STUDY OF MEWAT FEEDER PIPELINE PROJECT USING WATERGEMS SOFTWARE

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

HYDRAULICS AND WATER RESOURCES ENGINEERING

Submitted by

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CANDIDAT E ’S DECLARATION

I, KULDEEP SINGH, Roll no. 2K20/HFE/501, M.Tech Hydraulics and Water Resources Engineering, hereby declare that the project Dissertation titled “**Study of Mewat Feeder Pipeline Project Using WaterGems Software**” which is submitted by me to the department Hydraulics and Water Resource Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technological, is original and not copied from any source without proper citation. This work has not previously formed the basis for any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the project Dissertation titled "**STUDY OF MEWAT FEEDER PIPELINE PROJECT USING WATER GEMS SOFTWARE**" which is submitted by **KULDEEP SINGH**, Roll number **2K20/HFE/501** of M.Tech Part Time **(HWRE),** Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is record of the project carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or fully for any Degree or Diploma To this University or elsewhere.

Place: Delhi **(Prof. Munendra Kumar)**

Date: **(SUPERVISOR)**

ACKNOWLEDGEMENT

I take this opportunity to express my sincere regards and deep gratitude to **Prof. Prof. Munendra Kumar** (professor, civil engineering department, DTU) for his consistent guidance, monitoring and constant encouragement throughout the course of this project work. Also, I express my gratitude to **Department of Civil Engineering, DTU** for giving me such an opportunity to commence this project in the first instance.

Professors and faculties of the civil engineering, DTU have been very supportive and cooperative. They have been always present for their kind opinions and suggestions regarding this project work and therefore I am deeply obliged to them.

Last but not the least, I would like to thank my family and my colleagues from the department who encouraged me to bring work to a successful close.

Place: Delhi

Date: (KULDEEP SINGH)

ABSTRACT

The principal objective of water distribution system engineers is to ensure the provision of water that satisfies the requirements for both quantity and pressure. Regrettably, with the progression of time, the efficacy of a water distribution system to convey water tends to decline while the usual demands imposed on it tend to escalate. Apart from the inadequate functioning of a degraded network, there exist direct economic repercussions of a malfunctioning infrastructure. The water distribution system is a hydraulic infrastructure that comprises various components, including pipes, tanks, reservoirs, pumps, and valves. Its primary function is to facilitate the provision of water to consumers, making it an essential aspect of water supply. The components that constitute a distribution system encompass distribution mains, arterial mains, storage reservoirs, and system accessories, such as valves, hydrants, mainline meters, service connections, and backflow preventers. Distribution mains refer to the pipelines that constitute the distribution system. The primary role of water pipes is to transport water from its source or treatment facility to end-users. The water distribution system can be bifurcated into two primary components: The intermittent system is characterized by the periodic supply of water throughout the day. The provision of water may occur intermittently during specific time periods, such as a limited duration in the morning or evening. The quality of water is comparatively inferior in instances where negative pressure is present, as opposed to a consistent water supply system. The potential for this system to pose a significant threat to public health exists due to the possibility of contaminated groundwater infiltrating the distribution network. (ii) A system that operates continuously without interruption or discrete steps. The distribution system is maintained at a constant pressure to prevent the ingress of contaminated groundwater into the water pipelines, even in the presence of minor leaks within the system. Hence, it is imperative to implement inspection, control, and planned maintenance and rehabilitation programs for the effective functioning of the extant water distribution systems. Currently, there remains a lack of a practical method for assessing the dependability of water distribution networks. The conventional approach to designing a water distribution network involves utilizing the proposed street layout and the topographical features of the area. The modeler employs proprietary software to simulate the flows and pressures within the network, as well as the inflows and outflows to and from the tank, which are critical for loading purposes. The principal objective of water utilities is to provide individual customers with the appropriate amount of water at adequate pressure via a distribution network. The allocation of potable water within

distribution networks poses a technical challenge in both quantitative and qualitative aspects. The KMP Expressway is a current undertaking of the Haryana government which aims to establish a connection between Kundli (Sonipat) and Palwal (Ballabhgarh) through Manesar once it is fully implemented. The Highway traverses through topographically distinct terrain characteristics and along its path, intersects with railway lines and water conveyance systems such as the Delhi sub Branch Carrier, NCR Channel, and the Gurgaon Canal. The proposed Mewat Feeder Pipeline is intended to be installed along the KMP Expressway, spanning from GWS Channel RD 50.500 km to the intersection of the Expressway and Gurgaon Canal, which is situated downstream from GWS.

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1.1 General

Water is an essential component of biological systems and holds considerable importance in the socio-economic advancement of a nation. The provision of water to domestic and industrial users is reliant upon the presence of a water distribution system, which is considered a critical component of infrastructure. The hydraulic components, including pipes, valves, pumps, and tanks, facilitate the connection between consumers and water sources. The process of designing such systems is a multifaceted undertaking that entails a multitude of interrelated elements and necessitates meticulous deliberation. The design process necessitates the consideration of various crucial design parameters. The aforementioned parameters encompass factors such as the demand for water, the minimum pressure thresholds, the topographical features of the area, the dependability of the system, the economic considerations, the piping infrastructure, as well as the pumping and energy consumption requirements. The principal aim of engineers responsible for water distribution systems is to guarantee the provision of water that satisfies the specified requirements for both quantity and pressure.

Regrettably, with the progression of time, the efficacy of a water distribution network to convey water tends to decline, whereas the requirements imposed on it usually escalate. Apart from the inadequate functioning of a deteriorated network, there exist direct economic ramifications of a malfunctioning system. The upkeep and restoration of the hydraulic infrastructure of a water distribution system, encompassing components such as pipes, tanks, reservoirs, pumps, and valves, is of paramount importance. The constituents of a distribution system comprise of distribution mains, arterial mains, storage reservoirs, and system accessories such as valves, hydrants, mainline meters, service connections, and backflow preventers. Distribution mains constitute the primary conduits of the distribution network, serving the crucial function of transporting water from either the source or treatment facilities to the ultimate consumers. The classification of water distribution systems can be broadly divided into two categories, namely intermittent systems and continuous systems. In a periodic system, water is periodically provided at consistent intervals throughout the day, typically for a limited duration during the morning or evening. Nonetheless, this system may encounter negative pressure-related challenges, leading to inferior water quality in contrast to a water supply system that operates continuously. The sporadic nature of the system also presents potential health hazards as a result of the potential infiltration of polluted groundwater into the distribution network.

Conversely, within a continuous system, the distribution network is consistently pressurized, thereby impeding the infiltration of polluted groundwater, even in the event of minor leaks. Efficient operation of extant water distribution systems necessitates the implementation of appropriate inspection, control, and planned maintenance and rehabilitation programs. At present, there exists no facile approach to assess the dependability of water distribution networks. Conventional methodologies for the design of water distribution systems are based on the proposed street layout and topographic data. In the field of modeling, it is common practice to employ proprietary software for the purpose of simulating fluid dynamics and pressure within a given network. Additionally, such software can be utilized to monitor the inflow and outflow of fluids to and from tanks, which is crucial in determining the requisite loading specifications. The principal aim of water utilities is to guarantee the provision of water to individual consumers via a distribution network, meeting the necessary quantity and adequate pressure standards. The distribution of potable water through networks presents technical complexities pertaining to both the volume and caliber of the water. Ensuring a uniform and adequate supply of water that satisfies all the required qualitative and quantitative criteria to every point in the distribution network is of utmost importance. Water supply in several Indian cities is restricted to a few hours per day with inconsistent pressure. Moreover, the reliability of water quality is frequently uncertain. The aforementioned concerns stem from sporadic water supply, insufficient pressure, and uncertain service, which result in economic and health-related burdens for households in India. In order to tackle this issue, it is crucial to pinpoint areas of high leakage within the distribution system. The study area for this research has been designated as Mewat City. A network model shall be formulated and evaluated to assess the water losses within the designated region. Through an examination of the network model, scholars can acquire valuable knowledge regarding the magnitude of water losses and pinpoint prospective regions for enhancement. The present study aims to facilitate the formulation of effective measures to mitigate water losses and optimize the distribution network's performance in Mewat City.

1.2 Project Background

The KMP Expressway is a current undertaking by the Government of Haryana which aims to establish a connection between Kundli (Sonipat) and Palwal (Ballabhgarh) through Manesar. The Highway traverses through topographically distinct terrain characteristics and along its path, intersects with railway lines and water conveyance systems such as the Delhi sub Branch Carrier, NCR Channel, and Gurgaon Canal. The proposed Mewat Feeder Pipeline is intended to be installed along the KMP Expressway, spanning from GWS Channel RD 50.500 km to the point where the Expressway intersects with Gurgaon Canal, which is located downstream from GWS. The Mewat Feeder Pipeline has been designed with the objective of transferring a volume of 210 Cusec water during the initial phase, and an additional 200 Cusec (maximum) for potential future expansion, into the Gurgaon Canal. The intended use of this water is for irrigation purposes. The proposed Project outlined in this document is intended to possess a local conveyance capacity of 5.95 cubic meters per second, which will be divided between two pipelines. Each pipeline will be engineered to accommodate a maximum flow rate of 100 cubic feet per second (2.83 cubic meters per second). The development of the system necessitates making determinations concerning diverse pipeline characteristics, specifically the material, diameter, thickness, and strength. Naturally, these determinations will be indicative of expenses related to building, accessibility, and general practicality. The longitudinal profile spanning from the GWS channel to its outfall point into the Gurgaon Canal covers a distance of approximately 51 km and exhibits an initial elevation increase followed by a subsequent decrease in NSL.

1.3 Project Objective

In order to formulate a comprehensive development plan pertaining to the feeder pipeline network of the distribution section in Mewat, it is necessary to undertake a thorough analysis and evaluation of the existing infrastructure and identify areas for improvement. The design of water supply networks aims to minimize scarcity, pressure fluctuations, and overall costs while meeting water demand requirements at sufficient pressures for specified maximum discharge over an extended period. This approach seeks to ensure that network operation and maintenance are both low and economical. In cases where the present network fails to meet present and future demand, recommendations for remedial measures may be necessary.

- To develop a model of pipe network based on WaterGEMS software.
- To determine the head losses and flows in pipes modelled system so that the desired water flow in network is achieved.

2.1 Review of literature

Jiang et al. (2015) published a study in which hydraulic modeling of a dynamic pipe network is a method employed to optimize the scheduling and scientific operations of a municipal water supply network. The fundamental procedures for modeling pipe networks involve the acquisition of primary data, encompassing the identification of flow and pressure nodes. The acquisition and importation of model work through SCADA data is crucial in the establishment of an accurate model. The utilization of GIS data within an urban pipeline network results in the development of a dynamic model for the water supply network. The utilization of WaterGEMS for a comprehensive examination of the functioning of a water supply system is presented, with the aim of demonstrating the establishment of a model for the network, utilizing SCADA data as a basis. Practical illustrations are provided to support this approach.

Germanopoulos and Matsouki (2016) authored a study which involves EYDAP, is the organization responsible for providing water supply and sewerage services to the metropolitan area of Athens, Greece, as well as its surrounding suburbs and adjacent regions, which collectively support a populace of approximately 3.7 million individuals. The aggregate water usage in the year 2002 amounted to 421.7 million cubic meters. There are currently four operational water treatment plants, collectively possessing a capacity of 2.050.000 m3 per day. The aggregate length of the water distribution system surpasses 7000 kilometers. The area of supply is characterized by a significant variation in ground levels, resulting in the definition of over 200 pressure zones. Since 1992, a simulation model has been developed for the EYDAP principal mains network, which typically has a diameter greater than 300 mm. This model has been utilized to enhance operational efficiency and provide insight for future capital investment determinations. During the development of the model, a significant amount of data from numerous paper drawings and sketches was compiled and analyzed. To achieve model calibration, 483 hydraulic parameters were monitored through a combination of field measurements and data sourced from the pre-existing telemetry system. As a result of the vast coverage of the network, nine sub-networks were established, each of which was subjected to a distinct field program. Given the supplementary difficulty of managing the network to accommodate the demands and necessities of the Athens 2004 Olympics, the model underwent revisions and was employed to replicate the functioning of the primary mains network throughout the duration of the event. To derive the water demand and its spatial distribution during the Olympic Games, population estimates were generated for every municipality within the supply area. The study took into account the growth of the permanent resident population, migration patterns of seasonal holidaymakers within and outside the supply area, and the supplementary impact of visitors related to the Games.

Eazi (2017) studied the optimal design of water distribution networks necessitates the assessment of various factors, including but not limited to economic and technical analysis, mechanical and hydraulic considerations, and population-based approaches. Frequently, these objectives exhibit a degree of conflict such that the identification of the most advantageous solution for one objective results in a decrease in the usefulness of the other objective. The present study outlines a methodology for the selection of an optimal design from three pre-determined scenarios, which takes into consideration both economic and technical factors for the provision of adequate water supply to customers in the Darakeh neighborhood of Tehran, Iran. Additionally, the proposed approach aims to satisfy the criteria of decision makers and fulfill the design objectives. The WaterGEMS software, which incorporates a robust GIS-based approach for effectively simulating, administering, and safeguarding the precious resource of water, was employed to identify a management strategy and develop an ideal water supply system. The optimal choice for the water distribution network in the study region was determined by assessing economic and technical factors, resulting in the evaluation of one of the proposed scenarios as the most favorable option.

The author of the aforementioned text is Bryan Seppie, who holds a Professional Engineer (P.E.) designation and published the text in the year 2017. The Joint Powers Water Board (JPWB) of Sweetwater County, Wyoming, specifically in the Green River and Rock Springs areas, is currently engaged in the revision of their Master Plan, which involves a substantial enhancement of their hydraulic model. The intricate model that ensues is designed to fulfill diverse objectives, including the analysis of water quality. To facilitate the various applications, a comprehensive field investigation and calibration/validation program is currently underway. This program involves conducting three tracer tests and multi-hydrant flow tests, utilizing continuous pressure gauges. In order to address the issue of insufficient prior experience with cutting-edge technologies, a systematic engineering methodology was employed, which involved meticulous planning, rigorous testing, and meticulous implementation protocols. The outcome of this endeavor was a remarkably prosperous field operation, notwithstanding the fact that the expenses incurred on labor surpassed the initial projections. The hydraulic model was formulated utilizing a Geographic Information System (GIS) in conjunction with demand calculations that were derived by assigning meters to model nodes through the utilization of geo-coded meter data. The extended period simulation utilized historical SCADA data to establish diurnal demand curves that are representative. The utilization of these sophisticated methodologies leads to an increased level of assurance in the resultant model, albeit at a certain expense. The objective is to disseminate our experiential insights, expertise, and financial outlays related to this undertaking.

Mehta and Prajapati (2018) conducted a study in which the primary purpose of water distribution networks is to transport water from a source to individual consumers in sufficient quantities and at satisfactory pressures. In order to address any issue pertaining to water distribution, it is imperative to undertake the design of a new network or the enhancement of an existing one. The aforementioned issue can be resolved through the utilization of LOOP 4.0, STANET, EPANET 2.0, and WATERGEMS software. The city of Surat is currently encountering challenges related to water scarcity and pressure fluctuation. In order to conduct a thorough analysis of the existing water distribution network, the Punagam area has been chosen as the focus of this study. The software program WATERGEMS V8i will be utilized for this purpose. The aim of our investigation is to assess the current water distribution system in the Punagam region through the utilization of WATERGEMS V8i software. Additionally, we intend to propose potential solutions in the event that the current network fails to meet the present and future demand. The findings confirmed that the pressures at every junction and the flows, along with their velocities, in all pipes are sufficient to ensure the provision of adequate water to the network in the study area.

Liu and Walski (2018) examine the effects of isolation valve malfunction on three key parameters, namely the quantity of valves required to isolate a segment of a distribution system, the magnitude of distribution system segments, and the deficit in fulfilling demands during valve failure. A case study was conducted on a network featuring diverse isolation valve configurations, with variations in terms of valve density. The findings derived from the case study indicate that the malfunction of an isolation valve has significant and diverse effects on the operational efficiency of a system in the event of a shutdown. The density of valves within a given network is a determining factor in assessing the effects of valve malfunction on a system shutdown. In general, an increased density of isolation valves is associated with a decreased impact of valve failure. Ultimately, this study has yielded several conclusions that can be utilized to inform the maintenance and management of isolation valves based on a critical valve analysis.

Deering and Lim (2018) conducted a study on efficacy of pumping systems in frigid regions, specifically in the context of water distribution, is influenced by various scenarios. The enhancement of pumping system efficiency results in energy conservation, thereby rendering water distribution more ecologically sustainable. The issue of inefficient energy utilization in colder regions is frequently overlooked, despite the potential for enhancements. The issue of water distribution in cold climate regions can be attributed to ineffective design, which may result in various problems such as the freezing of water towers, pipe seals being stretched beyond their elastic limits, and the extraction of water from a frozen pressurized body of water. Field visits have been conducted to observe phenomena associated with cold climates. Pipe network software is employed to model various scenarios for pipe network designs, facilitating the comparison of water distribution conditions with hypothetical problems that may arise in cold climate regions. Comparisons demonstrate the inefficiency of freezing the stand pipe of a water tower. There is a potential for further investigation to enhance the efficacy of water distribution in regions with cold climates.

Walski and DeFrank (2019) studied automated techniques for calibrating models of water distribution systems have been in existence for a considerable duration. However, ascertaining the accuracy of any such method poses a significant challenge. Due to the inherent limitations of real-world systems, it is unfeasible to acquire a comprehensive dataset for model calibration in a water distribution system, as it is impossible to ascertain all usage and flow conditions at any given moment. In order to evaluate the efficacy of automated calibration techniques in accurately predicting the conditions of a water system, a physical model of a water distribution system was created at a laboratory scale. Subsequently, a calibration program utilizing genetic algorithms was employed to calibrate the model of the aforementioned system. The findings suggest that the automated calibration techniques were effective in approximating pipe roughness, demands, and identifying shut valves. Precisely, the calibration model that was automated exhibited an exact correspondence with the flows and pressures that were measured within the system. The system successfully detected the status of the valve closure and accurately determined the location of the demands. Given adequate data, the identification of pipe roughness was feasible. Challenges arose solely in cases where the quantity of unknown variables significantly surpassed the quantity of recorded observations. The model demonstrated comparable performance irrespective of the head loss equation employed, be it the Hazen-Williams, Darcy-Weisbach or Manning equation. Overall, the process of automated calibration yielded successful results. The manuscript delineates the methodology employed for the acquisition of laboratory data, and expounds upon the calibration program utilized to align the laboratory data. Additionally, the document proffers recommendations for users of an automated water distribution calibration model.

Mohini et al. (2019) findings, it can be concluded that water is a fundamental component necessary for the maintenance of life. The demand for potable water is consistently on the rise, in tandem with the growing global population. The escalating demand for water can be met through the development of efficient water distribution networks that incorporate advanced computing systems, such as contemporary hydraulic modeling and design software. The current investigation involves the development of a water distribution network for the Bakori region in Wagholi, situated in the Pune district of Maharashtra state, India. The design of the water distribution network at Bakori Phata involved an investigation of the current population, as well as projections for population growth over the next three decades. Additionally, an analysis of daily water demand and flow characteristics was conducted, and a survey of the village was carried out using digital GPS technology. The utilization of Bentleys WATERGEMS software has facilitated the analysis and design of the water distribution network for the villages. The purpose of water distribution network systems is to transport water from a source to individual consumers while ensuring that the appropriate quantity, quality, and pressure are maintained. The primary aim of designing water distribution networks is to achieve the optimal balance between cost reduction and meeting the water demand requirements at appropriate pressure levels. This study examines the optimal geometrical layout of a pipeline network that comprises a single source node and multiple demand nodes. The objective is to transport known demands from the source to consumers over an extended period. The provision of water is reliant on the essential infrastructure of a water distribution network. The system facilitates the linkage between end-users and water origins through the utilization of hydraulic apparatus, including pipes, valves, pumps, and tanks. The principal objective of a water distribution network is to provide water that satisfies the requirements for pressure and quality. WaterGEMS is a software tool that is utilized for hydraulic modeling, specifically for the purpose of analyzing and designing water distribution networks. This research paper provides a hydraulic analysis of the Shivaji Nagar region within the urban area of Panvel. The utilization of Google Earth has been observed to be effective in facilitating the design of water distribution networks, while satellite imagery of the study area has demonstrated its efficacy in enabling the identification of alternative road alignments. A steady state analysis was conducted to compute hydraulic parameters, including head pressure and flow rate. The findings confirm that the pressure levels at all junctions and the flow rates, along with their corresponding velocities, in all pipes are sufficient to ensure adequate water supply to the study area's network.

Labhade and Kotwad (2021) conducted a investigation pertains to the village of Nimgaon (Madh) in the Nashik district of Maharashtra, India, where a Water Distribution Network (WDN) was designed. The present study pertains to the design of the water distribution network in Nimgaon (Madh), which involved an analysis of the current population, a forecast of the population for the next three decades, an assessment of the daily water demand and flow, as well as a survey of the village of Nimgaon (Madh) using Auto Level technology. A cartographic representation was generated based on the data gathered from the Level survey, and the necessary measurements for the pipeline's elevation and length were determined for the village. The map of villages featured designations for both the node number and pipe number. The WaterGems/WaterCad software was utilized to design the water distribution network of the village and its results were compared with those obtained manually. The study revealed that utilizing software yielded greater precision, efficiency, and resource conservation in comparison to manual methods. The presence of water is a fundamental requirement for the maintenance of life. The demand for potable water is consistently rising in tandem with the growing population. The escalating need for water supply can be met through the development of effective water distribution networks utilizing sophisticated computational systems, such as contemporary hydraulic modeling and design software.

3.1 Haryana

The region under consideration is located in the north-central part of India. The region under consideration is demarcated by the state of Punjab and the union territory of Chandigarh to its northwest, the states of Himachal Pradesh and Uttarakhand to its north and northeast, the state of Uttar Pradesh and the union territory of Delhi to its east, and the state of Rajasthan to its south and southwest. Chandigarh, situated in the Chandigarh union territory, functions as the administrative center for not only the aforementioned territory but also for the states of Haryana and Punjab. On November 1, 1966, Haryana was established through the partition of the erstwhile state of Punjab into two separate states based on language- Punjabi-speaking Punjab and Hindi-speaking Haryana. The restructuring was initiated in response to the Sikh community's request for a Punjabi Sub, but it also significantly fulfilled the desires of individuals in the Hindi-speaking area of Punjab for a Vishal Haryana. The toponym Haryana, etymologically derived from the Sanskrit words Hari (referring to the Hindu deity Vishnu) and Ayana (meaning dwelling or abode), connotes the notion of a divine dwelling place. The geographical expanse in question measures 17,070 square miles or 44,212 square kilometers. The population count as of 2011 was 25,353,081.

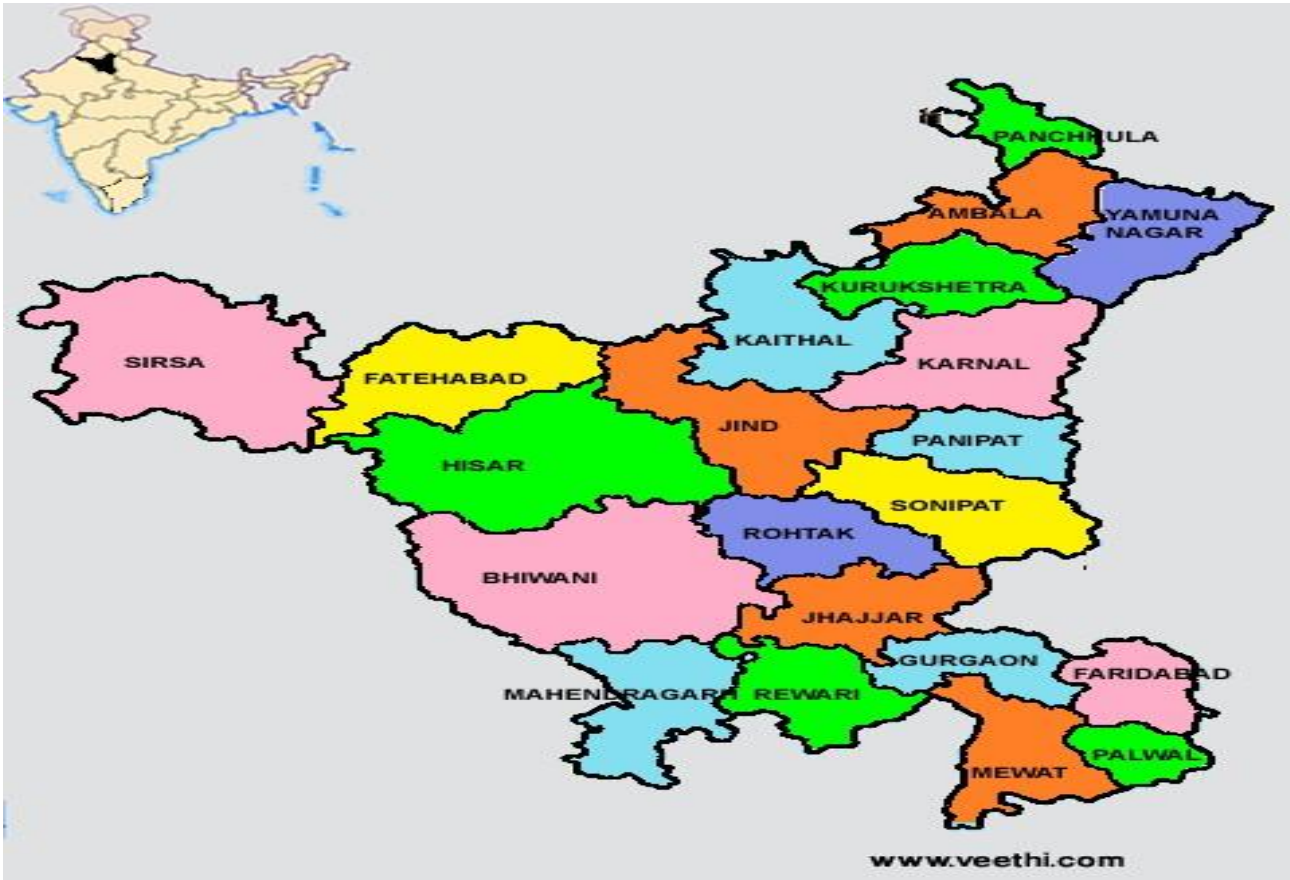

Figure 3.1. Districts of Haryana

Mewat The governmental authorities of Haryana have recently made the decision to alter the nomenclature of the district of Mewat to Nuh. The Mewat district is a constituent district of the state of Haryana. The 20th district was established on April 4, 2005, resulting from the partition of the former Gurgaon and Faridabad districts. The Mewat region is geographically bordered by the Gurgaon district to the north, the Rewari district to the west, and the Palwal and Faridabad districts to the east. The administrative center of Mewat district is located in the town of Nuh. The region encompasses Nuh, Nagina, Taoru, Punhana, and Firozpur Jhirka Blocks, comprising a total of 431 Villages and 297 panchayats. According to the 2011 census, the Mewat district spans an area of 1,499 square kilometers and is inhabited by a population of 1,089,406 individuals. The population has experienced a growth rate of 37.94 percent, resulting in a population density of 729 individuals per square kilometer. Agriculture and its associated agro-based activities constitute the primary occupation in Mewat, with animal husbandry serving as a secondary source of income. Mewat is alternatively referred to as the Land of the Meos. The individuals in question are members of a tribal community whose primary occupation is agriculture. The region of Mewat is a historically significant area located in the northwestern states of Haryana and Rajasthan, India. The Mewat dialect, which is a minor deviation from the Haryanvi and Rajasthani dialects of Hindi, is utilized in the rural localities of the region. The Mewati Gharana is a unique and discernible form of Indian classical music.

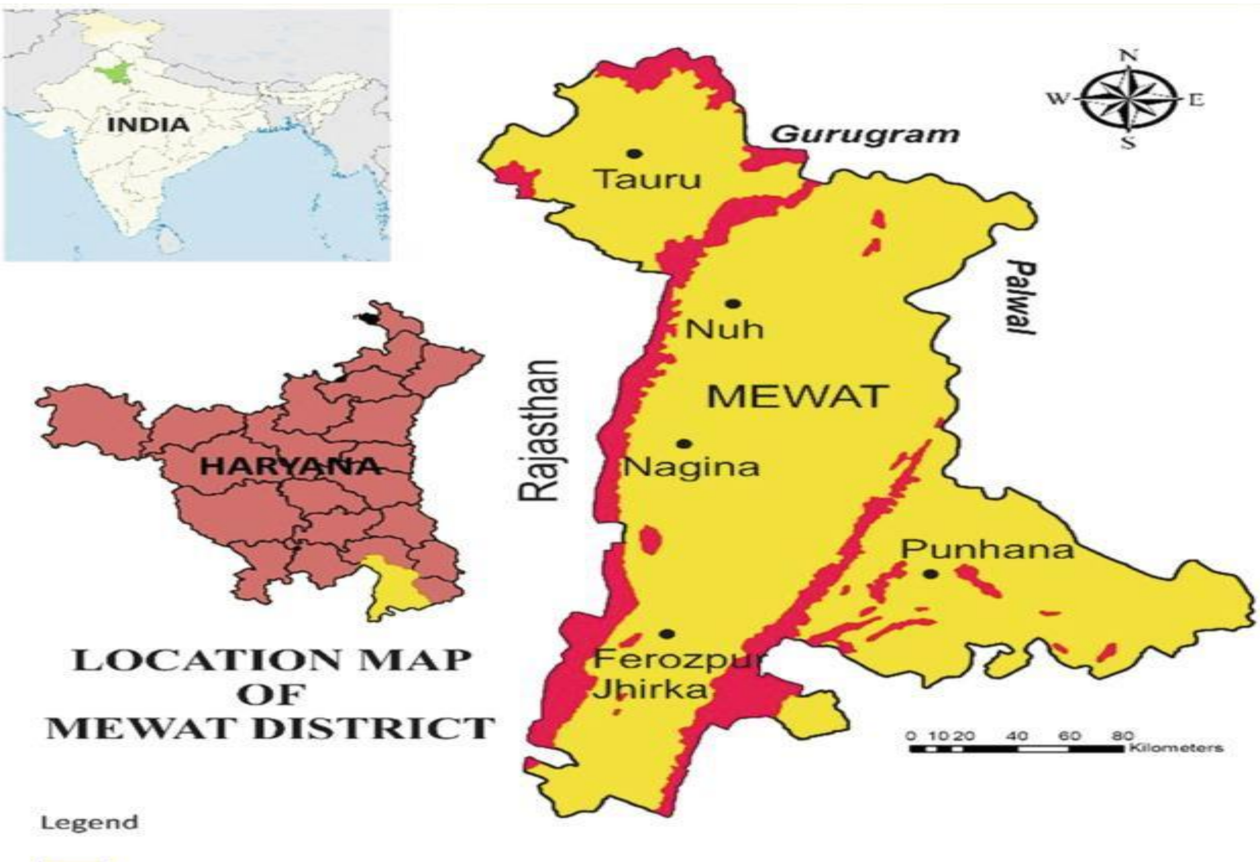

Figure 3.2. Study area

3.2 Potability of Water (Based on Geophysical Survey)

The findings of geophysical surveys conducted in the district have revealed the current state of groundwater quality as follows:

- Approximately 55% of the area (1050 sq.km.), particularly the Central, Southern, and Southeastern regions of Mewat surrounding Nuh, Malab, and Punhana, exhibit saline characteristics in their groundwater across all levels.
- According to the available data, the Mewat region has a limited fresh water availability, with only 26 to 30% (500 to 575 sqKm.) of the area having fresh water sources within a depth of 30 meters. This region encompasses the localities surrounding Tauru block, Mohun, and Ghata-shamsabad, situated in the northwest and southwest directions.
- According to the qualitative analysis of apparent resistivity data for half current electrode separation of 50m, 80m, 100m, and 150m, it has been observed that only 13% of the total area (250 sq. km) in Mewat has fresh water vertically beyond a depth of 40m, primarily located in the Northwest and Southwest regions.The aforementioned regions are situated in the Northwest of Touru block and the Southwest of Mewat, encompassing Patkhori and Patan-Udaipur.

3.3 Status of ground water development

The majority of the villages and towns located in Mewat district are equipped with a piped water supply system. The primary source of water supply in the district is derived from canal water and tube wells, which are situated at the foothills and ridges and are managed by the Public Health Department. The water supply in the Nuh, Nagina, Punhana, and Firozpur Jhirka blocks is inconsistent, and the quality of groundwater in the area ranges from brackish to saline. Fresh groundwater has been discovered in the vicinity of hill ranges. The primary mode of irrigation in the district is through the utilization of shallow tube wells. The minor irrigation unit density in the Nuh and Nagina blocks is 4 per square kilometer. Freshwater is present in certain areas of these blocks, but its distribution is limited to a depth of 20 meters. In order to fulfill the irrigation needs of the region, dug wells and tube wells (specifically of the cavity and filter variety) have been constructed at depths ranging from 10 to 20 meters. These wells have a discharge capacity that varies between 150 to 750 liters per minute. The Hathin and Punhana blocks encompass certain regions that are subject to canal irrigation.

3.4 Geophysical studies

Geophysical investigations have been conducted by CGWB to evaluate the vertical suitability of water in the Mewat region. This was achieved by analyzing ISO-Resistivity maps with a half current electrode separation ranging from 10m to 150m. The resistivity data was analyzed using both qualitative and quantitative methods. In conjunction with the extant borehole data, an endeavor has been undertaken to evaluate the depth to the bedrock within the Mewat region. The assessment of depth to bedrock has incorporated various factors, including the criterion of increase in bottom layer resistivity, the apparent resistivity at the larger half current electrode separation, and relevant data from prior exploratory drilling conducted at certain locations. Empirical evidence indicates that the depth to bedrock in a significant portion of Mewat exhibits non-uniformity, with the bedrock displaying an undulating topography.

3.5 Necessity of the project

Mewat District does not have adequate irrigation water in spite of existing Gurgaon canal network which is always short of water supplies. The rainfall in the region is scanty and erratic besides subsoil water being brackish and unfit for drinking and irrigation. At present supplies in Gurgaon Canal are received from 4.42 mile (7.120 km.) of Agra canal off taking from Okhla Barrage which is under the administrative control of U.P Irrigation Department. U.P Irrigation department officials do not release supplies as per share of Haryana at Okhla as mandated by UYRB under the MOU of May 12, 1994 despite several interventions by UYRB officials. Further, due to release of sewage in River Yamuna in the territory of the NCT of Delhi, water which is biologically and chemically contaminated comes into Gurgaon Canal and this ultimately is being used for Irrigation purposes in Mewat District. There is therefore dire necessity to provide an alternate assured source of fresh water to Mewat region. With this objective in view the Government of Haryana proposes the construction of Mewat Feeder Pipeline to supply necessary water to Mewat region. Based on the scope of work, the following parameters has been taken into account.

- According to the authorized capacity, the information is presented in the table below.
- The Mewat Feeder Pipeline has established a design capacity of 389.58 cusec, which aligns with the projected population demand for the year 2050. Additionally, a capacity

of 241.87 cusec has been determined for the year 2040, and a capacity of 171.45 cusec has been established for the year 2030, based on corresponding population demands. As per the official correspondence with the Chief Engineer of YWS (S), Haryana Irrigation & Water Resources Department, as documented in letter no. 587-89/1-GWS dated 09.02.2023.

Table 3.1. Demand at outlets

S.No.	Place		RD - MFP (Km)	Outlet Demand in 2030	Outlet Demand in 2040	Outlet Demand in 2050
1	Offtake Point		0.00			
2	HSIIDC	Manesar	22.70	39.00	58.50	78.00
3	PHED	Kasan	25.10	35.13	45.08	60.05
4	HSIIDC	Dharuhera	29.85	10.00	10.00	10.00
5	PHED	Sundh	39.00	13.33	17.80	23.83
6	HSIIDC	Sohna	49.65	10.00	14.00	14.00
7		Fututure Expansion	49.65	5.00	7.00	10.00
8	HSVP	Sohna	49.65	20.00	35.00	52.80
9	PHED	Sohna	49.80	3.74	7.07	9.19
		Panchgram	49.80	0.00	0.00	65.52
10		WTP Khor Basai	49.80	27.09	35.90	47.64
	Total Demand =			**163.29**	**230.35**	**371.03**
	Taking 5% Losses in Entire Pipeine =			**8.16**	**11.52**	**18.55**
	Total Capacity =			**171.45**	**241.87**	**389.58**

Note: **Demand 2030: 171.45 cusec (39.34 GWS + 132.11 NCR)**
Demand 2040: 241.87 cusec (80.2 GWS + 161.67 NCR)
Demand 2050: 389.58 cusec (216.54 GWS + 173.04 NCR)

4.1 Pipe Combination

Upon completion, the project is anticipated to facilitate a complete supply discharge of 389.58 cusecs (11.031 m3/s). The conveyance of this supply will be evenly distributed over two pipelines, which possess identical geometrical attributes and strength.

4.2 Pumping Stages

A single pumping stage has been evaluated for the purpose of transporting a discharge of 389.58 cusec, which corresponds to the projected population demand for the year 2050. Additionally, the pumping stage was assessed for conveying a discharge of 241.87 cusec, which corresponds to the projected population demand for the year 2040, and a discharge of 171.45 cusec, which corresponds to the projected population demand for the year 2030. The assessment was conducted by varying the velocity within the range of 0.62 m/s to 1.87 m/s. A solitary pump will be installed at the off-take location, situated at an altitude of 213.048 m, in order to transport water across the highest point or crown elevation at chainage 47.15 Km, which is positioned at an altitude of 276.545 m.

4.3 WATERGEMS

- The optimal solution is obtained through the utilization of the Gradient method in software algorithms. The software is capable of generating a network and subsequently transferring pre-existing data onto said network through the use of Model Builder. Elevation data is then applied to the network using Terex, and the demand is determined through the utilization of Load Builder. Finally, the network is simulated in order to provide an optimal design for the water supply network.
- The data collection process for the Mewat Water distribution network encompasses various aspects such as the network layout, topographical map, age of water distribution network, water demand at the consumer end point, water supply duration and pattern, number of reservoirs, pump station details, parameters of installed pumps, pipe type, and population.
- Create a water distribution network utilizing the WaterGEMS software.
- Utilize the WaterGEMS software to compute various parameters pertaining to the water distribution network.
- Examine the established criteria for the quality of water intended for human consumption.

- This study aims to investigate the reliability of the water distribution network with regards to the quantity of water supplied to a specific consumer type. Additionally, the impact of an increasing population on the reliability of the water distribution network will be analyzed using the geometric increase method of forecasting.
- This study examines the water distribution network under varying conditions, specifically when one or two pumps are in operation, and proposes a corresponding design layout.
- The water distribution network should be modified based on the findings of the study to meet consumer demands, including adequate water pressure, quantity, and continuous supply.

4.4 Design of water distribution network (WDN)

The design of a water distribution network must account for a prolonged period of water supply to adequately meet the demands of consumers. The water distribution system must meet the requirements of both quantity and available head. The majority of water systems are engineered with a lifespan of 30 to 40 years. It is imperative to explore alternative approaches or methods in order to achieve desired design objectives. The selection of these alternative approaches is based on the extent of service coverage during the phase period of the water distribution network. The aforementioned alternative approaches encompass the provision of enhanced water supply conditions to accommodate a growing population, the implementation of cost-effective measures to upgrade the water distribution network, and the development of a strategic plan. A distribution system is a complex network of pipelines, hydraulic elements, pumps, reservoirs, and valves that are utilized to distribute water to consumers. In order to analyze the water distribution network, it is common practice to represent all of the relevant components in a network format.

4.5 WaterGEMS -WATER DISTRIBUTION NETWORK TOOL

WaterGEMS offers a comprehensive methodology for addressing water distribution networks and serves as a user-friendly decision support tool for water networks. WaterGEMS facilitates comprehension of system behavior and data, including response to operational strategies and growth in response to population and consumer demand. WaterGEMS is a software tool that facilitates the simulation of fire flow and water quality, in addition to conducting criticality analysis and energy cost analysis. WaterGEMS provides a comprehensive solution that encompasses all necessary components within a functional environment. WaterGEMS offers a variety of software tools for the purpose of water management:

- The assessment of the water distribution network's ability to effectively supply water to consumers should be conducted in anticipation of system expansion, as a means of ensuring system reliability through intelligent planning. WaterGEMS was able to identify problematic areas and develop a plan for capital investments.
- Achieving optimal system efficiency in water distribution networks can be challenging due to the complexity of their operations, making pragmatic modeling essential. By utilizing WaterGEMS, one can optimize pumping strategies, plan shutdowns, and schedule routine operations in order to minimize any potential disruptions.
- The sustainability of a system can be ensured through dependable asset renewal decision support. In the context of a water distribution network, the process of renewing or replacing water infrastructure necessitates a comprehensive analysis of complex information pertaining to the network.
- This undertaking can prove to be a challenging and laborious task. The WaterGEMS software serves as a Pipe Renewal Planner, facilitating the analysis and comparison of a wide range of renewal approaches to prioritize and expedite the renewal process.
- WaterGEMS V8i series was utilized for the case study area in our analysis. The outcomes derived from WaterGEMS are utilized to evaluate the efficacy of a water distribution system in terms of its uniformity.

Different Formulas that have been considered for determining the Head losses through the entire pipe network.

Formula used to compute head loss as a function of flow rate in a pipe.
Choices are:

- Hazen-Williams
- Darcy-Weisbach
- Chezy-Manning

Methods

- Hardy Cross method
- Linear optimization technique
- **Linear programming model**

The optimization model utilized in designing a pipe network system is based on linear programming. The objective of this model is to minimize the total head loss of the pipe network system across all links while ensuring that the length, diameter, and pressure difference requirements are met at various node points. The components of a pipe network are characterized by the identification of the upstream node, j, and the downstream node, k. The pipe length constitutes the decision variables utilized in every link connecting the upstream node j and the downstream node k. The selection of upstream and downstream nodes for each link is optimized to minimize the losses incurred at the downstream node. The linear programming model is subject to constraints that pertain to the various link lengths.

$$X_{ijk} \geq 0 \qquad \forall\, i, j, k \tag{5.1}$$

Table 5.1. The various parameters that were calculated during the investigation

Start Node	Stop Node	Length (Scaled) (m)	Diameter (mm)	Material	Hazen-Williams C	Flow (cfs)	Velocity (m/s)	Headloss Gradient (m/km)	Hydraulic Grade (Stop) (m)	Pressure (Stop) (m H2O)
Pump	J-00	13	2,800	Steel	145	170.61	0.78	0.13	299.577	86.35
J-00	J-01	1,400	2,800	Steel	145	170.61	0.78	0.13	299.395	87.89
J-01	J-02	2,200	2,800	Steel	145	170.61	0.78	0.13	299.109	86.87
J-02	J-03	350	2,800	Steel	145	170.61	0.78	0.13	299.063	90.24
J-03	J-04	100	2,800	Steel	145	170.61	0.78	0.13	299.05	90.23
J-04	J-05	350	2,800	Steel	145	170.61	0.78	0.13	299.005	86.89
J-05	J-06	1,300	2,800	Steel	145	170.61	0.78	0.13	298.836	86.09
J-06	J-07	900	2,800	Steel	145	170.61	0.78	0.13	298.719	86.53
J-07	J-08	1,250	2,800	Steel	145	170.61	0.78	0.13	298.556	86.96
J-08	J-09	650	2,800	Steel	145	170.61	0.78	0.13	298.472	86.54
J-09	J-10	950	2,800	Steel	145	170.61	0.78	0.13	298.348	85.87
J-10	J-11	300	2,800	Steel	145	170.61	0.78	0.13	298.309	86.84
J-11	J-12	700	2,800	Steel	145	170.61	0.78	0.13	298.218	87.41
J-12	J-13	700	2,800	Steel	145	170.61	0.78	0.13	298.127	86.46
J-13	J-14	750	2,800	Steel	145	170.61	0.78	0.13	298.03	85.38
J-14	J-15	150	2,800	Steel	145	170.61	0.78	0.13	298.01	83.64
J-15	J-16	100	2,800	Steel	145	170.61	0.78	0.13	297.997	83.63
J-16	J-17	150	2,800	Steel	145	170.61	0.78	0.13	297.978	84.05
J-17	J-18	350	2,800	Steel	145	170.61	0.78	0.13	297.932	83.76
J-18	J-19	450	2,800	Steel	145	170.61	0.78	0.13	297.874	84.94
J-19	J-20	550	2,800	Steel	145	170.61	0.78	0.13	297.802	82.81
J-20	J-21	500	2,800	Steel	145	170.61	0.78	0.13	297.737	82.5
J-21	J-22	400	2,800	Steel	145	170.61	0.78	0.13	297.685	81.05
J-22	J-23	600	2,800	Steel	145	170.61	0.78	0.13	297.607	81.57
J-23	J-24	550	2,800	Steel	145	170.61	0.78	0.13	297.536	81.7
J-24	J-25	800	2,800	Steel	145	170.61	0.78	0.13	297.432	80.55
J-25	J-26	1,000	2,800	Steel	145	170.61	0.78	0.13	297.302	78.02
J-26	J-27	650	2,800	Steel	145	170.61	0.78	0.13	297.217	74.93
J-27	J-28	300	2,800	Steel	145	170.61	0.78	0.13	297.178	74.11
J-28	J-29	450	2,800	Steel	145	170.61	0.78	0.13	297.12	72.1
J-29	J-30	1,400	2,800	Steel	145	170.61	0.78	0.13	296.938	65.9
J-30	J-31	250	2,800	Steel	145	170.61	0.78	0.13	296.905	66.22
J-31	J-32	1,550	2,800	Steel	145	170.61	0.78	0.13	296.704	59.69
J-32	J-33	600	2,800	Steel	145	170.61	0.78	0.13	296.626	54.57
J-33	J-34	500	2,500	Steel	145	130.51	0.75	0.14	296.557	50.29
J-34	J-35	500	2,500	Steel	145	130.51	0.75	0.14	296.488	47.65

J-35	J-36	500	2,500	Steel	145	130.51	0.75	0.14	296.42	43.06
J-36	J-37	350	2,500	Steel	145	130.51	0.75	0.14	296.371	37.47
J-37	J-38	150	2,500	Steel	145	130.51	0.75	0.14	296.351	40.67
J-38	J-39	150	2,500	Steel	145	130.51	0.75	0.14	296.33	43.14
J-39	J-40	250	2,500	Steel	145	130.51	0.75	0.14	296.296	43.7
J-40	J-41	550	2,250	Steel	145	93.62	0.67	0.12	296.228	44.2
J-41	J-42	400	2,250	Steel	145	93.62	0.67	0.12	296.178	43.9
J-42	J-43	1,150	2,250	Steel	145	93.62	0.67	0.12	296.035	38.08
J-43	J-44	450	2,250	Steel	145	93.62	0.67	0.12	295.979	33.05
J-44	J-45	200	2,250	Steel	145	93.62	0.67	0.12	295.954	35.95
J-45	J-46	350	2,250	Steel	145	93.62	0.67	0.12	295.911	35.47
J-46	J-47	550	2,250	Steel	145	93.62	0.67	0.12	295.843	36.24
J-47	J-48	600	2,250	Steel	145	93.62	0.67	0.12	295.768	38.48
J-48	J-49	150	2,250	Steel	145	93.62	0.67	0.12	295.75	42.94
J-49	J-50	50	2,250	Steel	145	93.62	0.67	0.12	295.743	43.16
J-50	J-51	300	2,250	Steel	145	93.62	0.67	0.12	295.706	40.37
J-51	J-52	150	2,200	Steel	145	83.12	0.62	0.11	295.69	38.98
J-52	J-53	1,100	2,200	Steel	145	83.12	0.62	0.11	295.567	39.56
J-53	J-54	800	2,200	Steel	145	83.12	0.62	0.11	295.478	42.57
J-54	J-55	400	2,200	Steel	145	83.12	0.62	0.11	295.434	42.83
J-55	J-56	900	2,200	Steel	145	83.12	0.62	0.11	295.334	43.04
J-56	J-57	200	2,200	Steel	145	83.12	0.62	0.11	295.312	43.95
J-57	J-58	550	2,200	Steel	145	83.12	0.62	0.11	295.251	43.4
J-58	J-59	900	2,200	Steel	145	83.12	0.62	0.11	295.151	38.7
J-59	J-60	350	2,200	Steel	145	83.12	0.62	0.11	295.112	39.63
J-60	J-61	500	2,200	Steel	145	83.12	0.62	0.11	295.056	40.18
J-61	J-62	1,050	2,200	Steel	145	83.12	0.62	0.11	294.94	40.78
J-62	J-63	600	2,200	Steel	145	83.12	0.62	0.11	294.873	38.87
J-63	J-64	1,050	2,200	Steel	145	83.12	0.62	0.11	294.756	34.19
J-64	J-65	600	2,200	Steel	145	83.12	0.62	0.11	294.69	35.04
J-65	J-66	450	2,000	Steel	145	69.13	0.62	0.13	294.633	35.68
J-66	J-67	950	2,000	Steel	145	69.13	0.62	0.13	294.514	33.73
J-67	J-68	450	2,000	Steel	145	69.13	0.62	0.13	294.457	33.7
J-68	J-69	100	2,000	Steel	145	69.13	0.62	0.13	294.445	30.66
J-69	J-70	400	2,000	Steel	145	69.13	0.62	0.13	294.394	33.28
J-70	J-71	550	2,000	Steel	145	69.13	0.62	0.13	294.325	31.31
J-71	J-72	450	2,000	Steel	145	69.13	0.62	0.13	294.269	32.68
J-72	J-73	650	2,000	Steel	145	69.13	0.62	0.13	294.187	32.59
J-73	J-74	1,150	2,000	Steel	145	69.13	0.62	0.13	294.043	25.44
J-74	J-75	400	2,000	Steel	145	69.13	0.62	0.13	293.992	24.64
J-75	J-76	450	2,000	Steel	145	69.13	0.62	0.13	293.936	21.96
J-76	J-77	200	2,000	Steel	145	69.13	0.62	0.13	293.911	23.7
J-77	J-78	1,100	2,000	Steel	145	69.13	0.62	0.13	293.773	17.29
J-78	J-79	850	2,000	Steel	145	69.13	0.62	0.13	293.666	15.83

Reservoir	Pump	9	2,800	Steel	145	170.61	0.78	0.13	-0.001	0

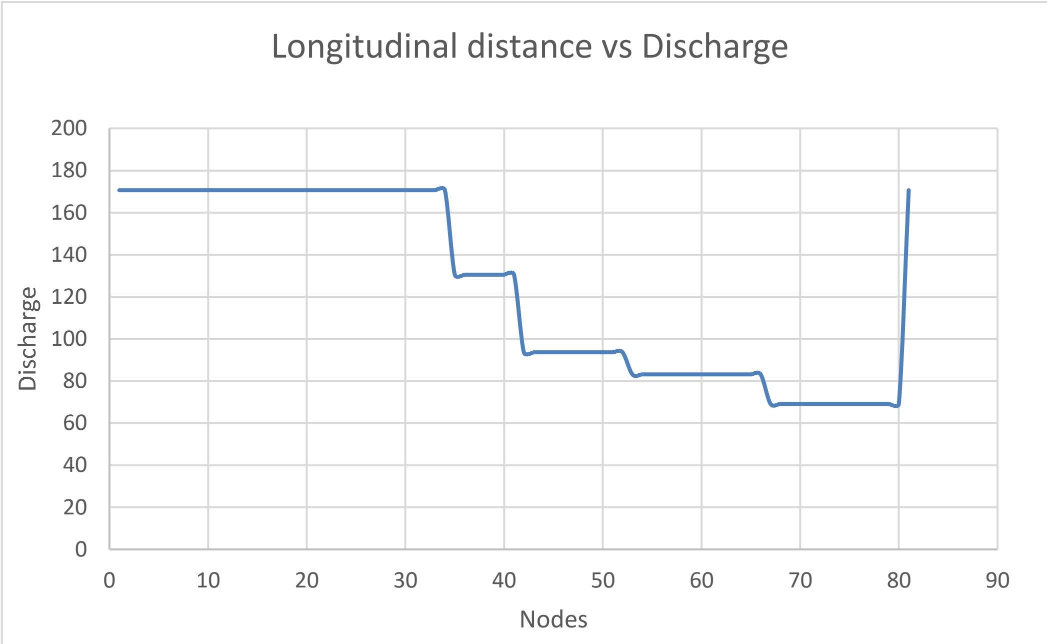

Figure 5.1. Variation of Discharge along the longitudinal distance

The diagram illustrates the fluctuation of the discharge in relation to the longitudinal distance of the pipeline. The discharge value remains consistent between the pump and node 32. A sudden change in discharge occurs after node 32, which can be attributed to the frictional losses that occur along the length of the pipeline. This discharge then remains constant until node 39. The phenomenon of discharge reduction is observed once more at node 40, and it persists at a consistent level until node 50. The discharge exhibits a sudden drop beyond node 50 and maintains a constant flow rate up to the reservoir.

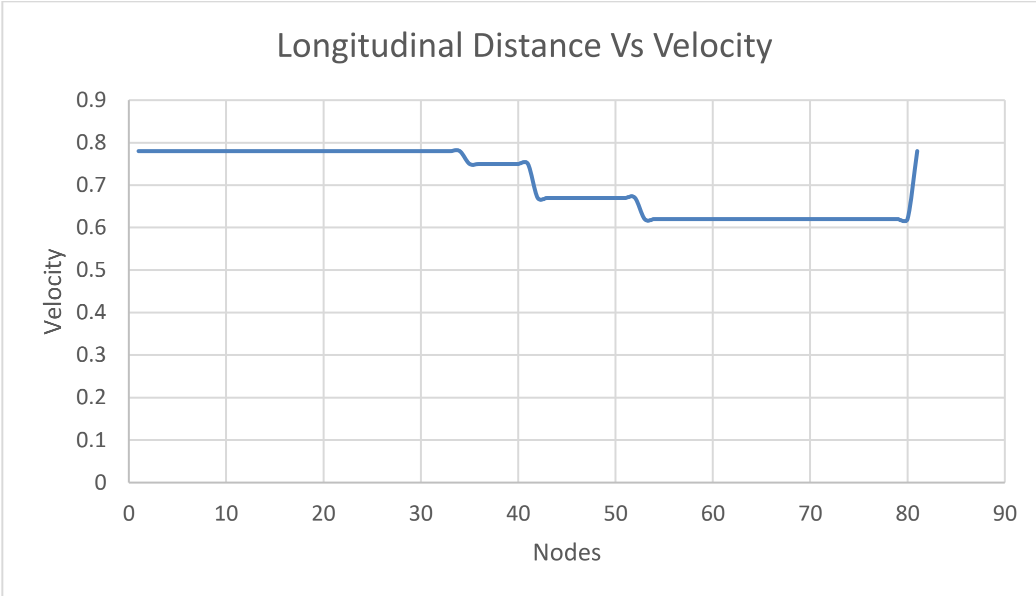

Figure 5.2. Variation of Velocity along the longitudinal distance

The velocity profile along the length of the pipeline is depicted in the figure. The velocity maintains a constant value until reaching node 32. A sudden alteration in velocity is observed at node 33, which subsequently remains constant until node 39. Subsequent to that, the velocity undergoes a modification and persists at a consistent level until reaching node 50. The velocity experiences a reduction at node 51 and maintains a constant value throughout the remaining length until the final node.

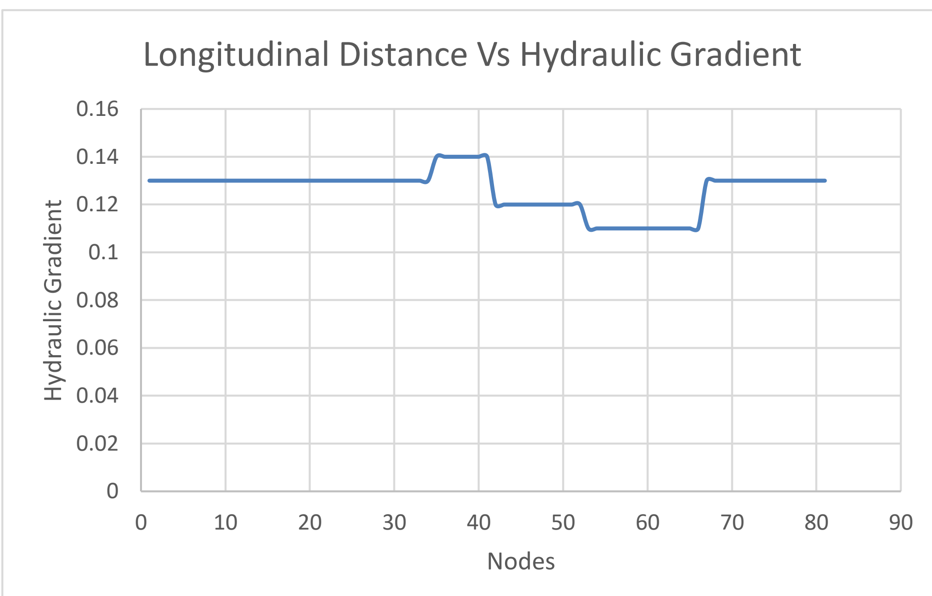

Figure 5.3. Variation of head loss gradient along longitudinal distance

The diagram illustrates the fluctuation of the head loss gradient over the longitudinal span of the pipeline. The hydraulic gradient exhibits a constant value until the point of intersection at node 32. When there is an increase in head loss, the value at node 33 exhibits a higher value and remains constant until node 39. Following node 39, the gradient of head loss experiences a decrease and maintains a consistent level until reaching node 50. The gradient of head loss experienced a decrease subsequent to node 50, and maintained a consistent level until node 64. Beyond this point, the gradient of head loss increased before stabilizing once more until the final node.

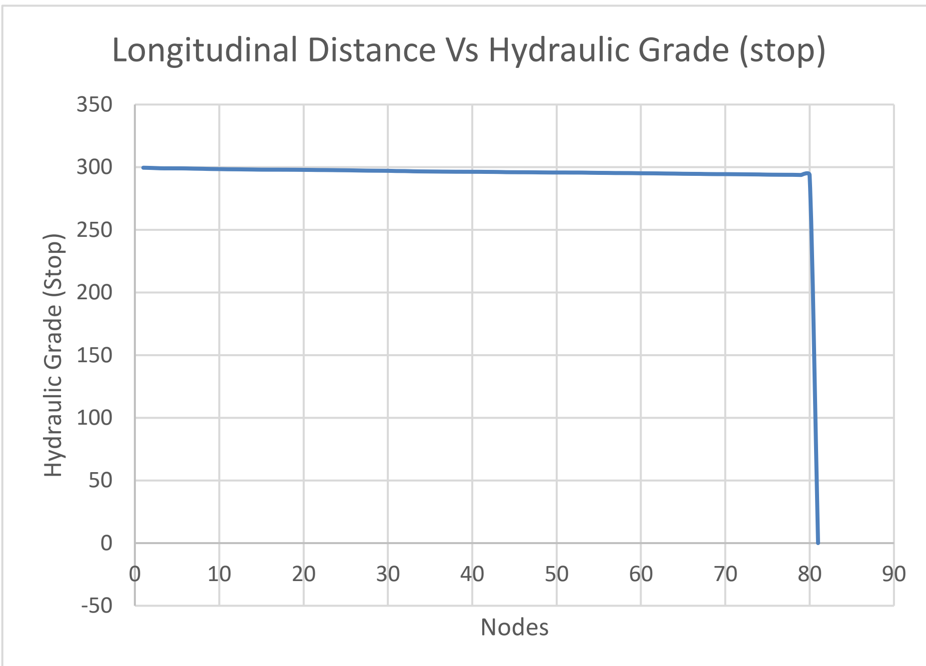

Figure 5.4. Variation of Hydraulic Grade (Stop) along the longitudinal distance

The diagram depicts the fluctuation of the hydraulic gradient over the longitudinal extent of the pipeline. The data indicates that the initial node is situated at a greater elevation, while the diminished levels of the interconnected nodes progressively decrease along the longitudinal span of the pipeline.

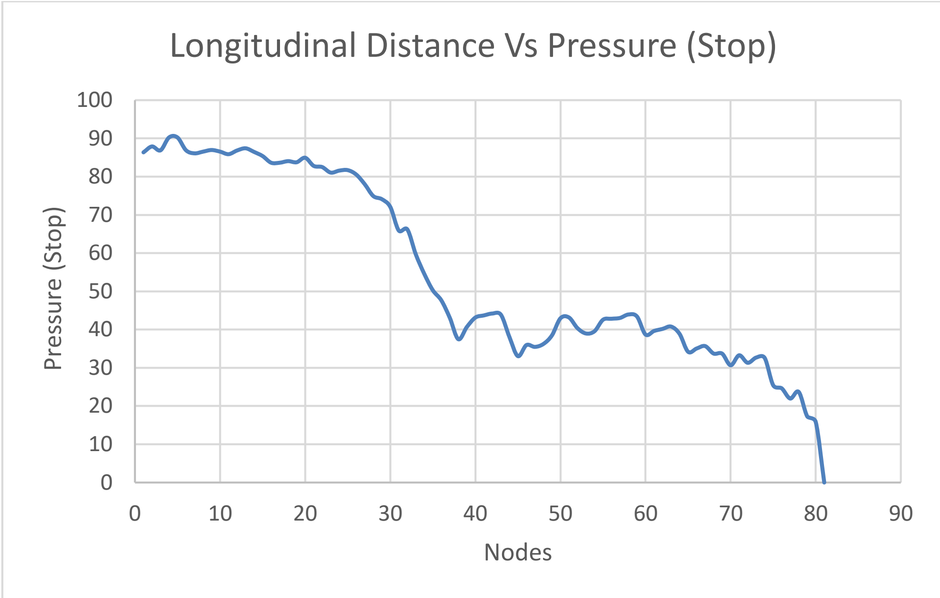

Figure 5.5. Variation of Pressure (Stop) along the longitudinal distance

Elevation Profile:

The pipeline section covers a distance of 49.80 km, consisting of a uniform relief profile for the initial 15 km, and a rising segment spanning 31.65 km. The elevation profile of the rising segment increases from 213.048 m to a maximum of 279.066 m above MSL. The profile undergoes a rapid descent of 67.775 m downstream of the crest, covering a distance of 1.35 km, and reaching an elevation of 211.291 m above the reference point. Ultimately, spanning a distance of 1.8 km and culminating at the outfall site, the final portion of the elevation profile experiences a decrease of 18.059 m, resulting in a final elevation of 192.782 m.

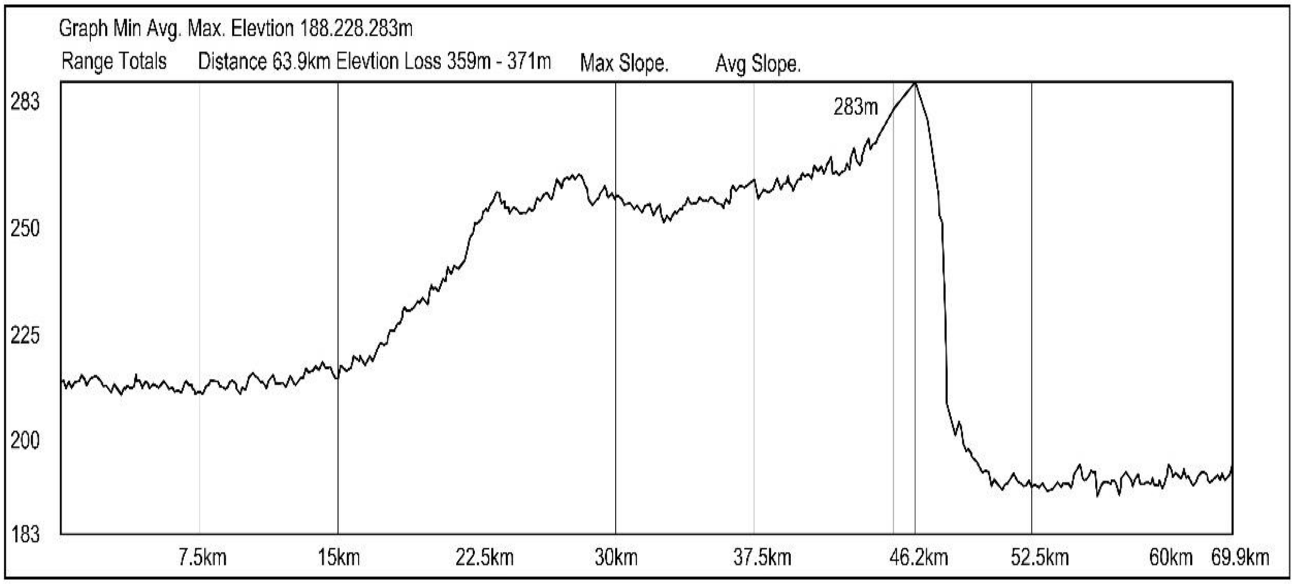

Figure 5.6. Elevations at different nodes

The proposed optimized design done will give an output or result with minimum head loss and economical diameter. In accordance with these appropriate head will be achieved with passage of desired flow at sufficient velocity through the pipe system. Overall about 70% of uniform pressure will be obtained for larger portion of command area. Variations in head, velocity and unit head loss during peak hours will be observed within standard criteria. In this project WATERGEMS software will be used for obtaining optimal design of water supply network of a part of Nasik city. With the help of WATERGEMS software, design of optimal water supply network will be done with achieving objective of minimizing the overall cost while meeting the water demand requirements at sufficient pressures for specified maximum discharge over a long period of time. The software also gives different alternative optimal design solution considering pipe diameters, pipe material and roughness coefficient based on head dependent analysis. The WATERGEMS software will provide required standard and economical design, analysis and troubleshooting of new and existing supply network with accuracy and minimum time duration. The software is also used for solving problems in existing network and also in expansion of existing water supply network.

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