Augmentation of Water Distribution Scheme for Sundernagar Municipal Council

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY IN

CIVIL ENGINEERING

Under the supervision

of

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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HIMACHAL PRADESH, INDIA

May – 2020

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled "**Augmentation of Water Distribution Scheme for Sundernagar Municipal Council"** submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT** is an authentic record of my work carried out under the supervision of **MR. Anirban Dhulia.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student

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31 May, 2020

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Augmentation of Water Distribution Scheme for Sundernagar Municipal Council"** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT** is an authentic record of work carried out by **Abhinandan Thakur (161055), Mayank Sharma (161637)** during a period from August, 2019 to May, 2020 under the supervision of **MR. Anirban Dhulia,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 7th June, 2020

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07/06/2020

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LIST OF ACRONYMS

MC	Municipal Corporation
WDS	Water Distribution System
WDN	Water Distribution Network
WSS	Water Supply System
SWS	Surface Water Scheme
CPHEEO	Central Public Health and Environmental Engineering Organization
I and P	Irrigation and Public Health Department
RS	Remote Sensing
GIS	Geographic information system
LWSS	Lift Water Supply Scheme
PHED	Public Health Engineering Department
OHSR	Over Head Service Reservoir
CWR	Clear Water Reservoir
WTP	Water Treatment Plant
RWM	Raw Water Mains
CWM	Clear Water Mains
DEM	Digital Elevation Model
LPCD	litres per capita per day
WSN	Water Supply Network

ABSTRACT

The Irrigation and Public Health (I and PH) Department of Himachal Pradesh is responsible for supplying water to all the domestic and commercial establishments in Sundernagar Municipal Corporation. As per the present water service level, 2.92 MLD is distributed in urban area in the planning area on per day basis. Currently there are ten water supply schemes which are operational in the urban area which supply water to the urban population. Both ground and surface water are the sources of potable supplied water in this area. Ground water is extracted by deep tube wells and then lifted to the main storage tanks. From the main storage tanks, water is supplied to the sub storage tanks through gravity. From the Sub storage tanks, the water is distributed throughout the Planning Area. Surface water is collected through lift water supply schemes from streams, rivers and rivulets. The water is stored in the sump well and then directed to Treatment plants where water is treated through slow sand filter belt by sedimentation process. The treated water is stored in main storage tanks. With the increasing growth in the population, the water necessity of Sundernagar municipal corporation is expected to be 5 MLD for the year 2051, which creates a noteworthy gap between present supply and expected demand. In order to fulfil the water demand of the society, a development plan has proposed a rate of 135 lpcd of water to be supplied to the town plus 10 lpcd for non household water demand as the city is small. The total necessity of water for the ultimate year of 2051 has been calculated using population projection and water demand was found to be 5 MLD.

Keywords: lift water supply schemes, population forecasting, water demand

CHAPTER 1

INTRODUCTION

1.1 SUNDERNAGAR MUNICIPAL CORPORATION

Sundernagar town, which is located at 31.53320˚ N and 76.89230˚ E, is a municipal council in Mandi district of Himachal Pradesh (Fig. 1.1). The district shares its boundaries with Bilaspur district in the south-west, Hamirpur district in the north-west, Kangra district in the north, Kullu district in the east and Shimla district in the south. Sundernagar MC is the headquarter of Sundernagar Tehsil and is located approximately 24 kms from Mandi town, the head-quarter of Mandi district and about 119 kms from the state capital, Shimla.

Sundernagar town was established as a Municipal Council (Nagar Parishad) in 1950 and it comprises of 13 wards within 10 Revenue mohals. It covers an area of 1215.93 Ha and has a population of 24,344 as per Census of India, 2011 (Table 1). The remaining 12 revenue mohals come under 9 Gram Panchayats. Out of the total population of 42,963 of the whole town, 56.7% i.e. 24,344 are in urban areas while the remaining 43.4% of the population i.e. 18,619 are in rural areas.

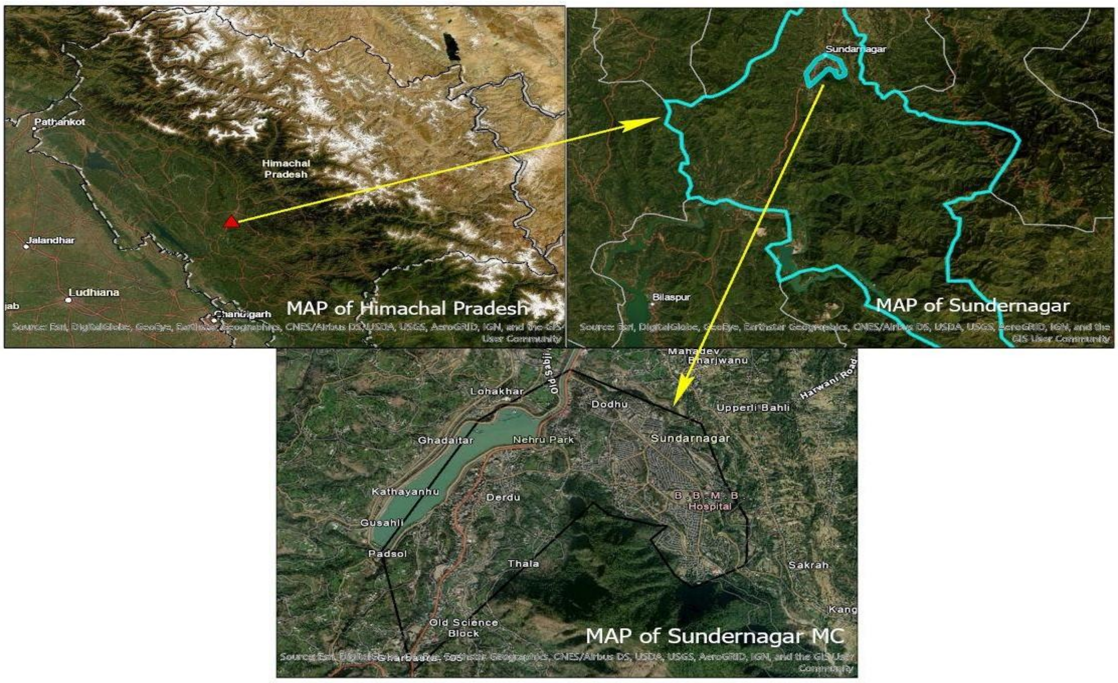

Figure: 1.1 Overview Map of Sundernagar (source: Arcgis)

Table 1. Planning Area Details

Total Area (Rural and MC)	2557.4 hectares
Area (MC)	1215.9 hectares
Total population (Rural and MC)	42963 (2011 Census)
Population (MC)	24344 (2011 Census)
Population Density	20 people per hectares
i) Elevation (maximum) ii) Elevation (minimum)	1600 meters 680 meters

1.2 BALANCING RESERVOIR

The manmade Balancing Reservoir in Sundernagar under the Beas – Satluj Link Project in Sundernagar holds a storage capacity of 370 Ha meters (3000 acre ft) and is constructed at the tail of Sundernagar – Satluj channel (Fig. 1.2). It was constructed to function as a balancing storage to provide for the variation between the supply required for the load and discharge of water conductor of the Dehar Power Plant, located on the right bank of Satluj river in Dehar near Bilaspur.

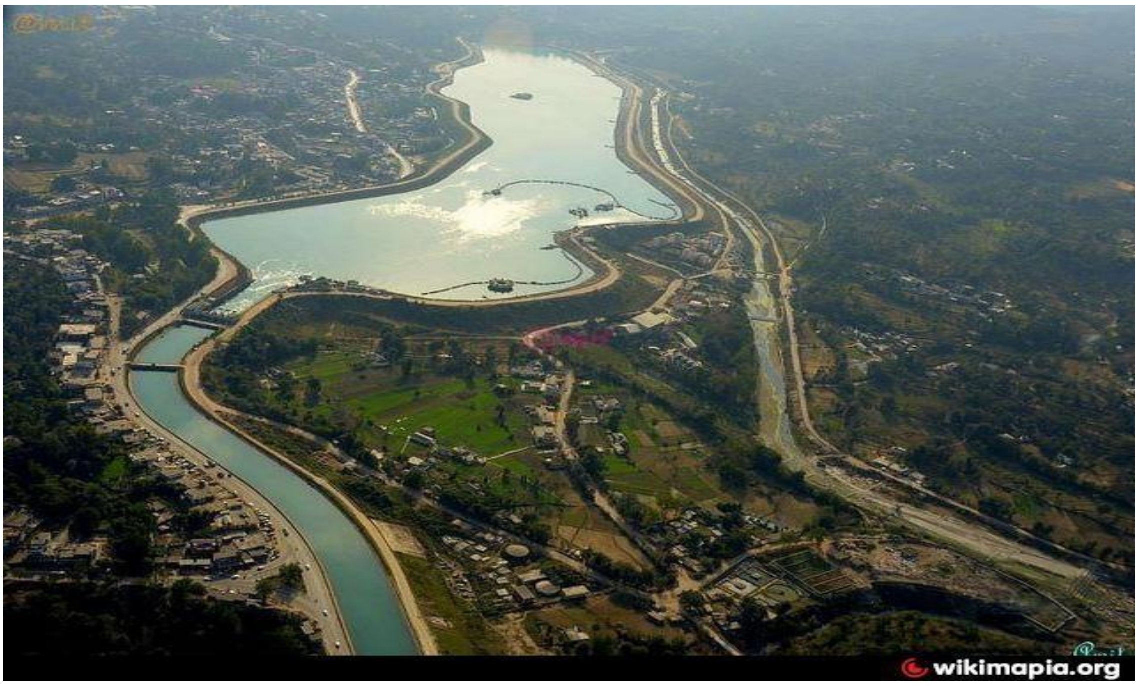

Figure: 1.1 Balancing Reservoir Sundernagar (source: Wikimapia.org)

1.3 OBJECTIVES OF THE STUDY

- To learn the present unpolluted water supply framework in Sundernagar MC.
- To recognize the water demand for present as well as the future population upto 2051.
- To examine the techno-economical aspects of transporting water from Balancing reservoir to Sundernagar MC.
- Designing the mechanism of the Water Supply Plan for Sundernagar MC.
- Creating land use map by ARCGIS software and analysing the data using WaterGems software.

The objectives and aims that are at first forecasted for development of any WSS plan are related to population of the planning area, social as well as economic status of the people living in the planning area, study of all water resources, their capacity and dependence for long term, future development plan of the region, present and proposed level of water supply, its quality and history of epidemicity of water borne diseases.

- Assessment of decadal population of the planning area and evaluation of population for future at the end of the planning period i.e 2051.
- Total daily necessity of water for the existing and future predicted population.
- Exploration of able and dependable water resources near or within the planning area.
- Designing and planning of distribution and collection system bearing in mind the geography and location of settlements within the planning area.

CHAPTER 2

LITERATURE REVIEW

2.1 REVIEWS

Brdys M.A. (1990). "Optimizing control of water supply/distribution networks": According to this research paper it has been found that costs of running the water supply systems can be significantly reduced if, e.g. pump schedules, valve positions, treatment plant operation or controlled flow rates are chosen appropriately to make use of reservoir storages and time varying electricity tariff.

Paneria, Dipali and Bhatt, Bhasker (2017). " Modernization in Water Distribution System": In this research paper, the main focus is to modernize the existing water distribution system. This paper tells us that because of the loss of water in the system the consumers might face many problems therefore detecting those losses is a primary concern inorder to maintain sufficient water supply. Thus with the use of contemporary equipments and tools the system might work with greater efficiently. With the use of WaterGEMS, the operations of the system will be so easy and if some issue is noted then the issue can be mended by the software easily. According to this study WaterGEMS is the most accurate tool. Also, leak detection plays a significant role in the efficient management of WDS, as it will help in reducing water wastage. With the application of modern tools in the system, the existing problems will be sorted and take us a step ahead for the designing of a smart city.

Akbari, Abolghasem and Varadharajan, Ramani Bai (2007). "Application of GIS and RS in rural water supply systems": This research paper tells us how GIS acts as a useful tools in designing water supply system. It can be used for collecting necessary data and monitoring, selecting site for the source of water, network analysis and design of pipelines and route optimization.

Kumar, Arjun and Kumar, Kankesh and B, Bharanidharan and Matial, Neha and Dey, Eshita and Singh, Mahan and Thakur, Vivek and Sharma, Sarit and Malhotra, Neeraj. (2015). "Design of water distribution system using EPANET": This research paper discusses about the use of EPANET which is a computer application acts as a WDS analyzer. EPANET provides us with an unified environment for editing input data in the network, running hydraulic and water quality simulations, and viewing the results in various formats.

These include color-coded pipeline network maps, data tables, time-series graphs, and contour maps.

Roy, Pankaj and Konar, Ankita and Banerjee, Gourab and Paul, Somnath and Mazumdar, Asis and Chkraborty, Ronjon. (2015). "Development and hydraulic analysis of a proposed drinking water distribution network using WATERGEMS and GIS": In this research paper different hydraulic models are analysed to give results which can be used to solve the water scarcity and water allocating problem in the concerned study area.

Mehta, Darshan and Waikhom, Sahita and Yadav, Vipin and Lakhani, Krunal. (2015). "Simulation of Hydraulic Parameters in Water Distribution Network using EPANET: A Case Study of Surat City": Key points are:

-Analyzing the WDS and identify deficiencies in its analysis, implementation and usage.

-It was observed that when the analysis gets over the resulting pressures at all the junctions and flows with their velocity at all pipes are adequate enough to provide water to the planning area.

Ayad, A., Awad, H., and Yassin, A. (2013). "Developed hydraulic simulation model for water pipeline networks.": This research states the use of ELGTnet compared to EPAnet to carry out hydraulic analysis and it is found that ELGTnet provides results in less notable time.

Xu, Y., and Zhang, X. (2012). "Research on pressure optimization effect of high level water tank by drinking water network hydraulic model.": This research paper states the solution for the problem of inadequate pressure of water in the southern and southeast area of City K. The paper involves analysing the different high water tank building plans through hydraulic model simulating, thus, providing an inexpensive and reasonable suggestion to the network's modification.

Sanz, G., and Pérez, R. (2014). "Demand pattern calibration in water distribution networks.": This research paper discusses the methodology used to test two WDNs, a real network with synthetic data and a software generated network. The method for the calibration of demand patterns based on single value decomposition is stated in this paper. It also is essential to check that the demand pattern relating to highest consumption is always calibrated the best, so a high percent of the water consumed and consequently, a great amount of the demand model is correctly identified.

Gama, M. C., Lanfranchi, E. A., Pan, Q., and Jonoski, A. (2015). "Water distribution network model building, case study: Milano,Italy": This paper discusses the WDN complete model building of the city of Milano which is a large city as the literatue available is on small cities or part of the network, the difficulties in calibration process and tasks and operations to be developed in the near future.

Surani J. Dhara, Dihora V. Gautam, Pathak P. Yashodhar, (2015). "Digitizing Water Distribution Network and Topography Mapping from Digital Elevation Model (DEM) Using 3D Analyst & Spatial Analyst": The main aim of this research work is to examine the existing water supply system of Bawaliyari village, Taluka Dholera, all sources of water and further planning WDS using ARC GIS. This research paper also focuses on the use of ARC GIS for planning and mapping the WDN. GIS based tools were used for the digitizing various ground features such as village , WDN and nodes. Village is represented by a polygon, WDN is represented by a polyline and node by point.

Ayad, ayman & Awad, Haytham & Yassin, Alaa. (2012). "Geographic Information Systems in Water Distribution Networks.": In this study, GIS is used to organize the data for usage in water distribution networks analysis, and design. Altogether, GIS provides a graphical display of results obtained from both optimization models, and hydraulic simulations; linking tabular data with graphical drawing and geographic locations.

Mansi, Prajapati & B.M.Marvadi, & Patel, Ajay & Prakash, Indra. (2016). "Planning of Water Distribution Network, Using GIS Techniques.": This research paper explains the insufficiency of WDN in baspa village and planning of sufficing WSS using GIS techniques. It was found that an increasing water demand due to agriculture usage and growing population entail proper distribution network system. GIS application in this study helps in planning a sufficing WDN. Planning and designing in respective sectors like road network, WDN and land use information has been carried out on the Software ArcGIS.

Iustina, Lates & Luca, Mihail. (2017). "The Management of Water Supply System Using GIS Application." : Management issue for WSSs is important increasingly considering the evolution of settlements continuously. WSNs should be in line with demand of consumer. The service quality should be monitored using GIS applications. Programs like Arc Map and Auto CAD help in creating thematic maps of specificed area. Using these programs and GIS applications are effective if you are working on layers of custom work on areas of operation and structure. Layers requires the databank attachment with various characteristics parameters. WSN management is effective by integration of all data relating to it in GIS applications. Thus we are able to accomplish reports, mathematical modelsand thematic maps in a short durations.

Shamsi M. Uzair. (2004). "GIS Applications for Water Distribution Systems": This study illustrates the geographic information system (GIS) applications for WDSs. The GIS applications that are used include, creation of thematic maps of the model output results, development of hydraulic models, computing nodal demands, network simplification (skeletonization) for hydraulic modelling, estimation of node elevations, water main isolation i.e., identification of the valves to be shut for repairing or a broken water main replacement, and delineation of pressure zones.

Sargaonkar, Aabha & Islam, Raisul. (2009). "Application of GIS in water distribution system assessment.": This research paper deals with a case study for assessment of pipeline conditions in WDN of Moinbagh area which is in Hyderabad (India). Pipe condition assessment (PCA) Model which is a mathematical model was used, which uses maps based on gis of WDN, sewer network, drains and soil as input in addition to data on physical properties of the network as well as operational parameters. The results show that the application of PCA identified that 3% pipes in the WDN were in poor state..

Alves, Z., Muranho, J., Albuquerque, T., & Ferreira, A. (2014). "Water Distribution Network's Modeling and Calibration. A Case Study based on Scarce Inventory Data.": This research emphasises on calibration and modeling of a poor and small documented water distribution network (WDN) that shows problems related to pressure. Field surveys are organised to mend the inaccuracies that are found in the inventory's drawings and to help build a preliminary WDN model. A trial and error technique was then used to create successive refinements for the desirable WDN's model fit.

Sharma, Sham & Kansal, M. & Tyagi, Aditya. (2013). "Augmentation Strategies for Sustainable Water Supply to Shimla - A Hill Station in India.": This research involves the augmentation of a water supply to fulfill the additional water demand within the city as it is a growing city. In order to fulfill this growing demand the option were made available. Further design of water distribution system is planned and designed to lift water from satluj river. Also this study discusses issues and challenges and reasons for water deficit, and indepth analysis of future demand and supply. Further, role of rainwater harvesting, feasible augmentation strategies.

Shinde Kumar Pravin, Patil Prashant,Hodage Rahul. (2018) "Design and Analysis of Water Distribution Network Using Water GEMS": This project study presents a hydraulic analysis of Shivaji Nagar territory of Panvel city. Google Earth was used for ensuring layout of water distribution network and Satellite image of planning area shows effectiveness for selection of alternate alignment of road. Steady state analysis was carried out for calculation of hydraulic parameters such as pressure head and discharge rate. The results envisaged verified that the pressure at all junctions and the flows with their velocities at all pipes are feasible enough to provide adequate water to the planning area.

Nekrasov, A. & Tsarev, N. & Adamova, A. & Ivanova, O. (2019). "Modeling and designing the combined drinking and fire protection water distribution system for an industrial park by using WaterGEMS.": The purpose of this project work was to develop a combined drinking and fire protection water distribution system for the industrial park. Modeling was done in WaterGEMS. Pipelines diameters were determined and optimized via Darwin designer. Modeling of the water distribution system was performed for four cases: 1) normal operation conditions; 2) emergency operating conditions in case of fire in the production facility with the highest water consumption; 3) emergency operating conditions in case of fire in the consumer's facility located in the most remote point; 4) emergency operating conditions in case of a failure on the water distribution network and simultaneous fire in the production facility with the highest water consumption. Continuous supply of water to consumers and for the purpose of fire fighting is provided in all above cases with required flow and head. The total length of the water distribution network came out as 7820 meters.

2.2 SUMMARY OF LITERETURE REVIEW

- Costs to running the water distribution system can be reduced if, e.g. pump schedules, valve positions, treatment plant operation or controlled flow rates are chosen appropriately to make full use of reservoir storages.
- Various computer applications such as WaterGems and EPAnet act as a WDS analyzer for editing network input data, running hydraulic and water quality simulations, and viewing the results in various variety of formats.
- Very essential to maintain optimum water pressure in pipes to solve the problem of inadequate supply in some areas.
- GIS acts as a useful tools in designing water supply system as it can be used for collecting necessary data and monitoring, selecting site for the source of water, network analysis and design of pipelines and route optimization.

CHAPTER 3

METHODOLOGY

1. Collection of essential and applicable data on the WSS from municipal corporation Sundernagar and Irrigation and Public Health Engineering (IPH), Sundernagar.

2. Analysing the available data.
   - Using the data to forecast population for future within the town and water demand calculation.
   - Computing the water surplus or deficit after and before addition of available water from balancing reservoir.

3. Land use categorization of the planning area and development of a land use map of the planning area Sundernagar MC using ARC GIS software depicting the various area such as residential, commercial and institutional.

4. Future forecast and calculating the water deficit to be satisfied by the balancing reservoir. Study of viability of techno-economical aspects of augumenting water from the balancing reservoir to Sundernagar MC.

5. Developing digital elevation map of the planning area and other contour as well as topographical maps of the planning area on ARC GIS software which helps in determining the ideal location of various components over the map.

6. Alignment of all the components over the digital map on ARC GIS and determining the capacities, elevations, lengths and other values used for design purpose.

7. With the help of the CPHEEO rules a detailed project report of the project is prepared which includes designs of variety of components of the water supply scheme in the town.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 EXISTING SCENARIO

The Irrigation and Public Health Department (I and PH) of Himachal Pradesh supply water to all the domestic and commercial establishments in sundernagar MC Planning Area. Both Ground and surface water are the sources of potable supplied water in this area. Ground water is extracted by deep tube wells and then lifted to the Main storage tanks. From the Main Storage Tanks (MSTs), water is supplied to the Sub Storage Tanks (SSTs) through gravity. From the SSTs, the water is distributed throughout the Planning Area. Surface water is collected through Lift Water Supply Schemes from Streams, Rivers and Rivulets. The water is stored in the sump well and then directed to Treatment plants where water is treated through slow sand filter belt by sedimentation process. The treated water is stored in Main Storage Tanks (MSTs).

As per I and PH, circle sundernagar MC, 2.92 MLD is supplied to all urban settlements in the Planning Area. Out of the total water supplied (2.92 MLD) to the Planning Area, 81 % is from combined sources that includes surface and ground water both, 15% is exclusively from ground water sources and rest 4 % is exclusively from surface water source.

4.2 EXISTING LOCATIONS OF POTABLE WATER SOURCES

Out of the total households within Planning Area, 73.95% households have the drinking water facility within premise, 24.16 % have the drinking water source nearby the premise and rest 1.87 % have the drinking water sources away from the premise. Comparing with the district average, the Planning area has more number of houses with drinking water source located within premise. The location of the drinking water sources should be inside the premise so that people do not need to travel in the hilly area for fetching water.

4.3 SUNDERNAGAR MC: GROWTH TREND

Sundernagar Municipal Council was constituted during 1950s. As per Census 2011, about 4% of the total Urban population of Himachal Pradesh are in sundernagar municipal council. The urban population of sundernagar MC increased from 2554 in 1921 to 24,344 in 2011.

Sundernagar MC recorded a growth rate of 268.45 % which is very high during 1961-71 and became second largest town of Himachal Pradesh. This excessive growth rate was due to migration of people into the town because of construction completion of Beas-Satluj Link Project. Sundernagar MC maintained its position in 1981 census also. During 1991 census Mandi town reached in second position relegating sundernagar MC to 5th position.

Sundernagar MC marked a negative growth rate during this period, which was connected with migration of people in large numbers into the town consequent upon the completion of Beas Satluj link Project.

4.4 POPULATION POPULATION PROJECTION

4.4.1 POPULATION RECORDS

Table 2. Past Decadal Population Data

Year	**Total Population**
1901	2179
1911	2394
1921	2554
1931	2401
1941	1725
1951	5257
1961	5782
1971	21304
1981	20780
1991	20397
2001	23986
2011	24344

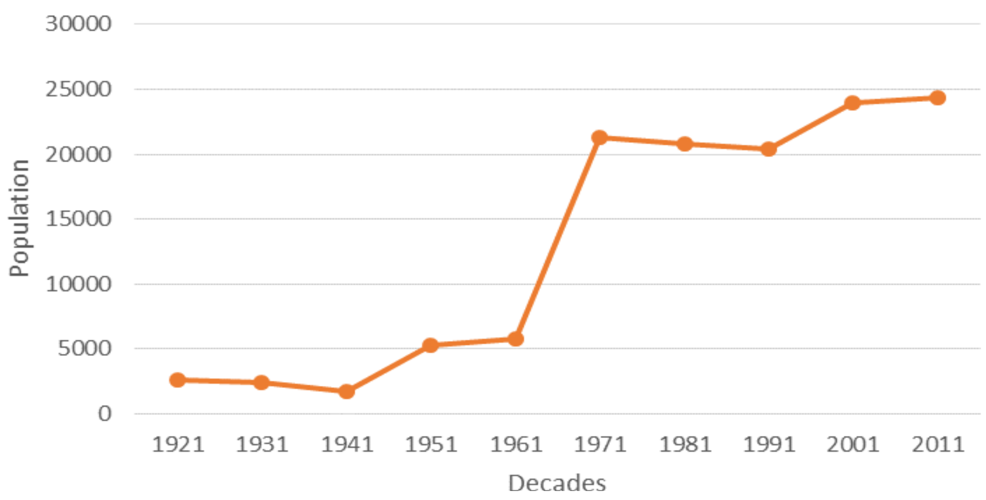

Figure: 4.1 Population Increase of Sundernagar Town (1921-2011) (Source: Census of India, 1921 – 2011)

4.4.2 POPULATION PROJECTION

As the intensity of urbainsation is high in the Panning Area, it has been taken into thought during population forecasting for 2051. The expected population by logistic curve method being more suitable to be adopted as this city does show decreasing population trend. Hence the estimated population for Sundernagar MC for the year of 2051 is 24377 (Fig 4.1). Hence, population of the Planning Area for 2035 is projected to be 24377 with the saturation population of 24376. But this technique seems unrealistic as there is still much room for expansion within the project area therefore this method is rejected. Thus the other four methods are used and their average value is used for further calculations of water demands. Decreasing growth rate method is also used as the towns shows increase in rate of decrease of population for the decade 2001 to 2011 (Table 2).

The city population is estimated up to the year 2051 for 30 years time as the base year being 2021. The four different techniques for population forecasting are:

1. Arithmetic increase method

In this method, the average increase of population for every decade is computed using the precedent data available which is added to the population at present to calculated out population value for the next decade .This technique provides us with a smaller value then the other forcasting techniques and is suitable for properly established and well-known community (Table 3).

Population after n^{th} decade,

$P_n = P + n * X$

where,

X=Average Increase

P_n=Population after‘n’number of decades P=Population at

present

Table 3 Population Forecasting using Arithmatic Increase Method

Year	‘n’ Value	Projected Population
2011	0	24344
2012	0.1	24462.6
2013	0.2	24581.1
2014	0.3	24699.7
2015	0.4	24818.3
2016	0.5	24936.8
2017	0.6	25055.4
2018	0.7	25173.9
2019	0.8	25292.5
2020	0.9	25411.1
2021	1.0	25529.6
2026	1.5	26122.5
2031	2.0	26715.3
2036	2.5	27308.1
2041	3.0	27900.9
2046	3.5	28493.8
2051	4.0	29086.6

2. Incremental increase method

This method is appropriate for a town which is average sized under standard conditions where the population growth rate is found increasing (Table 4). While in this method, the increase in increment is measured for calculation of population for future. For every decade the incremental increase is determined from the past population and the average value is added to the population at present beside with the average increase rate.

P_n=P+n*A+{n(n+1)/2}*B

where,

P_n=Population after n^{th} decade

A=Average increase in population

B= Incremental increase in population

Table 4 Population Forecasting using Incremental Increase Method

Year	'n' Value	Projected Population
2011	0	24344
2012	0.1	24483.1
2013	0.2	24626
2014	0.3	24772.6
2015	0.4	24922.9
2016	0.5	25077.1
2017	0.6	25234.9
2018	0.7	25396.5
2019	0.8	25561.8
2020	0.9	25730.9
2021	1.0	25903.6
2026	1.5	26823.7
2031	2.0	27837.3
2036	2.5	28944.4
2041	3.0	30144.9
2046	3.5	31439.1
2051	4.0	32826.6

3. Geometric increase method

This method assumes that the percentage increase in population for every decade is steady.

Geometric mean increase is has been used to calculate the increase in future population. As this method provides us with superior values. This therefore is useful for a new developing industrial town for some decades. The population at the end of n^{th} decade "Pn" can be computed as (Table 5):

$P_n=P(1+G/100)^n$

where,

G=Geometric mean (%)

P=Present population of the town

n=total number of decades

Table: 5 Population Forecasting using Geometric Increase Method

Year	'n' Value	Projected Population
2011	0	24344
2012	0.1	24480.3
2013	0.2	24617.3
2014	0.3	24755
2015	0.4	24893.6
2016	0.5	25032.9
2017	0.6	25173
2018	0.7	25313.9
2019	0.8	25455.6
2020	0.9	25598.1
2021	1.0	25741.3
2026	1.5	26469.8
2031	2.0	27218.9
2036	2.5	27989.2
2041	3.0	28781.3
2046	3.5	29595.8
2051	4.0	30433.3

4. Decreasing growth rate method

According to this method if the rate of percentage increase is decreasing then the average decrease in the rate of popluation growth is calculated. After that the percentage increase is manipulated by deducting the reduce in rate of growth. The method is appropriate only in those cases when the rate of population growth shows a decreasing trend as in the case of Sundarnagar as from 2001 to 2011 the total percentage increase in population has decreased from 17.6% to 1.49% (Table 6).

Table: 6 Population Forecasting using Decreasing Growth Rate Method

Year	**‘n’ Value**	**Projected Population**
2011	0	24344
2021	1.0	25025.6
2031	2.0	26054.2
2036	2.5	26760.4
2041	3.0	27466.1
2051	4.0	29314.5

Average of the Four Methods

The projected population for the planning area is computed by the use of the three methods that are stated above which illustrate that projected population from the arithmetical increase method is lower than geometrical increase method. Thus the city population has been anticipated by taking average values of all the four methods for every year (Table 7).

Table: 7 Population Forecasting using Average of the Four Methods

Year	**Average of the four methods**
2011	24344
2021	25550
2031	26956.4
2036	27753.6
2041	28573.3
2051	30415.25

4.4.3 WATER DEMAND ESTIMATION

Parameters and norms adopted for the calculation of water demand for the base year, intermediate year and vision year are based on Central Public Health and Environmental Engineering Organisation (CPHEEO) Manual. The water demand for domestic use is estimated per capita consumptions of 135 lt/day. Non-Domestic and Tourist water demand are also considered as 10 LPCD as per CPHEEO Manual on Water Supply and Treatment. The fire water requirement is computed based on the standards given in CPHEEO manual (Table 8).

Table: 8 Average Daily Demand, Maximum Daily Demand, Maximum Hourly Demand for Future

Year	Population	Average Daily Demand (MLD)	Maximum Daily Demand (MLD)	Maximum Hourly Demand (MLD)
2021	25550	4.26	7.7	11.55
2031	26956	4.49	8.1	12.12
2036	27753	4.62	8.3	12.45
2041	28573	4.76	8.6	12.9
2051	30415	5	9	13.5

4.5 CREATING LAND USE MAP

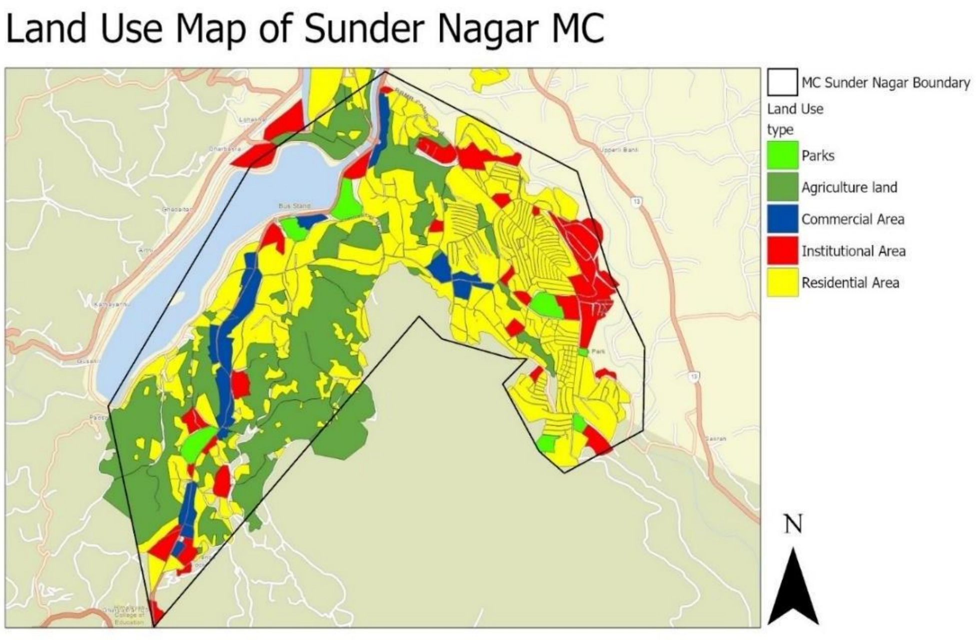

Figure: 4.2 Land Use Map of Sundernagar MC

In order to create the land use map we made the use of ArcGIS which is a geographic information system. This system provides a platform for working on different maps and has in built tools to edit and explore the data.

Firstly, a preliminary study of the planning area sundernagar MC was conducted in which the area was studied from google maps and google earth (Fig. 4.2). Some ancillary data like the district map and divisional map were collected and studied. This survey in observing the various settlement land use classes in the planning area and also help in adopting a suitable classification scheme for the final map.

Here, visual interpretation technique was applied in the study. Visual interpretation was shown to have more quality compared to digital classification for analyzing high resolution satellite data. Settlement features have been captured through on screen visual interpretation.

Hence, a reconnaissance of the planning area was carried out and different classes of the land use settlements can be demarcated on the satellite imagery in ArcGIS.

A final map was created by mapping different categories of land use settlements on the satellite imagery. Five categories of land use settlements were used which include a class 'Land use' with different types of subsets of the class as residential areas, commercial area, institutional area, parks and agriculture land.

In ArcGIS have used different feature classes to create different features on the map for example the boundary of sundernagar MC is create using a unique feature class which also acts as an over layer on the map and is represented by a polygon with the black outline.

Similarly, for creating different types of settlement land use areas we created a feature class for land use with different sub sets for the different land use areas of the planning area. Each feature sub set denotes a type of land use area.

The land use categories are classified by different colours such as yellow for residential and blue for commercial and red for institutional areas.

4.6 DIVIDING THE PLANNING AREA INTO ZONES

The area falling under Sundarnagar MC is disintegrated into four zones (Fig.4.3).

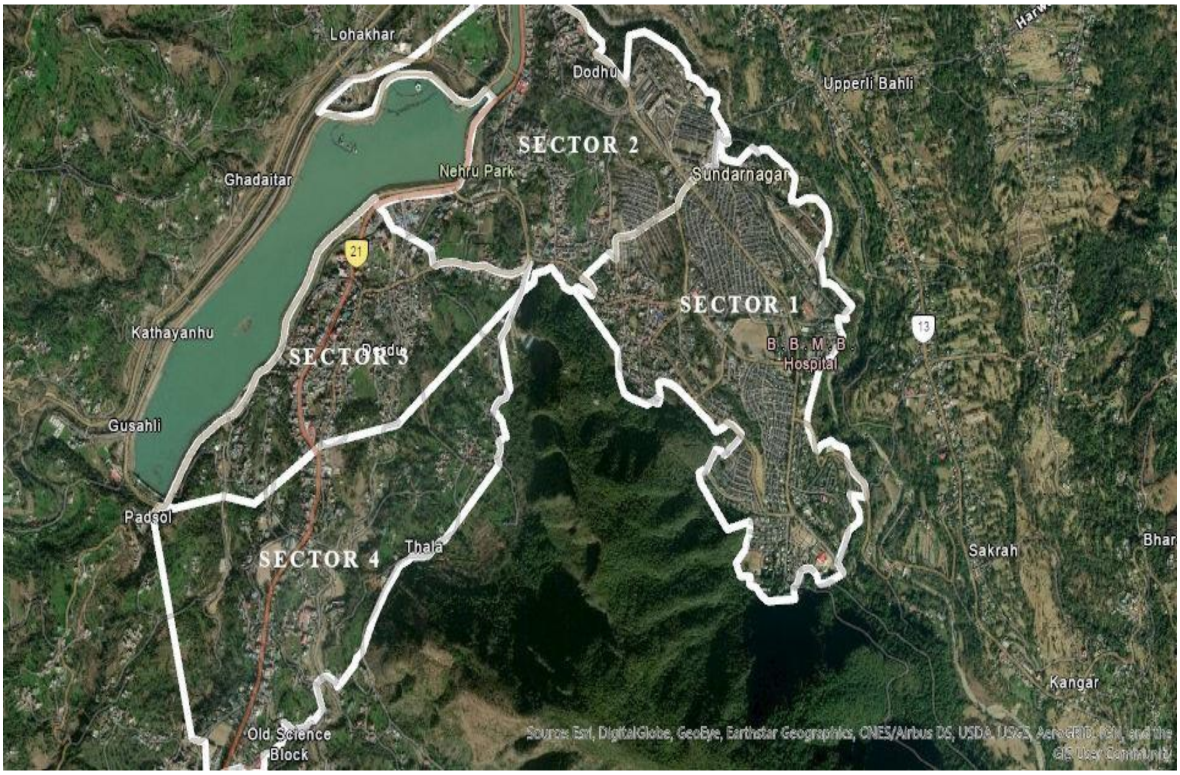

Figure: 4.3 Zonal Map of Sundarnagar MC

The water demands for the four zones are calculated exclusively for each zone. The water demands are computed using the land use statistics. This is done within the software arcgis using the statistics tool. All the area falling under a zone is selected and the statistics for that particular zone is computed. Various Standalone tables are extracted which give various values such are total residential, commercial, industrial areas falling under every zone. Thus the water demand for each zone is calculated by distributing the total demand among the zones (Table 9, 10).

Table: 9 Zone Wise Average Daily Demand, Maximum Daily Demand, Maximum Hourly Demand for 2036

	Water Demands (2036)		
Zones	Average Daily demand (MLD)	Maximum Daily demand (MLD)	Maximum Houlry Demand (MLD)
Zone 1	1.49	2.70	4.05
Zone 2	1.23	2.20	3.30
Zone 3	0.93	1.68	2.52
Zone 4	0.95	1.71	2.60

Table: 10 Zone Wise Average Daily Demand, Maximum Daily Demand, Maximum Hourly Demand for 2051

	Water Demands (2051)		
Zones	Average Daily Demand (MLD)	Maximum Daily Demand (MLD)	Maximum Houlry Demand (MLD)
Zone 1	1.62	2.91	4.37
Zone 2	1.34	2.40	3.60
Zone 3	1	1.80	2.70
Zone 4	1.03	1.90	2.80

4.7 Topographic Survey and Digital Elevation Model

Topographic survey is used to recognize and map the land contours of the area and existing features slightly below or above the earth's plane or on the plane of the earth. Topographical surveys need "benchmarks" to which land contours are related, information concerning plane and underground utilities, determination of necessary setbacks etc.

A digital elevation model is a CG 3D representation of any terrain's surface .

To create a DEM first we need to open google earth, in google earth we need to search the place whose DEM is to be made, in our case the place is Sundernagar, Mandi (H.P.).

Then in google earth we click on "Add Path" and start selecting the required area whose DEM is required.

After selecting the area we save this file as a "kml" file on computer and open a website "GPS Visualizer".

Now we add our "kml" file which we saved earlier in "GPS Visualizer" and run the program. After running the program it will give us the elevation data in the form of a "gpx" file. Download this file on the computer.

Now we open "arcGIS" software and start a new map project.

Now in arc tools we click on "Conversion Tools" and select "From GPS", click on "gpx to feature" option and a window opens. In this we add the downloaded gpx file from gps visualizer and run the program. It will add "Point Elevation" data on the map. And the area we selected on google earth opens in arcGIS with point elevation data.

Now we go in arc tools and click on “3D Analyst Tools”. Within this tool we select “Raster Interpolation” and then we select “IDW”. A small window opens and in this we add our point elevation data and select the “z value” as elevation and run the program. It will add the elevation data on the required area with a colour scheme defining the elevation.

Now again we go in arc tools and click “3D Analyst Tools” in this we select “Raster Surface” and in this we select “Contour”. Again a small window opens and in this we add our elevation data and then select the contour interval (In our case contour interval is 50) (Fig 4.4).

Now we run the program. It will add contours on the required area and our digital elevation model is ready. With the help of DEM we decide the location of various components of the water supply system.

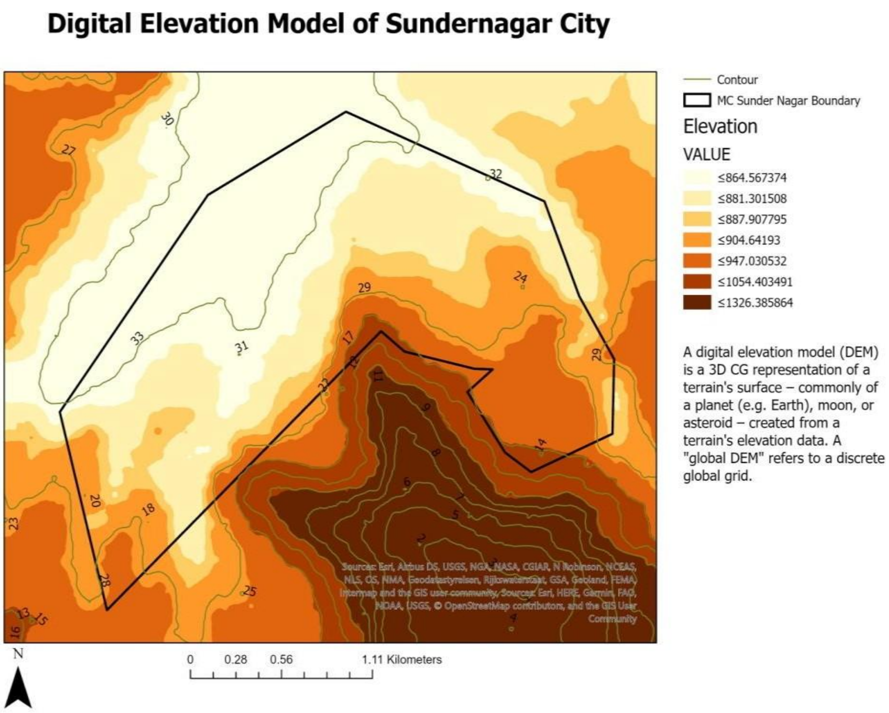

Figure: 4.4 Digital Elevation Model of Sundarnagar MC

4.8 Alignment of Water Distribution Network

New layout of water distribution network is prepared with the help of Digital Elevation Model (DEM) map as it gives the topographical data of the surface means it provides the necessary data about flat and hilly area along the village which is helpful in alignment of the water distribution pipe lines. Network is prepared with the help of boundary map of village which provides the enclosed area for networking and DEM map gives the elevations of ground. Water distribution network is prepared along with the roads in the village therefore it covers whole village (Fig 4.5, 4.6).

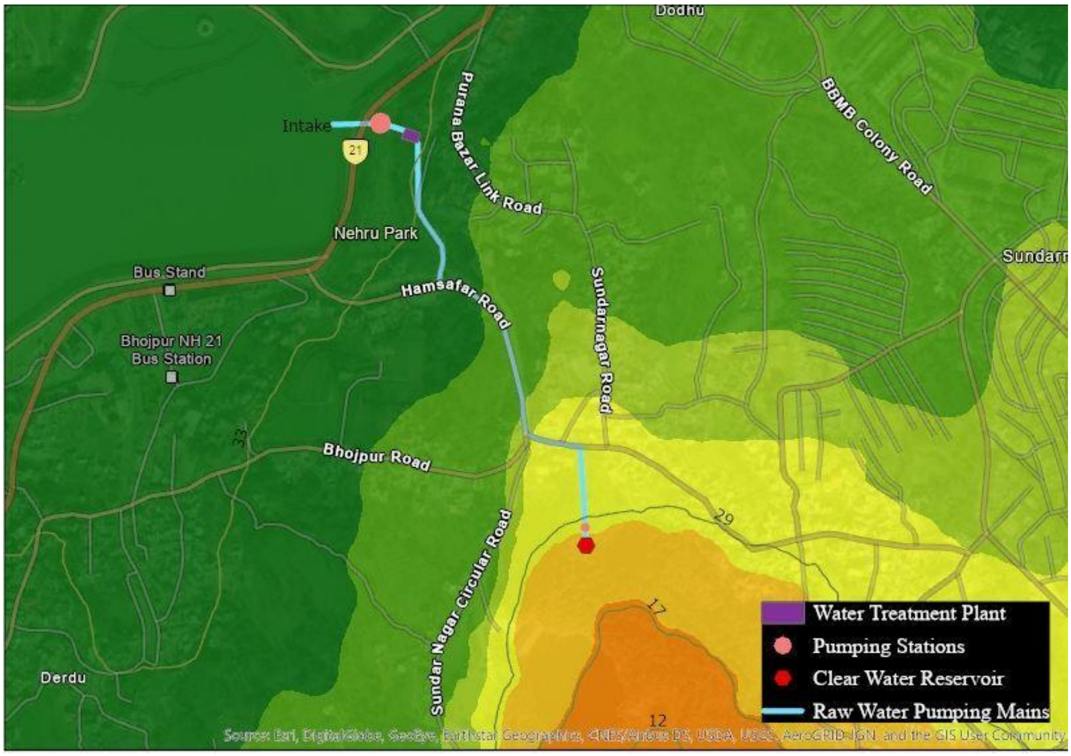

Figure: 4.5 Layout of WTP, Pumping Stations, Clear Water Reservoir and Raw water pumping mains over DEM

Figure: 4.6 Layout of WTP, Pumping Stations, Clear Water Reservoir and Raw Water Pumping Mains

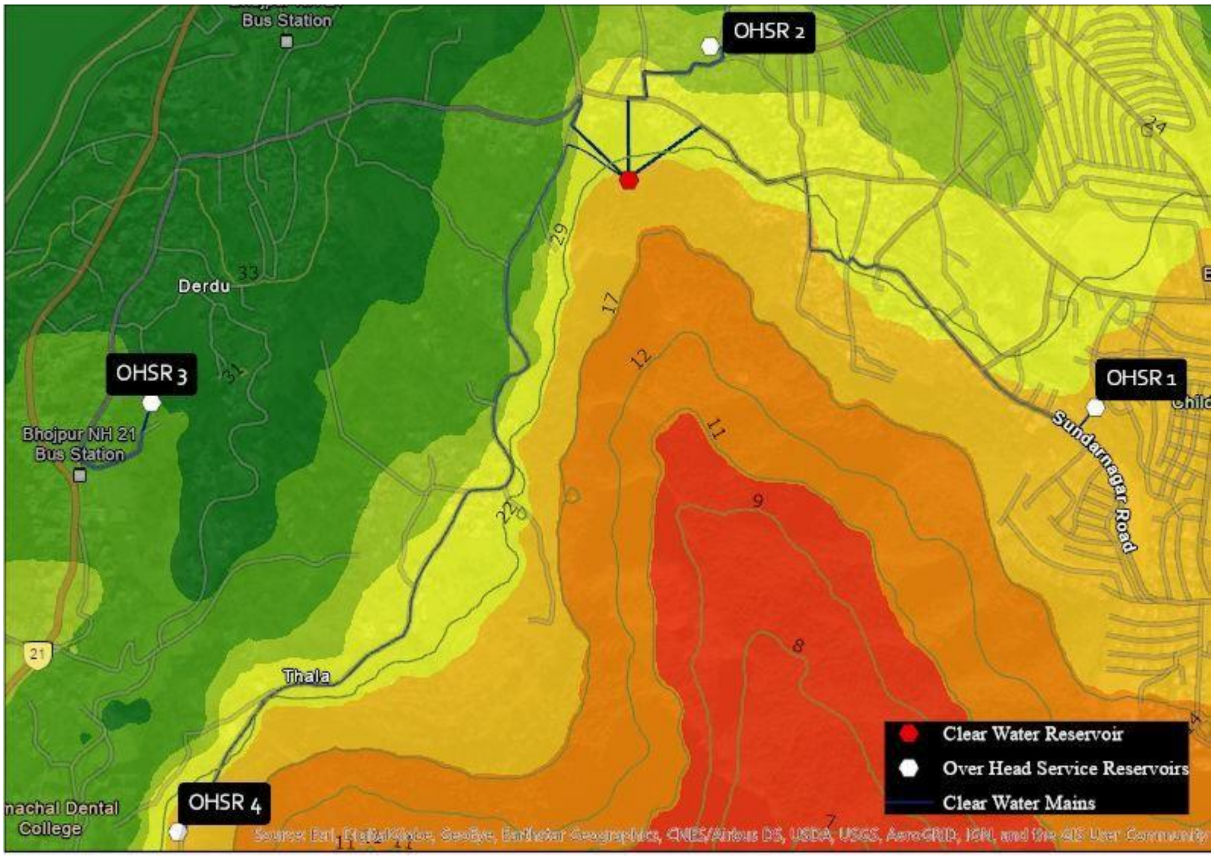

Figure: 4.7 Layout of Clear Water Reservoir, Clear Water Mains and Over Head Service Reservoirs over DEM

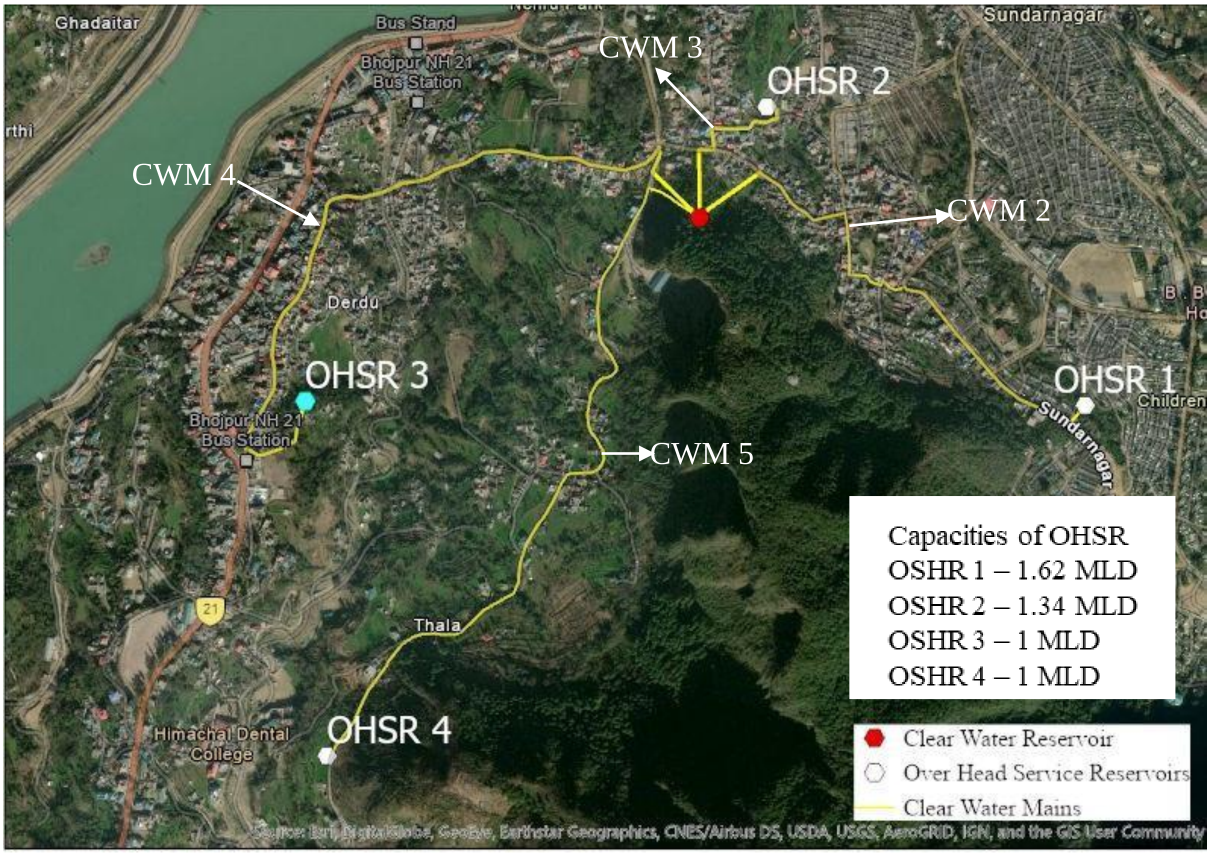

Figure: 4.8 Layout of Clear Water Reservoir, Clear Water Mains and Over Head Service Reservoirs over DEM

Figure: 4.9 LWSS for Sundarnagar MC

Table: 12 Pipeline Details

Pipe	Length (m)	Dia (mm)	Discharge (MLD)	Velocity (m/s)		Friction Losses in total pipe length (m)	
				1st Stage	2nd Stage	1st Stage	2nd Stage
RWM	105	400	9	0.77	0.83	0.13	0.15
CWM 1	898	400	9	0.77	0.83	1.24	1.08
CWM 2	1279	250	2.91	0.64	0.69	1.91	2.21
CWM 3	451	250	2.4	0.52	0.57	0.46	0.54
CWM 4	1870	250	1.8	0.40	0.43	1.19	1.36
CWM 5	1873	250	1.9	0.40	0.44	1.23	1.46

4.9 Parameters Used in Designing

4.9.1 Supply Hours

The final aim is to give all consumers within the planning area with a continuous supply of water for 24 hours, and every mechanism of the water distribution network should be designed keeping this aim in mind. But for the current conditions in the planning area, as well as the circumstances in other similar areas, it is unpractical to give non-stop supply of water right away after commissioning of the WSS. At first water supply period might be irregular, it is believed that once all customers in the planning area become familiar to this water supply and losses are minimised, the hours of supply can be increased until non-stop supply of water is achieved. Supplying water in a short duration of time will lead to a magnified flow through distribution pipes, which anyhow would be approximately equal to the final storage flow for which the WSS is designed. Designs would be checked for short duration water supply and sufficient measures would be constituted.

4.9.2 Pumping Hours

At the moment (PHED) Public Health Engineering Department considers supply for 16 hours in their schemes though accessibility of influence for each day is even lower in real practice. For a majour projects, system designs adopting lesser duration of control accessibility will result significant growth in the dimensions/capacity of all pump units to attain desired output, which will have a negative impact on the economic viability of the project. Considering various techno-economic aspects it has been proposed, a guaranteed accessibility of control should be considered at 16 hours per day either through a devoted feeder line or an in-house electric generator, the planned system will be designed in view of that.

4.9.3 Design Formula

A variety of formulae are used for hydraulic examination of water networks. Most widely used is Hazen–William's formulae, which constitutes variables such as flow in pipe, diameter of pipe, velocity of flow and the head loss due to resistance.

According to Hazen William's formula :

$V = 4.567 \text{ x}10^{-3} \text{ x } cd^{0.63} \text{ x } S^{0.54}$

where,

V = flow velocity

d = diameter of circular pipe section

C = Hazen Williams co-efficient of friction

S = Hydraulic Gradient Slope

Chapter 5

Conclusion

Sundernagar MC having a population of about 24344 (census 2011) has an water supply scheme of 2.92 MLD of which ground water sources are used the most for providing potable water to the planning area. Some surface water sources are also used. Also,0.57 MLD is lost as leakage and thefts in the year 2011. The water demand for 2021 4.26 MLD, sundernagar MC is facing a deficiency of about 1.34 MLD. As the current water supply has many defects in the network and has exceeded the design period limits for almost all the components therefore a new water supply is designed for Sundarnagar MC. This study was taken on to tap water from the balancing reservoir and distribute it within the area using combined gavity and pumping system. The software AcrGIS was used to create the settlement land use classification map of the area, creating the digital elevation map for the elevation data, and the layout of various components such as pipelines, WTP, clear water reservoirs, overhead reservoirs etc. The palnning area is divided into four sectors. For each sector water demand is calculated using various tools within ArcGIS. Further the components of the network are aligned with the help of DEM and elevation data keeping in mind the combined gravity and pumping system pattern. This defines the location and placement of different components on the map. The balancing reservoir acts as an intake and raw water pumping main of length 105 m carries the water to the WTP and further the water is pumped to the clear water reservoir which further pumps the water to the over head service reservoirs.

A Lift Water Supply Scheme (LWSS) design was planned out which includes the design of the rising mains, the price study of laying the rising mains and the pump system is passed out which amounts to about **9,74,86 thousand Rupees** . The most inexpensive diameters of the various rising mains and clear water mains has also been computed which varies from **250mm-400mm**. Two pump houses have to be installed each at intake and the location of clear water reservoir.

This project will provide a new LWSS which is the requirement at this time and also provide the expected demands in near coming years in Sundernagar MC up to the year 2051 by as long as a total maximum daily demand of 9 MLD of water.

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Annexure A

Design of Economic Size of Rising Mains/Pumping Mains

Table: 1 Design of RWM from Intake to WTP

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	7.70	mld	250	DI	K9	140	2581
B.	Intermediate			2036	8.30	mld	300	DI	K9	140	3269
C.	Ultimate			2051	9.00	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	105	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	8.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600
CALCULATIONS:					1st 15 years		2nd 15 years				
1) Discharge at Start OF PERIOD					7.70	mld	8.30	mld			
2) Discharge at the end of 15 yrs					8.30	mld	9.00	mld			
3) Average Flow					97	lps	104	lps			
4) Average Discharge					8.00	mld	8.65	mld			
5) Avg.pumping hours during the period					15.42	hrs	15.38	hrs			
6) KW required at combined efficiency of pumping set					1.89	* H1	2.05	* H2			
7) Annual charges for energy Rs.					50688	* KW	57527	* KW2			

						1		

Modified Hazen William's Formula

V=143.534CR r0.6575 S0.5525
h=[L(Q/CR)1.81]/[994.62D4.81]

Friction Head Loss (First 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)
250mm	1000	0.097	1.000	0.097	0.015	994.620	0.250	0.001	11.514
300mm	1000	0.097	1.000	0.097	0.015	994.620	0.300	0.003	4.790
350mm	1000	0.097	1.000	0.097	0.015	994.620	0.350	0.006	2.282
400mm	1000	0.097	1.000	0.097	0.015	994.620	0.400	0.012	1.201
450mm	1000	0.097	1.000	0.097	0.015	994.620	0.450	0.021	0.681
500mm	1000	0.097	1.000	0.097	0.015	994.620	0.500	0.036	0.410
600mm	1000	0.097	1.000	0.097	0.015	994.620	0.600	0.086	0.171
700mm	1000	0.097	1.000	0.097	0.015	994.620	0.700	0.180	0.081
800mm	1000	0.097	1.000	0.097	0.015	994.620	0.800	0.342	0.043
900mm	1000	0.097	1.000	0.097	0.015	994.620	0.900	0.602	0.024
1000mm	1000	0.097	1.000	0.097	0.015	994.620	1.000	1.000	0.015
1100 mm	1000	0.097	1.000	0.097	0.015	994.620	1.100	1.582	0.009

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.012		

						0.085	1.968
300	143.534	1.000	0.075	0.182	0.005	0.052	1.367
350	143.534	1.000	0.088	0.202	0.002	0.035	1.004
400	143.534	1.000	0.100	0.220	0.001	0.024	0.769
450	143.534	1.000	0.113	0.238	0.001	0.018	0.607
500	143.534	1.000	0.125	0.255	0.000	0.013	0.492
600	143.534	1.000	0.150	0.287	0.000	0.008	0.342
700	143.534	1.000	0.175	0.318	0.000	0.006	0.251
800	143.534	1.000	0.200	0.347	0.000	0.004	0.192
900	143.534	1.000	0.225	0.375	0.000	0.003	0.152
1000	143.534	1.000	0.250	0.402	0.000	0.002	0.123
1100	143.534	1.000	0.275	0.428	0.000	0.002	0.102

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)
250mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.250	0.001	13.262
300mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.300	0.003	5.518
350mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.350	0.006	2.629
400mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.400	0.012	1.383
450mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.450	0.021	0.785
500mm	1,000.000	0.104	1.000	0.104	0.017				

						994.620	0.500	0.036	0.473
600mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.600	0.086	0.197
700mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.700	0.180	0.094
800mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.800	0.342	0.049
900mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.900	0.602	0.028
1000mm	1,000.000	0.104	1.000	0.104	0.017	994.620	1.000	1.000	0.017
1100 mm	1,000.000	0.104	1.000	0.104	0.017	994.620	1.100	1.582	0.011

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.013	0.092	2.128
300	143.534	1.000	0.075	0.182	0.006	0.057	1.478
350	143.534	1.000	0.088	0.202	0.003	0.038	1.086
400	143.534	1.000	0.100	0.220	0.001	0.026	0.831
450	143.534	1.000	0.113	0.238	0.001	0.019	0.657
500	143.534	1.000	0.125	0.255	0.000	0.015	0.532
600	143.534	1.000	0.150	0.287	0.000	0.009	0.369
700	143.534	1.000	0.175	0.318	0.000	0.006	0.271
800	143.534	1.000	0.200	0.347	0.000	0.004	0.208
900	143.534	1.000	0.225	0.375	0.000	0.003	0.164
1000	143.534	1.000	0.250	0.402	0.000	0.002	0.133

1100	143.534	1.000	0.275	0.428	0.000	0.002	0.110

TABLE: 1.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		8	105.00		8
								8.00	2nd stage flow		
1	250	11.51	13.26	1.97	2.13	1.21	0.12	9.33	1.39	0.14	9.53
2	300	4.79	5.52	1.37	1.48	0.50	0.05	8.55	0.58	0.06	8.64
3	350	2.28	2.63	1.00	1.09	0.24	0.02	8.26	0.28	0.03	8.30
4	400	1.20	1.38	0.77	0.83	0.13	0.01	8.14	0.15	0.01	8.16
5	450	0.68	0.78	0.61	0.66	0.07	0.01	8.08	0.08	0.01	8.09
6	500	0.41	0.47	0.49	0.53	0.04	0.00	8.05	0.05	0.00	8.05
7	600	0.17	0.20	0.34	0.37	0.02	0.00	8.02	0.02	0.00	8.02
8	700	0.08	0.09	0.25	0.27	0.01	0.00	8.01	0.01	0.00	8.01
9	800	0.04	0.05	0.19	0.21	0.00	0.00	8.00	0.01	0.00	8.01
10	900	0.02	0.03	0.15	0.16	0.00	0.00	8.00	0.00	0.00	8.00
11	1000	0.01	0.02	0.12	0.13	0.00	0.00	8.00	0.00	0.00	8.00
12	1100	0.01	0.01	0.10	0.11	0.00	0.00	8.00	0.00	0.00	8.00

TABLE: 1.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

			1st stage flow in MLD		8.00		2nd stage flow in MLD		8.65		
S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
					25000				25000		105

1	250	K9	9.33	27	663		9.53	29	732	2581	271
2	300	K9	8.55	24	608		8.64	27	663	3269	343
3	350	K9	8.26	23	587		8.30	26	638	4075	428
4	400	K9	8.14	23	578		8.16	25	16	4914	428
5	450	K9	8.08	23	574		8.09	25	621	5880	617
6	500	K9	8.05	23	572		8.05	25	619	6840	718
7	600	K9	8.02	23	570		8.02	25	616	7015	737
8	700	K9	8.01	23	569		8.01	25	15	9622	1010
9	800	K9	8.00	23	569		8.01	25	615	12550	1318
10	900	K9	8.00	23	569		8.00	25	615	15314	1608
11	1000	K9	8.00	23	568		8.00	25	615	18354	1927
12	1100	K9	8.00	23	568		8.00	25	615	21600	2268

TABLE: 1.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		8.00	mld	2nd stage flow		8.65	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	663	473	3,597	4,260	732	548	4,171	4,903	1,174	250	5,705
2	608	434	3,298	3,905	663	497	3,779	4,443	1,064	300	5,312
3	587	419	3,186	3,773	638	478	3,633	4,271	1,023	350	5,223
4	578	413	3,138	3,716	16	469	3,570	3,586	859	400	5,002
5	574	409	3,115	3,689	621	465	3,540	4,162	996	450	5,302
6	572	408	3,103	3,674	619	463	3,524	4,143	992	500	5,384

7	570	407	3,092	3,662	616	462	3,510	4,127	988	600	5,386
8	569	406	3,088	3,657	15	461	3,505	3,520	843	700	5,510
9	569	406	3,086	3,655	615	461	3,503	4,118	986	800	5,958
10	569	406	3,085	3,654	615	460	3,502	4,117	986	900	6,247
11	568	406	3,085	3,653	615	460	3,501	4,116	985	1,000	6,566
12	568	406	3,085	3,653	615	460	3,501	4,116	985	1,100	6,906

Minimum Capitalized cost Rs 5,002 thousands

Table: 2 Design of CWM from WTP to CWR

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	7.70	mld	250	DI	K9	140	2581
B.	Intermediate			2036	8.30	mld	300	DI	K9	140	3269
C.	Ultimate			2051	9.00	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	898	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	104.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600

CALCULATIONS:

	1st 15 years		2nd 15 years	
1) Discharge at Start OF PERIOD	7.70	mld	8.30	mld
2) Discharge at the end of 15 yrs	8.30	mld	9.00	mld
3) Average Flow	97	lps	104	lps
4) Average Discharge	8.00	mld	8.65	mld
5) Avg.pumping hours during the period	15.42	hrs	15.38	hrs
6) KW required at combined efficiency of pumping set	1.89	* H1	2.05	* H2
7) annual charges for energy Rs.	50688	* KW1	57527	* KW2

Modified Hazen William's Formula

$V=143.534 C_R r^{0.6575} S^{0.5525}$

$h=[L(Q/C_R)^{1.81}]/[994.62 D^{4.81}]$

Friction Head Loss (First 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)
250mm	1000	0.097	1.000	0.097	0.015	994.620	0.250	0.001	11.514
300mm	1000	0.097	1.000	0.097	0.015	994.620	0.300	0.003	4.790
350mm	1000	0.097	1.000	0.097	0.015	994.620	0.350	0.006	2.282
400mm	1000	0.097	1.000	0.097	0.015	994.620	0.400	0.012	1.201
450mm	1000	0.097	1.000	0.097	0.015	994.620	0.450	0.021	0.681
500mm	1000	0.097	1.000	0.097	0.015	994.620	0.500	0.036	0.410
600mm	1000	0.097	1.000	0.097	0.015	994.620	0.600	0.086	0.171
700mm	1000	0.097	1.000	0.097	0.015	994.620	0.700	0.180	0.081
800mm	1000	0.097	1.000	0.097	0.015	994.620	0.800	0.342	0.043
900mm	1000	0.097	1.000	0.097	0.015	994.620	0.900	0.602	0.024
1000mm	1000	0.097	1.000	0.097	0.015	994.620	1.000	1.000	0.015
1100 mm	1000	0.097	1.000	0.097	0.015	994.620	1.100	1.582	0.009

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.012	0.085	1.968
300	143.534	1.000	0.075	0.182	0.005	0.052	1.367
350	143.534	1.000	0.088	0.202			

					0.002	0.035	1.004
400	143.534	1.000	0.100	0.220	0.001	0.024	0.769
450	143.534	1.000	0.113	0.238	0.001	0.018	0.607
500	143.534	1.000	0.125	0.255	0.000	0.013	0.492
600	143.534	1.000	0.150	0.287	0.000	0.008	0.342
700	143.534	1.000	0.175	0.318	0.000	0.006	0.251
800	143.534	1.000	0.200	0.347	0.000	0.004	0.192
900	143.534	1.000	0.225	0.375	0.000	0.003	0.152
1000	143.534	1.000	0.250	0.402	0.000	0.002	0.123
1100	143.534	1.000	0.275	0.428	0.000	0.002	0.102

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)
250mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.250	0.001	13.262
300mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.300	0.003	5.518
350mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.350	0.006	2.629
400mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.400	0.012	1.383
450mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.450	0.021	0.785
500mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.500	0.036	0.473
600mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.600	0.086	0.197
700mm	1,000.000	0.104	1.000	0.104					

					0.017	994.620	0.700	0.180	0.094
800mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.800	0.342	0.049
900mm	1,000.000	0.104	1.000	0.104	0.017	994.620	0.900	0.602	0.028
1000mm	1,000.000	0.104	1.000	0.104	0.017	994.620	1.000	1.000	0.017
1100 mm	1,000.000	0.104	1.000	0.104	0.017	994.620	1.100	1.582	0.011

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.013	0.092	2.128
300	143.534	1.000	0.075	0.182	0.006	0.057	1.478
350	143.534	1.000	0.088	0.202	0.003	0.038	1.086
400	143.534	1.000	0.100	0.220	0.001	0.026	0.831
450	143.534	1.000	0.113	0.238	0.001	0.019	0.657
500	143.534	1.000	0.125	0.255	0.000	0.015	0.532
600	143.534	1.000	0.150	0.287	0.000	0.009	0.369
700	143.534	1.000	0.175	0.318	0.000	0.006	0.271
800	143.534	1.000	0.200	0.347	0.000	0.004	0.208
900	143.534	1.000	0.225	0.375	0.000	0.003	0.164
1000	143.534	1.000	0.250	0.402	0.000	0.002	0.133
1100	143.534	1.000	0.275	0.428	0.000	0.002	0.110

TABLE: 2.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		104	898.00		104
								104.00	2nd stage flow		
1	250	11.51	13.26	1.97	2.13	10.34	1.03	115.37	11.91	1.19	117.10
2	300	4.79	5.52	1.37	1.48	4.30	0.43	108.73	4.95	0.50	109.45
3	350	2.28	2.63	1.00	1.09	2.05	0.20	106.25	2.36	0.24	106.60
4	400	1.20	1.38	0.77	0.83	1.08	0.11	105.19	1.24	0.12	105.37
5	450	0.68	0.78	0.61	0.66	0.61	0.06	104.67	0.70	0.07	104.78
6	500	0.41	0.47	0.49	0.53	0.37	0.04	104.41	0.42	0.04	104.47
7	600	0.17	0.20	0.34	0.37	0.15	0.02	104.17	0.18	0.02	104.19
8	700	0.08	0.09	0.25	0.27	0.07	0.01	104.08	0.08	0.01	104.09
9	800	0.04	0.05	0.19	0.21	0.04	0.00	104.04	0.04	0.00	104.05
10	900	0.02	0.03	0.15	0.16	0.02	0.00	104.02	0.03	0.00	104.03
11	1000	0.01	0.02	0.12	0.13	0.01	0.00	104.01	0.02	0.00	104.02
12	1100	0.01	0.01	0.10	0.11	0.01	0.00	104.01	0.01	0.00	104.01

TABLE: 2.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

			1st stage flow in MLD		8.00		2nd stage flow in MLD		8.65		
S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
					25000				25000		898
1	250	K9	115.37	328	8196		117.10	360	8995	2581	2318
2	300	K9	108.73	309	7725		109.45	336	8407	3269	2936
3	350	K9	106.25	302	7549		106.60	328	8188	4075	3659
4	400	K9	105.19	299	7473		105.37	324	2651	4914	3659
5	450	K9	104.67	297	7436		104.78	322	8048	5880	5280

6	500	K9	104.41	297	7417		104.47	321	8025	6840	6142
7	600	K9	104.17	296	7400		104.19	320	8004	7015	6299
8	700	K9	104.08	296	7394		104.09	320	2560	9622	8641
9	800	K9	104.04	296	7391		104.05	320	7993	12550	11270
10	900	K9	104.02	296	7390		104.03	320	7991	15314	13752
11	1000	K9	104.01	296	7389		104.02	320	7990	18354	16482
12	1100	K9	104.01	296	7389		104.01	320	7990	21600	19397

TABLE: 2.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		8.00	mld	2nd stage flow		8.65	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	8,196	5,848	44,480	52,677	8,995	6,736	51,237	60,232	14,420	250	69,414
2	7,725	5,511	41,920	49,644	8,407	6,296	47,890	56,297	13,478	300	66,058
3	7,549	5,386	40,965	48,513	8,188	6,132	46,641	54,829	13,126	350	65,299
4	7,473	5,332	40,553	48,025	2,651	6,061	46,103	48,754	11,672	400	63,357
5	7,436	5,306	40,355	47,791	8,048	6,027	45,844	53,893	12,902	450	65,974
6	7,417	5,292	40,252	47,669	8,025	6,010	45,709	53,734	12,864	500	66,676
7	7,400	5,280	40,160	47,561	8,004	5,994	45,590	53,594	12,831	600	66,691
8	7,394	5,276	40,126	47,521	2,560	5,988	45,545	48,105	11,517	700	67,678
9	7,391	5,274	40,112	47,503	7,993	5,986	45,526	53,519	12,813	800	71,586

10	7,390	5,273	40,105	47,495	7,991	5,984	45,517	53,508	12,810	900	74,057
11	7,389	5,272	40,101	47,490	7,990	5,984	45,512	53,502	12,809	1,000	76,781
12	7,389	5,272	40,099	47,488	7,990	5,983	45,510	53,499	12,808	1,100	79,693

Minimum Capitalized cost Rs 63,357 thousands

Table: 3 Design of CWM from CWR to OHSR 1

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	2.48	mld	250	DI	K9	140	2581
B.	Intermediate			2036	2.70	mld	300	DI	K9	140	3269
C.	Ultimate			2051	2.91	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	1279	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	10.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600

CALCULATIONS:					1st 15 years		2nd 15 years	
1) Discharge at Start OF PERIOD					2.48	mld	2.70	mld
2) Discharge at the end of 15 yrs					2.70	mld	2.91	mld
3) Average Flow					31	lps	34	lps
4) Average Discharge					2.59	mld	2.81	mld
5) Avg.pumping hours during the period					15.35	hrs	15.42	hrs
6) KW required at combined efficiency of pumping set					0.61	* H1	0.66	* H2
7) annual charges for energy Rs.					16332	* KW1	18709	* KW2

Modified Hazen William's Formula

$$V= 143.534 CR\, r^{0.6575} S^{0.5525}$$

$$h= [L(Q/CR)^{1.81}]/[994.62 D^{4.81}]$$

Friction Head Loss (First 15 years)

Dia. in	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)

mm									
250mm	1000	0.031	1.000	0.031	0.002	994.620	0.250	0.001	1.495
300mm	1000	0.031	1.000	0.031	0.002	994.620	0.300	0.003	0.622
350mm	1000	0.031	1.000	0.031	0.002	994.620	0.350	0.006	0.296
400mm	1000	0.031	1.000	0.031	0.002	994.620	0.400	0.012	0.156
450mm	1000	0.031	1.000	0.031	0.002	994.620	0.450	0.021	0.088
500mm	1000	0.031	1.000	0.031	0.002	994.620	0.500	0.036	0.053
600mm	1000	0.031	1.000	0.031	0.002	994.620	0.600	0.086	0.022
700mm	1000	0.031	1.000	0.031	0.002	994.620	0.700	0.180	0.011
800mm	1000	0.031	1.000	0.031	0.002	994.620	0.800	0.342	0.006
900mm	1000	0.031	1.000	0.031	0.002	994.620	0.900	0.602	0.003
1000mm	1000	0.031	1.000	0.031	0.002	994.620	1.000	1.000	0.002
1100 mm	1000	0.031	1.000	0.031	0.002	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.027	0.637
300	143.534	1.000	0.075	0.182	0.001	0.017	0.442
350	143.534	1.000	0.088	0.202	0.000	0.011	0.325
400	143.534	1.000	0.100	0.220	0.000	0.008	0.249
450			0.113				0.197

	143.534	1.000		0.238	0.000	0.006	
500	143.534	1.000	0.125	0.255	0.000	0.004	0.159
600	143.534	1.000	0.150	0.287	0.000	0.003	0.111
700	143.534	1.000	0.175	0.318	0.000	0.002	0.081
800	143.534	1.000	0.200	0.347	0.000	0.001	0.062
900	143.534	1.000	0.225	0.375	0.000	0.001	0.049
1000	143.534	1.000	0.250	0.402	0.000	0.001	0.040
1100	143.534	1.000	0.275	0.428	0.000	0.001	0.033

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)
250mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.250	0.001	1.727
300mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.300	0.003	0.719
350mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.350	0.006	0.342
400mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.400	0.012	0.180
450mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.450	0.021	0.102
500mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.500	0.036	0.062
600mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.600	0.086	0.026
700mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.700	0.180	0.012
800mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.800	0.342	0.006

900mm	1,000.000	0.034	1.000	0.034	0.002	994.620	0.900	0.602	0.004
1000mm	1,000.000	0.034	1.000	0.034	0.002	994.620	1.000	1.000	0.002
1100 mm	1,000.000	0.034	1.000	0.034	0.002	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.002	0.030	0.690
300	143.534	1.000	0.075	0.182	0.001	0.018	0.479
350	143.534	1.000	0.088	0.202	0.000	0.012	0.352
400	143.534	1.000	0.100	0.220	0.000	0.009	0.270
450	143.534	1.000	0.113	0.238	0.000	0.006	0.213
500	143.534	1.000	0.125	0.255	0.000	0.005	0.173
600	143.534	1.000	0.150	0.287	0.000	0.003	0.120
700	143.534	1.000	0.175	0.318	0.000	0.002	0.088
800	143.534	1.000	0.200	0.347	0.000	0.001	0.067
900	143.534	1.000	0.225	0.375	0.000	0.001	0.053
1000	143.534	1.000	0.250	0.402	0.000	0.001	0.043
1100	143.534	1.000	0.275	0.428	0.000	0.001	0.036

TABLE: 3.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		10	1279.00		10
								10.00	2nd stage flow		
1	250	1.50	1.73	0.64	0.69	1.91	0.19	12.10	2.21	0.22	12.43
2	300	0.62	0.72	0.44	0.48	0.80	0.08	10.88	0.92	0.09	11.01
3	350	0.30	0.34	0.33	0.35	0.38	0.04	10.42	0.44	0.04	10.48
4	400	0.16	0.18	0.25	0.27	0.20	0.02	10.22	0.23	0.02	10.25
5	450	0.09	0.10	0.20	0.21	0.11	0.01	10.12	0.13	0.01	10.14
6	500	0.05	0.06	0.16	0.17	0.07	0.01	10.07	0.08	0.01	10.09
7	600	0.02	0.03	0.11	0.12	0.03	0.00	10.03	0.03	0.00	10.04
8	700	0.01	0.01	0.08	0.09	0.01	0.00	10.01	0.02	0.00	10.02
9	800	0.01	0.01	0.06	0.07	0.01	0.00	10.01	0.01	0.00	10.01
10	900	0.00	0.00	0.05	0.05	0.00	0.00	10.00	0.00	0.00	10.01
11	1000	0.00	0.00	0.04	0.04	0.00	0.00	10.00	0.00	0.00	10.00
12	1100	0.00	0.00	0.03	0.04	0.00	0.00	10.00	0.00	0.00	10.00

TABLE: 3.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
			1st stage flow in MLD		2.59		2nd stage flow in MLD		2.81		
					25000				25000		1279
1	250	K9	12.10	11	278		12.43	12	310	2581	3301
2	300	K9	10.88	10	250		11.01	11	274	3269	4181
3	350	K9	10.42	10	240		10.48	10	261	4075	5212
4	400	K9	10.22	9	235		10.25	10	3	4914	5212

5	450	K9	10.12	9	233		10.14	10	253	5880	7521
6	500	K9	10.07	9	232		10.09	10	251	6840	8748
7	600	K9	10.03	9	231		10.04	10	250	7015	8972
8	700	K9	10.01	9	230		10.02	10	2	9622	12307
9	800	K9	10.01	9	230		10.01	10	249	12550	16051
10	900	K9	10.00	9	230		10.01	10	249	15314	19587
11	1000	K9	10.00	9	230		10.00	10	249	18354	23475
12	1100	K9	10.00	9	230		10.00	10	249	21600	27626

TABLE: 3.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		2.59	mld	2nd stage flow		2.81	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	278	198	1,504	1,782	310	233	1,769	2,078	498	250	5,581
2	250	178	1,351	1,601	274	206	1,567	1,841	441	300	6,223
3	240	170	1,294	1,534	261	196	1,492	1,753	420	350	7,165
4	235	167	1,269	1,505	3	192	1,459	1,462	350	400	7,066
5	233	165	1,258	1,491	253	190	1,443	1,696	406	450	9,417
6	232	165	1,252	1,483	251	189	1,435	1,687	404	500	10,635
7	231	164	1,246	1,477	250	188	1,428	1,678	402	600	10,851
8			1,244				1,425				

	230	164		1,474	2	187		1,428	342	700	14,123
9	230	163	1,243	1,473	249	187	1,424	1,674	401	800	17,925
10	230	163	1,243	1,473	249	187	1,424	1,673	401	900	21,460
11	230	163	1,243	1,473	249	187	1,423	1,673	400	1,000	25,348
12	230	163	1,242	1,472	249	187	1,423	1,672	400	1,100	29,499

Minimum Capitalized cost Rs 5,581 thousands

Table: 4 Design of CWM from CWR to OHSR 2

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	2.00	mld	250	DI	K9	140	2581
B.	Intermediate			2036	2.20	mld	300	DI	K9	140	3269
C.	Ultimate			2051	2.40	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	451	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	34.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600

CALCULATIONS:					1st 15 years		2nd 15 years	
1) Discharge at Start OF PERIOD					2.00	mld	2.20	mld
2) Discharge at the end of 15 yrs					2.20	mld	2.40	mld
3) Average Flow					25	lps	28	lps
4) Average Discharge					2.10	mld	2.30	mld
5) Avg.pumping hours during the period					15.27	hrs	15.33	hrs
6) KW required at combined efficiency of pumping set					0.50	* H1	0.54	* H2
7) annual charges for energy Rs.					13177	* KW1	15252	* KW2

Modified Hazen William's Formula

$$V=143.534 C_R r^{0.6575} S^{0.5525}$$

$$h=[L(Q/C_R)^{1.81}]/[994.62 D^{4.81}]$$

Friction Head Loss (First 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)
250mm	1000	0.025	1.000	0.025	0.001	994.620	0.250	0.001	1.023
300mm	1000	0.025	1.000	0.025	0.001	994.620	0.300	0.003	0.426
350mm	1000	0.025	1.000	0.025	0.001	994.620	0.350	0.006	0.203
400mm	1000	0.025	1.000	0.025	0.001	994.620	0.400	0.012	0.107
450mm	1000	0.025	1.000	0.025	0.001	994.620	0.450	0.021	0.061
500mm	1000	0.025	1.000	0.025	0.001	994.620	0.500	0.036	0.036
600mm	1000	0.025	1.000	0.025	0.001	994.620	0.600	0.086	0.015
700mm	1000	0.025	1.000	0.025	0.001	994.620	0.700	0.180	0.007
800mm	1000	0.025	1.000	0.025	0.001	994.620	0.800	0.342	0.004
900mm	1000	0.025	1.000	0.025	0.001	994.620	0.900	0.602	0.002
1000mm	1000	0.025	1.000	0.025	0.001	994.620	1.000	1.000	0.001
1100 mm	1000	0.025	1.000	0.025	0.001	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.022	0.517
300	143.534	1.000	0.075	0.182	0.000	0.014	0.359
350	143.534	1.000	0.088	0.202	0.000	0.009	0.264
400	143.534	1.000	0.100	0.220	0.000	0.006	0.202
450					0.000	0.005	

	143.534	1.000	0.113	0.238			0.159
500	143.534	1.000	0.125	0.255	0.000	0.004	0.129
600	143.534	1.000	0.150	0.287	0.000	0.002	0.090
700	143.534	1.000	0.175	0.318	0.000	0.001	0.066
800	143.534	1.000	0.200	0.347	0.000	0.001	0.050
900	143.534	1.000	0.225	0.375	0.000	0.001	0.040
1000	143.534	1.000	0.250	0.402	0.000	0.001	0.032
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.027

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)
250mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.250	0.001	1.206
300mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.300	0.003	0.502
350mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.350	0.006	0.239
400mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.400	0.012	0.126
450mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.450	0.021	0.071
500mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.500	0.036	0.043
600mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.600	0.086	0.018
700mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.700	0.180	0.009
800mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.800	0.342	0.004
900mm	1,000.000	0.028	1.000	0.028	0.002	994.620	0.900	0.602	0.003

1000mm	1,000.000	0.028	1.000	0.028	0.002	994.620	1.000	1.000	0.002
1100 mm	1,000.000	0.028	1.000	0.028	0.002	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.024	0.566
300	143.534	1.000	0.075	0.182	0.001	0.015	0.393
350	143.534	1.000	0.088	0.202	0.000	0.010	0.289
400	143.534	1.000	0.100	0.220	0.000	0.007	0.221
450	143.534	1.000	0.113	0.238	0.000	0.005	0.175
500	143.534	1.000	0.125	0.255	0.000	0.004	0.141
600	143.534	1.000	0.150	0.287	0.000	0.002	0.098
700	143.534	1.000	0.175	0.318	0.000	0.002	0.072
800	143.534	1.000	0.200	0.347	0.000	0.001	0.055
900	143.534	1.000	0.225	0.375	0.000	0.001	0.044
1000	143.534	1.000	0.250	0.402	0.000	0.001	0.035
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.029

TABLE: 4.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		34	451.00		34
								34.00	2nd stage flow		
1	250	1.02	1.21	0.52	0.57	0.46	0.05	34.51	0.54	0.05	34.60
2	300	0.43	0.50	0.36	0.39	0.19	0.02	34.21	0.23	0.02	34.25
3	350	0.20	0.24	0.26	0.29	0.09	0.01	34.10	0.11	0.01	34.12
4	400	0.11	0.13	0.20	0.22	0.05	0.00	34.05	0.06	0.01	34.06
5	450	0.06	0.07	0.16	0.17	0.03	0.00	34.03	0.03	0.00	34.04
6	500	0.04	0.04	0.13	0.14	0.02	0.00	34.02	0.02	0.00	34.02
7	600	0.02	0.02	0.09	0.10	0.01	0.00	34.01	0.01	0.00	34.01
8	700	0.01	0.01	0.07	0.07	0.00	0.00	34.00	0.00	0.00	34.00
9	800	0.00	0.00	0.05	0.06	0.00	0.00	34.00	0.00	0.00	34.00
10	900	0.00	0.00	0.04	0.04	0.00	0.00	34.00	0.00	0.00	34.00
11	1000	0.00	0.00	0.03	0.04	0.00	0.00	34.00	0.00	0.00	34.00
12	1100	0.00	0.00	0.03	0.03	0.00	0.00	34.00	0.00	0.00	34.00

TABLE: 4.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

			1st stage flow in MLD		2.10		2nd stage flow in MLD		2.30		
S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
					25000				25000		451
1	250	K9	34.51	26	644		34.60	28	707	2581	1164
2	300	K9	34.21	26	638		34.25	28	700	3269	1474
3	350	K9	34.10	25	636		34.12	28	697	4075	1838

4	400	K9	34.05	25	635		34.06	28	19	4914	1838
5	450	K9	34.03	25	635		34.04	28	695	5880	2652
6	500	K9	34.02	25	634		34.02	28	695	6840	3085
7	600	K9	34.01	25	634		34.01	28	695	7015	3164
8	700	K9	34.00	25	634		34.00	28	19	9622	4340
9	800	K9	34.00	25	634		34.00	28	694	12550	5660
10	900	K9	34.00	25	634		34.00	28	694	15314	6907
11	1000	K9	34.00	25	634		34.00	28	694	18354	8278
12	1100	K9	34.00	25	634		34.00	28	694	21600	9742

TABLE: 4.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		2.10	mld	2nd stage flow		2.30	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	644	455	3,459	4,102	707	528	4,014	4,720	1,130	250	6,396
2	638	451	3,429	4,067	700	522	3,973	4,673	1,119	300	6,660
3	636	449	3,418	4,054	697	520	3,958	4,655	1,114	350	7,006
4	635	449	3,413	4,048	19	520	3,951	3,971	951	400	6,836
5	635	448	3,411	4,045	695	519	3,948	4,643	1,112	450	7,809
6	634	448	3,409	4,044	695	519	3,947	4,642	1,111	500	8,240

7	634	448	3,408	4,043	695	519	3,945	4,640	1,111	600	8,317
8	634	448	3,408	4,042	19	519	3,945	3,964	949	700	9,331
9	634	448	3,408	4,042	694	519	3,944	4,639	1,111	800	10,813
10	634	448	3,408	4,042	694	519	3,944	4,639	1,111	900	12,059
11	634	448	3,408	4,042	694	519	3,944	4,639	1,111	1,000	13,430
12	634	448	3,408	4,042	694	519	3,944	4,639	1,111	1,100	14,894

Minimum Capitalized cost Rs 6,396 thousands

Table: 5 Design of CWM from CWR to OHSR 3

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	1.55	mld	250	DI	K9	140	2581
B.	Intermediate			2036	1.68	mld	300	DI	K9	140	3269
C.	Ultimate			2051	1.80	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	1870	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	46.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600

CALCULATIONS:

					1st 15 years		2nd 15 years	
1) Discharge at Start OF PERIOD					1.55	mld	1.68	mld
2) Discharge at the end of 15 yrs					1.68	mld	1.80	mld
3) Average Flow					20	lps	21	lps
4) Average Discharge					1.62	mld	1.74	mld
5) Avg.pumping hours during the period					15.38	hrs	15.47	hrs
6) KW required at combined efficiency of pumping set					0.38	* H1	0.41	* H2
7) annual charges for energy Rs.					10206	* KW 1	11639	* KW2

Modified Hazen William's Formula

$$V=143.534 C_R r^{0.6575} S^{0.5525}$$

$$h=[L(Q/C_R)^{1.81}]/[994.62 D^{4.81}]$$

Friction Head Loss (First 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)
250mm	1000	0.020	1.000	0.020	0.001	994.620	0.250	0.001	0.636
300mm	1000	0.020	1.000	0.020	0.001	994.620	0.300	0.003	0.265
350mm	1000	0.020	1.000	0.020	0.001	994.620	0.350	0.006	0.126
400mm	1000	0.020	1.000	0.020	0.001	994.620	0.400	0.012	0.066
450mm	1000	0.020	1.000	0.020	0.001	994.620	0.450	0.021	0.038
500mm	1000	0.020	1.000	0.020	0.001	994.620	0.500	0.036	0.023
600mm	1000	0.020	1.000	0.020	0.001	994.620	0.600	0.086	0.009
700mm	1000	0.020	1.000	0.020	0.001	994.620	0.700	0.180	0.004
800mm	1000	0.020	1.000	0.020	0.001	994.620	0.800	0.342	0.002
900mm	1000	0.020	1.000	0.020	0.001	994.620	0.900	0.602	0.001
1000mm	1000	0.020	1.000	0.020	0.001	994.620	1.000	1.000	0.001
1100 mm	1000	0.020	1.000	0.020	0.001	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.017	0.397
300	143.534	1.000	0.075	0.182	0.000	0.011	0.276
350	143.534	1.000	0.088	0.202	0.000	0.007	0.203
400	143.534	1.000	0.100	0.220	0.000	0.005	0.155
450	143.534	1.000	0.113	0.238	0.000	0.004	0.123
500	143.534	1.000	0.125	0.255	0.000	0.003	0.099
600	143.534	1.000	0.150	0.287	0.000	0.002	0.069
700	143.534	1.000	0.175	0.318	0.000	0.001	0.051
800	143.534	1.000	0.200	0.347	0.000	0.001	0.039
900	143.534	1.000	0.225	0.375	0.000	0.001	0.031
1000	143.534	1.000	0.250	0.402	0.000	0.000	0.025
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.021

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)

250mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.250	0.001	0.728
300mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.300	0.003	0.303
350mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.350	0.006	0.144
400mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.400	0.012	0.076
450mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.450	0.021	0.043
500mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.500	0.036	0.026
600mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.600	0.086	0.011
700mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.700	0.180	0.005
800mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.800	0.342	0.003
900mm	1,000.000	0.021	1.000	0.021	0.001	994.620	0.900	0.602	0.002
1000mm	1,000.000	0.021	1.000	0.021	0.001	994.620	1.000	1.000	0.001
1100 mm	1,000.000	0.021	1.000	0.021	0.001	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.018	0.428
300	143.534	1.000	0.075	0.182	0.000	0.011	0.297
350	143.534	1.000	0.088	0.202	0.000	0.008	0.218
400	143.534	1.000	0.100	0.220	0.000	0.005	0.167
450	143.534	1.000	0.113	0.238	0.000	0.004	0.132
500	143.534	1.000	0.125	0.255	0.000	0.003	0.107
600	143.534	1.000	0.150	0.287	0.000	0.002	0.074
700	143.534	1.000	0.175	0.318	0.000	0.001	0.055
800	143.534	1.000	0.200	0.347	0.000	0.001	0.042
900	143.534	1.000	0.225	0.375	0.000	0.001	0.033
1000	143.534	1.000	0.250	0.402	0.000	0.000	0.027
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.022

TABLE: 5.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		46	1870.00		46
								46.00	2nd stage flow		
1	250	0.64	0.73	0.40	0.43	1.19	0.12	47.31	1.36	0.14	47.50
2	300	0.26	0.30	0.28	0.30	0.49	0.05	46.54	0.57	0.06	46.62
3	350	0.13	0.14	0.20	0.22	0.24	0.02	46.26	0.27	0.03	46.30
4	400	0.07	0.08	0.16	0.17	0.12	0.01	46.14	0.14	0.01	46.16
5	450	0.04	0.04	0.12	0.13	0.07	0.01	46.08	0.08	0.01	46.09
6	500	0.02	0.03	0.10	0.11	0.04	0.00	46.05	0.05	0.00	46.05
7	600	0.01	0.01	0.07	0.07	0.02	0.00	46.02	0.02	0.00	46.02
8	700	0.00	0.01	0.05	0.05	0.01	0.00	46.01	0.01	0.00	46.01
9	800	0.00	0.00	0.04	0.04	0.00	0.00	46.00	0.01	0.00	46.01
10	900	0.00	0.00	0.03	0.03	0.00	0.00	46.00	0.00	0.00	46.00
11	1000	0.00	0.00	0.02	0.03	0.00	0.00	46.00	0.00	0.00	46.00
12	1100	0.00	0.00	0.02	0.02	0.00	0.00	46.00	0.00	0.00	46.00

TABLE: 5.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

			1st stage flow in MLD		1.62		2nd stage flow in MLD		1.74		
S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
					25000				25000		1870
1	250	K9	47.31	27	678		47.50	29	734	2581	4826
2	300	K9	46.54	27	668		46.62	29	720	3269	6113
3	350	K9	46.26	27	663		46.30	29	715	4075	7620
4	400	K9	46.14	26	662		46.16	29	20	4914	7620

5	450	K9	46.08	26	661		46.09	28	712	5880	10996
6	500	K9	46.05	26	660		46.05	28	712	6840	12791
7	600	K9	46.02	26	660		46.02	28	711	7015	13118
8	700	K9	46.01	26	660		46.01	28	20	9622	17993
9	800	K9	46.00	26	660		46.01	28	711	12550	23469
10	900	K9	46.00	26	660		46.00	28	711	15314	28637
11	1000	K9	46.00	26	660		46.00	28	711	18354	34322
12	1100	K9	46.00	26	660		46.00	28	711	21600	40392

TABLE: 5.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		1.62	mld	2nd stage flow		1.74	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	678	483	3,672	4,351	734	553	4,205	4,939	1,182	250	10,360
2	668	475	3,613	4,280	720	543	4,127	4,848	1,161	300	11,554
3	663	472	3,591	4,254	715	539	4,098	4,814	1,152	350	13,027
4	662	471	3,581	4,243	20	537	4,086	4,106	983	400	12,846
5	661	470	3,577	4,238	712	536	4,080	4,792	1,147	450	16,380
6	660	470	3,574	4,235	712	536	4,077	4,788	1,146	500	18,172
7	660	470	3,572	4,232	711	536	4,074	4,785	1,146	600	18,496
8	660	470	3,571	4,231	20	536	4,073	4,093	980	700	23,204
9	660	470	3,571		711						28,845

				4,231		535	4,073	4,783	1,145	800	
10	660	469	3,571	4,231	711	535	4,072	4,783	1,145	900	34,013
11	660	469	3,571	4,231	711	535	4,072	4,783	1,145	1,000	39,698
12	660	469	3,571	4,231	711	535	4,072	4,783	1,145	1,100	45,768

Minimum Capitalized cost Rs 10,360 thousands

Table: 6 Design of CWM from CWR to OHSR 4

1) Water requirement :				Year	Peak Discharge		Pipe Dia in mm	Material	Class	HWC	Rate Rs/m
A.	Initial			2021	1.58	mld	250	DI	K9	140	2581
B.	Intermediate			2036	1.71	mld	300	DI	K9	140	3269
C.	Ultimate			2051	1.90	mld	350	DI	K9	140	4075
2) Pumping main				LENGTH	1873	M	400	DI	K9	140	4914
3) Static head for pump				ST.HEAD	15.00	M	450	DI	K9	140	5880
4) Design period				YEAR	30	yr.	500	DI	K9	140	6840
5) Combined eff. of pump set				EFF. %	75	%	600	DI	K9	140	9021
6) Cost of pumping unit				Rs./KW	25000	Rs	700	DI	K9	140	11667
7) Interest rate				INTEREST	10.00	%	800	DI	K9	140	13092
8) Life of electric motor & pump set				P.Yrs	15	yr.	900	DI	K9	140	14445
9) Energy charges per kWh				P/KWH	500	paise	1000	DI	K9	140	17169
10) Pumping hours for discharge at the end of 15 years				hours	16	hrs	1100	DI	K9	140	21600

CALCULATIONS:

					1st 15 years		2nd 15 years	
1) Discharge at Start OF PERIOD					1.58	mld	1.71	mld
2) Discharge at the end of 15 yrs					1.71	mld	1.90	mld
3) Average Flow					20	lps	22	lps
4) Average Discharge					1.65	mld	1.81	mld
5) Avg.pumping hours during the period					15.39	hrs	15.20	hrs
6) KW required at combined efficiency of pumping set					0.39	* H1	0.43	* H2
7) annual charges for energy Rs.					10403	* KW1	11865	* KW2

Modified Hazen William's Formula

$$V=143.534 CR\, r^{0.6575} S^{0.5525}$$

$$h=[L(Q/CR)^{1.81}]/[994.62 D^{4.81}]$$

Friction Head Loss (First 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(First 15 yrs)
250mm	1000	0.020	1.000	0.020	0.001	994.620	0.250	0.001	0.657
300mm	1000	0.020	1.000	0.020	0.001	994.620	0.300	0.003	0.274
350mm	1000	0.020	1.000	0.020	0.001	994.620	0.350	0.006	0.130
400mm	1000	0.020	1.000	0.020	0.001	994.620	0.400	0.012	0.069
450mm	1000	0.020	1.000	0.020	0.001	994.620	0.450	0.021	0.039
500mm	1000	0.020	1.000	0.020	0.001	994.620	0.500	0.036	0.023
600mm	1000	0.020	1.000	0.020	0.001	994.620	0.600	0.086	0.010
700mm	1000	0.020	1.000	0.020	0.001	994.620	0.700	0.180	0.005
800mm	1000	0.020	1.000	0.020	0.001	994.620	0.800	0.342	0.002
900mm	1000	0.020	1.000	0.020	0.001	994.620	0.900	0.602	0.001
1000mm	1000	0.020	1.000	0.020	0.001	994.620	1.000	1.000	0.001
1100 mm	1000	0.020	1.000	0.020	0.001	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.017	0.405
300	143.534	1.000	0.075	0.182	0.000	0.011	0.281
350	143.534	1.000	0.088	0.202	0.000	0.007	0.206
400	143.534	1.000	0.100	0.220	0.000	0.005	0.158
450	143.534	1.000	0.113	0.238	0.000	0.004	0.125
500	143.534	1.000	0.125	0.255	0.000	0.003	0.101
600	143.534	1.000	0.150	0.287	0.000	0.002	0.070
700	143.534	1.000	0.175	0.318	0.000	0.001	0.052
800	143.534	1.000	0.200	0.347	0.000	0.001	0.040
900	143.534	1.000	0.225	0.375	0.000	0.001	0.031
1000	143.534	1.000	0.250	0.402	0.000	0.000	0.025
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.021

Friction Head Loss (Second 15 years)

Dia. in mm	L	Q	CR	Q/CR	(Q/CR)1.81	994.62	D	D4.81	h(Second 15 yrs)
250mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.250	0.001	0.778
300mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.300	0.003	0.324
350mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.350	0.006	0.154
400mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.400	0.012	0.081
450mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.450	0.021	0.046
500mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.500	0.036	0.028
600mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.600	0.086	0.012
700mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.700	0.180	0.005
800mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.800	0.342	0.003
900mm	1,000.000	0.022	1.000	0.022	0.001	994.620	0.900	0.602	0.002
1000mm	1,000.000	0.022	1.000	0.022	0.001	994.620	1.000	1.000	0.001
1100 mm	1,000.000	0.022	1.000	0.022	0.001	994.620	1.100	1.582	0.001

Velocity

Dia. in mm	143.534	CR	r=A/P=D/4	r0.6575	S	S0.5525	V
250	143.534	1.000	0.063	0.162	0.001	0.019	0.444
300	143.534	1.000	0.075	0.182	0.000	0.012	0.308
350	143.534	1.000	0.088	0.202	0.000	0.008	0.227
400	143.534	1.000	0.100	0.220	0.000	0.005	0.173
450	143.534	1.000	0.113	0.238	0.000	0.004	0.137
500	143.534	1.000	0.125	0.255	0.000	0.003	0.111
600	143.534	1.000	0.150	0.287	0.000	0.002	0.077
700	143.534	1.000	0.175	0.318	0.000	0.001	0.057
800	143.534	1.000	0.200	0.347	0.000	0.001	0.043
900	143.534	1.000	0.225	0.375	0.000	0.001	0.034
1000	143.534	1.000	0.250	0.402	0.000	0.000	0.028
1100	143.534	1.000	0.275	0.428	0.000	0.000	0.023

TABLE: 6.1 VELOCITY AND HEADLOSSES FOR DIFFERENT PIPE SIZES

S No	Pipe Size in mm	friction head loss per 1000 m		Velocity in m/sec	Velocity in m/sec	Friction head loss	other losses at 10%	total losses (H1) including static head	Friction head loss in total pipe length	other losses at 10%	total losses (H2) including static head
		1st stage flow	2nd stage flow	1st stage flow	2nd stage flow	1st stage flow		15	1873.00		15
								15.00	2nd stage flow		
1	250	0.66	0.78	0.40	0.44	1.23	0.12	16.35	1.46	0.15	16.60
2	300	0.27	0.32	0.28	0.31	0.51	0.05	15.56	0.61	0.06	15.67
3	350	0.13	0.15	0.21	0.23	0.24	0.02	15.27	0.29	0.03	15.32
4	400	0.07	0.08	0.16	0.17	0.13	0.01	15.14	0.15	0.02	15.17
5	450	0.04	0.05	0.12	0.14	0.07	0.01	15.08	0.09	0.01	15.09
6	500	0.02	0.03	0.10	0.11	0.04	0.00	15.05	0.05	0.01	15.06
7	600	0.01	0.01	0.07	0.08	0.02	0.00	15.02	0.02	0.00	15.02
8	700	0.00	0.01	0.05	0.06	0.01	0.00	15.01	0.01	0.00	15.01
9	800	0.00	0.00	0.04	0.04	0.00	0.00	15.01	0.01	0.00	15.01
10	900	0.00	0.00	0.03	0.03	0.00	0.00	15.00	0.00	0.00	15.00
11	1000	0.00	0.00	0.03	0.03	0.00	0.00	15.00	0.00	0.00	15.00
12	1100	0.00	0.00	0.02	0.02	0.00	0.00	15.00	0.00	0.00	15.00

TABLE: 6.2 KILOWATTS & COST OF PUMP SETS REQUIRED FOR DIFFERENT PIPE SIZES AND PIPE COST

			1st stage flow in MLD		1.65		2nd stage flow in MLD		1.81		
S No	Pipe Dia in mm	class of Pipe	H1 total head in meters	KW reqd plus 50% stand by	pump cost at Rs per Kw		H2 total head in meters	Kw required plus 50% stand by	Pump cost at Rs per KW	cost of pipe per meter	total cost of pipe in thousand Rs
					25000				25000		1873
1	250	K9	16.35	10	239		16.60	11	266	2581	4834
2	300	K9	15.56	9	227		15.67	10	251	3269	6123
3	350	K9	15.27	9	223		15.32	10	246	4075	7632
4	400	K9	15.14	9	221		15.17	10	2	4914	7632

5	450	K9	15.08	9	220		15.09	10	242	5880	11013
6	500	K9	15.05	9	220		15.06	10	241	6840	12811
7	600	K9	15.02	9	219		15.02	10	241	7015	13139
8	700	K9	15.01	9	219		15.01	10	2	9622	18022
9	800	K9	15.01	9	219		15.01	10	241	12550	23506
10	900	K9	15.00	9	219		15.00	10	240	15314	28683
11	1000	K9	15.00	9	219		15.00	10	240	18354	34377
12	1100	K9	15.00	9	219		15.00	10	240	21600	40457

TABLE: 6.3 COMPARATIVE STATEMENT OF OVERALL COST OF PUMPING MAIN FOR DIFFERENT PIPE SIZES

	1st stage flow		1.65	mld	2nd stage flow		1.81	mld			
S No	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Cost of pump set	Annual Energy Charges	capitalized energy cost	Pump cost+capitalized energy cost	Present cost of pump and capitalized cost of 2nd stage	Pipe Dia	Grand total cost first and second stage
	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	Thousand Rs	mm	Thousand Rs
1	239	170	1,294	1,533	266	197	1,498	1,764	422	250	6,790
2	227	162	1,231	1,459	251	186	1,414	1,665	399	300	7,980
3	223	159	1,208	1,431	246	182	1,382	1,628	390	350	9,453
4	221	158	1,198	1,419	2	180	1,369	1,371	328	400	9,380
5	220	157	1,193	1,413	242	179	1,362	1,604	384	450	12,811
6	220	157	1,191	1,410	241	179	1,359	1,600	383	500	14,605
7	219	156	1,188	1,408	241	178	1,356	1,597	382	600	14,929
8	219	156	1,188	1,407	2	178	1,355	1,357	325	700	19,754
9			1,187				1,354				

	219	156		1,406	241	178		1,595	382	800	25,294
10	219	156	1,187	1,406	240	178	1,354	1,595	382	900	30,471
11	219	156	1,187	1,406	240	178	1,354	1,594	382	1,000	36,165
12	219	156	1,187	1,406	240	178	1,354	1,594	382	1,100	42,245

Minimum Capitalized cost Rs 6,790 thousands

ANNEXURE B

Pump House Power Requirement

- Location of Pump House

   1) At Intake

   2) At Clear Water Release

- Kilowatts required for each rising main (including 50% standby)

   a) From intake to water treatment plant

First Stage	Second Stage
1.5*1.89*H1	1.5*2.02*H2
1.5*1.89*27.3	1.5*2.02*29.9
77.4 KW	90.6 KW

   b) From water treatment plant to clear water reservoir

First Stage	Second Stage
1.5*1.89*H1	1.5*2.02*H2
1.5*1.89*125.1	1.5*2.02*128.3
354.7 KW	388.74 KW

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