ANDHRA PRADESH WATER & ENVIRONMENTAL SANITATION PROJECT

STUDY OF WATER RESOURCES OF FOUR DISTRICTS ANDHRA PRADESH

&

STUDY OF NAGARJUNA SAGAR SUPPLY

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WATER RESOURCES DATA COLLECTION AND ANALYSIS AND STUDY OF NAGARJUN SAGAR SUPPLY

1. EXECUTIVE SUMMARY

The North Coastal Districts of Vishakapatnam, Vizianagaram & Srikakulam

These districts have two distinct land forms, the coastal plains and the hilly Eastern Ghats region. The coastal plains have high population densities and intensive agriculture. The hilly region accounts for 55 percent of the district geographical area in Visakapatnam and houses 15 percent of the district population. In Vizianagaram, the hilly region comprises 56 percent of the total geographic area and houses 53 percent of the population. The hilly tracts in Srikakulam account for 36 percent of the geographical area and house 33 percent of the population. The proportion of SC population is uniform within each district across the two regions, except in Srikakulam, where the Caste population proportion increases marginally in the Agency area. The tribal population is predominantly in the Agency area, but attains significant dominance in numbers in Visakapatnam district. In the other two districts, the proportion of tribal population in the Agency area does not exceed a fifth of the population.

The average rainfall across the districts varies from 1,000 - 1,500 mm. The plains generally receive lower rainfall as compared to the hills. The hilly areas can be classified as the hot sub-humid region. The trend of rainfall and Potential evapo-transpiration indicates that this region is sub-humid and the water demands for the traditional paddy drops may have to be met largely by the irrigation. The maximum water shortage season is spring and early summer periods. Lack of sufficient irrigation sources is one of the main constraints for growing a second crop in this region.

The coastal areas have a wide strip of alluvium and sand dunes, abutting the sea towards the south east and the eastern Ghats towards the north west. This region gets considerable amount of surface water from the neighbouring Orissa State since some of the rivers like Nagavalli rise from the neighbouring Orissa State. The catchment area of larger rivers like Vamsadhara and Nagavalli have forested regions in their catchment and some ground water flow in the lean seasons. The upper catchments of these rivers lie either in Orissa or in other districts of Andhra Pradesh, and the river flows are liable to be constrained by activities in these upper catchment areas.

The net irrigated area in Srikakulam district is 32 percent of which 50 percent is from medium and minor surface water projects, about 40 percent from tanks and 10 percent is irrigated by the wells. In Vizianagaram district, the net irrigated area is 20 percent of the geographical area. Of this, 27 percent is irrigated by medium irrigation projects, 64 percent by tanks and 10 percent by wells. In Vishakapatnam, out of the total geographical area of 11,161 km^2, only 10% of the area is irrigated. This is on account of the fact that nearly 60 percent of the area in the district is hilly. Of the irrigated area, nearly 30 percent is irrigated by canals (medium irrigation schemes), 30 percent by tanks and about 20 percent by wells and tube wells.

With surface water utilisation varying between 8 (Visakapatnam) and 25 (Srikakulam) percent equivalent of rainfall received, the possibility of enhanced harnessing of rain water for utilisation is seen to be low. There exists the potential to repair, rehabilitate and utilise existing structures and channels in a more efficient manner. The low reliance on water intensive cash crops and predominantly single season agriculture is likely to limit increased demand from agriculture, unless any shift occurs towards water intensive cash crops, driven by urban markets in the region. The sustainability of current base flows in the perennial streams has to be reviewed in light of the irrigation schemes being executed on rivers like *Vamsadhara* and *Nagavalli* and the various Lift Irrigation schemes of the APSIDC/ITDA in the upper catchments.

The three districts can be divided into three distinct hydro-geological zones. The hilly region has limited ground water potential and also very little utilisation. The second zone is sandwiched between the hill zone and coastal zone. This zone is mostly pediplain with thick soil cover and has medium ground water resources in weathered zones and the few hard rock aquifers along the fractured zone. The third zone is coastal alluvial and marine sediments with alluvial aquifers which may be saline at depths. This zone extends along the rivers quite deep into the second zone. There may be few paleo rivers in the zone Two and Three which may yield sufficient water for local water supply schemes.

Srikakulam has a total of 1073 MCM of utilisable ground water. In command areas of the medium irrigation projects, the ground water utilization is very low, whereas in non command areas, it ranges from two to 40 percent. In Vizianagaram district, the total utilisable ground water resource is estimated to be 903 MCM and a net draft of 18 percent is reported. The highest net draft within a Mandal was 33 percent and the lowest was 3 percent. Vishakapatnam's ground water potentials are estimated to be of the order of 1,062 MCM while the draft was 119 MCM. The highest utilisation at the Mandal level was about 64 percent in the plains area, and the lowest was just above 1 percent in Dumeriguda Mandal in the hilly region.

A clear trend of increasing ground water recharge, per unit area, can be seen from the southern Visakhapatnam district to the northern Srikakulam district.

The problem of drinking water source quality is more in the plains, where population densities are higher, irrigation and agriculture is more developed and competing demands from agriculture are also more. The Agency areas or the Uplands which house a substantial amount of the Tribal population in these districts report lesser incidence of quality problems. There are problems of provision of potable drinking water, due to limited availability of groundwater sources and the technical ease of extraction and supply. The preference for *cool, fresh, tasty* running water means that for most of the year, they would prefer not to access the hand pump or any such groundwater source.

In the coastal region the high TDS is associated with sodium chloride of marine origin. The high fluoride pockets are most probably to be found in the hard rock aquifers and not in the alluvial aquifers. Along the coast, a zone of high TDS is found, the width of this zone ranges up to about 20 kms. In the alluvial belt, along major rivers, the brackishness can extend deeper into the mainland. Deeper tube wells also have higher TDS than the shallow wells in these zones which tap fresh water aquifers underlain by brackish aquifers. In almost all the high TDS zones, the chloride content is high.

A few pockets of high fluoride are also reported. High iron content in the water has been reported in some areas, however it is not related to any specific geological formation but is due to the reducing, slightly acidic conditions in some aquifers and/or corrosion of pipes, especially after long periods of dis-use.

In the alluvial area, drinking water is generally sourced from hand pumps, mini and piped water schemes. Few comprehensive piped water schemes have been initiated in these districts, especially in areas where the local source is brackish. Brackishness of the water source is the main problem in the plain area. This is either on account of salinity or depletion of the resources.

In parts of Srikakulam district, the problem of brackishness is quite serious and 90 habitations have to be supplied water through tankers in the summer months. Around 30,000 people rely on tanker supply. Over 1,360 habitations in the district face a problem with regard to the quality of water. In Vizianagaram, a total of 418 habitations have brackish water and 185 have high fluoride content in the drinking water source. In Vishakapatnam, the water is brackish in 1,232 habitations and 276 habitations have high fluorides. The problem of brackishness occurs in a contiguous zone covering a set of habitations. It is unlikely that a sweet water source would be found in the vicinity and a CPWS seems to be the only option for such villages. At present, in most villages, multiple water sources are used for different end uses based on the quality of the water. The same principle needs to be followed in the design of a CPWS since brackish water can be used for all household needs other than drinking and cooking. Excess abstraction of a sweet water source can lead to conflicts and salt water ingress to the source, affecting larger areas.

Conclusion and Recommendations

1. Surface water resources have been harnessed moderately and utilization is moderate to high, with the level of utilization increasing from Visakapatnam to Srikakulam.

2. Potential exists to utilise groundwater resources in the Plains area of all the three districts, except in certain over-draft pockets (like the non-ayacut mandals in Srikakulam and mandals in the vicinity of urban Visakapatnam).

3. The Potential of utilisable groundwater resources in the Hilly or Upland areas (Agency) of the three districts is low and is further constrained by the spread-out nature of the population and problems of access.

4. Even where potential exists for utilising groundwater sources, it is noted that the plains area has fairly large areas where the quality of water is in doubt due to presence of excess Chlorides.

5. The three districts have a few perennial rivers and streams. However, with the construction of medium irrigation schemes and Lift irrigation schemes in the upper catchment as also the diversion of water to feed the drinking water needs of Visakapatanam, it is advisable to estimate safe yields and flows before utilising these sources by intake or infilitration wells for medium to large CPWS systems.

6 Each of the district have a number of MI /PRED tanks, often exceeding the number of habitations. There is a possibility of utilising some of the tank recharge areas (with adequate rehabilitation and maintenance) for groundwater extraction, specifically for drinking water. This would be a fairly reliable source of drinking water. However, considerable amount of hydrogeological surveys would be needed to select the sites and prevent direct seepage of water from the surface sources, which are likely to be muddy during the rains and contaminated by coliforms. The ownership structure of these tanks needs to be investigated further, but most appear to be owned by the government.

7. In the hilly areas, hand pumps can be installed which are fed by small seepages or in the fractured hard rock zones nearest to the settlements. Since the size of habitations is small in the *Agency* area, these hand pumps can be a reliable source of potable water. However, Calyx drilling or specialised rigs which can be assembled on site may be required. These may cost about 150-200 percent more, but they can provide reliable supplies.

8. The other option is of digging shallow wells, closing them with a concrete cover and installing hand pumps over them with a proper drainage. These have been tried out successfully in inaccessible terrains of the Himalayas. A seepage rate of 0.5 - 1 lpm is sufficient because of the large storage of the wells (3+ m^3). Some of the prospective areas may be near the stream beds.

9. The cultural barriers to consumption of water from a Hand pump and perceptions regarding its taste may take much longer to overcome. People in these regions prefer the taste of running water from the streams which have serious bacteriological contamination as several settlements are located along the streams. These streams are used both by the people and the cattle and defecation along the streams is common.

10. Any programme for water provision in the Uplands (Agency) has to be preceded and complimented by health education. The ITDA is the nodal agency for all programmes in the Agency areas and partnerships need to be built with them. Their network of Para Health Workers is fairly well developed, with one health worker for every three settlements. They are an important resource for health education and community mobilisation interventions in the Agency areas.

11. In the brackish water areas, the shallow groundwater in tank-bed areas is likely to be fresh water and ground water extraction by shallow wells or DCBWs are viable options for drinking water. However, the submergence area of these tanks should be of at least one hectare or more in size. In villages where no such tanks exist, and ground water is brackish, artificial recharge of water collected during the monsoon period can be an option, but this is possible only in certain areas where a reliable surface water source exists nearby. However, management implications of such options need to be worked out.

12 The populations densities in the plains is high (300 to 500 persons per km^2). The average population per village is about 2,500. These villages have fewer hamlets (2-3) with lower spatial dispersion. The average village sizes are about 5 km^2 . Hence, the yields of the sustainable wells in such areas have to be much larger and more than one

option may be necessary. Systems have to be designed with at least 50 percent redundancy for periods when the monsoons fail and people have to depend on ground water sources.

While the three northern coastal districts have problems of provisioning potable water to the population, these districts have the surface or groundwater resource potentials to tackle the problem.

Amongst the three districts, Srikakulam has the relatively worse record on health and poverty parameters. However, the CPWS schemes under execution along with timely execution of proposed ones would tackle the *Poverty of water* problem effectively.

Vizianagaram has pockets with quality problems, but the resource potential in and around these areas seems adequate. Also, this district is being assisted by the RGoN, which has initiated work along with the PRED in 14 habitations in 1998. The NAP proposes to expand in phases and cover about 500 habitations over 5 years. Their methodology based on scientific delineation of groundwater sources and community based planning would go a long way in augmenting PRED capabilities in both and also solving the *water problem.*

In Visakapatnam, the major problem of water quality (brackishness) is predominantly in the plains and coastal areas, which are more developed in terms of infrastructure and resource development. The poverty parameters which pull Visakapatnam into the 'Poor' category have to be seen in the light of the high spatial differentials. Poverty of health and economy is high due to the tribal population and development features of the Agency area where the IMR is almost double that in the Plains (Aide memoire, DFID), rather than these parameters in the Plains, which actually suffer the poverty of water. The problems of provision which exist in the Agency have attendant problems of access and attitudes, which may require interventions more from a health-extension perspective rather than technology-fixes for water supply.

Nalgonda District

Nalgonda is a semi-arid district, located in the northern Telengana region of the state. It receives an annual average rainfall of 722 mm. The southern boundary of the district is marked by the Krishna river but only a small part of the district (5 percent of geographical area) towards the south, receives irrigation from the Nagarjun Sagar dam on this river. There is a marked disparity in agricultural practices and incomes within the district, between areas that receive canal irrigation and others that rely on rain-fed or ground water based irrigation. The poverty indicators too reflect the under-development of Nalgonda, 40 percent of the population lives below the poverty line, the literacy rate is amongst the lowest in the state at 38 percent (female literacy is lower at 25 percent), and the IMR, CMR are high at 53 and 77 per thousand, respectively.

The first cases of fluorosis in the country were identified in this district, in 1936. Since then, over a hundred villages are reported to be affected by fluorosis though many more have high fluoride concentrations in their drinking water source. The source of fluorides are the pink granites, found in the southern and western parts of the district, which have fluorites and fluor-apatites as accessory minerals. People ingest fluorides from the water they drink and from crops cultivated in soils containing high fluorides and/ or irrigated by such waters. Fluorosis also affects cattle and bio-accumulation in animal tissues is said to be another secondary source of ingestion. The WHO norm for acceptable fluoride level in water is 1.5 ppm while the Bureau of India Standards (BIS) prescribes a lower limit of 1 ppm.

The severity of the symptoms of fluorosis is closely linked to the nutritional status of the population[1] and the poor are likely to be the worst affected in any region[2]. Skeletal fluorosis makes physical movement extremely painful and for a population that relies largely on agriculture (34 percent of main workers are cultivators) and agricultural labor (45 percent), has serious livelihood implications.

It is difficult to use the data available on fluoride levels in drinking water sources as it has been collected at different points in time, covering different water sources and geographical areas, and time series data for the same source has rarely been collected. The sample survey, conducted over 1991-93 for the Rajiv Gandhi National Drinking Water Mission (RGNDWM), was methodologically flawed as it recorded the highest level of fluoride and TDS found in any source within the village. It is only recently that the PRED has started conducting repeat surveys, but this data pertains to the worst affected Mandals, where both fluoride levels and the prevalence of fluorosis are known to be high. As per the sample survey (limitations of which have been stated above), there are 1,122 fluoride affected habitations in the district. The district was

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[1]Krishnamachary K A V R, Shivkumar O B : Endemic Genu Valgum : A New Dimension to the Fluorosis Problem in India, Fluoride, Vol 9, No. 4 (1976); Shrikantia SG : Endemic Fluorosis in Andhra Pradesh (undated) Nutrition Foundation of India, Archives

[2]The Rajiv Gandhi National Drinking Water Mission recommends two major interventions for addressing the problem of fluorosis. These are: reducing fluoride concentrations in drinking water to as low a level as possible; promoting a balanced diet with adequate calcium, vitamin C and anti-oxidants from vegetables and fruits

proposed to be covered under a Netherlands project Assisted Project (NAP, details in the following sections) which attempted the sub-zonation of the area into A, B,C and D areas. Zone A was the core area with high fluoride concentrations, B, the area adjoining it while C and D did not have high concentrations of fluoride but faced water scarcity. This classification did not have much scientific basis, since high fluoride levels have been reported from areas other than Zone A and B, but was a rough working definition for project design purposes.

The northern Mandals of the district draw their drinking water from the Musi river, which passes through Hyderabad city, and carries a high load of pollutants. The PRED has received an allocation from the RGNDWM for a CPWS scheme for this region but has not been able to identify a sustainable ground or surface water source in the vicinity. The southern and eastern parts of the district, irrigated by the Nagarjun Sagar Left Bank Canal and the Peleru rivers respectively, do not face water scarcity or quality problems.

The approaches to address the problem of high fluorides range from provision of a new or alternate source of water containing acceptable concentrations of fluoride; blending the water with another source containing low fluorides; treating water at the point of use; treating it at the source; or transporting safe water to the population.

Almost all defluoridation techniques, both household and community level, have been tried in Nalgonda over the last two decades, by a variety of institutions. Since most of them work at lower pH (less than 7) and water in most parts of the state is alkaline (with pH ranging between 7-8.5), it needs to be made acidic first, for the treatment to be effective, and then neutralized, to make it potable. Any variation in the quantities of chemicals used affects both the taste and the properties of the water. Household level treatment units have therefore not been successful while the larger community level units, have high operations and maintenance costs, which are beyond the means of the local panchayats who are meant to run them. The only community level unit functioning in the district, is run by the PRED.

In 1983, the district was identified for coverage under the Netherlands Assisted Project (NAP - AP I and later AP III). The project investigated several options ranging from tapping safe local sources, blending water, household level treatment, CPWS schemes, artificial recharge methods to increase well yields, etc. over the last 15 years. Detailed hydro-geological exploration was also conducted and a series of options were drawn up. The project found that it was not possible to use ground water in Zones A and B and exploration was focused in Zones C and D. Even in these areas, the success rate was between 40-50 percent and over extraction for irrigation was reported to be a major cause of failure of wells.

The ground water based option recommended the drilling of about 775 wells in 226 habitations, and the establishment of 35 community defluoridation plants[3]. Given the high failure rates of the wells, this option had serious cost implications, both in terms of capital costs and O&M of the defluoridation plants. Some of the recommendations for the sustainability of wells, such as the creation of 'well sanctuaries' by acquiring land around the wells and preventing the draft of ground water in the area, were not practical given the small land holdings (61 percent of cultivators are marginal farmers) and predominantly agricultural occupation profile of the district.

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[3] IWACO B.V (1993) Water Resources Study, Andhra Pradesh III, Vol 2, Main Report

TABLE (E.2) VILLAGE TYPOLOGIES, TECHNICAL OPTIONS & THEIR ACCEPTABILITY						
VILLAGE TYPE	TECHNICAL OPTIONS			SOCIAL ACCEPTABILITY & RISKS		
	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
1	Village-based schemes	CPWS, if en route		Medium	Preferred	
2	Defluoridation	CPWS, if en route	Conjunctive use & demand focused enduse system , artificial recharge	Low	Preferred	People likely to fall back to using untreated water for drinking
3	Village-based with Controls on abstraction			Very difficult to implement	Complex management issues	Preferred
4	Distant source supply			Preferred		
5	Distant source supply			Preferred		
6	Freeze abstraction to current levels	Improve Recharge	CPWS if en route	Difficult to implement, promotes status quo in water use	Repetitive activity likely to be stopped post project	Preferred
7	Distant source supply			Preferred		
8	Distant source supply			Preferred		
Source : TARU Analysis, 1999						

Our analysis indicates that even in the worst affected region, some villages have the potential to either use a locally managed system or adopt conjunctive use, based on seasonal availability and quality of water required for different end uses. Other villages (in Types 4 to 8) have few alternatives, other than a piped water supply schemes, based on a distant source. A similar set of options would be applicable for the other villages in the fluoride affected region. However, the geographical distribution of the problem of ground water scarcity, groundwater over extraction and fluoride levels have to be understood to design any sustainable solution. It may not be practically possible to isolate few villages with possible local option from a piped water supply scheme if they are enclosed by a group of problem villages with provision made for a CPWS.

It is also found that the in most cases larger villages have higher levels of ground water abstraction and higher fluoride levels, showing that an increasing amount of the contaminated water is used for irrigation, thereby further increasing the fluoride content in the soil (and ultimately the water). It seems higher availability of water resources has led to intensification of agriculture which in turn has increased population of habitations without catalysing education, out-migration or alternate livelihoods. This reflects that many villages are in an ecological trap, whereby over-exploitation of a natural resource results in a multitude of unanticipated negative consequences and only an external intervention, can break this chain of events. Since a large number of villages in the region have populations exceeding 1,000 (75 percent), such a trend is

While the AP III did not result in the initiation of a project, it generated a large amount of information on water quality and availability. The fall side of this was that since the district was being considered for coverage under AP III, it did not receive any allocation for a water supply scheme and while there are 56 CPWS schemes in the state, Nalgonda has none. The demand for a piped water supply scheme is gaining urgency and the district administration is now attempting to garner local resources to address the water crisis.

A study conducted by IWACO under NAP, covering 226 villages in the worst affected region, provides comprehensive information on ground water availability, its current levels of abstraction and quality. Based on this, eight types of villages can be identified in the region and the water supply options, their social acceptability and risks have been analysed for each of them and are shown in Table (E.1).

The combination of groundwater resource situation, levels of groundwater abstraction and fluoride levels at habitation levels causes magnification of problem from simple high fluoride in local source. Only 143 villages have fluoride problems whereas 137 villages have moderate or poor ground water resources and 90 villages have moderate to high ground water draft. In many habitations fluoride levels may be low but ground water resources may also be scarce and in others where fluoride levels may be high, ground water may be available in sufficient quantities. The technical options for different village types and their acceptability is presented in the subsequent table (E.2)

TABLE (E.1) VILLAGE TYPOLOGIES BASED ON GROUND WATER CONDITIONS IN FLUORIDE AFFECTED AREA OF NALGONDA DISTRICT (IWACO - NAP, 1993)

VILLAGE TYPE	GROUND WATER CONDITIONS			Number of Villages	Population
	POTENTIAL	ABSTRACTION	QUALITY (F ppm)		
1	High	Low	Good	21	[illegible]1,222
2	High	Low	Poor (>1.5)	19	37,043
3	High	Med - High	Good	13	23,188
4	High	Med - High	Poor	31	90,728
5	Medium	Med - High	Not Applicable	48	125,550
6	Medium	Low	Good	28	46,037
7	Medium	Low	Poor	42	79,632
8	Low	Not Applicable		19	23,577
Total				221*	456977

* Data is not available for 5 of the villages. Source : IWACO 1993 & TARU Analysis.

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In the past, the district has witnessed conflicts over water, both for drinking water needs among neighboring villages, and between irrigation and drinking water demands across a larger area. As water scarcity increases, such conflicts are likely to become more frequent.

The PRED has earlier explored CPWS options using Nidamannur and Alwal tanks as SSTs were pushed back in favour of using Akkampalle balancing reservoir as the SST after the state moved forward on utilisation of the Krishna waters through the Srisailam Left Bank Canal project. The balancing reservoir at Akkampalle is proposed to receive water from the Srisailam Left Bank Canal (SLBC), which is under construction. The SLBC involves the construction of about 46 km of tunnel in different segments which is an impediment to its speedy completion. As the state has to utilise the Krishna water allocated to it under the KDWT award by 2000 AD, water from the Srisailam project is being pumped up up to the canal and then to Akkampalle reservoir. Once the tunnel is completed, the flow would be by gravity. The quality of the water and its reliability are likely to be high since Akkampalle does not have an direct irrigation outlet. However, till the tunnels are completed, pumping of the water is an unreliable link in the chain.

The proposed scheme is technically feasible. As only project estimates have been done and the design work is not completed (no sanction given), it is rather inopportune to evaluate the distribution network. The hydraulic design is not done and various options like increasing the number of Treatment Plants are still being consideration.

Since the scheme is based on a single intake point and provides distribution over very long distances through three pumping stages the system reliability would be low. Adequate provision for redundancy would have to be built in, which would escalate costs.

The HMWSSB has submitted a proposal to the World Bank for sourcing drinking water for Hyderabad city from the Nagarjuna Sagar in order to augment water supply to Hyderabad city. Under the proposal, raw water from the Nagarjuna Sagar will be pumped to Akkampalle which is 23 km away from reservoir. This would be treated and then pumped in three stages, covering a gradient of 165 m at each stage, to Hyderabad city which is 114 km away from the reservoir.

The pipeline is proposed to be laid along the highway. The water production capacity of the project is 410 mld, with 22.5 mld reserved for en route villages situated at a distance 3-5 km from the pipeline. The project requires financing of the order of Rs. 2,400 million, of which 50 percent is being sought as a loan from the IBRD. The option of tapping water from this pipeline for a CPWS supply to Fluoride affected villages in Nalgonda was explored. Since the estimated cost of water supplied from the Nagarjuna Sagar pipeline would be about Rs. 25 per kl, the IBRD has cautioned the HMWSSB and also advocated exploration of alternative sources. However, if the HMWSSB wants to go ahead with this scheme, it would have to augment water tariff by 25% annually over two years, before the IBRD would take up the Nagarajuna Sagar component for active consideration. The GoAP/HMWSSB has not proceeded with this issue in 1998. The chances of an increase in 1999, an election year for the state government, are extremely low.

The implementation of a water supply system that responds to local resource conditions and offers both centralised and local solutions, is likely to be a major challenge. The involvement of several institutional partners, new approaches to design of systems, community participation and their informed decision making, arrangements for cost sharing and O&M responsibilities will need to be an integral part of the design approach.

RECOMMENDATIONS

Nalgonda offers one of the most challenging conditions for the design of a safe drinking water system. With dwindling groundwater resources, no controls over exploitation of groundwater, a distance of about 60 km between the worst affected community and the nearest safe source (Nagarjun Sagar), supplying safe water to at least a hundred fluoride affected villages will be a complex task. The fact that any piped water supply system will pass through areas that are not affected by fluoride but face water scarcity, adds an additional complexity, demanding negotiation with communities, participation of several institutional partners, framing of policy guidelines and community participation.

1. For villages in the zones A, B and D (as per AP-III), the nearest safe surface water source (Nagarjun Sagar) is 30-60 km away. For villages with more than 1.5 ppm fluoride content, the costs of supplying water from a safe surface water source or defluoridation of ground water are likely to be similar due to the low reliability of groundwater sources. A CPWS may be a more reliable and cost effective option in the long run. A geographically contiguous zone suffering from water quality and/or scarcity may have to be identified for CPWS.

2. A CPWS for the worst affected villages would demand proper management and sharing arrangements across villages. It is recommended that a few of the older operational CPWS in the state are visited, to gain a first hand understanding of the design, management and operation of such systems. A large CPWS, the Dasri scheme, in the fluoride affected Prakasam district may be considered for this. It has been operating for the past decade and it is reported that local cost sharing arrangements have also been developed.

3. Another option for villages where water availability is not a problem would be to set up defluoridation plants. However, the technical limitation of existing systems, low receptivity of the community to such options and the high costs of more recent systems such as Reverse Osmosis, do not make this an attractive proposition.

4. Two sets of options are possible for zone C (AP III). The first would include providing small PWS for a cluster of villages, using multiple points for tapping ground water to reduce the risks of simultaneous failure affecting large number of villages. The low fluoride ground water sources can be tapped during the period of canal closure if those sources are maintained. The other option is to adopt conjunctive use systems. During the rainy season, when water demands are not high, artificial recharge of existing bore wells can be resorted to which would serve as a reservoirs for use during canal closure. Such a mix of surface and groundwater use would lower the risks of failure and would not need large storage systems at the intake for dealing with water scarcity during canal closure.

5. Even though ground water usage control is not politically and economically viable, efforts should be made to promote less water intensive and more economically attractive crops in the region especially during the second crop period when water crisis reaches to it's maximum. Existing sources should be maintained to tide over un-foreseen breakdowns of the external source dependant water supply systems. Nalgonda district is located in the semi arid tracts of the Mysore plateau. The average rainfall in the district is 772 mm though the total contribution from the rainfall is 10,993 MCM. The major rivers in the district are the Krishna and its tributaries - Musi and Dindi. The district has a gross irrigated area of 2,842 km^2 (5% of the geographical area) and a net irrigated area of 1,855 km^2. Out of this 1,290 km^2 (45%) is irrigated from major and medium irrigation projects, 1,167 km^2 (41%) from wells and 308 km^2 (10%) by tanks.

6. The option of taking water from the Hyderabad Metrowater supply pipeline is economically not viable. If the area is to be served by a Comprehensive protected water supply, an independent option as suggested by PRED, would be more cost-effective. However, it is felt that the option of using large reservoirs enroute to the SLBC should be explored technically and in terms of competing demands for exploitation as Summer Storage tanks and intake points; to strive for a solution which is more modular and hence reliable.

2. WATER RESOURCES IN THE NORTHERN COASTAL DISTRICTS

2.0 Location, Demography and Land Use

Visakhapatnam district is the southern most district among the three north coastal districts of Andhra Pradesh and lies between the northern latitudes of 17°15' and 18°32' and between the eastern longitudes of 81°54' and 83°30'. It is bounded on the north by Vizianagaram district, west by Koraput district of Orissa state, on the east by the Bay of Bengal and on the south by the East Godavari district of Andhra Pradesh. The district has two natural region divisions - the plains and the hilly Agency tracts.

Vizianagaram district lies to the north of Visakhapatnam district between the northern latitudes of 17°15' and 19°15' and between the eastern longitudes of 83°0' and 83°45'. It is bounded on the north by Srikakulam district, west by Koraput and Ganjam districts of Orissa state, on the east by the Bay of Bengal and on the south by the Visakhapatnam district of Andhra Pradesh.

Srikakulam district lies in the north-eastern corner of the state between the northern latitudes of 18°20' and 19°10' and between the eastern longitudes of 83°5' and 84°50'. It is bounded on the north and west by Koraput and Ganjam districts of Orissa state, on the east by the Bay of Bengal and on the south by the Vizianagaram district of Andhra Pradesh.

The distribution of population and densities across the plains and the upland area in the three districts is shown in Table (2.1). The population density shows a marginal variation across the two natural regions in Vizianagaram and Srikakulam, while it is very marked in Visakapatnam. The population density in the plains of Visakapatnam is very high due to the industrial and commercial development in the area while the hill areas are inaccessible and sparsely populated.

TABLE(2.1): POPULATION DISTRIBUTION IN THE COASTAL PLAINS AND AGENCY AREA FOR THE NORTH-EASTERN DISTRICTS

District	Plains			Agency		
	Area (km^2)	Population	Density (per km^2)	Area (km^2)	Population	Density (per km^2)
Visakapatnam	4,938	2,711,006	549	6,223	468,838	75
Vizianagaram	2,230	825,291	370	2,877	922,152	321
Srikakulam	3,453	1,354,576	392	1,923	676,312	352

Source: Census of India, 1991; TARU Analysis, 1999

The hilly region accounts for 55 percent of the district geographical area in Visakapatnam and houses 15 percent of the district population. In Vizianagaram, the hilly region comprises 56 percent of the total geographic area and houses 53 percent of the population. The hilly tracts in Srikakulam account for 36 percent of the geographical area and house 33 percent of the population.

The distribution of Scheduled Caste (SC) and Scheduled Tribe (ST) population in these regions across the districts is provided in Table(2.2). It is observed that proportion of SC population is uniform within each district across the two regions, except in Srikakulam, where the Caste population proportion increases marginally in the Agency area. The tribal population is [illegible] in the Agency area, but attains significant dominance in numbers in [illegible] district. In the other two districts, the proportion of tribal population in the area does not exceed a fifth of the population.

TABLE(2.2): DISTRIBUTION OF SC AND ST POPULATION IN THE NORTH-EASTERN DISTRICTS

District	Plains			Agency		
	Population	SC	ST	Population	SC	ST
Visakapatnam	2,711,006	1%	4%	468,838	1%	91%
Vizianagaram	825,291	10%	2%	922,152	11%	18%
Srikakulam	1,354,576	8%	3%	676,312	13%	14%

Source: Census of India, 1991; TARU Analysis, 1999

The three northern coastal districts are predominantly agrarian in character, except for the close environs of Visakapatnam city, which are industrial in nature. The main crop is Paddy, followed by Sugarcane and plantation crops like Banana and Cashew. All the three districts have a developed network of rain water harvesting structures, which are utilised primarily for irrigation during the post monsoon months. The agriculture season is restricted to about 7 to 8 months in the year due to limitations in the availability of water for irrigation.

TABLE(2.3): SALIENT FEATURES OF LAND USE IN THE NORTH-EASTERN DISTRICTS

Feature	Visakapatnam	Vizianagaram	Srikakulam
Area under Forests (% of Geographic)	42%	18%	12%
Cultivated Area to Geographic area (%)	29%	52%	55%
Irrigated Area to Geographic area (%)	10%	11%	32%
Irrigated Area to Cultivated area (%)	34%	38%	41%

Source: Census of India, 1991; District Statistical Handbooks, 1991, 1994

The development of agriculture and irrigation show an increasing trend towards the north, from Visakapatnam to Srikakulam, with the latter having the highest proportion of cultivated and irrigated areas, amongst the three districts. This has its impacts on surface and groundwater resource utilization, as will be explained in the relevant sections of this report.

2.1 Water Resources

2.1.1 Rainfall

Visakhapatnam

The mean annual rainfall in the district is 1220 mm. with the north-western hilly part receiving about 1500 mm. and the plains receiving about 1000 mm. or less (CGWB1989). The district Statistical hand book (1991-92) quotes a lower figure for the average rainfall at 1082.5 mm only. There are on an average 55 rainy days, of which the South West monsoon period accounts for 35. The 85 year trend of rainfall in Visakhapatnam shows a minimum of about 500 mm. and a maximum of 1450 mm. The 10 year moving average shows a range of 875 mm - 1150 mm. In Visakhapatnam city, the normal annual rainfall is 954 mm. and at Araku valley, 1320 mm.

The coastal belt can be considered as a sub-humid to semi-arid region whereas the hilly areas can be considered as the hot sub-humid eco-region. Mild to severe water shortages can occur due to the fairly high variability in rainfall, even though serious droughts have not been reported.

Vizianagaram

The average rainfall in the district is 1055 mm out of which the South West monsoon contributes 60 percent and the North East, 25 percent. The remaining rainfall is received during the pre-monsoon period. The rainfall increases from the south to the north, from about 970 mm to 1150 mm. The standard deviation of annual rainfall is 267 mm and the co-efficient of variation is 24 percent. The Potential Evapo-Transpiration (PET) is 1390 mm and the climate of the region may be characterised as dry sub-humid with little or no water surplus.

Srikakulam

The average rainfall in Srikakulam district is 1100 mm out of which the South West monsoon contributes 66 percent and the North East, 25 percent. The remaining rainfall is received during the pre-monsoon period. The rainfall increases from the south east to north west, from about 1000 mm to over 1200 mm. The standard deviation of annual rainfall is 251 mm and the co-efficient of variation, 24 percent. The hilly areas, towards the north-west, receive more rainfall than the coastal region.

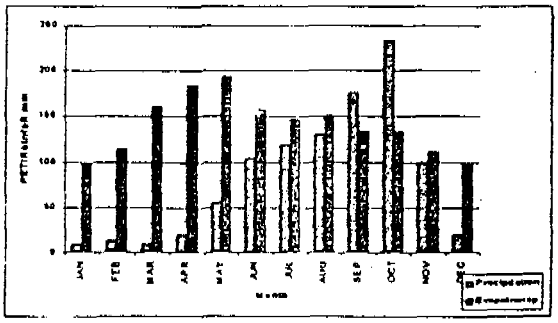


Figure 1 Rainfall and Potential evapo-transpiration, Visakhapatnam

The monthly average potential evapo-transpiration and 60 year average of rainfall for Vishakhapatnam is presented in the Fig 1. The rainfall is higher than PET in only two months and more than 80% for about three months. This means that this region is sub-humid and the water demands for the traditional paddy crops have to be met largely by the irrigation. Water shortage is high in spring and early summer periods. Lack of sufficient irrigation sources constrain the second crop

2.1.2 Drainage

Visakhapatnam

The most important rivers in this district are *Machkund, Tandava, Varaha, Sarada* and *Gostani.* Most of them are ephemeral in nature, going dry in the summer months. *Machkund,* a tributary of the Krishna river drains the northern part of the district and forms the boundary between Orissa and Andhra Pradesh states for a length of about 80 km. Some of the tributaries of *Machikund* are perennial, indicating substantial groundwater discharge while the other rivers dry up during the summers. Data regarding base flows of the streams and rivers in this district, could not be obtained from any source.

Vizianagaram

The district has two physiographic divisions, the eastern ghat mountainous area situated in the west and north and the plains with scattered hills in the central, southern and eastern parts of the district. The elevation of the hilly region ranges between 300 and 950 m amsl, whereas the plains have altitudes between 10 to 150 m amsl.

This region gets considerable amount of surface water from the neighboring Orissa State since some of the rivers like Nagavalli rise from the neighboring Orissa State. The catchment area of larger rivers like Vamsadhara and Nagavalli have forested regions in their catchment and some ground water flow in the lean seasons. The upper catchments of these rivers lie either in Orissa or in other districts of Andhra Pradesh, and the river flows are liable to be constrained by activities in these upper catchment areas.

The Nagavalli, Gostani and their tributaries Suvarnamukhi, Jhanjhavathi and Vegavati are the major rivers that flow through the districts. Of the rivers in the districts, only *Nagavalli, Suvarnamukhi* (a tributary of Nagavalli) and *Vegavati* are perennial.

Stream flows of the three streams - Vegavati, Peddagadda and Suvarnamukhi have been measured by the State Groundwater Department since 1974. The base flow of these three streams is of the order of 90.6 million m^3.

Srikakulam

This district has two physiographic regions, the Hill ranges in the north and the west tending in the NE-SW direction and the wide plain country along the coast. The relief is of the order of 900 m. The plains are about 15 km. wide in the south-west part of the district and narrow down towards the north-east to about 5 km.

Nagavali, Vamsadhara and *Suvarnamukhi* are the major rivers flowing through the district. All of them originate in the eastern ghats. Only the *Suvarnamukhi* is perennial whereas *Vamsadhara* dries up in summer in its lower reaches (CGWB, 1995). The drainage is predominantly from the NW to SE. Several other small streams originate from the hills nearby and join the sea.

The base flow of six perennial streams has been measured by the State ground water department. The ratio of dry weather base flow to total base flow was between 27 to 38 percent. Between 4.6 to 38.5 percent of the rainfall appears as base flow. The dry weather base flow ranges between 1.17 percent to 10.35 percent. The wide range of the base flow, from 38 mm to 274 mm per unit catchment, indicates the range of catchment conditions that prevail in the region. These three rivers can support a series of comprehensive water supply schemes except in the part near their mouths where saline water ingress is possible. These CPWS can supply water upto about 25 km on each bank. However, alternate sources may like ground water should be first explored so that the feasibility of local schemes are also explored. Only if the local schemes are not feasible the CPWS option should be a tried.

2.1.3 Present Use:

Visakhapatnam

There are four medium irrigation schemes in the district, of which three are in Narsipatnam mandal with an ayacut of 18,000 Ha. The fourth scheme is in Bheemunipatnam with an ayacut of only 300 ha. There were 5,627 minor irrigation tanks and reservoirs with an ayacut of about 53,353 ha., as per data from the Department of Economics and Statistics (DoE&S). This includes the ayacut under MI tanks maintained by the PRED and the Irrigation Department. Details of these schemes are provided in Annexure A. The total utilization of surface water, as opposed to the potential, was only 126,402 ha in 1991-92. This indicates a 72 percent utilization of the potential created and can be attributed to the decrease in the storage capacities of the tanks, many of which are old and not well maintained. No significant differences are seen in the utilization rates of Medium and Minor irrigation systems in the district.

With an average of 700 mm of irrigation per ha. for irrigated crops, the total irrigation potential of surface water structures works out to 92,502 ha m or 8 percent of the total rainfall contribution. The Kharif crop is the primary irrigated crop in the region and less than five percent of irrigation from surface water sources is used for the Rabi crop.

In all the three districts irrigation is restricted mostly to the monsoon paddy crop. About 60% of the surface irrigation is for rice crop and about 30% is for sugarcane. The other irrigated crops are groundnut, chillies and vegetables. Hence, water resources are available for drinking water in summers. The irrigation intensity is about 108-115% only in all these districts. However, the possibility of increase in irrigation intensity exists due to low possibility of extensification of agriculture in the plains. The lift irrigation schemes in the region can become a potential source of competing water demand. There is a need for integrated planning and management of water resources so that the possible conflict of use in the future would not happen.

Vizianagaram

There are 10 medium irrigation schemes in this district. There are a total of 9620 minor irrigation tanks in the district. The larger tanks (greater than 40 ha command area) are built and managed by the Minor Irrigation department whereas the smaller ones are built and managed by PRED. The details of Ayacut of surface water irrigation structures are presented in Annexure A.

The Minor Irrigation department manages a total of 901 MI tanks (with an average command area of 57.4 ha) and the PRED manages 8,719 tanks (with an average command area of 7.91 ha). Minor irrigation tanks account for about 75 percent of the surface water irrigation capacity

The total surface water resources in the district is estimated at 121,457 ha which is about 75 percent of the potential created.

The crop mix in Vizianagaram is similar to that in Visakhapatnam. The irrigation intensity, using surface water sources, is only 108 percent, with most of the irrigation being utilized for the Kharif crop. Existing surface water irrigation potential accounts for about 18 percent of the total rainfall received in the district. Almost 90 percent of the surface water resource are used for paddy cultivation in the district.

Srikakulam

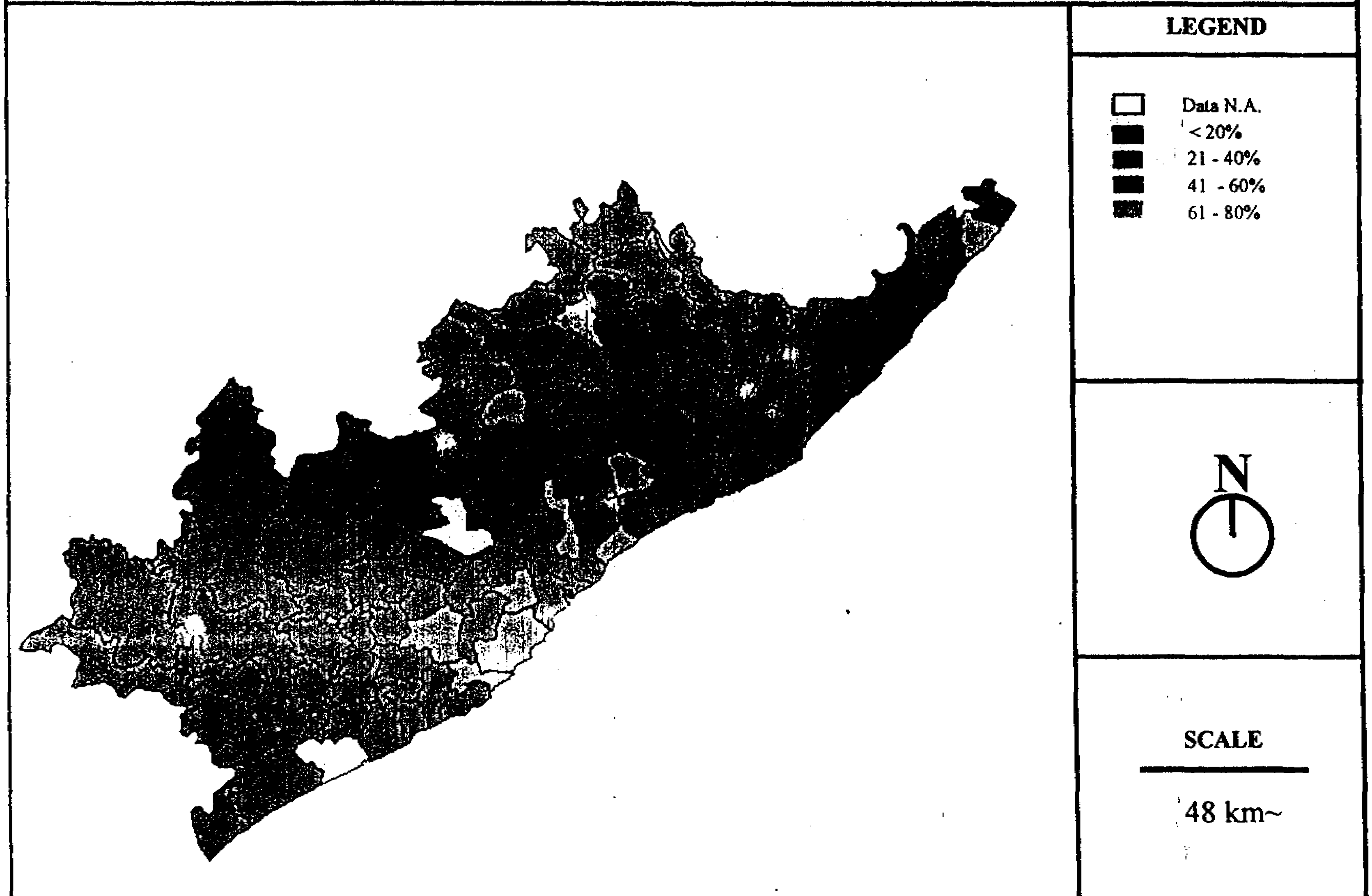
There 9 major irrigation schemes in the district which are capable of providing irrigation to nearly 116,839 ha (32 percent of total area irrigated by surface water sources). The contribution to irrigation by the minor irrigation structures in the district is nearly twice as much as that of the major irrigation schemes. There are no medium scale irrigation projects in Srikakulam. Details of various surface water irrigation schemes are presented in Annexure A.

The irrigation utilization data for the year 1994-95 shows that only 80 percent of the potential developed under the major projects was actually used while in the case of Minor irrigation tanks it was lower at 31 percent. A total of 10,438 minor irrigation tanks exist in the district and these are to be maintained by the Irrigation Department and the PRED. During the heavy rains, a substantial number of tanks in the lower reaches (in the plains and near the coast) get breached or have to be breached to minimise crop loss by continued submergence. The drainage channels are not maintained, necessitating this action.

In this district too, paddy (rice) is the principal irrigated crop. Sugar cane is cultivated in small patches. It appears that nearly 25 percent equivalent of rainfall received by the district is used for surface irrigation but in reality, a large proportion of this is contributed by rivers flowing through the district, but with catchments in the neighboring Orissa state.

In all three districts, irrigation is almost totally from surface water sources. Groundwater is used mostly for the second crops in small areas. The percentage area under ground water irrigation as a proportion of the Net irrigated area (NIA) is presented in the Map1. Only 12 Mandals have more than 20% of the NIA being irrigated by groundwater and only one mandal (Cheepurapalli of Vizianagaram district) has more than 60% area under groundwater. Hence groundwater can be used for drinking water purposes without much conflicting demands from irrigation. However the salinity of the ground water may have to be ascertained especially in coastal areas.

MAP 1: AREA IRRIGATED BY GROUNDWATER AS PERCENTAGE OF NET IRRIGATED AREA IN MANDALS OF VISAKAPATNAM, VIZIANAGARAM AND SRIKAKULAM DISTRICTS



Source: Department of Economics & Statistics, 1991, 1996, TARU Analysis 1999

Conclusion

A combination of factors ranging from medium to high rainfall, low reliance on water intensive cash crops and a history of development of surface water storage structures have led to the fact that a large proportion of the irrigation demand in the region is met from surface water sources. Given the low coefficient of variation in rainfall, meteorological droughts are rare and competition for water resources between domestic, livestock and agricultural needs, common in other parts of the state, are not seen in this region.

With surface water utilization varying between 8 (Visakapatnam) and 25 (Srikakulam) percent equivalent of rainfall received, the possibility of enhanced harnessing of rain water for utilization is seen to be low. However, there exists the potential to repair, rehabilitate and utilise existing structures and channels in a more efficient manner.

A substantial portion of surface water is being utilised for agriculture. The low reliance on water intensive cash crops and predominantly single season agriculture is likely to limit increased demand from this sector. However, any shift in agriculture markets in the region (dependent on the growth and demand from Visakapatnam city) towards water intensive cash crops, like vegetables, is likely to intensify groundwater abstraction in these districts.

The sustainability of current base flows in the perennial streams has to be reviewed in light of the irrigation schemes being executed on rivers like *Vamsadhara* and *Nagavalli* and the various Lift Irrigation schemes of the APSIDC/ITDA in the upper catchments. This would mean that any CPWS, based on infiltration or intake wells on these stream courses, have to be planned after a systematic analysis of flow data, which reflect these changes in the catchment areas.

2.1.4 Groundwater

2.1.4.1 Hydro geology

The three districts can be divided into three distinct zones in terms of hydro-geology. The first zone is the hilly region with limited ground water potential and also very little utilization. The second zone is sandwiched between the hill zone and coastal zone. This zone is mostly pediplain with mostly thick soil cover and has medium ground water resources. Mostly in weathered zone and few hard rock aquifers especially along the fractured zone. The third zone is coastal alluvial and marine sedimentaries with alluvial aquifers which may be saline at depths. This zone extends along the rivers quite deep into the second zone. There may be few paleo- rivers in the zone two and three which may yield sufficient water for local water supply schemes.

Visakhapatnam

About 10 percent of the area of the district has a fairly thick alluvial cover and the rest is covered by Khondalites and Charnockites. These are high grade metamorphic rocks and the groundwater potential in unfractured zones is limited to a thin weathered zone with a maximum thickness of about 15 m. In the hilly areas, some areas have residual laterite indicating an old erosional surface. In these flat topped hills, the thickness of the weathered zone reaches up to 25 m. or more. These hills are generally uninhabited. A few perennial springs originate from these horizons and they are used by the local community as a water source.

In the hard rocks, the main aquifers are in the weathered and fractured zones. Dug wells are common in the district with depths ranging from 5-10 m. and rarely over 10 m. The depth to water level varies between 4- 18 m. bgl. The yield of dug wells range from 30-70 cum per day. The yield of wells piercing fresh and jointed gneiss vary from 0.3-15 cum per hour, but are generally 5 cum per hour. A few patches of Gondwana sedimentary rocks are seen in Nakkapalle and Yellmanchalli Mandals which have good ground water potential. Wells in these areas yield up to 25 cum/hr.

Alluvial areas occur along the major rivers, their larger tributaries and along the coast. The widest patch of alluvium is seen near Madugula and Chodavaram areas, where alluvial fans of several tributaries coalesce and form potential areas for sinking shallow tube wells. In the alluvial areas, ground water is tapped through dug wells, Dug Cum Bore wells (DCBs), filter points and shallow tube wells. The depth to water level varies from artesian conditions to about 8 m. bgl. The shallow Dug wells yield between 50-300 cum per day. Tube wells yield between 20-60 m^3 per hour.

There is a thin strip of dunes or beach sands along the coastal zone. The depth to water level in these range between 3.55-8.65 m bgl

Vizianagaram

The Hydro geology of Vizianagaram district is similar to that of Visakhapatnam. Dug well in the coastal sands yield up to 10,000 lph for every metre of drawdown. The filter points yield up to 50,000 lph and can irrigate up to 3.5 ha of paddy. Filter points are common in the alluvial tracts of large rivers. The bore well in the Khondalites yield between 4 to 253 lpm and tubewells in the valley fills yield up to 250 lpm.

Srikakulam

The hydro geology of Srikakulam District is similar to neighboring Vizianagaram district but the percentage of land under alluvial plains is higher in Srikakulam. Nearly 60 percent of the district has slopes of less than two percent with large portion of such area under alluvial cover. In the alluvial areas, shallow tubewells or dugwells are common with yields ranging between 4000-5000 lph.

In the coastal sands, the depth to water level varies from 1.36 to 5.2 m. Filter point wells are common in the alluvial tracts of the major rivers. They yield between 4,000 to 50,000 lph. The fluctuations in water table vary from 1 to 6 m as recorded by the network of 22 hydrograph of the CGWB and the 42 observation wells of the SGWD.

2.1.4.2 Ground Water Resources

Vishakhapatnam

The total groundwater resource of the district is about 114,150 hectare metre (ha m). The distribution of this resource is uneven with the hard rock hilly regions in the north having very low resources and the southern alluvial plains being better endowed. The ground water resource is equivalent to 9 percent of the average rainfall contribution.

In general, the recuperation rate of alluvial wells is 10 times that of a well in the hard rock terrain. Shallow wells hardly yield water for irrigation and dry up in the summer months. The plains area, with alluvium, have higher resources compared to the hilly northern part which has a hard rock terrain. The hilly area acts as a runoff zone and the plains act as recharge and discharge zone. The ground water resource of the district is about 9 percent of the average rainfall. The Mandal-wise groundwater resources are presented in Annexure B.

Vizianagaram

Of the total geographic area of 6,300 km^2, the area suitable for groundwater recharge in the district is 4,909 km^2. The command area of surface irrigation is 1,048 km^2 and the rest is the non command area.

The total groundwater resource of Vizianagaram district is about 111,700 ha m.. The ground water resource equivalent is 18 percent of the average rainfall contribution, nearly double that of Visakhapatnam district. The utilisable recharge is of the order of 90,300 million m^3. This amount is large as a significant proportion of the land is in the command area of canals. The Mandal wise groundwater resources of the district are presented in Annexure B.

Srikakulam

This district has good ground water potential, especially in the coastal belt. The ayacut area of the major projects is continuously recharged for nearly 6 months in a year due to the cultivation of rice in most parts of the ayacut (about 1,809 km^2). Nearly 32 percent of the geographical area in the district is under irrigation. The replenish able ground water potential of this district is 16,400 ha m. It accounts for nearly 22 percent of the rainfall contribution in this district. A clear trend of increasing ground water recharge, per unit area, can be seen from the southern Visakhapatnam district to the northern Srikakulam district. The Mandal wise groundwater resources of the district are presented in Annexure B.

The mandal-wise groundwater utilization for all three districts is presented in the Map 2. The map shows that the current utilization in the region is generally low and only few pockets along rivers in the plain area have reached 20-405% utilization levels. The ground water can be used for drinking water purposes in the midland regions and hilly areas. In the coastal regions detailed groundwater surveys and hydro-geochemical studies may be needed. Shallow aquifers in the coastal regions may have small fresh water pockets that can be used for water supply of small habitations.

MAP 2: ESTIMATED GROUNDWATER UTILIZATION IN MANDALS OF VISAKAPATNAM, VIZIANAGARAM AND SRIKAKULAM DISTRICTS

LEGEND

<20%
21 - 40%
41 - 60%
61 - 80%

N

SCALE

48 km~

Source: CGWB, 1995-'96, TARU Interpretation 1999

2.1.4.3 Groundwater Quality

Visakhapatnam

Water quality generally depends on the type of rock and the location of the aquifer with respect to the coast in this region. The groundwater in this district is generally potable but there are a total of 1,232 habitations with sources having TDS more than 1500 ppm. The highest values are of the order of 5,000 ppm. Another 276 habitations had high fluoride content (more than 1.5 ppm) in their water source. The highest values reported are about 4 ppm. In Payakaropeta mandal, out of the 276 habitations, about 80 percent have 1.6 ppm of fluorides which is ,marginally over the WHO standards (1.5 ppm). The fluorides are often found along with TDS more than 1500 ppm. The high TDS in the plains is generally due to the high chloride content but in the hill areas it may be due to high carbonates and bicarbonates of Ca, Mg and Na in the water.

The CGWB has collected water samples during the course of systematic hydrogeological surveys and from the national network of Hydrograph stations in the districts. However, according to the CGWB, this data does not show much year to year variations. In most of the areas, carbonates are absent, except for *Saripalle* region, where it ranges from 0-84 ppm. In the upland areas, the water is generally less hard ranging from 77-200 ppm with chlorides ranging from 7 - 50 ppm.

In the flood plain and the coastal areas, hardness ranges between 10-685 ppm; Chlorides and Bicarbonates constitute 170-600 ppm and the specific conductance ranges between 880-2500 micro Siemens. In Ellamanchalli and Chodavaram Mandals, chlorides of over 1000 ppm have been reported (CGWB, undated). However, the PRED data, which is based on more extensive water sampling, reports problems of high TDS in villages situated in all types of terrains.

Of the 1,508 problem habitations, nearly two-thirds are situated in the plains but a significant 349 habitations are located in the hilly agency region. With more than 1200 mm rainfall in the hilly region with faster groundwater movement, the possibility of high TDS is generally low. For example in Araku valley, where 64 habitations have been reported to problems of brackishness, the CGWB observes that *"In the upland areas of Dharakonda, Chintapalle, Paderu and Araku, the water is less hard, with the hardness ranging between 77 to 200 ppm, very fresh with the Chloride ranging between 7 to 50 ppm and good with specific conductance ranging between 77 to 380 micro siemens."*(Suryanarayana & Reddy, CGWB). The occurrence of high TDS in these areas needs to be investigated further.

Vizianagaram

The pH of groundwater samples analysed by the CGWB indicate a range of 7.05-8.25, the samples do not have Carbonates, Bicarbonates range from 160-445 ppm and Sodium from 7.3 to 113 ppm. The water generally has low TDS, except in parts of the plains like *Srungavarapukota, Vizianagaram, Londatamarapalle, Ramabhadrapuram, Seethanagaram* and *Nathavalasa*. The total hardness ranges from 100 - 530 ppm. Electrical conductivity ranges from 260-1350 μ Siemen/cm. Samples collected by the PRED from the *Srungavarapukota* mandal show that 90 percent of the sources have TDS below 1000 ppm and the remaining between

1000-3000. In *Gajapathinagaram* mandal 26 out of 168 samples show more than 1,500 ppm of TDS.

High fluorides have been reported from Pusapatirega, Bhogapuram and Denkheda. A total of 212 habitations have greater than 1.5 ppm of fluorides in the ground water sources. About 724 habitations face a problem with brackishness with the highest values reaching up to 5600 ppm.

Iron is a problem in groundwater in two mandals - S. Kota and Kothavalasa. The recorded concentrations of iron groundwater from these two habitations are (respectively) between 1.3 and 1.5 mg/l and between 1.5 and 2.0 mg/l, and the local residents complain about the color and taste of the water. These villages are at the foothills and the presence of Iron is believed to be from the geological deposits to the north-west.

Mukkam is a coastal fishing village in Bhogapuram mandal of Vizianagaram. There are three prawn hatcheries along the coast and next to the settlement. The population of about 3,500 depends mostly on fishing. Most houses are on the seaward side and away from the approach road to the village. The village has two open wells, which are brackish; four boreholes with hand-pumps, and two MPWS sources supplying water to two cisterns, each of 20,000 litre capacity. Two of the hand pumps and both the MPWS systems are located by the side of the approach road.

The groundwater from all sources within the village is brackish, more so on the seaward side of the road. Villagers also report cases of dental fluorosis and a few cases of mild skeletal fluorosis in the village. Several young people were seen to have a horizontal line of discolouration on their teeth, but the teeth of older people showed no significant discolouration.

Fig: 3 Hand pump source for drinking water in coastal village, Vizianagaram

The MPWS schemes to Mukkam and a nearby habitation was built at a cost of Rs. 140,000 in 1994. The villagers have subsequently spent Rs. 18,000 in rehabilitating the schemes. The cisterns do not have any taps, because they get stolen or damaged through rough handling. The MPWS operator is to be paid a salary of 300 Rs/month, but has not been paid for about a year because of administrative delays.

Fig: 2 Brackish water well in coastal village, Vizianagaram

The open wells are used for laundry, and water from the hand-pumps and MPWS schemes are used for drinking and cooking. The boreholes are generally between 15 and 20 metres deep, though one was as deep as 36 metres. The two cisterns provided under the MPWS schemes each have about twelve outlets from which water can be collected. The two schemes are not being used now, as the villagers have been told not to use the pumps till the transformer is repaired. The hand-pumps are generally adequate to meet domestic water demands.

The Panchayat receives very little income from house-taxes paid by villagers, but receives about 9,000 Rs/year from the prawn hatcheries. The Panchayat needs permission before they can start collecting money for water supplies.

A proposal for a CPWS to serve Bhogapuram and another 36 villages (including Mukkam) was prepared in April 1997, and this proposal has been submitted to the Government of India. This scheme is estimated to cost Rs. 46,700,000 and Mukkam is at the very end of the proposed supply line.

In the hill areas, the quality of groundwater is generally good with conductivity less than 500. There are a few habitations where deeper ground waters have high Iron content (upto 1.5 ppm). These are isolated cases, probably due to highly reducing (lack of oxygen or aeration) conditions within the aquifers.

Srikakulam

There is a possibility of saline water intrusion in the coastal plain areas especially in those abutting the salt marshes. The pH of groundwater samples analysed by the CGWB indicate a range of 7.2-8.9, Carbonates form 0-60 ppm, Bicarbonates, 98-586 ppm and Sodium ranges from 16 to 587 ppm. The latter value indicates mixing with sea water. The total hardness ranges from 130 - 750 ppm. The higher values indicate the possibility of high hardness and can cause encrustation in water supply structures.

The electrical conductivity of the water samples ranges from 440-3200 μ Siemen/cm. Small localised pockets around *Itchapuram, Baruva, Kalingapatnam* and *Cheevalapalem* have conductivity values of about 3000 μ Siemen/cm.

The water samples collected by the PRED from habitations around *Tekkali* show conductivity values ranging from 2000-5100, indicating possible salt water intrusion. The sample with 5100 μ Siemen/cm conductivity has Chlorides of 2864. It is possible that some of the deeper horizons in this region are saline. An analysis of PRED data shows that about 1.3 million people live in 619 habitations that have a problem with brackish water and about 0.4 million in 116 habitations that have high fluorides in the water.

In the hill areas, the quality of groundwater is generally good with conductivity less than 500. The CGWB data of 28 water samples from its network of hydrograph stations show that two samples have Fluorides more than 1.5 ppm, these are from Cheevalapalem (2.7 ppm) and Amadavalasa (1.7 ppm) villages.

Tekkali, a mandal headquarters has 53 public hand-pumps, maintained by PRED, and 37 public standposts for the 3 PWS systems, maintained by the Gram Panchayat. Water is supplied to the standposts between 06:00 and 09:00 hours daily. No taps are in place at the standposts, because they have been broken and removed. The local Gram Panchayat plans to fit new taps and to weld them in place.

Fig: 4 Careful usage of the only sweet water supply point in Tekkali, Srikakulam district

In addition, a MPWS scheme supplies water to a cistern from which water can be collected from outlets set into the wall of the cistern. All taps for the cistern have been broken or removed, and local people insert pieces of plastic sheeting into the outlets to halt the flow of water. Water is supplied to the cistern between about 08:00 and 12:00, and again between about 15:00 and 18:00 or 19:00 hours. The cistern never fills, because water flows continuously from the outlets.

There are a few additional private hand-pumps. Only twelve of the public hand-pumps yield potable water, the rest produce water that has an unpleasant taste because it contains high concentrations of dissolved minerals. There are 3 mechanics in the mandal, who maintain about 175 hand pumps. All the hand pumps in Tekkali are maintained by one mechanic.

Local people do not currently pay for water supplies. The Gram Panchayat has an annual income of about Rs. 8,000,000, and spends about Rs. 1,600,000 on water supplies.

As per the data provided by PRED, who are in the process of updating their database on habitations, with source - quality problems, the predominant quality problem in the northern districts is of brackishness. The data regarding problem habitations in each district is provided in Table (2.4).

Of the 12,005 habitations in the three districts, about 28% had sources which had brackish water or Fluoride levels above 1.5 ppm. 45% of these problem habitations were located in Visakapatnam district, 28% in Vizianagaram and the rest in Srikakulam district.

A spatial analysis of this data reveals that about 70% of the problem habitations in Visakapatnam district were located in the Plains and 80% of these were reported brackish sources. In Vizianagaram, about 63% of the problem habitations were in the plains, with 75% reporting brackish sources. In Srikakulam, 74%of the problem habitations were in the plains of which 82% reported brackishness. Fluoride levels above 1.5 ppm were reported in only 27% of the problem habitations and their proportional distribution was even in the Plains and the Uplands.

TABLE(2.4): STATEMENT ON PROBLEM HABITATIONS IN THE COASTAL PLAINS AND AGENCY OF THE NORTH-EASTERN DISTRICTS					
District	Plains		Agency		Total Habitations
	Fluoride	Brackish	Fluoride	Brackish	
Visakapatnam	217	836	59	396	5378
Vizianagaram	151	430	61	294	2806
Srikakulam	81	609	35	210	3821
Source: PRED Survey, 1994, 1998; TARU Analysis, 1999					

Thus, the problem of drinking water source quality is more in the plains, where population densities are higher, irrigation and agriculture is more developed and competing demands from agriculture are also more.

It is to be noted that the Agency areas or the Uplands which house a substantial amount of the Tribal population in these districts report lesser incidence of quality problems (sparse data might be a reason). In these areas, there are problems of provision of potable drinking water, occassioned by limited availability of groundwater sources and the technical ease of extraction and supply. The nomadic nature of few tribal means that the water supply system will fall into disuse after a certain period. Also, the preference for *fresh, tasty* running water means that for most of the year, they would prefer not to access the Hand pump or any such groundwater source. The PRED solution of providing cisterns near the stream is to address this social preference, but is questionable on grounds of water quality.

In conclusion, both high Sodium Chloride bearing aquifers and brackish aquifers with non chloride high TDS zones can be found in the three districts. In the pedi-plain zone mostly high TDS zones are mostly associated with carbonates and Bicarbonates of sodium, magnesium and calcium. These can be classified as hard waters which are commonly found in semi-arid zones. In the coastal region the high TDS is associated with sodium chloride of marine origin. The high fluoride pockets are most probably to be found in the hard rock aquifers and not in the alluvial aquifers.

2.1.4.4 Present Use and Competing Demands

Visakhapatnam

Irrigation accounts for most of the groundwater use in the district. A total area of about 24,000 ha is irrigated using groundwater, over the Kharif and Rabi crops. In the Rabi season, 16,600 ha is irrigated while the rest is in the Kharif season. About 18% of the ground water is tapped by tube wells and bore wells and the rest through shallow wells. Most of this occurs in the plains area while agriculture in the hilly areas is largely rain fed..

At the district level, in 1993, ground water utilization was about 15.7 percent (CGWB, 1995). Munagapaka Mandal had the highest utilization (63 percent) followed by Kasimkota Mandal with 43 percent. Both are located in the plains and the former is likely to have reached the grey category in ground water abstraction by now.

The plains have about four times the population of the Agency areas. The population density is about 6 times that in the Agency. About 53 percent of the land is cultivated and a third of it is irrigated. Half of the irrigated area relies on tanks, whereas about a third is dependent on canals.

There is a marked difference in well densities between the Agency areas and the plains. In the plains, agriculture is well established and well densities reach up to 10 per km^2 and are increasing with the advent of exploratory drilling programme of the APSIDC and other institutions.

In the Agency areas, irrigation is restricted to valley-fill areas through Dug wells, even though at places, DCBW, borewells, filter points and shallow tube wells have been dug. Dug wells are constructed in all types of rock formations. The area under cultivation is only about 30 percent of the geographic area and less than a third of this is irrigated. Even within the irrigated area, most of the irrigation (about 70 percent) is from traditional sources like springs, waterfalls etc. The area irrigated by tanks in the Agency tract is only one-tenth (6,000 ha) of that in the plains.

In other parts of the district, energised dug wells are used on an average for about 120 days a year, working for 3 hours a day at a discharge of 22.5 m^3 per hour (roughly 0.086 ham per annum). Dug wells without pumpsets work for about six hours a day with an average discharge of 2.2.5 m^3 per hour (0.37 ham per annum).

Most of the bore wells in the district are used as drinking water sources. Bore wells yield between 1-15 m^3 per hour. The best yielding bore wells are generally found in the valley areas.

Vizianagaram

The net groundwater draft in the district was 12,483 ham in 1993 (13 percent of utilisable resources). Of the 34 Mandals in the district, the maximum draft is 32 percent of utilisable resources in Pusapatirega and the minimum in Gajapathinagaram mandal (<2 percent). At the district level, the net draft in 1993 was 13 percent. The well properties are fairly similar to that of neighboring Visakhapatnam and Srikakulam

The total area irrigated by ground water sources in this district during the Kharif season was 12,476 ha in 1994-95. However, the irrigation in the Rabi season was 9,423 ha. The main crops irrigated by ground water are Sugarcane, groundnut and tobacco.

Srikakulam

The total utilisable groundwater resources in the district are 765 million m^3 in ayacut areas and 308 MCM in non-ayacut areas. This is equivalent to 42 cm of irrigation in the ayacut and 7.5 cm in the non-ayacut areas.

For the purpose of groundwater resource estimation, the district can be divided into the ayacut area and the non-ayacut area. The total ayacut area in the district is 1,809 km^2 and the non-ayacut area 4,086 km^2. In the ayacut area, groundwater draft (1995) was estimated to be 0-6 percent (Gara). The non-ayacut area show large variations in groundwater draft ranging from 2 percent (Bhamini) to 130 percent (Gara). In parts of the non-ayacut areas, groundwater draft is very high and variable.

Mandals which have between 65-85 percent draft in the non-ayacut areas are Jalamuru, Burja, Palakonda, Ganguvari Sigadam and Srikakulam. Mandals with 85-100 percent draft are Ponduru and Pathapatnam. Kothabommalli, Polakki, R. Amdavalasa and Gara have exceeded 100 percent draft levels. This indicates the wide variation within Mandals between ayacut and non-ayacut areas.

There were 36, 076 groundwater abstraction structures in 1988-'89 increasing from 21,904 in 1981and groundwater sources accounted for about 17,500 ha of the irrigated area

A comprehensive picture of the abstraction of ground water for irrigation in the three districts is presented in Table (2.8) below.

TABLE (2.8) SOURCE -WISE IRRIGATION STATUS- NORTH COASTAL DISTRICTS

Source of Irrigation	Vishakhapatnam		Vizianagaram		Srikakulam	
	Gross irrigated area (ha) (91-92)	As % of Gross irrigated area	Net irrigated area (ha) (94-95)	As % of Net irrigated	Gross irrigated area (ha.) (94-95)	As % of Gross irrigated area
Canals	49101	37 %	33232	24 %	92461	47 %
Tanks	39163	30 %	88225	64 %	77517	39 %
Tube wells	4352	3 %	2928	2 %	10107	5 %
Other wells	19943	15 %	9548	7 %	10345	5 %
Lift Irrigation	770	1 %	807	1 %	331	0 %
Other sources	18816	14 %	2625	2 %	7050	4 %
Net Area Irrigated	126402	96 %	137365	100 %	187620	95 %
Gross Irrigated Area	132145	100 %	157472		197811	100 %

Source: District Statistical Handbooks, 1991, 1994

2.1.4.4 Changes to Aquifers

Visakhapatnam

The depth to water level varies widely over the same hydrogeological unit depending on topography, drainage patterns and fracturing. Water level fluctuations over 13 All-India Hydrograph network stations of CGWB show that water level fluctuations range between 0.5 - 4.8 m.. Most of the wells show quick response to rainfall, indicating very permeable soil conditions. In some of the areas, the groundwater fails to get recharged as it is already full to near surface levels and excess amounts are rejected as springs.

No incidence of changes in the aquifers levels have been reported from Vizianagaram district. Most of the hydrographs in the district show a gentle shallowing of groundwater, probably from the surface irrigation (CGWB 1991).

The analysis of pre and post monsoon water levels in Srikakulam reveal a marginal decline in the water table by about 0.30 m.bgl. The range of water levels observed in the pre-monsoon period ranges from 3.78 m.bgl. to 7.58 m.bgl. and vary from 1.94 m.bgl. to 4.19 m.bgl. during the post monsoon period.

2.1.4.5 Control Regimes for Abstraction

These districts have not yet experienced a competition for water resources. There are no restrictions on the abstraction of ground water and although 15 percent of the replenishable ground water is meant to be reserved for meeting drinking water and industrial requirements, this has not been enforced any where in the state. With low level of development, such enforcement is not critical in these districts at present.

2.1.5 Rainwater Harvesting

The hilly areas, with higher rainfall, are the most suitable for household level rainwater harvesting. However, this technology is not known to the local people and no investments have been made in the past to promote it. The network of minor irrigation tanks in the region effectively serve as rain water harvesting structures tapping nearly 2 to 3 percent of the rainfall.

2.1.5.1 Water Quality

Information on the quality of tank water is not available from any source. The tank water should be better in quality in specific zones of the districts where local conditions contribute salts to the underground aquifers. However, The bacteriological quality of the tank water is likely to be low due to their extensive use for washing and bathing by people and livestock. The run-off from local drains and cow dung storage pits often drains into the tanks adding to the bacteriological contamination.

Shallow wells are the traditional source of drinking water in Ellamanchalli village, and boreholes provide water for irrigation. More recently, 32 hand-pumps, two PWS schemes and one MWS scheme have been made functional in the locality, serving a population of approximately about two-thirds of the population in Ellamanchalli. The Protected Water Supply scheme supplies water to 8 wards of the village of Elamanchili, so coverage is only partial. 20% of the population of Elamanchalli have latrines. There are also about seven communal latrines, but the standard of construction is very poor.

Fig: 2 Source for a PWS, Visakaptnam

Water from a borehole inside the submergence zone of a mini check dam in neighboring Kothapalem village is the source for the rehabilitated PWS. Water is pumped to a ground level reservoir atop an adjoining hillock, from where it flows by gravity to parts of the village. Water can be collected from taps fitted to cisterns. Various interruptions to supply were experienced with the scheme initially, but the flow problems have been solved by fitting air-valves at certain locations between the reservoir and the village.

Fig: 3 Drinking water seller carrying water from open well, Visakapatnam

Within the village three different water supply systems co-exist. At one point near the Girls hostel run by the Social Welfare Department, a cistern and a hand pump have been installed. There is a tank next to this which has a hand-dug on one side. As in many villages in the coastal, brackish water zones, open wells inside or in the vicinity of tanks are used as the drinking water source. Local people favour the sweet taste of water from the well, and some household pay a person to collect and carry the water for them. There is a garbage dump at the edge of the tank and the tank is used both by cattle and human beings for bathing and washing.

The Gram Panchayat chairperson, Mrs Rama, said that the GP has instituted a license fee of Rs. 500. recently, for permission to households to drill a private borehole. A recent survey by the GP shows about 1000 households in the village having private boreholes. The Gram Panchayat has an annual revenue of about Rs. 3,300,000, of which about Rs. 900,000 is collected from house-taxes. It is possible to collect a fee for water supply along with the house tax, but politically it would be feasible only after ensuring water supply in all parts of the Muncipality.

Mrs. Rama identified major local health problems in the area as being stomach ulcers, intestinal tuberculosis, filariasis and HIV.

2.1.5.2 Quantity of Water Stored

In Vishakhapatnam district, there are a total of 5,627 tanks of which 274 are large and have an average command area of 73 ha. Smaller tanks, with average command area of 6.2 ha., were 5,353 in numbers.

In Vizianagaram district, there are a total of 9,620 tanks of which 901 are large tanks with an average command area of 57.4 ha. The smaller tanks, 8719 in number have an average command area of 7.9 ha.

In Srikakulam district there are a total of 10,438 tanks, fed mainly by rain water. Of these 3,977 tanks are large with an average command area of 48 ha, some of which are used as balancing tanks in the irrigation channels from the Medium Irrigation schemes. The rest are small with average command area of 8 ha.

2.1.5.3 Current Status

The traditional tanks in the district are still being used, but many have silted up considerably. More tanks are being built by the ID under various projects. The government does not invest on de-siltation of tanks or channels which is a maintenance function for which budgetary allocations are low. The traditional practice of de-silting the tanks and using the soil to improve the productivity of the agricultural fields has been discontinued by the farmers due to the high labor costs and easy availability of chemical fertilizers.

The tank and tank beds are under the control of various departments and institutions which takes away the responsibility of their upkeep from the local community. Under the *Janmabhoomi* programme of the state government, tank cleaning works have been taken up in some areas. In a few places the tank soils are used for making bricks.

2.2. Existing Water Supply Schemes

The existing water supply sources in these regions are a mix of private and public sources. Almost all villages have been covered under different water supply schemes ranging from simple hand pumps to piped water supply schemes under various programmes. In the plains, multiple schemes have covered some villages often leading to abandonment of the earlier schemes. Many of the high yielding borewells/tubewells have been converted into mini water supply schemes. In contiguous zones with a specific problem, like brackish water, the demand for a major piped water supply schemes is high but their requirement of water is also likely to be so high that the sustainability of the source feeding these systems is at risk.

2.2.1 Private Wells

Ground water is used extensively for most domestic needs and wherever of acceptable quality, as the drinking water source. In areas where piped water supply schemes are based on sweet water, most of the open wells have been abandoned. In areas where the deeper aquifers are brackish and the piped or the mini piped water schemes tap such aquifers, the community relies on a few community wells for water for drinking and cooking. The open wells that are used as the drinking water source are chlorinated, especially in the monsoon season, by the panchayats. Some of the larger panchayats even provide bleaching powder to households to chlorinate private wells to avoid epidemics. In the larger settlements (Ellamanchalli, Tekkali), richer households invest in private open-wells fitted with motors or hand pumps to ensure a regular supply of water. Since this water is often brackish, it is supplemented by water collected from a community source.

2.2.2 Hand pumps

In Vishakhapatnam district there are a total of 8,755 borewells fitted with hand pumps. Their current status is not known but it is reported that in the coastal belt many have gone brackish after a few years. In the hilly areas many have been abandoned as people have been traditionally accustomed to using water from flowing surface water sources.

As of 1998, Vizianagaram district had 8,378 hand pumps while Srikakulam district has 7,510 hand pumps and 170 energized wells /borewells.

2.2.3 Piped Water Schemes

There were 671 piped water supply schemes in Visakhapatnam district. They are based both on ground water as well as intake wells on rivers courses.

Vizianagaram district has 172 piped water supply schemes and 216 Mini Piped Water Supply schemes.

In Srikakulam district there are 86 piped water supply schemes and 143 mini piped water supply schemes. These are based on infiltration wells in the rivers, ground water sources or natural springs locally known as '*Bilas*'.

2.2.4 Comprehensive Piped Water Supply (CPWS) Schemes

Seven CPWS schemes are being executed in Visakhapatnam district covering a total population of about 63,830 (1991) spread across 30 habitations. The maximum number of habitations per scheme was low at six villages. Three schemes are operational in the district, the oldest, at Payakaropeta was established in 1985. One of the schemes had to be restored last year. All of them draw water from infiltration wells.

There are 3 CPWS schemes under execution in Vizianagaram district covering a total population of 104,577 (Census, 1991). The largest scheme covers 3 habitations at a cost of Rs. 21 million and has a total pumping length of 10.4 km. Only one of the schemes is fully functional and covers 4 settlements.

In Srikakulam district, there are three CPWS covering between 20 to 30 habitations. All are based on rivers and the pipe line length ranges between 13 to 23 km. Three schemes - Uddanam, Vamsadhara and Rajam-Saradhi - are currently under implementation. The largest amongst these is the Uddanam Project, which aims to cover 239 habitations at an estimated cost of Rs. 247.2 million. There are 12 more schemes (with coverage varying from 13 habitations to 151 habitations) which have been proposed for funding. These would cover 994 habitations, sourcing water from the rivers and '*bilas*' through infiltration and intake wells, to address water quality problems in the plains Mandals.

2.2.5 Supplementary Systems

In almost all the settlements visited people have more than one water supply source. The end use of the water is closely linked to its perceived quality (through taste and hardness). Centralized sources too do not provide water all through the day largely on account of the fact that they are reliant on power supply. The storage cisterns in most of the villages do not function as storage structures since many of them do not have taps or the taps have been broken long since. If the source on which these are based is perceived to be good people queue up to collect the water in pots when the water is pumped, else it is used for washing and bathing.

Almost all villages have the entire hierarchy of water supply systems ranging from open wells to hand pumps, piped water supply schemes to mini piped water supply scheme and sometimes a CPWS. Upkeep of the earlier systems depends on the quality of water supplied by the most recent system and its reliability. Cattle generally drink water from common surface water sources. The network of tanks in the districts ensures that recharge of ground water takes place and these structures also meet the washing and bathing needs of many communities.

2.2.6 Tanker Supply

Tanker supply had to be resorted to in 90 villages spread across Palasa and Tekkali Mandals in the northern part of Srikakulam district last summer. This is on account of fresh water sources (generally shallow wells in the agricultural fields) going dry in the summer months. The PRED bore the cost of water supply which had to be transported for about two months. These villages are to be covered under the *Uddanam* CPWS scheme which is under execution.

2.2.7 Social Acceptability of Schemes

The acceptability of the scheme is never a consideration during the design stage. Schemes are designed as per the norms and issues of source sustainability, local augmentation from other sources are not taken into consideration. The department does not have a clear allocation for

O & M costs and since most Panchayats do not collect charges for water supply, upkeep of the schemes become a major issue in later years.

For the community, the critical considerations for the acceptability of a scheme are the taste of the water and the location of the collection point. In the past, most schemes have been designed for providing public points only and since people have other sources of water within the house/ in the neighborhood, lack of individual connections was not cited as an issue in the villages visited.

2.2.8 Source Sustainability

Problems with regard to the sustainability of sources arise often, especially in piped water schemes. With the growth in population and water demand, pumping periods need to be increased resulting in the reduction in yields or drying up of wells. It is not uncommon to see Piped water supply schemes based on more than one source due to this problem.

In alluvial areas, with shallow freshwater lenses underlain by the saline zones, over pumping can result in saltwater ingress in to the wells. These are common problems when over pumping is resorted to cater to more villages from a single source.

The calculations for safe yield are either not done or are based on the pumping /drilling yields with little consideration to the size of the available fresh water resource. Over pumping of the sources above safe yield levels is common. This is one of the reasons why many of the villages which were fully covered have fallen back into the partially covered or not covered categories. Also, during the 1992-1993 random survey, the PRED included only those habitations which do not have quality problems in the list of covered habitations (which was different from earlier practice), thus increasing the number of uncovered habitations.

2.2.9 Cost

The accepted norms for water supply systems in the state are presented in the Table (2.9).

TABLE (2.5) WATER SUPPLY OPTIONS - COSTS AND O&M

Type	Per Capita Capital Cost (Rs.)	O&M Implications
Hand pump	200 – 4000	Little
MPWS	500-750	Low
PWS	1000 – 1500	Medium
CPWS	1000 – 2000	high

Source : PRED, 1998

As opposed to the figures above, the CPWS schemes in Vizianagaram district have a higher capita capital costs of about Rs. 6,000.

2.2.10 Operation & Maintenance

The accepted norm is that up to 10 percent of the annual RWS funds can be used for O&M. Except for CPWS schemes, the other schemes are handed over to the Gram Panchayat after commissioning. A portion of the funds collected by the Panchayat (from House tax, entertainment tax, etc) are used for O & M. The Gram Panchayats have to pay for the use of power only when they have an annual income of more than Rs. 30,000. In Vizianagaram district, the O& M cost of one CPWS system was about Rs 7 per capita per year but no collection is being made from the users.

2.2.11 Structures

The structure for the Mini Piped Water Supply schemes (MPWS) are essentially a bore-well / tube-well with a submersible pump, a pipe line from source to one or more Ground level storage tanks of up to about 20 m^3 capacity with a set of taps connected to the storage tank. The Piped Water Supply Schemes (PWS) usually have higher capacities and have an overhead reservoir. Water is distributed from this to stand posts and in some cases, to private connections. The comprehensive piped water supply schemes generally have a percolation well or other reliable water sources and supply water to a group of villages.

2.2.12 Reliability

The reliability of the system depends on a variety of factors like power availability, condition of the pipelines and the pumps. Breakdown of pumps and lack of three phase power supply are common problems. With poor construction of the bore wells, sand often gets into the borehole, damaging the submersible pump sets. The use of AC pipelines in the MPWS schemes also results in pipeline breakages, especially at the road crossing points.

2.2.13 Institutional Resources

The PRED is the nodal agency for execution of drinking water supply schemes in rural areas. The financial resources for these are allocated from Augmented Rural Water Supply (AWRS) and Minimum Needs Programme (MNP) funds from GoI, sub-mission and mini-mission funds from the RGNDWM and State Government resources. The personnel in the PRED are mainly from Engineering disciplines, supported by Geologists. The financial resources are generally budgeted for projects and there is no separate budget for O & M. Design are prepared by the PRED as per recommended norms and physical works are handled through local contractors.

The PRED is primarily an engineering organization with capabilities of design and supervision of physical works. The organization has limited interaction with local communities except during problem-solving situations or more recently in community-based programmes like the Janmabhoomi. The organisational capacity for community mobilisation and participation seems limited.

There are several village level groups and institutions, most of them initiated by the Government to deliver services under various programmes. Most of the services are social, health and literacy related activities. There are also many NGOs working, especially in Agency area. It was observed that there are only a few NGOs working with the villagers on issues related to drinking water supply. The growing conflicts between leftist armed groups in the area has created problems for the NGOs in recent times. However, the technical capability of these organizations to manage and carry out O&M operations is limited; they generally have people from social sciences and other non-technical backgrounds.

The village level groups are also constrained by multiplicity of programmes they have to respond to. However, there are cases of NGOs helping villagers to setup their own water supply schemes which have succeeded in mobilising the users to share costs and mange the O&M.

2.2.14 Inter-village Disputes

Inter-village disputes are not common in these regions. In fact, there are instances where drinking water from a well in one village has been transported to meet the needs of other villages in a zone affected by brackishness. But these are specific instances where the community and the PRED have been able to work out local solutions and can not be generalised to an approach to solve the water problem in the region.

2.3 Problems Specific to the Hilly Region

Each village in the hilly Agency Mandals, has several habitations. The hilly areas are predominantly inhabited by the tribal populations. Since independence, there has been a steady migration of other communities into the hills leading to changes in agricultural practices, land related conflicts and a shift in the aspirations of the indigenous people. The non tribal communities generally live in the valley areas which have more fertile soils while the tribal are concentrated in the ridges and hill slopes. Of late, concerns regarding forest protection and the desire for main-streaming the tribal have resulted in the relocation of many communities in the valley areas, in roadside settlements. Despite this, a considerable proportion of the population lives in inaccessible habitations and in the forests.

It is very difficult to design systems for drinking water supply to the smaller habitations, located far from the road, on hill slopes and hill tops. Often they have a population of less than 200, and are fairly dispersed even within a habitation. Many still practice shifting cultivation and may have more than one habitation depending upon the slope of the land, its productivity and the cycle time before the same patch of land can be brought under cultivation again. Therefore, it is likely that a source may be used only for a certain period of year and may fail into dis-repair soon.

The requirement of water is generally quite small and is collected from the nearest spring or stream. In the past, a series of springs flowed through the area but overtime, due to deforestation and other interventions in their catchment area, the yield in many of the streams has reduced. Biological contamination of the sources is a serious problem since people defecate along stream banks and the region has a large cattle population. Epidemics of water borne diseases have been reported with fair amount of regularity in the hilly areas, in recent years.

With deforestation and growth in the population, water demand and supply mismatches have started to manifest themselves. Bore holes for drinking water have been dug in the region since the late1970s and early 80s but this is expensive and requires considerable logistical support.

The ground water potential in the region is generally low because most of these hills have granitic/gneissic hard rocks with few fractures and a shallow soil cover. The hills act as runoff areas and their water holding capacity is very limited. The only potential areas for tapping water are the narrow valleys and the few perennial springs. The PRED provides cisterns for collection of the spring water with a tap attached to the cistern at the collection point. The water is not treated in any manner and people have to walk the same distance as they did to the spring to collect their water supplies.

2.4 Conclusions & Recommendations

An analysis of water resources in the three northern coastal districts show that:

1. Surface water resources have been harnessed moderately and utilization is moderate to high, with the level of utilization increasing from Visakapatnam to Srikakulam.

2. Potential exists to utilise groundwater resources in the Plains area of all the three districts, except in certain over-draft pockets (like the non-ayacut mandals in Srikakulam and mandals in the vicinity of urban Visakapatnam).

3. The Potential of utilisable groundwater resources in the Hilly or Upland areas (Agency) of the three districts is low and is further constrained by the spread-out nature of the population and problems of access.

4. Even where potential exists for utilising groundwater sources, it is noted that the plains area has fairly large areas where the quality of water is in doubt due to presence of excess Chlorides.

5. The three districts have a few perennial rivers and streams. However, with the construction of medium irrigation schemes and Lift irrigation schemes in the upper catchment as also the diversion of water to feed the drinking water needs of Visakapatanam, it is advisable to estimate safe yields and flows before utilising these sources by intake or infilitration wells for medium to large CPWS systems.

6. Each of the districts have a number of MI /PRED tanks, often exceeding the number of habitations. There is a possibility of utilising some of the tank recharge areas (with adequate rehabilitation and maintenance) for groundwater extraction, specifically for drinking water. This would be a fairly reliable source of drinking water. However, considerable amount of hydrogeological surveys would be needed to select the sites and prevent direct seepage of water from the surface sources, which are likely to be muddy during the rains and contaminated by coliforms. The ownership structure of these tanks needs to be investigated further, but most appear to be owned by the government.

7. In the hilly areas, hand pumps can be installed which are fed by small seepages or in the fractured hard rock zones nearest to the settlements. Since the size of habitations is small in the *Agency* area, these hand pumps can be a reliable source of potable water. However, Calyx drilling or specialised rigs which can be assembled on site may be required. These may cost about 150-200 percent more, but they can provide reliable supplies.

8. The other option is of digging shallow wells, closing them with a concrete cover and installing hand pumps over them with a proper drainage. These have been tried out successfully in inaccessible terrains of the Himalayas. A seepage rate of 0.5 - 1 lpm is sufficient because of the large storage of the wells (3+ m^3). Some of the prospective areas may be near the stream beds.

9. The cultural barriers to consumption of water from a Hand pump and perceptions regarding its taste may take much longer to overcome. People in these regions prefer the taste of running water from the streams which have serious bacteriological contamination as several settlements are located along the streams. These streams are used both by the people and the cattle and defecation along the streams is common.

10. Any programme for water provision in the Uplands (Agency) has to be preceded and complimented by health education. The ITDA is the nodal agency for all programmes in the Agency areas and partnerships need to be built with them. Their network of Para Health Workers is fairly well developed, with one health worker for every three settlements. They are an important resource for health education and community mobilisation interventions in the Agency areas.

11. In the brackish water areas, the shallow groundwater in tank-bed areas is likely to be fresh water and ground water extraction by shallow wells or DCBWs are viable options for drinking water. However, the submergence area of these tanks should be of at least one hectare or more in size. In villages where no such tanks exist, and ground water is brackish, artificial recharge of water collected during the monsoon period can be an option, but this is possible only in certain areas where a reliable surface water source exists nearby. However, management implications of such options need to be worked out.

12. The populations densities in the plains is high (300 to 500 persons per km^2). The average population per village is about 2,500. These villages have fewer hamlets (2-3) with lower spatial dispersion. The average village sizes are about 5 km^2 . Hence, the yields of the sustainable wells in such areas have to be much larger and more than one option may be necessary. Systems have to be designed with at least 50 percent redundancy for periods when the monsoons fail and people have to depend on ground water sources.

While the three northern coastal districts have problems of provisioning potable water to the population, these districts have the surface or groundwater resource potentials to tackle the problem.

Amongst the three districts, Srikakulam has the relatively worse record on health and poverty parameters. However, the CPWS schemes under execution along with timely execution of proposed ones would tackle the *Poverty of water* problem effectively.

Vizianagaram has pockets with quality problems, but the resource potential in and around these areas seems adequate. Also, this district is being assisted by the RGoN, which has initiated work along with the PRED in 14 habitations in 1998. The NAP proposes to expand in phases and cover about 500 habitations over 5 years. Their methodology based on scientific delineation of groundwater sources and community based planning would go a long way in augmenting PRED capabilities in both and also solving the *water problem*.

In Visakapatnam, the major problem of water quality (brackishness) is predominantly in the plains and coastal areas, which are more developed in terms of infrastructure and resource development. The poverty parameters which pull Visakapatnam into the 'Poor' category have to be seen in the light of the high spatial differentials. Poverty of health and economy is high due to the tribal population and development features of the Agency area where the IMR is almost double that in the Plains (Aide memoire, DFID), rather than these parameters in the Plains, which actually suffer the poverty of water. The problems of provision which exist in the Agency have attendant problems of access and attitudes, which may require interventions more from a health-extension perspective rather than technology-fixes for water supply.

3. WATER RESOURCES IN NALGONDA DISTRICT

3.0 Background

Nalgonda district lies between in the North Latitudes 16 ° 25' and 17 ° 50' and East Longitudes 78° 40' and 80° 05'. The district forms the southern part of the Telangana Region and is bounded in the north by Medak and Warangal districts, on the south by the Guntur and Mahaboobnagar districts, on the west by Mahaboobnagar and Rangareddy, and on the east by the Khammam and Krishna districts.

Nalgonda has a total of 1,115 villages and 59 revenue Mandals. It has an area of 14,240 km^2 and a population of 2.8 million (Census, 1991). The district is predominantly rural, with villages housing a population of 2.5 million. The decennial population growth rate (1981-91) was 25 percent. Agriculture is the main occupation with 32 percent of the main workers classified as cultivators; and about 43 percent as agriculture labor. The population density of the district is about 195 persons per km^2.

The poverty indicators too reflect the under-development of Nalgonda, 40 percent of the population lives below the poverty line, the literacy rate is amongst the lowest in the state at 38 percent (female literacy is lower at 25 percent), and the IMR, CMR are high at 53 and 77 per thousand, respectively.

This district is situated in the upper catchment of the watersheds of the tributaries of Krishna river. The soil thickness is generally low and most of the hilly areas are unsuitable for cultivation. Only about 40 percent of the district area is under cultivation as against available 70 percent.
The salient land use features for the district are presented in Table (3.1).

TABLE (3.1): LAND USE IN NALGONDA DISTRICT	
Population (1991)	2.8 million
Population Density (per km^2)	196
Irrigated area to geographic area (%)	22%
Cultivable area to Geographic area (%)	70%
Irrigated area to Cultivable area (%)	32%
Source: Census of India 1991; PRED, 1998	

3.1 Water Resources

3.1.1 Rainfall

The district generally has hot and dry summers except during the SW monsoon. The temperature begins to rise from February, and May is the hottest month in the year with a mean daily maximum temperature of about 40°C. December is the coldest month with a mean maximum temperatures of about 30°C and mean daily minimum of about 16°C. The average annual rainfall in the district is 772 mm. About 71 percent of the annual rainfall is contributed by the SW monsoon. The rainfall in the district increases from SW to NE. The climate of the Nalgonda district can be characterised by dry and semi arid and the potential evapo-transpiration is 1,381 mm.

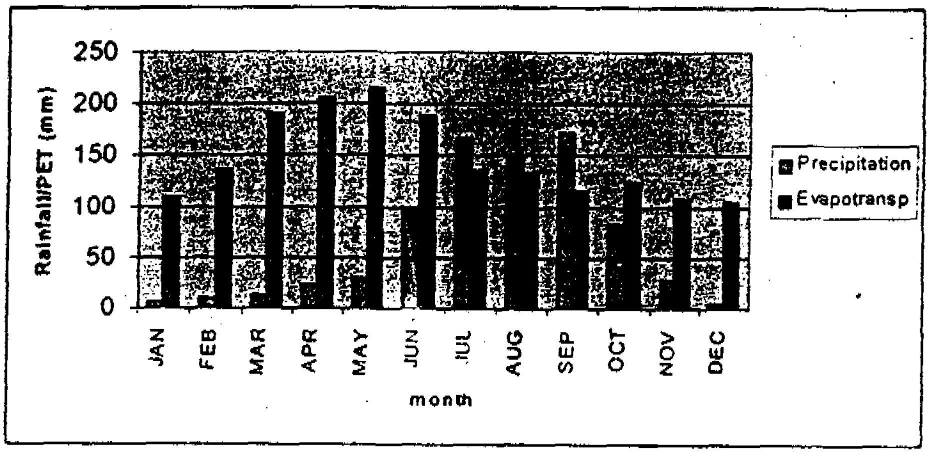


Figure 7 Rainfall and potential evapotranspiration, Hyderabad

Hyderabad is the nearest station to Nalgonda for which long time rainfall data and potentially evapotransipiration data is available. The data shows that this station gets more rainfall than PET for three months in a year. Water demand for paddy, which is the most common crop in this region as to be met mostly from irrigation. With large areas situated without sufficient sources of surface water irrigation means that ground water has to be tapped even to support crops like paddy which is grown during the period of July to October-November. The second crops are totally dependent on ground water except in the command area of Nagarjuna sagar canal system. There are pockets in the district were sugarcane is grown from ground water sources which causes is a major conflicting demand as against drinking water. The water supply personnel informed that whenever powercuts are common ground water availability from drinking water borewells improve.

3.1.2 Drainage

Nalgonda district lies in the upper part of the Krishna river basin. The rivers are shown in the Map - III. All the rivers, except the Dindi, are tributaries of the Krishna. Rivers Musi and Dindi enter the distr t and join the Krishna whereas the other tributaries of the Krishna originate within the district. The general drainage direction of the tributaries is from NNW toward SSE.

The Krishna river has a catchment area of nearly 0.2 million km² at the point of Nagarjun Sagar. Nagarjun Sagar has a gross storage of 11,559 million cubic meters. The Nagarjun Sagar Left Bank Canal irrigates the south-western portion of the district for about 10 months in the year before entering Khammam district. With the construction of the Srisailam left bank canal, nearly half of the western part of the district would be irrigated by the two canal systems of Srisailam and Nagarjun Sagar drawing water from the Krishna river. The command area of different types of schemes is presented in the Annexure A. Sixty four percent of the command area of surface irrigation structures is under the Nagarjun Sagar project. Minor Irrigation tanks contribute to about 17 percent of the irrigation potential. This estimate takes into account only those structures that are maintained by the PRED, for which the data was available.

The alignment of the Srisailam Left Bank Canal (SLBC) canal runs for about 100 km length within the district, along the southern and south-eastern edges of the Fluoride affected zone. It is still under construction and is expected to be completed by 2002. The KDWT award on inter-state sharing of Krishna waters allocates about 800 TMC of water from the Krishna river for Andhra Pradesh. The states are expected to utilise their allocations by the year 2000. States are also permitted to utilise in excess with the provisio that the state would not claim the excess as an entitlement after 2000. In order to maximise the state's allocations of water for irrigation under the KDWT award, the state government is going to pump up water from the Srisailam reservoir upstream of Nagarjun Sagar, into a series of balancing reservoirs. Once the SLBC project is completed, the water will come through gravity but until then the state has made standby arrangements for pumping up the water. It is to be noted here that *the SLBC project is being taken up under the initiative of the state government and that the project is still to obtain clearance from the Central Water Commission.*

The utilization of Krishna waters, is high on the agenda of the state government as it would irrigate substantial areas of the dry Telangana and Rayalseema regions. This has also been an issue for political mobilisation for over a decade. Most of the canal works have been completed, only the tunnels need to be built which will add up to about 40 km.

The run-off in the district is calculated to be about 20 percent of the rainfall. The total run-off would be about 2,200 MCM. A considerable part of the rain water could be collected by the tank systems in the district, but a substantial number are in need of repair and rehabilitation..

3.1.3 Present use

Of the gross irrigated area of 266,654 ha in 1993-94, surface sources accounted for 53 percent. Despite considerable investments in minor irrigation structures in the district, the contribution to irrigation by tanks remains low at 5 percent. This district has nearly 8 percent of its area under seasonal and perennial water bodies as per the toposheets, but most of them do not provide any dependable irrigation at present.

TABLE (3.3) SOURCE WISE GROSS IRRIGATION IN NALGONDA DISTRICT (1993-94)		
Source	**Area (ha.)**	**% of total**
Canals	127151	48%
Tanks	14162	5%
Total groundwater	107865	40%
Other sources	17476	7%
Total	266654	100%

Source: Department of Economics & Statistics (1995)

The utilization of irrigation potential created by all the projects, except the Nagarjun Sagar and the Gandhi Sagar, is lower than the desired level, with some projects not providing any irrigation benefits at all. There are about 1,500 MI tanks in the district which need urgent restoration out of a total of 4,100 tanks managed by PRED. Continuous neglect of O&M of the tanks would deprive communities of a seasonal water source in this semi-arid region. It is not clear if some of these tanks lie in the command area of the NSP and if that is the reason for their disuse. Also, hydrogeological investigations and PRED surveys have indicated more than permissible levels of Fluoride in waters in the vicinity of the tanks. So, even if these water harvesting structures contribute to greater availability of water, the quality needs to be verified on a case-to-case basis.

Considering an average of 1 m irrigation demand from the surface water, the total volume works out to be 13 percent of the rainfall contribution in this district. No estimation are available with regard to the use of surface water for irrigation except in the command areas of the tanks. With multiple departments having responsibility for irrigation, revenue collection, etc.; the data on surface water usage will need further investigations.

3.1.4 Groundwater

3.1.4.1 Hydrogeology

This district is contiguous to the Mysore plateau and slopes from W and NW to SE. The general elevation varies from 80 m to 480 m amsl. In general it has a rolling topography typical of gneissic country. The Western part of the district is hilly, where some of the hills attain an altitude of up to 600m amsl. In the southern part of the district, along the Dindi and Krishna rivers, quartzites along with gneissic granites, stand out as prominent hills interspersed with massive granite hills. Four major geomorphic units are recognised in the district; denudational hills , Dissected pediment, Pediplain and valley fills.

Almost the entire district is covered by Proterozoic and Archaean rocks. The Archaean are older metamorphic rocks comprising Amphibolites, Pyroxenites, Peninsular gneissic complex with foliated granite gneisses and some granites. The Proterozoic formations comprises quartzites, shales and limestones. The recent alluvium, comprising sands, gravels and sandy clay occur as narrow patches along the river courses. The maximum thickness of the alluvium is about 10 m. These soils are mostly mixed sandy loams and black cotton soils.

Groundwater occurs in almost all the geological formation of the district, though the aquifer properties vary with the rock type. The water-bearing formations of the district can be broadly divided into three categories:

1. Hard rock Archaean crystallines
2. Consolidated meta sedimentaries
3. Unconsolidated alluvial deposits

In the former two types of rocks, groundwater occurrence is predominantly controlled by the fracture zones. The fracturing continues to more than 35 m and aquifers are common upto those depths. The open spaces in the fractured zones decrease with depth. The specific yields in granitic terrain ranges from 1 to 3 percent. In the meta-sedimentaries, groundwater occurs along bedding planes, joints and fractures. In limestones, groundwater occurs mainly in solution channels, caverns, joints and fractures. In unconsolidated alluvium, groundwater occurs under water table conditions. Generally, dugwells are used in these areas for abstraction of ground water from alluvial areas.

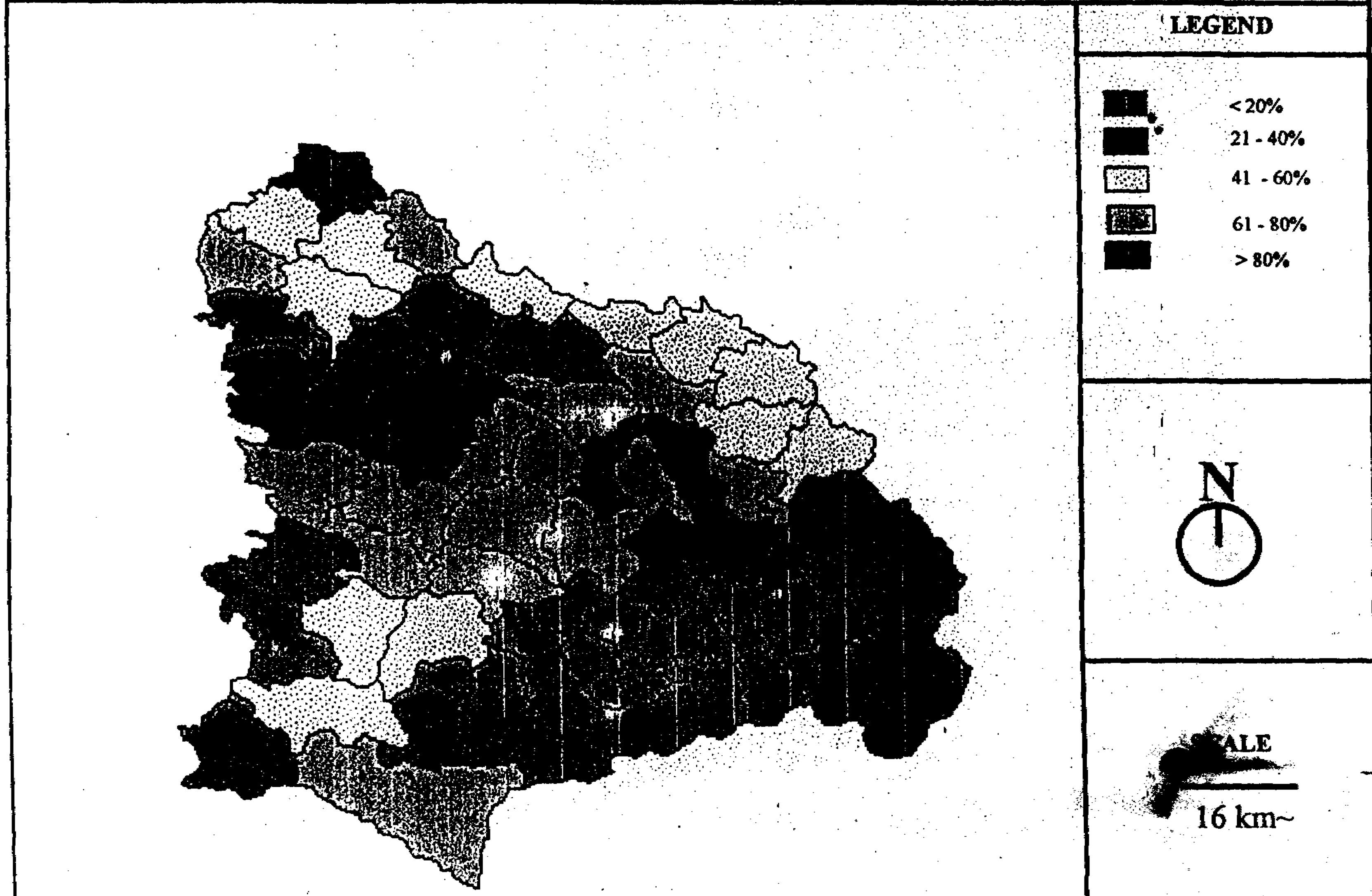
The irrigation dugwells are about 4-20 m in diameter, often deepened into the hard rock, yielding about 50-180 m^3 per day with 2-4 m drawdown which takes about 12-48 hours for full recovery. Borewells yield from nil to more than 500 m^3 per day.

The maximum well density was about 8 wells per km^2 in the western and northern Mandals of Bhongir, Ramannapet, Mothukur and Nakrekal. The north-eastern Mandals of Yadigirigutta, Thungathurti, Suryapet and Chandur had well densities of 7 wells per km^2 . In the other seven Mandals, densities are less than 5 wells per km^2. The lowest density of about 2 wells per km^2 are observed in the canal command areas. The gross groundwater irrigated area in the district is 130 percent of the net groundwater irrigated area (DoE&S, 1998). There were a total of 38 hydrograph network stations in 1991, of which the only well was a borehole (at Azampur). Twelve wells showed a decline in groundwater levels, whereas 25 wells showed a slight increase in water levels over the 1976 to 1991 period.

The mandalwise groundwater utilization is presented in the Map 3. This estimate is based on 1995 CGWB estimates(1993 data) with 2% annual increase in groundwater use. The map shows that in many of the central, western and northern mandals the groundwater utilization is high to very high. This region lies in hard rock terrain and the storage volume reduces at depth. When the utilization is about 40% or more, many of the shallow wells are likely to dry up and the area feasible for borewells also gets restricted to few fractured zones. The reported failure rates of borewells by PRED support this.

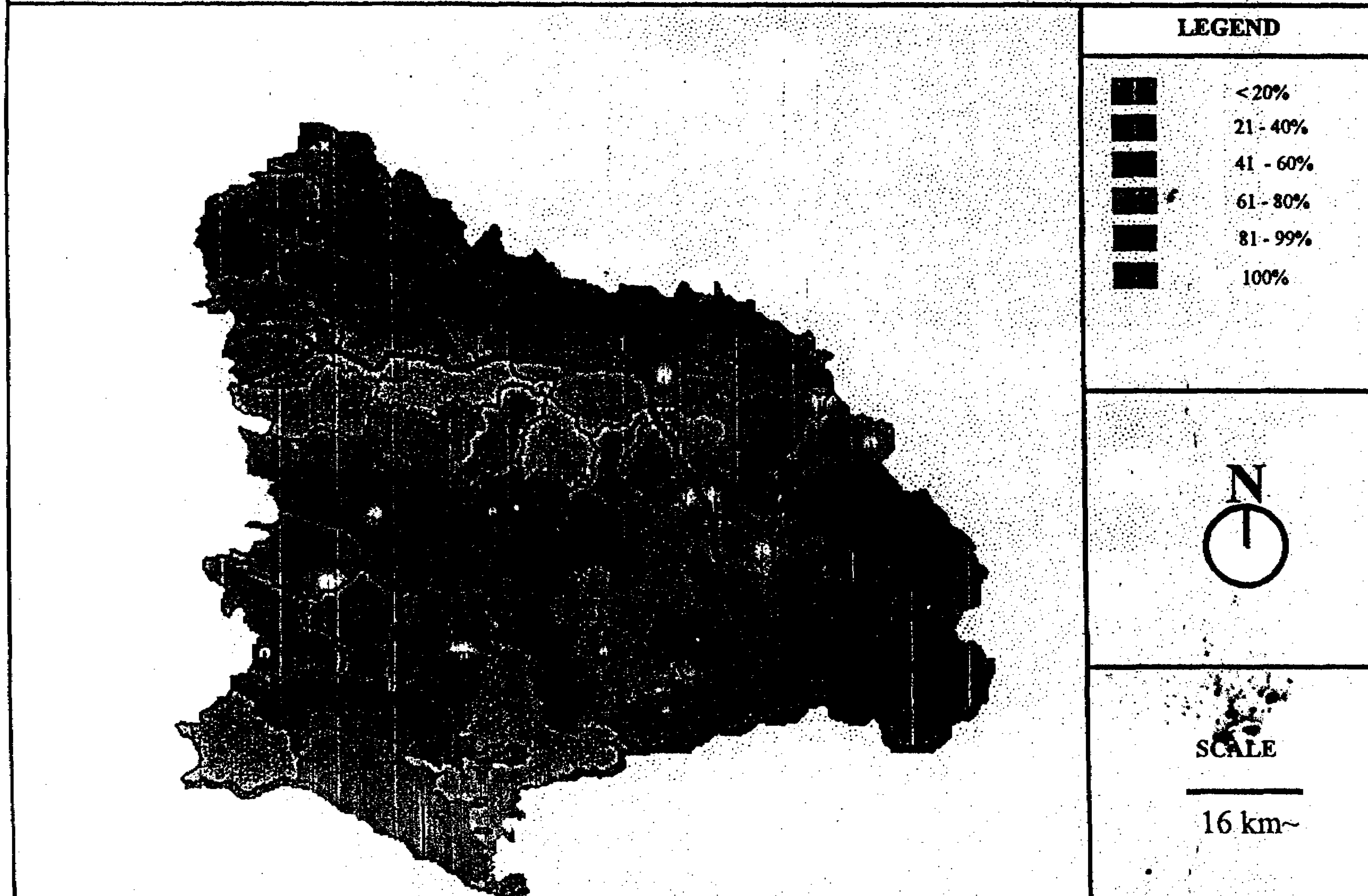
The percentage of area irrigated by groundwater to net irrigated area is presented in the Map.4. In the central and northern zone(tank irrigated areas) the ground water potential is low an are irrigated by ground water as percentage of net irrigated area is very high. The irrigation demand conflicts with the drinking water needs considerably. In the canal irrigated areas, the groundwater irrigated area as percentage of net irrigated area is lower.

MAP 3: ESTIMATED GROUNDWATER UTILIZATION IN MANDALS OF NALGONDA DISTRICT



Source: CGWB, 1995, TARU Interpretation, 1999

MAP 4: AREA IRRIGATED BY GROUNDWATER AS PERCENTAGE OF NET IRRIGATED AREA - NALGONDA DISTRICT



Source: Department of Economics & Statistics, 1997-'98, TARU Analysis 1999

With considerable demand from the irrigation, the sustainability of groundwater based water supplies is likely to be low. With additional problems of fluoride in the western part of the district, feasibility of developing local sources for drinking water is not advisable. At best, the ground water sources can be sued for non-drinking domestic uses.

3.1.4.2 Quantity

The latest estimates available show that the total replenishable ground water resource of the district was 119,415 ham. At the time of evaluation, the net draft was 46,132 ham. (CGWB 1995). The Mandal level ground water resources and their utilization is provided in the Annexure A.

3.1.4.3 Groundwater Quality

The Specific Conductance values of the samples collected by CGWB, indicate a range of 109-5629 μ Siemen/cm. However, the general range is likely to be 500 - 2000 μ Siemen/cm. Water is generally alkaline with pH more than 8 in most of the cases. The alkalinity is mostly due to Bicarbonates. With increase in salinity, there is corresponding increase in Chloride and Sulphate anions. The quality of groundwater also shows high variations over short distances. The highest saline tracts (more than 3000 μ Siemen/cm) are observed to be mostly confined to areas falling under the command of the Left Bank Canal of the NSP, which falls in the south-western part of the district.

Saline soils are also reported downstream of tanks due to shallow groundwater levels and evaporation. The fluoride content is highly variable. The pink granites, situated mostly in the western parts of the district, are reported to have higher flouride content mostly in an easily dissolvable form. Fluor-apatite, biotite and hornblende are other minerals with higher concentrations of fluorine. Weathering of these rocks releases the fluoride in to the water. Since fluorine is highly soluble in water, it does not re-precipitate unless the water evaporates completely. Such situations occur where the seepages from tanks etc evaporate in summers. The precipitated fluoride again dissolves in the rainy season.

In general, groundwater with high levels of fluoride is reported to contain low amounts of Calcium. The fluoride content of water is positively correlated to Bicarbonates. In areas where Kankar (re-precipitated Calcium Carbonate nodules in soils) beds are seen, the fluoride content is reported to be higher. The fluoride content shows very high variation even amongst water from different wells of a single village. Very little correlation is reported between the Fluoride content and the well-depth. It is not clear whether there is any significant difference in fluoride content between wells and borewells. Fluoride is reported to be present in high concentration in some millets, but "vegetation" are reported to have low concentrations (IWACO, 1991). However, there is contradictory hypothesis regarding concentration of Fluoride in leafy vegetables grown by irrigation with high fluoride water.

It is difficult to use the data available on fluoride levels in drinking water sources as it has been collected at different points in time, covering different water sources and geographical areas, and time series data for the same source has rarely been collected. The sample survey, conducted over 1991-93 for the Rajiv Gandhi National Drinking Water Mission (RGNDWM), was methodologically flawed as it recorded the highest level of fluoride and TDS found in any source within the village. It is only recently that the PRED has started conducting repeat surveys, but this data pertains to the worst affected Mandals, where both fluoride levels and the prevalence of fluorosis are known to be high. As per the sample survey (limitations of which have been stated above), there are 1,122 fluoride affected habitations in the district. The district was proposed to be covered under a Netherlands project Assisted Project (NAP, details in the following sections) which attempted the sub-zonation of the area into A, B,C and D areas. Zone A was the core area with high fluoride concentrations, B, the area adjoining it while C and D did not have high concentrations of fluoride but faced water scarcity. This classification did not have much scientific basis, since high fluoride levels have been reported from areas other than Zone A and B, but was a rough working definition for project design purposes.

The distribution of populations exposed to various concentrations of fluoride across the fifteen Mandals, based on the most recent PRED estimates, is presented in the following Table (E.1).

TABLE (3.1): FLUORIDE CONCENTRATION IN DRINKING WATER SOURCES IN THE WORST AFFECTED MANDALS & POPULATIONS AFFECTED (1991)

MANDAL	FLUORIDE RANGES (PPM) & POPULATION DEPENDENT ON SUCH WATER, AS %AGE OF MANDAL POPULATION				
	<1.5	1.5-2	2-4	>4	Total (100%)
Bhongir	73%	15%	12%	1%	107142
Chandur	1%	28%	46%	26%	41095
Chintapally	13%	26%	43%	18%	40228
Chityala	55%		40%	5%	48123
Kangal	55%	3%	42%		34889
Kattangur	21%	45%	34%		39,467
Marriguda		1%	44%	57%	33874
Munugode	5%	23%	52%	20%	38149
Nakrekal	22%	65%	13%		44905
Nalgonda	54%	8%	26%	12%	45827
Nampally	18%	23%	44%	15%	36100
Narayanpur		5%	86%	11%	39693
Narkatpally	14%	26%	45%	15%	40313
Shaligourara	70%	20%	10%		40458
Tipparthi	64%	13%	19%	4%	41438
Grand Total	37%	20%	33%	11%	703301

Source PRED, 1998

About a third of the population in these Mandals (260,000) has a safe drinking water source while 11 percent (77,000) have very high concentrations of fluorides in their water. The rest (53 percent or 372,000 persons) are exposed to fluoride levels ranging between 1.5 to 4 ppm.

The IWACO study (1993) found that the Fluoride content in 20 sample surface water bodies in the district, ranges from 0.35 ppm to 4.0 ppm. The average Fluoride values for all the tanks is 1.6 ppm and average value for surface water bodies with less than 1.5 ppm, is 0.8 ppm (9 out of 20 samples). The rest show an average of 2.3 ppm. The very high Fluoride content of 4 ppm was observed in the western margin of the district from streams flowing eastward. Moderate values of 2 ppm were observed in the southern part of the district; whereas very low Fluoride values (less than 1 ppm) were observed in the north-eastern part of the district. Tanks located in the valleys of large fracture zones are found to have higher Fluoride content. This may be due to lack of dilution effect from waters outside the high fluoride zone. It may be mentioned here that the Nagarjunasagar canal water has Fluoride levels of only 0.5 ppm.

3.1.4.4 Present Use & Competing Demand

The area irrigated by groundwater was 107,865 ha (DoE&S 1993-94). In this semi arid region, at least 1 m of irrigation is required for growing most of the crops like rice and may be up to 1.5 m for crops like sugarcane. The net draft estimates of CGWB of 46,132 ham seem to be an under-estimation. High ground water utilization is concentrated in the non-command western parts of the district. Since nearly 120,000 ha are covered under the NSP canal, the district level data fails to reveal the real ground level situation in the over extracting regions of the district.

Almost all the western Mandals have reached grey or dark status(65% to 85% and >85% utilization levels). The high ground water draft region is also the fluoride affected area. In Nalgonda district, 13 Mandals have been declared partially dark (59 villages), mostly in the western part. The ground water use is about 10 percent of the rainfall. Given an average of 8-10 percent of rainfall recharging the ground water in hard rock terrains, this figure is rather high and unsustainable without considerable recharge from surface water irrigation.

3.1.4.5 Changes to Aquifers

Depletion of groundwater in hard rock aquifers generally does not cause significant changes in its properties. The data on long term changes in water levels is available from the CGWB and the State Ground water Board. Five hydrographs show a declining trend out of a total of 26 network stations. All of them are situated in the western parts of the district.

It is reported that water from existing groundwater sources of Water Supply Schemes (PWS or MPWS) are available during periods when there is no power supply. It can be inferred that lack of power supply hinders abstraction for agriculture and also provides enough time for recharge of the aquifer, thus enabling withdrawal for drinking water supply. This would mean planning for sufficient redundancy in the event of utilising groundwater sources for drinking water supply.

3.1.4.6 Control Regime for Abstraction

Legislation with regard to ground water abstraction exists in the state but the administrative mechanisms to enforce it is absent. The banks are given the list of grey and dark blocks and asked not to give loans for groundwater related investments in these areas but this is rarely a deterrent for commercial farmers who can invest and recover the costs quickly.

3.1.4.7 Potential for Increased Aquifer Recharge

There is a scope for increasing the recharge of aquifers by artificial recharge by renovating the tanks and by direct injection into the larger fracture zones. The NGRI, Hyderabad had conducted some experiments in the similar terrains.

3.1.5 Rainwater Harvesting

Rain water harvesting at the household level has not been tried in the rural areas of the district. In neighboring Hyderabad city, government is actively encouraging rainwater harvesting. By such methods, it is possible to tap up to 60 percent of the rainfall under these conditions.

The tank systems are the rainwater harvesting structures in this district. There are about 4,100 small and medium tanks (<40 ha command area) and few large tanks in the district. Some are old structures while others are built by the government under various programmes but their maintenance is irregular.

3.2 Existing Water Supply Systems

The drinking water is mostly collected from government water supply systems. Most of the shallow wells dry up during the summers and people rely on centralized systems or a few private bore wells.

The northern Mandals of the district draw their drinking water from the Musi river, which passes through Hyderabad city, and carries a high load of pollutants. The PRED has received an allocation from the RGNDWM for a CPWS scheme for this region but has not been able to identify a sustainable ground or surface water source in the vicinity. The other possible likelihood is to take water from the HMWSSB. The southern and eastern parts of the district, irrigated by the Nagarjun Sagar Left Bank Canal and the Peleru rivers respectively, do not face water scarcity or quality problems.

The approaches to address the problem of high fluorides range from provision of a new or alternate source of water containing acceptable concentrations of fluoride; blending the water with another source containing low fluorides; treating water at the point of use; treating it at the source; or transporting safe water to the population.

Almost all defluoridation techniques, both household and community level, have been tried in Nalgonda over the last two decades, by a variety of institutions. Since most of them work at lower pH (less than 7) and water in most parts of the state is alkaline (with pH ranging between 7-8.5), it needs to be made acidic first, for the treatment to be effective, and then neutralized, to make it potable. Any variation in the quantities of chemicals used affects both the taste and the properties of the water. Household level treatment units have therefore not been successful while the larger community level units, have high operations and maintenance costs, which are beyond the means of the local panchayats who are meant to run them. The only community level unit functioning in the district, is run by the PRED.

In 1983, the district was identified for coverage under the Netherlands Assisted Project (NAP), AP-I and later AP-III. The project investigated several options ranging from tapping safe local sources, blending water, household level treatment, CPWS schemes, artificial recharge methods to increase well yields, etc. over the last 15 years. Detailed hydro-geological exploration was also conducted and a series of options were drawn up. The project found that it was not possible to use ground water in Zones A and B and explorations were focused in Zones C and D. Even in these areas, the success rate was between 40-50 percent and over extraction for irrigation was reported to be a major cause of failure of wells.

The ground water based option recommended the drilling of about 775 wells in 226 habitations, and the establishment of 35 community defluoridation plants[1]. Given the high failure rates of the wells, this option had serious cost implications, both in terms of capital costs and O&M of the defluoridation plants. Some of the recommendations for the sustainability of wells, such as the creation of 'well sanctuaries' by acquiring land around the wells and preventing the draft of ground water in the area, were not practical given the small land holdings (61 percent of cultivators are marginal farmers) and predominantly agricultural occupation profile of the district.

While the AP- III did not result in the initiation of a project, it generated a large amount of information on water quality and availability. The fall side of this was that since the district was being considered for coverage under AP- III, it did not receive any allocation for a water supply scheme and while there are 56 CPWS schemes in the state, Nalgonda has none. The demand for a piped water supply scheme is gaining urgency and the district administration is now attempting to garner local resources to address the water crisis.

3.2.1 Handpumps

The district has 15,636 handpumps but the number of those working at present is not known. They are installed primarily by the PRED and the respective Panchayats maintain them.

3.2.2 Piped Water Supply Schemes

There are a total of 1,460 piped water supply schmes in the district. They include both mini piped water supply schemes as well as piped water supply systems. There were 31 PWS and MPWS schemes in the fluoride affected western part so the district.

[1]IWACO B.V (1993) Water Resources Study, Andhra Pradesh III, Vol 2, Main Report

About 174 villages were considered to be affected by high Fluorides in 1993. Among these 31 villages have 47 GLSRs between them of various capacities ranging from 5000-140,000 l. Nine other villages have OHSRs of capacities ranging from 10-90 kl and there are a total of 891 borewells (4.5 inch), of which 574 were working in 1993. Summer yields of the borewells are reported to be very low and most of them have high Fluoride content.

There were 31 PWS and MPWS schemes in the fluoride affected area with 268 public standposts and 1,328 house connections. In the 9 PWS with OHSR, there were 147 public points and 35 house connections. All the PWS/MPWS schemes are handed over to the Gram Panchayat after completion and the O & M is their responsibility.

One hundred and thirty four villages do not have any schemes, except provision through hand pumps. All the existing schemes are based on borewells with either submersible or ejecto-pumps. Table (2.6) presents the water supply arrangements in the 174 villages affected by high fluoride.

TABLE(3.2): EXISTING SCHEMES IN FLUORIDE AFFECTED VILLAGES

Mandal	No. of Villages	Villages covered by PWS/MPWS with GLSRs	Villages covered by PWS s with OHSRs	Villages with no schemes
Chandur	6	4		2
Chintapally	21	4		17
Gurampode	28	5		23
Devarakonda	15	2		13
P.A. Pally	21	2	3	16
Marriguda	18	5	1	12
Nampally	27	5	1	21
Peddaoora	16	1	1	14
Narayanpur	3	2	1	
Kangal	8	1	1	6
Anumola	11		1	10
Total	174	31	9	134

Source: PRED (1998) Total population = 425,996

3.2.3 Comprehensive Piped Water Supply Schemes

There no major rural water supply schemes in the district, even though there are two schemes which have been sanctioned.

3.2.4 Quality of Drinking Water

The PRED is the main agency conducting water quality analysis of drinking water sources. Some of the data available from these sources may have to be verified and updated, especially water sample data from earlier periods. Most of the analysis is carried out by colorimetric methods and ion-specific electrode based analysis has started only recently. The water sample analysis provided in the documents, often do not provide information regarding season of collection (these are recorded) and sources beyond the village. There is a considerable need for improvement in the capacity for systematic data collection, analysis and interpretation of data.

It is difficult to deduce any clear trends in fluoride based on the available data. The IWACO study mentions that shallow wells have higher fluoride content than deeper borewells. However, it does not mention whether the well densities are higher in discharge zones where evaporation of waters have built up fluoride content in soils.

A study conducted by IWACO under NAP, covering 226 villages in the worst affected region, provides comprehensive information on ground water availability, its current levels of abstraction and quality. Based on this, eight types of villages can be identified in the region and the water supply options, their social acceptability and risks have been analysed for each of them.

TABLE (3.3) VILLAGE TYPOLOGIES BASED ON GROUND WATER CONDITIONS IN FLUORIDE AFFECTED AREA OF NALGONDA DISTRICT (IWACO - NAP, 1993)

VILLAGE TYPE	GROUND WATER CONDITIONS			Number of Villages	Population
	POTENTIAL	ABSTRACTION	QUALITY (F ppm)		
1	High	Low	Good	21	31,222
2	High	Low	Poor (>1.5)	19	37,043
3	High	Med-High	Good	13	23,188
4	High	Med-High	Poor	31	90,728
5	Medium	Med-High	Not Applicable	48	125,550
6	Medium	Low	Good	28	46,037
7	Medium	Low	Poor	42	79,632
8	Low	Not Applicable		19	23,577
Total				221*	456977

* Data is not available for 5 of the villages. Source : IWACO 1993 & TARU Analysis.

The combination of groundwater resource situation, levels of groundwater abstraction and fluoride levels at habitation levels causes magnification of problem from simple high fluoride in local source. Only 143 villages have fluoride problems whereas 137 villages have moderate or poor ground water resources and 90 villages have moderate to high ground water draft. In many habitations fluoride levels may be low but ground water resources may also be scarce and in others where fluoride levels may be high, ground water may be available in sufficient quantities. The technical options for different village types and their acceptability is presented in the following table (E.3)

TABLE (3.4) VILLAGE TYPOLOGIES, TECHNICAL OPTIONS & THEIR ACCEPTABILITY

VILLAGE TYPE	TECHNICAL OPTIONS			SOCIAL ACCEPTABILITY & RISKS		
	Option-1	Option 2	Option 3	Option 1	Option 2	Option 3
1	Village-based schemes	CPWS, if en route		Medium	Preferred	
2	Defluoridation	CPWS, if en route	Conjunctive use & demand focused end-use system, artificial recharge	Low	Preferred	People likely to fall back to using untreated water for drinking
3	Village-based with Controls on abstraction			Very difficult to implement	Complex management issues	Preferred
4	Distant source supply			Preferred		
5	Distant source supply			Preferred		
6	Freeze abstraction to current levels	Improve Recharge	CPWS if en route	Difficult to implement, promotes status quo in water use	Repetitive activity likely to be stopped post project	Preferred
7	Distant source supply			Preferred		
8	Distant source supply			Preferred		

Source : TARU Analysis, 1999

Our analysis indicates that even in the worst affected region, some villages have the potential to either use a locally managed system or adopt conjunctive use, based on seasonal availability and quality of water required for different end uses. Other villages (in Types 4 to 8) have few alternatives, other than a piped water supply schemes, based on a distant source. A similar set of options would be applicable for the other villages in the fluoride affected region. However, the geographical distribution of the problem of ground water scarcity, groundwater over extraction and fluoride levels have to be understood to design any sustainable solution. It may not be practically possible to isolate few villages with possible local option from a piped water supply scheme if they are enclosed by a group of problem villages with provision made for a CPWS.

It is also found that the in most cases larger villages have higher levels of ground water abstraction and higher fluoride levels, showing that an increasing amount of the contaminated water is used for irrigation, thereby further increasing the fluoride content in the soil (and ultimately the water). It

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It is also found that the in most cases larger villages have higher levels of ground water abstraction and higher fluoride levels, showing that an increasing amount of the contaminated water is used for irrigation, thereby further increasing the fluoride content in the soil (and ultimately the water). It seems higher availability of water resources has led to intensification of agriculture which in turn has increased population of habitations without catalysing education, out-migration or alternate livelihoods. This reflects that many villages are in an ecological trap, whereby over-exploitation of a natural resource results in a multitude of unanticipated negative consequences and only an external intervention, can break this chain of events. Since a large number of villages in the region have populations exceeding 1,000 (75 percent), such a trend is likely to be found in many other areas in the district.

In the past, the district has witnessed conflicts over water, both for drinking water needs among neighboring villages, and between irrigation and drinking water demands across a larger area. As water scarcity increases, such conflicts are likely to become more frequent.

The implementation of a water supply system that responds to local resource conditions and offers both centralised and local solutions, is likely to be a major challenge. The involvement of several institutional partners, new approaches to design of systems, community participation and their informed decision making, arrangements for cost sharing and O&M responsibilities will need to be an integral part of the design approach.

The distant-source option emerges as the possible solution for a majority of the Fluoride affected villages. The option proposed by the PRED and a few other alternates are explored in the next sections.

3.3 Distant-Source Supply

3.3.1 CPWS options Utilising Nagarjuna Sagar or Srisailam Left Bank Canal

Starting about 1990, the PRED has developed a set of proposals to provide potable drinking water to the fluoride affected habitations in the district. All of them considered the Nagarjuna Sagar reservoir as the source of supply. The proposals differed in as much as, each considered the different potential intake points for the Water supply system and varied the coverage of habitations as per the needs of the time.

Since the Royal Government of Netherlands was exploring the possibility of assisting the PRED in Nalgonda for the AP-III project, the initial set of proposals evolved through discussion between the two parties. These proposals were comprehensive schemes based on reservoirs or tanks fed by Nagarjuna Sagar Left bank Canal.

The Nagarjuna Sagar reservoir has a gross storage capacity of 408.16 TMC and live storage capacity of 240 TMC to utilise the allocated quantity of 264 TMC. This is distributed equally (i.e., 132 TMC each) over the right and the left bank canals. The Nagarjuna Sagar Left Bank Canal passes close to the proposed water supply project area. The KDWT, which examined the interstate allocations of Krishna waters has suggested that canal water releases are restricted to 132 TMC though at present, releases usually exceed this. The canal is closed for maintenance for an average of 75 days in a year.

The reservoirs under consideration in the initial phase - Nidamannur and Alwal were both intended to be used as intake points and to serve as summer storage reservoirs. These tanks are situated towards the south-eastern and eastern parts of the project area. During the period of canal closure, water is released once in 10-15 days. Only the tanks which had the capacity to store waters equivalent to the estimated demand of the project population and located near the project area were considered. Both these reservoirs, under consideration had direct irrigation outlets, and the Nidamannur reservoir was also the drinking water source for Nalgonda town. In the previous years, instances of conflict with local farmers in the command over priorities in water use had been recorded. It was felt necessary to restore the Alwal tank before being used as SSR in the project.

3.3.1.1 Scheme description

The Nagarjuna Sagar Left bank Canal (NSLBC) was considered as the source of supply. In the first phase of the project, it was proposed to draw water from the NSLBC at Nidamannur and utilise the existing SST during summer closure of the canal. The Nidamannur tank was being used as an SST by the PHED for providing water to Nalgonda town. It has a capacity of 0.11 TMC, with the PHED utilisation being 0.04 TMC. After an estimated 20% percolation and evaporation losses, the capacity of 0.09 TMC was considered enough for servicing the phase-I habitations during summer closure.

The raw water would be treated in Rapid Sand filters and supplied through a network pumping and gravity distribution lines to 82 revenue villages and 99 hamlets. The first phase was to take four years.

The second phase would draw water from the NSLBC at Alwal utilising the improved MI tank (Ramasamudram tank) as SST. This tank, after improvement would have a maximum capacity of only 0.06 TMC and hence the choice of additional SST at Nidamannur and the two phases.

After treatment similar to the first phase, the water was to be supplied through a network of pumping and gravity distribution lines to 144 revenue villages and 238 hamlets. This phase was envisaged to take four years. It was planned such that the two phases would have an overlap of two years.

3.3.1.2 Technical feasibilty

The proposed scheme is prima facie feasible technically. As only project estimates have been done and the design work is not completed (no sanction given), it is rather inopportune to evaluate the distribution network. However, as in such large systems, adequate care and modelling would have to be incorporated at the planning and design stages to lessen any future management problems arising from the distribution infrastructure. The branched piping system with dead ends supplied by water from main balancing reservoir by gravity nead to be analysed for hydraulic balancing under steady flow conditions. The residual head at the service reservoir outlet need to be worked out to check whether it is sufficient or not under steady flow conditions. The suitable modification of pipe line dimensions, where excess head is available need to be explored at the design stage itself. Since the network is of dead end type a certain degree of unreliabilty is to be expected with the tail end villages suffering more interuptions than the others, as a general rule.

The modularity of the scheme; having two intake points, make the reliability of the overall system good.

3.3.1.3 Cost of water

The cost of water in the PRED proposal is calculated as the recurring cost (O&M) for the design population (2020). This works to about Rs 1.6 per kl at 1994-95 prices. It is to be noted that about 65% of this cost component is the cost of power, which has been taken at Re. 1 per unit.

A rough-cut analysis analysis of cost of water (1998 prices), correcting for the power costs and based on present population would make the cost of water about Rs. 5.20 per kl. If escalation in costs of othe other components is taken into consideration the cost of water would be between Rs 6 - 7 per kl.

3.3.1.4 Coverage

The proposal covers 226 revenue villages and 337 hamlets within the jurisdiction of 16 mandals. Among these villages 172 have fluoride problems and 56 are either scarcity or source problem or enroute villages. The total design population (2020) was taken at 0.87 million.

3.3.1.5 Cost of O&M

The proposal suggested that a systematic approach is to be evolved for O&M, but had not gone into specifics. Subsequent discussions between the RGoN consultants and the PRED indicate the idea of setting up a four-tier institutional arrangement for planning, execution and management. This explored the idea of setting up of Village committees with the assistance of local NGOs after a baseline study. These village committees would act as interface between the users and PRED and would assume joint responsibility with the department for O&M at the village level. Representatives from these Village committees would be present in a Mandal level Project Committee. This committee would be chaired by the Executive Engineer and would also have representation from allied departments involved in other integrated aspects of the project.

An exclusive District project committee was proposed to be set up at the district levels led by the Superintendent Engineer from the PRED and consisting of representatives from Health, education and allied departments.

A state level apex steering committee headed by the Chief secretary, with the secretaries of the departments of Health, Education, Irrigation, Food, Animal Husbandry, Panchayat Raj and necessary sector specialists was also mooted.

The total cost of O&M estimated (1994-'95 prices) is Rs. 28 million. The power component of this cost is 65%. The rest are for routine maintenance and salaries. The Per Capita investment is estimated to be about Rs. 1,110 (1995 prices) and the per capita annual O&M cost Rs. 32.

3.3.1.6 Social and Political Risks

The supply of potable drinking water would be welcomed by the population. It is high on the political agenda of local population.

Nidamannur tank which would be used as a reservoir for the first phase villages, already has a provision of 0.4 TMC for supplying Nalgonda town. Conflicts have occurred in the past between farmers in the command and the PHED on priorities for water during summer. It is expected that this would continue to be the case, unless effective conflict resolution measures are adopted at the outset and systems set in place.

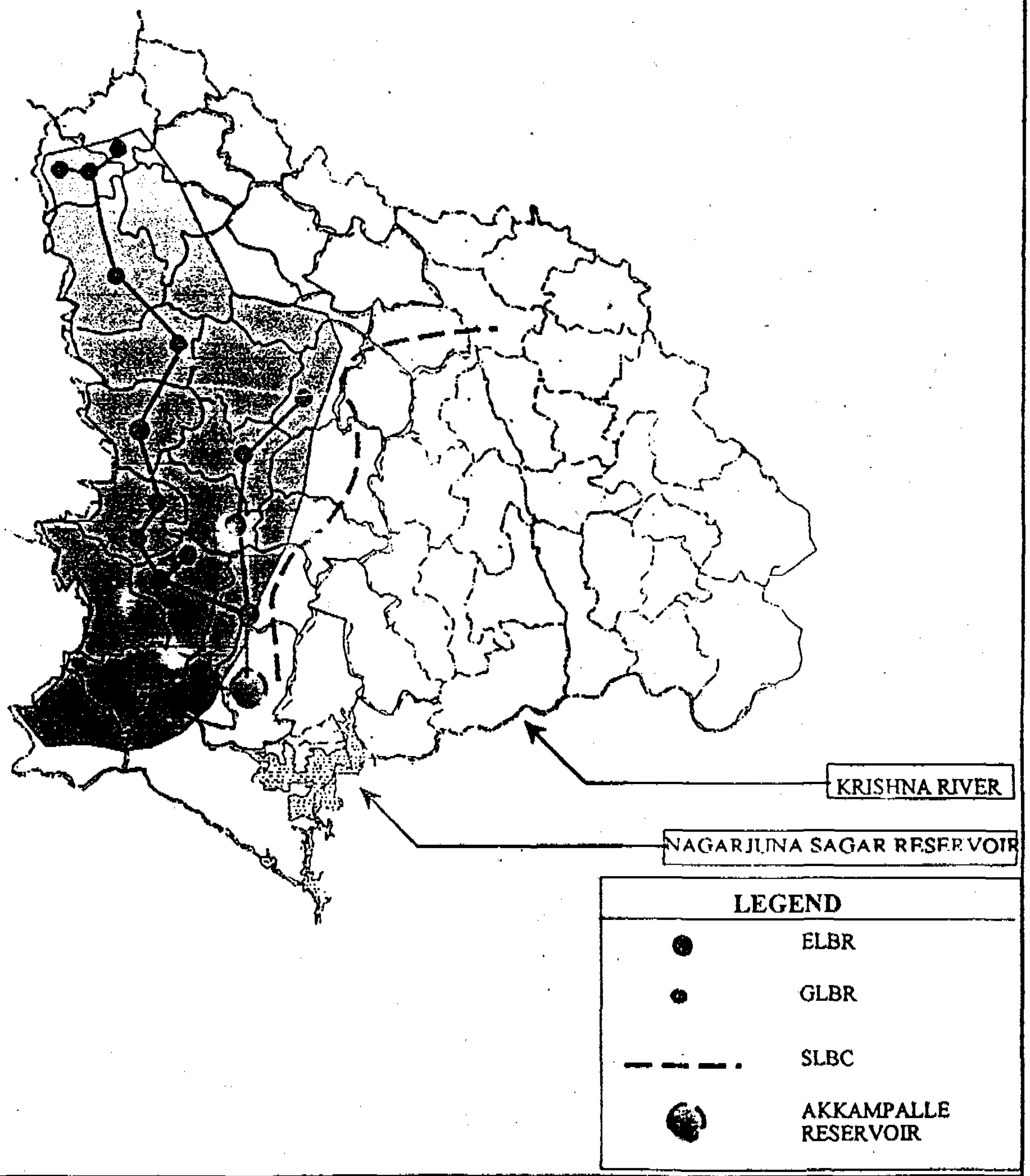
3.3.1.7 Current status

With the option of using the Akkampalle Balancing reservoir, this project option is not being actively pursued by the PRED.

NALGONDA DISTRICT

MAP 5: CPWS SCHEME FOR 533 HABITATIONS

SCHEMATIC ONLY



3.3.2 CPWS scheme with the SLBC as source and Akkampalle reservoir as intake point

The earlier options using Nidamannur and Alwal tanks as SSTs were pushed back in favour of using Akkampalle balancing reservoir as the SST after the state moved forward on utilisation of the Krishna waters through the Srisailam Left Bank Canal project. The balancing reservoir at Akkampalle is proposed to receive water from the Srisailam Left Bank Canal (SLBC), which is under construction. This involves the construction of about 46 km of tunnel in different segments which is an impediment to its speedy completion. As the state has to utilise the Krishna water allocated to it under the Bachawat award by 2000 AD, water from the Srisailam project is being pumped up up to the canal and then to Akkampalle reservoir. Once the tunnel is completed, the flow would be by gravity. The speedy completion of the SLBC is high on the political agenda and with the deadline for Krishna water utilisation (2000 A.D), the possibility of water being put into the canal and into Akkampalle is very high. The quality of the water and its reliability are likely to be high since Akkampalle does not have an direct irrigation outlet. However, till the tunnels are completed, pumping of the water is an unreliable link in the chain.

3.3.2.1 Scheme description

The Akkampalle Balancing reservoir for the SLBC is situated at about 100 m above the Nagarjuna Sagar reservoir sill level. The Akkampalle balancing reservoir has a storage capacity of 1.5 TMC. The balancing level of the reservoir is 245 m. The reservoir has no direct irrigation outlet. Raw water from the reservoir is proposed to be taken by gravity to sump (+232 m) located at Kachapuram village by gravity. The raw water would be pumped from the sump to Elevated Level Reservoir, ELBR1 (+270 m) on Kachapuram hillock. 33.1 MLD of water would be treated in facilities constructed, while the remaining water would be pumped to the second Elevated Level Reservoir ELBR3 (+340 m) on the same hillock. A portion of the treated water supplies the Kanchanpalle line, while remaining would be pumped to ELBR2. Treated water from ELBR2 would be flow by gravity to GLBR at Bheemla Tanda. The raw water in ELBR3 flows by gravity to Mallaprajapalle GLBR, where it would be treated by the second treatment facility. The treated water from the Mallaprajapalle GLBR would be carried by gravity to various ELBRs located at Nasarlapalle, Kondur, Tanderpalle and OHBR at Narayanpur. At Narayanpur, it would be again lifted to 420 m.

3.3.2.2 Technical feasibilty

The proposed scheme is technically feasible. As only project estimates have been done and the design work is not completed (no sanction given), it is rather inopportune to evaluate the distribution network. The hydraulic design is not done and various options like increasing the number of Treatment Plants are still being consideration.

Since the scheme is based on a single intake point and provides distribution over very long distances through three pumping stages the system reliability would be low. Adequate provision for redundancy would have to be built in, which would escalate costs.

The scheme earmarks substantial investment for dedicated power supply. There is no provision made for stand-by power.

3.3.2.3 Cost of water

The total project cost works to about Rs. 1,554 million (at 1997 prices). An analysis of cost of water (1998 prices), correcting for the power costs and based on present population would make the cost of water about Rs. 6 per kl.

3.3.2.4 Coverage

The scheme proposes to cover 533 habitations in Nalgonda in which 481 are fluoride problem habitations. Another 25 habitations have reported problems of brackishness, while 27 are enroute villages. The project expects to cover a design population (2020) of 10.38 lakhs in 20 mandals

3.3.2.5 Cost of O&M

The tentative cost of O&M, calculated is about 840 lakhs per annum. This includes power charges about 550 lakhs and the rest for maintenance and salaries.

3.3.2.6 Social and Political Risks

Water supply systems traversing such large dustances through pipelines always run the risk of manipulation by local population enroute. There is also the added risk of inter-village conflicts in the event of unequal supply caused by imbalances in the system.

3.3.2.7 Current Status

This scheme is still under active consideration of the PRED. As the investments are high, PREDis exploring possibilities of financial assistance from the GoI and bilateral agencies.

3.3.3 Drawing Water from the proposed pipeline to Hyderabad

3.3.3.1 Scheme Description

The HMWSSB has submitted a proposal to the World Bank for sourcing drinking water for Hyderabad city from the Nagarjuna Sagar in order to augment water supply to Hyderabad city. Under the proposal, raw water from the Nagarjuna Sagar will be pumped to Akkampalle which is 23 km away from reservoir. This would be treated and then pumped in three stages, covering a gradient of 165 m at each stage, to Hyderabad city which is 114 km away from the reservoir. The pipeline is proposed to be laid along the highway. The water production capacity of the project is 410 mld, with 22.5 mld reserved for en route villages situated at a distance 3-5 km from the pipeline. The project requires financing of the order of Rs. 2,400 million, of which 50 percent is being sought as a loan from the IBRD. The time frame for the project is estimated to be four years in the proposal.

3.3.3.2 Salient Features

The objectives of the project are:

(a) To improve living and health conditions in Hyderabad and adjoining municipalities through effective use of safe water and sanitation facilities by:

- improving water supply and sanitation services; and

- developing the Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) into an effective commercially-oriented water utility capable of sustaining the delivery of such services.

(b) To promote reform of the water supply and sanitation sector through demonstration effect and agreed state policy.

The main project components are:

(I) Construction of facilities for abstraction, treatment and conveyance of about 8.25 TMC water from Krishna River to Hyderabad, including intake and raw water pumping station; water treatment plant; clear water pumping stations; large 140 km long transmission pipeline and reservoirs; power supply and substation; telemetry and communication system;

(ii) Rehabilitation and strengthening of water distribution system; construction of new service connections; implementation of an accelerated unaccounted-for-water (UFW) reduction program;

(iii) Rehabilitation and extension of sewerage system and sewage treatment plants and construction of new service connections,

(iv) Implementation of low-cost sanitation program, including construction of 5,000 household latrines; construction of community latrines and community health education campaigns;

(v) Implementation of R&R program for project-affected people; and

(vi) Institutional strengthening, technical assistance and training of HMWSSB staff in project implementation and monitoring, including Consultancy studies for sector policy studies (private sector participation, willingness-to-pay, etc.), identification of future sources of supply for Hyderabad and detailed engineering designs.

The financing sought from IBRD is to the tune of 50% of the project cost of Rs. 24,000 million. The HMWSSB would put in about 10% and has to date not identified sources who would invest the remaining 40% (Rs. 9,600 million).

The Project envisages taking the raw water from the Nagarjuna Sagar to a reservoir within 14 km, where the water would be treated. The treatment standards have been prescribed by HMWSSB and it is expected to be placed for international bidding. This treated water would then be pumped to Hyderabad in three stages, with each stage achieving a lift of 165 m. The alignment for the twin pipeline is considered to be by the side of the highway to Hyderabad. This would necessitate minimum land acquisition. About 275 households are expected to be displaced by the pipeline and schemes for rehabilitation are built in to the proposal.

3.3.3.3 Current situation on Proposal

The World Bank sees the primary objective of the project as "developing the Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) into an effective commercially-oriented water utility capable of sustaining the delivery of improved services". With this in mind, they have provisionally finance the project in two stages. The first stage, " Hyderabad Urban Water Supply and sanitation - phase II" is focussed on the project component of rehabilitation and strengthening of water distribution system; construction of new service connections and implementation of an accelerated unaccounted-for-water (UFW) reduction program within the existing supply network in place in Hyderabad. The IBRD has indicated that this phase should be used to augment the water tariff in stages to a tariff, which would cover actual costs of water and ensure financial sustainability for HMWSSB. Since the estimated cost of water supplied from the Nagarjuna Sagar pipeline would be about Rs. 25 per kl, the IBRD has cautioned the HMWSSB and also advocated exploration of alternative sources. However, if the HMWSSB wants to go ahead with this scheme, it would have to augment water tariff by 25% annually over two years, before the IBRD would take up the Nagarajuna Sagar component for active consideration. The GoAP/HMWSSB has not proceeded with this issue in 1998. The chances of an increase in 1999, an election year for the state government, are extremely low.

3.3.3.4 Time-frame for Execution

The time frame envisaged by the HMWSSB is 5-6 years (1998-2004). The past record of HMWSSB in completing a Rs. 3,600 million project shows a time frame of 8 years. There have been delays already on this project and the fulfillment of certain conditionalities are likely to cause further delays. Even an optimistic view from the IBRD is that, if the political will is shown for necessary tariff increases and the project moves ahead, the commissioning would be in about 8-10 years time.

3.3.3.5 Technical Risks

The reliability may be higher due to multiple tapping points provided for in the Nagarjuna Sagar - Hyderabad pipeline as per the design. However, the HMWSSB has no past experience of management of water transmission through such long distances.

In the event of using water tapped from Chintapalli or Mall and supplying drinking water to those villages, which can be supplied by gravity, the PRED system reliability could be higher due to the need for fewer pumping stations.

3.3.4 Conclusion

The high cost of water which would be supplied by the HMWSSB pipeline makes the option of tapping water from the system an expensive proposition. Even though PRED investment of capital costs is subsumed by going along with another organisation's project, the cost of water is too exhorbitant to be borne by the rural population, considering their economic background.

Even if the HMWSSB functions as a commercial entity and treats the PRED as a bulk user consumer, past experience and ground realities show that there is likely to be political pressure on the HMWSSB to accord priority to the urban supply and this is likely to impact and marginalise rural supply when urban demand increases or in emergency situations.

The current provision made for rural supply is 22.5 mld and this is lesser than the estimated demand for the population that PRED is seeking to provide coverage to.

The HMWSSB is negotiating with the World Bank for assistance to cover 50% of the project costs. They are yet to identify prospective sources for 40% of the costs. Also, raising urban water tariffs to levels indicated would be a sensitive issue politically and the chances of the will being shown in present context is low.

The timeframe envisaged for the Nagarjuna Sagar Pipeline presents an optimistic completion date of 2008. Even this optimistic timeframe would mean untimely delay in servicing the villages to be covered.

The PRED option proposed with Akkampalle reservoir as intake and subsequent distribution over long distances and with high lift raises questions of system reliability and the need for enhanced technical and management options. A comparison is made of the two primary options in Table (3.5).

TABLE (3.5): COMPARATIVE FEATURES OF PROPOSALS TO USE NAGARJUNA SAGAR WATER

	Hyderabad Supply Pipeline	PRED Proposal
HIGH	Cost of Water	Technical + Management Requirements
	Chances for Delay	
	Priority for Urban Supply	
MODERATE		Cost of Water
LOW	Priority for Rural Areas	
	Chances of Urban Tariff increase	
	Past Experience in managing large and distant source systems	
UNKNOWN	Finance	Competing Agriculture demand

Source: TARU Analysis, 1999

3.4 Conclusions and Recommendations

Nalgonda offers one of the most challenging conditions for the design of a safe drinking water system. With dwindling groundwater resources, no controls over exploitation of groundwater, a distance of about 60 km between the worst affected community and the nearest safe source (Nagarjun Sagar), supplying safe water to at least a hundred fluoride affected villages will be a complex task. The fact that any piped water supply system will pass through areas that are not affected by fluoride but face water scarcity, adds an additional complexity, demanding negotiation with communities, participation of several institutional partners, framing of policy guidelines and community participation.

1. For villages in the zones A, B and D (as per AP-III), the nearest safe surface water source (Nagarjun Sagar) is 30-60 km away. For villages with more than 1.5 ppm fluoride content, the costs of supplying water from a safe surface water source or defluoridation of ground water are likely to be similar due to the low reliability of groundwater sources. A CPWS may be a more reliable and cost effective option in the long run. A geographically contiguous zone suffering from water quality and/or scarcity may have to be identified for CPWS.

2. A CPWS for the worst affected villages would demand proper management and sharing arrangements across villages. It is recommended that a few of the older operational CPWS in the state are visited, to gain a first hand understanding of the PRED experience in design, management and operation of such systems. A large CPWS, the Dasri scheme, in the fluoride affected Prakasam district may be considered for this. It has been operating for the past decade and it is reported that local cost sharing arrangements have also been developed.

3. Another option for villages where water availability is not a problem would be to set up defluoridation plants. However, the technical limitation of existing systems, low receptivity of the community to such options and the high costs of more recent systems such as Reverse Osmosis, do not make this an attractive proposition.

4. Two sets of options are possible for zone C (AP- III). The first would include providing small PWS for a cluster of villages, using multiple points for tapping ground water to reduce the risks of simultaneous failure affecting large number of villages. The low fluoride ground water sources can be tapped during the period of canal closure if those sources are maintained. The other option is to adopt conjunctive use systems. During the rainy season, when water demands are not high, artificial recharge of existing bore wells can be resorted to which would serve as a reservoirs for use during canal closure. Such a mix of surface and groundwater use would lower the risks of failure and would not need large storage systems at the intake for dealing with water scarcity during canal closure.

5. Even though ground water usage control is not politically and economically viable, efforts should be made to promote less water intensive and more economically attractive crops in the region especially during the second crop period when water crisis reaches to it's maximum. Existing sources should be maintained to tide over un-foreseen breakdowns of the external source dependant water supply systems.

6. The option of taking water from the Hyderabad Metrowater supply pipeline is economically not viable. If the area is to be served by a Comprehensive protected water supply, an independent option as suggested by PRED, would be more cost-effective. However, it is felt that the option of using large reservoirs enroute to the SLBC should be explored technically and in terms of competing demands for exploitation as Summer Storage tanks and intake points; to strive for a solution which is more modular and hence reliable.

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GLOSSARY AND ABBREVIATIONS

AKBR	-	Akkampalle Balancing Reservior
APSEB	-	Andhra Pradesh State Electricity Board
amsl	-	Above Mean Sea Level
CGWB	-	Central Ground Water Board
CPWSS	-	Comprehensive Protected Water Supply Scheme
Dark area	-	The Districts/Mandal with Groundwater draft more than 85% of utilisable groundwater resources (utilisable groundwater resource is equal to net groundwater resources - groundwater resource reserved for domestic and industrial use (about 15%)
DF	-	Defluoridation
DPAP	-	Drought Prone Area Programme
ELBR	-	Elevated Level Balancing Reservoir
GLBR	-	Ground Level Balancing Reservoir
GLSR	-	Ground Level Service Reservoir
GOAP	-	Government of Andhra Pradesh
GOI	-	Government of India
Grey area	-	The Districts/Mandal with Groundwater draft between 65% and 85% of utilisable groundwater resources
HP	-	Hand Pump
HMWSSB	-	Hyderabad Metropolitan Water Supply and Sewerage Board
ID	-	Irrigation Department
KDWT	-	Krishna Division of Waters Tribunal
kl	-	Kilo Liters = 1 m^3
LPCD	-	Litres per capita per day
m.bgl	-	Meters Below Ground Level
mld	-	Million Liters per day
MCM	-	Million Cubic Metres
MPWS	-	Mini Protected Water Supply
NEERI	-	National Environmental Engineering Research Institute
NGO	-	Non-Governmental Organisation
NGRI	-	National Geophysical research Institute
NSLBC	-	Nagarjuna Sagar Left Bank Canal
NSP	-	Nagarjuna Sagar Project

OHSR	-	Over Head Service Reservoir
O&M	-	Operation & Maintenance
PHED	-	Public Health Engineering Department
PRED	-	Panchayati Raj Engineering Department
PWS	-	Protected Water Supply
RGNDWM	-	Rajiv Gandhi National Drinking Water Mission
RGoN	-	Roayal Government of Netherlands
SGWD	-	State Ground Water Department
SLBC	-	SriSailam Left Bank Canal
TMC	-	Thousand Million Cubic Feet

ANNEXURE A

DETAILS OF SURFACE IRRIGATION STRUCTURES IN THE FOUR DISTRICTS

TABLE (A.1) COMMAND AREA OF MAJOR, MEDIUM & MINOR IRRIGATION STRUCTURES IN VISAKHAPATNAM DISTRICT, 1991-92

Name of the project	Ayacut(ha)	% Ayacut to total
I.Major Irrigation	**None**	
II.Medium Irrigation Total	**27753**	**16%**
a) Thandava Reservoir	13226	8%
b) Konam Reservoir	5889	3%
c) Raiwada Reservoir	8638	5%
III. Other Reservoirs	3071	2%
a) Kalyanapulova Reservoir	1815	1%
b) Revanapalli Reservoir	1013	1%
c) Gambheeramgadda Reservoir	243	0%
Total Medium Irrigation	33895	19%
III Minor Irrigation (Total)	53353	31%
Minor Irrigation (PWD)	20113	12%
Minor Irrigation (PRED)	33240	19%
Total Surface irrigation	174496	**100%**
Source: Deptt of Economics & Statistics (1991-92)		

TABLE (A.2) COMMAND AREA OF MAJOR, MEDIUM & MINOR IRRIGATION STRUCTURES IN VIZIANAGARAM DISTRICT, 1994-95		
Name of the project	**Ayacut (ha)**	**% Ayacut to total**
I.Major Irrigation	Nil	
II. Medium Irrigation:	**39298**	**25%**
Denkada Anicut Scheme	2061	1%
Thatipudi Reservoir	5612	4%
Vattigedda Reservoir	6746	4%
Paradi Anicut	3671	2%
Surapadu Anicut	759	0%
Vegavati Anicut	2428	2%
Seethanagaram Anicut	1666	1%
Nagavali Left side Channel	721	0%
Nagavali Right side channel	2111	1%
Peda Ankalam Anicut	3523	2%
Vengalaraya Sagar Project	10000	6%
II. Minor Irrigation:	120760	75%
Minor irrigation tanks (PWD)	51737	32%
Minor irrigation tanks (PRED)	69023	43%
Total surface irrigation	**160058**	**100%**
Source: Handbook of Statistics Vizianagaram (1994-95)		

TABLE (A.3) COMMAND AREA OF MAJOR, MEDIUM & MINOR IRRIGATION STRUCTURES IN SRIKAKULAM DISTRICT, 1994-95		
Name of the project	**Ayacut (ha)**	**% Ayacut to total**
MAJOR	**116839**	**32%**
Vamsadhara project	59990	17%
Thotapalli Regulaor on river Nagavali	16275	5%
Narayanapuram project	15863	4%
Vamsadhara open head channel	7028	2%
Nagavali open head channel	5173	1%
Bahuda river	2958	1%
Mahendrathanya open head channel	4626	1%
Pydlgam project	2367	1%
Vonigedda	2559	1%
Minor irrigation	**244320**	68%
Minor Irrigation (PWD)	191084	53%
Minor Irrigation (PRED)	53236	15%
Total surface irrigation	361159	100%
Source: District Statistical Handbook (1994-95)		

TABLE (A.4) AYACUT AREA OF MAJOR, MEDIUM & MINOR PROJECTS IN NALGONDA DISTRICT

Scheme	Registered ayacut	% of total	Gross irrigated	Gross irrigated area/ayacut
Major Irrigation projects	**123,528**	**64%**	**125,481**	102%
Nagarjun Sagar	123,528	64%	125,481	102%
Medium Irrigation projects	**31,218**	**16%**	**2,551**	8%
Musi Project	18,347	9%	1,169	6%
Dindi Project	5,040	3%	213	4%
Asif nahar	6,147	3%	847	14%
Utkur	1,684	1%	323	19%
Others total	5,867	**3%**	1,512	26%
Pendlipaka	1,613	1%		0%
Shaligowram	887	0%	403	45%
Bheemanapallo	484	0%		0%
Yedavelly	1,210	1%		0%
Gandhi sagar	665	0%	101	15%
Vemuloor	1,008	1%	1,008	100%
MI tanks	**33,507**	**17%**	**14,162**	42%
Total	**194,120**	**100%**	143,707	74%

Source: DoE&S 1995

* Data on ayacut of MI tanks under the Irrigation Department is not available

ANNEXURE B

DETAILS OF GROUNDWATER RESOURCES AND IRRIGATION POTENTIAL IN THE FOUR DISTRICTS

GROUNDWATER RESOURCE & IRRIGATION POTENTIAL SRIKAKULAM						(CGWB-1995)
Mandal	Total replenishable ground water resources MCM	Utilisable groundwater resources MCM	Gross draft (1993) MCM	Net Draft (1993) MCM	Level of ground water development % 1993	Current Level of ground water development % 1998
Amadalavalasa	36.224	30.790	4.243	2.97	10	10
Bhamini	20.129	17.110	1.171	0.82	5	5
Burja	31.412	26.700	4.9	3.43	13	14
Etcherla	35.612	30.270	8.857	6.2	20	22
G. Varsigadam	32.424	27.560	9.529	6.67	24	25
Gara	38.718	32.910	18.8	13.02	40	42
Hiramandalam	24.753	21.040	4.271	2.99	14	15
Ichapuram	26.294	22.350	0.914	0.64	3	3
Jalmuru	36.388	30.930	8.014	5.61	18	19
Kanchili	27.059	23.000	1.4	0.98	4	4
Kaviti	31.094	26.430	6.786	4.75	18	19
Kotabommali	38.8	32.980	14.9	10.43	32	33
Kothuru	33.294	28.300	5.229	3.668	13	14
Laveru	35.129	29.860	14.914	10.44	35	37
Mandasa	49.682	42.230	3.2	2.24	5	6
Meliaputti	23.788	20.220	6.343	4.44	22	23
Nandigama	39.694	33.740	5.729	4.01	12	12
Narasannapeta	37.518	31.890	8.429	5.9	19	19
Palakonda	43.412	36.900	7.986	5.59	15	16
Palasa	32.671	27.770	3.557	2.49	9	9
Pathapatnam	25	21.250	8.8	4.76	22	24
Polaki	44.094	37.480	12.714	8.9	24	25
Ponduru	27.565	23.430	11.829	8.26	35	37
Ramadalavalasa	40.165	34.140	12.514	8.76	26	27
Rajam	29.753	25.290	7.343	5.14	20	21
Ranasthalam	38.259	32.520	20.543	14.38	44	46
Santabommali	40.835	34.710	4.471	3.13	9	9
Santhakaviti	40.2	34.170	4.129	2.89	8	9
Saravakota	30.435	25.870	7.929	5.55	21	23
Srubujjili	49.071	41.710	5.743	4.02	10	10
Seethampeta	17.259	14.670	4.043	2.83	19	20
Sompeta	33.765	28.700	4.3	3.01	10	11
Srikakulam	41.012	34.860	13.371	9.38	27	28
Tekkali	33.482	28.460	3.643	2.55	9	9
Vajrapukothur	26.282	22.340	1.4	0.98	4	5
Vangara	30.976	26.330	6.1	5.67	22	23
Veeraghattam	42.012	35.710	7.786	5.45	15	16
Total district	**1264.26**	**1074.621**	**275.83**	**192.948**	18	19

GROUND WATER RESOURCE & IRRIGATION POTENTIAL VISHAKHAPATNAM						(CGWB-1995)
Mandal	Total replenishable ground water resources MCM	Utilisable groundwater resources MCM	Gross draft (1993) MCM	Net Draft (1993) MCM	Level of ground water development % 1993	Current Level of ground water development % 1998
Achutapuram	25.718	21.860	11.786	8.25	38	40
Anakapalli	38.447	32.680	15.971	11.18	34	36
Anandapuram	19.988	16.990	8.386	5.87	35	36
Anantagiri	22.882	19.450	0.457	0.32	2	2
Arakuvalley	18.788	15.970	0.871	0.61	4	4
Bheemunipatnam	17.094	14.530	1.943	1.38	9	10
Buchayyapet	34.565	29.380	4.671	3.27	11	12
Cheedikada	28.494	24.220	2.786	1.95	8	8
Chintapally	48.941	41.600	0.371	0.26	1	1
Chodavarai	36.082	30.670	16.443	11.51	38	39
Devarapadu	29.518	25.090	8.757	6.13	24	26
Dumbriguda	18.294	15.550	0.257	0.18	1	1
G.Kothaveedu	27.271	23.180	0.114	0.08	0	0
G. Madugula	26.765	22.750	0.229	0.18	1	1
Gajuwaka	8.918	7.580	1.357	0.95	13	13
Golugonda	25.435	21.620	2.714	1.9	9	9
Hukumpeta	32.859	27.930	0.188	0.13	0	0
K. Kotapadu	35.435	30.120	12.714	8.9	30	31
Kasimkota	23.776	20.210	13.957	9.77	48	51
Kotaurutla	21.541	18.310	8.2	5.74	31	33
Koyyuru	21.647	18.400	0.286	0.2	1	1
Madugula	34.318	29.170	9.529	6.67	23	24
Mkavarpalem	25.094	21.330	8.514	5.96	28	29
Manchigpattu	41.282	35.090	0.957	0.67	2	2
Mungapaka	19.118	16.250	14.814	10.37	64	67
Nakkapalli	28.624	24.330	5.7	3.99	16	17
Narsipatnam	18.906	16.070	4.171	2.92	18	19
Nathavaram	61.718	52.460	3.843	2.69	5	5
Paderu	29.153	24.780	0.543	0.38	2	2
Padmanabham	27.682	23.530	9.543	6.68	28	30
Parvada	17.882	15.200	3.443	2.41	16	17
Payakaraopeta	25.459	21.640	7.6	5.32	25	26
Peda Gantyada	9.706	8.250	0.043	0.03	0	0
Pedabayalu	34.482	29.310	0.243	0.17	1	1
Pendurthy	15.259	12.970	3.314	2.32	18	19
Rambilli	28.294	24.050	4.686	3.28	14	14
Ravikamatham	32.318	27.470	3.857	2.7	10	10
Regulagunta	28.671	24.370	3.786	2.65	11	11
G. Rayavaram	35.153	29.880	6.3	4.41	15	16
Sabbavaram	30.329	25.780	8.343	5.84	23	24
Visakhapatnam	12.859	10.930	1.3	0.91	8	9
Yelamanchili	22.741	19.330	5.471	3.83	20	21
Total District	1141.506	970.280	218.458	152.96	16	17

GROUND WATER RESOURCE & IRRIGATION POTENTIAL VIZIANAGARAM						(CGWB-1995)
Mandal	Total replenishable ground water resources MCM	Utilisable groundwater resources MCM	Gross draft (1993) MCM	Net Draft (1993) MCM	Level of ground water development % 1993	Current Level of ground water development % 1998
Badangi	32.753	27.84005	7.071	4.95	18	19
Balijipeta	39.776	33.8096	6.271	4.39	13	14
Bhogapuram	21.388	18.1798	7.443	5.21	29	30
Bobbili	46.518	39.5403	9.486	6.64	17	18
Bondapalli	33.565	28.53025	3.3	2.31	8	9
Cheepurupalli	20.047	17.03995	7.057	4.94	29	30
Dattirajeru	40.306	34.2601	7.771	5.44	16	17
Denkada	27.8	23.63	2.329	1.63	7	7
Gajapathinagaram	20.318	17.2703	0.486	0.34	2	2
Gantyada	31.812	27.0402	5.429	3.8	14	15
Garividi	43.071	36.61035	4.971	3.48	10	10
Garugubilli	24.8	21.08	9.114	6.38	30	32
Gummalaxmipuram	33.588	28.5498	8.571	6	21	22
Gurla	39.412	33.5002	3.9	2.73	8	9
Jami	38.506	32.7301	4.671	3.27	10	11
Jiyyammavalasa	46.306	39.3601	1.686	1.18	3	3
Komarada	38.035	32.32975	3.396	2.37	7	8
Kothavalasa	27.247	23.15995	4.357	3.05	13	14
Kurupam	23.365	19.86025	1.443	1.01	5	5
L.Kota	33.353	28.35005	3.5	2.45	9	9
Makkuva	28.765	24.45025	1.757	1.23	5	5
Mentada	29.682	25.2297	3.2	2.24	9	9
Merakamudidam	30.388	25.8298	5.257	3.68	14	15
Nellimarla	27.647	23.49995	7.6	5.32	23	24
Pachipenta	18.976	16.1296	4.814	3.37	21	22
Parvathipuram	48.8	41.48	5.371	3.76	9	10
Pusapatirega	25.612	21.7702	10.057	7.04	32	34
Ramabhadrapuram	28.141	23.91985	5.943	4.16	17	18
Saluru	36.035	30.62975	6.557	4.59	15	16
Seethanagaram	41.106	34.9401	10.586	7.41	21	22
S.Kota	45.035	38.27975	3.8	2.66	7	7
Therlam	37.294	31.6999	5.043	3.53	11	12
Vepada	31.153	26.48005	2.614	1.83	7	7
Vizianagaram	27.082	23.0197	3.486	2.44	11	11
Total district	1117.682	950.0297	178.337	124.83	13	14

GROUND WATER RESOURCE & IRRIGATION POTENTIAL NALGONDA						(CGWB-1995)
Mandal	Total replenishable ground water resources MCM	Utilisable groundwater resources MCM	Gross draft (1993) MCM	Net Draft (1993) MCM	Level of ground water development % 1993	Current Level of ground water development % 1998
Narayanpur	29.45	25.03	20.17	14.12	56	62
Gurrampode	25.25	21.46	12.51	8.76	41	45
Nampally	10.09	8.58	5.66	3.96	46	51
Maruguda	13,18	11.20	14.96	10.47	93	103
P.A.Pally	20.40	17.34	8.80	6.16	36	39
Chintapally	18.88	16.05	8.11	5.68	35	39
Munugodu	23.31	19.81	17.67	12.37	62	69
Devarakonda	29.85	25.37	14.53	10.17	40	44
Chendur	17.59	14.95	12.29	8.6	58	64
Chityal	23.15	19.68	22.81	15.97	81	90
Peddavoora	36.65	31.15	5.54	3.88	12	14
Narketpalli	26.42	22.46	18.16	12.71	57	62
Choutuppal	21.66	18.41	9.49	6.64	36	40
Nalgonda	37.68	32.03	28.11	19.68	61	68
Annamula	60.00	51.00	4.66	3.25	6	7
Kanagal	21.98	18.68	18.44	12.91	69	76
Rajapet	24.86	21.13	24.14	16.9	80	88
Shaligowraram	21.88	18.60	17.47	12.23	66	73
Suryapet	32.79	27.87	8.47	5.93	21	23
Tipparthy	23.58	20.04	18.46	12.92	64	71
Tripuram	45.97	39.07	2.01	1.41	4	4
Tungathurthy	27.74	23.58	15.07	10.55	45	49
Turkapally	19.86	16.88	11.71	8.2	49	54
Valgonda	34.31	29.16	8.49	5.94	20	22
Vemulapally	39.55	33.62	9.47	6.63	20	22
Yadagirigutta	31.19	26.51	18.24	12.77	48	53
Nakrekal	14.66	12.46	13.07	9.15	73	81
Alair	35.18	29.90	26.31	18.42	62	68
Atmakur (M)	20.98	17.83	10.59	7.41	42	46
Atmakur (S)	22.81	19.39	8.26	5.78	30	33
Bhongir	22.13	18.81	12.69	8.88	47	52
Bibinagar	22.26	18.92	5.03	3.52	19	21
Bommalaramara	12.04	10.23	8.27	5.79	57	62
Chandanpet	21.00	17.85	14.26	9.98	56	62
Chevemula	16.41	13.95	13.14	9.2	66	73
Chilkur	46.28	39.34	0.94	0.66	2	2
Damerachepla	58.87	50.04	4.59	3.21	6	7
Gardepally	71.20	60.52	4.06	2.84	5	5
Gundala	17.69	15.04	9.67	6.77	45	50
Gundlapally	38.37	32.61	11.49	8.04	25	27
Huzurngar	49.94	42.45	2.11	1.48	3	4
Jagireddyguda	17.93	15.24	12.31	8.62	57	62
Kathepalli	21.95	18.66	15.54	10.88	58	64
Kattangur	27.27	23.18	22.96	16.07	69	77
Kodad	151.18	128.50	1.20	0.84	1	1

GROUND WATER RESOURCE & IRRIGATION POTENTIAL NALGONDA						(CGWB-1995)
Mandal	Total replenishable ground water resources MCM	Utilisable groundwater resources MCM	Gross draft (1993) MCM	Net Draft (1993) MCM	Level of ground water development % 1993	Current Level of ground water development % 1998
Mattampally	43.39	36.88	1.50	1.05	3	3
Medlacheruvu	83.33	70.83	2.09	1.46	2	2
Miryalguda	84.97	72.22	3.56	2.49	3	4
Mothey	18.89	16.06	11.86	8.3	52	57
Mothukur	30.04	25.53	10.29	7.2	28	31
Munagala	37.21	31.63	7.67	5.37	17	19
Nandiguem	45.68	38.83	3.50	2.45	6	7
Neredcherla	74.02	62.92	4.30	3.01	5	5
Nidmanoor	41.93	35.64	6.96	4.87	14	15
Nutakkal	30.58	25.99	19.09	13.36	51	57
Penpahad	31.47	26.75	7.07	4.95	19	20
Pochampally	25.82	21.95	7.17	5.02	23	25
Ramannapet	21.27	18.08	9.33	6.53	36	40
Tirumalagiri	20.19	17.16	12.73	8.91	52	57
Total District	1994.16	1695.04	659.05	461.32	27	30