PUBLIC HEALTH ENGINEERING DEPARTMENT
(PHED)
THE STATE GOVERNMENT OF MANIPUR
THE REPUBLIC OF INDIA

PREPARATORY SURVEY ON IMPHAL WATER SUPPLY IMROVEMENT PROJECT

FINAL REPORT
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IND: Indian Rupee

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ABBREVIATIONS

Abbreviation	Full Name
ACR	Annual Confidential Report
AEE	Assistant Executive Engineer
B/C	Benefit to Cost
BPL	Below Bottom Line
CAD	Computer-Aided Design
CDP	City Development Plan
CPCB	Central Pollution Control Board
CPHEED	Central Public Health Engineering and Environmental Department
CT	Census Town
CZ	Central Zone
DIP	Ductile Cast Iron Pipe
DMAHUD	Department of Municipal Administration, Housing and Urban Development
DPR	Detailed Project Report
EE	Executive Engineer
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EoI	Expressions of Interest
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
GCM	Global Climate Model
GIS	Geographical Information System
GL	Ground Level
GLSR	Ground Level Service Reservoir
ICB	International Competitive Bidding
IFCD	Irrigation and Flood Control Department
IMC	Imphal Municipal Council
IMDD	Information Management and Development Division
IMS	Information Management System
INR	Indian Rupee
IPCC	Inter-governmental Panel on Climate Change

JERC	Joint Electricity Regulation Commission
JICA	Japan International Cooperation Agency
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LC	Local Currency
LCB	Local Competitive Bidding
Lpcd	Littre per Capita per Day
MCC	Magnetic Control Circuit
MD-I	Maintenance I Division
MD-II	Maintenance II Division
MIS	Management Information System
MLD	Million Littre per Day
MoUD	Ministry of Urban Development
MR	Master Reservoir
MSPDCL	Manipur State Power Distribution Company Limited
MSZ	Master Reservoir Zone
NGO	Non-Governmental Organization
NIC	National Informatics Center
NPV	Net Present Value
NRW	Non-Revenue Water
O&M	Operation and Maintenance
OG	Out-Growth
OHT	Overhead Tank
P/Q	Prequalification
PCD	Project Construction Division
PHED	Public Health Engineering Department
PIA	Project Implementation Agency
PIU	Project Implementation Unit
PMC	Project Management Consultants
RFP	Request for Proposals
RSC	Regular Steering committee
SCADA	Supervisory Control and Data Acquisition
SO	Section Officer
STP	Sewage Treatment Plant

SWOT	Strength-Weakness-Opportunity-Threat
TAC	Tender Approval Committee
TEC	Tender Evaluation Committee
UfW	Unaccounted-for Water
VAT	Value-Added Tax
WSZ	Water Supply Zone
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

CHAPTER 1: INTRODUCTION

Background

1. Imphal City, the capital of the State of Manipur, is one of the fastest growing cities in Northeastern India. It is the centre of both cultural and commercial activities in the State. With the growth in the urban population, there has been substantial stress on the available water supply infrastructure, resulting to severe lack of basic and quality water supply services provided to its citizens.

2. The Public Health Engineering Department (PHED), Government of Manipur, is in charge of providing water supply to the urban and rural areas of the State. In response to the need to improve water supply services, it produced the Detailed Project Report (DPR) in 2013, which examined the feasibility of a comprehensive water supply improvement project for Imphal.

3. While not initially proposed in the DPR, the project evolved into three phases with separate funding packages; namely: (i) Phase I project, which has already been sanctioned by the Ministry of Urban Development (MoUD), Government of India for funding under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) program; (ii) Phase II project, which is currently under review by MoUD for implementation under the same funding; and (iii) Phase III project, which PHED is currently seeking funding from the Japan International Cooperation Agency (JICA).

4. It was then mutually agreed between JICA and PHED that a review of the DPR was necessary. Thus, the *Preparatory Survey for the Improvement on Imphal Water Supply Project* was commissioned by JICA not only to review the DPR prepared by PHED, but also to carry out additional investigations to facilitate the formulation of the Imphal Water Supply Improvement Project. This report provides the results of the survey, the outline of the facility design and recommended arrangements for the execution of the Project.

Socio-Economic Conditions in Manipur State

5. The average rainfall at Imphal City is 1,338 mm, and its weather conditions are classified into the dry season (monthly average rainfall of 42.9 mm from October to March) and the rainy season (monthly average rainfall of 159.7 mm from April to September). The monthly average temperature fluctuates in the range of 13.4℃ in January to 26.0℃ in July/August.

6. The topography in Manipur State is mainly divided into two categories of the plain area (that includes Imphal City) and the hilly area (which surrounds the plain area). In the plain area, four river systems flow in the direction of north to south. Of these four rivers, the Thoubal, Iril, and Kongba rivers join downstream and form the Imphal River, which the flows into Loktak Lake.

7. The Manipur State has population of about 2.57 million. About 59% live in the lowland area

and about 41% live in the hilly area. About 38% of the entire state's population is concentrated in Imphal City. The hilly areas are home to the Naga, Kuki, Zomi, and other minority groups; while the lowland area is populated by the Meitei, Mamons, and Pangal tribes. Languages spoken are Meitei, Hindi, and English. In terms of religion, lowland area people are mainly Hindus and Muslims, while hill tribe people are mostly Christians.

8. Manipur is recognized as an agricultural state, and agriculture is the backbone of the economy. Around 76% of the population in Manipur are engaged in agriculture, but only about 9.4% of the area in the state is being cultivated.

9. The Manipur State Power Distribution Company Limited (MSPDCL) operates and maintains the distribution system by the Joint Electricity Regulation Commission (JERC) for Manipur and Mizoram to supply electricity to the consumers in both states. There is currently tight power supply situation observed against power demand in the Manipur State and continuous 24/7 electricity supply is far from being achieved.

CHAPTER 2: PRESENT CONDITIONS OF THE WATER SUPPLY SYSTEM

10. Imphal water supply covers the area of Imphal Municipal Council (Imphal West and Imphal East districts), the surrounding areas such as census towns and outgrowths, the urban fringe area along the main roads and the en-route area of main water transmission pipes. The total population of these areas was 536,267 persons with the total number of households of 114,146 according to Census 2011 data. The number of domestic connections was 20,598, covering around 19.2% of the total households (household size of five persons per household). The served population of Imphal water supply is, therefore, about 102,990 persons.

11. The existing water supply systems in the Imphal city depend mainly on surface water sources, at 90% and include the Imphal River, Iril River, Singda Dam and Leimakhong River. The only groundwater source of the existing water supply system is Potsanbam groundwater.

12. There are currently 19 water treatment plants (WTP) where 13 water supply systems have been formed that supplies water to 25 water supply distribution zones and areas. The existing water supply systems operate on an intermittent basis, and customers generally receive water for only three to four hours on alternate days.

13. Site survey investigations revealed that the existing intake facilities, the WTPs and pumping stations are badly deteriorated. In addition, most of the existing mechanical and electrical equipment are either not well maintained, or are no longer functioning. Flocculation, sedimentation and chemical dosing are not adequately carried out at the WTPs.

14. Survey on existing assets were also made indicating that: (i) existing clear water transmission mains, of approximately 71km in length, are experiencing heavy leakage and frequent pipe failures; and are also undersized to convey required flows; (ii) The existing mains, estimated to be around 319km, are ductile iron pipes although the existence of galvanized iron and cast iron

pipes still prevails. Pipes older than 20 years account for almost half of the existing mains; and (iii) The frequency of the recorded pipe failures is 1.2 incidents / km / year, considered extremely high, exacerbating the interrupted supply and raising concerns about contamination of the piped water.

CHAPTER 3: OPERATION AND MAINTENANCE OF EXISTING WATER SUPPLY FACILITIES

15. The operation and maintenance of the existing water supply facilities falls under three PHED Urban Circle divisions –Maintenance I Division (MD-I), Maintenance II Division (MD-II), and Project Construction Division (PCD).

16. The total of designed capacities of the WTPs is 104.25 MLD and present output is estimated as 81.38 MLD.

17. The revenue water volume can be summarized as following table:

Category	Domestic	Bulk	Tanker	Others	Total Authorized
Water Supply (m^3/day)	13,904	4,915	2,367	3,633	24,819

18. For treatment works, the following are used: aluminum sulphate (alum) as coagulant, slaked lime as alkali agent, and bleaching powder for disinfection. High turbidity and iron during rainy season are issues with regard to water quality.

19. Water quality examinations of samples from WTPs are conducted at State Laboratory Lamphelpat under Monitoring and Environment Division of Planning Circle, PHED.

20. The water service hours are limited to two to three hours depending on the water supply zone. The supply is controlled by manual operation of valves at the water supply facilities.

21. There is no staff responsible for rehabilitation works in PHED, and only minor repair works in WTPs and for pipelines are performed by pipe fitters. There is also no specific equipment for leakage detection being utilized. The unaccounted for water (UfW) is estimated at 70%.

22. Operation and maintenance records, although recorded daily, are not computerized. The data have also not been organized / summarized into monthly or yearly records. Except for some part of MD-I area, the technical and consumer ledgers on maps have not been prepared.

23. The present costs for operation and maintenance for fiscal year 2013-14 is estimated as:

Item	Chemical	Power	Salary	Repair and Maintenance	Total
Annual Amount (INR million)	30.1	50.0	53.9	22.6	156.6

CHAPTER 4: FINANCIAL CONDITIONS OF CURRENT WATER SUPPLY OPERATIONS

24. Manipur Water Supply Act, 1992 (Manipur Act No. 1 of 1993), authorizes PHED to fix any type of water tariff, including flat rate, rates of changes on metered basis, on the basis of number of points installed, or the basis of dimension of water pipe connected. The Government of Manipur has adopted the current flat rate of Rs. 150/connection for domestic users, which went into effect on 1 April 2011.

25. There is no official poverty measure that has been taken into consideration in the water charges, except water supply by public hydrant. Enforcement of water tariff collection from grass roots level is loosely done, since PHED officials recognizes that most people in Imphal come from the low income group.

26. The accounting system of the water supply works is not separate from the general account of the Government of Manipur. In 2013-14, the non-plan expenditure accounts for 42% of total budget of PHED, while the planned expenditure makes up 58%. The largest expenditure item in the non-plan item is regular salary, which accounts for 33% of the total budget.

27. For 2013-14, the revenue of PHED, (tax revenue, tender form fee and penalty from illegal connections) is Rs. 20,950 thousand, of which Rs. 17,524 thousand comes from the Imphal water supply system. For Imphal water supply system, tax revenue in the same year is Rs. 16,647 thousand, accounting for 95% of its total revenue.

28. For 2013-14, the expenditure of PHED is Rs. 1,396 million and around 18% of the expenditure is disbursed to the Imphal water supply system. Breakdown is as follows: 11% of total is for operation and maintenance cost, 48% is allocated to capital investment; and 41% is for non-plan expenditure. Only 8% of the system’s expenditure is covered by own revenue, and the rest is compensated/ subsidized by the Government of Manipur.

29. The PHED issues quarterly bill statement to water users and is delivered by billing and collection staff. However, the bills hardly reach the subscribers due to lack of delivery staff, with only 11 bill clerks covering all the subscribers on record. This means that one staff covers around 1,823 connections in the service area.

30. Most subscribers do not pay water tariff regularly and unpaid balances has accumulated for many. The average water tariff collection rate in Imphal Water Supply area is estimated at only 20% in 2014.

31. Total volume of NRW of three divisions in PHED is estimated at 69.9% of system input volume. However, a more accurate estimation is required through the installation of bulk meters (for detecting sources and volume of losses) and water meters (for assessment of real consumption).

32. In 2012, PHED has started a pilot study on water metering and installed water meter to 584 individual service connections. The connections are equipped by Indian-made water meter, accounting for 4.2% of total domestic connection in the three Divisions.

CHAPTER 5: REVIEW OF FACILITY PLANNING PROPOSED IN DPR

33. The design populations for Integrated Imphal Water Supply are 870,508 and 1,158,086 for the years of 2031 and 2046, respectively, including the floating population.

34. The main concept of the new water supply system in Imphal proposed in the DPR is to create six master reservoir zones along with five independent supply zones. Each of these master reservoirs and independent supply zones consist of its own intake, treatment, transmission and distribution facilities. The Master Reservoir Zone 6 is part of the JICA project scope and is comprised of a new 45 MLD Chingkheiching WTP, associated transmission mains and various overhead tanks.

35. The general arrangement of the new water supply system in the DPR is adequate. It should be noted that Phase I project, under JNNURM fund has already been sanctioned by MoUD, is ongoing, and the contract to rehabilitate the existing WTPs has recently been awarded to a contractor. It is therefore not possible to change the principle of the water supply system proposed in DPR at this stage.

36. Raw water for the new Chingkheiching WTP will be taken from the intake facility at Thoubal Dam located 35 km to the east of the Imphal city. The dam is currently under construction by Irrigation and Flood Control Department (IFCD); but the intake facility has already been constructed. The construction is scheduled to be completed in March 2015.

37. The construction of the new 18.55 km 1000 mm diameter raw water conveyance main, which includes 3.12 km of tunneling section, will commence in December 2014 and will see completion in March 2016. The work is executed by IFCD.

38. In the DPR, the Chingkheiching WTP is proposed at Chingkheiching hill in Nongmaiban district, approximately 8km to the northwest from Imphal City center. This location for the WTP is considered to be the most suitable site because: (i) It is located mid-way from Thoubal Dam to the Imphal city, and (ii) Raw water from Thobal Dam to the new WTP and treated water from the WTP to supply zones can be supplied by gravity.

39. The Chingkheiching WTP is outlined below:

Water Production:	45,000 m^3/day（45 MLD）
Water Source:	Thoubal Dam
Construction Site:	Chingkheiching hill in Nongmaiban
Site Area:	1.95 ha
Proposed GL:	GL + 830.0 m
Treatment Method:	Coagulation-Sedimentation + Rapid Sand Filter Process
Reservoir:	Master Reservoir MR-6 (to be constructed inside of the WTP)
Raw Water Conveyance Main:	Dia 1000mm, L= 18.55 km (Thoubal Dam to Chingkheiching WTP)

40. The construction of the new WTP at Chingheiching hill requires large-scale earth cutting (approximately 750,000 m^3) and the proposed soil disposal site is Lamphel Pat Sewage Treatment Plant, 8.8 km away from WTP. The transportation of the soil would have to be routed through the city center.

41. In this survey, alternative WTP sites were investigated to seek options for mitigating the impact of earth cutting and soil disposal: (i) Alternative Site -1: Situated on low-lying area in the city. With this option, earth removal work can be avoided for the construction of the new WTP; and (ii) Alternative Site -2: Site near the STP. With this site, long distance transportation of large amount of surplus soil can be avoided.

42. The Chingkheiching hill is recommended as the new water treatment plant site because: (i) Construction cost would be lower even if there will be large scale of earth cutting work and a longer distance to transport surplus soil; (ii) Foundation piles will not be necessary in the construction of civil structures; (iii) Water can be transferred to the reservoirs/ OHTs by gravity from Chingkheiching hill; (iv) Transmission pumps will not be required, and the power cost associated with pumping can be avoided; (v) Additional raw water conveyance pipe will not be required; and (vi) Land acquisition is under process.

43. The volume of sludge generated from Chingkheiching WTP is estimated to be 3.6 ton/day. And the sludge will also be disposed the Lamphel Pat STP.

44. The scope of reservoir works under the JICA funded project is summarized in the table below and it was confirmed that most of sites are currently owned by PHED or the state government and that there would be no land issues regarding the construction of the proposed works.

Type of Reservoir	No. to be Constructed	No. to be Rehabilitated
Master Reservoir	2	-
Ground Level Service Reservoir	3	5
Overhead Tank	21	-
Ground Level Emergency Reservoir	11	-
Total	37	5

45. The proposed storage capacity of the new reservoirs was confirmed to be generally adequate. For the overhead tanks, the previous design contained in the DPR was checked, and it also appeared to be adequate. For other reservoir structures, preliminary design was carried out in this survey for the purpose of the project cost estimation.

46. The scope of the transmission mains to be installed under the JICA funded project has been confirmed as shown in the table below. Subsequently, hydraulic modelling was carried out to

determine the pipe diameters of the proposed transmission mains for the project cost estimation. The pipe material for transmission mains was confirmed to be ductile iron.

	Transmission Main Name	Type	Total Length
1.	Transmission mains from MR-6 to various OHTs in the master zone	Gravity Main	32,461m
2.	Transmission mains from MR-2 to Langjing hilltop GLSR, Nepra Menjor OHTs and Thiyam Leikai OHT	Gravity Main	5,931m
3.	Transmission main from MR-2 to GLSRs in Langol zone and Langol Housing	Gravity Main	7,922m
4.	Transmission mains from Old Thumbuthong WTP to Old Thumbuthong Shift 1 OHT	Pumping Main	175m
5.	Transmission mains from Old Thumbuthong WTP to Old Thumbuthong Shift 2 OHT	Pumping Main	460m
6.	Transmission main from MR-2 to Iroisemba hilltop low level GLSR	Gravity Main	570m
7	MR-2 & MR-6 Transmission Main Cross Connection (North) (See **47** below)	Gravity Main	850m
8	MR-2 & MR-6 Transmission Main Cross Connection (South) (See **47** below)	Gravity Main	820m
	Total Length in JICA Project Area		49,189m

47. Cross connection pipes (total length: 1,670 m) between Master Reservoir 2 (MR-2) and Master Reservoir 6 (MR-6) transmission systems were proposed to enhance the resilience of the supply at the time of outage of the master reservoirs. For the MR-2 and MR-6 transmission systems, installation of 21 motorized valves and 26 flow meters on reservoir inlet / outlet pipes were also proposed to monitor and control flows in the transmission systems.

48. It was confirmed that the construction of 11 new pumping stations at the proposed ground level emergency reservoirs and replacing existing pumps at Old Thumbuthong WTP and Moirangkhom WTP are required to be included in the JICA project scope. General arrangement of the pumping stations was outline-designed and the mode of the operation was agreed with PHED.

49. Distribution networks within 21 (out of 26) water supply zones will be developed under JICA. Within these zones, a total of 36 water supply sub-zones were created, and each will be supplied by a single service reservoir. The total length of the distribution main within in the JICA project area is estimated to be 693 km and pipe material was confirmed to be ductile iron.

50. Hydraulic modelling work was carried out to determine required pipe diameters of the distribution mains for each water supply zone and to estimate the construction cost of the new distribution mains. The installation of six pressure reducing valves and 39 distribution flow meters was proposed for network pressure management and monitoring of the network system.

51. Results of ground corrosiveness tests carried out at 20 trial holes exhibit corrosiveness and the soils are considered to be aggressive to ductile iron pipes. Therefore, the use of polyethylene encasement was proposed as a corrosion protection measure and the associated material cost was included in the project cost estimate.

52. Among various pipe material options for service connection pipes, polyethylene pipes was proposed. Also, general arrangement and connection method of the service pipes were proposed and subsequently agreed with PHED. The total number of service connection to be made under the JICA funded project is estimated to be 71,391.

53. A central Supervisory Control and Data Acquisition (SCADA) system will be established at the existing Porompat WTP. The central SCADA system will monitor the entire water supply system dispersed across the water supply service areas in connection with the local SCADA systems, which will be established in 44 remote stations such as the Chingkeiching WTP, the emergency pump stations, the OHTs (overhead tanks), and the GLRs (Ground Level Service Reservoirs).

CHAPTER 6: MANAGEMENT, OPERATION AND MAINTENANCE OF THE IMPROVED IMPHAL WATER SUPPLY SYSTEM

Organisational Assessment

54. The Strength-Weakness-Opportunity-Threat Assessment was undertaken in conjunction with the Need-Gap Analysis to establish the factors that define the current state of PHED given its mandates in the context of current reforms and service standards, then enable the identification of factors required to reach the target state where institutional development interventions can be planned.

55. The results of these analyses show the need for the following: (i) To strengthen the water supply policy framework area through new laws on water resources management, water pollution control, sewerage, and the revision of the Water Supply Act of the State of Manipur 1992; (ii) To undertake amendments premised on improving governance of PHED; (iii) For financing the requirements for water services to move towards immediate recovery of O&M costs; (iv) For autonomy to be given to PHED to implement a tariff structure to fully support its operations; and (v) For PHED to start developing a modern and professional water supply and sewerage sector focused on improving services and being accountable to the customers, and by increasing financial sustainability and independence .

Project Implementation System

55. The project general project implementation framework identifies four project organisations as follows: (i) The Regular Steering Committee (RSC) composed of five stakeholder institutions on the state/ local level charged with the main role of facilitative coordination, particularly

during the project implementation stage, with no supervisory authority; (ii) The Project Implementation Agency (PIA), which is the Public Health Engineering Department of the State of Manipur; (iii) The Project Implementation Unit (PIU), which will be a new unit under the PHED, and (iv) The Project Management Consultants (PMC), who shall be engaged for the duration of the implementation of the project.

56. The PHED is the Project Implementation Agency (PIA) for the Imphal Water Supply Improvement Project. Since PHED has not had any experience implementing a project of the scale and cost as the proposed project under international loan from official development assistance sources, its institutional capacity both as an implementing agency and an implementing unit must be enhanced.

57. To ensure that the project is implemented as envisioned, PHED shall establish the Project Implementation Unit (PIU) within the Department with a staff complement of 22; set up as an adjunct / separate office attached to and directly under the Chief Engineer, PHED, with the Chief Engineer serving as the *de facto* Project Director. The PIU shall be the technical arm in managing, supervising and controlling day-to-day project activities, including the work of the consultants and contractors, project planning and management, construction supervision, environmental management monitoring and control, procurement and disbursements, and report preparation.

58. The Project Management Consultant (PMC) shall be engaged for project implementation/ construction supervision by providing consulting services as prescribed in the *Terms of Reference*, in areas such as preparation of detailed design, financial studies for water tariff determination, tendering, construction and project management services, and pre-operation and maintenance.

59. The roles and responsibilities of the project organisations are shown in the table below:

Responsibility	Project Organization	Level	Institution / Department	Role in Project Implementation
Project coordination	Regular Steering Committee (RSC)	State Level	1. PHED 2. IFCD 3. MAHUD 4. IMC 5. (PMC)	Over-all responsibility for facilitative coordination for Project implementation
Project implementation	Project Implementation Agency (PIA)	State Level	PHED	Organise the PIU; Ensure compliance with Loan Agreement
	Project Implementation Unit (PIU)	State Level	PHED	Directly responsible for undertaking actual field supervision and management of all the aspects of Project implementation
	Project Management Consultants (PMC)	State Level	Attached to PHED	Provides PHED with consulting services in detailed design and /or construction management during project implementation per Contract of Consulting Services

The Need for Enhanced Organisation Structure

60. The PHED organisation structure requires strengthening, improvement and enhancement, to enable it to discharge new and/or expanded activities, functions and tasks, which have come as a result of project completion. These activities are necessary for PHED to evolve/ transform into a modern, service-oriented, and self-reliant water utility leveling up from being a production and distribution utility to a self-supporting utility providing water supply service to the satisfaction of its customers. The re-organised structure is as shown below:

UNIT / DIVISION			SECTION		SUB-SECTION	
No.	Current Name	Proposed Name				
	Superintending Engineer	Superintending Engineer	1	Administration		-
			2	Accounting and Finance		-
1	Maintenance I	Zone I (West)	3	Production	1	Intake and Treatment
					2	Electro-Mechanical
					3	Water Quality
			4	Distribution	4	Network Maintenance
					5	Reservoirs and OHT
			5	Commercial Service	6	Billing and Collection
					7	Service Connection and Metering
					8	Customer Relations
			6	Store		-
2	Maintenance II	Zone II (East)	7	Production	9	Intake and Treatment
					10	Electro-Mechanical
					11	Water Quality
			8	Distribution	12	Network Maintenance
					13	Reservoirs and OHT
			9	Commercial Service	14	Billing and Collection
					15	Service Connection and Metering
					16	Customer Relations
			10	SCADA		-
			11	Store		-
3	Store	Zone III (Central)	12	Production	17	Intake and Treatment
					18	Electro-Mechanical
					19	Water Quality
			13	Distribution	20	Network Maintenance
					21	Reservoirs and OHT
			14	Commercial Service	22	Billing and Collection
					23	Service Connection and Metering
					24	Customer Relations
			15	Store		-
			16	Asset Management		-
			17	Water Audit		-
			18	MIS / GIS		-
			19	Sewerage		-
			20	Drainage		-

61. Functional areas to be strengthened are financial management leading to operational self-sufficiency; customer/ commercial service where the present urban customer base of 20,598 service connections is expected steadily increase to 120,000 in 2022; human resources/ personnel management such as training and capacity development; and operation and maintenance of the existing and the newly constructed water treatment plant, and over 700

kilometres of the new transmission and distribution pipelines to be funded by JICA, reservoirs and overhead tanks through utilisation of MIS/ GIS, asset management, NRW reduction through water audit.

62. The PHED Urban Circle will continue to provide water supply services through zonal division structure. However, instead of the two “Maintenance Divisions”, there will be three “Zone Divisions” where the existing O&M functions of production (intake and WTP) and distribution (network, reservoirs, tanks) will be performed, including newly institutionalized functions. The zones divisions will be named Zone 1 (Southeast) Division, Zone II (Northwest) Division, and Zone III (Central) Division.

63. Other organisational restructuring are: (i) Establishment of Commercial Service Section to perform and fully address commercial services functions/ activities such as service connections, metering, billing and collection, public information / grievance redressal. (ii) The “store” function, which used to be an entire and separate division by itself, will now be subsumed as a zonal division function with the creation of the Store Section; (iii) Establishment of new division from the former Project Construction Division, named as “Information Management and Development Division” to handle vital utility functions on information management systems (IMS) not earlier performed; and (iv) Creation of two new sections, the Administration Section and the Finance and Accounting Section, under the office of the Superintending Engineer.

Streamlining Decision Making Processes

64. The Project shall, in compliance with national state policy and state policy, process and/or call for open tenders for construction / engineering / technical work through the e-Procurement Solution of National Informatics Center (NIC) of the Government of India. Thus, all Expressions of Interest (EoI), Request for Proposals (RFP) for procurement of consulting services, construction works, and notifications for inviting tenders are electronically uploaded / published in the website of the State Government of Manipur under “Tenders”.

65. There is a system / level of approval of tenders for supplies and works specifying (i) The value of the tender; (ii) The name of the supply; (iii) The composition of the Tender Committee; and (iv) The accepting authority. The latest State Government Order dated 7-9-2011 was issued where tender of works of value exceeding Rs 3.00 crore only shall be placed before the Higher Tender Committee in respect of all Engineering Departments, and the accepting authority is the Minister of said engineering department.

66. There are five decision-making procurement processes on procurement proposed to be decentralised, with legal authority from the State:

- **Preparation of procurement-related documents** for each of the packages and the evaluation of all technical proposals received for the various packages under the Project the can be decentralised to the PIU, but shall be actively assisted by the PMC.

- **Technical evaluation** to be performed by the PIU with the assistance of the PMC.
- For the approval of **technical evaluation**, where a Tender Evaluation Committee (TEC) shall be legally created, constituted and given authority from the State under the Chief Engineer, PHED. The notification shall include the list of committee members, set the quorum for meetings, and specify the objective and scope of work of the TEC, which is to approve the technical responsiveness of the bidders for all the packages and recommend for the opening of the Financial Bids of the Substantial Responsive Bidders. Further, every meeting of the TEC shall be fully documented to form part of Project files and for submission to JICA, as required.
- **Cost / financial evaluation** of all cost / financial proposals received for the various packages under the Project shall be performed by the PIU with the assistance of the PMC. The PIU, upon examining all financial proposals received from the responsive bidders, shall send its recommendation to the Tender Approval Committee (TAC).
- The **approval of tenders** for the various packages shall be by the “Tender Approval Committee (TAC)”, which is to be legally created, constituted and given authority in the form of a Notification from the State Government for the establishment of a Tender Approval Committee (TAC) under the PHED Principal Secretary, after which the “accepting authority” shall be the PHED Minister.

67. Action plans for the Imphal Water Supply Project are proposed in this survey to be undertaken by PHED with the assistance of the PMC. It covers various institutional aspects, such as management, operation and maintenance, finance, legislation, natural and social conditions:

- Self-supporting organizational operation
- Preparation of long-term and annual business plans
- Provision of asset ledgers
- Improvement of information management system
- Water tariff revision and improvement of water tariff collection
- Mandatory water meter installation
- Preparation of financial statements
- Customer service
- Human resources / personnel management
- NRW reduction

68. It is proposed that an awareness campaign should be undertaken to support the main action plan. The topics to be taken up for the information / awareness campaign are: (i) Marketing and promotion of service connections for new connections; (ii) Information and education on importance of water metering for new and existing connections; (iii) Benefits received in regularization of illegal connections; (iv) Marketing and promotion of the necessity of payment of water tariff; and (v) Information and education on water conservation meaures

CHAPTER 7: ENVIRONMENTAL AND SOCIAL CONDITIONS

69. The Environmental Clearance for the proposed Chingkheiching WTP was granted from the Directorate of Environment and Ecology, the Government of Manipur, on 10th October 2014. The EC confirmed that there is no need to initiate the EIA procedures for the proposed WTP.

70. The proposed WTP site located on the fringe of Nongmaiching Reserved Forest which is owned by the state government. The transfer of the land ownership from the state government to the PHED will be processed by the application of Forest Clearance. The application of Forest Clearance was made by PHED to the Department of Forest and Wildlife on 27th October 2014. The result of the appraisal is expected after two months.

71. The planned WTP is to be constructed on the slope of Chingkheiching hill which requires large-scale land removal and grading. This will result to exposed/ bare land from by tree cutting activities that may cause the discharge of highly turbid land-drainage water. Re-planting of trees, grass and shrubs on the bare land is proposed to control the land drainage and prevent ground sliding. The construction of a sedimentation pond is also proposed to remove the turbidity of the water that will drain from the bare land.

72. Noise impact by pumps and blower installed at the WTP was examined and the noise equation calculations reveal that excessive noise will not be generated if the equipment are set up in the concrete rooms and the blower is attached with a silencer. In similar manner, noise impact from the pumps of GLSRs and OHTs was also checked with an assumed distance of about 10 m from neighboring houses. The results likewise indicate that if pumps were set in concrete room, noise will not be generated.

73. The project will see the simultaneous construction of the several facilities in several sites in Imphal City – the WTP, transmission and distribution pipelines with OHTs and GLSRs, master reservoirs at many sites. Thus, each Contractor should hire an environmental and work safety manger to control and monitor the environmental and work safety conditions and shall perform the works with the PMC and the PHED.

74. The proposed sites for the WTP, overheads and ground reservoirs are owned by the State government or PHED. These sites are vacant areas and have no inhabitants. Therefore, involuntary relocation and resettlement will not occur.

CHAPTER 8: IMPLEMENTATION PLAN AND PROJECT COST

75. Imphal Water Supply Improvement Project has been divided to three projects / funding packages (namely, Phase-I, II and III projects) by PHED. Phase I project has already been sanctioned by MoUD GOI for the funding under JNNURM, and phase II project is currently under review by them for the same funding. PHED requested JICA to fund Phase III project.

76. The project implementation schedule for the Phase III project is planned as follows:

Project Implementation Item	Timeline
Pledge of JICA Loan	June 2015
Signing of Loan Agreement	July 2015
Selection of PMC for Detailed Design and Construction Supervision	9 months
Detailed Design, Preparation of Specifications	9 months
Contractor Prequalification (P/Q), Evaluation and JICA Concurrence	3 months
Preparation of Tender Documents for Individual Project Components, including JICA Concurrence on Tender Documents	3 months
Project Tender Period	2 months
Evaluation of Contractor Proposals	3 months
JICA Concurrence on Tender Evaluation (Contractor Proposals)	1 month
Contract Negotiation	2 months
JICA Concurrence on Contract Award	1 month
Total Period of Construction Work	60 months
Completion of the Project	December 2022
Defect Notification	12 months

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CHAPTER 9: FINANCIAL AND ECONOMIC ANALYSIS

80. Metered tariff is composed of the basic tariff and the variable tariff. The former is estimated based on the fixed cost whereas the latter is estimated from the variable cost items with the following basic formula for estimating both tariff rates.

Basic Tariff (INR/month) = Fixed Cost (INR/month) ÷ Number of Connection

Volumetric Tariff (INR/m^3) = Variable Cost (INR/year) ÷ Water Production (m^3/year)

81. The willingness to pay (WTP) and the affordability to pay (STP) were obtained from the Social Condition Survey conducted by the JICA Survey Team. Among 321 valid respondents, 45% of household expressed their WTP is INR 150/month, whereas another 45% replied their WTP is INR 300/month. The average WTP is estimated at INR 265/month. Monthly income of below poverty line (BPL) is estimated at INR 7,500/month, and average WTP of this class is INR 159/month.

82. Affordability to pay is usually estimated at 3 to 5% of disposable income, and the lowest figure of 3% is applied in this analysis based on UNDP's guideline. Affordability to pay of the BPL is estimated at INR 225/month, and that of the lowest water consumption class (less than 10 m^3 per month) is INR 1,117/month.

83. Average monthly expenditures of individual connection were estimated and compared with the current tariff level, the WTP and the ATP. The following table shows the proposed water tariff rates of domestic connection. This will be revised in 2022.

Monthly Consumption (m^3)	Basic Charge (INR/ Connection/ Month) (1)	Volumetric Charge (INR/m3) (2)	Average Tax Payment (INR/Connection /Month) (1) + (2)	Reference /a (current payment with infration)		
				Current Payment Level (INR/ Connection /Month)	Willingness to Pay (INR/ Connection /Month)	Affordability to Pay (INR/ Connection /Month)
Less than 10	180	0	180	208	329	1,552
10 to 20	180	20	280	208	395	2,347
20 to 30	180	22	490	208	449	3,230
More than 30	180	24	720	208	834	11,514

Note: a/ Inflation rate of 4.2% per annium is considered.

84. The table shows the proposed water tariff rates of bulk consumers. This will be due for revision in 2022.

Monthly Consumption (m^3)	Basic Charge (INR/Connection/Month)				Volumetric Charge (INR/m3)
	Residential	Institutional	Commercial	Industril	
Less than 100m3	2,030	2,530	2,750	2,770	28
101-200m3	2,030	2,530	2,750	2,770	28
201-300m3	2,030	2,530	2,750	2,770	42
301-500m3	2,030	2,530	2,750	2,770	42
501-800m3	2,030	2,530	2,750	2,770	56
801-1000m3	2,030	2,530	2,750	2,770	56
1001-1500m3	2,030	2,530	2,750	2,770	70
More than 1501m3	2,030	2,530	2,750	2,770	70

85. Even if cost recovery is the basic principle of tariff revision, the introduction of the metered tariff should start from a lower rate/ level. Upon its introduction in 2022, the tariff level should not be much higher than the current tariff level, and the main focus at this time is to let consumers develop the habit of paying water tariff regularly, and for the water that they consume. Then for the next five years, the consumers will enjoy 24/7 safe, adequate and reliable water supply, and will find such a service indispensable. Afterwards, the tariff level could be increased to meet the cost recovery requirement.

86. If the proposed tariff would be approved by the Government of Manipur, the average monthly payment of the BPL households is estimated at INR 180, The amount is within willingness to pay of BPL class (INR 159/month) and the affordability to pay (INR 225/month).. According to the Social Condition Survey in 2014, the BPL class already pays INR 778/month on average to satisfy their water demand from various sources including PHED piped water and tanker supply.

87. The primary revenue is water tariff payment from users, in addition to other operational revenue including connection fee, penalty fee, and tender document fee. Management efforts also generate financial benefits, which include reduction in non-revenue water and O&M cost.

88. The result of financial analysis in terms of FIRR is estimated at 0.4%, and the cost recovery requirements of both O&M and replacement costs are satisfied during the mid-term operation and the long-term operation respectively.

89. The economic analysis was conducted by estimating those economic indicators (EIRR, NPV and B/C ratio). Economic benefits in the economic analysis include (1) Cost Saving from Current Water Acquisition, and (2) Increase in Water Supply Volume.

90. Result of economic analysis in terms of EIRR is 11.5%, NPV is INR 1,665,535 thousand, and B/C Ratio is 1.18. The results indicate that all economic indicators are positive. The policy rate of Reserve Bank of India (India's Central Bank) is 9% in 2014, and with the opportunity cost of capital in India, it can be said that project implementation is economically feasible.

91. The subsidy from the State Government of Manipur to recover the operating cost is not required from the second year of the short-term business plan. However, if to recover all costs including replacement cost, the subsidy is necessary until the second year of the long-term business plan.

CHAPTER 10: OPERATIONAL AND EFFECT INDICATORS

92. The operational and effect indicators for the Imphal Water Supply Improvement project is summarized below:

Category	Name of Indicators		JNNURM Area (Phase-II)		JICA Area (Phase-III)		Entire Service Area	
			Present (2014)	Target (2024)	Present (2014)	Target (2024)	Present (2014)	Target (2024)
Operational Indicators	(A) Population within Service Area	(Pers.)	180,122	204,424	432,368	498,763	612,490	703,187
	(B) No. of Domestic Connections	(Units)	11,001	35,630	9,597	75,954	20,598	111,584
	(C) Served Population = (B) × 5.0	(Pers.)	55,005	178,150	47,985	379,770	102,990	557,920
	(D) Water Production	(m^3/day)	24,430	39,220	56,950	83,340	81,380	122,560
	(E) Production Capacity	(m^3/day)	34,850	39,220	69,400	110,030	104,250	149,250
	(F) Water Consumption	(m^3/day)	11,360	27,984	13,459	58,250	24,819	86,234
	(G) Utilization Rate of Facility (%) = (D) / (E) × 100	(%)	70.1	100.0	82.1	75.7	78.1	82.1
	(H) Ineffective Water Rate (%) = [(D) – (F)] / (D) ×100	(%)	53.5	28.6	76.4	30.1	69.5	29.6
	(I) Leakage Rate (%)	(%)	N/A.	Less than 15%	N/A.	Less than 15%	N/A.	Less than 15%
Effect Indicators	(J) Population Coverage by Water Supply (%) = (C) / (A) × 100	(%)	30.5	87.1	11.1	76.1	16.8	79.3

CHAPTER 11: PROJECT RISK

93. Prior to the commencement of the JICA project, there are some related works to be undertaken by IFCD and PHED; namely, the installation of raw water transmission main from Thoubal

Dam to Chingkheiching Water Treatment plant and the refurbishment and renewal of the existing water supply facilities. At this moment, these works are expected to be completed before the commencement of the JICA project. Even though there may be some delay with the above works, it will take three years for the new WTP to be completed; thus, there will be less risk regarding the timely completion of the raw water transmission to the new WTP.

Chapter 1 Introduction

1.1 Introduction

1.1.1 Background

Imphal city, the capital of the State of Manipur, is a fast growing city and is the centre of cultural and commercial activities in the State. With the growth in urban population, there has been substantial stress on the available infrastructure, including water supply, and there is a severe lack of basic water supply services to the citizens.

The existing water treatment plants in Imphal were constructed between 1960' and 1990's, and most of the civil structures are deteriorated and associated equipment are either damaged or not functioning. Current supply water production for the city is approximately 81Mld against the demand of 114Mld. The existing distribution networks are also old, undersized and heavily leaking, resulting in high level of water loss (over 50%) and contamination of the supplied water. As a consequence, the population of Imphal city are facing hardships due to irregular, unreliable and inadequate supply of water.

In 2007, the Government of Manipur (GoM) prepared the City Development Plan (CDP) for Imphal, which focused on the development of various infrastructure, such as transportation, water supply, sanitation and solid waste management. Regarding Imphal water supply, the document set a target vision of providing the city with safe and sustainable 24x7 water supply to all its citizens at an affordable price. Subsequently, the Public Health Engineering Department (PHED), Government of Manipur, produced the Detailed Project Report (DPR), to propose and examine the feasibility of the water supply improvement project for Imphal.

Imphal Water Supply Improvement Project has been divided into three projects / funding packages (namely, Phase-I, II and III projects) by PHED. Phase I project has already been sanctioned by the Ministry of Urban Development (MoUD), Government of India for funding under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) program. Phase II project is currently under review by MoUD for implementation under the same funding. PHED is now seeking funding from JICA for the implementation of Phase III project.

In October 2013, Japan International Cooperation Agency (JICA) dispatched a mission to Imphal to discuss the project scope, implementing arrangements and requirements for further survey, to review the existing DPR and to carry out supplementary study to facilitate the formation of the project. The implementation of this preparation survey was subsequently agreed upon between PHED and JICA, and the minutes of the meeting was signed on 10^{th} October 2014.

1.1.2 Objective of Survey

The main objective of the Preparatory Survey is to formulate the Imphal Water Supply Improvement Project which is currently listed on the Rolling Plan of the Japanese ODA Loan Projects, by reviewing the existing DPR, carrying out various site surveys and re-assessing the project scope, cost estimate and details of the project components and implementation arrangement.

1.1.3 Survey Area

Imphal city area, State of Manipur

1.1.4 Scope of Work

The scope of work for the Preparatory Survey is as follow:

(1) Survey on the current status of the water supply in the study area, including the following:

1) Current water demand and production
2) Water demand projection
3) Water sources and source output
4) Existing water supply facilities
5) Un-accounted for water
6) Water tariff and status of collection of water charges
7) Effect of climate change on water supply and project execution
8) Delivery routes of construction materials

(2) Outline of the Imphal Water Supply Improvement Project, including the following:

1) Preliminary design of the proposed water supply facilities
2) Confirmation of progress status of related projects
3) Estimation of project costs
4) Confirmation of required sanctions for the project execution
5) Investigations into environmental and social considerations
6) Project implementation schedule
7) Procurement plan
8) Project execution and institutional arrangement
9) Operation and maintenance arrangements
10) Financial planning
11) Decision making process
12) Effects of the proposed project
13) Information Management System

14) Institutional capacity development

15) Project risks and countermeasures

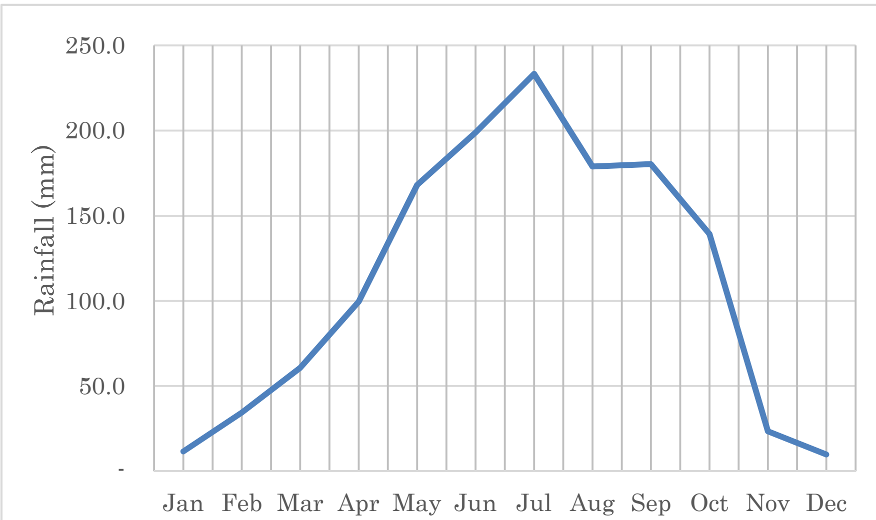
1.2 Socio-Economic Conditions in Manipur States

1.2.1 Natural Conditions

(1) Meteorology

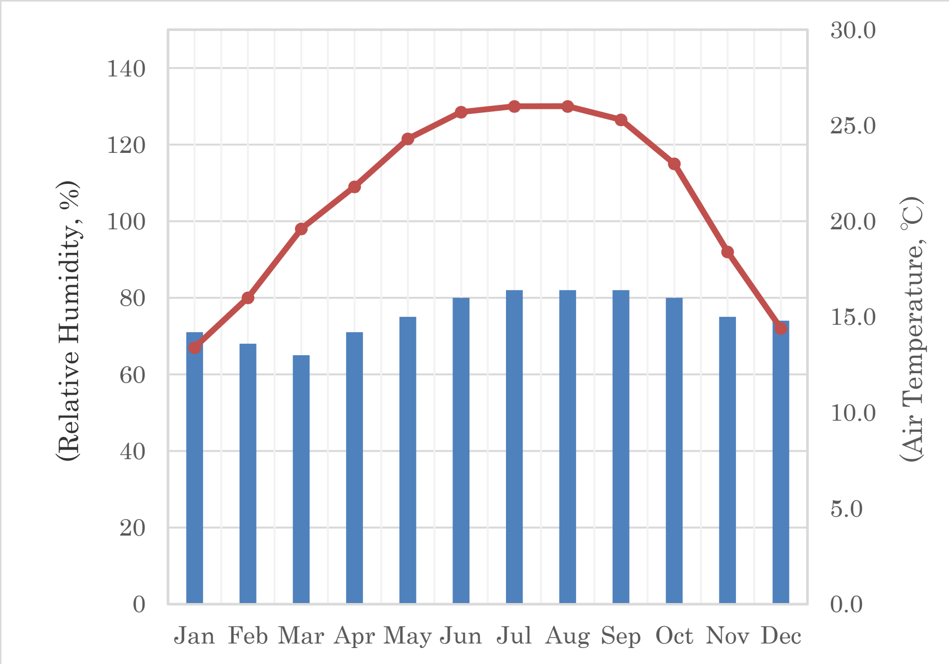
According to the 10-year (2004 to 2013) rainfall data collected at Imphal meteorological station of the Indian Meteorological Department (IMD), the average rainfall at Imphal City is 1,338 mm. The monthly average rainfall fluctuates from 9.9 mm in December to 233.4 mm in July. The weather conditions of the annual year are classified into dry and rainy seasons (local people call it "monsoon" season). The dry season occurs for six months, or from October to March, and monthly average rainfall during this time is 42.9 mm. The rainy season is around for six months, or from April to September, and the monthly average rainfall during this season is 159.7 mm. **Figure 1.1** shows monthly average rainfall.

Monthly average temperature fluctuates in the range of 13.4°C in January to 26.0°C in July and/August. Air temperature in the dry season is lower than that in the rainy season and monthly average temperature in the dry season is 17.5°C and that in the rainy season is 24.9°C. The difference between monthly minimum average temperature and monthly maximum average is 25°C and the monthly maximum and minimum temperatures fluctuate in the range of 29.9°C in June and 4.9°C in January, respectively. On the other hand, monthly relative humidity fluctuates in the range of 58% in March to 80% in June. Relative humidity has tendency to be lower in the dry season and to be higher in the rainy season. **Figure 1.2** shows monthly average temperature and relative humidity.



Source: India Meterological Department

Figure 1.1 Monthly Average Rainfall (2004 – 2013) in Imphal City



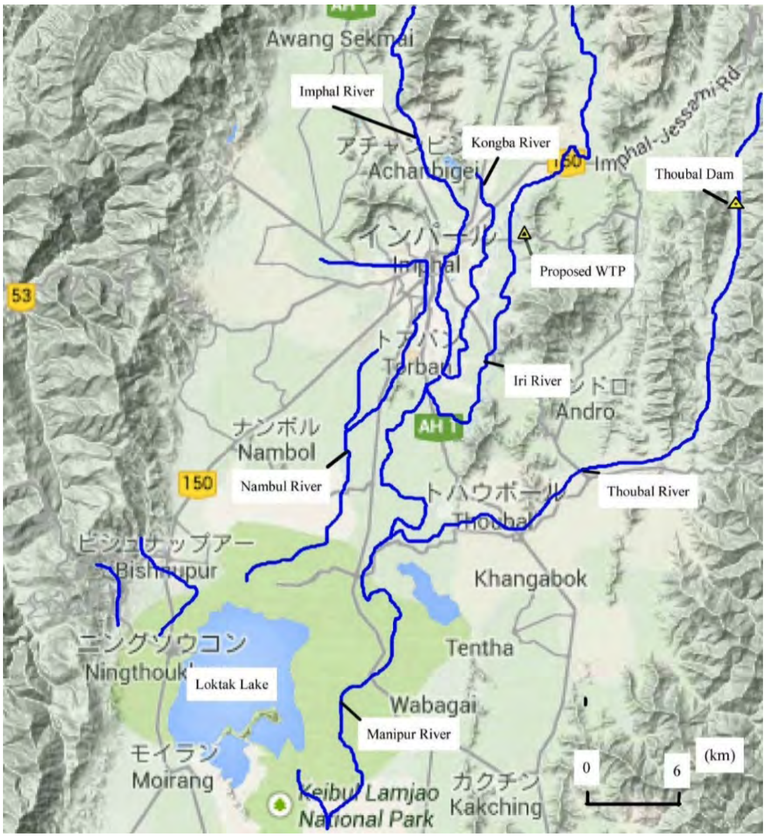
Source: India Meteorological Department

Figure 1.2 Monthly Average Temperature and Relative Humidity (2014 - 2013)

(2) Topography, River System, and Geology

Topography in Manipur State is mainly divided into two categories – the plain area including the Imphal City area and the hilly area surrounding the plain area. The topography of the plain area has no undulation and it is almost flat and has gentle slopes in the south direction of Loktak Lake. The elevation is 783 m in the City center area and 772 m in the periphery area of Loktak Lake. The size of the plain area is about 22 km in the direction of east to west, and about 59 km in the direction of north to south, where Imphal City area occupies a part.

In the plain area, four river systems flow in the direction of north to south and empty into Loktak Lake. Of the four rivers, the Thoubal, the Iri, and the Kongba Rivers join downstream to form the Imphal River, which then flows to Loktak Lake. The width of the rivers is less than 20 m and the rivers have no wide riverbeds with sedimentation of sand and gravel because river water comparatively flows slowly and surrounding hilly area is composed of soft soils. **Figure 1.3** shows conditions of topography and river system. The stream channels around Loktak Lake are not so clear because these originate from large swampy areas and lake surface area fluctuates in the dry and rainy season



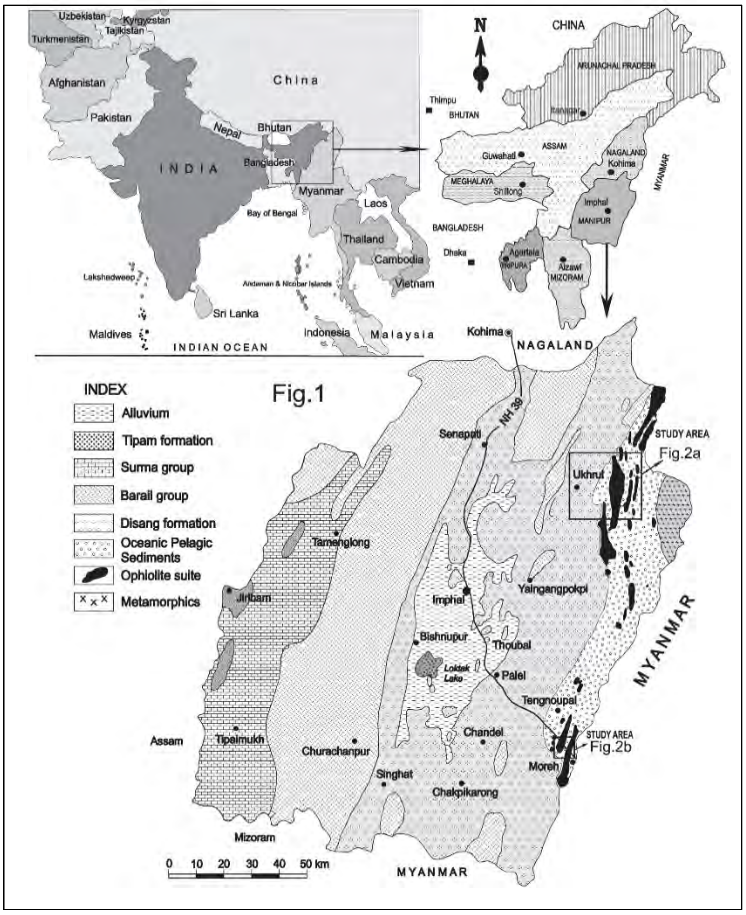
(Including proposed WTP and Thoubal Dam sites)

Figure 1.3 Topography and River System Map in Imphal Area

(3) Geology

The northeastern part of the India, including the Manipur State, belongs to boundary area between the Indian and the Myanmar Plates and constitutes a part of the India-Myanmar orogeny. The flat plain located in the center of the state is covered by the alluvium of the Quaternary. The alluvium is formed by the eroded sediments derived from its surrounded hilly areas and is composed of sand, silt, gravel, boulder and clay.

The surrounding hilly area is mainly tertiary formations, which consist of shale, siltstone, and sandstone etc. Along the national border between the India and the Myanmar, there are the upper formations of Cretaceous consisting of shale and greywacke. The geological map in the Manipur State is shown in **Figure 1.4** and the outline of stratigraphy is in **Table 1.1**. Ophyolite which was formed by ultramafic igneous rocks from eruptions during igneous activity at the initial stage of geosynclune period is distributed along the eastern boundary of the Manipur State.



Source: PGE Distribution in the Ultramafic Rocks and Chromitities of the Manipur Ophiolite Complex, Indo-Myammer Orogenic Belt, Northeast India, (Athokpam Krishnakanta Singn); Jouranl of Geological Society of India, Vol. 72, Nov. 2008, pp649-660

Figure 1.4 Geological Map in the Manipur State

Table 1.1 Outline of Stratigraphy in the Manipur State

No	Formation Name	Geology	Geological Age
1	Quaternary	Sand, Silt, Gravel, Boulder, and Clay, etc.	Recent
2	Tipam Group	Sandstone, Clay	Miocene, Tertiary
3	Surma Group	Alternating layers of shale and siltstone	
4	Barail Group	Sandstone mixed with coarse sand and gravel	Oligocene, Tertiary
5	Disang Group	Shale, Siltstone, and Graywacke	Upper formation: Eocene, Tertiary Lower formation: Lower Eocene to Upper Cretaceous, Mesozoic
6	Pelagic Sediments	Chart, Limestone, Shale, Graywacke	Lower Eocene, Tertiary ～ Cretacesou, Mesozoic
7	Ohyolite （Igneous rocks）	Volcanic rocks with breccia, Pyroxenite, Peridotite etc.	

Source: Geology and Mineral Resources of Manipur, Geological Survey of India, (2011)

1.2.2 Social Conditions

The Imphal Municipal Area governed by the Imphal Municipal Council belonging to both districts of Imphal West and Imphal East. Part of the area is the state capital of Manipur, located at the east end of the northeastern region of India, with a population of approximately 268,000 in a land area of 30.75 $km^{2.}$ It is the centre of culture, commerce and politics of the State.

Manipur is bound by Nagaland to the north, Mizoram to the south, Cachar District of the Assam to the west and the Republic of the Union of Myanmar to the east. Imphal is the city developed in the flat valley with an elevation of about 780 m surrounded by 1,000 m – 2,000 m high mountains. Loktak Lake, with a surface area of 266 km^2, has been designated as a wetland of International Importance under Lamsar Convention in 1990, and is located 35 km south of Imphal.

The decadal growth rate of the State of Manipur was more than 30% during 1961 to 1991, but dropped to more than 20% in 1991 and 2001, and further decreased close to 10% in 2011. This overall trend is the same as that of Imphal, but dropped to more than 10% earlier than the state. Up to now, the growth rate of the state has been over those of Imphal, but in 2011, the growth rate of Imphal exceeded that of the state, a sign of population concentration in Imphal.

Table 1.2 Census Population Movement of Manipur State and Imphal

	1951	1961	1971	1981	1991	2001	2011
Census Population							
Manipur State	577,635	780,037	1,072,753	1,420,953	1,837,149	2,293,896	2,570,390
Imphal West	140,989	178,944	242,060	301,889	380,801	444,382	517,992
Imphal East	89,821	135,594	189,713	255,365	330,460	394,876	456,113
Annual Growth Rate (%)							
Manipur State		3.24	3.24	2.85	2.60	2.25	1.14
Imphal West		3.07	3.07	2.23	2.39	1.56	1.54
Imphal East		3.22	3.22	2.82	2.61	1.80	1.45
Decadal Growth Rate (%)							
Manipur State		37.5	37.5	32.5	29.3	24.9	12.1
Imphal West		35.3	35.3	24.7	26.6	16.7	16.6
Imphal East		37.3	37.3	32.1	29.4	19.5	15.5

Note: The relationship among Imphal West District, Imphar East District, Imphal Municipal Council, Grearer Imphal Area, service area by water supply is shown in **Table 5.1** and **Figure 5.1**.

The Manipur State has population of about 2.72 million and about 59% live in the lowland area while about 41 % live in the hilly area. About 38% of the entire state population is concentrated in Imphal City alone. The hilly area is home to the Naga, Kuki, Zomi, and other minority groups while the lowland area is home to the Meitei, Bamons, and Pangal tribes. The public languages spoken are Meitei, Hindi, and English. People living in the hilly area and the lowland area have different languages so that the common language of trade is the Meitei language.[1]

The religiond of people living in the lowland area are Hindu and Muslim, while people dwelling in the hilly area are Christians who were converted by the British in the 19th century during the colonial period .

The State of Manipur was previously a semi-independent kingdom ruled by a king or maharaja. In 1947, the draft constitution of the Manipur State was formulated and the State of Manipur became a part of India ruled under its first chief minister. However, secessionism or separation from India is still being fought for by some groups since the establishment of the United National Liberation Front in 1961.

1.2.3 Economic Conditions

Manipur is recognized as an agricultural state and agriculture is the backbone of the economy. Around 76% of the population in Manipur are engaged in agriculture but cultivate only about 9.41% of the area in the state. And 52% is reserved in the valley alone. Paddy, pulses, wheat, turmeric, oil seeds, fruits like papaya, orange, banana and vegetables like the tomato, pumpkin, cauliflower; peas, cabbage are grown. In the hilly area, gum, tea, coffee, orange, and cardamom etc. are cropped and in the low land area, rice is cultivated. In the slope of the hilly area, shifting cultivation is conducted.

Nearly 7700 small-scale industries that include cottage industries, village industries, handicrafts as well as handlooms have been set up in Manipur and women take an aggressive part in this industry and play a significant part in the state's income generation. Manipur is famous for its handloom bed sheets, tablecloth, saris, fashion garments and the woven shawls that are made with exclusively Manipuri designs and material.

1.2.4 Power Supply Conditions

The Manipur State Power Distribution Company Limited (MSPDCL) is a licensee or distribution licensee granted the license to operate and maintain a distribution system by Joint Electricity Regulation Commission (JERC) for Manipur and Mizoram and supplies electricity to the consumers in these areas by exclusively undertaking electricity power supply to consumers at 11 kV or below.

There is currently tight power supply situation observed against power demand in the Manipur state just like other states in India. Accordingly, continuous electricity supply (24-hours-aday by 7-days-a-week) has not been achieved yet, but load shedding has to be carried out due to power shortage. In addition, there is fluctuation of electricity supply voltage (less than 360 V in some cases at low voltage supply) observed as well. According to MSPDCL, the power supply condition at the proposed project sites are summarized as follows:

[1] Data from the Department of the Welfare of Minorities and Other Backward Classes

1) Proposed WTP site at Chingkeiching:

- Independent line feasible, 12 hours power supply a day

2) Proposed sites for PSs (Pump Station), GLSRs (Ground Level Service Reservoirs), OHTs (Overhead Tanks)

- Independent lines feasible except Lalmbung, Nempra Menjor, and Nempra Menjor (Thiyam Leikei),
- 24 hour-a-day power supply for Porompat water distribution zone, 12 hours power supply a day for the other water distribution zones

According to JERC Manipur and Mizoram Electricity Supply Code Regulations, electricity power required is supplied at the following power system.

Table 1.3 Electricity Power Required

Low Tension	
All installations with a contracted load up to 8 kW	Single phase at 230 V
All installations with a contracted load above 8 kW and up to 50 kW	3 Phase, 4 wire at 400 V
High Tension	
Contracted load exceeding 59 kVA and up to 2000 kVA	3 Phase at 11 kV
Contracted load exceeding 2000 kVA and up to 10000 kVA	3 Phase at 33 kV
Extra High Tension	
Contracted load exceeding 10000 kVA	3 Phase at 110 kV/ 132 kV

Electricity charges consist of demand charge and energy charge and these are updated every two years by JERC taking into account the revenue and expenditure of the license during the previous two years. The consumers are categorized by supply voltage and power consumption as follows:

Table 1.4 Contract Category of Electricity Consumer

<table>
<tr><td>Contract</td><td>230 V</td><td>400 V</td><td>11 kV</td><td>33 kV</td></tr>
<tr><td>Kutilu Jyoti (low incmer)</td><td>Up to 8kW</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Domestic</td><td>Up to 8kW</td><td rowspan="2"><8kW and 50kW≦</td><td>-</td><td>-</td></tr>
<tr><td>Commercial</td><td>Up to 8kW</td><td><50kVA and 2000kVA≦</td><td><2000kVA and 10000kVA≦</td></tr>
<tr><td>Public lighting</td><td rowspan="4">Up to 8kW</td><td rowspan="4"><8kW and50kW≦</td><td>-</td><td>-</td></tr>
<tr><td>Public water works LT/HT</td><td rowspan="2">Above 50kW</td><td rowspan="2"><2000kVA and 10000kVA≦</td></tr>
<tr><td>Irrigation & Agriculture LT/HT</td></tr>
<tr><td>Small industries</td><td>-</td><td>-</td></tr>
<tr><td>Medium industries</td><td>-</td><td>-</td><td><50kW and 100kW≦</td><td>-</td></tr>
<tr><td>Large industries</td><td>-</td><td>-</td><td rowspan="2"><125kVA and 2000kVA≦</td><td rowspan="2"><2000kVA and 10000kVA≦</td></tr>
<tr><td>Bulk supply</td><td>-</td><td>-</td></tr>
</table>

Source：Tariff Oder 2014-2015 by JERC for Manipur and Mizoram

The electricity charge for the category of Public Water Works has been approved for financial year 2014 to 2015 by JERC as below.

- Fixed charge: 100 Rs/kW-Month for LT and 100 Rs/kVA-Month for HT with 0.85 power factor basis
- Energy charge: 4.9 Rs/kWh for LT and 4.6 Rs/kWh for HT

Chapter 2 Present Conditions of Water Supply System

2.1 Present Service Area and Service Population

Imphal water supply covers the area of Imphal Municipal Corporation composed of Imphal West District and Imphal East District, its surrounding area such as census towns and outgrowths, the urban fringe area along the main roads and the en-route area of main water transmission pipes. The total population of these areas was 536,267 persons for the total number of 114,146 households according to Census 2011 data (say 5.0 persons/HH). The number of domestic connections was 20,598 and the household coverage was only 19.2% with a served population of about 102,990 persons (= 20,598 connections × 5.0 persons/HH).

2.2 Water Sources and Water Supply Zones

The existing water supply systems in the Imphal city are mainly dependent on surface water sources, which account for more than 90% of the water sources in Imphal. Imphal River supplies raw water to 10 existing WTPs, while Iril River supplies raw water to four existing WTPs. Both these rivers flow through the city. Singda Dam, Leimakhong River and Polok River are located to the west of the city and supply raw water to Singda WTP, Kangchup WTP and Kangchup Extension WTP. These WTPs have large production outputs and currently cover a large distribution area.

Less than 10% of the total source output in Impha comes from the Potsanbam groundwater source to the north of the city. The source consists of five tube wells supplying ground water to Potsanbam - I WTP, and five infiltration wells supplying to Potsanbam - II WTP. **Table 2.1** shows output of each water source,

Table 2.1 Summary of Source Output

Source Name	Source Output (Mld)	
	(Mld)	(%)
Imphal River	32.97	31
Iril River	22.70	22
Singda Dam	18.16	17
Leimakhong River	14.53	14
Polok River	9.08	9
Potsanbam Groundwater Source	6.81	7
Total	104.25	100

Note: This table excludes source outputs for Ghari WTP and Lamjaotongba WTP supply zones.

There are currently 13 water supply zones established in Imphal city. The Urban Circle of the PHED operates 11 water supply zones and the Rural Circle (Imphal West Division) is responsible for the rest, namely, Ghari WTP zone and Lamjaotongba WTP zone.

Table 2.2 lists water source, WTP and distribution zones, which form each water supply zone. **Figure 2.1** and **Drawing No**. **IP-WSS-EX-001** shows the boundaries of the water supply zones and main facilities of the existing water supply system.

See supply flow diagrams in **Figure 5.5** for more details of the existing water supply system in each water supply zone.

Table 2.2 Existing Water Supply Zones

No.	WTP Zone	Water Source	WTP	Water Supply Zone (Distribution)
1	Potsanbam and Koirengei WTP Zone	5 nos. of tube wells 5 nos. of Imphal river infiltration wells Imphal River	Potsanbam - I WTP (6.81MLD) Potsanbam - II WTP (6.81MLD) Koirengei WTP (2.27MLD)	Koirengei Zone
2	Singda / Kangchup WTP Zone	Singda Dam, Leimakhong stream, Pollock stream	Singda WTP (18.16MLD) Kangchup WTP (14.53MLD)	Iroisemba Zone, Langjing Zone, Langol Zone, Cheiraoching Zone, Lalambung Zone, Assembly Zone
3	Kangchup Extension WTP Zone	Singda Dam,	Kangchup Extension WTP (9.08MLD)	Nepra Menjor Zone, Sangaiprou Zone, Irom Pukhri Zone, Chingthamleikai Zone, Keishampat Zone
4	Canchipur WTP Zone	Imphal River	Canchipur - I WTP (4.54MLD) Canchipur - II WTP (6.81MLD)	Canchipur Zone, Lilandolampak Zone
5	Irilbung WTP Zone	Iril River	Irilbung WTP (6.81MLD)	Irilbung Zone
6	Porompat WTP Zone	Iril River	Porompat WTP (2.27MLD) Porompat - I WTP (6.81MLD) Porompat - II WTP (6.81MLD)	Porompat Zone, Laiwangma Zone, Sajor Leikai Zone
7	Khuman Lampak WTP Zone	Imphal River	Khuman Lampak WTP (0.54MLD)	Khuman Lampak Zone
8	Minuthong WTP Zone	Imphal River	Minuthong WTP (1.14MLD)	Minuthong Zone
9	Ningthempukhri WTP Zone	Imphal River	Ningthempukhri WTP (4.54MLD)	Ningthempukhri Zone
10	Chinga and Moirangkhom WTP Zone	Imphal River	Chinga WTP (1.14MLD) Moirangkhom WTP (1.0MLD)	Chinga Zone
11	Old Thumbuthong WTP Zone	Imphal River	Old Thumbuthong WTP (2.00MLD)	Old Thumbuthong Zone
12	Ghari WTP Zone	Pond	Ghari WTP	Ghari Rural Supply Area
13	Lamjaotongba WTP Zone	Lubangi River	Lamjaotongba WTP (0.5MLD)	Lamjaotongba Rural Supply Area

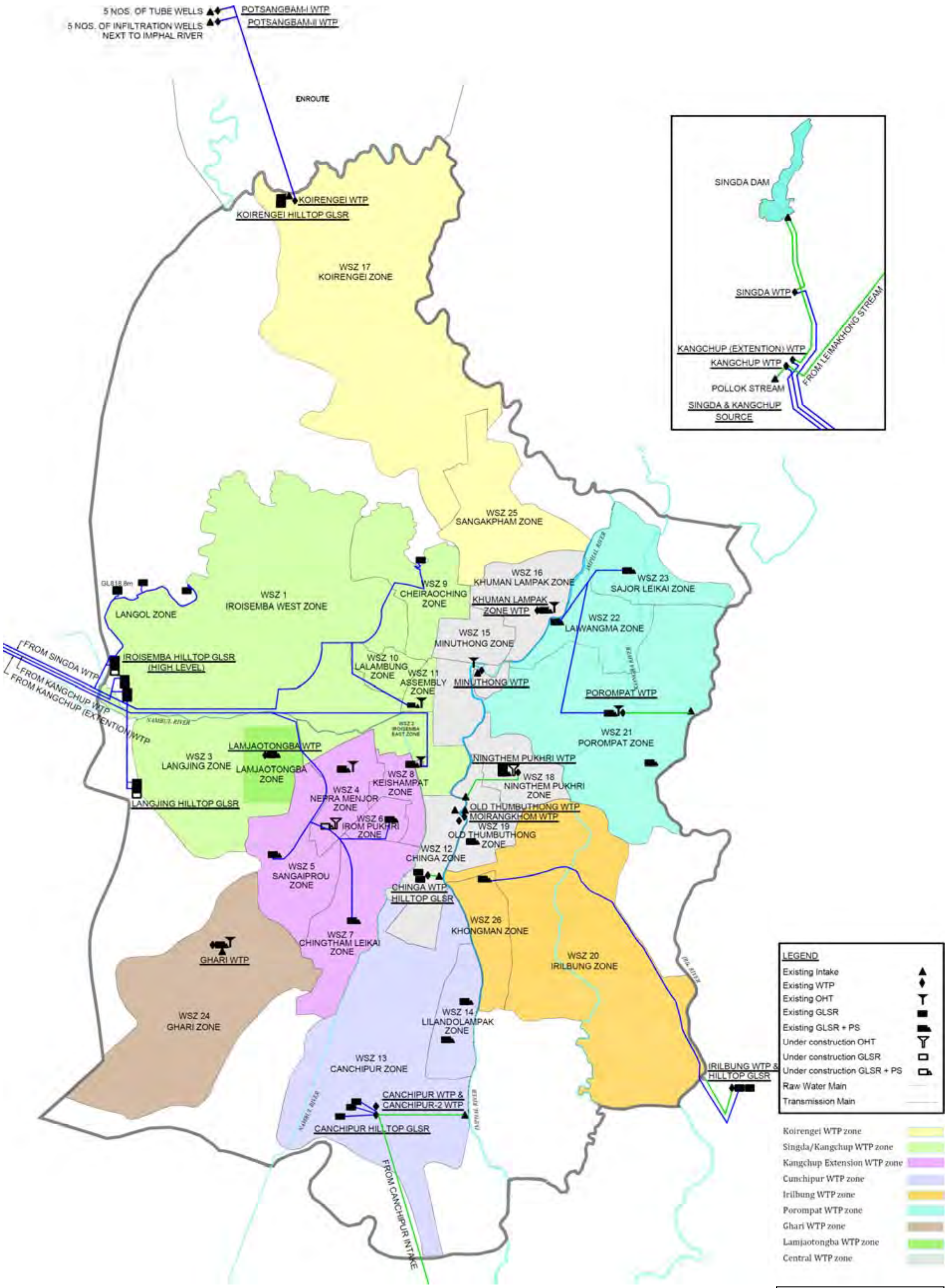


Figure 2.1 Existing Water Supply Zones

Note: Central WTP Zone includes Khuman Lampak WTP Zone, Minuthong WTP Zone, Ningthempukhri WTP Zone, Chinga & Moirangkhom WTP Zone and Old Thumbuthong WTP Zone.

2.3 Intake Works

Reconstruction of existing Intake Works has been proceeding as the Phase-I component of "Integrated Water Supply Project for Imphal Planning Area" by PHED under JNNURM fund. Nevertheless, the study team visited and surveyed Irilbung Intake Work, Ningthempukhri Intake Work and Porompat Intake Work in order to understand the present conditions of these existing intake works and raw water mains.

2.3.1 Irilbung Intake Work (Mechanical Equipment)

Irilbung Intake work is located at the bank of Iril River. There is one single suction volute pump (Mather & Platt Pumps Ltd., India, 426 m^3/hr × 65 m) installed on a steel platform with wheels, which is movable along the levee slope depending on the water level of Iril River. Specifically, the wheels mounted beneath the platform can be driven manually on the two steel rails, which are fixed on the concrete steps on the levee slope (as shown in **Photo 2.1**). Raw water used to be taken from the Intake Tower in the past, but is now presently taken by the pump as mentioned above.

There is a problem in the mechanism, which is unable to cope with rapid fluctuation in river water level. It is preferable to construct a new pumping station in which vertical turbine pumps or submersible pumps will be installed for raw water intake as recommended in the DPR.

Photo 2.1 Raw Water Pump at Irilbung Intake

2.3.2 Ningthempukhri Intake Work (Mechanical Equipment)

Ningthempukhri Intake work is located at the bank of Imphal River. Raw water used to be taken from two Intake Towers in which one vertical turbine pump each has been installed, however these pumps are not functioning at present. Now it is taken by single suction volute pump (details are unknown), which has been installed on the levee as shown in **Photo 2.2**. Since this pump has been installed outside, there is rust observed on the pump case, outer surface of the motor, and pipe and fittings.

Further, there is no standby pump provided.

There is the problem that this pump would be submerged under water in case of river swelling, because it is installed / fixed on the levee slope. It is preferable to construct a new pumping station in which vertical turbine pumps or submersible pumps will be installed for raw water intake as recommended in the DPR.

Photo 2.2 Raw Water Pump at Ningthempukhri Intake Work

2.3.3 Porompat Intake Work (Electrical Equipment)

The Porompat intake work is located at the bank of Iril River. Raw water used is lifted by two vertical turbine pumps; however, these pumps are not functioning at present. It is now taken by a single suction volute pump (details are unknown), which has been installed on the levee provisionally. The raw water pump starter panels are deteriorated, as shown in **Photo 2.3**, hence it is desirable to replace this with new one as soon as possible along with these pumps.

Photo 2.3 Raw Water Pump Starter Panels at Porompat Intake Works

2.4 Water Treatment Plants

2.4.1 Mechanical Equipment

Reconstruction of the existing WTPs has been proceeding as Phase-I component of "Integrated Water Supply Project for Imphal Planning Area" by PHED under JNNURM fund. Nevertheless, the study team visited and surveyed the existing WTPs in order to understand present conditions and problems of the existing WTPs, and to reflect the results of this survey for preliminary design of new Chingkheiching WTP. There are 18 existing WTPs with different water sources in the study area; for example, dam water, surface water and groundwater. Since the water source of Chingkheiching WTP is Thoubal Dam, the study team visited and surveyed the nine representative WTPs including Singda WTP with the same water source as the proposed Chingkheiching WTP. The locations of these WTPs are shown in **Appendix A2.2**.

The results of the field survey are shown in **Table 2.3**. The term of "pattern x" used in the table can be referred to the treatment processes applied on the WTPs, as shown below.

- Pattern 1 (conventional method):
  Cascade Aerator → Flash Mixer → Clariflocculator → Rapid Sand Filter
  → Clear Water Reservoir
- Pattern 2:
  Receiving Well → Grit Chamber → Sedimentation Tank → Flocculator
  → Sedimentation Tank with Tube Settlers → Rapid Sand Filter → Clear Water Reservoir
- Pattern 3:
  Cascade Aerator → Grit Chamber → Flocculator → Sedimentation Tank with Tube Settlers
  → Rapid Sand Filter → Clear Water Reservoir
- Pattern 4:
  Cascade Aerator → Horizontal Flow Baffled Flocculator → Sedimentation Tank with Tube Settlers → Rapid Sand Filter → Clear Water Reservoir
- Pattern 5:
  Cascade Aerator → Sedimentation Tank → Clear Water Reservoir

According to the results of the field survey, there are common problems observed at the nine existing WTPs as follows:

- Chemical dosing flow rate and its dosing ratio are not controlled / managed properly.
- Flocculation and sedimentation are inadequate due to improper chemical dosing as above.
- Operations and maintenance of equipment are inadequate.
- Service time of WTPs (duration of water supply) is limited to short duration.

Hence, it is required to overcome these problems in the preliminary design of Chingkheiching WTP.

Table 2.3 Results of field survey at nine existing WTPs

No.	Name of WTPs	Water source	Outline and Capacity	Problems observed	Evaluation
1	Singda WTP	Dam water Shingda Dam	18.0 MLD as present production, 20.0 MLD as designed capacity, Treatment process; Pattern 1 Completed in 1982	• Chemical dosing equipment is out of service / non functional such that the coagulant and hypochlorite solution are manually dosed by operators without proper control/management of the dosing flow rate along with the dosing ratio. • Flash Mixer is out of service / non-functional. • Flocculation function is insufficient. • De-sludging from the clarifier is insufficient due to malfunction of the sludge collector. • Two out of the four filtration units are out of service / non functional, hence each working unit is overloaded with higher filtration flux rate. • Backwash of filtration unit is insufficient due to malfunction of air blower. • All the equipment seems to have deteriorated considerably.	*
2	Kangchup WTP	Surface water Leimakhong, Pollock Stream	11.62 MLD as present production, 14.53 MLD as designed capacity, Treatment process; Pattern 2 Completed in 2001 (funded by France)	• Chemical dosing equipment is out of service / non-functional, then the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly.	**
3	Kangchup Extension WTP	Dam water Surface water Shingda Dam Pollock Stream	6.81 MLD as present production, 9.08 MLD as designed capacity, Treatment process; Pattern 3 Completed in 2000 (funded by France)	• Chemical dosing equipment is out of service / non-functional then the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly.	**

4	Porompat-I WTP	Surface water Iril River	4.77 MLD as present production, 6.81 MLD as designed capacity, Treatment process; Pattern 1 Completed in 1987	• Chemical dosing equipment is out of service / non-functional the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly. • One of the two flocculators of clariflocculator is out of service / non-functional, hence flocculation is inadequate. • All the equipment seems to have deteriorated considerably.	**
5	Porompat-II WTP	Surface water Iril River	4.77 MLD as present production, 6.81 as designed capacity, Treatment process; Pattern 1 Completed in 1992	• Chemical dosing equipment is out of service / non-functional, then the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly. • Although clariflocculator is working normally, flocculation is inadequate. • All the equipment seems to have deteriorated considerably.	**
6	Ningthempukhri WTP	Surface water Imphal River	2.27 MLD as present production, 4.54 as designed capacity, Treatment process; Pattern 1 Completed in 1980	• Chemical dosing equipment is out of service / non-functional, then the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly. • Flocculation is inadequate due to malfunction of flash mixer and clariflocculator. • One of the three filtration units is overloaded due to its effluent leakage at the trough. • Backwashes of the filtration units are inadequate. • All the equipment seems to have deteriorated considerably.	*

7	Old Thumbuthong WTP	Surface water Imphal River	2.0 MLD as present production, 3.66 as designed capacity, Treatment process; Pattern 4 Completed in 2008	・Chemical dosing equipment is out of service / non-functional, then the chemical dosing flow rate and the dosing ratio are not controlled/monitored properly. ・Flocculation is inadequate in horizontal flow baffled flocculator. ・Sedimentation is inadequate in sedimentation tank with tube settlers.	**
8	Moirangkhom WTP	Surface water Imphal River	1.0 ML as present production 2.24 as designed capacity Treatment process; Pattern 4 Completed in 2008	・Although chemicals are dosed through a dissolution tank, the dosing flow rate and the dosing ratio are not controlled/monitored properly. ・Flocculation is inadequate in horizontal flow baffled flocculator. ・Sedimentation is inadequate in sedimentation tank. ・Operating time of WTP is limited only two hours (6:30～8:30).	**
9	Potsangbam-I WTP	Groundwater	2.72 MLD as present production, 6.81 MLD as designed capacity Treatment process; Pattern 5 Completed in 1995	・Chemical dosing equipment is not provided, and the dosing flow rate and dosing ratio are not controlled/monitored properly. ・Supernatant from sedimentation tank is supplied to clear water reservoir by a temporary submersible pump, due to malfunction of clear water pump. ・All the equipment seem to have deteriorated considerably.	*

Notes: ****; in good condition, ***; possible to be used but not in good condition, **; possible to be used with repair and maintenance, *; unable to use

Source: JICA Study Team

2.4.2 Electrical Equipment

1) Singda WTP

There is a provision of 400V power supply in three-phase four-wire line system from a power distribution company in Manipur, and the power is used in all equipment and lighting at Singda WTP. A transformer has been installed on a pole in Singda WTP to feed power to the electrical room by overhead wire. A watt-hour meter, an incoming panel and distribution panels have been installed in the electrical room as shown in **Photo 2.4** and **Photo 2.5**. More than 30 years have passed since Singda WTP was constructed, hence the incoming panel and distribution panels in the electrical room are deteriorated, and the exposed bus bar in the incoming panel is in dangerous condition. It is desirable that all the electrical equipment be replaced with new ones at the time of reconstruction of the Singda WTP. Static capacitors for improving power factor are not installed, therefore it may be required to pay a penalty in case that the power factor is below 80%. It is compelled to stop all the equipment because a standby generator has not been installed. Furthermore, it is desirable that a starter panel for any equipment be replaced with new ones, because these panels are deteriorated.

Photo 2.4 Watt-hour meter at Singda WTP

Photo 2.5 Incoming and distribution panels at Singda WTP

It is assumed that a raw water flowmeter was installed in Parshall flume before, but there are no flowmeters and indicators at present, as shown in **Photo 2.6**. Loss of head gages for the rapid sand filters have been installed, but these are non-functional at present, as shown in **Photo 2.7**. Gates and valves installed in the filtration units are the manual type, and operators open and close these manually. There is no other instrumentation device provided, therefore operators operate all the mechanical equipment manually.

Since graphic panels for monitoring and/or SCADA system have not been installed, it is desirable that the monitoring control equipment consisting of PLC and PC will be installed at the time of the reconstruction of the Singda WTP.

Photo 2.6 Parshall flume at Singda WTP

Photo 2.7 A loss of head gage for Rapid Sand Filters at Singda WTP

2) Kangchup WTP

A transformer installed in Kangchup WTP feeds 400V power through three-phase four-wire line system to all equipment and lighting within the WTP as shown in **Photo 2.8**. The incoming panel and distribution panels are not deteriorated, and these are in usable condition. Starter panels for any equipment are not deteriorated, and these are also in usable condition as shown in **Photo 2.9**. Treated water flowmeters and loss of head gages for the filtration units have been installed, but these are non-functional at present.

Graphic panels for monitoring and/or SCADA system have not been installed, therefore operators operate all the mechanical equipment manually.

Photo 2.8 Transformer at Kangchup WTP

Photo 2.9 Starter panels for air blower and backwash pump at Kangchup WTP

2.5 Clear Water Pumping Stations

Reconstruction of the existing clear water pumping stations has been proceeding as Phase-II component of "Integrated Water Supply Project for Imphal Planning Area" by PHED under JNNURM fund. Nevertheless, the study team visited and surveyed Porompat-I and Old Thumbuthong clear water pumping stations in order to understand present conditions of these existing pumping stations, and to reflect the survey results into preliminary design of construction and reconstruction of the clear water pumping stations.

1) Porompat-I Clear Water Pumping Station

There have been two single suction volute pumps (details are unknown) installed in Porompat-I clear water pumping station located in Porompat-I WTP as shown in **Photo 2.10** and **Photo 2.11**. One is for water service zone (Porompat Zone), the other is for OHT (concrete-made, with 450 m^3 in capacity) in this WTP.

There are two problems observed in the clear water pumping station: (i) rusting and corrosion are observed on pump case, outer surface of the motor and piping and fittings, and (ii) standby pump is not installed. It is recommended that a standby pump will be installed and kept maintain in a proper manner to improve these problems.

Photo 2.10 Clear Water Pump at Porompat-I (for Porompat Zone)

Photo 2.11 Clear Water Pump at Porompat-I (for OHT)

2) Old Thumbuthong Clear Water Pumping Station

There is one single suction volute pump (Kirolskar Brothers Ltd., India, 306 m^3/hr × 30 m ×45 kW) installed in Old Thumbuthong clear water pumping station located in Old Thumbuthong WTP as shown in **Photo 2.12**. The pump supplies treated water to the service zone (Old Thumbuthong Zone) directly.

There are two problems observed in the clear water pumping station: (i) rusting and corrosion are observed on pump case, outer surface of the motor and attendant piping, and (ii) standby pump is not installed. It is recommended that a standby pump will be installed and maintained in a proper manner to solve these problems.

Photo 2.12 Clear Water Pump at Old Thumbuthong WTP

2.6 Clear Water Transmission Mains

Clear water transmission mains transfer bulk water from production centers to service reservoirs. The existing transmission mains in the supply area are summarized in **Table 2.4**. The total length of the existing transmission mains is estimated to be around 71km. The majority of the clear transmission mains are situated in the Singda, Kangchup and Kangchup WTP supply zones and water from the WTPs are fed into various service reservoirs by gravity. Other transmission mains are pumping mains to lift water from the WTPs to the respective service reservoirs. **Drawing No**. **IP-WSS-EX-001** shows routes of the existing transmission mains.

Table 2.4 Existing Clear Water Transmission Mains

No.	From	To	Pipe Details	Length	Type	Age
1	Singda WTP	Iroisemba Low Level GLSRs	DN500 CI	11.3km	Gravity Main	> 15 years
2	Kangchup WTP	Iroisemba High Level GLSRs	DN500 DI	11.3km	Gravity Main	> 15 years
3	Iroisemba High Level GLSR	Langjing GLSR	DN150 CI	2.3km	Gravity Main	> 20 years
4	Iroisemba	Langol GLSRs	DN200-300 DI	3.2km	Gravity Main	> 10 years
5	Iroisemba	Cheiraoching GLSR and Assembly OHT	DN200-450 CI	9.6km	Gravity Main	> 30 years
6	Kangchup (Extension) WTP	Nepra Menjor GLSR, Sangaiprou GLSR, Irom Pukhri GLSR, Chingthamleikai GLSR, Keishampat GLSR	DN200-400 CI and DI	26.7km	Gravity Main	> 10-20 years
7	Canchipur-1 WTP	Canchipur Hilltop GLSR (1.27Ml)	DN350 CI	0.5km	Pumping Main	> 40 years
8	Canchipur-1 WTP	Canchipur Hilltop GLSR (1.14Ml)	DN200 CI	0.5km	Pumping Main	> 40 years
9	Canchipur-2 WTP	Canchipur Hilltop GLSR (1.36Ml)	DN350 DI	0.8km	Pumping Main	> 20 years
10	Koirengei WTP	Koirengei Hilltop GLSR	DN350 CI	0.6km	Pumping Main	> 40 years
11	Porompat WTP	Laiwangma GLSR and Sajor Leikai GLSR	DN250-300 CI	4.1km	Pumping Main	> 40 years

Note: CI: Cast Iron, DI: Ductile Iron

It has been reported that the existing clear water transmission mains are experiencing heavy leakage and frequent pipe failures. Also, some have inadequate hydraulic capacity to convey required flows. Most of the existing transmission mains are currently planned to be abandoned and replaced with new mains under the Imphal Integrated Water Supply Project.

2.7 Service Reservoirs

There are currently 47 service reservoirs in the supply area and five service reservoirs are under construction by state funding schemes. The existing service reservoirs can be categorised in the following types:

1) Hilltop Ground Level Service Reservoir

These service reservoirs are located on hilltops and they supply water into the distribution by gravity. Some transfer water to downstream service reservoirs further. This type of the reservoir include Koirengei, Iroisemba, Langjing, Canchipur and Irilbung, are of Reinforced Cement Concrete (RCC) construction, and are generally large in capacity.

2) Ground Level Service Reservoir (Pump Suction Tank)

These service reservoirs are situated in the flat plain of the city and provide suction to distribution pumps. Some are located within WTP sites (e.g. Old Thumbuthong WTP) and others are located in the middle of the supply zone, are of RCC construction with capacities generally less than 1.0Ml. A pump house is also located within the sites and the operation of this type of the GLSR is solely dependent on pump operation and power availability.

3) Overhead Tank

There are currently a few RCC overhead tanks and a few steel made overhead tanks in the supply area. These receive gravity or pumped inflows and supply water to its supply zone by gravity. The most common size of the RCC OHT is 0.45Ml and its staging height is 15m. Recently built OHTs have piled foundation, but Porompat OHT, which is one of the oldest, has no piled foundation and appears to be subsided by about 1m. Some existing steel tanks, such as Khuman Lampak OHT, exhibit severe corrosion and require de-commissioning and dismantling for safety reasons.

Photo 2.13 shows some of the existing service reservoirs. lists details of the existing service reservoirs. Refer to **Drawing No**. **IP-WSS-EX-001** for the approximate location of these reservoirs.

The operation of the existing reservoirs currently relies on manual operation. As a general practice, a reservoir outlet valve is kept shut until the reservoir gets filled and the valve is opened to supply water to the zone (e.g. twice a day). An overflow pipe of many service reservoirs is connected to the outlet pipe to divert overflow to the distribution. This practice is only possible for the current intermittent supply as the outlet pipes are empty most of the time. However, at the time of implementing 24 x 7 water supply system, an appropriate overflow system shall be installed at each reservoir to avoid accidental structural damage caused by possible uncontrolled inflows.

	
【Canchipur Hilltop GLSR】 Capacity: 1.36Ml	【Ningthempukhri GLSR】 Pump Suction Tank, Capacity: 0.45Ml
	
【Khuman Lampak OHT】 Steel Construction, Capacity: 0.45Ml	【Keishampat OHT】 RCC Construction, Capacity: 0.45Ml

Photo 2.13 Existing Service Reservoirs

Table 2.5 Existing Service Reservoirs (1)

No	Water Supply Zone	Reservoir Location	Type	Capacity (Ml)	Year of Constructio	TWL (m)	LWL (m)	Remarks
1	Koirengei and Potsangbam WTP	Koirengei Hilltop	RCC GLSR	0.45	-	823.70	820.70	
2	Koirengei and Potsangbam WTP	Koirengei Hilltop	RCC GLSR	0.68	-	818.83	816.03	
3	Singda / Kangchup WTP	Iroisemba Hilltop High Level	RCC GLSR (Circular)	1.53	1965	850.95	847.55	
4	Singda / Kangchup WTP	Iroisemba Hilltop High Level	RCC GLSR (Rectangular)	1.53	1986	851.00	847.65	
5	Singda / Kangchup WTP	Iroisemba Hilltop High Level	Circular Steel Tank GLSR	0.45	1913	No Record	No Record	
6	Singda / Kangchup WTP	Iroisemba Hilltop High Level	Circular Steel Tank GLSR	0.45	1913	No Record	No Record	
7	Singda / Kangchup WTP	Iroisemba Hilltop Low Level	RCC GLSR	4.54	1983	825.83	821.56	
8	Singda / Kangchup WTP	Iroisemba Hilltop Low Level	RCC GLSR	1.81	1986	825.83	821.43	
9	Singda / Kangchup WTP	Iroisemba Hilltop Low Level	RCC GLSR	2.00	2008	825.53	822.08	Under construction
10	Singda / Kangchup WTP	Langol Hilltop No.1	RCC GLSR	0.09	2003	818.57	816.27	
11	Singda / Kangchup WTP	Langol Hilltop No.2	RCC GLSR	0.09	2003	815.54	813.24	
12	Singda / Kangchup WTP	Langol Hilltop No.3	RCC GLSR	0.09	2003	820.24	817.94	
13	Singda / Kangchup WTP	Langjing Hilltop	RCC GLSR	0.45	1989	803.40	800.35	
14	Singda / Kangchup WTP	Langjing Hilltop	RCC GLSR	0.36	1986	807.19	804.04	
15	Singda / Kangchup WTP	Langjing Hilltop	RCC GLSR	0.45	2011	809.92	806.22	Under construction
16	Singda / Kangchup WTP	Cheiraoching Hilltop	RCC GLSR	1.79	1980	823.00	818.00	
17	Singda / Kangchup WTP	Assembly	RCC OHT	0.45	2006	804.70	799.70	
18	Singda / Kangchup WTP	Assembly	RCC GLSR	0.68	2006	No Record	No Record	
19	Kangchup Extention WTP	Nepra Menjor	RCC GLSR	0.63	1988	No Record	No Record	
20	Kangchup Extention WTP	Nepra Menjor	RCC OHT	0.45	2013	800.70	795.70	
21	Kangchup Extention WTP	Sangaiprou	RCC GLSR	0.45	1988	No Record	No Record	
22	Kangchup Extention WTP	Irom Pukhri	RCC GLSR	0.45	1989	No Record	No Record	
23	Kangchup Extention WTP	Chingthamleikai	RCC GLSR	0.45	1986	No Record	No Record	
24	Kangchup Extention WTP	Keishampat	RCC GLSR	0.45	2003	No Record	No Record	
25	Kangchup Extention WTP	Keishampat	RCC OHT	0.45	2011	801.80	796.80	
26	Kangchup Extention WTP	Thiyam Leikai	RCC GLSR	0.45	2012	No Record	No Record	Under construction
27	Kangchup Extention WTP	Thiyam Leikai	RCC OHT	0.45	2013	801.00	796.00	Under construction
28	Canchipur WTP	Canchipur Hilltop	RCC GLSR	1.27	-	816.86	812.76	
29	Canchipur WTP	Canchipur Hilltop	RCC GLSR	1.14	-	816.39	812.44	

Note: Water levels obtained from PHED based on level survey carried out in this survey. The water levels shall be confirmed during the project design stage.

Table 2.5 Existing Service Reservoirs (2)

No.	Water Supply Zone	Reservoir Location	Type	Capacity (Ml)	Year of Construction	TWL (m)	LWL (m)	Remarks
30	Canchipur WTP	Canchipur Hilltop	RCC GLSR	1.36	-	831.70	828.90	
31	Canchipur WTP	Lilando Lampak	RCC GLSR	0.36	-	No Record	No Record	
32	Canchipur WTP	Lilando Lampak	RCC GLSR	0.06	-	No Record	No Record	PS not in operational.
33	Irilbung WTP	Irilbung Hilltop	RCC GLSR	2.72	2007	843.41	840.41	
34	Irilbung WTP	Khongman	RCC GLSR	0.45	-	No Record	No Record	Not in service
35	Porompat WTP	Porompat WTP	RCC OHT	0.45	-	No Record	No Record	
36	Porompat WTP	Porompat Shift 2B	RCC GLSR	2.50	-	No Record	No Record	PS not in operational.
37	Porompat WTP	Laiwangma	RCC GLSR	0.80	-	No Record	No Record	
38	Porompat WTP	Sajor Leikai	RCC GLSR	0.80	-	No Record	No Record	
39	Khuman Lampak WTP	Khuman Lampak WTP	Steel OHT	0.45	1999	No Record	No Record	
40	Khuman Lampak WTP	Khuman Lampak WTP	RCC GLSR	1.40	1999	No Record	No Record	
41	Minuthong WTP	Minuthong WTP	Steel OHT	0.23	1984	No Record	No Record	
42	Ningthempukhri WTP	Ningthempukhri WTP	RCC GLSR (Circular)	0.45	1980	No Record	No Record	
43	Ningthempukhri WTP	Ningthempukhri WTP	RCC GLSR (Rectangular)	0.45	1987	No Record	No Record	
44	Ningthempukhri WTP	Ningthempukhri WTP	RCC OHT	0.45	2013	802.93	797.73	Under construction
45	Chinga and Moirangkhom WTP	Chinga Hilltop High Level	RCC GLSR	1.59	-	816.30	812.50	
46	Chinga and Moirangkhom WTP	Chinga Hilltop Low Level	RCC GLSR	0.40	-	795.00	792.00	
47	Chinga and Moirangkhom WTP	Moirangkhom WTP	RCC GLSR	0.70	-	No Record	No Record	
48	Old Thumbuthong WTP	Old Thumbuthong WTP	RCC GLSR	0.45	-	No Record	No Record	
49	Old Thumbuthong WTP	Old Thumbuthong	RCC GLSR	0.45	-	No Record	No Record	
50	Ghari WTP (Imphal West Division)	Ghari WTP	RCC GLSR	0.11	2003	No Record	No Record	
51	Ghari WTP (Imphal West Division)	Ghari WTP	Steel OHT	0.45	1982	No Record	No Record	
52	Lamjaotongba WTP (Imphal West Division)	Lamjaotongba WTP	RCC GLSR	0.25	2005	No Record	No Record	

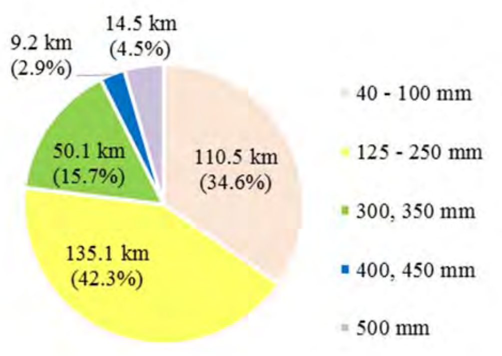
Note: Water levels obtained from PHED based on level survey carried out in this survey. The water levels shall be confirmed during the project design stage.

2.8 Distribution Mains

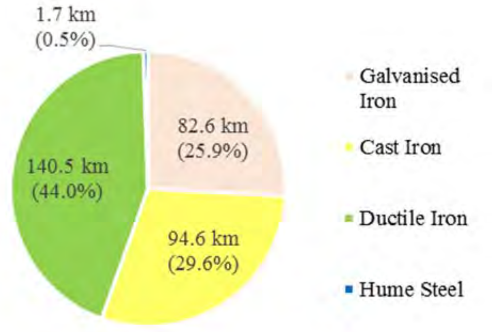
(1) Statistics of Existing Distribution Mains

At the time of the production of the DPR in 2007, details of the existing mains were collected and detailed analyses of all the pipes with reference to the length, age and materials were carried out. The DPR contains a summary of the collected data and analysis. The DPR also states that the total length of the existing distribution mains was 223km (as of 2008), although there were no further details available, such as locations of the existing mains.

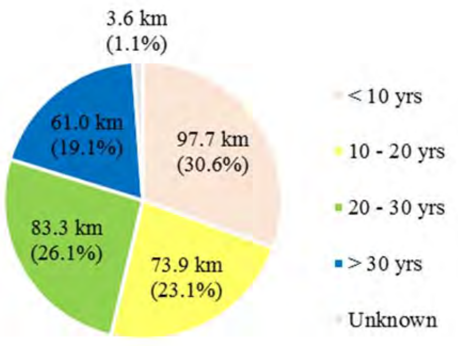
During this survey, the existing distribution network data was re-collected to ascertain the details of the existing distribution mains. **Table 2.6**, **Table 2.7** and **Table 2.8** show zone-wise pipe length details per pipe diameter, material and age respectively. The total length of the existing mains is estimated to be around 319km. **Figure 2.2 s**hows three pie charts, in which pipe lengths per different pipe diameter, material and age in the whole existing supply zone are illustrated.



a) Pipe Lengths per Pipe Diameter



b) Pipe Lengths per Pipe Material



c) Pipe Lengths per Pipe Age

Figure 2.2 Breakdown of Existing Distribution Pipe Lengths

From these charts, the following are evident:

- Although it appears that ductile iron pipes are widely used, the existence of galvanised iron pipes and cast iron pipes is still prevalent.
- Pipes older than 20 years old account for almost half of the existing mains.

Table 2.6 Details of Zone-wise Pipe Lengths per Pipe Diameter

WS Zone No.	WS Zone Name	Pipe Length per Pipe Diameter (m)															Total (m)
		40	50	60	65	80	100	125	150	200	250	300	350	400	450	500	
1	Iroisemba Evening	0	887	0	6,028	1,371	6,297	2,220	2,990	3,342	0	3,718	0	1,175	3,026	9,619	40,674
2	Iroisemba Morning	0	0	0	0	1,349	1,148	0	1,289	1,651	0	0	0	0	0	0	5,438
3	Langjing	0	129	0	0	803	1,592	8,710	1,447	2,597	0	3,009	1,132	2,015	0	0	21,434
4	Nepra Menjor	0	641	0	0	4,317	4,315	0	12,779	5,110	0	0	0	0	0	0	27,162
5	Sangaiprou	0	0	0	0	2,596	3,679	654	4,446	985	0	4,266	0	0	0	0	16,626
6	Irom Pukhri	0	0	0	0	603	2,713	0	610	0	0	1,726	0	0	0	0	5,652
7	Chingthamleikai	0	0	0	183	2,269	3,494	0	2,480	1,314	0	4,016	0	0	0	0	13,756
8	Keishampat	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
9	Cheiraoching	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
10	Lalambung	0	0	0	0	0	1,697	0	1,267	1,392	0	0	0	0	0	0	4,356
11	Assembly	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
12	Chinga	0	158	0	723	3,836	3,108	398	2,612	5,812	0	1,325	2,435	841	0	0	21,247
13	Canchipur	0	0	0	0	652	13,170	0	6,469	9,230	0	5,799	1,009	2,119	0	0	38,448
14	Lilandolampak	0	0	0	0	0	1,136	0	4,443	399	0	0	0	0	0	0	5,978
15	Minuthong	627	1,414	0	1,455	304	3,046	2,168	1,418	543	0	559	0	0	0	0	11,534
16	Khuman Lampak	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
17	Koirengei	0	0	0	0	0	3,958	0	0	5,531	0	6,862	0	0	0	0	16,351
18	Ningthepukhri	0	0	0	0	0	507	757	6,702	320	1,726	976	0	0	0	0	10,988
19	Old Thumbuthong	0	0	0	0	0	1,450	254	336	2,479	0	0	0	0	0	0	4,520
20	Irilbung	0	0	0	0	0	1,316	496	5,172	1,578	0	1,130	0	0	0	4,892	14,582
21	Porompat	0	0	0	810	298	13,811	794	3,494	5,263	3,498	9,166	1,215	0	0	0	38,348
22	Laiwangma	0	0	0	0	0	5,531	0	373	1,596	3,346	1,729	0	0	0	0	12,575
23	Sajor Leikai	0	0	0	0	165	1,087	0	0	1,496	828	0	0	0	0	0	3,575
24	Ghari	0	1,220	0	548	3,403	0	0	0	0	0	0	0	0	0	0	5,170
25	Sangakpham	0	0	0	0	0	700	290	0	0	0	0	0	0	0	0	991
26	Khongman	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Total (m)		627	4,450	0	9,747	21,964	73,754	16,741	58,328	50,638	9,397	44,279	5,791	6,150	3,026	14,511	319,403

Note: 1) Potsanbam & Koirengei WTP Zone , Singda / Kangchup WTP Zone , Kangchup Extention WTP Zone , Canchipur WTP Zone , Irilbung WTP Zone , Porompat WTP Zone , Ghari WTP Zone
Central WTP Zone (including Khuman Lampak WTP, Minutong WTP, Ninghempukhri WTP, Chinga & Moirangkhom WTP, Old Thumbuthong WTP), 2) See Figure 2.1 for the locations of WTP zones.

Table 2.7 Details of Zone-wise Pipe Lengths per Pipe Material

WS Zone No.	WS Zone Name	Pipe Length per Pipe Material (m)				Total (m)
		GI	CI	DI	HS	
1	Iroisemba Evening	10,117	12,531	17,453	573	40,674
2	Iroisemba West	1,965	679	2,794	0	5,438
3	Langjing	2,524	12,289	6,622	0	21,434
4	Nepra Menjor	5,874	3,175	18,113	0	27,162
5	Sangaiprou	5,356	6,242	5,029	0	16,626
6	Irom Pukhri	2,933	2,146	552	0	5,632
7	Chingthamleikai	5,946	3,068	4,741	0	13,756
8	Keishampat	No Data	No Data	No Data	No Data	No Data
9	Cheiraoching	No Data	No Data	No Data	No Data	No Data
10	Lalambung	958	1,593	1,805	0	4,356
11	Assembly	No Data	No Data	No Data	No Data	No Data
12	Chinga	5,390	5,774	10,074	0	21,237
13	Canchipur	11,289	14,125	13,034	0	38,448
14	Lilandolampak	334	430	5,215	0	5,978
15	Minuthong	6,366	2,168	3,055	0	11,589
16	Khuman Lampak	No Data	No Data	No Data	No Data	No Data
17	Koirengei	2,861	0	13,490	0	16,351
18	Ningthepukhri	0	5,968	5,010	0	10,978
19	Old Thumbuthong	0	3,877	643	0	4,520
20	Irilbung	0	5,223	9,359	0	14,582
21	Porompat	12,012	11,733	13,432	1,171	38,348
22	Laiwangma	2,470	3,061	7,034	0	12,565
23	Sajor Leikai	1,041	211	2,323	0	3,575
24	Ghari	5,170	0	0	0	5,170
25	Sangakpham	0	290	700	0	991
26	Khongman	No Data	No Data	No Data	No Data	No Data
Total (m)		82,605	94,583	140,476	1,744	319,408

Note: GI: Galvanised Iron, CI: Cast Iron, DI: Ductile Iron, HS: Hume Steel

Table 2.8 Details of Zone-wise Pipe Lengths per Pipe Age

WS Zone No.	WS Zone Name	Pipe Length per Age (m)					Total (m)
		< 10 yrs	10 - 20 yrs	20 - 30 yrs	> 30 yrs	Unknown	
1	Iroisemba Evening	5,879	22,763	12,032	0	0	40,674
2	Iroisemba Morning	3,828	397	1,090	122	0	5,438
3	Langjing	8,884	12,550				21,434
4	Nepra Menjor	18,899	473	7,791	0	0	27,162
5	Sangaiprou	6,044	2,002	6,672	1,908	0	16,626
6	Irom Pukhri	753	791	2,552	1,536	0	5,632
7	Chingthamleikai	3,182	2,362	6,576	0	1,637	13,756
8	Keishampat	No Data	No Data	No Data	No Data	No Data	No Data
9	Cheiraoching	No Data	No Data	No Data	No Data	No Data	No Data
10	Lalambung	1,739	1,900	717	0	0	4,356
11	Assembly	TBC	TBC	TBC	TBC	TBC	TBC
12	Chinga	2,502	10,351	5,507	2,522	355	21,237
13	Canchipur	6,731	5,777	11,443	14,586	0	38,537
14	Lilandolampak	4,463	0	1,516	0	0	5,978
15	Minuthong	4,289	6,685	559	0	0	11,534
16	Khuman Lampak	No Data	No Data	No Data	No Data	No Data	No Data
17	Koirengei	812	0	0	15,088	451	16,351
18	Ningthepukhri	3,825	1,184	1,803	4,165	0	10,978
19	Old Thumbuthong	643		1,529	2,348		4,520
20	Irilbung	9,359	0	3,162	2,062	0	14,582
21	Porompat	7,920	3,056	13,848	12,353	1,171	38,348
22	Laiwangma	3,555	281	5,985	2,744	0	12,565
23	Sajor Leikai	0	2,488	539	549	0	3,575
24	Ghari	4,364	807	0	0	0	5,170
25	Sangakpham	0	0	0	991	0	991
26	Khongman	No Data	No Data	No Data	No Data	No Data	No Data
Total (m)		97,669	73,867	83,320	60,973	3,614	319,442

To analyse characteristics of the existing mains further, pipe length data were examined for each pipe property (i.e. pipe diameter, material and age) and results are shown in **Table 2.9** and **Table 2.10**.

The following are some observations on the results:

- GI pipes are used for small diameter pipes (up to 125mm diameter), whereas CI and DI pipes are used for a wide range of the pipe diameters. Hume pipes are used for only selected diameters (i.e. 300mm and 500 mm).

- GI pipes and CI pipes have been used for more than last 30 years. Although the use of the CI pipes decreased in the last 10 years, GI pipes are still being used widely. The use of DI pipes increased over last 10 years. Hume pipes are also still in use within the last 10 years.

Table 2.9 Details of Pipe Lengths per Pipe Material and Diameter

Pipe Material	Pipe Length per Pipe Diameter (m)															Total
	40	50	60	65	80	100	125	150	200	250	300	350	400	450	500	
DI					538	12,904	418	36,097	32,756	8,887	24,994	4,476	4,001	2,009	13,919	14
CI				541	1,803	12,780	15,569	22,426	18,116	518	18,275	1,215	0	3,026		9
GI	627	4,350	0	9,105	19,653	48,037	654									8
HS											1,171				573	
Total (m)	627	4,350	0	9,647	21,994	73,721	16,641	58,523	50,872	9,405	44,440	5,691	4,001	5,035	14,491	31

Note: DI: Ductile Iron, CI: Cast Iron, GI: Galvanised Iron, HS: Hume Steel

Table 2.10 Details of Pipe Lengths per Pipe Material and Age

Pipe Age	Pipe Length per Pipe Material (m)				Total (m)
	GI	CI	DI	HS	
< 10 yrs	19,768	785	78,149	1,171	99,873
10 - 20 yrs	16,423	21,950	35,530	0	73,903
20 - 30 yrs	36,959	32,492	13,786	573	83,809
> 30 yrs	8,679	38,472	13,905	0	61,056
Unknown	806	0	0	0	806
Total (m)	82,636	93,698	141,370	1,744	319,448

Note: DI: Ductile Iron, CI: Cast Iron, GI: Galvanised Iron, HS: Hume Steel

(2) Conditions of Exiting Distribution Mains

During this survey, trial holes investigation was carried out and trial holes were excavated on 10 metallic mains to assess the surface conditions of the existing distribution mains.

Table 2.11 shows the results of the pipe condition survey and **Photo 2.14** contains photos taken during the survey. Conditions of the external surface are generally fair and there was no severe sign of pipe corrosion or encrustation observed on the pipes inspected.

Most of the pipes at the trial hole locations were found to be buried at a very shallow depth as indicated in **Table 2.11**. For the installation of the new mains, minimum of 1m pipe cover shall be maintained to meet requirements of the CPHEEO manual.

During the trial holes investigation, soils samples were taken at the depth of 1.5m and samples were tested to determine the ground corrosiveness in the project area. According to the results, the soil samples exhibit corrosiveness and the soils are considered to corrosive to metallic pipes. Refer to **5.8.3 (3)** of this report and **Appendix A5.8 (3)** for details of the analysis and recommended pipe protection measure.

Table 2.11 Results of Pipe Condition Survey

Pipe No.	Pipe Material	Diameter	Pipe Age	Pipe Cover	Soil Type around Pipe	Groundwater	Pipe Condition
1	GI	100mm	<10 yrs	150mm	Gravelly Soil	Slightly Appeared	Slightly Corroded
2	GI	100mm	10-20 yrs	150mm	Gravelly Soil	Slightly Appeared	Slightly Corroded
3	GI	100mm	20-30 yrs	300mm	Gravelly Soil	Not Appeared	Slightly Corroded
4	GI	100mm	>30 yr	300mm	Gravelly Soil	Slightly Appeared	Slightly Corroded
5	CI	150mm	10-20 yrs	120mm	Gravelly Soil	Slightly Appeared	Slightly Corroded
6	CI	250mm	20-30 yrs	150mm	Gravelly Soil	Not Appeared	Slightly Corroded
7	CI	350mm	>30 yr	450mm	Gravelly Soil	Slightly Appeared	Heavily Corroded
8	DI	300mm	<10 yrs	300mm	Gravelly Soil	Slightly Appeared	Not Corroded
9	DI	300mm	10-20 yrs	130mm	Gravelly Soil	Slightly Appeared	Slightly Corroded
10	DI	300mm	20-30 yrs	100mm	Gravelly Soil	Appeared	Slightly Corroded

Note: DI: Ductile Iron, CI: Cast Iron, GI: Galvanised Iron

	
【Trial Hole No.3】 Galvanized Iron Pipe, 100mm dia, 20-30 years old	【Trial Hole No.4】 Galvanized Iron Pipe, 100mm dia, 20-30 years old
	
【Trial Hole No.5】 Cast Iron Pipe, 150mm dia, 10-20 years old	【Trial Hole No.7】 Cast Iron Pipe, 350mm dia, >30 years old
	
【Trial Hole No.8】 Ductile Iron Pipe, 300mm dia, <10 years old	【Trial Hole No.10】 Ductile Iron Pipe, 300mm dia, 20-30 years old

Photo 2.14 Conditions of Existing Distribution Mains

2.9 Pipe Failure History

JICA survey team obtained data of pipe failures which have occurred over the last year in the Maintenance 1 & 2 supply zones. In total, 394 incident data were collected and for each incident, the following information were obtained.

1) Incident date
2) Incident location
3) Type of incident
4) Diameter of damaged pipe
5) Material of damaged pipe
6) Age of damaged pipe
7) Assumed cause of pipe failure

Figure 2.3 shows pie charts illustrating percentile breakdown of the pipe incident details for the above item 2) to 6). Characteristics of the pipe failures experienced in the Imphal supply area are given below:

- Pipe leaks account for most of the reported incidents (89%), whereas 11% of the incidents are reported as pipe bursts.

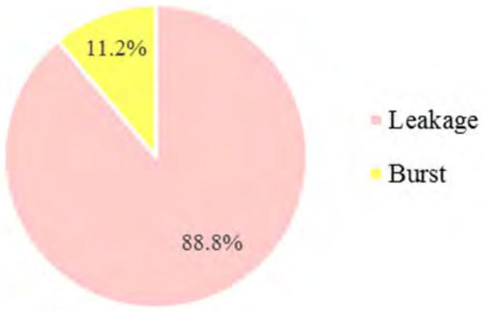
- Nearly 50% of the pipe failures occurred on small diameter distribution mains (up to 150mm diameter).

- Pipe materials failed in the most are either cast iron pipes (39%) or galvanised iron pipes (34%).

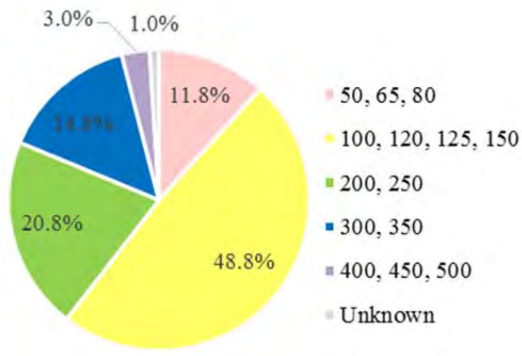
- Pipes aged between 21 and 30 years appears to have failed the most. However, pipes installed 11-20 years ago also account for 28 % of the total pipe failures.

- The main cause of the pipe failure is assumed to be pipe deterioration due to pipe age (35%), followed by heavy traffic load (9%).

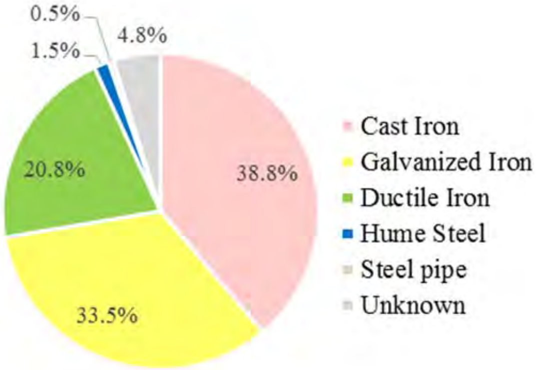
Figure 2.4 shows the number of pipe failure incidents for different pipe material and their age. This graph indicates that the number of the failures on the cast iron and galvanised iron pipes sharply increase after 15 to 20 years passed since they were installed. On the other hand, the number of failure incidents remains low for ductile iron pipes regardless of age although it exhibits a slight increase in pipe failure numbers as pipes get older.



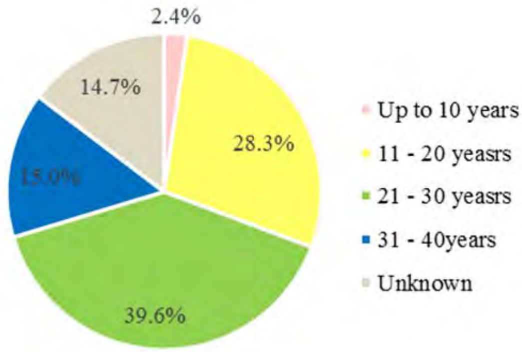
a) Type of Incident



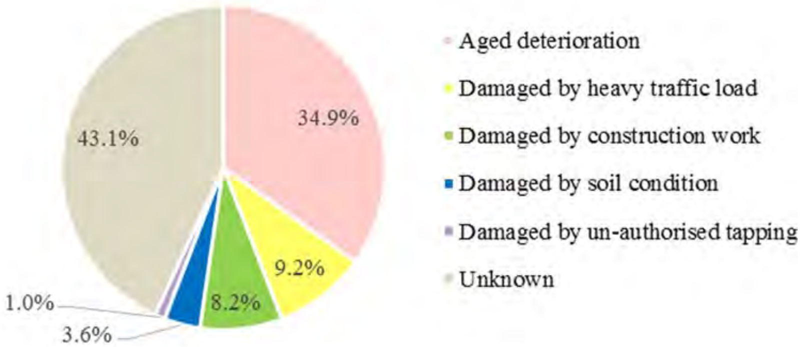
b) Diameter of Damaged Pipe



c) Material of Damaged Pipe



d) Age of Damaged Pipe



e) Assumed Cause of Pipe Failure

Figure 2.3 Pipe Failure Details

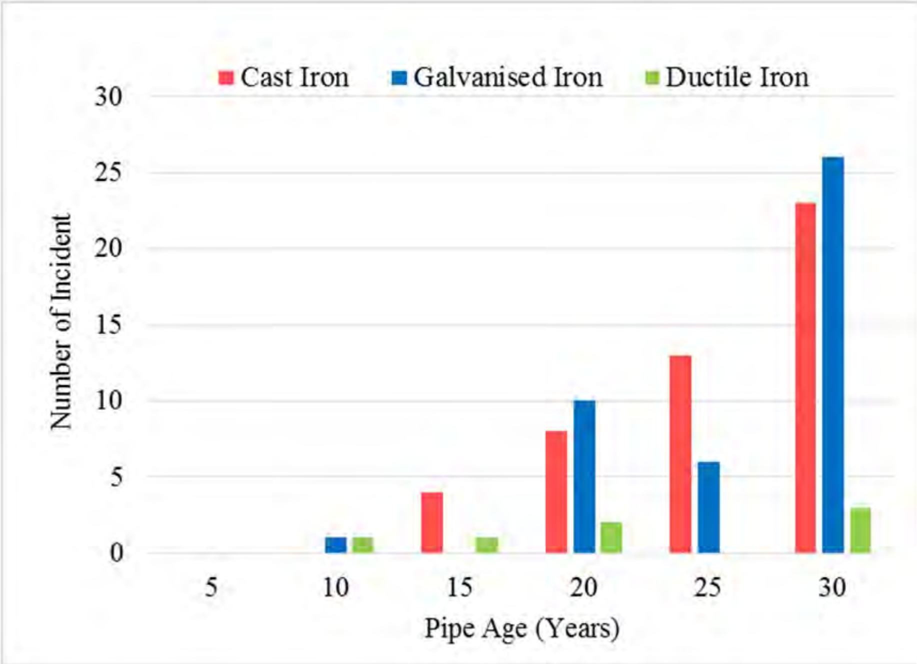


Figure 2.4 Numbers of Pipe Failure by Pipe Material and Age

During this survey period, the JICA survey team visited some pipe leakage sites in the supply area. **Photo 2.15** Pipe Leakage Incidents in Imphalshows images of the pipe leakage incidents, including those incidents occurred in the past.

It should be noted that the reported number of pipe failures per length per year in the Imphal supply area is extremely high (i.e. 1.2 incidents / km / year). These incidents are however only those which become visible on the ground and the scale of the actual leakage in the ground could be extensive. Also, it should be noted that due to the nature of intermittent supply in the Imphal city, the existing mains are more prone to be contaminated with polluted ground water through pipe defects.

The causes of pipe failures are known to be affected by various factors. These include pipe material, pipe age, pipe corrosion, pipe diameter, soil conditions, pressure, land use (e.g. traffic areas, residential areas) and pipe installation method. Hence, the rate of pipe failures in particular water system is attributed to these factors. Although it would be difficult to ascertain the main factors causing the high rate of the pipe failures in Imphal due to the limited information available, the following are observations made for the causes of the high pipe failure rate:

Pipe Material:

Cast iron pipe and galvanised iron pipes still consist of more than 50% of the existing network in Imphal. These pipe materials are prone to have the highest break rates and this may be the main factor causing the high pipe failure rate in Imphal. Note that the reported pipe failures per length per year for cast iron pipes and galvanised iron pipes are 1.61 and 1.59 incidents / km / year respectively.

Pipe Installation Method:

Trial holes investigation carried out in this survey revealed that many existing mains are being installed at shallow depths. Also, during this survey, it has been observed that there are many existing mains exposed at the ground level. It is likely that traffic loading on the pipes laid in shallow depth and / or excavations in the vicinity of the existing mains are causing pipe failures.

Soil Conditions:

According to the results of the soil corrositivity tests carried out in this survey, soils in Imphal city can be aggressive to iron pipes. Although heavy corrosion was not observed on the surface of the pipes inspected during the trial hole investigation, the presence of corrosive soil environment may contribute to failures of iron pipes at certain locations.

Pipe Age:

Currently, existing pipes aged 20 years and older accounts for 45% of the total length of the network. According to PHED, the oldest pipes in service are around 50 year old. The age of the existing mains may not be the single factor of the pipe failures, but it is apparent that it is a contributing factor, as **Figure 2.4** indicates that the pipe failure rates of the cast iron pipes and galvanized iron pipes increase sharply after 15-20 years of installation in Imphal.

Having considered the above, the following are recommended with regards to the improvement of the existing distribution mains:

- All the existing cast iron pipes, galvanised iron pipes and hume pipes should be replaced with ductile iron pipes regardless of the age of the pipes.

- For ductile iron pipes, any pipes older than 30 years should be considered for replacement. Replacement of ductile iron pipes which are less than 30 years old should be decided on a case by case basis during the project implementation stage, depending on the history of pipe failure for a particular pipeline. However, for the project cost estimation of this survey, it should be assumed that all the existing mains are replaced with new ones as the conditions of each existing mains is unknown at the moment.

Leak on hume pipe

Leak from air valve

Leak gushing out from pipe

Puddle created from leakage

Pipe repair work after leakage

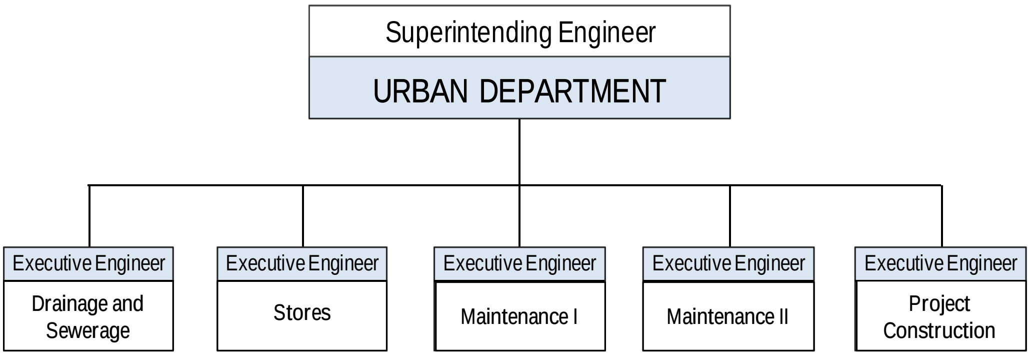
Pipe replacement after leakage

Photo 2.15 Pipe Leakage Incidents in Imphal

Chapter 3 Operation and Maintenance of the Existing Water Supply Facilities

3.1 The Current O&M Organisation

The operation and maintenance of the existing water supply facilities for Imphal City and its environs is the responsibility of the PHED Urban Circle, particularly three of its five divisions, namely, the Maintenance I Division, the Maintenance II Division, and the Project Construction Division. The two other divisions under Urban Circle are the Drainage and Sewerage Division, which is responsible for the operation and management of both urban sewerage and drainage facilities, and the Stores Division, which handles supplies' inventory and stocks as well as the securing the stockyard. **Figure 3.1** shows the organisation structure of PHED Urban Circle.



Source : PHED

Figure 3.1 Current Organisation Structure of PHED Urban Circle

3.1.1 Maintenance Division I

The Maintenance I Division (MD-I) is headed by an Executive Engineer and is assisted by four Assistant Engineers and 15 Section Officers. It is in charge of operating and maintaining the following water supply schemes, raw water mains, distribution mains: (i) Kangchup Water Supply Scheme; (ii) Kangchup Extension Water Supply Scheme; (iii) Raw water main and distribution mains of Kangchup and Kangchup Extension Water Supply Schemes; (v) Distribution water main for Langol and Langjing Zones; (vi) Minuthong Water Supply Scheme; and (vii) Khuman Lampak Water Supply Scheme.

There are a total of 49 O&M personnel distributed among the above-mentioned water supply schemes and raw water distribution pipelines, as shown in **Table 3.1**.

Based on **Table 3.1** and interview survey at sites, the existing organization with regard to operation and maintenance works in facilities in MD-I is shown in **Appendix 3.1 (1)**.

Table 3.1 Distribution of O&M Personnel for Maintenance Division I

WATER SUPPLY SCHEME	Supervisor	Junior Supervisor	Assistant Engine Operator	Technical Jugali	Sweeper	Khalasi	Total
Kangchup (Plant)	0	0	3	10	1	0	**14**
Kangchup Extension (Plant)	0	0	1	9	0	1	**11**
Kangchup and Kangchup Extension (Raw Water Main, Distribution Main)	0	0	1	9	0	0	**10**
Langol and Langjing (Water Distribution Mains)	0	0	3	2	1	0	**6**
Minuthong (Plant)	0	0	3	4	0	0	**7**
TOTAL	**0**	**0**	**11**	**34**	**2**	**1**	**48**

Source：PHED MD-I

3.1.2 Maintenance Division II

The Maintenance II Division (MD-II) is headed by an Executive Engineer and is assisted by three Assistant Engineers and 12 Section Officers. It is in charge of operating and maintaining the following water supply schemes, raw water mains, distribution mains: (i) Koirengei Water Supply Scheme; (ii) Ningthempukhri Water Supply Scheme; (iii) Porompat I Water Supply Schemes; (iv) Canchipur I Water Supply Scheme; (v) Canchipur II Water Supply Scheme; and (vi) Awang Potsumgbum I Water Supply Scheme; (vii) Awang Potsumgbum II Water Supply Scheme; and (viii) Old Thumbuthong Water Supply Scheme.

There are a total of 83 O&M personnel distributed among the above-mentioned water supply schemes and raw water distribution pipelines, as shown in **Table 3.2**.

Based on **Table 3.2** and interview survey at sites, the existing organization with regard to operation and maintenance works in facilities in Maintenance Division II is shown in **Appendix 3.1 (2)**.

Table 3.2 Distribution of O&M Personnel for Maintenance Division II

WATER SUPPLY SCHEME	Junior Supervisor	Assistant Engine Operator	Valve Operator	Lineman	Watchman	Electrician /Mechanic	Total
Koirengei	1	7	2	6	1	0	**17**
Ningthempukhri	2	11	1	4	1	0	**19**
Porompat I	1	6	2	6	1	0	**16**
Canchipur I	1	9	2	5	1	0	**18**
Canchipur II	1	7	1	0	0	0	**9**
Awang Potsumgbum I	0	1	0	0	0	0	**1**
Awang Potsumgbum II	3	0	0	0	0	0	**3**
TOTAL	**9**	**41**	**8**	**21**	**4**	**0**	**83**

Source：PHED MD-II

3.1.3 Project Construction Division

The Project Construction Division (PCD) is headed by an Executive Engineer and is assisted by two Assistant Engineers and four Section Officers. It is in charge of operating and maintaining the following water supply schemes, raw water mains, distribution mains: (i) Chinga Water Supply Scheme; (ii) Singda Water Supply Scheme; (iii) Augmentation of Porompat I Water Supply Schemes; (iv) Augmentation of Porompat II Water Supply Scheme; and (v) Irilbung Water Supply Scheme; and (vi) Moirangkhom Water Supply Scheme.

There are a total of 66 O&M personnel distributed among the above-mentioned water supply schemes and raw water distribution pipelines, as shown in **Table 3.3**.

Based on **Table 3.3** and interview survey at sites, the existing organization with regard to operation and maintenance works in facilities in Project Construction Division is shown in **Appendix 3.1 (3)**.

Table 3.3 Distribution of O&M Personnel for PCD

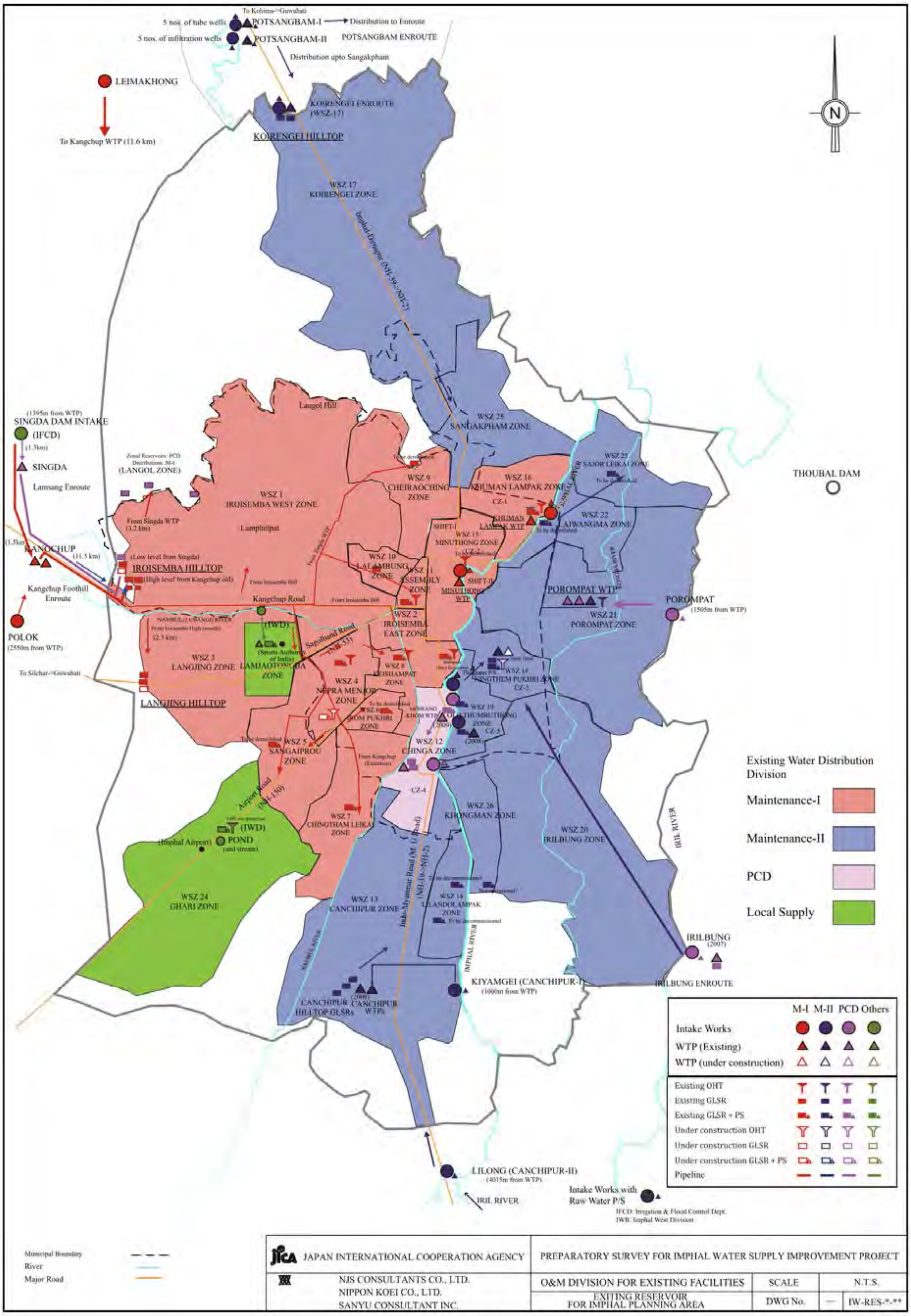
WATER SUPPLY SCHEME	Junior Supervisor	Assistant Engine Operator	Technical Jugali	Fitter Helper	Valve Operator	Chowkidar	Electrician/ Mechanic	Total
Chinga	0	6	1	1	1	0	1	**10**
Singda	1	2	8	1	3	1	0	**16**
Augmentation of Porompat I	1	3	3	0	1	1	1	**10**
Augmentation of Porompat II	0	3	9	0	0	0	0	**12**
Irilbung	1	3	6	1	0	1	0	**12**
Moirangkhom	1	1	3	0	1	0	0	**6**
TOTAL	**4**	**18**	**30**	**3**	**6**	**3**	**2**	**66**

Source：PHED PCD

3.1.4 Operation and Maintenance Division

Each water supply scheme which is operated and maintained by MD-I, MD-II and PCD is mentioned in **3.1.1** to **3.1.3**. However, the water supply schemes are basically composed of intake works and water treatment works and zone wise divisions in charge of transmission mains, distribution pipes and tariff collections are different from the schemes. The detailed categorizations of facilities and zones are shown in **Figure 3.2**. As shown in **Figure 3.2**, with regard to distribution pipes, PCD manages only the ones in Chinga Zone.

Meanwhile, Singda Dam and the intake work are managed by Irrigation and Flood Control Department (IFCD). In addition, Imphal West Division under Planning Circle, PHED supplies water to a part of Ghari Zone and Lamjaotongba Zone as a part of Langjing Zone. Lamjaotongba Zone is supplied from Langjing Hilltop GLSRs as MD-I’s facilities also.



Source: JICA Survey Team

Figure 3.2 Present Operation and Maintenance Divisions

3.2 Water Supply Records

3.2.1 Population Served

PHED does not have the statistical data on population served. Therefore, it was estimated based on the number of connections of each category and the unit parameters used by PHED for planning. The parameters used for the assumption are shown in **Table 3.4** and the population served estimated with the parameters is shown in **Table 3.5**.

Table 3.4 Parameters for Estimation of Population Served

No.	Parameter	Value	Source
1	Average number of head in household	5.0	Census 2011
2	Number of household per public hydrant	5	PHED
3	Daily consumption (L/day/capita)	135	PHED
4	Number of rooms in hostel/hotel	100	PHED
5	Number of beds in hostel/hotel rooms	2	PHED
6	Average number of staffs in school/college	150	PHED
7	Average number of staffs in office	250	PHED
8	Number of workers in industries/workshop	20	PHED

Table 3.5 Population Served (Assumption)

Sr No.	Type of Connection	MD-I		MD-II		PCD		Total	
		Number of Connection	Assumed Population	Number of Connection	Assumed Population	Number of Connection	Assumed Population	Number of Connection	Assumed Population
(A) Inhabited Population									
1	Domestic	11,467	57,335	6,529	32,645	2,602	13,010	20,598	102,990
2	Public hydrant	99	2,327	112	2,632	0	0	211	4,959
3	Tanker supply	6	1,520	125	16,014	0	0	131	17,534
	Sub-total	11,572	57,741	6,766	49,333	2,602	12,229	20,940	119,303
(B) Institution and Floating Population									
4	Hostel	19	3,800	0	0	0	0	19	3,800
5	Hotel	3	600	0	0	0	0	3	600
6	School/College	21	3,150	35	5,250	4	600	60	9,000
7	Office	63	15,750	51	12,750	0	0	114	28,500
8	Industries	5	100	0	0	0	0	5	100
9	Bulk supply	10	N/A	6	N/A	0	N/A	16	N/A
	Sub-total	121	23,400	92	18,000	4	600	217	42,000
Total		11,693	81,141	6,858	67,333	2,606	12,829	21,157	161,303

Source：JICA Survey Team based on PHED data (number of connections as of March 2014, parameters shown in Table 3.19)

Note: Numbers in tanker supply show the total number of tankers

Therefore, the domestic population is around 97,000 and total of inhabited population is around 120,000. The total population including institutions and floating population such as office workers and hotel guests is around 160,000. However, the following aspects should be noted on **Table 3.20**.

a) The tanker supply population includes the floating populations in some large hotels.

b) Bulk supply includes some hotels and offices.

c) Therefore, the number of connections for hostel/hotel and offices do not show the total number for which PHED actually supplies water.

d) Obviously, the unit parameters for number of rooms in hostels/hotels and average number of staff in the offices are too large.

e) Actual domestic population served is much larger if illegal connections are included.

3.2.2 Water Intake Volume

(1) Water Intake Volume

There are no water meters in the water intake works in Imphal City so there are also no records of water intake volumes from the rivers and from Singda Dam. Therefore, the water intake volume is substituted by water production at WTPs. The actual total intake volume by PHED is around 81.38 mld as shown in **Table 3.6**.

(2) Water Use Other than Public Water Supply System

Appendix 3.2 (1) shows the locations of tube wells and direct uses of pond/river water which could be confirmed in Greater Imphal. The ground water use with tube wells is quite limited and many tube wells are concentrated in Langol Hill Zone and the other northern part of the city. The direct water use from pond is limited to outskirts of Ghari Zone where are outsides of Ghari Water Supply. The direct water uses from rivers are limited to peripheries of Irilbung and Canchipur Water Supply Schemes.

The data on water-borne diseases originated by the unsanitary water uses are limited. **Appendix 3.2 (2**) shows the number of children admitted for water-borne diseases in the Dept. of Pediatrics, JN Institute of Medical Sciences (JNIMS), Imphal. The diseases such as diarrhea and enteric fever exist in the children but it should be noted that those numbers are not limited to children living in Imphal City.

The diseases were also studied in Social Condition Survey in the Preparatory Survey. The number of households which use the pond/river water as main source of drinking and cooking was four out of 322 samples and only one household out of four suffered from serious diarrhea.

Table 3.6 Water Intake Works and the Volumes for Imphal City

Intake Source	Name of the Intake Work	O&M Division	Water Treatment Plant	Installed Capacity mld	Present Output mld
Imphal River	Infiltration wells (5 nos.) next to Imphal River	MD-II	Potsangbam -II	6.81	6.81
	Minuthong	MD-I	Minuthong	1.14	0.57
	Khuman Lampak	MD-I	Khuman Lampak	0.45	0.45
	Koirengei	MD-II	Koirengei old	2.27	0.91
	Kiyamgei	MD-II	Canchipur	2.27	0.00
	Kiyamgei	MD-II	Canchipur-I	4.54	3.10
	Lilong	MD-II	Canchipur-II	6.81	6.81
	Chinga	PCD	Chinga	1.14	0.70
	Mahabali	MD-II	Ningthempukhri	4.54	2.27
	Moirangkhom	PCD	Moirangkhom	1.00	1.00
	Old Thumbuthong	MD-II	Old Thumbuthong	2.00	2.00
			Subtotal Imphal River Source	32.97	24.62
Iril River	Iribung	PCD	Irilbung	6.81	6.81
	Porompat	PCD	Porompat old	2.27	1.10
		PCD	Porompat -I	6.81	4.77
		PCD	Porompat -II	6.81	4.77
			Subtotal Iril River Source	22.70	17.45
Singda Dam	Singda Dam	IFCD	Singda	18.16	18.16
Leimakhong River	Leimakhong River	MD-I	Kangchup	14.53	11.62
Polok River	Polok River	MD-I	Kangchup Extension	9.08	6.81
Ground Water	Ground Water	MD-II	Potsangbam-I (A&B)	6.81	2.72
			Total	**104.25**	**81.38**

Source：PHED

(3) Operation Status of Intake Works and Raw Water Pumping Stations

The operation status of intake works and raw water pumping stations which were confirmed by interviews at the sites is shown in **Appendix 3.2 (3)**. The operation status of raw water pumping mains is shown in **Appendix 3.2 (4)**.

3.2.3 Water Production Volume

Table 3.7 shows the designed capacities and output volumes of 19 existing WTPs in Imphal City which were prepared by PHED and rearranged by JICA Survey Team. The total designed capacities is 104.25 MLD and the total present output is estimated at around 81.38 MLD. The values in present output are based on the average water productions recorded only as necessary and are not updated in every month. Therefore, PHED does not have the variable trend of the monthly production for each WTP.

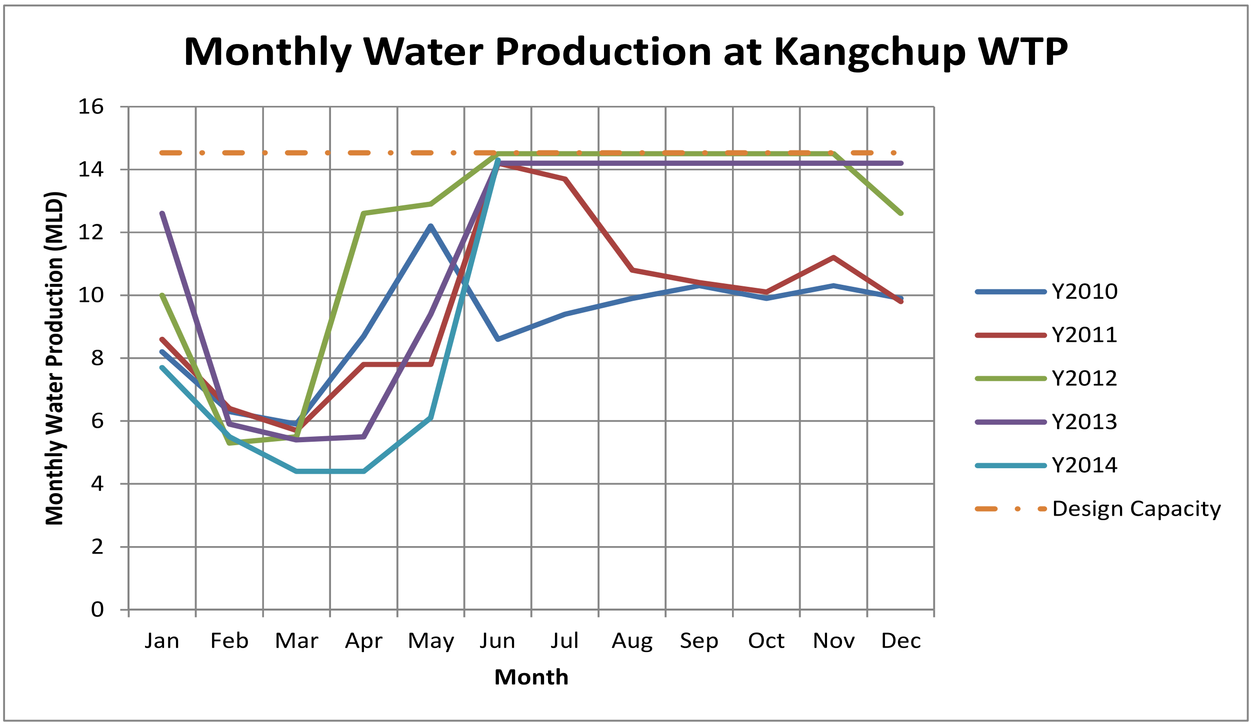
Table 3.7 Water Production in Imphal City

S. No.	O&M Division	WTP	Year Constructed	Status of Production (in MLD)		Distribution Zone
				Designed Capacity	Present Output	
1	M-I	Kangchup	1965	14.53	11.62	Iroisemba East (1), Iroisemba West (2), Langjing (3)
2	M-I	Kangchup (Extension)	2000	9.08	6.81	Nepra Menjor (4), Sangaiprou (5), Irom Pukhri (6), Chingthamleikai (7), Keishampat (8) (, Thiyam Leikai)
3	M-I	Minuthong	1977	1.14	0.57	Minuthong (15)
4	M-I	Khuman Lampak	1999	0.45	0.45	Khuman Lampak (16)
		Sub-total (M-I)		25.20	19.45	
5	M-II	Canchipur	1979	2.27	0.00	
6	M-II	Canchipur-1	1992	4.54	3.10	Canchipur (North, West) (13)
7	M-II	Canchipur-2	2009	6.81	6.81	Canchipur (East) (13), Lilando Lampak (14)
8	M-II	Koirengei	1979	2.27	0.91	Koirengei (17)
9	M-II	Potsangbam - I	1997	6.81	2.72	Koirengei (17)
10	M-II	Potsangbam - II	2008	6.81	6.81	Koirengei (17)
11	M-II	Ningthempukhri	1983	4.54	2.27	Ningthempukhri (18)
12	M-II	Old Thumbuthong	2008	2.00	2.00	Old Thumbuthong (19)
13	M-II	Porompat	1979	2.27	1.10	Hospital
		Sub-total (M-II)		38.32	25.72	
14	PCD	Singda	1983	18.16	18.16	Iroisemba East (1), Iroisemba West (2), Cheiraoching (9), Lalambung (10), Assembly (11), Langol
15	PCD	Chinga	1978	1.14	0.70	Chinga (12)
16	PCD	Moirangkhom	2008	1.00	1.00	Chinga (12)
17	PCD	Porompat-1	1989	6.81	4.77	Porompat (21)
18	PCD	Porompat-2	1992	6.81	4.77	Laiwangma (22)、Sajor Leikai (23)
19	PCD	Irilbung	2007	6.81	6.81	Irilbung (20), Khongman (26)
		Sub-total (PCD)		40.73	36.21	
		Total		**104.25**	**81.38**	

Source：PHED (Arranged by JICA Survey Team)

The water production was estimated based on the water levels at rectangular channels. Some bulk water meters have been installed at WTPs but none of the meters work properly. Therefore, all the records were estimated based on the water levels.

The accuracy of water production with water level is not high because the gauging of water levels were infrequent in the rainy seasons. In addition, the calculations of the water production volume have been mostly for large scale WTPs and no calculations were made by PHED for small scale WTPs. The JICA Survey Team requested PHED to provide the monthly variation data of the water production volumes for large scale WTPs. Only the data in Kangchup WTP was obtained during the first field work as shown in **Figure 3.3**.



Source：PHED MD-I

Figure 3.3 Monthly Variation Data of Average Water Production in Kangchup WTP (2010 - 2014)

3.2.4 Water Supply Volume

(1) Present status of Water Meter Installation

As a base information for calculating the water supply volume, the present status of water meter installation was confirmed. The installation of consumer meters started in 2012. The latest figures of meters as of July 2014 in each O&M division are shown in the table below. However, meter reading has not been done except for Sanjenthong Officer Colony in MD-II area because the installation is on trial basis and domestic consumers still pay the flat rate. Meanwhile, no bulk meters were installed in Imphal City.

Table 3.8 Consumer Meters installed by PHED

O&M Division	MD-I	MD-II	PCD	Total
Number of Meters	105	327	152	584

Source：PHED

The meter reading data of 10 samples in Wangkhei Yonglan Leirak and five samples in Sanjenthong Officer Colony were provided by MD-II. The data is shown in **Appendix 3.2 (5)**. The average water consumption volume was 137 liter per capita per day (lpcd) and 179 lpcd, respectively. However, it should be noted that these figures are more than average figure in all of Imphal City since PHED has selected the pilot locations of meter installations in areas where water consumption areas is generally higher.

(2) Water Supply Volume

Even with the situation mentioned above, no survey on the daily average supply per capita has been conducted so far.

1) Domestic Water Supply Volume

PHED's answer on the present water supply volume requested from questionnaire survey by JICA Survey Team was based on 135 lpcd as the standard value in India. This is also the same figure contained in the DPR. It should be noted that the value appears to be larger than the actual average considering the current status of water supply and use in Imphal City. Meanwhile, the average value taken from Social Condition Survey is 61 lpcd. However, since the water consumption data is based on respondents' assumptions without any volumetric data, it appears to be smaller than actual use.

As a result, since there is no reliable data obtained on the daily average supply per capita and the value in Wangkhei Yonglan Leirak shown in **Appendix 3.2 (5)** showed similar figure, 135 lpcd is adopted for the estimation of water supply volume.

Number of domestic connection:	20,598
Average number per household:	5.0
Volume of domestic water supply with pipe:	13,904 m^3/day (= 20,598 x 5.0 x 135)

2) Bulk Water Supply Volume

Bulk meter supplies are also not measured. Here, it is estimated with the financial data the bulk water volume can be assumed as follows: [list of bulk water consumers is shown in **Appendix 3.2 (6)**]

Charges by PHED for bulk water user:	Rs. 10/m^3
Annual billed amount of bulk water supply:	Rs. 17,939,604
Bulk water supply volume:	4,915 m^3/day (= 17,939,604 / 10 / 365 days)

3) Water Supply Volume by Water Tankers

Water supply volume by water tanker also can be assumed from the financial data and the charges.

Charges by PHED for the supply by water tankers:	Rs. 55 to 56 /m^3
Annual billed amount by water tanker supply:	Rs. 48,384,000

(Breakdown of the volume and billed amount is shown in **Appendix 3.2 (7)**)

Water tanker supply volume: 2,367 m^3/day (= 48,384,000/56/365 days)

4) Water Supply Volume to Hostels and Hotels

Water supply volumes to hostels and hotels were assumed with the number of connections and design parameters of PHED.

Table 3.9 Water Supply Volume to Hostel/Hotel

Item	Hostel	Hotel
Number of connections	19	3
Number of rooms	100	100
Number of beds per rooms	2	2
Consumption per capita per day (lpcd)	135	190
Water Supply (m^3/day)	513	114

Source：PHED

Water supply to hostels/hotels: 627 m^3/day

5) Water Supply Volume to School/College and Office/Industry

Water supply volumes to schools/colleges and offices/industries were assumed with the number of connections and design parameters of PHED.

Table 3.10 Water Supply Volume to School/College and Office

Item	School/College	Office	Industry
Number of connections	60	114	5
Average number of staffs	150	250	20
Consumption per capita per day (lpcd)	60	60	135
Water Supply (m^3/day)	540	1,710	14

Source：PHED

Water supply to school/college and office/industry: 2,264 m^3/day

6) Public Hydrant

Water supply volumes to public hydrants were assumed with the number of public hydrants and design parameters of PHED.

Number of public hydrant: 211

Number of household per public hydrant: 5

Average number per household: 5.0

Consumption per capita per day: 135 lpcd

Water supply volume from public hydrants: 712 m^3/day (= 211 x 5 x 5.0 x 135 lpcd/1000)

7) Billed Authorized Consumption

Total billed non-metered consumption is 24,789 m^3/day if all the water uses above are assumed to be properly billed.

Meanwhile, the volumetric billing system based on meters has been recently initiated in Sanjenthong Officer Colony and it should be counted as billed metered consumption. However, there is no data on the total consumption volume in the colony. Since the connections in the colony is already counted in domestic water supply, water tanker supply, and bulk water supply, the volume above is not adjusted as it is and billed authorized consumption is equivalent with the volume above.

8) Unbilled Authorized Consumption

PHED basically charges all institutions including the offices of state government. Usually, water used for firefighting is unbilled but firefighting hydrants do not exist in Imphal City. In addition, the water used by fire fighting vehicles of Fire Service Department, Government of Manipur is collected from the nearby river/ponds or even rain water stored in tanks.

Public faucets for the urban poor do not exist since PHED basically charges the same to the urban poor regardless of their actual payment.

Therefore, unbilled authorized consumption is limited to only PHED offices. Since PHED does not have the actual record of water consumption in the offices, the volume was assumed as follows:

Number of staffs:	492
Consumption per capita per day (lpcd):	60 (same with office)
Water supply volume to PHED offices:	30 m^3/day (= 492 x 60 /1000)

9) Total Authorized Consumption

Total authorized consumption:	24,819 m^3/day (= 24,789 + 30)

3.3 Status of Chemical Use

The JICA Survey Team conducted the interview survey with PHED on the status of chemical use at WTPs for last year. The aluminum sulphate (alum) as coagulant, slaked lime as alkali agent, and bleaching powder for disinfection are used for the water treatment works. The details of chemicals are shown in **Appendix 3.3**. Alum and lime are dosed directly in the channels or via solution tanks without dosing pumps in all the WTPs and bleaching powder is also dosed directly before service reservoirs except for Kangchup and Old Thumbuthong WTPs where it is dosed with manual diaphragm pump after dissolving the powder in solution tanks. Therefore, all the chemicals are not adequately dosed; however dosing rates are more or less based on the general experience of the perators.

The latest unit prices and estimated quantities of chemicals in each O&M Divisions are shown in **Table 3.11**. The annual quantities for alum, lime, and bleaching powder are 1,385, 594, and 185 in metric tons, respectively.

Table 3.11 Estimated Consumptions of Chemicals for 2013-14

Division	Type of Chemicals	Present Output of WTPs	Rate per metric ton (Rs/ton)	Quantity estimated for 2013- 14 (in metric ton)
MD-I	Aluminum Sulphate	19.45 mld	13,400	545.6
	Slaked Lime		10,600	259.3
	Bleaching Powder		28,350	40.0
	Sub-total			
MD-II	Aluminum Sulphate	25.72 mld	13,400	290.0
	Slaked Lime		10,600	151.0
	Bleaching Powder		28,350	59.0
	Sub-total			
PCD	Aluminum Sulphate	36.21 mld	13,400	549.0
	Slaked Lime		10,600	183.5
	Bleaching Powder		28,350	86.3
	Sub-total			
PHED Urban Total	Aluminum Sulphate	81.38 mld	13,400	**1,384.6**
	Slaked Lime		10,600	**593.8**
	Bleaching Powder		28,350	**185.3**

Source：PHED

Compared to the quantities and costs for fiscal year 2007 as mentioned in the DPR, the unit rates and quantities of alum and lime increased more than double from last year.

The chemicals are procured with contracts either by call of tender or by placing supply orders to suppliers with efficient quantities depending on market conditions. The contract periods are yearly or quarterly and the contractors are, more often than not, the companies in Guwahati. The procured chemicals are stocked in the warehouses of each WTP.

3.4 Water Quality Examination Regime

(1) Laboratories in Imphal City

There is a laboratory under PHED named State Laboratory Lamphelpat in Imphal. The laboratory belongs to Monitoring and Environment Division under the Planning Circle and it has two sections as follows:

- Main laboratory which examines mainly the water samples sent from WTPs (Urban Circle)
- Imphal West and East Divisions' laboratory which examines the water samples such as those from tube wells for rural water supply

There are following three other major laboratories in Imphal City.

- Manipur Pollution Control Board Laboratory in Lamphelpat: mainly in charge of effluents from industries (water, air)
- Environment and Forest Department Laboratory in Porompat: mainly in charge of river water quality
- Manipur University Laboratory

Out of all the laboratories, the main laboratory of State Laboratory Lamphelpat has better and more complete water examination equipment, and in cases of the parameters which cannot be examined in the laboratory, the samples are sent to Kolkata or Delhi. However, such a case is quite rare.

Kangchup WTP has a small laboratory in the administration building, but the laboratory is non-functional and is either insufficiently stocked or has broken equipment. Therefore, the water samples of the WTP also are sent to State Laboratory Lamphelpat.

(2) Staff for Water Quality Examination

The position and number of staff in the State Laboratory Lamphelpat are shown in the table below. Staff training is provided by the office of Communication and Capacity Development Unit (CCDU), which is under the Additional Chief Engineer of PHED.

Table 3.12 Position and Number of Staff in State Laboratory Lamphelpat

No.	Position	Number of Staff
1	Chemist	1
2	Lab assistant for urban water supply samples	2
3	Lab attendant	1
4	Jr. Chemist	2
5	Lab assistant for rural water supply samples	2
	Total	8

Source：PHED

(3) Sampling Points for Water Quality Examination

In general, the sampling points are taken at: (i) raw water at inflow point of WTPs, (ii) treated water at reservoirs in WTPs are weekly taken and (iii) supplied water at distribution points (taps in consumers' houses which are chosen at random). The samples are sent to the State Laboratory Lamphelpat and some examinations at distribution points are conducted with simple test kits with the consumers being asked to do the test.

(4) Analytical Parameters and Results of Water Quality Examination

Fourteen parameters such as total dissolved solid (TDS) and turbidity are examined in the laboratory. All examinations are based on "Standard methods for Examination of Water And Waste Water, 19th Edition 1995 (American Public Health Association Publications)."

An example of water examination result for water samples in Porompat Treatment Plant is shown in **Table 3.13**. As can be gleaned from the table, almost all the parameters observe the water quality standards of Bureau of India Standards (BIS 10500 Second Revision issued in 2012). However, results of iron show relatively high values in the raw water at many points and high turbidity values in the raw water. Even the results of treated water show the higher values than the permissible limit at some points in rainy season as in the case of Porompat WTP.

Meanwhile, BIS 10500 first edition in 1992 determined the essential characteristics of (i) colour, (ii) odour, (iii) taste, and (iv) residual free chlorine for drinking water but those parameters have not been examined and/or recorded. The residual free chlorine has been substituted by Coliform and E-coli in the table above.

According to PHED, there have not been any water quality accidents such as inflow of high concentrated heavy metals to the rivers since there are no industries upstream of the intake works.

Table 3.13 Example of Water Quality Examination (Porompat WTP)

GOVERNTMENT OF MANIPUR

PUBLIC HEALTH ENGINEERING DEPARTMENT

REPORT ON PHYSICO - CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF WATER SAMPLES

a	State	Manipur
b	District	Imphal East
c	Place	Porompat Treatment Plant (PH-I & II)
d	Name of Division	AE. I P.C.D
e	Village	
f	Habitation	
g	Type of water source	Raw water and Treated Water
h	Nature of water	1.Raw water (influent at WTP), 2&3 – Treated water
i	Lab. Name	State Lab. Lamphelphat
j	Sample No.	3 nos.
k	Date of sampling	10.07.2012
l	Lab. Testing Date	12.7.2012

Type of Parameters to be tested
(Physical, Chemical & Bacteriological)

SI No.	Quality Parameter	Unit of Measurement	BIS Desirable Limit	BIS Permissible Limit	Actual level Sample No.		
					1	2	3
1	Alkalinity	mg/l	200	600	78.00	62.00	54.00
2	Calcium	mg/l	75	200	28.00	34.00	36.00
3	Chloride	mg/l	250	1000	32.00	36.00	92.00
4	Coliform	MPN/100 ml	-	-	--	--	----
5	E-Coli	MPN/100 ml	-	-	---	---	--
6	Conductivity	mhos/m	0	0	140.00	190.00	195.00
7	Fluoride	mg/l	1.0	1.5	0.8	0.4	0.4
8	Hardness	mg/l	200	600	66.00	80.00	84.00
9	Iron	mg/l	0.3	1.0	2.0	0.4	0.2
10	Magnesium	mg/l	30	100	9.23	11.18	11.66
11	pH	mg/l	6.5	8.5	6.62	6.54	6.55
12	Sulphates	mg/l	200	400	Nil	10.00	30.00
13	TDS	mg/l	500	2000	91.00	123.00	126.75
14	Turbidity	NTU	1.00	5.00	300.00	23.00	20.00

Date : 13.07.2012
Source : PHED
Note : BIS desirable and permissible limits in the table originally referred the values in BIS10500-1992 but hardness and turbidity were revised by consultants based on BIS10500-2012.

3.5 Result of Water Quality Survey

The water quality survey was implemented for the purpose of (i) obtaining current water quality in the public waters, and (ii) obtaining necessary water quality data for a design on Chingkheiching WTP. The sampling location is indicated in **Table 3.14** and **Figure 3.4**. In this survey, 41 parameters that are necessary for WTP design, were analyzed. Among the analyzed parameters, 11 parameters that are regularly monitored for the operation of the existing WTP were included and were analyzed at State Laboratory of PHED. Forty-one parameters were analyzed at Sai International Sansthan. The analysis was performed in accordance with the Drinking Water-Specification in IS 10500 and the Drinking Water Quality Standards in Waterworks Law of Japan.

Table 3.14 Sampling Points for Water Quality Survey

Category		Sampling Point	
Raw Water	Thoubal Dam Lake (under construction)	No.1	Thoubal River
	Singda Dam Lake	No.2	Near intake at Singda Dam Lake
	River Water	No.3	Iril River (Intake for Prompat WTP)
		No.4	Imphal River (Intake for Ningthempukhri WTP)
	Groundwater	No.5	Tubewell (Intake for Potsangbam-I WTP)
Treated Water	Existing WTP	No.6	Outlet of rapid sand filter at Singda WTP
		No.7	Outlet of rapid sand filter at Prompat-I WTP
	Water Tap	No.8	Public Hydrant at Lamphel Super Market
		No.9	Tap at Porompat Office

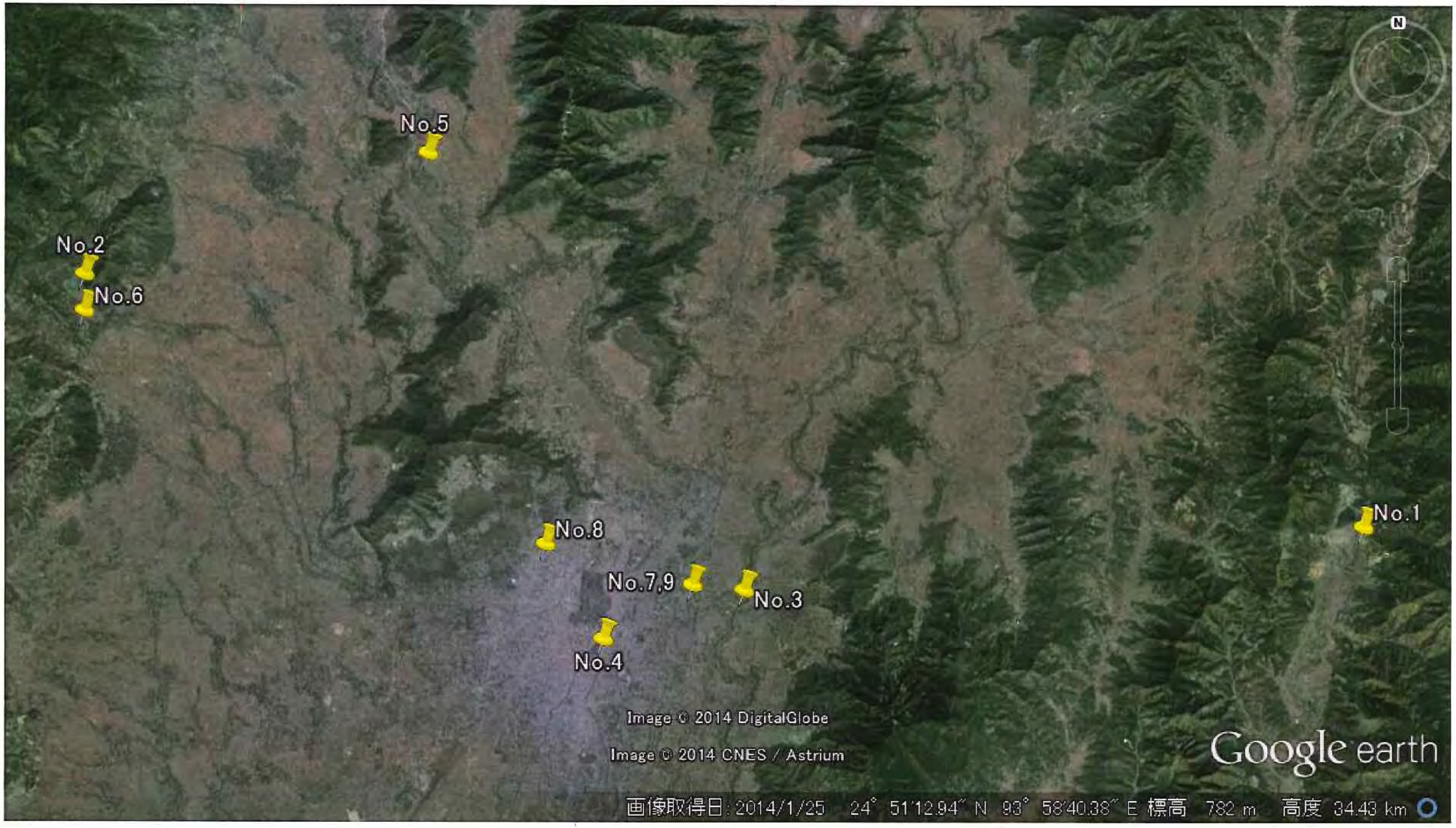


Figure 3.4 Sampling Points for Water Quality Survey

3.5.1 Raw water

(1) Dam Lake Water

The results of water quality survey at Singda Dam Lake are shown in **Table 3.15**. Water samples were collected near the intake tower of Singda WTP. Although it was rainy season when the water was collected, turbidity was relatively low at 11.0 - 27.0 NTU. The reason could be that it did not rain heavily before the sampling took place. The pH parameter was at 6.7 - 8.5, which satisfies the standard in IS 10500. Iron, whose presence can be observed by its color, was at 0.28 mg/L, satisfying the standard (0.3 mg/L). Total dissolved solids (TDS), suspended solids (SS), total hardness, alkalinity, and electric conductivity (EC) were measured at lower values as compared to the standard. Heavy metals giving harmful effects on human health were less than the detection limit. Regarding organic compounds, biochemical oxygen demand (BOD) was at less than 2.0 mg/L*, which is categorized in water supply class 2 and 3** of the Environmental Standards for Conservation of the Living Environment, Japan. The other parameters – chemical oxygen demand (COD), total nitrogen, phosphate, E-coli, and total coliform – were at 4.8 mg/L, less than the detection limit, less than the detection limit, not detected, and 58 MPN/100mL, respectively. This result indicates Singda Dam Lake as having clean water. In addition, it is expected that a large quantity of clear spring water flows into Singda Dam Lake due to a lower value of EC.

* The samples were analyzed at 27 ^{o}C for 3 days in accordance with IS 3025.
Japanese standard regulates the analysis at 20 ^{o}C for five days.

** Water treatment to be used sedimentation, filtration and other ordinary processes, or to be used pre-treatment and other advanced processes

(2) River Water

1) Thoubal River

The results of water quality survey at Thoubal River are shown in **Table 3.15**. Water samples were collected at upstream of Thoubal Dam. Since the samples were collected during the rainy season, water in the Thoubal River was turbid and reddish brown in color. Turbidity was measured at 78.0 -117.8 NTU, considered as relatively high values. The pH parameter was at 6.5 - 7.5, which satisfies the IS 10500 standard. Iron and manganese whose presence can be observed by its color, were at 0.31 - 0.65 mg/L, and 0.14 mg/L, respectively, which exceeded the standard. Alkalinity was relatively high at 78.0 - 82.0 mg/L. The values are considered to be sufficient even after alkalinity is reduced by flocculant dosing. Regarding organic compounds, BOD was at 2.5 mg/L*, which is categorized in water supply class 3*** of the Environmental Standards for Conservation of the Living Environment, Japan. COD was measured at 16.8 mg/L. For the other parameters, total nitrogen, phosphate, and heavy metals were less than the detection limit. E-coli, and total coliform were measured as not detected and at 63 MPN/100mL, respectively. The results show that this river has not been affected much by fertilizers, industrial wastewater or domestic wastewater.

This river will be dammed by Thoubal Dam which is currently being constructed. The dam lake will be a water source for new Chingkheiching WTP. The effective storage volume of lake is 124,580,000 m^3. Therefore, suspended solids flowing into the lake are expected to settled down. However, it is expected that iron, manganese and organic matters will be conveyed to Chingkheiching WTP so removal facilities for these parameters should be considered when Chingkheiching WTP is designed.

*** Water treatment to be used pre-treatment and other advanced processes

2) Iril River

The results of water quality survey at Iril River are shown in **Table 3.15**. Water samples were collected at the intake of Porompat WTP. It was rainy season when the water was collected and so turbidity was at 146.1 NTU, which is considered as a relatively high value. The pH parameter was at 7.4, which satisfies the standard in IS 10500. Iron and manganese, whose presence may be resulted in color, were at 1.8 mg/L, and 0.21 mg/L, respectively, which exceed the standard. Alkalinity was relatively high at 76.0 mg/L. The value is considered to be sufficient even after alkalinity is reduced by flocculant dosing. Regarding organic compounds, BOD was at 2.8 mg/L*, which is categorized in water supply class 3*** of the Environmental standards for conservation of the living environment, Japan. COD was measured at 23.2 mg/L. By detecting E-coli, Total Coliform and a high value of COD, it is expected that this river has an effect on domestic wastewater. For the other parameters, total nitrogen, phosphate, and heavy metals were less than the detection limit.

3) Imphal River

The results of water quality survey at Imphal River are shown in **Table 3.15**. Water samples were collected at the intake of Ningthempukhri WTP. It was rainy season when the water was collected. Due to that reason, turbidity was at 116.2 NTU, considered as a relatively high value. The pH parameter was at 7.4, which satisfies the standard in IS 10500. Iron and manganese whose presence can be observed by its color, were at 0.45 mg/L, and 0.15 mg/L, respectively, which exceed the standard. Alkalinity was at 26.0 mg/L which needs to be reduced through flocculant dosing. Regarding organic compounds, BOD was at 2.1 mg/L*, which is categorized in water supply class 3*** of the Environmental Standards for Conservation of the Living Environment, Japan. COD was measured at 11.2 mg/L. E-coli and total coliform were detected, and this is expected to have an effect on domestic wastewater. For the other parameters, total nitrogen, phosphate and heavy metals were less than the detection limit.

(3) Groundwater

The results of water quality survey at the tubewell for Potsangbam WTP, located in Imphal River basin, are shown in **Table 3.15**. Turbidity was at 36.8 NTU, considered as a relatively high value for groundwater. The pH parameter was at 6.9, which satisfies the standard in IS 10500. Iron whose presence is observed by its color was at 0.7 mg/L, which exceeds the standard. Alkalinity was relatively high at 102 mg/L. The value is considered to be sufficient even after alkalinity is reduced by flocculant dosing. Regarding organic compounds, BOD and COD were at less than 2.0 mg/L and 4.0 mg/L, respectively, which are considered as relatively low values. For the other parameters, total nitrogen, phosphate and heavy metals were less than the detection limit. E-coli and total coliform were measured as not detected and at 25 MPN/100mL, respectively. The results show that groundwater has not been affected much by fertilizer, industrial wastewater or domestic wastewater.

Table 3.15 Result of Water Quality Survey for Raw Waters

Parameters \ Locations	Unit	Standard* (IS 10500)	Thoubal River		Singda Dam		Tubewell at Potsangbam WTP	Intake of Prompat WTP (Iril River)	Intake of Ningthempukhri WTP (Imphal River)
Sampling date			11/07/2014	05/07/2014	11/07/2014	05/07/2014	10/07/2014	10/07/2014	10/07/2014
Colour (Hazen units)	-	5	10.0	-	< 5.0	-	50.0	10.0	10.0
Turbidity	NTU	1	117.8	78.0***	11.0	27.0***	36.8***	146.1	116.2
Total Dissolved Solids	mg/L	500	124.0	104.0***	65.0	65.0***	144.0	124.0	48.0
pH	-	6.5-8.5	7.50	6.51***	8.53	6.65***	6.90	7.40	7.39
Total Hardness (as $CaCO_3$)	mg/L	200	84.0	70.0***	44.0	40.0***	74.0	70.0	26.0
Copper (as Cu)	mg/L	0.05	< 0.01	-	< 0.01	-	< 0.01	< 0.01	< 0.01
Iron (as Fe)	mg/L	0.3	0.31	0.65***	< 0.1	0.28***	0.7	1.8	0.45
Manganese (as Mn)	mg/L	0.1	0.14	-	< 0.1	-	< 0.1	0.21	0.15
Nitrate (as NO_3)	mg/L	45	< 0.5	-	< 0.5	-	< 0.5	< 0.5	< 0.5
Fluoride (as F^-)	mg/L	1	0.67	0.10***	0.42	0.14***	0.74	0.62	0.58
Zinc (as Zn)	mg/L	5	< 0.05	-	< 0.05	-	< 0.05	< 0.05	< 0.05
Aluminium (as Al)	mg/L	0.03	< 0.01	-	< 0.01	-	< 0.01	< 0.01	< 0.01
Chloride (as Cl)	mg/L	250	8.3	9.0***	6.0	7.0***	13.3	8.7	5.0
Selenium (as Se)	mg/L	0.01	< 0.005	-	< 0.005	-	< 0.005	< 0.005	< 0.005
Sulphate (as SO_4)	mg/L	200	19.9	ND***	7.4	ND***	13.7	25.8	8.9
Alkalinity (as $CaCO_3$)	mg/L	200	82.0	78.0***	46.0	44.0***	102.0	76.0	26.0
Calcium (as Ca)	mg/L	75	18.7	54.0***	8.0	24.0***	13.4	12.8	5.3
Magnesium (as Mg)	mg/L	30	9.1	3.8***	5.8	3.9***	9.9	9.2	3.1
Phenolic Compounds (as C_6H_5OH)	mg/L	0.001	< 0.001	-	< 0.001	-	< 0.001	< 0.001	< 0.001
Sulphide (as H_2S)	mg/L	Below detectable limit	< 0.1	-	< 0.1	-	< 0.1	< 0.1	< 0.1
Mercury (as Hg)	mg/L	0.001	< 0.001	-	< 0.001	-	< 0.001	< 0.001	< 0.001
Cadmium (as Cd)	mg/L	0.003	< 0.001	-	< 0.001	-	< 0.001	< 0.001	< 0.001
Arsenic (as As)	mg/L	0.01	< 0.005	-	< 0.005	-	< 0.005	< 0.005	< 0.005
Cyanide (as CN)	mg/L	0.05	< 0.05	-	< 0.05	-	< 0.05	< 0.05	< 0.05
Lead (as Pb)	mg/L	0.01	< 0.005	-	< 0.005	-	< 0.005	< 0.005	< 0.005
Chromium (as Cr^{+6})	mg/L	0.05	< 0.05	-	< 0.05	-	< 0.05	< 0.05	< 0.05
Temperature**	deg.C	-	32.0	-	32.0	-	31.0	32.0	32.0
Conductivity	µS/cm	-	191.0	160.0***	92.0	100.0***	212.0	179.0	84.6
Total Suspended Solids	mg/L	-	174.0	-	20.0	-	34.0	229.0	204.0
Total Nitrogen	mg/L	-	< 1.0	-	< 1.0	-	< 1.0	< 1.0	< 1.0
Ammonical Nitrogen	mg/L	-	< 1.0	-	< 1.0	-	< 1.0	< 1.0	< 1.0
Silica (as SiO_2)	mg/L	-	7.3	-	2.5	-	9.5	3.9	1.5
Phosphate(as PO_4^{3-})	mg/L	-	< 0.5	-	< 0.5	-	< 0.5	< 0.5	< 0.5
Dissolved Oxygen	mg/L	-	4.3	-	4.5	-	4.0	4.5	4.4
BOD (3 days at 27 Deg.C)	mg/L	-	2.5	-	< 2.0	-	< 2.0	2.8	2.1
COD	mg/L	-	16.8	-	4.8	-	4.0	23.2	11.2
E.Coli	MPN/100 ml	not be detectable	Absent	-	Absent	-	Absent	Present	Present
Total Coliform	MPN/100 ml	not be detectable	63	-	58	-	25	150	120

Notes: *; Requirement for drinking water, **; Water temperature at the time of tested, ***; Data tested at State Laboratory of PHED

3.5.2 Treated water

(1) WTP

1) Singda WTP

The results of water quality survey at Singda WTP are shown in **Table 3.16**. Turbidity was at 13.6 - 17.5 NTU, exceeding the standard of 1 NTU. E-coli and total coliform were detected, which does not satisfy the standard. Iron was at less than 0.1 to 0.31 mg/L, some of which exceed the standard. As for the operational condition at the WTP, it was observed that the dosing rates of the flocculant and the disinfectant were not properly controlled. Two out of four filters were also not operating. At one in two non-operating filters, the filter media was washed away due to a damage of the underdrainage equipment. Furthermore, turbidity, E-coli, total coliform and iron were measured beyond the standard.

2) Porompat-I WTP

The results of water quality survey at Porompat-I WTP are shown in **Table 3.16**. In this survey, all parameters did not satisfy the standard. It was again observed that the dosing rates of the flocculant and the disinfectant were not properly controlled in the same manner as the other existing WTPs. Therefore, the possibility that standards may not be complied with at any time is very high.

(2) Water tap

1) Public Hydrant at Lamphel Super Market

The results of water quality survey on the public hydrant at Lamphel Super Market in the distribution area of Singda WTP are shown in **Table 3.16**. Turbidity was at 28.5 NTU, exceeding the standard of 1 NTU. E-coli and total coliform were detected, which does not satisfy the standard. Turbidity at Singda WTP was at 13.6 - 17.5 NTU, which is less than at the public hydrant. The reason could be explained as (i) accumulation of suspended solids in reservoirs and distribution pipes located in downstream of the WTP, (ii) corrosion inside the distribution pipes, and (iii) inflow of pollutants from outside.

2) Tap at Porompat Office

The results of water quality survey on the tap at Porompat Office in the distribution area of Porompat-I WTP are shown in **Table 3.16**. Turbidity was at 4.8 NTU, exceeding the standard of 1 NTU. The other parameters satisfy the standard. Turbidity at the tap is higher than that of treated water at Porompat-I WTP (below 1 NTU). The reason could be explained as (i) accumulation of suspended solids in reservoirs and distribution pipes located in downstream of the WTP, and (ii) corrosion inside the distribution pipes.

Table 3.16 Result of Water Quality Survey for Treated Waters

Parameters \ Locations	Unit	Standard* (IS 10500)	GLSR at Singda WTP		GLSR at Prompat WTP	Water tap at PHED Office****	Water tap at Porompat Office
Sampling date			11/07/2014	05/07/2014	10/07/2014	10/07/2014	11/07/2014
Colour (Hazen units)	-	5	< 5.0	-	< 5.0	< 5.0	< 5.0
Odour	-	Agreeable	Agreeable	-	Agreeable	Agreeable	Agreeable
Taste	-	Agreeable	Agreeable	-	Agreeable	Agreeable	Agreeable
Turbidity	NTU	1	17.5	13.6***	< 1.0	28.5	4.8
Total Dissolved Solids	mg/L	500	52.0	68.3***	134.0	49.0	132.0
pH	-	6.5-8.5	7.20	6.77***	6.58	7.14	6.96
Total Hardness (as $CaCO_3$)	mg/L	200	22.0	42.0***	72.0	24.0	82.0
Copper (as Cu)	mg/L	0.05	< 0.01	-	< 0.01	< 0.01	< 0.01
Iron (as Fe)	mg/L	0.3	< 0.1	0.31***	< 0.1	0.21	< 0.1
Manganese (as Mn)	mg/L	0.1	< 0.1	-	< 0.1	< 0.1	< 0.1
Nitrate (as NO_3)	mg/L	45	< 0.5	-	< 0.5	< 0.5	< 0.5
Fluoride (as F^-)	mg/L	1	0.39	0.05***	0.49	0.56	0.69
Zinc (as Zn)	mg/L	5	< 0.05	-	< 0.05	< 0.05	< 0.05
Aluminium (as Al)	mg/L	0.03	< 0.01	-	< 0.01	< 0.01	< 0.01
Chloride (as Cl)	mg/L	250	4.1	20.0***	16.7	6.7	18.3
Selenium (as Se)	mg/L	0.01	< 0.005	-	< 0.005	< 0.005	< 0.005
Sulphate (as SO_4)	mg/L	200	11.9	20.0***	59.6	10.4	53.2
Alkalinity (as $CaCO_3$)	mg/L	200	20.0	24.0***	24.0	24.0	30.0
Calcium (as Ca)	mg/L	75	6.7	24.0***	14.7	5.3	17.4
Magnesium (as Mg)	mg/L	30	1.3	4.4***	8.6	2.6	9.4
Residual free chlorine	mg/L	0.2	–	-	–	< 0.2	< 0.2
Phenolic Compounds (as C_6H_5OH)	mg/L	0.001	< 0.001	-	< 0.001	< 0.001	< 0.001
Sulphide (as H_2S)	mg/L	Below detectable limit	< 0.1	-	< 0.1	< 0.1	< 0.1
Mercury (as Hg)	mg/L	0.001	< 0.001	-	< 0.001	< 0.001	< 0.001
Cadmium (as Cd)	mg/L	0.003	< 0.001	-	< 0.001	< 0.001	< 0.001
Arsenic (as As)	mg/L	0.01	< 0.005	-	< 0.005	< 0.005	< 0.005
Cyanide (as CN)	mg/L	0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Lead (as Pb)	mg/L	0.01	< 0.005	-	< 0.005	< 0.005	< 0.005
Chromium (as Cr^{+6})	mg/L	0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Temperature**	deg.C	-	32.0	-	31.0	31.0	31.0
Conductivity	μS/cm	-	86.1	105.0***	210.0	75.0	214.0
Total Suspended Solids	mg/L	-	26.0	-	< 5.0	27.0	< 5.0
Total Nitrogen	mg/L	-	< 1.0	-	< 1.0	< 1.0	< 1.0
Ammonical Nitrogen	mg/L	-	< 1.0	-	< 1.0	< 1.0	< 1.0
Silica (as SiO_2)	mg/L	-	< 0.2	-	< 0.2	< 0.2	< 0.2
Phosphate(as PO_4^{3-})	mg/L	-	< 0.5	-	< 0.5	< 0.5	< 0.5
Dissolved Oxygen	mg/L	-	4.6	-	4.5	4.3	4.1
BOD (3 days at 27 Deg.C)	mg/L	-	2.4	-	< 2.0	< 2.0	< 2.0
COD	mg/L	-	12.0	-	7.2	4.8	< 4.0
E.Coli	MPN/100 ml	not be detectable	Present	Absent***	Absent	Present	Absent
Total Coliform	MPN/100 ml	not be detectable	300	Absent***	< 2.0	220	< 2.0

Notes: * Requirement for drinking water,
** Water temperature at the time of testing,
*** Data tested at State Laboratory of PHED
**** Water samples were taken at Lamphel Super Market in the same water supply zone

3.6 Operation and Maintenance Regime of Existing Facilities

The following were found on operation and maintenance (O&M) regime of existing facilities from interviews with PHED:

- O&M works are conducted only by PHED. There is no outsourcing in Imphal municipal area. Only one WTP (Old Thumbuthong WTP) is managed by an NGO but the owner is still PHED. In small WTPs in rural areas outside Imphal, there is no outsourcing to private contractors.
- The examples of operation times, number of shifts, number of staffs, working times of staffs, and water supply times in a part of existing facilities which are operated by the three O&M divisions are shown in **Table 3.17**. The operation times are 24 hours at maximum with 2 or 3 shifts of staffs depending on power supply. However, some intake works and WTPs such as Irilbung are 4 to 10 hours with one or two shifts of staffs.
- The service hours are basically two hours. It fluctuates from 1.5 to 3.5 hours depending on the water supply zones. It is controlled by the manual valve operation at the water supply facilities.
- In case of very high water levels at rivers, the pumps at intakes are dragged out and are returned after the levels get lower.
- The daily checks of existing pipes and equipment in facilities are done visually for only the visible parts. There are no manuals with specific checking contents.
- The residual head of 2m is maintained at consumer points as checking of water pressure of distribution pipelines.
- The records of pipe failures have been prepared with (i) incident dates, (ii) incident locations, (iii) types of incidents, (iv) diameters of damaged pipes, (v) materials of damaged pipes, (vi) ages of damaged pipes, and (vii) assumed causes of pipe failures.
- The operation records for facilities are filled out by hand and are not computerized. These are recorded daily, but have not been summarized into monthly or yearly records.
- The reporting of the operation records is basically limited inside PHED. The sub-division offices prepare the operation records for submission to the division offices. The records reach up to Chief Engineer, but basically checking is done by the Executive Engineers. The records are not shared with IMC or the central government. The reports should be daily based, but there are reports that can be done weekly, or monthly in some cases.
- The frequencies of solid waste management, such as extracting sediments in settling tanks of WTPs, are summarized in **Table 3.18**. The extracted wastes are discharged to drains in the WTPs and flow to the nearby rivers since there is no sludge drying beds. Dediments are sometimes kept in WTPs without any treatment.

Table 3.17 Examples of Operation, Working and Supply Times in Existing Facilities

Division	Water Supply Scheme	Facility	Operation	Number of Shifts	Number of Staff	Working Time of Staff	Supply Time	Note
MD-I	Kangchup	Leimakhong Intake	24 hrs	N/A	11	24 hrs (not fixed)	-	
	Kangchup	WTP	24 hrs	3	12 (4 each)	6:00-11:00 11:00-18:00 18:00-6:00	2 hrs	Operators at night: putting chemicals only All the equipments can be operated by diesel generator
	Kangchup	Iroisemba GLSRs (Low level)	24 hrs	1	1 watchman 1 operator	N/A	5:00-8:30 15:00-18:00 (Total: 6-6.5 hrs)	Construction of new GLSR started from 2008 and stopped at 2011
	Kangchup	Iroisemba GLSRs (High level)	24 hrs	1	1 watchman & operator	24 hrs	ditto	Construction of new GLSR started from 2008 and stopped at 2011
MD-II	Potsangbam-I	Intake and WTP	8 hrs	1	2	24 hrs (not fixed)	1 hr each for 2 villages (Total 1.5 - 2 hrs am)	
	Potsangbam-II	Intake and WTP	10 hrs	2	1 2 (Total 3)	11:00-16:00 17:00-22:00	average 2 hrs/day	12 staffs are required but only 3 are working
	Canchipur-I	Kiyamgei Intake	24 hrs (average: 18 hrs)	3	1 1 1 (Total 3)	6:30 to 11:30 11:00 to 18:00 17:30 to 6:00	-	Operation time depends on power supply
	Canchipur-II	Lilong Intake	24 hrs	3	1 1 2 (Total 4)	morning evening night	-	Working times depend on power supply
	Ningthempukhri	Intake	24 hrs	3	1 1 2 (Total 4)	6:00-12:00 12:00-18:00 18:00-6:00	-	
	Ningthempukhri	WTP	24 hrs	3	2 2 3 (Total 7)	6:00-12:00 12:00-18:00 18:00-6:00	13:30-17:00 (3.5 hrs)	
	Old Thumbuthong	Intake	7 hrs 8:00-12:00 15:00-18:00	1	4	8:00-18:00	-	
	Old Thumbuthong	WTP	4 hrs (am: 2hrs, pm: 2hrs)	1	1	N/A	1 hr (6:00-7:00 am) (to 3 areas: one area every 3 days)	around 600 connections
PCD	Porompat	Intake	24 hrs	3	1 1 2 (Total 4)	6:00-12:00 12:00-18:00 18:00-6:00	-	1 rising main is not operational out of 2
	Porompat-I	WTP	6 hrs	1			average 2 hrs/day	
	Porompat-II	WTP	6 hrs	1			average 2 hrs/day	
	Irilbung	Intake and WTP	8 hrs	1	1 Pump Opeator 1 Watchman 3 Linemen (Total 5)	Depend on power supply	2.5 hrs (3:00 to 5:30 pm)	
	Chinga	Intake	13 hrs	3		5:30-18:30	-	
	Chinga	WTP	13 hrs	3	3 Operators 1 Watchman (Total 4)	6::00-11:00 11:00-15:00 15:00-19:00	6:00-8:00am (2 hrs)	Watchman stays 24 hrs
	Moirangkhom	WTP	12 hrs	2	2 2 (Total: 4)	6:00-12:00 12:00-18:00	6:30 to 7:50 am 2:00 to 3:20 pm (in order for 3 areas: one time per 1.5 days for each area)	
	Singda	WTP	24 hrs	3	9 Operators 1 Watchman (Total 10)	6:00-12:00 12:00-18:00 18:00-6:00	Around 2 hrs/day	Supervisor in PCD office
IFCD	Singda	Intake	24 hrs	2	2 Watchman 2 Watchman (Total: 4)	12 hrs 12 hrs	-	Watchmen check water level
IWD	Ghari	WTP	5-6 hrs	1	N/A	N/A	5:00-8:00am (3 hrs)	

Source：JICA Survey Team based on Interviews to PHED

Table 3.18 General Frequencies of Solid Management in WTPs

Activity	Frequency
Extraction of sediments from settling tanks	- Once a week during rainy season - Once a month during lean period
Extraction of sediments from clariflocculator	3 to 5 times per month
Extraction of sediments from pre-sedimentation tank	3 to 5 times per year
Backwashing of filters	Daily
Desilting of sedimentation tanks and clarifiers	Twice a year

Source：PHED

The more detailed operation and maintenance status performed in water treatment plants were confirmed through site interviews and are shown in **Appendix 3.5**.

3.7 Repair and Rehabilitation Regime of Existing Facilities

The repair and rehabilitation regime of existing facilities were confirmed by PHED through interview. The following were found out:

- There is no staff in charge of carrying out rehabilitation works in PHED.
- The minor repair works are conducted by the PHED's O&M staff posted at the WTPs. Major repair and rehabilitation works are performed by contractors under the supervision of PHED staff. However, the major repair and rehabilitation works are rarely accomplished due to the lack of budget.
- Equipment parts such as fittings of pipes and pumps in WTPs (e.g. bolts, valves and bends) are changed three to four times per year according to PHED Maintenance-II, but are not often done by Maintenance-I and PCD. In fact, JICA Survey Team observed a number of water leakages in the fittings of pipes in WTPs.
- The spare parts for equipment are stored in the warehouses in WTPs. The parts are bought from outside the state by local suppliers.
- The pipes for replacement and new installation works are procured by each O&M division but these are stored in stock yard of Store Division in Lamphelpat since the space in each WTP and service reservoirs is limited. The valves and joints are stored in each facility.
- Many repair works have not been attended to for quite some time due to the technical and financial reasons resulting to high and numerous water leakage from valves.

3.8 Status of Water Losses

(1) Status of Water Losses

The unaccounted for water (UfW) was calculated based on the volume of estimated water supplies and water production which were explained in **3.2.3** and **3.2.4**.

Total daily water production:	81,380 m^3/day
Total billed authorized water consumption:	24,789 m^3/day
Accounted for water in water supply system:	30.5% (=24,789 / 81,380)
UfW in water supply system:	69.5% (= 100 – 30.5)

The reasons behind high UfW are water leakages and illegal connections. Water leakages can be observed all over Imphal City. According to the DPR and from interviews with PHED, the number of illegal connections has roughly been estimated as about the same number of legal connections. Since there is no reliable data on the illegal connections, the assumption is used for estimating the unauthorized consumption in this report. The following table shows the volumes and ratios of each water consumption and loss categories in PHED service area.

Table 3.19 Present Water Consumptions and Losses in PHED Service Area

<table>
<tr><td rowspan="10">Raw Water</td><td rowspan="9">System Input Volume (Production Volume)
81.4MLD
100%</td><td rowspan="4">Authorized Consumption
30.5%</td><td rowspan="2">Billed Authorized Consumption
30.5%</td><td>Billed Metered Consumption</td><td>0%</td><td rowspan="2">Revenue Water (Accounted-for water)
24.8MLD
30.5%</td></tr>
<tr><td>Billed Non-metered Consumption
- Domestic & Institutional
- Bulk supply
- Water distribution at standpipes</td><td>24.8MLD
30.5%</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
0.04%</td><td>Unbilled Metered Consumption</td><td>0%</td><td rowspan="7">Non-Revenue Water (NRW) (Un-accounted for water)
56.6MLD
69.5%</td></tr>
<tr><td>Unbilled Non-metered Consumption
- Water use in PHED office</td><td>0.03MLD
0.04%</td></tr>
<tr><td rowspan="5">Water Losses (UfW)
69.5%</td><td rowspan="2">Apparent Losses (Non-technical or Commercial Losses)
17.4%</td><td>Unauthorized Consumption (illegal use and connections)</td><td>14.2MLD
17.4%</td></tr>
<tr><td>Metering Inaccu racies
- No meters
- Meters not working
- Mmeters not recording accurately
- Meters misread</td><td>0%</td></tr>
<tr><td rowspan="3">Real Losses (Technical Losses)
52.1%</td><td>Leakage or Transmission and/or Distribution Main s</td><td rowspan="3">42.4MLD
52.1%</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connecting up to Customers' Meters</td></tr>
<tr><td colspan="6">Treatment Losses (Backwash etc.), Evapolation</td></tr>
</table>

Source：JICA Survey Team

(2) Countermeasures for Water Losses

The following are the current countermeasures for water losses by each O&M division in PHED.

Table 3.20 Countermeasures for Water Loss by PHED

O&M Division	MD-I	MD-II	PCD
ANSWERS	- Immediate attention be given to detection and appropriate repair - Staff posting to maintain raw water mains and clear water, distribution lines - Campaign against illegal connections using print and electronic media and taking legal action against them	- Repair leakage by line staff - Detect leakages - Detect and take legal action against unauthorized connections	- Employ three Technical Jugali for daily O&M of pipelines. - Install consumer water meter and regularly check pipelines (for future).

Source：PHED

However, considering the the total length of pipelines and the number of O&M staffs, the number of pipe fitters in PHED is few compared to necessary number. In addition, there is lack of proper equipment for leakage detection.

3.9 Present Operation and Maintenance Cost

PHED does not have actual records of operation and maintenance costs except for chemical cost. Therefore, O&M cost was estimated based on the following:

- Annual power cost was estimated based on actual bills of the latest month(s) for each facility from Electricity Department under State Government of Manipur.
- Manpower cost was estimated based on the actual salaries for some positions which were obtained from MD-I and PCD. However, the targets of salaries are O&M staffs at facilities and Executive Engineers, Assistant Engineers, Sections Officers, administration staffs and drivers were not included in the cost.
- Repair/replacement cost was derived from annual budget after proper categorization including exclusion of capital costs.
- Maintenance cost was estimated from total costs for chemical, power and manpower costs in case of MD-I and annual budgets in case of MD-II and PCD.

The operation and maintenance cost for financial year 2013-14 is shown in **Table 3.21**. Therefore, the total cost can be estimated at around INR 160 million.

The details of chemical and power costs and personnel expense are shown in **Appendix 3.9 (1).** The annual budgets for 2013-14 and 2014-15 which are the bases of repair/replacement and maintenance costs are shown in **Appendix 3.9 (2)**.

Table 3.21 Present Annual O&M Cost

S. No.	Description	Estimated Annual Amount in INR (2013-14)				Note
		MD-I	MD-II	PCD	Total	
1	Chemical Cost	11,194,471	7,159,250	11,748,439	30,102,160	
2	Power Cost	5,128,368	32,086,908	12,776,412	49,991,688	
3	Personnel Expense	21,300,000	18,996,000	13,597,776	53,893,776	
4	Repair/Replacement Cost	7,200,000	N/A	5,050,000	12,250,000	
5	Maintenance Cost	1,128,685	3,600,000	5,630,000	10,358,685	MD-I: 3% of items 1 to 3 MD-II, PCD: based on annual budgets
Total		**45,951,524**	**61,842,158**	**48,802,627**	**156,596,309**	

Source：JICA Survey Team based on PHED Data

3.10 Present Status on Utilization of Information Management System

(1) Existing Ledgers

PHED does not have any technical ledgers with the detailed information on existing facilities and on water transmission/supply pipelines; but has only A3-size drawings with facilities and main pipelines on satellite image map which was prepared by AutoCAD. However, this has not also been updated for a long time due to the lack of CAD operators.

Only MD-I has recently started preparing the mixed format of technical and consumer ledgers with rough pipe alignments, diameters, consumers' number and names as shown in **Appendix A3.10 (1)**. The file is prepared by Adobe Pagemaker and the file is only for Babupara Area as a pilot case of ledger preparation.

The list with consumers' serial numbers and names, connection dates for water supply system, billing and paid conditions of water tariffs is managed by "Water Billing System" through PHED website shown in **Appendix A3.10 (2)**. The system started to be uses from last year and the data inputs for each O&M Division were recently completed. The system will be upgraded with e-payment system in the near future since PHED is now negotiating with a vendor.

(2) Geographic Information System (GIS)

Geographic Information System (GIS) is a computer program that combines mapping with detailed information on physical structures with geographic areas. GIS has compatibility with AutoCAD design systems. The remote sensing maps can be used to prepare base maps of the utilities by using GIS. The GIS creates a database within a mapped area such as streets, valve chambers/manholes, pipe networks and pumping stations. The attributes can be address, number of valve chamber/manhole, pipe length, diameter, invert and quadrant (coordinates) and can also include engineering information, maintenance information and inspection information. The utility staff will get the facility to update the maps and retrieve information geographically. These maps can be used to inform the maintenance staff the locations of leaks and the work to be done. The utility can use a work order system for new/repair works so that after completion of the work (e.g. a line is added or a valve is fixed or a new connection is given) the work order can be used by the map unit for updates of the maps and the attributes. These maps are used to indicate layers of maps for water lines, sewers, power cables, telecom cables etc.

The following items are necessary for establishing the GIS for water supply system.

- Computer program for GIS (to be purchased and programmed)
- Maps prepared with topographic survey (should be updated periodically)
- Inventory of water supply facilities (pipe length and diameter, manholes, house connections water flows and pressures etc.)
- Auto-CAD plan drawings with maps and facilities' alignments and locations (compatibility with auto-cad design systems)
- Construction, maintenance and inspection information (years, dates)
- IT engineers in charge of GIS
- Design or as-built drawings of facilities (better)
- Alignments of other utilities (better)

(3) Management Information System (MIS)

Quite often there is an acute lack of information on material inventories, tools, spares, staffing pattern, costs etc. Hence setting up a Management Information System is one of the most important tasks in the institutional development which could lead to sustainable O&M. The authority must decide what information is important, who is to keep the record, periodicity of reporting system and formats of reporting. MIS is used to analyze and evaluate the performance of system. The MIS could also be used in assigning responsibilities and in distribution of human, material and financial resources to ensure sustainable O&M.

All the O&M divisions in PHED Urban Circle are positive to introduce and utilize the MIS in future. As the case of GIS, MIS also require the base information for the system such as spare parts, chemicals, staffing and costs to be basically shared for the centralized administrative control. The concerned staff, sections and divisions in charge of such as procurement, staffing and accounts in PHED should cooperate and coordinate with each other for the efficient management of water supply system.

(4) Supervisory Control and Data Acquisition (SCADA) System

Supervisory Control and Data Acquisition (SCADA) is a computer aided system which collects, stores and analyses the data on all aspects of O&M. The operating personnel can retrieve the data and control their operations and sometimes the system itself is programmed to control the operations on the basis of the acquired data. SCADA enhances the efficiency of the O&M staff who are better informed about the system and hence are in full control of the operations. Up-to the minute real time information is gathered from remote terminal units located at the water treatment plant, reservoir, flow meter, pumping station etc. and transmitted to a central control station(s) where the information is updated, displayed and stored manually or automatically. In a SCADA system the information is linked to a supervisory system for local display and alarm announcement. which may be linked to remote control of pumping operations or operation of valves etc.

The SCADA system has not installed in any water supply facility in Imphal City but all the divisions are positive to introduce and utilize the SCADA system in the future. Since there are so many water supply facilities to monitor and/or control remotely in central control station(s), the objectives and scale of SCADA system, installation of necessary instrumentations for existing facilities and locations of the central control station(s) were considered. The framework is explained in detail in 6.4.4 Improvement of Information Management System (IMS) in this report.

(5) Present Status of Information Management

The present status of information management in PHED such as the numbers of computers and software, internet connection, data sharing and number of operators were confirmed by interviews as shown in **Table 3.22**.

Table 3.22 Present Status of Information Management

Division	Computer			Software				Internet Conncetion	Data Sharing by Server	Approximate Number of Staff who can operate Software			Operator/Private Secretary			
	Desktop	Laptop	Total	Mapping /GIS	CAD	Adobe Pagemaker	Other			Microsoft Office	CAD	Other	Microsoft Office	CAD	Other	Total
Office Superintendent	-	-	-	-	-	-	-	LAN	-	2	N/A	N/A	1	0	0	1
MD-I	4	0	4	0	1	1	0	LAN	No	5	3	1	1	1 (leave soon)	0	2
MD-II	3	0	3	0	1	0	0	No	No	3	0	0	0	0	0	0
PCD	1	2	3	0	1	0	0	No	No	4	2 (1 leave soon)	0	0	0	0	1
Stores	1	0	1	0	0	0	0	No	No	2	0	0	0	0	0	0
Total	9	2	11	0	3	1	0	-	-	16	5	1	2	2	0	4

Source：JICA Survey Team based on interviews with PHED

From the interviews, following problems were found:

- Number of official computers is only around 10 in PHED Urban Circle and some computer works are supplemented by private / personal laptop computers of some staff.
- Numbers and type of software is quite limited and it is basically Auto CADs in each division.
- Porompat Office, which MD-II and PCD belong to, does not have Internet connection, so staff use their private mobile phone network to send emails.
- Data is not shared with any data server and computer files are scattered and not organized.
- Some staff can operate Auto CAD software due to the previous trainings but many operators will retire from PHED soon.

- Basically no professional computer operator belong to PHED. Therefore, data input works has been done by only the Assistant Engineers and/or Section Officers (and some Clerks in case of MD-I).

The data management in PHED for the following items with section/person in charge, work contents, type of data, and frequency of update are shown in **Appendix 3.10 (3)**.

1) Chemical use
2) Construction materials/ spare parts
3) Equipment
4) Human resources (list of staffs, salary etc.)
5) Water production and supply record (power supply, water production, water supply hour etc.)
6) Water quality record (Raw water, WTP, distribution points)
7) Maintenance record (equipment maintenance pipe failure and fitting etc.)
8) Consumer connection, billing and metering
9) Tariff revenue
10) Cost
11) Customer service (claims etc.)
12) Asset management
13) Plan (annual, three years)
14) Progress monitoring sheet

From the results, following problems were found and confirmed:

- Data prepared by computer files are quite limited for such as chemical procurement record, water quality examination record.
- Most of all the administration staff such as clerks who handle the consumer lists cannot operate computers.
- Data such as salaries and power charges are not recorded even with hand writing format.
- Summary tables such as water quality examinations have not been prepared.
- Some information such as actual power charges from state government, contract amount for water billing system is limited to only the Chief Engineer or the Executive Engineers.

Chapter 4 Financial Conditions of Current Water Supply Operations

4.1 Present Water Tariff

The Manipur Water Supply Act, 1992 (Manipur Act No. 1 of 1993), allows the PHED to set water tariff, including flat rate, adjust / change rates on metered charges on the basis of number of points installed, or dimension of water pipe connected. Based on the Act, the State government of Manipur adopts flat rates for their water supply service. Current water tariff came into effect on April 1st of 2011, based on the Governor's order dated 31st of March 2011.

The tariff schedule consists of 13 types of usage, including domestic individual connection, hospital, restaurant, hotel, schools, industries and other bulk consumptions. Water tariff for domestic individual connection is a flat rate of Rs.150 per connection per month. For other types of connection, which are also applied frat rate but different price levels, the Manipur Water Supply Act stipulates that the water tariff other than domestic purposes shall not be less than double the rate charged for domestic use. Details of tariff rate by type of water connection are shown in table below.

Table 4.1 Water Tariff Rate of Manipur State

No.	Type of Water Connection	Rs./ Connection/ Month
1	Domestic Individual Connection	Rs. 150 /-
2	Hospital a) Up to 100 beds b) Above 100 beds	a) Rs. 1,730 /- b) Rs. 2,100 /-
3	Hostel up to 100 rooms	Rs. 1,860 /-
4	Restaurant	Rs. 1,500 /-
5	Hotel up to 100 rooms	Rs. 3,000 /-
6	a) School/ College b) Office	a) Rs. 600 /- b) Rs. 1,000 /-
7	Cinema Hall/ Concert Hall/ Theatre	Rs. 760 /-
8	Industries Establishment/ Workshop a) Small Scale Industries b) Medium & Large Industries	a) Rs. 200 /- b) Rs. 1,000 /-
9	Public Hydrant	Rs. 300/- /-
10	Tanker Supply a) 4,500 liters capacity b) 8,000 liters capacity c) 9,000 liters capacity d) 10,000 liters capacity	a) Rs. 250/- per trip b) Rs. 450/- per trip c) Rs. 500/- per trip d) Rs. 550/- per trip
11	Supply to private tankers from treatment plants	Rs. 8/- per 1,000 liters
12	Bulk supply through pipe	Rs.10/- per 1,000 liters
13	Trailer tanker 1,000 liters capacity without jeep	Rs.100- per / trip/day

Source: PHED, Government of Manipur

Note: This tariff schedule is applicable only those areas beyond the jurisdiction of the Autonomous District Council, where fixing of water prices and collection of water tariff had already been developed.

At the time of the latest tariff rate revision, PHED roughly estimated that around 75% of water consumption was for domestic purpose, whereas remaining 15% was for institution and government offices, 5% was for industry and bulk consumption, and 5% was for public stand post. In this estimation, annual average volume of water production was 24,820 ML, and allocation for domestic use was 18,615 ML. Then, production cost of domestic water is obtained dividing annual O&M cost by the water volume, or around Rs. 2.3 per 1,000 liters.

Background concept of water tariff estimation for domestic individual connection is to cover annual maintenance cost of water supply system, whereas other tariffs are estimated by using unit consumption volume and unit production cost of water. Detailed formulas for water tariff estimation by PHED are shown in the table below.

Table 4.2 Detailed Formulas for Water Tariff Estimation

No.	Type of Water Connection	Formula
-	Production Cost of Water	a) Annual average production of water = 24,820 ML b) 75% of water for domestic consumption = 18,615 ML c) Annual expenditure of Operation and Maintenance = Rs. 567.81 Lakhs d) O&M cost for domestic consumers = Rs. 567.81 Lakhs÷75% = 425.85 Lakhs e) Cost of production per 1000ℓ = [425.85 Lakhs×1000]÷18,615 ML ＝Rs. 2.28 = say, **Rs. 2.3/-**
1	Domestic Individual Connection	a) annual maintenance cost = 567.81Lakhs b) 75% for domestic consumption = 425.85Lakhs c) No. of connection anticipated = 23,500 nos. d) cost of drinking water/connection/month = 425.85Lakhs÷23.500×12 = Rs.151.01 = say, **Rs.150/-**
2	Hospital	I. for number of bed not exceeding 100 beds a) capita supply/ day = 250ℓ/bed b) Max monthly requirement = 250ℓ×30days×100beds = 750,000ℓ c) cost of water per month = 750,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.1,725 = say, **Rs.1,730/-** II. for more than 100 beds but less than 500 beds a) capita supply/ day = 300ℓ/bed b) Max monthly requirement = 300ℓ×30days×100beds = 900,000ℓ c) cost of water per month = 900,000ℓ×Rs.2.3/1000ℓ÷1,000 = Rs.1,725 = say, **Rs.1,730/-**
3	Hostel up to 100 rooms	(Assuming 100 rooms @ 2bed/room) a) capita supply/ day = 135ℓ/ boarder b) requirement of water/ month = 135ℓ×30days×100×2 = 810,000ℓ c) cost of drinking water per month = 810,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.1,863 = say **Rs.1,860/-**
4	Restaurant	a) capita supply per day = 180ℓ b) requirement of water/ month = 180ℓ×30days×100 = 540,000ℓ c) cost of drinking water per month = 540,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.1,242 = say **Rs.1,500/-**
5	Hotel up to 100 rooms	(Assuming 2 beds per room) a) capita supply/ day = 190ℓ b) requirement of water/ month = 190ℓ×30days×100×2 = 1,140,000ℓ c) cost of drinking water/ month = 1,140,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.2,622 = say **Rs.3,000/-**

No.	Type of Water Connection	Formula
6	School/ College, Office	I. School/ Collage (an average of 150 staff) a) capita supply/ day = 60ℓ b) requirement of water/ month = 60ℓ×30days×150staff = 270,000ℓ c) cost of drinking water per month = 270,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.621 = say **Rs.600/-** II. Office (an average of 250 staffs) a) capita supply/ day = 60ℓ b) requirement of water/ month = 60ℓ×30days×250staff = 450,000ℓ c) cost of drinking water/ month = 450,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.1,035 = say **Rs.1,035/-**
7	Cinema Hall/ Concert Hall/ Theatre	a) capita supply/ day = 22ℓ b) requirement of water/ month = 22ℓ×30days×500 seats = 330,000ℓ c) cost of drinking water/ month = 330,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.759 = say **Rs.760/-**
8	Industries Establishment/ Workshop	I. Up to 20 workers a) capita supply/ day = 135ℓ b) requirement of water/ month = 135ℓ×30days×20workers = 81,000ℓ c) cost of drinking water/ month = 81,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.186.3 = say **Rs.200/-** II. Above 20 workers but not more than 100 a) capita supply/ day = 135ℓ b) requirement of water/ month = 135ℓ×30days×100workers = 405,000ℓ c) cost of drinking water/ month = 405,000ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.931.5 = say **Rs.1,000/-**
9	Public Hydrant	(taking five households @ six heads per HH) a) capita supply/ day = 135ℓ b) requirement of water/ month = 135ℓ×30days×30 = 121,500ℓ c) cost of drinking water/ month = 121,500ℓ×Rs. 2.3/1000ℓ÷1,000 = Rs.279.45 = say **Rs.300/-**
10	Tanker Supply	I. Expenditure of water tankers per month a) diesel (fuel) per month 5,250ℓ = Rs. 173,250 b) lubricant (M/oil, Grease, B/Oil, G/Oil) per month = Rs. 12,500 c) repairs and maintenance i/c per month = Rs. 16,000 d) staff salary for 8 drivers per month = Rs. 80,000 Total = Rs. 281,750 II. Nos of trips/ month considering 25 working days a) 10,000ℓ Tankers (2) @ 4 trips per day = 25×2×4 = 200 trips b) 9,000ℓ Tankers (3) @ 4 trips per day = 25×3×4 = 300 trips c) 4,500ℓ Tankers (1) @ 5 trips per day = 25×1×4 = 125 trips III. Total volume of water supplied by Tanker per month a) 10,000ℓ×200 trips = 2,000,000 trips b) 9,000ℓ×300 trips = 2,700,000 trips c) 4,500ℓ×100 trips = 562,500 trips Total = 5,262,500ℓ IV. Production Cost of Tanker Water (Rs./month/1000ℓ) - Unit O&M Cost of water tankers = Rs. 281,759÷5,262,500ℓ×1,000 = Rs. 53.53 - Total production cost of tanker water per 1000ℓ = Rs. 53.53 + Rs. 2.3 = Rs. 55.83 = say, Rs. 56/1000ℓ a) cost of 10,000ℓ Tanker = Rs. 56÷10 = Rs.560 = say **Rs. 550/-** b) cost of 9,000ℓ Tanker = Rs. 56÷9 = Rs.504 = say **Rs. 500/-** c) cost of 8,000ℓ Tanker = Rs. 56÷8 = Rs.448 = say **Rs. 450/-** d) cost of 4,500ℓ Tanker = Rs. 56÷4.5 = Rs.252 = say **Rs. 250/-**
11	Supply to Private Tankers from Treatment Plants	Treatment Plants (3): Porompat, Koirengei, Chanchipur a) Taking an average volume of 3 treatment plants per month = 3,480ℓ = 3.48KL b) Cost of production of water per 1000ℓ = 3.48KL ×Rs.2.3/1000ℓ = **Rs. 8/ 1000ℓ**

No.	Type of Water Connection	Formula
12	Bulk supply through Pipe	a) Volume of water supplied through pipe per month = 4,348ℓ = 4.348KL b) Cost of production of water per 1000ℓ = 4.348KL×Rs.2.3/1000ℓ= **Rs.10/ 1000ℓ**
13	Trailer Tanker 1,000ℓ Capacity without Jeep	a) Total production cost of tanker water per 1000ℓ = Rs. 56/- b) Cost of production of water per 1000ℓ = 1.79KL×Rs.56/1000ℓ = **Rs.100/ trip/day**

Source: PHED, Government of Manipur

4.2 Past Water Tariff Revision

According to Article 11 of the Manipur Water Supply Act, the State government of Manipur can revise water tariff rate from time to time by notification in the official gazette. By the legal ground, PHED, as the prescribed authority of water supply service, readjusts the tariff rate based on actual production cost of water. After the readjustment, PHED submits a proposal to the State Government, which examines and gives approval to the proposed new tariff rates if it is affordable. Then, the Governor of Manipur issues an order for the revised tariff through the Manipur Gazette.

The current water tariff rate, Rs.150 per connection per month for domestic use, came into effect on 1st of April 2011. Before the revision, water tariff for domestic consumption had been Rs.75 per connection per month for 10 years. The tariff level was half the current water tariff level, meaning before the latest revision, water tariff had been kept on a low level for long time. Since 1991, water tariff for domestic connection was revised four times, and the past revisions and their price levels are shown in the figure below.

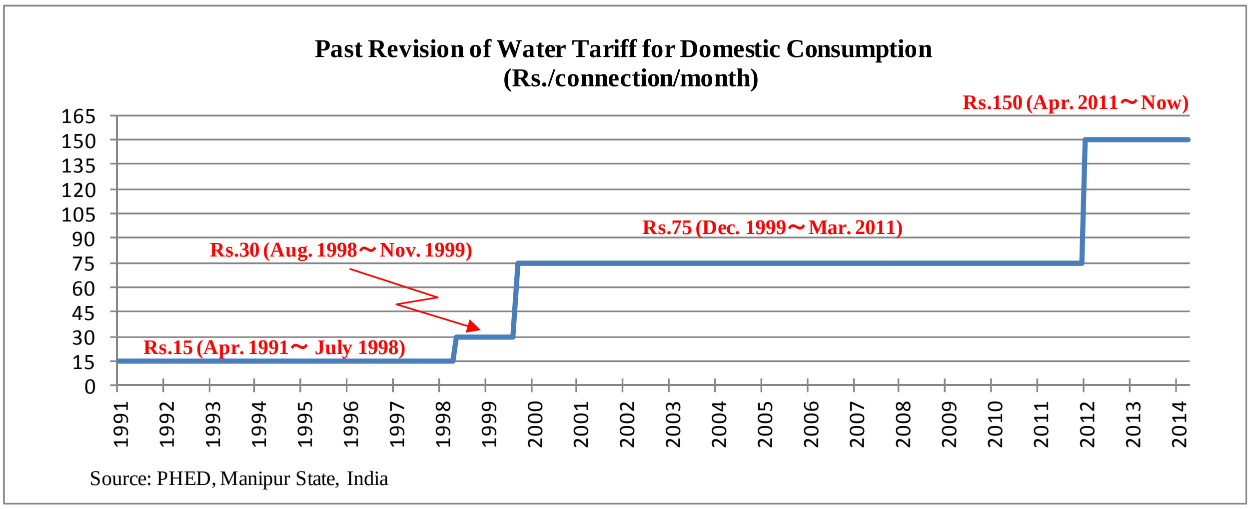


Figure 4.1 Past Revision of Water Tariff for Domestic Consumption

In 1996, water tariff for private water tap connections was fixed at Rs. 0.75 paisa per 1000 gallons, in a way of volumetric method. However, charging system of the tariff for domestic connection shifted to a flat rate per connection from April 1991, when the rate was set at Rs. 15 per connection per month. Since then, the rates became double or more at the time of readjustment. Historical change of water tariff in Manipur is shown in table below.

Table 4.3 Past Revision of Water Tariff

No.	Type of Connection	Year of Revision (Rs. per connection per month)				
		Sep. 1966	Apr. 1991	Aug. 1998	Dec. 1999	Apr. 2011
1	Domestic Individual Connection	Private Water Tap: Rs.0.75paisa/1000gallon	Rs. 15/-	Rs. 30/-	Rs. 75/-	Rs. 150 /-
2	Hospital a) Up to 100 beds b) Above 100 beds	—	Rs. 150/-	up to 50bed: Rs.250 a) Rs.500 b) Rs1,000	Rs.2.43/ 1000ℓ	a) Rs. 1,730 /- b) Rs. 2,100 /-
3	Hostel up to 100 rooms	Rs. 75/-	Rs. 300/-	Rs. 350/-	Rs. 750/-	Rs. 1,860 /-
4	Restaurant	Rs. 30/-	Rs. 150/-	Rs. 500/-	Rs. 750/- (up to 1000 rooms)	Rs. 1,500 /-
5	Hotel up to 100 rooms	Rs. 75/-	Rs. 300/-	Rs. 300/-	Rs. 1,500 /- /a	Rs. 3,000 /-
6	a) School/ College b) Office	a) Rs. 75/- /b b) Rs. 15/-	Rs. 150/-	Rs. 150/- (up to 100staffs)	Rs. 300/-	a) Rs. 600 /- b) Rs. 1,000 /-
7	Cinema Hall/ Concert Hall/ Theatre	—	—	Rs. 300/-	Rs. 600/-	Rs. 760 /-
8	Industry, Establishment/ Workshop a) Small Industries b) Medium & Large Industries	Rs. 15/- /c Rs. 22/- /d	Rs. 300/-	a) up to 20: Rs.60 b) above 20:Rs150	a) Rs. 120 /- b) Rs. 750 /-	a) Rs. 200 /- b) Rs. 1,000 /-
9	Public Hydrant	—	Rs. 30/-	Rs. 60/-	Rs. 100/-	Rs. 300/- /-
9+	Private Hydrant (PrH)	a) 0< PrH≤ 3: Rs. 4.5 b) 3< PrH ≤5: Rs.6.0 c) 5< PrH ≤10: Rs.7.5 d)7< PrH ≤10: Rs.9.0	—	—	—	—
10	Tanker Supply a) 4,500 liters capacity b) 8,000 liters capacity c) 9,000 liters capacity d) 10,000 liters	—	—	a) Rs. 100/trip c) Rs. 200/trip d) Rs. 300/trip	a) 200/ trip c) 350/ trip	a) Rs. 250/ trip b) Rs. 450/ trip c) Rs. 50/ trip d) Rs. 550/ trip

No.	Type of Connection	Year of Revision (Rs. per connection per month)				
		Sep. 1966	Apr. 1991	Aug. 1998	Dec. 1999	Apr. 2011
	capacity					
11	Supply to private tankers from treatment plants	—	—	—	Rs. 2.5/ 1,000ℓ	Rs. 8 / 1,000ℓ
12	Bulk supply through pipe	—	—	—	Rs. 3/ 1,000ℓ	Rs.10 / 1,000ℓ
13	Trailer tanker 1,000 liters capacity without jeep	—	—	—	Rs.20/trip/day	Rs.100/trip/day

Source: PHED, Government of Manipur

Note a/ Hostels with boarding

b/ Per connection for college and laboratories which requires water. Other educational institutions are applied Rs.15/-.

c/ Per connection for banks, industries drying and cleaning shops

d/ Per connection for motor car repairs garage owner

4.3 Consideration for Poverty in Water Tariff

Officially, there have been no particular poverty consideration measures that have been taken into account in determining current rates for the water supply service or water tariff in Manipur including exemption of payment. However, in reality, PHED does not force the collection of water tariff at the grass roots level, since PHED officials have recognized that most people in Imphal are of the low income group. In some areas, according to the social condition survey conducted by the JICA Survey Team, PHED officials have not delivered water bills to some individual households for long time.

The Planning Commission has periodically estimated poverty line and poverty ratio. For this purpose, household consumer expenditure surveys are conducted on quinquennial basis by the National Sample Survey Office (NSSO), under the Ministry of Statistics and Programme Implementation. The latest survey was implemented in 2011-12[1].

According to the latest estimation, the poverty line in the entire India is at Rs.27 per capita per day (Rs.816/ capita/ month) for rural areas and Rs.33 per capita per day (Rs.1,000/ capita/ month) for urban areas. The estimates indicate that around 217 million people in rural areas and around 53 million in urban areas are living below the poverty line (BPL). Chhattisgarh is the poorest state with almost 40% of population being BPL. Seven states in India, including Chhattisgarh, Bihar, Jharkhand, Madhya Pradesh, Odisha, Rajasthan and Uttar Pradesh, are traditionally poorest.

For Manipur State, the poverty lines in 2011-12 are estimated at Rs.37/ capita/ day (Rs.1,118/ capita/ month) for rural area, and Rs.39/ capita/ day (Rs.1,170/ capita/ month) for urban area. Peoples who live under the poverty lines are around 745 thousand in the rural area while 278 thousand in urban area in. The proportion of population below poverty line in Manipur is higher than the entire India as shown in table below.

[1] Press Note on Poverty Estimates, Planning Commission, Government of India, July 2013

Table 4.4 Number and Percentage of Population below Poverty Line (2011-12)

Nation/ State	Rural	Urban	Total
Manipur State	745,000 (38.80%)	278,000 (32.59%)	1,022,000 (36.89%)
All India	216,658,000 (25.70%)	53,125,000 (13.70%)	269,783,000 (21.92%)

Source: Press Note on Poverty Estimates, Planning Commission, Government of India, July 2013
Note: Population as of 1st March 2012 has been used for estimating number of persons below poverty line. (2011 Census population extrapolated)

4.4 Financial Information

The accounting system of the water supply works is not separated from the general account of the Government of Manipur. Budget planning starts from May and divisions of PHED prepare their budget proposals during May and June. Then, the state budget plan is consolidated and submitted by the Chief Minister to the State Assembly, which holds budgetary discussions during the month of July. The state budget is usually approved by the end of July or August. A part of the state budget is allocated to PHED, and is around Rs. 1,446 million in the fiscal year of 2013-14.

The budget of PHED consists of non-plan expenses and planned expenses, and the former includes regular salary, electricity bill, travel expenses, office expenses, and minor repairing of machinery and equipment, whereas the latter includes O&M cost and capital investment on water supply and sanitation services. In 2013-14, the non-plan expenditure accounts for 42% of total budget of PHED, while the planned expenditure makes up 58%. The largest expenditure item in the non-plan item is regular salary that accounts for 33% of the total budget.

According to officials of maintenance divisions, their budget allocation is not enough, and the usage of O&M expenditure needs to be prioritized. Higher priority is placed on securing budget for quality control such as the procurement of chemical materials, maintenance of old pipe to stop leakage, and power supply for daily operation.

Table 4.5 Annual Budget of PHED (Unit: Rs.1,000/-)

Item	2009-10	2010-11	2011-12	2012-13	2013-14
Non Plan Item (Operating Expenses)					
1 Salary	261,437	404,942	492,033	474,798	482,685
2 Travel Expenses	1,265	1,215	1,215	1,215	1,215
3 Office Expenses and Others	302,810	116,350	116,444	122,211	111,547
4 Machinery and Equipment	5,650	5,650	5,650	5,650	5,650
Subtotal	571,162	528,157	615,342	603,874	601,097
Planned Item (State Plan)					
5 Water Supply & Sanitation	3,300	3,300	2,300	2,300	2,000
6 Capital Outlay on Public Works (Office Building)	20,000	50,000	16,570	30,000	5,000
7 Capital Outlay on Water Supply and Sanitation	1,103,200	1,347,275	1,259,550	933,700	791,024
8 Capital Outlay on North Eastern Areas	0	0	0	0	47,134
Subtotal	1,126,500	1,400,575	1,278,420	966,000	845,158
Others	430,620	723,435	295,659	276,043	0
Total	2,128,282	2,652,167	2,189,421	1,845,917	1,446,255

Source: PHED

The revenue of PHED in 2013-14 is Rs. 20,950 thousand, of which Rs. 17,524 thousand is from Imphal water supply system. The revenue consists of tax revenue and others, including tender form fee and penalty from illegal connection. In Imphal water supply system, tax revenue in the same year is Rs. 16,647 thousand, accounting for 95% of its total revenue.

Total expenditure of PHED in the same year is Rs. 1,396 million and around 18% of the expenditure is disbursed to Imphal water supply system. According to the accounting section of PHED, 11% of total expenditure in Imphal water supply system is for operation and maintenance cost, whereas 48% is allocated to capital investment and 41% is for non-plan expenditure.

In 2013-14, the proportion of revenue from Imphal water supply system for its O&M costs is estimated at 66%, which is higher than that of PHED's total figure. However, this O&M costs does not include regular salary, fuel and electricity charges. Considering these charges, the revenue from Imphal water supply system covers only 14% of the O&M costs. In addition, revenue to expenditure of Imphal water supply system is unbalanced and the ratio is only 7%, far from being self-supporting because (i) PHED's service level is low and consumers do not want to pay water tariff, (ii) payment capacity of people is also quite low, and therefore, (iii) tax collection drive is almost impossible under the current situation.

Table 4.6 Revenue and Expenditure of PHED (Unit: Rs.1,000/-)

	2009-2010		2010-2011		2011-2012		2012-2013		2013-2014	
	PHED	Imphal Water Supply	PHED	Imphal Water Supply	PHED	Imphal Water Supply	PHED	Imphal Water Supply	PHED	Imphal Water Supply
I. Revenue										
a) Tax Revenue	7,846	7,031	17,917	7,499	10,398	9,070	15,772	15,155	18,674	16,647
b) Others /a	11,919	245	5,388	292	3,633	266	3,891	1,156	2,276	877
Subtotal	19,765	7,276	23,305	7,791	14,031	9,336	19,663	16,311	20,950	17,524
II. Expenditure										
a) O&M Cost	101,036	20,214	140,270	25,778	128,428	27,694	143,729	30,416	193,851	26,626
b) Capital Investment (works) /b	1,462,632	170,683	2,640,120	345,951	1,335,758	201,942	1,034,106	303,121	605,677	120,932
c) Non-Plan Expenditure /c	582,090	83,005	518,787	89,100	615,418	106,950	592,530	99,020	596,226	101,918
Subtotal	2,145,758	273,902	3,299,177	460,829	2,079,604	336,586	1,770,365	432,557	1,395,754	249,476
Revenue/ O&M Cost	20%	36%	17%	30%	11%	34%	14%	54%	11%	66%
Reveue/ Expenditure (%)	0.9%	2.7%	0.7%	1.7%	0.7%	2.8%	1.1%	3.8%	1.5%	7.0%

Source: PHED

Note: a/ Other revenue includes tender form fee, penalty, etc.

b/ "Works" includes transmission main, pumping station, service reservoir, treatment plant, distribution network, etc.

c/ Non-plan expenditure includes regular salary, electricity bill, travel expenses, office expenses, and minor repairing of machinery and equipment.

The past five years (from 2010-11 to 2013-14) show a decreasing trend for PHED’s annual budget and expenditure. In contrast, annual O&M costs increase year by year, where the O&M cost of Rs. 20,214 thousand in 2009-10 became Rs. 30,416 thousand in 2013-14. The revenue of Imphal water supply system also shows an increase in the past five years, from Rs. 7,276 thousand in 2009-10 to Rs. 17,524 thousand in 2013-14 due to significant efforts of the PHED staff.

4.5 Water Charge Collection System

The information management system of subscribers was computerized in June 2012, and the information includes the ID number of customers, the date of connection, subscriber’s name and address, last billing month, outstanding account, net balance, type of connection, and connection status. In addition to the PHED officials, customers can access the database using the one input ID number and password. On the database, consumers can check their payment balance, whereas water tariff collectors can monitor the subscriber’s payment status and issue the bill.

According to PHED, bills statements are issued quarterly to all the water users, and water tariff collection staff deliver the bill from door to door. However, the bills hardly reach all the subscribers due to the lack of delivery staff. To overcome such a situation, PHED plans to introduce the Internet billing system from 2014, if all goes smoothly. As of July 2014, there are 11 bill clerks to cover 20,056 subscribers, meaning one staff covers around 1,823 connections in the service area as shown in table below.

Table 4.7 Water Tariff Collection System

	Maintenance Division I	Maintenance Division II	Project Construction Division	Total
Number of Service Station	1	1	1	4*
Number of Collector (a)	8	2	1	11
Number of Connection (b)	11,687	5,763	2,606	20,056
Coverage Connection per Collector (b) / (a)	1,461	2,882	2,606	1,823

Source: PHED (2014)

Note: * including the main water tax collection counter at PWD compound.

There are three forms of payment – cash, check, and bank transfer. Each division has its own water tax collection counters in their offices, in addition to the main collection counter at the entrance of the Public Works Department where the office of the Chief Engineer of PHED is located. The tax collection counters open from 10:30 am to 2:00 pm and customers have to visit any the divisional offices to make payments. At the time of payment, so called “Challan” is issued by the State Government as an official receipt for the payment. The following table shows past trend of water tariff collection amount of three divisions.

Table 4.8 Past Trend of Water Tariff Collection in Three Divisions (Rs.)

<table>
<tr><th>Division</th><th>2009-2010 /a</th><th>2010-2011</th><th>2011-2012</th><th>2012-2013</th><th>2012-2014</th></tr>
<tr><td>Maintenance Division I /b</td><td rowspan="3">7,030,000</td><td rowspan="2">7,510,000</td><td>6,796,000</td><td>9,548,000</td><td>11,272,000</td></tr>
<tr><td>Maintenance Division II</td><td>1,261,000</td><td>7,085,000</td><td>5,628,000</td></tr>
<tr><td>Project Construction Division</td><td>72,000</td><td>403,000</td><td>508,000</td><td>560,000</td></tr>
<tr><td>Total</td><td>7,030,000</td><td>7,582,000</td><td>8,460,000</td><td>17,141,000</td><td>17,460,000</td></tr>
</table>

Source: PHED
Note: a/ Former Maintenance Division was divided in current three Divisions in 2010.
b/ The tariff includes water connection charge and regularization fee of unauthorized water connections.

4.6 Collection Rate

At present, water tariff collection rate of PHED is quite low, but accurate data on the collection rate does not exist. According to the PHED’s database, most subscribers have not paid the water tariff for the past many years and their payment balance has accumulated and ballooned. For example, a subscriber under coverage area of Maintenance Division II has not paid since March 2007, and his default of payment by the time of July 2014 is estimated at Rs. 9,525, whereas another subscriber’s default payment from January 1993 has reached Rs. 17,520, more than twice larger than average monthly expenditure of household in Manipur of Rs. 7,500[2].

The Study Team tried to estimate the water tariff collection rate of Imphal water supply system based on the information obtained from PHED. Among the three divisions in PHED, the water tariff collection rate of Maintenance Division I is the highest and covers around 47% of connections, even though its coverage area is the largest. On the other hand, those of Maintenance Division II and Project Construction Division are unusually low and cover only 10% and 12% respectively. As a result, average water tariff collection rate in Imphal Water Supply area is estimated at only 20% in 2014 as shown in table below.

Table 4.9 Water Tariff Collection Rate (2014)

Division	Number of Connection (a)	Billed Amount* (b)	Annual Tariff Revenue (c)	Collection Rate (c) / (b)
Maintenance Division I	11,687 (58%)	Rs.22,448,280	Rs.10,451,593	46.6%
Maintenance Division II	65,763 (29%)	Rs.56,930,160	Rs.5,628,000	9.9%
Project Construction Division	2,606 (13%)	Rs.4,712,400	Rs.560,000	11.9%
Total	20,056 (100%)	Rs.84,090,840	Rs.16,639,593	19.8%

Source: PHED (2014)
Note: * Billed amount is estimated by the JICA Survey Team based on water tariff and number of connection.

[2] Average monthly expenditure of household of Rs. 7,500 is estimated based on average monthly per capita expenditure in “NSSO Report No. KI.(68/1.0) on Key Indicators of Household Consumer Expenditure” and average family size in “Primary Census Abstract, Census of India 2011”.

According to Article 23 of the Manipur Water Supply Act 1992, PHED has a right to cut off the water connection of any premises or turn off their water supply, if the owner of the premises refuses or neglects to pay the bill of water charges within fifteen days from the date of the receipt of the bill. Also, Article 27 the Act stipulates that "a person who contravenes any of the provision of this Act and rules framed there under shall be punished with simple imprisonment of one month which may be extended to six months, or will pay a fine of Rupees five hundred which may be extended to Rupees three thousand, or both".

However, water tariff collection rate remains low due to following reasons. One of the main reasons is lack of bill delivery clerk as mentioned before. Because of this, according to the social condition survey conducted by JICA Survey Team, many subscribers have not received their bill for long time. Another is that PHED does not prioritize bill / revenue collection as a function, compared to the engineering side of utility management. Other reasons for the low collection rate are poor level of water supply service, dwellers' low income level, and peoples' mind-set as "water is money". Indeed, PHED cannot provide 24-hour water supply, and customers cannot get enough water due to low pressure in some areas. In addition, water quality is low due to contamination from dirty water that seeps into PHED pipe in some areas. As a result, customers are not satisfied with the service and do not want to pay for PHED's water services, with or without receiving the water bill.

4.7 Non-Revenue Water Rate

It is said that Non-Revenue Water (NRW) or Unaccounted for Water (UFW) of the Imphal water supply system is very high. The Draft Final Report (DFR) indicated that UFW of the water supply system is estimated at 50%, but there is no scientific basis and only an estimation of UFW has been made.

By definition, NRW and UFW have similar concepts, but their detailed calculation is different. According to International Water Association (IWA), UFW is defined as "water losses" and is composed of apparent (administrative) losses and real (physical) losses. The former includes unauthorized consumption and metering inaccuracies, whereas latter includes physical leakage on transmission and distribution mains, storage tanks, and service consumptions up to point of customer metering[3].

On the other hand, NRW includes Unbilled Authorized Consumption in addition to components of the UFW. The Unbilled Authorized Consumption is composed of unbilled metered consumption and unbilled unmetered consumption. The former includes adjusted non-revenue water due to problems caused by supply side, while the latter includes washing water for supply system, fire hydrant, etc.

[3] MCINTOSH 2003 Asian Water Supply Chap 9 Non Revenue Water

Table 4.10 Situation of Water Consumption in Imphal Water Supply

Definition by International Water Association (IWA)						Current Situation
Raw Water	System Input Volume (SIV)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (Including water exported)	Revenue Water	Water meter has been installed since 2012, but billing to the metered consumption has not even started yet.
				Billed Unmetered Consumption		Most connections are basically categorized, but many customers have not received bills for quite some time due to shortage of manpower.
			Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water [NRW]	Unbilled metered consumption, including adjusted NRW due to problems caused by supply side, does not exist.
				Unbilled Unmetered Consumption		Water consumption categorized in here is not exist
		Water Losses (UFW)	Apparent (Administrative) Losses	Unauthorized Consumption		Illegal use is detected at 15-20 cases per month but it is not easy to come up with the precise picture
				（Customer）Metering Inaccuracies		Water meter installation started in 2012, but study on meter inaccuracy has not been conducted yet.
			Real (Physical) Losses	Leakage on Transmission and/or Distribution Mains		No scientific and accurate data is available.
				Leakage and Overflows at Utility's Storage Tanks		No scientific and accurate data is available.
				Leakage on Service Consumptions up to point of Customer Metering		PHED recognizes that leakages from distribution pipe due to illegal connection are not negligible, but no scientific study has been conducted.
	Treatment Losses (Backwash etc.), Evaporation					

Source: PHED

As for illegal usage, PHED officials struggle every day against illegal connections, and usually around 15 to 20 illegal connections are detected in a month, according to the maintenance divisions of PHED. However, as a matter of course, the accurate number of the illegal connections is not easy to come up with. According to Maintenance Division I, around 47 users has requested for disconnected from April to May in 2014. Still it is unsure where these households will get their supply of water after voluntary disconnection.

Total volume of NRW of three divisions in PHED is estimated at 69.9% of system input volume. For more accurate estimation, the installation of bulk meters for detecting sources and volume of losses and water meters on all consumer connections for assessment of real consumption are urgent and necessary.

4.8 Water Meter Connection

As a pilot study in 2012, PHED started with water meter installation on a number of individual connections. The pilot area was selected from relatively easy-to-install location and in an upscale residential area, including Babupara and Tera areas in Maintenance Division I. As of July 2014, 530 connections were equipped by an Indian-made water meter, accounting for 2.5% of total domestic connection in the three Divisions as shown table below.

Table 4.11 Water Meter Connection

	Maintenance Division I	Maintenance Division II	Project Construction Division	Total
Number of Meter (a)	105	327	152	584
Number of Connection (b)	11,687	6,733	2,606	21,026
(a) / (b)	0.9%	4.9%	5.8%	2.8%

Source: PHED (July 2014)

The current water tariff charge system of the government of Manipur is the flat rate system, and the tariff schedule does not correspond to metered charge system. Furthermore, according to PHED officials, training for the meter reader has not yet been started, and meter-based billing system has not yet been fully materialized. Indeed, when the Survey Team visited a subscriber who had a metered connection in his housing compound, the subscriber said that he had never met any meter reader after the installation. Instead, some PHED officials visit their premises for the water meter to be a showcase. According to the Water Supply Act, PHED may install water meter at the cost of the consumers, and the subscriber paid once Rs. 1,100 as installation cost of the meter.

4.9 Salary System

(1) Salary of Government Officials

Based on Article 309 of the Constitution of India, the Governor of Manipur formulated a payment rule for the government officials, called the Manipur Services (Revised Pay) Rules 2010[4]. The latest rule came into effect on 1st of April, 2010. The salary schedule is composed of two parts. The first part is for common officials for all engineering and other departments, which includes Chief Engineer, Additional Chief Engineer, Executive Engineer, Assistant Engineer, Section Officer, Surveyor, Driver, and Accountant, etc. The second part is for different departments and the salary schedule for PHED includes Geo-hydrologist, Geo-physicist, Chemist, Biologist, and Computer Operator, etc. Each post or position has a range of payment (pay band), from minimum salary to maximum salary, and the pay band is corresponding to the pay grade of each as shown in table below.

[4] http://manipur.gov.in/?page_id=887

Table 4.12 Salary System of Manipur (Common for All Engineering & Other Departments)

No.	Name of Post	Pay Band (Rs./month)	Pay Grade
1	Chief Engineer [PWD/Power/IFCD/PHED]	37,400 – 67,000	8700
2	Additional Chief Engineer [PWD/Power/IFCD/PHED]	37,400 – 67,000	8700
3	Superintending Engineer/ Surveyor of Works [PWD/Power/IFCD/PHED]	15,600 – 39,100	7600
4	Executive Engineer/ (Civil)/ (Elect)/ Surveyor of Works/ Engineer Officer [PWD/Power/IFCD/PHED]	15,600 – 39,100	6600
5	Assistant Engineer/ Engineer Assistant/ Assistant Surveyor of Works [PWD/Power/IFCD/PHED]	9,300 – 34,800	4400
6	Section Officer [Grade-I (Civil/Elect.)]	5,200 – 20,200 9,300 – 34,800 (after 10 yrs.)	2800 4200 (after 10 yrs.)
7	Section Officer [Grade-II (Civil/Elect.)]	5,200 – 20,200	2800
8	Draughtsman Grade-I	5,200 – 20,200 9,300 – 34,800 (after 10 yrs.)	2800 4200 (after 10 yrs.)
	Draughtsman Grade-II	5,200 – 20,200	2400
	Draughtsman Grade-III	5,200 – 20,200	1900
9	Surveyor	5,200 – 20,200	2400
10	Diesel Mechanic	5,200 – 20,200	2400
11	Carpenter	5,200 – 20,200	2800 (Matric+Diploma in Wood-work and Carpentry) 2000 (Matric+ITI) 1800 (Class VIII+Certificate)
12	Senior Electrician	5,200 – 20,200	2800 (Matriculate + Diploma in Engg.)
	Electrician Grade-I	5,200 – 20,200	2400 (Matriculate + ITI)
	Electrician	5,200 – 20,200	1900 (for others)
13	Khalasi	4,440 – 7,440	1400
14	Jugali/ Electrical Jugali	4,440 – 7,440	1400
15	Driver (Heavy) [All categories of drivers and equivalent]	5,200 – 20,200	2000 2400 (after 10yrs.) 2800 (SG after 24yrs.)
16	Driver (Light) [All categories of drivers and equivalent]	5,200 – 20,200	1900 2400 (after 10yrs.) 2800 (SG after 24yrs.)
17	Librarian	9,300 – 34,800 5,200 – 20,200	4200 2800 (for non-B. Lib according to RRs)
18	Library Assistant	5,200 – 20,200	2400
19	Counter Attendant	5,200 – 20,200	1800

No.	Name of Post	Pay Band (Rs./month)	Pay Grade
20	Photographer	5,200 – 20,200	2400
21	Cameraman	5,200 – 20,200	2400
22	Dark Room Assistant	5,200 – 20,200	1800
23	Laboratory Assistant (other than Health & FW)	5,200 – 20,200	2400 (for PUSc. & above) 1900 (for Matriculate)
24	Binder Grade-I	5,200 – 20,200	1800
25	Binder Grade-II	4,440 – 7,440	1650
26	Principal Private Secretary (Hr. Selection Grade)	9,300 – 24,800 15,600 – 39,100 (SG after 5yrs.)	5400 6600 (SG after 5yrs.)
	Private Secretary	9,300 – 34,800	4400
	Assistant Private Secretary	9,300 – 34,800	4200
	Steno Grade-I	5,200 – 20,200	2800
	Steno Grade-II	5,200 – 20,200	2400
	Steno Grade-III	5,200 – 20,200	1900
27	Senior Accountant	5,200 – 20,200 5,200 – 20,200	2800 2800 (for others)
28	Accountant	5,200 – 20,200 5,200 – 20,200	2800 2400 (for others)
29	Junior Accountant	5,200 – 20,200	2400
30	Superintendent	9,300 – 34,800	4200
31	Head Clerk	5,200 – 20,200	2800
32	Upper Division Clerk	5,200 – 20,200	2400
33	Lower Division Clerk	5,200 – 20,200	1900 2000 (after 10yrs.)
34	All Grade-IV Posts	4,440 – 7,440	1300

Source: Pay Implementation Cell, Finance Department, Government of Manipur

A graduate from college or university and with a Bachelor of Engineering (BE) or Bachelor of Technology (BT) degree can join the service as an “Assistant Engineer/ Engineer Assistant/ Assistant Surveyor of Works”, or “Section Officer [Grade-I (Civil/Elect.)]”. In the case of Section Officer, the BE or BT starts from the Pay Grade 2800, and can became 4200 after 10 years. Master and Doctor degree holders also join to the same post in the above table.

Following table shows salary system for PHED specific officials.

Table 4.13 Salary System of Manipur (PHED)

No.	Name of Post	Pay Band (Rs./month)	Pay Grade
1	Geo-hydrologist	9,300 – 34,800	4400
2	Geo-physicist	9,300 – 34,800	4400
3	Sub-Inspector (Statistics)	5,200 – 20,200	2800
4	Chemist	9,300 – 34,800	4400
5	Biologist	5,200 – 20,200	2800
6	Computer Operator	5,200 – 20,200	2800
7	Jr. Supervisor	5,200 – 20,200	1900
8	Jr. Mechanic Grade-III	4,440 – 7,440	1650
9	Engine Operator	5,200 – 20,200	1900
10	Assistant Engine Operator	4,440 – 7,440	1650
11	Meter Reader-II	5,200 – 20,200	1900
12	Assistant Mechanic	5,200 – 20,200	1900
13	Assistant Wireman	4,440 – 7,440	1400
14	Driller	5,200 – 20,200	2800
15	Assistant Driller	5,200 – 20,200	2000
16	Store Keeper	5,200 – 20,200	2400
17	Store Assistant	5,200 – 20,200	1900
18	Technical Jugali	4,440 – 7,440	1400
19	Mason Grade-II	5,200 – 20,200	1900
20	Assistant Welder	5,200 – 20,200	1900
21	Head Mistry	5,200 – 20,200	2000
22	Mistry	5,200 – 20,200	2000
23	Mandol	5,200 – 20,200	1900 2000 (after 10yrs.)
24	Road Mohorrir	5,200 – 20,200	1900

Source: Pay Implementation Cell, Finance Department, Government of Manipur

(2) Minimum Wage Rate

Minimum wage rates in India are fixed at the National and State level, based on Section 3 of the Minimum Wages Act, 1948. The Act also specifies that minimum wage rates may be fixed for different skills and occupations. The Minimum wage rates are estimated based on basic wages and cost of living index. The yardsticks of its revision include: (i) three consumption units per earner, (ii) minimum food requirement of 2700 calories per average Indian adult, (iii) cloth requirement of 72 yards per annum per family, (iv) rent corresponding to the minimum area provided under the Government's Industrial Housing Scheme, (v) fuel, lighting and other miscellaneous items of expenditure to constitute 20% of the total Minimum Wages, (vi) children’s education, medical requirement, minimum recreation including festivals/ceremonies, and provision for old age and marriage etc. which constitute 25% of the total Minimum Wage[5].

In the State of Manipur, the Secretariat of Labor Department of the Government of Manipur decides the minimum wage rate, and the latest came into effect on 1st of February, 2011[6]. According to Manipur Gazette dated on March 16, 2011, the minimum wage rate for skilled labor is Rs. 3,978 per month, for semi-skilled labor is Rs. 3899 per month, and for unskilled labor is Rs. 3,663 per month, as shown in table below.

Table 4.14 Minimum Wage Rate of Manipur

	Category of Labor - Skill Wise		
	(3) Skilled Labor	(4) Semi-skilled Labor	(5) Unskilled Labor
Minimum Wage Rate (per day)	Rs. 132.60 /-	Rs. 129.97 /-	Rs. 122.10 /-
Minimum Wage Rate (per month)	Rs. 3,978.00 /-	Rs. 3,899.10 /-	Rs. 3,663.00 /-

Source: Secretariat, Labor Department, Government of Manipur

The government of Manipur also sets minimum wage rates for Water Supply, Sanitation and Drainage, Generation/ Transmission/ Distribution of Electricity Supply sector. In the sector schedule, detailed employment categories are stated as summarized in table below.

Table 4.15 Minimum Wage Rate of Manipur (Water Supply Sector)

Categories of Employee		Minimum Wage Rate	
		Per Day	Per Month
1	**Skilled Labor** Driver (Heavy), Clerk, Typist, First Class Mason, First Class Blacksmith, Foreman, Surveyor, Draftsman, Section Officer Grade I, Roller Driver, Dozer Driver, Crank Driver, Senior Head Commercial Clerk	132.60	3,978.00
2	**Semi-Skilled Labor** Driver (light), Road Mohorrier, Junior Supervision, Junior Bill Clerk, Tracer, Meter Reader, Fitter Grade I, Second Class Mason, Second Class Blacksmith, Second Class Carpenter, First Painter, Mechanic, Electrician, Wireman Grade I	129.97	3,899.10
3	Third Class Mason, Third Class Blacksmith, Third Class Carpenter, Wireman Grade I, Power House Operator, Engine Operator, Pump Operator, Driller, Welder, Asst. Mechanic, Switch Road Attendant, Asst. Meter Reader, Asst. Welder II, Lineman, Gauge Reader, Filter Grade II, Asst. Electrician, Printer, turban Operator, Electric Generator, Driver, Hand Pump Attendant	129.97	3,899.10
4	Chowkidar, Jugali, Khallashi, Asst. lineman, Asst. Engine Operator, Mali, Peon, Cleaner, Sweeper, Pump Attendant, Pump Operator, Wireman Grade II, Asst. Driller, Asst. Carpenter, Asst. Hand Pump Operator, Mazdoor, Store Attendant, Workshop Attendant, Store Assistant, Other Categories by Whatever name called Which are unskilled labor	122.10	3,663.00

Source: Secretariat, Labor Department, Government of Manipur

5 http://www.paycheck.in/main/salary/minimumwages/minfaqfolder/minimum-wages-in-india#Inf2
6 http://www.paycheck.in/main/salary/minimumwages/manipur

4.10 Electricity Tariff System

Based on the Electricity Act 2003, the government of India organized the Joint Electricity Regulatory Commission for the States of Manipur and Mizoram, through GOI Gazette (Extra Ordinary) Notification No. 23/3/2002 R&R dated on January 18, 2005. The commission was established as an autonomous authority responsible for regulation of the power sector in the both States, and determination of electricity tariff is one of its functions.

According to Tariff Order 2014-15 for Electricity Department of the Government of Manipur, fixed charge and energy charge for public water works are Rs.100/kW/kVA/month and Rs.4.30/kWh for the low tension supply, whereas those of high tension supply are Rs.100/kW/kVA/month and Rs.4.00/kWh respectively. The existing tariff structure and proposed tariff for FY 2014-15 are summarized in table below.

Table 4.16 Existing Tariff Structure and Proposed Tariff for FY 2014-15

<table>
<tr><td>Item</td><td colspan="2">Existing Tariff</td><td colspan="2">Proposed Tariff</td></tr>
<tr><td>Particulars</td><td>Fixed Charges (Rs./kW/kVA/Month)</td><td>Energy Charges (Rs./kWh)</td><td>Fixed Charges (Rs./kW/kVA/Month)</td><td>Energy Charges (Rs./kWh)</td></tr>
<tr><td colspan="5">LT Supply</td></tr>
<tr><td>Kutir Jyoti /a</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1-15 kWh</td><td>20</td><td>1.00</td><td>20</td><td>1.00</td></tr>
<tr><td>Above 15 kWh</td><td>20</td><td>1.50</td><td>20</td><td>1.50</td></tr>
<tr><td>Domestic Light and Power</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1-100 kWh</td><td>60</td><td>2.40</td><td>70</td><td>2.80</td></tr>
<tr><td>1-200 kWh</td><td>60</td><td>3.00</td><td>70</td><td>3.40</td></tr>
<tr><td rowspan="2">Above 200 kWh</td><td rowspan="2">60</td><td rowspan="2">3.60</td><td>201-300 kWh: 70</td><td>201-300 kWh: 4.10</td></tr>
<tr><td>Above 300 kWh: 70</td><td>Above 300 kWh: 4.60</td></tr>
<tr><td>Commercial</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1-100 kWh</td><td>80</td><td>3.30</td><td>90</td><td>3.80</td></tr>
<tr><td>1-200 kWh</td><td>80</td><td>3.90</td><td>90</td><td>4.50</td></tr>
<tr><td rowspan="2">Above 200 kWh</td><td rowspan="2">80</td><td rowspan="2">4.40</td><td>201-300 kWh: 90</td><td>201-300 kWh: 5.10</td></tr>
<tr><td>Above 300 kWh: 90</td><td>Above 300 kWh: 5.60</td></tr>
<tr><td>Public Lighting</td><td>60</td><td>4.30</td><td>70</td><td>4.90</td></tr>
<tr><td>Public Water Works</td><td>100</td><td>4.30</td><td>120</td><td>4.90</td></tr>
<tr><td>Agriculture</td><td>60</td><td>2.50</td><td>70</td><td>2.90</td></tr>
<tr><td>Cottage and Small Industry</td><td>60</td><td>2.50</td><td>70</td><td>2.90</td></tr>
<tr><td>Temporary Supply</td><td>80</td><td>4.30</td><td>90</td><td>4.90</td></tr>
<tr><td colspan="5">HT Supply</td></tr>
<tr><td>Commercial</td><td>100</td><td>4.00</td><td>120</td><td>4.60</td></tr>
<tr><td>Public Water Works</td><td>100</td><td>4.00</td><td>120</td><td>4.60</td></tr>
</table>

Agriculture	100	2.50	120	2.90
Medium Industry	100	3.30	120	3.80
Large Industry	100	3.80	120	4.40
Bulk Supply	100	3.40	120	3.90

Source: Tariff Order 2014-15 for Electricity Department, Government of Manipur against Petition No.2 of 2013, Joint Electricity Regulatory Commission for Manipur and Mizoram

Note: a/ Objective of the Kutir Jyoti scheme is to provide electricity to rural families living below the poverty line (BPL).

The following are some special notes on the current electricity tariff system of the Government of Manipur.

- The Electricity Act 2003 gives special emphasis on safeguarding consumer's interests, and simultaneously requires that the costs should be recovered in a reasonable manner.
- The Act instructs that tariff determination should be guided by the factors including encourage competition, efficiency, economical use of resources, good performance and optimum investment.
- The commission has considered special consideration to Kutir Jyoti connection and agriculture sector with lower tariff rates.
- In accordance with the National Electricity Policy, consumers below poverty line (BPL) can receive a special support through cross subsidy. Tariff rate for the BPL consumers will be at least 50% of the average cost of supply, and the support will be re-examined after five years.
- It is required that reduction of cross subsidy within plus minus 20% of the average cost of supply by 2010-11. However, it is not possible for the commission to achieve due to consumers' low payment capacity and relatively high cost of producing power.
- The National Tariff Policy (NTP) instructs adaptation of Multi-Year-Tariff (MYT) framework, but the commission cannot introduce the MYT under the current situation due to lack of requisite and reliable data.

To enhance efficiency and transparency in power supply operation, Electricity Department of Manipur (EDM) was converted into two state-owned corporations – the Manipur State Power Company Limited (MSCPL) and the Manipur State Power Distribution Company Limited (MSPDCL) on July 25, 2013[7]. The former is the Holding Company to discharge function of the state transmission and generation utility, while the latter takes charge of managing distribution function as a subsidiary of MSPCL. As a result of the organizational change, independent accounting system was introduced in the power supply management.

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[7] Manipurtimes, February 1, 2014 (http://www.manipurtimes.com/news-article/the-peoples-chronicle-news/item/7170-power-department-becomes-corporation-begins-operation)

EDM has made efforts to improve the revenue gap, which includes periodic change of the power tariff schedule. In addition, meter installation is more advanced in the power sector than the water supply sector, even though around 20%[8] of service connections have not been installed yet. To improve the revenue from power supply service, EDM recently introduced pre-payment system and has promoted installation of corresponding meter. Also, the government officials cannot receive their salary if they do not obtain "No Due Certificate" from MSPDCL. These experiences serve as a useful reference for the water supply service of PHED.

4.11 Social Condition Survey, Willingness to Pay

(1) Objective of the Social Condition Survey

It is important to understand the detailed current situation of the water supply in Imphal in order to formulate an effective implementation plan in the survey. The current situation was confirmed with its beneficiaries directly by door-to-door fielding of the questionnaire survey on social conditions and visiting a total of 322 households in each water supply zone (WSZ) of PHED, including the poverty area.

The social condition survey tackled the following matters:

1) Present Condition of Water Use (water source)
2) Water Consumption and Cost
3) Satisfaction Level to the Piped Water Service
4) Willingness-to-Pay to the Water Supply Service
5) Sanitary Conditions and Awareness

(2) Methodology of the Survey

The survey was conducted on a sub-contract basis on 25th of June, 2014 with an Imphal-based private firm, S. INAO SHARMA. The sub-contractor organized a survey team headed by Mr. Shamurailatpam Roshnikumar Sharma, who is a teacher of an International NGO, Art of Living, and has a lot of experiences in the field of social survey, consultation, and educational campaign. The interview survey was completed at the end of August, and final report of the sub-contractor was submitted to the Survey Team at the end of September in 2014.

The 322 household samples were selected randomly from 27 Wards of Imphal Municipality Council (IMC) area and seven selected zones of Greater Imphal area.

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[8] Tariff Order 2014-15 for Electricity Department, Government of Manipur against Petition No.2 of 2013, Joint Electricity Regulatory Commission for Manipur and Mizoram

(3) Summary of the Survey Results

The following is the summary of findings of the Social Condition Survey. Details are further analyzed and discussed in Chapter 10 Financial and Economic Analysis, particularly in 10.2 Social and Economic Conditions (Water Consumption), 10.3 Water Tariff Revision and Timing for Implementation (Willingness to Pay and Affordability to Pay), and 10.6 Economic Analysis (Estimation of Economic Benefits).

1) General Features

- Out of 322 respondents, 251 were male and 71 were female. Fifty nine percent of the respondents live in permanent house and the rest live in semi-permanent house.
- Around 222 households (69%) have PHED piped water connection, and three percent have metered connection installed by PHED.
- The average monthly income of the respondents is INR 49,703, whereas average monthly expenditure is INR 22,530.
- Five percent of the total respondents belong to the below poverty line (less than INR7,500/HH/month) [9], and the largest income group belongs to the INR 10-50 thousand per month, which accounts for 61% of total respondents.

2) Water Consumption

- Majority of households use PHED piped water for drinking purpose, and is estimated at 60% of total water sources. Next largest source of drinking water is tanker supply (28%), followed by public hydrant (6%), bottled water (4%), and pond/river (1%).
- Majority of surveyed households expressed that the reliability of water supply service as the most important issue over the price and the water quality issues.
- The general public in IMC area and Greater Imphal were found to have a high level of awareness regarding drinking water, with most of the surveyed households consuming water after either boiling/filtering or both. Even low income households were found to be following the same. As a result, water borne diseases were few and far between.
- Many households in Imphal spend a significant sum in procuring water through tanker suppliers.
- Open-end pipes (without the presence of stop cork or tap) were found in a vast majority of households. This is the primary factor for contamination in supplied water.

3) Consumer’s Mind-set

- The survey helped discover the mind-set of the general public regarding payment of water tariff, usage of water, etc.

[9] The poverty line is estimated based on the poverty estimates by Planning Commission of the Government of India. According to the estimates, Manipur’s poverty line is INR1,170/capita/month in urban area. The poverty line of household level is estimated by JICA Survey Team by applying family 6.3 person/ household, which is obtained from the social condition survey.

- Monthly bills were not paid by customers on a regular basis. Some make the payment on a yearly basis, while most customers never bother to pay at all.
- The number of households who expressed their willingness to pay for the 24×7 water supply are: 145 HH (45%) for INR150/month, 145HH (45%) for INR300/month, 30 HH (9%) for INR600/month, and 2 HH (0.6%) for INR1,000/month.

(4) Initial Findings through the Social Condition Survey

- Delivery of monthly water tariff bill to consumers on a regular basis (i.e. monthly or quarterly) is important.
- Establishment of water tax collection centers/ counters in various places of IMC (Imphal Municipality Council) and Greater Imphal areas is necessary to increase water tariff collection rate.
- Spreading awareness about the presence of a PHED grievance cell to the general public is necessary.
- As expressed by several respondents, it is suggested to increase frequency/quantity of water supply to those areas which are not able to meet requirements with the current quantity of supplied water.
- Lay new pipeline in those areas where there are old pipelines or no pipelines at all.
- Repair leakages from pipelines to prevent contamination of supplied water.
- Create awareness about water not being FREE of cost, and not to be taken for granted.
- Make payment of water tax mandatory for households with PHED pipeline connection. Helping PHED through regular payment of bills and judicious usage of water would allow PHED to function more efficiently in order to perform more effectively.
- As suggested by several respondents, PHED could form inspection teams to check leakages, unauthorized (illegal) connections, disruptions in water supply, condition of old pipelines, etc.
- Install tap/stop cork at every water connection to prevent water wastage due to open-end pipe.
- Install water meter at every connection to prevent overuse and negligent usage of water.
- Find and stop illegal (unauthorized) connections.
    - Levy a heavy fine on them.
    - Reward those persons who offer valid information on illegal activities prohibited by the Government.
- Constitute a support system in every Water Supply Zone (WSZ) to provide assistance to PHED in delivering bills or collecting taxes.
- Form an incentive system within PHED to encourage its own staff to dispense their duties more efficiently.

Chapter 5 Review of Facility Planning Proposed in DPR

5.1 Water Demand Projection

The Detailed Project Report for Integrated Imphal Water Supply System (hereinafter referred to as "DPR-II") was prepared in November 2013. It reviewed the planned water supply service area earlier prepared and proposed in 2007 under the Detailed Design Report for Augmentation of Water Supply for Imphal City by 45 MLD (10 MGD) with Raw Water from Thoubal Dam (hereinafter referred to as DPR-I). DPR-II reduced the planned service area and design population.

5.1.1 Planned Service Area

The planned service area shall be the same as that proposed in DPR-II, which had been accepted by PHED as shown in **Table 5.1** and **Figure 5.1.** The name of localities is shown in **Table 5.2**.

Table 5.1 Composition of Service Areas by Imphal Water Supply

Sr. No.	Type of Area	Area in (ha)	Census 2011		
			Total	Imphal West	Imphal East
	District	**122,800.00**	**974,105**	**517,992**	**456,113**
Service Area by Water Supply					
A	**Greater Imphal Areas (Municipal and Non municipal)**	**9,538.44**	**499474**	**278,861**	**220,613**
A-1	Imphal Municipal Area (IMC*1)	3,075.00	268,243	186,538	81,705
A-2	IMC Out-Growth & Census Town	2,418.81	118,142	45,455	72,687
A-3	Greater Imphal Area Other than (IMC OG & CT); Non municipal	4,044.63	113,089	46,868	66,221
B	**En-route (Pipeline Villages)**	**8,786*2**	**3,6793**	**32,320**	**4,473**
	Total		**536,267**	**311,181**	**225,086**

Note: The IMC (Imphal Municipal Council) covers the area of Ward No.1 to No.27.
The area of "en-route" shows the administrative area but not the service area by water supply.

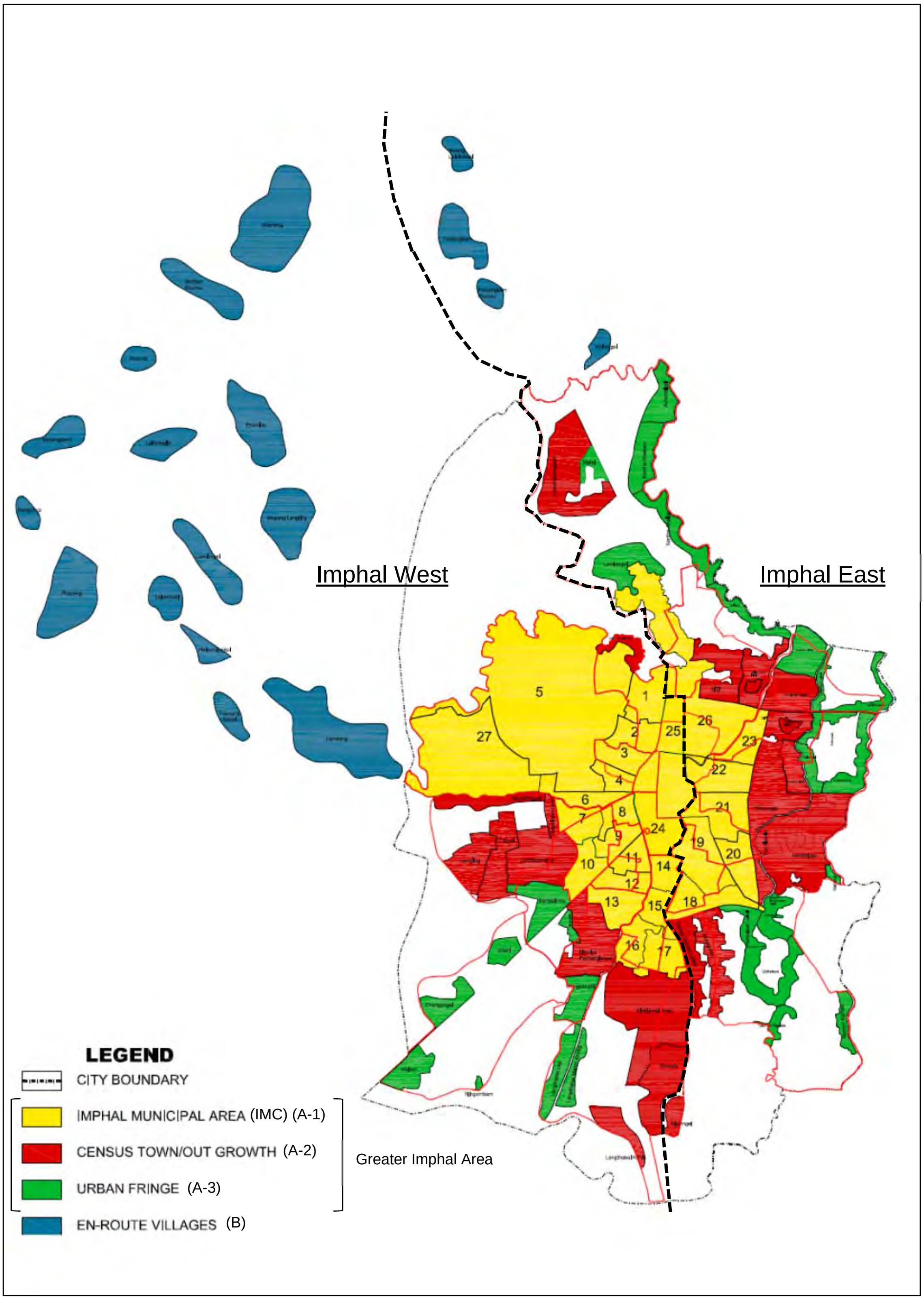
Table 5.2 Planned Service Area

Imphal Municipal Council Wards	Localities within Greater Imphal Planning Area	Villages en route existing pipelines
Ward No. 1	Meitei Langol、Tarol, Tanung*	Koutruk
Ward No. 2	Iroisemba*	Lairensajik
Ward No. 3	Lalambung (Part)*	Kadangband
Ward No. 4	Sangaipru	Lamlongei
Ward No. 5	Ghari	Kangchup
Ward No. 6	Changangei	Kharang Koireng
Ward No. 7	Malom	Phayeng
Ward No. 8	Heinoukhongnembi	Tairenpokpi

Imphal Municipal Council Wards	Localities within Greater Imphal Planning Area	Villages en route existing pipelines
Ward No. 9	Mongsangei	Kha-Leirenkabi
Ward No. 10	Maibam Leikai	Awang Leirenkabi
Ward No. 11	Ahongsangbam Leikai	Lambal
Ward No. 12	Sorokhaibam Leikai	Akham
Ward No. 13	Langthabal Lep	Ngariyambam
Ward No. 14	Oinam Leikai	Heibongpokpi
Ward No. 15	Leiphrakpam Leikai	Sanjenbam
Ward No. 16	Langthabal Mantrikhong	Awang Laikinthabi
Ward No. 17	Achanbigei	Tingri
Ward No. 18	Matai	Potsangbam Khoiru
Ward No. 19	Kongba Nongthombam Leikai	Senjam Khunou
Ward No. 20	Gangapat	Haorang Keirel
Ward No. 21	Uchkeckon & Khunou	Haorang Sabal
Ward No. 22	Bamon Kampu	Lamshang(P)
Ward No. 23	Wangkhei Loumanbi	Lamshang(NP)
Ward No. 24	Machahal	Kiyam
Ward No. 25	Naharup	Tharoijam
Ward No. 26	Top Naoriya	Maibakhul
Ward No. 27	Top Dusara (West)	Mongjam
Outgrowth And Census Towns	Khurai Khongnangkhong	Koirengei
Bijoy Govinda (OG) - Ward No.27 (381.15ha)	Khaidem Leikai	Kabo Siphai
Takyel (OG) - Ward No.28	Thangjam Leikai	Nilakuthi
Porompat Plan Area (OG)	Nandeibam Leikai	
Porompat (CT) -	Khurai Konsam Leikai	
Kongkham Leikai (OG) - Ward No.30	Laishram Leikai	
Khongman (CT) - Ward No.1 to 7	Ningthoubung	
Naoriya Pakhanglakpa (CT) - Ward No.1 to 9	Kontha Khabam	
Torban (Kshetri Leikai) (CT) - Ward No.1 to 6	Kontha Ahallup	
Oinam Thingel (OG) WARD NO.-0029	Kairang Meitei	
Naorem Leikai (OG) WARD NO.-0012	Lamlongei	
Langthabal Kunja (OG) WARD NO.-0010	Keikhu Hao	
Lamjaotongba (CT)	Thangbrijao	
Langjing (CT)	Kitna Panung	
Takyel Mapal (CT)	Basihkhong	
Sagolband (Part) (CT)	Loumanbi	
Chingangbam Leikai (CT)	Takhok awang	
Khurai Sajor Leikai (CT)	Takhok Makha	
Thongju (CT)	Keirao Makting	
Kiyamgei (CT)		
Lairikyengbam Leikai (CT)		
Laipham Siphai (CT)		
Luwangsangbam (CT)		
Kshetrigao (CT)		
Kangla Fort		
Capital Project*		
Games Village Langol*		

Note: Three sub-divisions of Meitei Langol-Thaol-Tanung、Iroisemba、Lalambung (Part) are added to **Table 5.3** of DPR-II, since the source population calculation sheet includes them

Source: "DPR for Integrated Water Supply Project in Imphal Planning Area", November 2013



Source: "DPR for Integrated Water Supply Project in Imphal Planning Area", November 2013

Figure 5.1 Planned Service Area

5.1.2 Design Population

(1) Design Population Projection

The design population of DPR-II have already been accepted by the Ministry of Urban Development (MoUD). It has also been the basis of the locally-funded project (Phase-I JNNURM) to back the process of tendering. In consideration, therefore, of such a situation, the design population proposed in DPR-II as shown in **Table 5.3** shall be used for facility design.

Table 5.3 Design Population for Integrated Imphal Water supply

Year	Greater Imphal Areas (Municipal & Non Municipal)		Existing En-Route Pipeline Villages		Total Population	Floating Population (10% of IMC and GI areas)	Grand Total
	Population	Growth Rate	Population	Growth Rate			
1961	67,717				67,717	6,772	74,489
1971	191,903	183.4	13,491	0.0	205,394	19,190	224,584
1981	269,611	40.5	21,142	56.7	290,753	26,961	317,714
1991	347,641	29.0	26,006	23.0	373,647	34,764	408,411
2001	445,829	28.3	30,915	18.9	476,744	44,583	521,327
2011	499,474	22.8	36,793	18.7	536,267	49,947	586,214
2016	556,453	11.4	40,242	9.4	596,695	55,645	652,340
2021	613,432	22.8	43,690	18.7	657,122	61,343	718,465
2031	744,799	21.4	51,229	17.3	796,028	74,480	870,508
2041	902,285	21.1	59,632	16.4	961,917	90,229	1,052,146
2046	994,405	10.2	64,240	7.7	1,058,645	99,441	1,158,086

Source: Table 5.11 in DPR-II

(2) Allocation of Design Population to Water Supply Zones

In DPR-II, the design population was allocated to the respective wards/towns by adjusting the population density first, after which the WSZ-wise design population was calculated based on the area percentage of wards/towns that composed each WSZ.

Table 5.4 Population Distribution in Water Supply Zone

Zone No	Water supply zone	Area	Wards/Villages/Areas Covered	Unit Area in Ha.	2011		2016		2021		2031		2041		2046	
					Den	pop	Den	pop	Den	pop	Den	pop	Den	pop	Den	pop
1	**Irosemba West**	IMC	Ward No. 27	319.00	30	9417	34	10846	37	11803	45	14355	52	16588	55	17545
		IMC	Ward No. 5p	881.20	24	21551	29	25555	32	28199	40	35248	47	41417	50	44060
		IMC	Ward No. 1p	4.99	218	1089	219	1094	219	1094	220	1099	220	1099	220	1099
		IMC	Ward No. 2p	32.04	119	3814	134	4293	148	4742	177	5671	206	6600	220	7048
		IMC	Ward No.6p	50.00	164	8206	177	8850	189	9450	214	10700	238	11900	250	12500
		IMC	WardNo. 4p	52.28	96	5008	118	6166	140	7314	184	9618	228	11912	250	13068
			Total	**1339.50**		**49079**		**56803**		**62601**		**76689**		**89520**		**95314**
2	**Irosemba East**	IMC	Ward No.7p	70.03	114	8001	127	8894	139	9734	164	11485	188	13165	200	14006
		IMC	Ward No.8p	35.43	199	7065	207	7334	214	7582	229	8114	243	8610	250	8858
		IMC	Ward No.24p	40.50	214	8653	219	8869	225	9112	235	9517	245	9922	250	10124
			Total	**145.95**		**23719**		**25097**		**26428**		**29116**		**31697**		**32988**
3	**Langjing**	OG & CT		150.00	49	7326	56	8400	63	9450	76	11400	89	13350	95	14250
		GI		340.29	28	9515	31	10440	34	11603	45	15410	63	21520	76	25914
			Total	**490.29**		**16841**		**18840**		**21053**		**26810**		**34870**		**40164**
4	**Nepramenjor**	IMC	Ward No.7p	2.97	114	340	127	378	139	414	164	488	188	559	200	595
		IMC	Ward No.8p	2.57	199	513	207	532	214	550	229	589	243	625	250	643
		IMC	Ward No.9p	45.53	79	3582	104	4736	128	5828	177	8060	226	10291	250	11384
		IMC	Ward No.10	83.00	96	7974	111	9213	126	10458	156	12948	186	15438	200	16600
			Total	**134.08**		**12409**		**14859**		**17250**		**22085**		**26913**		**29222**
5	**Sangaiprou**	OG & CT		250.66	49	12243	56	14037	63	15792	76	19050	89	22309	95	23813
		GI		0.00	28	0	31	0	34	0	45	0	63	0	76	0
			Total	**250.66**		**12243**		**14037**		**15792**		**19050**		**22309**		**23813**
6	**Irom Pukhri**	IMC	Ward No.12 part	34.78	171	5935	182	6331	194	6748	216	7513	239	8313	250	8696
		IMC	Ward No.11 part	16.70	179	2993	190	3172	200	3339	220	3673	240	4007	250	4174
			Total	**51.48**		**8928**		**9503**		**10087**		**11186**		**12320**		**12870**
7	**Chingtham Leikai**	IMC	Ward No.13	66.00	163	10736	168	11088	174	11484	184	12144	195	12870	200	13200
		OG & CT		145.09	49	7087	56	8125	63	9141	76	11027	89	12913	95	13784
		GI		48.82	28	1365	31	1498	34	1665	45	2211	63	3087	76	3718
			Total	**259.91**		**19188**		**20711**		**22290**		**25382**		**28870**		**30702**
8	**Keishampat**	I. M.C	Ward No.9p	60.47	79	4756	104	6288	128	7740	177	10702	226	13665	250	15116

Zone No	Water supply zone	Area	Wards/Villages/Areas Covered	Unit Area in Ha.	2011		2016		2021		2031		2041		2046	
					Den	pop	Den	pop	Den	pop	Den	pop	Den	pop	Den	pop
		I. M .C	Ward No.11p	26.30	179	4714	190	4998	200	5261	220	5787	240	6313	250	6576
		I. M .C	Ward No.12p	12.22	171	2085	182	2223	194	2370	216	2639	239	2920	250	3054
		I. M .C	Ward No.24p	0.50	214	108	219	110	225	113	235	119	245	124	250	126
			Total	**99.49**		**11663**		**13619**		**15484**		**19247**		**23022**		**24872**
9	**Cheiraoching**	IMC	Ward No 26p	6.19	105	650	111	687	117	725	128	793	140	867	145	898
		IMC	Ward No.5p	106.80	24	2612	29	3097	32	3418	40	4272	47	5020	50	5340
		IMC	Ward No.1p	47.01	218	10253	219	10295	219	10295	220	10342	220	10342	220	10342
		IMC	Ward No. 2p	59.96	119	7138	134	8035	148	8875	177	10614	206	12353	220	13192
		OG & CT		24.75	49	1209	56	1386	63	1559	76	1881	89	2203	95	2351
			Total	**244.72**		**21862**		**23500**		**24872**		**27902**		**30785**		**32123**
10	**Lalambung**	IMC	Ward No.3	42.00	178	7465	189	7938	199	8358	220	9240	240	10080	250	10500
		IMC	Ward No.4 part	22.73	96	2179	118	2682	140	3182	184	4181	228	5181	250	5681
			Total	**64.73**		**9644**		**10620**		**11540**		**13421**		**15261**		**16181**
11	**Assembly**	IMC	Ward No. 25 part	33.00	213	7043	219	7227	224	7392	235	7755	245	8085	250	8250
			Total	**33.00**		**7043**		**7227**		**7392**		**7755**		**8085**		**8250**
12	**Chinga**	IMC	Ward No. 16 p	41.91	115	4800	134	5616	154	6454	192	8047	231	9681	250	10478
		IMC	Ward No.17 p	32.48	150	4860	164	5327	179	5814	207	6723	236	7665	250	8120
		IMC	Ward No.15 p	49.17	134	6603	151	7424	168	8260	201	9883	234	11505	250	12292
		IMC	Ward No.14	50.00	145	7246	160	8000	175	8750	205	10250	235	11750	250	12500
			Total	**173.56**		**23509**		**26367**		**29278**		**34903**		**40601**		**43390**
13	**Canchipur**	IMC	Ward No.15p	6.83	134	917	151	1032	168	1148	201	1373	234	1599	250	1708
		IMC	Ward No.17p	45.52	150	6812	164	7466	179	8149	207	9423	236	10743	250	11381
		IMC	Ward No.16p	18.09	115	2072	134	2424	154	2786	192	3473	231	4179	250	4523
		OG & CT		300.00	49	14653	56	16800	63	18900	76	22800	89	26700	95	28500
		GI		500.96	28	14007	31	15369	34	17081	45	22685	63	31681	76	38149
			Total	**871.40**		**38461**		**43091**		**48064**		**59754**		**74902**		**84261**
14	**Lilandolampak**	OG & CT		132.95	49	6494	56	7445	63	8376	76	10104	89	11833	95	12630
			Total	**132.95**		**6494**		**7445**		**8376**		**10104**		**11833**		**12630**
15	**Minuthong**	IMC	Ward No. 22 p	19.76	203	4014	210	4149	217	4287	230	4544	244	4821	250	4939
		IMC	Ward No. 23 p	1.23	141	175	157	194	173	214	204	252	235	290	250	309
		IMC	Ward No. 26p	28.06	105	2944	111	3115	117	3283	128	3592	140	3928	145	4069

Zone No	Water supply zone	Area	Wards/Villages/Areas Covered	Unit Area in Ha.	2011		2016		2021		2031		2041		2046	
					Den	pop	Den	pop	Den	pop	Den	pop	Den	pop	Den	pop
		OG & CT		160.31	49	7830	56	8977	63	10099	76	12183	89	14267	95	15229
			Total	**209.36**		**14963**		**16435**		**17883**		**20571**		**23306**		**24546**
16	**Khuman Lampak**	IMC	Ward No. 26 p	48.49	105	5087	111	5383	117	5674	128	6207	140	6789	145	7031
		OG & CT		130.75	49	6386	56	7322	63	8237	76	9937	89	11637	95	12421
			Total	**179.24**		**11473**		**12705**		**13911**		**16144**		**18426**		**19452**
17	**Koirengei**	IMC	Ward No. 26 p	54.25	105	5692	111	6022	117	6348	128	6944	140	7595	145	7867
		OG & CT		0.00	49	0	56	0	63	0	76	0	89	0	95	0
		GI		1283.15	28	35877	31	39366	34	43751	45	58105	63	81147	76	97715
			Total	**1337.40**		**41569**		**45388**		**50099**		**65049**		**88742**		**105582**
18	**Ningthem Pukhri**	IMC	Ward No. 19 p	31.25	99	3086	107	3344	114	3563	129	4031	143	4469	150	4688
		IMC	Ward No.20 p	35.52	108	3822	121	4298	134	4760	161	5719	187	6642	200	7104
		IMC	Ward No.21 p	42.94	127	5461	145	6226	163	6999	198	8502	233	10005	250	10735
		GI		23.21	28	649	31	712	34	791	45	1051	63	1468	76	1768
			Total	**132.92**		**13018**		**14580**		**16113**		**19303**		**22584**		**24295**
19	**Old Thambuthong**	IMC	Ward No. 18 p	54.82	88	4815	104	5701	120	6578	152	8333	184	10087	200	10964
		IMC	Ward No. 19 p	62.39	99	6160	107	6676	114	7112	129	8048	143	8922	150	9359
			Total	**117.21**		**10975**		**12377**		**13690**		**16381**		**19009**		**20323**
20	**Irilbung**	IMC	Ward No.18 p	45.18	88	3968	104	4699	120	5422	152	6867	184	8313	200	9036
		IMC	Ward No.19 p	6.36	99	628	107	681	114	725	129	820	143	909	150	954
		IMC	Ward No.20 p	39.48	108	4248	121	4777	134	5290	161	6356	187	7383	200	7896
		OG & CT		35.00	49	1710	56	1960	63	2205	76	2660	89	3115	95	3325
		GI		871.96	28	24380	31	26751	34	29731	45	39485	63	55144	76	66402
			Total	**997.98**		**34934**		**38868**		**43373**		**56188**		**74864**		**87613**
21	**Porompat**	IMC	Ward No.21 p	47.06	127	5985	145	6824	163	7671	198	9318	233	10965	250	11765
		IMC	Ward No. 22 p	59.24	203	12034	210	12441	217	12856	230	13626	244	14455	250	14811
		IMC	Ward No.23 p	20.24	141	2862	157	3177	173	3501	204	4128	235	4755	250	5059
		OG & CT		595.00	49	29062	56	33320	63	37485	76	45220	89	52955	95	56525
		GI		67.92	28	1899	31	2084	34	2316	45	3076	63	4295	76	5172
			Total	**789.46**		**51842**		**57846**		**63829**		**75368**	**864**	**87425**		**93332**
22	**Laiwangma**	IMC	Ward No.23 p	44.53	141	6298	157	6991	173	7704	204	9084	235	10465	250	11133
		OG & CT		97.00	49	4738	56	5432	63	6111	76	7372	89	8633	95	9215

Zone No	Water supply zone	Area	Wards/Villages/Areas Covered	Unit Area in Ha.	2011		2016		2021		2031		2041		2046	
					Den	pop	Den	pop	Den	pop	Den	pop	Den	pop	Den	pop
		GI		29.92	28	837	31	918	34	1020	45	1355	63	1892	76	2278
			Total	**171.45**		**11873**		**13341**		**14835**		**17811**		**20990**		**22626**
23	**Sajor Leikai**	OG & CT		196.18	49	9582	56	10986	63	12359	76	14910	89	17460	95	18637
			Total	**196.18**		**9582**		**10986**		**12359**		**14910**		**17460**		**18637**
24	**Ghari**	GI		689.51	28	19279	31	21154	34	23510	45	31223	63	43605	76	52508
			Total	**689.51**		**19279**		**21154**		**23510**		**31223**		**43605**		**52508**
25	**Sangakpham**	IMC	Ward No.26 p	36.00	105	3777	111	3996	117	4212	128	4608	140	5040	145	5220
		OG & CT		72.53	49	3543	56	4062	63	4569	76	5512	89	6455	95	6890
		GI		188.90	28	5282	31	5795	34	6441	45	8554	63	11946	76	14385
			Total	**297.43**		**12602**		**13853**		**15222**		**18674**		**23441**		**26495**
26	**Khongman**	OG & CT		128.59	49	6281	56	7201	63	8101	76	9773	89	11445	95	12216
			Total	**128.59**		**6281**		**7201**		**8101**		**9773**		**11445**		**12216**
	En-route-A Pipeline Villages					36793		40242		43690		51229		59632		64240
	Total					**536,270**		**596,696**		**657,123**		**796,029**		**961,915**		**1,058,648**

Source: Table 5.13 in DPR-II

5.1.3 Water Demand

(1) Design Parameters

The PHED was given instructions from the (MoUD regarding DPR-I during discussions held on April 9, 2009. These were reflected in the preparation of DPR II and are shown in **Table 5.5**. It is for this reason that the JICA survey team has adhered to the design parameters as presented in DPR-II, in addition to the fact that there is almost no reliable data showing the operational performance of Imphal water supply system.

Table 5.5 Design Parameters

Design Parameter		Benchmark	Manual Urban*1	Manual Rural*2	DPR-I	DPR-II	JICA Survey
Per Capita Water Consumption							
Greater Imphal Areas	(Lpcd)	135	135	-	135	135	135
En-route-A Pipeline Villages	(Lpcd)	-	-	55	50	55**	55
Floating Population	(Lpcd)	-	-	-	40	40**	40
UFW ratio	(%)	15	15		15	15	15
Floating Pop. to GI Area Pop.	(%)				10	10**	10
Increase Rate of Bulk Demand	(%)				5	5	5
Population Coverage by Water Supply	(%)				100	100	100

GI: Greater Imphal

** Instructions at the discussion with the Ministry of Urban Development on April 9, 2009

*1 "Manual on Water Supply and Treatment", Central Public Health Environmental Engineering Organization (CPHEEO), May 1999

*2 "Manual for Preparation of Detailed Project Report for Rural Water Supply Schemes", Ministry of Drinking Water and Sanitation, February 2013

(2) Water Demand Projection

The water demand estimated under the above design parameters is shown in **Table 5.6**.

Figure 5.2 suggests that the water supply capacity will balance with water demand in the year of 2031.

Table 5.6 Water Demand Projection

Design Parameters

Per capita Water Consumption :

Greater Imphal Areas	135	lpcd
En-route-A Pipeline Villages	55	lpcd
Floating Pop. (10% of GI)	40	lpcd
UFW ratio :	15	%
% of Floating Pop. to Greater Imphal Area Pop. :	10	%
Increse Rate of Bulk Demand	5	% per 5 year
Population Coverage by Water Supply	100	%

(a) Projected Population for the Project Area

Sr. No.	Description	Census Pop.	Projected Pop.				
		2011	2016	2021	2031	2041	2046
a	Greater Imphal Areas (Municipal & Non municipal)	499,474	556,453	613,432	744,799	902,285	994,405
b	En-route-A Pipeline Villages	36,793	40,242	43,690	51,229	59,632	64,240
c	Floating Pop. (10% of GI)	49,947	55,645	61,343	74,480	90,229	99,441
	Total Pop. to Be Served	586,214	652,340	718,465	870,508	1,052,146	1,158,086

(b) Production Requirement for Greater Imphal Areas (Municipal & Non municipal)

Projected Pop. of Greater Imphal Areas	499,474	556,453	613,432	744,799	902,285	994,405
Demand in mld @ 135 lpcd	67.43	75.12	82.81	100.55	121.81	134.24
Quantity of UFW @ 15% in mld	11.90	13.26	14.61	17.74	21.50	23.69
Total Production Requirement in mld	79.33	88.38	97.42	118.29	143.31	157.93

(c) Production Requirement for the Existing En-route Villages

Projected Pop. of En-route Villages	36,793	40,242	43,690	51,229	59,632	64,240
Demand in mld @ 55 lpcd	2.02	2.21	2.4	2.82	3.28	3.53
Quantity of UFW @ 15% in mld	0.26	0.28	0.31	0.36	0.42	0.45
Total Production Requirement in mld	1.73	1.89	2.06	2.41	2.81	3.02

(d) Production Requirement for Floating Population

Projected Floating pop.	49,947	55,645	61,343	74,480	90,229	99,441
Demand in mld @ 40 lpcd	2.00	2.23	2.45	2.98	3.61	3.98
Quantity of UFW @ 15% in mld	0.35	0.39	0.43	0.53	0.64	0.70
Total Production Requirement in mld	2.35	2.62	2.88	3.51	4.25	4.68

(e) Total Water Production Requirements (in mld)

Greater Imphal Areas (Municipal & Non Municipal)	79.33	88.38	97.42	118.29	143.31	157.93
Existing En-route Villages	1.73	1.89	2.06	2.41	2.81	3.02
Floating Pop.	2.35	2.62	2.88	3.51	4.25	4.68
Bulk Demand	23.90	25.10	25.70	27.00	28.40	29.10
Total Water Requirement	107.31	117.99	128.06	151.21	178.77	194.73

Table 5.7 Water Demand Projection (Cont'd)

(f) Summary of Water Demand Projections

Sl. No.	Description	Census Pop.	Projected Pop. in Nos.				
		2011	2016	2021	2031	2041	2046
I	**Population**						
a	Greater Imphal Areas (Municipal & Non municipal)	499,474	556,453	613,432	744,799	902,285	994,405
b	En-route-A Pipeline Villages	36,793	40,242	43,690	51,229	59,632	64,240
c	Floating (10% of GI)	49,947	55,645	61,343	74,480	90,229	99,441
	Total Population to Be Served (a + b + c + d)	**586,214**	**652,340**	**718,465**	**870,508**	**1,052,146**	**1,158,086**
II	**Water Demand in mld**						
II-1	Domestic Water Demand						
a	Greater Imphal Areas (Municipal & Non Municipal)	67.43	75.12	82.81	100.55	121.81	134.24
b	En-route-A Pipeline Villages	2.02	2.21	2.4	2.82	3.28	3.53
c	Floating (10% of GI)	2.00	2.23	2.45	2.98	3.61	3.98
	Sub Total Domestic Water Demand (mld)	71.45	79.56	87.66	106.35	128.70	141.75
II-2	Bulk Demand (mld)	20.27	21.33	21.87	22.98	24.14	24.75
	Total Water Demand (mld)	**91.72**	**100.89**	**109.54**	**129.32**	**152.83**	**166.51**
III	**Unaccounted for Water in mld**	**16.19**	**17.80**	**19.33**	**22.82**	**26.97**	**29.38**
	Total Water Requirement mld	**107.91**	**118.69**	**128.87**	**152.14**	**179.80**	**195.89**

(g) Demand-Production Gap

Years	2011	2016	2021	2031	2041	2046
Projected Pop.	586,214	652,340	718,465	870,508	1,052,146	1,158,086
Projected Water Requirements in mld	107.91	118.69	128.87	152.14	179.80	195.89
Production Capacity in mld	104.25	149.25	149.25	149.25	149.25	149.25
Surpluses (+) & Deficits (-)	**-3.66**	**30.56**	**20.38**	**-2.89**	**-30.55**	**-46.64**

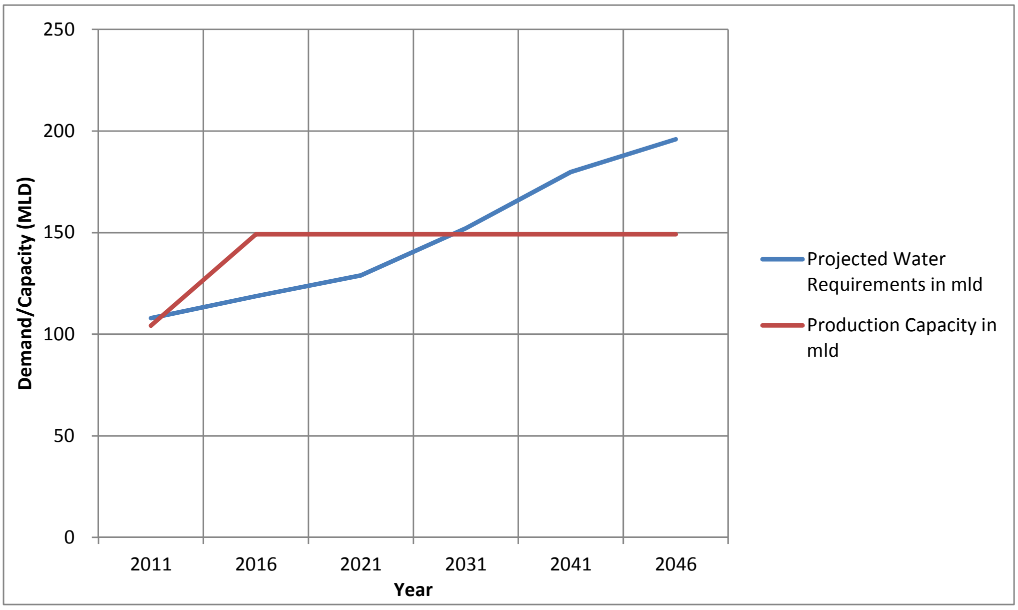


Figure 5.2 Water Demand versus Water Supply Capacity

5.1.4 Relationship with Design Population of City Development Plan: Imphal (2007)

The City Development Plan: Imphal (CDP) projected the population every ten years up to 2031 based on the actual performance within Imphal Municipal Corporation Area as shown in **Table 5.8**. This is the core area of Imphal and is composed of Wards No.1 to 26. Although the 2001 CDP population corresponds to the total census population of Wards No.1 to 26, there is plus/minus from the total census population in the other years as shown in **Table 5.8**. Using the population data by 2001 in **Table 5.8,** the population in 2031 was projected at 456,464 – more by 123,400 persons than the 333,061 persons contained in CDP. The CDP projection was based on the assumption that in a few decades, the stable growth rate will be maintained and a decadal growth rate of 10% was used. Taking into account the growth rate in the ward area, the population projection in CDP gave substantially conservative figures, as shown in **Figure 5.3**.

Table 5.8 Relationship of design Population with CDP

	Actual population					Projected population		
Census year	1961	1971	1981	1991	2001	2011	2021	2031
(A) CDP (pers.)	79,510	116,034	156,622	198,355	250,234	275,257	302,783	333,061
(B) Growth rate		46%	35%	27%	26%*	10%	10%	!0%
(C) Ward total (pers.)	67,717	102,925	161,971	200,264	223,177	(272,140)		
(A)-(B)	11,793	13,109	-5,349	-1,729	27,057			
(D) Total of Wards No.1 to 26 (pers.)	67,717	117,361	181,333	223,917	250,234	(299,419)		
(E) Growth rate of Wards No.1 to 26 (%)			55%	23%	12%	20%		

Note: All population growth rates (%) show the decadal growth rates.
2001 population of CDP corresponded to the total of Word No.1 to 36, the target area has been extended.
The figures in parentheses of Ward Total in 2011and Total of Wards No.1 to 26 show the results of Census 2011.
Source: “City Development Plan: Imphal”, Imphal Municipal Corporation

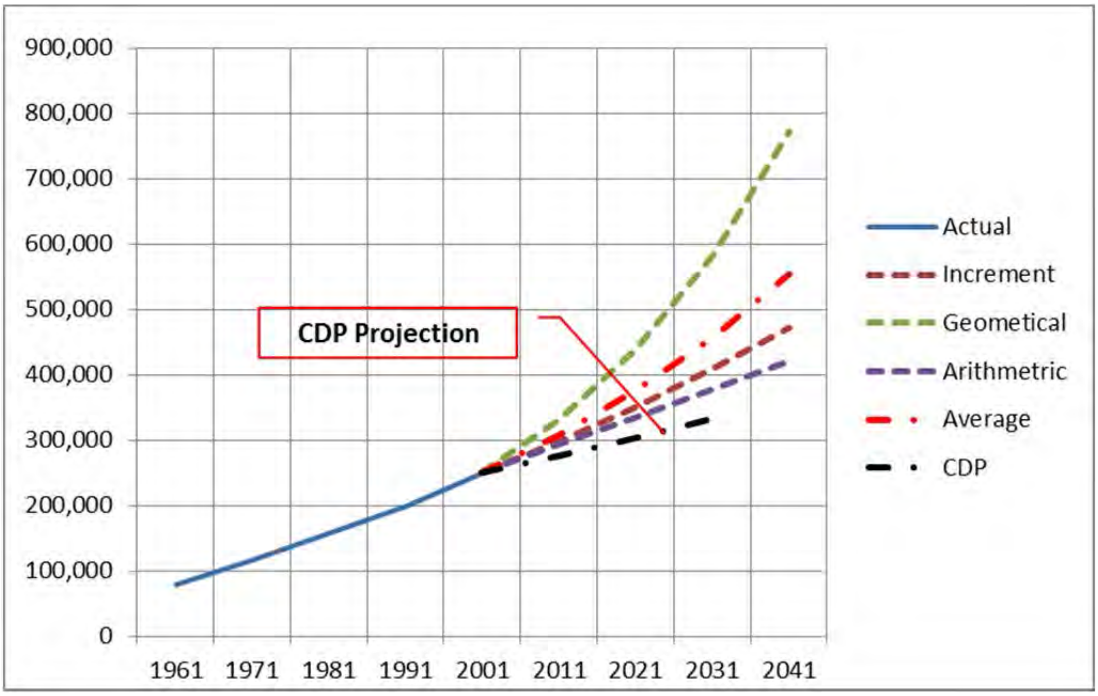


Figure 5.3 Comparison of Population Projection in CDP by Ordinary Method

5.1.5 Water Demand Distribution by Water Supply Zone

Based on the design population by water supply zone in **Table 5.4** and the design parameters in **Table 5.6**, the water demand by water supply zone was calculated as shown in **Table 5.9**.

The combination of water supply zones and water treatment plants was then reviewed taking into account the location and water production capacity of the respective water treatment plants, the location of water supply zones, the route of clear water transmission mains from Chingkheiching WTP, etc. so as to 5-13inimize the gap between water demand and water production capacity at the target year of 2031. Water supply zones were classified into six master reservoir zones and five independent WTP zones, which are to be covered by one or few water treatment plants as shown in **Table 5.10**.

Table 5.9 Water Demand by Water Supply Zone

Design Parameters

	2011	2016	2021	2031	2041	2046
Per capita Water Consumption (Lpcd)						
Greater Imphal Areas	95	105	115	135	135	135
En-route-A Pipeline Villages	55	55	55	55	55	55
Floating Pop. (10% of GI)	40	40	40	40	40	40
NRW ratio (%)	75	60	45	15	15	15
Floating Pop. to Greater Imphal Area Pop. (%)	10	10	10	10	10	10
Increase Rate of Bulk Demand (% per 5 year)	5	5	5	5	5	5
Population Coverage by Water Supply (%)	20	40	60	100	100	100

Zone No	Water Supply Zone		2011	2016	2021	2031	2041	2046
			Demand	Demand	Demand	Demand	Demand	Demand
1	Irosemba West	Sub-Total	2,730	4,327	6,366	12,651	14,534	15,392
		UFW	8,189	6,491	5,209	2,233	2,565	2,716
		Total	10,919	10,818	11,575	14,884	17,099	18,108
2	Irosemba East	Sub-Total	2,256	2,974	3,814	6,070	6,531	6,763
		UFW	6,768	4,461	3,121	1,071	1,152	1,193
		Total	9,024	7,435	6,935	7,141	7,683	7,956
3	Langjing	Sub-Total	3,783	4,840	6,074	9,621	11,306	12,349
		UFW	11,350	7,260	4,970	1,698	1,995	2,179
		Total	15,133	12,100	11,044	11,319	13,301	14,528
4	Nepramenjor	Sub-Total	323	729	1,314	3,156	3,833	4,156
		UFW	969	1,094	1,075	557	676	733
		Total	1,292	1,823	2,389	3,713	4,509	4,889
5	Sangaiprou	Sub-Total	622	1,011	1,537	3,077	3,552	3,772
		UFW	1,866	1,517	1,258	543	627	666
		Total	2,488	2,528	2,795	3,620	4,179	4,438
6	Irom Pukhri	Sub-Total	177	414	720	1,555	1,712	1,788
		UFW	531	621	589	274	302	316
		Total	708	1,035	1,309	1,829	2,014	2,104
7	Chingtham Leikai	Sub-Total	555	1,087	1,780	3,727	4,220	4,481
		UFW	1,664	1,631	1,456	658	745	791
		Total	2,219	2,718	3,236	4,385	4,965	5,272
8	Keishampat	Sub-Total	295	661	1,174	2,747	3,276	3,535
		UFW	884	992	960	485	578	624
		Total	1,179	1,653	2,134	3,232	3,854	4,159
9	Cheiraoching	Sub-Total	1,453	2,100	2,878	5,036	5,494	5,710
		UFW	4,360	3,150	2,355	889	969	1,008
		Total	5,813	5,250	5,233	5,925	6,463	6,718
10	Lalambung	Sub-Total	324	603	968	2,017	2,279	2,411
		UFW	972	905	792	356	402	425
		Total	1,296	1,508	1,760	2,373	2,681	2,836
11	Assembly	Sub-Total	492	687	908	1,477	1,542	1,577
		UFW	1,477	1,031	743	261	272	278
		Total	1,969	1,718	1,651	1,738	1,814	1,855
12	Chinga	Sub-Total	764	1,463	2,412	5,190	5,998	6,396
		UFW	2,293	2,195	1,973	916	1,058	1,129
		Total	3,057	3,658	4,385	6,106	7,056	7,525
13	Canchipur	Sub-Total	2,131	3,320	4,908	9,857	12,040	13,381
		UFW	6,393	4,980	4,016	1,739	2,125	2,361
		Total	8,524	8,300	8,924	11,596	14,165	15,742
14	Lilandolampak	Sub-Total	128	325	598	1,404	1,644	1,756
		UFW	384	488	489	248	290	310
		Total	512	813	1,087	1,652	1,934	2,066

15	Minuthong	Sub-Total	779	1,224	1,798	3,406	3,813	4,000
		UFW	2,336	1,836	1,471	601	673	706
		Total	3,115	3,060	3,269	4,007	4,486	4,706
16	Khuman Lampak	Sub-Total	926	1,290	1,747	3,036	3,394	3,557
		UFW	2,779	1,935	1,430	536	599	628
		Total	3,705	3,225	3,177	3,572	3,993	4,185
17	Koirengei	Sub-Total	5,678	7,163	8,974	14,917	18,554	21,077
		UFW	17,034	10,745	7,342	2,632	3,274	3,720
		Total	22,712	17,908	16,316	17,549	21,828	24,797
18	Ningthem Pukhri	Sub-Total	893	1,304	1,837	3,403	3,895	4,152
		UFW	2,678	1,956	1,503	601	687	733
		Total	3,571	3,260	3,340	4,004	4,582	4,885
19	Old Thambuthong	Sub-Total	298	624	1,064	2,367	2,737	2,922
		UFW	893	936	871	418	483	516
		Total	1,191	1,560	1,935	2,785	3,220	3,438
20	Irilbung	Sub-Total	783	1,790	3,195	7,913	10,514	12,289
		UFW	2,350	2,685	2,614	1,396	1,855	2,169
		Total	3,133	4,475	5,809	9,309	12,369	14,458
21	Porompat	Sub-Total	2,331	3,897	5,965	11,955	13,705	14,565
		UFW	6,994	5,846	4,881	2,110	2,418	2,570
		Total	9,325	9,743	10,846	14,065	16,123	17,135
22	Laiwangma	Sub-Total	242	588	1,067	2,483	2,926	3,154
		UFW	725	882	873	438	516	557
		Total	967	1,470	1,940	2,921	3,442	3,711
23	Sajor Leikai	Sub-Total	190	479	883	2,073	2,427	2,591
		UFW	570	719	722	366	428	457
		Total	760	1,198	1,605	2,439	2,855	3,048
24	Ghari	Sub-Total	1,436	2,033	2,817	5,536	7,317	8,586
		UFW	4,309	3,050	2,305	977	1,291	1,515
		Total	5,745	5,083	5,122	6,513	8,608	10,101
25	SANGAKPHAM	Sub-Total	797	1,181	1,678	3,217	3,911	4,351
		UFW	2,391	1,772	1,373	568	690	768
		Total	3,188	2,953	3,051	3,785	4,601	5,119
26	KHONGMAN	Sub-Total	166	358	623	1,405	1,641	1,749
		UFW	497	537	510	248	290	309
		Total	663	895	1,133	1,653	1,931	2,058
		Domestic	9,492	23,370	42,328	100,547	121,807	134,248
		En-Route	404	886	1,442	2,818	3,280	3,534
		Floating	397	891	1,471	2,980	3,607	3,977
		Bulk	20,259	21,325	21,858	22,951	24,099	24,701
		Sub-Total	**30,552**	**46,472**	**67,099**	**129,296**	**152,793**	**166,460**
		UFW	91,656	69,715	54,901	22,819	26,960	29,377
		Total	**122,208**	**116,187**	**122,000**	**152,115**	**179,753**	**195,837**
		Table 5.5 (a) b						

Table 5.10 Combination of Water Treatmment Plant(s) and Water supply Zone(s)

Master Reservoir No.	Master Reservoir Location	Water Treatment Plant	Design Capacity before Project	Design Capacity after Project	WS Zone No.	WS Zone Name	Water Demand in mld						Remarks
							2011	2016	2021	2031	2041	2046	
MR-1	Koirengei Hill Range	Koirengei Potsangbam I Potsangbam II	2.27 6.81 6.81	15.89	WSZ 17	Koirengei Zone	22.5	17.6	15.9	17.0	21.2	24.1	
					WSZ 25	Sangakpham Zone	3.2	3.0					
					Enroute	Potsangbam Enroute	0.3	0.4	0.4	0.5	0.6	0.7	
						Sub-total	26.0	21.0	16.3	17.5	21.8	24.8	Supplied from Khuman Lampak WTP 1.0mld
						Production	15.89	16.89	16.89	16.89	16.89	16.89	
						Balance	-10.1	-4.1	0.6	-0.6	-4.9	-7.9	
MR-2	Irosemba Hill Range	Singda	18.16	18.16	WSZ 1	Iroisemba East Zone	10.9	10.8	11.6	14.9	17.1	18.1	
					WSZ 2	Iroisemba West Zone	9.0	7.4	6.9	7.1	7.7	8.0	
					WSZ 9	Cheiraoching Zone	5.8	5.3	5.2	5.9	6.5	6.7	
					WSZ 10	Lalambung Zone	1.3	1.5					
					WSZ 11	Assembly Zone	2.0	1.7					
						Sub-total	29.0	26.7	23.7	27.9	31.3	32.8	
						Production	18.16	18.16	18.16	18.16	18.16	18.16	
						Balance	-10.8	-8.5	-5.5	-9.7	-13.1	-14.6	
		Kangchup	14.53	14.53	WSZ 3	Langjing Zone	13.8	10.2	8.8	8.5	10.1	11.0	
					Enroute	Kangchup foothill Enroute	0.4	0.5	0.6	0.8	0.9	1.0	
					Enroute	Lamsang Enroute	1.0	1.3	1.6	2.0	2.3	2.5	
						Sub-total	15.2	12.0	11.0	11.3	13.3	14.5	
						Production	14.53	14.53	14.53	14.53	14.53	14.53	
						Balance	-0.7	2.5	3.5	3.2	1.2	0.0	
		Kangchup Ext	9.08	9.08	WSZ 4	Nepramenjor Zone	1.3	1.8	2.4	3.7	4.5	4.9	
					WSZ 5	Sangaiprou Zone	2.5	2.5					
					WSZ 6	Irom Pukhri Zone	0.7	1.0					
					WSZ 7	Chingtham Leikai Zone	2.2	2.7					
					WSZ 8	Keishampat Zone	1.2	1.7					
					WSZ 24	Ghari Zone	5.7	5.1					
						Sub-total	13.6	14.8	2.4	3.7	4.5	4.9	
						Production	9.08	9.08	9.08	9.08	9.08	9.08	
						Balance	-4.5	-5.7	6.7	5.4	4.6	4.2	
						Total	57.8	53.5	37.1	42.9	49.1	52.2	
						Production	41.8	41.8	41.8	41.8	41.8	41.8	
						Balance	-16.0	-11.7	4.7	-1.1	-7.3	-10.4	
MR-3	Kanchipur Hill Range	Kanchipur I Kanchipur II	2.27+4.54 6.81	9.08 6.81 (+2.27)	WSZ 13	Canchipur Zone	8.5	8.3	8.9	11.6	14.2	15.7	
					WSZ 14	Lilando Lampak Zone	0.5	0.8	1.1	1.7	1.9	2.1	
					WSZ 26	Khongman Zone			1.1	1.7	1.9	2.1	
						Sub-total	9.0	9.1	11.1	15.0	18.0	19.9	
						Production	13.62	15.89	15.89	15.89	15.89	15.89	
						Balance	4.6	6.8	4.8	0.9	-2.1	-4.0	
MR-4	Irilbung Hill Range	Irilbung	6.81	6.81	WSZ 20	Irilbung Zone	3.1	4.5	5.8	9.3	12.4	14.5	
					WSZ 26	Khongman Zone	0.7	0.9					
						Sub-total	3.8	5.4	5.8	9.3	12.4	14.5	
						Production	6.81	6.81	6.81	6.81	6.81	6.81	
						Balance	3.0	1.4	1.0	-2.5	-5.6	-7.7	
MR-5	Porompat WTP	Porompat old Porompat I Porompat II	2.27 6.81 6.81	9.53 (-6.36)	WSZ 21	Porompat Zone	9.3	9.7	10.8	14.1	16.1	17.1	Supplied from thoubal 4mld
					WSZ 22	Laiw ngma Zone	1.0	1.5					
					WSZ 23	Sajor Leikai Zone	0.8	1.2					
						Sub-total	11.1	12.4	10.8	14.1	16.1	17.1	
						Production	15.89	13.53	13.53	13.53	13.53	13.53	
						Balance	4.8	1.1	2.7	-0.6	-2.6	-3.6	
MR-6	Chingkheiching WTP			45.00	WSZ 5	Sangaiprou Zone			2.8	3.6	4.2	4.4	
					WSZ 6	Irom Pukhri Zone			1.3	1.8	2.0	2.1	
					WSZ 7	Chingtham Leikai Zone			3.2	4.4	5.0	5.3	
					WSZ 8	Keishampat Zone			2.1	3.2	3.9	4.2	
					WSZ 10	Lalambung Zone			1.8	2.4	2.7	2.8	
					WSZ 11	Assembly Zone			1.7	1.7	1.8	1.9	
					WSZ 22	Laiw ngma Zone			1.9	2.9	3.4	3.7	
					WSZ 23	Sajor Leikai Zone			1.6	2.4	2.9	3.0	
					WSZ 24	Ghari Zone			5.1	6.5	8.6	10.1	
					WSZ 25	Sangakpham Zone			3.1	3.8	4.6	5.1	
						Sub-total			24.6	32.7	39.1	42.6	Toubal WTP 45mld - 11mld (Transferred) =34mld
						Production			34	34	34	34	
						Balance			9.4	1.3	-5.1	-8.6	
Independent WTPS	Chinga & Moirangkhom		2.14	2.14	WSZ 12	Chinga Zone	3.1	3.7	4.4	6.1	7.1	7.5	Service OHT is supplied from thoubal 4.0mld
							2.14	6.14	6.14	6.14	6.14	6.14	
							-1.0	2.4	1.7	0.0	-1.0	-1.4	
	Minuthong		1.14	1.14	WSZ 15	Minuthong Zone	3.1	3.1	3.3	4.0	4.5	4.7	Service OHT is supplied from thoubal 3.0mld
							1.14	4.14	4.14	4.14	4.14	4.14	
							-2.0	1.0	0.8	0.1	-0.4	-0.6	
	Khuman Lampak		0.45	4.54 (+4.09)	WSZ 16	Khuman Lampak Zone	3.7	3.2	3.2	3.6	4.0	4.2	
							0.45	3.54	3.54	3.54	3.54	3.54	1mld is supplied to MR-1
							-3.3	0.3	0.3	-0.1	-0.5	-0.7	
	Old Thumbuthong		2.00	2.00	WSZ 19	Old Thumbuthong Zone	1.2	1.6	1.9	2.8	3.2	3.4	
							2.0	2.0	2.0	2.0	2.0	2.0	
							0.8	0.4	0.1	-0.8	-1.2	-1.4	Inter zonal sharing of w ater
	Ningthem-pukhri		4.54	4.54	WSZ 18	Ningthempukhri Zone	3.6	3.3	3.3	4.0	4.6	4.9	
							4.54	4.54	4.54	4.54	4.54	4.54	
							0.9	1.2	1.2	0.5	-0.1	-0.4	
						Total	14.7	14.9	16.1	20.5	23.4	24.7	
						Production	10.27	20.36	20.36	20.36	20.36	20.36	
						Balance	-4.4	5.5	4.3	-0.1	-3.0	-4.3	
			104.25	104.25		Total	122.40	116.3	121.8	152.0	179.9	195.8	
						Production	104.25	115.25	149.25	149.25	149.25	149.25	
						Balance	-18.15	-1.05	27.45	-2.75	-30.65	-46.55	
						Without Project	104.25	104.25	104.25	104.25	104.25	104.25	

2.00 The existing WTP w ill be used continuously in the future. [grey cell] WSZ transffered to Toubal System (MR-6)

(+2.27) Difference betw een existing and new WTP capacities

5.2 Concept of Integrated Water Supply System

As discussed in Chapter 2 of this report, the conditions of most of the existing WTPs are severely deteriorated and their production capacity cannot even meet the current water demand. The existing transmission and distribution mains are old and leaking, which has resulted to high level of UFW.

The main concept of the Imphal Integrated Water Supply System proposed in the DPR is to reconstruct most of the existing outdated water supply facilities and to establish a totally new water supply system, in order to provide 24 × 7 water supply to the customers. The main capital investment works proposed in the DPR include:

- Reconstruction of nine existing intakes and WTPs
- Construction of a 45Mld new WTP at Chingkheiching
- Construction of five master reservoirs
- Construction / rehabilitation of 12 GLSRs
- Construction of 23 overhead tanks
- Construction of 12 emergency reservoirs with associated PSs
- Installation of new raw water mains (28.80 km*)
- Installation of clear water mains (27.20 km*)
- Installation of new transmission mains (24.41 km* + 49.19 km)
- Installation of new distribution mains (298.58 km* + 693.08 km)
  * under Phase-II project

For the new water supply system, water will be produced at the 14 existing WTPs, most of which will be reconstructed, and new 45 Mld WTP at Chingkheiching. This proposed new WTP is required to supplement the shortfall of production capacity to the planning horizon.

New transmission and distribution mains are to be extensively installed in the supply area to transfer and distribute water to the customers in the 26 distribution zones, along with new master reservoirs and service reservoirs.

It is proposed that the existing and new WTPs will form six master reservoir zones and five small independent WTP zones. Each of the master reservoir and small independent WTP zone has its own water source and distribution zones. **Table 5.11** summarises the key component of each zone. See **Figure 5.4** and **Drawing No**. **IP-WSS-NE-001** for geographical location of each mater reservoir zone, as well as main facilities of the new water supply system.

Table 5.11 Master Reservoir and Independent WTP Zones

Master Reservoir / Independent WTP Zone	Water Source	WTP	Distribution Zone
MRZ-1	Imphal River, 10 tube wells	Koirengei WTP (15.89MLD)	Koirengei Zone (WSZ 17)
MRZ-2	Singda Dam, Leimakhong stream, Pollock stream	Singda WTP (18.16MLD) Kangchup WTP (14.53MLD) Kangchup Extension WTP (9.08MLD)	Iroisemba East Zone (WSZ 1), Iroisemba West Zone (WSZ 2), Langjing Zone (WSZ 3), Nepra Menjor Zone (WSZ 4), Cheiraoching Zone (WSZ 9)
MRZ-3	Imphal River	Canchipur WTP (9.08MLD) Canchipur-2 WTP (6.81MLD)	Canchipur Zone (WSZ 13), Lilandolampak Zone (WSZ 14), Khongman Zone (WSZ 26)
MRZ-4	Iril River	Irilbung WTP (6.81MLD)	Irilbung Zone (WSZ 20)
MRZ-5	Iril River	Porompat WTP (9.53MLD)	Porompat Zone (WSZ 21)
MRZ-6	Thoubal Dam	Chingkheiching WTP (45MLD)	Sangaiprou Zone (WSZ 5), Irom Pukhri Zone (WSZ 6), Chingthamleikai Zone (WSZ 7), Keishampat Zone (WSZ 8), Lalmbung Zone (WSZ 10), Assembly Zone (WSZ 11), Laiwangma Zone (WSZ 22), Sajor Leikai Zone (WSZ 23), Ghari Zone (WSZ 24)
CZ-1	Imphal River	Khuman Lampak WTP (4.54MLD)	Khuman Lampak Zone (WSZ 16)
CZ-2	Imphal River	Minuthong WTP (1.14MLD)	Minuthong Zone (WSZ 15)
CZ-3	Imphal River	Ningthempukhri WTP (4.54MLD)	Ningthempukhri Zone (WSZ 18)
CZ-4	Imphal River	Chinga WTP (1.14MLD) Moirangkhom WTP (1.0MLD)	Chinga Zone (WSZ 12)
CZ-5	Imphal River	Old Thumbuthong WTP (2.00MLD)	Old Thumbuthong Zone (WSZ 19)

Note:
1) MRZ: Master Reservoir Zone, CZ: Central Zone, WSZ: Water Supply Zone
2) Distribution zones are those formed in 2046.

The following are general characteristics of the proposed water supply system in the DPR, as well as some observations made by the JICA survey team:

- The new 45Mld Chingkheiching WTP shall supplement the shortfall of production capacity, and water will be supplied to a wider area in the city by gravity. The latter is advantageous in terms of energy costs and its ability to maintain continuous supply at the time of power outage.

- The route of the transmission main from Chingkheiching WTP is planned to supply water to the area where shortfall of water is expected in the future. The proposed transmission mains will be interconnected with other master supply zones in the city, enabling support supplies to other water supply zones and providing contingency supplies at the time of the source and plant outage.

- Six master reservoir zones are created and their supply zone boundaries shall be formed to balance production capacity and demand generated in each zone. Rezoning of 26 existing supply zones will be undertaken accordingly.

- Master reservoirs and ground level service reservoirs are located on hilltops in the outskirts of the supply area. Provision of additional storage capacity under this scheme is essential to meet future demand and ensure uninterrupted supply.

- Twenty-three new overhead tanks are proposed in the area of flat topography to provide sufficient pressure for delivery into the distribution system. Most of overhead tanks are located in the centre of each supply zone, achieving the economic layout.

- New transmission mains are proposed to transfer output of WTPs to respective supply zones. Expensive installation of new distribution mains is also proposed to renew the aging distribution network and to cover the entire supply area.

Overall, the general arrangement of the new water supply system proposed in the DPR is adequate.

With regards to the possibility of the consolidation of the existing small WTPs in the central zone, PHED officials stated that it is not really possible due to lack of land within the city to build a larger capacity of a WTP. The recent hike of land price would make it difficult to acquire the required land in the city centre. Thus the only choice is to reconstruct the existing WTPs within their premises.

It should be noted that the Phase 1 project under JNNURM fund has already been sanctioned by MoUD and the contract to rehabilitate the existing WTPs will soon be awarded to the contractor(s). It is therefore not possible to change the principle of the water supply system proposed in DPR at this stage.

Figure 5.5 (1)–(4) shows the supply flow diagram of the new water supply systems. On the diagrams, currently planned scope of the works under JNNURM and JICA funding is also indicated.

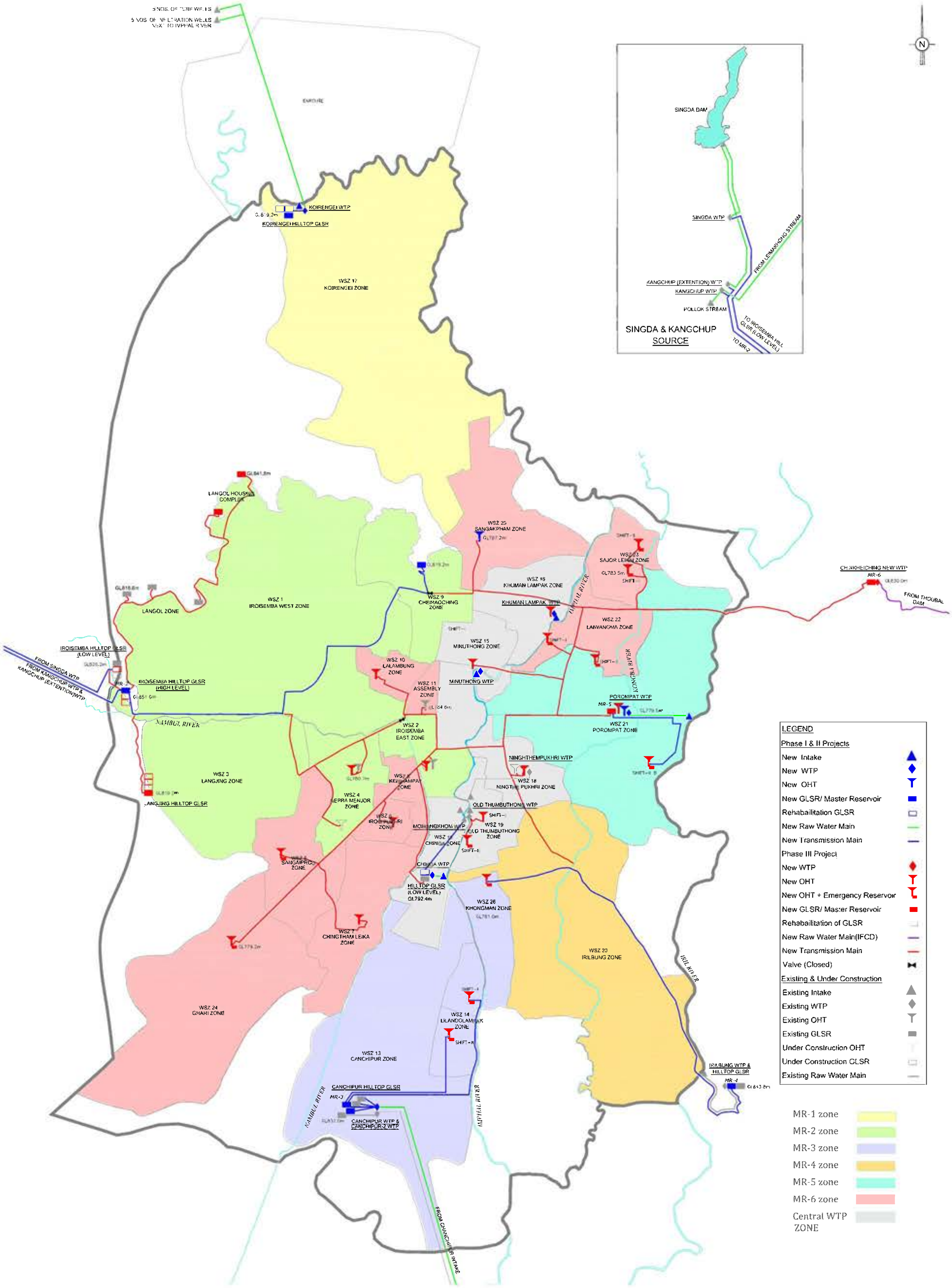


Figure 5.4 Proposed Water Supply Zones (2046)

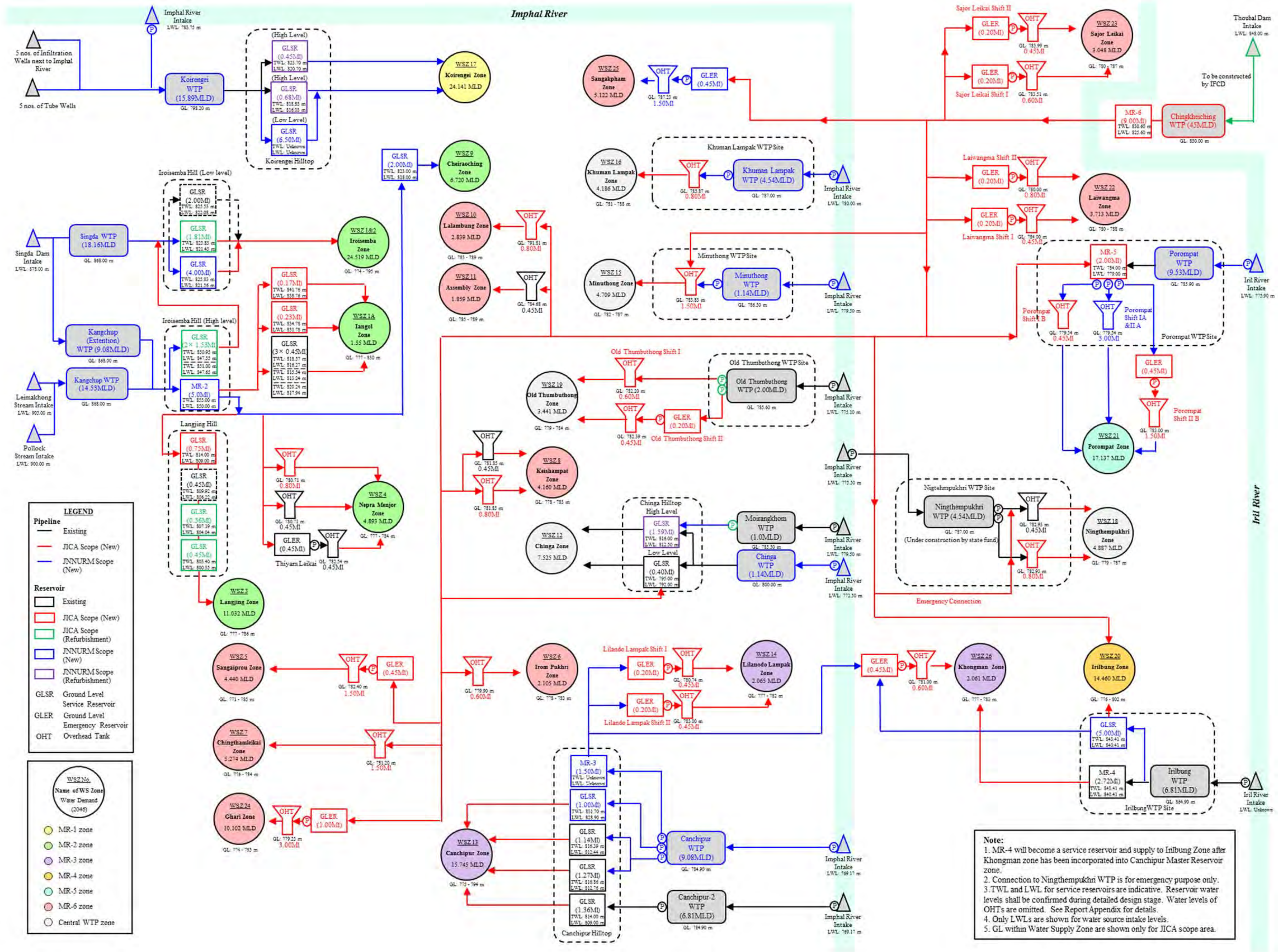
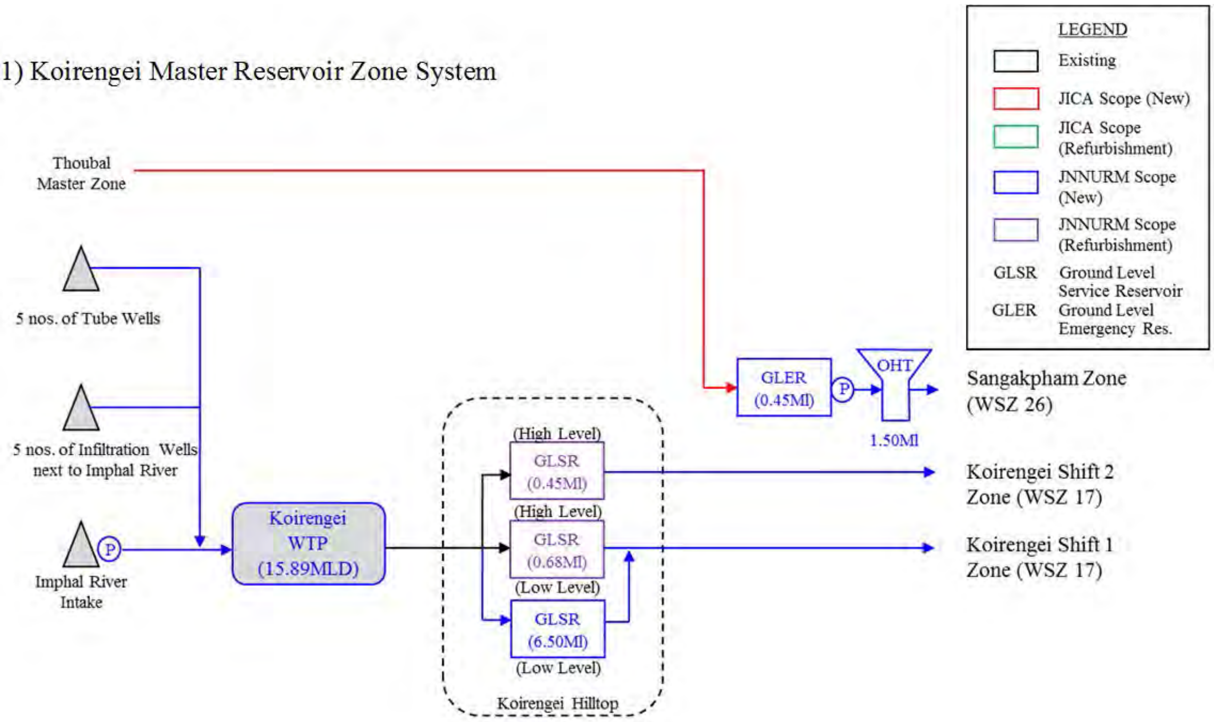


Figure 5.5 Water Transmission Flow Diagram (Entire)

1) Koirengei Master Reservoir Zone System



2) Iroisemba Master Reservoir Zone System

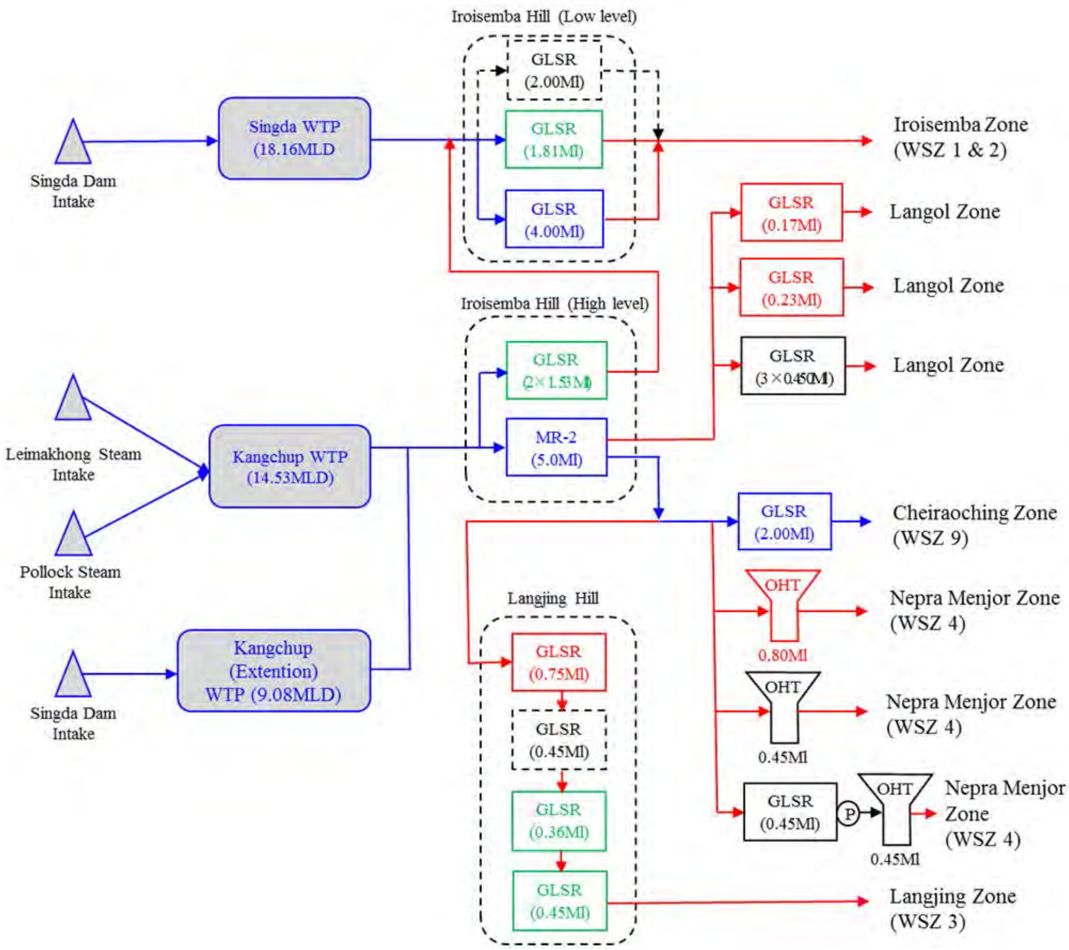
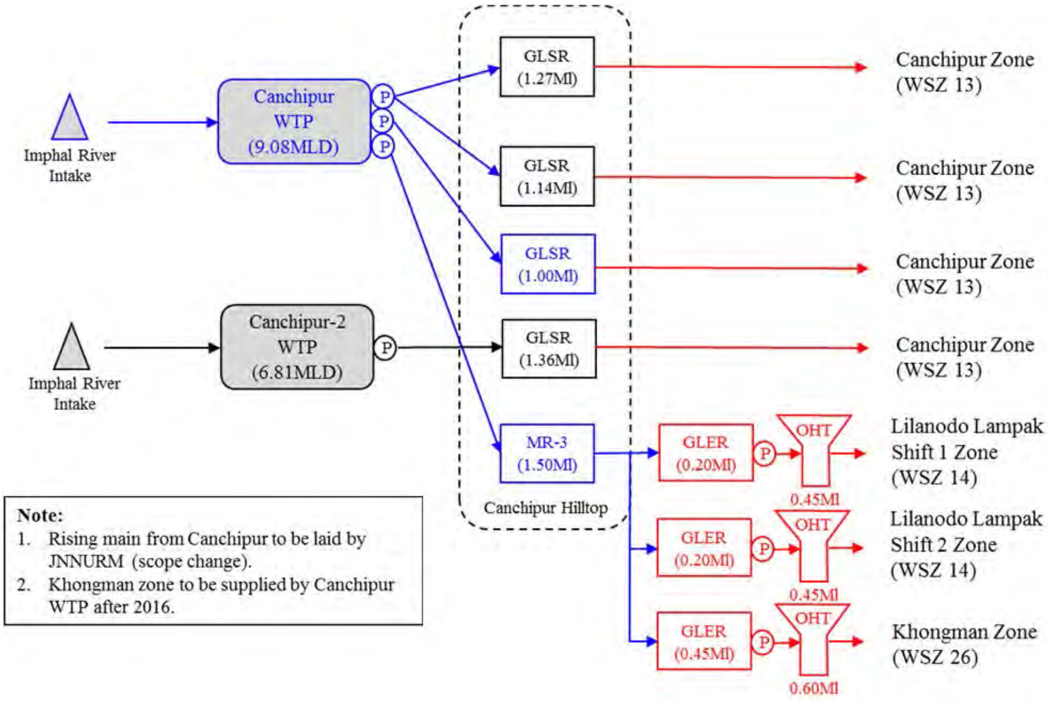
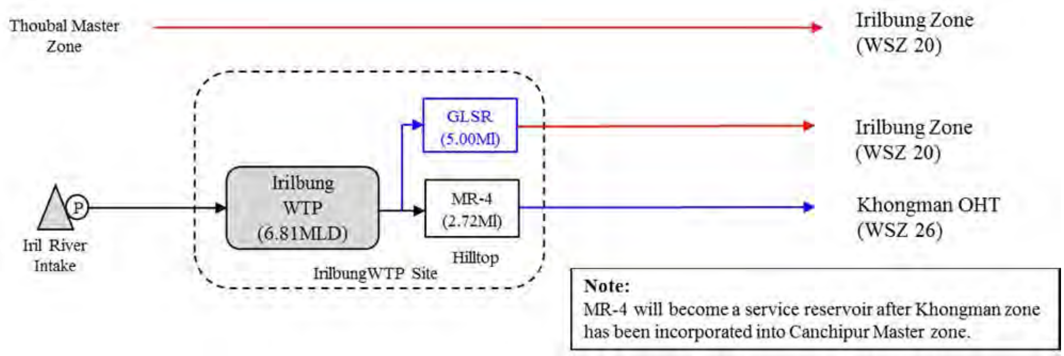


Figure 5.5 Water Transmission Flow Diagram (1)

3) Canchipur Master Reservoir Zone System



4) Irilbung Master Reservoir Zone System



5) Porompat Master Reservoir Zone System

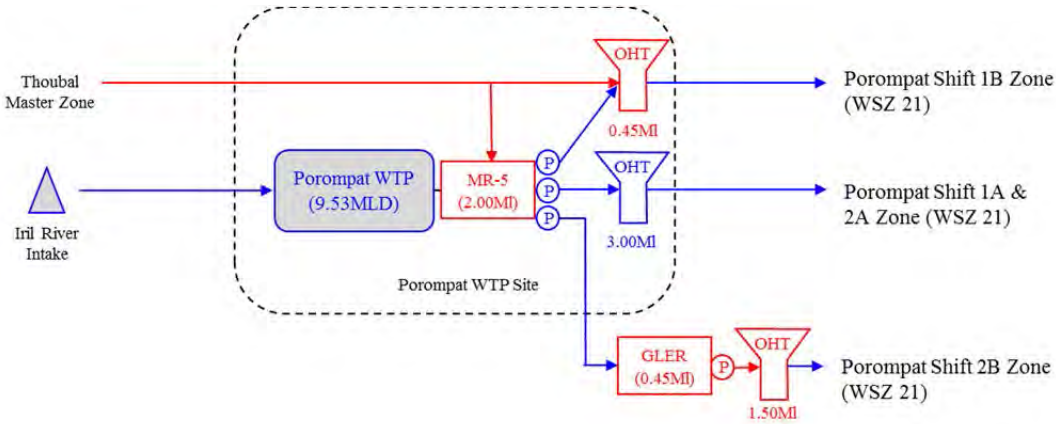
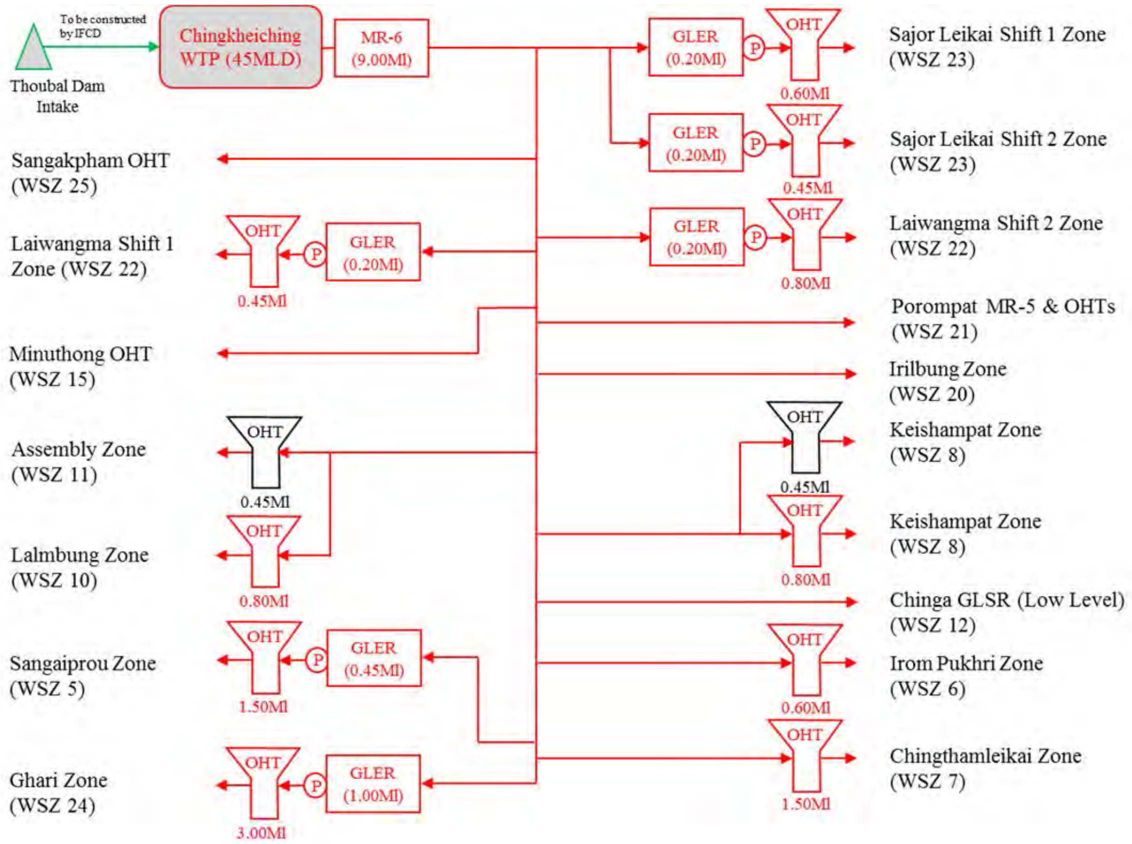
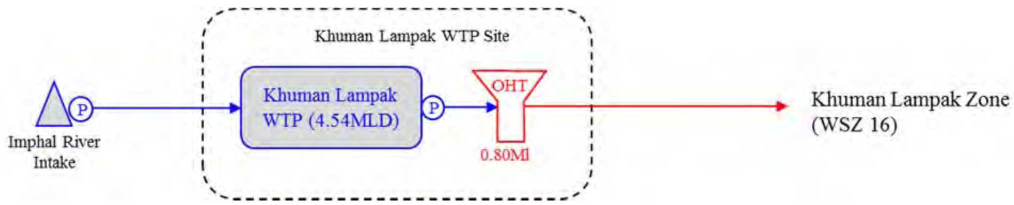


Figure 5.5 Water Transmission Flow Diagram (2)

6) Chingkheiching Master Reservoir Zone System



7) Khuman Lampak WTP System



8) Minuthong WTP System

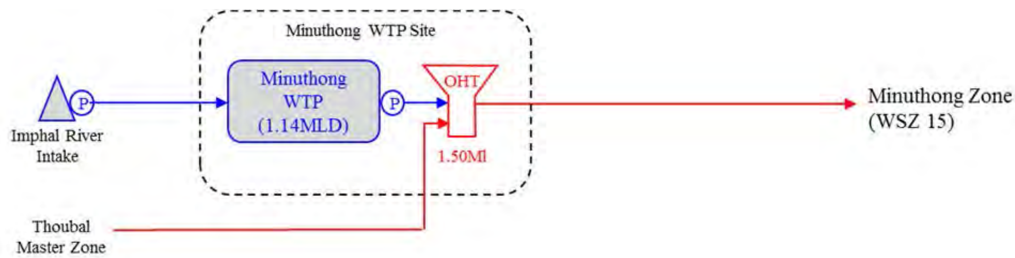
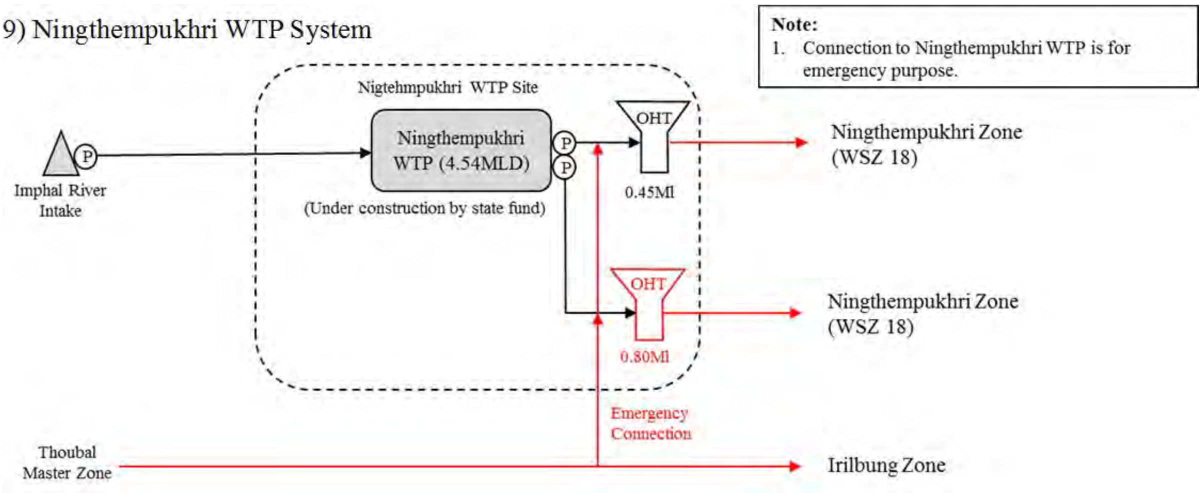
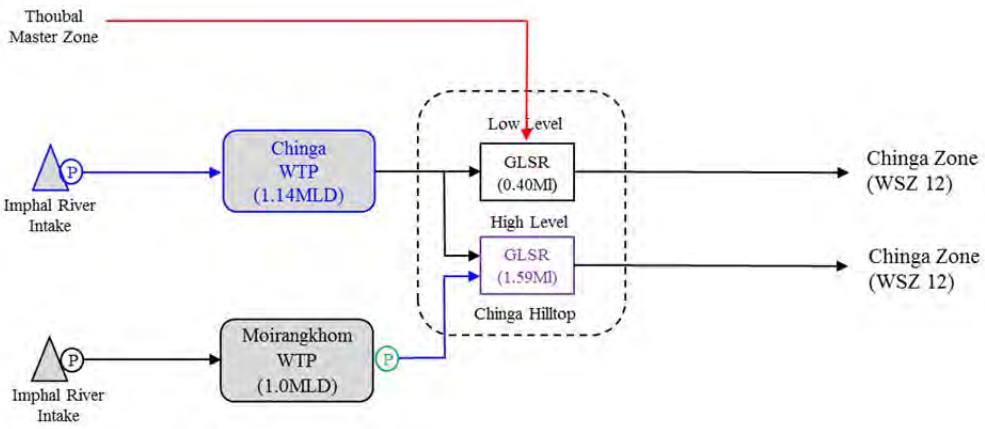


Figure 5.5 Water Transmission Flow Diagram (3)

9) Ningthempukhri WTP System



10) Chinga and Mirangkhom WTP System



11) Old Thumbuthong WTP System

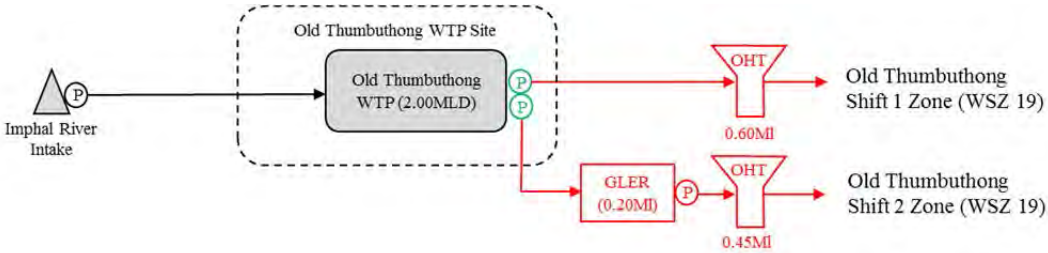


Figure 5.5 Water Transmission Flow Diagram (4)

5.3 Intake Facilities and Raw Water Conveyance Pipe from Thoubal Dam

5.3.1 Thoubal Dam

Thoubal dam is a multi-purpose dam which is currently under construction by the Irrigation and Flood Control Department, Manipur (IFCD). It is located on the bank of Thoubal River, 35km to the east from Imphal City. According to "Status on Thoubal Multipurpose Project – September, 2014" (see **Appendix A5.3 (1)**) construction work includes the installation of a raw water conveyance main scheduled to be completed in March 2016. Water intake facility for Chingkheiching WTP is under construction inside of this dam facility. The outline of the project is shown below.

Project Name:	Thoubal Multipurpose Dam Project
Implementation Organization:	IFCD
Purpose of Dam:	Annual Irrigation (35,160 ha), Water Supply (45 MLD), Power Generation (7.50 MW)
Implementation of the Project:	1980
Completion of the Project:	March, 2015
Progress of Construction Work:	Dam (89.50%), Spillway (83.39%), Barrage (100 %) at 2014
Dam Facility:	
Type:	Uniformity Type Earthfill Dam
Location：	Maphou, Senapati District
Inlet River:	Thoubal River
Capacity:	Effective Storage Volume 124,580,000m^3 (Total Storage Volume176,380,000m^3)
Bank Elevation:	+886.00m
Design High Water Level:	+882.68m (MWL: Maximum Water Level)
Design Low Water Level:	+848.00m (Dead Storage Level)
Top of Dam:	+886.00m
Water Collection Area:	527km^2
Elevation:	GL +840.00m
Spillway:	Chute Type
Total Project Cost:	16,942.6 million Rs

Around 90% of construction work has been completed as shown in **Photo 5.1**. Current outstanding works include the construction of a section of the embankment, installation of gates at spillway, and construction of power generation facility etc. All the works associated with the dam construction are currently scheduled to be completed by March 2015.

【Overall View of Dam】
Dam is almost constructed.

【Spillway】
Gates are not yet installed.

Photo 5.1 Thoubal Dam

5.3.2 Water Intake Facility

The water intake facility for Chingkheiching WTP has already been constructed inside of Thoubal Dam. A bellmouth pipe entry along with manually operated valve is installed at each intake water level as shown in the Figure below, although valve access platforms are not installed at the moment.

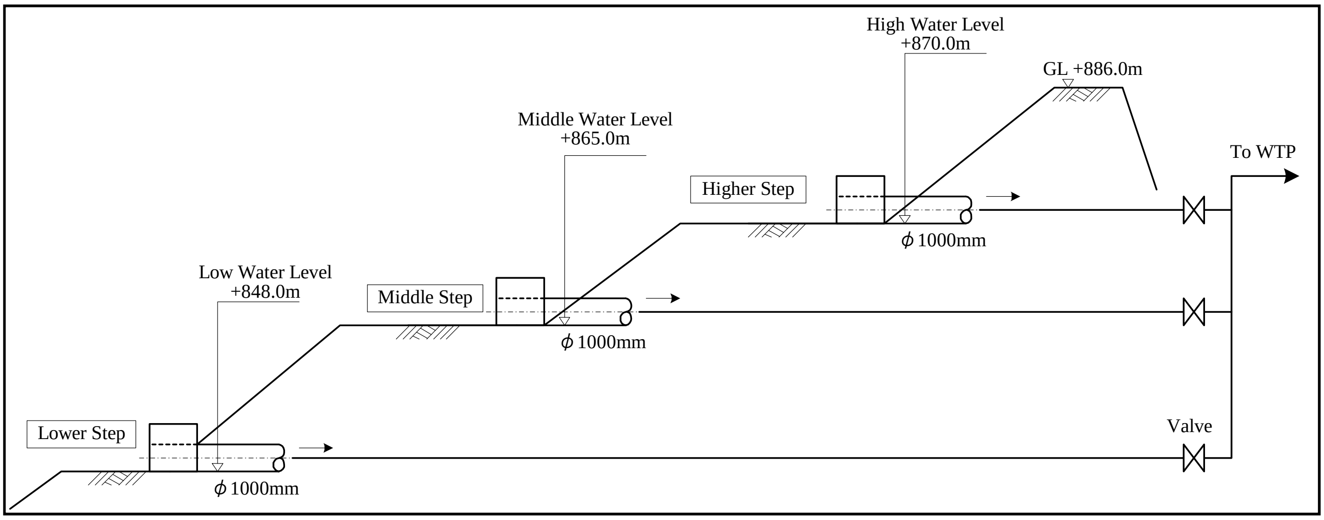


Figure 5.6 Intake Water Level

Invert level of each intake pipe is set to the same level as the ground level at upper level, middle level and low level. Raw water shall be taken from high and middle water level bellmouths because raw water from the low water level bellmouth might have sand, leaves and sediment from the bottom of dam. But low water level bellmouth shall be used in case dam water level falls lower than middle water level.

A sand pit has not been built at each location as shown in **Photo 5.2**. With this arrangement, sand, gravel and fallen leaves around the intake entry may easily enter into raw water conveyance pipe. JICA Survey Team requested IFCD to modify three intake entries as shown in **Figure 5.7** to prevent gravel and fallen leaves from entering into the pips. Subsequently, IFCD accepted the proposal of the pipe modification work and agreed that they would carry out the modification as per the proposed design.

	
【Intake Facility】 Three intake facilities are installed inside dam.	【Bellmouth type intake at middle level drawoff point】 Invert level of intake pipe is set at the same level as ground level.

Photo 5.2 Water Intake Facility

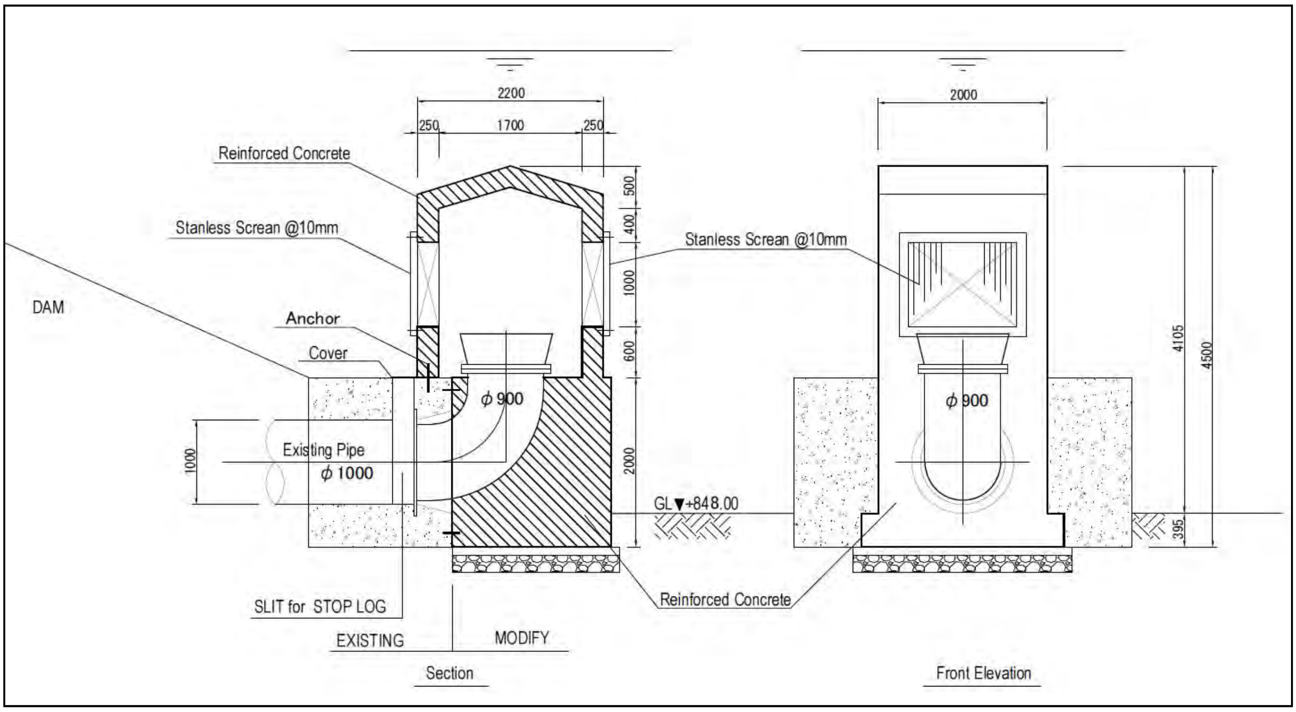


Figure 5.7 Proposed Modification Arrangement for Intake Point

Three raw water conveyance pipes (Dia 1000mm) from each intake point joint merge together at the valve pit inside dam facility. The raw water conveyance main to Chingkheiching WTP will be installed under the project of "Tunnel for Extension of Raw Water Pipeline from Thoubal Dam to the Treatment Plant of PHED under Thoubal Multipurpose Project, Manipur".

The water right to take water from Thoubal dam for the water supply in Imphal was discussed between IFCD and PHED in April 2009, and IFCD issued "Commitment for Reservation of Water in Thoubal Dam" (see **Appendix A5.3 (2)**).

5.3.3 Raw Water Conveyance Facilities

The construction work of the raw water conveyance main (18.55km of 1000mm diameter DI main) and two tunnels is being funded by AIBP (Accelerated Irrigation Benefit Program, Ministry of Water Resources), and construction work is scheduled to start from December 2014.

(1) Scope of the Project

Scope of the project for raw water conveyance facilities conducted by IFCD is shown below.

Project Name: Tunnel for Extension of Raw Water Pipeline from Thoubal Dam to the Treatment Plant of PHED under Thoubal Multipurpose Project, Manipur

Implementation Organization: IFCD

Pipe Route: Thoubal Dam to Chingkheiching WTP (see **Figure 5.8**)

Pipe Diameter: Dia 1000mm

Pipe Material: Ductile Cast Iron Pipe (DIP)

Pipe Length: 18.55km (included tunnel part 3.12km)

Water Flow: 46,350m^3/day (46.35 MLD)

Tunnel: Yaingangpokpi RF Tunnel, Length 2,280m
Khem RF Tunnel, Length 840m

<u>Contract Packaging</u>

Package-1: Procurement of Pipe Material
Package-2: Installation of Pipe
Package-3: Tunnel Construction Work

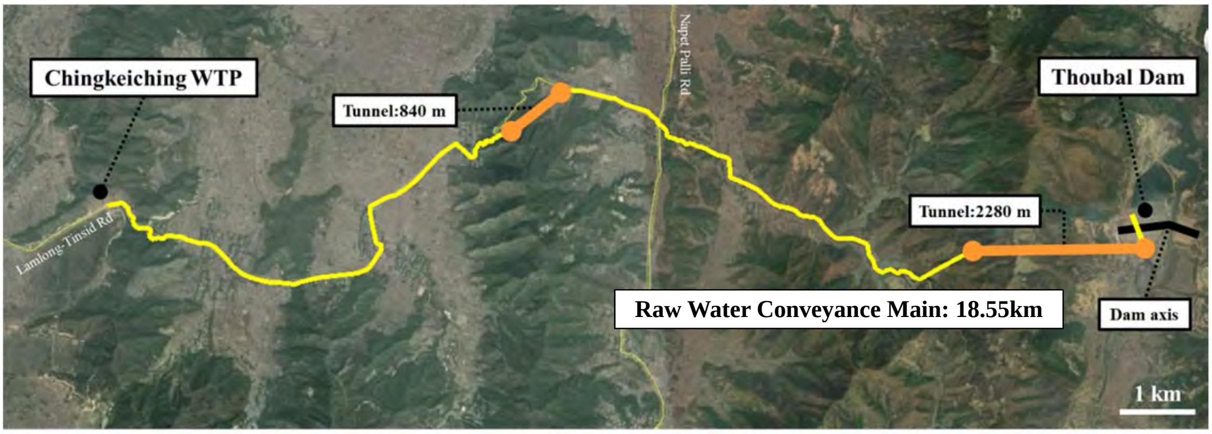


Figure 5.8 Raw Water Conveyance Pipeline Route

(2) Current Status of Project Schedule of each Package

The progress of each contract package is shown below (as of October 2014):

1) Package-1 (Procurement of Pipe Material)

Tender and selection of supplier were conducted and progress as shown below:

May, 2014:	Completion of Publishing/Downloading Tender Document
June:	Completion of Submission of Tender and Completion of Opening Technical Bidding (tendered by two suppliers)
July:	Bidding was conducted again
September:	Supplier was selected
October:	State government will approve, Contract will be awarded to the Supplier
November:	Pipe will be procured by the Supplier

2) Package-2 (Installation of Pipe)

Pipe installation work will start from December 2014. Pipe will be installed by local contractors, and will be completed by March 2016.

3) Package-3 (Tunnel Construction Work)

Tunnel Construction Work will start from January 2015. Contractor will be selected by tender process, and construction work will be completed by the end of 2016. Tender and selection of contractor are progressing as shown below:

July, 2014:	Completion of Publishing/Downloading Tender Document
August:	Completion of Submission of Tender and Completion of Opening Technical Bidding (Tendered by 4 contractors) The tenderers' qualifications were not approved by IFCD, due to lack of qualification
September:	Bidding was conducted again
November:	Contractor will be selected
December:	State government will approve
December:	Contract will be done with Contractor
January, 2015:	Tunnel construction work will start
March, 2016:	Tunnel construction work will complete

(3) Reserved Forest

A part of raw water conveyance main will be installed in the Reserved Forest Area. The installation of the mains was approved by Department of Forest in the Manipur State. Details are discussed in the environment section of this report.

5.4 Chingkheiching Water Treatment Plant

5.4.1 Necessity of Water Treatment Plant

Current capacity of the existing water treatment plants is not sufficient to meet future demand in the Imphal City. It is proposed that Chingkheiching Water Treatment Plant (hereinafter referred to as "Chingkheiching WTP") will be constructed to supply water to Water Supply Zone (WSZ) 5, 6, 7, 8, 10, 11, 22, 23, 24, 25 and a part of WSZ- 21, 12, 15. The construction of Chingkheiching WTP has been included in Phase III project of the "Integrated Water Supply Project in Imphal" by PHED.

5.4.2 Outline of Chingkheiching WTP

Outline of Chingkheiching WTP is shown below.

WTP Name: Chingkheiching WTP
Water Production: 45,000m^3/day（45 MLD）
Intake Amount: 46,350m^3/day (considered 3% of treatment loss)
Intake Point: Thoubal Dam
Treatment Method: Coagulation-Sedimentation + Rapid Sand Filter Process
Construction Site: Nongmaiban on Chingkheiching hill (see **Figure 5.9**)
Proposed GL: GL + 830.0m
Site Area: 1.95 ha
Reservoir: Master Reservoir MR-6 (constructed inside of the WTP)
Raw Water Conveyance Main: Dia 1000mm, L= 18.55km (Thoubal Dam to Chingkheiching WTP)
Transmission/Distribution: Supply water from MR-6 in the WTP to water supply zones (WSZ- 5, 6, 7, 8, 10, 11, 22, 23, 24, 25, a part of WSZ- 21, 12, 15)

Chingkheiching WTP is proposed to be constructed at Chingkheiching hill in Nongmaiban district, situated approximately eight km to the north-west from Imphal city center as shown in **Figure 5.9.** This location is considered to be the most suitable site as it is located mid-way from Thoubal Dam to Imphal city and raw water from Thobal Dam to the new WTP and treated water from the WTP to supply zones can be supplied by gravity.

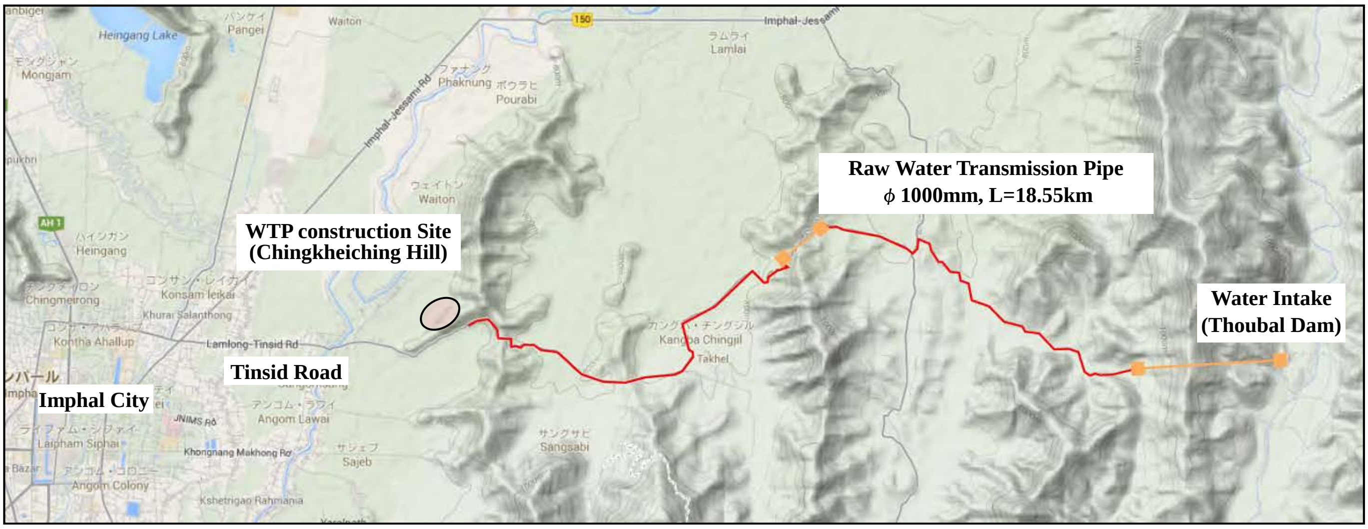


Figure 5.9 Location of Chingkheiching WTP

5.4.3 Review of Hydraulic Design of Raw Water Conveyance Main

In the DPR, it is proposed that raw water from Thoubal dam to Chingkheiching WTP was to be conveyed via a raw water conveyance main by gravity. In this section, the adequacy of the pipeline design in the DPR is evaluated.

1) Calculation Conditions

Design Intake Flow: 46,350m^3/day = 1,931.25m^3/hr = 32.19m^3/min = 0.54m^3/sec
Pipe Materials: DIP (K-9)
Hazen-Williams Coefficient: C = 130

In-pipe friction loss was calculated based on Hazen-Williams Formula and loss in pipe was computed based on Hydraulic Formula.

2) Hydraulic Calculation

According to Hazen-Williams Formula, hydraulic gradient "I" is calculated as follows:

$I = 10.666C^{-1.85}D^{-4.87}Q^{1.85}$

where, C : Friction Coefficient = 130
D : Pipe Diameter = 1000mm
Q : Flow Amount = 0.54m^3/sec
Therefore, "I" was computed as 0.415.

Head loss of raw water conveyance main is calculated for various diameters and the results are summarized in **Table 5.12**. According to the results, head loss is very high for pipe diameter of 800mm and 900mm and it would be difficult to transfer the design flow from the intake point to the WTP. On the other hand, flow velocity and head loss are small for pipe diameter of 1000mm and 1100mm. Therefore the proposed 1000mm dia main is adequate.

Table 5.12 Hydraulic Calculation Results for Raw Water Conveyance Pipe

Location	Thoubal Dam Intake to Chingkheiching WTP			
Pipe Materials	DIP			
Pipe Diameter(mm)	Dia 800	Dia 900	Dia 1000	Dia 1100
C value	130			
Pipe Length(m)	18,550m			
Hydraulic Gradient I (‰)	1.229	0.693	0.415	0.261
Friction Loss(m)	22.80	12.85	7.68	4.84
Velocity(m3/sec)	1.07	0.85	0.69	0.57
Evaluation			○	

3) Hydraulic Calculation Result

Low water level at Thoubal Dam water intake is set to LWL+848.00m and friction loss for Dia 1000mm pipe is calculated at 7.69m. The minimum water level at the WTP can be calculated as shown below:

Water Level = LWL+848.00m - Pipe Loss 7.69m = **+840.32m**

> +840.10m (Proposed Grit Camber Water Level) ⇒ **OK**

It is therefore confirmed that water conveyance from the intake to the WTP is feasible by gravity as calculated sincewater level is higher than the proposed water level at Grit Chamber in the WTP.

5.4.4 WTP Construction Site

The Chingkheiching WTP is planned to be constructed on the ridge of Chingkheiching hill along Tinsid road in Nongmaiban distrct. (see **Photo 5.3**) The distance from the ridge to Tinsid road is about 200m and elevation of the ridge at the WTP construction site ranges from +850m to 870m. The WTP will be constructed after earth cutting of about 20m to 40m in height and site level to be set at the proposed WTP GL +830m. Elevation of Tinsid road is around the WTP is +802m to +820m. An access road needs to be constructed from Tinsid road to the WTP site since there is no existing road on the hill.

	
【Site Overview of Proposed WTP Site】 Chingkheiching hill needs to be cut to prepare the site for new WTP. Sign board is posted on site which indicates that the area is for the new WTP site.	【Ridge of Chingkheiching Hill】 Photo taken from the ridge of Chingkheiching Hill. Earth cutting is required from the ridge of the hill for the construction of the new WTP.

Photo 5.3 Proposed Construction Site of Chingkheiching WTP

The proposed site of the new WTP shall be made flat at the proposed level of GL+830m by cutting Chingkehiching hill. This work, however, requires large-scale ground development work.

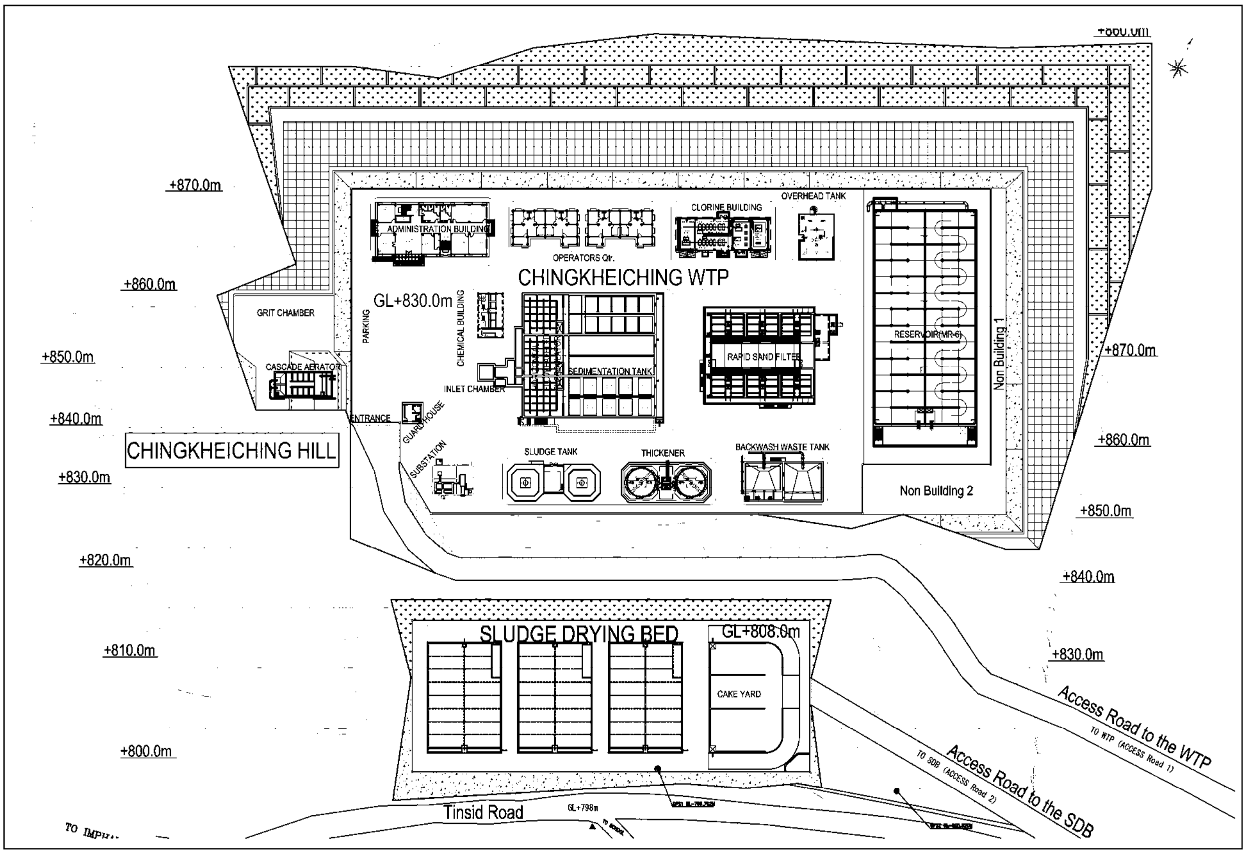


Figure 5.10 Proposed Site Layout of Chingkheiching WTP

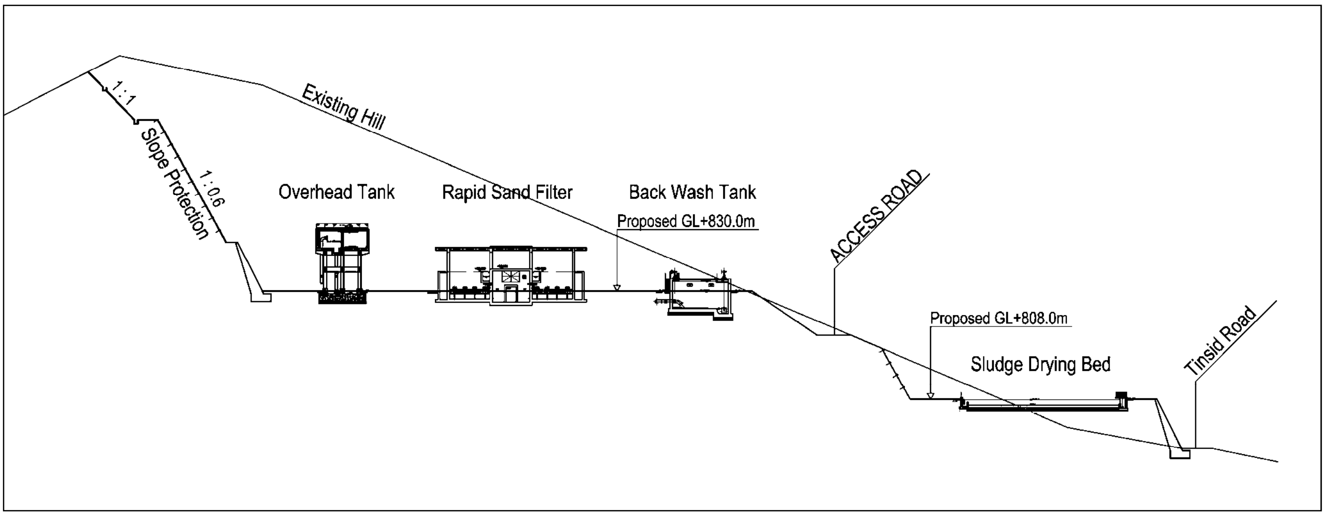


Figure 5.11 Cross Section of Chingkheiching WTP

The acquisition of the land for the new WTP is currently undertaken by transferring the land from the Regional Office of Ministry of Environment and Forest, Central Government to PHED. A land area of 1.95 ha was requested by PHED for the construction of the WTP.

There are no residents around Chingkheiching hill, and almost all the area is used as paddy field at present. A temple and a school are currently under construction on the Chingkheiching hill area and Mega Manipur School is on the opposite side across Tinsid road. It is anticipated that the construction of the new WTP and its operation would have no signification impact on the schools as they are located more than 150m away from the WTP site.

5.4.5 Review of Site Selection for New WTP

The DPR proposed the construction of the new WTP at Chingheiching hill. Siting the WTP at the proposed location is feasible, however, it requires large-scale earth cutting and a huge amount of surplus soil shall be transported to a disposal site at Lamphel Pat STP, which is some distance away from the WTP. The use of Lamphel Pat STP as a disposal site was suggested by PHED.

In this survey, the following alternative sites were investigated for the location of the new WTP.

Alternative Site -1: Sites situated on low-lying area in the city. With this option, earth removal work can be avoided for the construction of the new WTP.

Alternative Site -2: A site near the STP. With this site, long distance transportation of large amount of surplus soil can be avoided.

The alternative locations of the new WTP location are shown in **Figure 5.12**. Features of each location option are outlined below.

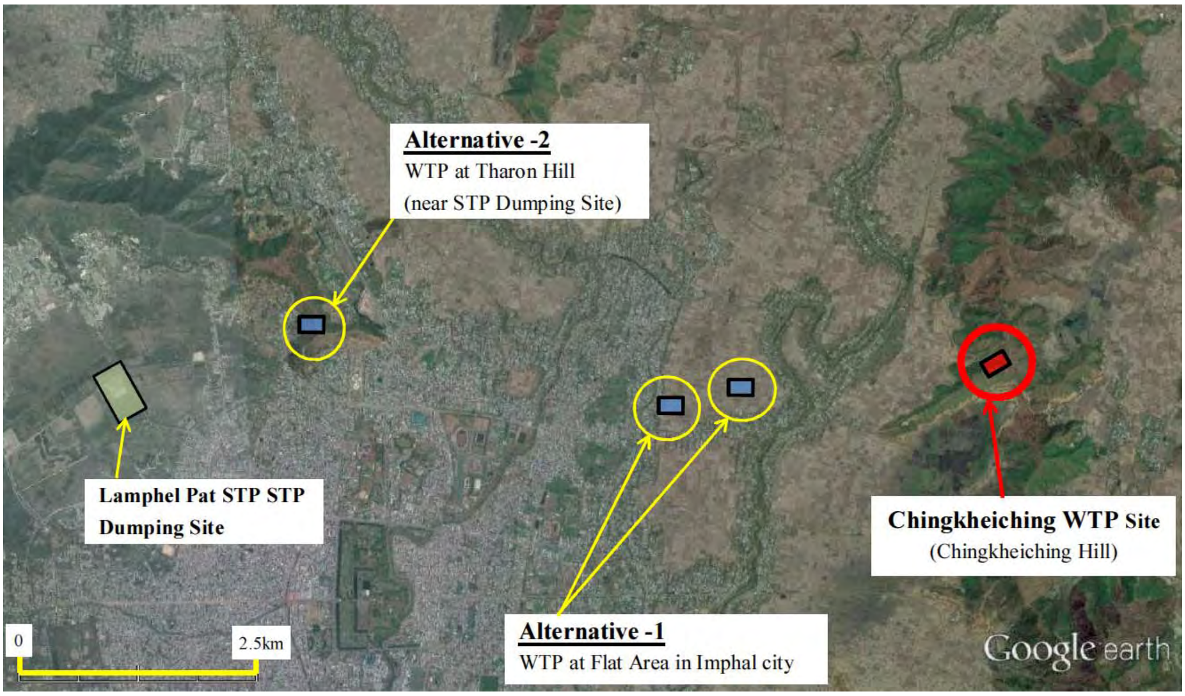


Figure 5.12 Locations of Alternative Sites for WTP

(1) Construction of the new WTP at Chingkheiching Hill based on DPR

- A large scale earth work (earth cutting work) at the hill ridge is required.
- Transportation of surplus soil to the STP disposal site will be at a distance of approximately 10km.
- Stable water transmission is possible due to water transmission by gravity so transmission pump is not required.
- Land acquisition is almost completed.

(2) Construction of the new WTP in flat Imphal city area

- Transmission pump is required to transfer water to GLSRs and OHTs.
- Pile foundation work is necessary since flat area in Imphal city is mainly paddy field where soil conditions are weak.
- Raw water conveyance pipe must be three km longer than construction of a new WTP at Chingkheiching hill case.
- Land for the new WTP is not secured. Land acquisition is required.

(3) Construction of the a new WTP at Tharon Hill

- A large scale earth work (earth cutting work) at the hill ridge is required.
- Transportation of surplus soil to the STP dumping site will be shorter distance (approximately two km).
- Stable water transmission is possible due to water transmission by gravity. (Transmission Pump is not required)

- Raw water conveyance pipe must be 10km longer than the case of the construction of the new WTP at Chingkheiching hill.
- Land for the new WTP has been not secured. Land acquisition is required.

Table 5.13 shows details of comparison between the above three cases. As a result of this comparison, it is proposed that construction of the WTP at Chingkheiching hill should be adopted for the following reasons.

1. Construction cost will be lower even though large scale of earth work is required and longer distance of surplus soil transport is necessary.
2. Foundation pile work is not necessary.
3. Water can be transferred to the reservoirs/ OHTs by gravity.
4. Transmission pump is not required and the power cost associated with pumping can be avoided.
5. Additional raw water conveyance pipe is not required.
6. Land acquisition is almost complete.

Table 5.13 Comparison of the WTP Location

Comparison Items	DPR Proposed Plan (Construction of the WTP on Chingkheiching Hill)	Alternative Plan -1 (Construction of a new WTP in Imphal city Area)	Alternative Plan -2 (Construction of a new WTP on Tharon Hill)
Outline	- Construction of the WTP on Chingkheiching Hill. - Water is able to send by gravity; Intake ⇒ WTP ⇒ Reservoir/ OHT. - A large scale of civil work is necessary.	- Construction of a new WTP in Imphal city area. - Pump equipment is required to send water to Reservoirs and OHTs. - A large scale of civil work is not necessary.	- Construction of a new WTP on Tharon Hill. - Water is able to send by gravity; Intake ⇒ WTP ⇒ Reservoir/ OHT. - A large scale of civil work is necessary.
1. Proposed Ground Level	GL+830.0m	GL+780.0m (approximately)	GL+830.0m
2. Raw Water Conveyance Pipe (Thoubal Dam to the WTP)	Pipe Length: 18.55km Water Level Difference: 52m Design Inner Pipe Pressure: 13.17kg/cm^2 (considering Water Hummer)	Pipe Length: 30.0km (approximately) Water Level Difference: 102m Design Inner Pipe Pressure: 14.56kg/cm^2 (considering Water Hummer)	Pipe Length: 28.55km Water Level Difference: 52m Design Inner Pipe Pressure: 13.17kg/cm^2 (considering Water Hummer)
3. WTP Facilities	Grit Chamber + Aerator + Rapid Mixing Tank + Flocculator + Sedimentation Tank + Filter + Reservoir	Grit Chamber + Aerator + Rapid Mixing Tank + Flocculator + Sedimentation Tank + Filter + Reservoir + **Transmission Pump**	Grit Chamber + Aerator + Rapid Mixing Tank + Flocculator + Sedimentation Tank + Filter + Reservoir
4. Reservoir (MR-6)	Pump is not necessary to transmit water to the reservoirs /OHTs in Imphal city by gravity.	Pump is necessary to transmit water to the reservoirs/ OHTs in Imphal city.	Pump is not necessary to transmit water to the reservoirs /OHTs in Imphal city by gravity.
5. Backup Generator	Generator capacity is small, due to backup generator is only for light, backwash pump and blower pump.	A large scale of generator is required for large transmission pumps.	Generator capacity is small, due to backup generator is only for light, backwash Pump and blower pump.
6. Earth Work	Large scale earth work at the hill ridge is required. DPR already considered this large scale of earth work for cost estimation. Distance of surplus soil transportation is longer than Alternative-2 (Tharin hill case). (L= 10km)	Large scale earth work is not necessary because WTP construction site will be flat area in Imphal city.	Large scale earth work at the hill ridge is required. Distance of surplus soil transportation is shorter than Chingkheiching WTP case. (L= 2km)
7. Access Road	Access road will be constructed along the hill. (GL+820m ⇒ GL+830m, 5% slope, L = 250m)	Access road will not be necessary in case the WTP will be constructed near the road.	Access road will be constructed along the hill. (GL+820m ⇒ GL+830m, 5% slope, L = 250m)
8. Running Cost for Transmission Pump	Power cost for Transmission Pump is not necessary.	Power cost is required every year and eternal. Running Cost for Transmission Pump: **Approx. 15,000,000Rs/year**	Power cost for Transmission Pump is not necessary.
9. Transmission System	Stable water transmission is possible because water will be transmitted by gravity. Water level control at each Reservoirs and OHTs will be done by Float Valve.	Water level control is very difficult at reservoirs and OHTs because water is sent by pump and water level at each reservoir and OHT is different. Water control valve must be required.	Stable water transmission is possible because water will be transmitted by gravity. Water level control at each Reservoirs and OHTs will be done by Float Valve.
10. Raw Water Conveyance Pipe,	Additional raw water conveyance pipe is not necessary.	Raw water conveyance pipe must be 3km longer than construction of WTP at Chingkheiching hill case.	Raw water conveyance pipe must be 10km longer than construction of WTP at Chingkheiching hill case.

Comparison Items	DPR Proposed Plan (Construction of the WTP on Chingkheiching Hill)	Alternative Plan -1 (Construction of a new WTP in Imphal city Area)	Alternative Plan -2 (Construction of a new WTP on Tharon Hill)
11. Land Acquisition	Land acquisition is almost completed (1.95 ha). Large scale of foundation work is not necessary since this hill site has stiff soil condition.	WTP land is not yet secured in Imphal city. It will take time for selection of land/ negotiation/ procedure of land acquisition. Pile foundation work will be necessary since flat area in Imphal city is mainly paddy field with soft soil condition.	The WTP land is not secure yet. It will take time for selection of land/ negotiation/ procedure of land acquisition. A large scale of foundation work is not necessary since this hill site has stiff soil condition.
12. Construction Cost (Earth Work, Construction of WTP, Raw Water Conveyance Pipe, Clear Water Transmission Mains, Transmission Pump)	(1) Earth Work : 413 mil. Rs (2) Pile Work : - (3) WTP : 1,000 mil. Rs (4) Transmission Pump : - (5) Raw Water Conveyance Pipe : - (6) Clear Water Transmission Main : 578 mil. Rs **Total Construction Cost : 1,991 mil. Rs**	(1) Earth Work : 20 mil. Rs (2) Pile Work : 483 mil. Rs (3) WTP : 912 mil. Rs (4) Transmission Pump : 80 mil. Rs (5) Raw Water Conveyance Pipe : 110 mil Rs (6) Clear Water Transmission Main : 498 mil. Rs **Total Construction Cost : 2,103 mil. Rs**	(1) Earth Work : 291 mil Rs (2) Pile Work : - (3) WTP : 1,000 mil Rs (4) Transmission Pump : - (5) Raw Water Conveyance Pipe : 366 mil. Rs (6) Clear Water Transmission Main : 461 mil Rs **Total Construction Cost : 2,118 mil Rs**
13. Evaluation	- Construction cost will be lower with large scale earth work and long distance to transport surplus soil. DPR already considered earth work for cost estimation - Water is sent to reservoirs/ OHTs by gravity. - Transmission pump is not necessary and there will be no power cost for this to be operated. - Land acquisition is almost complete. **Considering above, the WTP shall be constructed at Chingkheiching Hill the same proposal as in the DPR.**	- Construction cost will be higher than construction of WTP at Chingkheiching hill. - Water is not sent to reservoirs/ OHTs by gravity. - Transmission pump must be necessary with attendant power cost to operate. - Power cost for transmission pump operation must be required 15,000,000Rs every year. - It will take plenty of time/ days for selection of land/ negotiation/ procedure of land acquisition. - Raw water conveyance pipe must be 3km longer. **Considering above, a new WTP shall not be proposed to be constructed at Imphal city.**	- Construction cost will be higher than construction of WTP at Chingkheiching hill. - Water is sent to reservoirs/ OHTs by gravity. - Transmission pump is not necessary and there will be no power cost for this to be operated. - It will take time for selection of land/ negotiation/ procedure of land acquisition. - Raw water conveyance pipe must be 10km longer **Considering above, a new WTP shall not be proposed to be constructed at Tharon Hill.**

Source : JICA Survey Team

5.4.6 Water Treatment Process

The water treatment process proposed in the DPR is "coagulation / precipitation + rapid sand filtration process". This is a typical treatment process used in India, Japan and other countries. However, if turbidity is low, slow sand filtration treatment process can be applied. Slow sand filtration, rapid sand filtration and membrane filtration are general process for water treatment, but rapid sand filtration process is mainly used in Imphal. Although membrane filtration process was used at a WTP in Imphal, this process is no longer currently used since supply of the membrane material is very difficult according to the DPR.

The selection of rapid and slow sand filtration process basically depends on raw water quality. Slow sand filtration process cannot treat high turbidity raw water, whereas rapid sand filtration is mostly adopted for raw water with turbidity of 10 NTU and higher.

Considering limited site space at Chingkheiching, WTP performance in Imphal and construction cost, the rapid sand filtration process proposed by the DPR should be adopted for the following reasons:

- Raw water turbidity in the monsoon rainy season can reach around 100 NTU, hence slow sand filtration process cannot treat water completely.
- Coarse filtration basin is required if the raw water with turbidity of 100 NTU needs to be treated by slow sand filtration process.
- There are plenty of trees, stretches of natural shrubs and greenery at and around Thoubal Dam.
- After construction of the dam, shrubs and greenery will be submerged in the dam, this will affect dam water, and water quality will not be stable for several years. This may have adverse effects to slow sand filtration process.
- It takes a lot of time and manpower to scrape sand from the slow sand filtration bed surface as this process requires large surface area.
- It is very difficult to arrange this system in the limited WTP site.
- In addition, skilled technicians are required to scrape the sand properly so as not to destroy the biological layer. Therefore, use of slow sand filter process is very difficult since PHED doesn't have much experience in O&M of the slow sand filtration process.
- Construction cost of slow sand filtration can be several times higher than that of rapid sand filtration because a large scale of civil work is needed to construct huge size of facility.
- Proper and sustainable O&M can be carried out for the rapid sand filtration process as compared to slow sand filtration process since PHED has sufficient experience in the operation of rapid sand filtration process in Imphal.

5.4.7 Review of Design Criteria for Chingkeiching WTP in DPR

The preliminary design of the Chingkeiching WTP in the DPR is based on design criteria set out in the "Manual on Water Supply and Treatment" published by CPHEEO (Central Public Health and Environmental Engineering Organization). This was first compared with the design criteria of those specified in the Japanese Design Manual for waterworks facilities, as shown in **Table 5.14**, and then assessed for appropriateness of the facility design in the DPR.

(1) Cascade Aerator

The proposed cascade aerator includes five steps with $0.03m^2/m^3/hr$ of the surface contact area. This is within the range of the design criteria specified in the CPHEEO manual (i.e. 4 to 6 steps and 0.15～$0.045m^2/m^3/hr$). Although the use of cascade aerators is not common in Japan, the design of the cascade aerator in the DPR is considered to be appropriate as it complies with the CPHEEO's design criteria.

(2) Inlet Chamber

There is no design criteria provided in CPHEEO manual for inlet chambers. Therefore, the design of the inlet chamber was reviewed against the Japanese design criteria as described below.

1） Detention Time

The inlet chamber is designed with the detention time of 60 sec. The Japanese standard specifies that it should be more than 90 sec, but there is only marginal difference between the two. The detention time will be checked again at the time of the detailed design.

2） Depth and Surface Area

The designed depth of the inlet chamber in the DPR is 4.6m, which is within the range of 3 to 5m specified in the Japanese design criteria. Therefore, the depth is appropriate. Surface area of the inlet chamber is designed to $9m^2$ (3m x 3m). In Japan, surface area is generally set to more than 10 m^2 in order to stabilize surface water motion, as well as considering the constructability of the shuttering work.

(3) Flash Mixer

1） Detention Time

The detention time of flash mixer is designed at 60 sec in the DPR and this corresponds to the standard values specified in CPHEEO manual. Japanese design criteria set that 60 sec is sufficient if adequate mixing can be provided. Therefore, the detention time of the design is appropriate.

Table 5.14 Comparison of Design Criteria for Key Design Parameters of WTP

Sr No.	Component	Particulars	Design criteria			Reference
			Detailed Project Report (DPR)	CPHEEO Manual on Water Supply and Treatment	Japanese design criteria for waterworks facilities (2012)	
1	Cascade Aerator	Height of structure	2.5 m	-	-	
		No of steps / trays	5	4 to 6	-	
		Area of aerator	0.03 $m^2/m^3/hr$	0.015 to 0.045 $m^2/m^3/hr$	-	
2	Inlet Chamber	Detention time	60 sec	-	more than 90 sec	No design criteria provided in CPHEEO manual for inlet chambers
		Depth	4.6 m	-	3.0 to 5.0 m	
3	Flash Mixer (Rapid mixing Device)	Detention time	60 sec	30 to 60 sec	60 to 300 sec	60 sec is enough if adequate mixing can be provided.
		Depth	3 m	-	-	
		Ratio of Impeller diameter to Tank diameter	0.4	0.20 to 0.40	-	
		Ratio of Tank height to diameter	1.5	1 to 3	-	
4	Flocculator (Slow mixing Device)	Depth of tank	3 m	3 to 4.5	-	Japanese design criteria only refer to rectangular shaped structure
		Detention time	30 min	10 to 40 min	20 to 40 min	Shortage of detention time causes drastical decrease of effect on flocculation.
		Vel. Gradient "G"	40 to 60 /sec	10 to 75 /sec	10 to 75 /sec	
		Range of "Gt"	72,000	10,000 to 100,000	23,000 to 210,000	
5	Sedimentation tank	Detention time	2.5 hr	2 to 2.5 hr	3 to 5 hr *	
		Depth of tank	3.0	2.5 to 5.0 m	approx. 3.0 to 4.0 m *	
		Surface loading	25 $m^3/m^2/day$	25 to 75 (normally 30 to 40) $m^3/m^2/day$	21.6 to 43.2 $m^3/m^2/day$	The loading rate in DPR is on the safe side.
		Weir loading	297.05 $m^3/m/day$	100 to 300 $m^3/m/day$	less than 500 $m^3/m/day$ *	
		Floor slope	1 in 12	1 in 12	1 in 10 to 20 **	
6	Rapid Sand Filters	Rate of filtration	5.0 $m^3/m^2/hr$ (120 m/day)	4.8 to 6 $m^3/m^2/hr$ (115 to 144 m/day)	5 to 6.25 $m^3/m^2/hr$ (120 to 150 m/day)	
		Length to breadth ratio	1.33	1.25 to 1.33	less than 5	
		Depth of sand	600 mm	600 to 750 mm	600 to 700 mm	
		Uninformity coefficient	-	1.3 to 1.7	less than 1.7	To be designed (Not discibed in DPR)
		Depth of gravel bed	450 mm	300 to 500 mm normally 450 mm	300 to 500 mm	
		Compressed air for back wash	600 $L/m^2/min$ at 0.35kg $/cm^2$ pressure	600 to 900 $L/m^2/min$ at 0.35kg $/cm^2$ pressure for 5 minutes	800 to 1500 $L/m^2/min$ for 5minutes	Air volume for air wash method
		Wash water	500 $L/m^2/min$	400 to 600 $L/m^2/min$	600 to 800 $L/m^2/min$ for 10 minutes	Water volume for air wash method
7	Velocity of Water in different components	Inlet pipe Raw water	1.5 m/ sec	0.9 to 1.8 m/ sec	lses than 3.0 m/ sec	
		Inlet pipe Flocculator	1.0 m/ sec	0.8 to 1.8 m/ sec	0.5 to 1.5 m/ sec	
		Filtered Water Outlet Pipe	1.25 m/ sec	0.9 to 1.8 m/ sec	0.6 to 1.5 m/ sec normally 1.0 m/sec	
		Wash water Inlet Pipe	3.2 m/ sec	2.4 to 3.6 m/ sec	1.5 to 3.0 m/ sec normally 2.0 m/sec	Pressure of wash water should be equalized at each filter pond.
		Wash Water Out let Pipe	1.4 m/ sec	1.2 to 1.4 m/ sec	1.5 to 3.0 m/ sec normally 2.0 m/sec	Water velocity should be set enough fast to discharage effluent rapidly.

* Reference: A chemical sedimentation tank described in "Waterworks engineering practice (Gakken-sha)".

**Reference: A circular sedimentation tank described in "Japanese design criteria for swage treatment facilities (2009)".

2) Others

The depth of flash mixer, ratio of impeller diameter to tank diameter and the ratio of tank height to diameter correspond to those values specified in the CPHEEO manual respectively.

(4) Flocculator

1) Depth

The flocculator is designed as an integral circular structure with clarifier in the DPR. As for the depth, it is designed to 3m, which is within the design range in the CPHEEO manual (i.e. 3 to 4m). Although Japanese design criteria for clariflocculator only refers to rectangular shaped structure, the depth of the flocculator proposed in the DPR corresponds to the standard values in the CPHEEO manual. Hence, the depth of the structure is appropriate.

2) Others

Detention time of the flocculator, G value and Gt value are appropriate because these designed time and value are within the range of the standard values in the CPHEEO manual and also meet the Japanese design criteria.

(5) Sedimentation Tank

1) Detention Time

The sedimentation tank is designed with the detention time of 2.5hr, which is within the range specified in the CPHEEO manual. Japanese design criteria for sedimentation tanks is based on rectangular structures and there is no reference for circular structures. A 3 to 5 hr of detention time is recommended for circular sedimentation tanks in “Waterworks engineering practice”, the detention time of the design in the DPR can be considered to be appropriate.

2) Surface Loading

The designed surface loading of the sedimentation tank in the DPR is $25m^3/m^2$/day. As the CPHEEO manual recommends 25 to $75m^3/m^2$/day (normally, 30 to $40m^3/m^2$/day), the loading rate of the design is on the safe side. This will be reviewed in the detailed design if change in the capacity of the facility is required.

3) Others

The design of the tank depth, weir loading rate and floor slope are appropriate as these meet the design criteria of the CPHEEO manual, as well as standard values recommended for circular sedimentation tanks in Japan.

(6) Rapid sand filters

1) Rate of Filtration

Filtration rate of rapid sand filters is designed to $5.0m^3/m^2/hr$, which is within the range of the standard values of the CPHEEO manual (i.e. 4.8 to $6m^3/m^2/hr$). Therefore, the rate is appropriate although it seem to be slightly low loaded operation.

2) Length to Width Ratio

Length to width ratio of the rapid sand filters designed in the DPR is 1.33, which is based on the CPHEEO manual. By contrast, Japanese design criteria specifies that the ratio should be under 5 because the large ratio makes water stream difficult to flow uniformly in the filter basin. Although the designed length to breadth ratio is considered to be appropriate, it will be checked again at the time of the detailed design.

3) Sand and Gravel

The depth of the sand and gravel bed is 600mm and 450mm respectively in the DPR. These depths are based on the specified values in the CPHEEO manual and also meet the Japanese design criteria. Therefore, these are appropriate. On the other hand, uniformity coefficient has not been considered in the DPR. This will be examined at the time of the detailed design as it has impact on the treatment performance.

4) Air and water volume for air wash method.

As for washing the sand filters, air wash method is adopted, using 0.35 kg/cm^2 compressed air and 600 $L/m^2/min$ of back wash water. Both parameters are within the standard values in the CPHEEO manual although both are a little lower than those of the Japanese design criteria.

(7) Water velocity of each pipe

Regarding water velocity of the raw water main, inlet pipe to flocculator, filtered water outlet pipe, wash water inlet and outlet pipe in DPR, the velocity in each pipe is within the range of the values specified in the CPHEEO manual. By referring to the Japanese design criteria, water velocity of each pipe is deemed to be appropriate.

(8) Conclusion

In conclusion, it has been confirmed that the design parameters used in the WTP design in the DPR are based on the design criteria specified in the CPHEEO manual. These values are also deemed to be appropriate by comparing these to the Japanese design standard. For those parameters requiring clarifications, further assessment will be carried out during the detailed design stage.

5.4.8 Selection of Flocculator and Sedimentation Tank Type

Flocculation and sedimentation are very important and essential process in water treatment. “Clariflocculator” and “Horizontal Flow Baffled Flocculator and Sedimentation Tank” are considered to likely process options for Chingkheiching WTP. The former type was proposed in the DPR, and it is used widely in India. The latter is widely used in Japan as this process does not require mechanical equipment.

(1) Clariflocculator

A clariflocculator has characteristics that the flocculation and sedimentation processes are effectively incorporated into one unit as shown in **Figure 5.13**. One clariflocculator has a double tank structure consisting of inner and outer circular tanks made of reinforced concrete. Flocculation and sedimentation are processed in the inner “flocculation zone” and the outer “sedimentation zone”, respectively.

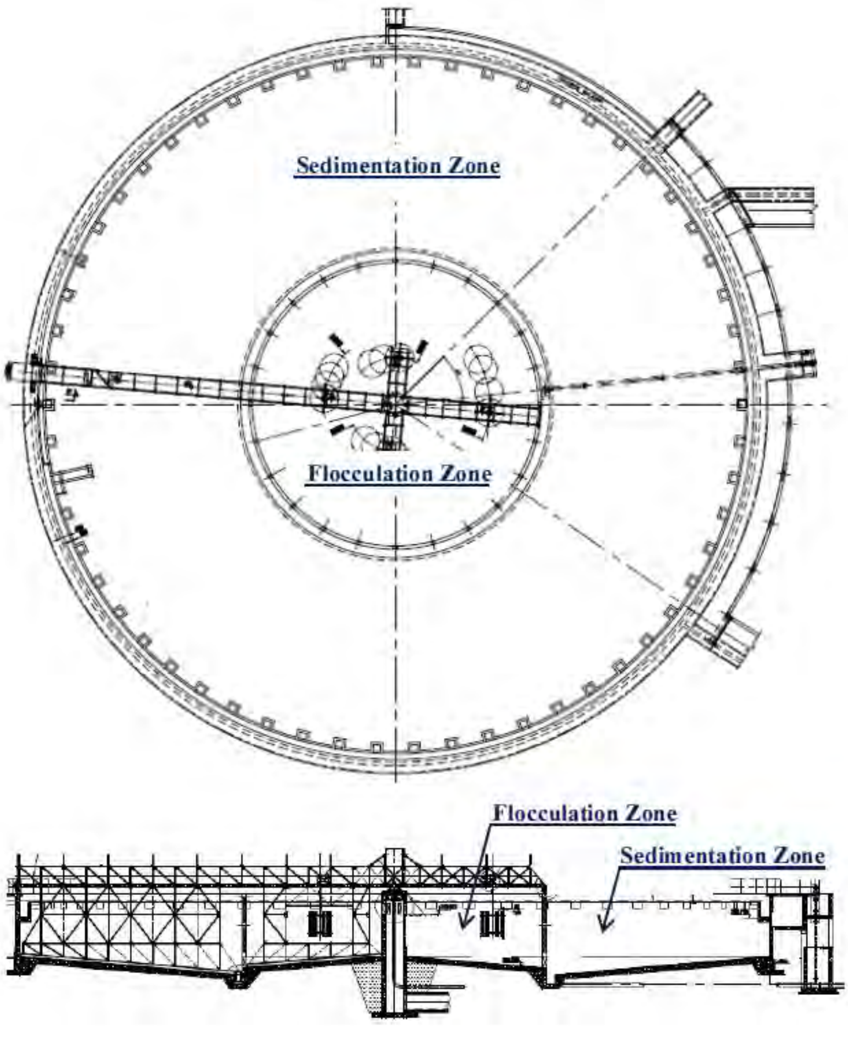


Figure 5.13 Typical Clariflocculator

1) Flocculation

Raw water containing microflocs after coagulation flows into the inner “flocculation zone” from an inlet pipe rising from the bottom, and slow mixing is performed with two mechanical flocculators with vertical paddles. The flocculated water enters into the “sedimentation zone” through wide openings at the bottom of the “flocculation zone” as shown in **Figure 5.13**.

2) Sedimentation

Flocs in flocculated water settle down by gravity under appropriate surface loading and detention period. Settled sludge is collected into a pit by mechanical scrapers rotating slowly at the bottom of the tank, and released by opening valves.

(2) Horizontal Flow Baffled Flocculator and Sedimentation Tank

“Horizontal Flow Baffled Flocculator” has characteristics that there is no need for mechanical equipment in the flocculation process and sedimentation process as shown in **Figure 5.14**.

1) Flocculation

Raw water containing microflocs after coagulation flows into a rectangular flocculation tank, and slow mixing is performed by a horizontal water flow with baffles located at appropriate distance as shown in **Figure 5.14**. The intensity of slow mixing is regulated so as to be gradually reduced towards the downstream. After this flocculation, microflocs are grown into large and settleable flocs and flow into sedimentation tank. There is no need of mechanical equipment and power in the flocculation process.

2) Sedimentation

Flocculated water flows into rectangular sedimentation tank horizontally as shown in **Figure 5.14**. Flocs settle by gravity with appropriate surface loading and detention period. Settled sludge is collected into a pit by gravity, and released by opening valves. There is no need for mechanical equipment and power in the sedimentation process.

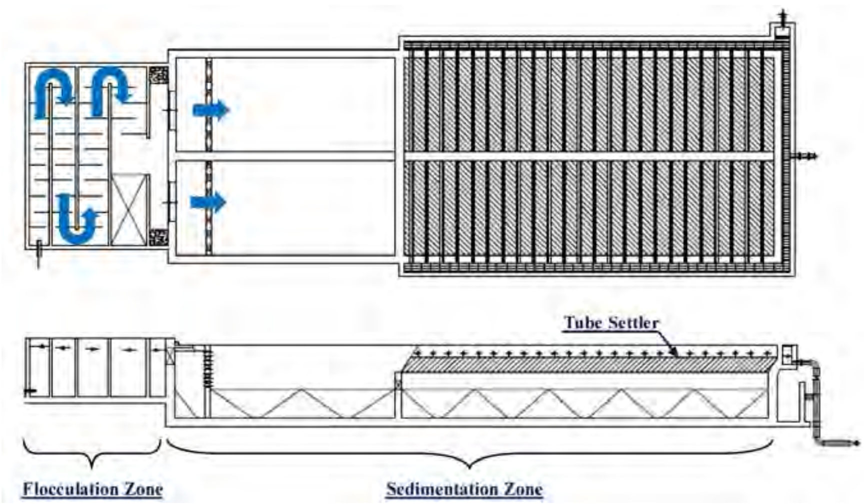


Figure 5.14 Typical Horizontal Flow Baffled Flocculator and Sedimentation Tank

(3) Present Operation Status

1) Clariflocculator

"Clariflocculators" are operating at Singda WTP, Porompat-I and II WTP, and Ningthempukhri WTP. Flocculant dosing equipment has not been used in all existing WTPs because of malfunction, and cakes of ferric alum have been put into the channel after cascade aerator and the dosing ratio has not been controlled. The present operation status of "Clariflocculators" at above WTPs is shown in **Table 5.15**. According to result of this survey, it appears that these are not working appropriately.

Table 5.15 Present Operation Status of "Clariflocculator" at Existing WTPs

No.	Name of WTP	Present Operation Status
1	Singda WTP	・Clarifier is not working / is malfunctioning ・Removal efficiency of turbidity was about 46% -Turbidity of raw water: 27.0 NTU -Turbidity of treated water after sedimentation: 14.7 NTU ・Flocs could not be observed in flocculation zone
2	Porompat-I WTP	・One of the two flocculators is not working / is malfunctioning
3	Porompat-II WTP	・All devices are working normally
4	Ningthempukhri WTP	・All devices are not working / is malfunctioning

2) Horizontal Flow Baffled Flocculator and Sedimentation Tank

As a result of the field survey at Old Thambuthong WTP and Moirangkhom WTP, regarding method of dosing flocculant, cakes of ferric alum have been put into the channel after the cascade aerator and the dosing ratio has not been controlled in both WTPs. Regarding status of flocculation and sedimentation, flocs could not be observed in flocculator and flocs were carried over from sedimentation tank, because it is thought that important design criteria such as detention period, GT value, and surface loading are not satisfied and intermittent operation due to power supply condition is affecting proper flocculation.

(4) Comparison of Design Criteria

Design criteria of both types are shown in **Table 5.16**.

Table 5.16 Design Criteria of both Types

Design Parameter		Design Criteria	
		Clariflocculator*1)	Horizontal Flow Baffled Flocculator*2)
Detention time	Flocculation zone	10-40 min	20-40 min
	Sedimentation zone	2-2.5 hr	3-5 hr
Peripheral velocity of blades	Flocculation zone	0.3-0.4 m/s	-
GT value	Flocculation zone	10,000-100,000	23,000-210,000
Surface loading	Sedimentation zone	30-40 m^3/m^2/day	21.6-43.2 m^3/m^2/day (15-30 mm/min)
Weir loading	Sedimentation zone	below 300 m^3/m/day	below 500 m^3/m/day

Source: *1) "Manual on Water Supply and Treatment", Central Public Health and Environmental Engineering Organization (1999)
*2) "Design Criteria for Waterworks Facilities", Japan Water Works Association (2012)

Regarding the flocculator, the detention time of both types is almost same, say 10-40 minutes for "Clariflocculator" and 20-40 minutes for "Horizontal Flow Baffled Flocculator and Sedimentation Tank". However, GT values (useful parameter for the flocculation) of "Clariflocculator" are in the range of 10,000-100,000 and these values of "Horizontal Flow Baffled Flocculator and Sedimentation Tank" are in the range of 23,000-210,000. It is thought that the latter is better for appropriate flocculation than the former because the latter has high upper limit and wide range of GT value.

To obtain higher GT value, it will be required to raise the power of drive unit (to increase mixing speed of flocculator) or to increase the area of paddles for "Clariflocculator".

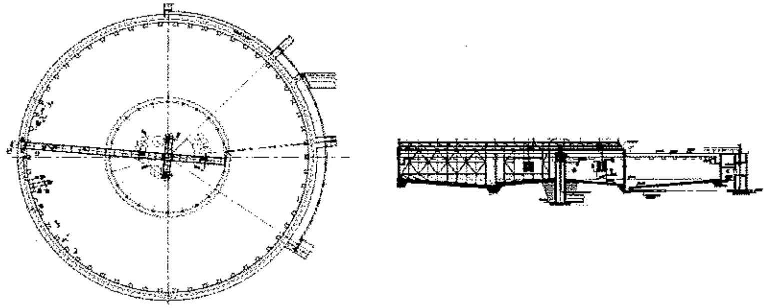
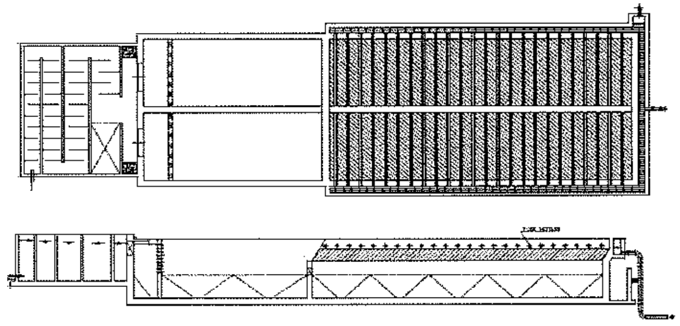
Regarding the sedimentation tank, detention period of "Clariflocculator" is shorter than that of "Horizontal Flow Baffled Flocculator and Sedimentation Tank" ("Clariflocculator": 2-2.5 hr < "Horizontal Flow Baffled Flocculator and Sedimentation Tank": 3-5 hr). However, surface loading of both types have about the same value ("Clariflocculator": 30-40 m3/m2/day, "Horizontal Flow Baffled Flocculator and Sedimentation Tank": 21.6-43.2 m3/m2/day). According to the above results, "Horizontal Flow Baffled Flocculator and Sedimentation Tank" is desirable for appropriate sedimentation than "Clariflocculator" because the former has longer detention period.

(5) Evaluation

According to the above study, "Horizontal Flow Baffled Flocculator and Sedimentation Tank" is preferable to "Clariflocculator" and recommended by the following reasons (as shown in **Table 5.17**).

- Construction cost is lower than "Clariflocculator".
- There is no need for mechanical equipment and power in the flocculation and sedimentation process.
- Running cost is lower for the above reason.
- Facilities can be easily laid out rather than circular tank of "Clariflocculator".
- Stable flocculation can be performed since GT value is higher.
- Stable sedimentation can be done since detention time is longer.

Table 5.17 Comparison between "Clariflocculator" and "Horizontally Baffled Flow Flocculator and Sedimentation Tank"

		Clariflocculator (described in DPR)	Horizontal Flow Baffled Flocculator and Sedimention Tank
Outline		 ・It is widely used in Imphal City and India. ・Flocculation is done in iner "flocculation zone" and Sedimentation is done in outer "sedimentation zone".	 ・It is widely used in Japan. ・Flocculation is performed by a horizontal water current and Sedimentation is done in rectangular sedimentation tank.
Design Criteria	Flocculation	Detention period: 20-30 min (CPHEEO criteria: 10-40 min) GT value: 20,000-75,000 (CPHEEO criteria: 10,000-100,000)	Detention period: 20-40 min GT value: 23,000-210,000
	Sedimentation	Detention period: 2.5 hr (CPHEEO criteria: 2-2.5 hr) Surface loading: 25 m^3/m^2/day (CPHEEO criteria: 30-40m^3/m^2/day)	Detention period: 3-5 hr Surface loading: 21.6-43.2 m^3/m^2/day (15-30 mm/min)
Merits		・Operators in Imphal city become skilled in operating and maintaining the WTP. ・It is possible to flocculate by adjusting mixing speed, in case that quantity of water to be treated will decrease.	・There is no need of power in the flocculation and sedimentation proc ・Running cost is lower for the above reason. ・It is easier in terms of facility layout rather than circular tank.
Demerits		・Running cost is higher, because it is necessary to power for drive units of flocculator and clarifier. ・It is necessary to have more space for facility layout rather than rectangular tank.	・It is not easy to flocculate in case that flow rate of raw water will change. ・It is necessary to instruct operators in operation and maintenance of it.
Construction Cost*		100	75
O&M Cost (power cost)*		100	0.01
Evaluation		Fair	Recommendable

5.4.9 Preliminary Design for Chingkheiching WTP

(1) Design Flow

The water source of the new WTP is from Thoubal Dam. Intake flow is 46,400m^3/day which will be drawn off from three levels in the dam. The dam water will be conveyed to Chingkheiching WTP, which produces treated water of 45,000m^3/day. The loss during the treatment process is estimated at 3% of intake flow or 1,350m^3/d, which is the difference between intake water of 46,350m^3/day and the treated water of 45,000m^3/day.

(2) Design Water Quality

1) Design Value of Turbidity

Thoubal Dam, which will be the source of Chingkheiching WTP, is currently being constructed. Therefore, the raw water quality for the WTP cannot be measured at the moment. However, the raw water quality of the source needs to be determined for the assessment of the WTP design. In this JICA survey, data on surface water turbidity was obtained for i) Thoubal River, a water source of Thoubal Dam, and ii) Singda Dam located outskirt of Imphal city. The obtained data are summarized in **Table 5.18** and **Table 5.19**. Thoubal Dam has a large storage volume of 124,580,000 m3 with long retention time. Under this condition, it is expected that a certain amount of suspended solids, which is the main component of turbidity, will settle down. It is therefore expected that the turbidity of water abstracted from Thoubal Dam will be lower than that of Thoubal River. Also, it may be more appropriate to use the results of the turbidity data of Singda Dam for the design of new WTP and the results of turbidity date obtained from Thoubal River should be only used for the reference data. Based on this approach, the design value of turbidity is selected at 27 NTU, an average turbidity during dry season extended over eight months in a year at Singda Dam. For a high turbidity, the design value is selected by 108 NTU, which is four times of 27 NTU, by the estimation method generally used in Japan. This value should be considered appropriate because the maximum value of turbidity at Singda Dam is 94.0 NTU, which is less than the design high turbidity of 108 NTU.

Table 5.18 Turbidity at Thoubal River

Sampling date	Turbidity (NTU)		Data Source
	Rainy Season (May - August)	Dry Season (September - April)	
May 2007	93.0	—	PHED
January 2010	—	24.0	DPR
April 2010	—	94.0	
July 2010	100.0	—	
October 2010	—	54.0	
July 2014	51.8	—	Upstream side, JICA survey
July 2014	93.3	—	Downstream side, JICA survey
July 2014	117.8	—	Upstream side, JICA survey
Average	91.2	57.3	
	78.5		

Table 5.19 Turbidity at Singda Dam

Sampling date	Turbidity（NTU）		Data Source
	Rainy Season (May - August)	Dry Season (September - April)	
January 2010	—	14.0	DPR
April 2010	—	42.0	
July 2010	94.0	—	
November 2013	—	71.8	PHED
December 2013	—	57.2	
January 2014	—	9.3	
January 2014	—	11.3	
February 2014	—	4.9	
March 2014	—	2.0	
June 2014	34.8	—	
July 2014	27.0	—	JICA survey
July 2014	11.0	—	
Average	41.7	26.6	
	31.6		

Note: Sampling was conducted at the cascade aerator of Singda Water Treatment Plant

2） Design Values of Water Quality Parameters

The design values of the main water quality parameters are selected from the results of the water quality survey at Thoubal River because the river water will be stored as Thoubal Dam, and it will be directly conveyed to Chingkheiching WTP. The turbidity is an average value of dry season as discussed previously. **Table 5.20** presents the selected water quality parameters as the design values.

Table 5.20 Design Water Quality for Chingkheiching WTP

Parameter	Design Value	Remarks
Turbidity	27 NTU	Estimated Value
pH	7.5 (-)	
Alkalinity	63 mg/L	
Total Iron	2.7 mg/L	
Total Manganese	0.1 mg/L	

3） Design Criteria for Each Facility

The design criteria for each facility are summarized as follows:

Table 5.21 List of Design Criteria

Facility	Design (type, treatment method)	Retention Time	Capacity	No of Tank	Size (per 1 tank)
Aerator	1. RC, rectangular 2. Cascade method	―	―	1	weir width 7.0m×5 steps
Inlet Chamber	1. RC, rectangular	1.57 min	50.4 m^3	1	width×length×effective depth 4.1m×4.1m×3.0m
Flash Mixer	1. RC, rectangular	1.02 min	32.8 m^3	1	width×length×effective depth 3.2m×3.2m×3.2m
Flocculator	1. RC, rectangular 2. Horizontal flow baffled type 3. G value: 30.2sec 4. GT value: 74,313	39.4 min	422 m^3	3	width×length×effective depth 12.0m×11.9m×4.0m
Sedimentation Tank	1. RC, rectangular 2. Transverse ventilation (with sloped pipes) 3. Hoppers are used for desludging.	―	1,809.6 m^3	3	width×length×effective depth 5.8m×26.0m×4.0m
Rapid Sand Filter	1. RC, rectangular 2. Gravitational convention type 3. Underdrain system 4. Filter Sand: diameter of φ0.6mm 5. Sand washing - Application of both backwash and air-washing - Gravitational flow for backwash from washing tank 6. Backwash rate and time Backwash: 0.6 m^3/m^2/min for 10 min Air-washing: 0.9 m^3/m^2/min for 5 min	filtration rate 119 m/day	filtration area 65 m^2/tank	6	width×length (5.0×6.5)×2
Backwash Waste Tank	1. RC, installed near rapid filter 2. Capacity: one time of average volume for backwash	―	405 m^3	1	width×length×effective depth 10.0m×13.5m×3.0m
Reservoir (MR-6)	1. RC, flat slab (rectangular)	5 hr	9,600 m^3	2	width×length×effective depth 15.0m×66.0m×5.0m
Sludge Tank	1. RC, polygon 2. Capacity: average sludge volume for 24 hours 3. Sludge collector: screw type 4. One tank for standby	―	300 m^3	2	width×length×effective depth 10.0m×10.0m×3.0m
Drain Tank	1. RC, rectangular 2. Capacity: one time of draining volume for washing 3. Bottom slab is sloped as steeply as possible. Sludge collector is not installed.	―	450 m^3	2	width×length×effective depth 11.3m×11.4m×3.5m
Thickener	1. RC, polygon 2. Conveyance of sludge: gravitation	52.3～15 hr (ave. ～high turbidity)	320 m^3	2	diameter×effective depth 10.0m×4.0m
Sludge Drying Bed	1. RC, rectangular	58.7 d	700 m^3	3	width×length×effective depth 22.0m×32.0m×1.0m

4） Hydraulic Profile for Each Facility

The hydraulic profile for each facility is summarized in **Table 5.22** and **Table 5.23.** Raw water will be first received at the grit chamber with water level of +840.10m and treated by gravity. Treated water will be stored at MR-6 with water level of +830.00m, then transmitted to Imphal city for distribution. Hydraulic calculation is shown in **Appendix A5.4 (1)**.

Table 5.22 Hydraulic Profile for Water Treatment Facilities

Thoubal Dam	Grit Chamber	Aerator	Inlet Chamber	Flash Mixer	Flocculator	Sedimentation Tank	Rapid Sand Filter	Reservoir (MR-&)	Backwash Waste Tank
1st Intake WL+870m 2nd Intake WL+865m 3rd Intake WL+848m	WL +840.10m	WL +840.00m	WL +834.30m	WL +833.24m	WL +832.94m	WL +832.64m	WL +832.30m	WL +830.00m	WL +842.00m

Table 5.23 Hydraulic Profile for Sludge Treatment Facilities

Draining Tank	Sludge Tank	Thickener	Sludge Drying Bed
WL +830.00m	WL +832.34m	WL +835.00m	WL +807.70m

5） General Layout of the WTP

The general layout plan of the WTP is shown in **Figure 5.15**. The WTP is planned to be constructed on the hill side. Therefore, the layout of the WTP needs to be planned as compactly as possible in order to reduce earth cutting volume. As a result of the investigation, Chingkheiching Hills should be cut up to GL+830m to develop the flat area for the WTP. The access road shall also be constructed from Tisid Road (GL+820 m) to the WTP site.

The flow system of the WTP is designed by gravity in the sequence of aerator, inlet chamber, flocculator/sedimentation tank, to rapid sand filter. The treated water will be stored at MR-6 Reservoir, then transmitted to reservoirs and OHTs in Imphal city. Chemical and administration buildings are planned to be built at the north and the entrance of the WTP, respectively.

For sludge treatment facilities, sludge tank and thickener are planned to be built near the sedimentation tank in order to shorten the sludge conveyance distance. In addition, the sludge drying bed is planned to be built at GL+808m in consideration of conveying the thickened sludge by gravity and carrying out the dried sludge.

It is currently estimated that flat areas of 1.95 ha and 0.57 ha are required for the water treatment facilities and the sludge drying bed, respectively.

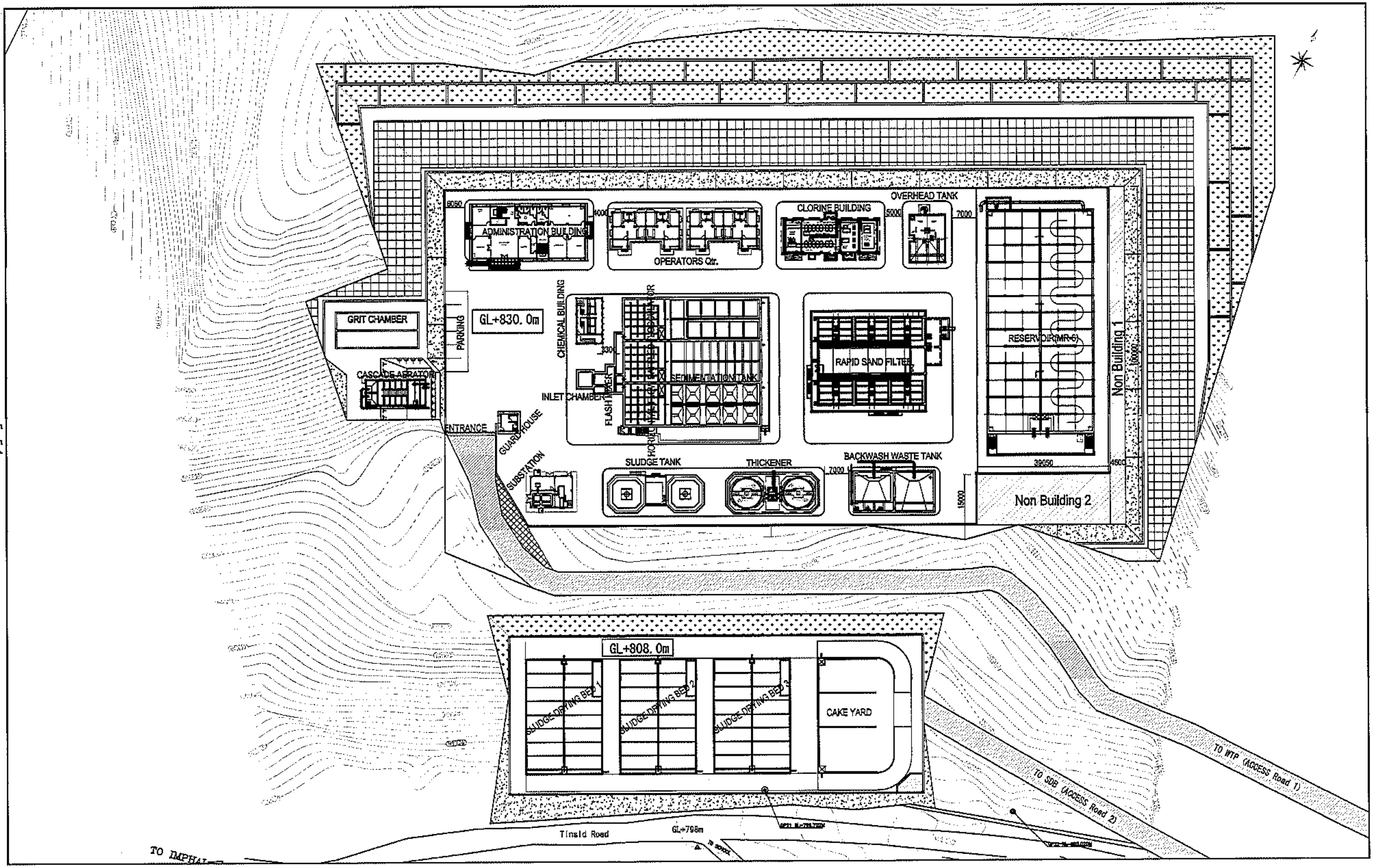


Figure 5.15 General Layout Plan of WTP

6） Selection of Foundation Type

In general, foundations for superstructures are categorized in spread foundation and pile foundation based on the supporting methods. The spread foundation utilizes a concept of supporting the load to the ground directly. On the other hand, the pile foundation utilizes a concept of supporting the load to the ground through the piles.

- The spread foundation is used when the load-bearing layer is shallow, and is the most economical in the foundation methods.
- The friction pile in the pile foundation is applied when the load-bearing layer is not located at a reasonable depth. The structure safety is ensured with a certain allowance.
- The bearing pile in the pile foundation is applied when i) the load-bearing layer is located at deep ground, and ii) the structure safety is ensured with a small range of allowance.

The excavation level for the WTP is from GL+825m to +829m. The required bearing capacity of the ground is estimated at 100~150 kN/m^2 and above for the construction of the WTP. In order to apply the load to the spread foundation, N value of 15 and above is required for satisfying the loading condition.

The soil condition was investigated by samples from three boreholes. The findings of the investigation are:

- weathering shale at a depth of 0 to 12m from a surface of the ground
- unweathering mudstone or slate below 12 m from a surface of the ground
- N value of 15 or more at GL+830m or the WTP installation level

Higher N values derive from the high viscosities and a long period of the loading by the upper soil layers. By satisfying the allowable bearing pressure on sand, the spread foundation is applied for the structures of the WTP.

The spread foundation is adopted for the construction of Chingkheiching WTP

7） Outline of Each Facility

Figure 5.16 shows the flow diagram for the water treatment process and capacity calculation is shown in **Appendix A5.4 (2)**.

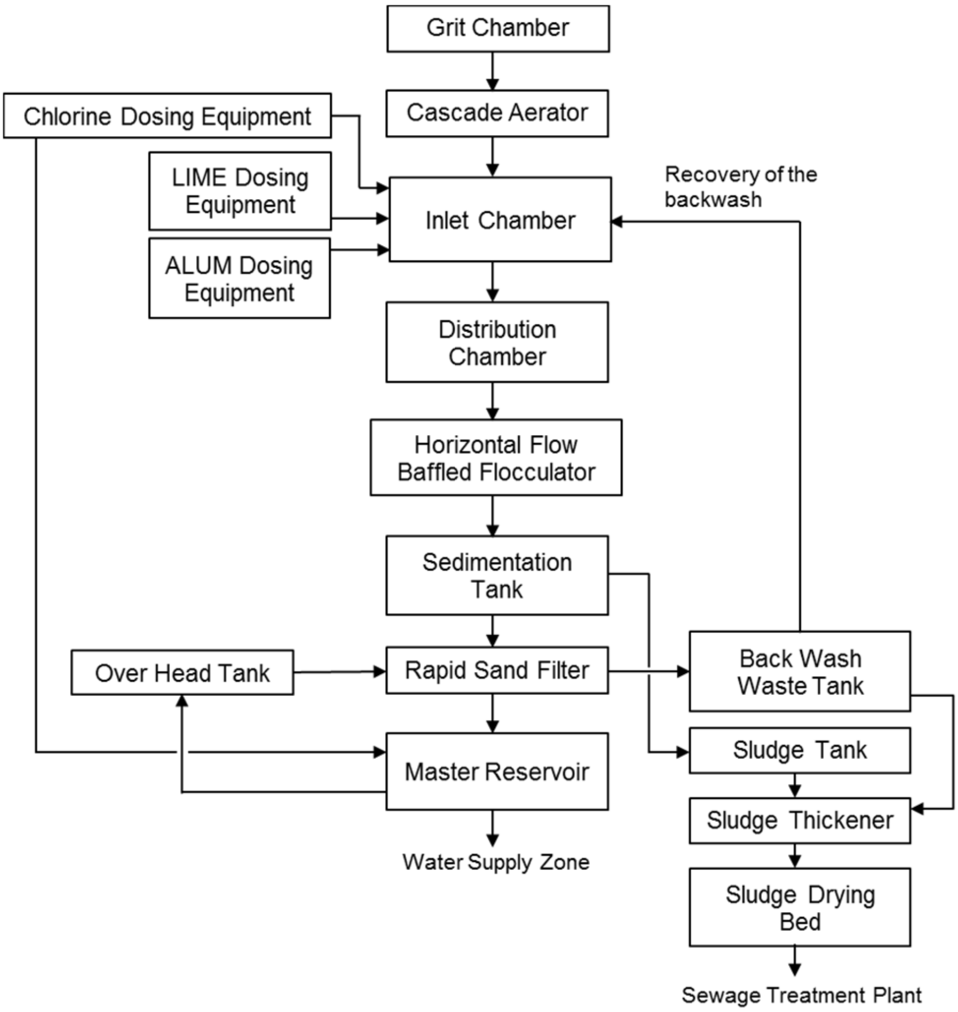


Figure 5.16 Process Flow Diagram of WTP

(3) Grit Chamber, Aerator and Inlet Chamber

The raw water will be conveyed from Thoubal Dam to Chingkheiching WTP through a 1000mm diameter raw water conveyance main. The water inlet facilities consist of grit chamber, screen, aerator, inlet chamber, flow control valves. (See **Table 5.24**). The grit chamber will be installed for sedimentation of sand, fallen leaves in case that raw water contains these. The screen will be installed to prevent flowing driftwood, fallen leaves and garbage into the WTP. The function of the aerator is to remove volatile components of free carbonates, and to oxidize metals such as iron. The flow control valves are capable of controlling the inflow for the design flow of 46,350m^3/day. Chlorination as pre-chlorination, alkali agents (dosed if necessary), and flocculants are dosed to the inlet chamber.

Table 5.24 Outline of Aerator and Inlet Chamber Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Grit Chamber	width 4.0m×length 23.0m×effective depth 3.0m	1 unit	-
2	Screen		2 units	-
3	Aerator	Cascade type, 5 steps	1 unit	-
4	Inlet Chamber	Width 4.1m×length 4.1m×effective depth 3.0m	1 unit	-
5	Flow Control Valve	Sinking comb type flow control valve, diameter of 500mm	2 units	2 units

1) Flocculation / Sedimentation Facilities

The flocculation / sedimentation facilities consist of baffled type flocculator and sedimentation basin with tube settler (see **Table 5.25**). The baffled type flocculator has an advantage over energy consumption because mechanical stirring is not required for the flocculation process. Floc is formed after mixing the raw water and the flocculants by water flow produced by baffled walls installed at a certain distance. The mixing rate is designed larger at the upstream and smaller on the downstream. The raw water contains settleable flocs that flow into the sedimentation basin. The purpose of installing the tube settler is to help the settlement of the flocs effectively at a small surface area. The settled sludge is collected at the pit by gravity, and discharged into the sludge tank periodically from the sludge valve.

Table 5.25 Outline of Flocculation / Sedimentation Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Flocculator	baffled type flocculator width 12.0m×length 11.9m×effective depth 4.0m/tank	3 tanks	-
2	Sedimentation Tank with tube settler	up flow type sedimentation basin, resin tube settler width 12.0m×length 22.0m×effective depth 4.0m/tank	3 tanks	-
3	Sludge Valve	Motorized eccentric valve, diameter of 200 mm	3 units	-

2) Rapid Sand Filtration Facilities

The rapid sand filtration facility consists of rapid sand filter and air-washing blower (see **Table 5.26**). The function of the rapid sand filter is to remove fine flocs, which is not removed at the sedimentation basin with tube settler, by the unit of filtration sand, gravel, underdrainage equipment, trough, and valves. The longer the filtration process is operated, the larger the filtration resistance is increased by attaching and accumulating the flocs on the filter sand. As a result, the production rate shall not meet the requirement. Avoiding this phenomenon, periodic backwash is required. In order to increase the washing efficiency, the backwash process of both water and air is applied. The backwash water is supplied from the overhead tank together with an appropriate water pressure. The air for the air-washing is supplied by the blower with an appropriate pressure and the necessary volume. The filtration and the backwash treatment processes are automatically operated with the sequence control or manual on-site.

Table 5.26 Outline of Rapid Sand Filter Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Rapid Sand Filter	Gravity filtration tank, filtration rate: 119 m/d (operating 6 tanks), surface area of filter: 65 m^2/tank	6 tanks	-
2	Air-washing blower	roots blower: 60m^3/min×3,500mmAq×55W	1 unit	1 unit

3) Sludge Treatment Facilities

Sludge treatment facilities consist of backwash waste tank, sludge tank, thickener, and sludge drying bed (see **Table 5.27**). The backwash waste tank receives backwash waste from the rapid sand filter. Then the backwash waste at the tank is conveyed to the inlet chamber by pump. When the raw water with high turbidity is received, the backwash waste is drained to the thickener through a bypass pipe. The backwash waste tank is designed to have this bypass system. The sludge tank receives sludge from the sedimentation tank, and conveying sludge to the thickener with a uniform concentration. The conveyed sludge is thickened to a solid concentration of 4 % at the thickener. The thickened sludge is conveyed to the sludge drying bed by gravity. The sludge drying bed is the facility which dries the thickened sludge naturally for four months. The dried sludge is then conveyed to a wastewater treatment plant located outside of the WTP.

Table 5.27 Outline of Sludge Treatment Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Backwash Waste Tank	width 11.3m×length 11.4m×effective depth 3.5m, effective volume 450m^3/tank	2 tanks	-
2	Backwash waste pump	Submersible sewage pump, 3.8m^3/min×15m×22kW	1 unit	1 unit
3	Sludge Tank	Width 10.0m×length 10.0m×effective depth 3.0m、effective volume 300m^3/tank	1 tank	1 tank
4	Sludge Pump	non-clog type sludge pump, 1.4m^3/min×12m×11W	1 unit	1 unit
5	Thickener	Gravity type thickener, diameter 10.0m×effective depth 4.0m, effective volume 320m^3/tank	2 tanks	—
6	Sludge Collector at Thickener	Central driving suspended type, diameter 10.0m, motor 0.4kW	1 unit	1 unit
7	Sludge Valve	Motorized eccentric valve, diameter 200mm	1 unit	1 unit
8	Sludge Drying Bed	Width 22.0m×length 32.0m×effective depth 1.0m, effective volume 700m^3/bed	3 beds	-

4) Chemical Dosing Facilities

The chemical dosing facilities consist of dosing facilities for flocculant, alkali agent, and chlorine (see **Table 5.28**). The flocculant dosing facility is to dose alum (or aluminum sulfate) to the inlet chamber by gravity after alum is diluted to the required concentration at the mixer. Forty five (45) day worth of the alum slabs are stocked in the warehouse. The alum is selected as the flocculant because PAC (poly aluminium chloride) is unprocurable in Imphal or Guwahati, and its procurement cost is higher than alum. The alkali agent dosing facility is to dose lime (or calcium hydroxide) to the inlet chamber after lime is diluted to the required concentration at the mixer. Forty five (45) day worth of the lime powder in plastic bags is stocked in the warehouse. The chlorine dosing facility is to dose chlorine to the inlet chamber as pre-chlorination, and to outlet of rapid sand filter as post-chlorination by an ejector after liquid chlorine in 1t cylinder is completely evaporated by evaporator. Because chlorine gas is hazardous, a monitor and a neutralization facility are installed as a safety purpose. 45 days worth of the chlorine gas in 1t cylinders is stocked in the warehouse.

Table 5.28 Outline of Chemical Dosing Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Alum mixing tank	RCC rectangle tank, volume 9.0m^3/tank, paddle type mixer 0.2kW×1 unit/tank *45 day worth of the alum slabs are stocked in the warehouse.	2 tanks	-
2	Alum solution tank	Resin, volume 0.1m^3/tank	1 tank	-
3	Alum dosing equipment	Gravity flow type, dosing rate 130 - 350 L/hr	1 unit	1 unit
4	Lime mixing tank	RCC rectangle tank, volume 9.0m^3/tank, paddle type mixer 0.2kW×1 unit/tank **45 day worth of the lime powder in plastic bags is stocked in the warehouse.	2 tanks	-
5	Lime solution tank	Resin, volume 0.1m^3/tank	1 tank	-
6	Lime dosing equipment	Gravity flow type, dosing rate 80～550L/hr	1 unit	1 unit
7	Pre-chlorination equipment	Independent panel type, ejector dosing type, dosing rate 10kg/hr (max) ***45 day worth of the chlorine gas in 1t cylinders is stocked in the warehouse.	1 unit	1 unit
8	Post-chlorination equipment	Independent panel type, ejector dosing type, dosing rate 4kg/hr (max) ***45 day worth of the chlorine gas in 1t cylinders is stocked in the warehouse.	1 unit	1 unit
9	Chlorine pump	Horizontal single suction volute pump, 0.2m^3×50m×5.5kW	1 unit	1 unit
10	Evaporator	Independent panel type, evaporation capacity 50kg/hr (max), 8kW	1 unit	1 unit
11	Neutralization Equipment	Package type, treatment capacity 1,000kg, 13kW	1 unit	-

5） Reservoir Facilities

The reservoir facilities consist of a master reservoir (MR-6), an overhead tank at WTP, plant water pump for on-site water use, plant water booster pump for on-site water use (see **Table 5.29**). The master reservoir, as it corresponds to the DPR, stores a 5-hour volume of the design maximum daily water supply of 45,000m^3/day. The backwash water for the rapid sand filter, the dilution water for dosing chemicals and the other water for on-site use are supplied from the overhead tank at the WTP. Water will be lifted to the overhead tank, using water pumps. Water for on-site use includes washing water for draining pipes, hydrant, and sprinkling water. However, the overhead tank at the WTP may not have enough head when the water level is at LWL. Adding a supplemental head, plant water booster pumps are installed.

Table 5.29 Outline of Reservoir Facilities

No.	Facility	Specification	Quantity	
			Duty	Standby
1	Master Reservoir (MR-6)	Width 15.0m×length 63.5m×effective depth 5.0m, effective volume 4,800m^3/tank×2 tanks = 9,600m^3	2 tanks	-
2	Overhead tank at WTP	Width 10.0m×length 13.5m×effective depth 3.0m, height 12.6m (above GL), effective volume 400m^3/tank	1 tank	-
3	Pumps for on-site water use	Horizontal single suction volute pump, 6.7m^3/min ×20m×37kW	1 unit	1 unit
4	Booster pump for on-site water use	Line pump, 0.6m^3/min×35m×7.5kW	1 unit	1 unit

(4) Electrical Equipment

1) Electricity Power Supply

a） Incoming Facilities

According to JERC (Joint Electricity Regulation Commission) for Manipur and Mizoram Electricity Supply Code Regulations, electricity power required is supplied with the following power system.

Low Tension	
All installations with a contracted load up to 8 kW	Single phase at 230 V
All installations with a contracted load above 8 kW and up to 50 kW	3 Phase, 4 wire at 400 V
High Tension	
Contracted load exceeding 59 kVA and up to 2000 kVA	3 Phase at 11 kV
Contracted load exceeding 2000 kVA and up to 10000 kVA	3 Phase at 33 kV
Extra High Tension	
Contracted load exceeding 10000 kVA	3 Phase at 110 kV/ 132 kV

For the proposed Chingkeiching WTP, the electricity power will be supplied with 3-phase at 11 kV as per the regulation shown above. There are 250 kW (346 kVA) and 175 kW (242 kVA) estimated as power requirements for the WTP loads and demand power respectively. The breakdowns for the power requirements at the WTP, the central SCADA system are summarised as shown below.

Description		Power requirement (kW)
WTP	Inlet chamber/Chemical dosing facilities	12.4
	Sand filter unit	8.4
	Air blower	55.0
	Master reservoir/Chlorine dosing facilities	76.25
	Sludge process	40.2
	Small power and lighting	57.5
	Total power requirement	250 (346 kVA)
	Demand power (Total power requirement x 0.7)	175 (242 kVA)
Central SCADA System		8 (10 kVA)

It has been confirmed that MSPDCL (Manipur State Power Distribution Company Limited) can supply the electricity power required through an independent/dedicated line to the proposed project site at Chingkeiching WTP in the meeting dated on 6th of July, 2014.

Electricity rate discount for both the fixed charge and the energy charge based on power factor correction is not stipulated in the MSPDCL tariff. However, it is preferable for PHED as public sector to improve power factor reasonably so that PHED can contribute to power distribution networks in good condition. On this design, static capacitor for power factor correction from 85 percentage to 95 percentage will be applied for the reason above. The static capacitors are arranged at the low voltage bus bars in the low voltage distribution panel to be located at the electrical room in the electrical substation.

The installation cost for 11kV medium voltage distribution line to the proposed WTP proposed site has been estimated at approximately 2.87 million Rs by MSPDCL on 2014 basis.

b) Current situation of electricity power supply source

It has be confirmed through the study team’s interview with MSPDCL that power supply service is not provided continuously and there is unstable voltage due to tight power supply against demand within the study area, just like another states in India. A standby generator set is planned to back up critical loads for the plant operation considering the situation at the main power supply at the proposed project WTP site, even if the independent/dedicated power line is available.

c) Power demand and rates

The electricity for the category of Public Water Works has been proposed for financial year 2014 to 2015 by JERC for Manipur and Mizoram Electricity Supply Regulation as below.

➢Fixed charge: 120 Rs/kW-Month
➢Energy charge: 4.9 Rs/kWh

The yearly electricity rate for the proposed WTP at Chingkeiching is estimated based on above figures as below.

➢Fixed charge: 252,000 Rs based on 175 kW demand power
➢Energy charge: 53,655,00 Rs

d) High voltage switch gear

A high voltage incoming panel will be installed at the electrical substation in the WTP to receive electricity power required to operate the WTP at 11 kV from the grid of MSPDCL. The high voltage incoming panel will consist of one VCB (Vacuum Circuit Breaker), surge arresters, three over-current relays, and electrical parameter measuring devices such as an ammeter and a voltmeter.

e) Power transformer

The electricity power required the WTP will be supplied at 11 kV, while the plant loads will be driven by low voltage of 415 V adequate considering the individual motor output. Accordingly, a power transformer has to be provided at the WTP to step down the supplied electricity from 11 kV to 415 V.

Transformer capacity is calculated by the formula below.

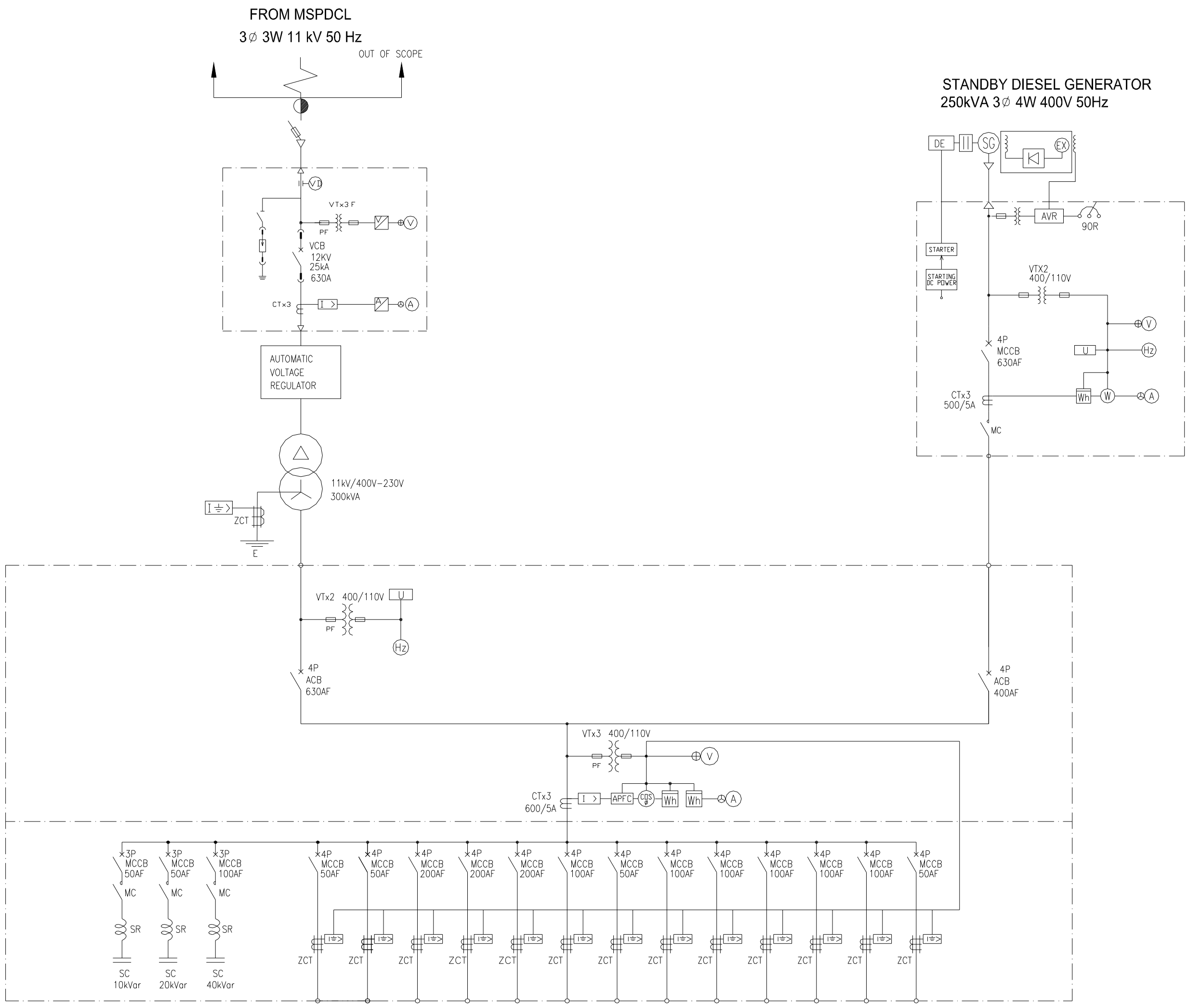
Transformer Capacity (kVA) = Total Loads (kW) $*(\beta*\alpha)/(\eta*\varphi)$
Here, φ: Total power factor
η: Total efficiency
β: Demand factor
α: Safety factor

In this formula, spare motor capacity will not be included in the Total Loads. Finally, the transformer capacity has been derived with 300 kVA through the calculation formula above.

f) Standby Generator Set

Power failure occurs frequently on daily basis and there is also a wide range of supply voltage fluctuations, sometimes below 360 V due to tight power supply against demand. Given the power supply condition, a standby generator set is planned to ensure continuous treatment process and continuous water supply service by backing-up the critical plant loads during power failures. The standby generator set will have a diesel engine from the view of availability in market and economy. Further, the storage volume of fuel tank will be designed for twenty-four hours use so as to have sufficient fuel when the fuel storage becomes low. The fuel tank will be basically installed outdoor.

The capacity of the required generator set is estimated at 250 kVA and the generator with diesel engine driven, 400 V, 50 Hz, 3-pahes, 4-wire system. The single line diagram is shown below.



CAPACITY (KW/kVA)	12.4	8.4	55	55	76.25	40.2	7.5	10.0	40.0				
APPLICATION	INLET / CHEMICAL IDOSING FACILITIES	FILTER UNITS	AIR BLOWER – NO.1	AIR BLOWER – NO.2	MASTER RESERVOIR / CHLORINE FACILITIES	SLUDGE PROCESS FACILITIES	UPS	DISTRIBUTION BOARD FOR INLET FACILITIES	DISTRIBUTION BOARD FOR OTHER BUILDING	RESERVE	RESERVE	RESERVE	RESERVE

Figure 5.17 Single Line Diagram for Chingkeiching WTP

2) Low Voltage Switchgears/Control Gears

There are two low voltage switchgears planned, such as a low voltage incoming panel and a low voltage feeder panel for receiving electricity power at 400 V from the transformer and the diesel generator set, and for distributing electrical power at 400 V to each MCC and another facilities respectively. Furthermore, MCCs (Motor Control Centers) will be installed to drive the plant loads properly in association of the instrumentation devices and PLCs (Programmable Logic Controllers) at the electrical rooms, such as the electrical substation and the filter unit building.

The incoming low voltage panel consists of two ACBs (Air Circuit Breakers) and an electrical parameter measuring devices such as an ammeter, a voltmeter, a frequency meter, a power factor meter, a watt meter, and a watt hour meter. Meanwhile, the low voltage feeder panel consists of MCCBs (Molded Case Circuit Breakers) ranging from 50 A to 200 A, and static capacitors, for distributing low voltage electrical power to each MCC and other facilities, and compensating power factor respectively.

A total of four MCCs are proposed at the electrical substation and the filter unit building to drive the plant loads properly such as the inlet/chemical loads facility MCC, the filter unit MCC, the master reservoir/chlorine facility MCC, and the sludge process facility MCC. Further, two air blower starter panels are required independently at the filter unit building considering their motor output size. The air blower starter panels consist of a soft starter with 55 kW and static capacitors compensating power factor individually. Each MCC is comprised of the following components:

i) Panel enclosures
ii) Bus-bars with MCCB's (Distribution section)
iii) Supply incoming section
iv) Small power distribution section
v) Motor starting sections
vi) Automatic controllers and indicators
vii) Cabling

Incoming section will require following items.

i) One 4-pole molded case circuit breaker of adequate capacity with thermal overload and earth fault trip
ii) One ammeter with selector switch for monitoring phase currents
iii) One voltmeter with selector switch for monitoring phase to neutral and phase to phase voltages
iv) One supply voltage monitor with the following features and interlocked with all motor starters
   ① Phase failure protection
   ② Supply voltage imbalance (adjustable)
   ③ Under and over voltage (adjustable)
   ④ Phase reversal
i) Lamp indicator to indicate operating condition of supply voltage monitor
ii) Incoming terminals
iii) Surge suppression device (surge arrestors)
iv) Duty selector switch with interlocking arrangements

Motor starters shall comply with IEC 60947-3 (Specification Motor starters and controllers) or equivalent starter shall be adequately rated for the required number of starts per hour and, in any case, not less than six starts per hour. Motor starter types are selected adequately for each load according to the motor output capacity as follows:

i) Less than 15 kW: Direct on-line method,
ii) 15 kW or over and less than 55 kW: Start-delta method,
iii) 55 kW or over: Soft starter method,

3) Instrumentation Devices

There will be flow meters, level meters, pressure meters, valve position meters (valve built-in), weighing meter, and water quality analysers installed at various fields in the WTP to operate and monitor the treatment process properly. As for water quality analysing parameters, there are turbidity, pH for raw water and settled water, turbidity, pH, and residual chlorine for treated water to be monitored at on-line basis in general. Sampling pumps will be arranged to convey the settled water and the treated water continuously to the laboratory in the administration building for on-line monitoring water quality.

A surge arrester will be installed to both transmitter and receiver to prevent from lightning surge anticipated at the proposed project site.

There are four types of typical flow meters, electromagnetic type, inserting electromagnetic type, venture (orifice) with differential pressure transmitter type, and ultrasonic type. The accuracy of inserting electromagnetic type and ultrasonic type is about ±2%, and this accuracy could be even much worse depending on the fixing. The electromagnetic type flow meters are applied in this project from the view point of its accuracy within ±0.5%. Flow meters will be proposed at the raw water inlet and the treated water effluent under this project.

As for level meters, there are differential pressure type, submersible hydrostatic type, float type, capacitance type, ultra-sonic type, and so on. In principle, ultrasonic type or the submersible hydrostatic type is proposed considering the accuracy and ease of installation. Level meters will be installed in the following points in the WTP.

i) Distribution chamber
ii) Alum solution tank
iii) Lime solution tank
iv) Filter units
v) Overhead water tank
vi) Master reservoir

(5) Disposal of Surplus Soil from Earth Cut from Chingkheiching WTP Site

The Chingkheiching WTP is planned to be installed at GL+870m to +880m after cutting the hill up to GL+830m and leveling the site. Therefore, it is expected that a large amount (approximately 750,000m^3) of cut earth will be generated that will have to be disposed. The proposed disposal site is a low-lying area next to Lamphel Pat sewage treatment plant, located around 8.8 km away from WTP and owned by PHED. The site is i) 2m lower than the surroundings, ii) has wet condition all the time, and iii) us not utilizable at present. For an effective utilization, the cut earth should be disposed at this broad stretch of the low land.

Figure 5.18 Location of Lamphel Pat STP (Under Construction)

Figure 5.18 indicates the area owned by PHED. The total area is 31.92 ha. Currently, an existing STP at the site occupies 6.46 ha out of the 31.92 ha. The remained land, 25.46 ha, will be utilized for the soil disposal. Issues to be considered are listed below.

i) The land is located at lower position than the surrounding area. It is positioned around 2m lower than the adjacent roads.
ii) Therefore, the land is in wet condition due to its badness of drainage as rain water tends to gather at the lower place.
iii) Besides, considering that some puddle can be seen on the surface, and groundwater level is relatively high and it causes to soften the soil of land.
iv) As a result, the soil of land needs to be considered as insufficient bearing capacity with the risk of settling when embankment and structures will be newly constructed.

Considering the situation mentioned above, it is recommended to take countermeasures for the embankment (soil disposal) to the proposed site as shown below.

i) Conduct embankment slowly enough to make the level of the land surface equal.
ii) The embankment shall be conducted at the centre of the proposed site to minimize ground heaving on the surrounding area caused by the soil brought from another place.
iii) Embankment height as lower than 5m.

iv) Position the embankment at least 10m away from the land boundary, adjacent roads and other structures considering the risk of circular slip.

v) It is considered approximately 90% of final settlement will be completed within 2 years.

As for construction method, lowering groundwater level method such as paper drain method can be considered as an option. However, the groundwater level could be recovered again after a period of time, since the proposed site is located at lower position than the surrounding area. Therefore, it would result in spending useless time and cost so it is not recommended to adopt the option.

On the other hand, structures to be planned in the future at the site would have no problem with pile foundation. The condition of the soil surface can be improved by ground surface improvement method. So land consolidation only by weight of the embankment itself would be applied as the best solution at this time.

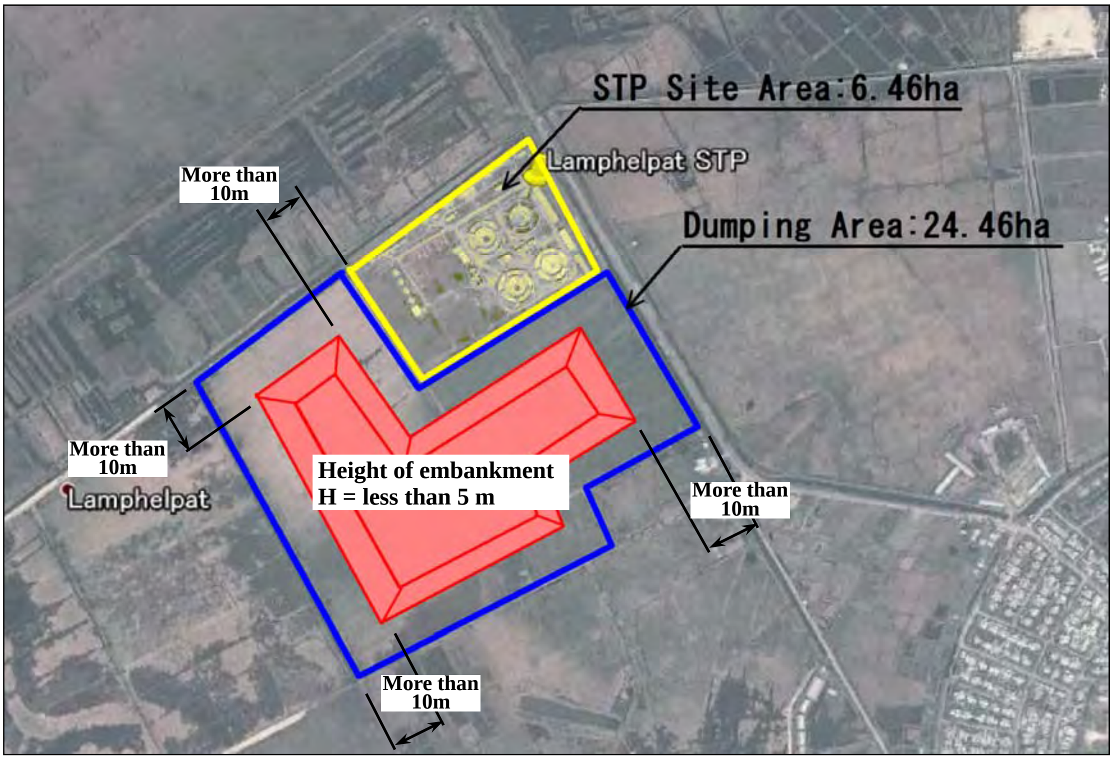


Figure 5.19 Site Plan of Lamphel Pat STP (Under construction)

The volume of sludge generated from Chingkheiching WTP is estimated at 3.6 ton/day. The sludge will be disposed at the STP as well.

5.5 Reservoirs

5.5.1 Type of Reservoirs

In the new water supply system in Imphal, the following types of reservoirs have been proposed in the DPR and are defined as follows:

(1) Master Reservoir

There have been six master reservoirs proposed in the DPR. Each master reservoir will receive source output from a WTP which will form its master reservoir zone. These are located on the hillside apart from MR-5 at Porompat WTP, and stored water in the reservoirs is further transferred to the downstream service reservoirs. Note that the function of the master reservoirs are the same as that of clear water reservoirs at WTP sites, which are used to store treated water before transferring it to service reservoirs.

(2) Ground Level Service Reservoir

Ground level service reservoirs (GLSRs) are rectangular (or circular) service reservoirs situated on the hilltop. Most of them are of RCC construction. These provide supplies to the distribution network and its main function is to balance the fluctuating demand in the distribution zone.

(3) Overhead Tank

Overhead tanks (OHTs) are elevated tanks located in the areas of flat topography and provide supply into the distribution system as a service reservoir. The main function of the OHTs is to balance the fluctuating demand in the distribution zone, same as GLSRs.

(4) Ground Level Emergency Reservoir

Ground level emergency reservoirs (GLERs) are underground storage reservoirs situated at the OHT sites to provide emergency storage capacity in the case of loss of supplies from the transmission mains. All the GLERs are equipped with a pumping station which will lift water from the GLER to its OHT.

See Drawing IP-WSS-NE-001 for the locations of the above mentioned reservoirs in the new water supply system in Imphal. **Table 5.30** summarises the number of the reservoirs to be constructed or rehabilitated under the JICA project. In the following sections, the assessment of the reservoir design in the DPR and proposed works in the JICA scope are discussed.

Table 5.30 Number of Reservoir Construction / Rehabilitation (JICA Scope)

Type of Reservoir	No. of Construction	No. of Rehabilitation
Maser Reservoir	2	
Ground Level Service Reservoir	3	5
Overhead Tank	21	
Ground Level Emergency Reservoir	11	
Total	37	5

5.5.2 Master Reservoirs

(1) Proposed Master Reservoirs

Five new master reservoirs have been proposed in the DPR. The master reservoirs are located at the production sites or en route to the master reservoir supply zones. The main function of the master reservoirs is to store bulk water from the WTP and transfer it to zonal service reservoirs in each master reservoir zone. Among these reservoirs, the construction of MR-1, MR-5 and MR-6 was initially included in the scope of JICA project by PHED.

During this survey, the need for building each master reservoir was assessed. Regarding MR-1, the purpose of building the reservoir was to supply bulk water to Sangakpham OHT. It is also understood that MR-6 is intended to supply bulk water to the OHT when a transmission main has been installed from MR-6 under the JICA-funded project. However, the MR-1 and the transmission main will be constructed around the same time and the OHT could receive bulk water from MR-6 as soon as the transmission has been installed. Therefore, it appears that there is not much benefit of building MR-1. Therefore, it was agreed with PHED that MR-1 will be removed from the both JICA scope, as well as overall scheme scope.

Also, during this survey, PHED has confirmed that the capacity of MR-2 will be reduced to 5Ml from the original capacity of 9Ml proposed in the DPR.

It should also be noted that according to the DPR, MR-4 will become a service reservoir after Kongman zone has been incorporated into Canchipur master reservoir zone.

Table 5.31 is a summary of the master reservoirs in the new water supply system in Imphal, with the name of funding agency and their proposed capacity.

Table 5.31 Proposed Mater Reservoirs

No.	Master Reservoir Name	Location	Funding Agency	Capacity (Ml)
1	MR-1	Removed from scope of scheme		
2	MR-2	Iroisemba Hilltop	JNNURM	5.00
3	MR-3	Canchipur Hilltop	JNNURM	1.50
4	MR-4	Irilbung	Existing	2.72
5	MR-5	Porompat WTP	JICA	2.00
6	MR-6	Chingkheiching WTP	JICA	9.00

(2) Assessment of Proposed Storage Capacity

The DPR set a design criteria that the clear water reservoirs at WTP sites shall require a two-hour storage capacity and the master reservoirs shall also require a two-hour storage capacity, considering the possible future shut down time of the WTP. Details of calculations of the storage capacity for each master reservoir were, however, not presented in the DPR.

From the information on the DPR, it is understood that MR-2 and MR-3 are designed to function as a master reservoir, which requires two hours' storage capacity, whereas MR-4, MR-5 and MR-6 are designed to function as both clear water reservoir and master reservoir, which requires four hours' storage capacity based on the criteria set in the DPR.

Table 5.32 shows water retention time calculated for each master reservoir. According to the results, the currently proposed capacity of MR-5 and MR-6 meet the above design criteria. However, it should be noted that MR-3 appears to be oversized considerably and that MR-4 has more than two days' storage capacity for Khongman zone.

Regarding MR-4, as mentioned earlier, it is supposed to function as a service reservoir for the Irilbung zone once Khongman zone has been incorporated in Canchipur master reservoir zone (in 2016 planned in the DPR). Therefore, it would be more appropriate to assess its capacity against the criteria of the service reservoir. With regards to MR-2, the proposed capacity is slightly oversized and an option of utilizing its capacity is discussed in Section 5.5.3(2) of this report.

Table 5.32 Master Reservoir Retention Time

Master Reservoir Name	Proposed Capacity (Ml)	Funding Agency	Supply Point and Zone	DPR 2046 Supply Zonal Demand (Mld)	Transfer Rate (Mld)	Water Retention Time (hrs)
MR-1 Koirengei	Removed from scope of scheme					
MR-2 Iroisemba	9.0	JNNURM	Langjing GLSRs	11.032	24.195	5.0
			Cheiraoching GLSRs	6.720		
			Nempra Menjor OHTs	4.893		
			Langol Zones GLSRs	1.550		
MR-3 Canchipur	1.5	JNNURM	Lilandolampak OHT	2.065	4.126	8.7
			Khongman OHT	2.061		
MR-4 Irilbung	2.72	Existing	Khongman OHT	1.230	1.230	53.1
MR-5 Porompat	2.0	JICA	Porompat Shift 1A, 1B, 2A, 2B OHTs	17.137	9.530	5.0
MR-6 Chingkheiching	9.0	JICA	Sangaiprou OHT	4.440	45.000	4.8
			Irom Pukhri OHT	2.105		
			Chingthamleikai OHT	5.274		
			Keishampat OHT	4.160		
			Lalmbung OHT	2.839		
			Assembly OHT	1.859		
			Laiwangma OHTs	3.713		
			Sajor Leikai OHTs	3.048		
			Ghari OHT	10.102		
			Sangakpham OHT	5.122		
			Porompat OHTs	4.000		
			Minuthong OHT	3.000		
			Chinga GLSR	4.000		
			Irilbung Zone	5.000		

Note:

1) Future demand for Porompat, Minuthong, Chinga, Irilbung obtained from DPR Page 10-6&7.
2) Future demand for Irilbung is that of 2016.
3) Future demand for Porompat, and Chingkheiching master zone is 17.135Mld and 59.919 respectively, higher than production capacity. Therefore, transfer rate is dictated by production capacity.

(3) Proposed Master Reservoirs under the JICA Scope

The current JICA scope includes the construction of MR-5 and MR-6. In this section, the construction of MR-5 is discussed. See **Section 5.4.9, (7), 6)** of this report for the proposed details of MR-6.

1） Proposed Site

The MR-5 is proposed to be constructed within the premises of the existing Porompat WTP. At this WTP, the construction of one OHT (i.e. Porompat, Shift 1B) is also planned under the JICA project.

It is currently proposed that MR-5 is to be built where the existing dis-used pre-sedimentation pond is located. **Figure 5.20** shows the site location and **Photo 5.4** show the site views.

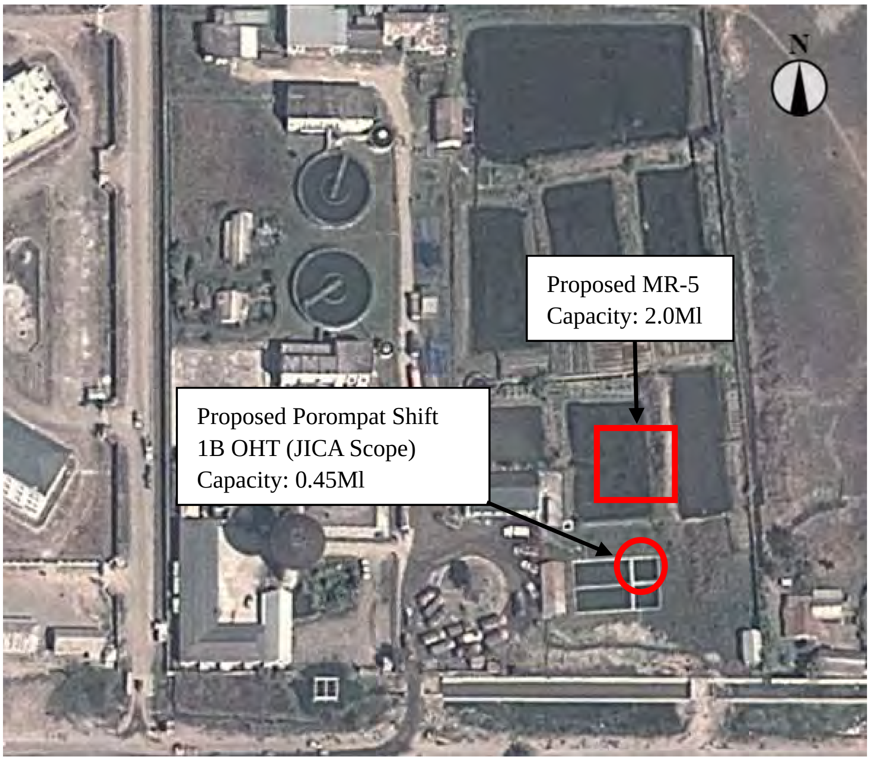


Figure 5.20 Proposed Construction Site for MR-5 at Porompat WTP

【Proposed Location of MR-5 – Disused Pre-Sedimentation Pond Site】

Photo 5.4 Views of Proposed Site for MR-5

2） Proposed Reservoir Structure

There are two types of reservoirs found in Imphal, namely circular reservoir and rectangular reservoir. The features of each type of reservoir are described below:

Circular Reservoir: It is of RCC structure with a dome roof. This type of reservoir usually consists of single cell, hence it would not be easy to carry out the cleaning without supply interruption. Also, because of the circular cell, water flow pattern is not uniform and careful design would be required to arrange the position of the inlet / outlet pipework to prevent water circulation and dead spot.

Rectangular Reservoir: It is of RCC structure supported by columns and beams. This type of reservoir usually consists of twin cells. One cell can be easily taken out of service for the cleaning. If baffle walls are built, they allow plug flow from the inlet and outlet, resulting in good mixture of chlorine and prevent water circulation and dead spots.

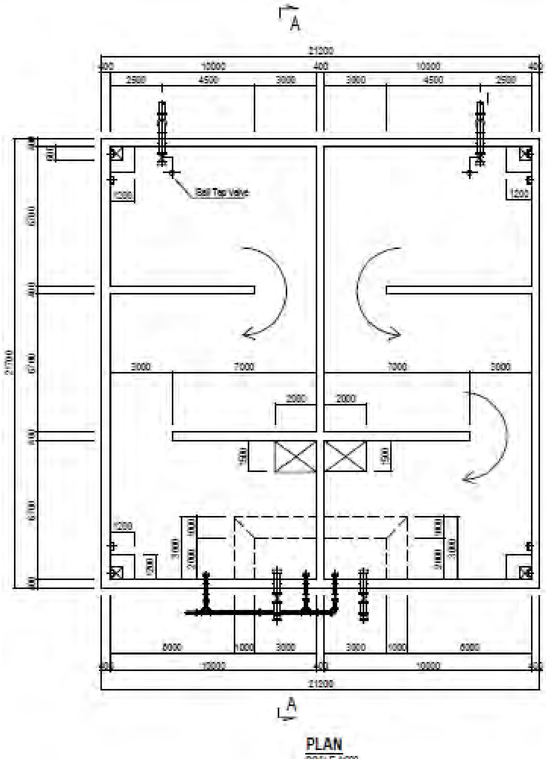
For the reasons above, rectangular cell structure was selected for the preliminary design of MR-5 in this survey. **Table 5.33** summarizes the details of the proposed MR-5.

Table 5.33 Details of Proposed MR-5

	Details
Capacity	2.00 Ml
Shape	Rectangular Twin Cells
Dimension	10.0m x 27.0m x 5.0m deep x 2 nos.
Proposed GL	GL+785.90m
Structure	RCC
Foundations	Piled Foundation

Figure 5.21 shows the general arrangement of the proposed MR-5. See **Drawing No. IP-RES-PM-002** and **003** for more details of the preliminary design of the master reservoir.

Note that MR-5 will receive water from Porompat WTP and stored water will need to be lifted to three. of new OHTs for the distribution, namely Porompat 1B OHT, 1A and 2A OHT and 2B OHT. PHED confirmed that the new pumping station and other associated work will be carried out by JNNURM fund and that the work scope of the JICA project is to build the master reservoir only.



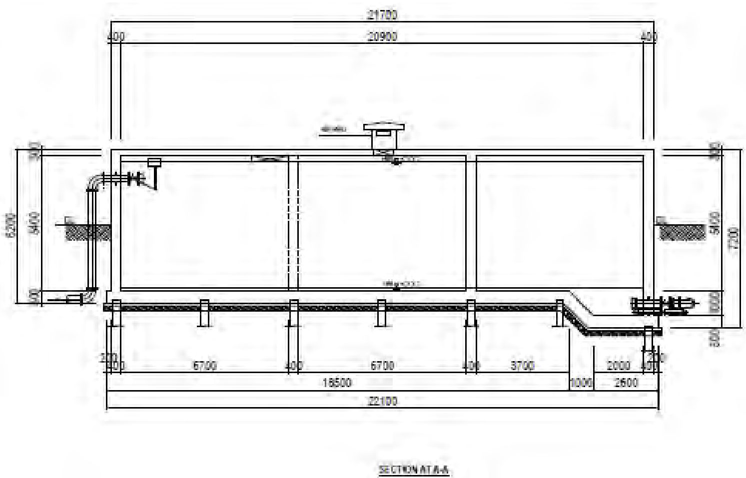


Figure 5.21 General Arrangement of Proposed MR-5

5.5.3 Ground Level Service Reservoir

(1) Proposed Ground Level Service Reservoir

According to the current facility plan proposed in the DPR, a total of 25 ground level service reservoirs (GLSRs) are planned for the new water supply system in Imphal. Details of the GLSRs are given in **Table 5.34**. These include 16 existing GLSRs, seven new GLSRs and two GLSRs which are currently being constructed under the state funding scheme.

During this survey, PHED has confirmed that the existing 4.54Ml GLSR at the low level of Iroisemba Hill will be demolished and a new GLSR with capacity of 4.00 Ml will be built at the same location under the Phase 1 project.

Table 5.34 Ground Level Service Reservoir (Future)

No.	Reservoir Name	Master Reservoir Zone / WTP Zone	Supplying WSZ Zone	Exiting / New / Refurb.	Funding Agency	Capacity (Ml)	GL (m)	TWL (m)	LWL (m)
1	Koirengei Hilltop	MRZ-1	WSZ17	Refurbishment	JNNURM	0.45	824.150	823.70	820.70
2	Koirengei Hilltop	MRZ-1	WSZ17	Refurbishment	JNNURM	0.68	819.380	818.83	816.03
3	Koirengei Hilltop	MRZ-1	WSZ17	New	JNNURM	6.50	819.292	unknown	unknown
4	Iroisemba Hilltop High Level (Circular)	MRZ-2	WSZ 1&2	Refurbishment	JICA	1.53	851.649	850.95	847.55
5	Iroisemba Hilltop High Level	MRZ-2	WSZ 1&2	Refurbishment	JICA	1.53	851.649	851.00	847.65
6	Iroisemba Hilltop Low Level	MRZ-2	WSZ 1&2	Refurbishment	JICA	1.81	826.234	825.83	821.43
7	Iroisemba Hilltop Low Level	MRZ-2	WSZ 1&2	Refurbishment	JICA	4.54	826.234	825.83	821.56
8	Iroisemba Hilltop Low Level	MRZ-2	WSZ 1&2	Under Const.	-	2.00	826.234	825.53	822.08
9	Langjing Hilltop	MRZ-2	WSZ 3	Refurbishment	JICA	0.45	803.990	803.40	800.35
10	Langjing Hilltop	MRZ-2	WSZ 3	Refurbishment	JICA	0.36	807.490	807.19	804.04
11	Langjing Hilltop	MRZ-2	WSZ 3	New	JICA	0.75	810.223	814.00	809.00
12	Langjing Hilltop	MRZ-2	WSZ 3	Under Const.	-	0.45	810.223	809.92	806.22
13	Canchipur Hilltop	MRZ-3	WSZ 13	Existing	-	1.27	817.593	816.86	812.76
14	Canchipur Hilltop	MRZ-3	WSZ 13	Existing	-	1.14	817.000	816.39	812.44
15	Canchipur Hilltop	MRZ-3	WSZ 13	Existing	-	1.36	832.077	831.70	828.90
16	Canchipur Hilltop	MRZ-3	WSZ 13	New	JNNURM	1.00	832.077	831.70	828.90
17	Cheiraoching Hilltop	MRZ-3	WSZ 9	New	JNNURM	2.00	819.255	823.00	818.00
18	Chinga Hilltop (High Level)	CZ-4	WSZ 12	Refurbishment	JNNURM	1.59	816.983	816.00	812.50
19	Chinga Hilltop (Low Level)	CZ-4	WSZ 12	Existing	-	0.40	792.413	795.00	792.00
20	Irilbung Hilltop	MRZ-4	WSZ 20	New	JNNURM	5.00	843.860	843.41	840.41
21	Langol Zone 1	MRZ-2	WSZ 1	Existing	-	0.45	818.873	818.57	816.27
22	Langol Zone 2	MRZ-2	WSZ 1	Existing	-	0.45	815.844	815.54	813.24
23	Langol Zone 3	MRZ-2	WSZ 1	Existing	-	0.45	820.540	820.24	817.94
24	Langol Housing Complex Zone 1	MRZ-2	WSZ 1	New	JICA	0.23	834.879	834.78	831.78
25	Langol Housing Complex Zone 2	MRZ-2	WSZ 1	New	JICA	0.17	841.860	841.76	838.76

Note: 1) MRZ: Master Reservoir Zone, CZ: Central Zone

During this survey, it has been confirmed with PHED that six existing GLSRs are planned to be refurbished and that three new GLSRs are to be constructed under the JICA funded project, as shown in **Table 5.34**.

(2) Assessment of Proposed Storage Capacity

The main function of GLSRs is to balance the fluctuating demand from the distribution network, the same as the overhead tanks. The DPR contains the storage capacity calculation for each water supply zone, using the mass diagram method referenced in the CPHEEO manual.

During this survey, the calculations of the storage capacity requirement were checked to see if the original calculations were made correctly. The results of the calculations are contained in **Appendix A5.5 (1)**. The results confirm that there is no error found in the original calculations.

Table 5.35 shows the storage capacity of each GLSR and calculated storage requirement for each water supply zone. In general, the planned storage capacity of each supply zone meets the storage capacity requirement. It is however should be noted that the proposed storage capacity of GLSRs at Langjing Hill is smaller than the calculated storage requirement.

Langjing Hilltop has a limited space and it would be difficult to build any additional GLSR after a new 0.75Ml GLSR has been built under the JICA project. However, the storage capacity deficit at Langjing Hill may be improved by directly infusing water from MR-2 to the Langjing distribution zone, as MR-2 has sufficient storage capacity. This would be possible by making a cross connection between the MR-2 transmission main leading to the Langjing GLSR and a distribution main in Langjing zone via a pressure reducing valve. Should this proposal be adopted, a non-return valve shall also be fitted on the outlet of the Langjing reservoir to prevent backflow from MR-2 into the Langjing reservoir through the distribution mains. See **Figure 5.22** the possible location of the cross connection for reference. This option shall be further investigated during the project implementation stage.

Table 5.35 Storage Capacity of Proposed GLSR and Water Retention Time

No.	Service Reservoir Name	New / Existing / Under Const.	Funding Agency	Storage Capacity (Ml)	Total Storage Capacity (Ml)	Calculated Storage Requirement (Ml)	Supply Zone	DPR 2046 Supply Zonal Demand (Mld)	Reservoir Retention Time (hrs)
1	Iroisemba High Level	Existing	JICA	1.53	10.87	7.80	Iroisemba East & West	24.519 (excluding Langol zone)	10.6
2	Iroisemba High Level	Existing	JICA	1.53					
3	Iroisemba Low Level	Existing	JICA	1.81					
4	Iroisemba Low Level	Existing	JICA	4.54					
5	Iroisemba Low Level	Under Cost.	-	2.00					
6	Langol Zone 1	Existing	-	0.45	1.35	Not calculated	Langol (part of Iroisemba West)	1.550	20.9
7	Langol Zone 2	Existing	-	0.45					
8	Langol Zone 3	Existing	-	0.45					
9	Langol Housing Complex Zone 1	New	JICA	0.23					
10	Langol Housing Complex Zone 2	New	JICA	0.17					
11	Langjing Hill	Existing	JICA	0.45	2.01	3.30	Langjing	11.032	4.4
12	Langjing Hill	Existing	JICA	0.36					
13	Langjing Hill	New	JICA	0.75					
14	Langjing Hill	Under Cost.	-	0.45					
15	Cheiraoching Hilltop	New	JNNURM	2.00	2.00	2.00	Cheiraoching	6.720	7.1
16	Chinga Hilltop (High Level)	Existing	JNNURM	1.59	1.99	2.20	Chinga	7.525	6.3
17	Chinga Hilltop (Low Level)	Existing	-	0.40					
18	Canchipur Hilltop	Existing	-	1.27	4.77	4.70	Canchipur	15.745	7.3
19	Canchipur Hilltop	Existing	-	1.14					
20	Canchipur Hilltop	Existing	-	1.36					
21	Canchipur Hilltop	New	JNNURM	1.00					
22	Koirengei Hilltop	Existing	JNNURM	0.45	7.63	7.10	Koirengei	24.141	7.6
23	Koirengei Hilltop	Existing	JNNURM	0.68					
24	Koirengei Hilltop	New	JNNURM	6.50					
25	Irilbung	New	JNNURM	5.00	5.00	4.30	Irilbung	14.460	8.3

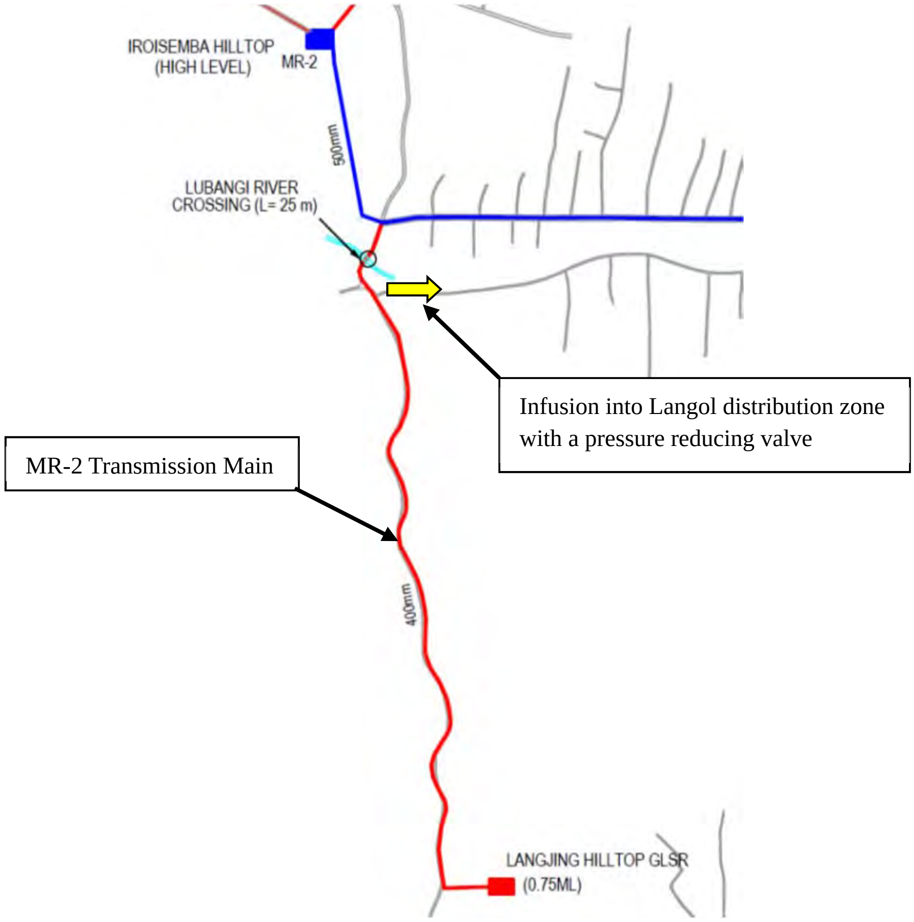


Figure 5.22 Proposed Cross Connection between MR-2 Transmission Main and Langol Distribuiton main

(3) Proposed Reservoir Works under the JICA Scope

In this section, the GLSR reservoir works that have been included in the JICA scope at the following sites are discussed:

- Iroisemba Hilltop (High Level)
- Iroisemba Hilltop (Low Level)
- Langjing Hilltop
- Langol Housing Complex Hilltop

3） Iroisemba Hilltop (High Level)

At the higher level of the Iroisemba hill, there are two existing GLSRs which are planned to be rehabilitated under the JICA project. Both GLSRs have same capacity of 1.53Ml, but one is rectangular and the other is circular in shape. **Table 5.36** summarises details of the GLSRs and their locations are shown in **Figure 5.23**.

Table 5.36 Details of Existing Reservoirs (Iroisemba High Level)

	Rectangular GLSR	Circular GLSR
Capacity	1.53 Ml	1.53 Ml
Year of Construction	1965	1965
Dimensions	19.5m x 24.0m x 3.3m deep	22.0m diameter x 4.2m deep
Ground Level	+851.65m	+851.65m
Structure	RCC	RCC

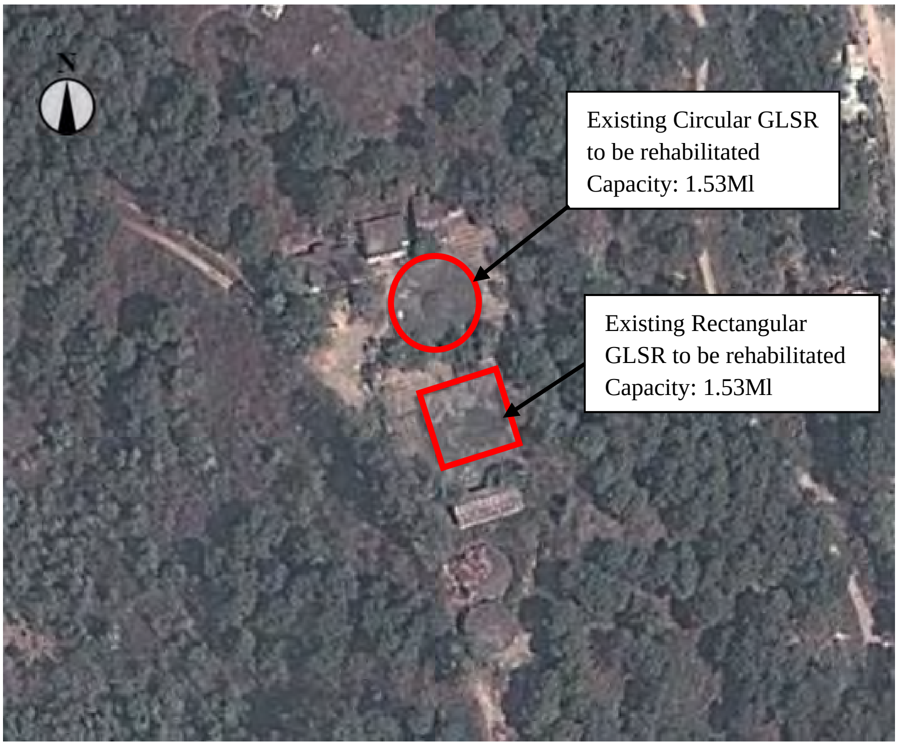


Figure 5.23 Location Plan – Iroisemba Hilltop (High Level)

During this survey, a site investigation was carried out to inspect the current conditions of the GLSRs and to determine the need and scope of the rehabilitation work.

Having inspected the rectangular GLSR, leakage was observed from cracks on the external concrete surface of the reservoir walls. It was also found that the outlet valve chamber was flooded with leaks from a flange of the valve installed in the chamber.

On the other hand, the circular GLSR appeared to be in good condition externally. However, the outlet valve chamber was also filled with water leaks from the valve installed within. Considering the age of the structure, it is envisaged that leaks from the external concrete surface of the reservoir walls may occur in the near future.

Based on the results of the site inspections, it is recommended that the following rehabilitation work should be carried out for both the rectangular and circular GLSRs at Iroisemba hilltop (high level):

- Waterproofing work to the internal walls, using epoxy resin
- Repair of external concrete wall surface and cover slab, using mortar etc.
- Replacement of leaking valves in the valve chambers

See **Photo 5.5** for the current conditions of the rectangular and circular GLSRs at Iroisemba hilltop (high level).

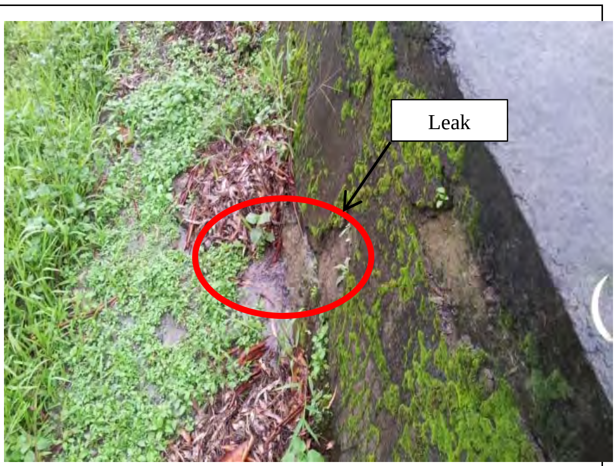
	
【Rectangular GLSR】 Site view of rectangular GLSR	【Rectangular GLSR】 Leak from concrete crack on side wall.
	
【Rectangular GLSR】 Deteriorated concrete surround on inlet pipe	【Rectangular GLSR】 Flooded valve chamber caused by leaking valve
	
【Circular GLSR】 No leakage observed from external walls	【Circular GLSR】 Flooded valve chamber caused by leaking valve

Photo 5.5 Current Conditions of Existing GLSRs at Iroisemba Hilltop (High Level)

4） Iroisemba Hilltop (Low Level)

At the lower level of the Iroisemba hill, there are existing 1.81 Ml GLSR and 4.54 Ml GLSR. The 1.81 Ml GLSR is planned to be rehabilitated under the JICA project, whereas 4.54Ml will be reconstructed under the JNNURM fund. Both GLSRs are of RCC structure and rectangular in shape, but they were built in different years. **Table 5.37** summarises details of the GLSRs and their locations are shown in **Figure 5.24**.

Table 5.37 Details of Existing GLSRs (Iroisemba Low Level)

	1.81 Ml GLSR	**4.54 Ml GLSR**
Capacity	1.81 Ml	4.54 Ml
Year of Construction	1965	1989
Dimensions	20.0m x 20.0m x 4.6m deep	20.0m×25.0m×4.6m deep x 2nos
Ground Level	+826.23m	+826.23m
Structure	RCC	RCC

Figure 5.24 Location Plan – Iroisemba Hilltop (Low Level)

During the inspection of the 1.81Ml GLSR, a water damp patch was observed on the surface of the reservoir sidewall. According to a PHED official, water leakage appears on the surface when the water reaches high level. Leakage on a valve was also observed in the outlet valve chamber.

Based on the results of the site inspections it is recommended that the following rehabilitation work should be carried out for 1.81Ml GLSR under JICA scope:

- Waterproofing work to the internal walls, using epoxy resin
- Repair of external concrete wall surface and cover slab, using mortar etc.
- Replacement of leaking valves in the valve chambers

See **Photo 5.6** for the current conditions of the 1.81Ml GLSR at Iroisemba hilltop (low level).

	
【1.81ML GLSR】 Site view of 1.81ML GLSR	【1.81ML GLSR】 Damp patches appear on reservoir sidewall.
	
【1.81ML GLSR】 Leakage from valve in outlet valve chamber	

Photo 5.6 Current Conditions of Existing 1.81 GLSR at Iroisemba Hilltop (Low Level)

5） Langjing Hilltop

At the Langjing hilltop GLSR site, rehabilitation of two existing GLSRs and construction of one new GLSR are currently included in the JICA project. The exiting GLSRs have storage capacity of 0.36Ml and 0.45Ml for each. The proposed capacity of the new GLSR is 0.75Ml.

Table 5.38 summarises the details of the existing GLSRs to be rehabilitated and their locations are shown in **Figure 5.25**. This figure also shows the location of the new 0.75Ml GLSR.
The existing GLSRs are positioned side by side and 0.36Ml GLSR is situated at a higher location than the 0.45Ml GLSR.

Table 5.38 Details of Existing GLSRs (Langjing Hilltop)

	0.45 Ml GLSR	**0.36 Ml GLSR**
Capacity	0.45 Ml	0.36 Ml
Year of Construction	1989	1986
Dimensions	9.5m×16.0m x 3.0m deep	11.0m×11.0m x 3.0m deep
Ground Level	+803.99m	+807.49m
Structure	RCC	RCC

Figure 5.25 Location Plan – Langjing Hilltop

A site inspection was carried out at the Langjing hilltop to assess the current conditions of the existing GLSRs.

The external concrete wall surface of the 0.45Ml GLSR generally appears to be in good condition, although there are some locations where water is leaking through cracks on the sidewalls. Also, there was a leak from a valve in the valve pit.

On the other hand, the external concrete wall surface of the 0.36Ml GLSR is in good condition without any sign of leakage on the external walls. According to the PHED, the reservoir cell experienced leakage on the walls in the past and concrete surface was repaired three months ago. The valve pit of the GLSR had, however, leakages from a valve installed within.

Based on the results of the site inspections, it is recommended that the following rehabilitation work should be carried out for both of the GLSRs:

- Waterproofing work to the internal walls, using epoxy resin
- Replacement of leaking valves in the valve chambers

In addition to the above, concrete repair work on the wall surface and cover slab should be carried out to 0.45Ml GLSR.

See **Photo 5.7** for the current conditions of the existing GLSRs at the Irilbung hilltop.

	
【0.45ML GLSR】 Overall view of 0.45Ml. Generally in good condition externally	【0.45ML GLSR】 Leak from valve observed
	
【0.45ML GLSR】 Leak from crack in reservoir wall observed	【0.45ML GLSR】 Leak from crack in reservoir wall observed
	
【0.36ML GLSR】 External concrete surface appears to be good since repair work was carried out three month ago.	【0.36ML GLSR】 Leak from valve observed

Photo 5.7 Current Conditions of Existing GLSRs at Langjing Hilltop

On the Langjing hilltop, a new 0.75 Ml GLSR has been proposed in the DPR, and its construction is currently included in the JICA project. During this survey, the survey team carried out a preliminary design of the GLSR and the proposed GLSR is outlined as shown in **Table 5.39**.

Table 5.39 Details of Proposed GLSR (Langjing Hilltop)

	Details
Capacity	0.75 Ml
Shape	Rectangular Twin Cells
Dimension	6.0m x 16.1m x 5.4m deep x 2 nos.
Proposed GL	GL+810.00m
Structure	RCC
Foundations	Direct foundation

The new GLSR is proposed to be constructed to the south of the existing GLSRs where land space is available. See **Photo 5.8** for the site location and **Figure 5.26** for general arrangement of the site.

The ground level of the new GLSR is higher than the levels of any other existing GLSRs. Therefore, the new GLSR should be designed to receive inflows from MR-2 and water should be cascaded to the downstream of the existing reservoirs before it is supplied for distribution.

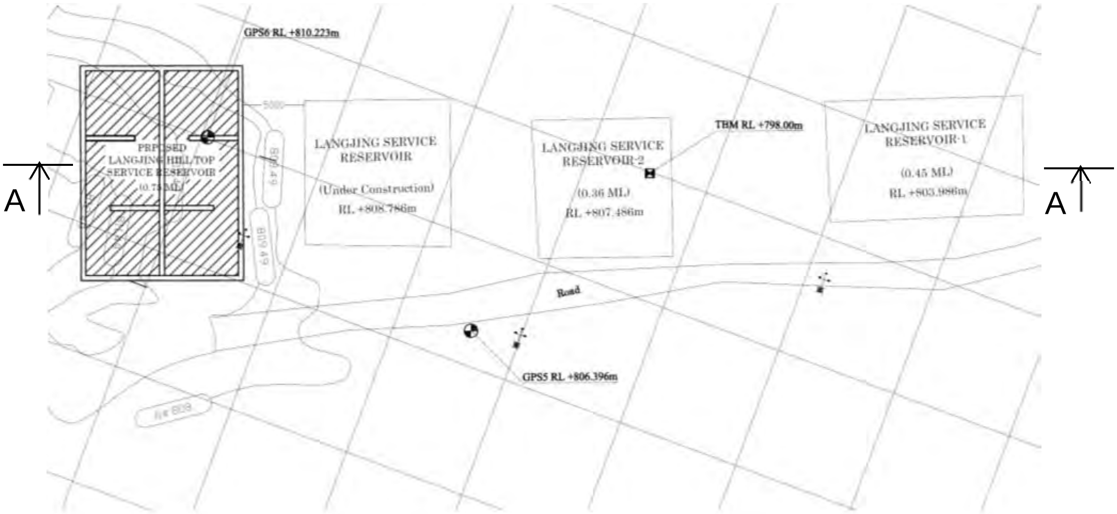
New actuated valves are currently designed to be installed on the inlet of the new GLSR, along with a level sensor for the level control (See **5.6.3** in this document for details). Also, each GLSR at the Langjing hill should be equipped with a float valve on the inlet, so that the valve can be shut automatically when water level in the reservoir reaches overflow level.

The new GLSR is designed to have two cells, which enable one of cells taken out of service for maintenance without causing interruption to the supply. See **Drawing No. IP-RES-LS-002** & **003** for the general arrangement of the proposed new GLSR.

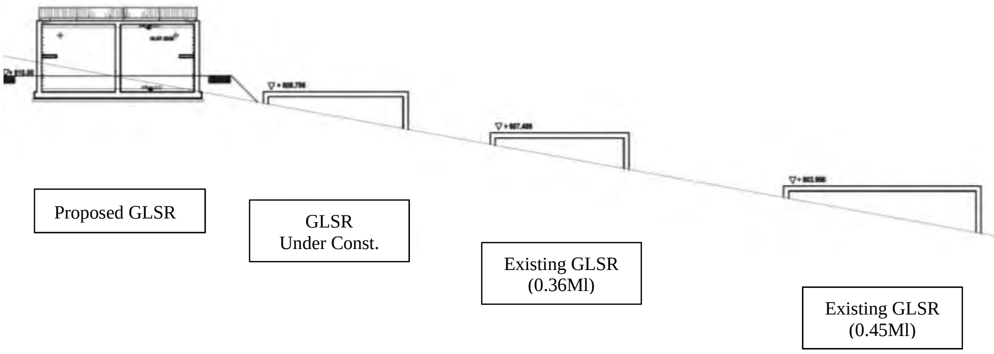
The capacity of the new GLSR is based on the proposal in the DPR, although it may not be sufficient for the four GLSRs on the Langjing hill to balance the demand in Langjing zone as discussed in **5.5.3 (2)** of this report. Since it would not be possible to construct a new GLSR with larger capacity at this site due to the site space limitation, alternative distribution method (including suggested option referred in **5.5.3 (2)**) should be investigated further during the detailed design stage of this project.

【Proposed Reservoir Construction Site】
Level of new GLSR is higher than other existing GLSRs.

Photo 5.8 Proposed Construction Site of New GLSR at Langjing Hill



a) Plan



b) Section (A-A)

Figure 5.26 General Site Arrangement at Langjing Hill

6) Langol Housing Complex Hilltop

Langol housing complex is located to the north west of Iroisamba West Water Supply Zone. According to a PHED official, there used to be borehole wells in the area but they were abandoned in 1990's due to depletion of the ground water. Since then, the residents in the zone are using hand pumps installed in the community for their water supply.

This area was not included in the future water supply zone at the time of the production of the DPR. During this survey, PHED requested that this area should be included in the water supply zone and that the necessary infrastructures, such as distribution mains and service reservoirs, are to be built as a part of the JICA project scope. Subsequently, a site survey and preliminary design of the distribution system in this zone was carried out in this survey.

Considering the topography of the area, it is proposed that two new GLSRs should be built in this zone, one supplying the south side of the zone and the other supplying the north side. This reservoir arrangement is same as that of the old water supply system when the area was supplied by borehole wells. The new GLSRs will be sited at the locations of the disused old service reservoirs and each site is owned by PHED.

Figure 5.27 shows area map indicating the proposed locations of the new GLSRs, as well as new distribution mains in the zone. **Photo 5.9** Proposed Construction Site of New GLSRs at Langol Housing Complex shows views of proposed construction sites of the new GLSRs.

Figure 5.27 Location Map for New GLSRs - Langol Housing Complex (JICA Scope)

	
【Langol Housing Complex Zone 1 GLSR】 Open space available to build proposed 0.23Ml GLSR.	【Langol Housing Complex Zone2 GLSR】 Existing disused GLSR to be demolished prior to construction of new 0.17Ml GLSR.

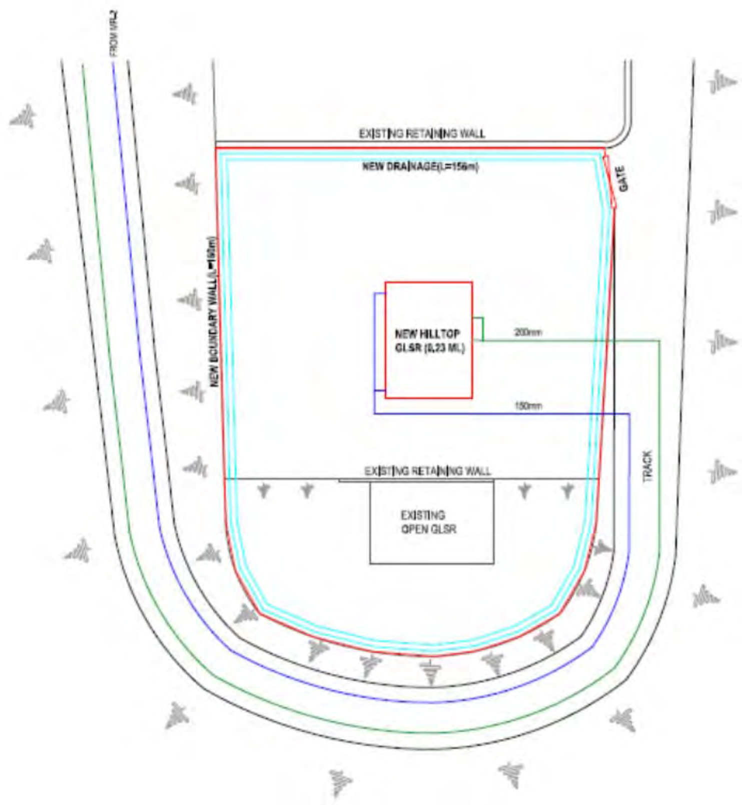
Photo 5.9 Proposed Construction Site of New GLSRs at Langol Housing Complex

Table 5.40 summarises the results of the prelimanary design carried out for the new GLSRs. Regarding the required capacity of Zone 1 and Zone 2 GLSRs, the storage capaicty for each GLSR was first calculated, using the mass balance method in the CPHEEO manual. The results indicated that 0.14Ml and 0.10Ml would be required for the respsetitve GLSRs, which provides 7-8 hours' storage capacity. In general, small zones, such as Langol Housing Complex zone, are more susceptible to diurnal demand fluctuation. Also, there is no alternative supply for the Langol Housing Complex zone. It was therefore agreed with PHED that these GLSR should be designed to provide 12 hours' supply capacity and the proposed storage capacity was determined.

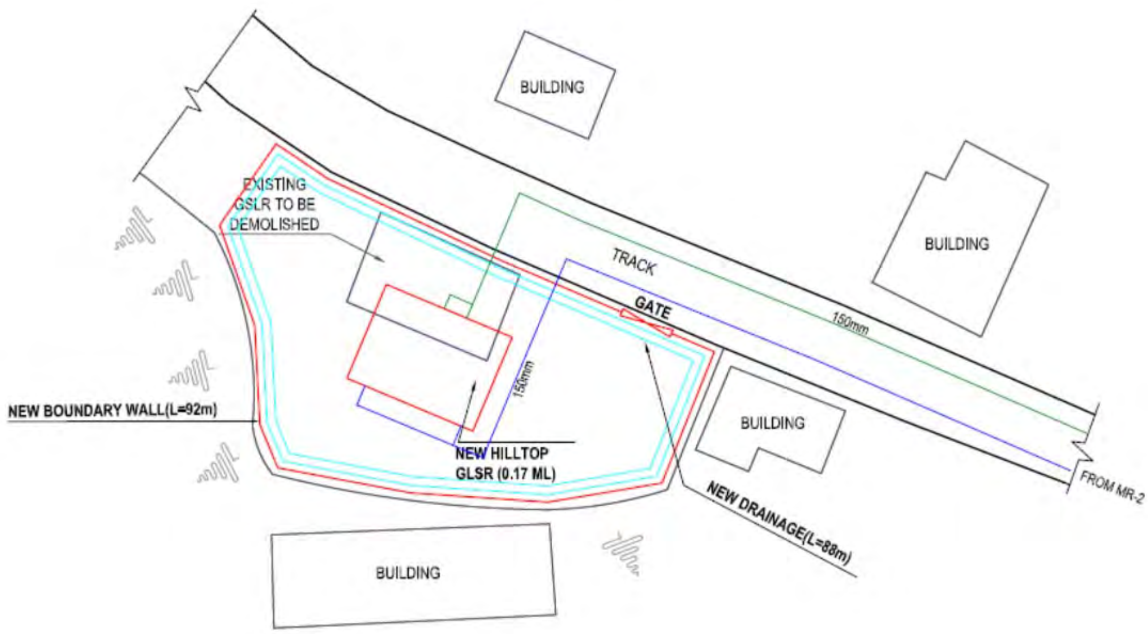
Table 5.40 Details of Proposed GLSRs (Langol Housing Complex)

	Zone 1 GLSR	Zone 2 GLSR
Capacity	0.23 Ml	0.17 Ml
Shape	Rectangular	Rectangular
Dimension	5.1m x 7.6m x 3.3m deep x 2 nos.	4.4m x 6.6m x 3.3m deep x 2 nos.
Proposed GL	GL+834.88m	GL+841.86m
Structure	RCC	RCC
Foundations	Direct foundation	Direct foundation

See **Figure 5.28** for the general site arrangement of the both proposed GLSRs. See **Drawing No. IP-RES-LA1-002** and **IP-RES-LA2-002** for the general arrangement of the proposed reservoir structures.



a) Langol Housing Complex Zone 1 GLSR



b) Langol Housing Complex Zone 2 GLSR

Figure 5.28 General Site Arrangement (Langol Housing Complex GLSRs)

5.5.4 Overhead Tanks

(1) General Arrangement of Overhead Tanks

A total of 23 overhead tanks (OHTs) are proposed to be built for the Imphal new water supply system in the DPR. Among these, 21 OHTs are currently included in the JICA scope and these OHTs are all situated in the low-lying area of the Imphal city. See **Figure 5.29** and **Drawing No. IP-WSS-NE-001** for the approximate locations of the OHTs. **Table 5.41** shows a summary of the proposed OHTs to be delivered by the JICA project.

The proposed capacity of the OHTs was standardized to be 0.45, 0.60, 0.80, 1.50 and 3.00Ml in the design of the DPR. The proposed staging height of the OHTs designed in the DPR is approximately 13-15m.

Most of the OHTs are designed to receive bulk water from master reservoirs via transmission mains by gravity, however some OHTs will receive bulk water from clear water reservoirs at the WTP by pumping. These OHTs include Khuman Lampak OHT, Ningthepukhri OHT, Old Thumbuthong Shift 1 OHT, Old Thubuthong Shift 2 OHT and Porompat Shift 1B OHT.

The 11 OHTs included in the JICA scope will also have a ground level emergency reservoir (GLER) and pumping station as illustrated in **Figure 5.29**. The provision of the GLER is not specified in the CHPEEO manual, however, according to the PHED officials, the provision of 11 GLERs has already been accepted by the CHPEEO at the time of the review of the DPR. Note that some of the overhead tanks are not provided with a GLER. According to PHED, this is due to i) lack of land space, ii) existing GLSR being converted to GLER, or iii) overhead tank being located within or near a WTP and receiving water from clear water reservoir. The reason for not building the GLER at each site is also shown on **Table 5.41.**

Under normal operation, the OHT with a GLER receive inflows from a transmission main and GLER is isolated from the transmission main. However, stored water in the GLER will be supplied to the OHT in the event of loss of supply from the transmission main.

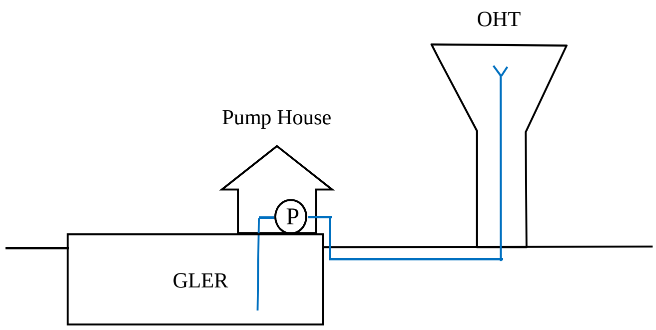


Figure 5.29 General Arrangement of OHT with GLER

Table 5.41 Proposed Overhead Tanks in DPR (JICA Scope)

No.	OHT Name	Master / WTP Zone	OHT Capacity (Ml)	Provision of GLER	GLER Capacity (Ml)
1	Nepra Menjor	MR-2	0.80	N (1)	-
2	Sangaiprou	MR-6	1.50	Y	0.45
3	Irom Pukhri	MR-6	0.60	N (1)	-
4	Chingthamleikai	MR-6	1.50	N (2)	-
5	Keishampat	MR-6	0.80	N (1)	-
6	Lalmbung	MR-6	0.80	N (1)	-
7	Lilandolampak Shift 1	MR-3	0.45	Y	0.20
8	Lilandolampak Shift 2	MR-3	0.45	Y	0.20
9	Minuthong	Minuthong WTP	1.50	N (1)	-
10	Khuman Lampak	Khuman Lampak	0.80	N (3)	-
11	Ningthepukhri Zone	Ningthepukhri WTP	0.80	N (3)	-
12	Old Thumbuthong Shift 1	Old Thumbuthong WTP	0.60	N (3)	-
13	Old Thumbuthong Shift 2	Old Thumbuthong WTP	0.45	Y	0.20
14	Porompat Shift 1B	MR-5	0.45	N (3)	-
15	Porompat Shift 2B	MR-5	1.50	Y	0.45
16	Laiwangma Shift 1	MR-6	0.45	Y	0.20
17	Laiwangma Shift 2	MR-6	0.80	Y	0.20
18	Sajor Leikai Shift 1	MR-6	0.60	Y	0.20
19	Sajor Leikai Shift 2	MR-6	0.45	Y	0.20
20	Ghari	MR-6	3.00	Y	1.00
21	Khongman	MR-3	0.60	Y	0.45

Note : GLER: Ground Level Emergency Reservoir
Y: GLER to be built at OHT site
N (1): GLER cannot be built due to limited site space
N (2): GLER not required as existing GLSR can be converted to GLER
N (3): GLER not required as OHT located within or closer to WTP and receiving water from clear water reservoir

(2) Design of Overhead Tanks

The OHTs proposed in the DPR are of RCC circular tanks supported by staging columns and raft base with a group of foundation piles. See **Table 5.42** for the summary of the OHT design of each storage capacity. **Figure 5.30** shows the general arrangement of the 0.45Ml OHT. See **Drawing IP-OHT-GA-01** to **05** for details of the general arrangement proposed in the DPR for each size of the OHTs.

The design review reveals that the proportions of the structure seems to be adequate as compared to those being constructed elsewhere. The foundations arrangement, including the pile cap being kept 2m below the ground level, also seems to be adequate for weak ground in the Imphal city and may be effective for possible earthquake movements / liquefaction.

Staging height of the proposed OHTs is limited within 15m, although 20m staging height would be required for the 3.00Ml OHT at Ghari according to the hydraulic modelling results, in order to provide necessary pressure into the Ghari distribution zone. Limiting the staging height would be preferable in terms of earthquake resistance as Imphal falls under seismic zone V. Lower staging height is also advantageous in terms of construction costs.

The proposed OHTs are designed to be supported by a group of RCC bored piles. During this survey, the survey team obtained five logs of boreholes sunk in the Imphal city in the past. In addition to this, borehole investigation was carried out at three locations during this survey (i.e. Sajor Leikai, Ghari, Lilandolampak) to ascertain the general ground conditions of the project area. According to the borehole logs, ground bearing below the ground surface is low and the underlying soil layers exhibit high settlement potential. Therefore, it was confirmed that the piling arrangement proposed in the DPR design is adequate.

It should be noted that further borehole investigation will be required at each OHT location for the foundation design during the detailed design stage. Also, design of OHTs shall be further reviewed during the detailed design stage in terms of achieving economical design, as well as maintaining adequate pressures in the distribution zones.

Table 5.42 Summary of OHT Design in DPR

Storage Capacity (Ml)	Staging Height (m)	Top Dome Height (m)	Max. Water Depth (m)	Water Tank Diameter (m)	Pile Cap Diameter (m)	RCC Column	RCC Foundation Pile
0.45	15.0	23.5	6.8	9.6	12.9	D450 × 12	D550 × 67 × 27m deep
0.60	15.0	23.8	6.9	11.2	12.8	D550 × 12	D550 × 67 × 27m deep
0.80	12.0	21.5	7.5	12.3	14.7	D550 × 12	D550 × 67 × 27m deep
1.50	14.6	26.0	8.7	16.1	20.7	D600 × 16	D600 × 67 × 27m deep
3.00	13.0	26.6	9.5	22.0	29.3	D900 × 16	D900 × 67 × 27m deep

Source：DPR design drawings

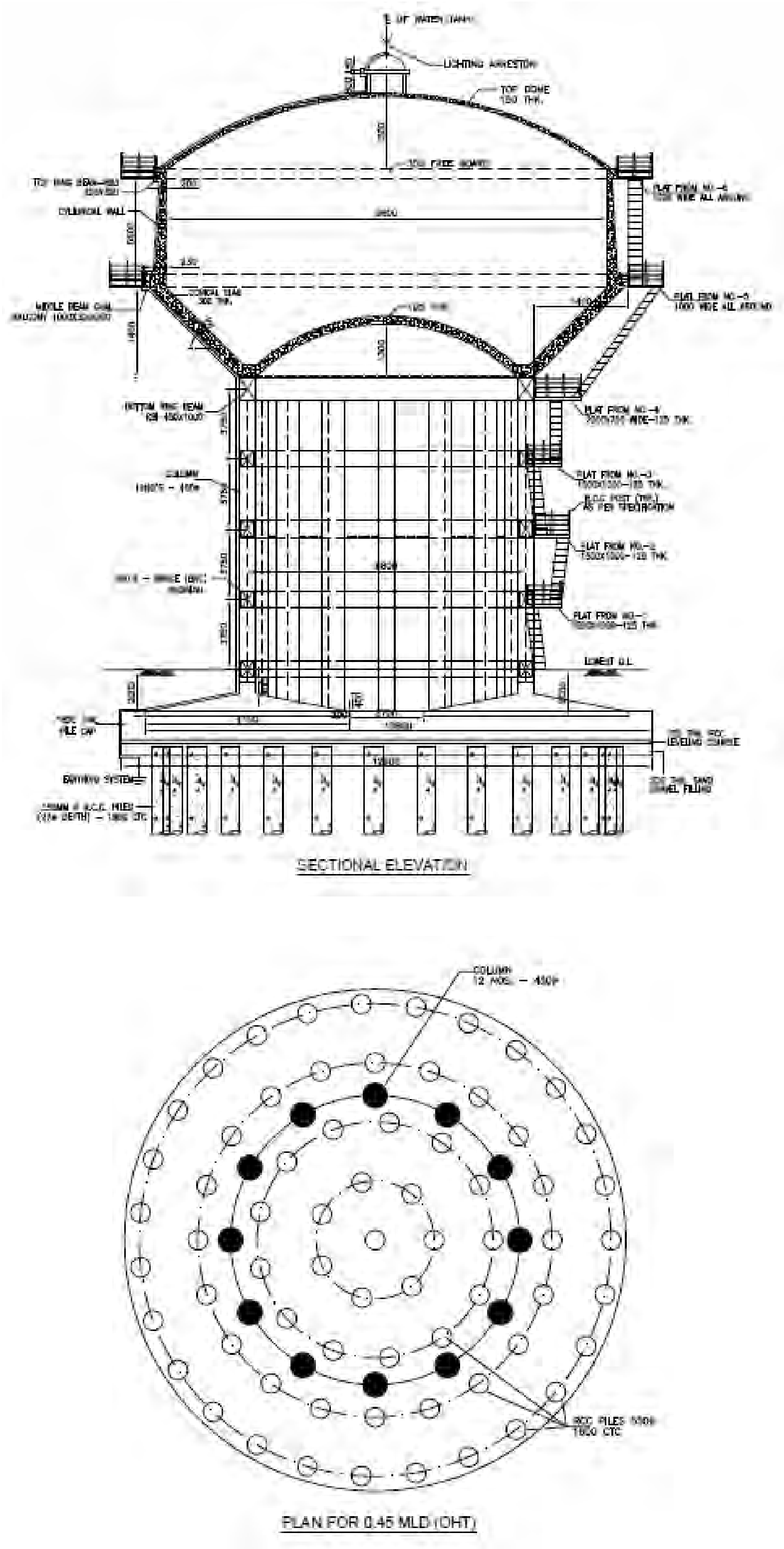


Figure 5.30 General Arrangement of Overhead Tank (0.45Ml)

(3) Assessment of Proposed Storage Capacity

The main function of the OHTs is to balance the fluctuating demand from the distribution network, permitting the source to give a steady output. The DPR contains storage capacity calculations for each water supply zone, using the mass diagram method referenced in the CPHEEO manual.

During this survey, storage capacity calculations were checked to see if the original calculations were made correctly. The results of the calculations are contained in **Appendix A5.5 (1)**. The results confirm that there is no error found in the original calculations.

Table 5.43 shows proposed storage capacities and calculated storage requirement for each overhead tank (or a group of overhead tanks supplying the same supply zone). In general, values of the proposed storage capacity were given close to or higher than calculated values of the calculated storage requirement. However, it should be noted that the proposed storage capacity for the new Khuman Lampak OHT is smaller than the calculated storage requirement. This is because that the existing steel OHT was assumed to be retained at the time of the preparation of the DPR. However, the site survey revealed that the steel OHT and its staging are in bad condition. It was therefore agreed with PHED that the existing steel OHT is to be demolished and that the capacity of the new Khuman Lampak OHT be increased to 1.50Ml to ensure uninterrupted supply in the zone.

Regarding the storage capacity proposed in the DPR, another point should be noted is that peak factor of 2.5 was used in the calculations of the storage deficit in the DPR, whereas peak factor of 3 was used for pipe sizing of the distributions mains. If peak factor of 3 was used for the reservoir storage calculations, the required reservoir capacity would be larger than the current values. **Table 5.43** shows calculated water retention time in each (or group of) OHT. According to the results, each reservoir achieves 6 to 8 hours' supply capacity or more than 25% of the average daily zonal demand at minimum. This should be considered sufficient to level out the hourly fluctuation of demand from a distribution system. Hence, the currently proposed storage capacity of each overhead tank (except for Khuman Lampak OHT) should be considered to be adequate.

Table 5.43 Storage Capacity of Proposed OHT and Water Retention Time

No.	Name of OHT	New / Existing / Under Const.	Funding Agency	Proposed Storage Capacity (Ml)	Total Proposed Storage Capacity (Ml)	Calculated Storage Requirement (Ml)	Water Supply Zone	2046 Zonal Demand (Mld)	Water Retention Time (hrs)
1	Nepra Menjor	New	JICA	0.80	1.70	1.40	Nempra Menjor	4.893	8.3
2	Nepra Menjor	Existing	-	0.45					
3	Thiyam Leikai	Under Const.	-	0.45					
4	Sangaiprou	New	JICA	1.50	1.50	1.30	Sangaiprou	4.440	8.1
5	Irom Pukhri	New	JICA	0.60	0.60	0.60	Irom Pukhri	2.105	6.8
6	Chingthamleikai	New	JICA	1.50	1.50	1.60	Chingthamleikai	5.274	6.8
7	Keishampat	New	JICA	0.80	1.25	1.20	Keishampat	4.160	7.2
8	Keishampat	Existing	-	0.45					
9	Lalmbung	New	JICA	0.80	0.80	0.80	Lalmbung	2.839	6.8
10	Assembly	Existing	-	0.45	0.45	0.50	Assembly	1.859	5.8
11	Lilandolampak Shift 1	New	JICA	0.45	0.90	0.60	Lilandolampak	2.065	10.5
12	Lilandolampak Shift 2	New	JICA	0.45					
13	Minuthong	New	JICA	1.50	1.50	1.40	Minuthong	4.709	7.6
14	Khuman Lampak	New	JICA	0.80	0.80 (1.50)	1.20	Khuman Lampak	4.186	4.6 (8.6)
15	Ningthepukhri	New	JICA	0.80	1.25	1.40	Ningthepukhri	4.887	6.1
16	Ningthepukhri	Existing	-	0.45					
17	Old Thumbuthong Shift 1	New	JICA	0.60	1.05	1.00	Old Thumbuthong	3.441	7.3
18	Old Thumbuthong Shift 2	New	JICA	0.45					
19	Porompat Shift 1A & 2A	New	JNNURM	3.00	4.95	5.10	Porompat	17.137	6.9
20	Porompat Shift 1B	New	JICA	0.45					
21	Porompat Shift 2B	New	JICA	1.50					
22	Laiwangma Shift 1	New	JICA	0.45	1.25	1.10	Laiwangma	3.713	8.1
23	Laiwangma Shift 2	New	JICA	0.80					
24	Sajor Leikai Shift 1	New	JICA	0.60	1.05	0.90	Sajor Leikai	3.048	8.3
25	Sajor Leikai Shift 2	New	JICA	0.45					
26	Ghari	New	JICA	3.00	3.00	3.00	Ghari	10.102	7.1
27	Sangakpham	New	JNNURM	1.50	1.50	1.50	Sangakpham	5.122	7.0
28	Khongman	New	JICA	0.60	0.60	0.60	Khongman	2.061	7.0

Note: 1) Storage deficits were calculated by the method given in CPHEEO Manual Appendix 10.1

2) ( ): Change in capacity of OHT is recommended.

(4) Water Levels of Overhead Tanks

Water levels of the proposed OHTs are determined by the ground level and staging height of the respective OHT. For the hydraulic modelling of this survey, water levels of overhead tanks were provisionally set and details of the levels using in the hydraulic modelling work can be referred in **Appendix 5.8 (2)**. However, water levels of each OHT shall again be determined during the detailed design stage through structural design of the OHTs and hydraulic modelling work for the distribution zones.

(5) Site Layout and Construction Issues

During this survey, the survey team visited proposed sites of the OHTs and GLERs with PHED officials. The purpose of the visit was to check i) current land usage, ii) landownership, iii) land space availability for the construction of the proposed OHTs and GLERs. Following the site visit, the layout of proposed facilities at each site was preliminary designed.

Table 5.44 summarizes the findings of the site visit and subsequent desktop study. Most of the sites are existing operational sites of PHED or public open spaces which are owned by the state government. The only site where land is owned by a private owner is Sajor Leikai Shift 1. According to PHED, the landowner of the site has already assured the PHED that the land would be donated to the state government for the construction of the overhead tank.

See **Drawings IP-OHT-LA-001** to **021** for the proposed layout of each site. Note that there are some sites where space of the land is limited for the construction of the proposed OHTs and GLERs, although it has been confirmed that all the OHTs and GLERs proposed in the DPR can still be constructed at the proposed sites.

It should be noted that there are sites where existing structures need to be demolished and / or the sites need to be prepared in advance to enable the construction of the overhead tanks and other facilities. Having discussed this issue with PHED, it was confirmed that any necessary enabling works would be carried out by PHED, using a separate funding, prior to commencement of the construction work under the JICA project.

Table 5.44 Summary of Land Issues at Proposed OHT Sites

No.	OHT Name	Current Land Usage of Proposed Site	Need for Land Purchase	Space Availability	Remarks
1	Nepra Menjor	Existing OHT / GLSR site	N	Y	Existing GLSR and PS needs to be demolished for construction.
2	Sangaiprou	Existing GLSR site	N	Y	Existing GLSR and PS needs to be demolished for construction.
3	Irom Pukhri	Existing GLSR site	N	Y	Existing GLSR needs to be demolished for construction.
4	Chingthamleikai	Existing GLSR site	N	Y	Open space available.
5	Keishampat	Existing OHT / GLSR site	N	Y	Existing GLSR needs to be demolished for construction.
6	Lalambung	Open space (PHED site)	N	Y	Existing OHT recently demolished. Open space available.
7	Lilandolampak Shift 1	Open space (currently public area)	N	Y	Land owned by PHED.
8	Lilandolampak Shift 2	Open space (currently public area)	N	Y	Land owned by state government.
9	Minuthong	Existing OHT / GLSR site	N	Y	Existing OHT and GLSR need to be demolished for construction.
10	Khuman Lampak	Existing WTP site	N	Y	Existing OHT needs to be demolished for construction.
11	Ningthepukhri Zone	Existing WTP site	N	Y	Existing RSF building needs to be demolished for construction.
12	Old Thumbuthong Shift 1	Pond	N	Y	Land owned by state government.
13	Old Thumbuthong Shift 2	Open space (currently public area)	N	Y	Land owned by state government. Exiting building needs to be demolished and road needs to be re-aligned for construction. The building owned by state government.
14	Porompat Shift 1B	Existing WTP site	N	Y	Existing structures may need to be demolished.
15	Porompat Shift 2B	School playground next to existing GLSR	N	Y	Land owned by state government.
16	Laiwangma Shift 1	Open space (currently public area)	N	Y	Land owned by state government.
17	Laiwangma Shift 2	Open space (currently swamp)	N	Y	Land owned by state government.
18	Sajor Leikai Shift 1	Open space (currently swamp)	N	Y	Land to be donated to PHED by private landowner.
19	Sajor Leikai Shift 2	Pond	N	Y	Land owned by state government.
20	Ghari	Existing WTP site	N	Y	Existing OHT and other structures need to be demolished.
21	Khongman	School playground next to existing GLSR.	N	Y	Land owned by state government.

5.5.5 Ground Level Emergency Reservoirs

(1) General Arrangement

Ground Level Emergency Reservoirs (GLERs) provide contingency storage to OHTs at the time of loss of supplies from the connected transmission main (e.g. mains burst and subsequent repair work). As discussed in **5.5.4**, some of the overhead tanks are not provided with a GLER. This is due to i) lack of land space, ii) existing GLSR being converted to GLER, or iii) overhead tank being located within or near a WTP and receiving water from clear water reservoir.

The capacity of the GLERs proposed in the DPR is 0.20Ml, 0.45Ml and 1.00Ml. However, there is no detail of the reservoir design presented in the DPR. During this survey, the general arrangement of the GLERs was preliminary designed for each reservoir size. **Figure 5.31** shows the side view of the 0.20Ml GLER. See **Drawings IP-ER-GA-01** to **03** for the proposed general arrangement of each size of the GLERs.

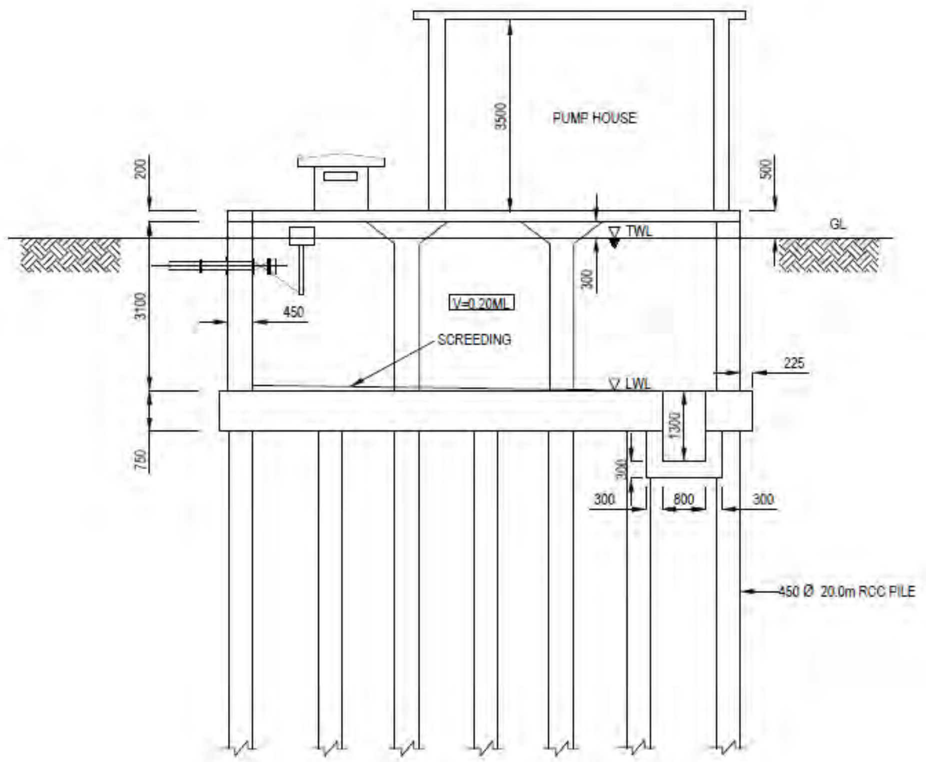


Figure 5.31 Side View of Proposed Ground Level Emergency Reservoir (0.20Ml)

Each GLER is designed to have a pump house built on the cover slab of the reservoir, so that it can be built in a limited space. This arrangement will also reduce the cost of foundation necessary for the pump house if it was built separately. Also, it can eliminate possible flooding in the pump house which may occur if it was built below ground. All the GLERs require piling foundation as they are built in the low-laying area of the city where ground bearing is low and potential of ground settlement is high.

See **5.7** of this report for the design and operation of the pumping stations.

(2) Assessment of Proposed Storage Capacity

The storage capacity of the GLERs should be determined, considering the nature of the source, layout of the mains and contingency measures available. However, there are no calculations or design basis for the proposed storage capacity in the DPR. During this survey, PHED officials stated that CHPEEO had accepted 2 to 3 hours' storage capacity for the GLERs at the time of the project appraisal.

Table 5.45 shows calculated storage time for each proposed GLER. It varies from 2 to 5 hours. In the true sense, these storage times may not be sufficient to respond to major pipe failure events on the transmission mains without causing interruption to supply, however these would provide the ability to maintain the supply in such an event, but only to some extent.

Most of the sites where emergency reservoirs are proposed have limited land space, hence increasing capacity would be difficult. Therefore, alternative method of contingency supply should be sought, including interconnections between supply zones to enable infusion of water from other zones in the event of supply loss. This alternative contingency supply method shall be investigated in detail during the project implementation stage.

Table 5.45 Calculated Water Storage Time in Ground Level Emergency Reservoir

No.	Emergency Reservoir Name	Proposed Storage Capacity (Ml)	Water Supply Zone	DPR 2046 Zonal Demand (Mld)	2046 Estimated Reservoir Inflow (Mld)	Water Storage Time (hrs)
1	Sangaiprou	0.45	Sangaiprou	4.440	4.440	2.43
2	Lilandolampak Shift 1	0.20	Lilandolampak	2.065	1.033	4.65
3	Lilandolampak Shift 2	0.20			1.033	4.65
4	Old Thumbuthong Shift 2	0.20	Old Thumbuthong	1.475	1.475	3.25
5	Porompat Shift 2B	0.45	Porompat	5.193	5.193	2.08
6	Laiwangma Shift 1	0.20	Laiwangma	3.713	1.337	3.59
7	Laiwangma Shift 2	0.20			2.376	2.02
8	Sajor Leikai Shift 1	0.20	Sajor Leikai	3.048	1.742	2.76
9	Sajor Leikai Shift 2	0.20			1.306	3.67
10	Ghari	1.00	Ghari	10.102	10.102	2.38
11	Khongman	0.45	Khongman	2.061	2.061	5.24
12	Sangakpham	0.45	Sangakpham	5.122	5.122	2.11

5.6 Clearwater Transmission Mains

5.6.1 Transmission Mains

(1) Proposed Transmission Mains under the JICA Scope

Various types of clear water transmission mains have been proposed in the DPR. These include:

- Clear water transmission mains from WTP to master reservoir
- Clear water transmission mains from WTP to GLSR and / or OHT
- Clear water transmission mains from master reservoir to GLSR and / or OHT

Drawing No. IP-WSS-NE-001 shows proposed transmission mains in the Imphal water supply scheme.

During this survey, it has been confirmed with PHED that the transmission mains summarised in **Table 5.46** are required to be installed under the JICA funded project:

Table 5.46 Proposed New Clearwater Transmission Mains (JICA Scope)

No.	Transmission Main Name	Type	Total Length
1	Transmission mains from MR-6 to various OHTs in the master zone	Gravity Main	32,461m
2	Transmission mains from MR-2 to Langjing hilltop GLSR, Nepra Menjor OHTs and Thiyam Leikai OHT	Gravity Main	5,931m
3	Transmission main from MR-2 to GLSRs in Langol zone and Langol Housing	Gravity Main	7,922m
4	Transmission mains from Old Thumbuthong WTP to Old Thumbuthong Shift 1 OHT	Pumping Main	175m
5	Transmission mains from Old Thumbuthong WTP to Old Thumbuthong Shift 2 OHT	Pumping Main	460m
6	Transmission main from MR-2 to Iroisemba hilltop low level GLSR	Gravity Main	570m
7	MR-2 & MR-6 Transmission Main Cross Connection (North)	Gravity Main	850m
8	MR-2 & MR-6 Transmission Main Cross Connection (South)	Gravity Main	820m
Total Length in JICA Project Area			49,189m

Note: Above lengths do not cover the lengths of cross connection pipelines between MR-2 & MR-6, discussed in 5.6.2 of this report.
For 7 and 8 in the above table, see **Subsection 5.6.2**.

Figure 5.32 shows locations of these proposed clear water transmission mains. See transmission main route plans (**Drawing No. IP-TM-GA-001** to **006**) for more details of the pipeline routes and service reservoirs which the proposed transmission mains are connected to. Also, refer to **Figure 5.4** or **Drawing No. IP-WSS-NE-001** to see which master reservoir / water supply zones these transmission mains are transferring water to.

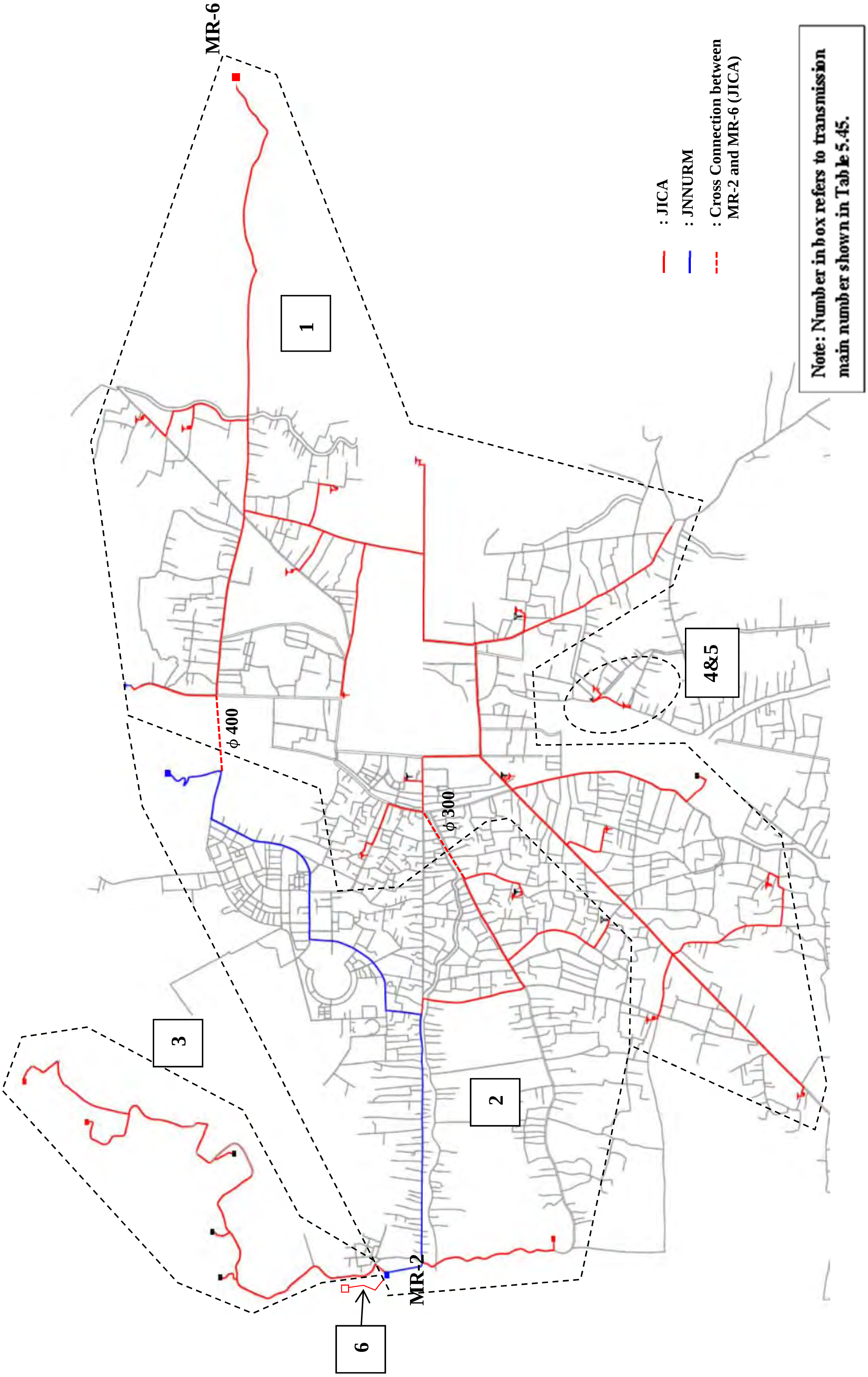


Figure 5.32 Proposed Clearwater Transmission Mains (JICA Scope)

(2) Pipe Material

The pipe material of the transmission mains proposed in DPR is ductile iron (K-9 Class). For large diameter pipes, the use of mild steel pipes is an alternative pipe material option and it may provide lower material cost, compared to ductile iron pipes. Having discussed the pipe material options with PHED, the preference of using ductile iron pipes over the mild steel pipes was expressed, as they claimed that the steel pipes are more susceptible to corrosion and it would be more difficult to maintain good workmanship for the pipe installation on site, such as site welding. Therefore, in the project cost estimation of this survey, it was assumed that ductile iron pipes would be used for this project.

As a part of this study, ground corrositivity tests were carried at 10 trial holes excavated along the proposed route of the proposed transmission mains. The results of the tests indicate that the ground is corrosive to some extent and may affect buried metallic pipes. Further detailed soil assessment would be required during the detail design stage of the project to ascertain the degree of the ground corrositivity and pipe protection method against it. For the project cost estimation in this study, the cost of polyethylene sleeves was included in the material costs.

(3) Hydraulic Design

Following the identification of the required transmission mains within the JICA scope, a hydraulic modelling work was carried out to confirm the diameters of the MR-2 and MR-6 transmission mains.

In the hydraulic modelling, upon the agreement with PHED, each transmission main was designed to transfer 120% of the average zonal demand to the respective service reservoirs over 24 hour’s period to provide extra system capacity. For the modelling, C value of 140 was used as per the CPHEEO design guideline.

Hydraulic modelling diagrams in Appendix (**Drawing No. IP-TM-HM-001** & **002**) show the results of the hydraulic modelling work for the transmission mains from MR-6 and MR-2.

Table 5.47 summarises lengths of proposed transmission mains in different diameters. See also **Drawing No. IP-TM-GA-001** to **006** for details of the pipeline routes, as well as the selected diameter for each section of the mains.

Table 5.47 Summary of Length of New Transmission Mains (JICA Scope)

No.	Transmission Main's Name	Pipe Length (m)												Total Length
		150mm	200mm	250mm	300mm	350mm	400mm	450mm	500mm	700mm	800mm	900mm	1000mm	(m)
1	MR-6 Chingkheiching Master Reservoir Zone Transmission Mains	0	0	691	10,194	4,238	3,329	0	1,927	2,248	445	5,253	4,136	32,461
2	MR-2 Iroisemba Master Reservoir Zone Transmission Mains	0	1,358	30	2,890	0	1,482	171	0	0	0	0	0	5,931
3	Langol Zone Transmission Mains	2,843	3,315	0	1,764	0	0	0	0	0	0	0	0	7,922
4	Old Thumbuthong Zone Transmission Mains (Shit 1)	0	175	0	0	0	0	0	0	0	0	0	0	175
5	Old Thumbuthong Zone Transmission Mains (Shit 2)	0	460	0	0	0	0	0	0	0	0	0	0	460
6	MR-2 to Iroisemba Low Level GLSR Transmission Main	0	0	0	0	570	0	0	0	0	0	0	0	570
7	MR-2 & MR-6 Transmission Main Cross Connection (North)	0	0	0	0	0	850	0	0	0	0	0	0	850
8	MR-2 & MR-6 Transmission Main Cross Connection (South)	0	0	0	820	0	0	0	0	0	0	0	0	820
Total Length in JICA Project Area (m)		2,843	5,308	721	15,668	4,808	5,661	171	1,927	2,248	445	5,253	4,136	49,189

Note: For 7 and 8 in the above table, see **Subsection 5.6.2**.

(4) Other Design and Construction Issues

In this survey, the routes of the proposed transmission mains were surveyed and it was revealed that there are no major physical obstructions along the routes, apart from river crossings. **Table 5.48** lists the details of the identified river crossing points for the proposed transmission mains. Also, see transmission main route plans (**Drawing No. IP-TM-GA-001** to **006**) for their locations.

The existing transmission mains at river crossing points are installed on truss bridges. For the new transmission mains, the same river crossing method should be adopted for the ease of the construction. See **Photo 5.10** for an existing river crossing, as well as some of river crossing points for the new transmission mains.

During this survey, various utilities companies were contacted to identify underground services buried along the proposed pipeline routes. The only existing buried infrastructures identified are telecommunication cables. However, it is envisaged that these cables will not affect the pipe-laying of the proposed transmission mains.

Table 5.48 Summary of River Crossing for Transmission Mains (JICA Scope)

No.	Transmission Main	River Name	Location	Crossing Length	Pipe Diameter	Remarks
1	Transmission Main from MR-6	Irill River	24°49'19.84"N, 93°59'08.08"E	65m	1000mm	
2	Transmission Main from MR-6	Kongba River	24°49'22.44"N, 93°58'17.64"E	20m	1000mm	
3	Transmission Main from MR-6	Imphal River	24°49'24.73"N, 93°57'37.07"E	50m	400mm	
4	Transmission Main from MR-6	Imphal River	24°48'50.65"N, 93°56'56.48"E	70m	300mm	300mm dia. new distribution main (Minuthong zone) also to be installed on the same truss bridge
5	Transmission Main from MR-6	Imphal River	24°48'09.31"N, 93°56'36.36"E	45m	900mm	
6	Transmission Main from MR-6	Nambul River	24°48'27.48"N, 93°55'59.53"E	10m	300mm	350mm dia. new distribution main (Iroisemba East zone) also to be installed on the same truss bridge
7	Transmission Main from MR-6	Nambul River	24°47'59.19"N, 93°56'07.04"E	35m	800mm	300mm and 350mm dia. new distribution mains (Keishampt zone) also to be installed on the same truss bridge
8	Transmission Main from MR-6	Nambul River	24°47'02.04"N, 93°56'02.69"E	35m	300mm	
9	Transmission Main from MR-2	Lubangi River	24°48'25.83"N, 93°53'19.65"E	25m	400mm	
10	Transmission Main from MR-2	Lubangi River	24°48'26.50"N, 93°54'53.22"E	25m	300mm	300mm dia. new distribution main (Iroisemba East zone) also to be installed on the same truss bridge

	
【Existing River Crossing at Kongba River 】	【Irill River Crossing point for 1000mm dia. MR-6 Transmission Main】
	
【Imphal River Crossing point for 900mm dia. MR-6 Transmission Main】	【Nambul River Crossing point for 300mm dia. MR-6 Transmission Main】

Photo 5.10 Existing Pipe Bridge and River Crossing Points for New Transmission Mains

Most of the pipeline sections will be installed in public highways, which include national and state highway. All the roads in the Imphal city is maintained by the Public Work Department (PWD). The survey team had a meeting with PWD's official to discuss the pipe-laying in the public roads. PWD envisages that there would be no major issues with the proposed pipe-laying, but they stated that application of pipe-laying shall be made to the PWD prior to the construction. They also stated that highway reinstatement will be carried out by them, hence the need to pay advance payment before the permission is granted.

The trial hole investigation carried out in this survey also confirmed that there is no hard ground (e.g. rocky ground) identified at the locations of the trial holes and it is envisaged that there should be no problems with trenching work for the proposed transmission mains.

5.6.2 Cross Connections for Emergency Supply

Some sections of the transmission mains from the MR-2 and MR-6 are planned to be laid approximately one km apart in the centre of the Imphal city. Making cross connections between the two transmissions systems could provide contingency supply from one system to the other when supply from one of the master reservoir has been lost or reduced.

In this study, the following two cross connection options were investigated:

Option 1:

– 450mm dia. cross connection pipeline in Uripok Kangchup Road (1.8km in length)

Option 2:

– 300mm dia. cross connection pipeline in Sagolband Road (820m in length)
– 400mm dia. cross connection pipeline in Thangemiband – Langol Road (850m in length)

Note that the diameter of the cross connection pipes was chosen to be the same diameter as the adjoining mains at each cross connection point.

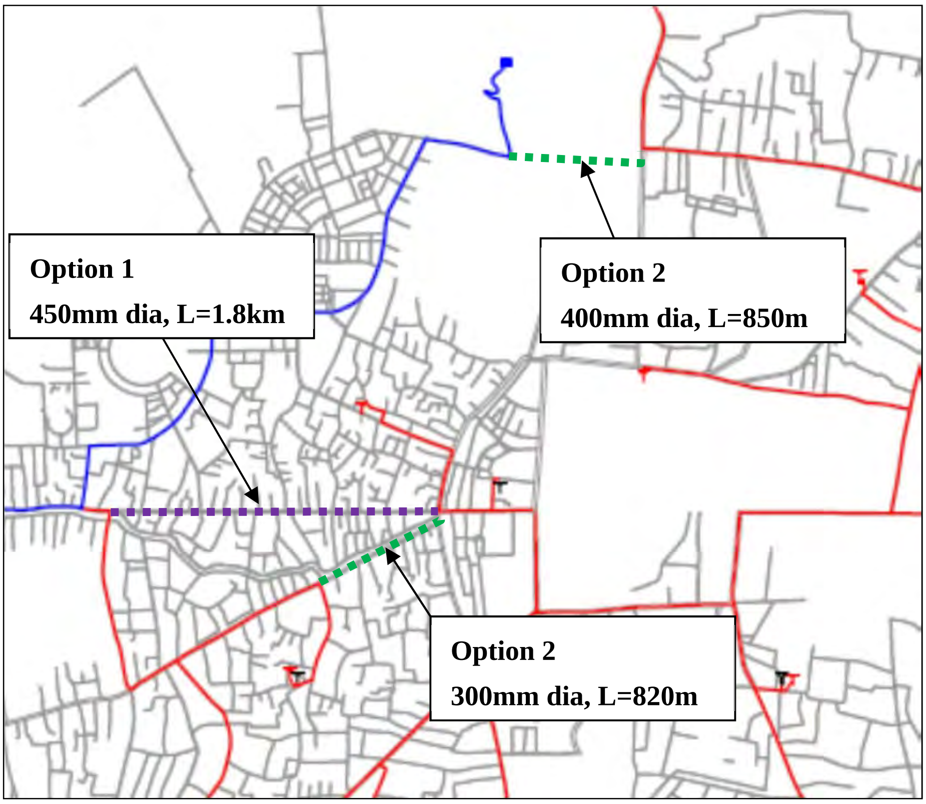


Figure 5.33 MR-2 & MR-6 Transmission Main Cross Connection Options

Following the identification of the possible cross connections, hydraulic modelling simulations were carried out to assess how much flows can be transferred from one transmission system to the other in an event of the outage of the master reservoirs.

For the simulations, it was assumed that the whole supply system would undergo intermittent supply in the contingency event. For example, in case that MR-6 has been taken out of service, MR-2 would be used to supply water to the OHTs in the MR-6 supply zone for a certain period of time, whilst the OHTs and GLSRs in the MR-2 supply zone are isolated from the MR-2 transmission mains. The supply to MR-2 supply zone would then be resumed after MR-6 zone has received the emergency supply from the MR-2.

The following are the source outage cases and **Table 5.49** shows the results of the simulations.

Case A: Outage of MR-2

Case B: Outage of MR-6

Table 5.49 Results of Hydraulic Modelling Simulations (Emergency Cases)

	Transfer Flow Rate	
	From MR-6 to MR-2 Zone	**From MR-2 to MR-6 Zone**
Cross Connection Options 1		
Case A	10.5 Mld	-
Case B	-	22.5 Mld
Cross Connection Options 2		
Case A	12.7 Mld	-
Case B	-	24.4 Mld

The results indicate that Cross Connection Option 2 would provide higher transfer capacity during the emergency events. The simulated flow rates of 12.7Mld and 24.4Mld in Option 2 equates 56% and 46% of the average demand in the respective master reservoir supply zones. The Cross Connection Option 2 would also entail less capital cost, compared to Option 1. It is therefore proposed that the Cross Connection Option 2 should be adopted.

For the operation of the emergency supply, it should be noted that there would be some reservoirs which cannot be fed by the master reservoirs through the cross connection due to the elevation difference and hydraulic capacity constraints in the transmission mains (e.g. Cheiraoching Hilltop GLSR). Further detailed assessment should be carried out during the detailed design stage of this project.

In the DPR, connections between MR-6 and the following master reservoir / water supply zones have been proposed from the point of view of the future supply and demand balance:

- MR-5 Porompat Master Reservoir Zone
- MR-4 Irilbung Master Reservoir Zone
- Chinga / Moirangkhom WTP Zone
- Minutong WTP Zone

Note that Ningthepukhri WTP is located close to the route of the MR-6 transmission main. Upon a request made by PHED, a connection between the WTP and MR-6 transmission main has been added to the project scope, so that emergency supply can be provided from the transmission main to the WTP in an event of the outage of the WTP.

5.6.3 Operation of Transmission System

(1) Flow Control

For the MR-6 and MR-2 transmission systems, it is proposed to install a motorized valve on each inlet of the connecting service reservoirs as illustrated in **Figure 5.34**. These valves are designed to shut when a level instrument installed in a service reservoir senses that water reaches high water level. It is also proposed that a float valve is installed on the reservoir inlet pipework, in order to isolate the service reservoir when water level reaches overflow level, in case of a failure of the motorized valve or loss of the site power. See also **Figure 5.35** and **Drawing No. IP-ER-GA-04** for the proposed arrangement of the motorized valve and float valve at an OHT site.

For both the MR-6 and MR-2 transmission systems, there will be situations where some of the service reservoirs are filled up quicker than other service reservoirs due to hydraulic characteristics of the transmission systems. For example, service reservoirs with the lower water level and / or those reservoirs located closer to the master reservoir may receive more inflows than other reservoirs. Having the proposed motorized valve one each service reservoir enables control of flow into each reservoir remotely from the control center via SCADA system. These motorized valves also can be used at the time of a master reservoir emergency event as discussed in the previous section.

Table 5.50 lists the proposed motorized valves to be installed under the JICA project.

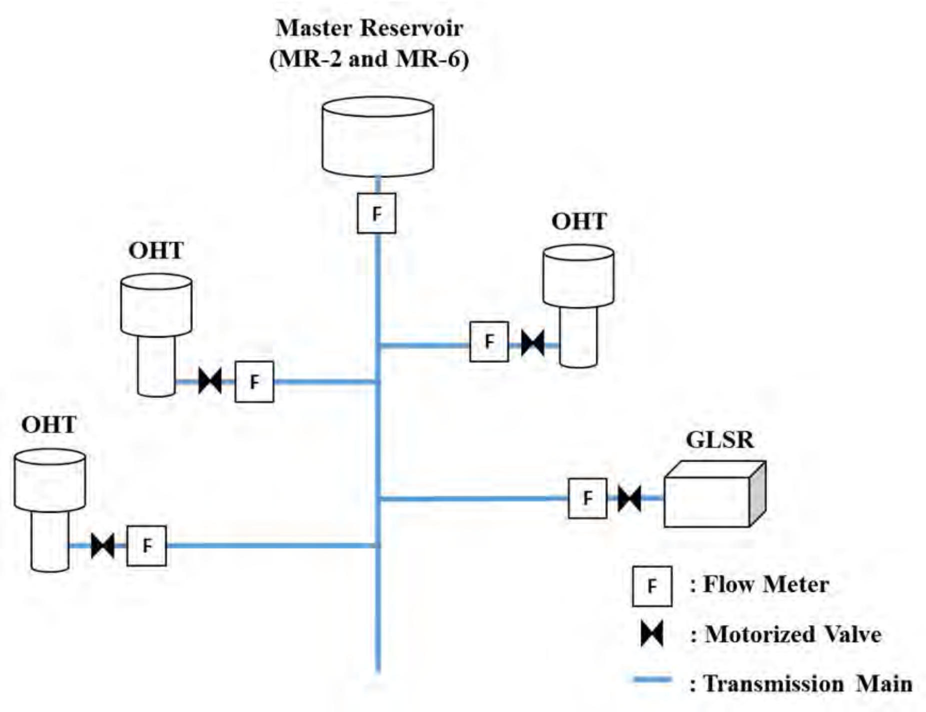


Figure 5.34 Control and Monitoring of Flows in Transmission System

Table 5.50 Proposed Motorized Valves on Transmission Mains (JICA Scope)

No.	Reservoir Name	Reservoir Type	Reservoir Work Funding Agency	Size of Motorized valve to be installed on reservoir inlet
Hilltop GLSR				
1	Langjing Hill (0.75Ml)	New	JICA	400mm
2	Cheiraoching Hilltop	New	JNNURM	350mm
3	Chinga Hilltop (Low Level)	Existing	-	300mm
OHT				
4	Nepra Menjor	New	JICA	250mm
5	Nepra Menjor	Existing	-	200mm
6	Thiyam Leikai	Under Const.	-	200mm
7	Sangaiprou	New	JICA	300mm
8	Irom Pukhri	New	JICA	250mm
9	Chingthamleikai	New	JICA	350mm
10	Keishampat	New	JICA	300mm
11	Keishampat	Existing	-	250mm
12	Lalmbung	New	JICA	300mm
13	Assembly	Existing	-	300mm
14	Minuthong	New	JICA	300mm
15	Porompat Shift 1B	New	JICA	300mm
16	Laiwangma Shift 1	New	JICA	300mm
17	Laiwangma Shift 2	New	JICA	300mm
18	Sajor Leikai Shift 1	New	JICA	300mm
19	Sajor Leikai Shift 2	New	JICA	300mm
20	Ghari	New	JICA	500mm
21	Sangakpham	New	JNNURM	400mm

Note:

1) Motorized valve No.2 to be retrofitted to reservoir inlet of Cheiraoching Hilltop GLSR

2) Motorized valve No.21 to be retrofitted to reservoir inlet of Sangakpham OHT.

(2) Flow Measurement

It is also proposed that an electromagnetic flow meter should be installed on the outlet of the master reservoir and each inlet of the connecting service reservoirs, so that transfer rates to each reservoir can be measured. The data of flow meters can also be used to detect major leakage or pipe burst by comparing the outflow of the master reservoir to combined inflows into the reservoirs on the SCADA. The SCADA system should be programmed so that an alarm can be raised if such an incident occurs and an operator can respond to the incident by closing the valve on the outlet of the master reservoir to contain the outflows.

For other transmission mains to be built under the JICA scheme (i.e. transmission main for Langol zone and Old Thumbuthong OHTs), it is proposed that a flow meter should only installed on the outlet of the reservoirs at this stage. **Table 5.51** lists the proposed flow meters to be installed under the JICA project.

Table 5.51 Proposed Flow Meters on Transmission Mains (JICA Scope)

No.	Reservoir Name	Reservoir Type	Reservoir Work Funding Agency	Flow Meter to be installed on reservoir outlet	Flow Meter to be installed on reservoir inlet
Master Reservoir					
1	Master Reservoir 2	New	JNNURM	500mm	---
2	Master Reservoir 2	New	JNNURM	300mm	---
3	Master Reservoir 6		JICA	1000mm	---
WTP					
4	Old Thumbuthong WTP GLSR	Existing	-	200mm	---
5	Old Thumbuthong WTP GLSR	Existing	-	200mm	---
Hilltop GLSR					
6	Langjing Hill (0.75Ml)	New	JICA	---	400mm
7	Cheiraoching Hilltop	New	JNNURM	---	350mm
8	Chinga Hilltop (Low Level)	Existing	-	---	300mm
OHT					
9	Nepra Menjor	New	JICA	---	250mm
10	Nepra Menjor	Existing	-	---	200mm
11	Thiyam Leikai	Under Const.	-	---	200mm
12	Sangaiprou	New	JICA	---	300mm
13	Irom Pukhri	New	JICA	---	250mm
14	Chingthamleikai	New	JICA	---	350mm
15	Keishampat	New	JICA	---	300mm
16	Keishampat	Existing	-	---	250mm
17	Lalmbung	New	JICA	---	300mm
18	Assembly	Existing	-	---	300mm
19	Minuthong	New	JICA	---	300mm
20	Porompat Shift 1B	New	JICA	---	300mm
21	Laiwangma Shift 1	New	JICA	---	300mm
22	Laiwangma Shift 2	New	JICA	---	300mm
23	Sajor Leikai Shift 1	New	JICA	---	300mm
24	Sajor Leikai Shift 2	New	JICA	---	300mm
25	Ghari	New	JICA	---	500mm
26	Sangakpham	New	JNNURM	---	400mm

Note:

1) Flow meter No.1 to be retrofitted to reservoir outlet of MR-2 for transmission to Cheiraoching, Langjing GLSR and others.
2) Flow meter No.2 to be retrofitted to reservoir outlet of MR-2 for transmission to Langol zone GLSRs.
3) Flow meter No.4 to be installed on new transmission main to Old Thumbuthong Shift 1 OHT.
4) Flow meter No.5 to be installed on new transmission main to Old Thumbuthong Shift 2 OHT.
5) Flow meter No.7 to be retrofitted to reservoir inlet of Cheiraoching Hilltop GLSR.
6) Flow meter No.26 to be retrofitted to reservoir inlet of Sangakpham OHT.

In addition to the proposed flow meters listed in **Table 5.51**, one 350mm flow meter will be required at the termination point of the MR-6 transmission main in Irilbung, in order to measure flow rate of bulk water to be transferred to the Irilbung distribution zone. This meter would need to be installed in highways.

5.7 Clearwater Pumping Stations

5.7.1 Pumping Station at Ground Level Emergency Reservoir

The scope of the JICA project includes the construction of 11 clear water pumping stations at the Ground Level Emergency Reservoir (GLER) sites. Each pumping station is designed to lift water from a GLER to the associated OHT.

As discussed in **5.5.4**, a GLER provides contingency supply to the associated OHT at the time of loss of supplies from the connected transmission main. Therefore, the clear water pumping stations are only required to be operated in such an event. It is proposed that an operator should operate the pumps manually whilst checking water levels in the OHT. It is recommended that the pumps should be operated at least once in a week to turn over the stored water in the GLERs to maintain adequate chlorine level in them. See **Figure 5.35** and **Drawing No. IP-ER-GA-04** for the proposed process diagram of the pumping stations.

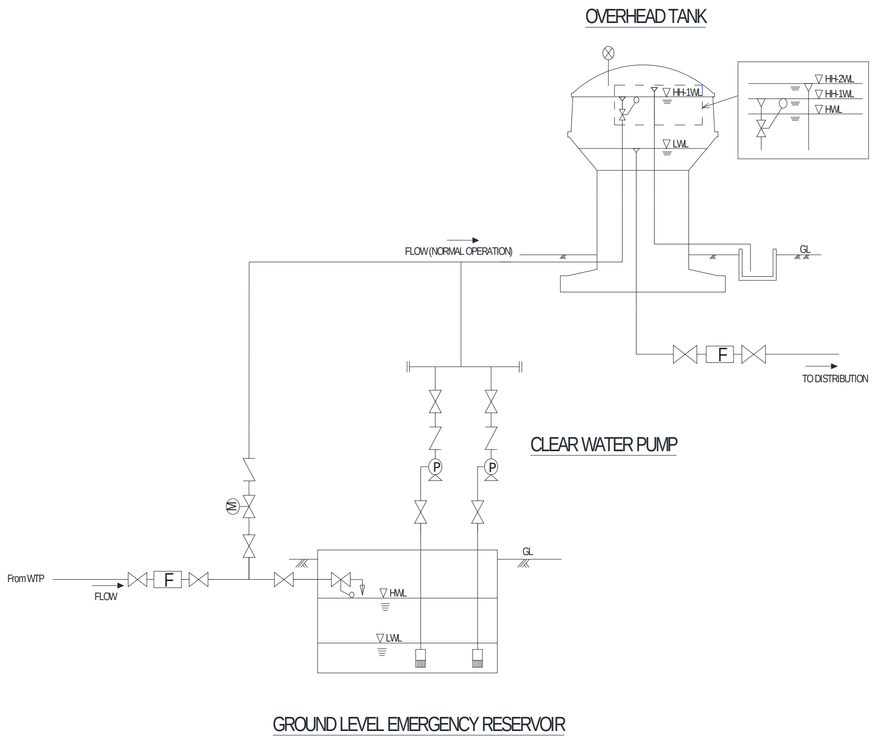


Figure 5.35 Proposed Process Diagram of Clear Water Pumping Stations

As discussed in **5.5.4 (1)**, the pumps will be installed in the pump house, each of which will be built on the cover slab of the emergency reservoir.

At each pumping station, centrifugal pumps are to be installed in duty / standby arrangement with a suction pipe dropped in the GLER. A foot valve should be installed at the bottom of the suction pipe to prevent loss of prime in the pumping system. Details of the proposed pumps at each location are shown in **Table 5.52**.

With regards to power supply to the pumping stations, installation of a low voltage cable (400V) would be required at each site and the cable installation work should be carried out by the electricity distribution company of the Manipur state.

Table 5.52 Details of Clear Water Pumps at Emergency Reservoirs

No.	Name of GLER	Pump Details	Quantity (Unit)	
			Duty	Standby
1	Sangaiprou	150mm x 125mm, 3.7m^3/min x 28m x 30kW	1	1
2	Lilandolampak Shift 1	100mm x 80mm, 0.9m^3/min x 28m x 11kW	1	1
3	Lilandolampak Shift 2	100mm x 80mm, 0.9m^3/min x 28m x 11kW	1	1
4	Old Thumbuthong Shift 2	150mm x 100mm, 1.2m^3/min x 28m x 11kW	1	1
5	Porompat Shift 2B	150mm x 125mm, 2.4m^3/min x 28m x 18.5kW	1	1
6	Laiwangma Shift 1	150mm x 100mm, 1.1m^3/min x 29m x 11kW	1	1
7	Laiwangma Shift 2	150mm x 100mm, 2.0m^3/min x 28m x 15kW	1	1
8	Sajor Leikai Shift 1	150mm x 100mm, 1.5m^3/min x 28m x 15kW	1	1
9	Sajor Leikai Shift 2	150mm x 100mm, 1.1m^3/min x 29m x 11kW	1	1
10	Ghari	250mm x 200mm, 8.4m^3/min x 35m x 75kW	1	1
11	Khongman	150mm x 100mm, 1.7m^3/min x 28m x 15kW	1	1

Note: Power supply: 400V, 50Hz

5.7.2 Other Pumping Stations

The current scope of the work under the JICA project also includes replacing the existing clear water pumps at Old Thumbuthong WTP and Moirangkhom WTP.

At Old Thumbuthong WTP, there is single pump installed in the pump room at present. Under this project, two pump sets are required, one supplying to Old Thumbuthong Shift 1 OHT and the other supplying to Old Thumbuthong Shift 2 OHT. One pump set should be installed in the existing pump room and the other should be installed in the adjoining storage room which needs to be converted to a pump room. See **Photo 5.11** for the locations of the proposed pumps and refer to **Drawing No. IP-PS-GA001** for the general layout of the proposed pumping station.

At Moirangkhom WTP, there is also single pump installed in the pump room at present. The required new pumps are duty / standby pumps to transfer water to the existing Chinga Hilltop GLSR (High Level). The existing pump room may need to be extended to accommodate the new pumps. See **Photo 5.11** for the views of the existing pump room and refer to **Drawing No. IP-PS-GA002** for the general layout of the proposed pumping station.

	
【Old Thumbuthong WTP】 Existing pump room	【Old Thumbuthong WTP】 Existing storage room to be converted to pump room
	
【Moirangkhom WTP】 Existing pump house	【Moirangkhom WTP】 Internal view of existing pump house

Photo 5.11 Locations of New Pump Sets at Old Thumbuthong WTP and Moirangkhom WTP

The type of new pumps at each WTP should be same as existing pump (i.e. single suction volute pump) and these should be installed in duty / standby arrangement. Details of the proposed pumps are shown in **Table 5.53**.

Regarding power supply, power incoming equipment (400V) are already available at both WTPs.

Table 5.53 Details of Replacement Pumps at Existing WTPs

No.	Name of WTP	Supplying Reservoir Name	Pump Details	Quantity (Unit)	
				Duty	Standby
1	Old Thumbuthong	Old Thumbuthong Shift 1	150mm x 100mm, 1.6m^3/min x 32m x 15kW	1	1
2	Old Thumbuthong	Old Thumbuthong Shift 2	150mm x 100mm, 1.2m^3/min x 34m x 15kW	1	1
3	Moirangkhom	Chinga Hilltop (High level)	150mm x 100mm, 2.8m^3/min x 30m x 22kW	1	1

Note: Power supply: 400V, 50Hz

5.8 Distribution Mains

5.8.1 Establishment of Distribution Zones

The DPR proposed to rezone the existing 26 existing water supply zones (WSZs) into six master reservoir zones. The boundaries of each water supply zone were however proposed to be kept same as the existing boundaries. This approach is reasonable as the existing supply zones have already been established in line with topographic features and that keeping the boundaries of the existing water supply zones may be desirable so as not to disrupt well established water supply regimes in the future.

Figure 5.36 and **Drawing No. IP-WSS-NE-002** show the 26 water supply zones in the Imphal city. Out of these zones, 21 water supply zones will be developed under the JICA assisted project. Each water supply zone is adjoining each other, but it is essential to close valves on the zone boundaries to isolate the zones hydraulically. Isolation of the zones enables measurement of inflows into each zone and estimation of NRW levels by installing a flow meter at the outlet of the service reservoirs and readings from customer meters.

Each water supply zone is to be supplied with water from one or multiple zonal reservoirs. For the zones with multiple zonal reservoirs, establishment of sub-zonal boundaries was investigated in this survey, so that each service reservoir can have its dedicated supply zone which is hydraulically isolated from adjoining zones. In total, 37 water supply sub-zones were created in the JICA scope area as shown on **Table 5.54**.

A series of further divided smaller sub-systems is often referred to as District Meter Areas (DMAs). Each DMA is commonly comprised of service connections between 1000 and 2000. The design of the DMAs is a complex process and involves detailed hydraulic modelling to ensure the establishment will not affect pressures in the sub-network. Setting up DMAs may also require high level of capital investment as significant numbers of flow meters would be required. Also, creating DMAs in low pressure zones, such as zones to be supplied by OHTs in the Imphal city, would require additional feeder and reinforcement mains so as not to exacerbate low pressure issues. The establishment of DMA should be investigated in detail during the project implementation stage.

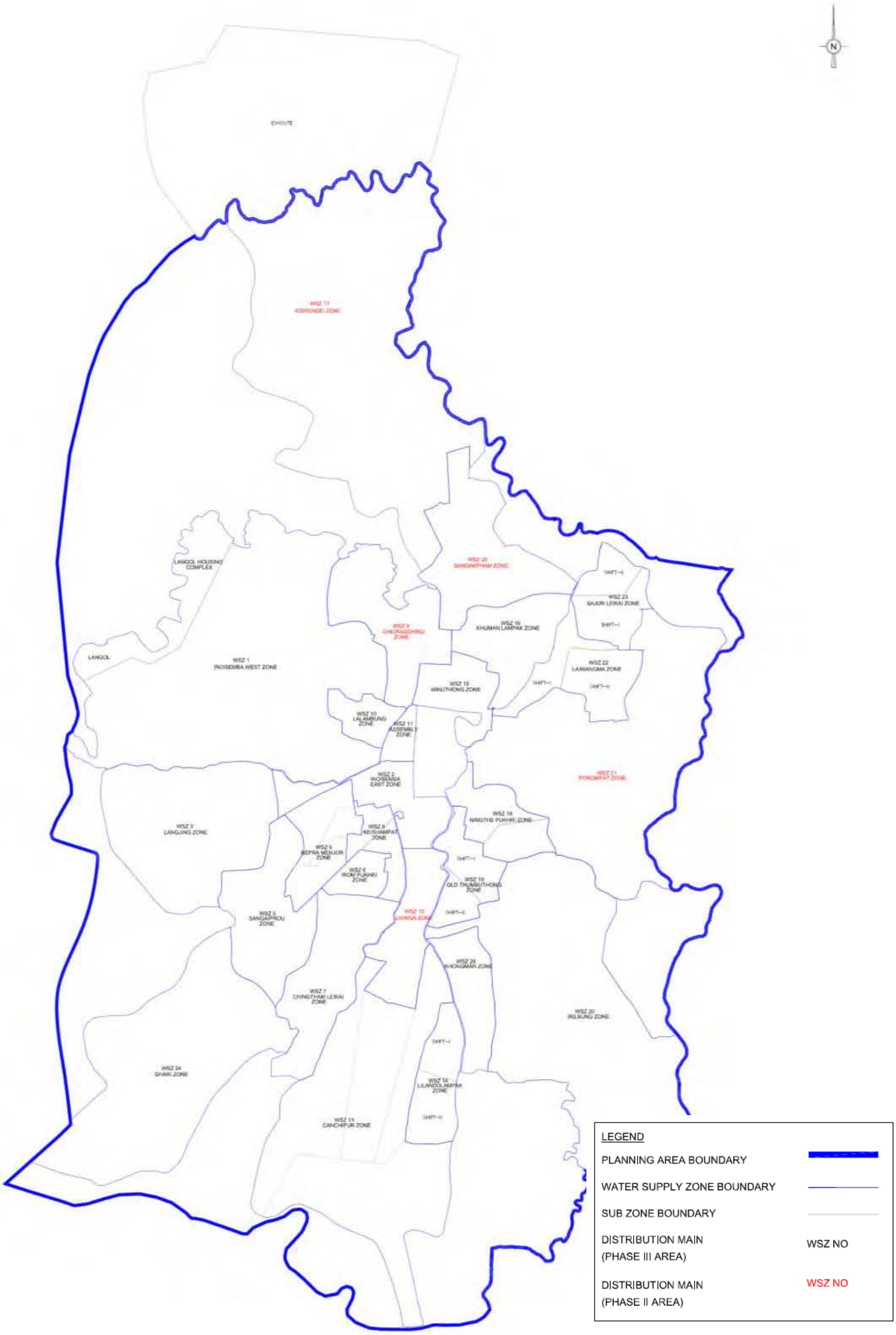


Figure 5.36 Distribution Zones under the JICA Project Area

Table 5.54 Proposed Water Supply Sub-Zones (JICA Scope)

WS Zone	Water Supply Zone	Water Supply Sub-Zone
WSZ1	Iroisemba West	Iroisemba West
		Langol Zone 1
		Langol Zone 2
		Langol Zone 3
		Langol Housing Complex Zone 1
		Langol Housing Complex Zone 2
WSZ2	Iroisemba East	Same as Water Supply Zone
WSZ3	Langjing	Same as Water Supply Zone
WSZ4	Nepra Menjor	Nepra Menjor Existing OHT Zone
		Nepra Menjor New OHT Zone
		Thiyam Leikai OHT Zone
WSZ5	Sangaiprou	Same as Water Supply Zone
WSZ6	Irom Pukhri	Same as Water Supply Zone
WSZ7	Chingthamleikai	Same as Water Supply Zone
WSZ8	Keishampat	Keishampat Existing OHT Zone
		Keishampat New OHT Zone
WSZ10	Lalambung	Same as Water Supply Zone
WSZ11	Assembly	Same as Water Supply Zone
WSZ13	Canchipur	Canchipur Existing 1.27 Ml GLSR Zone
		Canchipur Existing 1.14 Ml GLSR Zone
		Canchipur Existing 1.36 Ml GLSR Zone
		Canchipur New 1.00 Ml GLSR Zone
WSZ14	Lilandolampak	Lilandolampak Shift 1 Zone
		Lilandolampak Shift 2 Zone
WSZ15	Minuthong	Same as Water Supply Zone
WSZ16	Khuman Lampak	Same as Water Supply Zone
WSZ18	Ningthepukhri	Ningthepukhri Existing OHT Zone
		Ningthepukhri New OHT Zone
WSZ19	Old Thumbuthong	Old Thumbuthong Shift 1 OHT Zone
		Old Thumbuthong Shift 2 OHT Zone
WSZ20	Irilbung	Same as Water Supply Zone
WSZ22	Laiwangma	Laiwangma Shift 1 OHT Zone
		Laiwangma Shift 2 OHT Zone
WSZ23	Sajor Leikai	Sajor Leikai Shift 1 OHT Zone
		Sajor Leikai Shift 2 OHT Zone
WSZ24	Ghari	Same as Water Supply Zone
WSZ26	Khongman	Same as Water Supply Zone

5.8.2 Distribution Mains

(1) Proposed Distribution Mains in DPR

Table 5.54 and a table in **Appendix A5.8 (1)** summarize lengths of zone-wise distribution mains proposed in the DPR. This table also shows estimated lengths of the mains within both JNNURM and JICA project areas. According to the estimation, a total of 693km of distribution mains would be required within the JICA project area.

During this survey, JICA survey team reviewed the DPR's distribution mains design and results of the hydraulic modelling work which were contained in Volume 4 of the DPR. The following are some observations made:

- The DPR included network diagrams showing the results of the hydraulic modelling work. However, there were no other network plans available in the DPR to show the pipeline routes in relation to the road layout. Hence, the JICA survey team was unable to verify the details of the proposed distribution mains. In addition, it appears that the network diagrams did not cover all the water mains that is deemed necessary in the supply area.

- Peak hourly factor of 3 was used for the modelling of each supply zone. Although it is felt that the use of the peak factor of 3 seems rather high for the population of the Imphal city, it complies to the recent guidance note issued by CPHEEO, which states that peak factor of 3 can be used for zones with population not more than 50,000. However, it was noted that peak factor of 3 was also used for zones with population more than 50,000 (e.g. Iroisemba West, Canchipur), although peak factor of 2.5 should have been used for these zones.

- Having close examination of the modelling results, it appears that the outflow from each reservoir is much higher than the design flow factored by 3 and that actual simulated flows are 4 to 5 times higher than the average demand. This may have resulted in the oversizing of the distribution mains overall.

- Water levels used in the modelling differ from the results of the level survey carried out in this survey, which raises concern over the credibility of the modelling results.

Considering the deficiencies identified above, it was agreed with PHED that another distribution design and hydraulic modelling should be carried out by the JICA survey team for the supply zones within the JICA project area, in order to define the scope of the distribution work with confidence.

(2) Design Criteria for Distribution Mains

The key design issues for the distribution design and hydraulic modelling work are summarized below:

1） Routes of Distribution Mains

The routes of the distribution mains were first identified by PHED officials, so that all the potential customers in the supply area can access to the distribution mains. In general, distribution mains have been routed in most of roads that appear on Google map. For the routes fall under wide roads (including state highway, national highway), distribution mains were planned on either side of the roads. Lengths of the pipeline route are based on the route survey results.

2） Mode of Distribution

All the distribution mains in the JICA scope area will be supplied from service reservoirs by gravity.

3） Pipe Material and Minimum Diameter

Ductile iron pipe (K-7 Class) was chosen as the pipe material and the minimum diameter of the distribution main was set to 100mm as per the CPHEEO manual. At this stage of this project, on the agreement with PHED, it was assumed that all the existing mains in the supply zone will be replaced with new mains regardless of the age of the pipes. If any particular newly installed existing distribution mains have adequate hydraulic capacity for the future demand, a decision of keeping it in service will be made on case-by-case basis during the detailed design stage of this project.

4） Service Reservoir Water Levels and Ground Elevation

Reservoir levels and ground elevations are critical factors in the distribution design and hydraulic modelling work. Elevations of the service reservoirs sites were surveyed using the Differential Global Positioning System. Ground elevations in the distribution network were obtained from Google Map.

5） Future Demand and Peak Factor

For the hydraulic modelling work, zonal average demand in 2046 was used and nodal demand was factored by peak factors set in the CPHEEO manual, depending on the population of each supply zone. Firefighting flow case was not simulated since fire demand is not required for the distribution system in Imphal, as advised by PHED.

6） Target Residual Network Pressure

For the hydraulic modelling work and pipe diameter selection, the minimum network pressure was set to 7m, which is the required minimum pressure for single story building recommended in the CPHEEO manual, as agreed with PHED. However, distribution mains were designed to achieve 10m residual pressure where possible.

Figure 5.37 shows distribution mains identified in the 21 water supply zones to be developed under the JICA project. See also **Drawing No. IP-WSS-NE-003** for the zone-wise distribution network which is superimposed on satellite image. Note that a total of 693,082m of distribution mains was identified in the JICA project area, longer than that of DPR by 37km.

Note that the total length of the existing distribution mains in the JICA scope area is estimated to be 242km according to the information in **Table 2.7**. Therefore, 242km of the existing mains will need to be replaced with new mains, and 451km of new distribution mains will need to be installed where there is currently no existing mains.

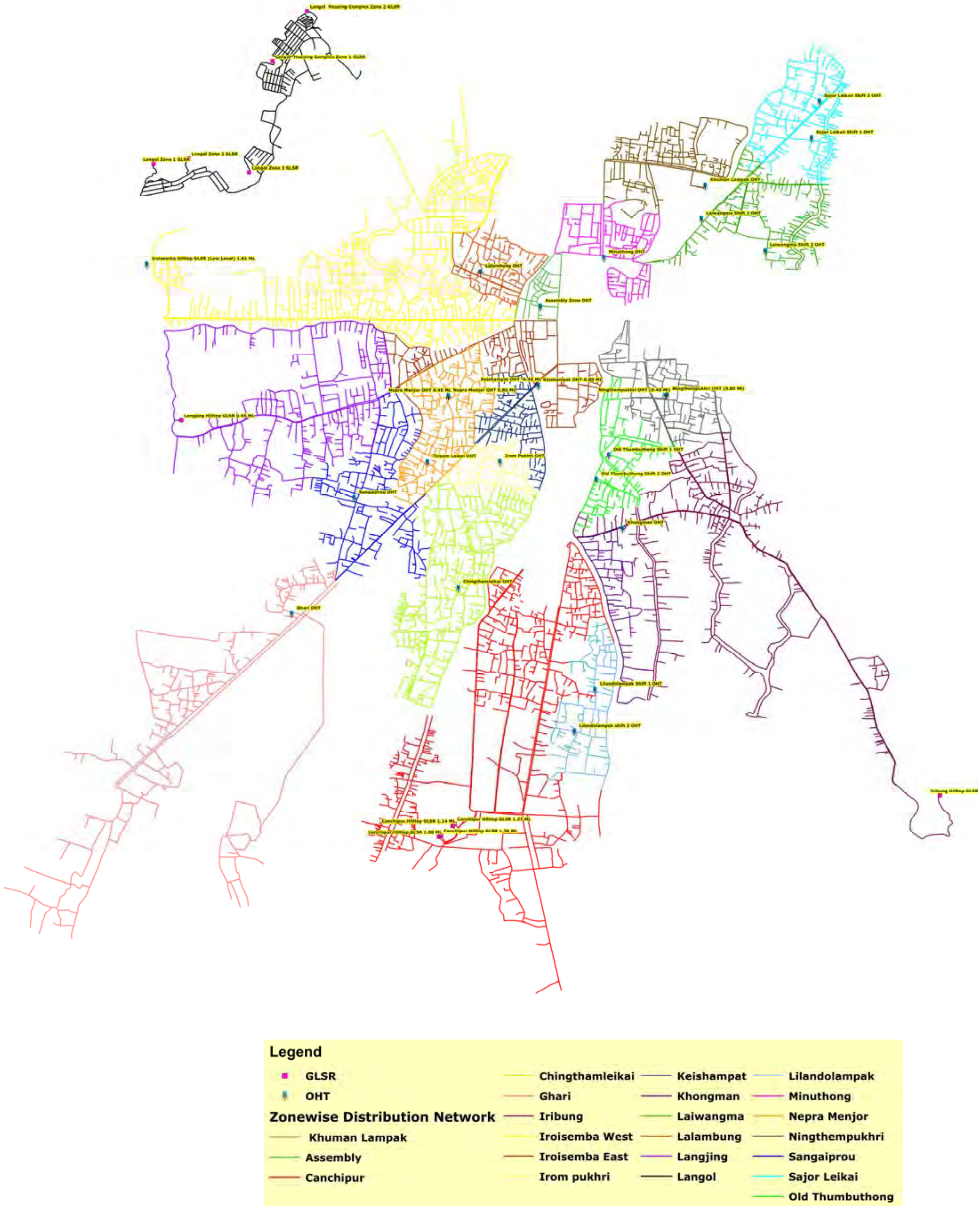


Figure 5.37 Identified Zone-wise Distribution Mains in JICA Project Area

(3) Results of Hydraulic Modelling

Hydraulic modelling was carried out to select appropriate size of the distribution mains. The total length of the mains modelled in this survey is 543,414m. Results of the modelling work are contained in **Appendix A5.8 (2)**. The appendix also includes parameters used for the modelling work, such as water levels of the service reservoirs. **Drawing No. IP-DM-HM-001** to **022** shows pipe and nodal identification numbers used in the modelling work.

Drawings No. IP-DM-GA-001 to **022** show network plan showing distribution mains of different diameters for each zone. **Figure 5.38** in this report shows a network plan of Lilandolampak zone with pipe diameters as an example. Note that these plans show additional 100mm diameter distribution mains, as well as those included in the hydraulic models.

Table 5.55 shows the summary of the lengths of the distribution mains per pipe diameter in each water supply zone. The selected pipe diameters range from 100mm to 800mm.

Note that the main purpose of the hydraulic modelling in this survey was to obtain pipe information required for the budget project cost estimation of this project. Further hydraulic modelling shall be carried during the project implementation stage for the detailed design and construction of the distribution mains.

(4) Comparison of Pipe Lengths between DPR and JICA Survey

Table 5.56 shows the zone-wise pipe lengths obtained from both the DPR and JICA survey. It should be noted that there is a large variance between the two. Although it is understood that the increase of the pipe length in Iroisemba West zone is due to the inclusion of Langol zone into the Iroisemba West zone, it is unknown what caused the variations for other zones.

Looking at Lilandolampak for an example, the pipe length estimated in the DPR is longer than that of this survey by 15km. **Figure 5.39** shows a hydraulic modelling diagram of this zone, extracted from the DPR. As it can been seen, there are not many distribution mains designed in the zone, compared to the network plan produced in the JICA survey (i.e. **Figure 5.38**). This raises a doubt as to whether the distribution network design was carried out appropriately during the production of the DPR.

As discussed earlier, the total pipe length obtained from the DPR and this survey are very close each other and its variation is 6%. However, the approximation of these values should be regarded as a mere coincidence.

Figure 5.38 Network Plan (Lilandolampak Zone)

Table 5.55 Summary of Length of New Distribution Mains (JICA Scope)

Zone No.	Zone Name	Pipe Length (m)												Total Length (m)
		100mm	150mm	200mm	250mm	300mm	350mm	400mm	450mm	500mm	600mm	700mm	800mm	
WS1	Iroisemba West	73,359	17,726	2,279	2,390	558	1,194	157	0	6,083	626	2,799	103	107,275
WS2	Iroisemba East	12,884	7,623	1,974	1,087	894	547	0	0	6	0	0	0	25,016
WS3	Langjing	30,534	6,483	1,270	1,127	2,169	5,368	0	0	218	86	0	0	47,255
WS4	Nepra Menjor	20,732	3,736	1,793	418	37	0	0	0	0	0	0	0	26,715
WS5	Sangaiprou	24,585	3,298	1,244	205	773	81	9	0	0	0	0	0	30,194
WS6	Irom Pukhri	6,910	1,672	613	190	35	20	0	0	0	0	0	0	9,440
WS7	Chingthamleikai	31,426	11,130	1,801	236	509	124	93	0	0	0	0	0	45,319
WS8	Keishampat	10,803	3,109	247	718	610	123	0	0	0	0	0	0	15,610
WS10	Lalambung	6,714	8,478	500	77	24	0	42	0	0	0	0	0	15,835
WS11	Assembly	4,165	1,530	73	70	42	0	0	0	0	0	0	0	5,879
WS13	Canchipur	51,727	14,082	6,473	7,097	4,573	3,232	1,086	110	0	0	0	0	88,380
WS14	Lilandolampak	14,745	2,281	74	28	0	0	0	0	0	0	0	0	17,128
WS15	Minuthong	10,669	5,438	1,245	399	357	247	25	0	0	0	0	0	18,380
WS16	Khuman Lampak	16,305	4,531	962	448	624	0	392	0	0	0	0	0	23,262
WS18	Ningthepukhri	16,815	5,128	888	648	59	174	55	0	0	0	0	0	23,767
WS19	Old Thumbuthong	14,440	3,892	564	119	9	9	0	0	0	0	0	0	19,034
WS20	Irilbung	31,798	13,688	1,939	2,215	1,979	2,938	2,949	3,493	0	1,892	0	0	62,891
WS22	Laiwangma	19,177	7,161	682	387	300	0	0	0	0	0	0	0	27,706
WS23	Sajor Leikai	20,515	3,250	623	30	61	0	0	0	0	0	0	0	24,479
WS24	Ghari	28,224	4,585	5,108	3,434	591	4,976	379	0	0	0	133	0	47,430
WS26	Khongman	7,900	1,597	1,544	788	193	67	0	0	0	0	0	0	12,089
Total Length (m)		454,427	130,416	31,895	22,110	14,398	19,100	5,187	3,603	6,307	2,604	2,933	103	693,082

Table 5.56 Comparison of Pipe Lengths between DPR and JICA Survey

WSZ No.	WSZ Name	Pipe Length (m)		Difference
		DPR (A)	JICA Study (B)	(B)-(A)
1	Iroisemba West	79,256	107,275	28,019
2	Iroisemba East	30,829	25,016	-5,813
3	Langjing	21,551	47,255	25,704
4	Nepra Manjor	23,681	26,715	3,034
5	Sangaiprou	20,933	30,194	9,261
6	Irom Pukhri	6,495	9,440	2,945
7	Chingthamleikai	25,826	45,319	19,493
8	Keishampat	14,715	15,610	895
10	Lalambung	13,100	15,835	2,735
11	Assembly	7,741	5,879	-1,862
13	Canchipur	82,067	88,380	6,313
14	Lilandolampak	32,481	17,128	-15,353
15	Minuthong	19,305	18,380	-925
16	Khuman Lampak	19,820	23,262	3,442
18	Ningthempukhri	20,998	23,767	2,769
19	Old Thumbuthong	15,771	19,034	3,263
20	Irilbung	85,397	62,891	-22,507
22	Laiwangma	36,453	27,706	-8,747
23	Sajor Leikai	41,787	24,479	-17,308
24	Ghari	46,448	47,430	982
26	Khongman	11,918	12,089	171
Total Length (m)		656,572	693,082	36,510

Figure 5.39 Hydraulic Modelling Diagram Extracted from DPR (Lilandolampak Zone)

(5) Other Design and Construction Issues

Most of the distribution mains will be laid in municipal roads (or inter-village roads) in Imphal city. Application for the road works and advance payment for the surface reinstatement will be required for the installation of the distribution mains. According to the PWD official, there is hardly any private roads in the Imphal city. The route survey carried out in this survey also did not identify any private road where distribution mains are proposed.

5.8.3 Ancillaries of Distribution Mains

(1) Pressure Reducing Valves

It has been well known that high pressures in distribution systems contribute to the increase in leakage level. In the Imphal city, the water supply zones to be supplied by the hilltop GLSRs will be subject to high system pressures, particularly in the night time when demand is low. These water supply zones include Iroisemba West and East, Canchipur and Irilbung. **Table 5.57** shows maximum static pressure that could be experienced in these zones.

It is proposed that a pressure reducing valve (PRV) should be installed on the outlet main of the GLSRs in these zones to reduce the system pressure and resultant leakage level. The PRV can automatically reduce a higher inlet pressure to a pre-set outlet pressure. According to the CPHEEO manual, distribution system should not ordinarily be designed for residual pressures exceeding 22m. Therefore, network pressures would need to be reduced by 15m to 42m via PRVs, depending on the zones.

Table 5.57 shows the proposed PRVs for inclusion into the project cost estimate. The size of the valves and valve setting requirements shall be confirmed during the detailed design stage.

Table 5.57 Proposed Pressure Reducing Valves (JICA Scope)

Service Reservoir	Water Supply Zone	Maximum Static Network Pressure	Reservoir Outlet Diameter	PRV Diameter	Location
Iroisemba Low Level GLSR (1.81Ml)	Iroisemba West Zone	47m	800mm	600mm	24°48'51.53"N, 93°53'16.07"E
Canchipur Hilltop GLSR (1.27Ml)	Canchipur Existing 1.27 Ml GLSR Zone	37m	350mm	250mm	24°44'57.42"N, 93°55'32.18"E
Canchipur Hilltop GLSR (1.14Ml)	Canchipur Existing 1.14 Ml GLSR Zone	37m	400mm	250mm	24°44'56.25"N, 93°55'31.36"E
Canchipur Hilltop GLSR (1.36Ml)	Canchipur Existing 1.36 Ml GLSR Zone	53m	450mm	300mm	24°44'51.33"N, 93°55'26.15"E
Canchipur Hilltop GLSR (1.00Ml)	Canchipur New 1.00 Ml GLSR Zone	52m	350mm	250mm	24°44'50.80"N, 93°55'25.45"E
Irilbung GLSR	Irilbung Zone	64m	600mm	400mm	24°45'10.51"N, 93°58'54.49"E

(2) Flow Meters

Measuring flows from service reservoirs is necessary for the operation of the distribution system. It is also important to evaluate leakage level in the supply zones. In Imphal city, all the customers' service connections will be metered. Hence, it should be possible to estimate the level of leakage using a "top down" water balance. This requires an assessment of total customer use, which can then be subtracted from the total flow into the system. The difference equates to the leakage. For the distribution flow meters, the use of electromagnetic meters is proposed, which provides improved accuracy, compared mechanical flow meters.

In the JICA project area, a total of 36 electromagnetic flow meters are proposed to be installed on the outlet of the service reservoirs. Also, three flow meters are proposed to be installed in roads to measure flows transferred from Iroisemba West zone to Iroisemba East zone. **Table 5.58** shows the proposed flow meters that have been included in the project cost estimate.

It should be noted that the size of the meters shall be confirmed during the detailed design stage.

Table 5.58 Proposed Flow Meters on Distribution Mains (JICA Scope) (Reservoir Outlet)

No.	Reservoir Name	Reservoir Type	Reservoir Work Funding Agency	Flow Meter installed on reservoir outlet for distribution
Hilltop GLSR				
1	Iroisemba Low Level (1.81Ml)	Existing	JICA	800mm
2	Langol Zone No.1	Existing	-	150mm
3	Langol Zone No.2	Existing	-	150mm
4	Langol Zone No.3	Existing	-	150mm
5	Langol Housing Complex Zone 1	New	JICA	200mm
6	Langol Housing Complex Zone 2	New	JICA	150mm
7	Langjing Hill (0.45Ml)	Existing	JICA	600mm
8	Canchipur Hilltop (1.27Ml)	Existing	-	350mm
9	Canchipur Hilltop (1.14Ml)	Existing	-	400mm
10	Canchipur Hilltop (1.36Ml)	Existing	-	450mm
11	Canchipur Hilltop (1.00Ml)	New	JNNURM	350mm
12	Irilbung	New	JNNURM	600mm
OHT				
13	Nepra Menjor	New	JICA	300mm
14	Nepra Menjor	Existing	-	300mm
15	Thiyam Leikai	Under Const.	-	250mm
16	Sangaiprou	New	JICA	400mm
17	Irom Pukhri	New	JICA	350mm
18	Chingthamleikai	New	JICA	400mm
19	Keishampat	New	JICA	350mm
20	Keishampat	Existing	-	300mm
21	Lalmbung	New	JICA	400mm
22	Assembly	Existing	-	300mm
23	Lilandolampak Shift 1	New	JICA	250mm
24	Lilandolampak Shift 2	New	JICA	250mm
25	Minuthong	New	JICA	400mm
26	Khuman Lampak	New	JICA	400mm
27	Ningthepukhri	New	JICA	400mm
28	Ningthepukhri	Existing	-	300mm
29	Old Thumbuthong Shift 1	New	JICA	350mm
30	Old Thumbuthong Shift 2	New	JICA	300mm
31	Laiwangma Shift 1	New	JICA	300mm
32	Laiwangma Shift 2	New	JICA	300mm
33	Sajor Leikai Shift 1	New	JICA	300mm
34	Sajor Leikai Shift 2	New	JICA	300mm
35	Ghari	New	JICA	700mm
36	Khongman	New	JICA	350mm

(Network Infusion)

No.	WSP Zone	Location	Flow Meter Diameter	Remarks
1	Iroisemba East	Connection with Iroisemba West distribution main	300mm	24°48'26.50"N, 93°54'53.22"E
2	Iroisemba East	Connection with Iroisemba West distribution main	300mm	24°48'25.85"N, 93°55'58.79"E
3	Iroisemba East	Connection with Iroisemba West distribution main	350mm	24°48'27.48"N, 93°55'59.53"E

(3) External Pipe Corrosion Protection

During the trial holes' investigation carried out in this survey, soils were tested against the following parameters to determine the ground corrosiveness in the project area:

- Soil resistivity
- pH
- Oxidation-reduction (redox) potential
- Sulphides
- Moisture

The test results were then assessed using 10-point soil evaluation procedure recommended in AWWA C105 standard. Soil sample results and the 10-point soil evaluation results are contained in **Appendix A5.8 (3)**. According to the results, the soil samples taken from 17 locations (out of 20 locations) exhibit corrosiveness and the soils are considered to be aggressive to ductile iron pipes.

Although the number of the soil samples is limited, it is prudent that corrosion protection measures are taken into account in the pipe installation and the necessary costs should be allowed in the project cost estimation at this stage of the project.

It is therefore recommended polyethylene encasement be used to protect new ductile iron pipes in the potential corrosive grounds in Imphal. Polyethylene encasement involves simply wrapping the pipe with a tube or sheet of polyethylene before installing the pipe. It is easy for construction crews to this install on-site and is by far the most economical way to protect ductile iron pipes.

5.9 Service Connections

(1) Material of Service Pipes

There is no description of the service connection arrangement found in the DPR, although the number of required service connections is indicated in the document.

According to PHED, Galvanised Iron (GI) pipe was assumed to be the material of the service pipes in the DPR. However, GI pipes have largely fallen out of use due to corrosion issues. The study team examined pros and cons of GI pipe, uPVC pipe and Polyethylene pipe for the selection of pipe material for the JICA assisted project. The summary of the material comparison is shown in **Table 5.59**.

The service pipe material must be fit for the purpose, be economical, safe for use with potable water, be durable and time tested. Having discussed the pipe material options with PHED, it was agreed that PE pipes should be used as a service pipe in the JICA project area.

Table 5.59 Service Pipe Material Selection

Material	Pros and Cons	Selection
Galvanized Iron Pipe	• May corrode after 5-10 years, causing leakage. • Many municipals in India stopped using GI pipes. • Easy to be tapped illegally.	
uPVC Pipe	• Easy to make connections using solvent joints. • Lack of durability and susceptible to fracture caused by traffic and point loading. • Easy to be tapped illegally.	
Polyethylene Pipe (PE80)	• No corrosion • Has become the industry standard worldwide and many municipals started to use them in India. • Difficult to be tapped illegally.	Chosen

(2) Customer Meters

Accurate metering and proper installation of customer meters are crucial for the billing and sound operation of the water supply business. According to PHED, the installation of customer meters will be mandatory under the operation of the new water supply system.

In general, customer meters in common use are of two types: positive displacement meter (volumetric meter) and inferential meter (velocity meter). The positive displacement meters are more accurate, especially at lower flows, and retain their accuracy for a longer period. However, this type of meter may be more susceptible to clogging compared to inferential meters and they are not widely used in India at present.

On the other hand, inferential meters are considered to be less susceptible to clogging and they are widely used in India. Among inferential meters, there are multi-jet type and single-jet type. The multi-jet meters generally offer advantages over the single-jet meters in terms of better retention of accuracy over time, better resistance to wear caused by particulates, and overall longer service life.

For these reasons, at this stage of the project, it is recommended that the new customer meters should be of the Class C multi-jet type inferential meters. During the implementation stage, meters with Automatic Meter Reading (AMR) capability should also be considered. With this type of meter, a pulse emitter can be retrofitted to the meter in the future to allow the meter to be read remotely, using a walk-by radio transceiver.

According to our site survey, existing customer meters are installed above ground without a meter box. It is recommended that a meter should be installed within a meter box to protect the meter from the damage, where possible.

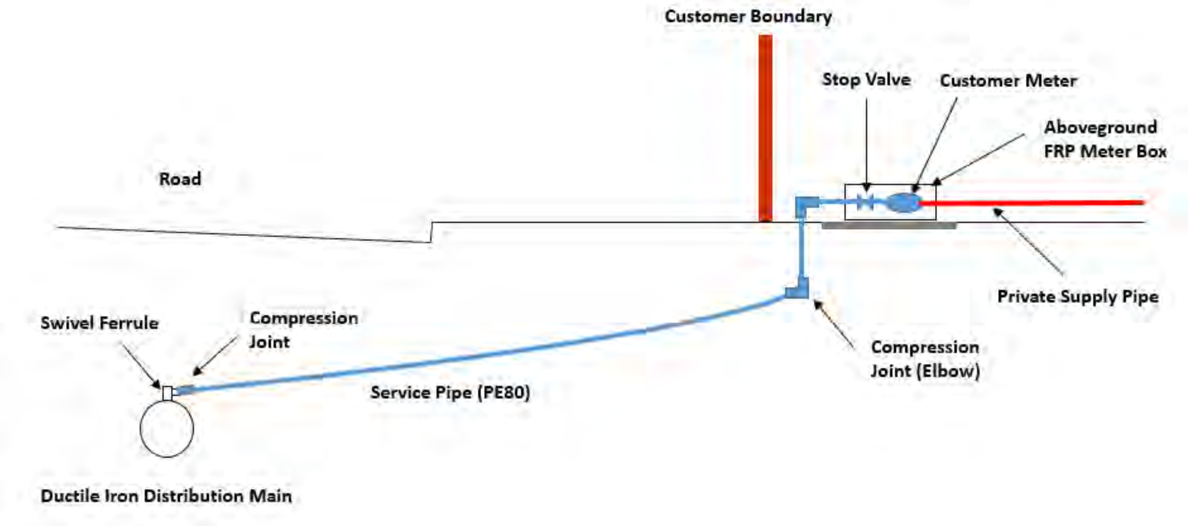
(3) Pipe Installation Method

Regarding the jointing method of PE service pipes, there are essentially two viable methods to consider, namely, electro-fusion welding and compression types. Electro-fusion jointing melts pipe and fittings by induced heat, therefore it would eliminate leakage if jointing work has been carried out properly. However, this jointing method requires skilled plumbers, and good workmanship is essential to achieve high quality electrofusion joints.

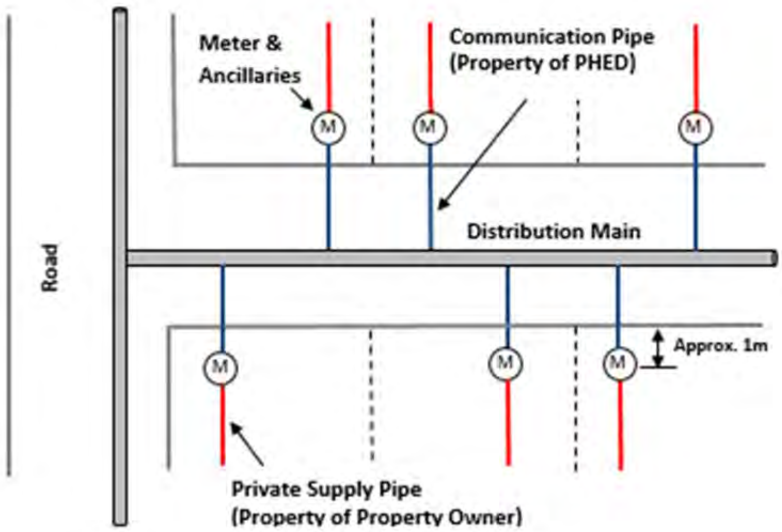
On the other hand, compression joints can be made easily and can withstand the pressures expected within the system. This type of joints has already been used in other municipalities in India. At this stage of this project compression jointing is recommended, however the further assessment on the selection of the joining method should be carried out during the project implementation stage.

Regarding the method of the connection of the service pipes onto distribution mains, currently dry tapping is carried out, as water is supplied intermittently at present. However, the new water supply system aims to achieve 24 x 7 supply, hence under-pressure tapping should be used to make service connections during the operational stage. For the initial connections of the service pipes on completion of the distribution mains under the JICA scope, under-pressure tapping is also recommended so that leak on tapping ferrules can be checked at the time of the tapping.

Figure 5.40 shows the proposed general arrangement of the service pipe. In general, water meters should be installed within the property boundary, where the customer can take appropriate measures to protect the meter from vandalism. Meters should be installed at a quiet location on the property not normally subject to pedestrian or vehicular traffic, and which reasonably minimizes both the distance to the water main tapping point and the need to make cuts into existing roadways and footpaths. In all cases, meter locations should allow for easy access for meter reading, testing, servicing and replacement.



(a) Section



(b) Plan

Figure 5.40 General Arrangement of Service Connections

(4) Required Number of Service Connections

Table 5.60 shows the estimated number of the service connections required within JICA project area. This estimate was provided by PHED during this survey. According to PHED, the number of the service connections was estimated based on the following assumptions:

- Zone-wise population: 2016 projected population
- Number of household: 5
- Customers with affordability: 90% of households

The cost associated with the service connections has been allowed in the project cost estimation.

Table 5.60 Required Number of Service Connections (JICA Scope)

WSZ No.	WSZ Name	Zone-wise Population in JICA Scope Area (2016)	No. of Household	Affordable Customers (No. of Connections)
1	Iroisemba West	63,980	12,784	11,506
2	Iroisemba East	25,097	5,019	4,517
3	Langjing	18,840	3,768	3,391
4	Nepra Manjor	14,859	2,972	2,675
5	Sangaiprou	14,037	2,807	2,526
6	Irom Pukhri	9,503	1,901	1,711
7	Chingthamleikai	20,711	4,142	3,728
8	Keishampat	13,619	2,724	2,452
10	Lalambung	10,620	2,124	1,912
11	Assembly	7,227	1,445	1,301
13	Canchipur	43,091	8,618	7,756
14	Lilandolampak	7,445	1,489	1,340
15	Minuthong	16,435	3,287	2,958
16	Khuman Lampak	12,705	2,541	2,287
18	Ningthempukhri	14,580	2,916	2,624
19	Old Thumbuthong	12,377	2,475	2,228
20	Irilbung	38,868	7,774	6,997
22	Laiwangma	13,341	2,668	2,401
23	Sajor Leikai	10,986	2,197	1,977
24	Ghari	21,154	4,231	3,808
26	Khongman	7,201	1,440	1,296
27	Langol	7,177	1,423	1,281
Total		396,676	79,322	71,391

5.10 SCADA System

A SCADA (Supervisory Control And Data Acquisition) system will be installed at the proposed WTP as a local SCADA system for operators to operate and monitor the treatment process in an adequate manner. Meanwhile, a central SCADA system will be established at the Porompat WTP instead of the Chingkeiching WTP considering their locations in Imphal water supply areas. The central SCADA system functions to monitor the entire water supply system scattered within the water supply service areas in association with the local SCADA systems, which will be established at remote stations such as the Chingkeiching WTP, the emergency pump stations, the OHTs (overhead tanks), and the GLRs (Ground Level Service Reservoirs).

The local SCADA systems at the remote stations will be integrated into the central SCADA system by linkages through GPRS (General Packet Radio Devices) modems over wireless networks. The GPRS can work on packet-data oriented transmission method based on GSM technology.

There are 44 Remote Stations to be integrated into the SCADA systems for operators to monitor the entire water supply system within Imphal water supply service areas as follows.

1	Master Reservoir
2	WTP (existing)
11	Hilltop GLSRs
25	OHT
4	Network Infusion
1	Proposed WTP at Chingkeiching

The local SCADA system arranged at the proposed Chingkeiching WTP is comprised of PLCs (Programmable Logic Controllers), an Operator Station, an Engineering Station, Data Servers and LED Large Screens. The former is located at local control rooms and the latter are located at the central control room respectively. The local SCADA system at the PSs, the OHTs, and the GLSRs is comprised of a PLC based control system along with a communication device to transmit the field data to the central SCADA system at Porompat WTP. The PLCs collect and/or transmit the field data such as process values, the status of the equipment/plant loads, alarms of the equipment to the Data servers. Furthermore, the PLCs will give auto mode operations to the equipment/plant loads through motor control centers in association with instrumentation devices. The operator station plays a role of the data collection to backward and command set points for automatic control logics to the PLCs. The operator station also work as HMI (Human Machine Interface) for assisting the operating staff to control/monitor the WTP properly. There are some set points given to the control logic for the equipment/plant loads as a manipulating value, for ex. levels, flows, etc. The data/SCADA servers play a role of data processing, generating reports such as daily, monthly and yearly, warning alarms. There are some ancillary/ incidental devices provided at the central-control room to make the local SCADA system complete, like printers, Ethernet managed switches and telecommunication devices. Fiber optic cables may be utilized as data transmission medium within the WTP to link among the PLCs and the Data server.

The central/master SCADA system will be established at the master station, which will be located at the existing Porompat WTP. The central/master SCADA system functions as master station to monitor the entire water supply system efficiently and offers the data to the operating staff and/or management staff for data analysis and decision about water supply facilities.

There is another option available in which both the central SCADA and the local SCADA systems will be located at Chingkeiching WTP.