SCIP-03: PROGRAM MANAGEMENT, PROJECT PREPARATION AND IMPLEMENTATION SUPPORT FOR PLANNING AND DEVELOPMENT DEPARTMENT

ADB Loan No. 2499-PAK

.

SUB-PROJECT ACTIVITIES ASSESSMENT

WATER SUPPLY SECTOR

CENTRAL SINDH TOWNS

MIRPURKHAS (ANCHOR TOWN)
TANDO ALLAHYAR
UMERKOT
SHAHDADPUR
SANGHAR
TANDOADAM

DONALD R. MAKINI
BCE WATER SUPPLY EXPERT

APRIL 2012

Engineering General Consultants
EGC (Pvt) Ltd.

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Contents

1.0 INTRODUCTION and EXECUTIVE SUMMARY

1.1 General

This is a preliminary take on the activities for potential sub-projects that can be considered for possible inclusion under the SCIP-03 Investment Program. It describes the components of the sub-projects based on the findings of the field visits conducted in February/March 2012. This work is being advanced to meet predetermined program deadlines but is wanting in detail in the absence of relevant information and data.

It needs to be mentioned that the non-availability of information and data on any of the water supply schemes will hinder proper assessment of potential sub-projects. Neither the TMAs nor the PHED have any information on the schemes under their care. Other national studies undertaken in Sindh have also experienced difficulties in acquiring information relating to water supplies[1]. On this basis, the information and data used here is purposely to make some start in identifying activities that can be incorporated into potential sub-projects. As more reliable data and information on the cluster towns is needed, this assessment is not conclusive and is highly subject to further changes and refinement.

1.2 Guiding Principles

The activities in the potential infrastructure sub-projects identified here are will be developed within the wider framework of water conservation with emphasis on managing the demand for water. Water demand management under its many complementing aspects will provide the basis on which a sustainable delivery of services can be assured. These however will be undertaken on the proviso that the water to be supplied from these schemes will be of good quality. Water quality issues will dictate the minimum systems configurations as well as the operations and maintenance of the physical infrastructures to provide these services.

On this premise, the minimum water quality to be delivered for public consumption is that which is clear, colorless, without unpalatable taste or odor and should not contain any suspended matter, harmful chemical substances or pathogenic micro-organisms. In fact, *"Diseases related to contamination of drinking-water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health"*.[2]

Cognizant of these facts, there are realities in Sindh which need to be taken on board and where time and resources will be needed before compliance with the water quality standards can be guaranteed. In particular and as recognized under the National Environment Quality Standards *"The existing drinking water treatment infrastructure is not adequate to comply with WHO guidelines. The arsenic concentration … in some parts of Sindh have been found high then Revised WHO guidelines. It will take some time to control arsenic through treatment process".* [3]

Notwithstanding the foregoing, a combination of providing quality water through an active water demand management approach will ensure that water is accessible to all citizens in safe and adequate

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[1] *Technical Assessment Survey Report of Water Supply Scheme, Sindh Province,* Dr, Muhammad Aslam Tahir, Engr. Muhammad Khan Marri & Engr. Faizan ul Hassan. Provision of Safe Drinking Water Project, Pakistan Council of Research in Water Resources, Ministry of Science and Technology, November 2010.

[2] Drinking-water Quality, 3rd Edition Incorporating the First and Second Addenda, Volume 1 Recommendations, World Health Organization, Geneva, 2008.

[3] National Standards for Drinking Water Quality. The Gazette of Pakistan, Extra, November 26 2010.

quantities at an *"affordable cost and in an equitable, efficient and sustainable manner"*[4]. These infrastructure sub-projects will involve the rehabilitation and improvement of schemes to meet this policy mandate and will commence by improving the existing infrastructures to meet current demand.

1.3 Basic Systems

The improvements to the existing water supply schemes will be implemented in the spirit of the foregoing broad principles. As a minimum, the schemes will be upgraded so they will be able to meet current demand. These improvements will be undertaken at each of the basic stages represented below:

Source -> Treatment -> Distribution

At each stage, the quality of the water will not be compromised to safeguard the general health and hygiene of the people being serviced. In the first instance, this requires infrastructure facilities that are properly designed and constructed to ensure contamination of the water does not occur or is avoided. Proper operations and maintenance practices under a strict and efficient management regime will further ensure that the quality of the water from the source to the end-user does not degrade.

1.4 Approach to Improvements:

Improvements to the water supply schemes in the cluster towns will be undertaken through a gradual and systematic process of improving the infrastructure facilities at each stage of the supply process. The scope and magnitude of the required improvement works will need to be assessed both their physical state and their fitness for delivering the expected service.

Initial field visits to the cluster towns have revealed a consistent deterioration of all infrastructures. As earlier mentioned, the lack of pertinent information is an issue in this process but efforts are being taken to address this. While information is being acquired, the activities that are needed to inform further development of the sub-projects are highlighted in the ensuing sections. These are grouped under the stages highlighted above and are based on the information currently in hand.

1.5 Potential Sub-projects:

All water supply infrastructure facilities will either be rehabilitated or replaced. Mirpurkhas and Umerkot may have sufficient storage but their overall systems throughput will need to be improved. In addition to these improvements, Tando Allahyar and Tando Adam will also need hydro-geological investigations to establish potential water sources while Shahdadpur requires a fully functioning water supply system. Reactivating the raw water storage ponds in the old Sanghar waterworks and combining it with the raw water storage ponds at the new waterworks should give Sanghar sufficient storage during the planning period and with improved throughput could meet the expected demand.

Water quality is not usually given much priority in all towns so a significant part of these improvements will be to improve treatment in all schemes. This will cover source protection works at the intakes and around the raw water storage ponds, the conveyance of the water to the treatment plants and the treatment plants themselves. Filtration processes where they were originally incorporated in the schemes will be reactivated, either by rehabilitating existing facilities or installing new ones. Which filtration option to adopt will depend on a number of considerations as discussed further in this report. Chlorination will be mandatory in all schemes and training of personnel to

[4] *National Drinking Water Policy*. Government of Pakistan, Ministry of Environment. September, 2009.

operate, maintain and carry out water testing and monitoring duties will be a component part in improving the treatment plants.

Actual locations and conditions of below-ground pipelines cannot be verified so details of improvement activities will be confirmed once the necessary surveys and relevant mapping work is done. Meanwhile, pipe capacity, material and age could dictate priority replacement works, where the latter two will depend on TMA maintenance records.

Any improvements or extensions to the pipeline distribution networks must be done with a commitment to water conservation and demand management. These broad requirements will underlie the way distribution networks will be arranged with an emphasis on creating hydraulically defined zones, having a single in-flow point. Associated with improvements to the distribution network will be an undertaking to carry out a comprehensive metering program in all schemes. While the eventual aim will be to meter all end-users, the initial program will be to meter all major strategic in-flow and out-flow points in the distribution network (including commercial, industrial and institutional connections) to undertake regular water audits.

The activities identified here are general in both scope and content. Any design at this stage will mainly be to establish broad parameters than to recommend or confirm specific components of the water supply schemes

It will suffice to state at this stage of sub-project activity identification/assessment that all existing systems must be rehabilitated so they will be able to meet current demand. Based on the condition of the existing infrastructure, this rehabilitation program could be quite extensive.

It is strongly recommended that the national water supply engineer as allowed for in the TOR should be engaged immediately. It is essential that some of the detailed information on site must be acquired and confirm or otherwise some of the assumptions adopted in this report. With this information, some basic, preliminary design can be attempted while the mapping activities are progressing.

2.0 SUB-PROJECT ASSESSMENT ISSUES

The steps given here will be adopted in the feasibility study to be undertaken for the selected sub-projects. This initial assessment and identification of potential infrastructure activities will be undertaken in all cluster towns to be in line with the spirit of the SCIP-03.[5]

The initial thrust of these sub-projects is to provide for the water supply needs of the current population as a minimum. Further and following the acquisition of additional information, the requirements from these systems for the next 25 years will be incorporated in the design if the data necessitates the need to. For purposes of this approach, the following information will need to be acquired or derived from other reliable sources where it is available. Further refinement to the scope and extent of the required improvement can be made on the basis of such information.

2.1 Basic Planning Data

There are some basic data for planning and designing the sub-projects which will be needed and are being acquired under SCIP-03. The design standards to be adopted will be according to what is currently in use and proven to be acceptable in the country. Unless there are merits to do otherwise, the appropriateness of the technology to be adopted will be given due consideration in view of the existing capacity to operate and maintain them.

Specific information for input to this work is as follows:

2.1.1 *__Population Estimates__:-* Population projections for the current year up to 2037 were just recently acquired (as of 9th April 2012) and are presented in Table 1 under Section 3 below. These are based on the 1998 Census with forecasts generated using average annual growth rates derived from the last known population counts of 1981. As the projections are based on data from an era that may not be representative of the situation now, more recent population data and forecasting methods would be considered reliable.

There are inconsistencies in the population figures tendered on the cluster towns, which vary from those collecting the information and those providing it. Furthermore, population growth rates are areas of contention as they are also influenced by other changes in the demographics of the towns depending on the particular situation at a given time.

Probabilities of expansion in these towns depend on other factors, some of which could be influenced by the sorts of development being planned or envisaged in these locations by the town planners. In the same token, events or issues beyond the control of the urban towns can also have an opposite effect on the population. To progress this work high estimates are used to project demand. Demand projections as explained are determined by population so work is still required to update these estimates.

2.1.2 *__Service Connections__:-* Records of service connections are required. These should preferably coincide with the years where population figures are available. Service connections will represent the different classes of consumers depending on whether they are commercial, industrial, institutions and residential. The latter can be further classified into single-family residence and multi-family residence and if available, slums. In general there is much

[5] ADB Proposed Multi-tranche Financing Facility and Technical Assistance Grant - Islamic Republic of Pakistan: Sindh Cities Improvement Investment Program, Report and Recommendations of the President to the Board of Directors, Project Number: 37220, November 2008.

information on service connections that is needed to better understand the coverage of the service in these locations.

There is evidence that some TMAs have this information but it cannot be confirmed if they are current or not. As part of sub-project development and to build cooperation with the TMAs through their participation, some work can be undertaken by them to update this information at this stage.

2.1.3 *Water Use*:- Historical water usage and production will help in understanding the trends in supply and demand and how they are influenced by the seasons as well as the different consumer categories or classes highlighted above. An important management and operational information that will be derived from this is the amount of water lost from the schemes, which is the difference between production and consumption. The most reliable means of acquiring this information is through metering. In its absence, these (production, consumption and loss) can be deduced but the results could be unreliable as they are normally based on the ratings used in the design of the existing facilities, which will only be true if they are functioning as originally designed.

Metering is not happening in any of the cluster towns. In this context, any information relating to flows where it is provided should be properly verified. While there is no substitute for reliable and accurate meter records, in the absence of proper metering and billing of customers, a consumption (demand) rate of 40 gallons per person per day (gpd) will be adopted as the average daily demand (ADD). In terms of meeting basic water needs for drinking and cooking, this amount is quite high. This represents the 'domestic' category of consumers and does not take into account commercial, industrial, institutional or other civic interests, which need to be assessed separately due to the specific needs or nature and magnitude of their activities and operations.

2.1.4 *Service Area Characteristics*:- Service area will comprise all the land within the town boundary including those which are currently served but which may not be formally recognized as urban or do not lie within the formal urban limits. The service area will be re-defined to accommodate future expansions in the service due to growth. Additional end-users occupying infill areas within the existing urban boundaries can also increase demand.

A clear definition of the service area is important where it may have legal implications for the service provider due to local situations. Further, it also allows the service provider to have some control or legal jurisdiction over its 'area of operations' where it can or should exercise its roles and responsibilities within the powers accorded to it under the various legislations empowering it to do so.

2.1.5 *Land use and zoning*:- This information will enhance knowledge of possible/potential growth areas or in the same token, undevelopable areas. Broad categories will include, industrial, commercial, institutions, high & low density residential area, floodways including agricultural lands and civic areas.

Much of this information will reside with the TMAs or the town planning authorities. Before projecting future requirements, the existing land use and zoning in the towns must be understood to fully appreciate the potential growth that can be expected from these cluster towns.

2.1.6 *Water Supply Systems & Distribution Network Drawings*:- The existing water supply systems in the cluster towns have no drawings. Drawings will carry all the necessary information on the overall system from their general layout to detailed pipe connections. Data on pipe materials, length, size, age, routes, as well as invert levels and elevations of the laid pipe. Information on reservoir capacities and elevations, pumping equipment, boosting stations, boundary valves, bulk meters, air-valves and scour valves and valve chambers. Longitudinal and cross-sections at specific locations, including details of cross-connections, high and low water levels in storage tanks, pipe-work in pumping stations and treatment plants, electrical controls and switching arrangements in balancing tanks or high service reservoirs and all other pertinent information that will assist in the proper planning, management, operations and maintenance of the systems. The drawings are superimposed on normal topographical and cadastral maps at the relevant scales and up-dated every time there is a change in any part of the system.

Due to the non-availability of maps, other aids like Google Earth are used on which the system facilities may be identified and their coordinates, distances and elevations obtained. Effective use of this tool lies in the familiarity of the site or location and for water supply systems, a good knowledge of the overall system and all the pipeline routes. This again highlights the need for actual drawings of the system so assumptions and guesswork on the existing systems are eliminated.

Drawings of existing systems are essential and for improvement works, they significantly aid in understanding the system and how they operate. Much data collection time is saved as the information is readily available and designs will be based on reliable information that is representative of the real situation.

The foregoing covers the basic information that is needed to go into the development of the infrastructure sub-projects. While the information is being collated the sub-projects will be developed along the lines discussed in the following sections.

2.2 Water Demand

An average daily demand (ADD) of 40gpd[6] will form the basis for estimating maximum day demand (MDD) and peak hour demand (PHD). These parameters will be used to size the various components of the system.

MDD will be used to determine the required production capacity from wells, transmission lines and treatment plants. It represents the maximum daily water use during hot weather - which is usually higher than normal. This will ensure that water production capacity must, at a minimum, be equal to the maximum daily demand.

Similarly, PHD (peak hourly use during the maximum day) will be used to size all facilities within the distribution network including storage tanks, booster pump facilities, high service reservoirs and the pipelines. This factor will also cater for sudden events or periods that may last for hours like firefighting and major pipe bursts.

Factors to be adopted for MDD and PHD can be derived through reviewing historical water use records over several years. Such records do not exist in the cluster town schemes so peaking factors will have to be assumed based on other water system design literature. On this premise typical MDD/ADD peaking factors ranges from 1.5 to 3.0 and PHD/ADD peaking factors range from 2.5 to 5.0.

[6] PSU has confirmed the peaking factors to be adopted for MDD and PHD and advised 40gpd as the ADD.

For purposes of maintaining consistency with standards used by the North Sindh Urban Services Corporation[7] (NSUSC) a MDD of 1.5 x ADD and a PHD of 2.25 x ADD is adopted although the latter falls outside the normal range. The reasonableness of these peak factors remains to be tested.

Deriving ADD, MDD and PHD are more reliable when systems are metered, as water usage is actually measured over several years. As there is no universal metering in place in any of these cluster towns, the ADD adopted (40gpd) is based on what is normally used here. From this and based on the above peak factors, MDD and PHD are 60gpd and 90gpd respectively. The use of these rates and the general approach adopted here are subject to further review and advice if there are other preferred standards that should be used.

Considering that the demand rates used here (MDD & PHD) are relatively high, they could potentially stretch scarce water resources. It is further proposed that system losses and fire-fighting requirements will be assumed to be included under the PHD rate of 90gpd. This should not be perceived as imposing a limit on the requirements of the consumers but rather should be taken as a bold initiative to usher in water conservation principles, where there is a high expectation on the service provider to properly manage and control water usage.

2.3 Water Pressure

Piped water must be available continuously 24hours a day at adequate pressure at all points in the system. Intermittent service must be avoided as they can create negative pressures causing backflow where contamination of the system can occur. Further, an intermittent service is not desirable for the health and convenience of the consumer and is bad for the reputation of the service provider.

Minimum recommended pressure where one-storey buildings are common should be 7m and 12m where 2-storeyed buildings are predominant. Fire fighting pressure requirements can be boosted further by fire engines.

2.4 Water Quality:

As the existing treatment infrastructures have either deteriorated or are inadequate, water quality has been compromised. It is mandatory that all water supply schemes must have functioning water treatment plants. The ultimate aim is to ensure the water supplied to the people is free from disease-causing pathogenic organisms. It must be clear, colorless and odorless, does not have any unpalatable taste, does not contain harmful and/or toxic chemicals or substances and is free from radiological material or activity. This requires that water sources are protected so that the quality of the water entering the system is not worse than the raw water. It also means that treatment of the water must be such that the qualities broadly outlined in the foregoing are maintained throughout the system until it reaches the end-user.

The improvements to the cluster town systems will ensure that the quality of the water is maintained at the conditions described, beginning from where it is extracted all the way to the end-user. In terms of quality standards, the minimum will be as specified in the WHO Drinking Water Guidelines.

2.5 Design Period:

For long-term development planning purposes, water supply project infrastructures may be designed to meet the requirements over a thirty year period after their completion. For these sub-projects, it will be desirable to take into account the time lag between design and completion of the sub-projects.

[7] Peak factors are confirmed by PSU on 16/04/2012

Further, to inform proper assets management including operations and maintenance of facilities, the following design periods can be used as a guide:

Storage and Infiltration Works	30 years
Pumping Stations:	
Pump House (civil works)	30 years
Electric Motors and pumps	15 years
Water Treatment	15 years
Pipe-work in treatment units	30 years
Raw water and clear water conveyance mains	30 years
Clear water reservoirs at head works, balancing tanks and service reservoirs (overhead and ground level)	15 years
Distribution systems	30 years

Establishing the design periods of the infrastructures provide a strong basis for the service provider to develop realistic asset management plans where requirements are properly planned, their maintenance efficiently executed, operations are monitored and performance analyzed and reported.

Additionally, the adoption of an organization-wide asset management planning framework will ensure the service provider keeps its assets functioning to deliver services by implementing an effective operations and maintenance program.

2.6 Asset Management

The state of below-ground assets in the distribution systems were only accorded a cursory assessment during the field visits due mainly to time constraints. However, the conditions of the above-ground distribution facilities provide some useful indicators as to the probable state of below-ground assets.

In general, the maintenance of assets would appear to be given less priority in the delivery of services. This is based on the overall condition of the facilities in the various schemes visited. Although maintenance activities are carried out, these are reactive and not planned. The reasons for this are numerous and multi-faceted and range from a lack of resources (materials, funds and logistics), to capacity constraints and an absence of priority to maintain assets. On an organizational context, maintenance does not feature as an important activity as none of the TMA Water Supply Divisions or Sections have dedicated Maintenance Units in their organization. On the other hand, all teams are operations-oriented. This situation virtually dictates the organization’s priorities where maintenance does not feature strongly. It is the lack of maintenance that led to the gradual deterioration of assets and resulted in the general sub-standard or poor level of service being delivered to the public.

In such an operating environment, there is no guarantee that improving the infrastructures will result in a corresponding improvement to the provision of service. It is desirable that any improvements to the infrastructure must also emphasize the need for effective asset management approaches without which, a sustainable level of service may not be achievable.

2.7 Most Limiting Factor

The capacity of a given system is best evaluated by determining its ‘most limiting factor’. Once this is established, the sub-projects will basically focus on correcting what is limiting the capacity of the system. The performance of a system can be limited by any of – Treatment Capacity, Pumping, Distribution System, Storage, Power Supply, System Losses, Fire Flow and even the capacity limitation of the wastewater system.

The reality in the cluster towns is that identifying a single limiting factor would be difficult. Many facilities in the different stages of the supply systems are dysfunctional and are not performing as originally designed. Exacerbated by the lack of maintenance, these problems were allowed to escalate and gradually progressed throughout the system resulting in their inability to cope.

Rather than focus on improving a particular component or facility, the activities identified here will address the total system from source to end-user. Guided by a commitment to conserve water, maintain water quality and deliver an affordable, sustainable service, these sub-projects will first and foremost forecast on meeting the needs of the present population.

It is anticipated that in improving the existing infrastructures, appropriate operations and maintenance practices and relevant management approaches to service delivery will be nurtured and provide the basis on which water supply services will be provided in these cluster towns.

The following sections provide a general overview of the cluster town water supply schemes and summaries of the work likely to be required.

3.0 GENERAL INFRASTRUCTURE IMPROVEMENTS

3.1 Population

The latest population figures in the cluster towns are presented in Table 1, which are based on the 1998 census figures. The average growth rates are derived by SCIP-03 based on the change in population since the last census of 1981. The demand on water supply services that these populations will place on the respective schemes will determine the scope and magnitude of the improvements that will be required at these locations. As such, the reliability of the population forecasts is crucial to ensure that these improvements will actually meet the water supply needs of the people in these cluster towns up to 2037. It is also the demand generated by these populations that will determine the size of the various components of the schemes.

Cluster Towns	Population 1998	Average Household	Population 19981	1981-98 Ave Annual	Projected 2012	Projected 2017	Projected 2022	Projected 2027	Projected 2032	Projected 2037
Mirpurkhas	200,004	8.0	124,371	2.51	282,987	320,330	362,600	410,449	464,612	525,923
Umerkot	66,304	6.6	13,742	5.75	14,032	191,808	253,670	335,483	443,683	586,779
Tando Allahyar	106,108	7.0	37,421	6.24	247,617	335,136	453,588	613,906	830,888	1,124,560
Tando Adam	104,931	7.0	62,744	3.07	160,234	186,388	216,810	252,197	293,360	341,242
Sanghar	60,923	7.3	29,239	3.29	95,851	112,691	132,489	155,766	183,131	215,305
Shahdadpur	90,647	8.6	42,107	2.36	125,654	141,198	158,665	178,292	200,347	225,130

Table 1: Population Projections in 5 - Year Intervals from 2012 to 2037. Source: SCIP-03 Statistician.

For this assessment, the highest population estimates presented in Table 7 in Section 4 will be adopted as they give the worse case scenarios for the cluster towns. The Table 7 estimates are a combination of Table 1 above and what were acquired from the TMAs. Due to the scatter of these estimates, further refinement will be needed for use in the final sub-projects.

3.2 Source Water Extraction and Storage

Raw water storage ponds are provided for all surface water systems while groundwater systems pump direct to distribution and high service reservoirs. The storage ponds provide settling of sediments and are effectively the first stage of 'treatment'. Table 2 summarizes the situation at the point of extraction at the water sources.

Safe yields from the sources (canals and bore wells) are not known and flows into the ponds are not measured. Raw water conveyance systems run between the water source and storage ponds or treatment plants but no means of bulk flow measurement is adopted.

Improvements required at the extraction points will focus on source protection particularly in controlling access to the ponds by humans and livestock. Efforts to maintain the quality of the water will begin at the sources and extraction points. Where they are not provided, rustproof protective grids will be installed where the raw water is diverted to the water supply schemes to prevent the entry of debris.

Scheme		Source & (Safe Yield – MGD)		Conveyance to RWS (MDG)		Raw Water Storage Capacity (MG)	Conveyance RWS to WTP
		Surface	Ground	Pumped	Gravity Flow		
Mirpurkhas	**Satellite Town**	(n/a)	-	(n/a)	-	32.5	16"Ø from Jarwari
	Mirpur	(n/a)	-	-	(n/a)	20.0	-

	Minor						
	West Jamrao	(n/a)	-	-	(n/a)	60.0	-
	East Jamrao	(n/a)	-	-	(n/a)	33.0	-
Umerkot	**Surface**	(n/a)	-	(n/a)	-	21.3	18” Ø from Tharwa
	Ground		(n/a)	(n/a)	-	Combine with Surface Water	-
Tando Allahyar		-	(n/a)	-	-	Direct to distribution and 0.06MG HSR	-
Tando Adam		-	(n/a)	-	-	Direct to distribution and 0.1 MG HSR	-
Sanghar	**Old**	(n/a)	-	-	(n/a)	5.4	-
	New	(n/a)	-	-	(n/a)	12.0	-
Shahdadpur		No Reticulated Water					

Table 2: Source Yield and Raw Water Storage Capacity

Notes:

1. *(n/a) denotes the flows at these locations/ facilities are not available as there is no bulk-metering in place*
2. Safe Yields from the sources will need to be established by proper hydro-geological investigations
3. Raw Water Storage Capacity for Sanghar are deduced from Google Earth and assuming a minimum depth of 6ft/pond

Raw water storage ponds will be rehabilitated and an extensive de-silting program undertaken. This will ensure the designed capacity is always available when required. A re-design of the transfer pumping between the raw water ponds (pre-settlement basins) and the water treatment plants can be carried out if turbidity levels are high. This ensures extraction occur at the clearer top-third portion of the stored water.

Pump houses will be rehabilitated or replaced if the level of dilapidation is extensive. Pumps and motors will be replaced as well as all electrical control devices and related accessories.

Pump station pipe-work including valves and fittings will be replaced. The installation of bulk flow meters in all pumping stations will be mandatory. This is essential for purposes of water conservation and monitoring of water loss.

Standby power supply and related electrical controls must be made a mandatory requirement to ensure continuity of supply during periods of power outage.

A summary of areas requiring improvement works is shown in Table 3.

Scheme		**Pumping Stations**			**Electrical & Power Supply**	**Raw Water Ponds**			**Appurtenance**		**Source or Pond Protection**
		House	**Pump**	**Motor**		**Rehab**	**De-silt**	**New**	**Valves Fittings**	**Flow Meter**	
Mirpurkhas	**Satellite Town**	●	●	●	●		●			●	●
	Mirpur Minor				●		●			●	●
	West Jamrao						●			●	
	East Jamrao						●			●	
Umerkot	**Surface**	●	●	●	●		●		●	●	●
	Ground	Combined with SW									
Tando Allahyar		●	●	●	●			●	●	●	
Tando Adam		●	●	●	●			●	●	●	
Sanghar	**Old**	●	●	●	●	●	●		●	●	●
	New		●	●	●		●		●	●	●
Shahdadpur		New Fully Functioning System Required									

Table 3: Improvement Works at Source & Extraction Point Facilities

3.3 Water Treatment

All treatment facilities have deteriorated, some have stopped functioning due to operational issues while others due to lack of chemicals. The overall situation is unacceptable and a lot of focus will be given to improve all water treatment facilities in the cluster towns.

Not only will the improvements focus on the physical infrastructures but emphasis will also be given to the training and equipping of operations personnel as well. Personnel must be able to perform water treatment tasks properly, be competent in operating the facilities and understand the use of test equipment to perform the relevant tests and monitor the quality of water.

In general, the raw water storage ponds in the cluster towns have contributed to the pre-settlement of suspended matter in the raw water. Their rehabilitation and de-silting will ensure that their carrying capacity is guaranteed. A comprehensive de-silting program will be carried out at all schemes where they exist.

Where they exist, the clarification processes will be reactivated by rehabilitating the coagulation and flocculation facilities. Rehabilitation will include the stocking of the required chemicals in appropriate quantities as well as appropriate training of personnel. This will ensure the facilities will function continuously.

Chlorination facilities will be installed in all schemes. These will be properly housed and protected from the elements and adequate quantities of the required chemicals stocked. Operations-wise, chlorine residual testing will be mandatory and operators (or water quality technicians) will be trained to be competent in testing and monitoring the quality of water using portable test kits.

Filtration will be mandatory in all schemes. Existing slow sand filters can be rehabilitated and their capacity increased by mirroring the existing plants within the existing water works area. Simplicity of operations is one advantage of slow sand filters. However consideration will also be given to introducing and adopting rapid filters, with careful consideration given to the following:

i) freeing up space occupied by existing plants for other requirements like clear water tanks and high service reservoirs

ii) consistency and standardization of filtration process to be in line with existing plants, and

iii) more scope for increasing throughput to meet increasing demand

Training on the operations and maintenance of filtration plants will be mandatory.

The condition of the treatment facilities in the existing systems are as shown in Table 4.

Scheme		Pre-Treatment Settlement	Clarification		Filtration		Chlorination	Clear Water Tanks
			Coag	Flocc	Slow	Rapid		
Mirpurkhas	**Satellite Town**	Functional	-	-	Non-functional	-	Functional	Functional
	Mirpur Minor	Functional	-	-	-	Functional	Functional	-
	West Jamrao	Functional	Non-functional	Non-functional	-	Functional	Functional	Functional
	East Jamrao	Functional	Non-functional	Non-functional	-	Functional	Functional	Functional
Umerkot	**Surface**	Functional	-	-	-	-	-	Functional
	Groundwater	Combine with SW	-	-	-	-	-	Combine with SW
Tando Allahyar		-	-	-	-	-	Functional	-
Tando Adam		-	-	-	-	-	-	-

Sanghar	**Old**	Non-functional	-	-	Non-functional		-	-
	New	Functional	-	-	-	-	-	Functional
Shahdadpur		-						

Table 4: Treatment Facilities in Cluster Towns

Notes:

1. *Non-functional represents the facilities are not working due to unserviceable equipment, operational problems, logistical issues, lack of operator capacity*

Faulty valves and fixtures in all treatment plants will be replaced and leaking pipe work replaced. Valve chambers will be repaired and covered.

Clear water tanks will be rehabilitated and the associated pumping equipment and electrical controls replaced to meet anticipated demand.

Bulk flow meters will be installed at every clear water tank before the water is distributed to the end-users. This will be mandatory.

The likely improvement activities at the treatment process are summarized in Table 5.

Scheme		**Raw Water Storage**		**Clarifier**	**Filtration**	**Chlorination**	**Clear Water Tanks**		**Bulk Metering & Valving**
		Rehab / De-Silt	**New**				**Rehab**	**New**	
Mirpurkhas	**Satellite Town**	●			●	●	●		●
	Mirpur Minor	●			●	●	●		●
	West Jamrao	●		●		●			●
	East Jamrao	●		●		●			●
Umerkot	**Surface**	●		●	●	●	●		●
	Ground	Combine with SW							●
Tando Allahyar						●		●	●
Tando Adam						●		●	●
Sanghar	**Old**	●				●	●	●	●
	New	●				●		●	●
Shahdadpur		Fully Functioning Scheme Required							

Table 5: Improvements to Treatment Plants/Processes

3.4 Distribution

In the absence of up-to-date pipeline drawings of the existing network, the magnitude of the required rehabilitation or pipe replacement works is difficult to verify. However, all below-ground pipes that have aged, deteriorated or prone to numerous bursts will be replaced. A rough indicator to pipe replacement could be age and material but maintenance records of pipelines will also determine priority of replacement that will be required. Maintenance records from TMAs will be helpful in this regard.

High service reservoirs will be replaced where they are deemed unsuitable for rehabilitation. The reservoirs will be resized to meet demand and carry adequate capacity for fire-fighting requirements as well as other storage requirements. In this context the high service reservoir must ensure they have capacity to provide at least the following:

- Operating Storage so water is available to be drawn off the tank while the pumps are not operating
- Balancing storage so water is available when the pumps are operating below the system's peak demand rate

- Emergency or fire storage so there is capacity in the tank for use during emergency events like major pipe bursts while maintenance work is undertaken or during fires

Booster pumps to the high service reservoirs will be properly sized and appropriate electrical controls switches installed to ensure they effectively perform their function as balancing tanks to maintain flow and pressure throughout the network.

Booster pump stations will be re-designed and/or re-configured where necessary to ensure capacity to meet growing demand while all faulty and leaking fixtures and pipes will be replaced.

Bulk flow meters (with appropriate valving) will be installed at the exit points of all booster pumping stations and high service reservoirs. Every common entry points to clearly defined distribution zones, sub-zones or districts will also have bulk flow meters installed. This level of flow measurement will assist in water demand management and conservation efforts. However, this work will be quite limited if not difficult in the absence of up-to-date pipeline network drawings.

A summary of the areas in the distribution needing attention are depicted in Table 6. Scope of works for primary and secondary distribution pipes are pending up-to-date pipeline distribution drawings but replacement of aging and leaking pipes can be determined from TMA maintenance records.

Scheme		Primary Distribution	Secondary Distribution	HSR/CWT		Booster Pumping Station		Zone/District Valving/Metering
		Rehab/New	Rehab/New	Rehab	New	Rehab/New	Pump/Motor	
Mirpurkhas	Satellite Towns	●	●	●		●	●	●
	Mirpur Minor	●	●		●			●
	West Jamrao	●	●				●	●
	East Jamrao	●	●			●	Include Power Supply ●	●
Umerkot	Surface	●	●	●		●	●	●
	Ground	Combine with SW						
Tando Allahyar		●	●	●	●	●	●	●
Tando Adam		●	●	●	●	●	●	●
Sanghar	Old	●	●		●	●	●	●
	New	●	●	●	●	●	●	●
Shahdadpur		New Fully Functioning Scheme Required						

Table 6: Improvements to Distribution Network

All facilities in the distribution system (after the treatment plant) will be designed to meet the PHD of 90gpd. This will ensure water is available to end-users even in the event of sudden increased demand lasting several hours.

The state of underground assets in all distribution systems could not be ascertained for reasons already discussed. Replacement of aged and leaky pipes will be a major component of the pipeline distribution rehabilitation works but the scope of these activities can only be confirmed on the basis of up-to-date pipeline network drawings and maps.

Increased demands over time can render pipelines to be under-sized and create restrictions to system performance. These ‘restriction’ points will be identified and corrected following proper analysis of the systems. The zones and districts will be hydraulically-defined so they are fed from only one common point and are capable of being isolated from the rest of the system. This approach to pipeline improvement to the distribution is comprehensive in scope and content as it eliminates redundancies in the system (getting rid of under-sized pipes) and simultaneously introduces water loss management approaches.

4.0 POTENTIAL SUB-PROJECTS BY CLUSTER TOWN

Sizing of the various system facilities will be determined by the maximum daily demand (MDD) and peak hourly flow (PHD). Facilities from the source including the raw water storage and all equipment up to and including the treatment plant will be designed to meet the MDD of 60gpd. After the treatment plant, all distribution pipes and facilities within the distribution will be sized to cater for the PHD of 90gpd.

Table 7 gives the likely demand situation for each cluster towns, projected in 5-year intervals. Two population scenarios (low and high) are shown pending confirmation on the estimates to be adopted. For purposes of progressing this work, the high population scenarios are adopted.

Schemes	Year	Population (Low)	ADD 30gpd (MGD)	MDD 60gpd (MGD)	PHD 90gpd (MGD)	Population (High)	ADD 40gpd (MGD)	MDD 60gpd (MGD)	PHD 90gpd (MGD)	Supply (MGD)	RWSP (MG)
Mirpurkhas	2012	282,987	8.490	16.979	25.469	600,000	24.000	36.000	54.000	8000	145.500
	2017	320,330	9.610	19220	28.830	695,564	27.823	41.734	62.601		
	2022	362,600	10.878	21.756	32.634	806,350	32.254	48.381	72.571		
	2027	410,449	12.313	24.627	36.940	934,780	37.391	56.087	84.130		
	2032	464,612	13.938	27.877	41.815	1,083,667	43.347	65.020	97.530		
	2037	525,923	15.778	31.555	47.333	1,255,267	50.251	75.376	113.064		
Umerkot	2012	145,032	4.351	8.702	13.053	175,000	7.000	10.500	15.750	3.084	27.865
	2017	191,808	5.754	11.508	17.263	202,873	8.115	12.172	18.259		
	2022	253,670	7.610	15.220	22.830	235,185	9.407	14.111	21.167		
	2027	335,483	10.064	20.129	30.193	272,644	10.906	16.359	24.538		
	2032	443,683	13.310	26.621	39.931	316,069	12.643	18.964	28.446		
	2037	586,779	17.603	35.207	52.810	366,411	14.656	21.985	32.977		
Tnado Allahyar	2012	100,000	3.000	6.000	9.000	247,617	9.905	14.857	22.286	0.000	0.060
	2017	112,041	3.361	6.722	10.084	335,136	13.405	20.108	30.162		
	2022	125,533	3.766	7.532	11.298	453,588	18.144	27.215	40.823		
	2027	140,648	4.219	8.439	12.658	613,906	24.556	36.834	55.252		
	2032	157,584	4.728	9.455	14.183	830,888	33.235	49.853	74.780		
	2037	176,559	5.297	10.594	15.890	1,124,560	44.982	67.474	101.210		
Tando Adam	2012	160,198	4.806	9.612	14.418	160,234	6.409	9.614	14.421	0.000	0.100
	2017	186,345	5.590	11.181	16.771	186,388	7.455	11.183	16.775		
	2022	216,760	6.503	13.006	19.508	216,810	8.672	13.009	19.513		
	2027	252,140	7.564	15.128	22.693	252,197	10.088	15.132	22.698		
	2032	293,294	8.799	17.598	26.396	293,360	11.734	17.602	26.402		
	2037	341,165	10.235	20.470	30.705	341,242	13.650	20.475	30.712		
Sanghar	2012	78,706	2.361	4.722	7.084	95,851	3.834	5.751	8.627	0.000	17.400
	2017	95,298	2.859	5.718	8.577	112,691	4.508	6.761	10.142		
	2022	115,389	3.462	6.761	10.385	132,489	5.300	7.949	11.924		
	2027	139,714	4.191	7.949	12.574	155,766	6.231	9.346	14.019		
	2032	169,168	5.075	9.346	15.225	183,131	7.325	10.988	16.482		
	2037	204,831	6.145	10.988	18.435	215,305	8.612	12.918	19.377		
Shahdadpur	2012	125,654	3.770	7.539	11.309	130,000	5.200	7.800	11.700	0.000	0.000
	2017	141,198	4.236	8.472	12.708	146,081	5.843	8.765	13.147		
	2022	158,665	4.760	9.520	14.280	164,152	6.566	9.849	14.774		
	2027	178,292	5.349	10.698	16.046	184,458	7.378	11.067	16.601		
	2032	200,347	6.010	12.021	18.031	207,276	8.291	12.437	18.655		
	2037	225,130	6.754	13.508	20.262	232,917	9.317	13.975	20.962		

Table 7: Demand Projections in 5-year intervals based on ADD, MDD and PHD for Low and High Population scenario

Notes:

1. *ADD= Average Daily Demand, MDD = Maximum Daily Demand, PHD =Peak Hour Demand*
2. *Supply for Tando Allahyar, Tando Adam, Sanghar and Shahdadpur are not available*
3. *Storage for the ponds in Shahdadpur are deduced from Google Earth and an assumed depth of 6ft*

As observed, low and high population estimates for some cluster towns have huge differences. The method to derive them and the growth rate assigned to each town has a significant influence on the estimates and the resulting demand projections.

While the populations in the cluster towns are being confirmed, other detailed information are also required. Of significance is the layout of the respective water supply schemes, where much of their physical description, configuration and orientation can be gauged. This will enhance efforts to confirm specific information and data which could not be accessed earlier. In the absence of such information, the activities identified here lack some key details. However, the areas and/or activities highlighted generally cover the broad issues needing attention that will eventually form the sub-projects.

4.1 Mirpurkhas

4.1.1 General

Based on the MDD figures, the existing raw water storage ponds can provide back-up supply of about 2 days by the year 2037. However this is for the overall Mirpurkhas scheme, which comprises four separate systems and where each system is either dedicated to a particular supply area or combines with another system to supply a given area.

Table 8 gives the situation in the overall Mirpurkhas scheme with regards to the worse population scenario and the demand that will be expected up to 2037. Comparisons are made on the capacity of the existing supply to meet these projections based on MDD and PHD.

Existing Daily Supply (MGD)			8.000				
Existing Storage (MG)			145.500				
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (3.0%)		600,000	695,564	806,350	934,780	1,083,667	1,256,267
Demand in MGD							
ADD (gpd)	**40**	24.000	27.823	32.254	37.391	43.347	50.251
MDD (gpd)	**60**	36.000	41.734	48.381	56.087	65.020	75.376
PHD (gpd)	**90**	54.000	62.601	72.571	84.130	97.530	113.064
Days of Storage							
ADD (gpd)	**40**	8.1	7.0	6.0	5.2	4.5	3.9
MDD (gpd)	**60**	**4.0**	**3.5**	**3.0**	**2.6**	**2.2**	**1.9**
PHD (gpd)	**90**	2.7	2.3	2.0	1.7	1.5	1.3
Required Daily Supply (MGD)							
ADD (gpd)	**40**	16.000	19.832	24.254	29.391	35.347	42.251
MDD (gpd)	**60**	**28.000**	**33.734**	**40.381**	**48.087**	**57.020**	**67.376**
PHD (gpd)	**90**	46.000	54.601	64.571	76.130	89.530	105.064

Table 8: Population, Demand, Storage and Supply

To better appreciate the situation in Mirpurkhas and be able to identify the scope of improvements required, the assessment has to be made on a system by system basis. A major hindrance to this approach will be to determine the population that is being or will be served by each system. Where the systems mix in distribution, it is even more difficult to assign populations to a particular system.

Assessing the situation in Mirpurkhas without information on the actual population separately served by each systems, could yield erroneous results. Further, it is not proper to treat Mirpurkhas as one system because each (separate) system may have its own specific issue that could be better addressed in isolation of the others. Additionally, adopting the overall Mirpurkhas data to size the facilities in these smaller independent systems could result in over-designed facilities.

There is a limit to the population that can be served from each of these independent schemes when considered in the light of their existing supply capacity. Table 9 attempts to define this population limit by relating the current supply from these schemes to the design rates (MDD or PHD).

Further, to provide for the projected growth in population, the facilities may have to be improved quite significantly. The magnitude of the improvements and actual requirements will be spread among the individual schemes, some requiring more attention than others depending on the actual distribution of the population and where they occur in relation to the individual systems. The availability of developable areas with potential for future growth will also be a determining factor to the improvement works.

Schemes	Daily Supply Capacity (MGD)	Equivalent Population that can be served based on MDD and PHD Rates	
		MDD @ 60gpd	PHD @ 90gpd
Satellite Town	2.55	42,500	28,300
Mirpur Minor	0.4	6,700	4,400
West Jamrao	3.0	50,000	33,300
East Jamrao	2.0	33,300	22,200
Total		132,500	108,200

Table 9: Maximum population size that can be served by the existing small schemes using MDD and PHD

The existing daily supply from the individual systems places a limit on the population that can be served. If the population were to increase the supply capacity will have to be increased as well. How much additional demand will be placed on these systems and whether they will need to be upgraded depends on the development potential or future growth prospects of the areas to be served.

As information is sketchy, it may not be possible to define the level of improvement required to meet future demand. However, immediate improvements to the existing equipment and facilities are long overdue and are recommended for replacement or rehabilitation.

Progressing on a stage by stage basis the following will be undertaken in Mirpurkhas.

4.1.2 Source

As emphasized in the foregoing, the population served by each individual scheme in Mirpurkhas is critical. While this information is still to be acquired, the following remedial works are recommended on each individual scheme.

Jarwari Canal Extraction Point –

- Secure the perimeter of the pump station including the extraction well with security fencing and provide lockable gates.
- Install proper stainless grid or screen on diversion to stilling pond at the pumping station suction end.
- Rehabilitate the pump house structure and associated pipe-work to the pumps.
- Replace all valves and fittings at both suction and delivery ends of the pumps
- Install bulk flow meter on rising mains exiting the pump house
- Upgrade all electrical work, installations and control devices
- Install standby generator
- Pending information on specific demand from this system, replace the pumps and motors with the same rating and configuration as the existing equipment:
    - 1 No 12” x 12” pump with 50HP motor
    - 2 No 12” x 12” pump with 60HP motor
- Replace sections of 16” Ø steel transmission pipe to supply Satellite Town Waterworks

Mirpur Minor –

- Install proper stainless steel grid at entrance to diversion channel leading to the raw water storage ponds
- Raise the height of the protective wall around the whole perimeter of raw water storage ponds
- Provide concrete covers on the open channel leading to the raw water storage ponds where it traverses the farmland and agricultural plots

West Jamrao –

- Install proper stainless steel grids at the entrance to diversion channel leading to the raw water storage ponds
- Provide concrete covers to all exposed sections of the raw water intake channels.

East Jamrao –

- Install proper stainless steel grid at entrance to diversion channel leading to the raw water storage ponds.

4.1.3 Treatment

Establishing the required throughput for each treatment plant requires information on the population being serviced by each system is so that demand can be assessed.

For water quality requirements and based on the field visits, there are physical improvement needed at each of the four systems that contribute to the overall Mirpurkhas scheme. Raw water ponds are considered an inherent part of the treatment process by virtue of the initial settlement they provide to the raw water during transition between the source and water treatment plants. On this premise, the Mirpur Minor system is also included under this section.

The improvements listed below are based on observations made during the field visit. As more detailed and specific information is acquired on the treatment plants, the activities identified here will be revised.

Satellite Town –

- Rehabilitate and de-silt all existing raw water storage ponds.
- Re-configuring the pumping arrangements between the raw water storage pond and water treatment plant so the clearer top portion of the 'settled water' is transferred.
- Install modular construction treatment plant (coagulation, flocculation and filtration) capable of high outputs with capacity to handle high raw water turbidity
- Rehabilitate or replace leaking pipe-work within the treatment plants including associated valves and fittings
- Replace and/or upgrade the chlorination equipment so the process occurs under cover and away from the elements with proper housing and mixing/storage bays for the chemicals
- Refurbish and upgrade all electrical wiring, installations and control devices
- Rehabilitate all clear water tanks and high service reservoirs
- Install proper pumping/switching arrangement at the high service reservoirs to enhance balancing tank operation
- Pending information on the specific demand from this system, replace the pumps and motors with the same rating and configuration as the existing equipment:

  - 1 No 8” x 8” turbine pump with 100HP motor to supply 27”Ø and 12”Ø mains
  - 1 no 8” x 8” turbine pump with 80HP motor to fill high service reservoir
  - 1 No 6” x 5” pump with 75HP motor to supply 12”Ø mains to Rewachand Booster
  - 1 No 5” x 4” pump with 50HP motor to maintain the clear water tank
  - 1 No 8” x 8* pump with 40HP motor to maintain the clear water tank
  - 1 No 6” x 5” pump with 25HP motor to maintain the clear water tank
  - 1 No 6” x 5” pump with 20HP motor to maintain the clear water tank
  - 1 No 3” x 2$^1/_2$” pump with 5HP motor to maintain the clear water tank
- Refurbish pipe-work and connections between pumps and delivery mains exiting the treatment plant
- Install bulk flow meter(s) at all the outlet(s) or primary distribution mains exiting the water treatment plant

Mirpur Minor –

- Rehabilitate and de-silt all raw water storage ponds
- Re-configuring the pumping arrangements between the raw water storage pond and water treatment plant so the clearer top portion of the ‘settled water’ is transferred.
- Rehabilitate and replace all pipe-work within the booster pumping station including all associated valves and fittings
- Replace and/or upgrade the chlorination equipment so the process occurs under cover and away from the elements with proper housing and mixing/storage bays for the chemicals
- Refurbish and upgrade all electrical wiring, installations and control devices
- Pending information on the specific demand from this system, replace the pumps and motors with the same rating and configuration as the existing equipment:
  - 2 No 8” x 8” turbine pump with 100HP motor to supply 12”Ø mains
- Install modular construction treatment plant (coagulation, flocculation and filtration) capable of high outputs with capacity to handle high raw water turbidity
- Refurbish pipe-work and connections between mains and pump discharge
- Install bulk flow meter(s) at the mains exiting the water treatment plant

West Jamrao –

- Rehabilitate and de-silt all raw water storage ponds
- Refurbish the non-functioning coagulation and flocculation facilities
- Refurbish all the pipe-work and associated valves and fittings in treatment plant
- Refurbish the clear water tank
- Replace and/or upgrade the chlorination equipment so the process occurs under cover and away from the elements with proper housing and mixing/storage bays for the chemicals
- Upgrade power supply and electrical equipment and controls
- Pending information on the specific demand from this system, replace the pumps and motors with the same rating and configuration as the existing equipment:
  - 1 No 8” x 8” turbine pump with 125HP motor to supply 18”Ø steel rising main
  - 1 No 8” x 8” turbine pump with 100HP motor to supply 18” Ø ACP rising main
  - 2 No bilge pumps with 40HP motor for sedimentation tanks
  - 3 No 6” x 5” pumps with 20HP motor for clarifiers

  - 2 No 5” x 4” pumps with 20HP motor to fill high service reservoir
  - 2 No 5” x 4” pumps with 20HP motor for filter bed washouts
  - 2 No mixing pumps with 5HP motor for mixing and dosing of alum and chlorine
- Install bulk flow meter on the rising main leaving the clear water tanks

East Jamrao –

- Rehabilitate and de-silt all raw water storage ponds
- Pending information on the specific demand from this system, replace the pumps and motors with the same rating and configuration as the existing equipment:
  - 1 No 8” x 8” turbine pump with 125HP motor to supply 18”Ø steel rising main
  - 2 No bilge pumps with 40HP motor for sedimentation tanks
  - 3 No 6” x 5” pumps with 20HP motor for clarifiers
  - 2 No 5” x 4” pumps with 20HP motor to fill high service reservoir
  - 2 No 5” x 4” pumps with 20HP motor for filter bed washouts
  - 2 No mixing pumps with 5HP motor for mixing and dosing of alum and chlorine
- Refurbish all the pipe-work in the treatment plants including associated valves and fittingsRefurbish the clear water tanks
- Refurbish the clarifiers (coagulation/flocculation facilities)
- Replace and/or upgrade the chlorination equipment so the process occurs under cover and away from the elements with proper housing and mixing/storage bays for the chemicals
- Upgrade power supply and electrical equipment and controls
- Install bulk flow meter on the rising mains leaving the clear water tanks

4.1.4 Distribution

In the first instance, the distribution pipeline network in all the water supply schemes in Mirpurkhas town will be assessed to determine the need for replacement to cater for the current population and that over the next 25 years.

There are pipelines that will need to be replaced due to their age and the frequency of bursts they have been subjected to over the years. Prior to replacing them, their capacity to meet projected demand will also be assessed so they can be sized accordingly.

Pipeline replacement will be undertaken as part of a comprehensive water loss management program. This requires the identification of specific zones to be supplied from single supply points. A universal bulk metering program will be part of this exercise as well. For every zone and district identified, a bulk flow meter with appropriate valving will be installed at the single entry point to the zone or district. At the same time, all other pipe-work that can potentially supply water to the said zone or district will have valves that will remain permanently closed as their default operating position. This work can only proceed on availability of up-to-date pipeline network maps of the distribution systems.

With four separate schemes, priority analysis should be undertaken on a scheme by scheme basis so the extent of each scheme to supply current areas must be established. It is proposed that the analysis should commence with the scheme having the highest available storage and supply. An assessment will be made on how much of the existing and future Mirpurkhas supply area it can serve. Through this approach the full extent of the area that can be serviced by one scheme can be established and the analysis is repeated for each subsequent scheme.

The capacity of all high service reservoirs and on-line booster pumping stations and clear water tanks will be evaluated on the basis of the population/demand to be met directly from these facilities. All on-line reservoirs will have sufficient capacity for fire-fighting requirements and if insufficient, provisions will be made in the design to increase their capacity.

The function of high service reservoirs as balancing tanks will be reactivated with the necessary booster arrangements incorporated in the pipe-work and the electrical circuitry to control the operations of the float level switches. Alternatively, altitude valves can also be considered to avoid the use of electrically controlled float level controls but these will have to properly assessed. The Rewachand Garden high service reservoir will be rehabilitated and all pipe-work replaced including the associated, valves and fittings.

Table 10 shows the equipment in the booster pumping stations located in the schemes supplying Mirpurkhas town will be considered for replacement depending on the likely demand the individual systems will be subjected to. Bakra Piri booster station will be sized and commissioned to improve coverage of the East Jamrao scheme if the network analysis on the system recommended this action.

Scheme	Running Mode	Running Motors	Pump Configuration	Remarks
Rewachand Garden Booster Station	100HP Turbine	1	8” x 8”	For High Service Reservoir
	80HP Turbine	1	8” x 8”	12”Ø Supply Line
Thamsabad Boosting Station	125HP	1	8” x 8”	Supply 18” Ø Black Steel Rising Mains
Bakra Piri	-	-	8” x 8”	-

Table 10: Booster Stations in Mirpurkhas Scheme

4.2 Umerkot

4.2.1 General

According to TMA data, the total storage capacity of the overall Umerkot scheme is 27.865MG. This volume comprises the raw water storage ponds at the Tharwah Canal, the Groundwater source at the Umerkot waterworks and the series of clear water storage tanks within the distribution system. Only the Tharwah and Groundwater sources contribute to the Umerkot scheme while the storage tanks in the distribution are merely distributing what has been extracted from the two raw water sources.

Tharwah storage ponds have a capacity of 21.3 MG which are located 13km from Umerkot town. The surface water mixes with groundwater where it is extracted at the Umerkot waterworks. More than 5.5MG of the combined Tharwah water and groundwater are stored at the waterworks before distributing to the end-users. As there is no metering, it is not possible to establish how much the surface water and groundwater systems contribute to the combined storage at the waterworks.

The Umerkot system has a series of in-line storage tanks and booster stations supplying to a number of zones, which are simultaneously being supplied by the Tharwah and groundwater systems. This state of affair makes the Umerkot system quite a challenge to comprehend. To aid understanding the system will need to be properly surveyed and mapped with all the facilities and pipelines clearly identified. To recommend improvements to such a system without this basic information can be testing.

Information from the TMAs showed that the total supply to Umerkot is 3.084MGD, although it cannot be verified how this rate is acquired or arrived at. Further, according to TMA records there are 3,700 connections shared by 20,000 to 25,000 households.

4.2.2 Source

Tharwah Canal being the major contributor to Umerkot's water supply needs, has a total storage capacity equivalent to 2-days' requirement at current demand estimates. This will reduce to 1-day's storage by 2037. When taking the sum of all the storage ponds and tanks in the whole Umerkot supply area into consideration, there is sufficient storage for 2.7 days and 1.3 days for 2012 and 2037 respectively.

Water extraction is suspended 15days a month at which time reliance is placed on the stored water at the Tharwah Canal and groundwater at the Umerkot waterworks including the in-line storage provided by the storage tanks in distribution. An analysis of the overall distribution system will help establish supply areas from particular distribution storage tanks. Information on the service connections and potential developable areas will be considered to project the future demand that will be placed on these facilities.

Table 11 gives the situation in Umerkot for the high population scenario and the demand that will be expected between now and 2037. Comparisons on the capacity of the existing supply to meet these projections are based on the MDD of 60gpd. There is an ongoing PHED project which should be considered here if the exact details are understood.

Existing Daily Supply (MGD)			3.084				
Existing Storage (MG)			21.300				
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (3.0%)		175,000	202,873	235,185	272,644	316,069	366,411
Demand in MGD							
ADD (gpd)	40	7.000	8.115	9.407	10.906	12.643	14.656
MDD (gpd)	60	10.500	12.172	14.111	16.359	18.964	21.985
PHD (gpd)	90	15.750	18.259	21.167	24.538	28.446	32.977
Days of Storage							
ADD (gpd)	40	3.0	2.6	2.3	2.0	1.7	1.5
MDD (gpd)	60	**2.0**	**1.7**	**1.5**	**1.3**	**1.1**	**1.0**
PHD (gpd)	90	1.4	1.2	1.0	0.9	0.7	0.6
Required Daily Supply (MGD)							
ADD (gpd)	40	3.916	5.031	6.323	7.822	9.559	11.572
MDD (gpd)	60	**7.416**	**9.088**	**11.027**	**13.275**	**15.880**	**18.901**
PHD (gpd)	90	12.666	15.175	18.083	21.454	25.362	29.893

Table 11: Population, Demand, Storage and Supply

All pumping equipment at the Tharwar Canal intake will be replaced to have the original complement of pumps and motors operating again. In particular, the 3 units (pumps and motors) which are virtually unserviceable at the pump station will be replaced. Further the 2 No 100HP transfer pumps from the raw water storage to the Umerkot water works 13km away will be replaced.

A bulk flow meter will be installed on the transmission mains after the pumping station.

The 18"Ø steel transmission main will be rehabilitated where it has been vandalized, which on the basis of field visits has been observed to have happened at an air-valve. On this note, all air-valves and scour valves will be rehabilitated or replaced and proper valve chambers constructed with heavy concrete covers installed. An assessment of the requirements for this work can be done on the ground, after reliable demand estimates from this particular system is established.

4.2.3 Treatment

There is no further treatment of the water apart from the initial settlement in the raw water storage ponds. An ongoing PHED project includes a water treatment plant with facilities for clarifiers, filtration and chlorination. Details on the capacity of the plant are not available but this installation should greatly improve the quality of the water for the overall Umerkot township when it is commissioned.

The option to install appropriate modular or packaged treatment plants can be considered for Umerkot in view of the limited land available at the Umerkot waterworks area. However with construction of the treatment plant still underway, it is more appropriate to establish the capacity of the new plant with PHED before considering any action or other options for water treatment.

Meanwhile disinfection of the water must not be compromised and appropriate chlorination equipment and/or facilities will be installed at appropriate locations in the system. New chlorination equipment, in properly constructed all-weather housing will be installed at the Umerkot waterworks clear water tanks before the water goes into distribution. Similar equipment may also be installed at selected clear water storage tanks in the distribution, depending on chlorine residual test results. The use of other forms of disinfection can be considered depending on the simplicity of the technology, effectiveness of the process and the capacity of operators to operate and maintain the equipment.

Bulk flow meters will be installed in every pipeline that exits the waterworks and distributes water directly into the town's network.

4.2.4 Distribution

All aging and leaking pipelines will be replaced as a matter of immediate priority. This is mainly to reduce ongoing wastage but the result could lead to some noticeable improvements in availability of water.

The high service reservoir will be rehabilitated after proper structural checks to determine the extent of the required rehabilitation work. Pipe-work to the high service reservoir will be replaced including associated valves and fittings and the booster arrangements will be refurbished so some effective balancing can be obtained. The electrical controls to operate the booster will also be replaced.

The overall distribution system will be divided into supply zones and sub-zones or districts and single entry points will be identified for each zone. An analysis of the distribution network will be carried out to identify critical points or sections where pipe replacement will be carried out. These critical points or sections will be areas of excessive flows and high pressures as well as low flow and low pressure areas, which the pipe replacement or improvement (including proper sizing) activities will target.

Boundary (zone) valves will be installed at strategic locations around the system. These will control the distribution of water going into specific supply zones so there is only one point of supply per zone.

All existing pumping equipment located within the Umerkot supply area will either be replaced with similar rated equipment or with equipment that will accommodate the anticipated increase in demand, which has yet to be established for each supply area. The following equipment will be effected:

- At the Boosting Station PII & PIII,
    - 2 No sump pumps connected to the 16”Ø AC to fill the high service reservoir
    - 2 No 30kW pump connected to 2 No 14”Ø uPVC to fill ground water tank
    - 2 No 30kW diesel pump connected to 8”ØAC pipe for direct supply
    - 5 No 37kW pump connected 4”Ø connected to dedicated Police and Temple mains
- At Chachro Road – 3 No 60HP connected 12”Ø mild steel pipe
- At Koli Daro – 3 No 100HP connected to 12”Ø mild steel pipe

Bulk flow meters will be installed within the distribution network at the outlet of all clear water tanks, booster pump stations and high service reservoirs.

4.3 Tando Allahyar

4.3.1 General

Improvements in Tando Allahyar will be for the estimated current population of almost 250,000, which is estimated to peak at around 1.1million in 2037. These estimates are quite high as they are based on a growth of 6.24% whereas a 2.3% growth was adopted in initial estimates. In fact initial estimates based on the latter growth rate showed that the population projected for 2037, is nearly 250,000 while the 2012 population is only around 140,000.

The 6.24% population growth is twice the national rate and could only be attributed to other specific social or demographical characteristic peculiar to Tando Allahyar. Whatever the reasons for the high growth, these figures are currently being reviewed through the local statistics bureau to ascertain their veracity.

While the population figures may be under contention, Tando Allahyar town remains in dire need of improved water supply services. Groundwater is exploited and though arsenic contamination has been reported recent hydro-geological investigations under the SCIP-03 revealed that these only affect shallow wells. The town’s water, sourced from tube wells are relatively free from contamination as the extraction is taking place at depths void of arsenic.

The nearby Naseer Canal, which replenishes the tube-wells is a potential water source that can be exploited for Tando Allahyar if needed. Hydro-geological investigations have commenced which will also include testing the fitness of the canal water for drinking. As canal water naturally contains high sediment levels, there is additional infrastructure requirement in terms of raw water storage pond (pre-settlement tanks), clarifiers (coagulation and flocculation) and filtration plants. On the other hand, groundwater-based systems use the aquifer as storage and the water which is brought up to the surface only needs disinfection before distributing to the users.

Additional supply will be available once the three tube wells developed by PHED are commissioned and handed over to the TMA. This will also increase Tando Allahyar's reliance on groundwater, which is naturally drinkable. On the basis of quality, groundwater would be the preferred water source and additional wells may need to be developed progressively to keep abreast of the rising demand. The main constraint will be the safe yield of the aquifer, which needs to be established and relate it to the expected growth in demand.

4.3.2 Source

Information on the safe yield of the groundwater and the capacity of the pumps to extract the raw water are not available. Pending further confirmation on the expected population to be served, the current extraction rates form the pumps and information on the performance of the wells is needed. Hydro-geological investigations have recently commenced and results from the relevant tests will provide some pointers on how further extraction from the groundwater can or should be progressed.

The situation in Tando Allahyar is shown in Table 12. A high population scenario is used to assess the likely demand that will be expected up to 2037. As water is pumped directly into distribution, there is no storage except the high service reservoirs which also facilitates balancing of the system.

Existing Daily Supply (MGD)			0.000				
Existing Storage (MG)			0.000				
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (6.24%)		247,617	335,136	453,588	613,905	830,886	1,124,558
Demand in MGD							
ADD (gpd)	**40**	9.905	13.405	18.144	24.556	33.235	44.982
MDD (gpd)	**60**	14.857	20.108	27.215	36.834	49.853	67.474
PHD (gpd)	**90**	22.286	30.162	40.823	55.251	74.780	101.210
Days of Storage							
ADD (gpd)	**40**	0.0	0.0	0.0	0.0	0.0	0.0
MDD (gpd)	**60**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
PHD (gpd)	**90**	0.0	0.0	0.0	0.0	0.0	0.0
Expected Daily Supply (MGD)							
ADD (gpd)	**40**	9.905	13.405	18.144	24.556	33.235	44.982
MDD (gpd)	**60**	14.857	20.108	27.215	36.834	49.853	67.474
PHD (gpd)	**90**	22.286	30.162	40.823	55.251	74.780	101.210

Table 12: Population, Demand, Storage and Supply

It can be deduced from Table 12 that the system has to be run continuously to keep it fully charged, especially during peak hours. No information on the operations routine of the three tube wells is provided. It cannot be established whether one pump is on standby while two are running or all three are running continuously. Some sense of how the wells operate and their capacities would provide some useful indicators on the situation at the point of extraction. However, on the basis of information available and observations during the visits, some critical rehabilitation work will be required.

Where three were mentioned, only two wells were observed to be operating. All three however will need to undergo significant refurbishment involving the following:

- Clean wells and replace well screens and blank casings where necessary
- Install emergency power supply to handle at least two pumps running simultaneously during times of power outage
- Replace all power cables and electrical wiring including associated control panels and switching equipment
- Replace all hoisting gear for use during maintenance activities or normal operations
- Re-plaster walls of the structure housing the pumps
- Replace all existing pipe-work including valves and fittings between the pumps and rising mains
- Replace the pumps and motors in all three wells with ratings to cater for the anticipated increase in demand while operating within the safe yield of the groundwater. This will also include risers and associated pipe-work, valves and fittings and other ancillary items
- Install bulk flow meters at the discharge end of each tube well pump

4.3.3 Treatment

Chlorine solution is injected into the discharge end of the pump as the water is pushed straight into distribution. The water is not subject to any other form of treatment apart from chlorination. Recent water quality test under SCIP-03 have revealed other quality characteristics to be well within WHO guidelines so other treatment processes will not be required.

Improvement work to be undertaken here will involve the replacement of the existing chlorination equipment at all three tube wells with proper facilities housed in vandal and weather-proof enclosures with appropriate dosing and monitoring devices as well as storage and handling bays for chemicals.

4.3.4 Distribution

Pipelines in the distribution will need to be upgraded to meet anticipated increase in demand. Where aging and frequent bursts are common the particular sections will be replaced. An accurate physical assessment of the existing pipeline should be undertaken if and when the network drawings of the system are available. All in-line valves (including scour valves, air-valves, boundary valves etc.) and fittings will be replaced with appropriately sized items. All valve chambers will be refurbished and fitted with heavy concrete covers.

Pipeline assessment will also identify areas where wastewater and/or domestic drains are overflowing into surrounding areas and can potentially be a source of contamination threatening the quality of the drinking water. This is particularly critical where negative pressures can develop in the system due to intermittent supply (as a result of power load shedding) and the probability of contaminated or polluted water being drawn into the system is high.

In anticipation of the 3 tube wells to be handed over to the TMA and in the absence of details on the wells, information on how and where they will be connected to the existing system may have to be investigated. This will be done in consultation with PHED but can be made a part of the design to improve Tando Allahyar’s distribution system.

The high service reservoir has deteriorated and must be replaced. As it is filled directly from the tube wells and distributes to the network its function will be reviewed to ensure it fulfills the requirements expected of a storage reservoir. This will require the reservoir to carry enough capacity to meet the operational and emergency needs of the system.

Apart from increased capacity, the improvement work on the reservoir will also include replacement of associated pipe-work, valves and fittings. Again the demand expected to be placed on the Tando Allahyar system will be instrumental in determining the various storage requirements and subsequently the size of the structure.

Bulk flow meters will be installed at the outlet to the high service reservoir and at the discharge of any booster pump that by-passes the high service reservoir and delivers water directly into distribution

4.4 Tando Adam

4.4.1 General

Groundwater is exploited in Tando Adam but salinity problems confined extraction to the west end of the town. A nearby potential surface water source (Tando Branch Canal) is not tapped but is assumed to be replenishing the west end groundwater system.

The disparities in the groundwater quality between east and west will be better understood from hydro-geological investigations currently underway in SCIP-03. These findings may show if there are locations in the east end that can be exploited. The investigations will also test the quality of the water in the canal to establish its fitness for consumption.

Options to increase supply to the town are being considered. One is to develop more wells in the existing well fields and pipe the water across town to the east end. The other option is to exploit the Tando Branch Canal if water quality tests do not reveal any significant issues.

PHED is currently engaged in schemes to improve supply to Tando Adam but details of this are yet to be shared with SCIP-03.

4.4.2 Source

The capacity of the existing tube-wells to meet demand cannot be ascertained due to non-availability of relevant information. In particular, there is no means to establish the amount of water extracted as there is no metering carried out.

Table 13 depicts the Tando Adam scheme and the expected demand up to 2037. As is the case for Tando Allahyar, this system also pumps the raw water straight into distribution via a 0.1MG high service reservoir.

Existing Daily Supply (MGD)			0.000				
Existing Storage (MG)			0.000				
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (3.07%)		160,234	186,387	216,809	252,196	293,360	341,241
Demand in MGD							
ADD (gpd)	**40**	6.409	7.455	8.672	10.088	11.734	13.650
MDD (gpd)	**60**	9.614	11.183	13.009	15.132	17.602	20.474
PHD (gpd)	**90**	14.421	16.775	19.513	22.698	26.402	30.712

Days of Storage							
ADD (gpd)	**40**	0.0	0.0	0.0	0.0	0.0	0.0
MDD (gpd)	**60**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
PHD (gpd)	**90**	0.0	0.0	0.0	0.0	0.0	0.0
Required Daily Supply (MGD)							
ADD (gpd)	**40**	6.409	7.455	8.672	10.088	11.734	13.650
MDD (gpd)	**60**	9.614	11.183	13.009	15.132	17.602	20.474
PHD (gpd)	**90**	14.421	16.775	19.513	22.698	26.402	30.712

Table 13: Population, Demand, Storage and Supply

While the Table highlights the lack of storage, as a groundwater system, this is already provided by the aquifer so it is the capacity of the aquifer to sustain current and/or future extraction that will need to be established. This activity is now underway in SCIP-03.

Daily supply equivalent to MDD rates for the projected populations will have to be met by the Tando Adam tube wells.

As the west end well field is a tested groundwater source, the east end can be supplied from this location. The logistics of bringing the water across the town to the east end will need to be assessed as well as the overall capacity of the aquifer to accommodate additional extraction.

Improvements to the Tando Adam scheme will involve refurbishment and replacement (where necessary) of the existing groundwater extraction facilities, involving four tube wells.

- Clean wells and replace well-screens and blank casings where necessary
- Install emergency power supply to handle at least two pumps running simultaneously during times of power outage
- Replace all power cables and electrical wiring including associated control panels and switching equipment
- Replace all existing pipe-work including valves and fittings between the pumps and rising mains
- Replace the pumps in all four wells with ratings to cater for the anticipated increase in demand while operating within the safe yield of the groundwater. This will include motors, risers and associated pipe-work, valves and fittings
- Install bulk flow meters at the discharge end of each tube well pump

4.4.3 Treatment

Chlorine solution is introduced into the discharge end of the pumps as the water is put into the distribution network. The water is only disinfected by chlorination. Unless ongoing water quality tests reveal irregularities, no other form of treatment will be undertaken.

However it is proposed that the existing chlorination equipment be replaced and upgraded with proper facilities which are housed in vandal and weather-proof enclosures with appropriate dosing and monitoring devices installed. Appropriate provisions must also be made for the storage and handling of chemicals.

4.4.4 Distribution

The high service reservoir has deteriorated severely to the stage that it should be replaced immediately. The replacement reservoir will be designed with sufficient capacity to meet normal operational needs, systems balancing requirements and emergencies.

All associated pipe-work, valves and fittings will be replaced, including appropriate float switches where necessary for the system balancing requirements to be met.

Bulk flow meter will be installed at the outlet to the high service reservoir and at the discharge of any booster pump that by-passes the high service reservoir and delivers water directly into distribution.

Distribution pipelines will be re-sized and replaced if necessary following the acquisition of relevant data as well as pipeline drawings of the distribution network. A comprehensive exercise of identifying supply zones will be undertaken where the zones will have single supply points and easily isolated from the rest of the system. Every zone will be metered at the single supply point, with all other possible entry points closed off at boundary valves.

4.5 Sanghar

4.5.1 General

Water sources in Sanghar are saline and highly brackish, while widespread water-logging problems contribute to the poor state of the water supply problems.

An old waterworks and new waterworks make up the Sanghar system which will be complemented by a PHED project currently underway to bring water to the town from Mithro Canal about 6km away via a 24”Ø HDPE pipe.

Facilities in the old waterworks suffered from inadequate maintenance over the years due to a host of reasons. The consequences of this is a slow sand filter that has ceased to function, silted-up raw water storage ponds, a high service reservoir that is no longer in use and is now condemned, a dilapidated pump house and unserviceable pumping equipment. These are manifestations of operational practices that will need to change if the improvements advocated here are to be beneficial.

Coverage of the water supply service is reported to be 100% but according to the TMA is unsatisfactory as supply times are 2 hours in the mornings and 2 hours in the evenings.

4.5.2 Source

The potential combined capacity of the raw water storage ponds in the old and new waterworks were estimated using Google Earth and an assumed depth of 6ft for the ponds. This estimation includes all the ponds in the old waterworks, some of which have already severely silted. With this capacity, all the ponds combined could potentially provide 3 days supply at current population projections or a little over 1 day back-up in 2037.

There is no means of measuring the capacity of the system or the volume of water that leaves the waterworks facilities. Information on system production is not available but as can be deduced from the TMAs, the overall system is not coping with demand.

Table 14 summarizes the projected population and demand expected from Sanghar for the next 25years up to 2037. The system has to produce around 6MGD and 13MGD between now and 2037 respectively and the ongoing PHED project is assumed may be able to improve supply. Details of this project are not available so it is not known how much of Sanghar's water supply service requirements will be met by the new project or what the extent of the project is.

Regardless of the level of improvement expected from the PHED project, the current situation warrants an immediate improvement to the existing infrastructures at the intakes/extraction points of which the following will be accorded priority:

- Rehabilitate and de-silt all raw water storage ponds in the old waterworks
- Rebuild the pump house for the extraction pumps
- Replace all pumps and motors and re-configure pumping arrangements if warranted by design
- Replace all pipe-work to suit the re-configured pump arrangements including valves and fittings at both the suction and discharge ends of the pumps
- Replace all electrical cabling and control panels with the latter housed in vandal-proof cabinets

Similarly, at the new waterworks, the following priority activities will be undertaken:

- Rehabilitate and de-silt all raw water ponds
- Replace all unserviceable pumps and motors
- Replace existing pipe-work including valves and fittings
- Install valve chambers with concrete covers.

Existing Daily Supply (MGD)			0.000[8]				
Existing Storage (MG)			17.400[9]				
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (3.29%)		95,851	112,691	132,489	155,765	183,131	215,305
Demand in MGD							
ADD (gpd)	**40**	3.834	4.508	5.300	6.231	7.325	8.612
MDD (gpd)	**60**	5.751	6.761	7.949	9.346	10.988	12.918
PHD (gpd)	**90**	8.627	10.142	11.924	14.019	16.482	19.377
Days of Storage							
ADD (gpd)	**40**	4.5	3.9	3.3	2.8	2.4	2.0
MDD (gpd)	**60**	**3.0**	**2.6**	**2.2**	**1.9**	**1.6**	**1.3**
PHD (gpd)	**90**	2.0	1.7	1.5	1.2	1.1	0.9
Required Daily Supply (MGD							
ADD (gpd)	**40**	3.834	4.508	5.300	6.231	7.325	8.612
MDD (gpd)	**60**	5.751	6.761	7.949	9.346	10.988	12.918
PHD (gpd)	**90**	8.627	10.142	11.924	14.019	16.482	19.377

Table 14: Population, Demand, Storage and Supply

Bulk flow meters will be installed at the discharge end of all extraction pumps.

[8] Data not available
[9] Capacity deduced from Google Earth assuming a depth of 6ft for the ponds

4.5.3 Treatment

Since the failure of the slow sand filters at the old waterworks, Sanghar's water supply is not treated. Any form of treatment applied to the water is what occurred at the raw water storage ponds where, there is some pre-settlement of sediments from the water.

Water quality has clearly been compromised and this situation will need to be reversed through some drastic and immediate action. Filtration will need to be reactivated but whether this applies to the existing slow sand filters is a decision which has to be in the light of other issues. Essential to this decision is the capacity of the service provider to manage, operate and maintain the facility. Another major consideration is the capacity of the plant to meet current and expected demand. In view of the expected increase in demand and the probability that other waterworks facilities may also be required, land constraints could potentially be another issue.

The non-functioning filter plant has a throughput of 0.3MGD. There is sufficient land beside the disused filter plant to mirror the plant and theoretically double the filtration throughput. All things being equal, this will result in an increased filtration throughput of 0.6MGD. However, on an MDD of 60gpd, the 2012 demand is 10 times what two filters will produce. This will rise to almost 22 times in 2037.

On the basis of plant throughput and land constraints, slow sand filters may not be able to adequately meet the requirements. Throughput and land constraint however can be easily accommodated with the use of rapid filters or modular and pre-engineered treatment systems. Both require less land but involve other conventional treatment steps and not filtration only. Running costs for operations, chemicals and parts add to the cost of these options, which makes slow sand filters much cheaper in comparison.

Cost and simplicity of technology/operations favor slow sand filters, while good quality water in sufficient quantities to meet basic requirements is almost a mandatory requirement under the National Drinking Water Policy. It follows that as it is incumbent on the service provider to deliver services demanded by the populace, the use of rapid filters and/or modular treatment plants should be considered. The old waterworks area has ample space with additional land available if the disused slow sand filter is removed.

New clear water tanks of adequate quantity to meet projected demand will be constructed to collect the filtered water.

The clear water will be disinfected by chlorination. Upgraded chlorination equipment will be housed in vandal and weather-proof enclosures with appropriate dosing and monitoring devices installed. Appropriate provisions will also be made for the safe storage and handling of chemicals.

Bulk flow meters will be installed at the discharge of the clear water tanks prior to distribution.

4.5.4 Distribution

Accurate assessment of the distribution network is not possible due to the absence of drawings of the system. Replacement of aging pipes and those susceptible to frequent burst s will be replaced where their identification will depend on TMA maintenance records.

Right-sizing of distribution pipelines will be pending acquisition of relevant pipe data to analyze the overall distribution network.

A comprehensive exercise of identifying supply zones will be undertaken where the zones will have single supply points and easily isolated from the rest of the system. Every zone will be metered at the single supply point, with all other possible entry points closed off at boundary valves.

4.6 Shahdadpur

4.6.1 General

There is no reticulated water supply system in Shahdadpur. The population relies on private wells to satisfy daily domestic requirements but as most wells are found to be saline with incidents of arsenic contamination, limited water is provided via a water purification plant to supplement requirements.

A nearby canal was exploited in the past to meet the water supply needs of Shahdadpur. However, it has been abandoned and the settling ponds remain unused while the transmission main from the ponds to the town has rusted in places. The absence of a proper reticulation network in the town plus the use of poorer quality water, has led to reported incidences of water-borne diseases[10]. As the situation continues to deteriorate, PHED now has plans to rehabilitate and reactivate the abandoned system.

Considering the situation currently confronting Shahdadpur, PHED's plans could make a lot of difference to the town's water supply. However, the scope and extent of PHED's initiative, is unclear as no information has been shared yet with SCIP-03. It is hoped that some approaches will be made to PHED to acquire details of its activities, primarily to determine where SCIP-03 can contribute to the ongoing activities.

Where PHED could have already undertaken to develop the bulk of Shahdadpur's water supply system, the involvement of SCIP-03 may focus on the softer aspects of developing Shahdadpur's water supply sector. Some understanding of what PHED will be responsible for is needed so the involvement of SCIP-03 can be appropriately defined.

Rather than duplicate PHED's activities, SCIP-03 can identify areas where it can contribute. The overarching objective is to ensure the achievements of PHED can be sustained long into the future. It is therefore crucial that the details of PHED's program in Shahdadpur are made known to SCIP-03. Until this is known, it may be premature to propose a definite course of action for Shahdadpur.

4.6.2 Source

Notwithstanding PHED's ongoing program, SCIP-03 is undertaking further water quality tests into Shahdadpur's groundwater and surface water sources. Depending on the practicality of performing them, investigations to determine the safe yields from the groundwater sources will also be undertaken using proper hydro-geological methods. Without undermining PHED's work, these tests should provide additional information on the quality of the raw water

[10] SCIP-03 Field Visit Report to Central Sindh Towns 19th – 23rd September 2010, Anwar Mujahid BCE Municipal Services Engineer (WSS), October 2010.

sources which could assist in identifying ways to effectively treat the water for drinking purposes if need to.

With the population projections generated in Table 15 below, there will be almost a quarter of a million people in Shahdadpur by 2037. Daily demand is forecasted to go from 11.7MG to almost 21MG in 2012 and 2037 respectively.

Details of the abandoned settling ponds are not known but a couple of days' storage to accommodate requirements ranging from 7.8MG to 14MG will be needed. In the absence of information relating to PHED's program and based on field visits the settlement ponds will need some refurbishment to function again. The pumping station will need to be completely rehabilitated with new and appropriately sized pumps and motors installed.

All pipe-work on the suction and delivery sides of the pumps will have to be replaced including valves and fittings, with proper valve chambers built. Standby power supply and associated electrical control systems will be installed for uninterrupted operations of the system.

Existing Daily Supply (MGD)		0.000					
Existing Storage (MG)		0.000					
Year		**2012**	**2017**	**2022**	**2027**	**2032**	**2037**
Population (2.36%)		130,000	146,081	164,152	184,458	207,276	232,917
Demand in MGD							
ADD (gpd)	**40**	5.200	5.843	6.566	7.378	8.291	9.317
MDD (gpd)	**60**	7.800	8.765	9.849	11.067	12.437	13.975
PHD (gpd)	**90**	11.700	13.147	14.774	16.601	18.655	20.962
Days of Storage							
ADD (gpd)	**40**	0.0	0.0	0.0	0.0	0.0	0.0
MDD (gpd)	**60**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
PHD (gpd)	**90**	0.0	0.0	0.0	0.0	0.0	0.0
Required Daily Supply (MGD)							
ADD (gpd)	**40**	5.200	5.843	6.566	7.378	8.291	9.317
MDD (gpd)	**60**	**7.800**	**8.765**	**9.849**	**11.067**	**12.437**	**13.975**
PHD (gpd)	**90**	11.700	13.147	14.774	16.601	18.655	20.962

Table 15: Population, Demand, Storage and Supply

Bulk flow meters will be installed at the delivery end of the pumps and transmission lines will be re-sized and replaced.

Essentially the foregoing plus other improvement activities would have already been catered for under PHDED's plans and need not be highlighted. However, this is an assumption that needs to be confirmed with PHED

4.6.3 Treatment

Again, PHED may have considered treatment of the water including details of where the treatment plant will be located and the treatment processes that will be employed.

As a suggestion, the use of rapid filters and/or modular and pre-engineered treatment plants as discussed for Sanghar would be worth considering.

For water demand management purposes, all main distribution pipes leaving the treatment plant will have bulk flow meters connected to them.

4.6.4 Distribution

The abandoned water supply system should be replaced with a new distribution network, appropriately sized to cater for the projected demand.

As continuously advocated throughout this report, the creation of supply zones and metering them will become an inherent part in improving the water supply system and the overall delivery of service. A commitment by TMAs to water demand management will be very useful to progress these activities.

4.6.5 Shahdadpur Water Demand Management Program

As the development in Shahdadpur could resemble a new system, it would be worth considering using the town to pilot water demand management programs. Shahdadpur can be used by the central cluster towns as a training ground to plan and implement demand management activities and programs where the other cluster town personnel can be inducted into the process. This will have to be properly organized in collaboration with PHED and the TMAs.

There are a numerous activities that are normally performed in isolation but which can be structured into a program where some synergy can be achieved through understanding of their inter-relationships. This promotes active participation and builds cooperation among the people in the organization and enhances organization capacity. With regards to demand management, the following activities will have an impact on the way it is implemented. This highlights the integrated nature of these activities and the importance of addressing them in some structured way.

Further, these are not one-off tasks but are recurring activities, through which improvements in the approaches used can be made and tailored specifically to the communities being serviced and the schemes being managed:

- Collection and creation of customer database
- Customer awareness and community consultation programs
- On-site data capture of systems infrastructures and facilities
- Identification and establishing zones and sub-zones/districts
- Installation of bulk flow meters and boundary valves
- Metering of commercial and industrial customers
- Modeling system performance
- Conduct leak detection and water loss reduction programs
- Develop proactive maintenance programs and activities
- Initiate asset management planning and practices
- Implement customer metering and regularization of illegal connections
- Conduct water audits and develop system-wide water balance

The foregoing list is not conclusive and the activities may not directly lead to improvements in the physical infrastructure. However, through their combined effect, they will strengthen efforts in ensuring that infrastructures are being managed and utilized for the purposes they are meant for.

5.0 ADDITIONAL INFORMATION & DATA

Some useful information that will enhance further development of the sub-projects and help in their feasibility will be required in the following areas:

5.1 Facilities Drawings and System Flow Charts

With existing systems and facilities, the task of recommending improvement works should be much easier. This is because problems can be quickly identified and the most appropriate remedy can be recommended based on the assessments undertaken and the information provided through drawings of the overall systems and facilities. Not all facilities operate the same way although they may be presented as such. Pipe-works within waterworks and treatment plants may be similar but the inclusion (or exclusion) of a valve or valves for example could change the way a process is performed. Clear flow-charts of how the facilities operate will greatly help in these instances.

This applies to all stages of supplying water and not just at treatment plants. Arrangements of the pipe-work at the booster pumping stations and high service reservoirs including clear water tanks are critical so a better appreciation can be acquired on how the existing schemes are supposed to operate. Balancing of the pressure (and flow) in the systems via HSR is an effective practice. How it actually works needs to be defined through a clear presentation of the switching arrangements between HSR and clear water tanks or other system parameters that may be used to control the operations of the HSR/balancing tanks.

5.2 Operations and Maintenance Records

The performance of the schemes can be assessed, through these records. However as recording of operations and maintenance activities are not usually done, some effort to make a start is recommended. Water conservation requirements and the advantages of monitoring water loss is an area where data collection is important and is an activity that should be compulsorily undertaken – both for its importance and to initiate a record keeping practice.

Over time and through regularly performing the activity, the type of data and their source can be expanded to include other aspects of operations. Analyzing the data and interpreting them in terms of systems performance will make these practices meaningful when corrective actions are taken and bear tangible meaningful results. Similarly keeping records of maintenance activities gives specific pointers on weaknesses in the system so appropriate mitigating actions can be planned and decisions on their fitness for service can be determined.

5.3 Water Quality

A comprehensive analysis or results of analysis carried out on the water from the sources being exploited will set the scope for the type of treatment to be adopted. These tests will be conducted to cover the physical, chemical and biological characteristics of the source water. Where is it is absolutely necessary relevant toxicology and/or radiology tests can be performed as well.

Apart from establishing the type of treatment that will be required, these tests can also inform whether the source(s) are worth exploiting. Water quality is mandatory and the most appropriate, simple and effective method should be adopted, where the operators are competent in operating, maintaining and monitoring the process. The most effective and efficient method using the latest technology will guarantee the quality needed for drinking water but if it fails for whatever reason, it is not different from not having any treatment – appropriateness and simplicity of operation should guide thinking in the choice of technology to be adopted, although sometimes they may even have to be trialed before a choice is made.

An offshoot from the water quality testing is an analysis of the sediments contained in the raw water. These are varied and have different properties. With the use of settling basins (raw water storage ponds) their effective operation can be determined from the properties of the sediments transported in the raw water. Having an effective pre-treatment process (settlement in the raw water ponds) is an additional advantage to the down-stream treatment process as less chemicals are used and operator times are reduced in terms of frequency of filter cleaning and back-washing operations.

5.4 Distribution Network Drawings

As earlier mentioned, assessing existing systems should be less daunting as there should be no unknowns. Analysis of an existing pipeline distribution network can immensely ease the process of troubleshooting system performance. But this is only possible if the information on the system is available.

Whether the analysis is undertaken manually or via complex computer software, there are basic data that must be input to the analysis to get meaningful results on how the system is or will perform under different scenarios. The need for this information cannot be emphasized more. Assumed information can be adopted, however for an existing system there is more sense in using actual data.

Drawings of the whole water supply network are the most reliable source of information in existing systems – if they are up-to-date. Details of the pipes (length, material, diameter); tanks (location, dimensions, volume, elevation, water level); valves and fittings (location, type, size, connection details); pump stations (location, piping arrangement, valves, meters, fittings, pump characteristics), and locations and details of installation or critical system components (intakes, treatment works, air valves, scour valves, bulk flow meters). The water supply network is digitally superimposed on a topographic map of the area where identification along the ground can be easily done.

With the relevant information and data, analyzing the system is more convenient. Problem areas can be identified when subjecting the system to different operating scenarios (e.g. demand flows) and possible solutions can be input to the analysis until a balanced system is obtained.

For water loss management, up-to-date pipeline drawings of the system are essential. Supply zones and districts once established can be clearly defined on maps which can then be used to assist with leak detection activities, where all detailed information on pipeline and associated fixtures are available.

Pipeline drawings also provide a visual representation of the assets of the water supply service provider, which is useful for asset management purposes.

5.5 Customer Database

Reliable planning of water supply schemes need information on existing customers and their water consumption habits. Such information is available when customers are metered and are billed for the water they use. As the category or class of customers is varied, they have different consumption levels based on their specific needs.

Information on customers can provide useful pointers on the consumption trends and patterns on a monthly or yearly period, from which daily and weekly rates can be derived. ADD values for example are derived from such database which is normally different for every location depending on factors peculiar to these locations. As the means of verifying consumption is through metering, embarking on a universal metering program should be encouraged and initiated in tandem with these improvement activities.

Customer database also captures information on the location of the customer within a supply area, which is useful for planning purposes as well as systems management in conducting water audits.

The determination of water demand from a system can be more convenient when it is based on the equivalent residential unit (ERU). This basically equates the non-residence or multi-family residence consumption to the equivalent of a single family residential consumption. However these need to be developed over time for a system where there is universal metering and for which there is a system of collecting, storing, retrieving and analyzing data through and effective customer database.

5.6 Hydro-geological Investigations

Development in these cluster towns will continue long after 2037. Populations will continue to grow and demand on the water supply services will increase correspondingly. The need to locate or establish potential raw water sources in these locations is therefore important. While the target demand under these sub-projects is for the next 25years, the results of the hydro-geological investigations should also help town planners to look beyond the current planning horizon. Without departing too much from the focus of these current investigations, it is important for TMAs to capitalize on the ongoing activities for the benefit of their communities and acquire as much information they can acquire for the ongoing hydro-geological investigations.

6.0 RECOMMENDATIONS

The sub-projects discussed in Section 4 are broad and lacking in many details. However, the activities identified and the broad principles laid down to guide the development of sub-projects are relevant. Should any infrastructure improvement activities are to be undertaken in the cluster towns, the activities discussed here will become a part.

Changes to these activities will be considered on the basis of additional information or data that was not previously available but which could affect the overall focus or significant components of the sub-projects.

The overall implication from the foregoing is the want for up-to-date and relevant information on the water supply schemes in the cluster towns. As previously alluded to, these are existing schemes and the task of confirming details of the required improvement works will be made easier once the relevant information is available.

This assessment is not only general but provides insight into the areas where specific information and data may need to be acquired so that the identification of sub-projects can be taken to another level of detail and certainty. On this premise, the engagement of the national water supply engineer will be instrumental to assist in following up on these activities and embark on preparing preliminary designs and cost estimates.

The upcoming survey and mapping program will be critical in finalizing the details of the sub-projects to the point of generating cost estimates with some level of confidence and accuracy.

PHED has a number of ongoing programs in most of the cluster towns. Unfortunately, little is known about their scope and extent, which can be problematic for SCIP-03, when it comes to prioritizing its own program. Discussions should be initiated between PHED and SCIP-03 so the focus of both can be clearly defined leaving little room for duplication of efforts or clash of objectives.

APPENDIX 1: SUMMARY OF ACTIVITIES IN POTENTIAL SUB-PROJECTS

			Physical Infrastructure Improvement Activities				
Stage	**Cluster Town**	**Scheme**	**General**	**Water Quality**	**Water Conservation**	**Non-Physical Improvement Activities**	**Information & Data Requirement**
SOURCE	**Mirpurkhas**	**Jarwari**	• Rehabilitate pump station • Replace pumps & motors with appropriately rated equipment • Replace pipe-work, valves & fittings at suction & discharge ends • Provide emergency power supply • Upgrade all electrical wiring, install control cabinets with auto-switch devices & hour-meters	• Install security fence around pump house including intake at the stilling pond • Install stainless steel grid at entrance to stilling pond	• Replace leaking & aging sections of transmission mains from Jarwari to Satellite Town Water Supply Scheme with consideration for HDPE pipe depending on flow advantage.	• Collect/record pump-hour data • Implement recording of maintenance & operations activities	• Establish safe/allowable source yield/flow • Determine population directly supplied from this source to establish demand
		Mirpur Minor	• Provide emergency power supply	• Raise height of protective wall around perimeter of raw water storage ponds (RWSP) • Install stainless steel grid at entrance to diversion channel leading to RWSP • Install concrete covers on channel leading to RWSP where it traverses farmland & agricultural plots		• Implement recording of maintenance & operations activities at source and intake facilities	• Establish safe/allowable source yield/flow • Determine population directly supplied from this source to establish demand
		West Jamrao		• Install stainless steel grid at entrance to diversion channel leading to RWSP • Install concrete covers to exposed section of raw water intake channels		• Implement recording of maintenance & operations activities at source and intake facilities	• Establish safe/allowable source yield/flow • Determine population directly supplied from this source to establish demand
		East Jamrao		• Install stainless steel grid at entrance to diversion channel leading to RWSP		• Implement recording of maintenance & operations activities at source and intake facilities	• Establish safe/allowable source yield/flow • Determine population directly supplied from this source to establish demand
	Umerkot	**Tharwar**	• Rehabilitate and de-silt all RWSP • Rehabilitate pump station • Replace all inoperable pumps & motors with appropriately rated equipment • Replace pipe-work, valves & fittings at suction & discharge ends • Provide emergency power supply • Upgrade all electrical wiring, install control cabinets with auto-	• Install perimeter fence around RWSP and intake structures to keep humans and animals away	• Repair visible leaks on transmission mains to Umerkot town • Install bulk flow meters at the discharge of each pump at the Tharwar intake • Install pressure gauge on transmission mains to Umerkot town • Install bulk flow meter on transmission mains immediately prior to the Umerkot	• Implement recording of maintenance & operations activities at source and intake facilities • Record pump operating data, flows and pressure	• Produce pipeline drawing of Tharwar intake facilities and route of transmission mains to Umerkot, indicating all valves, fittings, off-takes and pipe inverts

			switch devices & hour-meters • Replace sections of transmission mains that are leaky or susceptible to frequent bursts, with consideration for HDPE pipe • Install air-valves and scour valves along transmission mains to Umerkot town • Construct chambers with heavy concrete covers to house valves		Waterworks storage reservoirs		
		Groundwater	• Clean existing bores, check condition of well-screens & blank casings and replace if necessary • Replace inoperable borehole pumps & motors • Refurbish all electrical wiring, auto-switching & control devices to borehole pump operations, including hour-meters		• Install flow meters at discharge ends of all borehole pumps	• Record pump operating data, flows and pressure • Introduce practices around tube well extraction points to limit human activities relating to crop cultivation, animal husbandry and safe disposal of waste.	• Establish safe yield of existing Umerkot groundwater system
	Tando Allahyar		• Refurbish existing pump house structures • Clean existing wells, check condition of well-screens & blank-casings and replace • Replace associated riser pipe-work, valves and fittings pus other ancillary items • Install emergency power supply to run 2 No. pumps simultaneously during power outage • Replace all power cables, electrical wiring including associated control panels and switching equipment including pump hour-meter at each pump station • Replace hoisting gear for use during maintenance or normal operations • Replace pumps &motors in all three wells with ratings to cater for the anticipated increase in demand, while operating within the safe yield of the groundwater • If Naseer Canal is found drinkable, consider construction of raw water storage ponds with capacity to provide relevant settlement throughput to handle anticipated demand	• If Naseer Canal is favorable, consider installation of modular treatment plants with adequate throughput to handle anticipated demand & high turbidity	• Install flow meters at discharge of each pump • Install level indicators at wells • Replace transmission mains from wells to distribution and to HSR	• Collect/record pumping data relating to flows and operating hours • Implement recording of maintenance & operations activities • Introduce practices around tube well extraction points to limit human activities relating to crop cultivation, animal husbandry and safe disposal of waste.	• Establish safe yield of groundwater system of Tando Allahyar • Confirm actual or realistic population projections for the planning horizon • Acquire details of the 3 No. wells developed by PHED

	Tando Adam		• Clean existing wells, check condition of well-screens and blank-casings and replace • Replace associated riser pipe-work, valves and fittings pus other ancillary items • Install emergency power supply to run 2 No. pumps simultaneously during power outage • Replace all power cables, electrical wiring including associated control panels and switching equipment including pump hour-meter for each pump • Replace pumps and motors in all four wells with appropriate ratings to cater for the anticipated increase in demand, while operating within the safe yield of the groundwater • If Tando Branch Canal is found drinkable, consider construction of raw water storage ponds with capacity to provide relevant settlement throughput to handle anticipated demand	• If Tando Branch Canal is favorable, consider installation of modular treatment plants with adequate throughput to handle anticipated demand & high turbidity	• Install flow meters at discharge end of each pump before going into distribution and to the HSR • Replace transmission mains from wells to distribution and to HSR	• Collect/record pumping data relating to flows and operating hours • Implement recording of maintenance & operations activities • Introduce practices around tube well extraction points to limit human activities relating to crop cultivation, animal husbandry and safe disposal of waste.	• Identify additional groundwater fields in east end to supplement existing sources in the west end • Establish safe yields from potential sources at east end • Investigate potential of nearby Tando Branch Canal as a surface water source • Establish details of PHED water supply improvement initiatives
	Sanghar	**Old and New Intakes Combined**	• Rehabilitate and de-silt all RWSP at the old intake& de-silt RWSP at new intake • Rebuilt pump house at the old intake & refurbish pump house at the new intake • Replace all pumps & motors at the old intake and the inoperable equipment at the new intake with appropriately rated equipment to cater for anticipated demand over the planning period • Replace all pipe-work at pump station including valves & fittings at both intakes • Install emergency power supply • Replace all electrical cabling including control & switching device including hour-meters in vandal-proof cabinets at both intakes	• Protect RWSP areas at both intakes with perimeter fence	• Install flow meters before the discharge manifolds at every pump and before the WTP at the Old Waterworks	• Collect/record pumping data relating to flows and operating hours • Implement recording of maintenance & operations activities	• Establish details regarding the scope & extent of the PHED project to source water from the Mithro Canal 6km away
	Shahdadpur		**In collaboration with PHED and depending on the actual scope of its initiative:**	**In collaboration with PHED and depending on the actual scope of its initiative:**	**In collaboration with PHED and depending on the actual scope of its initiative:**	**In collaboration with PHED and depending on the actual scope of its initiative:**	• Acquire details of the scope and extent of PHED's water supply

			• Rehabilitate & de-silt abandoned RWSP and consider need for additional storage capacity to meet anticipated increase in demand • Rebuild pump station • Install new pumps & motors to cater for anticipated • Renew electrical wiring, control & switching devices including hour-meters. • Renew pipe-work, including valves & fittings	• Protect area around abandoned RWSP with perimeter fence	• Install bulk flow meters at discharge of each pumps	• Collect/record pumping data relating to flows and operating hours • Implement recording of maintenance & operations activities	improvement initiative relating to its proposed source of water • Carry out hydro-geological investigations to establish safe yield of groundwater source as well as that of
TREATMENT	**Mirpurkhas**	**Satellite Town**	• Rehabilitate & de-silt RWSP • Upgrade all electrical wiring & control devices within water treatment plant (WTP) • Install standby power supply • Rehabilitate clear water tanks (CWT) & high service reservoir (HSR) • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Replace pumps & motors with appropriately rated equipment	• Install modular construction treatment plants with high throughput & capacity to handle high raw water turbidity • Upgrade mixing/dosing equipment for chlorination in all-weather, vandal-proof housing with safe storage for chemicals	• Rehabilitate leaking pipe-work, valves & fittings within WTP • Install bulk flow meters on primary distribution line(s) supplying Rewachand BPS and directly into distribution • Install pressure gauges on outlet of pumps at Satellite Town Water Supply System supplying Rewachand BSP	• Train personnel on recording & collection of data in WTP facilities (production, pump-hour, pressure, chemical usage) • Implement recording of maintenance & operations activities • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Determine population directly supplied by this scheme to establish demand
		Mirpur Minor	• Rehabilitate & de-silt RWSP • Upgrade all electrical wiring & control devices • Rehabilitate CWT • Replace pumps & motors with appropriately rated equipment • Rehabilitate pump station structure • Replace pipe-work, valves & fittings at suction & discharge ends of pumps • Upgrade all electrical wiring, install control cabinets with auto-switch devices & hour-meters	• Install modular construction treatment plants with high throughput & capacity to handle high raw water turbidity • Upgrade mixing/dosing equipment for chlorination in all-weather, vandal-proof housing with safe storage for chemicals	• Install bulk flow meter on primary distribution line leaving WTP and/or CWT • Install pressure gauges on outlet of pumps at CWT	• Train personnel on recording & collection of data in WTP facilities (production, pump-hour, pressure, chemical usage) • Implement recording of maintenance & operations activities Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Determine population directly supplied from this source to establish demand
		West Jamrao	• Rehabilitate & de-silt RWSP • Replace pumps & motors with appropriately rated equipment	• Refurbish non-functioning coagulation and flocculation facilities and	• Install bulk flow meter on primary distribution line(s) leaving CWT	• Upgrade operator skills in WTP operations • Train personnel on	• Determine population directly supplied from this source to establish

			• Replace pipe-work, valves & fittings at suction & discharge ends of pumps • Upgrade all electrical wiring, install control cabinets with auto-switch devices & hour-meters	equipment • Refurbish filtration facilities including pipe-work, valving, filter media and backwash system • Upgrade mixing/dosing equipment for chlorination in all-weather, vandal-proof housing with safe storage for chemicals	• Install pressure gauges on outlet of pumps at CWT	recording & collection of data in WTP facilities (production, pump-hour, pressure, chemical usage) • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	demand
		East Jamrao	• Rehabilitate & de-silt RWSP • Replace pumps & motors with appropriately rated equipment • Replace pipe-work, valves & fittings at suction & discharge ends of pumps • Upgrade all electrical wiring, install control cabinets with auto-switch devices & hour-meters	• Refurbish non-functioning coagulation and flocculation facilities and equipment • Refurbish filtration facilities including pipe-work, valving, filter media and backwash system • Upgrade mixing/dosing equipment for chlorination in all-weather, vandal-proof housing with safe storage for chemicals	• Install bulk flow meter on primary distribution line(s) leaving CWT • Install pressure gauges on outlet of pumps at CWT	• Upgrade operator skills in WTP operations • Train personnel on recording & collection of data in WTP facilities (production, pump-hour, pressure, chemical usage) • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Determine population directly supplied from this source to establish demand
	Umerkot	**Umerkot Waterworks & Groundwater system Combined**	• Replace inoperable pumps & motors at the waterworks • Refurbish electrical wiring, control and auto-switching devices • Replace pipe-work, valves & fittings to pumps in pumping station at the waterworks	• Upgrade mixing/dosing equipment for chlorination in all-weather, vandal-proof housing with safe storage for chemicals • Consider modular treatment plant based on PHED planned commissioning of WTP	• Install flow meter on each pump delivering clear chlorinated water directly to the distribution system	• Train personnel on recording & collection of data in WTP facilities (production, pump-hour & chemical usage) • Implement recording of maintenance & operations activities • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Establish details of capacity of WTP under PHED project.
	Tando Allahyar			• Install appropriate chlorination equipment in	• Install flow meter on each pump delivering clear chlorinated	• Train personnel on recording & collection of	• Establish quality of groundwater system with

				all-weather, vandal-proof housing with safe storage for chemicals at the discharge end of the pumps in all tube wells • Consider modular treatment plant if Naseer Canal is to be exploited	water directly to the distribution system	data in WTP facilities (production, pump-hour, pressure, chemical usage) • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	regards to arsenic contamination • Establish quality of Naseer Canal for drinking water purposes
	Tando Adam			• Install appropriate chlorination equipment in all-weather, vandal-proof housing with safe storage for chemicals at the discharge end of the well pumps • Consider modular treatment plant if Tando Branch Canal is to be exploited	• Install flow meter on each pump delivering clear chlorinated water directly to the distribution system	• Train personnel on recording & collection of data in WTP facilities (production, pump-hour, pressure, chemical usage) • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Test quality of groundwater source at east end to establish extent of salinity problem • Establish quality of Tando Branch Canal as potential source of drinking water
	Sanghar	**Old Waterworks (to treat water from both the Old & New Intakes)**		• Install modular treatment plant at Old Waterworks location with high throughput to cater for anticipated increase in demand and capacity to handle high turbidity	• Install flow meter on each pump delivering clear chlorinated water directly to the distribution system	• Train personnel on recording & collection of data in WTP facilities (production, pump-hour, chemical usage) • Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	• Acquire details of PHED water supply improvement initiative reading water treatment
	Shahdadpur		**In collaboration with PHED and depending on the actual scope of its initiative:** • Locate treatment plant near intake facilities if no suitable area is available at Shahdadpur town	**In collaboration with PHED and depending on the actual scope of its initiative:** • Install modular treatment plant at favored location, with high throughput to cater for anticipated increase in demand and	**In collaboration with PHED and depending on the actual scope of its initiative:** • Install flow meter on each pump delivering clear chlorinated water directly to the distribution system	**In collaboration with PHED and depending on the actual scope of its initiative:** • Train personnel on recording & collection of data in WTP facilities (production, pump-hour, chemical usage)	• Acquire details of the scope and extent of PHED's water supply improvement initiative relating to its proposed treatment processes

				capacity to handle high turbidity		• Conduct training on water quality testing • Implement chlorine residual testing & training personnel on chlorine residual test procedures • Procure water quality test equipment & train personnel on use of equipment	
DISTRIBUTION	**Mirpurkhas**	**Satellite Town**	• Rehabilitate CWT & HSR at the Rewachand BPS • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Upgrade pipeline mains supplying Rewachand BPS to HDPE pipe • Replace pipelines identified from the modeling that limit performance of the system • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers	• Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install flow meter to measure volume leaving the Rewachand BPS HSR and CWT • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to the supply zone based on pipeline network drawings & sub-zones or districts within the supply zones • Carry out household and customer census in sub-zones • Model system to identify system limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define the supply area to be covered by the Satellite Town system, without contribution from another source or system • Verify the population that is supplied directly from this system so the demand can be established
		Mirpur Minor	• Replace leaking and aging primary distribution mains with appropriately sized pipes, preferably with HDPE • Replace pipelines identified from the modeling that limit performance of the system • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers	• Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to the supply zone based on pipeline network drawings & sub-zones or districts within the supply zones • Carry out household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define the supply area to be covered by the Mirpur Minor system, without contribution from another source or system • Verify the population that is supplied directly from this system so the demand can be established
		West Jamrao	• Replace leaking and aging primary distribution mains with appropriately sized pipes, preferably with HDPE • Refurbish CWT at Thamsabad Waterworks • Replace pipelines identified from the modeling that limit performance of the system • Replace all non-functioning valves and fittings in the distribution	• Upgrade mixing/dosing equipment at Thamsabad Waterworks for chlorination in all-weather, vandal-proof housing with safe storage for chemicals • Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install bulk flow meter on primary distribution line from West Jamrao to Thamsabad Waterworks • Install bulk flow meter from Thamsabad Waterworks to	• Identify a single inflow point to the supply zone based on pipeline network drawings & sub-zones or districts within the supply zones • Carry out household and customer census in sub-zones • Model system to identify limitations	• Produce pipeline network drawings of the distribution system • Define the supply area to be covered by the West Jamrao system, without contribution from another source or system • Verify the population that is supplied directly from this system so the

			• Refurbish valve chambers and install heavy concrete covers	test locations	whole distribution • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Introduce water loss reduction program and train staff in techniques and methodology	demand can be established • Define the supply area to be served by Thamsabad Waterworks • Verify the population that is supplied directly from Thamsabad Waterworks to establish demand
		East Jamrao	• Replace leaking and aging primary distribution mains with appropriately sized pipes, preferably with HDPE • Connect electricity power supply to Bakra Piri BPS • Replace pipelines identified from the modeling that limit performance of the system • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers	• Install mixing/dosing equipment at Bakra Piri BPS for chlorination in all-weather, vandal-proof housing with safe storage for chemicals • Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install bulk flow meter on primary distribution line from East Jamrao to Bakra Piri BPS • Install bulk flow meter from Bakra Piri BPS to whole distribution • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to the supply zone based on pipeline network drawings & sub-zones or districts within the supply zones • Carry out household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define the supply area to be covered by the East Jamrao system, without contribution from another source or system • Verify the population that is supplied directly from this system so the demand can be established • Define the supply area to be served by Bakra Piri BPS • Verify the population that is supplied directly from Bakra Piri BPS to establish demand
	Umerkot	**Umerkot Waterworks & Groundwater system Combined**	• Refurbish all CWT in the overall distribution to cater for the supply zones that will be served by them • Upgrade pumps and motors in all CWT to cater for the anticipated increase in demand over the planning period in the specific zones they will supply • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Replace pipelines identified from the modeling that limit performance of the system • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers	• Install mixing/dosing equipment at each CWT for chlorination in all-weather, vandal-proof housing with safe storage for chemicals • Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install bulk flow meters from each CWT in the Umerkot distribution system • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to each supply zones & sub-zones or districts within the supply zones based on pipeline network drawings • Carry out household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define overall Umerkot supply area • Identify distinct supply zones in the Umerkot supply area to be served from each CWT throughout the Umerkot distribution • Verify the population that are supplied directly from each CWT throughout the Umerkot distribution
	Tando Allahyar		• Replace pipelines identified from the modeling that limit performance of the system	• Identify fixed locations in distribution to carry out chlorine residual tests,	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge &	• Identify a single inflow point to each supply zones & sub-zones or districts	• Produce pipeline network drawings of the distribution system

			• Replace HSR • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers • Provide for connecting PHED tube wells to the existing Tando Allahyar scheme in anticipation of these facilities being handed over eventually	which will be complemented by random test locations	bulk flow meter at single supply point • Install bulk flow meters from the HSR in the Tando Allahyar distribution system • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	within the supply zones based on pipeline network drawings • Conduct household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Define overall Tando Allahyar supply area • Identify distinct supply zones in the Tando Allahyar supply area
	Tando Adam		• Replace pipelines identified from the modeling that limit performance of the system • Replace HSR • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Replace all non-functioning valves and fittings in the distribution • Refurbish valve chambers and install heavy concrete covers	• Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install bulk flow meters from the HSR in the Tando Adam distribution system • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to each supply zones & sub-zones or districts within the supply zones based on pipeline network drawings • Conduct household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define overall Tando Adam supply area • Identify distinct supply zones in the Tando Adam supply area
	Sanghar	**Old & New Systems Combined in Distribution**	• Replace pipelines identified from the modeling that limit performance of the system • Replace old HSR & increase its capacity including associated pipe-work to cater for increased demand • Refurbish new HSR including pipe-work for risers, valves & fittings • Upgrade pumping/switching arrangements at HSR to properly facilitate balancing tank function • Refurbish valve chambers and install heavy concrete covers	• Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random test locations	• Install boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply point • Install bulk flow meters from the HSRs in the Sanghar distribution system • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions • Regularize all illegal connections	• Identify a single inflow point to each supply zones & sub-zones or districts within the supply zones based on pipeline network drawings • Conduct household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	• Produce pipeline network drawings of the distribution system • Define overall Sanghar supply area • Identify distinct supply zones in the Sanghar supply area
	Shahdadpur		**In collaboration with PHED and depending on the actual scope of its initiative:** • Design appropriate distribution system for Shahdadpur town and accommodate old abandoned facilities • Replace old distribution pipelines	**In collaboration with PHED and depending on the actual scope of its initiative:** • Identify fixed locations in distribution to carry out chlorine residual tests, which will be complemented by random	**In collaboration with PHED and depending on the actual scope of its initiative:** • Identify locations of boundary valves in the hydraulically defined zones. • Install valve, pressure gauge & bulk flow meter at single supply	**In collaboration with PHED and depending on the actual scope of its initiative:** • Identify a single inflow point to each supply zones & sub-zones or districts within the supply zones based on pipeline network	**In collaboration with PHED and depending on the actual scope of its initiative:** • Produce pipeline network drawings of the distribution system for Shahdadpur • Define overall Shahdadpur

		• Install new distribution lines to cater for anticipated increase in demand • Rehabilitate old HSR in Shahdadpur • Install appropriate pumping and switching arrangement to facilitate balancing of flow and pressure through old HSR • Install relevant electrical system to control operations of booster pump at old HSR	test locations	point • Install bulk flow meters from the HSR in the Shahdadpur distribution system • Install flow meters at all industrial, commercial & high consumption service connections including public & social institutions	drawings • Conduct household and customer census in sub-zones • Model system to identify limitations • Introduce water loss reduction program and train staff in techniques and methodology	supply area • Identify distinct supply zones in the Shahdadpur supply area