Redesigning Khardi Rural Piped Water Network Scheme for Sustainability

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List of Abbreviations

A.C.	Asbestos Cement
C.I.	Cast Iron
D.I.	Ductile Iron
ESR	Elevated Storage Reservoir
GP	Gram Panchayat
GIS	Geospatial Information System
GPM	Gallon per minute
GSR	Ground Storage Reservoir
HP	Horse power (unit of power)
LPCD	Litre per capita per day
MBR	Mass Balancing Reservoir
MJP	Maharashtra Jeevan Pradhikaran
M.S.	Mild Steel
MVS	Multi village scheme
NGO	Non Government Organization
PHCC	Primary Health Care Centre
PWS	Piped Water Scheme
SVS	Single Village Scheme
WTP	Water Treatment Plant
ZP	Zilla Parishad

Executive Summary

This report presents performance analysis of the 25 year Khardi multi-village drinking water pipeline scheme (MVS) from technical, operational, institutional, financial, and social perspective.

It also presents a design of Kundan dam based scheme as a sustainable solution compared to the new scheme for Khardi based on Bhatsa back water proposed by MJP and comparative feasibility analysis between them.

Brief History: The current scheme based on tail water of Bhatsa dam was designed in 1983-84 by MJP, the then WSSB(Water Supply and Sewerage Board) to supply piped drinking water to Khardi and five other villages namely Umbarkhand, Chanda, Golban, Lahe and Kukambe in Shahapur taluka of Thane district in Maharashtra. After its implementation in 1990, it was successfully operated by MJP for a period of two years and then handed over to Thane ZP. Since then it has been owned and operated by ZP.

Current Status: Currently, only three villages, namely Khardi, Lahe and Kukambhe are serviced throughout year. The remaining three villages namely Umbarkhand, Chanda, Golban are supplied water from the scheme only during pre-summer and summer months (January to May).Although, the scheme is functional, it hardly meets desired objective of drinking water supply as outlined below.

- Due to breakages of the old A.C. pipeline on the outskirts of the villages, the performance of the scheme has degraded over the years.

- The beneficiary villages are able to get water once in 2-4 days only for a period of 45 minutes. It is far from meeting the minimum needs of the people. In summer, Khardi, the tail end village gets water almost once a week, making people dependent on bore-wells, public wells and private tankers to meet their household water needs at additional financial cost.

- The water treatment is carried out by adding TCL in ESR/GSR or open wells of individual villages due to which it is difficult to maintain the quality of water.

Issues: The scheme faces the following issues:

- There is no Mass Balancing Reservoir (MBR).Hence there is no buffer storage to maintain continuity of service in the face of frequent power failures prevalent in the area.

- There is no WTP; hence, it is difficult to maintain the quality of water consistently across the villages.

- The elevation of source location (62m) is too low compared to the elevation of villages (220-240m) jeopardising the financial sustainability of the scheme due to high pumping costs. The tariff recovery is hardly Rs. 4 lakh while annual energy cost is around Rs. 16 lakh.

- Due to frequent power failures prevalent in the area, the ten km long main pipeline empties to a great extent. The loss of service time caused by it combined with loss of pressure due leakages in the AC pipeline has made the water supply insufficient, erratic and unreliable.

- Since the pipe lines are not laid along the road, the maintenance and repairs becomes extremely difficult consuming a lot of time and efforts.

- The operational staffs have been working as daily wage earners for many years at a low wage of Rs 154 per day. Hence they have very low morale.

New Khardi Scheme Proposed by MJP: To address the failure of the current scheme, MJP has been working on design of a new scheme since 2005 based on Bhatsa back water as source. The salient features of the scheme are given below.

- The scheme is designed only for Khardi village and newly developing semi urban area around. The scheme does not cover the neighbouring villages like Umbarkhand, Golban and Chanda that are still dependent on the old scheme.

- The elevation of the source (~122 m) is still very low compared to Khardi (~240m).Also, the raw water mains is 10 km long. This has resulted into high capital as well as energy cost.

- The per capita capital cost of the scheme is Rs. 3092 while the energy cost is Rs. 8.73 out of Operation and Maintenance cost of Rs. 13 per 1000 lit of water.

Kundan Dam Based Scheme Proposed by CTARA, IIT Bombay: To address the question of long term financial sustainability raised by MJP scheme due to relatively high energy cost & O&M cost, CTARA, IIT Bombay had undertaken an exercise of redesigning Khardi scheme for sustainability by evaluating all the alternate sources with an emphasis on reducing energy cost. The logical outcome of this exercise was a scheme proposal based on Kundan dam as source. Kundan dam offered critical advantage over Bhatsa due to its higher elevation than Khardi resulting into drastic reduction in energy cost and thereby paving the way for long term financial viability. The scheme was designed by us using MJP protocol. BRANCH software was used for network design and extensive hydraulic performance simulations were done using EPANET.

- The gravity assisted scheme based on Kundan dam covering two more villages besides Khardi is more cost effective than the MJP scheme design based on the Bhatsa back water with drastic reduction in capital, energy and O&M cost.

    - The per capita capital cost of scheme based on Kundan Dam is Rs. 1917 against Rs. 3092 for the MJP scheme.

    - The energy cost is Rs. 2.04 and the Operating and Maintenance cost is Rs. 6.92 per 1000 litre of water compared to Rs. 8.73 and Rs. 13 respectively for the MJP scheme.

- In the light of the reducing demand for irrigation water due to urbanization in surrounding area, the water from the dam can be used for drinking purpose with permission from appropriate authorities.

- Even if current reservation of water for irrigation purpose is maintained, adequate storage for drinking water supply can be created by increasing the height of the dam by 3 m.

In summary, the current scheme is financially unsustainable due to intrinsic design issues, outdated assets and its failure to meet even the bare minimum drinking water needs of the people. The MJP design based on Bhatsa back water, though better than the current scheme, doesn’t have long term financial sustainability due to high energy costs. Comparatively, the Kundan dam based gravity assisted scheme provides the best option as a viable and cost effective solution and hence is recommended as a long term solution to the drinking water crisis in the Khardi area. The lesson learnt through this exercise calls for over hauling the current process of source selection by placing energy consideration at higher priority than just proximity of source in every future scheme design.

Keywords Piped water supply, rural water supply, multi village scheme, piped network design, drinking water, piped water source selection.

1 Introduction

1.1 Background

Khardi is a small village with a population of about 5000 in Shahapur taluka of Thane district in the state of Maharashtra. It is located on Mumbai Nasik road (NH – 3) at a distance of about 90kms from Mumbai in the vicinity of Bhatsa reservoir, one of the major reservoirs supplying drinking water to Mumbai city as shown in Fig 1 below. It is also a railway station on the Mumbai Suburban Railway system on the Central line route between Kalyan and Kasara.

Fig 1: Geographical view

This report presents the performance analysis of Khardi Multi-Village Drinking Water Scheme that was planned and executed by MJP in 1988 and subsequently handed over to Thane ZP in 1990. Since then it has been operated by Rural Water Supply and Sanitation (RWSS) division of Thane ZP.

Firstly, the study was prompted by the increasing significance of surface water as a sustainable source of drinking water in face of large scale source failure of Single Village Schemes (SVS) based on ground water (About 60%). Secondly, multi village drinking water schemes based on surface water as a sustainable drinking water solution for rural and per urban area needs innovative approaches in its design. The study is expected to bring to fore lessons from the field that can be incorporated in planning, design and operation of Multi Village Schemes to address the institutional and other weaknesses traditionally associated them and make them into a financially viable solution.

The existing Khardi scheme is based on tail water of Bhatsa dam and all the beneficiary villages are located in the vicinity of the Bhatsa reservoir, as shown in Fig 2. Khardi, the largest village among them is lying at the tail end of the scheme located at a distance of 12 Kms from the source of the water. Chanda and Umbarkhand are small habitations within the same Gram Panchayat (GP) while Lahe and Kukambe are independent villages with their own GPs.

Fig 2:Villages covered by the Khardi scheme

The population of the beneficiary villages and their social composition is given in Table 1.

Habitation	No. of Households	Total	SC	ST	GEN
Kukambe	91	538	0	162	376
Lahe	275	1471	42	310	1119
Chanda	25	232	0	68	164
Umbarkhand	30	559	4	308	513
Khardi	997	4707	418	1016	3273

Table 1: Census 2011 Data for villages covered by Khardi Scheme[5]

Although the population of Khardi village is shown as 4707 in the above table, the surrounding area has witnessed steadily increasing urbanization in the recent years, mostly in the form of second homes and weekend homes. The population growth of these areas has shot up to around 18000[1] - almost four times the population of Khardi village. This has put a lot of stress on the drinking water supply, with local population already facing crisis due to under-performance of the existing water supply scheme.

Average annual rainfall in Shahapur taluka in which Bhatsa dam and the beneficiary villages are located, is around 2500mm. Ironically, these villages still have to depend on the tanker water in summer as other water sources go dry and the scheme is unable to meet the water demand. Alternative source of water besides the schemes are government wells, private wells, private bore-wells and private tankers of varying capacity as depicted in Table 2.

Sr. No.	Village	Alternate source of water in each village
1	Kukambe	• Three wells near by the village at a distance of 1- 1.5 km • Tankers of capacity 5000 litres (Cost- Rs 1000)
2	Lahe	• 2 wells (One at a distance of 0.5 km and other 1 km away) • Private bore wells
3	Chanda	• 1 well in the village • 1 well on the outskirt of the village at a distance of 5km
4	Umbarkhand	• 4 wells at distance of 1 km • 8 private bore wells • Tankers of capacity 8000 litres (Cost- Rs 1000)
5	Khardi	• Tankers (8000lts cost Rs 1000 and 3000lts cost Rs 400 • Private bore wells (sells water @ Rs 30-50 per 200 litres barrel • 12 government wells (only 3 wells suitable for drinking) • 2 private wells

Table 2: Alternate Sources of water for villages covered by Khardi Scheme[4]

The economy of most of the villages is primarily based on agriculture, mainly paddy cultivation during Kharif season. However, due to proximity to the city of Mumbai and connectivity by means of railway line as well as Mumbai Nashik road, there has been industrialization to some extent. Also, there are many important reservoirs like Bhatsa, Tansa and Vaitarna in the surrounding area. Hence, people have found employment both in government departments as well as expanding service sector in the form of roadside hotels and restaurants, weekend homes etc.

1.2 Objective and Scope

- The first objective of the study is to analyze the performance of the existing Khardi multi-village drinking water pipeline scheme (MVS) from technical, operational, institutional, financial and social perspective.

- The second objective is exploration of a more cost effective solution compared to the new scheme proposed by MJP for long term financial sustainability.

- The third objective is to make recommendations for planning and design of new Multi Village Schemes based on the lessons learnt from the field.

The scope of the work includes the study of current Khardi scheme design document, its assets and its performance. The scope also includes study of design document of the new scheme proposed by MJP, exploration of potential sources and designing an alternative to the new scheme proposed by MJP and the high level cost estimation of the alternative scheme. The structural design of the civil structures of the scheme and detailed cost estimates of all the components are out of scope of the current study.

1.3 Approach and Methodology

- Obtain documentation of Khardi Scheme from the district MJP office
- Field visits to make assessment of scheme assets

- Field visits to beneficiary villages covered by the scheme for studying scheme performance and problems
- Simulation for technical design validation using EPANET.
- Detailed analysis of the scheme from technical, operational, social, financial and organizational perspective
- Exploration of all the potential sources for selection of the best source.
- Step by step design of the scheme components following MJP protocol
- High level cost estimation based on MJP Schedule of Rates.
- Side by side comparative analysis for long term financial sustainability.

1.4 Stakeholders

The people: The primary stakeholders in this project are the people of Khardi and five villages serviced by the scheme. CTARA's team made a total of four visits to the beneficiary villages to talk to the people and get their feedback about the current performance of the scheme and to understand the quality of service from sufficiency, adequacy and reliability.

Elected representatives and policy makers: Sustainable implementation of MVS schemes, reasons for their failures and recommendations for reviving these schemes are of particular interest to elected representatives at the state and central level. Through this report, our hope is to communicate the lessons learned from this rural pipeline scheme and create an impact on policy and decision making.

Maharashtra Jeevan Pradhikaran (MJP): MJP is responsible for conceiving, preparing and implementing water supply and sewerage schemes both in urban and rural areas in the state of Maharashtra. MJP also acts as an advisor to the Government in respect of planning, operation, training, etc. MJP acts under the aegis of the Water Supply and Sanitation Department. The primary objective of the Pradhikaran is to promote potable water supply and satisfactory sanitation facilities so as to achieve and maintain clean environment. The current scheme has been designed and implemented by MJP's Thane office.

Minor Irrigation Department: Small dams such as Kundan dam servicing irrigation area between 100ha and 250ha come under the jurisdiction of state sector of Minor Irrigation department of Government of Maharashtra. In view of highest priority given to drinking water in allocation of water from irrigation dam, it can play an important role in solving the severe drinking water scarcity in rural area.

Rural Water Supply and Sanitation Division, Thane Zilla Parishad (RWSS, ZP): RWSS has its district office in Thane and field offices in Taluka Panchayat Samiti offices in the district. It is responsible for supply of drinking water and sanitation facilities in rural areas.

The organization of the rest of the report is as follows. The second chapter gives description of physical assets and layout of the scheme. The current situation is described in third chapter while the fourth chapter presents the performance analysis of the scheme. The fifth chapter is devoted to the description of the new scheme proposed by MJP. Along with its features and issues associated with it. The sixth chapter presents systematic exploration for a sustainable solution as an alternative to MJP design and Kundan dam based scheme design proposed by CTARA, IIT Bombay. The seventh chapter presents a comparative analysis of the MJP design and CTARA design. Finally, the conclusions and recommendations are summarized in chapter eight which is followed by appendix.

2 Scheme Description

The current scheme based on the tail water of Bhatsa dam is 25 years old. The general layout of the scheme is presented in Fig 2 and the detailed specifications are given in Appendix A. A jackwell is built on the bank of river Bhatsa from where water is first pumped to a sump well. There is neither a Water Treatment Plant (WTP) nor a Mass Balancing Reservoir (MBR). In absence of a WTP, untreated water is pumped directly from sump well to ESRs located in the beneficiary villages. The water from individual ESRs is distributed to villages through secondary network and finally it is distributed to public stand posts or individual homes via private connections through tertiary network.

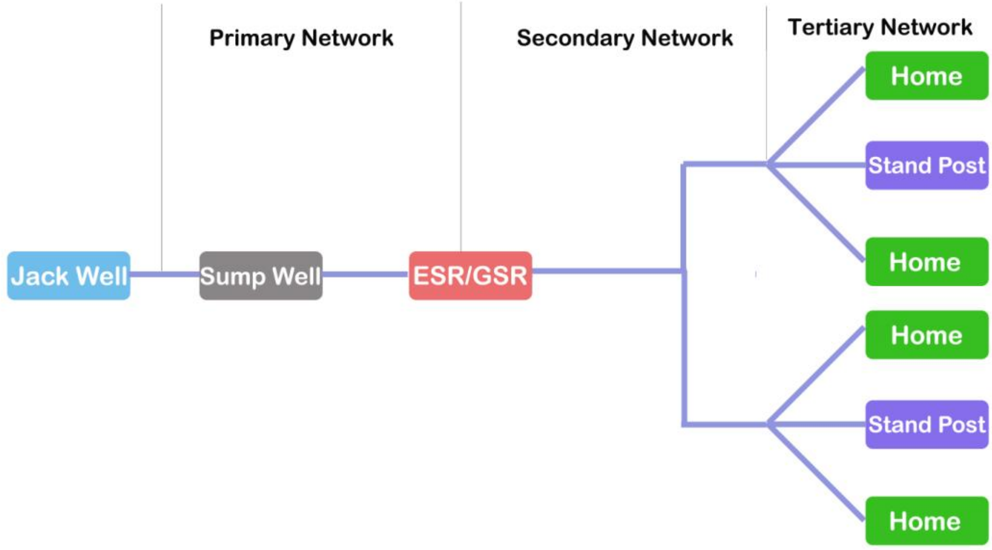

Fig 3: Khardi Scheme Layout

The details of the scheme and its physical assets are given below.

2.1 Source, Raw Water Pumping and Treatment

The source of the scheme is the tail water of Bhatsa dam. There is an inlet well built into the river from which water flows to Jack Well built on the bank of the river through Trench Gallery as shown in Fig 4. The trench gallery is filled with a bed of sand, gravel and coal for filtration of water coming from the river to the Jack well. The Jack Well is 10 m deep and has diameter of 5 m.

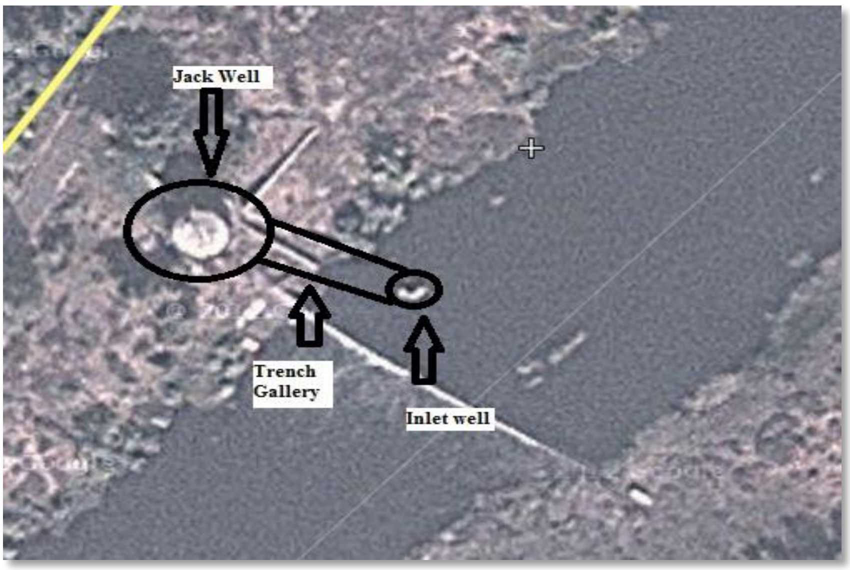

Fig 4: Bhatsa Water Source and the Intake System

The raw water from the Jack Well is pumped by a 50 hp submersible pump through a 200 mm diameter pipe to a sump well located at a distance of 1.25km and at an elevation of 150m from the Jack Well. There is no Mass Balancing Reservoir for the scheme.

The Sump well has dimensions of 9m X 6m X 3.3m. There used to be a settling tank (Fig 5) for pre treatment before the water entered sump well. But it is no longer in operation .Now the water is directly pumped into the sump well without any pre treatment. There are two submersible pumps of 50HP each, one of which is standby, used for pumping water from sump well to ESRs/GSRs in the beneficiary villages.

Fig5: Settling tank (Not Operational)

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2.2 Water Mains and Distribution Network

The twelve km long main pipeline carrying water from sump well to ESRs in beneficiary villages runs along Mumbai Nasik road up to Khardi village located at tail end of the scheme. Since Khardi is located at higher elevation (~240m) the water has to be pumped against a head of 120m. Initially, the entire length of main pipeline was made of A.C. However, it was changed from time to time because of easy breakage and consequent leakages affecting the performance of the scheme .as shown in Table 3.

Sr. No.	Type	Diameter	Total Pipe Length
1	M.S.	200 mm	600 m
2	A.C.	200 mm	600 m
3	A.C.	150 mm	7610 m
4	D.I.	150 mm	2548 m
5	C.I.	150 mm	938 m
		Total:	12296 m(1.2km)

Table 3: Description of Main Pipeline and its Sections

Since there is no MBR, water is directly pumped into the village level reservoirs (see Table 4). It is then distributed in the respective villages by gravity through secondary and tertiary distribution network summarized in Table 5. The details of pipeline distribution network are given in Appendix B.

Sr. No.	Place	Type	Capacity (Litres)
1	Kukambe	ESR	10,000
2	Lahe	GSR	35,000
3	Chanda	GSR	55,000
4	Khardi Village	GSR	1,80,000
5	Anand Nagar, Khardi	ESR	85,000
6	Regional P.H.C.	ESR	10,000
7	Panchshil Nagar	ESR	70,000

Table 4: Village Level Service Reservoirs

Sr. No.	Village Name	Total Length of pipe	Diameter	Pipe Material
1	Kukambe	725 m	50 mm	G.I.
2	Lahe	1125 m	100 mm	A.C. & G.I.
3	Chanda	490 m	100 mm	A.C. & G.I.
4	Umbarkhand/ Pachamba	2735 m	100 mm	A.C., G.I. & PVC
5	Khardi	3100 m	100 mm	G.I. & PVC
			80 mm / 65 mm	G.I. & PVC

Table 5: Village wise Secondary & Tertiary Distribution Pipeline

3 Current Status

3.1 Status of Scheme Assets

This scheme is 25 years old and many assets of the scheme are dilapidated condition. The Intake Well and Trench Gallery is damaged and it is no more functional as shown in the Fig 6.

Fig 6: Intake Well and Trench Gallery

There is no WTP as mentioned before. Even the settling tank earlier used for settling solid matter in the water is no longer functional (Fig 5) and hence the water from the sump well is directly pumped to ESRs/GSRs and TCL is added in the water at the destination villages. The sections of water mains made of AC have leakages at multiple points along the road as a result of breakages. In order to minimize the problem, a few AC sections of the mains are replaced with DI, CI or MS pipe. Out of a total 12 km length of the pipe about 4 km length has been now replaced with other pipes (see Table 3).

There are breakages on the outskirt of villages that lie on the head side of the scheme. The leakages of water from the main pipeline are observed at many places on the road along Shende and Kukambe. On two kms stretch, there are as many as 11 leakages wasting a huge quantity of water. The details of leakages at different locations are shown in Appendix C. The remaining sections of A.C. pipeline which are vulnerable to easy breakage are neither repaired nor replaced due to budget constraints.

3.2 Overall Operational Status

The scheme has not been functioning well for many years except for first couple of years after its implementation. Due to leakages at multiple points, the scheme performance has degraded to a great extent. Due to head loss, it is not possible to fill the reservoirs simultaneously. The whole operation is handled manually, filling out reservoirs one at a time, and handling the demand intermittently. A section of operational schedule is displayed in Table 6. It is seen that water supply hardly lasts for a few minutes at a time and the frequency of water supply is every alternate day or less.

Day	Time	Medium	Duration	Place
Saturday	Morning	Main line	7:00 - 7:20	Kukambhe
			7:20 - 8:30	Lahe
			8:30 - 9:30	Sump well
	Noon	Main line	2:30 - 3:10	Khardi Naka
			3:10 - 4:00	Khardi Bazaar
			4:00 - 4:40	Mahatma Phule Colony
			4:40 - 5:40	Station Bazarpeth
	Night	Main line	6:00 - 6:00	ESR, GSR filling
Sunday	Morning	Main line	7:00 - 7:20	Kukambhe
		Main line	7:20 - 8:30	Chanda
		ESR	7:00 - 9:00	Rohiddas Nagar, Anandnagar, Muslim Mohulla
		GSR	7:00 - 9:00	Aanganpada, Bagchapada, Khardi
	Noon	Main line	2:30 - 3:30	Mahatma Phule Colony
			3:30 - 4:30	Station Bazarpeth
			4:30 - 6:30	Panchsheel Nagar
	Night	Main line	6:30 - 11:30	Vaaknaachivihir
Monday	Morning	Main line	7:00 - 7:20	Kukambe
			7:20 - 8:30	Lahe
	Noon	Main line	2:30 - 3:30	Khardinaka
			3:30 - 4:30	Khardi bazaar
	Night	Main line	6:00 - 6:00	ESR, GSR filling

Table 6: Operational Schedule for the year 2013

In absence of WTP, water is purified by adding chemicals to either ESR/GSRs in individual villages or in the wells. Hence, it is difficult to maintain water quality consistently.

There is absence of reliable supply of electricity and unpredictable power failures occur daily besides planned outages every Friday. The original scheme design was based on the assumption of 22 hours of operation of raw water pump at Jackwell. However, pumping can be hardly done for 17-18 hours mainly due to power failures. The pumps have to be shut down on Friday because of planned outage. Every time power fails, a lot of water drains from the 12km long water mains due to leakages and it takes almost an hour to fill the water mains back.

In summary, a combination of factors like frequent power failures, absence of MBR and pipeline leakages has created disastrous situation for the scheme, making the operation erratic and completely unreliable. Though the scheme is operational, it fails to meet even the bare minimum needs of the villages as outlined below.

3.3 Village wise Operational Status

The geographical layout of the beneficiary villages is reproduced below in Fig 7. As can be seen Khardi lies at the tail end of the scheme and is worst affected. Kukambe and Lahe are lying closer to the source and hence they are relatively better serviced by the scheme. At the minimum, the villagers expect water supply at least for a period of 45 minutes daily. However, the water supply is available once in 4-5 days only for a period of 30 minutes. Besides being erratic and unreliable, it hardly meets their bare minimum requirements. We next describe village-wise operational status.

Fig 7: Khardi Scheme Layout

Khardi

Khardi is the main village for which the scheme was designed. Khardi has about 1000 households with a current population of about 5000 people. It is located at the tail end of the scheme. The village has a 10 bed Primary Health Centre (PHC) and a school with a capacity of 1500 students serviced by the scheme apart from the residential population.

Due to urbanization the population in surrounding area has grown multi fold. There are many second and weekend home projects coming up in this. At the time of scheme design the population of Khardi was assumed 3775 in the year 2006 but the population of the greater Khardi area alone is close to 18000.

According to current schedule, Khardi is expected to get water at least three times a week for a period of 45 min to 1 hour. However, the water supply lasts hardly for a period of 10 minutes and the frequency falls below once a week in summer. As a result, many people have opted for private bore wells. Some of them also sell water from their bore wells. Due to acute shortage of water in the village, the villagers have to pay about Rs 20 for 200 litres of water and additional charge of Rs 60 for home delivery. The day to day life of people in this area is adversely impacted by water scarcity issue as they have to spend lot of time in fetching water. The situation is worse in summers when sometimes people have to travel by train to the nearby stations like Kasara to fetch water for their daily needs.

According to Mr. G.N. Gaikwad(Senior clerk of the school) the ,normal schedule of water supply in the school is once in 4-5 days which falls to once in 10-11 days during summer. Therefore they have to depend on tanker water from March onwards and try to store as much water as possible.

Mr.NR Patil, Supervisor of the school, mentioned that people from Khardi are migrating to nearby places such as Shahapur where services are far better.

The Primary Health Centre (PHC) has a staff of 8-10 members (2 doctors, 2 sisters and other all PHCC). Out of 100 OPD patients visiting PHC daily, about 8 to 10 get admitted. The water supply from Khardi scheme is not sufficient to fulfil water requirement of the PHC. In spite of having a 70,000 litres ESR in its premises, the water supply to the PHC is done once in 8 to 10 days for a few minutes.

According to Mr. Madhukar Bhoir, a member of Khardi Gram Panchayat, who lives in Anand Nagar, Khardi, tanker is required once in 5 days in summer costing about Rs 500-600. In spite of regular payment of water tax, they have to spend additional amount to buy tanker water and make appropriate storage as shown in Fig 8.

Fig 8: Household Drinking Water Storage Tanks in Khardi

Mrs.Sakshi Sandeep Khardikar, one of the resident of Sant Rohitdas Nagar, Khardi, said that small tanker of capacity 3000 lit costs about 400/- to 500/- while a large tanker of capacity 8,000 Lit cost Rs. 900/- to 1000/- .

Khardi Data at a glance:

No. Private connections: 334
No. Of Stand Posts: 54
Tariff for private connection: Rs 50 per month
Tariff for stand post: Rs 75 per year (included in *gharpatti*)
Total no. of houses: 1000
Tariff recovery: 60-90%
Operational Schedule: Once in 4 days for 30-45 min
Max amount of water per household at stand post: 100 lit
No.of Students in Primary School: 500
No. Of Students in High School: 1500
No of private hospitals: 8.
No. of hotels: 8 (fed by private tankers)
Alternative sources: 12 government wells & 2 private wells.
Cost of a 8000 lit water tanker: Rs. 900-1000.
Cost of private bore well water: Rs. 30-50 per 200lit.

In summary, people of Khardi have no option but to fulfil their water requirements from tankers, private bore wells and other sources at an extra cost.

Chanda

Chanda is a very small village compared to other villages covered by the scheme. There are only 25 houses in the village. There is a common GSR with a capacity of 55000 lit (Fig 9) located on a nearby hill. This GSR is used to provide water to Chanda, Umbarkhand and Pachambha. The water from the scheme is provided to these villages only during pre-summer and summer season. Umbarkhand is out of service from scheme for last six years. The people of Umbarkhand have made their own private arrangement for drinking water. In Chanda, the water in no more provided through distribution network and stand posts due to fights among people at stand post and other problems. Instead, it is directly released in the common well used by the villagers shown in Fig 10. The well is 4.5m diameter and 5m deep. According to villagers, the water from the scheme is put in the well once a week. But Mr. Sase, Jr. Engineer maintains that water is supplied once in two days. The quality of drinking water in the well is a serious issue in absence of proper water treatment as seen in Fig 11. According to Mr. Sase, the villagers are instructed to add TCL to the well but it seems there is no awareness among the villagers. If there is no water in the well then the only option for the villagers is to use Khardi well located at a distance of 600m from the village. The villagers especially women, have to go through a lot of hardship to fetch water from the well (Fig 12) due to bad roads.

Fig 9: GSR- Chanda village (55000lts capacity)

There is a widespread anger and frustration among the villagers about this scheme. According to the villagers, they are willing to have private connections at their home and pay for the water tariff for a dependable scheme and reliable service. As the Khardi scheme fails to fulfill their piped drinking water needs, villagers say that they should get water from the new scheme under execution in Ratandhale, the neighboring village.

Fig 10: Well in Chanda village (water directly put in the well)

Fig 11: Quality of water in Chanda well

Fig 12: A Daily Chore for Chanda Women

The scheme under construction in Ratandhale village includes 2 Padas namely, Ratadhalepada and Pradhanpada apart from Ratandhale village. It is based on a well situated near Ratandhalepada which never dry up. Based on past experience of other schemes, the villagers have planned to charge Rs 1000 as one time connection fee per household to provide for big ticket maintenance expenses, as per Mrs. Nanda Bhikar, a Pani Samiti member. The amount of monthly O&M charges is fixed at Rs 100 per month.

Lahe

Lahe is a moderate size village. Lahe Gram Panchayat includes Lahe village and two padas namely Mandunpada and Katkarivadi. The total population of this village is 1471 comprising of 275 households. There are a total of 5 wells in Lahe out of which Ranivihir and Pallichivihir are used for drinking water but they dry up by the end of March.

There is a separate GSR (capacity 35,000 Lit) for this village. This is a well developed village due to industrialization in its neighborhood. The Gram Panchayat (GP) of this village is financially sound. Many villagers have their own borewells or have private connections. There are four common stand posts while the most of the people have their own private water connection. The frequency of public water supply is about once in three days for half an hour. In case of shortage of water supply, the GP supplies water to the villagers from a private bore well located 200m away from the village. Typically tanker water is supplied by GP from beginning of April month with a daily average of 2-3 tankers of 7000 litres each.

Fig 13: Source of water for the proposed Lahe Scheme

Due to erratic and unreliable supply of drinking water from Khardi scheme, Lahe village GP has proposed a Single Village Scheme for their own village based on a perennial source of water(*haud measuring 30 ft X 30 ft X 30ft shown in Fig 13*) located at about 1km away from the village.

According to Harshad Kisan Kamble, a clerk at Lahe GP, the cost of the proposed scheme is estimated at Rs. 58 Lacs and the annual tariff per household will be Rs 2150. Based on our talk with the villagers, the people of Lahe are willing to pay the amount for a reliable supply of water and improved service.

Kukambe

Kukambe village is the nearest village to the Bhatsa dam as well as the sumpwell. It is a small village having 80-90 households with a total population of 538. It is under Bhirwadi Gram Panchayat but is serviced by Khardi Water Scheme. There are about 35 private connections while remaining population depends on common stand posts. There is a GSR of 10,000 litres capacity in the village but it is lying in damaged condition (Fig 17).

Fig 14: A public stand post in Kukambhe Village   Fig 15: ESR in Kukambhe (Capacity 10,000 Lit)

Also, its capacity of 10,000 litres is insufficient for the present population. According to the villagers, water supply from the scheme is available once in two to four days only for a period of 20-30 minutes. The current situation is quite evident from the condition of a public stand post depicted in Fig 14. Since it is not possible to meet the minimum requirements of the villagers, the women from the village have no other option but to get additional water from a well located at about 1km from the village. But Mr. Sase, Jr. Engineer in RWSS division maintains that water is supplied on alternate days between 7:00AM and 7:30AM in the morning. It is learnt that the villagers frustrated with the functioning of the scheme, break the pipe line passing by the village to meet additional requirement of water. This leads to a lot of wastage of water.

4. Performance Analysis

There are many aspects to performance of a Piped Water Scheme. The hydraulic performance based on technical analysis and the resultant service performance in terms of stipulated supply of drinking water in a reliable and affordable manner is important. Besides this, the performance analysis from financial, institutional and social perspective is also important.

4.1 Service Performance

The service performance of a water scheme is measured by three important parameters, adequacy, reliability and affordability as explained below.

A. **Adequacy:** The adequacy of a scheme is measured by the frequency and duration of actual water supply as compared to the design norm of 40LPCD water supply.

B. **Reliability:** The reliability of a scheme is the degree of matching of the actual schedule with the published one.

C. **Affordability:** In our survey a total monthly expenditure of Rs. 100 or less is considered as affordable for a reliable and adequate supply of drinking water by most of the people in the beneficiary villages. If the service fails to meet the drinking water requirements, the coping cost needs to be taken into account to compute the affordability. The coping cost is the cost incurred to deal with the deficiencies with the drinking water service available from the scheme.

The adequacy and reliability of the service can be easily seen from Table 7. It is evident that the frequency and the duration of water supply are far from the design norm. The supply is worse for the villages located at the tail end of the scheme, like Khardi and Chanda, as compared to those located close to the source such as Kukambe and Lahe.

Sr. No.	Village	Design Frequency and Duration	Design Frequency	Actual Frequency	Duration of water	Seasonality	Remarks
1	Kukambe	Daily Three Hours	Daily	Everyday (except Friday)	8-8:30 (30 min)	12 month	
2	Lahe	Daily Three Hours	Daily	Alternate days(except Friday)	30 min	12 month	
3	Umbarkhand	Daily Three Hours	Daily	N/A	N/A	N/A	No more in service
4	Chanda	Daily Three Hours	Daily	Once in a week	Water drained in wells directly	March-June	
5	Khardi	Daily Three Hours	Daily	Once in four days	30-45 min	12 month	

Table 7: Village wise Scheme Water Supply Data

Different strategies are adopted by the villagers to make up for the water shortfall, such as fetching water from a public or private dug well, or a bore well, storage of water, or buying water from private tankers. The coping cost is higher for the tail end villages such as Umbarkhand and Khardi as they have to largely depend on private tankers and bore wells especially in summer. Umbarkhand has been out of service and is entirely dependent on private source. Hence, it has the highest coping cost. In case of Chanda village, it is the cost of longer time spent by women in fetching water from distant wells.

Sr. No	Village Name	Cost of tankers (CPCM)*	Notional Cost of fetching water (CPCM)*	Cost of Water from private bore wells(CPCM)*	Total Coping Cost(CPCM)*
1	Khardi	100.00	37.50	75.00	212.50
2	Umbarkhand	150.00	60.00	120.00	330.00
3	Chanda	0.00	187.50	0.00	187.50
4	Lahe	0.00	28.15	0.00	28.15
5	Kukambe	0.00	37.50	0.00	37.50

Table 8: Coping Cost Analysis of the Beneficiary Villages

*CPCM- Cost per capita per month in Rupees.

** We have assigned notional cost of Rs 1 for fetching 20 liters of water from a well located at a distance of 1km.

4.2 Technical Performance

The technical analysis will focus on the hydraulic performance of the scheme based on verification of design of individual components of the Scheme as depicted in the Fig 21 below as against the standard set of components in a MVS following MJP protocol.

4.2.1. Location of Source

The source of the existing scheme is tail water of Bhatsa dam and it is located at about 12 km south of Khardi, the main beneficiary village. Also, the elevation of source is only 62m compared to the 260m elevation of Khardi village. Due to a large elevation difference, it has become necessary to use two stages pumping. The hydraulic head from source to sump well is 150 m and it is 120m for the second stage. This has double disadvantage. There is a large capital investment, repair and maintenance cost for the pumps. Also, at Rs. 16 lacs, the annual energy cost is very high due to the large head difference.

4.2.2 Raw Water Mains

The pipeline of a PWS should be laid along road for easy maintenance. However, the raw water mains of Khardi scheme is not laid along the road as can be seen from Fig 16.

Fig16: Raw Water mains from Jack Well to Sump Well

In present situation, maintenance and repairs of this pipeline is extremely difficult.

4.2.3 Water Treatment Plant (WTP)

The purpose of WTP is disinfection of water by chemical treatment after removing suspended solids by a series of operations such as flocculation, coagulation, sedimentation and filtration. This helps in maintaining consistent water quality across the beneficiary villages. Khardi scheme has no WTP and hence, water purification is done at village level, by just manually adding chorine. People are instructed to add chorine to water either to ESR or open well. However, it is difficult to manage the manual operation due to erratic schedule, resulting in poor water quality.

4.2.4 Mass Balancing Reservoir (MBR)

This scheme does not have any buffer capacity since there is no MBR. It is a major design flaw because of the adverse impact on the performance of the scheme in the event of power failures. A lot of time is wasted in refilling 12km long the main pipeline which gets drained during power failures due to leakages at multiple points. A rough calculation shows that it takes almost one hour to refill the pipeline before water can be delivered to the ESRs located in different villages.

4.2.5 Water Mains

The water from sump well is directly pumped to ESRs. Originally the pipeline was made of A.C., which is vulnerable to breakage. We observed 11 breakages over a stretch of just 3kms from the sump well (Ref Appendix B) to the main road. Over last 25 years, some sections of the pipeline have been replaced with D.I. /C.I. pipes but 8km of the 12km long pipeline still remains to be A.C., mainly due to budget constraints. The details are shown in Appendix B.

4.2.6 Pumping Capacity

The design was based on the assumption of 22 hours of pumping for Jack well pump and 11 hours of pumping for Sump Well pump. However, multiple power failures and planned outages make it on an average pumping no more than 12 hours. This has made it necessary to operate the pumps intermittently the scheme for proper operation of submersible pump at sump well. Due to reduced pumping and the leakages in the pipeline, it has become necessary to fill the ESRs one at a time.

In summary, the scheme has intrinsic design issues such as wrong selection of source, absence of WTP and MBR, pipe material vulnerable to easy breakage, and unrealistic pumping hour requirements.

4.3 Financial Performance

The financial performance of a scheme is measured by its ability to meet its running expenses including incidental repair and maintenance costs, from the revenue generated through tariff recovery. The day to day running expenses include operational and maintenance staff wages, energy cost, cost of chemicals and cost of water. The income side consists of the revenue generated from scheme tariff recovery for private connections and public stand posts. A consistent positive balance of income over expenditure is desired for financial viability while a negative balance would be cause of concern. A one year summary of income and expenditure is presented below for evaluating the scheme's financial performance.

4.3.1 Annual Expenditure

The running expenses of the scheme consist of establishment charges, electricity charges, cost of chemicals and repair and maintenance charges. In absence of WTP, chemical charges are not considered in the analysis.

4.3.1.1 Establishment Charges:

The establishment charges consist of labour needed for pump operation, valves operation and pipeline maintenance as depicted in Table 9.

Sr. No.	Description	Av. Pay	No.	Months	Amount(Rs.)
1	Pump Operators	4600	4	12	2,21,760
2	Valve man-cum Labour	4600	8	12	4,41,600
	Total				**6,63,360**

Table 9: Annual Establishment Charges

4.3.1.2 Energy Charges:

The energy charges for the scheme consist of electricity charges for pumps at jack well and sump well inclusive of lighting at the pumping stations as depicted in Table 10. It is evident that the energy cost of the scheme is very high.

Sr. No.	Description	Amount(Rs.)
1	Pumps at Jack well	10,00,000
2	Pumps at Sump well	6,00,000
	Annual Energy Charges	**16,00,000**
	Energy Charges per 1000 Lit of water based on design water demand of 0.211 MLD	**20.77**

Table 10: Electricity Charges

The details of month to month Electricity bills for a one year period are given in Appendix D.

4.3.1.3 Maintenance & Repairs Charges:

The scheme has been incurring high repair and maintenance charges mainly for replacement of A.C. pipeline which is vulnerable to easy breakage and the repair of 25 year old pumping machinery. The details of the repairs since 2006 are given below in Table 11 and average is calculated for the purpose of assessment of financial performance of the scheme.

Sr. No.	Description	Amount(Rs.)
1	Pump Machinery Repairs in 2006-07	7,00,000
2	Pump Machinery Repairs and Replacement of main rising pipeline in 2007-08	18,00,000
3	Change in rising main pipeline in 2008-09	13,00,000
4	Change in rising main pipeline in 2008-09	11,00,000
	Average Annual Repairs Cost over seven years	7,00,000

Table 11: Repair and Maintenance Charges

4.3.1.4 Summary of Operation and Maintenance Charges

The summary of operation and maintenance charges is presented in Table 12. It shows that the operation and maintenance charges per 1000 lit of water are much higher than the economic cost of Rs. 16 for MVS as reported in World Bank report on review of rural water supply schemes in India published in 2008.

Sr. No.	Description	Amount(Rs.)
1	Establishment Cost	6,63,360
2	Energy Cost	16,00,000
3	Maintenance & Repairs Cost	7,00,000
	Total Annual O&M Expenditure	**30,63,360**
	O&M Charges per 1000 Lit of water	**39.77**

Table 12: Summary of Operation and Maintenance Charges

4.3.2 Tariff Recovery:

The current tariff is Rs. 50 per month for a private connection and Rs. 75 per year for a public stand post. The average tariff recovery from the village varies between 60 and 90% depending on the water supply and the service. However, in absence of actual tariff data, we have estimated the maximum amount of annual tariff based on the no. of private and public connections in each village and the tariff rates. The computations are shown in Table 13.

Sr. No	Village Name	No. Of House holds	No. Of Private Connect ions	Maximum Collection from Private connections (Rs)	Maximum Collection from public connections (Rs)	Total Amount(Rs)
1	Khardi	997	334	2,00,400	49,725	2,50,125
2	Umberkhand	30	0	0		Not in service
3	Chanda	25	0	0	1,875	1,875
4	Lahe	275	65	39,000	15,750	54,750
5	Kukambe	91	73	43,800	1,350	45,150
				Total Amount:		**3,51,900**

Table 13: Estimation of Annual Tariff

Total Annual Income **Rs 3, 51,772**
Income over expenses **Rs.(27,11,460)**

Income as percentage of O&M expenses **11.5%**

The grave financial condition of the scheme is evident from the above data and needs no further explanation. The scheme has been running into losses for years. It is caught in a vicious cycle - the tariff recovery is low due to lower service performance. To improve the performance, it is critical to replace the old and outdated assets, but ZP has no funds for the scheme. Hence, the assets such as A.C. pipeline are not repaired due to budget constraints, the overall performance remains in degraded state and people are left to live with a hopeless situation.

4.4 Institutional Performance:

The scheme is owned and operated by ZP since 1990. Thereafter, no efforts have been made to create an institutional mechanism to manage the scheme and gradually transfer the ownership of the scheme to community.

The main aspects of the institutional performance are listed below.

- Employee Morale: There are a total of 12 workers working on the scheme for operating pumps at jack well and sump well (Fig17), operating valves and maintaining pipeline. They have been working as temporary workers since beginning on low wages of Rs 154 per day. While the rates have been revised for new schemes, they continue to be paid by the old rates. Hence the morale is very low.

- Ownership issues: The scheme is owned and operated by ZP. There is neither participation of people nor any ownership. The scheme is operated and managed by ZP. It has been incurring huge losses year after year. However, no visible efforts are evident on part of ZP to create an institutional set up for better management of the scheme or empowerment of the community.

Fig 17: Workers at Sump well

4.5 Social Issues

The impact of underperformance of the scheme is felt highest at the tail end villages. In summer, as the water supply situation gets worse, on one hand there are instances of more pipeline breakages in the stretch from Shende to Kukambe and on the other hand, people in the tail end villages like Khardi have to keep struggling for getting drinking water extra financial burden for tanker water. This leads to social conflicts among the beneficiary villages.

Umbarkhand has not been getting any water from the scheme for last few years though officials say that water is dropped in the well in the summers. They have drilled private bore wells from which the water is provided to the whole village through private mechanisms.

Similarly, there is a conflict between Chanda and Ratandhale over the new scheme under execution in Ratandhale which is currently limited to Ratandhale and Ratandhalepada. According to RWSS officials, the source has excellent sustainability and the scheme can be easily extended to Chanda village. They also argue that it will make the scheme economically viable due to additional tariff recovery as the Ratandhale and Ratandhalepada are adivasi villages and they may not be able to maintain financial sustainability of the scheme on their own.

However, Ratandhale village community is resistant to inclusion of Chanda village in their scheme referring to past history of piped water supply in Chanda. They do not believe that inclusion of Chanda village would make their scheme more viable. On the contrary, their apprehension is that refusal to pay tariff by Chanda residents can cause problems in recovering tariff from other members, leading to social conflicts, and jeopardizing the entire scheme.

In summary, individual villages are seeking exit paths from the scheme; Khardi people are looking forward to the implementation of new MJP scheme. While people of Chanda want to be included in Ratandhale scheme, Lahe people are pursuing a Single Village Scheme (SVS) for themselves. Umbarkhand people are deprived of benefit from either current or new Scheme and Kukambe may join Birwadi scheme.

5 New Scheme Proposed by MJP

To address overall failure of Khardi scheme, MJP has undertaken design of New Khardi Scheme. Initiated back in 2005, the scheme design has undergone multiple revisions until December 2012.

5.1 Scheme Description

This scheme is based on Bhatsa back water as source, as shown in Fig 18. It is designed to supply drinking water only to Khardi village and the surrounding area under new development. The source is located at a distance of 12 km from Khardi. Raw water will be pumped from the jack well by a pump through a 250mm diameter DI K-9 pipeline to a WTP located at a distance of 10.6 km. There is no MBR proposed for the scheme. Besides using the existing infrastructure, an additional ESR of capacity 1.8 lakh lit is proposed to be located at hillock near west of Kasara village.

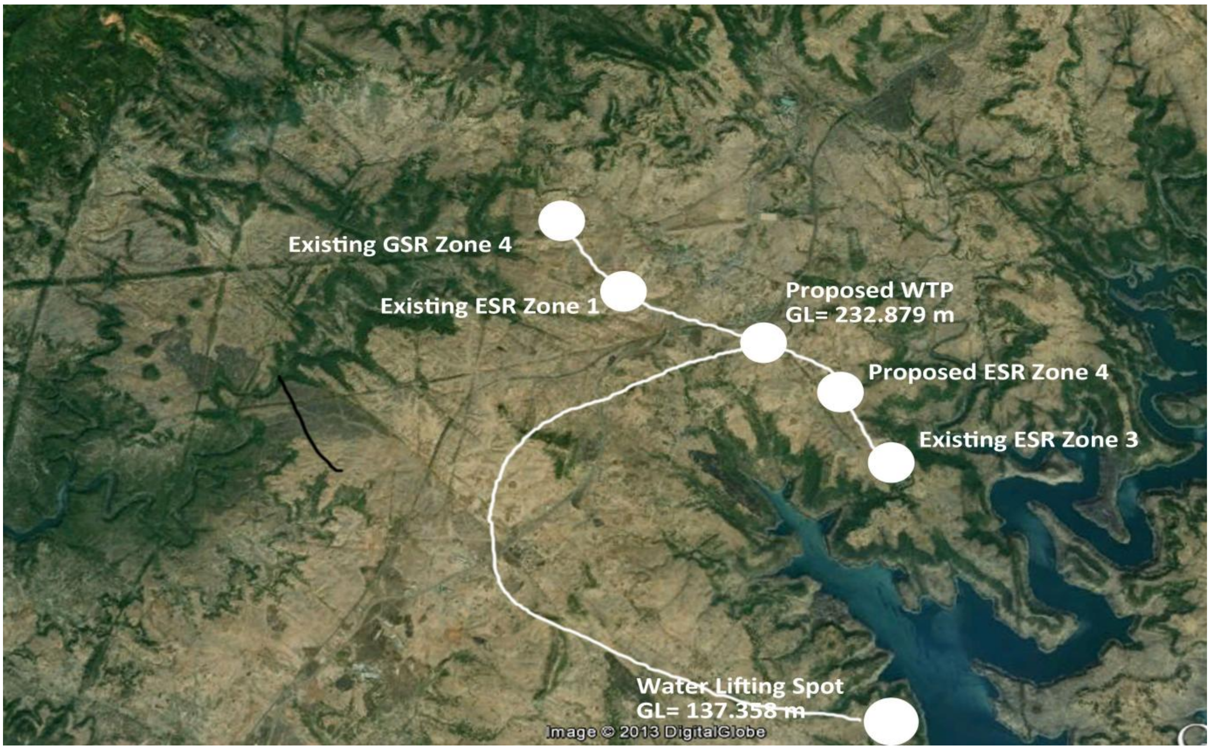


Fig 18: New Khardi Scheme – MJP Design[1]

5.2 Issues with the Proposed Scheme

This scheme is designed only for Khardi village. As per MJP design documents, the per capita Capital Cost is Rs. 3092 which is below the conservative rural norm of Rs 3495. However, the O&M (Operation and Maintenance) cost is relatively high (~Rs. 13/1000 litre) due to which the long term sustainability is a question mark. This scheme may run into the problems with tariff recovery similar to what is being experienced currently. The pace of urbanization in surrounding areas in terms of second homes and weekend homes can put a big strain on demand as the scheme is designed based on rural norm of 40lpcd of water whereas the demand of urbanized area may exceed 100lpcd. Also, neighbouring villages namely, Umbarkhand and Chanda are left out from the New Scheme which can lead to social conflicts.

6 Scheme Proposed by CTARA, IIT Bombay

In view of the performance analysis of the current scheme and the assessment of the scheme proposed by MJP, we focussed our attention on the long term sustainability of the proposed MJP scheme. The question was whether there is a better alternative to MJP proposal from the point of view of long term sustainability. It became critical to reduce energy cost, a major component of O&M cost. This called for a fresh look at the scheme design right from the selection of source. Was there an alternate source that would help reduce energy cost? The search for an appropriate source eventually led to Kundan dam located 10km north of Khardi and at a higher elevation than Khardi facilitating gravity assisted scheme design as a highly cost effective solution.

The elevation of Kundan dam is 320 m, significantly higher than the elevation of Khardi (~240). Hence, the logical solution was an energy efficient gravity assisted scheme. The techno economic feasibility study of Kundan dam based scheme presented below confirms the cost effectiveness of this option. The per capita capital investment cost comes down to Rs. 1917 from Rs. 3092 for the MJP design. The O&M cost comes to Rs. 6.92 as compared to Rs. 13 for the former option mainly because the energy cost comes down from Rs.8.73 to Rs. 2.04. The lesson learnt through this exercise calls for over hauling the current process of source selection by placing energy consideration at higher priority than just proximity of source in every future scheme design.

6.1 Design Methodology and Design Parameters

While designing the alternate scheme for Khardi, the standard MJP protocol depicted in Table 14 was followed.

1	Identify the source
2	Population Forecast (Rate of growth, migration (floating population) rise, current and expected rise, new developing areas)
3	Daily Demand Calculation (using LPCD norm) – which gives us Gross demand = population*rate of demand + losses
4	Design of pumping machine for raw water (rate of pumping, heads, hours of pumping, description of pumps)
5	Size of proposed Rising Main from source (total daily demand and hours of pumping give the required diameter)
6	Capacity of WTP (calculated based on the total daily demand)
7	Design of pumping machine for raw water (rate of pumping, heads, hours of pumping, description of pumps)
8	Size of proposed Rising Main from source (total daily demand and hours of pumping give the required diameter)
9	Details of MBR (MBR should 1/3 rd of the total daily demand)
10	Design of the secondary distribution network (A software analysis - Branched Water Distribution Design Programme) (BWDDP Version 3.0)
11	ESR Capacity calculation located in each zone: (Calculated according to respective daily demands)
12	Run the network using EPANET and do the steady state and extended time period simulation
13	Total calculation of O&M cost (Establishment, Electricity, Materials, chemicals etc)

Table 14: MJP Protocol for MVS Design

The design details including design parameters for each individual component are given in Appendix E.

6.2 Identification of Alternate Source

The key factor in selection of source for Khardi happens to be its elevation apart from source sustainability. Khardi is located at a much higher elevation (~240m) compared to Bhatsa reservoir. Hence, a reservoir located at a higher elevation than Khardi within a reasonable distance would offer a critical advantage over Bhatsa. By bringing down energy costs and thereby bringing down over all O&M charges, it can ensure the long term financial viability of the scheme.

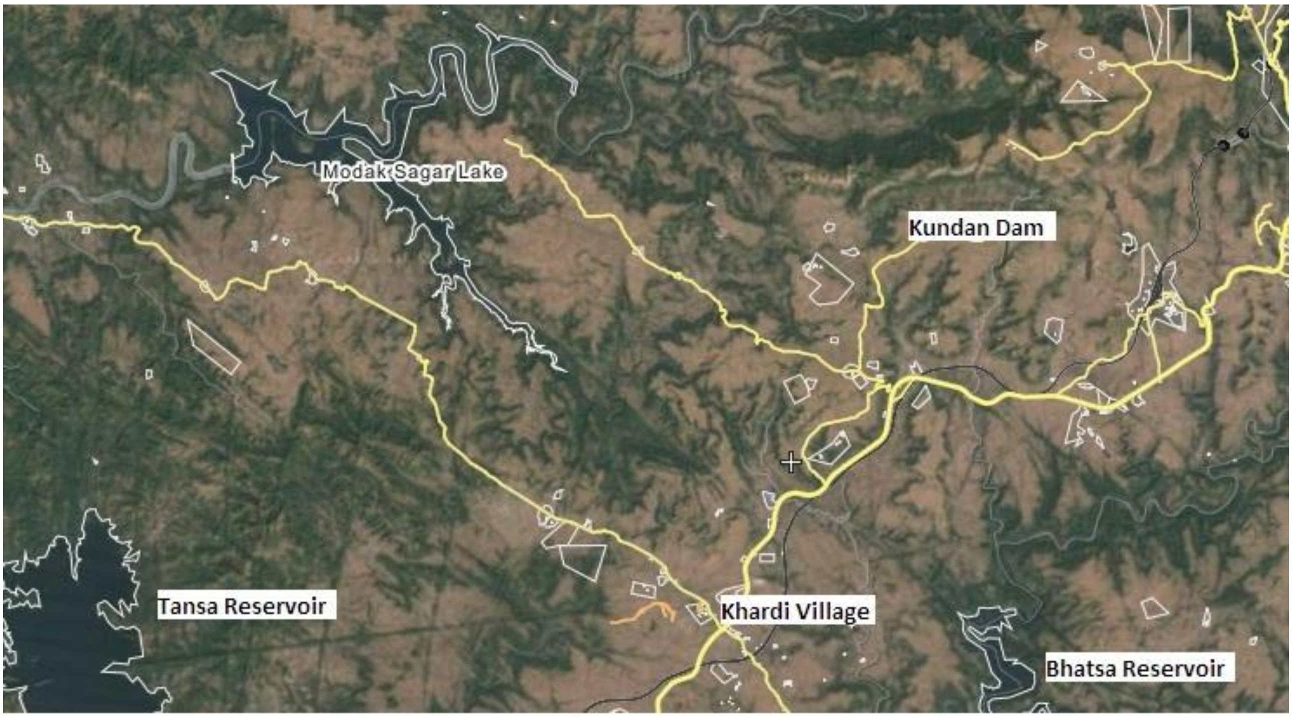


Fig 19: Location of surface water sources surrounding Khardi Village

There are many reservoirs surrounding Khardi such as Bhatsa, Tansa, Modak Sagar and Kundan dam as shown in Fig 19. Among them Bhatsa, Tansa and Vaitarna are major reservoirs supplying drinking water to Mumbai. The elevation of source of new scheme design by MJP based on Bhatsa is 122m. The elevation of Tansa is still lower(~110m) while that of Modak Sagar is around 150m, still lower than that of Khardi. Comparatively, Kundan dam elevation (~320m) is significantly higher than Khardi (~240m) and hence it is a promising source.

6.3 Kundan Dam as Source

Kundan dam is a percolation dam located at about 10 km north of Khardi as shown in Fig 20. It is built on a local nullah designed for irrigating 102 hectare of land in nearby villages namely Shirol and Kundanpada.

Fig 22: Location of Kundan Dam and Khardi Village

Based on the foregoing assessment of alternate sources, CTARA designed a scheme based on Kundan dam as an alternative to MJP proposal. Due to its higher elevation than Khardi, it was found that pumping cost is reduced significantly. The detailed design calculation showed the feasibility of the scheme.

6.4Scheme Description

As mentioned before, this is a Multi Village Scheme. Besides Khardi, two more villages suffering from high water scarcity problem, namely, Shirol and Kundanpada are also covered by this scheme. A jack well is constructed on the downstream side of Kundan dam from where water will be pumped to WTP located at a distance of 240m and at an elevation of 337 m. After treatment, pure water is pumped from WTP to a Mass Balancing Reservoir constructed on a nearby hill at a distance of 126m and at an elevation of 342 m. The primary distribution network consists of MBR and three ESRs located in Khardi, Shirol and Kundanpada respectively as shown in Fig 23 below servicing respective villages.

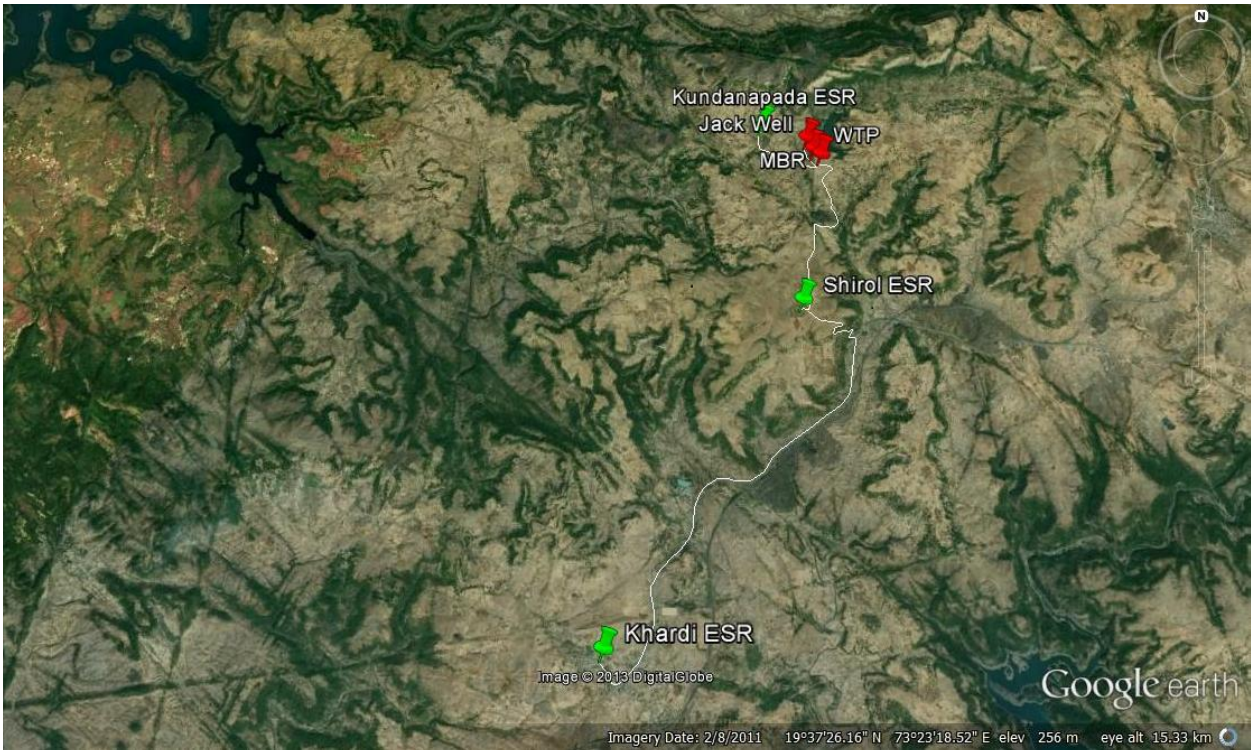


Figure 23: Kundan Dam based scheme proposed by CTARA, IIT Bombay

6.5 Main Capital Cost Contributors

A typical MVS built on surface water source has various components such as Jack Well, WTP, MBR, and ESRs. The components involved in scheme design and high level cost estimation are tabulated in Table 15.

Sr. No.	Description of Component
1	Source
2	Jack Well
3	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	Primary Distribution Network
11	ESRs
12	Secondary Distribution Network
13	Miscellaneous (including Land Acquisition, Approach Roads, fencing, Compound Wall and Trial Run)

Table 15: MVS Cost Components.

The cost for individual components of the scheme was estimated using schedule of rates published by MJP (2010-2011)[2] and updating the same with inflation factor of 7% per year.

6.6 Design Details

The detailed design is worked out using MJP protocol and a step by step design methodology presented above based on standard design parameters is used in sizing of various components.

6.6.1 Forecasting Design Population and Drinking Water Demand

Assuming the scheme is implemented two years later, i.e.in 2015, the design population is forecasted for year 2030, 15 years after the implementation of the proposed scheme. Khardi is the main beneficiary village of the scheme. The urbanization around Khardi has led to accelerated population growth and the population of peri urban area is triple than the Khardi village population as shown in Table 16. The village wise break up of design population is shown in Table 17 and the corresponding water demand, calculated using rural norm of 40 lpcd of water is shown in Table 18.

Description	Current Population (2013)	Design Population(2030)	Water Demand lpcd	Water Demand Lit/day	Gross water demand (including 20% loss)
Khardi Village Population	6,225	8,247	40	3,29,880	3,95,856
Developing bungalows and Flats	18,600	31,125	40	12,45,000	14,94,000
Total Khardi Population	**24,825**	**39,372**	**40**	**15,74,880**	**18,89,856**
Floating Population	800	1,200	15	18,000	21,600
Institutional Demand				82,000	98,400
Total				**16,74,880**	**20,09,856**

Table 16: Estimation of Khardi Population and Demand in Year 2030

Sr. No.	Village name	Current population (2013)	Design Population(2030)			
			Incremental Method	Geometrical Method		Average
1	Khardi	6225	8126	8367		8247
2	Kundanpada	400	507	538		523
3	Shirol	800	1151	1076		1114
	Total					9884

Table 17: Village wise Design Population in Year 2030

Village Name	Gram Panchayat	Elevation (Ground level)	Population Forecast for year 2030	Total Daily Demand, Lit	Gross Daily Demand, Lit (including 20% losses)
Kundanpada	Shirol	286	523	20,920	25,104
Shirol	Shirol	331	1,114	44,560	53,472
Khardi	Khardi	240	39,372	16,74,880	20,09,856
Total			41,009	17,40,360	20,88,432

Table 18: Village wise Design Water Demand

6.6.2 Pumping Machinery, WTP and MBR

The sizing of pump for raw water as well as pure water was done assuming 12 hours of pumping. The Water Treatment plant sizing is done based on 24 hours of retention time. Similarly, sizing of MBR was based on assumption of one third of daily demand, as per MJP protocol. The detailed design calculations including design parameters are shown in Appendix E.

6.6.3 Primary Distribution Network

First, layout of villages, and network of roads connecting them was prepared, and the daily water demand for each village was estimated for the design population. Due to large distances among the villages and high elevation difference, it was decided to have a separate ESR for each village. Otherwise, secondary network cost will be very high. After deciding location of ESRs, we performed the network analysis using BRANCH software which gives us the lowest pipe diameters satisfying the hydraulic requirements. We assumed 12 hours of operation a day for primary network and 6 hours for secondary network to meet demand. HDPE pipes rated to withstand a head of 80m water are used in secondary network. Then the cost of construction of ESRs as well as the cost of piping was estimated using schedule of rates from MJP (Maharashtra Jeevan Pradhikaran) for year 2010-2011[2]. The cost was further adjusted for inflation at a rate of 7% /yr to make it up to date. The final summary of size and cost of ESRs is depicted in Table 19.

Village name	Population	Demand (lpd)	Elevation (m)	ESR staging height (m)	ESR capacity (Lit)	Cost of ESR (Rs.)	Cost of ESR(adjusted for inflation)
Khardi	8247	20,09,856	248	10	10,00,000	52,05,000	59,33,700
Kundanpada	523	25,104	286	10	13,000	2,86,000	3,26,040

Shirol	1114	53,472	331	10	27,000	5,78,000	6,58,920

Table 19: Size and Cost of ESRs

The detailed design of all the components including design parameters and cost estimation is presented in Appendix E.

6.6.4 Verification of Network using EPANET[6,7]

The network design was verified by using EPANET software that performs extended period simulation of hydraulic behaviour within pressurized pipe networks. After completing the sizing and layout of piping and ESRs, we performed extended period simulation of the proposed network model (depicted in Fig 28) to confirm that at least 7m of head is present at all nodes within the network during the operational cycle (Fig 29). We could also analyze how the various ESRs in the network fill up and empty during the daily cycle of supply and demand fulfilment. The simulation run demonstrated that all the ESRs fill up in time.

Fig 28: EPANET Model

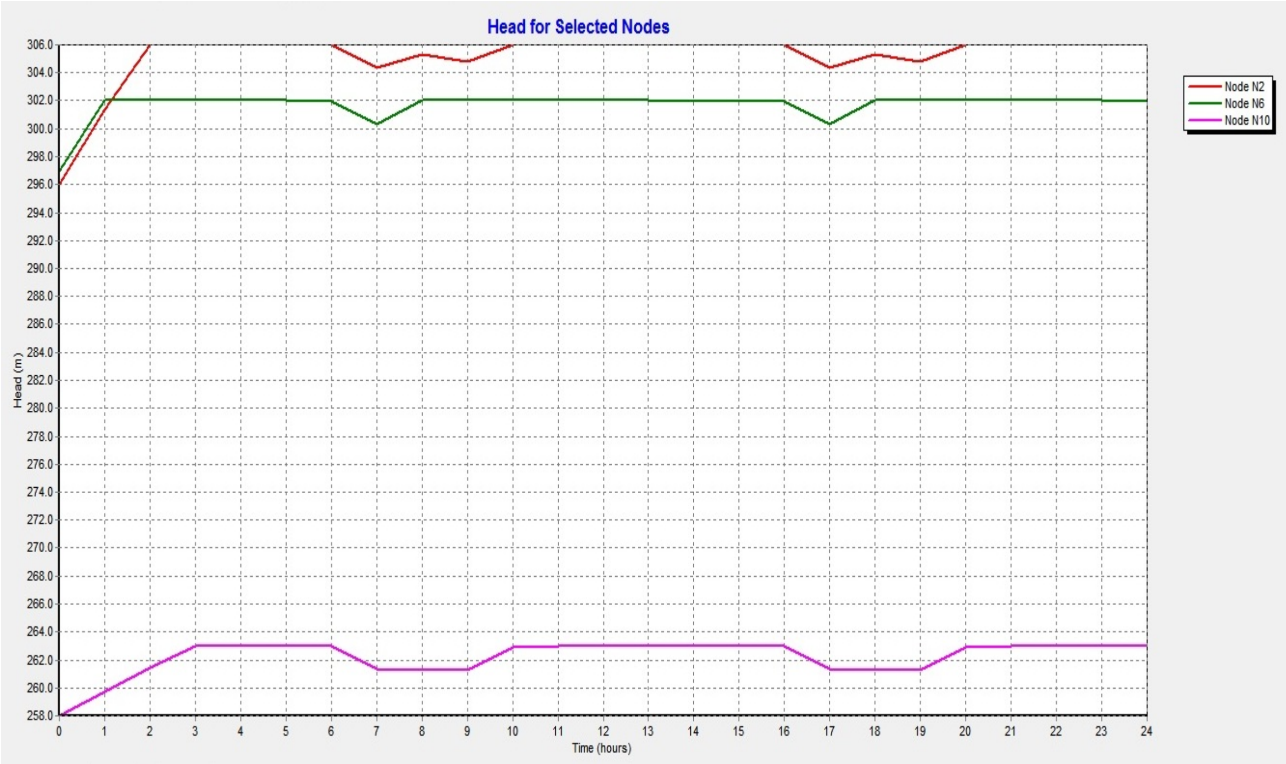


Figure 29: Hydraulic Head Analysis using EPANET. Node N2: Kundanpada ESR ; Node N6: Shirol ESR; Node N10: Khardi ESR

6.6.5 Water Availability from Kundan dam

Kundan dam was primarily constructed for irrigation of 102 hectares of land in the neighbouring villages. Hence, it is necessary to make an assessment of availability of water from this dam to meet the demand of the beneficiary villages within the norms and rules and regulations of Minor Irrigation department. These calculations are presented in Table 20.

Sr. No.	Description	Amount
1	Total Live Storage(Tcum)	1251.33
2	Current Reservation for Drinking Water Supply(Tcum)	94.65
3	Daily Drinking Water Demand(MLD)	2.1
4	Yearly Water Demand(Tcum)	766.50
5	Irrigation Area (hectares)	102
6	Yearly Water Requirement for irrigation(Tcum)	1191.60
7	Total water requirement(Tcum)	1932.10
8	**Additional Water Needed(Tcum)**	**680.77**

Table 20: Water Balance Calculations for Kundan dam

Thus, 681Tcum of additional water is needed for meeting drinking water demand from the scheme assuming that the current requirement for irrigation will continue in future. According to Mr.Madan, an engineer in Minor Irrigation department, the additional storage of water can be accomplished by increasing the height of dam by 3m. There is no risk of submergence of any villages by raising the height of dam since it is located in a valley with sufficient depth to take care of additional storage of water.

There is another view about the availability of water. In last ten years no water has been used for irrigation partly because the canal work has not been completed and partly because there has not been pressing demand from the villagers as they mostly depend on rain fed agriculture. They grow mostly paddy in Kharif season. In recent years, new infrastructure projects are growing in the area and the land meant for agriculture is diminishing. The second home and weekend home projects are coming up. Hence, there is a big shift in the potential utilization of water. There is a growing demand for water for drinking and household purpose.

6.7 Capital Cost Summary

The capital cost estimated for individual components of the scheme is summarized in Table 21.

Sr. No.	Cost Component	Cost (Rs) (adjusted for inflation)	Misc. Factor	Net Cost (Rs)	Remarks
1	Jack well	28,50,000	1	28,50,000	Standard dimensions for Jack well
2	WTP	62,24,400	1	62,24,400	Extrapolated from WTP of MJP design and then adjusted for inflation.
3	Raw water rising main	6,79,349	1.479	10,04,757	Based on MJP schedule of rates and adjusted for 7% inflation per year
4	Pure water rising main	3,56,658	1.379	4,91,832	Based on MJP schedule of rates and adjusted for 7% inflation per year.
5	MBR	45,99,416	1.151	52,93,929	Based on the schedule of rates published by MJP
6	Raw water pump	12,54,000	3.185	39,93,990	Extrapolated from MJP design
7	Pure water pump	10,03,200	2.652	26,60,486	Extrapolated from MJP design
8	Excavation	44,04,618	1.273	56,07,079	Extrapolated from MJP design
9	Piping	2,29,40,197	1.273	29,20,2871	Obtained from BRANCH
10	ESRs	69,18,660	1.142	69,18,660	
12	M.S.E.B.	20,00,000	1	20,00,000	Extrapolated from MJP design
13	Land Acquisition	15,00,000	1	15,00,000	Extrapolated from MJP design
14	Contingencies	22,67,000	1	22,67,000	Extrapolated from MJP design
15	Plans and Estimates	9,06,801	1	9,06,801	Extrapolated from MJP design
16	W.C.	9,06,801	1	9,06,801	Extrapolated from MJP design

17	Total Gross Cost			8,05,12,736	
18	Cost per capita			1,917	Design population of ~ 42,000

Table 21: Capital Cost Summary of the proposed Kundan dam based design

The gross cost of the scheme is about Rs. 8 Crores and the per capita cost is Rs. 1917.

6.8 Operation and Maintenance (O&M) Cost

The operating and maintenance cost consists of establishment cost, energy cost, cost of chemicals, cost of water, maintenance and repairs charges and sampling/quality control charges as described in the following sections.

A. Establishment Cost:

Sr. No.	Description	No.	Rate(Rs./day)	Total Cost(Rs./day)
1	pump operators	2	363	726
2	Electrician	1	399	399
3	Filter attendant	4	399	1596
4	Fitter	2	399	798
5	Valve Man	2	315	630
6	Helpers	4	399	1596
	Total			**5,745**

Table 22: Establishment Cost

B. Energy Costs:

Sr. No.	Description	Pump HP	Pump KW	Hours of Operation	Rate(Rs./KW)	Cost(Rs./Day)
1	Raw Water Pump	50	37.3	12	4.5	2,025
2	Pure Water Pump	40	29.84	12	4.5	1,620
	Total					**3,645**

Table 23: Energy Cost

C. Cost of Chemicals:

Sr. No.	Chemical/ Description	Requirement [1](kg/mL)	Demand mL/day	Qty per day	Rate Rs./kg	Cost Rs./day
1	Alum	15	2.1	31.5	7.93	250
2	TCL	3	2.1	6.3	19	119.7
3	Chlorine	3	2.1	6.3	30	189
4	Sundry Costs					27.3
	Total					**586**

Table 24: Cost of Chemicals

D. Annual Maintenance and Repair Charges:

Annual M&R charge	Gross Cost	% M&R	Annual M&R charge
Raw water pumping machinery	39,93,990	2.5	99,850
DI-K9 DI pipe for raw water rising main	10,04,757	0.25	2,512
Conventional WTP	62,24,400	1	62,244
Pure water pumping machinery supplying installing etc	26,60,486	2.5	66,512
Pure water rising main	4,91,832	0.25	1,230
ESR construction	69,18,660	0.5	34,593
DI-K9 DI pipes for distribution network	2,92,02,871	1	2,92,029
Chain link fencing and MS gate	20,17,300	3	60,519
Repairs for ESRs and GSRs	28,36,651	0.5	14,183
		Total	6,33,672
		Amount per day	1,736

Table 25: Maintenance and Repair Charges

E. **Cost of Raw Water:** This is the cost charged by owner of water source. The Kundan dam is owned by Minor Irrigation department and hence they will charge the scheme for supply of bulk water from the dam. We have assumed a cost of Rs. 264 per ML of water based on Khardi scheme design and computed the final cost by adding 10% cess. The final cost per day comes to Rs. 610 for demand of 2.1ML

F. **Water Sample Charges**: These are the charge for sampling of water and quality control. In Khardi scheme design, the amount of water sample charges assumed is Rs. 12000 per yr. The same is assumed for the present design, which is Rs. 33/day.

Sr. No.	**Description**	**Amount(Rs./day)**
1	Establishment Cost	5,745
2	Energy Cost	3,645
3	Cost of Chemicals	586
4	Maintenance and Repairs	1,736
5	Cost of Raw Water	610
6	Water Sampling and Quality Control	33
7	Total	12,355
	Energy cost per 1000L of water*	**2.04**
	O&M cost per 1000L of water*	**6.92**

Table 26: Summary of Operation and Maintenance Charges

*****The cost calculation is based on net water supply.

It is observed that the establishment cost and energy cost are the major components of operation and maintenance charges.

7 Comparison of MJP and CTARA Scheme

A comparison between new Khardi scheme designed by MJP, based on Bhatsa back water and the scheme designed by CTARA based on Kundan dam is instructive. Firstly, it demonstrates superiority of Kundan dam as source over Bhatsa back water. Bhatsa back water scheme is proposed to supply water to Khardi village alone. The scheme based on Kundan dam, on the other hand, supplies water not only to Khardi but also to Kundanpada and Shirol villages which have been facing water scarcity problems for a long time. Also, the scheme based on Kundan dam has significantly lower capital cost as well as operating cost as compared to the scheme based on Bhatsa back water. **The per capita capital cost for Kundan dam based scheme is Rs. 1917 compared to Rs. 3092. The energy cost is Rs. 2.04 per 1000 litre compared to Rs. 8.73 while the O&M cost is Rs. 6.92 per 1000 litre compared to Rs. 13.** The detailed comparison of different cost components of the two schemes is presented in Table 27 and Table 28 respectively. It is to be noticed that the energy charges are significantly lower in Kundan dam scheme because of gravity assisted scheme having positive elevation difference between the source and the beneficiary villages.

		MJP Khardi Scheme Design		Kundan Dam Based CTARA Design	
Sr. No.	**Cost Component**	**Specifications[1]**	**Cost (Rs.)[1]**	**Specifications**	**Cost (Rs.)**
1	Jack Well		26,00,000		26,00,000
2	WTP	Capacity 4MD	1,69,50,600	Capacity of 2.1 MLD	62,24,400
3	Raw water rising main	250 mm Dia -DI K-9 10560m	4,51,46,100	250 mm Dia -DI K-9 240m	10,04,757
4	Pure water rising main	250mm Dia, DI K-9, 2125m length to ESRs 1&2	67,30,700	250mm Dia, DI K-9, 126 m length	4,91,831
5	MBR	No MBR		0.7 MLD is the capacity	52,93,928
6	Raw water pump	200HP Submersible, 183000 lit/hr,132m head	67,03,800	50 HP submersible and 50 m head	39,93,990
7	Pure water pump	12.5 HP centrifugal monobloc, 31356 lit/hr, 21m Head 30HP centrifugal monobloc, 135144 lit/hr,21m Head	16,22,700	40 HP submersible and 43 m head	26,60,486
8	Excavation	Total length of piping is 10560m and 1 m^2 is cross section area is assumed	31,68,000	the total length of piping is 10560m and 1 m^2 is cross section area is assumed	56,07,078
9	Piping	Distribution Network	3,02,51,600	Distribution network	2,92,02,871
10	ESRs		54,09,300		69,18,660
11	Misc	Fencing and MS Gate	20,17,300	Include all other costs like MSEB, fencing, MS gate, contingencies etc	1,65,14,732
12	**Total cost**		**12,06,00,100**		**8,05,12,736**
	Design population	39,000		42,000	
13	**Cost per capita**		**3,092**		**1,917**

Table 27: Capital Cost Comparison between MJP and CTARA Design

Sr. No.	Description	MJP Khardi Scheme Design[1]	Kundan Dam based CTARA Design
1	Establishment Charges	16,52,355	20,96,925
2	Energy Charges	50,93,184	13,30,425
3	Chemical Charges	1,90,000	2,13,791
4	Misc Charges	22,000	12,000
5	Raw Water Charges	2,07,540	2,22,591
6	Annual M&R Charges	7,29,848	6,33,671
7	**Total**	**78,94,927**	**45,09,405**
8	Annual water requirement	714.67	766.5
9	Actual Water for billing	607.4695	651.525
10	**Energy Charges per 1000L**	**8.73**	**2.04**
10	**Cost of water per 1000L**	**13**	**6.92**

Table 28: O&M Cost Comparison between MJP and CTARA Design

8 Conclusions and Recommendations

The conclusion from performance analysis of the existing Khardi scheme, assessment of New Khardi Scheme designed by MJP and the CTARA design of Khardi scheme based on Kundan dam are summarized below.

Conclusions

- The two stage pumping due to high head requirements of 270m has lead to high capital and energy cost. The annual electricity bill is around Rs. 16 Lacs. This is attributed to wrong source selection. It would have made critical difference if gravity assisted scheme was designed using a source having elevation higher than Khardi and other beneficiary villages.
- Use of AC for main pipeline has severely impacted the performance of the scheme. The selection of appropriate piping material is critical for the successful operation of a piped water scheme.
- In absence of MBR, there is no buffer storage to maintain continuity of service. It has adversely impacted the performance of the scheme.
- The backwater source used in the new Khardi scheme has relative advantages over the old scheme due to its high elevation of 122m as compared to 62m of current source. However, it still fails to ensure long term financial sustainability due to high energy requirements.
- The CTARA scheme based on the Kundan Dam is much more cost effective that the MJP scheme based on Bhatsa back water as shown below.
  - The per capita capital cost of the Kundan Dam based scheme is Rs. 1917 against Rs. 3092 for Bhatsa back water scheme.
  - The energy charges per 1000L of water for Kundan dam scheme are Rs. 2.04 as compared to Rs. 8.73 for Bhatsa back water scheme.
  - The Operating and Maintenance cost per 1000L of water for Kundan dam scheme is Rs. 6.92 compared to Rs 13 for Bhatsa back water scheme.

Recommendations

New Khardi Scheme Design:

- We recommend that MJP should redesign Khardi scheme based on Kundan dam instead of pursuing the current design based on Bhatsa back water.
- Shirol and Kundanpada in the vicinity of Kundan dam should also be incorporated into the proposed Khardi scheme due to severe drinking water scarcity faced by those villages.
- The increase in height of the dam needed to make it sufficient for water supply to Khardi scheme should be ascertained by rigorous engineering calculations.

MVS Design in General

- Energy cost should be given prime consideration in designing piped water schemes and appropriate norms should be developed by MJP.
- All the alternate sources should be given careful consideration taking into account topology of the area for robust design and optimization of capital and energy cost.
- It is utmost important to have a MBR for a multi village scheme for maintaining buffer capacity that can used to service the village ESRs in case of power failures or other issues with pumps.
- Reliability of electricity supply should be given due consideration while determining hours of operation. Generally speaking it is a better practice to base scheme design by assuming 12 hours of operation. Impact of erratic electricity supply on any scheme viability needs a separate study.
- The potential for urbanization of rural area should be given careful consideration during design for correct forecast of population. It is to be noted that while the population of Khardi village is around 6000, the urbanization surrounding it because of weekend homes and second homes has a population three times the village population.
- The pipeline should always be laid along the road for easy accessibility for maintenance and repairs.
- Extensive simulations should be carried out to ensure that adequate water pressure is obtained at the tail end of the scheme as well as all the points in the distribution network
- The Lowest Draw Level of water based on staging data should be considered during design to ensure that adequate water is available at source during summer months.
- Simulations should be carried out to check financial viability of scheme when individual villages can opt out of the scheme for a separate scheme or they look for only seasonal service. The flexibility of design needs a detailed study.

9 References

1. Khardi Scheme Design Report by MJP
2. MJP Schedule of Rates (2010-11)
3. Piped Water Scheme based on Upper Vaitarna for Tanker fed Villages in Mokhada Taluka: A Techno Economic Feasibility Study,IITB
4. National Rural Drinking Water Programme(indiawater.gov.in)
5. Census of India (2011)
6. EPANET and Development: How to Calculate Water Networks by Computer, Santiago Arnalich
7. EPANET(www.epa.gov/nrmrl/wswrd/dw/epanet.html)

10 Appendix

Appendix A: Main Features of Khardi Scheme

Name of work: Khardi Water Supply Scheme,
Tal. Shahapur, Dist. Thane

1. Name of village:	Khardi
2. Taluka:	Shahapur
3. District:	Thane
4. Location:	Lat. 19-35” N
	Long 73-37” E
5. Source of supply:	Bhatsa Dam Tail Water
6. Population in persons as per census:	4707
7. Daily water supply:	40 LPCD
8. Daily Pumping:	Jack well: 22hrs
	Sump well: 11 hrs
9. Cost of scheme:	Rs. 48, 71,367
10. Per capita Cost of Scheme:	Rs. 1,034.92
11.General water tax per house per year:	Rs. 150

12 Population Data:

Name of village	**1981(census)**	**2006(Projected)**
Khardi	Data not available	3295
Umbarkhand		773
Chanda		245
Kukambe		1158
Lahe		1030
Total	1093(total taxable families in Khardi region)	6501

Table 29: Population Forecast Data

Raw water rising main (Head=150 m):

	First Half	Second Half
Type of Pipe	200mm	200mm
Material Of Pipe	A.C.	M.S.
Length	600 m	600 m

Specification of Jack Well and Sump Well

I. Source of the scheme :Bhatsa river tail water
II. Intake channel : Broken/Damaged
III. Jack well ::
   a. Diameter = 5m
   b. Depth = 10m
IV. Sump well :
   a. Length = 9m
   b. Breadth = 6m
   c. Depth = 3.3m
   d. No MBR. Sump well is made up of stones and can store water upto 1,25,000 liters.

V. Pumps Specifications

	Jack Well	Sump Well
Pumping Hours	22 Hrs	11 Hrs
Number of Pumps	2	2
Capacity of Pumps	50 Hp	50 Hp
Type of Pump	Submersible	Submersible
Head	150 m upto sump well	120 m upto Khardi

Appendix B : Pipeline Distribution from Sump well to villages

Chain Age	From	To	Details of pipe line		Distanc
			Size (dia) (mm)	Type and class	In meter
1200-4800	Sump well	Kukambegoun	150	A.C.	3600
4800-5100		Poltary	150	D.I.	300
5100-5900		Vaganpada	150	A.C.	800
5900-5962		--	150	C.I.	62
5962-6040		--	150	A.C.	78
6040-6130		Vaganpada	150	C.I.	90
6130-6330		Farm house	150	A.C.	200
6330-6460		Pradhanpada	150	C.I.	130
6460-6560		Lahe (valve)	150	A.C.	100
6560-6660		Pradhanpada	150	C.I.	100
6660-7260		Thaparnagar	150	A.C.	600
7260-7345			150	C.I.	85
7345-7387			150	A.C.	42
7387-7465		High way	150	C.I.	78
7465-7570		Gree view hotel	150	A.C.	105
7570-9818		High way	150	D.I.	2248
9818-9878			150	A.C.	600
9878-9926		Railway bridge	150	A.C.	480
9926-10526		Dalkhan	150	A.C.	600
10526-10706		Khardi valve	150	C.I.	180
10706-11346		ESR	150	A.C.	640
11346-11916		ESR	150	A.C.	570
11916-12081			150	C.I.	165
12081-12276		GSR	150	A.C.	195
					12276 (Total Distance)

Appendix C:Leakages in the Piping Network

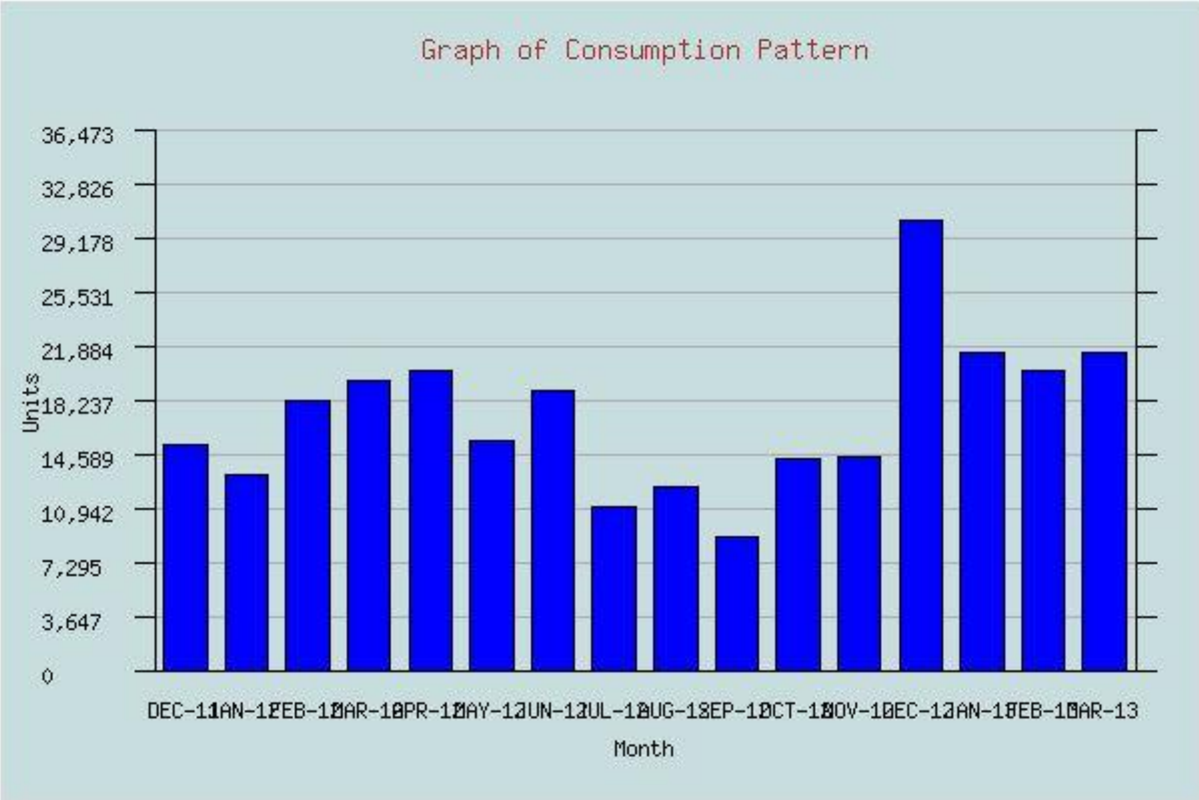
Points	Chain Age	From	To	Remarks
0-A	0-600	Jackwell		
	600-1200		Sump well	4 no. of leakages
A-B	1200-4800	Sump well	Kukambe goun	11 no. of leakages
	4800-5100		Poltary	
	5100-5900		Vaganpada	8 no. of leakages
	5900-5962		--	
	5962-6040		--	11 no. of leakages
	6040-6130		Vaganpada	
	6130-6330		Farm house	2 no. of leakages
	6330-6460		Pradhanpada	
B-C	6460-6560		Lahe (valve)	9 no. of leakages
	6560-6660		Pradhanpada	
	6660-7260		Thaparnagar	
	7260-7387			
	7387-7465		High way	
D	7465-7570		Gree view hotel	
	7570-9818		High way	
E-F	9818-9878			
E-F	9878-9926		Railway bridge	
	9926-10526		Dalkhan	
	10526-10706		Khardi valve	
F-G	10706-11346		ESR	4 no. of leakages
	11346-11916		ESR	
	11916-12081			

G	12081-12276		GSR	

Appendix D: Power Consumption and Electricity Bill Data

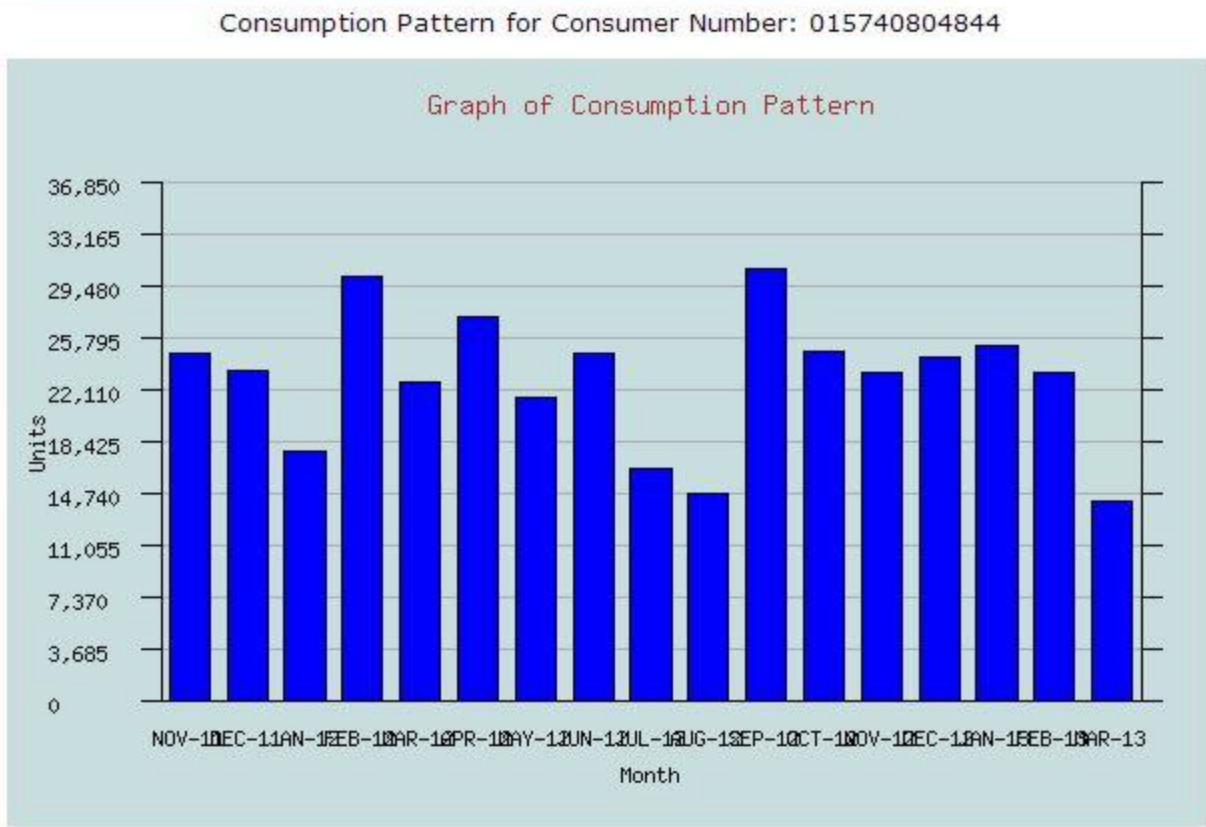
Consumer No: 015740804852	The Sarpanch, Gram Panchayat Khardi	Bhatsa Nagar, Shahapur	Shahapur S/Dn 421601		
Bill Month/Year	**No. of Units**	**Status**	**Net Bill**	**Paid Amount**	**Payment Date**
Mar-13	21400	LIVE	69,290.00	134,390.00	2-Mar-13
Feb-13	20151	LIVE	134,390.00	0.00	8-Jan-13
Jan-13	21400	LIVE	68,420.00	101,740.00	8-Jan-13
Dec-12	30394	LIVE	99,750.00	117,260.00	11-Dec-12
Nov-12	14394	LIVE	116,170.00	0.00	8-Oct-12
Oct-12	14286	LIVE	60,260.00	63,080.00	8-Oct-12
Sep-12	9001	LIVE	62,430.00	0.00	31-Jul-12
Aug-12	12420	LIVE	28,720.00	165,270.00	31-Jul-12
Jul-12	11025	LIVE	146,980.00	0.00	7-May-12
Jun-12	18904	LIVE	107,440.00	0.00	7-May-12
May-12	15517	LIVE	47,610.00	63,630.00	7-May-12
Apr-12	20151	LIVE	62,390.00	121,260.00	27-Mar-12
Mar-12	19576	LIVE	121,260.00	95,600.00	1-Feb-12
Feb-12	18236	LIVE	155,230.00	0.00	14-Dec-11
Jan-12	13232	LIVE	94,720.00	42,300.00	14-Dec-11
Dec-11	15169	LIVE	92,070.00	0.00	8-Nov-11

Consumption Pattern for Consumer Number: 015740804852



Consumer No: 015740804844	The Sarpanch, Gram Panchayat Khardi	Bhatsa Nagar, Shahapur	Shahapur S/Dn 421601

Bill Month/Year	No. of Units	Status	Net Bill	Paid Amount	Payment Date
Mar-13	14165	LIVE	44,020.00	170,000.00	2-Mar-13
Feb-13	23215	LIVE	170,010.00	0.00	8-Jan-13
Jan-13	25241	LIVE	86,820.00	92,470.00	8-Jan-13
Dec-12	24367	LIVE	90,710.00	338,400.00	11-Dec-12
Nov-12	23245	LIVE	336,610.00	0.00	31-Jul-12
Oct-12	24730	LIVE	243,960.00	0.00	31-Jul-12
Sep-12	30708	LIVE	148,990.00	0.00	31-Jul-12
Aug-12	14690	LIVE	36,280.00	209,680.00	31-Jul-12
Jul-12	16387	LIVE	193,000.00	0.00	7-May-12
Jun-12	24643	LIVE	138,710.00	0.00	7-May-12
May-12	21452	LIVE	63,610.00	149,320.00	7-May-12
Apr-12	27216	LIVE	147,730.00	0.00	23-Feb-12
Mar-12	22523	LIVE	66,750.00	150,190.00	23-Feb-12
Feb-12	30119	LIVE	150,190.00	0.00	31-Dec-11
Jan-12	17620	LIVE	56,430.00	149,780.00	31-Dec-11
Dec-11	23443	LIVE	148,240.00	0.00	8-Nov-11
Nov-11	24696	LIVE	69,920.00	82,910.00	8-Nov-11



Appendix E :Kundan Dam Scheme Design Calculations

The detailed scheme design calculation involved in step by step design are shown below.

Population forecast and daily demand calculation

Population for the previous five decades for Khardi village was obtained from census data. Growth rate was also given with these data. Based on this data, projections for the year 2030 were made using the incremental and geometric methods.

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

Geometrical method:
Projected population = Current population * (1 + decadal growth rate) (no. of years/10).

The average of the two methods is taken for estimation of population. This gives us Khardi population growth rate = 0.190 as shown in Table 30. Based on this the forecast for Khardi population in year 2030 is 8247.

In case of Kundanpada and Shirol, previous population data couldn't be obtained so we also assumed same growth rate as Khardi. This gives us a projected population of all three villages together equal to 9884 for the year 2030. Floating population, estimated by assuming the same growth rate is 1200.

Sr. No.	Year	Population	Increase in decade	Incremental increase in decade	Rate of Growth for decade
1	1961	2411			
			468		0.194
2	1971	2879		407	
			875		0.304
3	1981	3754		-327	
			548		0.146
4	1991	4302		-143	
			405		0.094
5	2001	4707		1113	
			1518		0.322
6	2011	6225			
	Average		763	263	0.190

Table 30: Population Forecast[1]

The water demand was estimated from population forecast based on rural norm of 40 lpcd (litres per capita per day). For floating population this is taken as 15 lpcd. So demand for floating population is 15*1200= 18,000 lpd. For Kundanpada, daily demand is 523*40 = 20,920 lpd. Similarly, for Shirol, daily demand is 1114*40= 44560 lpd. No floating population was assumed for Kundanpada and Shirol. Khardi has highest fraction of total daily demand because its population is much higher than other two villages. The institutional demand is assumed the same as in MJP design. Summing it all, we get a total demand of 17,40,360 lpd (litres per day) for all the three villages together. By assuming 20% loss, gross water demand estimated. Thus, we get total designed water demand 1.2*1740360= 2088432 or 2.1MLD.

Water Pumping Machinery, Water treatment Plant (WTP) and MBR

Raw Water Pump Design: The main factor that affects the pump design is the requirement of the total head for the pump. We calculate the total head using the following equation:

Total Head = Static Head + Friction Head + Hammer Head

The Horse Power of the Pump is calculated using standard equations assuming an efficiency of 70%..

Pump capacity required is calculated using the water flow rate and the head difference. For raw water rising main it is 48.34 lps and head difference of 50 m. Assuming efficiency of 70%, we get power requirement of ~ 44.41 hp which is rounded up to 50 hp.

Raw Water Rising Main: It was assumed that the raw water pump will be operated for 12 hours. and the diameter of the raw water rising main was calculated based on economic velocity of water of 1.25 m/s.

Flow = daily demand/time, therefore flow = 2088432 Lit / 12 hours = ~ 48.34 lps
Diameter = 2*root(flow/(pi*vel)) = 2*root(48.34 lps/1000/(3.14*1.25 m/s)) = ~222 mm
Rounding it up, we use a standard diameter of 250 mm.

The distance between the source and WTP is 240 m. The calculated diameter rounded to the standard diameter pipe is 250 mm. Due to the high pressure environment, we choose D.I. pipe for the rising main. This gives us a cost of ~ Rs 6.79 Lacs for the rising main. We also assumed cost factor =1.479[1] which takes accessories into account and thus effective cost comes out to be ~ 10.05 Lacs.

Water Treatment Plant (WTP): The capacity of the Water Treatment Plant(WTP) is assumed to be equal to the daily demand inclusive of 20% losses.

Thus, the capacity of WTP is 2.1 ML. 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 Lacs in the Khardi Scheme[1]. So cost of our WTP will also be 26*2.1=54.6 Lacs. After adjusting it for inflation and cost factor provided in MJP protocol, it comes to approximately 62.25 Lacs.

MBR: The MBR was designed with a capacity of 1/3 of the daily demand i.e. 0.7 MLD. The base of the MBR is assumed to be at the height of 10 m and further height of 5 m is the design height of MBR.This gave us a cost of around Rs 40 Lacs. This cost is calculated from the rates given by MJP[2]. To construct a MBR of 0.5 MLD cost is 32.5 Lacs. For additional size Rs.4/litre is added in that cost per MJP schedule of rates. So cost is =3250000+ (696144-500000)*4 = Rs. 40,34,576 ~ 40 Lacs. After adjusting it for cost factor (= 1.151) and inflation cost of 7% per annum, it comes to ~53 Lacs.

Pure Water Pump Design: Similar to Raw Water Pump design, we have a flow of 48.34 lps and head difference of 43 m which gives us a pump power requirement of 32.69 hp. It is then rounded up to 40 hp.

Cost of the pumps is calculated by extrapolation from the cost of 100 hp pump in Khardi scheme[1] which was 22 Lacs. So the cost of our 50 hp and 40 hp pumps is Rs. 11 Lacs and 8.8 Lacs respectively. After including the cost factor[1] of 3.185 and 2.652 and 14 % cumulative inflation for two years, we get 39.94 Lacs and 26.6 Lacs respectively.

Pure Water Rising Main: Similar to Raw Water Rising Main calculations, the same number of hours of operation are assumed here.

The distance is 126 m and the diameter is 250 mm as before. We again use D.I. pipe which gives us a cost of ~ Rs 3.7 Lacs and after multiplying with cost factor it comes out to Rs. 4.92 Lacs.

ESRs and Primary Distribution Network

Gravity Main: Water flows by gravity from MBR to all the ESRs in the primary network. BRANCH calculations are performed with the condition that at least 7m head exists in all the distribution points and also at all the points in the network.

ESR Capacity: ESRs are intermediate reservoirs between MBR and secondary distribution network. Generally, it has design capacity of 50% of daily demand of that village or cluster of villages serviced by the ESR. A minimum staging height of 10m and max of 15m is used in the calculations. To be on conservative side, all the cost estimations are done based on the staging height of 10m.

Cost of ESR is calculated by using MJP protocol and schedule of rates for different capacities with extrapolation for ESR with intermediate capacity.

Cost factor is a factor which is multiplied to take care of other miscellaneous cost that is imposed by MJP while constructing the scheme. And we haven't taken that cost into account. These include things like valves, sluices, various structural costs etc.

While designing a pipe water network it is important to include dummy nodes at points of higher 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 all point along the path.

Secondary Network

Table 31 shows piping data in secondary network. This is the output from BRANCH software.

Sr. no.	From node	To node	Peak flow (lps)	Diameter (mm)	Hansen's constant	Head Loss (m)	Length (m)	HL/km (m)
1	11	2	1.16	63	140	4.64	1561	2.97
2	11	3	95.52	315	140	4.01	976	4.11
3	3	4	95.52	315	140	4.36	1063	4.10
4	4	5	95.52	280	140	1.86	255.78	7.27
				315	140	2.56	624.22	4.10
5	5	6	2.47	110	140	0.15	187.00	0.80
6	5	7	93.05	280	140	18.94	2730.00	6.94
7	7	8	93.05	250	140	5.40	448.07	12.05
				280	140	6.45	928.93	6.94
8	8	9	93.05	250	140	27.82	2309.00	12.05
9	9	10	93.05	250	140	24.54	2037.00	12.05
10	1	11	96.68	315	140	0.06	14	4.29

Table 31: BRANCH Output for Secondary Network

Appendix F: Kundan Dam - Salient Features& Specifications

Name of Work :- Kundanpada M.I.Scheme. Tal-Shahapur Dist- Thane

NAME OF DIVISION : Minor Irrigation (L. S.) Division Thane
NAME OF SUB DIVISION : Minor Irrigation (L. S.) , Sub-Division, Shahapur

Salient Features

Sr. No.	Particulars	As per Revised Estimate	
1	2	4	
1	Scope of the Scheme	Irrigation & Water supply	
	(Name of village benefited)	Shirol ,kundanpada	
2	Source	Local Nalla	
	(Name of River / Tributary / Nalla)		
3	Location		
	I) Topo Sheet No.	47 E / 6	
	ii) Latitude	19^0 45'25" N	
	iii) Longitude	73^0 93' 30" E	
	iv) Nearest Town	Shahapur	
	v) Nearest Railway Station	Shahapur	
4	Catchment Area	1.660 Sq.Miles	
		4.30 ~~0.000~~ Sq.Km.	
5	Nearest Raingauge Station	Shahapur	
	(Name & Distance in Km from site)	30 Km from site	
6	Average Annual Rainfall	254.12	cm
7	75% Dependable Rainfall	223.10	cm
	50% Dependable Rainfall	257.55	cm
8	Average Yield in Tcum	7977.36	Tcum
9	75% Dependable Yield (Tcum)		Tcum
10	50% Dependable Yield (Tcum)		Tcum
11	Gross Storage Proposed (Tcum)	1562.58	Tcum 55.18 mcft
12	I) Sill R. L.	94.51	m
	ii) F.S.L. R.L.	106.00	m
	iii) H.F.L. R.L.	107.50	m
	iv) T.B.L. R.L.	109.00	m
13	Lowest nalla bed R.L.	87.62	m

223.65

9794.0810

98

1257.33x10^3

1257.33x10^3x10^3 Liter

= 1257.33x106 Liter

= 1257.33 MLD

2.1 MLD

766.5 Liter

Sr. No.	Particulars	As per Revised Estimate	
1	2	4	
14	Maximum Height of Dam	21.38	m
15	Dead Storage proposed (Tcum)	77.40	Tcum
16	Evaporation Losses (Tcum)	223.65	Tcum
17	Live Storage (Tcum)	1251.33	Tcum
18	Carryover	......	
19	Provision for Water Supply (Tcum)	94.65	Tcum
20	Gross Storage (Tcum)	1562.58	Tcum
21	Area under Submergence (Ha)	19.76	Ha.
22	Type of Dam	Earthen Dam	
	I) Quantity of Casing	85197	Cum
	ii) Quantity of Hearting	30056	Cum
	iii) Quantity of C. O. T	5586	Cum
23	Length of Dam	190	M
	Location From Chainage to Chainage		
24	Type of Head Regulator &	Well Type with RCC Conduit	
	Its Location (Chainage)	120	m
25	Type of Waste Weir	Clear over fall type	
		(Broad crested)	
26	Length of Waste Weir &	48	m
	Its Location (Chainage)	180	228
27	Maximum Flood Discharge (Cumecs)	5314.15	Tcum
		150.5	Cusecs
28	Canal Capacity at H. R. (Cumecs)	5.76	Cusecs
29	CANALS	RBC	LBC
	I) Length in k m	1.335	1.29
	ii) No. of C. D. Works		
	iii) Canal Capacity (Cumecs)	5.76	Cumecs
		RBC	LBC
	iv) Area under Irrigable Command (Ha)	57	45
	v) Bed Width in m	0.75	0.65.
	vi) Side slopes	,1 : 1	1:01