iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VII Month of publication: July 2020

DOI: https://doi.org/10.22214/ijraset.2020.30363

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

An Approach to Preparation of Detailed Project Report for Drinking Water Supply Scheme

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Abstract: ***Water supply system is a basic infrastructure needed in any human habitation. Therefore, government needs to develop drinking water supply scheme in every human habitation. Keeping this in view, different programs are initiated by central and state governments in India to construct drinking water supply schemes. But, urban local bodies and government agencies involved in construction of water supply schemes lack adequate skills to plan and design the schemes in an efficient manner. This is due to the fact that multi disciplinary skills are needed to plan and design piped drinking water supply scheme. In the research paper, the author high lights the major activities to be performed in preparing detailed project report of a piped water supply scheme. The paper can be an useful guidance to concerned officials of government agencies, urban local bodies and engineering students involved in planning and design of piped water supply schemes.***
Keywords: Source of water, intake works, raw water pumping station, raw water transmission main, water treatment plant, treated water pumping station, feeder mains, storage reservoir, distribution network.

I. INTRODUCTION AND CONTEXT

Drinking water supply system is the most important infrastructure needed in any human habitations. To supply drinking water to every household in India, central and state governments in India have taken up several programs. Some of these programs are under implementation. Success of any water supply scheme depends on adequate planning, engineering design and construction of the scheme. At the same time, planning and design of piped water supply scheme is multi disciplinary in nature and therefore need diverse skills. To plan and design any piped water supply scheme, inputs are needed from water resource engineer, water treatment plant engineer, hydraulic engineer for design of water supply distribution network, structural engineer, mechanical engineer, electrical and instrumentation engineer and quantity surveyor. A team of engineers having different skills as mentioned above needs to work together. In the research paper, the author highlights the different major activities to be performed by the planning and design team in preparing detailed project report of a water supply scheme. The author separately highlights the design criteria to be used in design of major components of a water supply scheme along with selection of material for the water supply scheme.

II. MAJOR ACTIVITIES TO BE PERFORMED FOR PREPARING DETAILED PROJECT REPORT

The major activities to be performed for preparing detailed project report of a piped water supply scheme include the following:

1) Preparation of note on back ground of the proposed scheme: The note needs to justify the need of the proposed water supply scheme with regard to existing situation on water supply.
2) Profiling of project area: Profile of the project area needs to include topography, climate and rainfall, ground water table, geology and soil condition, important institutions, religious and tourist destinations, population growth trend, population density, industrial profile.
3) Study of existing water supply scheme: This needs to includes history of the existing water supply system, description of existing water supply system including present sources of water and head works, raw water pumping station and pumping main, water treatment plant, treated water pumping station, feeder mains from water treatment plant to service reservoirs, service reservoirs, water distribution zones and existing water distribution network, water supply connections and water tariff and water quality.
4) Evaluation of performance of the existing water supply scheme: This needs to be done with respect to service level benchmarks approved by Government of India. Functional status of the components of existing water supply scheme needs to be derived by field investigation. Their rehabilitation needs are to be documented. Evaluation of existing water supply scheme will also involve household survey analysis, water audit and leak detection, flow and pressure measurement in distribution network and energy audit of electrical equipments. Energy audit involves conducting performance test on the existing electrical and mechanical equipments in pumping stations to gauge present operating condition of the motors and pumps installed. Based on the performance tests conducted and data recorded, the results are analyzed for potential savings of electrical power in the pumping systems.

5) Survey and Investigation: This needs to include geo-technical investigation at locations of major components of the water supply scheme, environmental investigation and topographical surveys in project area.
6) Projection of Population in Project Area: This starts with finalising design year of the proposed water supply scheme. Other activities includes population forecasting for project area by all population projection methods for design year, selection of a population projection method appropriate for the project area, assessment of floating population and population of surrounding areas and ward wise population projection. Population projection methods generally used include arithmetic progression method, geometrical progression method, incremental increase method, growth method and graphical method. The appropriate method of population projection is selected based on comparison of projected population figures by all the methods with available census data. Generally, the projection method, whose projected population figures have minimum variation with past census data is the appropriate method.
7) Water Demand Assessment in Project Area: This is done by considering per capita supply for domestic needs, design population, institutional water demand, fire fighting requirement and industrial needs.
8) Finalisation of System Design Criteria: This is to be done for all components of pumping stations, pumping mains and water treatment plant, storage reservoirs, C value in Hazen William's formula for hydraulic design of pipelines, pressure requirement in distribution network, etc.
9) Selection of Material: This needs to be done for all major components of the scheme such as pipelines, valves, pumping machinery, electrical equipment, etc.
10) Proposed Improvement of Water Supply System: This activity includes detailing out required improvement works for all components of existing water supply scheme to meet water demand in design year.
11) Hydraulic design of components of proposed water supply scheme: This activity includes hydraulic design of all components of the scheme such as intake works, raw water pumping stations and transmission mains, water treatment plant, pure water pumping stations and feeder mains to storage reservoirs, sizing of the storage reservoirs and hydraulic design of distribution network from the storage reservoirs.
12) Hydraulic Design of Distribution Network: It includes rezoning of existing distribution network, if needed and hydraulic design of proposed distribution network by using computer software such as WateGems, Epanet or any suitable software. For hydraulic design of water distribution network by using computer software, input data are prepared which includes details of nodes and links. The input data required for nodes is ground elevation, base demand contributing to that node. Input data required for links is length, diameter, and coefficient of roughness (C value) of pipe. The water demand at a node is derived by
13) calculating total length of the pipe network in a water distribution zone, deriving water demand per unit length of pipe network by dividing total water demand of the distribution zone by total length of pipe network in the zone and finding out water demand of each node by multiplying total length of pipes meeting the node with water demand per unit length of pipe network. The software checks the adequacy of the assumed pipe diameter to meet required discharge, velocity and minimum residual pressure required at farthest end or consumer point in distribution system.
14) Structural design of components of proposed water supply scheme: Structural design is needed for civil structures of intake well, shell thickness of large diameter water transmission mains, RCC structures in water treatment plants, large sized valve chambers, approach bridge to intake works of surface water based water supply scheme, storage reservoirs, pipe or saddle supports, anchor blocks at bends of pipelines.
15) Preparation of estimates of proposed works along with description of cost basis: Latest schedule of rates applicable for the location of the water supply scheme needs to be used for finding out rates for items of works. For items, whose rates are not available in project location specific schedule of rates, rates from schedule of rates from other states of the country can be referred. For items, whose rates are not available in any schedule of rates, market rates should be collected. Annual operation and maintenance cost of the water supply scheme also needs to be derived.
16) Preparation of operation and maintenance plan: This involves study of existing O & M system and preparation of plan for preventive maintenance and break down and emergency maintenance. Plan for both types of maintenance will have to be prepared for all components of the water supply scheme.
17) Environmental and social assessment of proposed water supply scheme: This involves environmental profiling of project area, prediction of impact on environment during construction and operation phase, suggesting mitigation measures of environmental impacts by preparing an environmental management plan.

18) Implementation Plan for the water supply scheme: The implementation plan includes contract packaging of all works of the water supply scheme for inviting bids for construction and procurement. It also includes proposed Institutional arrangement for implementation of capital works and operation and maintenance.

III. RECOMMENDATION ON SITE SELECTION AND SYSTEMS DESIGN CRITERIA

Site selection criteria of major components of water supply scheme and design criteria to be used for planning and design of water supply scheme are listed and detailed below:

1) *Selection Of Locations Of Intake Works, Water Treatment Plant, Storage Reservoirs And Alignment Of Major Pipelines:* In planning for any water supply scheme, identification of location of intake works for surface water based water supply scheme is an important and critical activity. For indentifying location of intake works, factors to be considered are water availability at the source location in all seasons and during lean flow period, safety from damage during flood in the river and feasibility of developing approach bridge to intake works from river bank. Equally important activity is the selection of locations of water treatment plant and service reservoirs. In urban water supply scheme, problems are faced in identifying land for water treatment plant and service reservoirs. Ideally, locations of ground level service reservoirs should be at higher elevations, so that gravity based water distribution network can be designed.
2) *Design Period Of Different Project Components:* Overall, design period of 30 years is generally considered for designing proposed improvements of an existing water supply system. However, component wise design periods of the water supply scheme considered are as below:

a) 30 years for civil works of intake works.
b) 15 years with provision of expansion up to a total period of 30 years for water treatment plant.
c) 15 Years for pumping machinery and electrical equipment.
d) 15 Years with a provision of expansion for a period of 30 years for storage reservoirs.
e) 30 years for pumping mains and trunk mains between storage reservoirs.
f) 30 years for distribution network.

3) *Per Capita Demand:* Generally, a per capita demand of 135 lpcd is considered for planning and design of urban water supply scheme. This is the net per capita demand and the gross per capita demand will be higher due to consideration of transmission, distribution and other losses.
4) *Peak Factor In Design Of Transmission Mains And Distribution Network:* Generally, a peak factor of 1.2 is considered for hydraulic design of pumping mains. For water distribution network, the following peak factors are used for different population served by the distribution network:

a) 3 for population less than 50,000
b) 2.5 for a population less than 50,000 to 2,00,000
c) 2 for population above 2,00,000

5) *C Value in Hazen Williams Formula:* The recommended C values to be considered in hydraulic design of pipelines for different pipe materials are as below:
a) Cast iron, Ductile iron and Mild Steel pipes lined with cement mortar or epoxy (up to 1200mm dia pipe): 140
b) HDPE, UPVC, GRP and other plastic pipes: 145

6) *Pressure Requirement in Distribution Network:* For towns, where one-storeyed buildings are common and for supply to the ground level storage tanks in multi-storeyed buildings, the minimum residual pressure at ferrule point considered is 7m. In towns, where two-storeyed buildings are common, minimum residual pressure can be 12m and where three-storied buildings are prevalent, minimum 17m residual pressure is considered. For fire fighting, required pressure is obtained by boosting with fire engines.

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7) *Design Criteria for Water Treatment Plant:* Design criteria for major components of a water treatment plants are given below:

a) *Flash Mixer*

Sl. No.	Parameters	Unit	Range
1.	No. of Units		1
2.	Detention time	Sec.	20-60
3.	Velocity Gradient	Sec^{-1}	300-600
4.	Agitator		Turbine Impeller
5.	Agitator Speed	RPM	100-120
6.	Agitator Material		SS – 316
7.	Ratio of Impeller Dia. to Tank Dia.		0.3-0.5
8.	Ratio of Tank Height and Diameter		1:1 to 3:1
9.	Power Consumption	$Watt/m^3h.$	1– 3
10.	Clariflocculator inlet pipe diameter	M	NA
11.	Velocity at normal flow	m/sec.	-
12.	Velocity at overload	m/sec.	-

b) *Flocculator*

1.	Detention time	Min.	20-30
2.	Floor slope	%	8.33
3	Agitator		Slow-speed turbine,
4.	Agitator speed	RPM	2-5
5	Material of Construction of Agitator		MS, epoxy coated arms with SS-304 shaft for the full length

c) *Clarifier*

1.	Overflow rate for average flow	cum/sqm/day	30 – 36
2.	Overflow rate for peak flow	cum/sqm/day	36 – 44
3.	Side Water Depth	m	3.5 - 3.81
4.	Detention time	Hrs.	2.5
5.	Weir loading rate for average flow	cum/m/day	Within 300
6.	Weir loading rate for peak flow	cum/m/day	Within 360
7.	Scraper Velocity	m/min	2.4 - 3.0
8.	Bottom Floor Slope	%	8.33
9.	Material of Construction of underwater parts		MS, epoxy coated
10.	Diameter of Main Sludge line	mm	200 & 250
11.	Diameter of Auto Sludge line	mm	100
12.	Diameter of Telescopic Sludge line	mm	100

d) Rapid Gravity Filter

1.	Normal Filtration Speed	cum/sqm/hr	4.8
2.	Filtration Speed at Overload	cum/sqm/hr.	6.0
3.	Length to Breadth Ratio		1.25 to 1.33
4.	Air Scouring Rate	cum/sqm/min	0.75
5	Wash Water Rate	cum/sqm/min.	0.60
6.	The velocity ranges in the pipe network:	m/sec.	
	Filter Inlet		0.5 – 0.75
	Filter Outlet		1.0 – 1.5
	Filter Waste		2.0 – 2.2
	Filter wash(Combined Wash)		2.4 – 3.0
	Back Wash Ring Main		3.0 – 3.5
	Vertical Back Wash Down take from Overhead Tank		3.0 – 3.5
	Air Scour		20 – 25
7.	Effective Size of Sand	mm	0.45 – 0.70

8) Depth of Cover to Pipelines: One meter cover on pipe line is normal and generally sufficient to protect the lines from external damage. When heavy traffic is anticipated, depth of cover is increased by considering structural aspects.
9) Minimum Pipe Diameter: Generally, 90mm diameter is considered as minimum size of pipe in distribution network.

IV. MATERIAL SELECTION FOR WATER SUPPLY SCHEME

Selection criteria of material of major components of any water supply scheme are mentioned below:

1) *Pipe Material:* Based on study of different technical parameters such as utility and life span, cost of pipes and availability, mild steel, ductile iron and HDPE pipes are found suitable for use in water supply scheme. Generally, for large diameter pipe above 600mm, internally cement mortar lined and cement mortar out coated or gunited mild steel pipes can be used. For pipe size below 600mm, use of ductile iron pipe is preferred. For pipes in distribution network of below 300mm dia, HDPE pipes can be proposed.
2) *Bulk Flow Meters:* Bulk flow meters are essential for water audit is any water supply scheme. They are to be installed at the locations of major water supply points and major transfer mains. Automatic meter reading (AMR) full bore electromagnetic flow meters with 24 hour battery backup should be installed. Data transmission shall be through data analyzer by use of GPRS or GSM. All bulk flow meters shall be suitable for indefinite immersion under water.
3) *Pressure Gauges:* For monitoring pressures in the local distribution network in the field, pressure gauges should be installed at all important road junctions and at critical points as sudden dips or humps.
4) *Level Indicators:* Float type level indicators needs to be installed at all water storage reservoirs.
5) *Valves in Pipeline:* Different types of valves are used in water supply scheme. The valves are mentioned below.

Sluice valves are provided in the water distribution system for isolating a portion of the distribution network, when needed. These are usually installed on branch pipes for easy operation. By sluice valves, each water distribution zone can be completely isolated to perform maintenance works and repairs. The Indian Standard relating to sluice valves are IS: 780 for valves up to 300mm diameter and IS: 2906 for valves from 350mm diameter to 1200mm diameter.
Butterfly valves are installed to regulate and stop the flow in larger diameter pipes.
Scour valves are installed at the lowest point in any pipeline alignment so that periodically pipelines can be cleaned by draining out water after opening the scour valves.
Kinetic air valves are most commonly used as air valves on pipe line to release water from within pipelines. Presence of air within pipelines can be the cause of serious troubles such as delay in filling of main, reduction in discharging capacity and risk of water hammer.

Non-return valves are used as controlling device to ensure unidirectional flow in pipeline. They are also used in pumping stations to avoid water hammer effect on pipeline.

6) Anchorage in Pipeline: Anchorages are designed and installed in pipelines at bends, tees and crosses to protect the pipe from unbalanced forces.
7) Pumping machinery: In water pumping station, total installed capacity of pumps is for meeting the peak rate of flow with 100% standby. The general practice is to provide two pumps in a pumping station with 100% stand by arrangement, where a single pump gives the full discharge required. For large capacity pumping stations, more than two pumps are provided. Installing vertical turbine pumps in raw water jack well pumping station and the horizontal split casing pumps in pure water pumping system is a general practice.
8) Electrical equipment: The electrical equipment need to be adequate, reliable and safe. The adequacy is determined by the continuous current required for the load and the available short circuit characteristics of the power supply. The reliability depends upon the capability of the electrical system to deliver power. Some of major electrical equipment are as below:
9) High and Low voltage Switchgear: Functions of a switch gear in distribution system include normal and fault switching operations and equipment protection. Considering safety, 11KV HT outdoor sub station is provided. Low voltage i.e., 440 volts, 50H z, 3 phase switchgear are provided for LT motors. The equipment is for indoor installation. The LT panels are to be made of metal clad totally enclosed, rigid, floor mounted, air insulated, cubicle type for use on 415 V, 3 phase, 50 Hz system with a fault level of 50 kA rms. The equipment is designed for operation in high ambient temperatures and high humidity tropical atmospheric conditions.
10) Transformer: Generally, HT 11/0.433 KV ONAN outdoor transformers are provided with suitable KVA according to the load of the pump house. The transformers are operated through gang operated disc-connectors/Switch (GOD/GOS) and the dropout fuses are provided to protect the transformer by overload and short-circuit current. The transformers are sized to provide 100% efficiency. The transformers feed a 415 V distribution board located in the 415V switchgear room.

a) Motors: Selection of type of motors is based various criteria such as constructional features desired and type of duty. Squirrel cage motors are most commonly used up to 250 KW, 3 phase ac. and 415V supply. For motors of rating 225 KW and above, where HT voltages of 3.3 KV, 6.6KV & 11KV can be chosen. The choice shall be made by working out relative economics of investment and running cost, taking in to consideration costs of transformer, motor, switchgear, cables and others. All the motors are to be suitable for continuous duty. When vertical Turbine pump is provided in jack wells, vertical mounted motors are used. When horizontal split casing pumps are used in the pure water pumping station, horizontal foot mounted motors are used. LT motors are used in water treatment plant for alum mixing motors, flash mixer motor, floculator motors and clarifier motor.
b) Cables: The size of the cable is selected in a manner that the total drop in voltage, when calculated as the product of current and the resistance of the cable, shall not exceed 3%. The current carrying capacity should be appropriate for the lowest voltage, and lowest power factor. The cables should be suitable for carrying the short circuit current for the duration of the fault. The HT and LT cables are provided according to the voltage class of the system.

11) *SCADA System:* Wireless Remote Monitoring system or SCADA (Supervisory Control & Data Acquisition) is essential in water supply schemes. The system basically monitors and controls the remote pumping machinery from a control room through wireless GSM network. A device called iRTU (Intelligent Remote Terminal Unit) or PLC (Programmable Logic Controller) is installed at the site, which automatically and independently operates the pumping machinery. The iRTU keeps track of all important conditions and events taking place at site and transmits the data to the Master Control Station.

V. CONCLUSIONS

The technical details as mentioned above can be useful as guide lines for preparing detailed project reports of any piped water supply schemes. By performing all the activities required for preparing a detailed project report, all necessary details for the report will become available. The details will have to be compiled suitably to complete the detailed project report. The compiled details will be different for different water supply schemes.

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Disclaimer: The findings and conclusions presented in the paper are personal opinion of the author.