LIST OF TOOLS AND MACHINERY

Sl. No.	Rig No.	Make	Received Year	Specification
1.	03	Tone Top - 300 Tube Well Drilling Rig	1980	Multipurpose Truck Mounted Well Drilling Rig complete with accessory equipment These Rigs are capable of drilling 350 mm Ø bore holes to a depth of 60 m and 150 mm Ø holes to 100 m depth.
2.	05	Tone Top - 300 Tube Well Drilling Rig	1981	
3.	06	Tone Top - 150 - TCM Tube Well Drilling Rig	1982	Multipurpose Truck Mounted Well Drilling Rig complete with accessory equipment, These Rigs are capable of drilling 350 mm Ø bore holes to a depth of 50 m and 150 mm Ø holes to 60 m depth.
4.	09	Tone Top - 150 - TCM Tube Well Drilling Rig	1982	
5.	14	KOKEN FSW - 200 S Tube Well Drilling Rig	1984	Multipurpose Truck Mounted Well Drilling Rig complete with accessory equipment. These Rigs are capable to drilling 350 mm Ø bore holes to a depth of 100 m and 150 mm Ø holes to 125 m depth
6.	15	KOKEN FSW - 200 S Tube Well Drilling Rig	1984	
7.		P.D.R. - 250 Air Man Air Compressor	1980	Potable Trailer Mounted Air Compressor, 100 psi. 250 cfm.
8.		P.D.R. - 370 Air Man Air Compressor	1981	Potable Trailer Mounted Air Compressor, 100 psi. 370 cfm.
9.		P.D.S.H. - 500 Air Man Air Compressor	1982	Potable Trailer Mounted Air Compressor, 150 psi. 500 cfm.
10.		P.D.S.H. - 700 Air Man Air Compressor	1984	Potable Trailer Mounted Air Compressor, 150 psi. 700 cfm.
11.		P.D.S.H. - 700 Air Man Air Compressor	1984	Potable Trailer Mounted Air Compressor, 150 psi. 700 cfm.

14.12.2000
SP/tjp

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資料3－8 (2)

WATER RESOURCES BOARD

SUMMARY OF VEHICLE FLEET

1. Cars - 06 Nos.
2. Double Cabs - 04 Nos.
3. Single Cabs - 01 No.
4. Jeeps - 05 Nos.
5. Lorries - 09 Nos.
6. Pump Units - 01 No.
7. Motor Cycles - 02 Nos.

11.12.2000

BRA/sp

4・2 2-(b)

LIST OF GEOPHYSICAL EXPLORATION EQUIPMENT

Instrument	Quantity	Year of Manufactured	Specification
1. ABEM SAS 300 Terrameter Made in Sweden	07	1984	Transmitter :- Selectable currents - 0.2, 0.5,1, 2, 5, 10, 20 m A Voltage, max. - 160 V (320 V_{p-p}) Receiver :- Input Ipedance - 10 M min. Input Range - 1,10,1000,5000 V Precision - $\pm$ 0.0000IV (IV range) Noiser rejection - 95 dB at 50 - 60 Hz 85 dB at 16 - 20 Hz Resistivity Ranges - 1,100, 10K, 1M OHM Precision - 0.0005 OHM (20 m A, One readings) System Date :- Selectable cycle time - 3.6, 7.2, 14.4 seconds Selectable total averaging period (1 - 64 Readings) - 3.6 - 920 seconds Temperature :- Within specification - 0.......+60°C operation Power supply:- - Reachargeable 12 V battery Battery Capacity - 3500 - 5000 m Ah Weight - 5.6 Kg. (incl. battery)

..../ 2

Instrument	Quantity	Year of manufactured	Specification
2. ABEM AC Terrameter Made in Sweden	03	1979	Type :- Alternating current 4 Hz Square Wave Depth :- The Terrameter is suitable for use instructural investigations down to depths of 600 meters (2000 feet) Measuring Unit (V-Box) Range - The measuring range is from as low as 0.003 ohm to as high as 10.000 ohms in five selectable ranges 0-1, 0-10, 0-100, 0-1000, and 0-10,000 ohms. Accuracy - ± 3% for readings down to 0.01 ohm and ± 10% for readings 0.009 to 0.003 ohms. Batteries- Two 9V Standard dry cells. Gain - Coars gain control - 3 randes 0.1, 3, 100 Weight - 4.6 Kg with batteries Power supply unit (G1-Box) Out put voltage - Selectable 100, 200 or 400 V Out put power - Helf about 3 W, full about6 W Batteries - Twelve 1.5 V standard dry cells. Weight - 8.7 Kg. with batteries.

Instrument	Quantity	Year of manu-factured	Specification	
03. EM 16 VLF Instrument Made in Canada	02	1984	Measured Quantity	: In phase and quod phase components of vertical magnetic field as a percentage of horizontal primary field
			Sensitivity	: In phase ± 150 % Quod Phase ± 40 %
			Resolution	: ± 1 %
			Output	: Nulling by audio tone
			Operating Frequency	: 15 - 25 KHz, VLF Radio Band
			Power Supply	: 06 disposable 'AA' Cells
			Weight	: 1.6 Kg (Instnument)
04. Altimeter (Paulin) Made in America	02	1984	Measuring Range Minimum Interval Dial Face	: 1000 feet : 01 feet : 06 "
05. HANNA E.C. Meters Made in Italy	10	1991, 1996 1997	Range	: µs/cm 0.0 to 199.9 ms/cm 0.00 to 19.99
			Acuracy	: ± 01 % fall scale
			Temperature	: Manual from 0 to 50° C
			Battery	: 09 V Alkaline
			Weight	: 355 g

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Instrument	Quantity	Year of manu-factured	Specifications
06. Global Positioning System GP 2002 Made in Germany	02	1999	Display : 4 X 20 Char LCD Power : 6 X AA Rechargeable Batteries or 12 - 18V DC with external power Memory : I) EEPROM for safe storage II) 99 waypoints plus 6 waypoints in special memory keys III) 10 routes with 10 waypoints each IV) RAM log allowing recording of G.P.S. data Receiver : 05 channel parallel with high sensitivity (-163 dBW) for use in abstract terrain where most other GPS receivers would fail. Weight : 500 g Keys : 24 Keys
07. Stereoscope, Mirror type MS - 27 Made in Japan	02	1984	
08. Water Level Recorder	09	1984 1997 1999	Length : 80 m and 50 m Indicator : Buzzir and LED Cable : Fiber Glass Power : 6 V (Size C X 4) Graduation : 1 cm intervals printed on cable.

14.12.2000

ARS/wcp

WATER QUALITY ANALYSIS EQUIPMENT

EQUIPMENT	SPECIFICATIONS		DATE OF RECEIVED TO LABORATORY
Atomic Absorption Spectrophoto Meter	Dimensions (cm):	Width 80.5 Depth 49.5 Height 47.2	1983
	Weight(kg):	50	
Model: SP 9 series (pye unicam)	Electrical supply (50Hz/60Hz):	Input transformer with primary tapped at 220VAC, 240VAC	
Model number: spg – 800	Primary voltage deviation:	± 10%	
	Consumption:	750VA, max	
Serial number: 31682	Secondary electrical supplies:	+115C ± 1% -15V ± 1% +24V +12V +5V ± 2% OV to –2000V detector EHT +600V (normal) HCL supplies 18kV/100Hz pulsed – spark ignition.	
	Wavelength range:	190-853nm (for Rb, Cs and K a red-sensitive p.m.t. is available)	
	Wavelength reading accuracy:	± 1nm	
	Monochromator:		
	Type:	Ebert diffraction grating	
	Focal length:	174mm (approx)	
	Aperture:	f8.5 (approx)	
	Grating area (mm):	20 x 20	

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	Lines per mm:	1200	
	Blaze:	250nm	
	Dispersion:	4.7nm/nm	
	Spectral bandwidth	0.2, 0.5, 1.0, 2.0, 10 0nm.	
	Limiting resolution nm:	0.2nm	
	Absorbance range:	-0.5 to 1.999A (3A including background)	
	Absorbance accuracy:		
	0 to 1A:	1% or 0.002A (whichever is greater)	
	1A to 2A:	2.5%	
	Readout factors (instrument):		
	Presentation:	3.5 digit 7-segment bipolar display	
	ADC range:	-1999mV to +1999mV	
	Sample overrange:	3.0A w.r.t. curvature correction input	
	Scale expansion:	Continuous from 0.5 to x25	
	Autozero response:	000+/- 002 within 2 seconds	
	Damping time constants:	0.1, 0.55, 2.0 seconds	
	Readout factors (external):		
	Pen recorder output:	0V to 10mV for 0-1A	
	Control signals (external):	All external control signals pass via the SP9 Computer (see Fig 1.2)	
	Incoming: 1.	Remote autozero command.	

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	2.	'Flame off' command.	
	3.	Inhibit autozero.	
	4.	'Blank display'.	
	Outgoing: 1.	Sample 'Overange'.	
	2.	'AZ in progress'.	
	3.	AAS/FES mode'.	
	Sample volume:		
	Flame analysis:	3.4 ml/min	
	Minimum volume:	0.5ml	
	Flameless:	0-20ul from micro pipette or furnace auto-sampler	
	Standard volume:	10ul	
UV/VIS spectrophoto meter Model: DR 400U	Wavelength Range:	190 to 1100nm (DR.4000U), 320 to 1100nm (DR/4000V)	1998/10/23
	Wavelength Accuracy:	±1nm	
	Wavelength Reproducibility:	±0.1nm	
	Wavelength Resolution:	0.1nm	
	Wavelength Calibration:	Internal, automatic at power-up with visual feedback	
	Scan Speed:	400nm/minute at 2.0nm steps 200nm/minute at 1.0nm steps 100nm/minute at 0.5nm steps 40nm/minute at 0.2nm steps 20nm/minute at 0.1nm steps	
	Spectral Bandwidth:	4nm nominal	
	Source Lamp:	Tungsten and Deuterium (DR/40000U), Tungsten	

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		(DR/4000V)	
	Sample Path Length:	100nm	
	Monochromator Design:	Seya-Namioka split-beam	
	Grating:	1200 Lines/mm: 8nm/mm dispersion	
	Outputs:	Parallel printer port and Serial I/O (RS232)	
	Display:	Backlit, graphic, liquid crystal display with adjustable viewing angle and contrast control	
	Storage Temperature:	-17 to 60 ^{0}C, 85% relative humidity, non-condensing	
	Operating Temperature:	10 to 40 ^{0}C; 95% relative humidity, non-condensing at 25 ^{0}C, 75% relative humidity non-condensing at 40 ^{0}C	
	Readout Modes:	Concentration, Absorbance, or transmittance	
	Line Power requirements:	AC line power selectable for 115/230 Vac ± 17%, 50/60 Hz, 230 VA maximum	
	Sample Compartments:	Modular, easily accessible, interchangeable for divers testing requirements	
	Dimensions:	42W x 29D x 16H cm (16.5 x 11.4 x 6.3 inches)	

4－2　2(e)

Instrument	Specifications	Date of received to laboratory
3. PH meter Model – 290 A	PH PH Range - -2.000-19.999 Resolution - 0.001/0.01/0.1 Relative Accuracy - +/- .005 Slop - 80 to 120% Concentration Concentration Range - 0.000 to 19900 Relative Accuracy - +/- 0.5% of reading Temperature Temperature Rang - -5.0 to 105.0°C Resolution - 0.1 C Relative Accuracy - +/- 1.0°C Milivolts Milivolt Range - +/- 1600 (0.1) mV Ralative Accuracy - +/- 0.2 mV +/- 0.05% of Reading, Display - Custom LCD Power Requirement -One 9V alkaline Or lithium battery, Line adapter for 110V, 220V, or 240V	1999.11.15
4. Conductivity Meter Model – FE287	Annex. 1	1999.11.9
5. Portable Turbidity Meter Orbeco-Hellige Model- 966	Annex. 2	1998.10.15

Dep the chemist.

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Specifications

Conductivity:	Ranges and resolution:	0.00 - 19.99μS/cm or1.999mS/m
		00.0 - 199.9μS/cm or 19.99 mS/m
		0000 - 1999 μS/cm or 199.9 mS/m
		0.00 - 19.99 mS/cm or 1999mS/m
		00.0 - 199mS/cm or 19.99S/m
	Accuracy:	±0.3% of reading
TDS:	Ranges and resolution:	0 - 13.20 mg/L
		0 - 132.0 mg/L
		0 - 1320 mg/L
		0 - 13.2g/L
		0 - 132g/L
	Accuracy:	±0.3% of reading
Resistivity:	Ranges and resolution:	0.00 - 1.999MΩ.cm or 0. 019MΩ.m
		0.00 - 19.99 MΩ.cm or 0.199 MΩ.m
Accuracy:		±0.3% of reading
Salinity:		In accordance with UNESCO data, 2.0 - 42
Accuracy:		±0.3% of reading
Salinity temperature compensation:		-2.0 to +35°C
Concentration:		Automatic ranging, choice of units background off set function
Temperature:	Range:	-30 to +130°C
	Resolution:	0.1°C
	Accuracy:	±0.3°C
Temperature Compensation:		0 - 50°C
Reference Temperature:		25°C (Selectable to 20.0°C)
Temperature Coefficient:		Default 2%/°C. User adjustable 0 - 5%/°C
Recorder Output:		±200mV, 2x 4mm sockets
Power:		9V battery
Instrument size:		100 x 180 x 44mm
Instrument weight:		410g

SPECIFICATIONS

RANGES and RESOLUTION in NTU	LOW: 0.00 to 19.99 - resolution 0.01 MEDIUM: 00.0 to 199.9 - resolution 0.1 HIGH: 000 to 999 - resolution 1
ACCURACY..........	±2% of reading for low and medium ranges.
REPEATABILITY.....	±1%
LIGHT SOURCE......	10,000 hour Tungsten Bulb
POWER REQUIREMENT	Four AA Alkaline Batteries (supplied) or optional 110v or 220v 50/60Hz AC Adapters
TEMPERATURE RANGE (Instrument only)	Storage: $-10^{o}C$ to $70^{o}C$ Operating: $0^{o}C$ to $45^{o}C$ (Allow at least 15 minute waiting period after change in ambient temperature).
SAMPLE TUBE.......	Optically matched glass vial with screw cap; 28mmOD x 61mm long.
SAMPLE VOLUME.....	20 mL minimum required.
STANDARDS SUPPLIED	Permanent USEPA-approved Primary, 40.0 NTU, non-hazardous; and Permanent Zero Std.
INSTRUMENT SIZE...	7.5"L x 4"W x 3"H (19 x 10.2 x 7.6 cm.)
SHIPPING WEIGHT...	5 lbs. (2.2 Kg.) including carrying case.
WARRANTY..........	2 years; see Section 8 for details.

* * * * *

IV. Groundwater Management Policy

A. Introduction

Sri Lanka's groundwater is a limited and strategic water resource, widely used for domestic, small-scale irrigation, industrial and commercial and other purposes. Groundwater conditions vary considerably throughout the country. In some areas there are shallow aquifers which are replenished quickly during rainy seasons or from nearby surface water sources. This form of groundwater can be easily tapped and is susceptible to over use by numerous small users. In other places groundwater at deep levels is slowly replenished and is often expensive to develop and extract.

Demand for groundwater has grown rapidly as a result of population increases and economic development. A wide variety of users such as small-scale irrigators, households and housing development schemes, industries and industrial promotion zones, hotels, shrimp farms are now tapping groundwater to an unprecedented extent. Subsidies have been introduced for shallow wells in some areas and groundwater exploitation is being actively promoted by some politicians, often without adequate knowledge of the availability of the resource. Well drilling and pumping technologies have spread, increasing the risk of over-extraction and groundwater contamination.

Groundwater is also, by nature, a hidden resource. Users often have little or no understanding of its location or quantity and few incentives exist to protect groundwater supply and quality. Groundwater may be referred to as a "common pool resource" – it is relatively accessible but the control of new users on existing uses or on environmental and social benefits of maintaining the resource are harder.

Groundwater in most shallow aquifers is closely connected to surface water. It is replenished directly from rainfall and infiltration from surface water bodies such as rivers, streams, tanks and ponds. Groundwater is also the source of river flow and other surface water during periods of low precipitation or drought. During these periods shallow groundwater is slowly released through springs and other seepage pathways, providing more stable surface water supply.
Groundwater replenishment and flows are normally slow, relative to surface water. As a result, groundwater is often a more localised resource than surface water and in some cases is relatively slow to recover from depletion or contamination.

It is fundamentally important to recognise that groundwater is part of the overall hydrologic cycle, directly connected to surface water. Although groundwater has special characteristics which must be appreciated and taken into account, surface and groundwater must be viewed and managed together. As a result, this "Groundwater Management Policy" is closely tied to the other components of the National Water Resources Policy and should be viewed together with them.

B. Groundwater Resources

Several main types of groundwater, or regional aquifers, have been identified in Sri Lanka. Each of these has distinctive characteristics, each faces specific issues and needs and each will require its own management strategy and actions. The following descriptions illustrate the range of groundwater in the country and provide a basis for a management strategy which is a) tailored to the specific characteristics and needs of the aquifer in question and b) integrated with surface water management.

1. Shallow Karstic Aquifer of the Jaffna Peninsula

The shallow aquifer of the Jaffna peninsula is found in channels and cavities (karsts) in the local limestone. A large volume of rainfall and other surface waters infiltrate into these spaces during wet periods. Of this amount, possibly 50 percent eventually drains to sea outlets, the remainder being available for extraction and use.

The Jaffna aquifer has been, until recently, one of the most intensively utilised groundwater resource in this country. Approximately 80 percent of this groundwater is being used for intensive high value agriculture, and the remaining 20 percent is being used for domestic requirements including septic tank flushing demands. During the early seventies it was observed that there was a growing imbalance between the draw-off and the recharge ratio, and several monitoring studies were initiated by the Water Resources Board (WRB). Although the remedial measures that were proposed based on these studies have not been implemented, the unsettled situation that has existed in the Jaffna peninsula since the mid-1980s has somewhat eased the critical exploitation situation and the earlier imbalances have now been mitigated to some extent.

Water quality studies carried out during the mid-1980s have shown enhanced levels of nitrate pollution in the domestic wells in the more densely settled areas of the peninsula. It is reported that in 1984 there were over 100,000 open dug wells constructed to a depth of 5 to 10 meters, used mainly for small-scale agriculture. There was no meaningful strategy in place at that time to manage the expansion in the construction of such wells nor was there any control mechanism to limit the growing number of septic tanks from private dwellings.

2. Coastal Sand Aquifers

Shallow and moderately deep aquifers are found in unconsolidated sands around a major part of the country's coast line. These aquifers consist of "lenses" of fresh water floating above denser saline water. The volume of freshwater in these aquifers usually expands during the rainy season and contracts during dry seasons, with fluctuating brackish and saline boundaries. Heavy exploitation cause contraction or depletion of the aquifer and may leave some wells in the brackish or saline zone. Because infiltration rates and lateral movement of water through these sand aquifers are relatively high, they are susceptible to seasonal depletion and contamination from surface sources. Some of the sand aquifers suffer from heavy nitrate contamination.

The Kalpitiya peninsula is one of the best examples of a shallow aquifer on coastal sands which has, over the last two decades, been subjected to intensive exploitation mainly for agricultural purposes. There has been a gradual build up of salinity and high rates of leaching of various agro-chemicals due to intensive agricultural practices on the peninsula. The nitrate concentration in well water has exceeded the WHO recommended values, making it unsuitable for human consumption. Researchers have observed that some sections of the peninsula are prone to saline water intrusion and that, as a result, exploitation of the groundwater within the peninsula must be done carefully with a proper understanding of the hydro-geological conditions of the area.

Coastal sand aquifers have traditionally been used in a very sparing manner by homestead settlements. Many of them are now being exploited by tourist resorts and hotels that have started to over-extract the limited supply. Similarly, some of the less shallow but more productive aquifers located along the north-west coast around Chilaw are being exploited beyond their limits to meet the needs of prawn culture ponds, thus affecting the use of domestic shallow wells. Industrial promotion zones and many industrial, commercial and tourist establishments also draw water from coastal sand aquifers and discharge contaminants into them.

3. Deep Confined Aquifers in Northwest Limestone Base

A number of distinct and confined aquifers exist in the limestone and sandstone formations of the north-western and northern coastal plain. These are relatively deep aquifers and therefore cannot be exploited by shallow, private tube or dug wells. They also have relatively high recharge rates. Aside from heavy use of one of these aquifers in the Puttalam area for prawn production, the north-west limestone aquifers have been relatively little developed.

One example is the deep confined aquifers of Vanathavillu and the Mannar-Mulankavil basins which have, up to now, been exploited only to a very limited extent. Tube wells around 30 to 40 meters deep can withdraw 3-10 litres / sec. from selected freshwater basins. Although over 200 tube wells have been drilled in these limestone aquifers, these wells are not fully exploited for agricultural uses. In the Vanathavillu basin, which has been more intensively used for irrigated agriculture of high value crops since 1978, a 20 percent increase in the electrical conductivity of the tube well water had been observed by 1993. This has been caused by a leaching of salts from the cultivated soil overburden to the groundwater table. A long term build up of soil salinity on these red latosols has to be prevented.

4. South-western Laterite Region Aquifer

The laterite soils of south-western Sri Lanka have considerable water holding capacity, depending on local depth. In general, these support relatively shallow aquifers, accessible to private dug and tube wells. The laterite region aquifer of the south-west wet zone today faces the most severe over exploitation, especially in the area between Gampaha and Kalutara districts. The rapid expansion of industrial estates, urban housing schemes and other developments taking place in this area are exerting a tremendous pressure on the groundwater resource. Because of the high infiltration rate of the upland higher level laterite, the groundwater drains off quickly into the adjacent broad valleys. It is the groundwater in these lower valleys that are now being extracted by the new small and medium scale enterprises.

There is no systematic monitoring of groundwater trends in this region, but increasing complaints of rapid exhaustion of the groundwater aquifer are being made by residents located in the new housing estates and also by those in the densely settled areas, especially during average dry weather periods. There are also reports indicating a deterioration of the quality of the groundwater in some of the critical areas, particularly where adequate spacing between wells and sanitary facilities is not maintained.

The deeper aquifer that occurs below the laterite aquifer is also being over-exploited by larger industrial enterprises that have been established in the free trade zone as well as hotels in Colombo and its suburbs. Because of the close interconnection between this deep aquifer and the overlying laterite aquifer, the overall balance of the groundwater hydrology can be adversely affected. Enhanced nitrate levels have also been reported from some domestic wells around Colombo and regional suburbs.

5. Alluvial Aquifers

A number of the rivers and stream which cross the coastal plain have associated alluvial aquifers, particularly along their lower reaches. Rivers such as Mei Oya, Deduru Oya, Kelani Ganga, Bentota Ganga, Menik Ganga and Mahaweli Ganga have significant alluvial aquifers.

These aquifers are generally shallow and are directly connected to the surface water in the river or stream. Even in periods of low surface flow, therefore, these alluvial aquifers are quickly recharged and constitute a considerable and often under-utilised source of water.

Because of the close hydrologic connection between the surface and groundwater in these areas, the two must be treated as fully interconnected sources. Groundwater withdrawals will have a corresponding impact on river flows and contamination of either the surface or groundwater will affect the other.

6. Shallow Aquifers of the Hard rock Region

The inland valleys and small tank cascade systems of the North Central Province and North Western Province, as well as some parts of Northern and Southern Province, have shallow aquifers in the local valley alluvium. These aquifers are closely linked with the surface water in streams, canals and tanks. They are also ephemeral in nature – expanding and contracting in response to wet and dry season conditions. When properly located in areas with sufficient groundwater and transmissivity (potential for groundwater movement), shallow wells in this area can be an important source of water for domestic, irrigation and other purposes – either by themselves or in conjunction with surface supplies. Being shallow, however, these aquifers are susceptible to agricultural and other forms of contamination. Some areas are also prone to salinity.

The shallow, dry zone aquifers are being rapidly exploited for domestic and small-scale irrigation purposes, as described below. In some areas, well density and groundwater pumping has passed the sustainable limit and, as a result, wells have failed and been abandoned. Not only does this deprive the owners of older wells from their share of groundwater, but it is also an inefficient use of public and private funds for well construction. In other areas, wells have been constructed immediately adjacent to irrigation canals and these are adversely affecting the effectiveness of the canal.

7. Deep Aquifers of the Hard rock Region

Throughout several parts of the metamorphic hard rock areas in each of the climatic zones, deep aquifers can be found. These are present in joints, fractures and fissures and are therefore discontinuous and sporadic and can be exploited only through deep tube wells. The level of exploitation is still small relative to the apparent supply, although general assessment and research on this type of aquifer has not been conducted.

Much of the development of deep, hard rock groundwater has been carried out by the National Water Supply and Drainage Board (NWSDB) and they report a well development success rate of approximately 80 percent. Other tube wells have been developed by individual industrial and commercial firms.

The quality of groundwater in deep, hard rock aquifers is generally good, with little or no man-made contamination. In some areas high iron or fluoride levels from natural sources have been found.

8. Others

This list of regional aquifer types is not complete. In the wet zone, hard rock areas there are aquifers at variable depths in the valleys of the lower and dissected middle peneplains. Many of the shallow aquifers are extensively used by means of shallow wells. In parts of the hill country and elsewhere, springs of low to high discharge can be found, indicating confined aquifers of various kinds. Also, all of the above general aquifer types can be subdivided into more specific and localised groundwater areas. Specific management plans will require detailed information at these levels.

C. Groundwater Management Issues

1. Domestic Water Supply

Groundwater is the preferred low-cost source of water for most rural and peri-urban domestic water supply. Up to 80 percent of the rural drinking water supply needs are met from groundwater by means of dug wells and tube wells. The shallow, open dug wells that are distributed across the country provide the basic drinking and domestic water supply to a major proportion of rural residents. Under low population pressure in the past, these wells, often constructed and maintained by the village, were sufficient for the rural population, with a balance between supply and demand during all but very dry periods.

With the rapid expansion in rural and peri-urban settlement that has taken place over the last few decades, there has been an increasing stress experienced in both the quantity and quality of water in the shallow aquifers supplying domestic needs. This is being reflected in the increasing occurrence of domestic wells drying up during dry periods and the deterioration of the quality of these domestic well waters.

2. Commercial and Industrial Use

Groundwater is a critical resource for the development of industry and commerce in the export promotion zones, industrial estates and elsewhere. In many areas, groundwater provides industrial and commercial users with a margin of safety where surface sources and piped water systems are not fully reliable. This is particularly true for hotels or other users for which dependable supply is critical. In remote locations and other areas where piped supply systems are not available, groundwater is the only alternative. In other cases still, groundwater provides a cheaper water supply source, particularly when tariff structures for treated and piped water are significantly higher than for domestic users.

Where groundwater is a safe, good quality supply which can be self-managed, it may be the preferred supply source for drinking water supplies and commercial enterprises such as industries and hotels. Financial calculations and risk evaluations are often the deciding factors. Increasingly, however, it is becoming difficult for new firms to find suitable locations with adequate quality and quantity of surface or groundwater. Widespread and reasonably detailed groundwater assessments are needed to provide information to guide the location of new industrial and commercial uses of groundwater.

3. Irrigation

Groundwater is a key water source for irrigation by small farmers, particularly during drought periods when tank storage or direct river diversion is inadequate. In many areas "agro-wells" are used to tap shallow groundwater to supplement surface water or as the only irrigation water supply. Where groundwater is used by small, subsistence farmers and other rural dwellers, the important equity aspects of its management need to be recognised and protected. Groundwater is also a key buffer against drought and normal variation in rainfall in the North Central, North Western and Northern Provinces and therefore reduces agricultural production risk and may allow the cultivation of higher-valued, other field crops and specialty crops which require dependable water supply. Access to groundwater is a key factor for enhanced food security and rural development.

As mentioned above, private agro-wells have been installed in command areas of irrigation schemes and adjacent to irrigation canals and tanks. Shallow tube wells have also been installed near rivers and streams and are often used together with surface water. In this manner agro-well and tube well users encroach into the management and abstraction of water from canals and rivers. These uncontrolled practices need to be integrated into the management of the surface water systems.

4. Shrimp Aquaculture in Coastal Areas

Shrimp aquaculture is a priority area for investment and is being expanded in the Puttalam District of North Western Province. The preferred locations of shrimp farms is close to lagoons and river mouths with access to brackish water suitable for production. Some of these farms draw fresh water from deep tube wells to balance the salinity of sea water. This may affect groundwater level and quality and cause conflict with domestic groundwater users. Freshwater use could be reduced by introducing new, low-cost technology (biological treatment in fishponds) to treat and re-circulate the water to the shrimp ponds as closed systems.

5. Environmental Protection

Since shallow groundwater tends to be released slowly to rivers and other surface water bodies, it plays and important role in maintain river flows during dry periods and in protecting important environmental areas such as wetlands, estuaries and the lower reaches of rivers. Groundwater release helps to limit saline intrusion in the coastal river mouths and dilute increasing urban and industrial waste disposal and agricultural return flows to maintain an acceptable surface water quality in the dry season, and maintenance of in-stream fisheries and aquatic ecosystems.

In addition to benefits related to discharge to surface water bodies, shallow groundwater plays a critical role in maintaining native trees and other vegetation, especially in the dry zone. The diverse pattern of vegetation in irrigated areas of the dry zone, for example, is directly related to water storage, seepage and groundwater availability.

In a few areas, excess groundwater (water-logging, salinity or other indicators) becomes an environmental issue, with drainage of shallow groundwater a possible solution.

6. Groundwater Quality

Groundwater pollution is increasing in some areas as a result of "point-source" discharges, such as industrial effluents and leaking sewers in urban areas. This results in pollution of shallow aquifers and may lead to contamination of deeper aquifers where they are connected to and recharged by shallow aquifers.

Groundwater pollution also results from non-point sources, in particular return flows from agriculture, leading to gradual increase in nitrates, pesticides and other contaminants with adverse health and environmental impacts.

7. Groundwater Information and Research

Information on groundwater resources in this country is very limited. The boundaries of aquifers are poorly defined and management areas and interdependent user groups are difficult to determine. Although records are usually kept for tube well drilling and pump testing, there is no ongoing program of groundwater monitoring. In the case of shallow domestic and agro-wells there is little information on the number of wells and the amount of water use.

This lack of groundwater information is related to institutional gaps. No single agency is responsible for groundwater development or regulation. There is no single publication available that lists and summarises status of different aquifers in order to assess the available resource, its behaviour and boundaries along with the level of exploitation and issues arising from quantity and quality deterioration.

8. Public Awareness

Lack of awareness on the part of the public and policy makers regarding the importance of the resource, the significance of emerging problems and the nature of management options represents a major constraint to groundwater management. A two-way educational process where stakeholders and groundwater managers arrive at a common understanding regarding management needs and options is critical to a wider stakeholder involvement to promote community-based groundwater management.

D. Current Groundwater Management Practices

1. Introduction

The Water Resources Board (WRB), National Water Supply and Drainage Board (NWSDB) and the Agricultural Development Authority (ADA) are all currently engaged in groundwater resources investigations and development. The WRB is mainly involved in investigations, providing technical services and commercial drilling for groundwater resources development while NWSDB undertakes groundwater development projects using deep tube-wells for rural water supply schemes. The ADA is promoting an agro-well construction program in selected districts through a subsidy scheme. None of these agencies are responsible for management of the groundwater resources of the country, in terms of quantity and quality aspects. There is no legislative basis for proper assessment, planning and management of groundwater and adequate financial and human resources are not being provided.

There has been a considerable number of deep tube wells constructed by private industry and commercial entities without concern to sustainable groundwater capacities, environmental concerns and socio-economic impacts. The development process on agro-wells and tube wells has undoubtedly contributed towards achieving economic development objectives of the country, but have also resulted in a series of problems associated with inequity, health hazards and environmental damage to the society.

2. Agro-Well Program

The Agricultural Development Authority shallow well subsidy scheme in the dry zone, where agriculture traditionally relies on the monsoon and rain fed agriculture, was started in 1989. Driven by market and pricing conditions for horticultural products (chilli and onions), this program resulted in rapid development of agro-wells for supplementary irrigation. The agro-wells which to a large extent rely on seepage were often constructed without a hydrological assessment of the available groundwater resources.

Individual farmers have developed a large number of wells using own resources and the number of agro-wells has reached more than 15 000, exceeding the originally planned target of 12 000 agro-wells. There are also on-going water resources development projects under foreign assistance through which agro-wells have been promoted for individual benefits and community groups. Densely and inappropriately sited wells and competitive extraction for permanent irrigation have created groundwater scarcity for some users, high salinity levels, conflict in the cascade systems and impacts on the low flows in streams.

Recent studies on small tank cascade systems have helped in the understanding of shallow aquifers in the north-central dry zone. These studies also developed a methodology for determining the location, distribution and carrying capacity of agro-wells within an individual small tank cascade. It was founds that in 5 of the 50 studied cascades, the upper limit on density of agro-wells had already been exceeded.

3. Tube Well Construction

Over the last two decades deep tube wells have been provided by the National Water Supply and Drainage Board to villages and rural and peri-urban settlements across the entire country. Although the quality of deep groundwater is generally good, there are reported instances where tube wells have been abandoned because of high iron content or fluoride content of the water. It is evident that in future development of drinking water supplies there will be a strong need for proper assessment of groundwater resource and proper guidelines for balanced and sustainable use of this water resource. This should apply to both rural and urban water supply.

4. Environmental Impact Assessment and Local Authority Control

The management of groundwater resources have been addressed under the Environmental Impact Assessment regulations with provision to control extraction levels beyond a daily extraction rate of more than 50,000 gallons. However, there has been hardly any industry that have been subjected to EIA process falling into the above category. The local authorities have also been entrusted with control of distances between domestic shallow wells and sanitary pits of households and business premises.

E. Deficiencies of the Current System

The preceding review of groundwater management issues and current programs has illustrated a number of deficiencies and problems which should be corrected through the implementation of a national groundwater policy.

- Ownership, and therefore management responsibility, of groundwater is not clearly defined in legislation.

- Responsibility for investigation, development and regulation of groundwater is not formally assigned to any agency. A number of agencies are involved in various aspects of groundwater investigation and development as a consequence of other mandates or on no proper legal basis.

- There is no co-ordinated groundwater information program. Many studies have been undertaken and considerable data exists, but it has not been consolidated and is not being used to any great extent in management decisions.

- Even when a considerable body of information on seasonal behaviour and quality is available (e.g. Jaffna peninsula), there is no institutional authority for control and regulation of the resource.

- There is no groundwater planning system. Problems and issues are being dealt with on an ad hoc basis. The vital linkage between surface and groundwater is being largely ignored and the results of lack of groundwater regulation are affecting surface water management.

- There is no legal basis for groundwater allocation. Being an essentially unregulated resource, groundwater is being exploited in a haphazard and, in some cases, rapid manner. Over-extraction is taking place in some places, with significant costs for existing (and sometimes vulnerable) users.

- There is no public information and awareness program regarding groundwater. The resource is widely misunderstood, even by decision makers. Although there are significant local impacts from lack of groundwater management, local stakeholders lack information and means of involvement.

F. Groundwater Policy

It is essential that the following groundwater policy be viewed along with other components of the National Water Resources Policy. Statements regarding ownership, management strategies and principles, planning, allocation and demand management, and institutional recommendations which appear elsewhere in the policy are not repeated here but apply equally to both surface and groundwater.

1. Objective

The objective of this policy is to promote the sustainable development and management of groundwater resources in Sri Lanka.

2. Groundwater Management Principles

a. Groundwater will be managed in a sustainable manner, recognising natural replenishment rates. Long-term damage arising from pollution or depletion of the resource will be minimised.

b. Information on groundwater resources will be continuously strengthened and planning and management will be based on the best available information.

c. A consistent and integrated approach will be used for the management of surface and groundwater.

d. Responsibility for the management of groundwater resources will be assigned to the National Water Resources Authority. The NWRA will delegate or contract technical, decentralised or other appropriate functions to appropriate national agencies, lower levels of government or the private sector, with necessary capacity building. (see section VI, D "Groundwater Administration" below)

e. Strong community and water user participation and awareness will be promoted to facilitate planning and management of groundwater resources.

3. Sustainable Management of Groundwater

In order to achieve the sustainable management of groundwater resources, the distinctive characteristics of specific aquifers will be recognised. In particular, the rate of aquifer replenishment and the sensitivity of aquifers to depletion and contamination will be taken into account in groundwater planning and allocation.

(Further information on this policy's sustainable management focus can be found in the "Water Resources Policy Framework").

4. Co-ordination of Surface and Groundwater Management

4.1 All national water resource policies will apply equally to surface and groundwater.

- Water management and groundwater sensitive areas will be declared where priority issues and management needs exist.
- Surface and groundwater resources will be planned and allocated in a fully co-ordinated manner and in accordance with the policy on "Water Rights and Allocation." (see Section II) In declared "water management areas" and "groundwater sensitive areas" water entitlements will be required for major users of surface and groundwater. Small water users will not be required to hold entitlements.
- Groundwater entitlements will be transferable in the same way as surface water entitlements.
- All demand management policies, including sharing of water resource management costs, will apply equally to groundwater.

4.2 Integrated management of surface and groundwater will be promoted. This may involve education and other means to encourage water users to use surface water when it is available and to save groundwater for use during periods of surface water shortage. It will also recognise the recharging of aquifers which takes place through surface water management (e.g. irrigation water discharge).

4.3 The "Institutional Structure for Water Resource Management" (see Section VI) will apply equally to surface and groundwater management.

The National Water Resources Authority will carry overall responsibility for management of water resources, while other national agencies, provincial and local governments, and community organisations will be fully involved through delegation and co-operative arrangements, with necessary capacity development.

5. Management of Small Scale Groundwater Use

In most cases the exploitation of shallow groundwater is through small scale domestic and agricultural wells. While each of these wells use only a small amount of water, their cumulative impact can be considerable. It is considered impractical to regulate these small wells through water entitlements. However, steps must be taken to control the over-use of shallow aquifers and thus to safeguard the water supplies of existing shallow well users. The following procedures will be employed:

5.1 Within declared water management or groundwater sensitive areas, and subject to water resource management plans, local governments will be encouraged to register small wells in order to improve the available information on the number of wells, amount of groundwater use, etc.

5.2 Guidelines and management recommendations on sustainable use of shallow groundwater, including recommended well density, will be developed and provided to local governments and other appropriate agencies.

5.3 Information on groundwater and water conservation will be provided to owners of small wells.

5.4 Land alienation will be co-ordinated with groundwater availability. Where domestic demand for shallow groundwater exceeds sustainable supply, surface water alternatives will be investigated.

6. Groundwater Information Management

Reliable information is essential for sound management of water resources. However, information on groundwater availability and quality is currently very limited.

6.1 Groundwater data collection and information management will be strengthened.

A strategic approach to groundwater information will be used. Research, assessment and ongoing monitoring will be undertaken both on a widespread, reconnaissance basis and, more intensively, in priority aquifers and declared water management and groundwater sensitive areas.

Water entitlements and registration of small scale groundwater use will be used as ongoing sources of groundwater information.

6.2 In accordance with the "Information Management Policy," data collection will be carried out by existing agencies and non-government and private sector organisations. Under data sharing agreements, groundwater data will be co-ordinated by the National Water Resources Authority.

7. Groundwater Quality

7.1 An effective water quality monitoring mechanism will be developed with the participation and assistance of stakeholder groups.

7.2 Groundwater quality protection and other environmental objectives will be pursued in co-ordination with national and provincial environmental agencies.

7.3 "Groundwater sensitive areas" will be defined on the basis of vulnerability of important aquifers or parts thereof to contamination or depletion due to over-extraction of the resource. Appropriate preventive or corrective measures will be defined and implemented for such areas.

8. Awareness and Participation

Public awareness of groundwater resources is low and misunderstandings regarding groundwater exist. In many areas groundwater is a relatively localised resource with a corresponding need for local participatory management.

8.1 Greater awareness of groundwater resources will be promoted through co-operative programs involving other agencies, levels of government and NGOs.

Where appropriate, special efforts will be made to promote public and water user awareness of groundwater characteristics and the need for groundwater conservation.

8.2 Stakeholders will be encouraged to participate in groundwater planning and monitoring. Community groups will be involved in collection of information, particularly regarding shallow groundwater.

9. Strategic Approach

Groundwater management will be based on the particular needs and characteristics of regional and local aquifers. The following table indicates management issues associated with regional aquifer types and suggested actions which can be taken to improve groundwater management.

Action plans will be developed for high priority aquifers. These will be based on the suggested management strategies and will be carried out by appropriate national and other government agencies and other groups, under the co-ordination of the Water Resources Secretariat / National Water Resources Authority.

Aquifer Type	Major Issues	Management Strategy	Priority
1. Shallow Karstic Aquifer, Jaffna Area	Heavy exploitation through shallow wells, agricultural and domestic pollution, potential for saline contamination	Registration of shallow wells by local governments; water entitlements for large users; promote public awareness and water conservation; control heavy use of agricultural chemicals and enforce minimum separation of wells and sanitary facilities	High
2. Coastal Sand Aquifers	Seasonally fluctuating supply, usually limited surface water alternatives, locally heavy exploitation for domestic and commercial purposes (hotels, prawn cultivation), high potential for saline contamination	Registration of shallow wells by local governments, water entitlements and monitoring of large users; promote public awareness of groundwater, maximum well density and pumping rates; promote water conservation, particularly in dry zone and for large water users; control heavy use of agricultural chemicals and industrial and other point-source pollution	High in heavily developed aquifers
3. Deep Confined Aquifers, North-west Limestone	Exploitation of one aquifer for shrimp production; otherwise, limited development and management issues	Monitor, regulate future development	Low
4. Southwest Laterite Region Aquifer	Increasing exploitation and local depletion due to urban and industrial development; high potential for domestic, industrial and agricultural contamination	Registration of shallow wells by local governments; increased local enforcement of well spacing guidelines; co-ordination of groundwater management with planning of land use and pipe-born water systems; increased public awareness	High

5. Alluvial Aquifers	Some saline or other contamination; otherwise, limited management issues due to high recharge	Manage groundwater surface water in close co-ordination; direct new users to areas of significant unused supply	Low in the wet zone. Moderate in the dry zone.
6. Shallow Dry Zone Aquifers	Seasonal fluctuation of supply; extensive ongoing exploitation related to government subsidy programs and potential impact of existing users; potential agricultural contamination; close linkage to surface water management (natural streams and irrigation system)	Registration of shallow wells by local governments; close co-ordination of surface and groundwater management systems; development / promotion of guidelines for well density, pumping rates, etc.; adjustment of current well development assistance programs; increase public awareness and promotion of water conservation	High
7. Deep Hard rock Aquifers	Slow recharge, potential difficulty to correct contamination, limited information on location and extent; high value for urban, commercial and industrial water supply systems	Water entitlements for large users; increased resource assessment, monitoring and research	Moderate
8. Other	Shallow aquifers in other hard rock areas throughout the island are being heavily exploited and contaminated	Further investigation and characterisation; registration of shallow wells by local governments; close co-ordination of surface and groundwater management systems; development / promotion of guidelines for well density, pumping rates, etc.; increase public awareness and promotion of water conservation	Moderate – high.