CHAPTER 3

EXISTING CONDITION OF THE WATER SUPPLY AND SANITATION / SEWERAGE SYSTEMS

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3.1 Water Supply System

3.1.1 General

There are seven existing regional water supply schemes depending on surface water sources in Goa. These are listed in Table 31.1 and shown on Figure 31.1.

Table 31.1 List of Surface Water Supply Schemes in Goa

	Water Supply Scheme	Water Treatment Plant		Name of Taluka mainly supplied by the Scheme
		No. of Plants	Total Capacity	
1	Salaulim	1	160 MLD	Mormugao, Salcete, Quepem, Sanguem
2	Opa	4	112 MLD	Ponda, Tiswadi
3	Chandel	1	15 MLD	Pernem
4	Assonora	2	42 MLD	Bardez
5	Sanquelim	3	52 MLD	Bicholim
6	Dabose	1	5 MLD	Satari
7	Canacona	1	5 MLD	Canacona
Total			391 MLD	

Goa's 11 Talukas are served by 7 regional water supply schemes. Areas that are not served by these 7 regional schemes are served by small scale rural water supply schemes. The rural water supply schemes mainly source their water from groundwater or springs.

In May 1999, CPHEEO, Ministry of Urban Development issued "Manual on Water Supply and Treatment" and the manual includes drinking water quality standard, methodologies of planning and designing water supply facilities. PWD Goa also refers to the manual and the PWD plans and operates facilities according to the manual.

The current condition of the existing regional water supply schemes is described below.

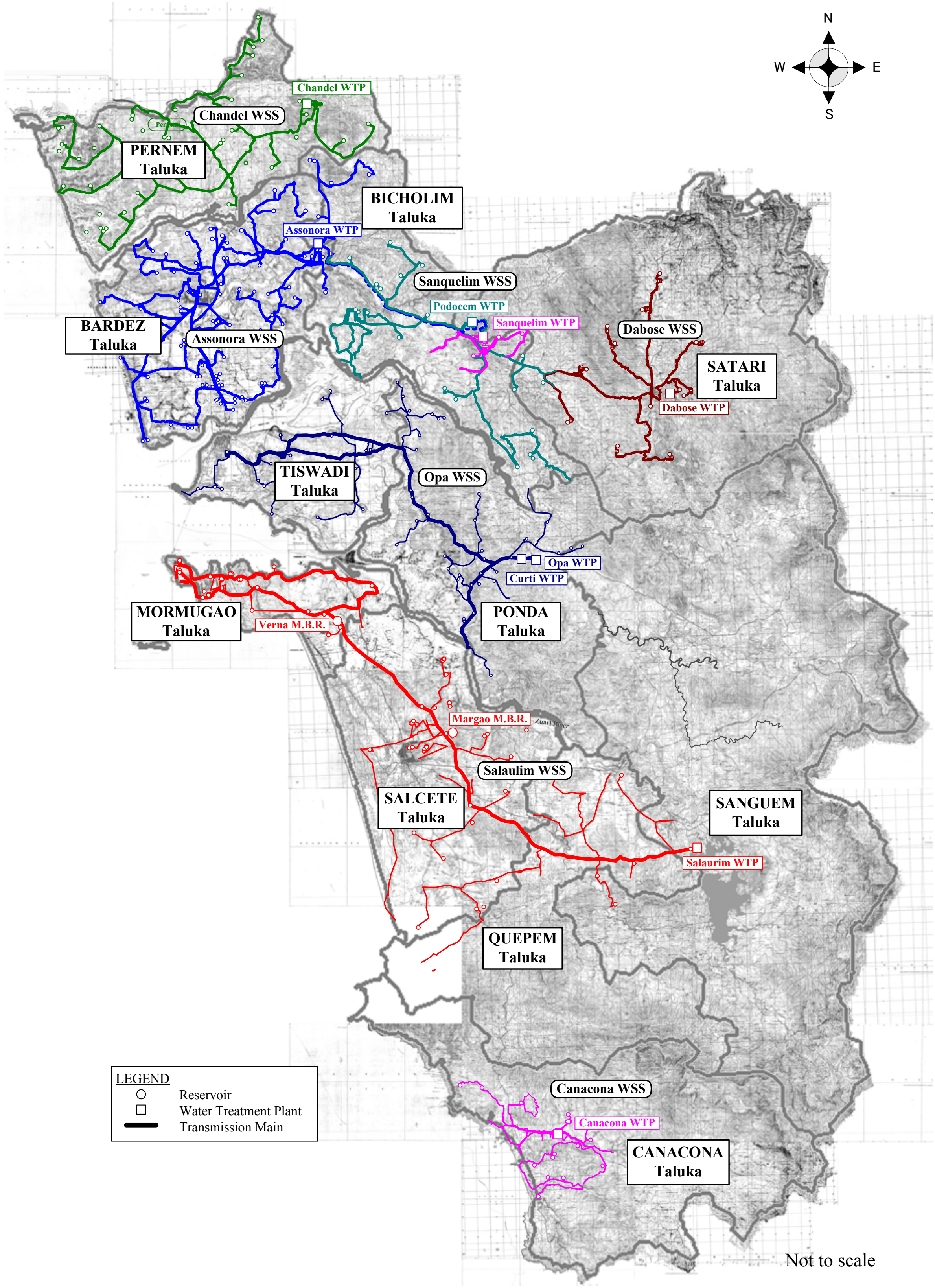


Figure 31.1 Regional Water Supply Schemes in Goa

3.1.2 Salaulim Water Supply Scheme

(1) Outline of the Scheme

Salaulim Water Supply Scheme (WSS) has one water treatment plant (WTP), which has a capacity of 160 MLD. The WTP is located next to Salaulim Dam in Sanguem Taluka. The WSS supplies treated water to the following four Talukas: Mormugao Taluka, Salcete Taluka, Quepem Taluka and Sanguem Taluka, as shown on Figure 31.3.

(2) Treatment Plant

The Salaulim WTP was commissioned in 1989. It has a design capacity of 160 MLD, although the plant sometimes produces up to 170 MLD, as shown on Figure 31.2.

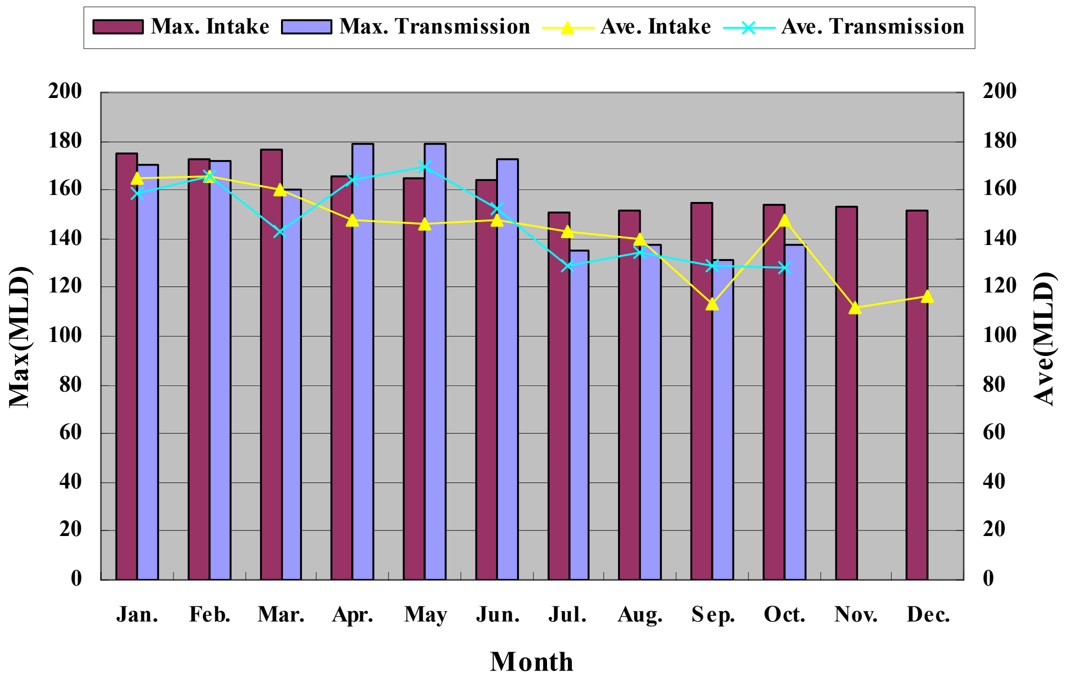


Figure 31.2 Intake and Transmission Flow Rates

The water pump house supplies raw water to the WTP via two no. 1,000mm rising mains. The WTP is located approximately one kilometre from the raw water intake point. Raw water is delivered to the existing plant from Selaulim Dam. The plant schematic is shown on Figure 31.4. Detailed asset data for the WTP are attached to Volume IV Appendix M31.1 Salaulim Water Supply Scheme.

(3) Transmission and Distribution System

Table 31.2 outlines the transmission and distribution system for the Salaulim WSS.

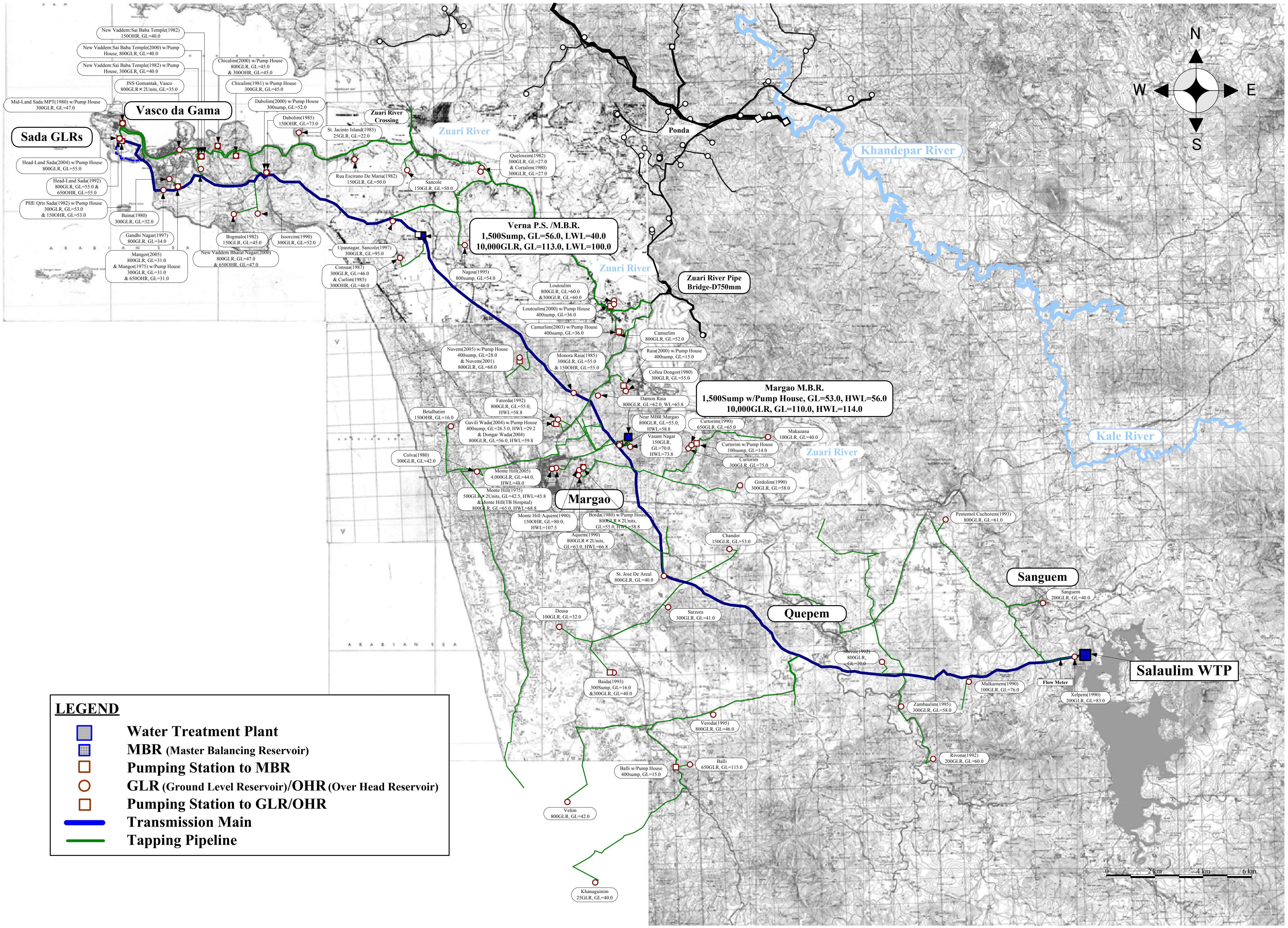


Figure 31.3 Salaulim Water Supply Scheme

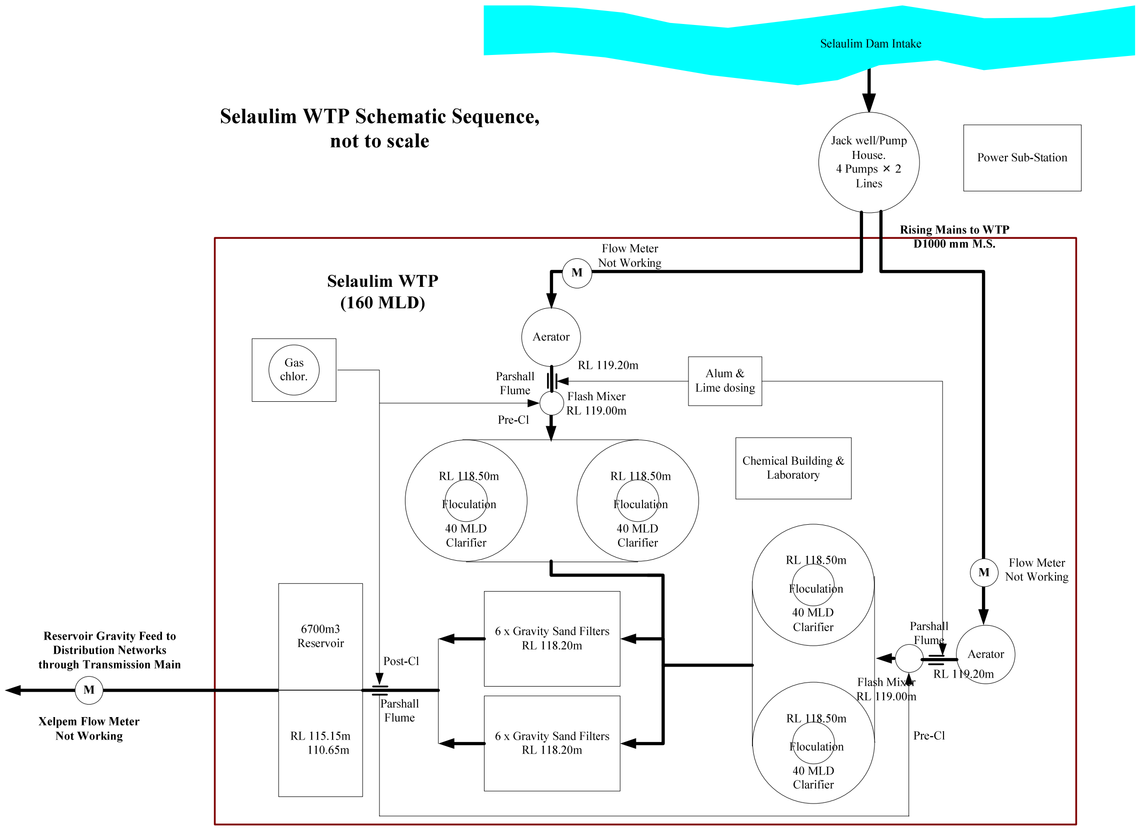


Figure 31.4 Salaulim WTP Schematic

Table 31.2 Details of the Transmission and Distribution System for the Salaulim WSS

a. Length of Transmission Mains	276,586 m
- Mild Steel, 300mm – 1400mm	19,690 m
- PSC, 150mm – 1400mm	82,012 m
- Cast Iron, 80mm – 1200mm	90,574 m
- Others	84,310 m
b. Number of Distribution Reservoirs	91
c. Capacity of Reservoirs	53,000 m^3
d. Length of Distribution Mains	1,424,990 m
- Cast Iron, 80mm – 400mm	132,440 m
- Ductile Iron, 80mm – 300mm	4,800 m
- A.C., 80mm – 300mm	490,650 m
- PVC, 63mm – 160mm	797,100 m

Source: Sector Status Study – WSS Goa, 2004, (Data was confirmed to the PWD in 2005)

Figure 31.5 shows the longitudinal section along the main route of transmission mains, between the Salaulim WTP and Vasco da Gama City. The PWD has replaced the first 10 kilometres of the old PSC pipes with mild steel pipes. This was necessary because the existing pipes were corroding and there was a lack of re-bars for the PSC pipes.

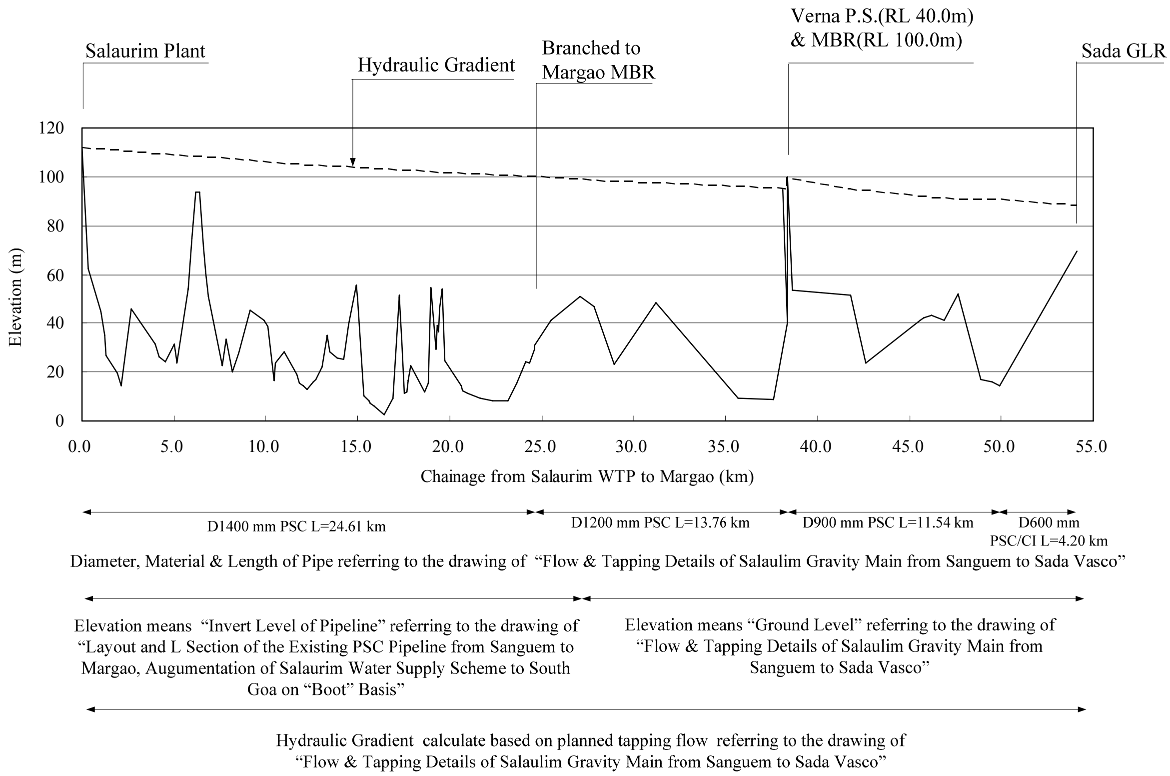


Figure 31.5 Longitudinal Section along the Transmission Mains from Salaulim WTP

(4) Water Quality

The most important design parameters for WTP are turbidity levels and its fluctuations of the raw water. Turbidity varies considerably depending on whether the intake is from a dam or a river. Turbidity of raw water from a dam is generally lower than that from a river. This is because dams promote natural sedimentation. Figure 31.6 presents the turbidity level results for Salaulim Dam's raw and treated water.

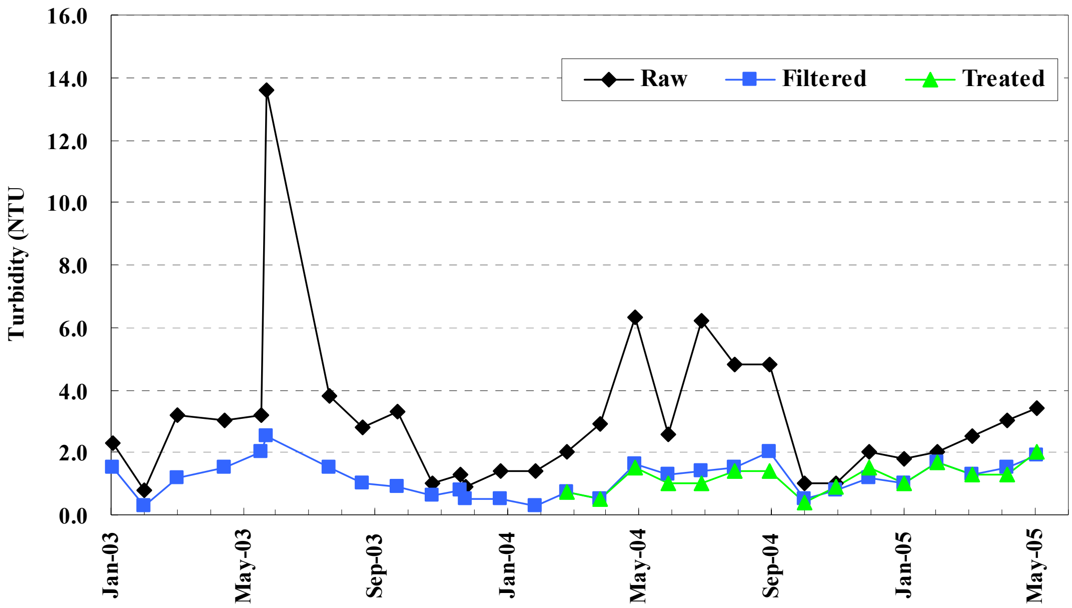


Figure 31.6 Turbidity of Raw Water from Salaulim Dam

The results show that the raw water turbidity at Salaulim Dam is relatively low and that there are no significant fluctuations resulting from rainfall runoff during the wet season.

The Manual on Water Supply and Treatment (Ministry of Urban Development, CPHEEO, May 1991) recommends that turbidity of water that is delivered to consumers should not exceed 1 NTU. Generally the turbidity of the treated water at the Salaulim WTP exceeds 1 NTU. This high turbidity may result of the poorly functioning treatment process.

Figure 31.7 shows that the concentration of manganese in the raw water in 1997 and from 2000 to 2004 was relatively high. Therefore, it might be necessary for upgrades to the WTP to consider manganese treatment.

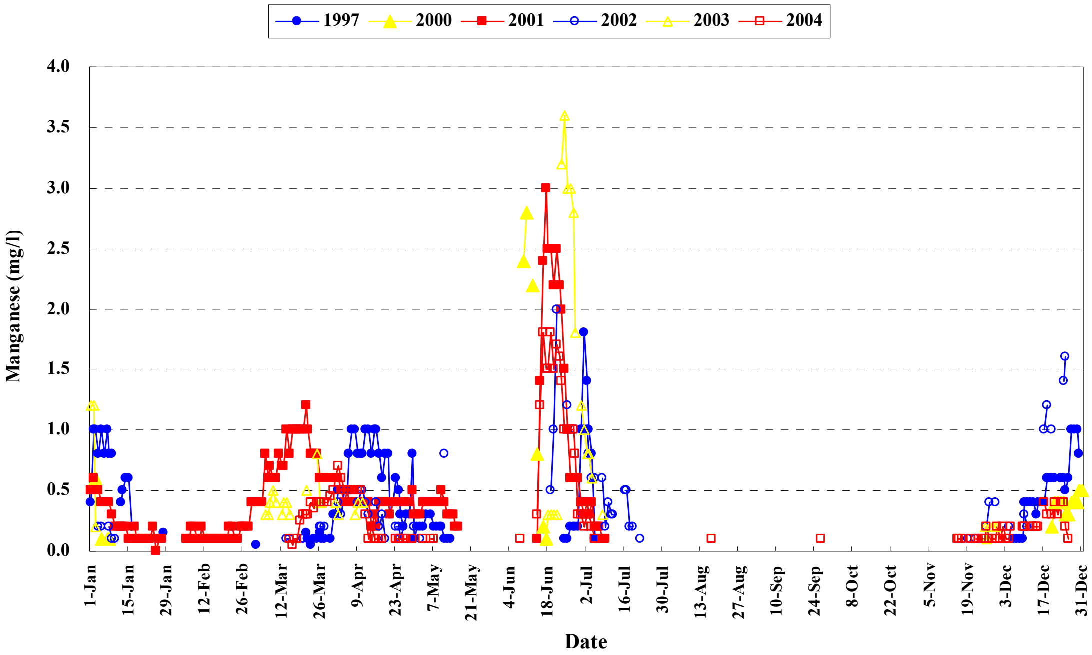


Figure 31.7 Manganese Concentration in Raw Water at Salaulim WTP

The residual chlorine concentrations in consumers' tap water was tested as part of this study. Simple water quality analysis kits were used to carry out the tests. Residual chlorine was detected at all the test points. Therefore, it is concluded that the chlorination system at the plant and/or the reservoirs is functioning properly. Section 3.1.11 provides more details regarding the residual chlorine analysis.

(5) Operation and Maintenance

PHE staff are responsible for operation and maintenance and for reacting to breakdowns. Although regular maintenance (such as oiling and greasing) and periodic maintenance is carried, it is not recorded and does not follow a formal procedure. Preventative maintenance systems do not exist, and there are no plans for such systems to be developed. Major breakdowns are repaired by staff from the divisional offices concerned. Records are kept manually and there are no plans for installing a computerised maintenance management system.

Guarding of machinery is not adequate, especially for high speed rotating equipment (i.e. pump couplings/shafts).

Safety awareness by staff is low and plant operators/maintenance staff are not issued with personal protective equipment (PPE).

Safety awareness and practices for use of chlorine gas does not exist. For example, there are no written procedures for handling, connecting cylinders to chlorinators, or for equipment maintenance (such as the replacement intervals for copper piping). Gas detectors are not installed and personal breathing apparatus is available but is not used or maintained.

There are no operating procedures or process control charts/parameters displayed on-site. Some equipment catalogues are kept on site but there are no written 'standard operating procedures' (SOP's), 'O&M manuals' (with the exception of the newest plant), 'H&S procedures', 'Safe Systems of Work' (e.g. plant isolation/lock-off procedures for maintenance of moving machinery, working in confined spaces, etc) or 'Emergency/Contingency plans'.

The study team could not identify any established formal systems for reporting compliance and performance data, maintenance issues, maintenance of assets data, H&S issues and other management information.

(6) Problems Identified

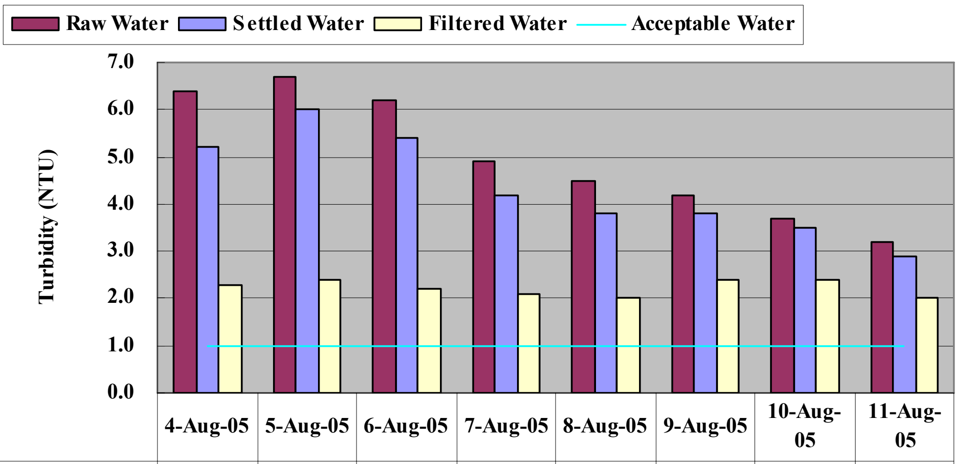
The problems listed below were identified during the Reconnaissance Survey as part of Phase I of this project.

1) Lack of flow measurement and flow control systems

The water treatment plant intake and transmission flow rates are not measured directly by flow meters. As there are no measurements, the intake volumes were estimated from the pump capacity and hours of operation. Lack of flow measurement means accurate chemical dosage is difficult to control. Also, the transmission flow rate is not measured along the transmission mains therefore the actual transmission flow rate is not understood. This means flow control cannot be properly carried out.

2) Ineffective coagulation and sedimentation

The sedimentation basins are not effectively managed because the inflow turbidity and pH are not adequately understood. An understanding of these parameters is required to determine the correct chemical dosing rates. Figure 31.8 shows that turbidity is not effectively reduced.



	4-Aug-05	5-Aug-05	6-Aug-05	7-Aug-05	8-Aug-05	9-Aug-05	10-Aug-05	11-Aug-05
Raw Water	6.4	6.7	6.2	4.9	4.5	4.2	3.7	3.2
Settled Water	5.2	6.0	5.4	4.2	3.8	3.8	3.5	2.9
Filtered Water	2.3	2.4	2.2	2.1	2.0	2.4	2.4	2.0
Acceptable Water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 31.8 Reduction of Turbidity as a Result of the Treatment Process at the Salaulim WTP

Figure 31.8 shows that the majority of turbidity is removed at the filtration basin. When turbidity levels are high and therefore the sediment load at the filtration basin is large, more frequent backwashing of the filters is required.

The aluminium concentration in the treated water is shown in Figure 31.9. The presence of aluminium in the treated water indicates that the chemical dosing rates are not well controlled or that the mixing is not sufficient.

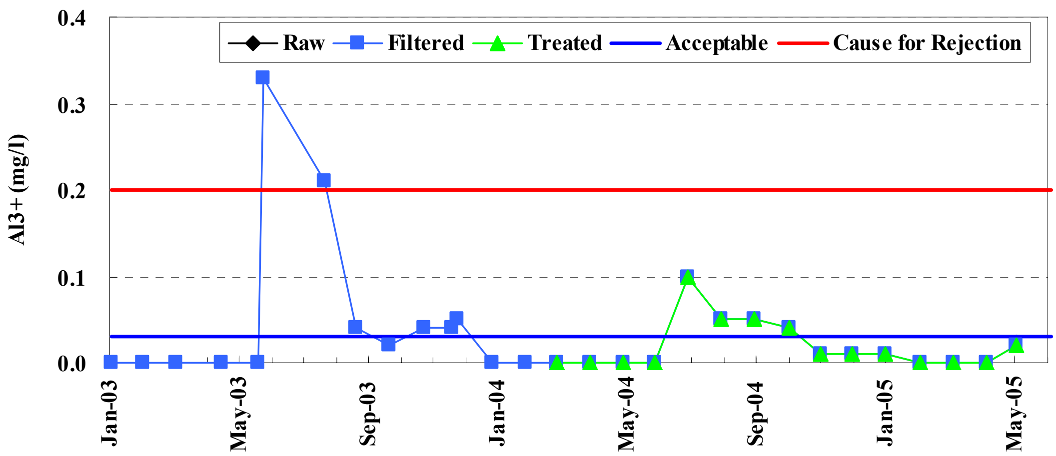
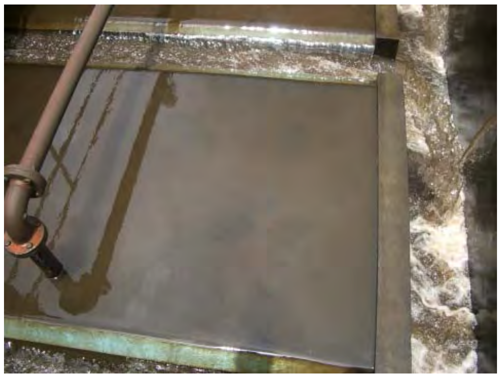


Figure 31.9 Concentration of Aluminium in Treated Water

3) Insufficient backwashing

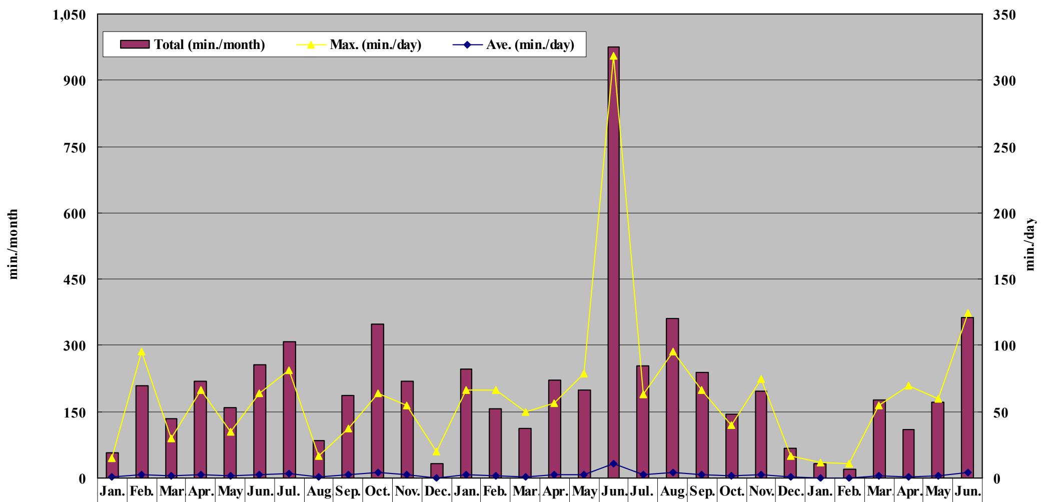
The field investigation found that turbid water is discharged from the filter even immediately after the filter is backwashed (see Photo 31.1). This may be because the backwashing procedure (which uses air scouring) is not sufficient, for example the duration of backwashing is not sufficient, and/or there is a structural problem of the filter basin.

Photo 31.1 Backwashing at Salaulim WTP



4) Frequent Electric Power Outages

During 2004, the operation of the Salaulim WTP was interrupted for approximately 3,170 minutes (8.7 minutes/day, on average) as shown in Figure 31.10.



	2003												2004												2005					
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Total (min./month)	56.0	210.	134.	219.	159.	255.	309.	85.0	187.	347.	218.	33.2	247.	156.	111.	221.	199.	975.	253.	360.	239.	144.	195.	66.0	32.0	21.0	177.	109.	171.	362.
Max. (min./day)	15.0	95.0	30.0	66.0	35.0	64.2	81.0	17.0	37.0	63.6	55.0	20.0	66.0	66.0	50.0	56.0	79.2	318.	63.0	95.4	66.0	40.0	75.0	17.0	12.0	11.0	55.0	69.6	60.0	124.
Ave. (min./day)	1.8	7.5	4.3	7.3	5.1	8.5	10.0	2.7	6.2	11.2	7.3	1.1	8.0	5.6	3.6	7.4	6.4	32.5	8.2	11.6	8.0	4.6	6.5	2.1	1.0	0.8	5.7	3.7	5.5	12.1

Figure 31.10 Power Outages in 2004

To prevent intermittent water supplies and damage to facilities resulting from water hammer effects, the following measures to protect against power outages should be considered:

- provide surge control to address water hammer problems;
- provide a standby electrical power generator; and
- provide sufficient reservoir capacity to store water.

5) Many visible leaks at the WTP and along the transmission mains

There are many visible leaks at the WTP and at almost all the air valves along the transmission mains (see Photos 31.2 and 31.3). As the first step towards reducing leakages, reactive measures to fix visible leaks should be implemented.

Photo 31.2 Leakage from Valve at Salaulim WTP

Photo 31.3 Leakage from Air Valve along the Transmission Main

6) Lack of operation and maintenance manuals and plans

There are no standard operation and maintenance manuals or plans for any part of the scheme (treatment plant, transmission system or distribution system). This means, appropriate and coordinated operation and proactive maintenance cannot be performed.

7) Lack of asset drawings, asset data and process data

Current asset drawings and data are not available. This means:

- evaluation of performance is difficult;
- operation and maintenance is inadequate because basic facility information is not available; and
- responses to problems/emergencies are inadequate or delayed.

3.1.3 Opa Water Supply Scheme

(1) Outline of the Scheme

Opa Water Supply Scheme (WSS) has four WTPs with a total capacity of 112 MLD. The Opa WSS is located in Ponda Taluka and supplies treated water to the following two Talukas: Tiswadi Taluka and Ponda Taluka (as shown in Figure 31.11). The Khandepar River supplies water to the scheme. In recent years, raw water from Salaulim Dam has been used to augment the supply. This is achieved by diverting water to the Kale River, which is a tributary of the Khandepar River.

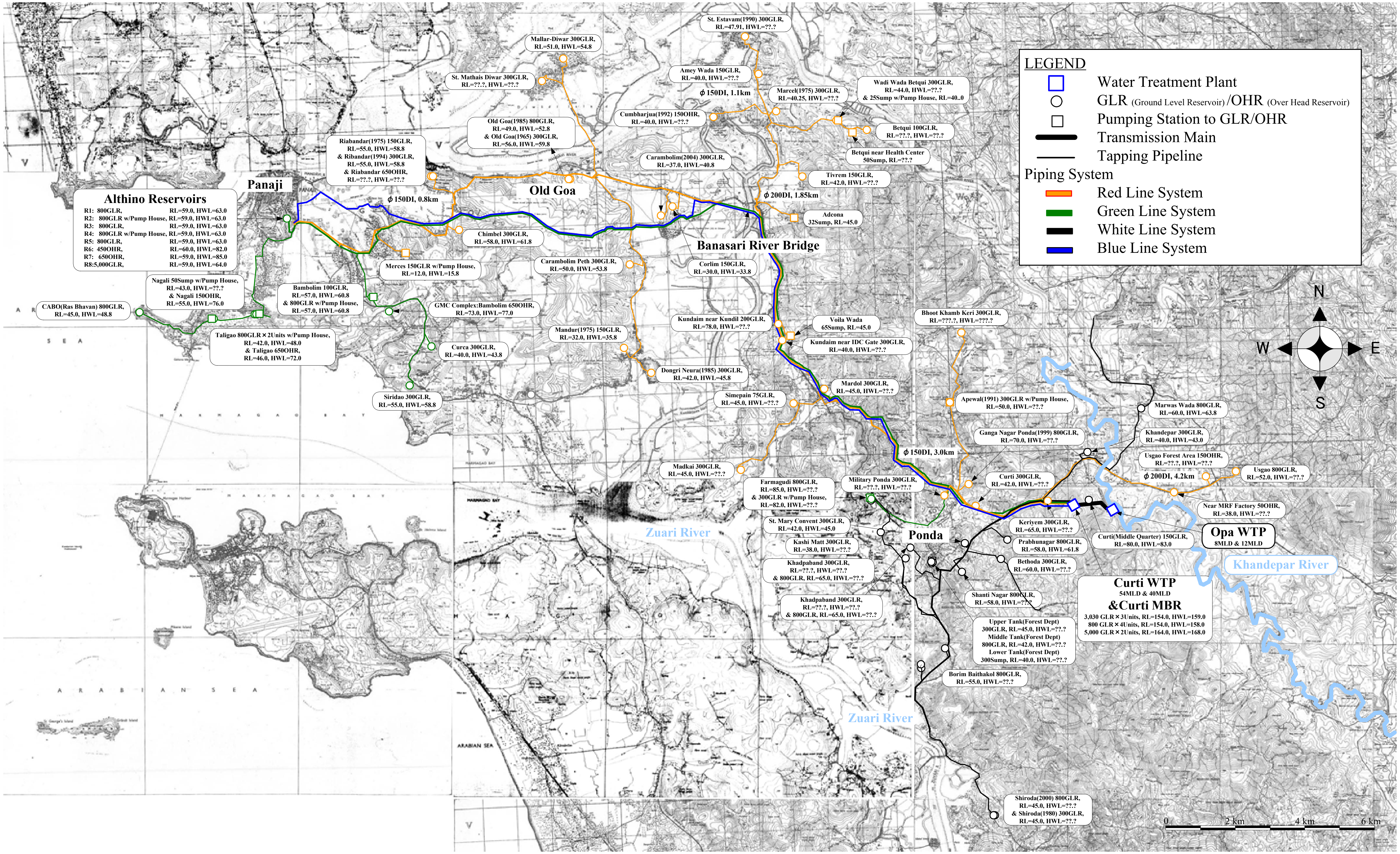


Figure 31.11 Opa Water Supply Scheme

(2) Treatment Plant

The Opa WTP has been augmented over the years and currently consists of four river intakes (one for each self contained WTP). The original Opa site contains the following two plants:

- Plant I (8MLD) which was commissioned in 1957; and
- Plant II (12 MLD) which was commissioned in 1967.

The two additional plants listed below have since been built at Curti, which is approximately two kilometres from Opa:

- Plant III (52 MLD) which was commissioned in 1972 (this plant was later increased to a capacity of 72 MLD by adding two extra filter beds); and
- Plant IV (40 MLD) which was commissioned in 2004.

The total intake flow rates for Plant I, Plant II and Plant III (having a combined total capacity of 92 MLD) was calculated from pump capacity and pump operation hours. These flow rates are shown in Figure 31.12. Figure 31.12 indicates that the plants are overloaded.

Since Plant IV was only commissioned in 2004 there are no accumulated records. When the flow meter was checked during the site visit, the intake flow was 60,700 m^3/day which is 1.5 times above the design capacity.

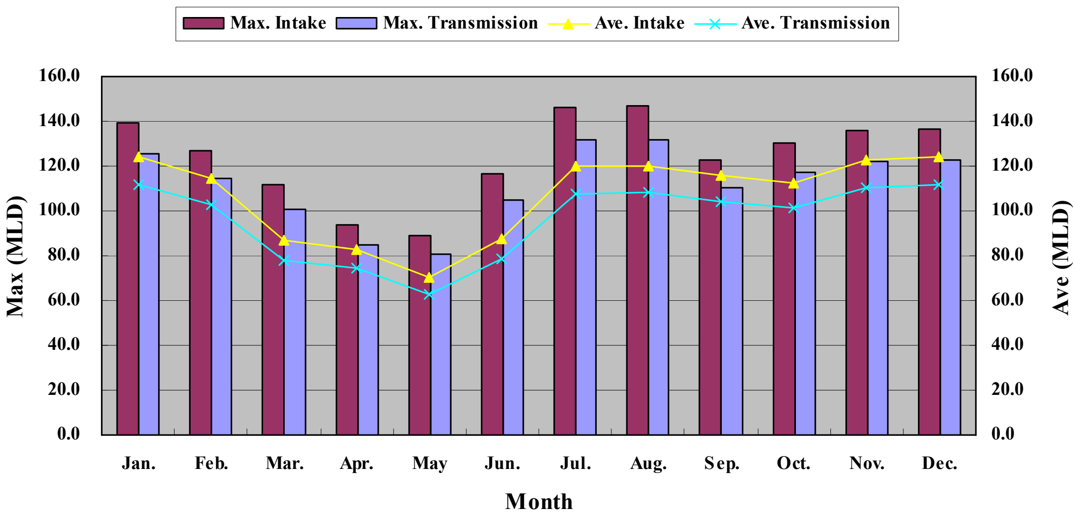


Figure 31.12 Intake and Transmission Flow Rates

The plant schematic is shown in Figure 31.13. Detailed asset data for the plant are shown in Volume IV Appendix M31.2 Opa Water Supply Scheme.

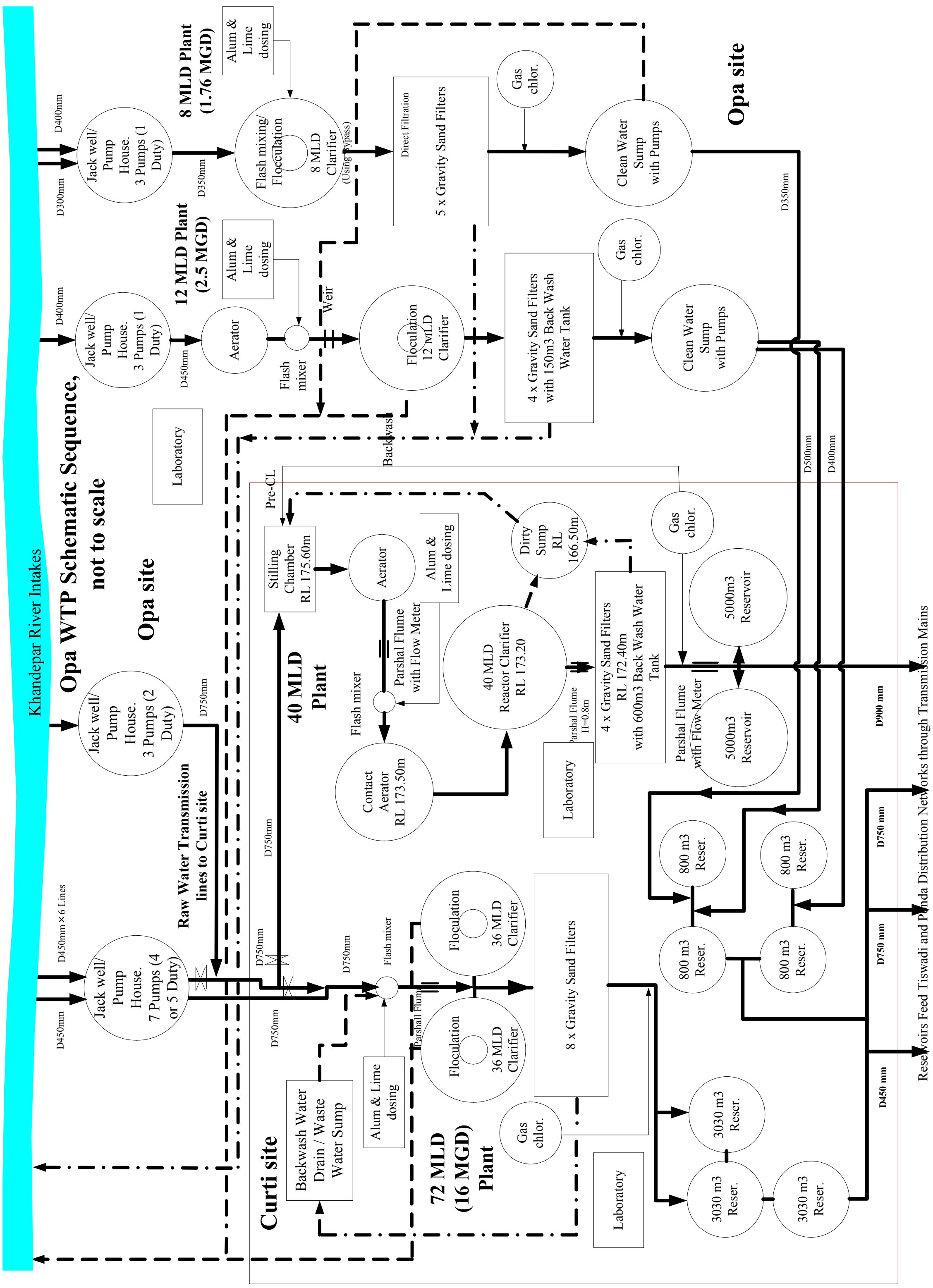


Figure 31.13 Schematic Diagram for the Opa WTP

(3) Transmission and Distribution System

Table 31.3 lists the components of the Opa WSS transmission and distribution system. The PDW is currently adding a transmission main, dia. 900 DI, from the Opa WTP to Panaji City, with the aim of securing water supply to Panaji City (the capital city of Goa). Laying of this transmission main will be completed by 2007. This transmission main is, therefore, considered to be the existing pipeline for the Study.

Table 31.3 Details of Opa WSS's Transmission and Distribution System

a. Length of Transmission Mains	183,567 m
- Mild Steel, 400mm – 750mm	1,625 m
- Ductile Iron, 150mm – 1400mm	3,300 m
- Cast Iron, 80mm – 750mm	160,942 m
- Others	17,700 m
b. Number of Distribution Reservoirs	91
c. Capacity of Reservoirs	36,000 m^3
d. Length of Distribution Mains	704,003 m
- Cast Iron, 40mm – 350mm	93,318 m
- Ductile Iron, 40mm – 150mm	1,340 m
- A.C., 40mm – 250mm	139,695 m
- PVC, 40mm – 200mm	410,380 m
- G.I., 40mm – 250mm	57,530 m
- HDPE, 40mm – 150mm	1,740 m

Source: Sector Status Study – WSS Goa, 2004, (Data was confirmed to the PWD in 2005)

Figure 31.14 shows the longitudinal section along the main route of the transmission mains from the Opa WTP to Panaji City.

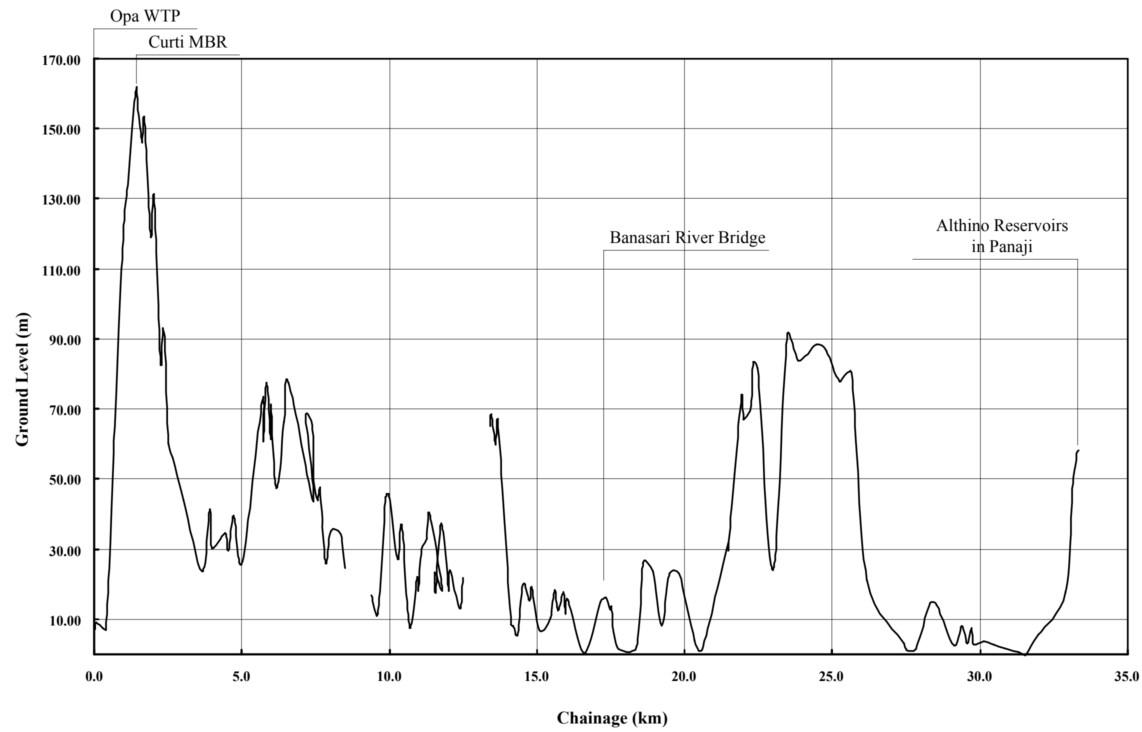


Figure 31.14 Longitudinal Section of Transmission Mains from Opa WTP

(4) Water Quality

Water qualities of raw and treated water are monitored at water treatment plant and parameters are pH, turbidity, alkalinity, hardness, chloride ion, manganese iron, DO and residual chlorine. These parameters are rather for operation of the plant but not for confirmation of safety of the treated water. Detailed records of water quality are shown in Volume IV Appendix M31 Existing Water Supply System.

The turbidity of raw water from rivers usually fluctuates in response to rainfall runoff during the wet season more than the turbidity levels in dams. The turbidity of the raw water from the Khandepar River at Opa WTP is shown in Figure 31.15.

The results show that the turbidity of the raw water taken from the Khandepar River fluctuates and during the wet season (from May to October) the turbidity increases as a result of rainfall runoff.

Figure 31.16 shows the concentration of iron in the raw water from 2003 to the present. This figure shows that iron concentrations occasionally increase. These increases could be a result of diverting water from Salaulim Dam to the Khandepar River, which is the source of raw water for the Opa WTPs.

The residual chlorine concentration in water at consumers' taps was checked during the study. Residual chlorine was detected at all points therefore it is concluded that the chlorination system is functioning properly. Section 3.1.11 provides more detailed results of the residual chlorine analysis.

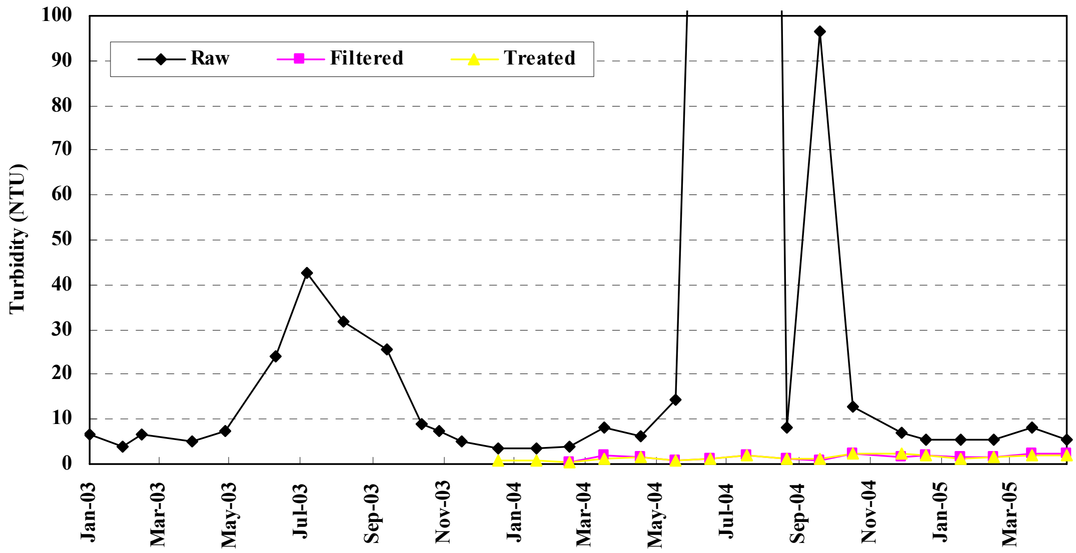


Figure 31.15 Turbidity of Raw Water taken from Khandepar River

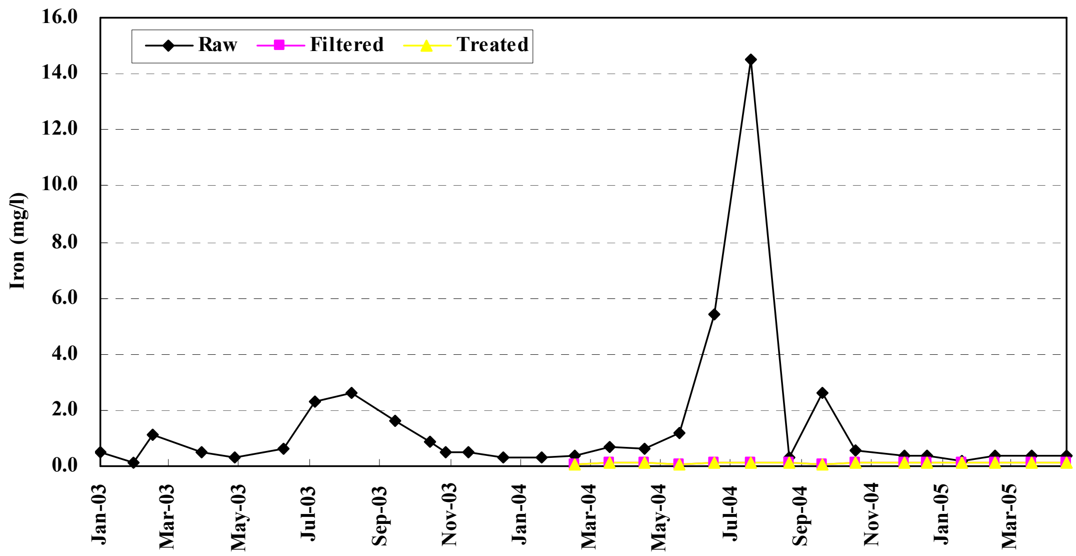


Figure 31.16 Iron Concentration in the Raw Water at the Opa WTP

(5) Operation and Maintenance

Situations of operation and maintenance are very similar to one of Salaulim WTP previously discussed. Specific problems concerning Opa WTPs are described in following (6).

(6) Problems Identified

During the Reconnaissance Survey completed as part of Phase I of this project, the following problems with the Opa WSS were identified:

1) Lack of flow measurement and flow control systems

Intake and transmission flow rates at the water treatment plant are not measured by flow meters. Therefore, a record of the intake volume from the Khandepar River was estimated using the pump capacity and operation hours. Without an accurate understanding of the flow rates, accurate chemical dosage is difficult to control. The transmission flow rates are not measured along the transmission mains. This means the actual transmission flow rate is not understood and therefore flow control cannot be carried out properly. Since the Opa WSS supplies water to Panaji City, which is a capital city of the Goa, flow control is very important.

2) Ineffective coagulation, sedimentation and filtration

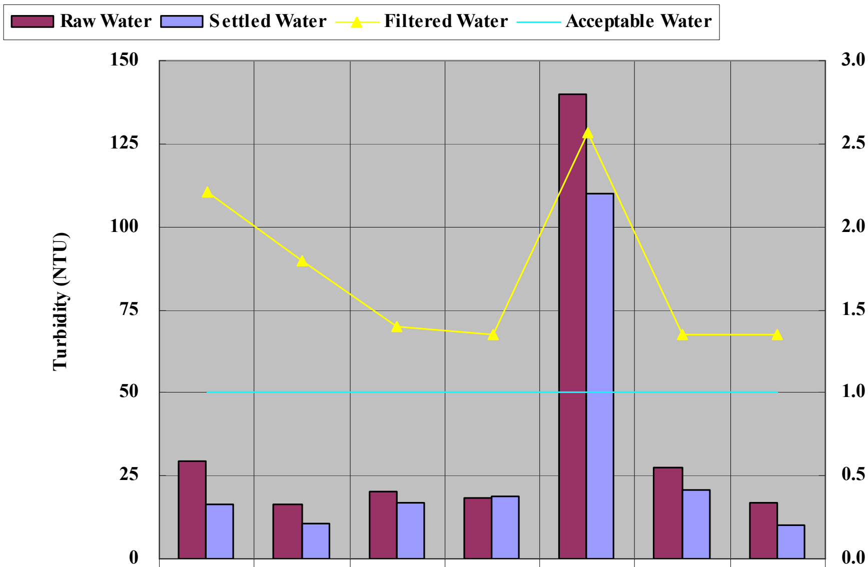
Figures 31.17 and 31.18 indicate that the turbidity of the raw water and the settled water are similar. This means turbidity is not reduced by the sedimentation basins (see Photo 31.5). The sedimentation basins are inefficient because the chemical dosing rate cannot be accurately determined due to the lack of information regarding turbidity and pH of the water being treated.

These figures show that the filtration basin removes most of the turbidity. As turbidity increases more frequent backwashing of the filters is required. The filtration rate of Plant IV (40 MLD) is 10.2 m/hr on average. A standard filtration rate is 4.8 to 6.0 m/hr. This rate may result in high turbidity levels in the treated water.

Photo 31.4 Sedimentation Basin at Plant IV

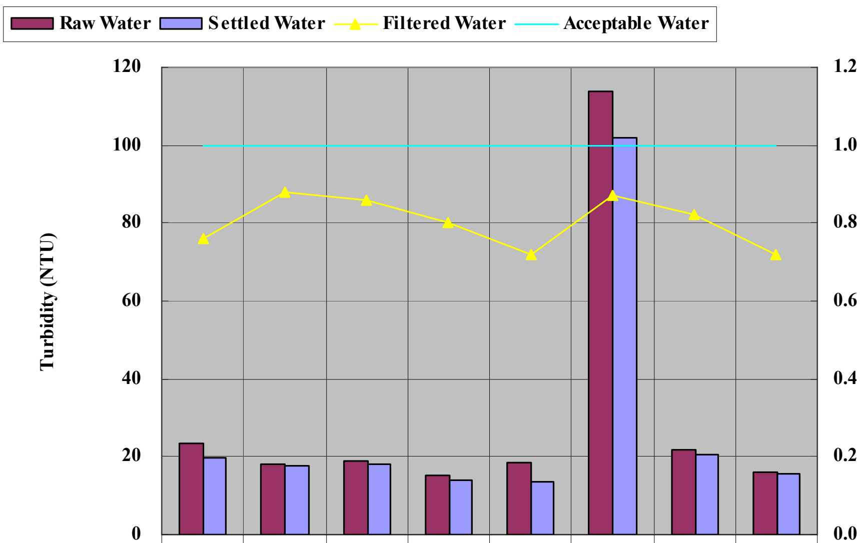
(carryover because of overloading)

The Manual on Water Supply and Treatment (Ministry of Urban Development, CPHEED, May 1991) recommends that the turbidity of water delivered to the consumers should be less than 1 NTU. The treated water turbidity at Plant III (52 MLD) exceeds 1 NTU. This may be because the treatment process does not function well.



	4-Aug-05	5-Aug-05	6-Aug-05	8-Aug-05	9-Aug-05	10-Aug-05	11-Aug-05
Raw Water	29.3	16.2	20.3	18.3	140.0	27.3	17.0
Settled Water	16.5	10.6	16.8	19.0	110.0	20.8	10.0
Filtered Water	2.21	1.79	1.40	1.35	2.57	1.35	1.35
Acceptable Water	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 31.17 Reduction of Turbidity by OPA's WTP (Plant III)



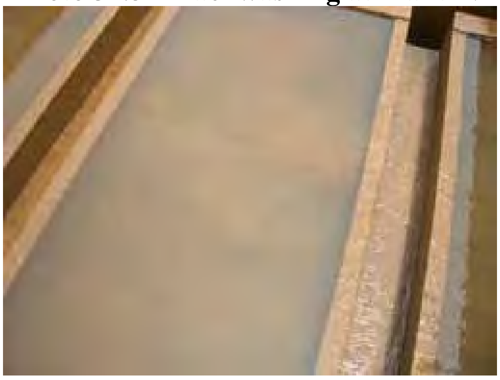
	4-Aug-05	5-Aug-05	6-Aug-05	7-Aug-05	8-Aug-05	9-Aug-05	10-Aug-05	11-Aug-05
Raw Water	23.3	17.9	19.0	15.4	18.4	114.0	21.8	16.0
Settled Water	19.8	17.6	17.9	14.0	13.5	102.0	20.7	15.8
Filtered Water	0.76	0.88	0.86	0.80	0.72	0.87	0.82	0.72
Acceptable Water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 31.18 Reduction of Turbidity by OPA's WTP (Plant IV)

3) Insufficient backwashing

The field investigation indicated that the water coming out of the filter is turbid (see Photo 31.6). This means that backwashing (using air scouring) may not be sufficient because the duration of backwashing is not sufficient and the sequence is not appropriate and that there may be a structural problem of the filter basin.

Photo 31.5 Backwashing at Plant IV



4) Measures to Control Manganese and Iron Concentrations

As mentioned above, in recent years the concentrations of manganese and iron in the Khandepar River have been increasing. Therefore, it may be necessary to provide additional facilities (such as pre-chlorination) to reduce manganese and iron during the treatment process.

5) Frequent Electric Power Outages

There were 36 days during 2004 when the Opa WTP experienced power outages. In total, there was no power for 1,594 minutes, as shown in Figure 31.19.

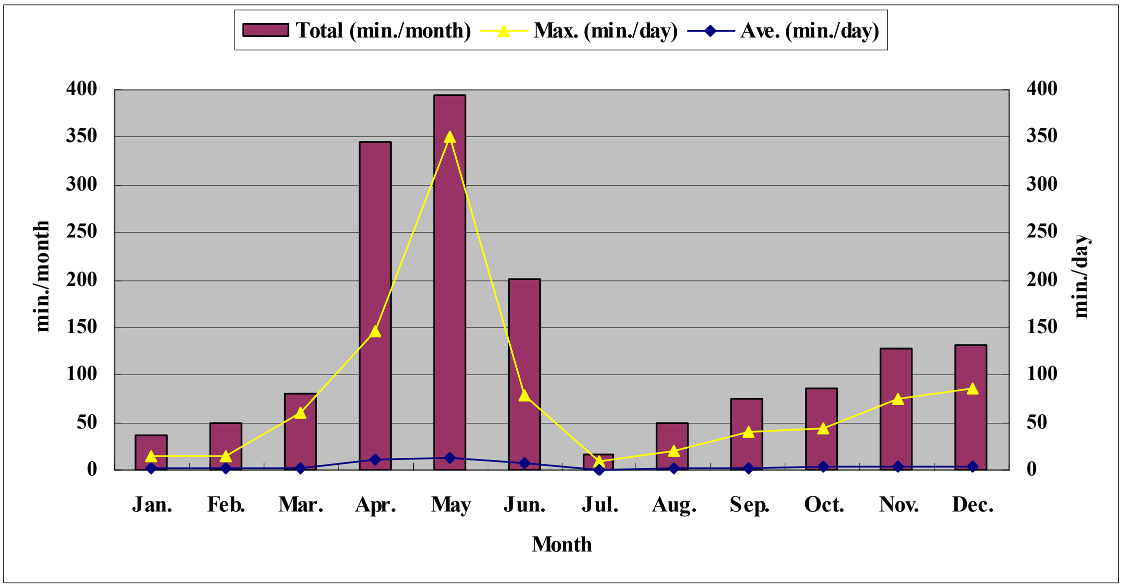


Figure 31.19 Power Outages During 2004

Power outages result in intermittent water supplies and facilities are damaged from water hammer. The following protective measures should be considered:

- surge control to address the water hammer problems;
- install a standby generator; and
- ensure the reservoirs have sufficient capacity to store water.

6) Numerous visible leaks at the WTP and along the transmission mains

There are many visible leaks at the WTP and along the transmission mains (see Photos 31.7 and 31.8), however there are fewer leaks than at the Salaulim WSS. The first step to reduce leakage should be a reactive approach of fixing visible leaks.

Photo 31.6 Leakage from Intake Pump at the Curti Plant

Photo 31.7 Leakage from Air Valve along the Transmission Main

7) Lack of Operation and Maintenance Manuals and plans

There are no standardised operation and maintenance manuals and plans for the scheme. Also, there is no safety management or control. This means appropriate operation and proactive maintenance is difficult.

8) Lack of asset drawings, asset data and process data

Current asset drawings and data are not available. This means:

- performance evaluation is difficult;
- operation and maintenance is inadequate because basic facility information is unavailable; and
- responses to problems/emergencies are inadequate and delayed.