Ministry, a number of Omani graduates will take part in the project during its implementation stage. The aim is to help the Ministry's technical personnel acquire the technological expertise used by the Boston University team in implementing the project.

HMR

بسم الله الرحمن الرحيم

Oman Daily Observe
17th October, 1996.

Al Aufi visits site in Sharqiyah region

New groundwater stocks extensive

MUSCAT — Water Resources Minister Hamid bin Said al Aufi says that the new groundwater stocks announced by His Majesty the Sultan on Monday during his meeting with shaikhs and dignitaries of the Sharqiyah region at Seeh al Yahmedi have already begun to gush forth from the sands of Sharqiyah.

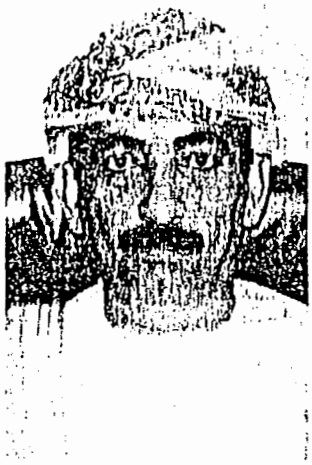
In a joint statement to the Oman News Agency and Sultanate of Oman TV during a visit to the groundwater site yesterday, Al Aufi said that the stocks were extensive and lay beneath the desert sand.

He added that the ministry had carried out two years of studies in this area and other areas deeper in the desert and had found that the stocks lay within an area of around 1000 sq km. This was a huge volume and he hoped it would help the region as a whole.

Initially, though, it was of major importance for the towns and villages around Bidiya, Al Kamil W'al Wafi, Bilad Bani Bu Ali and Bilad Bani Bu Hassan.

Al Aufi explained that the field work would be completed next January. "After that, and after the analyses have been carried out and we know the quantity and quality of the water, which so far is excellent and sweet, we shall know how the first stage of exploiting the water will be," he said.

In response to a question on the percentage of the water currently produced, Al Aufi said in his statement that around four million gallons were being pumped out daily. Tests would go on for three to four days to determine the water's depth and identify the extent of the reserves.



HAMID AL AUFI

He pointed out that the test had been going on for two days and that the water had not changed until now.

On the studies which had been carried out by the Ministry of Water Resources previously to avoid falaj sources, the minister said the region in which the water had been discovered was far away from cities and that the nearest city was more than 15km away from Falaj al Mashaykhi. The ministry had begun making experiments and monitoring all the villages in the region and this monitoring would continue during the test period. In addition, some samples would be taken from the monitored wells in the region.

Asked whether the new water reserves would be suitable for drinking or only used for agricultural purposes, Al Aufi said: "At this stage we are only talking about drinking water. Later we shall see if there is any surplus.

"On the basis of the stocks confirmed so far, it was possible that the reserves were greater than present estimates indicated and would be extended in future phases, particularly in the western areas of the site on the borders of the niyabat of Sinaw, in the wilayat of Al Mudhaibi," he said.

He explained that the question of using the water for agricultural purposes was included in the ministry's current plan and we hope to be able to continue working in that region. However, as far as present stocks are concerned, we are talking about drinking water.

Al Aufi explained that groundwater was much cheaper than desalinated water. The ministry's plans were concerned with discoveries like Hawdh al Masarrat, Hawdh Rimal al Sharqiyah, Hawdh Wadi Rawnab, and other underground reservoirs in the south Batinah region and Al Najd. Some of these reservoirs needed to be developed and the latest groundwater reservoir would be developed in phases.

He added that when the tests had been completed it would be possible to determine the amount of drinking water that would be pumped daily.

Al Aufi explained that over the past five years there had been several major water discoveries, including Hawdh al Masarrat.

Hawdh al Masarrat was now at

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Groundwater stocks

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the tender stage and a decision will be taken during the next two months on the company that will be awarded the tender. Work would begin next year on piping the water to the wilayats of Ibri, Dhank and Yanqul, and to the surrounding areas.

As far as the latest water discovery was concerned, the ministry's studies had begun in 19[illegible] and had geophysical surveys, he said. Forty-five wells had been sunk — 25 in the sand dunes and 20 in the areas around them. Pumping had only been carried out from four of them.

بسم الله الرحمن الرحيم

Oman Daily Observe
30th October, 1996.

Aquifer can meet water needs of Sharqiyah towns for 25 years

By Conrad Prabhu

MUSCAT — The extensive aquifer discovered recently beneath the desolation of Sharqiyah's sand-sea is adequate enough to meet growth projections in the water needs of nearby towns over the next 25 years. Bountiful as it is, and replenishable as well, the aquifer could ensure a sustainable supply of potable water for a long time to come, says a key official of the Ministry of Water Resources.

"It's a huge discovery indeed, with enough capacity to meet the projected growth demands of nearby towns as far into the future as the year 2020," said Aley al Marjebi, the Ministry's Director-General of Water Resources Assessment.

Sharqiyah's hidden bounty was first revealed to the nation by His Majesty Sultan Qaboos during a meeting with local shaikhs and dignitaries about a fortnight ago. The discovery will go a long way in alleviating the drinking water shortage in parts of this arid region.

According to Al Marjebi, controlled tests on four wells drilled in the area yielded 200 litres of water per second, equivalent to four million gallons per day — which is enough to supply some 13,000 medium-sized homes daily.

The tests were performed at depths of 250 metres, providing data on the water-bearing and transmitting capacity of the aquifer. Significant reserves of good water were found in the sand itself, and in the underlying alluvium, he noted.

The difficult terrain, Al Marjebi said, made field work and the confirmatory drilling tests far from easy. The site area, straddling the Sharqiyah sands, is criss-crossed by extensive sand-dunes that reach heights up to 100 metres.

"We encountered access problems necessitating special precautions for communications and safety," the official told the *Observer*. Special tracks had also to be prepared for the mobility of survey and drilling equipment, and the supervisory staff, he said.

Given the vast size of the area being investigated, and the rugged landscape, assessment teams have

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Scope for further water stocks

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had to initially depend on geophysical surveys of the region. Coupled with satellite imaging, geological mapping, topographic surveys and findings from exploratory drilling, officials were able to study the aquifer extent and thickness.

During the test drilling, careful attention was paid to existing water users in the immediate vicinity, Al Marjebi said. "Local wells and aflaj flows are monitored some weeks in advance of a test and continued throughout the test to check the possibility of interference and flow reductions caused by pumping," he noted.

The monitoring data garnered as a result can be used to calculate aquifer parameters and determine aquifer characteristics, he added. This data is combined with all other data to develop a computer model of the aquifer system.

Aley al Marjebi

The model would provide a means to evaluate the full potential of the system and determine the optimal water abstraction scenario, the director-general observed.

Great quantities of water have been discharging into the sand since the pumping tests began, but much has of this has percolated back into the underground reservoir, he added.

As a renewable source, recharged by filtration and downward percolation of rain water in catchment areas, the aquifer can potentially yield a perennial supply of good quality drinking water for a considerable time to come.

According to Al Marjebi, there is still scope for further water stocks beyond the test area, currently encompassing an area of toughly 1,000 sq km in the Sharqiyah desert. "The potential for more water south and west of the test area is very encouraging, but more work needs to be done," he stated.

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بسم الله الرحمن الرحيم

Oman Daily Observer
15th February, 1997.

Research under way for recycling huge quantities of water

By Conrad Prabhu

MUSCAT — Scientists at Sultan Qaboos University (SQU) have begun work on a research project aimed at recycling the huge quantities of water produced along with oil during the production of crude oil.

The pioneering study has vital significance to the oil industry, and the cause of environmental and water conservation as well, according to Dr Mohammed Hamed al Rumhy, Assistant Professor of Petroleum Engineering at SQU's College of Engineering.

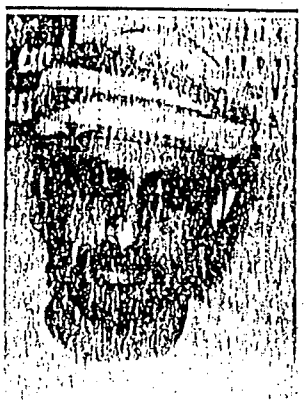
Roughly two million barrels of water, which naturally occurs along with oil, is being produced by Petroleum Development Oman (PDO), in the course of sustaining a daily production of 900,000 barrels of oil.

This works out to, on average, two barrels of water for every barrel of oil produced in the Sultanate, Dr Al Rumhy, who heads the research project, told the *Observer*.

The study, under way in collaboration with Japanese scientists, will help determine ways to purify this 'produced water', as it is called, and render it safe various applications.

Because the water contains traces of oil, its use has hitherto been extremely limited. In the northern oil-fields of Oman, the water is re-injected back into the oil-wells as a way of pressurising the well formation and consequently extracting oil.

But in the oil-fields of the South, especially in the Marmul and Nimr areas, re-injection is deemed unnecessary because the well formations come naturally pressurised. Over the years, the waste water has routinely been disposed off in shallow wells some 200 metres below ground.



Dr Mohammed Hamed al Rumhy

However, concerns expressed by the Ministry of Regional Municipalities and Environment that this contaminated water may find its way into sweetwater aquifers, prompted PDO to come up with a new water management plan. It involved the re-injection of the waste water deeper into the ground. This method, although said to be technically difficult and expensive, is currently applied in the southern oil fields of Oman.

But a recent initiative by the Ministry of Water Resources, advocating the recycling of the water, paved the way for the current research project at SQU.

Preliminary studies show that water produced in the southern fields is relatively sweet and contains a maximum of 6,000 parts per million (PPM) of dissolved salt, apart from traces of oil. Such water, once free of oil, is deemed suitable for certain kinds of agriculture.

The SQU research project is aimed at devising a technically, qualitatively and financially viable method of recycling the millions of barrels of water produced along with oil in the Sultanate every year, said Dr Al Rumhy.

The study will be aided by the Japanese government's Petroleum Energy Centre; an organ of the Japanese Ministry of International Trade and Industry.

Various departments of Oman's government, notably the Ministry of Regional Municipalities and Environment, Ministry of Petroleum and Minerals, and Ministry of Water Resources, will also be associated with the project. PDO will be a key participant as well.

Researchers have already begun testing samples of 'produced water' and, by the year-end, hope to have a pilot plant in place at SQU, to handle large quantities of water. "Once we perfect the technology, we hope to have a full-scale plant in the field in a few years," Dr Al Rumhy said.

The study, he noted, would be a joint effort by SQU and Japanese experts. "We would like to see Japanese scientists seconded to the University on a long-term basis, working shoulder-to-shoulder with our experts," he commented.

Users of this technology — once it is determined feasible — will mainly be oil producing countries, especially those with scarce water resources, according to Dr Al Rumhy.

Re-injection of 'produced water', although considered the safest practice to date, still holds a potential risk. Also, water produced at offshore wells is currently disposed off directly into the sea, posing potential environmental hazards. SQU's research project would provide the answers to making the water environmentally safe, the researcher observed.

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بسم الله الرحمن الرحيم

Oman Daily Observer
9th March, 1997.

Third Gulf water conference opens today

MUSCAT — Watertech '97 — an exhibition showcasing the latest in water technology — opens at Al Bustan Palace Hotel here today, on the sidelines of the Third Gulf Water Conference.

His Highness Sayyid Haitham bin Tareq al Said, Secretary General of the Ministry of Foreign Affairs, will open the five-day conference at Sultan Qaboos University today.

Watertech '97 will feature key international players who will offer solutions and assistance to professionals involved in water resource management projects. Equipment on display will include actuators, cathodic protection, effluent water treatment systems, reverse osmosis equipment, seawater and brackish water treatment plants, and water pollution control systems.

The exhibition will run till 12 March and will be open from 9 am to 6 pm on all days.

Oman Daily Observer
5th March, 1997

SQU exhibition on desert water

MUSCAT — Shaikh Ahmed bin Mubarak bin Mustahail, Under-Secretary for Environmental Affairs, yesterday opened the "water in the desert" exhibition. The exhibition was organised by Sultan Qaboos University in conjunction with Germany's Goethe Institute and the German embassy in Muscat.

The exhibition, being held at the exhibition hall at SQU, documents the results of 15 years of scientific research into desert water problems and water resources and presents scientific solutions for utilising groundwater resources.

The exhibition includes telesensory methods, a geological atlas of Africa, climate changes in the eastern desert of Africa, the administration of the environment system, raw materials in the desert, the transfer of information and academic exchanges with Africa. — ONA

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