



The Urban Unit

Urban Sector Planning & Management Services Unit (Pvt.) Ltd

REGIONAL DEVELOPMENT PLAN SARGODHA

Water Supply & Sanitation Sector

Water Supply & Sanitation Sector

Sargodha Regional Development Plan

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Suggested Citation:
The Urban unit. 2022. *Water & Sanitation Sector: Sargodha Regional Development Plan*.

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EXECUTIVE SUMMARY

The adequate provision of water and sanitation services (WSS) continued to be essential requirement for protecting public health and maintaining basic living conditions. Sargodha Region is no exception, however, as per data collected and analysis carried out by Urban Unit, the public sector investment and delivery model in cities and rural is inadequately planned and financed in the past, making the condition of assets for delivery of services inadequate and institutions weak and fragmented. In simple words, large population of Sargodha region continue to lack access to clean drinking water and the basic sanitary conditions required for a healthy life.

Although there is no shortage of Technological solution to these problems and if finances are in placed as a targeted and planned interventions, the quality of services can be improved. Quality of services is neither the result of physical – natural constrains such as water scarcity, or finances, the WSS existing crises is ignorance of needs & inadequately response to WSS requirement is due to a "crisis of governance in institutional sitting ". These needs of service delivery and governance is responded through two prone approaches in SRDP, i) investment where is needed as per technical solutions ii) through a well-coordinated institutional arrangement such as ringed fenced water and sanitation utility or entity for city or at regional scale. The institution purpose is to design, planned, operate and manage WSS services and well capacitated for responding to need of the sector with accountability.

The satisfaction level of community for water services varies from 50 to 80% whereas sewerage is 20 to 60%. The Area of Khushab and Bhakar are most neglected areas in the development planning and financing. The willingness to pay despite low income is high with range of Rs 300 to Rs 50 in the Region, demonstrating important of services to communities. The majority of tube well are not functional i.e more than 70%, which is reflection of role of local authorities responsible for Water and Sanitation, which requiring attention to better created inter-linkages between public policy and management. Similarly, sewerage has same issues, highlighting poor quality of assets and services.

Water quality is reflected in 83% area is contamination due to microbial contamination & excessive Chloride, Nitrate, Hardness, Iron, and TDS. Presence of high brackish water due to major contribution from Sodium and Chloride ions, thus making public service delivery important. Infant mortality rate of 66% is reported in rural areas of Punjab as per MICS 2018-19 published report. There is presence of 9-40% TDS Pollution in water of Sargodha Division with minimum contamination of 9% in Bhakkar and maximum in Sargodha district. Sargodha and Khushab are classified as highly brackish zones while Mianwali water possesses medium contamination and Bhakkar is categorized as sweet water zone. Arsenic contamination is prevalent in some areas of Sargodha and Mianwali districts**.**

The aspect of disparities and inequities in services are always found among districts as highlighted in one of the published WASH Scorecard reports of UNICEF in 2019. Khushab is categorized in to lowest rank of 35 and 25 among all districts of Punjab with respect to rural water and sanitation index, which highlights the need of immediate planning and respective interventions in the district

The regional plan has advanced an integrated approach for cities and rural area based on detail and rapid assessment and thus a model of regional plan which is dynamic and well-structured and respond to short, medium- and long-term investment needs of sector. Projects worth over 30 billion have been identified for 10 years in these four districts of Sargodha division. The Regional Plan has proposed Total Urban WSS Project: 30, with Grant Total: 12,483 million OR 12.4 billion and Rural Water schemes of Grand Total: 17,421 million with adequate solarization component.

The quality of asset and service delivery has demonstrated that the existing institutional design of PHED designing and constructing the assets and Local Government operating the asset with inadequate financing and human resources is not a proper techno-organizational fit for WSS. Establishment of city specific and Regional WASA under Punjab Development of Cities Act 1976 as a public sector driven model is advanced as an institutional design in this regional plan. In the rural area the community model with no finances and regulation has impacted the provision of water supply, thus needs a public management model to address deprivation is needed lead by PHED. There is evidence internationally and regionally that current drive to integrated the responsibilities for drinking water and sewerage to bring better manage the water cycle is leading in practice, to the transfer of these responsibilities to the newly created supra-local organizations i.e., WASAs and PHED in Rural Area is workable solution and hence proposed.

BACKGROUND

In Pakistan, the administrative jurisdictions are divided into divisions, districts and tehsils. These administrative units serve as the baseline for public spending from various tiers of government. As we move up the administrative hierarchy from cities and districts, division plays a crucial role in providing public services more efficiently due to economies of scales and higher decision making power. Considering the existing administrative structure of Punjab, the term division is used as an economic 'Region' so that adoption of the plan requires minimal changes to existing processes on which current planning and systems have evolved. The Sargodha Division is an emerging economic hub of Punjab and has high potential for growth. The division comprises of 4 districts i.e. Sargodha, Khushab, Mianwali and Bhakkar. This report presents the Regional Development Plan of all four districts in the Sargodha division.

Drinking Water and Sanitation are the most essential elements for human life and its dignity. Access to drinking water and sanitation services is recognized as a fundamental human right by Government of Pakistan in the Constitution under Article 9 that "no person shall be deprived of life or liberty save in accordance with law". The Government of Punjab also envisions providing safe drinking water and sanitation facilities to the entire rural and urban communities in an equitable, efficient and sustainable manner.

The plan is developed using participatory approach combined with the field visits of all the districts in Sargodha division, primary and secondary data analysis at local as well as regional level. The planning exercise included all the relevant stakeholders and local community in identification of key projects and their timelines - short-medium-long term investment plan at district and regional level.

The report comprises of fourteen chapters. The chapters I-IV discusses the introduction to the division, existing WSS indices, methodology adopted and the community perception survey. The chapters V-XII discusses the detailed plan for water and sewerage of Sargodha, Khushab, Mianwali and Bhakkar including their existing infrastructure, conditional assessment, baseline situation, demand-supply gaps and proposed project plans for the future.

Sargodha is the 11th most populous city of Pakistan and the 5th most populous city of Punjab and is the divisional headquarters of the Sargodha division. The district lies in the middle of Punjab. The geo-strategic importance has led to establishment of air base of Pakistan Air Force here. The underground water of Sargodha is brackish and the main source of water for the city are the seepage tube wells installed along the Lower Jhelum Branch Canal and the direct intake of water from the same canal. The water is pumped from the source to Ground Storage Tanks throughout the city from where it is distributed at household level. There are a total of 53 tube wells, 7 OHRs and 14 Water Works within the boundary of MC Sargodha. Majority of these assets have long outlived their lives and are in deteriorating condition. The condition of Sewerage in Sargodha is also dire with undersized pipes and overflowing disposals. There are a total of 11 disposal stations in the city all of which are in deteriorating condition.

Khushab is another district of Sargodha division with a population of about 1.28 million. Khushab is situated between the districts Sargodha and Mianwali, lying at the edge of river Jhelum. The water of Khushab is also brackish. The main water supply system is based on tube wells installed along the Jhelum river as well as direct intake from the 1-L Khushab canal. The water is stored in storage tanks in the city from where it is further distributed. There are total of 28 tube wells, 2 GSTs and 3 water works owned by MC Khushab. These assets are on the verge of their design life and need immediate rehabilitation measures. The sewerage system in Khushab is practically non-existent with only one disposal station available. Open drains/ditches are used to dispose waste water away from the urban centers.

The district of Mianwali is an important district of Sargodha division lying on the edge of sandy plains of Thal. The mighty Indus river flows through the Mianwali district, due to which sub surface water is available in abundance. The rich aquifer has led to increase in private boring in the district. The water supply system in Mianwali consists of 11 tube wells and 5 OHRs. These schemes supply water to the population via direct pumping. The water supply infrastructure in the city has been graded as average to satisfactory based on its condition. The system of sewerage and drainage is the major issue for Mianwali with only one disposal station currently functional. The waste water of the city is carried through channels and sullage carriers away from the city and is eventually disposed into Indus. Urban flooding and water ponding is a common occurrence during rainy season. The overall condition of sewerage of Mianwali is dire.

The district of Bhakkar is the largest district of the Sargodha division with respect to area. The district lies on the edge of Thal and has sweet underground water available in abundance. The water supply schemes of Bhakkar is based on direct supply from tube wells with OHRs available for storage. There are 9 tube wells and 6 OHRs owned by MC Bhakkar. These assets are in dire condition with most of them needing immediate maintenance. The sewerage system of Bhakkar is old and outlived with choked sewers throughout the city. There are total 6 disposal stations owned by MC Bhakkar all of which are in deteriorating condition.

The Sargodha division has a rural population of about 6 million indicating 9% of the rural population of Punjab to be settled there. Public Health Engineering Department (PHED) is the main department responsible for the installation or execution of water supply and sanitation schemes in rural areas of Punjab. One of the major challenges of Service Delivery in rural areas is the distribution of responsibilities to execute and operate the infrastructure. PHED is responsible for execution or installation of the municipal services infrastructure which is usually handed over to Community Based Organizations (CBOs) for its operation and maintenance (O&M). There are approximately 540 rural water supply schemes 70% of which are in functional state. Rural sewerage system mostly of open drain type (92%) is present in approximately 700 villages of Sargodha Division which make average of 33% coverage in rural areas while 67% villages are still unserved for sewerage facilities.

Considering these facts and figures, a number of projects are proposed in short-medium-long term basis for Sargodha Division in order to make the existing network efficient and enhance the water supply and sewerage coverage. Projects of worth over 30 Billion have been identified in these four districts of Sargodha division. These projects have been identified after performing demand-supply analysis and are planned in order to cater for the existing gap in the system. These projects have a vast scope including but not limited to rehabilitation of existing infrastructure, extension of water and sewerage facilities to unserved areas, capacity building programs for MCs, divisional uplift projects, establishment of DNI Zones, Waste Water Treatment Plants, water quality labs, solar interventions, training centers and more. These projects aim to solve the existing water supply and sewerage crisis by providing a result-oriented, efficient and streamlined path for planned regional development in the region.

01 Overview

1.1. TOPOGRAPHY

Sargodha is the 11th most populous city in Pakistan and the 5th most populous city in Punjab. Sargodha is located in the north-east of Pakistan and mainly comprises of flat, fertile plains, although here are a few small hills on the Sargodha-Faisalabad Road. The River Jhelum flows on the western and northern sides, and the River Chenab lies on the eastern side of the city.

1.2. GEOGRAPHY AND CLIMATE

Sargodha is located 172 kilometers northwest of Lahore and lies about 30 miles from the M-2 motorway, which connects Lahore and Islamabad. Sargodha is roughly 94 km from Faisalabad, due southeast. Directly east connected by the M-2 motorway are Lahore and the route to Rawalpindi and Islamabad. Due east is the city of Jhang; toward the west are the city of Mianwali and the Chashma Barrage.

Sargodha has a climate of extreme heat and cold. The maximum temperature reaches 46°C in the summer while the minimum temperature recorded is as low as 3°C in the winter. (Meteoblue, n.d.) Sargodha experiences significant seasonal variation in monthly rainfall. The month with the most rain in Sargodha is July, ranging from 2mm to 50mm. (Meteoblue, n.d.)

Figure 1: Annual Temperature & Precipitation Trends of Sargodha District

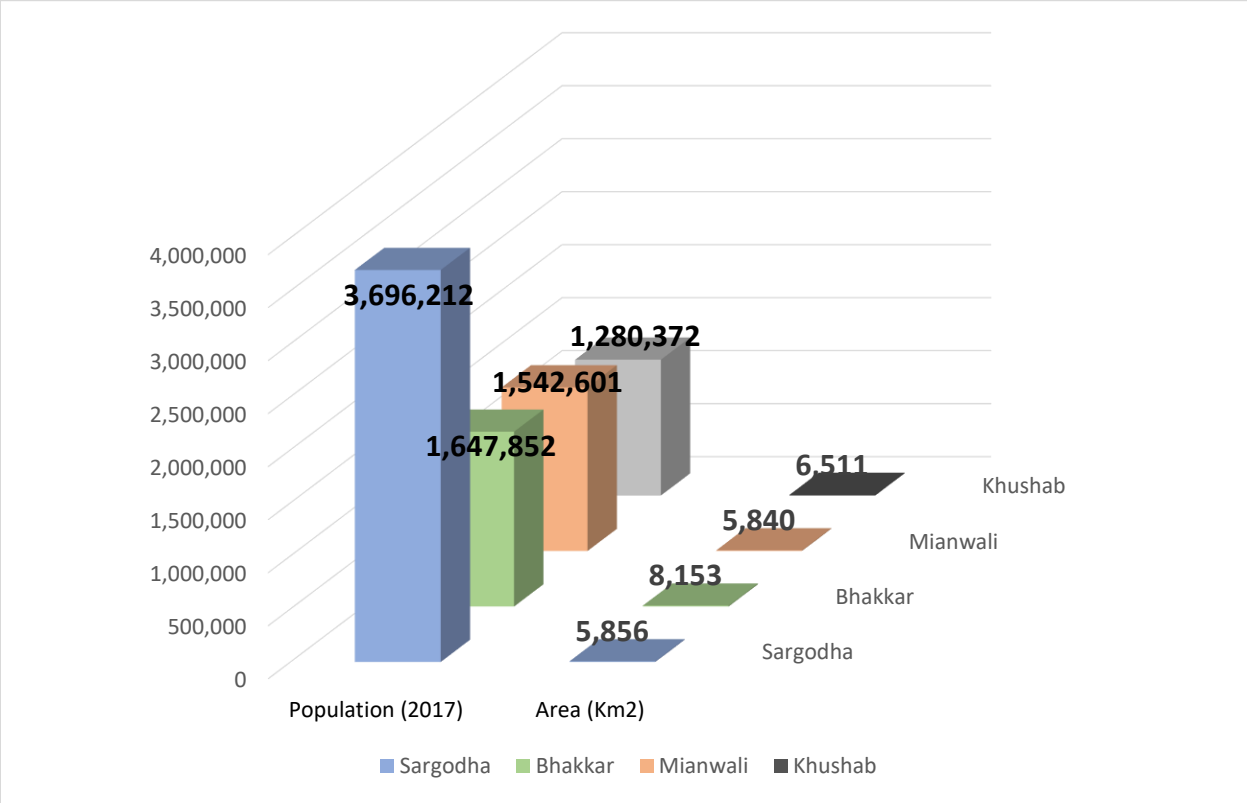
1.3. DISTRICTS PROFILE & DEMOGRAPHY

Sargodha Range was established on July 1, 1960, and it included the districts of Sargodha, Mianwali, Jhang, and Faisalabad. The Khushab and Bhakkar Sub Divisions of the Sargodha and Mianwali Districts, respectively, were raised to district status on July 1, 1982. Faisalabad District was also given the status of Range, due to which the districts of Jhang and Faisalabad were seprated from Sargodha.

Table 1 describes the district wise demographic information of Sargodha Division.

Table 1: Demographic Information of Sargodha Division

Sargodha Region					
Sr. #	**Particulars**	**Sargodha District**	**Khushab District**	**Mianwali District**	**Bhakkar District**
1.	**Location**	32.1566° N, 72.8043° E	32.3259° N, 72.1416° E	32.6645° N, 71.4774° E	31.6082° N, 71.0854° E
2.	**Area (km²)**	5,854	6,511	5,840	8,153
3.	**Population (2017)**	3,696,212	1,280,372	1,542,601	1,647,852
4.	**No. of Tehsils**	07 (Sargodha, Kot Momin, Bhalwal, Shahpur, Sillanwali, Sahiwal, Bhera)	04 (Khushab, Noorpur, Quaidabad, Nowshehra)	03 (Mianwali, Isa Khel, Piplan)	04 (Bhakkar, Darya Khan, Kallurkot, Mankera)



1.4. WATER SUPPLY & SANITATION AT A GLANCE

Sanitation and drinking water are the most basic necessities for human existence and dignity. Government of Pakistan regards access to drinking water and sanitation services as a fundamental human right enshrined in **Article 9** of the Constitution of Pakistan, which states that "no one shall be deprived of life or liberty except in compliance with law." Therefore, the government is responsible for providing safe drinking water) and sanitation services to the urban and rural populations in order to meet the Sustainable Development Goals (SDGs) Target (Goal 6.1 & 6.2) by 2030.

1.4.1. WASH INDEX IN SARGODHA DIVISION

The Water, Sanitation and Hygiene (WASH) is a composite index of three pillars: water, sanitation and hygiene. UNICEF created a detailed district-by-district WASH scorecard and published a report in 2019 to help relevant stakeholders make educated decisions about sector-specific interventions in order to boost advocacy and evidence-based investments. Disparities and imbalances in WASH exist throughout districts/divisions, urban as well as rural populations.

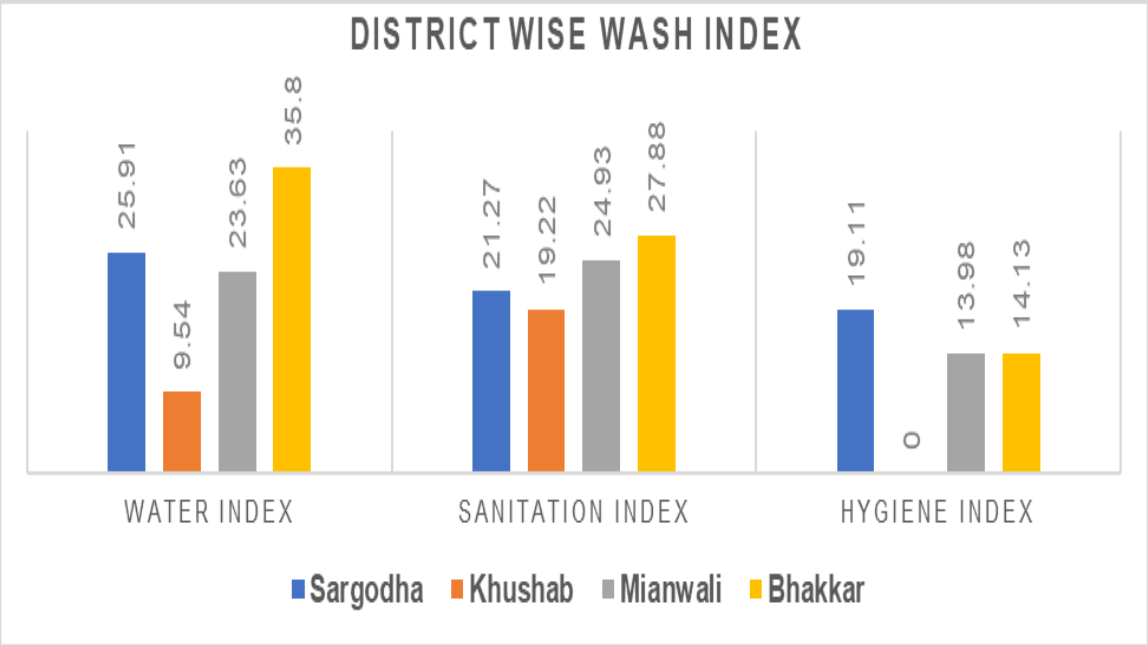


Figure 2: District wise WASH Index

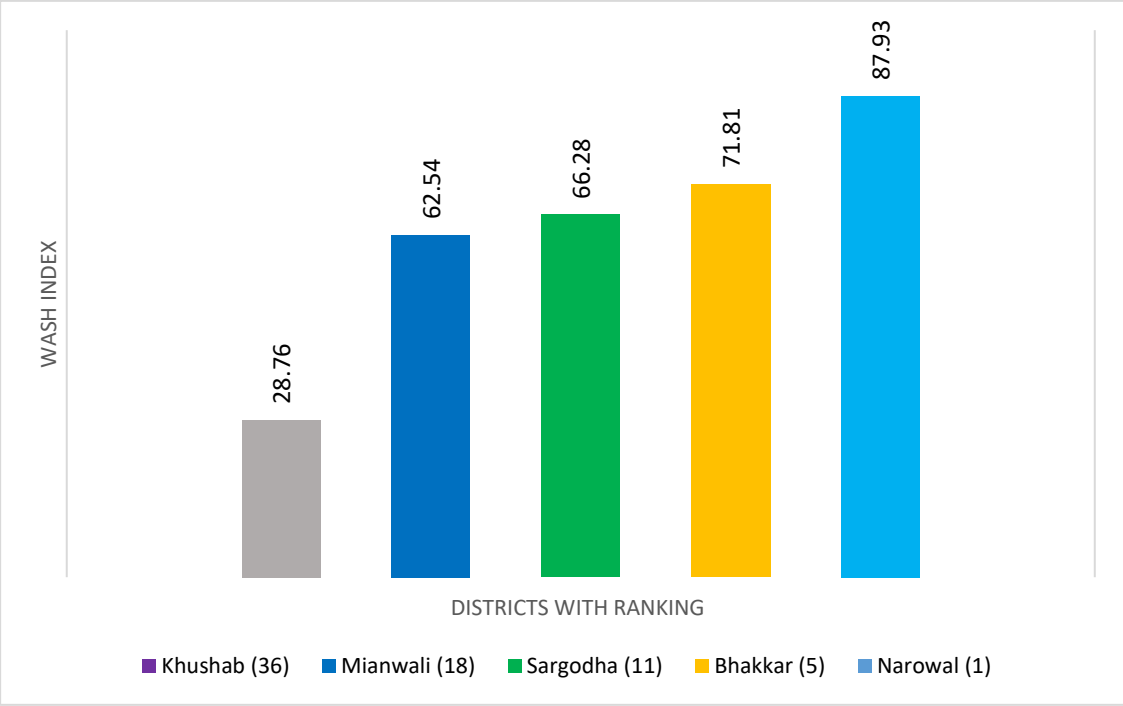


Figure 3: Overall WASH Index Comparison

1.5. METHODOLOGY

The technique for the full task of developing a regional development plan for water supply and sanitation (WSS) has been separated into distinct sections, which are summarized and enumerated in Figure 4:

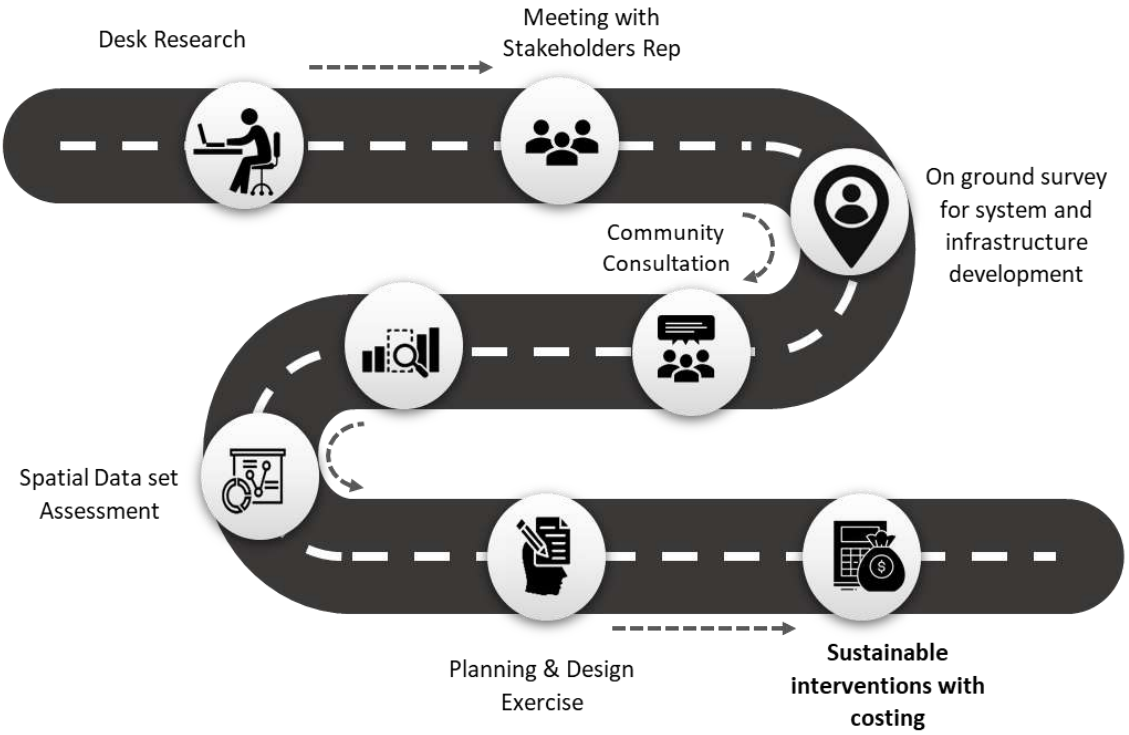


Figure 4: Methodology for Development of Plan

1.5.1. DESK STUDY

In order to assess the state of water supply and sanitation (WSS) in the Sargodha Region over the last decade, a complete desk research was performed. The desk study considered the current legislative landscape, the most recent WSS ADP Schemes, development plans, and pertinent published papers, publications, and journals. The number of initiatives and programs that were completed in previous years to strengthen WSS infrastructure were also evaluated. The team also engaged with relevant departments to share any secondary or primary sectoral data/reports, which were reviewed and used.

1.5.2. MEETING WITH STAKEHOLDERS

Team carried out a detailed 10-day visit (January 16 - January 23, 2022) to Sargodha Division where meetings with multiple relevant stakeholders were carried out:

- XENs & SDOs Public Health Engineering Department (PHED)
- Chief Officer Municipal Corporations
- Community Development Officers (CDOs) PHED
- Junior Research Officers (JRO) PHED

During the consultations, relevant department officials were inquired about the current situation, challenges and future required WSS interventions in the districts. Major Challenges expressed by concerned officers included Outlived WSS Infrastructure; Absence of groundwater quality testing; High electricity tariffs; Non-existent metering system; Sewerage network leakages polluting water supply infrastructure; Political & feudal influence in Urban & Rural area schemes; Presence of brackish groundwater; Existence of Unserved WSS Pockets; Absence of legal cover to CBOs; Theft issues and Lack of Proper Human Resource and Capacity Building Mechanism.

1.5.3. ON-GROUND SURVEY

To analyze the condition of the WSS infrastructure in both urban and rural areas, the team undertook a field survey. To analyze the state of all assets for the Water Supply and Sewerage System, the team employed a variety of technologies and designed survey forms based on international best practices. Tube Wells, Overhead Reservoirs (OHRs), Ground Storage Tanks (GSTs), Water Filtration Plants (WFPs) and Disposal Stations were among the key data sources. WSS Infrastructure Machinery, Civil Structure, and Electrical Components were all assessed and grouped into the following ratings based on their condition. The team also used mobile water testing kits to conduct random water quality testing. Table 2 is used as criteria for condition assessment exercise.

Table 2: Grading Chart for Asset Condition Assessment

Rating	Asset Condition	Description
A	Excellent	No noticeable defects. Some aging or wear may be visible.
B	Good	Only minor deterioration or defects are evident.
C	Fair	Some deterioration or defects are evident, but function is not significantly affected
D	Poor	Serious deterioration in at least some portion of the structure. Function is inadequate
F	Failing	No longer functional. General failure or complete failure of a major structural component.

Figure 5: Example of Condition of WSS Infrastructure- very Poor

1.5.4. COMMUNITY CONSULTATIONS

The Urban Unit team conducted several consultation sessions in all districts of Sargodha division. To perform the exercise, each city was subdivided into 6 to 7 densely populated areas. This activity included consulting citizens of various ages (ranging from 21 to 65 years old). To collect feedback from citizens, survey forms were developed and used. The team received comments from more than 100 residents in each city on average.

1.5.5. IDENTIFICATION OF GAPS

The gaps in service delivery were observed and asses related to in the development of WSS services in the region, based on consultations with stakeholders and the community. In addition to it, population projections along with water budgets were also taken in to account to figure out priority areas of interventions and technical requirement.

1.5.6. SPATIAL DATA SETS ASSESSMENTS

All geo-tagged data from the field was transferred to ArcGIS, a GIS-based Asset Inventory system was created, and all assets were mapped according to their condition ratings. For the four districts of Sargodha Division, base maps were created including all above ground and subsurface assets, as well as their condition. To assess and plan the actions, different geographic data sets such as communities, river tributaries, secondary water quality layers, groundwater table, and other critical relevant data were layered on existing WSS infrastructure.

1.5.7. PLANNING & DESIGN EXERCISE

The team strategized a plan for providing drinking water and sanitation services to meet the demand of people based on primary data collecting and existing secondary data. For planned short, medium, and long-term phases, future population and water demand were calculated. The team also looked at the current infrastructure and potential gaps in order to provide solutions to satisfy future demand for sustainable planning. In the sectoral plan, all parts of the water supply system were reviewed and planned in detail, including design criteria, infrastructure requirements, equipment, machinery, and facilities requirements, and monitoring requirements.

1.5.8. SUSTAINABLE INTERVENTIONS WITH COSTING

The team categorized the key neglected/problematic regions, the most severe difficulties, and identified the list of interventions in the water supply and sanitation sector needed to meet the needs in a sustainable manner based on the gap analysis and need assessment. Projects and actions were ranked according to their level of urgency. The interventions were identified and arranged in short (2023), medium (2026), and long-term (2031) phases based on the immediacy of the necessity and the severity of the issue to deliver the most efficient level of municipal services.

The anticipated extension of water supply and sewage lines, as well as accompanying machinery and infrastructure, water quality tests, required equipment and machinery, and provision of possible water

treatment solutions, were all discussed, along with other development elements. WSS infrastructure was conceptually designed, and detailed costing for the identified short, medium, and long-term plans were developed.

1.6. PERCEPTION SURVEY

Water supply and sanitation are important municipal services that contribute to inhabitants' health and quality of life. For proper assessment and planning, effective community involvement is required to consider residents' perceptions of the existing state of services and their desire for improvement. The team planned to conduct a perception survey in each district and designed a survey form to collect information about water supply and sanitation services supplied by concerned MCs, based on the scope of work to be carried out in the sectoral WSS regional development plan. To conduct the survey, each city was separated into 6 to 7 densely inhabited zones, and the team received responses from more than 100 residents ranging in age from 21 to 65 years old. People were asked to rate the satisfaction level and their willingness to pay for improved Water Supply and Sanitation services. The outcomes of survey are represented in the form of charts in Figure 6.

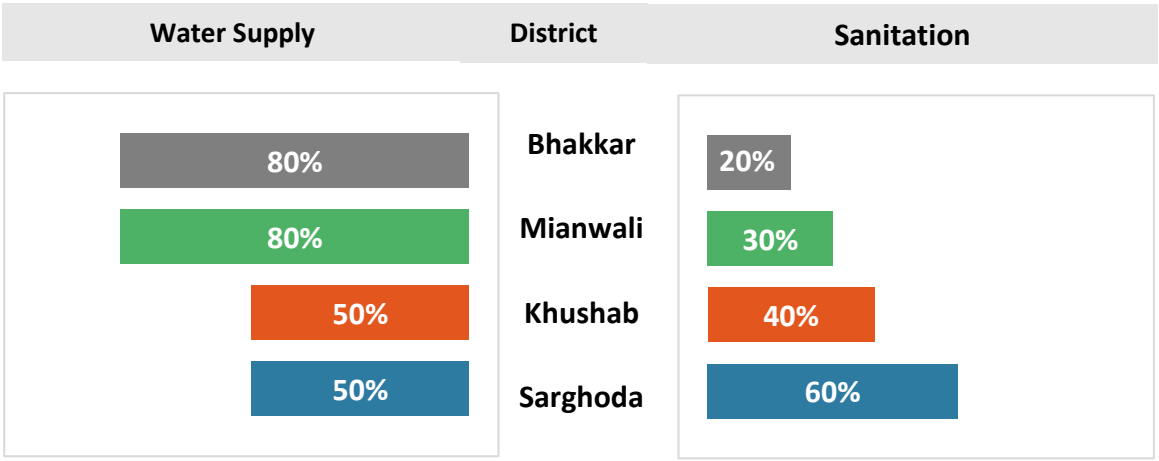


Figure 6: Result of Perception Survey

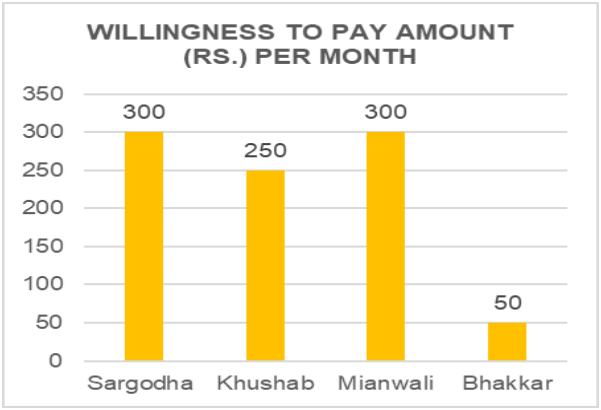


Figure 7: Results of Willingness to Par Survey

The analysis of the poll data revealed that the majority of inhabitants were dissatisfied with the sanitation services offered to them. It was discovered that 80% of the residents of both Mianwali and Bhakkar were satisfied with their water supply, this is because they mainly rely on private bores installed at their households due to availability of sweet water. However, the degree of satisfaction with sanitation services was found around 20% and 30% in Bhakkar and Mianwali respectively. It demonstrates the need for action to improve the services. Around 50% of the residents of Sargodha and Khushab unlike Mianwali and Bhakkar were unhappy with the municipal services. They can be attributed to outlived water supply infrastructure and non-existent sanitation network. The overall condition of the region depicts the need for taking the steps to improve the services.

Figure 8: Consultation conducted with local community

02 Water Supply & Sanitation – Sargodha

A. WATER SUPPLY OF SARGODHA

Sargodha City water supply is managed by Municipal Corporation (MC) Sargodha after Public Health Engineering Department (PHED) designs are executes the water supply schemes in the city. The underground water of Sargodha is brackish. Canal water and seepage wells along Lower Jhelum Branch Canal are the only two sources of fresh water for water supply schemes of the city. The oldest water supply schemes in the city are from pre-partition era dating back to 1904 that is still being operated. Further schemes were added and extended as the population of the city increased. Sargodha is the divisional headquarter of Sargodha Division with a population of about 500,000 individuals. This high-water demand paired with limited sources of fresh water presents a complex situation for the effective delivery of fresh water to the people of the city. The gap in service delivery and the demand is significant and calls for immediate interventions to be addressed.

2.1. EXISTING WATER SUPPLY INFRASTRUCTURE

Sargodha water supply is not fulfilling the required water demand of the city. According to the latest census of 2017, the population of Sargodha is more than 500,000 with almost 80,000 households in the city. Almost 70-80% area of Sargodha city has MC water supply network. The water supply schemes extract water through either direct pumping from Lower Jhelum Branch Canal (LJBC) which is then treated through Slow Sand Filters or from seepage tube wells installed along the canal. This water is then pumped to Water Works (GST) present in various parts of the city from where they are further distributed. A total of 14 MC owned Water Works are currently present in Sargodha. These water works are old with the earliest one being constructed in 1904 and the last constructed in 2006. 13 out of these 14-water works are currently functional. But despite this, the delivery volume of water from these water works in far less than the water demand of the city thus creating a big shortage in demand and supply.

The water system of Sargodha also includes Overhead Reservoirs that are constructed at various locations throughout the city and provide emergency storage to the network. The distribution network of Sargodha is 30-50 years old and covers about 80% of the city. These old pipes have leakages and damages, and the inter-mixing of sewerage is a common occurrence.

Hence, there is a need to rectify and improve these service delivery gaps in order to provide a sustainable plan for the water supply system for Sargodha. A water supply scheme is currently planned and undergoing in Sargodha City.

Table 3: Urban Water Supply Infrastructure in Sargodha City

Tube wells	**53**
Operational	31
Non-Operational	22
Overhead Reservoir	**7**
Operational	7
Non-Operational	0
Water Works	**14**
Operational	13
Non-Operational	1
Water Supply Pipeline	
City Coverage	70-80%

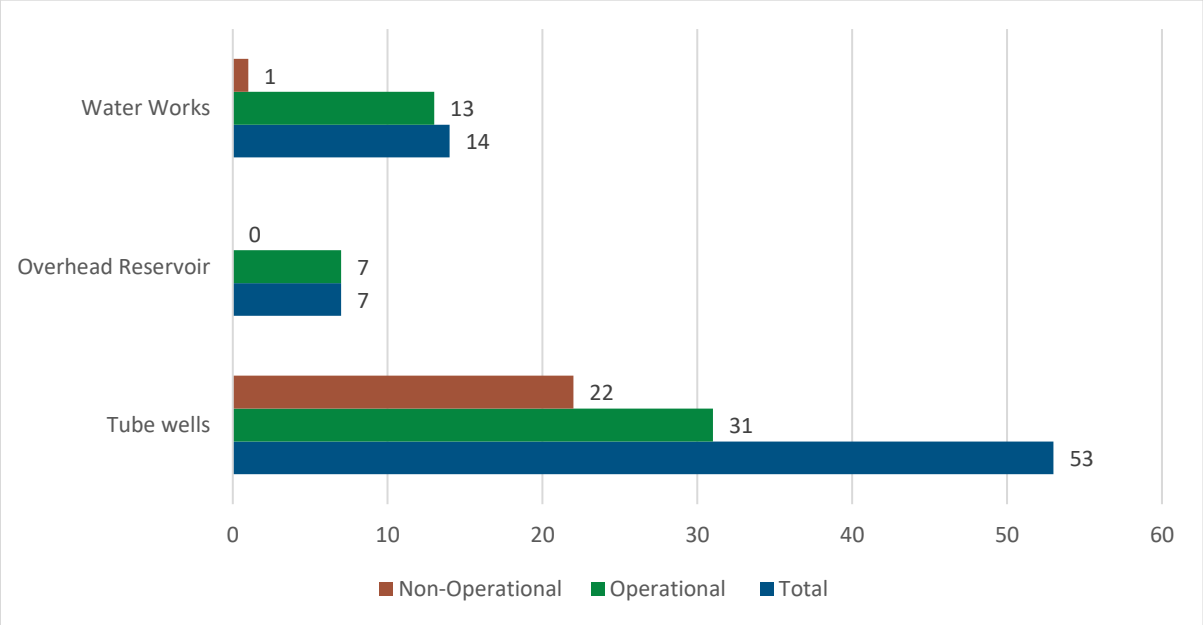


Figure 9: Bar Chart depicting Water Supply Infrastructure of Sargodha City

With regard to condition assessment of the water supply system, overall civil structure, machinery and electrical components associated with water supply infrastructure present in the city has been evaluated as “D” which indicates serious deterioration in at least some portion of the structure and the function being inadequate. The distribution network as a whole is evaluated as “C” meaning that some deterioration or defects are evident but the function is not significantly affected.

2.1.1. TUBE WELLS

The MC Sargodha owns 53 tube wells, 31 out of which are operational. These tube wells were installed along the Lower Jhelum Canal in various schemes from 1960-2006. Most of these tube wells are of 0.5 cusecs discharge capacity except the tube wells of Ludhewala Scheme No. 2, which has 10 tube wells of 1 cusec capacity. The details of tube wells and their relevant schemes are provided as annexure to this report.

14 tube wells have been abandoned due to a number of reasons including system damage, outlived machinery and brackish water issues (Eisanagar Tube wells). The condition of pump houses of the older tube wells is also deteriorating. 8 tube wells are currently under repair by the MC Sargodha. Further, the number of tube wells in the city are also insufficient to cater for the demand of whole city and additional wells are required to fulfill this demand-supply gap.

The pictures below show the different tube wells installed at different locations in Sargodha.

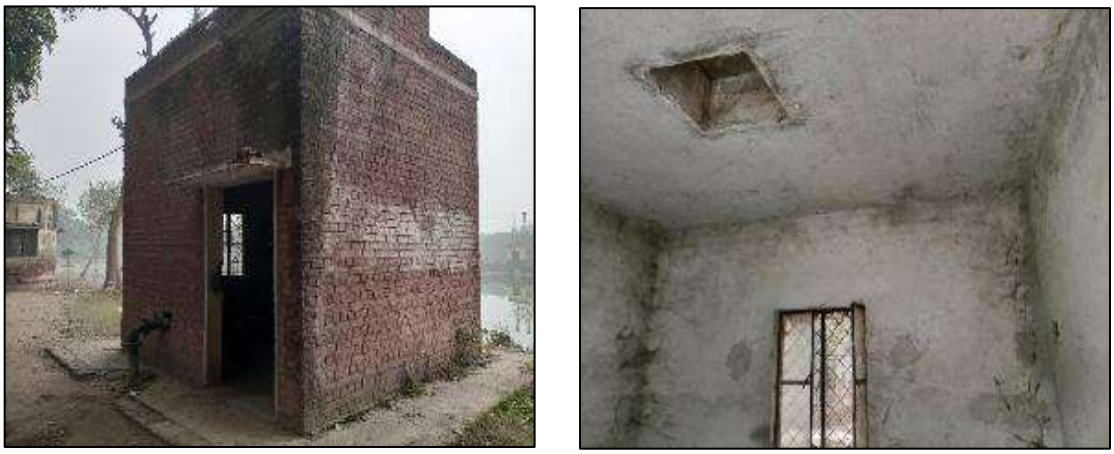


Figure 10: Tube well inside Main Water Works Sargodha

Figure 11: Inside view of an abandoned Tube wells along Lower Jhelum Canal

2.1.2. OVERHEAD RESERVOIR (OHR)

There is a total of 7 Overhead Reservoirs in Sargodha city. All 7 of these OHRs are functional and provide storage to the water supply network of Sargodha city. These OHRs are of different storage capacities and the details are provided as Annexure to this report.

2.1.3. WATER WORKS

Water Works in Sargodha is a water supply facility that is made up of various assets like Ground Storage Tank, Pumping machinery and in some cases a Slow Sand Filter and an Overhead Reservoir. There are a total of 14 Water Works under MC Sargodha out of which 3 Water Works are termed as Main Water Works and the other 11 are Pumping Stations.

2.1.3.1. MAIN WATER WORKS (DIRECT INTAKE FORM CANAL)

The Main Water Works 1925, Main Water Works NST and the Main Water Works Johar Colony are the three Main Water Works of Sargodha. These have a direct intake of water from the Lower Jhelum and Mathalak Rajbah Canals. The pumped water is then treated through Slow Sand Filter beds before storing in GSTs. The water is then distributed to different areas of the city. The Main Water Works of Sargodha was established in 1904 and is still operational. Due to old age of the structure, deteriorating civil structure and machinery of the water works was observed. The lining of the pond was damaged and the sand beds had vegetal growth. The Ground Storage tanks also needed repairs but were functional. Spalling of plaster was observed.

Figure 12: Damaged lining of pond and Damaged GST at Main Water Works Sargodha

Figure 13: Damaged civil structure and Sand Filter bed at Main Water Works Sargodha

2.1.3.2. MAIN WATER WORKS (FED BY TUBE WELLS)

There are 11 smaller Water Works in Sargodha City. These water works are fed from tube wells installed along the Lower Jhelum Canal. Since the tube wells are at a distance from the city, the head is reduced and these water works act as pumping stations for supply of water to various parts of the city. The water from these tube wells is stored in GSTs at these water works and then is distributed further.

Figure 14: Ground Storage Tanks at Gill wala and Satellite Town Water Works

The civil structure of GST of these water works was satisfactory. The machinery and electrical components however had outlived their life with little to no maintenance and needed replacement. The condition of these water works is evident from the pictures attached below:

Figure 15: Electro-Mechanical components of Water Works Satellite Town

2.1.4. FILTRATION PLANTS

There are around 22 Filtration Plants within the boundary of MC Sargodha. These filtration plants are RO plants and are operated by the MC Sargodha. Some of these filtration plants are in dire condition and need major rehabilitation.

Figure 16: Filtration Plant at Katcheri Road, Sargodha

2.1.5. WATER SUPPLY PIPELINES:

The water supply pipelines of Sargodha are 30-50 years old with almost 70-80% coverage of the city. These pipelines are of varying diameters and materials like PVC, CI, MS and AC. The main water supply lines of Sargodha have an approximate length of 50.7 km and range in size from 6”-24”. The distribution network of Sargodha has an approximate length of 300 km and the range in size of 2”-16”. These pipelines are old and have leakages with valves buried under the road in most cases.

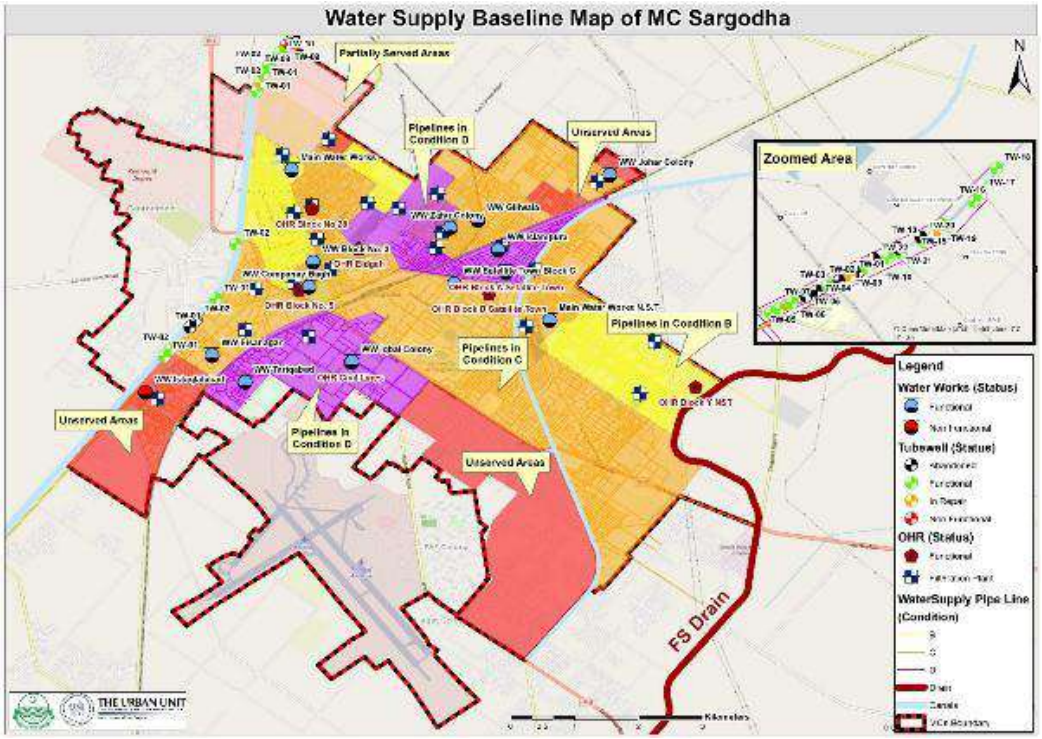


Figure 17: Baseline Water Supply System in Sargodha City

2.2. PLANNING & DESIGN CRITERIA

This section refers to the design of main components of water supply network. The main components are discussed in the subsequent sections. Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 gallons per capita per day i/c 20% as unaccounted for water (NRW) & 15% of commercial water demand and 10% of Industrial and 10% of Institutional water demand have also been added in the design, the current (2022) water demand and future (2025, 2030 and 2040) water demands are shown in **Table 4** below.

Table 4: Estimated Water Demands for Sargodha City

Attributes	Water Demand (Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	558,476	591,266	650,249	786,455
Domestic Demand 33 GPCD (including 20% NRW)	18,429,708	19,511,778	21,458,217	25,953,015
Industrial (Cottage industries, Factories) 10% of Domestic Demand	1,842,970.8	1,951,177.8	2,145,821.7	2,595,301.5
Institutional (Educational, Institutions and Hospitals) 10% of Domestic Demand	1,842,970.8	1,951,177.8	2,145,821.7	2,595,301.5
Commercial (Shops & Restaurants etcetera.) 15% of Domestic Demand	2,764,456.2	2,926,766.7	3,218,732.55	3,892,952.25
Average Day Demand (MG/D)	**25**	**26**	**29**	**35**
Max Day Demand (MG/D)	**37**	**40**	**43**	**53**

Design Criteria

The main objective of design is to evolve a water supply network, which can be operated with minimum maintenance for design life of the project. There is a need to develop a sustainable system for water supply that takes into account the impact of population growth and efficient aquifer recharge mechanism.

- **Planning Horizons**

Planning horizon for this plan is 18 years i.e., 2022-2040. Short-, medium- and long-term phases are identified for 3, 5 & 10 years i.e., 2025, 2030 and 2040 respectively.

- **Population Projection**

The population projections are determined by using following formula:

$P_n = P_o (1+r)^n$

Where,

P_n = Projected population for required year

P_o = Population of base year

r = Population annual growth rate (taken from last Census Report 2017)

n = Number of years, counted from the base year

Growth rate in case of Sargodha city is taken as 1.92% as per 2017 Census report of Pakistan.

- **Maximum Day Demand**

Maximum day demand is taken as 1.5 times the average day demand.

- **Tube Well Working Hours**

Tube Well Working Hours are taken as 16 Hours/day in city as proposed in Design Criteria for WASAs by Urban Unit

- **Overhead Reservoir**

Overhead reservoirs are designed for the continuous supply of water. Capacity of overhead reservoirs is taken as 1/10th of average day demand.

- **Ground Storage Tanks**

When the length of the rising main is such that the loss of head is very high, intermediate pumping stations comprising a storage tank and pumping machinery installed in a pump house will be used. Capacity of ground water storage tanks is taken as 1/4th of average daily demand.

- **Drinking Water Requirement**

Water requirement of 33 Gallons per capita per day as recommended by WASA is used for the design calculations in this report.

2.3. PROPOSED INTERVENTIONS

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

2.3.1. SHORT TERM PLAN

The Short-Term interventions of Sargodha are focused on rehabilitation of sewerage network of the city and hence, no interventions for water supply are proposed during this phase.

An establishment of Backup store and inventory is proposed during the short-term phase to quickly deal with problems with the WSS infrastructure in the city.

Other than these interventions, solar energy potential for public buildings can also be explored as this energy can be used to power nearby WSS infrastructure. University of Sargodha is one such site in the city with a DC potential of almost 885 Kw, and if properly harnessed can provide clean and sustainable solution to power this infrastructure.

Table 5: WS Short - Term Interventions in Sargodha City

WS Short - Term Interventions	
Machinery	▪ 3 Sucker and 3 Jetting Machines ▪ Mobile Workshop Units
Back – up Store	▪ Establishment of Backup store in MC Sargodha

2.3.2. MEDIUM TERM PLAN

In the medium phase interventions, new infrastructure will be installed in order to cater for the future aforementioned population and water demand. The Extension of Water Supply Scheme in Sargodha city is thus proposed which includes the construction of fifty (50) tube wells (complete with elevated pump houses) along the River Jhelum. Due to distance from the city, an Intermediate Pumping Station (IPS) with 5 Storage Tanks of 600,000 Gallons is also proposed. The water will be carried through 40" rising main to the IPS and then to the city. Five (5) new Ground Storage Tanks (600,000 Gallons each) and six (6) Overhead Reservoirs (100,000 Gallons each) are proposed to be constructed to integrate the new water supply with the existing water supply network of the city. The locations of these new Overhead Reservoirs and Storage Tanks have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Extension of water supply to unserved areas of Sargodha is also proposed during the medium-term phase, which includes the laying of HDPE pipelines along with valves and joints in the unserved localities of Sargodha.

A Distribution Network Improvement Zone (DNI Zone) is proposed to be established in Satellite Town Block A of Sargodha. The existing 22 filtration plants of Sargodha are to be provided with 4kW solar systems to make them self-sufficient in terms of energy consumption.

Table 6: WS Medium - Term Interventions in Sargodha City

WS Medium - Term Interventions	
Infrastructure	**Tube wells:** ▪ New 50 no. of Tube wells each of 1-Cusec. **Intermediate Pumping Station (IPS):** ▪ New 1 No. IPS (Along with 5x600,000 Gallons GSTs) **Overhead Reservoirs (OHRs):** ▪ New 6 No. OHRs (100,000 Gallons each) **Ground Storage Tanks (GSTs):** ▪ New 5 No. GSTs (600,000 Gallons each) **DNI Zone:** ▪ Establishment of Distribution Network Improvement Zone for Satellite Town Block-A, Sargodha
Machinery	▪ Chlorinators ▪ Bulk Meter
Back – up Store	▪ Solarization of 22 Filter Plants in Sargodha

2.3.3. LONG TERM PLAN

In the long-term phase, construction of Training Center for technical training of MC sanitary staff is proposed. Construction of a Water Quality Lab is also proposed during long term for the effective monitoring of water quality in the city.

The water infrastructure of the city was replaced during the medium term and hence, water metering is proposed during the long-term phase in order to quantify the water supply to the city.

Table 7: WS Long - Term Interventions for Sargodha City

WS Long - Term Interventions	
Machinery	▪ Water Meters / Flow Meters
Back – up Store	▪ Establishment of Water Quality Lab
Training Center	▪ Establishment of Training Center at MC Sargodha

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 8: Proposed WS Projects Interventions for Sargodha City

Sr. #	Plan Period	Project Title	Justification & Scope
1.	**Short – Term (2025)**	Machinery Procurement including 03 sucker & 03 jetting machines and establishment of Backup Store with Mobile Workshop	▪ Machinery in order to quick fix sewerage blockage ▪ Store for backup spares and mobile workshop units for repair & maintenance of WSS Infrastructure
2.	**Medium – Term (2030)**	New Water Supply scheme: Construction of 50 No. of new Tube-wells along Jhelum River along with IPS, OHR and GST in Sargodha City	▪ Construction of 50 pump houses with Tube wells & 01 IPS (5x600,000 GLNS GST each) with 2x40" dia HDPE Rising Main. ▪ 06 OHR's (100,000 GLNS) & 05 (600,000 GLNS) GST to integrate with rest of the city ▪ Augmentation of water supply is needed
3.		Extension of water supply in unserved areas of Sargodha City (Johar Colony, Din Colony, Aheer Colony, Istaqlalabad, Gulshan Colony, Maryam Town, Dhodhi Colony, Bus Adda) & establishment of DNI Zone in Satellite Town Block A	▪ Provision of distribution network with HDPE pipes, installation of new valves, joints & air valves ▪ DNI Zone with SCADA
4.		Solarization of 22 filtration plants in Sargodha city (4 kW system)	▪ Rooftop 4 kW solar system with installation of solar panels, inverters and electrification
5.	**Long – Term (2040)**	Construction of Training Center with Water Quality Lab & Water Metering of the whole city	▪ Training of WSS officials for: Asset Management, Geo Tagging of WSS Infrastructure, O&M of E&M equipment & Water Quality Testing Lab establishment

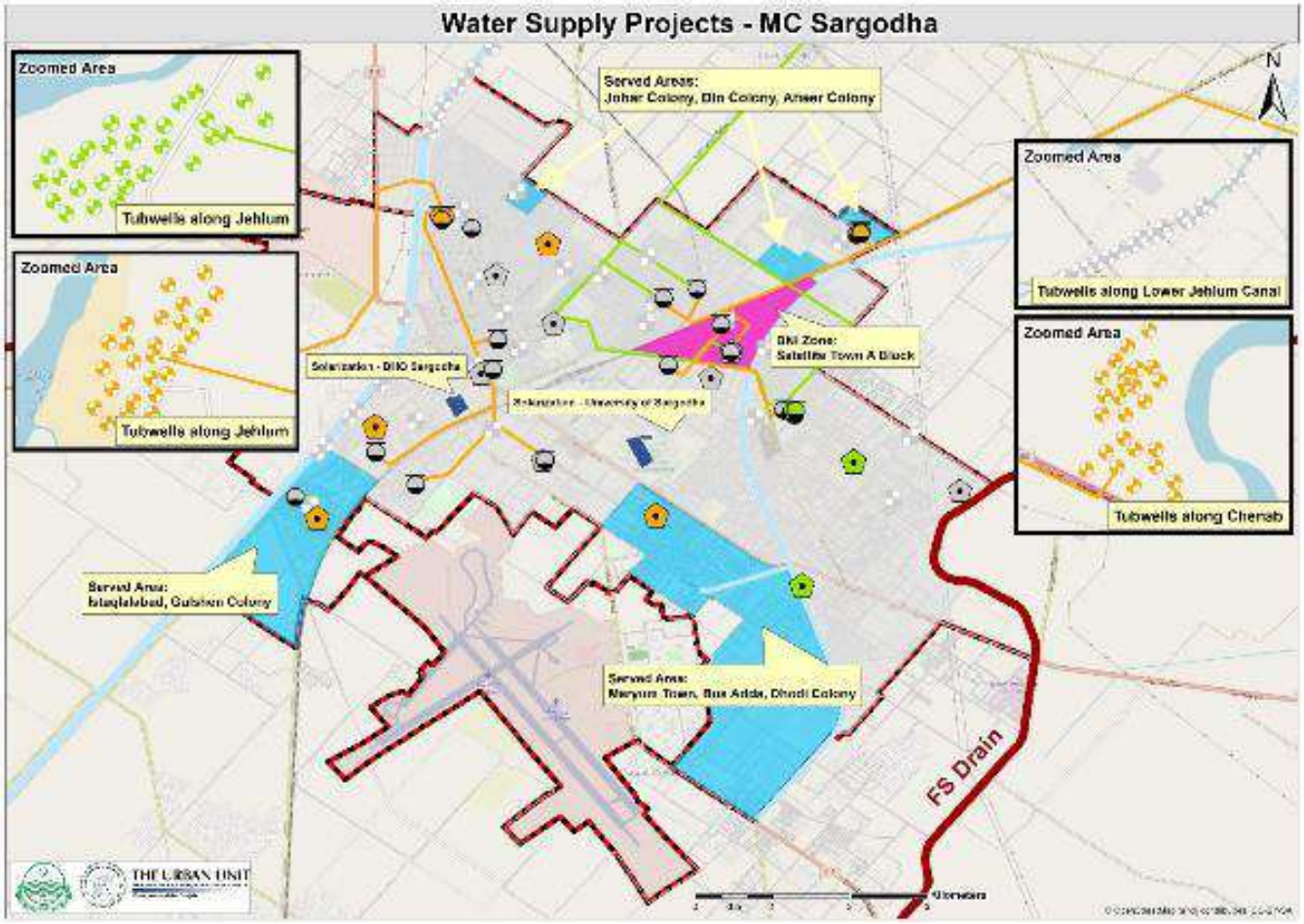


Figure 18: Proposed Spatial WS Interventions for Sargodha City

B. SEWERAGE SYSTEM SARGODHA

Provision of sewerage services in Sargodha is the responsibility of MC Sargodha. The sewerage schemes are designed and executed by Public Health Engineering Department (PHED) and then handed over to Municipal Corporation Sargodha for its Operation and Maintenance. The current sewerage system of Sargodha is insufficient as compared to the huge population of the city and is outlived. The condition of disposal stations specially the main disposals is dire. The structure is in deteriorated condition and overflowing issues are common at these disposals. The sewage of the whole city is carried through two drains; FS and Mona drain that passes through the outskirts of the city. The sewerage system of Sargodha is in sub-standard condition that needs to be immediately addressed.

2.4. EXISTING SEWERAGE INFRASTRUCTURE

The existing sewerage system of Sargodha is old and sub-standard. Almost 70% area of Sargodha has sewerage schemes but this sewerage network is more than 30 years old. The existing system of sewerage constitutes of old RCC sewer lines ranging from 9" to 72" diameter. There are 11 disposal stations in the city, 3 of which are termed as Main Disposals. The sewerage water of the entire city is pumped by various disposals and then reach the Main Disposals of the city. Main Disposal Jinnah Colony and NST carry the waste water via 54" trunks to the FS Drain whereas the Sillanwali Road Main Disposal carries the waste water via 72" trunk to the Mona Drain. These drains carry the waste of the entire city to the agricultural fields.

The outskirt areas of the city are still deprived of proper sewerage network. Open drains are a common sight. Currently, a sewerage scheme is under works by Public Health Engineering Department (PHED) for Maqam-e-Hayat area of the city.

Overall, the existing Sewerage disposal system is not sufficient to meet current and future waste disposal demand of the city & condition of the existing structure especially sewerage lines needs attention so that it is properly disposed-off.

Table 9: Sewerage Infrastructure in Sargodha City

Disposal Stations	**11**
Operational	11
Non-Operational	0
Waste Water Treatment Plants	**0**
Operational	0
Non-Operational	0
Sewer Lines	
City Coverage	70%

With regard to condition assessment of the sewerage system, overall civil structure, machinery and electrical components associated with sewerage infrastructure present in the city has been evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate. The distribution network as a whole is also evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate.

Table 10: Asset condition of Sewerage infrastructure in Sargodha

Assets	Rating
Civil Structure	D
Sewerage Network	D
Electrical Components & Machinery	D

2.4.1. DISPOSAL STATIONS

There are a total of 11 MC owned Disposal Stations in Sargodha City. 3 out these are termed as Main Disposal Stations. These main disposals are bigger than the rest and the sewage of the entire city is collected in these before it is disposed in the drains. These disposal stations were built more than 30 years ago and have not been properly maintained. Almost all of these have spalling civil structure. The walls of wet wells are well deteriorated due to action of Sulphur. There are no screening chambers present in any of the disposal.

The Ghani Park disposal is a special case that needs to be mentioned as it is present in a highly congested area with no boundary wall. This disposal is undersized and the waste water is almost always overflowing. The road leading up to the disposal is filled with stagnant and polluted water and is a breeding ground for mosquitos. This create a highly unsanitary and unhygienic condition for the people around the disposals.

Figure 19: Houses just beside Ghani Park Disposal

Figure 20: Overflowing waste water from Ghani Park Disposal

The Jinnah Colony Main Disposal has extremely outlived structure. The wells and the machinery are barely functional. The boundary wall was damaged and the wet well was in deteriorating condition. Overflow issue was reported in this disposal during load shedding hours. The main sewer line was also choked due to silting. The Sillanwali Road Main Disposal was in the same condition.

Figure 21: Well and Roof Girders of Jinnah Colony Main Disposal

The pumps and motors in all of the disposals are in highly derogated condition and open wiring is used. The waste water from the disposals is dumped in Mona drain and FS drain that pass outside the city and is carried to the fields.

2.4.2. SEWERAGE NETWORK

The sewerage network consists of RCC pipes of diameters ranging from 9” to 72”. These sewer lines have an approximate spread of 70% of the city. These pipelines are in unsatisfactory condition with most of them being undersized. A new sewerage scheme for Maqam-e-Hayat area is under works by PHED.

2.4.3. WASTEWATER TREATMENT PLANTS

Oxidation ponds, also called stabilization ponds, these are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. There are currently no Waste Water Treatment Plant in Sargodha City.

2.5. PLANNING & DESIGN CRITERIA

The purpose of this planning exercise was to assess the current gaps and future wastewater disposal demand for the citizens of the city. The sewage generation of Sargodha is expected to rise up to 83.63 MGD at the end of 2040. It should be noted that sewage flow generated by Sargodha Cantonment area (adjacent to Sargodha MC) is also included in the final calculations of sewage flow for Sargodha City. It is evident that the current capacity of the functional disposal station is lesser than the sewage generated by the city.

Based on the current and projected populations for the Municipal Corporation (and Sargodha Cantonment), the proposed water demand of 33 Gallons per Capita per Day, the current (2022) and future (2025, 2030 and 2040) waste water flows are calculated and shown in the table below.

Table 11: Estimated Sewage Flow of Sargodha City

Attributes	Sewerage Flow (Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	558,476	591,266	650,249	786,455
Population (Sargodha Cantt.)	167213	177030	194690	235472
Average Sewage Flow for 33 GPCD (including 20% NRW)	19.16	20.28	22.31	26.98
Peak Sewage Flow	38.32	40.57	44.61	53.96
Storm Water Flow (33%)	19.16	20.28	22.31	26.98
Non-Domestic Flows (5%)	0.96	1.01	1.12	1.35
Infiltration (5%)	0.96	1.01	1.12	1.35
Total Sewage Flow (MG/D)	**59.39**	**62.88**	**69.15**	**83.63**

- **Design Criteria**

Average waste water is taken as 80% of the Average Water Demand of the city. The Peak Factor of 2 is used for this design considerations as the population of city is (>100,000). Storm water flow is taken as 50% of the Average Water Demand as Sargodha City lies in the Northern Zone of Punjab. Non-Domestic Flows and Infiltration as 5% of the Average Water Demand is used. The collective sewage flow of Sargodha city and Sargodha Cantonment is calculated for this report.

2.6. PROPOSED INTERVENTIONS

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

2.6.1. SHORT TERM PLAN

The Short-Term interventions of Sargodha are focused on rehabilitation of sewerage network in the city. Rehabilitation of nine (9) disposal stations in the city is proposed with measures like upgradation of pumping machinery, capacity enhancement of wells (where possible) and repair of civil structure. Screening chambers are also proposed for all the disposals in the city.

The two main disposals; Main Disposal Jinnah Colony and Main Disposal Sillanwali Road are in very unsatisfactory condition and rehabilitation and capacity enhancement are proposed for these main disposals. The civil structure is to be repaired as per the condition and screening chambers are to be provided. Moreover. The main sewer line of Jinnah Colony Disposal is proposed to be replaced with 72" HDPE line to cater for the rise in future population and increase in sewage flow of the city.

Table 12: Sewerage Short - Term Interventions in Sargodha City

Sewerage Short - Term Interventions	
Infrastructure	**Disposal Stations:** ▪ Upgradation of nine (9) Disposals in Sargodha City ▪ Upgradation and Capacity Enhancement of Main Disposal Jinnah Colony and Main Disposal Sillanwali Road **Sewer Line:** ▪ Replacement of main sewer line of Jinnah Colony Main Disposal (72" HDPE)
Machinery	▪ Screening Chamber

2.6.2. MEDIUM TERM PLAN

In the medium-term phase, interventions related to water supply system of Sargodha are proposed and hence no intervention related to Sewerage System of Sargodha is proposed in this phase.

2.6.3. LONG TERM PLAN

In the long-term phase interventions, new infrastructure will be installed in order to cater for the unserved areas of Sargodha and waste water generated by these localities. It is proposed to lay sewerage system for the unserved and partially served communities of Sargodha including laying of trunk sewers, partial and secondary lines in these areas. The sewerage system is to be connected to the existing network.

Moreover, two (2) Waste Water Treatment Plants of 35 MGD capacity each are proposed at both FS and Mona Drains in Sargodha complete with all the sludge carrier, pumping machinery and oxidation ponds.

Table 13: Sewerage Long - Term Interventions for Sargodha City

Sewerage Long - Term Interventions	
Infrastructure	**Disposal Stations:** ▪ Two (2) Waste Water Treatment Plants of 35 MGD each **Sewer Line:** ▪ New sewerage system for the unserved areas of Sargodha

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 14: Proposed Sewerage Projects Interventions for Sargodha City

Sr. #	Plan Period	Project Title	Justification & Scope
1.	**Short – Term (2025)**	Rehabilitation and capacity enhancement of Main Disposal Stations of Sillanwali road & Jinnah colony	▪ Upgradation of pumping machinery & electrical components, installation of screening chambers, renovation of civil structures, new wells, ▪ Replacement of main sewerage pipe of Jinnah Colony Main Disposal Stations with 72" HDPE
2.		Rehabilitation of 09 Disposal Stations and installation of screening chambers. Disposal Stations: D/S Istiklalabad Colony, D/S Model Town, D/S Eid gah, D/S Block-A Satellite Town, D/S Block-C Satellite Town, D/S Ghanni Park, D/S Fazal Town and D/S Mohamandi Colony	▪ Upgradation of pumping machinery, capacity enhancement of wells & rehabilitation of civil structures
3.	**Long – Term (2040)**	Extension of sewerage network in Din Colony, Johar Colony, Mujahid Colony, Old Civil Lines, Aziz Bhatti Town, Tariqabad, Sabir Town, Cheema Colony, Peer Muhammad Colony, Bus Adda, Ghalla Mandi	▪ Laying of Trunk Sewers and sewage network for safe disposal of sewage to the WWTP

		Areas and Cantonment area including PAF Colony	
4.		Construction of 02 Waste Water Treatment Plants (Oxidation Ponds) on Mona & F.S drains/Nullah	▪ Construction of 02 Oxidation Ponds of 35 MGD capacity (each) for treatment of Waste Water

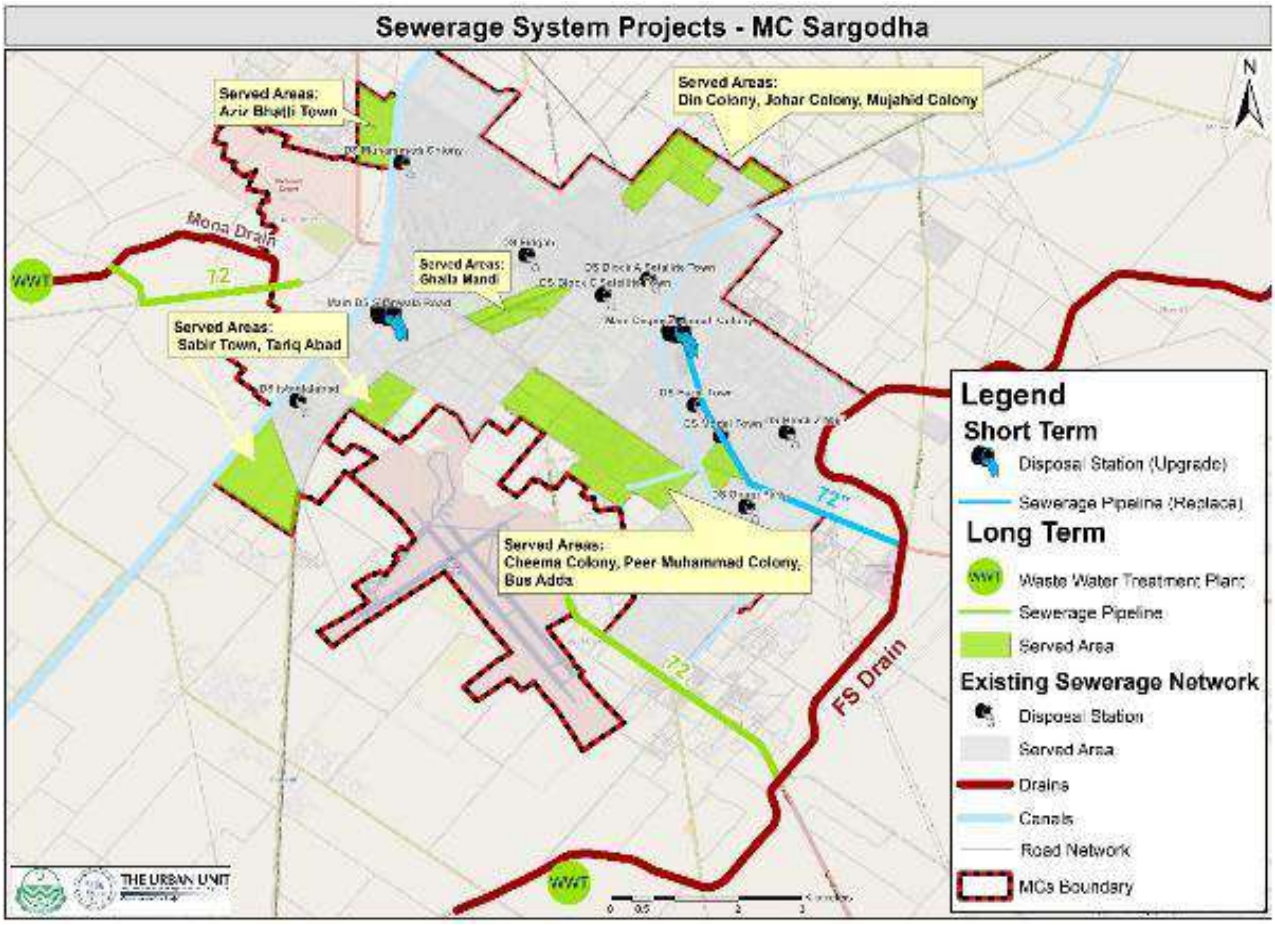


Figure 22: Proposed Spatial Sewerage Interventions for Sargodha City

03 Water Supply & Sanitation – Khushab

A. WATER SUPPLY – KHUSHAB

Khushab City water supply is managed by Municipal Committee (MC) Khushab after Public Health Engineering Department (PHED) designs are executes the water supply schemes in the city. The underground water of Khushab is brackish. The two main sources of water for the city are seepage wells along the Jhelum River and direct intake from canal. The water from the tube wells is stored in Ground Storage Tanks across the city from where it is further distributed. The water from the canals is treated in Water Works and then supplied to the city. The population of Khushab according to the latest census of 2017 is about 120,000 and the absence of sweet underground water presents a complex situation for the effective delivery of fresh water to people of the city. The water supply schemes cannot be operated at their full capacity due to a number of technical reasons and gap between the service delivery and demand calls for immediate interventions to be addressed.

3.1. EXISTING WATER SUPPLY INFRASTRUCTURE

The water supply of Khushab presents a complex situation. The population of Khushab is approximately 120,000 whereas the MC water supply connections are a mere 10,000. Almost 60-70% city has MC water supply network. The water supply of Khushab is dependent on sweet water extracted from 1-L Khushab Minor Canal and tube wells along the Jhelum River.

There are three (3) water works in Khushab city. These water supply facilities have direct intake of water from the 1-L Khushab Minor Canal. The water is stored in a large pond from where it is treated through Slow Sand Filters and stored in Ground Storage Tanks. The water is then supplied to the city from these tanks. There are total of twenty-eight (28) tube wells installed along the flood plains of River Jhelum. These tube wells are provided in two locations; Kacha Khushab and Kacha Shahpur. Most of these tube wells have been constructed in 2015-2016 in two phases. The water from these tube wells is carried through a pipeline to the city where it is stored in two (2) Storage Tanks. These storage tank then further distributes the water to different areas of the city. Most of these tube wells are non-operational due to a number of reasons like theft of machinery, bore issues and such.

The water supply pipes of Khushab are in working condition. The force main from the tube wells to storage tanks is however under sized and consists of patches of different material pipes. Bursting and leakage problem is a common occurrence.

It is evident from the aforementioned reasons that the water supply of Khushab is insufficient as compared to the actual demand of the city. Hence, there is a need to rectify and improve these service delivery gaps in order to provide a sustainable plan for the water supply system for Khushab.

Table 15: Urban Water Supply Infrastructure in Khushab City

Tube wells	28
Operational	8
Non-Operational	20
Ground Storage Tanks	**2**
Operational	2
Non-Operational	0
Water Works	**3**
Operational	3
Non-Operational	0
Water Supply Pipeline	
City Coverage	60-70%

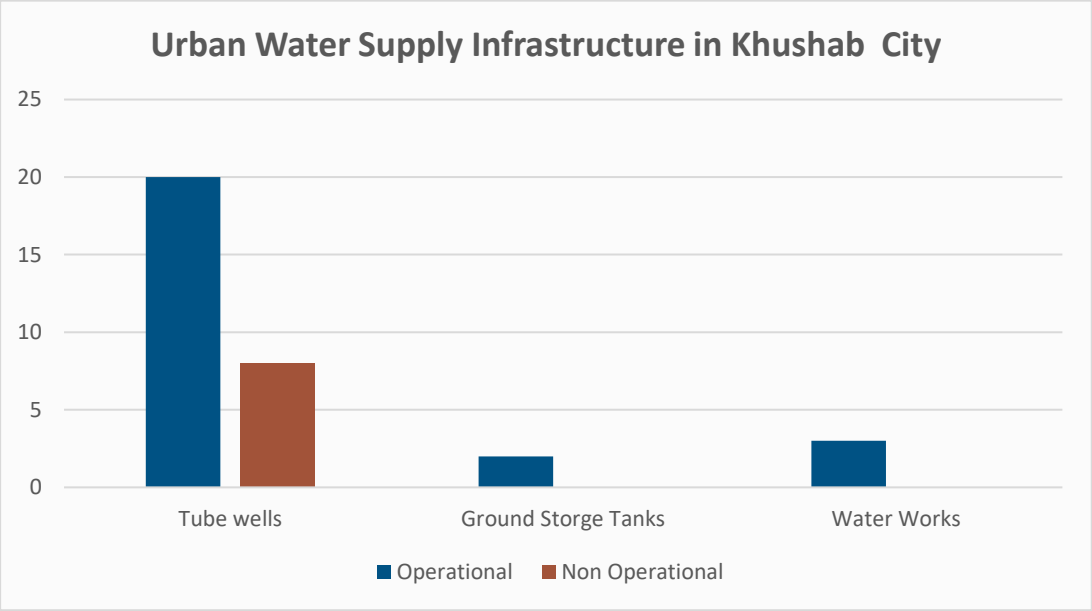


Figure 23: Bar Chart dipicting Urban Infrastructure pf Khushab District

With regard to condition assessment of the water supply system, overall machinery and electrical components associated with water supply infrastructure present in the city has been evaluated as “D” which indicates serious deterioration in at least some portion of the structure and the function being inadequate. The distribution network as a whole is evaluated as “C” meaning that some deterioration or defects are evident but the function is not significantly affected. Similarly, the civil structures of water supply infrastructure are evaluated as “C” meaning that some deterioration or defects are evident but the function is not significantly affected.

Table 16: Asset Rating in Khushab City

Assets	Rating
Civil Structure	C
Distribution Network	C
Electrical Components & Machinery	D

3.1.1. TUBE WELLS

The MC Khushab owns a total of 28 tube wells but only 8 out of them are currently functional. These tube wells are installed in two locations along the River Jhelum; Kacha Shahpur and Kacha Khushab. Most of these tube wells were installed by PHED in 2015-2016 and have a discharge capacity of 0.5 cusecs. The details of these tube wells is provided as annexure.

There are 24 tube wells in Katcha Shahpur scheme, but only 7 of them are functional. All of the tube wells in Katcha Shahpur scheme are of 0.5 cusec discharge capacity. These tube wells are installed along the flood plains of River Jhelum and have been constructed on raised pillars (raised framed structure) for protection against floods. Most of the non-functional tube wells have motors and transformer issues. The civil structure of these tube wells in generally fine except for bulged floor and cracked stairs in some of them. Similarly, there are 4 tube wells in Kactha Khushab scheme but only one of them is currently functional. These 4 tube wells also have a discharge capacity of 0.5 cusecs. The tube wells in this scheme suffer from transformer theft and motor issues.

It should be added that the MC Khushab is unable to operate all of these tube wells at the same time because of undersized force main from the wells to the storage tank. The pictures below show the different tube wells installed at different locations in Khushab.

Figure 24: Bulged floor of a tube well in Kacha Shahpur

3.1.2. WATER WORKS

The term Water Works is used for a water supply facility that is made up of various assets like Ground Storage Tank, Pumping machinery and in some cases a Slow Sand Filter and an Overhead Reservoir. There are a total of 3 Water Works under the ownership of MC Khushab. These water works have direct intake of water from the 1-L Khushab Minor Canal. The water from the canal is stored in a pond for days when the canal is cut off. The water is then passed through slow sand filter beds. From there it gets to the clearing tank from where it is distributed throughout the city. The details of these water works is provided as Annexure to this report.

Figure 25: Water Pond and GST at Water Works (Scheme No 2) in Khushab

The water works of Khushab were in deteriorating condition. The civil structure of the filter beds had cracks and spalling plaster. The slow sand filter beds had vegetal growth in them. The civil structure of GST of these water works also had minor cracks. The machinery and electrical components however had outlived their life with little to no maintenance and needed replacement. The condition of these water works is evident from the pictures attached below:

Figure 26: Slow Sand Filter at Water Works Khushab in deteriorating condition

3.1.3. GROUND STORAGE TANKS (GST)

There are two (2) Ground Storage Tanks in Khushab City; Rehmatwala GST and Badliwala GST. These tanks are designed to store the water coming from the tube wells of Kacha Shahpur and Kacha Khushab schemes. Badliwala GST has a storage capacity of 400,000 Gallons whereas the Rehmatwala GST has a storage capacity of 600,000 Gallons. Both of these tanks are currently in functional condition with minor damages related to parapet walls and plaster. The electro-mechanical components of these GSTs are also in satisfactory condition. The details of these Ground Storage Tanks are provided as annexure to this report.

Figure 27: Water Ponding beside Rehmatwala GST

Figure 28: Rehmatwala GST Khushab

3.1.4. FILTRATION PLANTS

There are around 4 Filtration Plants within the boundary of MC Khushab. All of these filtration plants are Ultra-filtration plants are in dire condition. The civil structure is damaged. The tiles and outside walls have algae and fungal growth creating a very unhygienic condition for a drinking water collection point. The condition of these filtration plants is evident from the pictures below.

Figure 29: Filtration plant beside PHED office Khushab

3.1.5. WATER SUPPLY PIPELINES

The water supply pipelines of Khushab cover approximately 60-70% area of the city. These pipelines are of varying diameter and materials like PVC, CI, MS, GRP and AC. The condition of water supply distribution network is mostly satisfactory with minor leakages. The force main from the tube wells however, is undersized (24" AC). Bursting of pipe and leakages are common and creates a hurdle in the supply of water to the city.

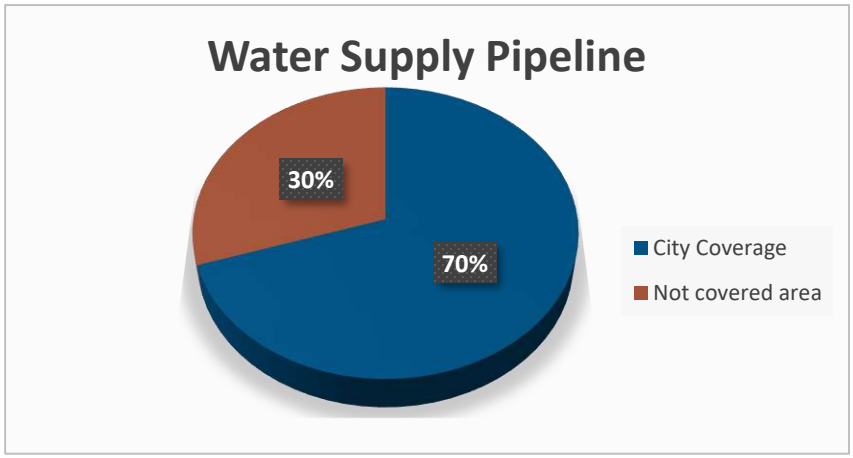


Figure 30: Pie Chart showing water supply pipelines coverage of Khushab

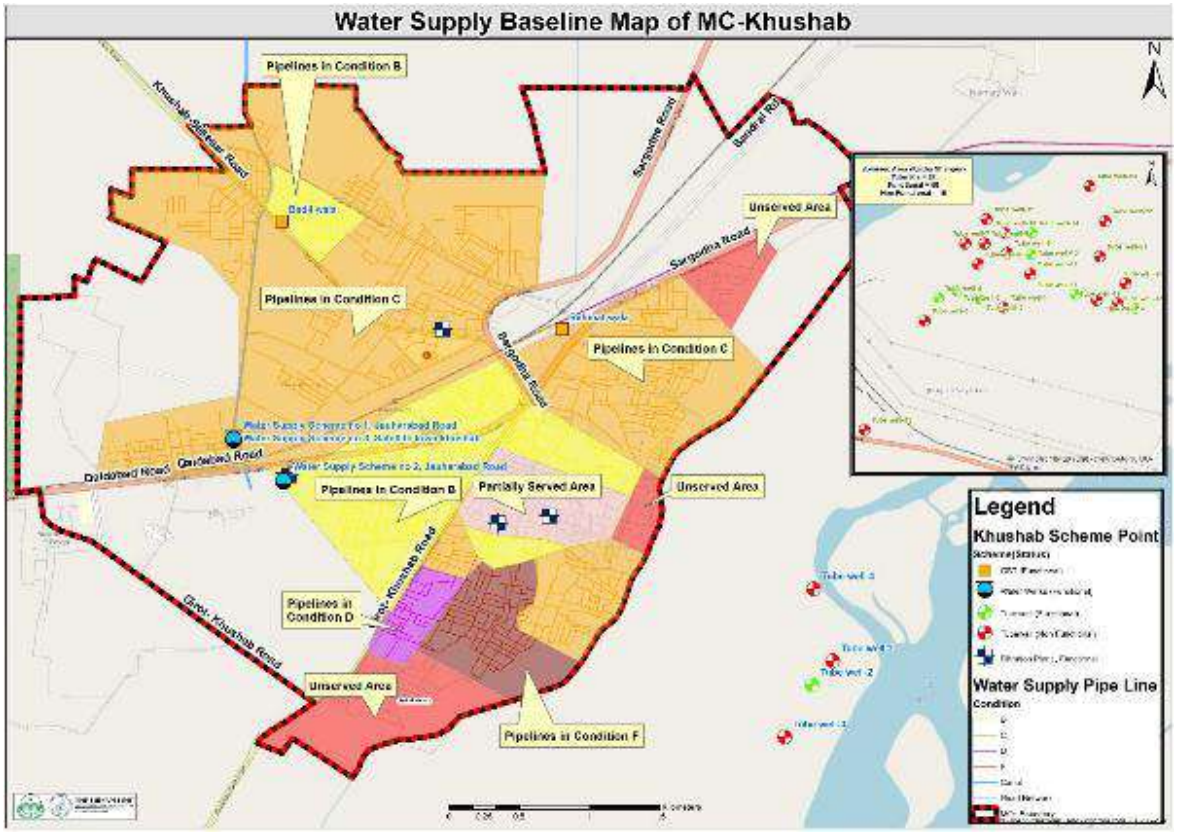


Figure 31: Baseline Water Supply System in Khushab City

3.2. PLANNING & DESIGN CRITERIA

This section refers to the design of main components of water supply network. The main components are discussed in the subsequent sections. Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 gallons per capita per day i/c 20% as unaccounted for water (NRW) & 15% of commercial water demand and 10% of Industrial and 10% of Institutional water demand have also been added in the design, the current (2022) water demand and future (2025, 2030 and 2040) water demands are shown in **Table 3** below.

Table 17: Estimated Water Demands for Khushab City

Attributes	Water Demand (Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	133,825	143,315	160,650	201,865
Domestic Demand 33 GPCD (including 20% NRW)	4,416,225	4,729,395	5,301,450	6,661,545
Industrial (Cottage industries, Factories) 10% of Domestic Demand	441,622.5	472,939.5	530,145	666,154.5
Institutional (Educational, Institutions and Hospitals) 10% of Domestic Demand	441,622.5	472,939.5	530,145	666,154.5
Commercial (Shops & Restaurants etcetera.) 15% of Domestic Demand	662,433.75	709,409.25	795,217.5	999,231.75
Average Day Demand (MG/D)	**5.96**	**6.38**	**7.16**	**8.99**
Max Day Demand (MG/D)	**8.94**	**9.58**	**10.74**	**13.49**

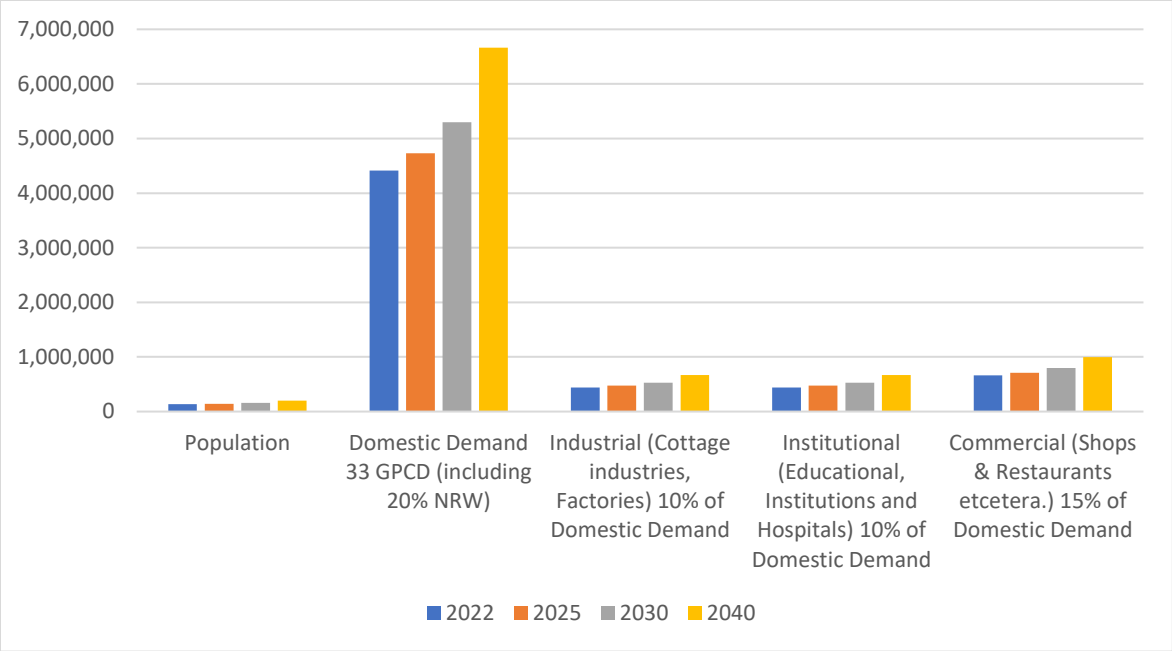


Figure 32: Estimated Water Demand in Khushab City

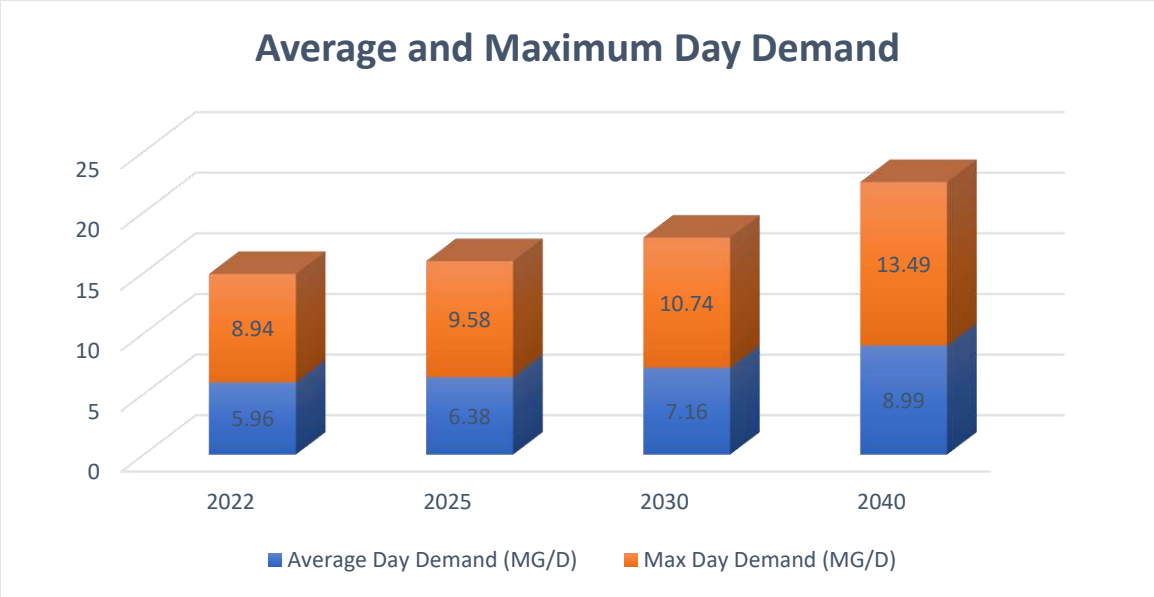


Figure 33: Average and Maximum Day Demand

Design Criteria

The main objective of design is to evolve a water supply network, which can be operated with minimum maintenance for design life of the project. There is a need to develop a sustainable system for water supply that takes into account the impact of population growth and efficient aquifer recharge mechanism.

- **Planning Horizons**

Planning horizon for this plan is 18 years i.e., 2022-2040. Short-, medium- and long-term phases are identified for 3, 5 & 10 years i.e., 2025, 2030 and 2040 respectively.

- **Population Projection**

The population projections are determined by using following formula:

$Pn = Po (1+r)n$

Where,

P_n = Projected population for required year

P_o = Population of base year

r = Population annual growth rate (taken from last Census Report 2017)

n = Number of years, counted from the base year

Growth rate in case of Khushab city is taken as 2.31% as per 2017 Census report of Pakistan.

- **Maximum Day Demand**

Maximum day demand is taken as 1.5 times the average day demand.

- **Tube Well Working Hours**

Tube Well Working Hours are taken as 16 Hours/day in city as proposed in Design Criteria for WASAs by Urban Unit

- **Overhead Reservoir**

Overhead reservoirs are designed for the continuous supply of water. Capacity of overhead reservoirs is taken as 1/10th of average day demand.

- **Ground Storage Tanks**

When the length of the rising main is such that the loss of head is very high, intermediate pumping stations comprising a storage tank and pumping machinery installed in a pump house will be used. Capacity of ground water storage tanks is taken as 1/4th of average daily demand.

- **Drinking Water Requirement**

Water requirement of 33 Gallons per capita per day as recommended by WASA is used for the design calculations in this report.

3.3. PROPOSED INTERVENTIONS IN KHUSHAB

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

3.3.1. SHORT - TERM PLAN

The Short-Term plan for Khushab is focused on rehabilitation of water supply infrastructure to make it functional at 100% capacity. Rehabilitation of sixteen (16) tube wells is thus proposed during this phase. Moreover, capacity enhancement of these tube wells is also proposed and it is recommended to upgrade these tube wells from 0.5 cusecs to 1 cusec each. The force main (24"AC) is also proposed to be replaced by 36" HDPE pipeline. Construction of 2 new Overhead Reservoirs of 100,000 Gallons in Khushab is also included in this phase. Water Proofing of Rehmatwala GST is also proposed to protect It from waste water accumulated adjacent to it.

Other than these interventions, solar energy potential for public buildings can also be explored as this energy can be used to power nearby WSS infrastructure. DPS Khushab and the Sarwar Shaheed Library are such sites in the city with a DC potential of almost 671 and 25.9 Kw each and if properly harnessed can provide clean and sustainable solution to power this infrastructure. A canal-top solar power project is proposed for 1-L Khushab Minor canal to supply renewable energy to Water Works nearby and make it self-sustainable.

Table 18: WS Short - Term Interventions in Khushab City

Water Supply Short - Term Interventions	
Infrastructure	▪ Rehabilitation/Upgradation of 16 Tube wells from 0.5-cusec to 1-cusec ▪ Construction of 2 new OHR of 100,000 Gallons ▪ Water Proofing of Rehmatwala GST
Machinery	▪ Chlorinators / Bulk Meters
Pipelines	▪ Replacement of Force Main of 24" AC with 36" HDPE pipeline
Renewable / Solar	▪ Canal Top Solar System at 1-L Khushab Minor

3.3.2. MEDIUM TERM PLAN

In the medium phase interventions, new infrastructure will be installed in order to cater for the future aforementioned population and water demand. The Extension of Water Supply Scheme in Khushab city is thus proposed which includes the construction of twenty-one (21) tube wells of 1-cusec capacity each along river Jhelum. Two (2) Ground Storage Tanks of 400,000 Gallons and Two (2) Overhead Reservoirs of 100,000 Gallons are also proposed with a 36" HDPE rising main to integrate these tube wells with the existing water supply system of the city. The locations of these new Tube wells, Overhead Reservoirs and

Storage Tanks have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Construction of five (5) new Ultrafiltration Plants is also proposed during the medium-term phase. A Distribution Network Improvement Zone (DNI Zone) is proposed to be established in Islampura area of Khushab.

Table 19: WS Medium-Term Interventions in Khushab City

Water Supply Medium - Term Interventions	
Infrastructure	**Tubewells:** ▪ New 21 no. of Tube wells each of 1-Cusec. **Overhead Reservoirs (OHRs):** ▪ New 2 No. OHRs (100,000 Gallons each) **Ground Storage Tanks (GSTs):** ▪ New 2 No. GSTs (400,000 Gallons each) **DNI Zone:** ▪ Establishment of Distribution Network Improvement Zone for Islampura, Khushab
Machinery	▪ Chlorinators ▪ Bulk Meters

3.3.3. LONG TERM PLAN

In the long-term phase, construction of Training Center for technical training of MC sanitary staff is proposed. Construction of a Water Quality Lab is also proposed during long term for the effective monitoring of water quality in the city.

The water infrastructure of the city was replaced during the medium term and hence, water metering is proposed during the long-term phase in order to quantify the water supply to the city.

Table 20: WS Long Term Interventions for Khushab City

WS Long - Term Interventions	
Machinery	▪ Water Meters / Flow Meters
Back – up Store	▪ Establishment of Water Quality Lab
Training Center	▪ Establishment of Training Center at MC Khushab

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 21: Proposed WS Projects Interventions for Khushab City

Sr. #	Plan Period	Project Title	Justification & Scope
1	**Short Term (2025)**	Rehabilitation of sixteen (16) no. of Tubewells – Shahpur Water Supply Scheme & Replacement of existing undersized pipe – Shahpur Water Supply Scheme	▪ Capacity enhancement of malfunctioned Tubewells (enhance to 1 cusecs) ▪ Undersized pipe (24" AC pipe) replacement with (36" HDPE pipe) & 02 new OHRs (100,000 GLNS each) ▪ Water Proofing of 01 existing GSTs as sewage water infiltrates in the existing tanks (Rehmat Wala)
2		Provision of 60 Kw Solar system for waterworks on Irrigation canal (1L Khushab Minor)	▪ Utilization of Public land to reduce O&M of WSS Infrastructure and encourage sustainability to provide uninterrupted power supply
3	**Medium Term (2030)**	Extension of water supply scheme for unserved areas (Jhok Badshah, Ahemadpura & Hussainabad Wasti) and fulfil targeted water demand. Includes construction of 21 (1 Cusecs) Tubewells & 02 GST/WW (400,000 GLNS) and 02 (100,000 GLN) OHRs with 36" HDPE rising main and establishment of DNI Zone in Islampura	▪ Current Supply Infra. will be not be able to meet Water Demand of Year 2030 hence demand will be more than yield ▪ 05 Ultrafiltration Plants in MC owned open area/Parks -Outnumbered (public reported long queue in summer) ▪ DNI Zone with SCADA
4	**Long Term (2040)**	Training Center with integrated Water Quality Lab and Water Metering of the whole city	▪ Training of WSS officials for: Asset Management, Geo Tagging of WSS Infrastructure, O&M of E&M equipment & Water Quality Testing Lab establishment ▪ Metering to avoid wastage of clean water

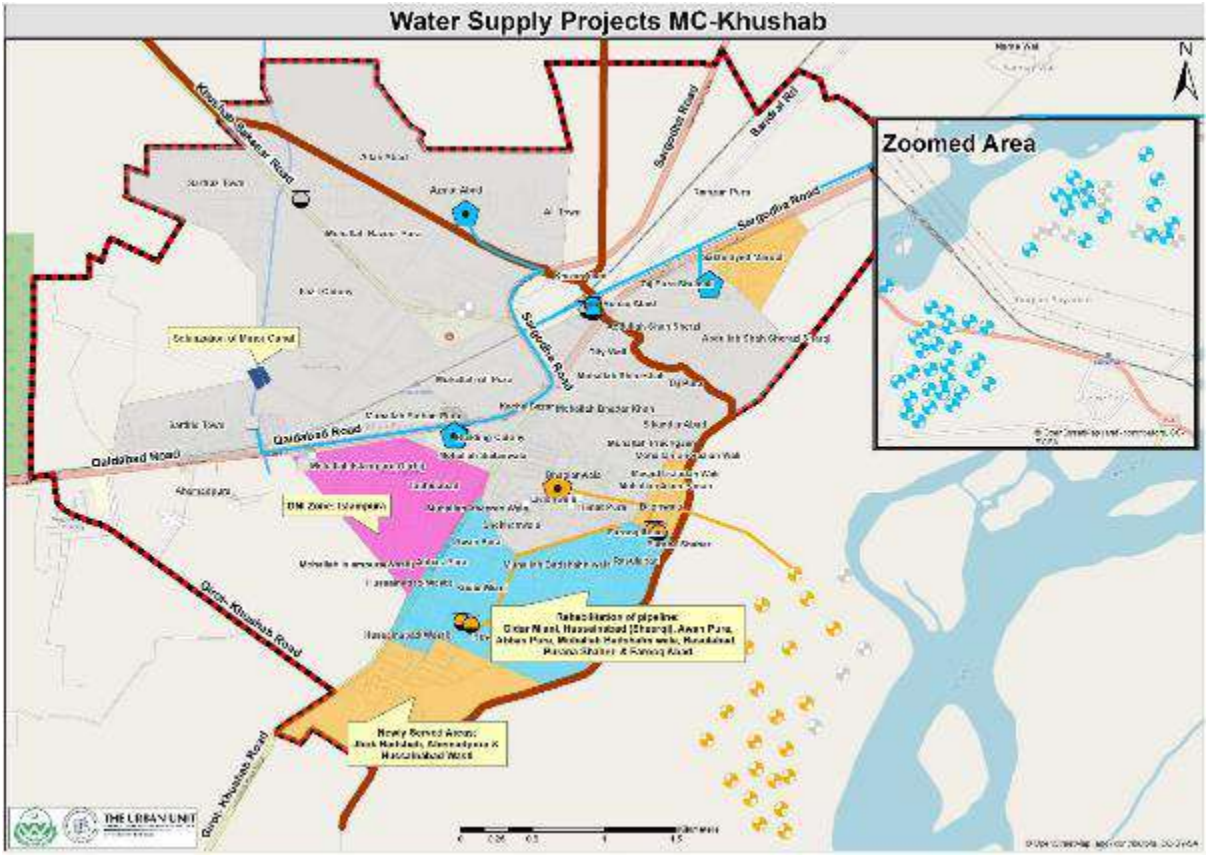


Figure 34: Proposed Spatial WS Interventions for Khushab City

B. SEWERAGE SYSTEM – KHUSHAB

Provision of sewerage services in Khushab is the responsibility of MC Khushab. The sewerage schemes are designed and executed by Public Health Engineering Department (PHED) and then handed over to Municipal Committee Khushab for its Operation and Maintenance. The current sewerage system of Khushab is practically non-existent. Only the posh areas of Satellite Town and Ansar Colony have sewerage with only one disposal station. The disposal station disposed the waste water into fields via a sludge carrier. The sewerage system of Khushab is thus in sub-standard condition that needs to be immediately addressed.

3.4. EXISTING SEWERAGE INFRASTRUCTURE

The existing sewerage system of Khushab consists of only one disposal station and a sludge carrier. The sewerage system is practically non-existent with majority of the city using open drains and roadside ponds/drains to drain their waste away from the city. The sewer lines are laid on only the posh areas of Satellite Town and Ansar Colony and have a spread of almost 10% of the city. The disposal station is operated as required and disposes the waste water in to the sludge carrier, that carries the waste to the agricultural fields.

The outskirt areas of the city are still deprived of proper sewerage network. Open drains are a common sight. Overall, the existing Sewerage disposal system is not sufficient to meet current and future waste disposal demand of the city & condition of the existing structure especially sewerage lines needs attention so that it is properly disposed-off.

Table 22: Urban Sewerage infrastructure in Khushab

Disposal Stations	**1**
Operational	1
Non-Operational	0
Waste Water Treatment Plants	**0**
Operational	0
Non-Operational	0
Sewer Lines	
City Coverage	10%

3.4.1. CONDITION ASSESSMENT OF ASSETS

With regard to condition assessment of the sewerage system, overall civil structure, machinery and electrical components associated with sewerage infrastructure present in the city has been evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate. The distribution network as a whole is also evaluated as "C" which indicates that there is some deterioration or defects, but the function is not significantly affected.

Table 23: Asset condition of Sewerage infrastructure in Khushab

Assets	**Rating**
Civil Structure	**D**
Sewerage Network	**C**
Electrical Components & Machinery	**D**

3.4.2. DISPOSAL STATIONS

There is only one Disposal Station in Khushab city which serves the areas of Satellite Town and Ansar Colony. This disposal was constructed in 2010, but is in extremely deteriorating condition due to neglect and lack of maintenance. The waste gets accumulated in the wet well and the pumps are only used once the well is about to overflow. The waste water is carried through Sludge carrier to the outskirts of the cities and is used for agricultural purposes. The sludge carrier is also incomplete.

Figure 35: Disposal Station Satellite Town Khushab

The civil structure of the Disposal Station of Khushab is in dire condition. The well has cracking and spalling. Honey combing of concrete is observed indicating poor workmanship. Plaster is spalled due to action of Sulphur and other gases. The electrical and mechanical components are also barely functional with no maintenance whatsoever.

Figure 36: Condition of Sludge Carrier of Disposal Station Khushab

3.4.3. SEWERAGE NETWORK

The sewerage network consists of RCC pipes of diameters ranging from 9” to 24”. These sewer lines have an approximate spread of 10% of the city. These pipelines are in satisfactory condition.

3.4.4. WASTEWATER TREATMENT PLANTS

Oxidation ponds, also called stabilization ponds, these are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. There are currently no Waste Water Treatment Plant in Khushab City

3.5. PLANNING & DESIGN CRITERIA

The purpose of this planning exercise was to assess the current gaps and future wastewater disposal demand for the citizens of the city. The current sewage generation of Khushab is almost 10.95 MGD which is expected to rise up to 16.52 MGD at the end of 2040.

Based on the current and projected populations for the Municipal Committee, the proposed water demand of 33 Gallons per Capita per Day, the current (2022) and future (2025, 2030 and 2040) waste water flows are calculated and shown in the table below.

Table 24: Estimated Sewage Flow of Khushab City

Attributes	Sewerage Flow (Million Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population (Khushab MC)	133,825	143,315	160,650	201,865
Average Sewage Flow for 33 GPCD (including 20% NRW)	3.53	3.78	4.24	5.33
Peak Sewage Flow	7.07	7.57	8.48	10.66
Storm Water Flow (50%)	3.53	3.78	4.24	5.33
Non Domestic Flows (5%)	0.18	0.19	0.21	0.27
Infiltration (5%)	0.18	0.19	0.21	0.27
Total Sewage Flow (MG/D)	**10.95**	**11.73**	**13.15**	**16.52**

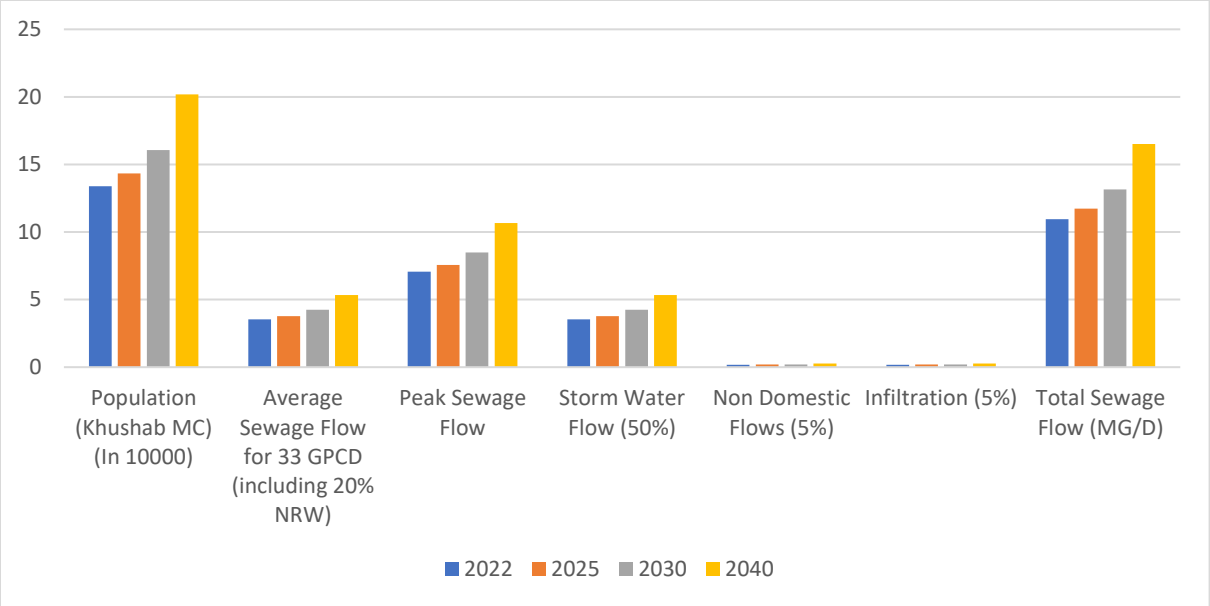


Figure 37: Total Sewerage Flow

- **Design Criteria**

Average waste water is taken as 80% of the Average Water Demand of the city. The Peak Factor of 2 is used for this design considerations as the population of city is (>100,000). Storm water flow is taken as 50% of the Average Water Demand as Khushab City lies in the Northern Zone of Punjab. Non-Domestic Flows and Infiltration as 5% of the Average Water Demand is used.

3.6. PROPOSED INTERVENTIONS

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

3.6.1. SHORT TERM PLAN

The Short-Term interventions of Khushab are focused on rehabilitation of water supply infrastructure of the city and hence, no major intervention related to Sewerage is proposed in this section.

Establishment of Backup Store, Mobile Workshop Unit and Procurement of machinery is proposed during the short-term phase.

Table 25: Sewerage Short - Term Interventions in Khushab City

Sewerage Short - Term Interventions	
Machinery	▪ Procurement of 2 Sucker and 2 Jetting machines
Back – up Store	▪ Establishment of backup store with mobile workshop unit

3.6.2. MEDIUM TERM PLAN

The Medium-Term Plan of Khushab is focused on providing sewerage system for the unserved areas of the city to cater for the increase in the future population and sewage flow of the city. This includes laying of sewer lines and 9 km trunk sewer (54" and 36" diameters).

Table 26: Sewerage Medium - Term Interventions in Khushab City

Sewerage Medium - Term Interventions	
Infrastructure	▪ Sewer lines in Khushab city ▪ Truck Sewer of length = 9 km and diameter (36" and 54")

3.6.3. LONG TERM PLAN

In the long-term phase, a Waste Water Treatment Plant of capacity 20 MGD is proposed to be constructed in order to treat the waste water from the city before disposing it in to the fields.

Table 27: Sewerage Long - Term Interventions for Khushab City

Sewerage Long - Term Interventions	
Infrastructure	**Wastewater Treatment Plant** ▪ New Waste Water Treatment Plants of 20 MGD each

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 28: Proposed Sewerage Projects Interventions for Khushab City

Sr. #	Plan Period	Project Title	Justification & Scope
1.	**Short – Term (2025)**	Establishment of back-up store, mobile workshop unit and machinery procurement (02 sucker & 02 jetting) machines	▪ Procurement of Machinery, Store for backup spares and mobile workshop units for repair & maintenance
2.	**Medium – Term (2030)**	Comprehensive Sewerage Scheme for Khushab City including 9 KM Trunk Sewer (36" and 54" dia) HDPE material with sewerage network and open drains for all the unserved areas in the city	▪ Sewerage Network almost doesn't exist and mixing of sewage ponds with water supply pipeline causing inconvenience to the nearby locals. ▪ Scheme encompasses Trunk sewers, sewerage & drain network with disposal stations ▪ WWTP
3.	**Long – Term (2040)**	Construction of Waste Water Treatment Plant (Oxidation Pond) - 20 MGD	▪ Construction of Oxidation Pond, sullage carriers and pump houses for treatment of Waste Water of ultimate disposal site

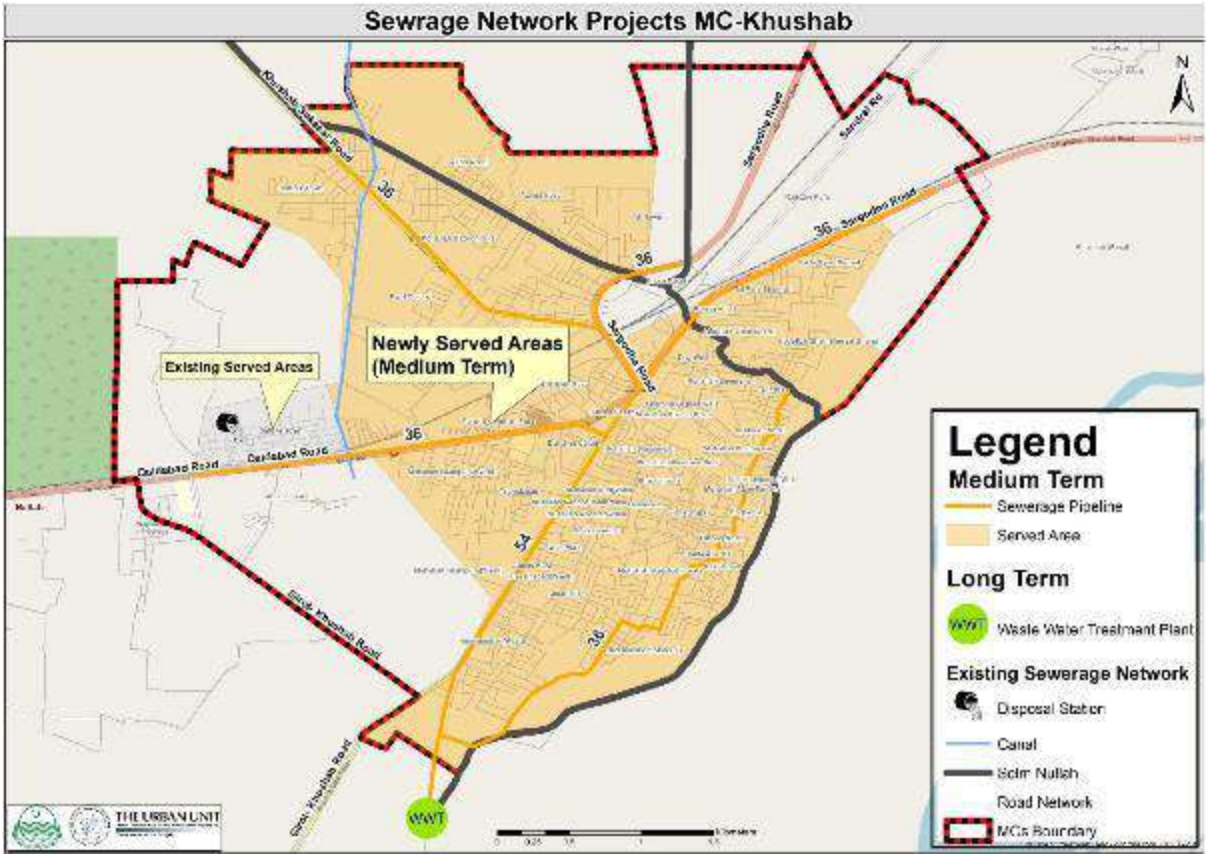


Figure 38: Proposed Spatial Sewerage Interventions for Khushab City

04 Water Supply & Sanitation – Mianwali

A. WATER SUPPLY – MIANWALI

Mianwali City water supply is mainly managed by Municipal Committee (MC) Mianwali after Public Health Engineering Department (PHED) designs and executes the water supply schemes in the city. Mianwali lies on the edge of River Indus and the groundwater in Mianwali district is sweet and fit for drinking with little to no TDS and contamination issues. People of Mianwali use MC water supply schemes but majority have household bores to fulfill their water demand. The household bores however, present a challenge as it can lead to overexploitation of underground water reserves. The MC owned water schemes are although operational, but their supply capacity is very less as compared to actual demand of the city and hence intervention related to water are required to close this demand-supply gap.

4.1. EXISTING WATER SUPPLY INFRASTRUCTURE

The water supply system of Mianwali is insufficient as compared to the actual water demand of the city. According to the latest census, the population of Mianwali is almost 130,743 in 2022 with, which is expected to rise up to approximately 184,000 in the year 2040. There are a total of 11 MC owned water supply schemes in the city out of which 10 are operational. The total number of water connections in Mianwali are approximately 8000. The underground water is sweet and easy availability of fresh water has led to majority of population of the city relying on bores to fulfill their water demand. This is also the reason why most of the people are unwilling to pay for MC water supply schemes. Most of these schemes have outlived their design life with the most recent ones installed in 2004. There are about 7 water supply schemes installed by PHED after that but they have not yet been handed over to the MC.

All the water supply schemes rely on tube wells to extract the underground water. Overhead Reservoirs are present in the city but not a single one of them is functional as direct pumping is preferred in the city. The tube wells feed the water supply network of the city, which is interconnected with each other such that one dysfunctional tube well does not affect the supply of water to the area. The overall water supply distribution network of Mianwali city covers about 70-80% of the city, providing safe and clean water to the residents of the city.

Table 29: Urban Water Supply Infrastructure in Mianwali City

Tube wells	**11**
Operational	10
Non-Operational	1
Overhead Reservoir	**5**

Operational	0
Non-Operational	5
Water Supply Pipeline	
City Coverage	70-80%

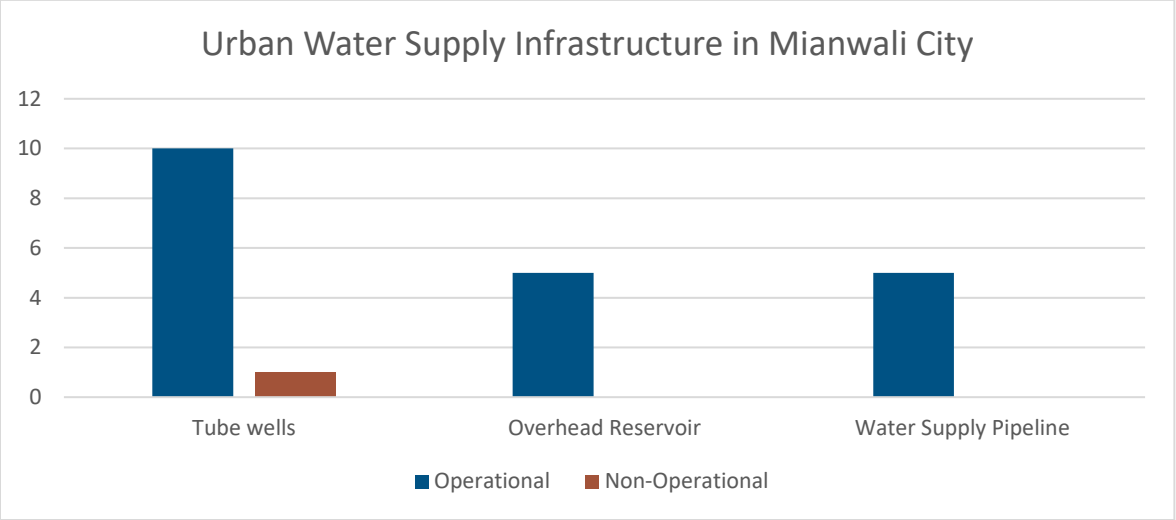


Figure 39: Bar Chart depicting Urban Water Supply Infrastructure in Mianwali City

4.1.1. CONDITION ASSESSMENT OF ASSETS

With regard to condition assessment of the water supply system, overall civil structure has been evaluated as in condition "B", which indicates that only minor deteriorations and defects are evident. The overall electro-mechanical components as well as the distribution network has been evaluated as having condition "C" meaning that some deterioration or defects are evident but the function is not significantly affected.

Table 30: Asset Rating in Mianwali City

Assets	Rating
Civil Structure	B
Distribution Network	C
Electrical Components & Machinery	C

4.1.2. TUBE WELLS

The MC owns a total of 11 tube wells, 10 out of which are operational. These tube wells have a discharge capacity of 0.5 to 1 cusecs and are part of various water supply schemes spread across the city. The details

of these tube wells are provided as annexure to this report. These tube wells were installed during various phases as the population of the city grew with the most recent ones built in 2004. Some of the older tube wells do not have a pump house and are installed open to sky with a simple corrugated sheet acting as a shed to protect against the elements. The newer tube wells had pump houses that were in satisfactory condition with minor repairs required. The number of tube wells in the city are insufficient as compared to the demand of the city and additional tube wells are needed to fulfill this demand-supply gap.

The civil structure of tube wells was in satisfactory condition (most of these tube well did not have any pump house). The tube well that did not have any pump house had rusted motors and open electrical wiring was observed in almost all the cases. Chlorinators were present in some of the tube wells but not in all.

The picture below shows different tube wells installed at different locations across Mianwali.

Figure 40: Tube wells in Mianwali City

Figure 41: Civil structure and electrical components of tube wells in Mianwali City

4.1.3. OVERHEAD RESERVOIR (OHR)

There are 5 Overhead Reservoirs in Mianwali city with a total storage capacity of 350,000 Gallons. All of these Overhead Reservoirs are not functioning as direct pumping is preferred in the city. These OHRs were constructed from 1971-1986 with different water supply schemes but are currently not working.

The pictures below show the different overhead reservoirs installed at different locations in Mianwali city.

Figure 42: Overhead Reservoirs across Mianwali City

4.1.4. FILTRATION PLANTS

There are around 4 Filtration Plants within the boundary of MC Mianwali. All of these are Ultrafiltration Plants (UF).

These filtration plants are owned by MC Mianwali and only 2 of them are currently in working condition.

The water filtration plant of Hockey Stadium is shown in picture below.

Figure 43: Filtration Plant in Mianwali City

4.1.5. WATER SUPPLY PIPELINES:

The water distribution network of Mianwali city has an approximate length of 150 km and covers about 70-80% of the city. The pipes are mostly of PVC and AC and have diameters ranging from 2" to 8". The condition of distribution network of most of the city was satisfactory with minor leakages at some places.

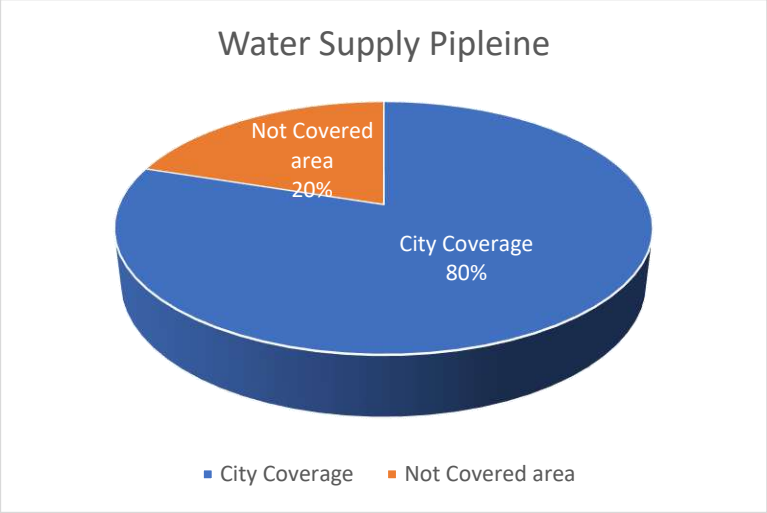


Figure 44: Pie chart depicting Wayer Supply Pipelines coverage in Mianwali city

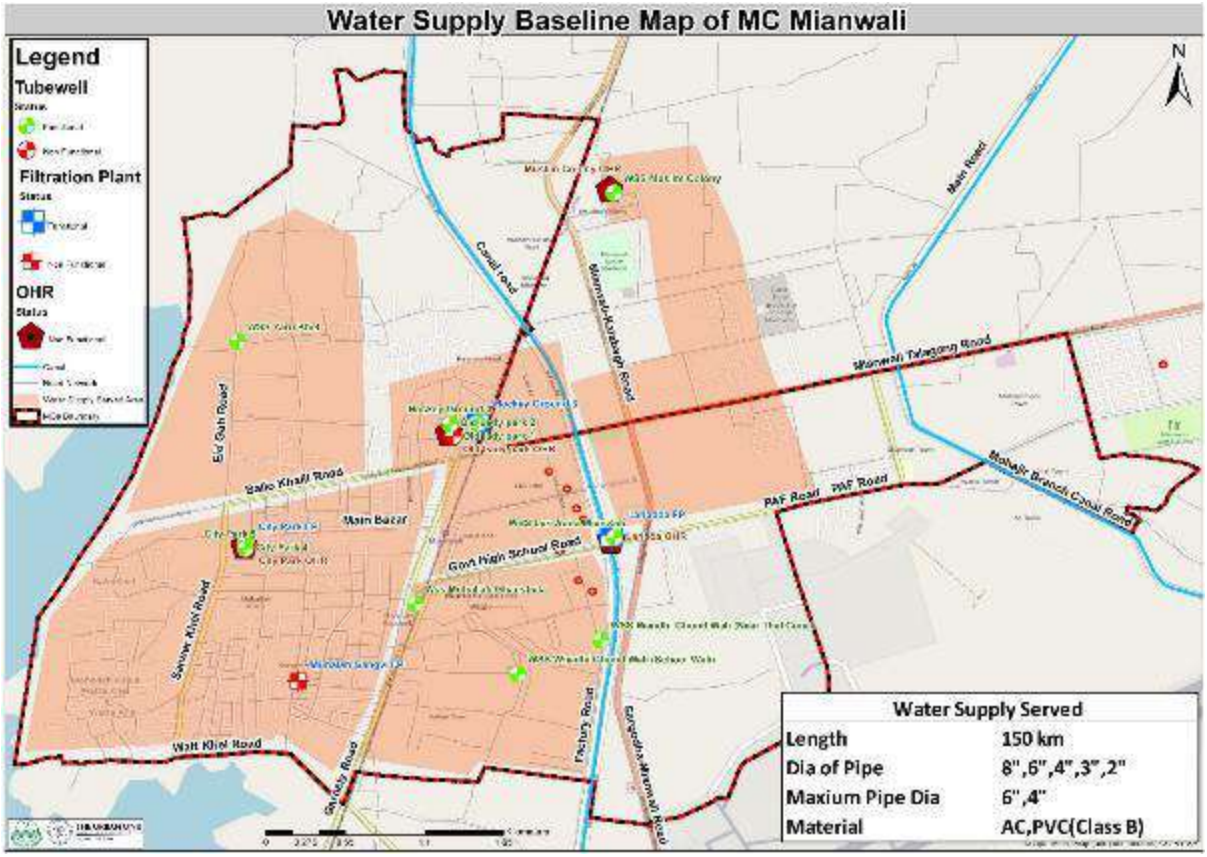


Figure 45: Baseline Water Supply System in Mianwali City

4.2. PLANNING & DESIGN CRITERIA

This section refers to the design of main components of water supply network. The main components are discussed in the subsequent sections. Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 gallons per capita per day i/c 20% as unaccounted for water (NRW) & 15% of commercial water demand and 10% of Industrial and 10% of Institutional water demand have also been added in the design, the current (2022) water demand and future (2025, 2030 and 2040) water demands are shown in **Table 31** below.

Table 31: Estimated Water Demands for Mianwali City

Attributes	Water Demand (Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	130,743	138,419	152,227	184,114
Domestic Demand 33 GPCD (including 20% NRW)	4,314,519	4,567,827	5,023,491	6,075,762
Industrial (Cottage industries, Factories) 10% of Domestic Demand	431,452	456,783	502,349	607,576
Institutional (Educational, Institutions and Hospitals) 10% of Domestic Demand	431,452	456,783	502,349	607,576
Commercial (Shops & Restaurants etcetera.) 15% of Domestic Demand	647,178	685,174	753,524	911,364
Average Day Demand (MG/D)	**5.82**	**6.17**	**6.78**	**8.20**
Max Day Demand (MG/D)	**8.74**	**9.25**	**10.17**	**12.30**

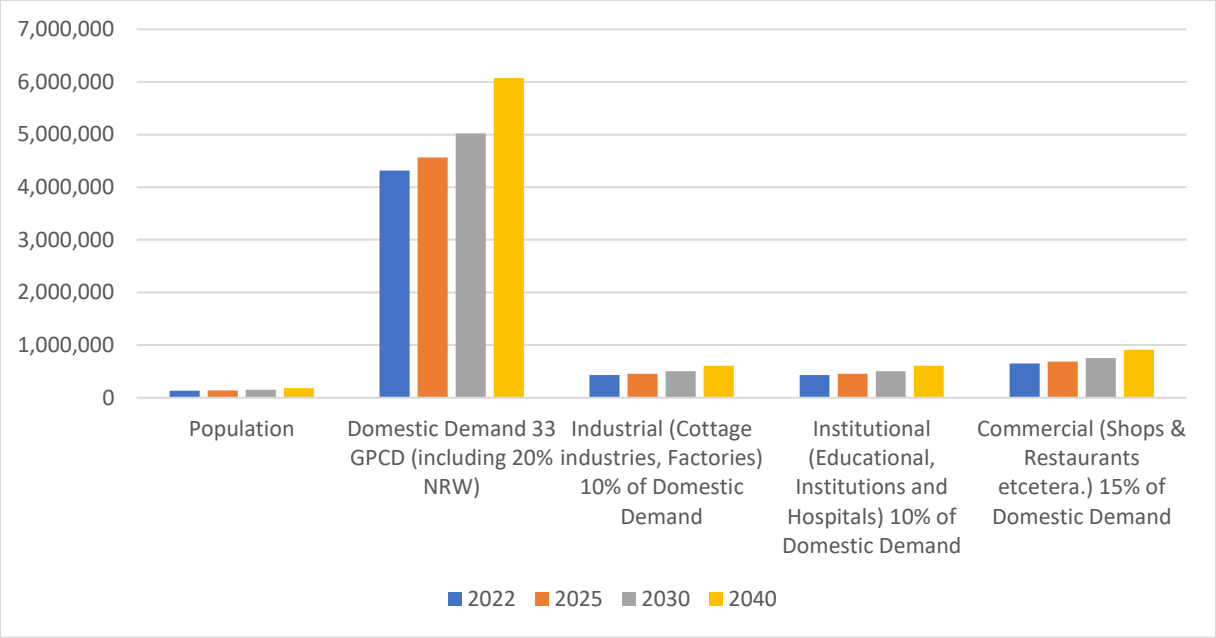


Figure 46: Estimated Water Demand for Mianwali City

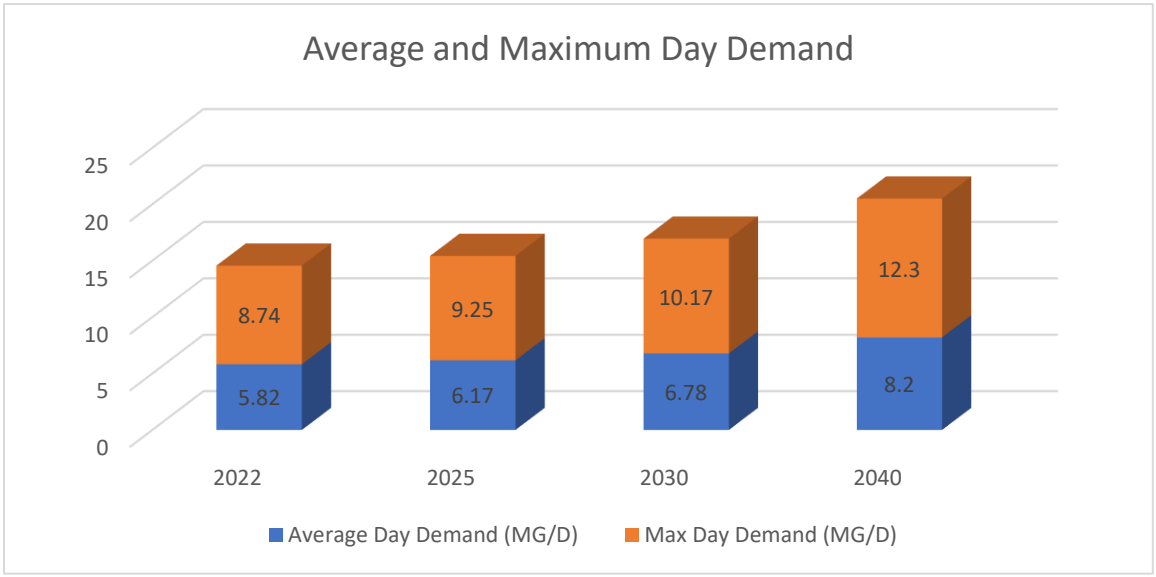


Figure 47: Average and maximum day demand in Mianwali City

Design Criteria

The main objective of design is to evolve a water supply network, which can be operated with minimum maintenance for design life of the project. There is a need to develop a sustainable system for water supply that takes into account the impact of population growth and efficient aquifer recharge mechanism.

- **Planning Horizons**

Planning horizon for this plan is 18 years i.e., 2022-2040. Short-, medium- and long-term phases are identified for 3, 5 & 10 years i.e., 2025, 2030 and 2040 respectively.

- **Population Projection**

The population projections are determined by using following formula:

$Pn = Po (1+r)n$

Where,

P_n = Projected population for required year

P_o = Population of base year

r = Population annual growth rate (taken from last Census Report 2017)

n = Number of years, counted from the base year

Growth rate in case of Mianwali city is taken as 1.92% as per 2017 Census report of Pakistan.

- **Maximum Day Demand**

Maximum day demand is taken as 1.5 times the average day demand.

- **Tube Well Working Hours**

Tube Well Working Hours are taken as 16 Hours/day in city as proposed in Design Criteria for WASAs by Urban Unit.

- **Overhead Reservoir**

Overhead reservoirs are designed for the continuous supply of water. Capacity of overhead reservoirs is taken as 1/10th of average day demand.

- **Ground Storage Tanks**

When the length of the rising main is such that the loss of head is very high, intermediate pumping stations comprising a storage tank and pumping machinery installed in a pump house will be used. Capacity of ground water storage tanks is taken as 1/4th of average daily demand.

- **Drinking Water Requirement**

Water requirement of 33 Gallons per capita per day as recommended by WASA is used for the design calculations in this report.

4.3. PROPOSED INTERVENTIONS IN MIANWALI

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

4.3.1. SHORT TERM PLAN

During the Short-term phase, the existing water supply network is updated to cater for the current water demand of the city. Ten (10) new tube wells of 2-cusec capacity are proposed during this phase. Two (2) new Overhead Reservoirs of 100,000 Gallons capacity are also proposed to provide storage and to link the new network with the existing water supply distribution network of the city. One existing tube well is also proposed to be rehabilitated to make it functional. Five (5) new Ultrafiltration Plants are also proposed in this phase. The locations of these new Tube wells and Overhead Reservoirs have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Other than these interventions, solar energy potential can also be explored as this energy can be used to power nearby WSS infrastructure. A canal-top solar power project is proposed for Thal canal with a DC potential of 4 MW, which can be used to supply renewable energy to Water Works nearby and make it self-sustainable.

Table 32: WS Short - Term Interventions in Mianwali City

Water Supply Short - Term Interventions	
Infrastructure	**Tubewells:** ▪ Ten (10) new Tube wells in Mianwali city of 2-cusec each. ▪ Rehabilitation of one (1) existing tube well **Overhead Reservoirs (OHRs):** ▪ Construction of New 2 No. OHRs (100,000 Gallons each) **Filtration Plant:** ▪ Construction of five (05) new Ultrafiltration Plant
Machinery	▪ Chlorinators ▪ Bulk Meters / Flow Meters
Solar / Renewable	▪ Canal top solar system for Thal Canal

4.3.2. MEDIUM TERM PLAN

During the Medium-term phase, the existing water supply network is updated to cater for the current water demand of the city. Eight (8) new tube wells of 2-cusec capacity are proposed during this phase. Two (2) new Overhead Reservoirs of 100,000 Gallons capacity are also proposed to provide storage and to link the new network with the existing water supply distribution network of the city. Five (5) new

Ultrafiltration Plants are also proposed in this phase. The locations of these new Tube wells and Overhead Reservoirs have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Table 33: WS Medium - Term Interventions in Mianwali City

Water Supply Medium - Term Interventions	
Infrastructure	**Tubewells:** ▪ Eight (08) new Tube wells in Mianwali city of 2-cusec each. **Overhead Reservoirs (OHRs):** ▪ Construction of New 2 No. OHRs (100,000 Gallons each) **Filtration Plant:** ▪ Construction of five (05) new Ultrafiltration Plant
Machinery	▪ Chlorinators ▪ Bulk Meters / Flow Meters

4.3.3. LONG - TERM PLAN

In the long-term phase interventions, rehabilitation of Training Center in MC Mianwali along with a water quality lab is proposed. This facility would provide training relevant to WSS sector operation and practices to the sanitary workers and other staff. House metering of served areas of Mianwali along with establishment of Distribution Network Improvement Zone (DNI Zone) for the area of Wandi Sayeddan Wali and Mohallah Jinnah Hospital is also proposed for long term phase.

Table 34: WS Long Term Interventions for Mianwali City

Water Supply Long - Term Interventions	
Machinery	▪ House Water Metering
DNI Zone	▪ Establishment of DNI Zone in Wandi Sayeddan Wali and Mohallah Jinnah Hospita
Training Center	▪ Establishment of Training Center at MC Mianwali

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 35: Proposed WS Projects Interventions for Mianwali City

Sr. #	Plan Period	Project Title	Justification & Scope
1.	**Short – Term (2025)**	**Extension of Water Supply Scheme** including construction of 10 new Tube-wells (2 cusecs) with 02 (100,000 GLNS) OHR, Rehabilitation of new one (01) Tube-well (of existing scheme) & provision of 05 Ultrafiltration Plants	▪ Current Infra. can only fulfil around 30% of the Water Demand in year 2025 ▪ Bore Failure (New Tube-well bore is required) ▪ Outnumbered functional water treatment plant & tube-wells
2.	**Medium – Term (2030)**	**New Water Supply Scheme** including construction of 08 new Tubewells (2 Cusecs) & two (02) Over Head Reservoir (100,000 GLNS each) for Turabaz Town, Wandhi, Roshan Wali, Awanpur, Mohammadi Town and Shaheen Town area and construction of (05) Ultrafiltration Plants in Government schools	▪ Existing Water Supply will be able to fulfil around 60% of the Water Demand year 2030 hence more infrastructure will be needed ▪ Unaddressed areas coverage
3.	**Long – Term (2040)**	Construction of **Training Center** with integrated **Water Quality Lab**	▪ Training of WSS officials for ▪ Asset Management, Geo Tagging of WSS Infrastructure, O&M of Electrical & Mechanical equipment and Water Quality Testing Lab establishment
4.		**Metering** of the Water Supply Registered Connections and Establishment of **DNI Zone in Wandi Sayeddan Wali & Mohallah Jinnah Hospital**	▪ Metering of Water Supply connections for billing and demoting wastage and irresponsible use ▪ DNI Zone with SCADA, meters and related Infrastructure

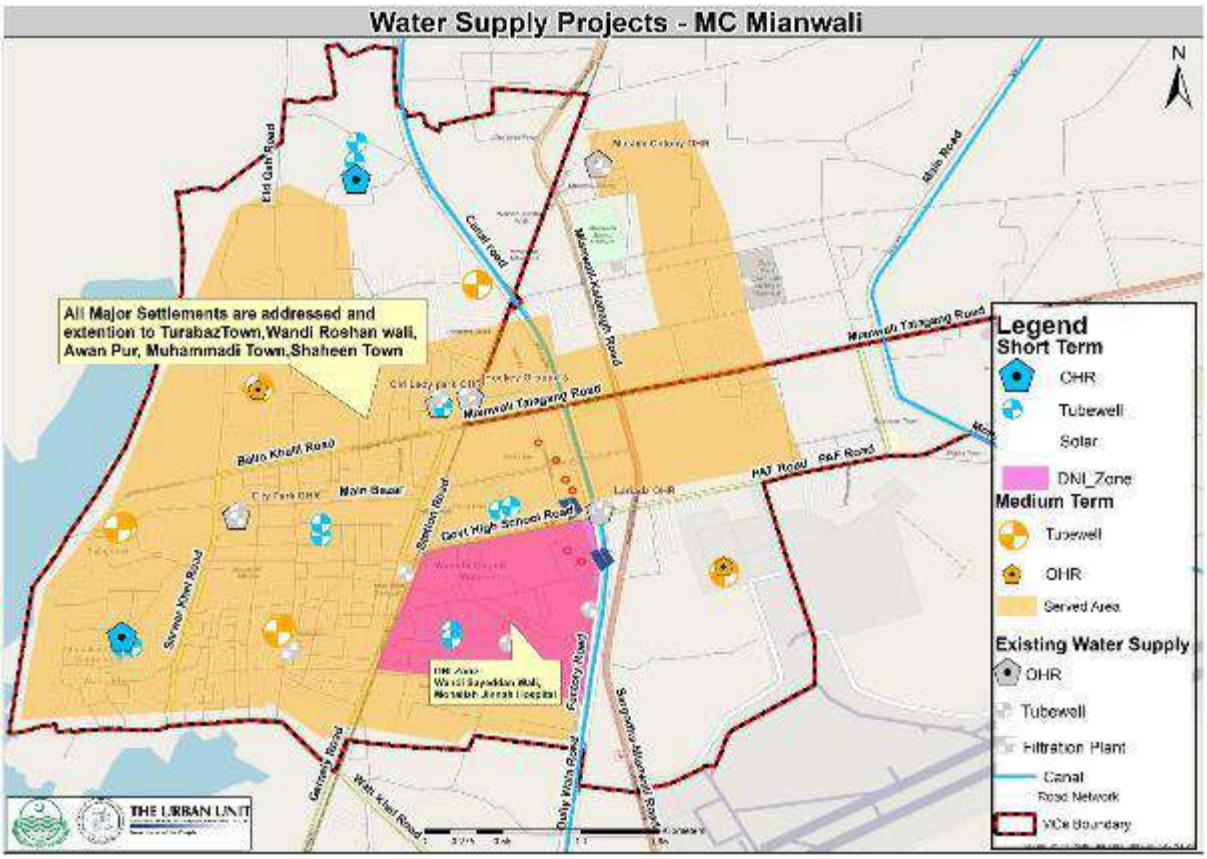


Figure 48: Proposed Spatial WS Interventions for Mianwali City

B. SEWERAGE SYSTEM MIANWALI

Provision of sewerage services in Mianwali is the responsibility of MC Mianwali. The sewerage schemes are designed and executed by Public Health Engineering Department (PHED) and then handed over to Municipal Committee Mianwali for its Operation and Maintenance. The current sewerage system of Mianwali city is insufficient and has completed its design life. The sewerage network of the city has an approximate coverage of 70% of the city but is undersized as compared to the waste water generation of the city. The sewerage of Mianwali is gravity based with only one disposal station that has been abandoned. The sewerage system is thus in sub-standard condition that needs to be immediately addressed.

4.4. EXISTING SEWERAGE INFRASTRUCTURE

The sewerage system of Mianwali city is sub-standard. Almost 70% area of the city is served by sewerage schemes but these schemes are more than 30 years old. Majority of the pipelines have overflow issues due to choking. The sewerage system is operated via gravity and is made up of RCC pipes ranging from diameters 12” to 36”. The estimated overall length of sewer lines in the city is 155 km. The waste water from the entire city is guided via drains and then disposed in to River Indus and agricultural fields.

The overall system of drainage is also poor. Urban flooding and overflow is a common occurrence after rain. The only underpass of the city gets filled with rain water and in closed even during the slightest of rain. Overall, the existing Sewerage disposal system is not sufficient to meet current and future waste disposal demand of the city & condition of the existing structure especially sewerage lines needs attention so that it is properly disposed-off.

Table 36: Urban Sewerage infrastructure in Mianwali City

Disposal Stations	**1**
Operational	0
Non-Operational	1
Waste Water Treatment Plants	**1**
Operational	0
Non-Operational	1
Sewer Lines	
City Coverage	70%

4.4.1. CONDITION ASSESSMENT OF ASSETS

A rating criterion for the assessment of sewer schemes has been developed in order to categorize the current infrastructure system. To measure the condition, physical inspection and the performance parameters are evaluated. Following table is used to rate the assets based on their condition.

Table 37: Asset Condition Assessment Criteria

Rating	Asset Condition	Description
A	**Excellent**	No noticeable defects. Some aging or wear may be visible.
B	**Good**	Only minor deterioration or defects are evident.
C	**Fair**	Some deterioration or defects are evident, but function is not significantly affected
D	**Poor**	Serious deterioration in at least some portion of the structure. Function is inadequate
F	**Failing**	No longer functional. General failure or complete failure of a major structural component.

With regard to condition assessment of the sewerage system, overall civil structure, machinery and electrical components associated with sewerage infrastructure present in the city has been evaluated as “C” which indicates some deteriorations are present but the overall functioning is not significantly

affected. The distribution network as a whole is also evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate.

Table 38: Asset condition of Sewerage infrastructure in Mianwali

Assets	Rating
Civil Structure	C
Sewerage Network	D
Electrical Components & Machinery	C

4.4.2. DISPOSAL STATIONS

The entire sewerage system of Mianwali is operated by gravity. There is only one disposal station present in the city which has been abandoned. The waste water of the whole city is carried through drains to the outskirts of the city. Sludge carries then carry the waste water to the agricultural fields ultimately disposing in the River Indus.

4.4.3. SEWERAGE NETWORK

The sewerage network of the city is made of RCC pipes of diameters ranging from 12" to 36". Majority of the sewer pipes are undersized. The sewerage network has an approximate coverage of 70% of the city with an approximate length of 155 km.

4.4.4. WASTEWATER TREATMENT PLANTS

Oxidation ponds, also called stabilization ponds, these are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. There are two waste water treatment plants in the city. Both of these have an approximate area of 3.5 acres.

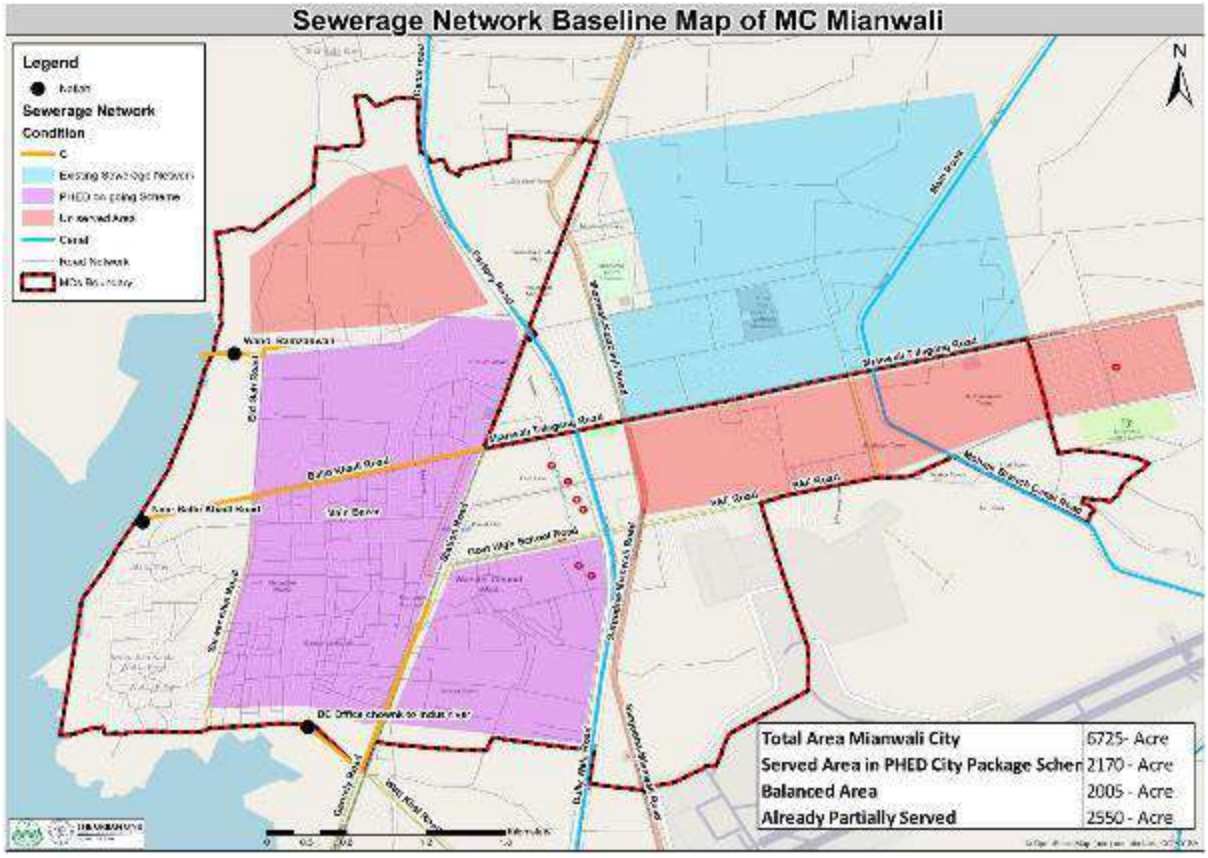


Figure 49: Baseline Sewerage map of Mianwali City

4.5. PLANNING & DESIGN CRITERIA

The purpose of this planning exercise was to assess the current gaps and future wastewater disposal demand for the citizens of the city. The current population of the city is approximately 130,000 with total wastewater flow of 10.70 MGD. The current capacity of the sewerage system of the city is lesser than the waste water generated by the city.

Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 Gallons per Capita per Day, the current (2022) and future (2025, 2030 and 2040) waste water flows are calculated and shown in the table below.

Table 39: Estimated Sewage Flow of Mianwali City

Attributes	Sewerage Flow (Million Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	130,743	138,419	152,227	184,114

Average Sewage Flow for 33 GPCD (including 20% NRW)	3.45	3.65	4.02	4.86
Peak Sewage Flow	6.90	7.31	8.04	9.72
Storm Water Flow (50%)	3.45	3.65	4.02	4.86
Non-Domestic Flows (5%)	0.17	0.18	0.20	0.24
Infiltration (5%)	0.17	0.18	0.20	0.24
Total Sewage Flow (MG/D)	**10.70**	**11.33**	**12.46**	**15.07**

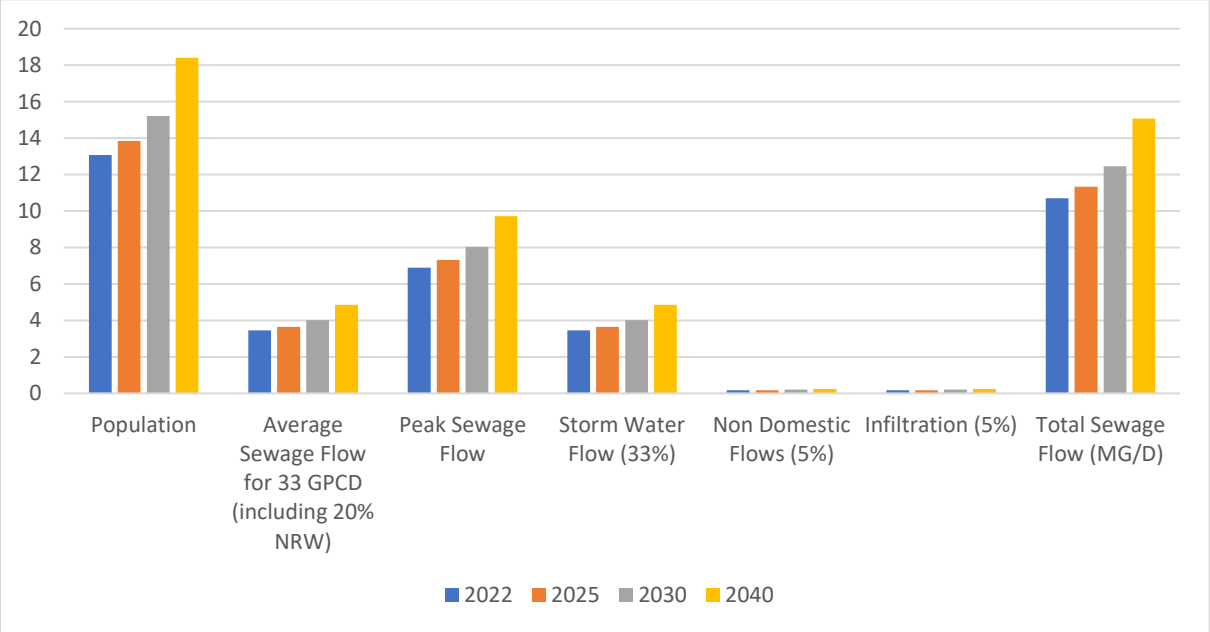


Figure 50: Estimated Sewage Flow of Mianwali City

- **Design Criteria**

Average waste water is taken as 80% of the Average Water Demand of the city. The Peak Factor of 2 is used for this design considerations as the population of city is (>100,000). Storm water flow is taken as 50% of the Average Water Demand as Mianwali City lies in the Northern Zone of Punjab. Non-Domestic Flows and Infiltration as 5% of the Average Water Demand is used.

4.6. PROPOSED INTERVENTIONS

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

4.6.1. SHORT TERM PLAN

The Short-Term interventions of Mianwali are focused on rehabilitation of water supply infrastructure of the city and hence, no major intervention related to Sewerage is proposed in this section.

4.6.2. MEDIUM TERM PLAN

The Medium Term Plan of Mianwali is focused on providing sewerage system for the unserved areas of the city to cater for the increase in the future population and sewage flow of the city.

Table 40: Sewerage Medium Term Interventions in Mianwali City

Sewerage Medium - Term Interventions	
Infrastructure	▪ Sewer lines in Mianwali City

4.6.3. LONG TERM PLAN

In the long-term phase, interventions are focused on the water supply infrastructure of the city and hence, no major interventions related to sewerage is proposed in this section.

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 41: Proposed Sewerage Projects Interventions for Mianwali City

Sr. #	Plan Period	Project Title	Justification & Scope
1	**Medium Term (2030)**	Provision of Sewerage Pipe Network & Open Drains for unserved and/or partially served areas: Balo Khel, Mohallah Kaala, Watta Khel, Civil Line, Wandhi Roshan Wali, Awanpur Mianwali, Turabaz Town, Bithian, Kot Amir Khan, Jinnah Colony and Penu Kheyl Town	▪ Non-existent Sewerage Network ▪ Outlived pipeline prompting leakages and polluting nearby water bodies and network

4.6.4. URBAN SEWERAGE SCHEME FOR MIANWALI CITY

An urban sewerage scheme for Mianwali city is designed by Public Health Engineering Department (PHED). The scheme includes a gravity flow sewerage system, that carries the sewerage of the entire city through RCC sewer pipes of diameter ranging from 9” to 36”. The waste water is then carried through truck pipes of 36” diameter to Waste Water Treatment Plant. The schemes include construction of new

disposal in the outskirts of city as well as a construction of Waste Water Treatment Plant along with a Super Disposal.

The details of the Sewerage Schemes are provided in the table below:

Table 42: Urban Sewerage Scheme for Mianwali City by PHED

Name of Project Scheme	Revamping/Comprehensive Sewerage and Drainage including Tough Tile and PCC scheme for Mianwali City
GS No.	1695
Project ID	38258
Designed by	Housing Urban Development & Public Health Engineering Department (HUD & PHED)

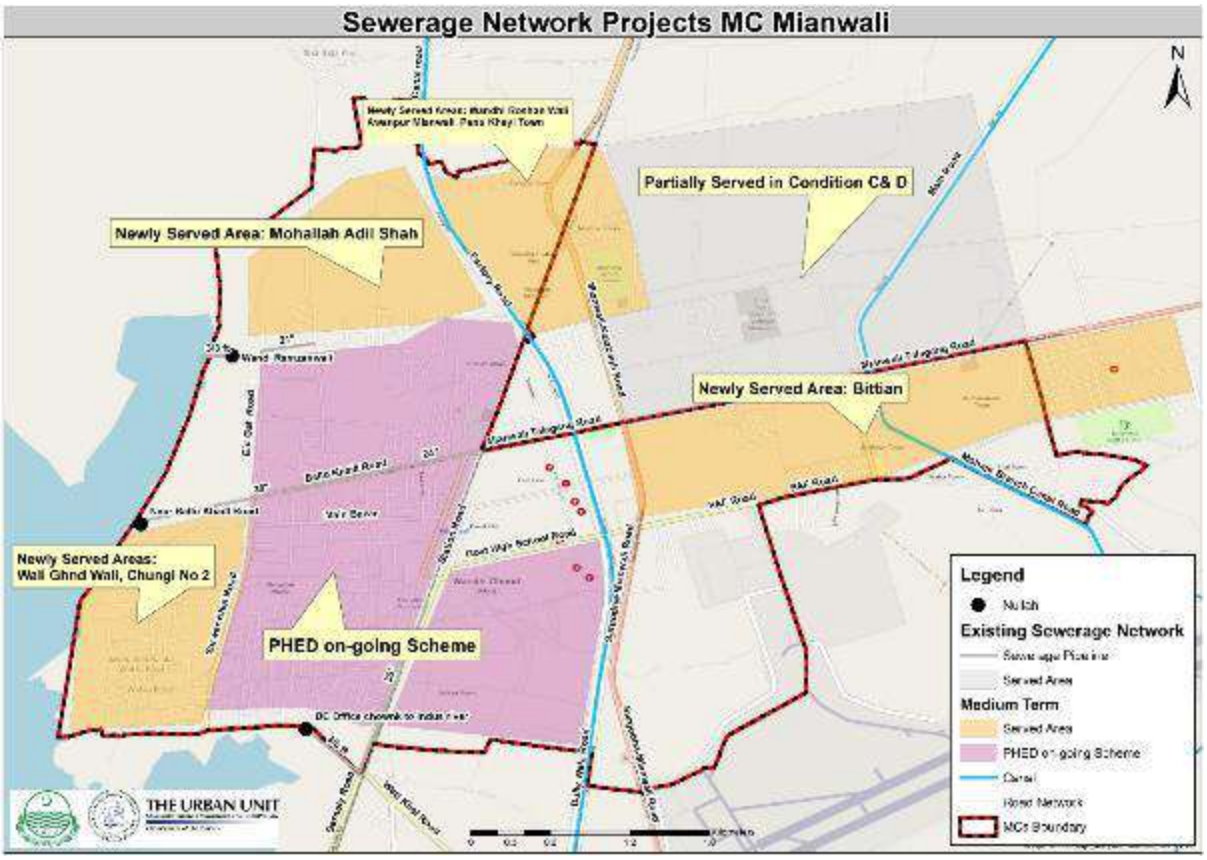


Figure 51: Proposed spatial Sewerage Interventions for Mianwali City

05 Water Supply & Sanitation – Bhakkar

A. WATER SUPPLY – BHAKKAR

Bhakkar City water supply is mainly managed by Municipal Committee (MC) Bhakkar after Public Health Engineering Department (PHED) designs and executes the water supply schemes in the city. The groundwater in Bhakkar district unlike Sargodha is sweet and fit for drinking with little to no TDS and contamination issues. This has however led to overexploitation of underground water reserves as almost every household in Bhakkar is using private bores to extract underground water and fulfill their water demand. The reliance of public on household bores has also led to abandonment of MC water supply schemes as people are unwilling to pay for a service they don't need. Most of the water supply schemes in city are currently non-functional with the main reason being non-payment of WAPDA dues and lesser number of connections. A water quality lab is established by PHED in Bhakkar city and is currently monitoring the water quality situation in Bhakkar district. Minor Arsenic issues were reported in urban areas of Bhakkar by PHED but overall quality of underground water in Bhakkar is satisfactory

5.1. EXISTING WATER SUPPLY INFRASTRUCTURE

Bhakkar water supply is not fulfilling the required water demand. According to the latest census, there are approximately 17,000 households in Bhakkar MC, out of which only 552 households have MC water supply connection. Almost 70% area of MC Bhakkar receives water from MC supplied water schemes. A total of nine (09) MC owned water supply schemes are currently present in Bhakkar city. These water supply schemes are installed during 1950-1990. These schemes are outlived and have completed their design life. Only 2 out of these 9 water supply schemes are currently functional. Most of the schemes are non-functional due to non-payment of WAPDA dues as people are unwilling to pay for water supplied by MC. Hence, there is a need to rectify these service delivery gaps in order to provide a sustainable plan for the water supply system

In Rural areas schemes designed by PHED are handed over to relevant CBOs. There are total of 12 water supply schemes that were completed during 1984-1998. Out of these only one scheme present in Mankera is currently functional. Vast distances and availability of sweet fresh underground water at a shallow depth is the major issue of abandonment of these water schemes.

The water supply system in Bhakkar is supplied by tube wells constructed at various locations in the city. Over-Head Reservoirs are constructed adjacent to these tube wells that serves as storage for the network. The water supply pipelines are old and have leakages. These schemes are interconnected; if one or two tube wells are dysfunctional, other tube wells in the vicinity and OHRs feed the system thus catering for emergency needs. There are no Ground Storage Tanks or Water Works present in MC Bhakkar. Almost

70% area of MC Bhakkar currently has water supply pipelines but only approximately 20% area of the city (mostly Mandi Town) is currently being served by water supply schemes.

Table 43: Urban Water Supply Infrastructure in Bhakkar City

Tube wells	**9**
Operational	7
Non-Operational	2
Overhead Reservoir	**6**
Operational	2
Non-Operational	4
Ground Storage Tanks	**0**
Operational	0
Non-Operational	0
Water Supply Pipeline	
City Coverage	60-70%

5.1.1. CONDITION ASSESSMENT OF ASSETS

A rating criterion for the assessment of water supply have been developed in order to categorize the current infrastructure system. To measure the condition, physical inspection and the performance parameters are evaluated. Following table is used to rate the assets based on their condition.

Table 44: Condition Rating of Assets

Rating	Asset Condition	Description
A	**Excellent**	No noticeable defects. Some aging or wear may be visible.
B	**Good**	Only minor deterioration or defects are evident.
C	**Fair**	Some deterioration or defects are evident, but function is not significantly affected
D	**Poor**	Serious deterioration in at least some portion of the structure. Function is inadequate
F	**Failing**	No longer functional. General failure or complete failure of a major structural component.

With regard to condition assessment of the water supply system, overall civil structure, machinery and electrical components associated with water supply infrastructure present in the city has been evaluated as “D” which indicates serious deterioration in at least some portion of the structure and the function

being inadequate. The distribution network as a whole is evaluated as "C" meaning that some deterioration or defects are evident but the function is not significantly affected.

Table 45: Asset Rating in Bhakkar City

Assets	Rating
Civil Structure	D
Distribution Network	C
Electrical Components & Machinery	D

5.1.2. TUBE WELLS

The MC owns a total of 9 tube wells, 2 of which are operational. These tube wells are of 0.5 cusec discharge capacity and are part of different water supply schemes spread across the city. The details of these tube wells are provided in **Annexure A**. These tube wells were installed during 1950-1990 and have outlived their design life. Within the municipal limits, most households have private bores to cater for their water needs. This has led to lesser number of connections for water supply schemes as people are fulfilling their needs on their own. Lesser connections and outlived machinery is the major reason of dysfunctional tube wells in the city. There are no chlorinators installed at any of the tube well. These tube wells also have no pump-houses and are installed open to sky with a simple corrugated steel sheet acting as a shed to protect against the elements. The quarter rooms are provided but are in dire condition. The number of tube wells in the city are also insufficient to cater for demand of the whole city and additional wells are required to fulfill this demand-supply gap.

The pictures below show the different tube wells installed at different locations in Bhakkar.

Figure 52: Tube wells at different location in Bhakkar City

5.1.3. OVERHEAD RESERVOIR (OHR)

There are a total of 6 Overhead Reservoirs in Bhakkar city with a total storage capacity of 270,000 Gallons. Only 2 out of these 6 OHRs are currently in service with a total storage of 100,000 Gallons. These Overhead Reservoirs are provided with tube wells to provide storage to the piped network in the city.

The pictures below show the different overhead reservoirs installed at different locations in Bhakkar city.

Figure 53: Overhead Reservoirs at different locations in Bhakkar City

5.1.4. FILTRATION PLANTS

There are around 4 Filtration Plants within the boundary of MC Bhakkar. All of these are Ultrafiltration Plants (UF). The MC Bhakkar currently does not claim these and these filtration plants are operated and maintained by a private NGO. All of these filtration's plants are functional and in satisfactory condition.

5.1.5. WATER SUPPLY PIPELINES:

The water is supplied through AC, CI and PVC pipelines laid throughout the city. These pipes vary from 3" to 6" diameter pipes. Most of the pipes are more than 30 years old and have outlived their usable life. The water supply pipelines in the area of Mandi Town are in better condition as compared to rest of the city.

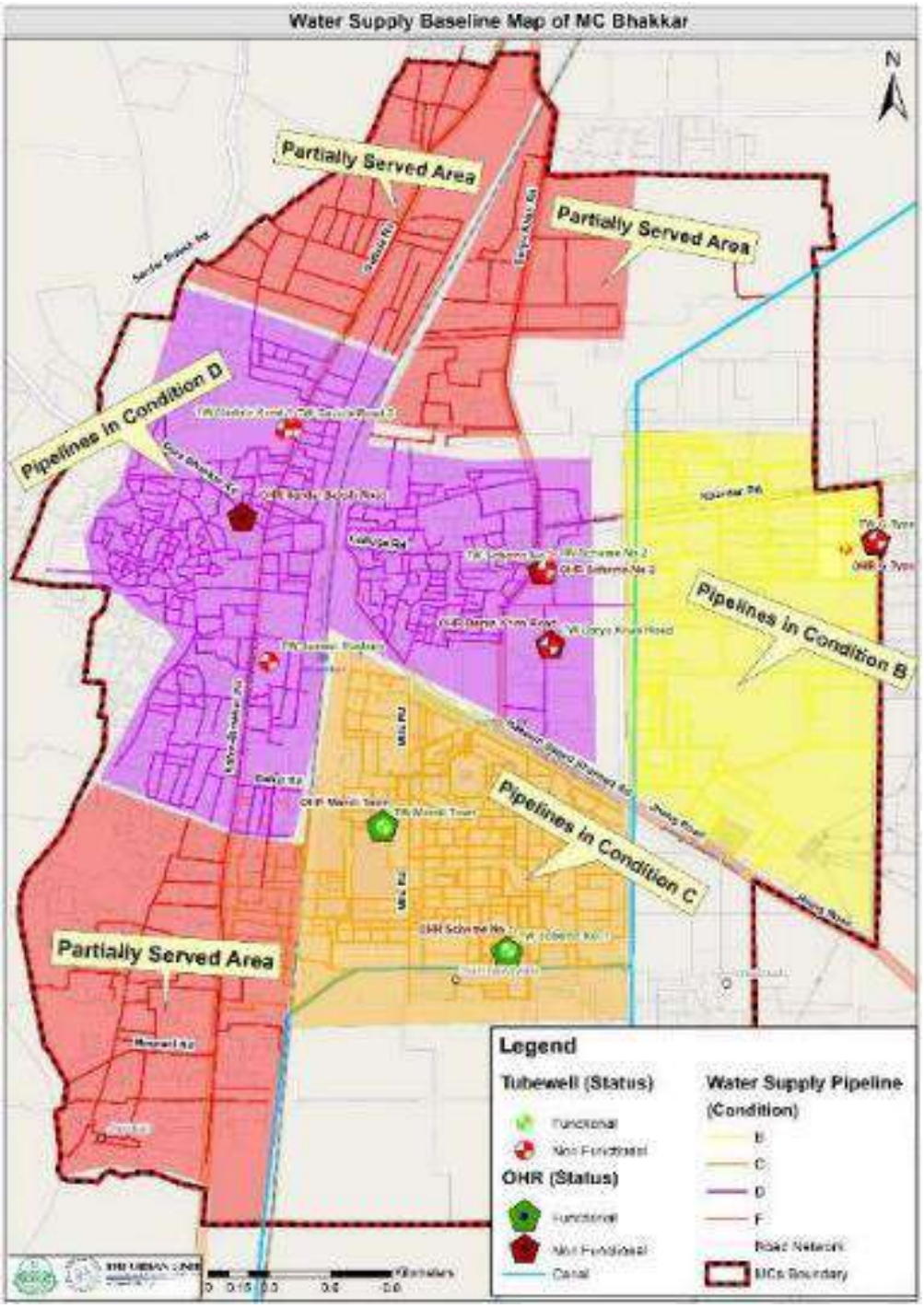


Figure 54: Baseline Water Supply System in Bhakkar City

5.2. PLANNING & DESIGN CRITERIA

This section refers to the design of main components of water supply network. The main components are discussed in the subsequent sections. Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 gallons per capita per day i/c 20% as unaccounted for water (NRW) & 15% of commercial water demand and 10% of Industrial and 10% of Institutional water demand have also been added in the design, the current (2022) water demand and future (2025, 2030 and 2040) water demands are shown in **Table 46** below.

Table 46: Estimated Water Demands for Bhakkar City

Attributes	Water Demand (Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	128,620	138,996	158,184	204,873
Domestic Demand 33 GPCD (including 20% NRW)	4,244,451.83	4,586,882.76	5,220,086.40	6,760,795.43
Industrial (Cottage industries, Factories) 10% of Domestic Demand	424,445.18	458,688.28	522,008.64	676,079.54
Institutional (Educational, Institutions and Hospitals) 10% of Domestic Demand	424,445.18	458,688.28	522,008.64	676,079.54
Commercial (Shops & Restaurants etcetera.) 15% of Domestic Demand	636,667.77	688,032.41	783,012.96	1,014,119.31
Average Day Demand (MG/D)	**5.73**	**6.19**	**7.05**	**9.13**
Max Day Demand (MG/D)	**8.60**	**9.29**	**10.57**	**13.69**

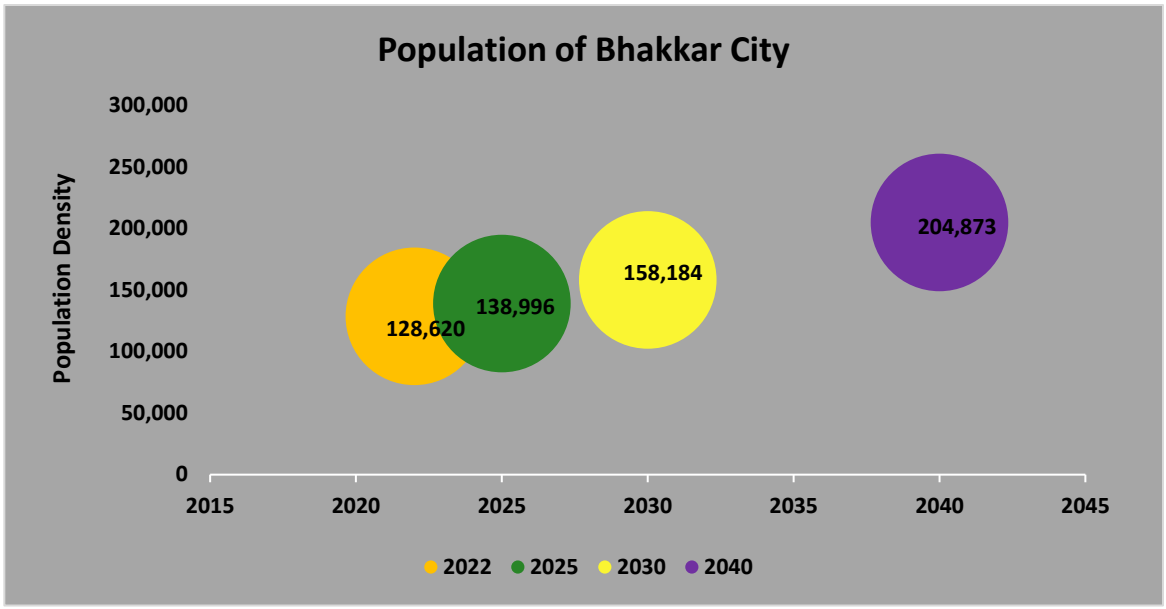


Figure 55: Estimated Population for Bhakkar City

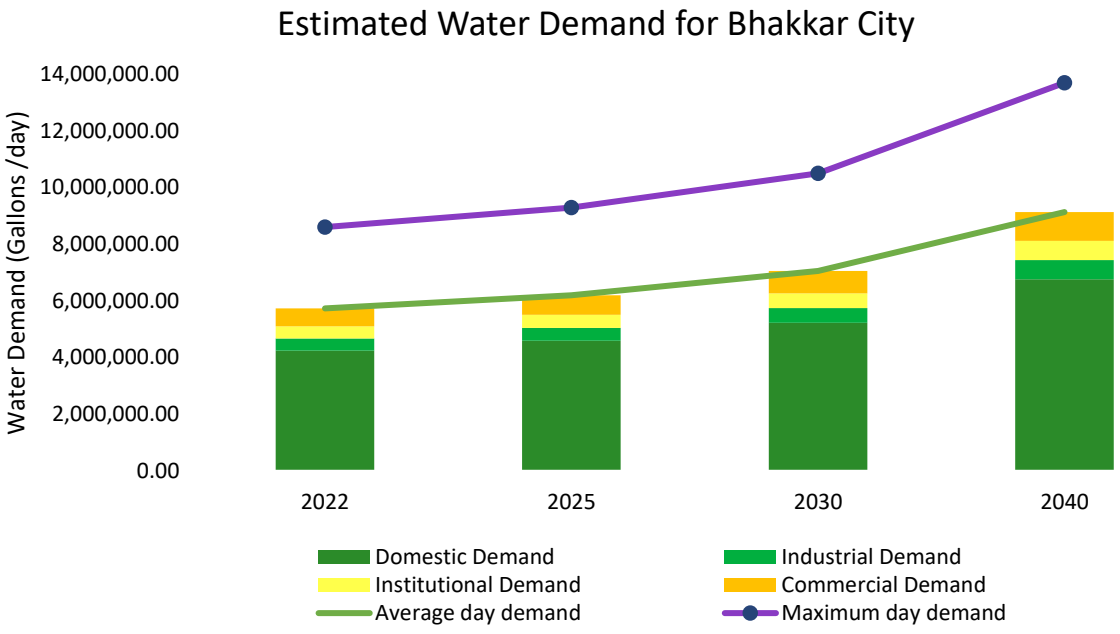


Figure 56: Estimated Water Demand for Bhakkar City

Design Criteria

The main objective of design is to evolve a water supply network, which can be operated with minimum maintenance for design life of the project. There is a need to develop a sustainable system for water supply that takes into account the impact of population growth and efficient aquifer recharge mechanism.

- **Planning Horizons**

Planning horizon for this plan is 18 years i.e., 2022-2040. Short-, medium- and long-term phases are identified for 3, 5 & 10 years i.e., 2025, 2030 and 2040 respectively.

- **Population Projection**

The population projections are determined by using following formula:

$Pn = Po (1+r)n$

Where,

P_n = Projected population for required year

P_o = Population of base year

r = Population annual growth rate (taken from last Census Report 2017)

n = Number of years, counted from the base year

Growth rate in case of Bhakkar city is taken as 2.62% as per 2017 Census report of Pakistan.

- **Maximum Day Demand**

Maximum day demand is taken as 1.5 times the average day demand.

- **Tube Well Working Hours**

Tube Well Working Hours are taken as 16 Hours/day in city as proposed in Design Criteria for WASAs by Urban Unit

- **Overhead Reservoir**

Overhead reservoirs are designed for the continuous supply of water. Capacity of overhead reservoirs is taken as 1/10th of average day demand.

- **Ground Storage Tanks**

When the length of the rising main is such that the loss of head is very high, intermediate pumping stations comprising a storage tank and pumping machinery installed in a pump house will be used. Capacity of ground water storage tanks is taken as 1/4th of average daily demand.

- **Drinking Water Requirement**

Water requirement of 33 Gallons per capita per day as recommended by WASA is used for the design calculations in this report.

5.3. PROPOSED INTERVENTIONS IN BHAKKAR

Based on the existing infrastructure analysis including condition survey and service delivery gap analysis, the recommendations are divided into three phases: i.e., Short (Year 2025), Medium (2030) and Long (2040) term plans in order to reduce the financial stress.

5.3.1. SHORT TERM PLAN

During the Short-term phase, the existing water supply network is upgraded and repaired to make it functional. The Nine (9) tube wells of 0.5 cusec capacity in existing water supply schemes will be upgraded to 1 cusec capacity. Moreover, pump houses will be constructed for these tube wells to provide shelter against the elements. Chlorinators and Bulk meters are also to be provided. Valves and quarter rooms at these tube wells will be repaired. 6 existing Overhead Reservoirs in the city are to be rehabilitated as well. Two new Overhead Reservoirs of 50,000 Gallons are also proposed to be constructed during this phase. The locations of these new Overhead Reservoirs have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

According to the conditional assessment of the distribution lines, more than 50% of the pipe lines are outlived and require immediate interventions. Most of the pipes are corroded and damaged. It is proposed to replace the old water supply pipelines of the city with HDPE ones.

Table 47: WS Short - Term Interventions in Bhakkar City

Water Supply Short - Term Interventions	
Infrastructure	**Tubewell:** ▪ Upgradation of 9 no. existing Tube wells of 0.5-Cusec capacity to 1-Cusec **Overhead Reservoir (OHR):** ▪ Rehabilitation of 6 no. of OHRs (4 no. 50,000 Gallons, 1 no. 40,000 Gallons, 1 no. 30,000 Gallons) ▪ Construction of 2 no. of OHRs (50,000 Gallons) **Water Supply Pipe Line:** ▪ Replacement of water supply pipeline of varying dia
Machinery	▪ Chlorinators ▪ Bulk meter/ Flow meter

5.3.2. MEDIUM TERM PLAN

In the medium phase interventions, new infrastructure will be installed in order to cater for the future aforementioned population and water demand. These interventions include construction of 7 new tube wells of 2 cusec discharge capacity each; including construction of pump houses, installation of

chlorinators and bulk meters, and laying of pipes to connect these to the existing water supply network. Two (2) new OHRs (50,000 Gallons each) are also proposed to be constructed during this phase.

DNI Zone is proposed for the area of Mandi Town. House metering of served areas will be initiated during this phase as well. The locations of these new Overhead Reservoirs and Tube wells have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Table 48: WS Medium - Term Interventions in Bhakkar City

Water Supply Medium - Term Interventions	
Infrastructure	**Tubewell:** ▪ New 7 no. of Tube wells each of 2- Cusec **Overhead Reservoir (OHR):** ▪ Construction of 2 no. of OHRs (50,000 Gallons) **DNI Zone:** ▪ Establishment of Distribution Network Improvement Zone for Mandi Town Bhakkar
Machinery	▪ Chlorinators ▪ Bulk meter/ Flow meter

5.3.3. LONG TERM PLAN

In the long-term phase interventions, new infrastructure will be installed in order to cater for the future aforementioned population and water demand. These interventions include construction of 8 new tube wells of 2 cusec discharge capacity each; including construction of pump houses, installation of chlorinators and bulk meters, and laying of pipes to connect these to the existing water supply network. Two (2) new OHRs (50,000 Gallons each) are also proposed to be constructed during this phase. The locations of these new Overhead Reservoirs and Tube wells have been shown in the proposed intervention map however these locations are tentative and can be changed as per the requirement of the stakeholders involved.

Rehabilitation of Training Center in MC Bhakkar is also proposed. This facility would provide training relevant to WSS sector operation and practices to the sanitary workers and other staff. A back-up store with workshop for repair of MC machinery and vehicles is also proposed for long term.

Table 49: WS Long Term Interventions for Bhakkar City

Water Supply Long - Term Interventions	
Infrastructure	**Tubewell:** ▪ New 8 no. of Tube wells each of 2- Cusec **Overhead Reservoir (OHR):** ▪ Construction of 2 no. of OHRs (50,000 Gallons) **DNI Zone:** ▪ Establishment of Distribution Network Improvement Zone for Mandi Town Bhakkar
Machinery	▪ Chlorinators ▪ Bulk meter/ Flow meter
Back- up Store	▪ Establishment of Back – up store with workshop
Training Center	▪ Establishment of Training Center at MC Bhakkar

Comprehensive list of interventions projects and spatial overview for the city water supply system under this regional development plan are shown in table and figure.

Table 50: Proposed WS Projects Interventions for Bhakkar City

Sr. #	Plan Period	Project Title	Justification & Scope
1.	**Short – Term (2025)**	Upgradation of Nine (09) Tube-wells & Rehabilitation of Six (06) Over Head Reservoirs in Bhakkar City	▪ Upgradation of 09 TWs (of 0.5 cusec capacity) to 1 cusec capacity ▪ Construction of pump houses and/or operator quarters for all 9 TWs ▪ Rehabilitation of 04 No. OHRs of 50,000 gallons capacity & 1 of 40,000- and 30,000-Gallons capacity
2.		Replacement of Water Supply Pipelines of Bhakkar City & Construction of Two (02) new Over Head Reservoir in Bhakkar City	▪ Replacement of old pipes of PVC, CI, AC with HDPE Pipes ▪ Replacement of valves ▪ Construction of two OHR of 50,000 Gallons capacity in Bhakkar city

3.	**Medium – Term (2030)**	New Water Supply scheme: Construction of 7 No. of new Tube-wells in Bhakkar City & Two (02 No.) new Over Head Reservoir in Bhakkar City	▪ Installation of 07 TWs of 2 cusecs each ▪ Construction of pump houses and operator rooms ▪ Extension of Water Supply network to unserved areas of Karor-Bhakkar Road, Darya Khan Road North and Graveyard-Gadola Road ▪ Construction of 02 OHRs of 50,000 Gallons capacity in Bhakkar city
4.		Metering of all the served areas of Bhakkar City and establishment of DNI Zone in Mandi Town	▪ Installation of water meters in served areas of Bhakkar City ▪ DNI Zone with SCADA
5.	**Long – Term (2040)**	Extension of Water Supply scheme including construction of 08 new Tube-wells & 02 new Over Head Reservoir in Bhakkar City	▪ Installation of 08 TWs of 2 cusecs each ▪ Construction of pump houses and operator rooms ▪ Provision of pipes to link to existing water network ▪ Construction of 02 OHR of 50,000 Gallons capacity in Bhakkar city
6.		Rehabilitation of Training Center in MC office Bhakkar and establishment of back-up store	▪ Store for backup spares and mobile workshop units for quick repair & maintenance ▪ Training of WSS officials for: Asset Management, Geo Tagging of WSS Infrastructure, O&M of E&M equipment & Water Quality Testing Lab establishment

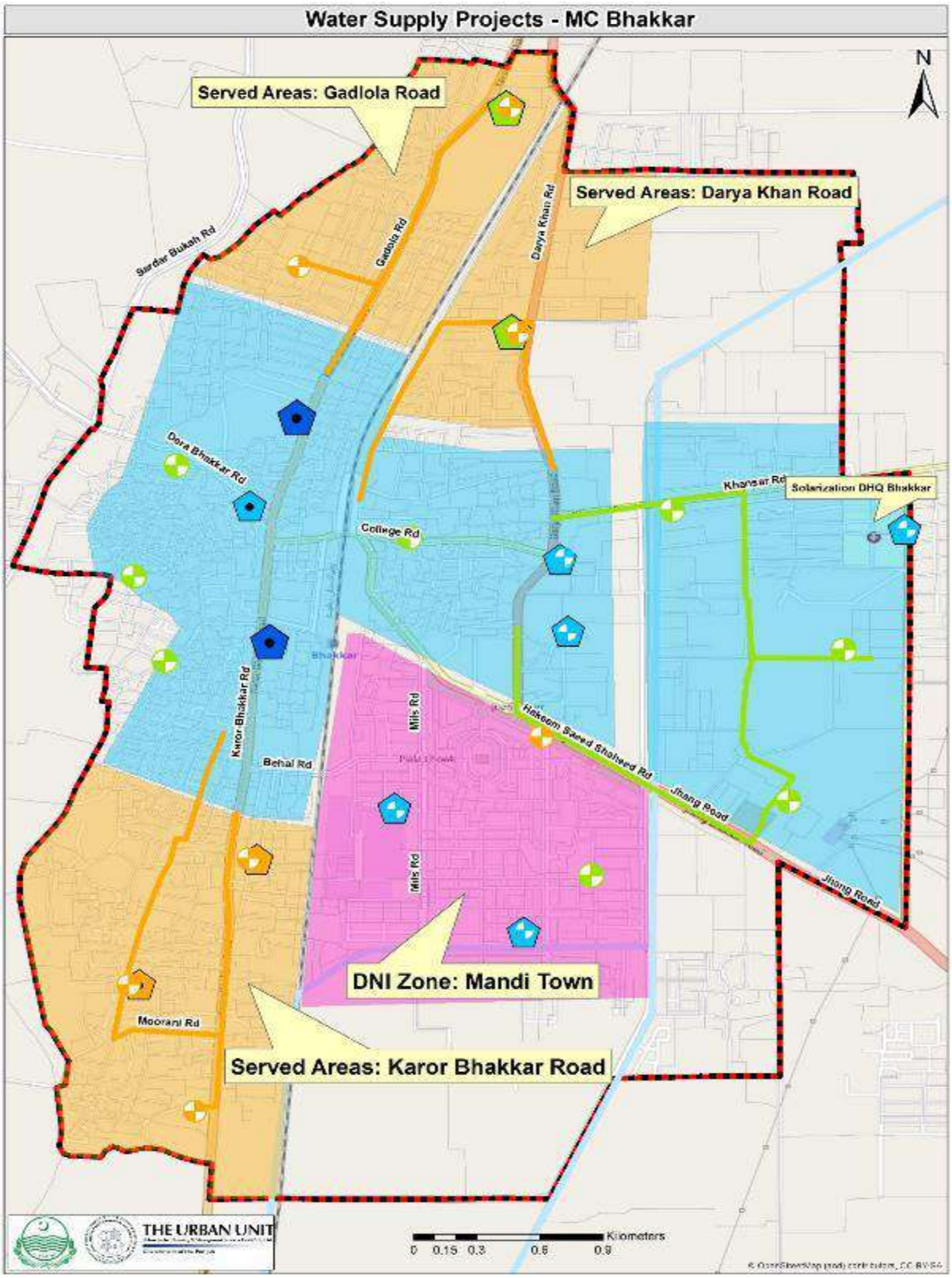


Figure 57: Proposed Spatial WS Interventions for Bhakkar City

B. SEWERAGE SYSTEM BHAKKAR

Provision of sewerage services in Bhakkar is the responsibility of MC Bhakkar. The sewerage schemes are designed and executed by Public Health Engineering Department (PHED) and then handed over to Municipal Committee Bhakkar for its Operation and Maintenance. The current sewerage system of Bhakkar city is insufficient and outlived. Choked and overflowing sewers are a common sight. Open channels/drains are used which routinely get accumulated with solid waste. An old river creek passes through the city and the waste of the city is either dumped in this creek or is disposed-off into water ponds. This has created a highly unsanitary and sub-standard condition of sewerage in the city that needs to be immediately addressed.

5.4. EXISTING SEWERAGE INFRASTRUCTURE

The sewerage system of Bhakkar city is sub-standard. Almost 60-70% area of the city is served by sewerage schemes but these schemes are more than 30 years old. Majority of the pipelines are chocked and hence unusable. This has reduced the sewerage coverage of the city to approximately 40-50%. Overflowing sewers are a common site. Mainly RCC sewer pipes are currently present which are settled, chocked and damaged at different locations. The existing sewer pipes diameters range from 9" to 30". These sewers carry the waste water to water ponds and old river creek (old creek of River Indus) that lie on the outskirts of the city.

Mechanism of cleaning of sewer lines is traditional, making it more challenging and difficult for sanitary staff to clean sewer lines as per standard. As a result, inundation can be observed in low income and congested areas. The MC Bhakkar owns two Sucker and two Jetting machines. It must be mentioned here that leakage of these sewerage pipes also pollutes water supply lines when penetrated into it.

Overall, the existing Sewerage disposal system is not sufficient to meet current and future waste disposal demand of the city & condition of the existing structure especially sewerage lines needs attention so that it is properly disposed-off.

Table 51: Urban Sewerage Infrastructure in Bhakkar City

Disposal Stations	**6**
Operational	3
Non-Operational	3
Waste Water Treatment Plants	**0**
Operational	0
Non-Operational	0
Sewer Lines	
City Coverage	60-70%

5.4.1. CONDITION ASSESSMENT OF ASSETS

A rating criterion for the assessment of sewer schemes has been developed in order to categorize the current infrastructure system. To measure the condition, physical inspection and the performance parameters are evaluated. Following table is used to rate the assets based on their condition.

Table 52: Asset Condition Assessment Criteria

Rating	Asset Condition	Description
A	Excellent	No noticeable defects. Some aging or wear may be visible.
B	Good	Only minor deterioration or defects are evident.
C	Fair	Some deterioration or defects are evident, but function is not significantly affected
D	Poor	Serious deterioration in at least some portion of the structure. Function is inadequate
F	Failing	No longer functional. General failure or complete failure of a major structural component.

With regard to condition assessment of the sewerage system, overall civil structure, machinery and electrical components associated with sewerage infrastructure present in the city has been evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate. The distribution network as a whole is also evaluated as "D" which indicates serious deterioration in at least some portion of the structure and the function being inadequate.

Table 53: Asset condition of Sewerage infrastructure in Bhakkar

Assets	Rating
Civil Structure	D
Sewerage Network	D
Electrical Components & Machinery	D

5.4.2. DISPOSAL STATIONS

There are a total of 6 Disposal Stations in Bhakkar city. 3 out of these 6 Disposals are currently functional. The "Disposal Works Underpass" is operated only to drain storm water flow. These disposal stations were built more than 30 years ago and have not been properly maintained. Most of the disposals have spalling civil structures. The condition of wet wells is also highly deteriorated with spalled off plaster and cracks in walls. No screening chamber is present in any of the disposal station in the city.

The pumps and motors are in highly derogated condition and open wiring is used. The waste water from the disposals is either carried to the fields or disposed-off into water ponds along the path of old river creek (an old river creek of Indus).

Figure 58: Disposal Station in MC Bhakkar

Figure 59: Waste Water being carried to fields

Figure 60: Inside Wet Well of Disposal Station Mandi Town

Figure 61: Outside Wet Well of Disposal Station

5.4.3. SEWERAGE NETWORK

The sewerage network consists of RCC pipes of diameters ranging from 9” to 30”. Majority of the sewer pipes are choked and damaged. The condition of pipelines in Mandi Town area is better as compared to less of the city with little to no choking issues.

5.4.4. WATER PONDS AND OLD RIVER CREEK

Waste water of the city is dumped in water ponds along the path of old river creek. Old River creek is path of an old creek of River Indus that once passed through Bhakkar. Water gets disposed into this creek resulting in water ponds and stagnant pools of water. Moreover, solid waste is also dumped in these water ponds further aggravating the issue and creating an extremely unsanitary scenario.

Figure 62: Water Ponding in Bhakkar City

Figure 63: Waste being dumped along Old River Creek, Bhakkar City

5.4.5. WASTEWATER TREATMENT PLANTS

Oxidation ponds, also called stabilization ponds, these are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. There are currently no Waste Water Treatment Plant in Bhakkar City.

5.5. PLANNING & DESIGN CRITERIA

The purpose of this planning exercise was to assess the current gaps and future wastewater disposal demand for the citizens of the city. The current population of the city is approximately 130,000 with total wastewater flow of 10.70 MGD. The current capacity of the sewerage system of the city is lesser than the waste water generated by the city.

Based on the current and projected populations for the Municipal Committee and the proposed water demand of 33 Gallons per Capita per Day, the current (2022) and future (2025, 2030 and 2040) waste water flows are calculated and shown below.

Table 54: Estimated Sewage Flow of Bhkkar City

Attributes	Sewerage Flow (Million Gallons per Day)			
	2022	2025	2030	2040
	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary	Existing Urban Boundary
Population	128,620	138,996	158,184	204,873
Average Sewage Flow for 33 GPCD (including 20% NRW)	3.6078	3.8989	4.4371	5.7467
Peak Sewage Flow	7.2156	7.7977	8.8741	11.4934

Storm Water Flow (50%)	2.3811	2.5732	2.9285	3.7928
Non-Domestic Flows (5%)	0.1804	0.1949	0.2219	0.2873
Infiltration (5%)	0.1804	0.1949	0.2219	0.2873
Total Sewage Flow (MG/D)	**9.96**	**10.76**	**12.25**	**15.86**

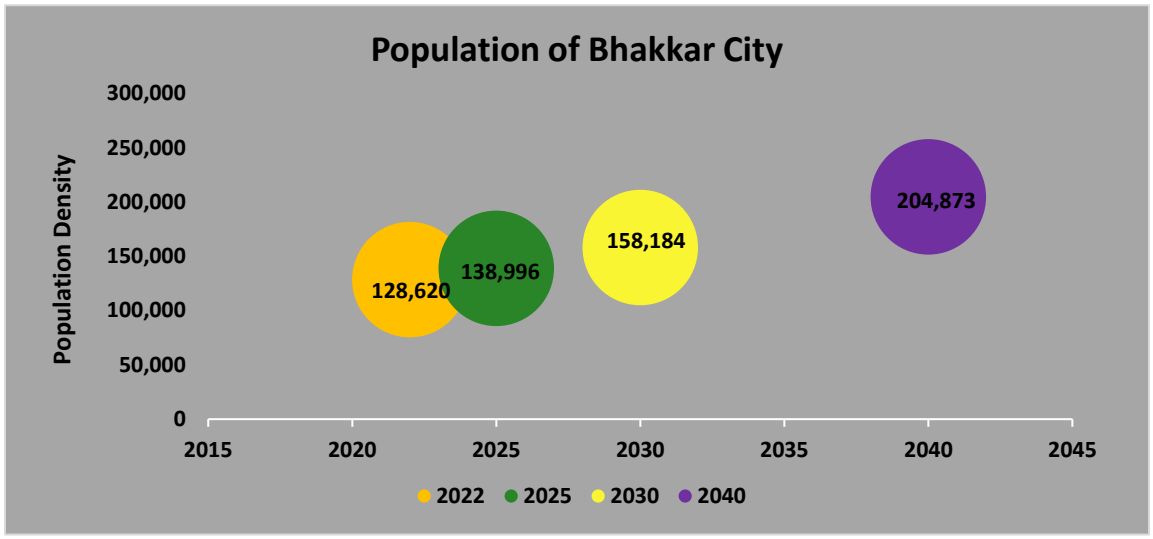


Figure 64: Population of Bhakkar District

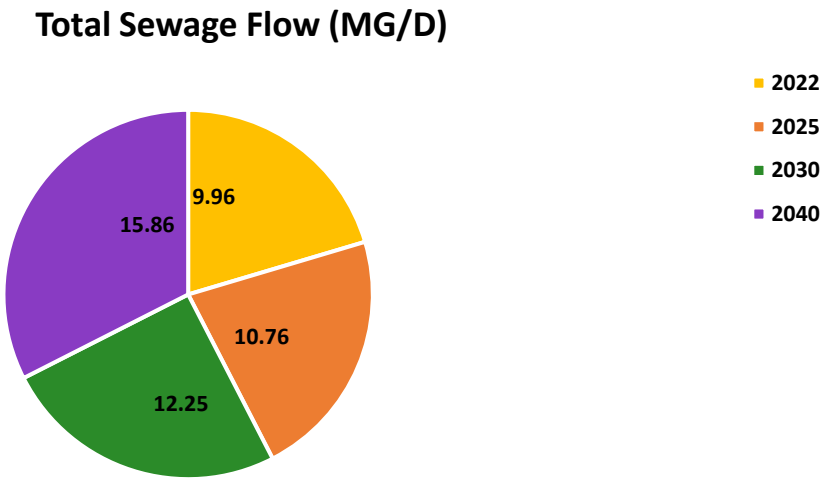


Figure 65: Total Sewage Flow of Bhakkar District

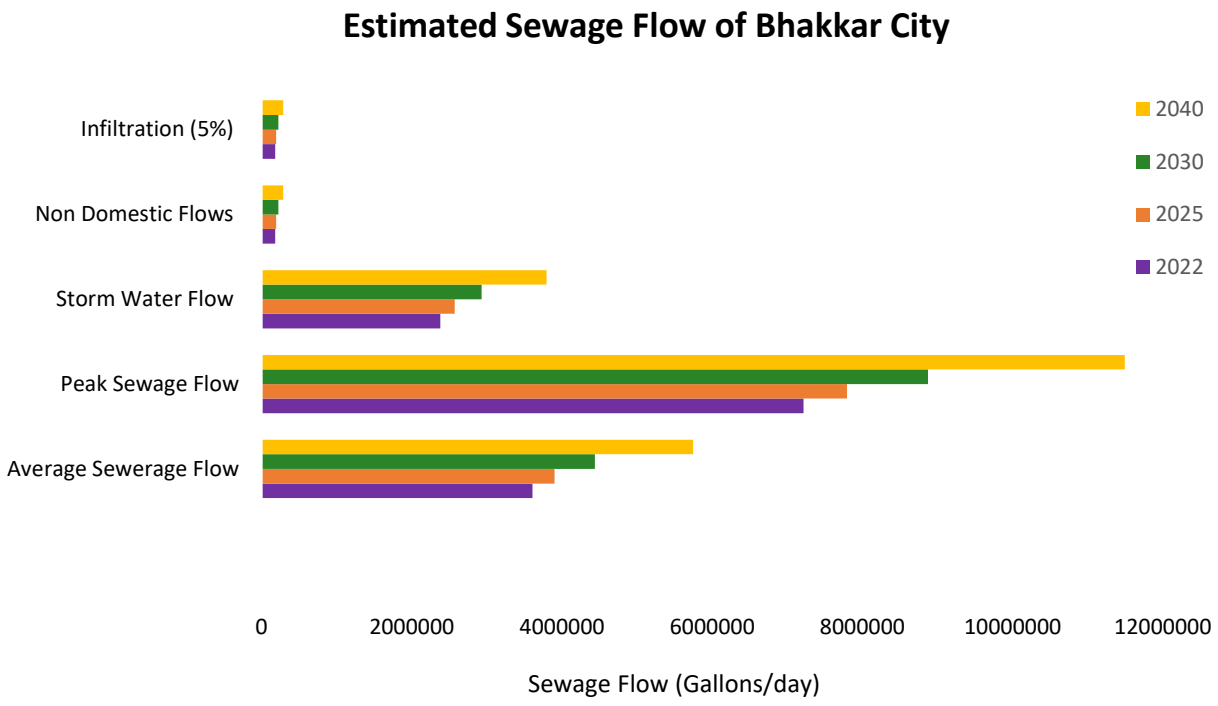


Figure 66: Estimated Sewage Flow of Bhakkar City

Design Criteria

Average waste water is taken as 80% of the Average Water Demand of the city. The Peak Factor of 2 is used for this design considerations as the population of city is (>100,000). Storm water flow is taken as 50% of the Average Water Demand as Bhakkar City lies in the Northern Zone of Punjab. Non-Domestic Flows and Infiltration as 5% of the Average Water Demand is used.

5.6. PROPOSED INTERVENTIONS

It is evident from aforementioned analysis that Bhakkar city lacks a proper sewerage system to dispose the waste water generated by the city. There is also no Waste Water Treatment Plant to treat the polluted water before disposing it in the fields. Also, the water ponding is a major issue that needs immediate addressable as they not only create an unsanitary environment, but also acts as breeding grounds for mosquitos and other diseases.

Fortunately, there is an Urban Sewerage Scheme for Bhakkar City designed by Public Health Engineering Department (PHED) that is approved and already in execution phase. Once completed it will solve the sewerage related issued of Bhakkar city. Therefore, no interventions related to sewage are proposed in Bhakkar city as the schemes will cover all the major sewerage issues in the city.

5.6.1. URBAN SEWERAGE SCHEME FOR BHAKKAR CITY

An urban sewerage scheme for Bhakkar city is designed by Public Health Engineering Department (PHED) and is currently in construction phase. The scheme includes a gravity flow sewerage system, that carries the sewerage of the entire city to Sial Road through RCC sewer pipes of diameter ranging from 9" to 72". The waste water is then carried through truck pipes of 72" diameter to Waste Water Treatment Plant. The schemes include construction of new disposal in the outskirts of city as well as a construction of Waste Water Treatment Plant along with a Super Disposal.

Figure 67: RCC Sewer pipes being casted for PHED Sewerage Scheme

The details of the Sewerage Schemes are provided in the table below:

Table 55: Urban Sewerage Scheme for Bhakkar City by PHED

Name of Project Scheme	Urban Sewerage/Drainage PCC Slab & Brick Pavement in Bhakkar City
GS No.	1438
Project ID	14232
Designed by	Housing Urban Development & Public Health Engineering Department (HUD & PHED)

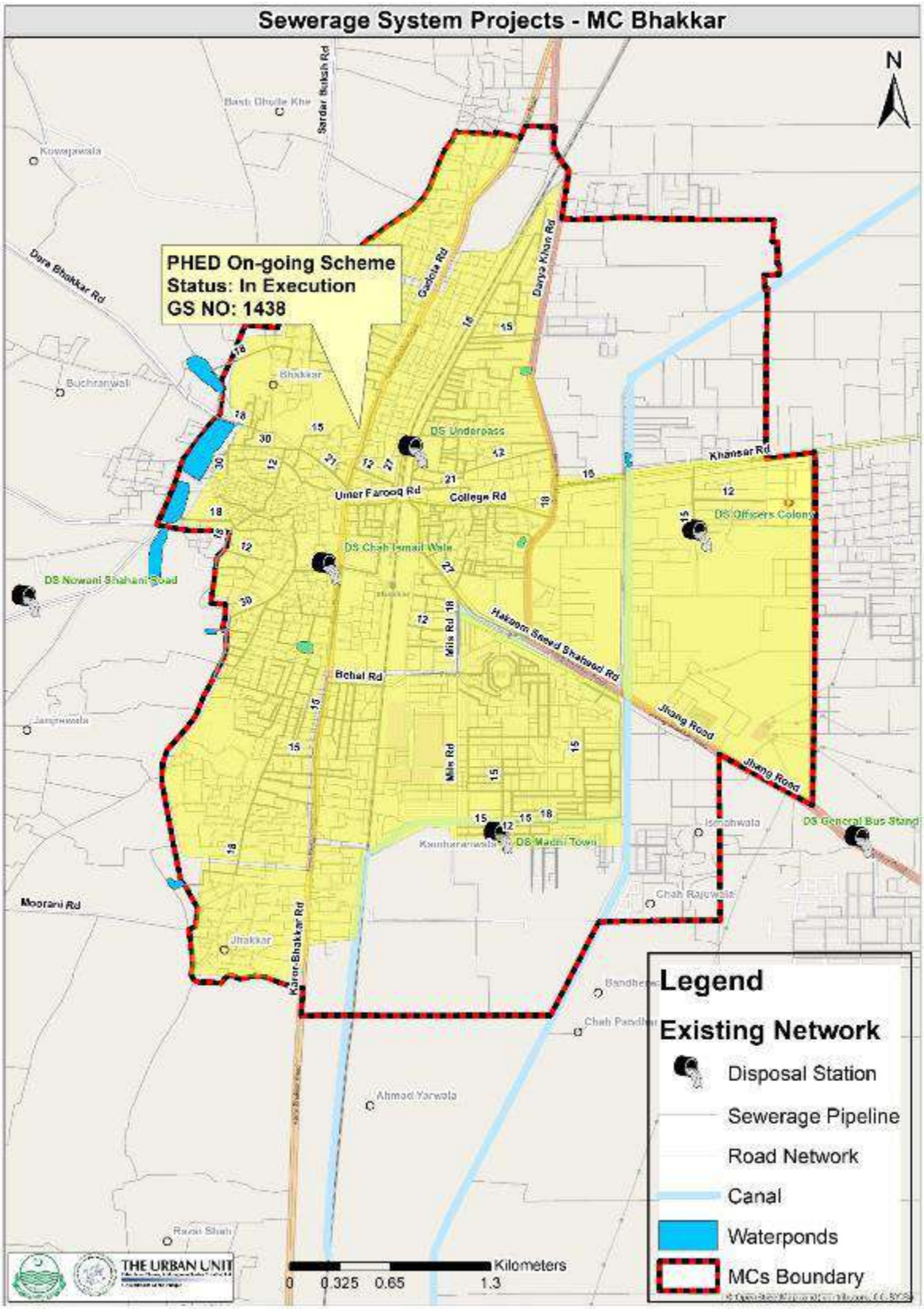


Figure 68: Proposed spatial Sewerage Interventions for Bhakkar City

06 Rural WSS – Sargodha Division

Drinking Water and Sanitation are the most essential elements for human life and its dignity. The Government of Punjab also envisions providing safe drinking water and sanitation facilities to the entire rural and urban communities in an equitable, efficient and sustainable manner.

Provision of safely managed drinking water (use of an improved drinking water source located on premises that is accessible to all and is free from contamination on sustainable basis) and sanitation services to rural population is the responsibility of the Government in achieving the ***Sustainable Development Goals (SDGs) Target***-Goal 6.1 & 6.2- by 2030. Currently, only 48% Rural Punjab population is reported to have access to safely managed water supply services, which seems to be far behind in achieving SDG 6 targets and this clearly needs intervention by the higher end in order to improve the current situation of service delivery in rural settlements.

By 2018, only 13 percent of rural households had access to piped water, as compared to 29 percent of urban households, but even where piped water was available, less than 4% was piped into dwellings. These figures bring attention towards existing disparities among urban and rural areas. Concerning sanitation situation, it is stated that 73 percent rural households are seen as

Rural household accessed to piped water (by 2018)

Urban household accessed to piped water (by 2018)

having access to improved sanitation. However, only 4.9 percent have access to flush/pour-flush latrines connected to a sewer system, and another 50 percent have access to flush/pour-flush latrines connected to septic tanks with any overflow leading to a communal drain.

It goes without saying that the need of the hour is the need of addressing the prevalent disparities and inequalities of basic services in rural and urban settlements. This can truly stimulate significant progress in course of achieving equitable growth and actualizing our SDG commitments. Furthermore, Reliable and appropriate water infrastructure that allows for easy access to a safely managed water supply and sanitation services will lead to an improved lifestyle of rural people, produce resultantly fit and dynamic labor, escalate rural economies and create jobs.

Stakeholder Consultation in Inception Visit, Primary data collection from Public Health Engineering Department (PHED), brief field survey assessment and secondary data available on Water and Sanitation Sector (WSS) gave the team an insight about the existing state of WSS in rural areas of Sargodha Division in Punjab. Current situational analysis stating 30% water and sewerage coverage pronounce that medium level focus has been given in the past to invest for the provision of efficient municipal service delivery and improve the living condition of people in rural areas.

6.1. BASELINE ASSESSMENT OF WSS SYSTEM

Punjab is the most populous province of Pakistan with almost population of 110 million, out of which 63% (70 million) reside in the rural areas. Sargodha is one of the administrative divisions of Punjab having 18 tehsils and rural population of approximately 06 million as per census of 2017 indicating that 9% rural population of Punjab residing over there. Rural area segment is very significant to be analyzed and considered while developing the regional sectoral plan as major chunk i.e., 75% population of division lie in rural settlements as compare to 25% in urban areas. Division comprises of four districts with Sargodha district encompasses largest while Khushab least proportion of rural divisional population. This section is written to cover the current situation as well as future endeavors of water and sewerage sector in rural areas of four districts namely Sargodha, Mianwali, Khushab and Bhakkar that lie in Sargodha Division. The aspect of disparities and inequities in services are always found among districts as highlighted in one of the published WASH Scorecard report of UNICEF in 2019. Multiple indicators govern the WASH situation contribute towards the overall ranking of the districts with respect to water and sanitation. Khushab is categorized in to lowest rank of 35 and 25 among

Figure 69: Districts of Sargodha with Rural Population

all districts of Punjab with respect to rural water and sanitation index, which highlights the need of immediate planning and respective interventions in the district. Overall, the captured water and sanitation index and respective ranking of rural areas of four districts as depicted in figure xx makes the basis for essential need of planning and implementing WASH interventions in the region.

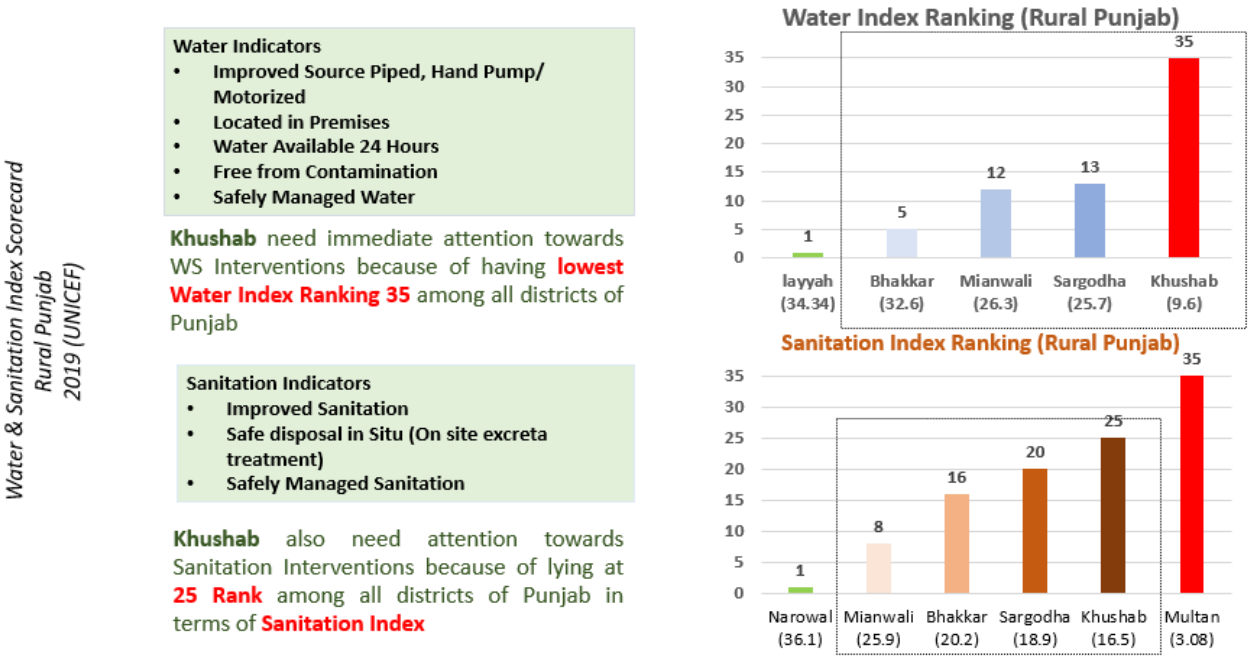


Figure 70: Rural Water and Sanitation Index in Sargodha Division

Public Health Engineering Department (PHED) is the main department responsible for the installation or execution of water supply and sanitation schemes in rural areas of Punjab. One of the major challenges of Service Delivery in rural areas is the distribution of responsibilities to execute and operate the infrastructure. PHED is responsible for execution or installation of the municipal services infrastructure, which is currently handed-over to Community Based Organizations (CBOs) for its operation and maintenance (O&M). The significant constraints behind the scene are absence of technical and financial capacity of CBOs as well as conflicts and ownership concerns. Currently CBOs carrying out the O&M of the installed water schemes are facing many challenges and issues due to low revenue collection, high electricity cost, theft issues and other legal bindings as highlighted during the brief field assessment carried out by Urban Unit team in January 2022.

Team carried out rapid assessment survey of rural areas in all four districts to have an overview of prevailing service delivery situation and Community opinion regarding WSS services. Community voiced for the need of water supply scheme in brackish areas of the division. Abandoned Water Supply Infrastructure, absence of decentralized wastewater treatment plant and water ponding were some of the issues observed during the field assessment visit. Glimpse of some of the consultation with rural community are highlighted in figure below.

Figure 71: Consultation of Urban Unit Team with Rural Community of Sargodha Division

6.1.1. WATER SUPPLY INFRASTRUCTURE

Currently both groundwater and canal seepage water are used as source of water for domestic usage and especially for drinking purposes. Water is provided to the rural community through installed 540 water supply schemes installed by PHED and maintained by CBOs in division. Schemes are based on tube wells of different capacity installed mostly along canal. According to data provided by PHED, currently there are total 376 water schemes in functional condition from total installed water schemes indicating that 30% of the infrastructure is Non-Functional. Total functional schemes currently serving only 28% of rural divisional population.

It was informed by concerned CBOs that 164 water schemes are non-functional in division and approximately 16% population is currently deprived of water supply due to this non-functional infrastructure as per data provided by PHED in 2022. It is noted that Water schemes are in non-working condition due to multiple reasons including failure of machinery, damaged rising main, bore failure, expiry life, community conflicts and non-payment of WAPDA dues. Highest non-functionality rate of (60%) is observed in Sargodha and minimum in Mianwali (15%) indicating the largest and least investment in Mianwali and Sargodha respectively. Bhakkar is the case where mostly fresh water aquifer is present and people are reluctant to pay for water, therefore, only 11 water schemes are installed among which all are non-functional due to absence of willingness of community to pay.

People are using their own bores and hand pumps for meeting their water needs where PHED' water supply schemes are not present. However, it is pertinent to mention that division groundwater lies in sweet to brackish water zones. Consumption of groundwater in sweet zone is of no concern while consumption of own bore water without treatment in those identified brackish area may pose serious impact on health of community and need immediate consideration as it is estimated that approximately 1 million of rural Sargodha population is residing in Brackish area.

Summary of water supply infrastructure in rural areas of all districts of Sargodha is given in table while detailed attributes of all water schemes are presented in Annexure. Functional and Non-Functional Rural Water Supply Schemes in districts of Sargodha division are mapped and presented in map.

Table 56: Summary of Rural Water Schemes

	Sargodha	Khushab	Bhakkar	Mianwali
Pop 2017	2,612,543	928,469	1,390,404	1,217,699
Total TWs	**156**	**159**	**12**	**213**
Functional TWs	65	131	1	179
Non-Functional TWs	91	28	11	34
Served Pop due to Functional TWs (2022)	345,895	506,820	21,129	1,024,023
No of Unserved Villages (No RWSS)	734	173	515	166

It is also noted that Ultrafiltration (UF) plants were installed and present in Bhakkar District but all of these are abandoned. Neither PHED/CBOs wants to operate due to high electricity cost and absence of revenue nor community have aspirations because of presence of fresh water aquifer zone in district. It is pertinent to mention that there are still approximately 1500 villages, which are deprived of water supply infrastructure with stating 80% unserved population in Sargodha Division.

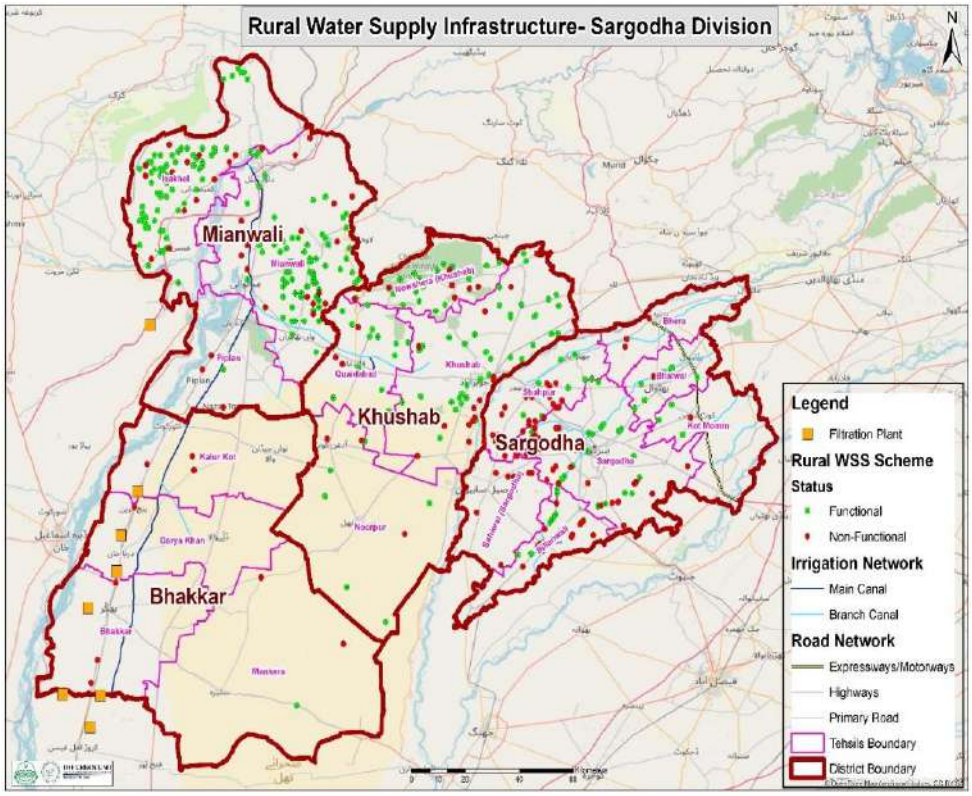


Figure 72: Rural Water Schemes in Sargodha Division

6.1.2. WATER QUALITY

The Urban Unit has carried out an analysis of available UNICEF Water Quality Data, PSLM & MICS data about WASH in Punjab Spatial Strategy, which resulted in to Spatial Mapping of districts of Punjab. According to that analysis, medium to high level WASH Interventions are needed among districts of Sargodha division.

PCRWR conducted water quality testing in Sargodha city 2021, which reflected 83% contamination in drinking water sources due to microbial contamination, excessive Chloride, Nitrate, Hardness, Iron, and TDS. Presence of excessive brackish water was reported in the study area due to major contribution from Sodium and Chloride ions. Such high level of microbial contamination is directly linked with reported Infant mortality rate of 72% in Sargodha according to latest MICS report.

UNICEF & PHED carried out detailed screening of water quality in rural areas of whole Punjab in 2014-16. This is only recent data set available on such a large scale in Punjab. Samples were taken from multiple sources and analysis of Total Dissolved Solids (TDS), Arsenic, Nitrate and Fluoride was carried out at that time. Presence of 9-40% TDS pollution in water of Sargodha division with minimum contamination of 9% in Bhakkar and maximum in Sargodha district clearly calls for the need of immediate mitigation interventions in Sargodha District. Sargodha and Khushab are classified as highly brackish zones while Mianwali and Bhakkar lie in medium to sweet water zone. Water quality condition with extremely high concentration of TDS say greater than 5000 ppm in groundwater aquifer due to presence of salt rock aquifer in the region is alarming as imposes the serious health threats to approximately 1 million human population residing and drinking that contaminated water. Slight Arsenic contamination (2%) with maximum reported value of 100 ppb was also observed in some areas of Sargodha and Mianwali districts, which may affect approximately 70,000 people residing and consuming groundwater in affected areas. Data on Water quality TDS results at village level is presented in tabular form attached at Annexure. Spatial overview of water quality situation presented in map with indication of Identified hotspots of Brackish and arsenic polluted villages need attention towards the need of immediate interventions of installation of respective filtration plants to protect the human health. It is noted that PHED has its own water quality testing laboratory facility in each of its district but water testing is carried out only on water schemes sources or on demand basis.

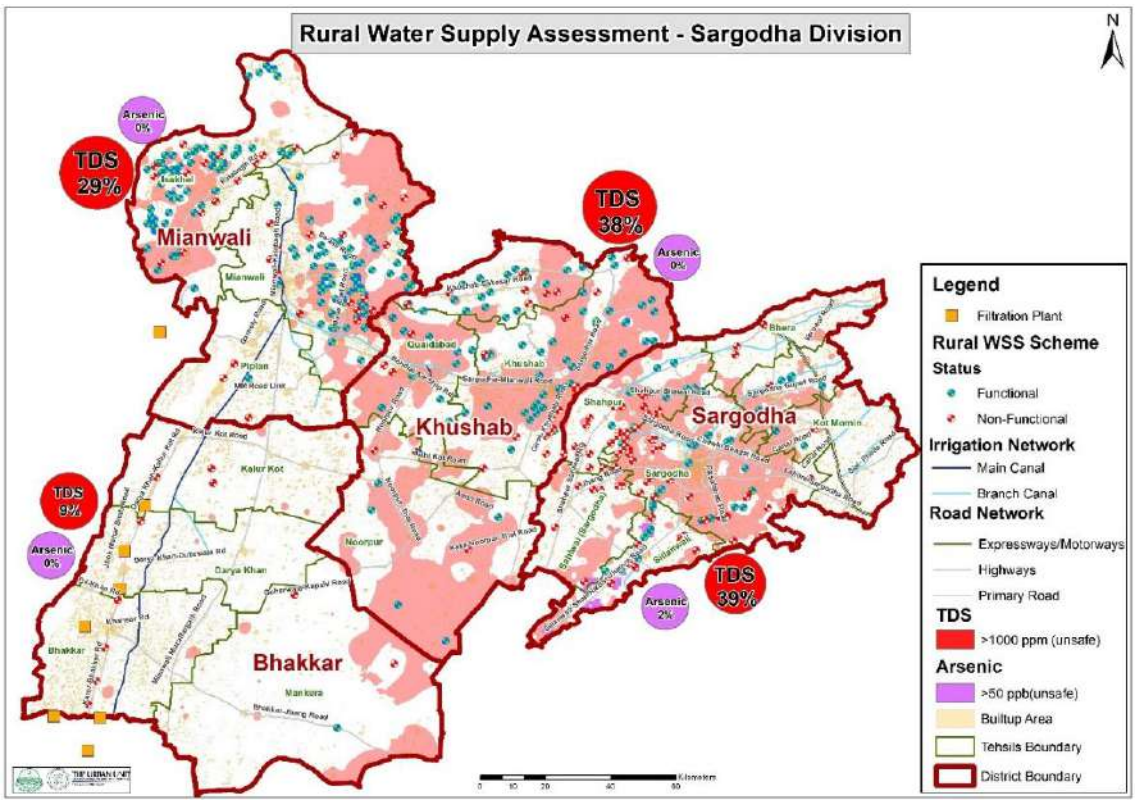


Figure 73: Shoot of Rural Water Quality Situation

6.1.3. SEWERAGE SYSTEM

Rural areas make major part of the districts because of having considerable population. It is very unfortunate to mention that usually rural extents are neglected in comparison to urban areas in terms of sanitation as indicated from disparity and inequity figures reported by UNICEF in its published reports. The negligence in investment consequently result in to the poor health and lower standard of living. Although the provision of equitable and safe drinking water and sanitation is the main responsibility of Government and as well as right of people. Provision of proper sewerage and drainage system in rural areas seems to be neglected because of multiple reasons such as absence of any company/organization responsible for proper operation and maintenance (O&M) of infrastructure, lack of funds, poor revenue collection, absence of technical expertise and machinery. Currently PHED plan, design and execute the sewerage and drainage schemes in rural areas whereas its operation and maintenance is mostly over-looked by concerned CBOs. Sewerage system in rural areas is normally consist of open drains while underground covered conduit system is rarely present in some villages. It is important to note that currently sewerage system with 92% open drain type and 8% underground sewers is present in approximately 700 villages of Sargodha division which make total of only approx. 33% coverage in rural areas. While on the other hand, a large number of populations is still deprived of basis right of sewerage facilities in 67% villages of division.

Table 57: Overview of Sewerage Situation in Rural Sargodha

	Sargodha	Khushab	Bhakkar	Mianwali
Tehsil Name	Sargodha, Bhalwal, Kot Momin, Bhera, Sillanwali, Shahpur Saddar, Sahiwal	Quaidabad/ Noor Pur	Bhakkar, Mankera, Darya Khan, Kallur Kot	Mianwali
Total No of Villages	835	313	580	255
Total no of Sewerage Schemes installed	38	3	27	7
No of Open Drains Schemes	424	-	1	134
No of Underground sewerage system schemes	14	3	26	7
No of Unserved Villages	359	310	553	114
Wastewater Treatment Plant WWTP (Yes/No)	NO	No	No	No
No of Wastewater treatment Plant	NO	No	N/A	Zero
Technology of WWTP	NO	No	N/A	NA

The baseline data summary collected from concerned PHED regarding existing situation of sewerage and drainage in villages of four districts of Sargodha Division is presented in table while disparity of rural sewerage coverage among districts can be seen in Map as well. Khushab and Bhakkar are districts where highest percentage of unserved area is present as compare to Sargodha and Mianwali indicating the need of more number of schemes needed in Khushab & Bhakkar. Wastewater collected through these open drains is normally drained and dumped in to agriculture fields and nearly water bodies without any treatment.

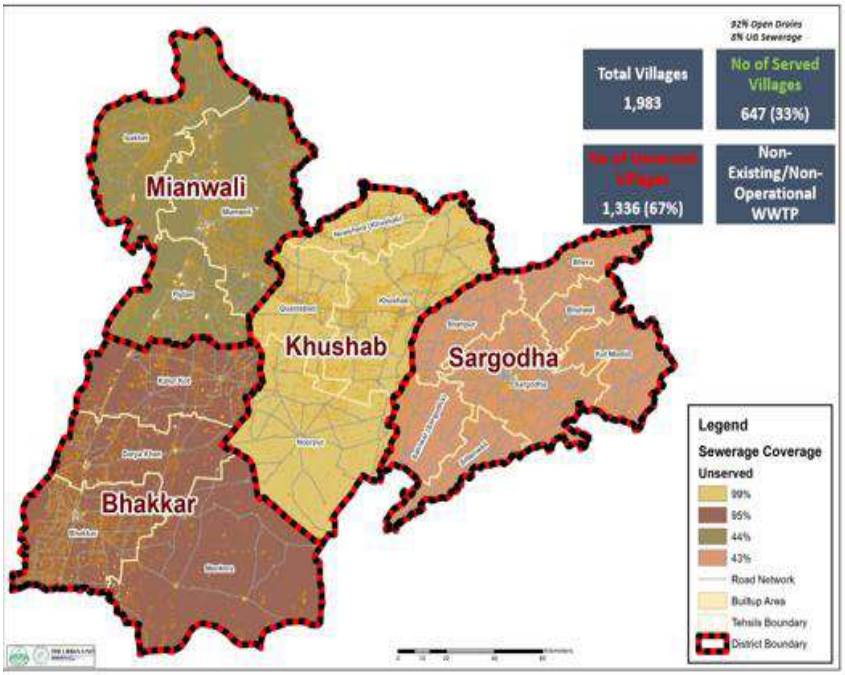


Figure 74: Sewerage Coverage in Rural Areas of Sargodha Division

6.2. RURAL WSS INTERVENTIONS

Once the situation of water supply and sanitation is analyzed as discussed in above section, the next step is to address the issues and challenges currently prevailing in rural areas. The major broadly challenges in rural water and sanitation sector articulated are abandoned Infrastructure, poor water quality- Brackish Zone, high electricity cost, less WSS coverage and financial & ownership issues. Large number of population residing in these areas are badly affected or deprived of safe WSS facilities. These some of the challenges are taken in to account and resultant actions of interventions are identified to cater the issues as water and sanitation are considered basic services that need to be provided on immediate basis for health environment and human well-being. Proposed Interventions lying around water supply & sanitation are categorized in to short (2025), medium (2030) and long (2040) term phases on basis of need of urgency and predominant severity of situation.

The summarized concrete challenges along with proposed interventions of Approximately PKR 17 Billion are presented in figure below. Along with proposed interventions, implementing agencies have also been identified and proposed for execution of proposed schemes. Punjab Aaab-e-Pak Authority (PAPA) has mandate of installation and execution of water treatment plants and schemes in rural areas of Punjab. Therefore, PAPA is proposed to install RO plants in identified brackish area based on actual testing. Furthermore, PHED is proposed to install and operate canal based rural water supply schemes in radius of 5km from brackish area village because of having technical capacity and relevant experience instead of CBOs.

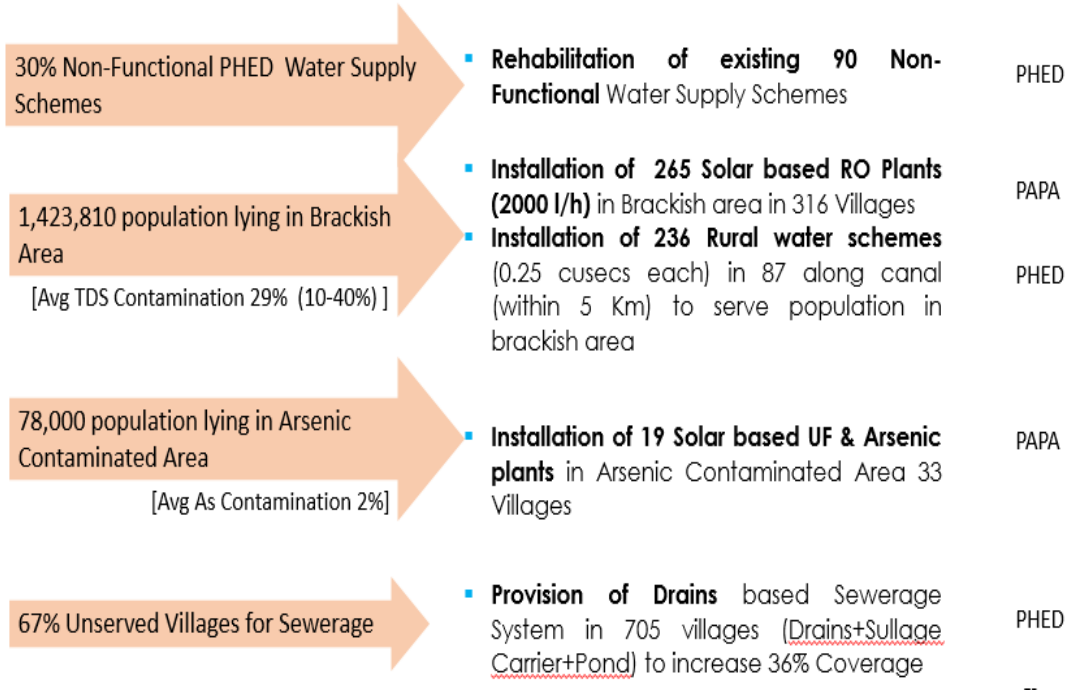


Figure 75: Proposed Rural WSS Interventions

6.2.1. SHORT - TERM

Short-term plan includes immediate interventions to be taken to cater the priority needs of water supply and sanitation. It majorly includes rehabilitation of dys-functional infrastructure, installation of Reverse Osmosis (RO) plants in highly brackish areas, addressing the arsenic contamination in rare areas, and provision of sewerage & drainage schemes in unserved areas. Open drains-based sewerage system along with sullage carrier and decentralized open oxidation pond is suggested in unserved villages of the division.

6.2.2. MEDIUM - TERM

Medium term plan focusses on provision of safe drinking water to people residing in brackish area. In this case, spatial exercise is carried out to identify the nearby water bodies such as canals to install the water supply schemes based on canal seepage water at the radius of 5 km from affected unserved villages. However, where nearby canal source is not available, RO plants are proposed in areas where TDS values are much higher than prescribed standard safe limits. Similarly, sewerage schemes are also proposed to bring the unserved villages in network.

6.2.3. LONG - TERM

Long-term plan also consists of same interventions such as installation of RO Plants, canal based water supply schemes and provision of sewerage network. But in this case, schemes are proposed in areas where situation of contamination is rather less severe as compare to those which have been identified and addressed in short and medium term. Conversion of rural infrastructure on renewable energy like solarization of schemes is also proposed.

Summarized identified intervention projects of worth PKR 17 Billion categorized in short, medium and long-term phases are articulated in table. It is envisaged that these proposed interventions will benefit the approximately 5.8 Million Population in Sargodha division.

Table 58: Phase wise proposed WSS Interventions

SHORT TERM PLAN (TILL YEAR 2025) PKR 2.39 Billion	MEDIUM TERM PLAN (TILL YEAR 2030) PKR 4.08 Billion	LONG TERM PLAN (TILL YEAR 2040) PKR 10.94 Billion
▪ **Rehabilitation of existing 90 Non-Functional** Water Supply Schemes ▪ **Installation of 53 Solar based RO Plants (2000 l/h)** in Brackish area ▪ **Installation of 18 Solar based UF & Arsenic plants** in Arsenic Contaminated Area ▪ Hygiene awareness program ▪ **Provision of Drains** based Sewerage System in 85 villages (Drains+Sullage Carrier+Pond)	▪ **Installation of 6 Solar based UF & Arsenic plants** in Arsenic **Contaminated** Area ▪ **Installation of 113 Solar based RO Plants (2000 l/h)** in Brackish area ▪ **Installation of 131 Rural water schemes** (0.25 cusecs each) along canal to serve population in brackish area ▪ **Provision of Drains** based Sewerage System in 250 villages (Drains+Sullage Carrier+Pond)	▪ **Installation of 99 Solar based RO Plants (2000 l/h)** in Brackish area ▪ **Installation of 106 Rural water schemes** (0.25 cusecs each) along canal to serve population in brackish area ▪ **Solarization of 300** Rural Water Supply Schemes ▪ **Provision of Drains** based Sewerage System in 370 villages (Drains+Sullage Carrier+Pond)
POP SERVED: 969,147	*POP SERVED: 1,386,359*	*POP SERVED: 3,473,070*
COST: 1454 + 923 = 2,377 Million	**COST: 3210+3505 =6,714 Million**	**COST: 3,075+5,276= 8,351 Million**
GRAND TOTAL: 17,442 Million		

Spatially mapped water supply and sewerage interventions are visualized in maps below. It is envisaged that approximately 2 Million residents will be benefited from proposed water supply interventions while sewerage coverage will increase from 33% to 70% after execution of proposed schemes.

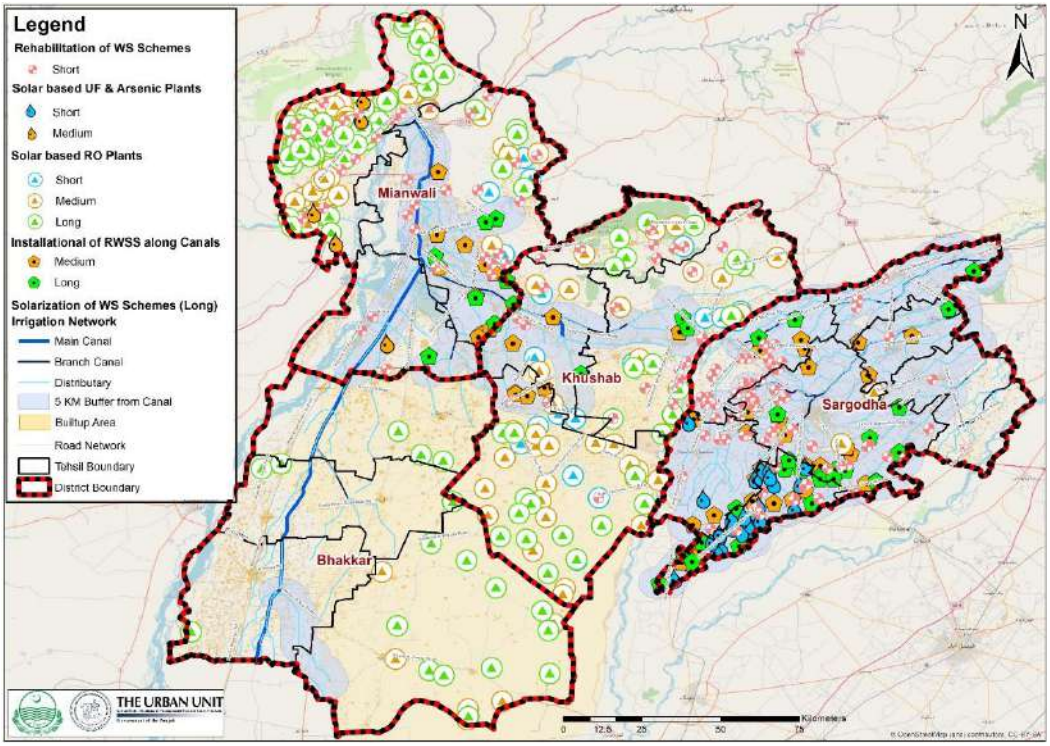


Figure 76: Proposed Rural Water Supply Interventions

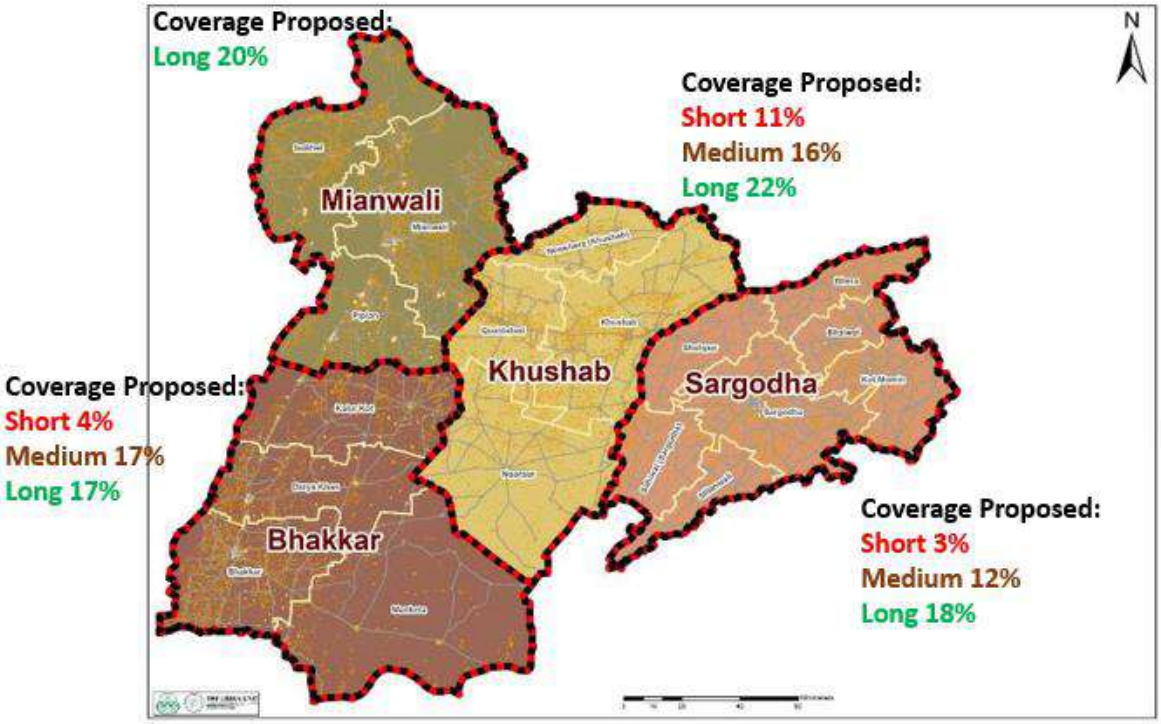


Figure 77: Proposed Rural Sewerage Interventions

Brief description as scope of projects identified in short term plan is written in table 59 while detailed list of projects proposed in each district in short-, medium- and long-term phases is placed at table ahead.

Table 59: Scope of Short Term WSS Interventions:

Sr. #	Planning Period	Sector	Project Title	Justification & Scope	Cost Million
1	**Short - Term (2025)**	Water Supply	Rehabilitation of 90 Rural Non-Functional Water Supply Schemes in Sargodha, Khushab & Mianwali	Make sure enable functioning of abandoned rural water supply schemes through replacement of damaged machinery, equipment, chlorinator, bulk meter, new borehole, and rising main. This project intends to serve approximately 6 lac rural population through provision of safe water supplies to community.	**1102.73**
2		Water Supply	Installation of 30 Solar based RO Plants (2000 l/h) in 17 villages of Khushab and 23 RO plants in 14 villages of Mianwali	Installation of Solar based RO plants are proposed in 17 villages of Khushab where TDS Values reported are 2000-7000 ppm and it will serve approx. 117,000 population. Similarly, 23 plants are proposed in Mianwali where TDS reported values are 2100-3000 ppm. RO plants are proposed in these selected villages where no canal water is available within 5 km distance	**251.75**
3		Water Supply	Installation of 18 Solar based UF& Arsenic plants in Sargodha	Solar-based 18 Arsenic Treatment Plant are proposed in 27 villages of Sargodha where arsenic values reported are 100-250 ppb. It will serve approx. 65000 population.	**97.2**
5		Sewerage	Provision of Package of 85 Sewerage Schemes in Khushab, Bhakkar and Sargodha	Comprehensive sewerage schemes with open drains, sullage carrier and associated ponds are proposed to provide coverage in 35 85 multiple villages of Khushab, Bhakkar and Sargodha. It will serve approx. 122000 population.	**923.17**
(MRS, 1ST BI-ANNUAL-2022 (01.01.2022 to 30.06.2022)				**TOTAL COST (SHORT): 2,374 Millions**	

Table 60: Rural WSS Projects

	Sector	Phase	Districts	Project Name	Cost PKR M
1	Water	Short	Sargodha	Rehabilitation of 47 Non-Functional Rural Water Supply Schemes in Sargodha	638.35
2	Water	Short	Khushab	Rehabilitation of 18 Non-Functional Rural Water Supply Schemes in Khushab	214.38
3	Water	Short	Mianwali	Rehabilitation of 25 Non-Functional Rural Water Supply Schemes in Mianwali	250
4	Water	Short	Khushab	Installation of 30 Solar based RO Plants (2000 l/h) in 17 villages of Khushab	142.50
5	Water	Short	Sargodha	Installation of 18 Solar based UF& Arsenic plants in Sargodha	97.2
6	Water	Short	Mianwali	Installation of 23 Solar based RO Plants (2000 l/h) in 14 villages of Mianwali	109.25
7	Water	Short		Hygiene Awareness program in Division	2.0
8	Water	Medium	Mianwali	Installation of 6 Solar based UF & Arsenic Plant in Mianwali (Bhat; Amir Abbas Khan wala; Ouda Wala(Narri wala); Kundal; Seda Khan wala; and Hafiz Wala)	38.52
9	Water	Medium	Bhakkar	Installation of 2 Solar based RO Plants (2000 l/h) in 6 villages of Bhakkar	9.50
10	Water	Medium	Bhakkar	Installation of 40 Solar based RO Plants (2000 l/h) in 36 villages of Bhakkar	190
11	Water	Medium	Mianwali	Installation of 64 Solar based RO Plants (2000 l/h) in 81 villages of Mianwali	304
12	Water	Medium	Sargodha	Installation of 7 Solar based RO Plants (2000 l/h) in 2 villages of Sargodha	33.25
13	Water	Medium	Sargodha	Installation of 67 Rural water schemes (0.25 cusecs each) in 32 villages of Sargodha along canal to serve population in brackish area	1314.54
14	Water	Medium	Khushab	Installation of 8 Rural water schemes (0.25 cusecs each) in villages of Khushab along canal to serve population in brackish area	156.4
15	Water	Medium	Mianwali	Installation of 56 Rural water schemes (0.25 cusecs each) in 11 villages of Mianwali along canal to serve population in brackish area	1163.68
16	Water	Long	Mianwali	Installation of 47 Solar based RO Plants (2000 l/h) in multiple 113 villages of Mianwali	223.25
17	Water	Long	Bhakkar	Installation of 15 Solar based RO Plants (2000 l/h) in multiple 19 villages of Bhakkar	71.25
18	Water	Long	Khushab	Installation of 37 Solar based RO Plants (2000 l/h) in multiple 30 Brackish villages of Khushab	175.75

	Sector	Phase	Districts	Project Name	Cost PKR M
19	Water	Long	Sargodha	Installation of 50 Rural water schemes (0.25 cusecs each) in 26 villages of Sargodha along canal to serve population in brackish area	981
20	Water	Long	Khushab	Installation of 11 Rural water schemes (0.25 cusecs each) in 4 villages of Khushab along canal to serve population in brackish area	215.05
21	Water	Long	Mianwali	Installation of 45 Rural water schemes (0.25 cusecs each) in 9 villages of Mianwali along canal to serve population in brackish area	935.1
22	Water	Long		Solarization of 300 Rural Water Supply Schemes	474
23	Sewerage	Short	Khushab	Provision of sewerage system in rural areas of Khushab [drains, Nullah and pond] 35 villages	377.825
24	Sewerage	Short	Sargodha	Provision of sewerage system in rural areas of Sargodha [drains, Nullah, little Disposal station and pond] 25 villages	276
25	Sewerage	Short	Bhakkar	Provision of sewerage system in rural areas of Bhakkar [drains, Nullah, little Disposal station and pond] 25 villages	269.35
26	Sewerage	Medium	Khushab	Provision of sewerage system in rural areas of Khushab [drains, Nullah, little Disposal station and pond] 50 villages	623.5
27	Sewerage	Medium	Sargodha	Provision of sewerage system in rural areas of Sargodha [drains, Nullah, little Disposal station and pond] 100 villages	1104
28	Sewerage	Medium	Bhakkar	Provision of sewerage system in rural areas of Bhakkar [drains, Nullah, little Disposal station and pond] 100 villages	1777
29	Sewerage	Long	Khushab	Provision of sewerage system in rural areas of Khushab [drains, Nullah, little Disposal station and pond] 70 villages	955.5
30	Sewerage	Long	Sargodha	Provision of sewerage system in rural areas of Sargodha [drains, Nullah, little Disposal station and pond] 150 villages	1656
31	Sewerage	Long	Bhakkar	Provision of sewerage system in rural areas of Bhakkar [drains, Nullah, little Disposal station and pond] 100 villages	2125
32	Sewerage	Long	Mianwali	Provision of sewerage system in rural areas of Mianwali [drains, Nullah, little Disposal station and pond] 50 villages	539
Total Amount in Millions Sargodha Division: 17,442 Million PKR					

Rough Cost estimates are calculated of all identified projects based on MRS rates 1ST BI-ANNUAL-2022 (01.01.2022 to 30.06.2022. Summary of cost of proposed sectoral projects for division is given at table below. Detailed projects costing of all projects scope is attached at Annexure.

Table 61: Summary of Cost of Rural WSS Projects

Sargodha	Khushab	Bhakkar	Mianwali
▪ Rural Water Supply 3,064 M ▪ Rural Sewerage 3,036 M	▪ Rural Water Supply 1,094 M ▪ Rural Sewerage 1,956 M	▪ Rural Water Supply 80.7 M ▪ Rural Sewerage 4,171 M	▪ Rural Water Supply 3,023 M ▪ Rural Sewerage 539 M
COST: 6,100 Million	**COST: 3,050 Million**	**COST: 4,252 Million**	**COST: 3,562 Million**
GRAND TOTAL: 17,442 Million or 17.4 Billion			