Design and Optimization of Piped Water Supply Scheme based on Upper Vaitarna for tanker fed villages in Mokhada Taluka

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Acronyms and Abbreviations

ESR Elevated Storage Reservoir

GIS Geographical Information System

GP Gram Panchayat

LPCD Litres Per Capita per Day

MBR Mass Balance Reservoir

MJP Maharashtra Jeevan Pradhikaran

MSEB Maharashtra State Electricity Board

MVS Multi Village Scheme

NGO Non Government Organization

PWS Piped Water Scheme

SVS Single Village Scheme

WTP Water Treatment Plant

Contents

Abstract

Many parts of coastal area of Maharashtra face severe drinking water shortage in spite of high rainfall lying typically in the range of 2000mm-3000mm. Thane district alone has more than 160 tanker fed villages, majority of which are concentrated in Jawhar, Mokhada and Shahapur talukas which are dominated by tribal population[4]. Ironically, this area has the distinction of being the major supplier of drinking water to city of Mumbai through reservoirs like Upper, Lower and Middle Vaitarna and Bhatsa. The Middle Vaitarna project, the latest among them undertaken by Municipal Corporation of Greater Mumbai (MCGM) is expected to augment drinking water supply of Mumbai city by 455MLD at a cost of about Rs. 2000 crores.

The source of Karegaon scheme, a piped water scheme based on water supply from Vaitarna River will be submerged due to the above project. It is learnt from local Water Supply department officials that MCGM has assured to finance the new Karegaon scheme. However, the scope of the new scheme under design in terms of coverage has been left unchanged. There is a cluster of tanker fed villages north of Karegaon (Palsunde to Kiniste) and another one south of Karegaon extending from Vihigaon to Kothare. Earlier studies have indicated that it would be possible to solve the water scarcity problem of the cluster of tanker fed villages at a tiny fraction of cost (~ 1%) of Middle Vaitarna project by appropriately designing a multi village scheme based on Upper Vaitarna as source.

The present study was undertaken to evaluate techno economic feasibility of a multi-village scheme for supplying water to the north cluster of tanker fed villages including the four villages covered by Karegaon scheme based on Upper Vaitarna as the source of water. The average elevation of the 13 tanker fed villages in this area is 363m. Preliminary simulation studies had indicated that a multi-village scheme based on Middle Vaitarna as source is not feasible due to the large elevation difference between the source located at elevation of 285m and the villages in the cluster. The much higher elevation of Upper Vaitarna (603m) on the other hand, offers a critical advantage to the proposed scheme by leveraging gravity flow of water thereby reducing both capital cost of piping as well as energy cost for pumping. A step by step design methodology based on protocols followed by MJP was followed for the design and cost estimation of the proposed scheme. The study revealed that the per capita cost of supplying water to the cluster of 17 villages having current population of about 18000 and ultimate design population of 48407 works out to be Rs. 2890, much below the current rural norm of Rs. 3495 and the estimated cost of Rs. 5083 of the Karegaon scheme being designed[1]. Also, the annual O&M cost including energy cost works out to be Rs. 6.34 per 1000L of water much below the norm of Rs 16. Thus, by shifting the source from Middle Vaitarna to Upper Vaitarna, it is possible to drastically bring down the cost thereby providing a permanent solution to the water scarcity problem of the 13 tanker fed villages. Hence, revamping the scope of current Karegaon scheme by including the cluster of 13 tanker fed villages and shifting the source to Upper Vaitarna deserves a serious high level consideration. Furthermore, adopting ‘inclusion’ model, it should be possible to solve the water scarcity problem in similar areas well within the current norms of capital cost. It will not only help do away with recurring cost of supplying water by tankers but also remove the perpetual dependency of large number of rural population on tanker supplied water at subsistence level.

Keywords

Piped water supply, rural water supply, multi village scheme, piped network design, drinking water, domestic water, Karegaon, Mokhada, Upper Vaitarna, Maharashtra

1. Introduction

1.1 Background:

The Middle Vaitarna project undertaken by MCGM to augment water supply to Mumbai by 455 MLD by building a dam on Vaitarna River in Mokhada taluka of Thane district was recently commissioned. Karegaon Rural Water Supply Scheme in the vicinity of the project is being revamped because of submergence of its assets due to Middle Vaitarna project. The neighbouring villages facing severe water scarcity problem are upset over the fact that they were not included in the scope of redesigned scheme. There is a cluster of about 13 villages to north of Karegaon that have been dependent on tanker supplied water. In most instances single village water supply scheme fail rural per capita norms of Rs. 3495 due to high elevation (350 m and higher) of most of these villages. According to the villagers, they do not object to their water being taken away as long as their need of drinking water is addressed as part of the project. In this background, the present study was undertaken.

Given this background, it was thought worthwhile to assess the feasibility of a multi village scheme based on Upper Vaitarna as source for solving the water scarcity problem of the cluster of tanker fed villages to the north of Karegaon in Mokhada Taluka. Further, it was worth looking into the feasibility of the scheme by including the four villages covered by the Karegaon.

1.2 Objectives and Scope:

- One of the objectives of the study was evaluation of techno economic feasibility of a multi village water supply scheme (MVS) to supply drinking water to the cluster of tanker fed villages in the neighbourhood of Karegaon scheme in Mokhada Taluka. A step by process following guidelines and protocols used by MJP in their design process will be used for this purpose.

- The primary focus of the study was to assess the feasibility of the scheme by including all the four villages covered by the current Karegaon Scheme in the above scope.

- This will be a stepping stone for the long term objective of standardization of the design process that can be universally applied to any multi village scheme by incorporating best practices from time to time.

1.3 Approach and methodology:

Based on the objective and the scope outlined above, the following approach and methodology was adopted.

- Identify all major cost components involved in capital cost estimation of a multi village scheme based on the current MJP protocol.

- Locate all the tanker fed villages in the cluster on the map of Mokhada Taluka along with road network connecting them in the target area and mark them on Google Earth.

- Determine alternate configurations for MBR, ESRs and the entire primary and secondary piping network.
- For each configuration, follow a step by step high level design process and a standard cost estimation method wherever applicable for individual design components/assets of the scheme based on schedule of rates published by MJP after applying appropriate inflation factors as appropriate. Then compute per capita capital cost of the scheme by dividing the total cost by the ultimate design population to compare it with the prevalent rural norms.
- Choose the most 'optimal' configuration based on a set of criteria such as cost, level of service etc.,

2. Design Methodology and Design Parameters

2.1 The Cost Components of the Scheme

The layout of a typical multi village scheme is depicted in Fig below.

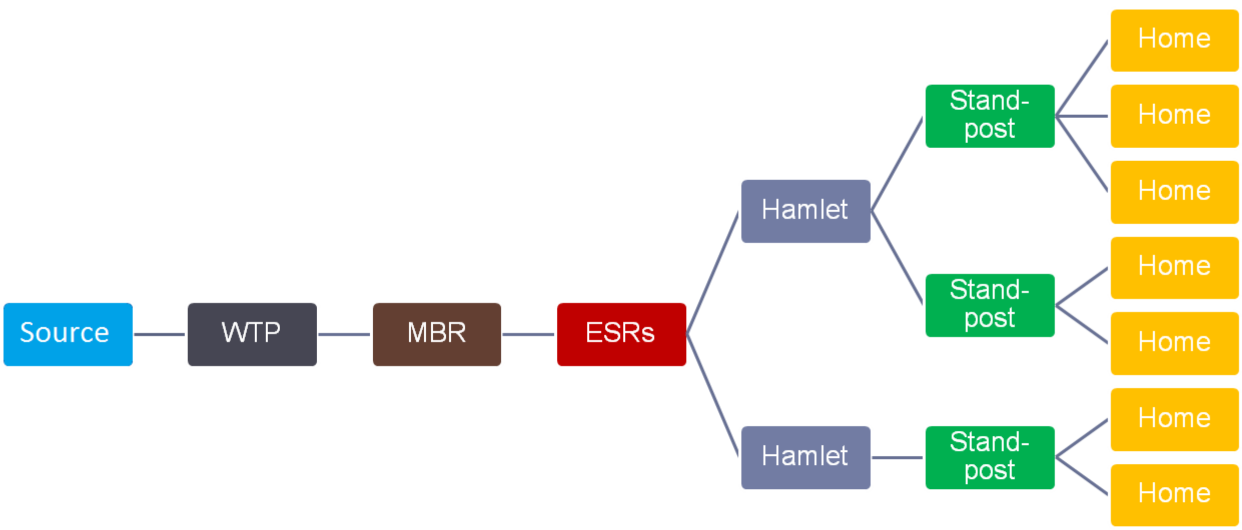


Figure 1: Layout of a typical Rural Piped Water Scheme

Water is pumped from the source to the water treatment plant (WTP). From the WTP it is then pumped to the mass balancing reservoir (MBR). Then we have the primary network where the water is distributed from the MBR to several ESRs. Then comes the secondary network where the water goes from the ESRs to the individual hamlets. Finally we have the tertiary network where water goes from the hamlets to individual stand posts/homes. In our study we restrict ourselves to the primary/secondary networks.

The major cost components of the scheme are displayed in the table below

Sr. No.	Description of Component
1	Working Survey
2	Jack Well
3	Approach Bridge
4	Raw Water Pumping Machinery
5	Raw Water Rising Main
6	Water Treatment Plant(WTP)
7	Pure Water Pumping Machinery
8	Pure Water Rising Main
9	Mass Balance Reservoir(MBR)
10	ESRs
11	Primary Distribution Network
12	Secondary Distribution Network
13	Miscellaneous (including Land Acquisition, Approach Roads, Compound Wall and Trial Run)

2.2 Scheme Design Parameters and Cost Estimation:

The design protocol along with standards and specifications followed by MJP was used as a guideline for the sizing of the scheme components. Then Schedule of rates published by MJP was applied for estimating cost of individual scheme components.
The MJP design protocol involves the following steps.

1	Principal Features : existing source and proposed source, specs of various machines, wells, mains, reservoirs, etc.
2	Population Forecast : Rate of growth, migration (floating population), current and expected, calculations
3	Daily Demand (zone wise): LPCD norm=> Gross demand = population*rate of demand + losses + other effects.
4	Design of pump machine for raw water: rate of pumping, heads, hours of pumping, description of pumps.
5	Size of proposed R/Main from source
6	Capacity of WTP
7	Design of pump machine for pure water: rate of pumping, heads, hours of pumping, description of pumps.
8	Size of pure water rising Main (tables)
9	Details of MBR (calculations)
10	Statement showing Gravity Main : A software analysis - Branched Water Distribution Design Programme (BWDDP Version 3.0)
11	Capacity of ESR located in each zone : calculation according to respective daily demands
12	Hydraulic Statement (zone wise) : BWDDP calculation
13	Annual Estimate and Other Charges: Establishment, Electricity, Materials, Raw water, etc.
14	Annual M & R Charges : Pumping + Supply + Survey + …

2.3 Identification of Source:

- The proposed source along with specifications of wells (Jackwell), intake channel, inlet pipe, reservoir FSL (Full Service Level) and LDL (Lowest Draw Level)

2.4 Daily Demand Calculation

- Population Forecast: Assuming 15 years life of the scheme population forecasting is done by incremental method as well as geometrical method and then average of the two is used in the calculations.

- The current rural norm is 40lpcd as against 200lpcd used for urban piped water supply schemes. The per capita cost of Mumbai city is Rs. 7000 per capita (unadjusted for any inflation since the date of publication). The corresponding rural norm is Rs. 3495/- per capita.

2.5 Water Pumping Machinery, WTP and MBR

- Design of Pump for Raw Water: The raw water pump is designed based on a daily operation of 12 hours. This is usually limited by the realistic no. of hours of assured supply of electricity in rural area. The flow capacity is based on a velocity of 1.25m/s. The total head is computed based on the following formula:

  Total Head = Static Head + Friction Head + Hammer Head

  Based on Flow and Head requirement, pump selection is made and then the cost is estimated based on extrapolation in our case.

- Water Treatment Plan: Water Treatment Plant is generally designed for a capacity of total daily demand. This includes the demand calculation along with any losses. The general loss is assumed at 20% for the purpose of cost estimation. The per unit capacity cost is used for estimation of WTP cost.

- Pure Water Rising Main: Here again all the calculations are made on the assumption of 12 hours operation. As in case of raw water main calculation, a velocity of 1.25 m/s is assumed to arrive at pipe diameter. Based on the head requirement a class of pipe is selected. In our case a pressure of 4kg/sq. cm is sufficient due to lower head requirements.

- Mass Balance Reservoir (MBR): The MBR capacity is designed for 2 hours of storage. The cost is estimated based on cost figures available is schedule of rates published by MJP.

2.6 ESRs and Primary Distribution Network

- Gravity Main: Water is distributed to all the ESRs in the network by gravity main. Water will be continuously distributed to ESR by gravity feed. BRANCH calculation is used to ensure that at least 7m head exists in all the distribution points and also at all the points in the network.

- ESR Capacity: ESR is generally designed for 50% of the daily demand serviced by the ESR. A minimum staging height of 10m and max of 18m is used in the calculations. The staging height is increased until an optimum point is reached. The cost of ESR goes up along with increase in staging height but it is compensated by reduction is pipe size due to availability of higher head and corresponding reduction in cost. The total cost passes through a minimum. To be on conservative side, in our calculation, all the cost estimations are done based on the staging height of 10m.

- The cost of ESRs rises sub linearly with increasing capacity. For example a 1 lakh litre capacity ESR costs Rs 13.12 lakhs (at 2011-12 prices) and a 2 lakh litre capacity ESR costs Rs 18.87 lakhs. Therefore to minimize ESR cost the optimum option is to have one big ESR for the entire network. But with additional number of ESRs the piping cost goes down. Following is an example, where we look at two different situations for the thirteen tanker fed villages. Note that for both options ESRs are located at a height of 10m and are 5m tall. That is the minimum to maximum level goes from 10 to 15m above the elevation of the ground where the ESR is located. The diameters for the ESRs are sized according to the capacity required.

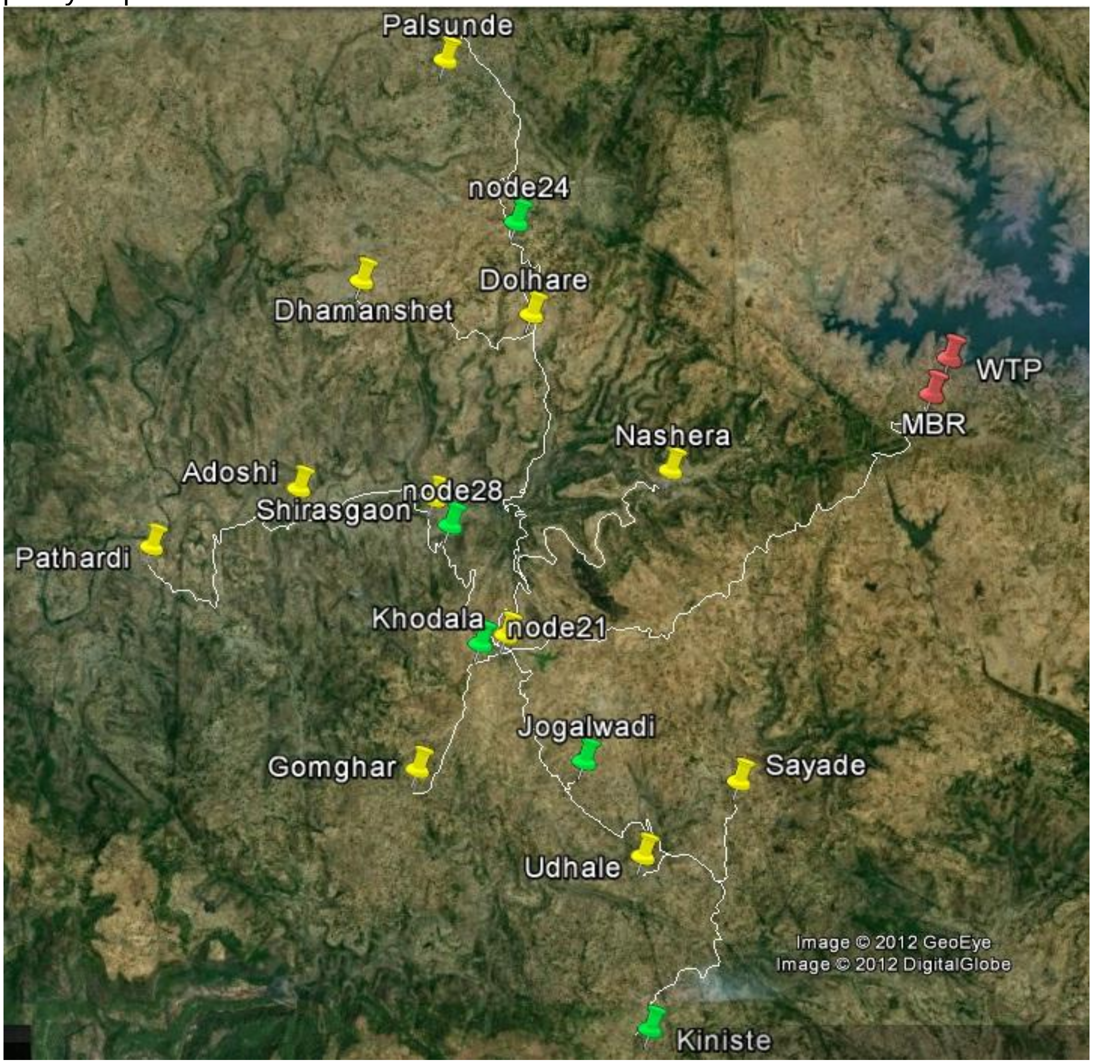


Figure 2: Option A - ESRs serving multiple villages (marked in green)

Option A: ESRs serving multiple villages

We place the ESRs at central locations such that each ESR serves 2-3 villages each. A total of 5 ESRs are chosen. On simulating in BRANCH and calculating ESR costs from MJP schedule of rates we get the following cost breakup:

Piping (Primary network)	Piping (secondary network)	ESR	Total
1,78,31,176	1,82,65,553	1,11,11,980	4,72,08,708

This corresponds to a per capita cost of Rs 808.

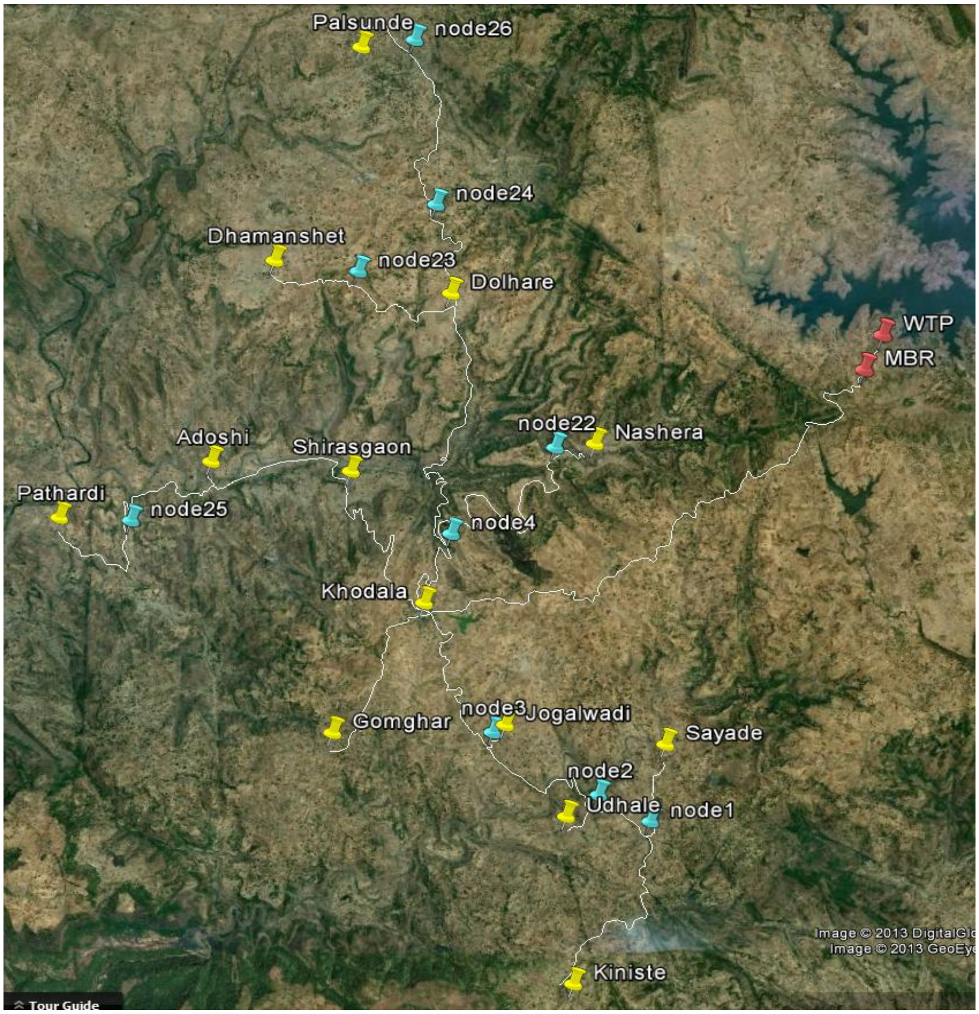


Figure 3: Option B – An ESR at each village (marked in yellow)

Option B: An ESR at each village

Here we place an ESR at each village location. For the 13 villages we get 13 ESRs. As there is an ESR at each village there is no secondary network. The cost breakup is as follows:

Piping (Primary network)	Piping (secondary network)	ESR	Total
2,30,36,897	0	1,66,35,614	3,96,72,510

This corresponds to a per capita cost of Rs 679.

It is to be noted from the above example that increasing number of ESRs has in fact resulted into lower total cost. As can be seen, there is a reduction of almost Rs. 75 lakhs in the capital cost which turns out to be 16% reduction in per capita cost. Since there is no secondary network in Option B, the reduction is pipe cost has more than offset the increase in capital cost due to additional number of ESRs. But this may not be always true since it depends on the actual pipe network and its configuration.

- The choice of ESR location crucially decides the cost of the network. This is because fixing the ESR, fixes the primary and secondary networks. Several ESR configurations must be considered. It is advisable to not have ESRs that serve villages across Gram Panchayats to ease the functioning.

- Important point to note while designing the pipe network is to include dummy nodes at points of highest elevation along paths. This is because water not only has to reach the end point but also it has to meet the minimum head requirement of 7m at the highest point along the path.

- The choice of pipe quality depends on the maximum pressure that the pipe is under throughout its length. Greater the pressure, greater the thickness of the pipe required and more the cost of the pipe. If pressure is high and one can do with lower pressures then pressure reducing valves or break-pressure reservoirs can be utilized. This would lower downstream pressures resulting in lower pipe costs.

3. Scheme Description

3.1 Karegaon Scheme:

Since the source of Karegaon scheme is submerged due to Middle Vaitarna Project, Karegaon scheme is being revamped. The coverage area of the old scheme includes villages Karegaon, Kaduchivadi, Kochale and an Ashramshala as shown in Fig 2 below.

Figure 4: Karegaon Scheme Scope

There is a cluster of tanker fed villages in Mokhada taluka to the north of Karegaon extending from Palsunde to Kiniste as shown in Fig 3 below.

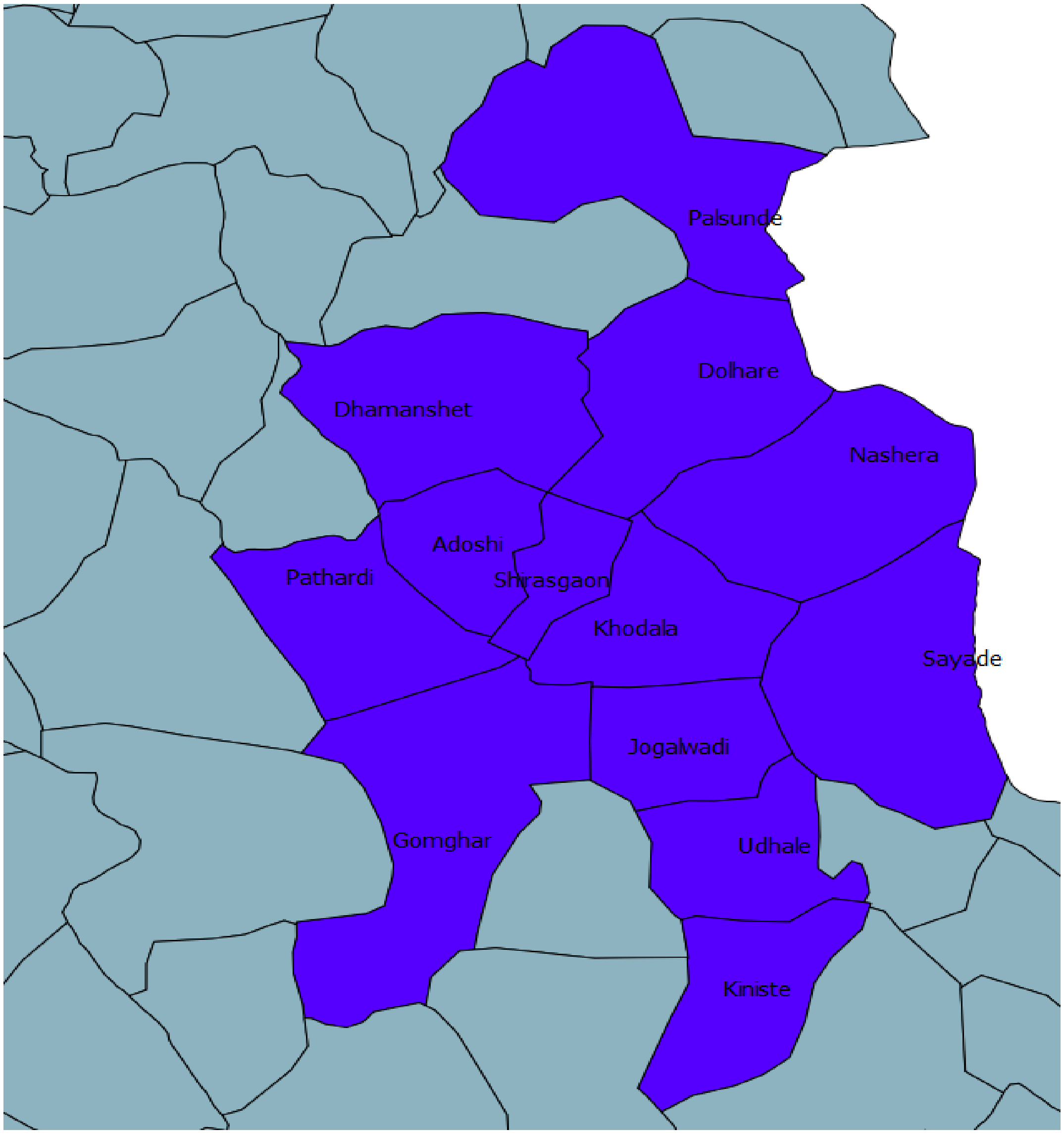


Figure 5: Cluster of tanker fed villages

However, the scope of revamped Karegaon scheme has not been expanded to include any of the villages including Kiniste which has long been demanding extending the scheme to them due to its proximity to Kochale. At this juncture many other villages also have been demanding that they should be included in the new scheme.

3.2 Problem Revisited

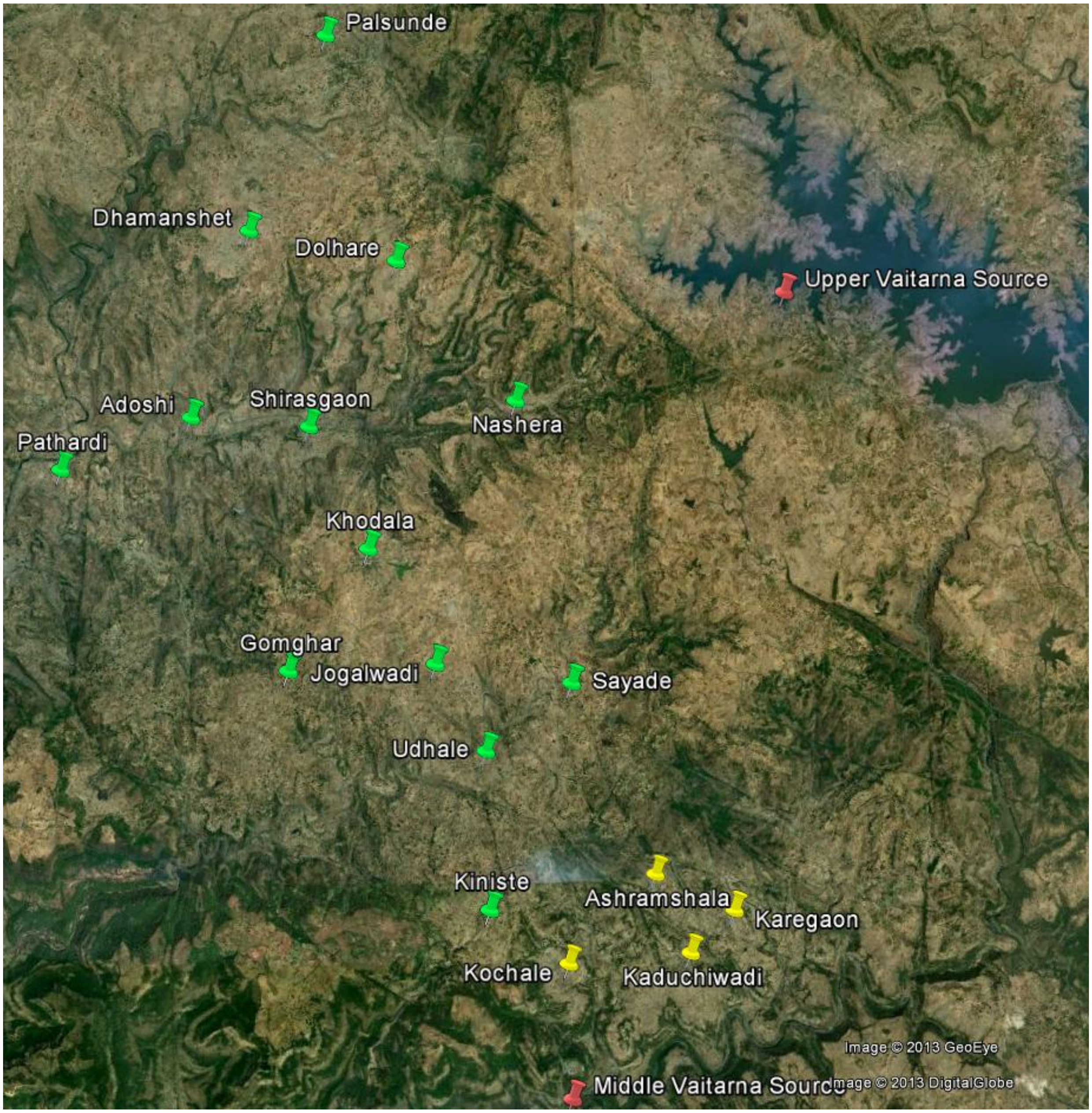


Figure 6: Alternative Sources (in red), Tanker Fed Villages (in green) and Karegaon Scheme Villages (in yellow)

There were two alternative sources under consideration to solve the drinking water problem of the tanker fed villages in the vicinity of Karegaon scheme. One was to consider Middle Vaitarna reservoir as source as per current assumption of Karegaon scheme. The other alternative was to consider Upper Vaitarna reservoir as source. The FSL level of middle Vaitarna is 285 m while the same for Upper Vaitarna is 603 meters. Hence the latter offers considerable advantage over the former due to its high elevation in terms of savings not only in capital cost but also in energy costs. Earlier studies indicated that the scheme based on Middle Vaitarna as source is not feasible. Hence, the focus of current studies was maintained on Upper Vaitarna as source.

Another important question is that of choosing the scope of the scheme. Should we design a separate scheme for only the tanker fed villages? Or do we design a consolidated scheme that includes the tanker fed villages as well as the villages that are part of the existing Karegaon scheme. While we focus on the latter, the cost estimates for the former scheme were also worked out (the details for which are included in the appendix).The focus on latter would show impact of including the villages under Karegaon on the feasibility of the scheme. It will also provide a new direction for solving the water scarcity problem for a large number of villages by entirely revamping the Karegaon scheme based on Upper Vaitarna as source.

3.3 The Proposed Scheme

A Jack well will be constructed on the basin of Upper Vaitarna reservoir as the source of the proposed scheme. Water will be pumped from this well to Water Treatment Plant (WTP) located at about half a km from the source. After the treatment, water will be pumped to Mass Balance Reservoir (MBR) located at a distance of about 600m and at an elevation of 640m from where it will be distributed by gravity to ESRs located at different places in the network supplying water to 17 villages described below. Choosing Upper Vaitarna has a source now allows us to have a consolidated scheme in the area. Prior reason for not including Kiniste and northern villages was that due to their elevations they could not be served by the Karegaon scheme which drew its water from Middle Vaitarna.

4. Design Details:

4.1 Identification of Source:

Two possible source locations were considered. One lying in middle Vaitarna and another in upper Vaitarna. Preliminary analysis suggested the latter to be a better source. This is because several villages are at higher elevations than the former source (which is at 285m elevation). Since the scheme is designed as a gravity-fed one, significant pumping is required at source. Therefore we choose the source from upper Vaitarna which has a lowest draw level of 595m.

4.2 Population Forecast and Daily Demand Calculation:

Population for the year 2001 and 2011 was got from census data [7]. Using this data, projections for the year 2030 were made using the incremental and geometric methods (assuming construction in year 2015 and a 15 year design). Where population decreased in the decade 2001-2011, geometric estimates give very low values. To be on the more conservative side we have instead assumed a decadal growth rate of 42% instead (which is the average growth rate for the villages that showed population increase in the 2001-2011 decade).

Incremental method:

Projected population = Current population + decadal growth * (no. of years/10)

Geometrical method:

Projected population = Current population * (1 + decadal growth rate) $^{(\text{no. of years}/10)}$

To get our projection we then take the average of the two methods. This gives us a projected population of 48407 for the year 2030.

Drinking water demand was estimated from population at 40 lpcd (litres per capita per day). This gives a total demand of 23,23,536 litres per day for the 17 villages. A further 20% loss factor was added to the demand for the simulations. This gives us a demand of 2.3 MLD.

Node No	Village Name	Population (2011)	Population (2030 est.)	Gross Demand(litres per day)	Elevation (m)
6	Kiniste	939	2957	141936	460
7	Udhale	1064	2281	109488	422
8	Jogalwadi	812	2245	107760	426
9	Khodala	2807	7721	370608	434
10	Sayade	1770	3006	144288	420
11	Gomghar	1228	1536	73728	419
12	Shirasgaon	526	1454	69792	243
13	Dolhare	1141	1838	88224	380
14	Nashera	733	4179	200592	354
15	Adoshi	923	1060	50880	202
16	Dhamanshet	1241	3431	164688	384
17	Palsunde	1365	3774	181152	393
19	Pathardi	661	4153	199344	192
33	Kochale	609	1684	80832	345
34	Ashramshala	750	2073	99504	350
35	Karegaon	1196	3306	158688	350
36	Kaduchiwadi	618	1709	82032	350
	Total	18,381	48,407	23,23,536	

Table 1: Village Details

4.3 ESRs and Primary Distribution Network

We now have our network of villages and the daily water demand for each village. We now need to decide where we want to place our ESRs. As discussed in section 2.6 we look at different configurations for ESRs and do the ESR+Piping costing for each. In our situation the better alternative is to have an ESR placed at each location. Once we have our ESRs, we run the network in the software BRANCH which gives us the optimal pipe diameters that need to be laid out to satisfy the demand at each location. Using the schedule of rates from MJP (Maharashtra Jeevan Pradhikaran) we can then estimate the cost of building the ESRs as well as the cost of piping. In branch we assume that the primary network is pumped for 12 hours a day and the secondary network is pumped for 6 hours a day. Pipes in the network are HDPE pipes rated to withstand 80m of head. Where higher head is required we use D.I. K-9 pipes which can withstand upto 400m of head (marked with * below).

The details for the cost of the piped network and the ESRs are as below:

Sr. No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Headloss (m)	HL/km (m)	Length (m)	Cost (1000 Rs)
1*	MBR	Khodala	53.76	200	59.48	12.95	4595	8523.73
				225	38.78	7.29	5316	9861.18
2	Khodala	3	21.39	160	21.84	6.98	3130	1993.81
3	3	2	18.90	140	12.09	10.64	1137	557.04
				160	8.07	5.55	1455	926.96
4	2	Udhale	2.53	63	7.26	12.58	577	56.55
5	2	1	16.37	140	7.74	8.15	950	465.5
6	3	Jogalwadi	2.49	63	3.47	12.22	284	27.83
7	Khodala	21	1.70	63	3.77	6.02	626	61.35
8	21	Gomghar	1.70	63	14.65	6.03	2430	238.14
9*	Khodala	Shirasgaon	7.41	90	60.60	16.17	3747	3900.63
10	Shirasgaon	Adoshi	5.79	75	66.61	24.90	2675	390.55
11	Adoshi	25	4.61	75	40.83	16.33	2500	365.00
12	25	Pathardi	4.61	75	32.67	16.33	2000	292.00
13	Khodala	4	14.68	125	25.23	11.57	1181	462.95
*			14.68	125	25.23	11.57	1000	1594.68
14	4	22	4.64	75	77.69	16.53	4700	686.20
15	22	Nashera	4.64	75	13.03	16.54	788	115.05
16	4	Dolhare	10.04	110	59.44	10.68	5568	1609.15
17	Dolhare	23	3.81	75	23.08	11.48	2010	293.46
18	23	Dhamanshet	3.81	75	16.68	11.48	1453	212.14
19	Dolhare	24	4.19	90	11.27	5.64	2000	392.00
20	24	26	4.19	90	17.80	5.63	3160	619.36
21	26	Palsunde	4.19	75	16.61	13.69	1214	177.20
				90	1.39	5.64	246	48.28
22	1	Sayade	3.34	63	29.26	21.04	1391	136.32
23	1	29	13.03	140	5.93	5.34	1110	543.90
24	29	30	5.16	110	1.87	3.12	600	173.40
25	30	Kiniste	3.29	90	7.20	3.60	2000	392.00
26	30	32	1.87	63	15.11	7.20	2100	205.80
27	32	Kochale	1.87	63	1.80	7.20	250	24.50
28	29	31	7.87	90	36.16	18.08	2000	392.00
29	31	Ashramshala	2.30	63	4.22	10.55	400	39.20
30	31	Karegaon	3.67	75	21.42	10.71	2000	292.00
31	31	Kaduchiwadi	1.90	63	13.33	7.41	1800	176.40
						Total	68393	36246.26

Table 2: Pipe Network Details

Node No	Village Name	Population (2041 est.)	Net Demand(litres per day)	Elevation (m)	ESR Staging Height (m)	ESR Capacity (l)	Cost of ESR (Rs)
6	Kiniste	2957	1,18,280	460	470	71000	11,54,340
7	Udhale	2281	91,240	422	432	55000	10,01,700
8	Jogalwadi	2245	89,800	426	436	54000	9,92,160
9	Khodala	7721	3,08,840	434	444	186000	19,22,840
10	Sayade	3006	1,20,240	420	430	73000	11,73,420
11	Gomghar	1536	61,440	419	429	37000	7,61,080
12	Shirasgaon	1454	58,160	243	253	35000	7,31,400
13	Dolhare	1838	73,520	380	390	45000	8,79,800
14	Nashera	4179	1,67,160	354	364	101000	13,97,875
15	Adoshi	1060	42,400	202	212	26000	5,97,840
16	Dhamanshet	3431	1,37,240	384	394	83000	12,56,100
17	Palsunde	3774	1,50,960	393	403	91000	13,19,700
19	Pathardi	4153	1,66,120	192	202	100000	13,91,250
33	Kochale	1684	67,360	345	355	41000	8,20,440
34	Ashramshala	2073	82,920	350	360	50000	9,54,000
35	Karegaon	3306	1,32,240	350	360	80000	12,32,250
36	Kaduchiwadi	1709	68,360	350	360	42000	8,35,280
	Total	48407	19,36,280				1,84,21,475

Table 3: ESR Details

4.4 Verification of Network using EPANET

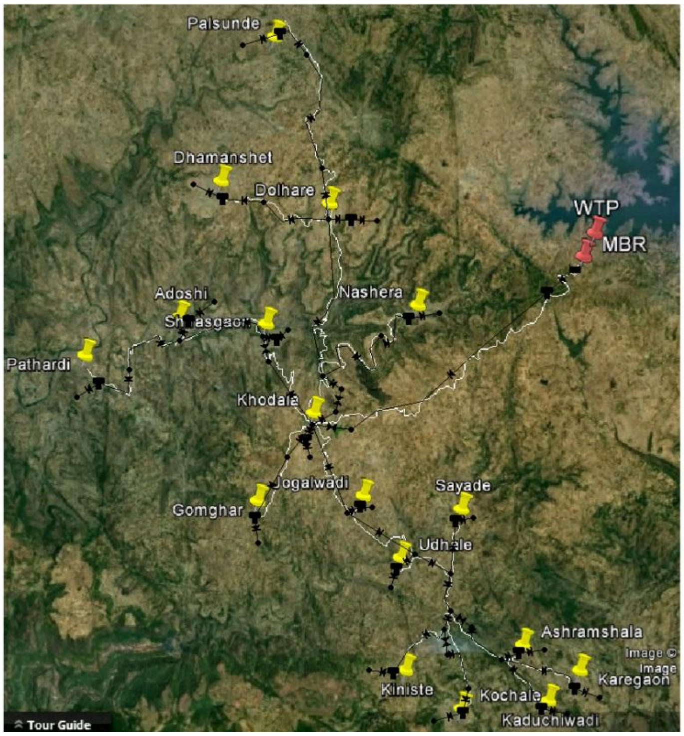


Figure 7: EPANET model

The network design was verified by using EPANET (www.epa.gov/nrmrl/wswrd/dw/epanet.html). EPANET [8] is a software tool that models the flow of water in pressurized piped networks. After completing the sizing and locations of the pipes and ESRs we construct the network in EPANET to verify whether sufficient head is being realized at all nodes. EPANET allows analysing how the various ESRs in the network fill up and empty during the daily life cycle. This helps indicates if there are any "problem" nodes where sufficient head is not being met.

As can be seen below upstream villages get filled up first. Khodala in particular being the first village in the network gets filled up within the first hour. Other villages gradually fill up and empty during the demand period which is hours 9-12 and 21-24.

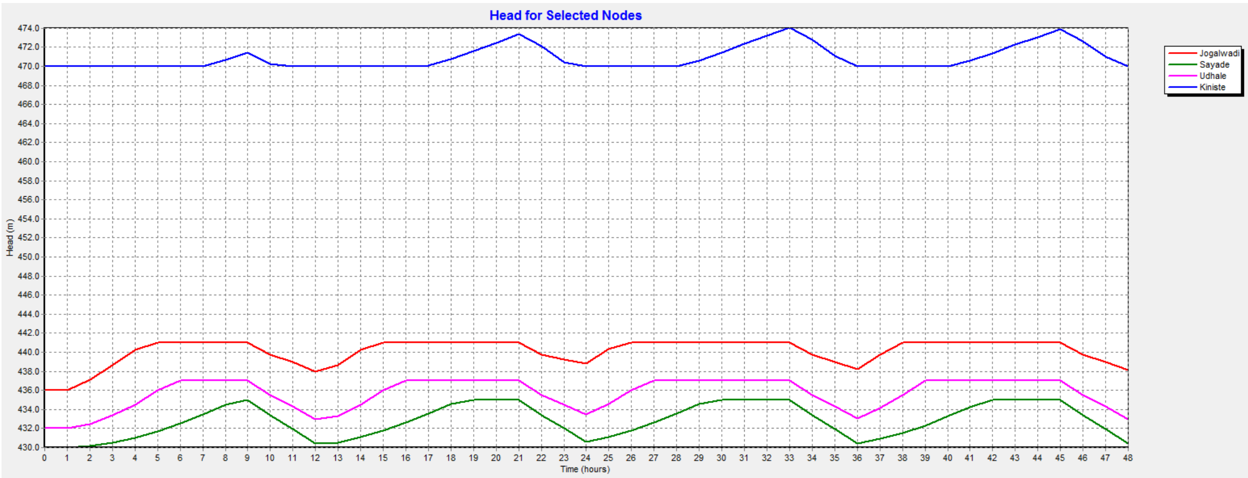


Figure 8: ESR heads

Note that supply occurs at hours 1-6 and 13-18.

4.5 MBR and WTP

The costing for the WTP has been done by comparing it with the costing done in Khardi Scheme. A WTP for 1 MLD cost Rs 26 lakhs in the Khardi Scheme. For us the daily demand is 2.3 MLD. Accordingly we priced our WTP at 26 * 2.3 *1.1 = Rs 66 lakhs. The 1.1 factor is to account for an inflation of 10% in prices. The MBR was designed with a capacity of one third the daily demand i.e. 0.77 MLD. This gave us a cost of almost Rs 30 lakhs.

4.6 Pumping Machinery and Rising Main

Water has to be pumped at two places: from Source to WTP and from WTP to MBR. The lowest draw level of source is 595m. The elevation of WTP and MBR is 631m and 640m respectively. While pumping to the WTP or MBR a further height of 8m has to be accounted for since that is the assumed height of the infrastructure. The diameter of the rising mains is calculated using the flow of water required and assuming a velocity of 1.25 m/s.

Flow = daily demand/time, therefore flow = 2.3 MLD / 12 hours = ~ 53.8 lps

Dia = 2*root(flow/pi*vel), therefore dia = 2*root(53.8 lps/3.14*1.25 m/s) = ~234mm

We round up this value and use a diameter of 250mm.

Raw water rising main: The distance is of 500m and diameter required is 250mm. Due to the high flow we choose D.I. pipe for the rising main. This gives us a cost of ~ Rs 13.3 lakhs for the rising main.

Pure water rising main: The distance is of 650m and the diameter is 250mm as before. We again use D.I. pipe which gives us a cost of ~ Rs 17.3 lakhs.

Pumping machinery: Pump capacity required is calculated using the flow rate of water that needs to be pumped and the head difference. For raw water rising main it is 53.8 lps and head difference of 50m. Assuming an efficiency of 70% we get a power requirement of ~ 50hp. Similarly for the pure water rising main, we have a flow of 53.8 lps and head difference of 25m which gives us a pump power requirement of 25hp. Cost for the two pumps is calculated by comparing it with the cost of a 100hp pump in Khardi scheme which was 22 lakhs. So our 50hp and 25hp pumps cost 11 lakhs and 5.5 lakhs respectively. We also include an additional misc. factor to our cost estimates to account for components that we have not included in our estimates. These include things like valves, sluices, various structural costs etc. Such factors are estimated from [1].

4.7 Capital Cost Summary:

Sr. No.	Cost Component	Cost (Rs)	Misc. Factor	Net Cost (Rs)	Remarks
1	Jack Well	25,00,000	1	25,00,000	standard dimensions for Jack well
2	WTP	66,45,313	1	66,45,313	Khardi has 1MLD costing 26lakh. Our MLD is 2.3. so we choose 26*2.3[2]
3	Raw water rising main (Length 500m, Dia. 250mm)	13,28,405	1.479	19,64,711	Based on schedule of rates 2010-11[3] and plus 7% increase for 2011-12 cost
4	Pure water rising main (Length 650m,Dia. 250mm)	17,26,927	1.379	23,81,432	

5	MBR	30,59,408	1.151	35,21,379	
6	Cost of raw water pump (50HP)	11,00,000	3.185	35,03,500	Based on cost of 100HP pump used for Khardi Scheme[2]
7	Cost of pure water pump (25HP)	5,50,000	2.652	14,58,600	
8	Excavation	2,05,17,900	1.273	2,61,19,287	From schedule of rates[3] avg cost is around 300 Rs/m^3. Assuming a volume of 1 x 1 x length of piping. Total pipe network is ~ 68.4 kms
9	Piping	3,86,99,749	1.273	4,92,64,781	Based on schedule of rates 2010-11[3] and plus 7% increase for 2011-12 cost
10	ESRs	2,02,63,623	1.142	2,31,41,057	Including inflation factor
11	Tertiary Network	1,59,06,008	1	1,59,06,008	Estimated as a % of total cost from the Karegaon scheme design by ZP[1]
12	M.S.E.B.	20,00,000	1	20,00,000	From [1]
13	Land Acquisition	15,00,000	1	15,00,000	From [1]
14	Total Cost			13,99,06,066	
15	Cost per capita			2890.20	Design population of ~ 48,407

Table 3: Capital Cost Details

4.8 Operating and Maintenance Cost:

a. Energy Costs :
Cost per kWh = 6.5 Rs
Per day consumption of 50hp pump = 50 x 12 = 600 hph = 447.4 kWh
Cost per day of operating 50hp pump = 447.4 x 6.5 = Rs 2908
Per day consumption of 25hp pump = 25 x 12 = 300 hph = 223.7 kWh
Cost per day of operating 25hp pump = 223.7 x 6.5 = Rs 1454
Total Energy Cost = Rs 4362 per day

b. Cost of Operators :

operators	no	rate	total	Comments
pump operator	4	400	1600	(2 each for raw and pure water rising main)
attendant	2	200	400	(1 each for raw and pure water rising main)
filter operator	1	400	400	for wtp
attendant	1	200	200	for above
chemist	1	400	400	for wtp
clerk	1	400	400	for wtp
fitter	5	200	1000	1 for 10-15 km
helper	10	200	2000	2 for 10-15 km
valveman	5	200	1000	1 for 10-15 km
			7400	

c. Cost of Chemicals :
Cost of alum = Rs 5500 per ton
Alum required per ML = 7 kg

Total Alum required per day = 2.3 * 7 = 16.1 kg
Total Cost of alum per day = 16.1/1000 * 5500 = Rs 89.45
Cost of TCL = Rs 15000 per ton
TCL required per ML = 5 kg
Total TCL required per day = 2.3 * 5 = 11.5 kg
Total Cost of TCL per day = 11.5/1000 * 15000 = Rs 174.26
Sundry Costs per month = Rs 3000
Sundry Costs per day = 3000/30 = Rs 100
Total chemical costs per day = Rs 363.72

d. Cost of Water:
   Cost of water per ML = Rs 1000
   Cost of water per day = 2.3 x 1000 = Rs 2323.53

e. Pump Maintenance:
   Cost per hp per day = Rs 3.98
   Cost per day for 50hp pump = Rs 198.9
   Cost per day for 25hp pump = Rs 99.45
   Total Pump maintenance cost = Rs 298.35
   Therefore the total O&M cost per day = 4362.34 + 7400 + 363.72 + 2323.53 + 298.35 = 14747.96
   O&M cost per 1000 L = 14747.96/2323 = Rs 6.34

Therefore the cost for every 1000 litres of water comes to only Rs 6.34. Another measure of interest could be the per capita cost per annum. This comes to around Rs 111. So for self-sustenance of the operation an annual charge of Rs 111 will have to be charged per person.

5. Conclusion:

Our design for the proposed multi village scheme for supplying piped water to 17 villages (inclusive of four villages covered by the current Karegaon scheme) from Upper Vaitarna has an estimated capital cost of Rs. 2890 per capita at a demand of 40 lpcd for a design population of 48407. Given the fact that the capital cost of Mumbai city water supply scheme is in the neighbourhood of Rs. 7000 while the same for Thane city is Rs. 10,000, it is a foregone conclusion that it is possible to solve the water scarcity problem of the taker fed villages in this area at a fraction of cost of a city water supply scheme. The cost figures indicate that it is well below the current norm for a rural water supply scheme. The difference is even more striking when compared with the cost figure of Rs. 5083 of the Karegaon scheme. The advantages offered by high elevation of the source go further beyond the capital cost savings. The cost of water per 1000L based on the annual O&M charges inclusive of energy cost of pumping works out to be Rs. 6.34 (Assuming cost of water from reservoir at Rs. 1000 per ML). This again is significantly lower than the O&M cost figures published by World Bank Report for multi village schemes. (There is a wide variation of 26 to 38 while the economical figure is quoted as Rs. 16 per 1000L)

This should make it clear that it makes sense to shift the source from Middle Vaitarna to Upper Vaitarna and revamp the scheme cover all the 13 tanker fed villages besides the four in the current scope. This has significance given the background that earlier attempts to extend the Karegaon scheme to other villages like Kiniste had failed to satisfy the rural norms of capital cost because of higher elevation villages as compared to the source elevation of 285m.

The extended period simulation studies done using EPANET indicate that the demand for all the villages is fulfilled for designed supply of six hours per day including that of Kiniste, the village having the highest elevation.

Another important aspect is the selection of ESR locations and elevation. Although the feasibility studies pass the current norms, further optimization is possible by using software like BRANCH and EPANET.

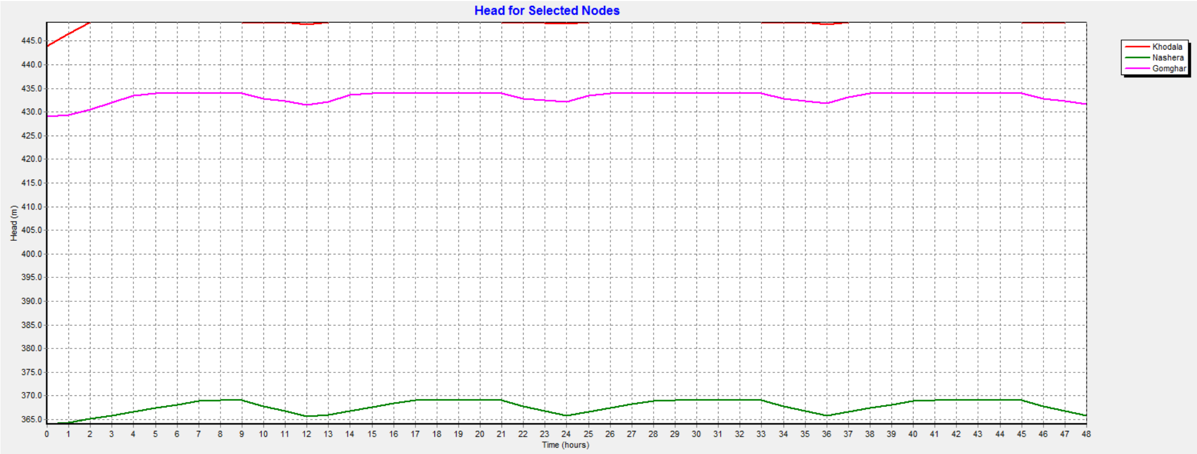
6. References:

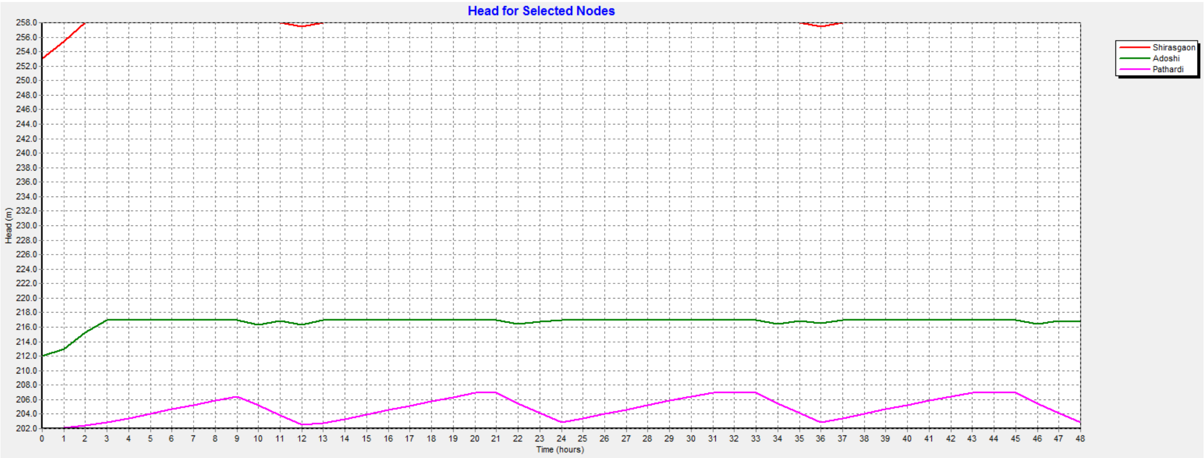
1. Karegaon Scheme Design report by ZP
2. Khardi Scheme Design report by MJP
3. MJP Schedule of Rates (2010-11)
4. Analysis of Tanker-fed villages in Thane for Multi-village schemes, IITB.
5. The North Karjat Feasibility Study (2010), IITB.
6. Epanet and Development: How to calculate water networks by computer, Santiago Arnalich
7. Census of India (2011)
8. EPANET(www.epa.gov/nrmrl/wswrd/dw/epanet.html)

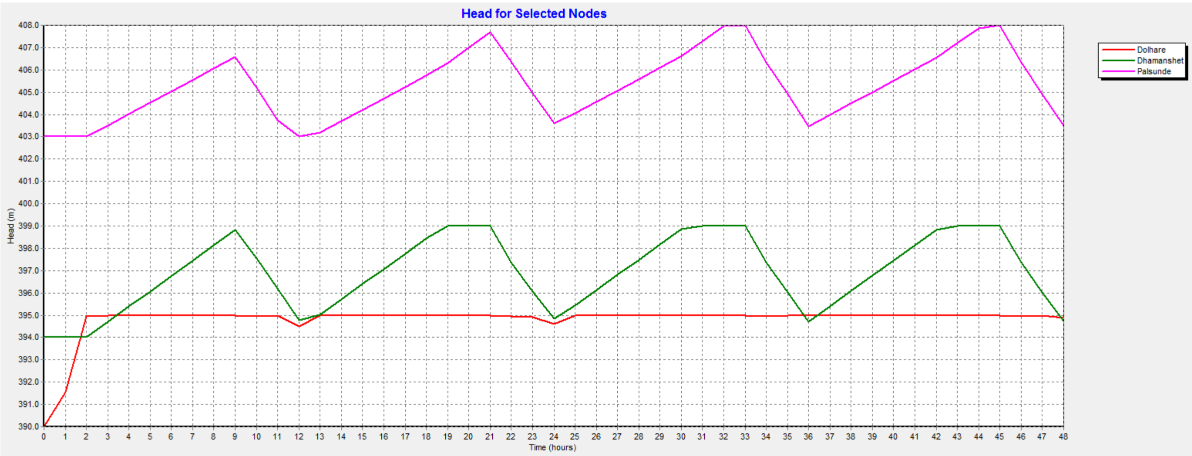
7. Appendix:

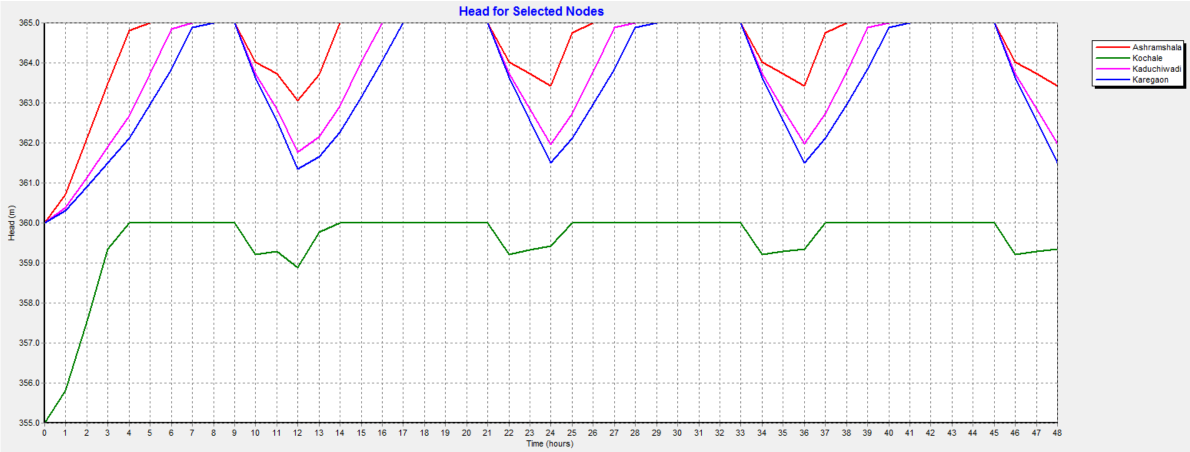
7.1 EPANET Simulation Graphs:

These are the graphs from EPANET simulations for the all the ESRs. ESRs that show an almost flat line do so because of their low demand and elevations. Therefore the demand is able to get fulfilled as the supply comes in. This suggests that sizing of these ESRs can be substantially reduced. Note that demand occurs in hours 9-12 and 21-24.


Head for Selected Nodes
Khodala
Nashera
Gomghar
Head (m)
Time (hours)


Head for Selected Nodes
Shirasgaon
Adoshi
Pathardi
Head (m)
Time (hours)


Head for Selected Nodes
Dolhare
Dhamanshet
Palsunde
Head (m)
Time (hours)



7.2 Details of scheme for only tanker fed villages:

We also looked at the scenario where the two components i.e. the thirteen tanker fed villages and the four villages under Karegaon scheme would be kept separated. We looked at the design for the scheme for just the thirteen villages. This scheme would have a design population of around 39000 people.

a) Piped Network and ESR cost details

Sr. No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Headloss (m)	HL/km (m)	Length (m)	Cost (1000 Rs)
1	MBR	Khodala	48.63	200	106.58	10.75	9911	10032.12
2	Khodala	3	11.8	125	20.91	7.72	2707.89	1135.79
				140	1.88	4.45	422.11	221.31
3	3	2	9.05	125	12.25	4.73	2592	1087.18
4	2	Udhale	2.45	63	6.84	11.85	577	60.51
5	2	Sayade	2.99	63	40.12	17.14	2341	245.48
6	3	Jogalwadi	2.75	63	4.17	14.68	284	29.78
7	Khodala	21	1.38	63	2.57	4.11	626	65.64
8	21	Gomghar	1.38	63	9.96	4.1	2430	254.81
9	Khodala	Shirasgaon	9.38	110	35.27	9.41	3747	1158.68
10	Shirasgaon	Adoshi	7.6	90	45.34	16.95	2675	561.00
11	Adoshi	25	6.67	90	33.28	13.31	2500	524.30
12	25	Pathardi	6.67	90	26.62	13.31	2000	419.44
13	Khodala	4	17.06	140	19.18	8.79	2181	1143.50
14	4	22	6.44	90	58.64	12.48	4700	985.68
15	22	Nashera	6.44	90	9.83	12.47	788	165.26
16	4	Dolhare	10.62	110	34.59	11.85	2919.96	902.94
				125	16.83	6.36	2648.04	1110.69
17	Dolhare	23	4.2	75	27.63	13.75	2010	314.00
18	23	Dhamanshet	4.2	75	19.98	13.75	1453	226.99
19	Dolhare	24	4.62	90	13.5	6.75	2000	419.44

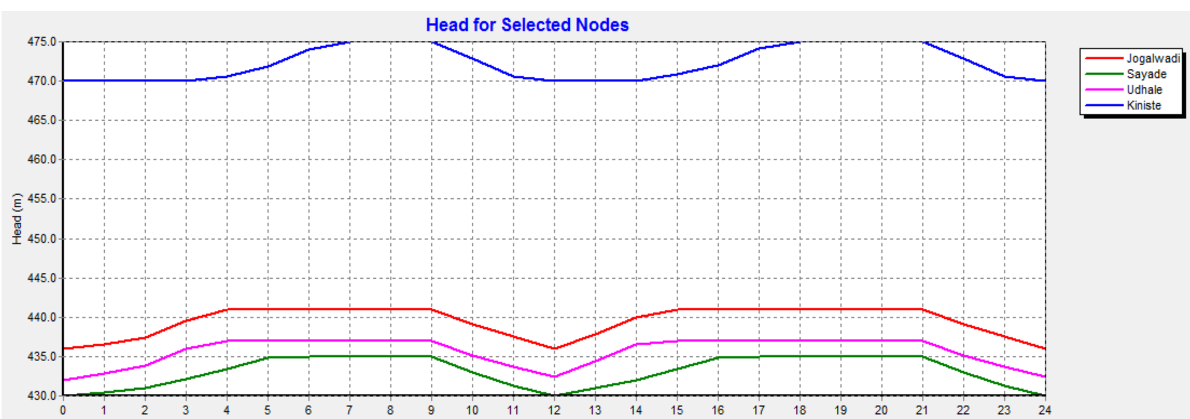
20	24	26	4.62	90	21.33	6.75	3160	662.72
21	26	Palsunde	4.62	75	13.84	16.39	844.2	131.88
				90	4.16	6.76	615.8	129.15
22	2	Kiniste	3.61	90	21.38	4.28	5000	1048.60
						Total	61133	23036.90

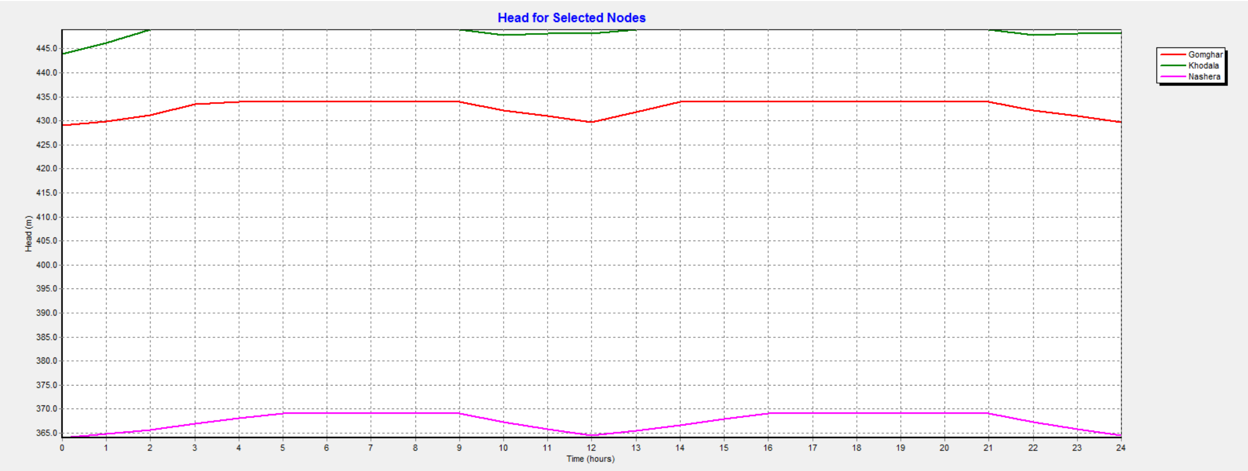
Table 4: Pipe Network Details

Node No	Village Name	Population (2041 est.)	Demand(litres per day)	Elevation (m)	ESR Staging Height (m)	ESR Capacity (l)	Cost of ESR (Rs)
6	Kiniste	4342	1,73,680	460	470	79000	1346730
7	Udhale	2939	1,17,560	422	432	53000	1080882
8	Jogalwadi	3301	1,32,040	426	436	60000	1154340
9	Khodala	10813	4,32,520	434	444	195000	2183335
10	Sayade	3594	1,43,760	420	430	65000	1206810
11	Gomghar	1663	66,520	419	429	30000	722920
12	Shirasgaon	2139	85,560	243	253	39000	869836
13	Dolhare	2160	86,400	380	390	39000	869836
14	Nashera	7733	3,09,320	354	364	140000	1821875
15	Adoshi	1114	44,560	202	212	21000	538692
16	Dhamanshet	5046	2,01,840	384	394	91000	1451670
17	Palsunde	5550	2,22,000	393	403	100000	1530375
19	Pathardi	8007	3,20,280	192	202	145000	1858313
	Total	58,401	23,36,040				16635614

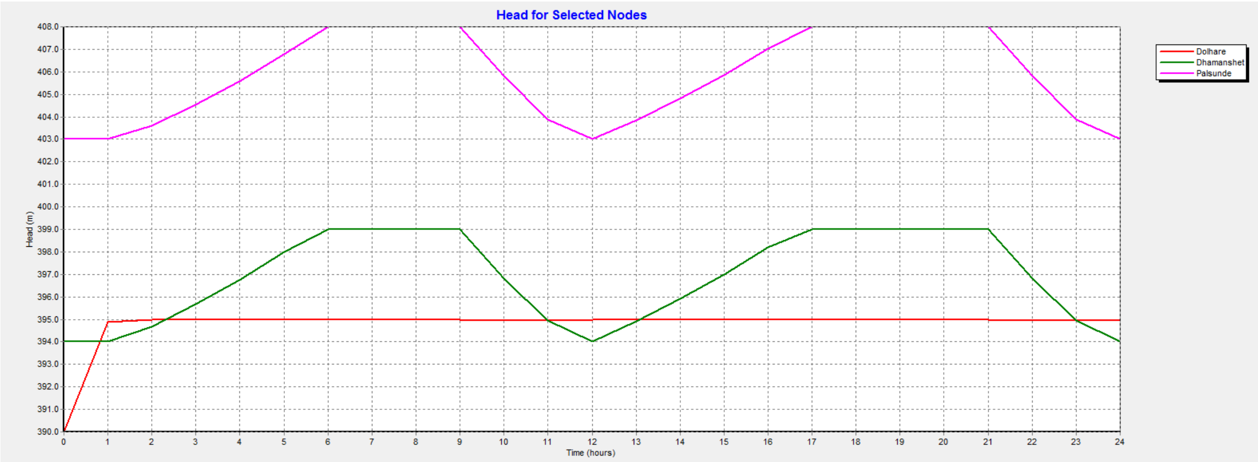
Table 3: ESR Details

b) EPANET simulation graphs:




Head for Selected Nodes
Gomghar
Khodala
Nashera
Head (m)
Time (hours)


Head for Selected Nodes
Shirasgaon
Adoshi
Pathardi
Head (m)
Time (hours)


Head for Selected Nodes
Dolhare
Dhamanshet
Palsunde
Head (m)
Time (hours)

c) Total Capital Cost

Sr. No.	Cost Component	Cost (Rs)	Misc. Factor	Net Cost (Rs)	Remarks
1	Jack Well	25,00,000	1	25,00,000	standard dimensions for Jack well
2	WTP	80,08,000	1	80,08,000	Khardi scheme of 1MLD has WTP cost of 26lakh. Our MLD is 2.8. so we choose 26*2.8
3	Raw water rising main (Length 500m, Dia. 250mm)	13,28,405	1.479	19,64,711	Based on schedule of rates 2010-11 and plus 7% increase for 2011-12 cost
4	Pure water rising main (Length 650m,Dia. 250mm)	17,26,927	1.379	23,81,432	
5	MBR	47,79,500	1.151	55,01,205	
6	Cost of raw water pump (50HP)	11,00,000	3.185	35,03,500	Based on cost of 100HP pump used for Khardi Scheme
7	Cost of pure water pump (25HP)	5,50,000	2.652	14,58,600	
8	Excavation	1,80,74,700	1.273	2,30,09,093	From schedule of rates avg cost is around 300 Rs/m^3. Assuming a volume of 1 x 1 x length of piping. Total pipe network is ~ 60 kms
9	Piping	2,30,36,897	1.273	2,93,25,970	
10	ESRs	1,66,35,614	1.142	1,89,97,871	
11	Tertiary Network	96,65,038	1	96,65,038	Estimated as a % of total cost from the Karegaon scheme design by ZP[1]
12	M.S.E.B.	20,00,000	1	20,00,000	From [1]
13	Land Acquisition	15,00,000	1	15,00,000	From [1]
14	Total Cost	7,77,40,042		10,98,15,420	
15	Cost per capita	2790			Design population of ~39,365

d) Operating and Maintenance Cost

a. Energy Costs :
Cost per kWh = 6.5 Rs
Per day consumption of 50hp pump = 50 x 16 = 800 hph = 596.6 kWh
Cost per day of operating 50hp pump = 596.6 x 6.5 = Rs 3878
Per day consumption of 25hp pump = 25 x 16 = 400 hph = 298.3 kWh
Cost per day of operating 25hp pump = 298.3 x 6.5 = Rs 1939
Total Energy Cost = Rs 5817 per day

b. Cost of Operators :
Cost per Operator per day = Rs 400
Operators for ESRs = 13 x 1 = 13
Operators for WTP and MBR = 4
Cost for Operators per day = 400 x 17 = Rs 6800

c. Cost of Chemicals :
   Cost of alum = Rs 5500 per ton
   Alum required per ML = 7 kg
   Total Alum required per day = 2.8 * 7 = 19.6 kg
   Total Cost of alum per day = 19.6/1000 * 5500 = Rs 108

   Cost of TCL = Rs 15000 per ton
   TCL required per ML = 4 kg
   Total TCL required per day = 2.8 * 4 = 11.2 kg
   Total Cost of TCL per day = 11.2/1000 * 15000 = Rs 168
   Sundry Costs per month = Rs 3000
   Sundry Costs per day = 3000/30 = Rs 100
   Total chemical costs per day = Rs 376

d. Cost of Water:
   Cost of water per ML = Rs 1000
   Cost of water per day = 2.8 x 1000 = Rs 2800

   Therefore the total O&M cost per day = 5817 + 6800 + 376 + 2800 = 15793
   O&M cost per 1000 L = 15793/2800 = <u>Rs 5.64</u>

Therefore the cost for every 1000 litres of water comes to only Rs 5.64. The per capita cost per annum comes to around Rs 100. So for self-sustenance of the operation an annual charge of Rs 100 will have to be charged per person.

7.3 Schedule of Rates (ESR):

This is the schedule of rates provided by the MJP. Note that these rates are for the year 2011-12. For our calculation we have included a 7% rise in prices of pipes and a 10% rise in the prices of ESRs.

XX. RCC ESR

	Designing (aesthetically), and constructing RCC elevated service reservoirs of following capacity with RCC staging consisting of columns, internal and external bracings spaced vertically not more than 4.5 meters center to center for ESR having Capacity upto 500 Cum. and not more than 6 m c/c for ESRs having capacity above 500 cum including excavation in all types of strata, foundation concrete, cement plaster with water proofing compound to the inside face of the container including refilling disposing of the surplus stuff within a lead of 50 meters, all labour and material charges including lowering, laying, erecting, hoisting and jointing of pipe assembly of inlet, outlet, washout, overflow and bypass arrangements as per departmental design, providing and fixing accessories such as M.S. ladder, C. I. manhole frame and covers water level indicatiors, lightening conductor, G. I. pipe railing around walk way and top slab, providing spiral staire case from ground level to roof level,M.S.grill gate of 2 mtr.height with locking arrangement of approved design. B.B. masonry chambers for all valves, ventilating shafts, providing and applying three coats of cement paint to the structure including roof slab epoxy painting to internal surface &anti termite treatment for underground parts of the structure. and giving satisfactory water tightness test as per I.S. code, The job to include painting the name of the scheme and other details on the reservoir as per the directions of Engineer-in-charge.		
	Note :		
1	The design of the structure be in accordance with relevant (I.S. 3370 - 1965 or revised.)		
2	The design shall satisfy the stipulations as per		
	IS 1893 -1984 and I.S. 13920 / 1993 for seismic force and I. S.-11682/1985 for R.C.C. staging of overhead tanks.		
3	For design having more than 6 columns, provision of internal bracing is obligatory. External bracing is also obligatary.		
4	The Entire structure shall be constructed in M300 only.		
5	Plain round mild steel bars grade - I confirming to I.S. 432 part-I or high yield strength deformed bars confirming to I.S. 1786 or I. S. 1139 shall be used, grade-II mild steel bars will not be allowed.		
6	Irrespective of the type of foundation proposed in the		
	design, one set of bracing be provided at the ground level.		

7)	These rates include providing M.S. ladder for E.S.R's up to 2 lakh litres capacity and providing spiral staircase for E.S.R. above 2 lakh litres capacity.		
8)	Stagging shall have to be designed with stresses of M-250 for ESR. However all RCC construction should be done in M-300		
9)	These rates are including the cost of uplift pressure if any and entire dewatering during execution. In case of water logging area where water is struck at shallow depth extra provision of dewatering shall be made as per site condition.		
10)	All conditions given in the Member Secretary's Circular No.MJP / TS-I / 350 / 1668 dt. 2-8-97 and MJP / S-1/350/2127 dt. 13-7-99 shall be strictly followed and additional cost, if any, due to these conditions is included in the rates mentioned below.		
11)	75% part rate shall be payable for reinforcement concrete and plastering items of containers of E.S.R. till satisfactory hydraulic testing for water tightness in given; and till that work shall be treated as incomplete.		
12)	The rates indicated in the table are excluding the cost of pipes, specials and valves required for inlet, outlet, washout, overflow and by-pass arrangement. The scope of work, however and includes cost of erecting, laying and jointing of pipes and valves including cost of jointing materials up to 5 M beyond outer face of outermost column.		
13)	For ESR up to 500 cum capacity C.I. Double flanged pipe up to 300 mm dia shall be provided and C.I. specials shall be used. For ESR above 500 cum capacity C.I. /M.S. pipe assembly with minimum 8 m.m. thick ness up to 500 mm dia. and minimum 10 mm. thickness above 500 mm.dia can be used with proper anti-corrosive epoxy treatment from inside and outside.		
14)	Below mentioned rates are for foundations, with individual footing with bearing capacity of 20 tonnes per square metre. For raft foundations, these rates shall be increased by.7.5% Where safe bearing capacity (SBC) is 5 M.T. per sqm and by 5% where SBC is more than 5 MT/ sqm and upto 10 MT /Sqm. This % of 5% or 7.5 % is applicable for estimation of amount of L.S. item of ESR. For Extra Item due to change from individual foundation to raft, actual increase in concrete and steel be paid as per relevent DSR Item.		

15	The rate shall be increased by 30% for bearing piles upto depth of 10 m & for further increased in depth by 5 M each, it shall be increased by another 10%. These rates are applicable where raft is not feasible for pile foundations sulphate resistant cement shall only be used. Single pile for the column is not permitted Group of piles shall be designed with pile cap for each column of ESR.		
16	The rates are applicable for staging height of 12 M. These rates shall be increased or decreased for per metre variation in this staging height as below.		
	12 to 16 M staging - 2% per metre		
	16 to 20 M staging - 3% per metre		
	20 M and above - 4% per metre		
	For 17 M Staging height percentage calculation will be like below.		
	12 to 16 M --- 4 X 2 = 8 %		
	16 X 17 M --- 1 X 3 = 3 %		
	Total = 11 %		
	For 21 M Staging height percentage calculation will be like below.		
	12 to 16 M --- 4 X 2 = 8 %		
	16 X 20 M --- 4 X 3 = 12 %		
	20 X 21 M --- 1 X 4 = 4 %		
	Total = 24 %		
17	Following rates are for seismic zone-III For zone-IV, these rates shall be increased by 5% and for zone - II, these rates shall be decreased by 5%. Concerned Executive Engineer shall confirm the seismic zone for the scheme from seismic zones plan before estimation and adopt appropriate rates as per actual seismic zones. (Seismic maps attached in this C.S.R.)		
	Note :		
1)	Conditions from Sr. No. 1 to 11 of form a part and parcel of the tender shall be included in the draft tender papers for works of R.C.C.E.S.R.		
2)	Conditions from Sr. No.12to17 are for estimation purpose only and shall not be appear in the tender.		
Sr. No.	**Capacity in litres**	**Unit**	
1	Upto 25,000 litres	Per Lit.	22
2	Cost of 25,000 litres capacity E.S.R.	----	5,50,000.00

3	Add for capacity		
	above 25,000 upto 50,000 litres	Per Lit.	14
4	Cost of 50,000 litres capacity E.S.R.	-----	9,00,000.00
5	Add for capacity		
	above 50,000 upto 75,000 litres	Per Lit.	9
6	Cost of 75,000 litres capacity E.S.R.	-----	11,25,000.00
7	Add for capacity		
	above 75,000 upto 1,00,000 litres	Per Lit.	7.5
8	Cost of 1,00,000 litres capacity E.S.R.	-----	13,12,500.00
9	Add for capacity		
	above 1,00,000 upto 1,50,000 litres	Per Lit.	6.25
10	Cost of 1,50,000 litres capacity E.S.R.	-------	16,25,000.00
11	Add for capacity		
	above 1,50,000 upto 2,00,000 litres	Per Lit.	5.25
12	Cost of 2,00,000 litres capacity E.S.R.	----	18,87,500.00
13	Add for capacity		
	above 2,00,000 upto 2,50,000 litres	Per Lit.	5
14	Cost of 2,50,000 litres capacity E.S.R.	-----	21,37,500.00
15	Add for capacity		
	above 2,50,000 upto 3,00,000 litres	Per Lit.	4.75
16	Cost of 3,00,000 litres capacity E.S.R.	-----	23,75,000.00
17	Add for capacity		
	above 3,00,000 upto 4,00,000 litres	Per Lit.	4.5
18	Cost of 4,00,000 litres capacity E.S.R.	----	28,25,000.00
19	Add for capacity		
	above 4,00,000 upto 5,00,000 litres	Per Lit.	4.25

20	Cost of 5,00,000 litres capacity E.S.R.	-----	32,50,000.00
21	Add for capacity		
	above 5,00,000 upto 7,50,000 litres	Per Lit.	4
22	Cost of 7,50,000 litres capacity E.S.R.	-----	42,50,000.00
23	Add for capacity		
	above 7,50,000 upto 10,00,000 litres	Per Lit.	3.75
24	Cost of 10,00,000 litres capacity E.S.R.	-----	51,87,500.00
25	Add for capacity		
	above 10,00,000 upto 15,00,000 litres	Per Lit.	3.5
26	Cost of 15,00,000 litres capacity E.S.R.	-------	69,37,500.00
27	Add for capacity		
	above 15,00,000 upto 20,00,000 litres	Per Lit.	3.25
28	Cost of 20,00,000 litres capacity E.S.R.	----	85,62,500.00

7.4 Schedule of Rates (Pipes):

X : H.D.P.E. Pipes				
1	Providing and supplying in standard lengths Polyethelene Pipes, confirming to IS 4984 / 14151 / 12786 / 13488 with nesessary jointing material like mechanical connector i. e. thread / insert joint / quick release coupler joint / compression fitting joint or flanged joint, including all local & central taxes, transportation and fright charges inspection charges, loading / unloading charges, conveyance to the departmental stores / site & stacking the same in closed shade duly protecting from sunrays & rains, etc. complete.			
			Proposed rate 10-11	
A)	PE-100		With E.D.	Without ED
c)	6kg/sq,cm			

i)	63mm	Rmt	78	71
ii)	75mm	Rmt	112	101
iii)	90mm	Rmt	156	142
iv)	110mm	Rmt	227	206
v)	125mm	Rmt	309	280
vi)	140mm	Rmt	388	352
vii)	160mm	Rmt	503	457
viii)	180mm	Rmt	634	576
ix)	200mm	Rmt	744	675
x)	225mm	Rmt	959	870
xi)	250mm	Rmt	1177	1068
xii)	280mm	Rmt	1476	1339
xiii)	315mm	Rmt	1870	1696
xiv)	355mm	Rmt	2370	2150
xv)	400mm	Rmt	3105	2817
xvi)	450 mm	Rmt	4090	3711
xvii)	500 mm	Rmt	5058	4588
xviii)	560 mm	Rmt	6331	5743
xix)	630 mm	Rmt	10334	9375
xx)	710 mm	Rmt	10956	9939
d)	8kg/sq,cm			
i)	63mm	Rmt	98	89
ii)	75mm	Rmt	146	133
iii)	90mm	Rmt	196	178
iv)	110mm	Rmt	289	262
v)	125mm	Rmt	392	355
vi)	140mm	Rmt	490	445
vii)	160mm	Rmt	637	578
viii)	180mm	Rmt	803	728
ix)	200mm	Rmt	946	858

x)	225mm	Rmt	1215	1102
xi)	250mm	Rmt	1497	1358
xii)	280mm	Rmt	1878	1703
xiii)	315mm	Rmt	2374	2154
xiv)	355mm	Rmt	3005	2726
xv)	400mm	Rmt	3947	3581
xvi)	450 mm	Rmt	5278	4788
xvii)	500 mm	Rmt	6510	5906
xviii)	560 mm	Rmt	8172	7413
xix)	630 mm	Rmt	12381	11232
xx)	710 mm	Rmt	14137	12825
e)	10kg/sq,cm			
i)	63mm	Rmt	123	111
ii)	75mm	Rmt	173	157
iii)	90mm	Rmt	247	224
iv)	110mm	Rmt	364	331
v)	125mm	Rmt	469	425
vi)	140mm	Rmt	586	531
vii)	160mm	Rmt	761	691
viii)	180mm	Rmt	965	876
ix)	200mm	Rmt	1131	1026
x)	225mm	Rmt	1448	1314
xi)	250mm	Rmt	1808	1640
xii)	280mm	Rmt	2233	2026
xiii)	315mm	Rmt	2868	2602
xiv)	355mm	Rmt	3599	3265
xv)	400mm	Rmt	4794	4349
xvi)	450 mm	Rmt	6379	5787
xvii)	500 mm	Rmt	7884	7152
xviii)	560 mm	Rmt	9482	8602

xix)	630 mm	Rmt	14986	13596
xx)	710 mm	Rmt	17151	15560
f)	12.5kg/sq,cm			
i)	63mm	Rmt	144	131
ii)	75mm	Rmt	203	184
iii)	90mm	Rmt	293	266
iv)	110mm	Rmt	432	392
v)	125mm	Rmt	557	506
vi)	140mm	Rmt	698	634
vii)	160mm	Rmt	909	825
viii)	180mm	Rmt	1150	1043
ix)	200mm	Rmt	1351	1226
x)	225mm	Rmt	1744	1582
xi)	250mm	Rmt	2145	1946
xii)	280mm	Rmt	2690	2440
xiii)	315mm	Rmt	3405	3089
xiv)	355mm	Rmt	4323	3922
xv)	400mm	Rmt	5682	5155
xvi)	450 mm	Rmt	7593	6889
xvii)	500 mm	Rmt	9359	8491
xviii)	560 mm	Rmt	11732	10644
xix)	630 mm	Rmt	16232	14725
g)	16kg/sq,cm			
i)	63mm	Rmt	174	157
ii)	75mm	Rmt	245	222
iii)	90mm	Rmt	351	319
iv)	110mm	Rmt	520	471

v)	125mm	Rmt	671	609
vi)	140mm	Rmt	837	760
vii)	160mm	Rmt	1098	996
viii)	180mm	Rmt	1382	1254
ix)	200mm	Rmt	2386	2165
x)	225mm	Rmt	3016	2736
xi)	250mm	Rmt	3721	3376
xii)	280mm	Rmt	4667	4234
xiii)	315mm	Rmt	5899	5352
xiv)	355mm	Rmt	7484	6789
xvii)	400mm	Rmt	9694	8795
xvi)	450 mm	Rmt	12288	11147
xvii)	500 mm	Rmt	15153	13747
-				
2	Lowering, Laying and Jointing H. D. P. E. pipes by heating to the ends of pipes with the help of tefflon coated electric mirror / heater to the required temparature and then pressing the ends together against each other, to form a monolithic & leak proof joint by thermosetting process. The pressing may be required to be done with Jacks/ Hydraulic Jacks/Butt fusion machine etc. complete with all materials labours as directed by Engineer - in - charge, including, given satisfactory hydraulic test.			
			DSR 10-11	
i)	63mm	Rmt	34	
ii)	75mm	Rmt	36	
iii)	90mm	Rmt	50	
iv)	110mm	Rmt	53	
v)	125mm	Rmt	60	
vi)	140mm	Rmt	81	
vii)	160mm	Rmt	86	
viii)	180mm	Rmt	86	

ix)	200mm	Rmt	96	
x)	225mm	Rmt	124	
xi)	250mm	Rmt	128	
xii)	280mm	Rmt	158	
xiii)	315mm	Rmt	174	
xiv)	355mm	Rmt	190	
xv)	400mm	Rmt	192	
xvi)	450mm	Rmt	216	
xvii)	500mm	Rmt	280	
xviii)	560mm	Rmt	314	
xix)	630mm	Rmt	353	

7.5 Sample BRANCH input/output:
Primary network for Option A

```
BRANCH: Branched Water Distribution Design Program - (C) The World Bank
Output Data File : ZA13_1.OUT      05 December 2012      Page #  1

 Echoing Input Variables
------------------------

 Title of the Project                      : thane
 Name of the User                          : abc
 Number of Pipes                           :  7
 Number of Nodes                           :  8
 Number of Commercial Diameters            :  20
 Peak Design Factor                        :  1
 Minimum Headloss in         m/km          :  .1
 Maximum Headloss in         m/km          :  25
 Minimum Residual Pressure   m             :  7
 Type of Formula                           : Hazen's

 Pipe Data
------------
 ============================================================
 Pipe  From   To     Length    Diameter  Hazen's   Status
  No.  Node  Node      m          mm      Const    (E/P)
------------------------------------------------------------
    1    18     9     9911.00
    2     9    28     2800.00
    3     9    24     9850.00
    4     9     3     3130.00
    5     3     8      284.00
```

6	3	6	7219.00
7	9	21	626.00

Node Data

Node No.	Peak Factor	Flow lps	Elevation m	Res. Press m	Meet Res. Pres (Y/N)?
18	1.00	0.000	617.00	7.00	
9	1.00	0.000	434.00	7.00	
28	1.00	-9.380	320.00	7.00	
24	1.00	-10.630	440.00	7.00	
3	1.00	0.000	402.00	7.00	
8	1.00	-8.190	441.00	7.00	
6	1.00	-3.620	475.00	7.00	
21	1.00	-16.840	464.00	7.00	

Reference Node Data

Node No.	Grade Line m
18	640.00

Commercial Diameter Data

Pipe Dia. Int. (mm)	Hazen's Const	Unit Cost Rs /m length
63.0	140.00000	98.00
75.0	140.00000	146.00
90.0	140.00000	196.00
110.0	140.00000	289.00
125.0	140.00000	392.00
140.0	140.00000	490.00
160.0	140.00000	637.00
180.0	140.00000	803.00
200.0	140.00000	946.00
225.0	140.00000	1215.00
250.0	140.00000	1497.00
280.0	140.00000	1878.00

315.0	140.00000	2374.00
355.0	140.00000	3005.00
400.0	140.00000	3947.00
450.0	140.00000	5278.00
500.0	140.00000	6510.00
560.0	140.00000	8172.00
630.0	140.00000	12381.00
710.0	140.00000	14137.00

Branched Water Distribution Network Design OutPut

Pipe Details

Pipe No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Hazen's Const	HL (m)	HL/1000 (m)	Length (m)	Status (E/P)
1	18	9	48.660	200.0	140.00000	106.70	10.77	9911.00	

Pipe Details cont`d

Pipe No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Hazen's Const	HL (m)	HL/1000 (m)	Length (m)	Status (E/P)
2	9	28	9.380	110.0	140.00000	26.36	9.41	2800.00	
3	9	24	10.630	110.0	140.00000	50.90	11.86	4290.00	
				125.0	140.00000	35.40	6.37	5560.00	
4	9	3	11.810	125.0	140.00000	14.94	7.74	1930.73	
				140.0	140.00000	5.34	4.45	1199.27	
5	3	8	8.190	90.0	140.00000	5.53	19.47	284.00	
6	3	6	3.620	90.0	140.00000	31.02	4.30	7219.00	
7	9	21	16.840	125.0	140.00000	9.34	14.92	626.00	

Node Details

Node No.	Peak Flow (lps)	Elevation (m)	H G L (m)	Cal Pres (m)	SpcPres (m)	Meet Res Pres. (Y)
18 S	48.660	617.00	640.00	23.00	7.00	
9	0.000	434.00	533.30	99.30	7.00	
28	-9.380	320.00	506.94	186.94	7.00	
24	-10.630	440.00	447.00	7.00	7.00	

3 T	0.000	402.00	513.02	111.02	7.00
8 T	-8.190	441.00	507.50	66.50	7.00
6 T	-3.620	475.00	482.00	7.00	7.00
21	-16.840	464.00	523.97	59.97	7.00

Cost Summary

Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
90.0	7503.00	1470.59	1470.59
110.0	7090.00	2049.01	3519.60
125.0	8116.73	3181.76	6701.35
140.0	1199.27	587.64	7289.00
200.0	9911.00	9375.81	16664.80

Pipe-wise Cost Summary

Pipe No	Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
1	200.0	9911.00	9375.81	9375.81
2	110.0	2800.00	809.20	10185.01
3	110.0	4290.00	1239.81	11424.82
	125.0	5560.00	2179.52	13604.34
4	125.0	1930.73	756.85	14361.18
	140.0	1199.27	587.64	14948.82
5	90.0	284.00	55.66	15004.49
6	90.0	7219.00	1414.92	16419.41
7	125.0	626.00	245.39	16664.80

BRANCH: Branched Water Distribution Design Program - (C) The World Bank

7.6 Sample EPANET input/output:

The sample EPANET input/output provided below is for the case of steady-state analysis. For extended-period analysis refer to the graphs in Appendix 6.1

Page 1 11/25/2012 7:53:55 PM

```
**********************************************************************
*                E P A N E T                  *
*         Hydraulic and Water Quality         *
*         Analysis for Pipe Networks          *
*              Version 2.0                    *
**********************************************************************
```

Input File: Upper Vaitarna.net

MVS based on Upper Vaitarna for tanker fed villages in Mokhada Taluka

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
PI1	RE1	TA1	600	250
PI3	TA1	JU15	500	250
PI4	JU15	JU2	500	250
PI5	JU2	JU3	500	250
PI6	JU6	JU7	500	250
PI7	JU7	JU8	500	250
PI8	JU8	JU9	600	250
PI9	JU9	JU10	500	250
PI10	JU10	JU11	600	250
PI11	JU11	JU12	1000	300
PI12	JU12	JU16	700	250
PI13	JU16	JU13	800	250
PI14	JU13	JU14	1500	250
PI15	JU14	JU17	500	50
PI16	JU17	JU18	2430	50
PI17	JU14	JU28	500	110
PI18	JU28	JU29	3747	110
PI19	JU29	JU30	2675	90
PI20	JU30	JU31	2440	90
PI21	JU30	JU32	500	50

PI22	JU14	JU33	2181	125
PI23	JU33	JU34	500	90
PI24	JU34	JU35	500	90
PI25	JU35	JU36	500	90
PI26	JU36	JU37	500	90
PI27	JU37	JU38	1700	90
PI35	JU20	JU21	500	300
PI36	JU21	JU22	500	300
PI37	JU22	JU23	500	300
PI38	JU23	JU24	577	50
PI39	JU23	JU25	500	300
PI40	JU25	JU26	1391	63
PI41	JU25	JU45	2000	63
PI42	JU45	JU27	1677	63
PI44	JU3	JU4	500	250
PI46	JU4	JU5	500	250
PI47	JU5	JU6	600	250

Page 2 MVS based on Upper Vaitarna for tanker fed villages in Mokhada Taluka
Link - Node Table: (continued)

Link ID	Start Node	End Node	Length m	Diameter mm	
PI48	JU14	JU46	500	110	
PI49	JU29	JU47	500	50	
PI50	JU33	JU40	5568	110	
PI51	JU40	JU48	500	50	
PI52	JU40	JU49	5160	90	
PI53	JU40	JU41	2000	90	
PI54	JU20	JU50	500	50	
PI55	JU14	JU20	3130	110	
PU1	JU1	TA1	#N/A	#N/A	Pump

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
JU1	0.00	523.67	-79.33	0.00
JU2	0.00	653.43	30.43	0.00
JU3	0.00	651.64	56.64	0.00

JU4	0.00	649.85	40.85	0.00
JU5	0.00	646.52	32.52	0.00
JU6	0.00	642.52	36.52	0.00
JU7	0.00	639.19	29.19	0.00
JU8	0.00	635.85	37.85	0.00
JU9	0.00	631.86	82.86	0.00
JU10	0.00	628.52	73.52	0.00
JU11	0.00	624.52	60.52	0.00
JU12	0.00	621.78	79.78	0.00
JU13	0.00	611.78	181.78	0.00
JU14	0.00	601.79	154.79	0.00
JU15	0.00	655.21	45.21	0.00
JU16	0.00	617.12	140.12	0.00
JU17	0.00	590.68	141.68	0.00
JU18	1.35	536.68	104.68	0.00
JU20	0.00	518.98	116.98	0.00
JU21	0.00	518.92	518.92	0.00
JU22	0.00	518.85	518.85	0.00
JU23	0.00	518.79	518.79	0.00

Node Results: (continued)

Node ID	Demand LPS	Head m	Pressure m	Quality
JU24	2.45	480.13	45.13	0.00
JU25	0.00	518.76	112.76	0.00
JU26	3.00	495.17	62.17	0.00
JU27	3.60	431.35	-41.65	0.00
JU28	0.00	593.19	248.19	0.00
JU29	0.00	528.77	288.77	0.00
JU30	0.00	445.49	241.49	0.00
JU31	6.67	385.85	180.85	0.00
JU32	0.93	439.92	224.92	0.00
JU33	0.00	540.45	195.45	0.00
JU34	0.00	528.99	178.99	0.00
JU35	0.00	517.54	167.54	0.00
JU36	0.00	506.09	133.09	0.00
JU37	0.00	494.63	152.63	0.00
JU38	6.44	455.69	88.69	0.00
JU40	0.00	475.34	95.34	0.00

JU41	4.20	464.21	67.21	0.00	
JU45	0.00	471.21	11.21	0.00	
JU46	9.00	593.78	159.78	0.00	
JU47	1.75	510.80	254.80	0.00	
JU48	1.80	456.41	63.41	0.00	
JU49	4.63	440.94	34.94	0.00	
JU50	2.75	477.48	38.48	0.00	
RE1	198.04	603.00	0.00	0.00	Reservoir
TA1	-246.61	657.00	4.00	0.00	Tank

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
PI1	-198.04	4.03	90.00	Open
PI3	48.57	0.99	3.57	Open
PI4	48.57	0.99	3.57	Open
PI5	48.57	0.99	3.57	Open
PI6	48.57	0.99	6.67	Open
PI7	48.57	0.99	6.67	Open
PI8	48.57	0.99	6.67	Open
PI9	48.57	0.99	6.67	Open
PI10	48.57	0.99	6.67	Open
PI11	48.57	0.69	2.74	Open
PI12	48.57	0.99	6.67	Open
PI13	48.57	0.99	6.67	Open
PI14	48.57	0.99	6.67	Open
PI15	1.35	0.69	22.22	Open
PI16	1.35	0.69	22.22	Open
PI17	9.35	0.98	17.19	Open

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
PI18	9.35	0.98	17.19	Open
PI19	7.60	1.19	31.13	Open
PI20	6.67	1.05	24.45	Open
PI21	0.93	0.47	11.14	Open

PI22	17.07	1.39	28.12	Open
PI23	6.44	1.01	22.91	Open
PI24	6.44	1.01	22.91	Open
PI25	6.44	1.01	22.91	Open
PI26	6.44	1.01	22.91	Open
PI27	6.44	1.01	22.91	Open
PI35	9.05	0.13	0.12	Open
PI36	9.05	0.13	0.12	Open
PI37	9.05	0.13	0.12	Open
PI38	2.45	1.25	67.00	Open
PI39	6.60	0.09	0.07	Open
PI40	3.00	0.96	16.96	Open
PI41	3.60	1.15	23.77	Open
PI42	3.60	1.15	23.77	Open
PI44	48.57	0.99	3.57	Open
PI46	48.57	0.99	6.67	Open
PI47	48.57	0.99	6.67	Open
PI48	9.00	0.95	16.02	Open
PI49	1.75	0.89	35.93	Open
PI50	10.63	1.12	11.69	Open
PI51	1.80	0.92	37.85	Open
PI52	4.63	0.73	6.67	Open
PI53	4.20	0.66	5.57	Open
PI54	2.75	1.40	82.98	Open
PI55	11.80	1.24	26.46	Open
PU1	0.00	0.00	-133.33	Open Pump