Islamic Republic of Pakistan
Housing, Urban Development and
Public Health Engineering Department
Government of the Punjab

THE PROJECT FOR IMPROVING THE CAPACITY OF WASAS IN PUNJAB PROVINCE PHASE 2 IN THE ISLAMIC REPUBLIC OF PAKISTAN

PROJECT COMPLETION REPORT

FEBRUARY 2024

JAPAN INTERNATIONAL COOPERATION AGENCY

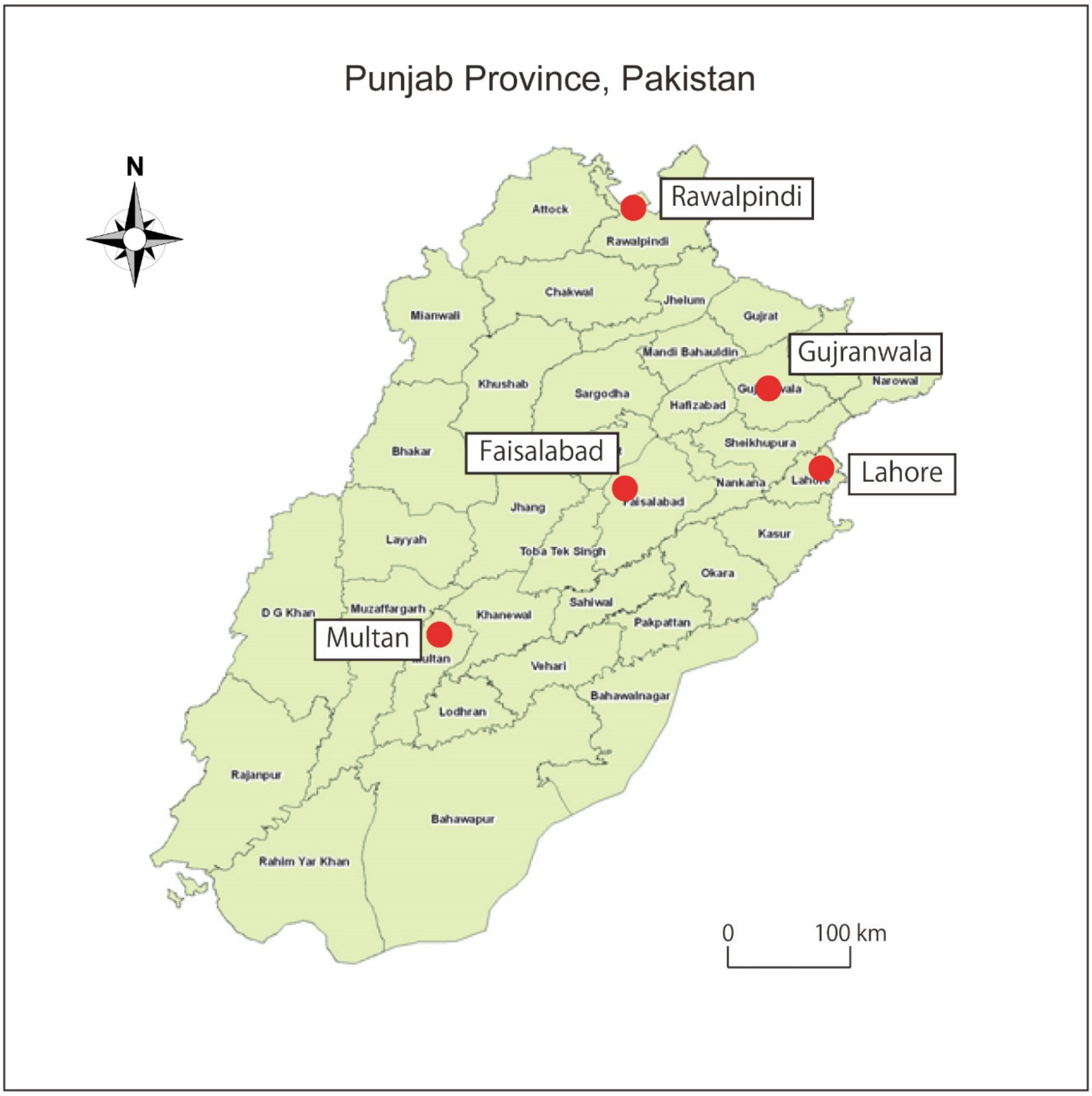
JAPAN TECHNO CO., LTD.
NJS CO., LTD.
YOKOHAMA WATER CO., LTD.

US$ 1.00 = Yen 147.49

PKR 1.00 = Yen 0.53

(Average in February, 2024)

(Source: https://www.jica.go.jp/about/announce/manual/form/consul_g/__icsFiles/afieldfile/2024/02/01/rate202402.pdf)



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Abbreviations

AD	Assistant Director
AFD	Agence Française de Développement
AJWA	Al-Jazari Water and Sanitation Academy
BPS	Basic Pay Scale
BCP	Business Continuity Plan
CAPEX	Capital Expenditure
CEO	Chief Executive Officer
COVID-19	Corona Virus Disease 2019
C/P	Counterpart Personnel
DD	Deputy Director
DMD	Deputy Management Director
FY	financial year
GIS	Geographic information system
HDPE	High Density Polyethylene
HUD&PHED	Housing, Urban Development and Public Health Engineering Department
JCC	Joint Coordinating Committee
JET	JICA Experts Team
JICA	Japan International Cooperation Agency
MCU	Motor Control Unit
M/M	Minutes of Meetings
NRW	Non-Revenue Water
OHR	Overhead Reservoir
OPEX	Operational Expenditure
O&M	Operation and Maintenance
PCC	Project Coordination Committee
PDM	Project Design Matrix
P&D	Planning and Development Board
PKR	Pakistan Rupee
PO	Plan of Operation
PSC	Project Steering Committee
R/D	Record of Discussion

SDO	Sub Division Officer
TAC	Technical Advisory Committee
ToT	Training of Trainers
UU	Urban Unit
WASA	Water and Sanitation Agency
WASA-F	Water and Sanitation Agency Faisalabad
WASA-G	Water and Sanitation Agency Gujranwala
WASA-L	Water and Sanitation Agency Lahore
WASA-M	Water and Sanitation Agency Multan
WASA-R	Water and Sanitation Agency Rawalpindi
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
XEN	Executive Engineer

Explanation of Terms

Term	Explanation
Training course	Name of major subject areas to be covered in the training
Training module	A unit of training that comprises a course. One or more related training topics organized from results of training needs assessment are designed together as one module. However, WASA-L has traditionally used the term "training module" and not the term "training course". Therefore, in this report as well, the term "training module" is used when describing the existing training programs of WASA-L, and the term "training course" is used when it is necessary to refer to a major subject area related to a new module.
Training topic	The major item of the training module is referred to as a "training topic". However, in some cases, "training module" and "training topic" become the same because a 2-3 hours in-house training at WASA focuses on only a single training topic.
Training content	The content learned by trainees in each training topic
Trainers	Trainers at Al-Jazari Water and Sanitation Academy
Professional training	Training at Al-Jazari Water and Sanitation Academy
ToT	ToT is implemented by trainers of Al-Jazari Water and Sanitation Academy to WASA Trainers.
WASA Training Center	Training facility of WASA Lahore
4WASAs	WASA Rawalpindi, WASA Faisalabad, WASA Multan, WASA Gujranwala
In-house training	Training implemented at each WASA. The trainees are all members of WASA staff including field workers.
WASA Coordinator	The coordinator for in-house training at each WASA.
WASA Trainer	The trainer for in-house training at each WASA
JICA Coordinator	The local consultant employed by JICA Experts Team

1. Project Outline

1-1 Background

Punjab Province in the Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") has more than half of the country's population (about 110 million in 2017), and more than half of the country's gross domestic product, making it a central province in Pakistan's economy. In the five most populous major cities in Punjab Province (Lahore, Faisalabad, Multan, Gujranwala, and Rawalpindi), the Water and Sanitation Agency (hereinafter referred to as "WASA") of each city, namely WASA Lahore (hereinafter referred to as "WASA-L"), WASA Faisalabad (hereinafter referred to as "WASA-F"), WASA Multan (hereinafter referred to as "WASA-M"), WASA Gujranwala (hereinafter referred to as "WASA-G"), and WASA Rawalpindi (hereinafter referred to as "WASA-R") is responsible for providing water and sewerage services in its area. However, there are many challenges in terms of operation and maintenance (hereinafter referred to as "O&M"), and finance. Specifically, the major issues of O&M are i) intermittent supply, and insufficient water pressure and quality due to leaks in the distribution pipe network caused by inappropriate management, ii) insufficient capacity of staff, and iii) inadequate human resources development. In addition, the major issues on the financial side are i) deficit operation due to inexpensive and flat-rate tariff, and ii) insufficient funds for O&M and renewal.

Under such situation, Al-Jazari Water and Sanitation Academy (hereinafter referred to as "AJWA") was established for training to the senior and middle management staff of WASAs in Punjab in consideration of the training facilities owned by WASA-L. However, AJWA's operational management system was required for the development. Therefore, JICA launched "The Project for Improving the Capacity of WASAs in Punjab Province (hereinafter referred to as "Phase 1") (July 2015 - July 2018). The achievement of Phase 1 was to develop AJWA's training system and strengthen AJWA faculty's capacity to conduct training.

However, the practical skills training especially utilized for the field work did not achieve the requirements of WASA. In addition, in-house training could not be held to the field staff (Basic Pay Scale (hereinafter referred to as "BPS") 1-10) of WASA, because they were unable to participate in the training at AJWA. Among 5 WASAs[1], only WASA-L had its own training facility for the field staff, namely "WASA Training Center". However, there is a need for improvement in the training contents. Based on these backgrounds, the Government of Pakistan requested "The Project for Improving the Capacity of WASAs in Punjab Province Phase 2" (hereinafter referred to as "Phase 2" or "Project").

Phase 2 envisages an improvement of water supply and sewerage services by resolving O&M and financial issues of WASA through strengthening of the collaboration between WASA and AJWA. The

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[1] 5 WASAs: WASA Lahore, WASA Faisalabad, WASA Multan, WASA Rawalpindi, WASA Gujranwala
4 WASAs: WASA Faisalabad, WASA Multan, WASA Rawalpindi, WASA Gujranwala

approach on the achievement is to i) improve the quality of the training through WASA staff as guest lecturers along with AJWA and providing training of trainers (hereinafter referred to as "ToT"), ii) establish an in-house training system at each WASA, applicable for dissemination of the training content, and iii) establish the training system that enables sustainable capacity development of staff at 5 WASAs through supporting an improvement of training at WASA Training Center.

1-2 Project Outline

The vision of the Project is "water and sanitation services of 5 WASAs in Punjab province is improved". The following shows the Project Site, Relevant agencies/organizations, Overall Goal and Project Purpose, and Outputs.

Project Site:	Punjab Province, Pakistan
Relevant Agencies / Organizations:	Planning and Development Board, Housing, Urban Development and Public Health Engineering Department, Urban Unit, 5 WASAs

Narrative Summary	Objectively Verifiable Indicators
Overall Goal	
Training systems for 5 WASAs in Punjab province continue to function.	1. All WASAs continue conducting in-house training. 2. Recommendations presented by the project are implemented.
Project Purpose	
Training systems for 5 WASAs in Punjab province are established.	1. 4 WASAs* conduct in-house trainings. 2. Recommendations for trainings are presented to the Project Coordination Committee.
Outputs	
1. Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.	1-1 ToT components are included in training contents/materials of 3 thematic areas. 1-2 All of the selected training contents are revised/updated based on technical advisory committee's recommendations.
2. Capacity to plan and conduct training at WASA Training Center is improved.	2-1 Training contents, modules and methodologies that required revisions or improvements are fulfilled.
3. Capacity to formulate and implement training plans is strengthened in 4 WASAs*.	3-1 Priority sectors for in-house training at WASAs were identified by the end of Year 1. 3-2 Training plans are updated every year at 4 WASAs* from Year 2.
4. Capacity to conduct in-house training is strengthened in 4 WASAs*.	4-1 Each WASA achieves 3 of thematic areas that in-house training is conducted. 4-2 More than 50% of in-house training participants feel their skills are improved by training.

*: 4 WASAs indicate Faisalabad, Gujranwala, Multan, and Rawalpindi

For further information such as "Objectively Verifiable Indicator" (hereinafter referred to as "Indicator") and "Activity", refer to PDM (see Annex 1.2.1) and PO (see Annex 1.2.2). Fig. 1.2.1 presents the project implementation structure and Outputs.

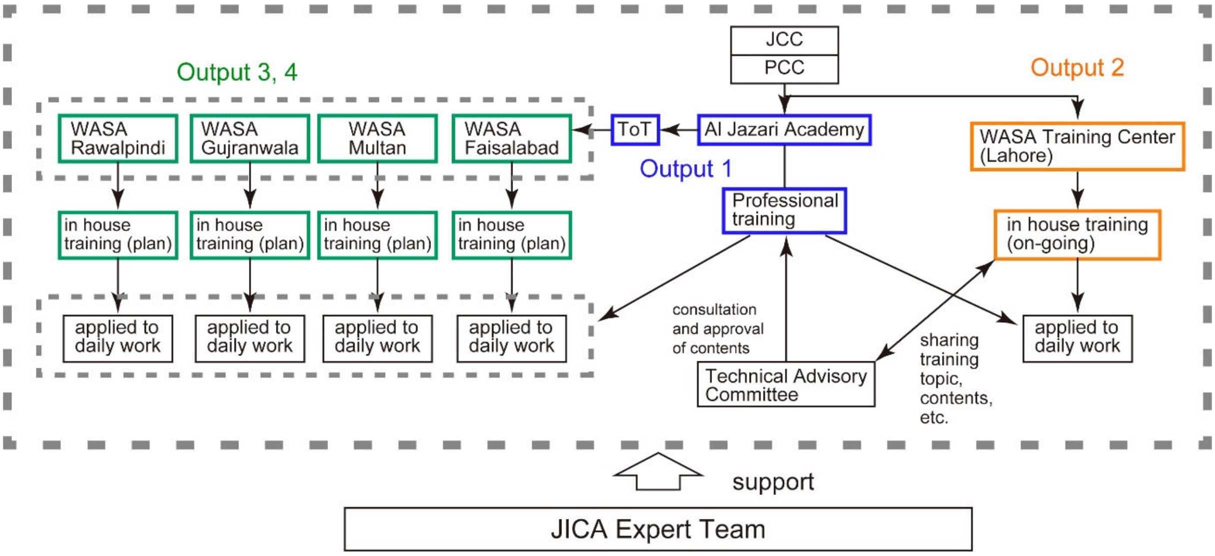


Fig. 1.2.1 Implementation Structure and Each Output

In order to strengthen the capacity of 5WASAs in Punjab, this project aims for continuous functioning of the training system by establishing a training system for 5WASAs. The specific approach on strengthening the capacity is i) to provide the training at AJWA that meets the needs of the 5WASAs, ii) to improve the contents of training courses at WASA Training Center, and iii) to establish an in-house training system to disseminate the necessary knowledge and skills through the training to field staff at each WASA.

Output 1 is to support AJWA in improving the quality of training. The approach on this support is that i) Technical Advisory Committee (hereinafter referred to as "TAC"), chaired by Deputy Management Director (hereinafter referred to as "DMD") WASA Lahore, is established, ii) TAC provides advices on the contents of training according to the needs of WASA, and iii) contents and modules of the professional training are revised. In order to establish an in-house training system at 4WASAs in Output 3 and 4, candidates of WASA Trainers are trained through ToT as the qualified WASA Trainers. In addition, each WASA nominates one WASA Coordinator from respective WASA, whose role is to coordinate the implementation of in-house training. In order to share experiences between WASA Coordinators, the meeting among WASA Coordinators is held. In Output 2, the technical assistance on an improvement of contents, modules, and methodology for the training at WASA Training Center is implemented. The details of the assistance are i) to prepare a list of improvement items for the existing training, and ii) to upgrade contents, modules, and methodology for the regular training. In Output 3 and 4, the technical assistance on establishing in-house training systems at 4 WASAs is implemented. The details of the assistance is i) to select challenges on implementing the training mainly by WASA Coordinator, and ii) to prepare the training plan. The plan is reviewed regularly, and revised/upgraded repeatedly. As a result, Plan-Do-Check-Act (PDCA) is expected to be accepted as a routine approach.

1-3 Objective

The objective of the Project is to achieve the Project Purpose by achieving Outputs through implementation of Activities of PDM agreed in R/D of the Project.

2. Summary of Project Progress Report (1)

"Project Progress Report (1)" described the activities in the first project year from February 2021 to March 2022. Activities in Pakistan were scheduled to start in June 2021. However, the activities started in September 2021 due to COVID-19. Although the start of the activities in Pakistan was delayed, the delay was minimized by the continuous online activities. As a result, the trainings at AJWA and WASAs started from May 2022 along the course of "O&M on Mechanical and Electrical Equipment" and "O&M on Sewerage and Drainage" as scheduled. Regarding the course of "Leakage control, plumbing, and pipe replacement plan", AJWA and WASAs required continuous preparation with the support of JICA Experts Team (hereinafter referred to as "JET") for the first training in October 2022.

The summaries of the progress for each output are as follows.

Output 1: Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened. (see 4-1)
Based on the results of the training needs survey conducted for each WASA, JET reviewed the contents of the professional training to be conducted at AJWA. Based on the results of the review, JET discussed the training courses of the project with the Pakistani side. The following three courses to be supported in the Project were agreed upon at the 2nd JCC.

- O&M on Mechanical and Electrical Equipment
- O&M on Sewerage and Drainage
- Leakage Control, Plumbing, and Pipe Replacement Plan

The specific training content was explained at TAC held on January 17, 2022. TAC reviewed the progress on the content being prepared. In addition, ToT for WASA Trainers by AJWA faculty was conducted on January 24-25, 2022 for implementation of in-house training.

Output 2: Capacity to plan and conduct training at WASA Training Center is improved. (see 4-2)
JET assessed the existing training at WASA Training Center, conducted the training needs survey, and agreed on the training modules to be supported in the project. The WASA Training Center planned to start the training from June 2022.

Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs. (see 4-3)
Each WASA nominated a WASA Coordinator and WASA Trainers. In-house training plan and schedule for 2022 were prepared by WASA Coordinators and WASA Trainers. The in-house training was planned to start in May or June 2022.

Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs. (see 4-4)
The pilot training for some of the in-house training modules was conducted at WASA-G, WASA-F, and WASA-R. JET and AJWA's trainers advised WASA Trainers on the facilitation procedures and teaching methods.

Table 2.1.1 and 2.1.2 summarize the achievements of i) each Activity and ii) each Output and Project Purpose, respectively.

Table 2.1.1 Achievements of Each Activity

Activity	Achievement (%)
Activity in Output 1	
1-1 Conduct training assessment (needs, capacity) including interviews to WASAs.	100
1-2 Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules.	100
1-3 Update or revise training modules and materials of thematic sectors where ToT will be incorporated.	50
1-4 Conduct pilot ToT and evaluate the training.	100
1-5 Formulate ToT training schedules.	100
1-6 Conduct ToT.	40
1-7 Conduct review of ToT regularly and update or revise contents.	25
1-8 Technical advisory committee (TAC) reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements.	100
1-9 Based on the recommendations, revise or update the professional training contents.	80
1-10 Technical advisory committee approves revised and updated professional training contents.	80
1-11 Conduct professional training with approved training contents.	0
1-12 Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators.	100
1-13 Organize semi-annual WASA coordinators meetings.	0
Activity in Output 2	
2-1 Assess and evaluate current training of WASA Training Center.	100
2-2 Based on the results of evaluation, list up thematic areas and methodologies that require revisions or improvements.	100
2-3 Update and revise training contents, modules and methodologies.	70

Activity	Achievement (%)
2-4 Conduct training with revised contents, modules and methodologies.	0
2-5 Reevaluate training and update or revise the training contents, modules and methodologies regularly.	0
Activity in Output 3	
3-1 Notify WASA coordinator in each WASA.	100
3-2 WASA coordinator conducts training assessment for in-house training needs and training capacity.	100
3-3 Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers.	100
3-4 WASA coordinator formulates in-house training plans semiannually.	20
3-5 WASA coordinator reviews implementation of in-house training plans and budget annually and revises the plans and budget if necessary.	0
Activity in Output 4	
4-1 Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules.	100
4-2 WASA trainers conduct pilot training at each WASA	20
4-3 WASA trainers and WASA coordinator review pilot in-house training and update the training contents and modules.	0
4-4 WASA trainers conduct in-house training.	0
4-5 Regularly, review and update in-house training contents, modules, and methods.	0

Table 2.1.2 Achievements of Each Output and Project Purpose

Indicator	Achievement (%)
Indicators in Output 1	
1-1 ToT components are included in training contents/materials of 3 thematic areas.	70
1-2 All of the selected training contents are revised/updated based on technical advisory committee's recommendations.	70
Indicator in Output 2	
2-1 Training contents, modules and methodologies that required revisions or improvements are fulfilled	70

Indicator	Achievement (%)
Indicators in Output 3	
3-1 Priority sectors for in-houses training at WASAs were identified by the end of Year 1.	100
3-2 Training plans are updated every year at 4 WASAs from Year 2.	0
Indicators in Output 4	
4-1 Each WASA achieves 3 of thematic areas that in-house training is conducted.	0
4-2 More than 50% of in-house training participants feel their skills are improved by training.	0
Indicators in Project Purpose	
1. 4 WASAs conduct in-house trainings.	0
2. Recommendations for trainings are presented to the Project Coordination Committee	0

3. Methodologies of Project

3-1 PDM and PO

As described in "1-2 Project Outline", the vision of the project is that "Water and sanitation services of 5WASAs in Punjab province is improved". For envisagement, the indicators of PDM (see Appendix 1.2.1) were prepared. In order to achieve the indicators, the activities in PO (see Appendix 1.2.2) were prepared. The activities of this project follow the activities in PO.

The contents of PDM and PO were revised at the 1st JCC in May 2021. The revisions with reasons are described in "3-4 Revision of Project Implementation Plan and Reasons, (2) Revision of Terms in PDM and PO".

3-2 Flowchart

The flowchart is attached as Annex 3.2.1.

3-3 Inputs of JICA Experts

Fig. 3.3.1 and 3.3.2 show the inputs of JICA Experts in Term 1 and 2, respectively. Major changes in the inputs of JICA Experts are described in "3-4 Revision of Project Implementation Plan and Reasons".

	Field	Name	Plan/ Actual	Yr 2021 2	3	4	5	6	7	8	9	10	11	12	Yr 2022 1	2	3	MM
Work in Pakistan	Chief Advisor/Training Management / Water and Sewage Facility Management	Nobuyuki Sato	Plan						(45)		(60)		(60)			(45)		7.00
			Actual									(41)			(75)			3.87
	Human Resource Development Specialist / Training Planner	Mikiko Azuma	Plan						(45)				(45)			(30)		4.00
			Actual											(24)				0.80
	Sewer Pipe and Drainage Cleaning Specialist	Tatsuo Tomidokoro	Plan								(45)					(45)		3.00
			Actual									(41)		(40)				2.70
	Civil Engineer (Pipe Replacement Planning)	Shuntaro Kinno	Plan										(30)					1.00
			Actual															0.00
	Plumbing Specialist 1	Toshimichi Naganuma	Plan											(60)				2.00
			Actual											(8)	(52)			2.00
	Mechanical Engineer	Yusaku Numajiri/ Ryuta Kudo	Plan						(45)				(45)			(45)		4.50
			Actual									(41)		(24)		(30)		3.17
	Electrical Engineer	Tabusa Hiroyuki	Plan						(45)							(36)		2.70
			Actual									(41)				(38)		2.63
	Leakage Control Specialist	Yasuhiro Matsuoka	Plan									(45)				(45)		3.00
			Actual															0.00
		Hiroyuki Morita / Kazuhiro Kayanoma	Plan															0.00
			Actual													(46)		1.53
	Numbers inside ( ) is indicated in "days".													Sub total	Plan			27.20
															Actual			16.70

Fig. 3.3.1 Inputs of JICA Experts in Term 1 (1/2)

	Field	Name	Plan/ Actual	Yr 2021											Yr 2022			MM
				2	3	4	5	6	7	8	9	10	11	12	1	2	3	
Work in Japan	Chief Advisor/Training Management / Water and Sewage Facility Management	Nobuyuki Sato	Plan		(36)													1.80
			Actual	(5)	(15)	(10)	(8)	(15)	(15)	(10)	(5)		(14)	(4.6)				5.08
	Human Resource Development Specialist / Training Planner	Mikiko Azuma	Plan		(36)													1.80
			Actual	(2)	(3)	(10)	(12)	(15)	(19)	(15)	(6)	(5)		(2) (2)	(6)			4.85
	Sewer Pipe and Drainage Cleaning Specialist	Tatsuo Tomidokoro	Plan		(16)													0.80
			Actual	(2)	(3)	(3)	(3)	(4)	(2)	(2)	(1)				(2)			1.10
	Civil Engineer (Pipe Replacement Planning)	Shuntaro Kinno	Plan		(26)													1.30
			Actual	(2)	(3)	(5)	(4)	(2)	(3)	(4)	(4)	(5)	(7)	(7)				2.30
	Plumbing Specialist 1	Toshimichi Naganuma	Plan		(16)													0.80
			Actual	(1)	(3)	(3)	(2)	(1)	(2)	(3)			(1)					0.80
	Mechanical Engineer	Yusaku Numajiri/ Ryuta Kudo	Plan		(20)													1.00
			Actual	(1)	(3)	(1)		(5)	(7)	(2)	(5)		(14)	(1)	(7.6)			2.33
	Electrical Engineer	Tabusa Hiroyuki	Plan		(16)													0.80
			Actual		(3)	(5)	(4)	(2)	(2)					(1.4)				0.87
	Leakage Control Specialist	Yasuhiro Matsuoka	Plan		(22)													1.10
			Actual	(1)	(3)	(3)	(4)	(4)	(3)	(4)								1.10
		Hiroyuki Morita / Kazuhiro Kayanoma	Plan															0.00
			Actual								(4)	(3)	(10)	(11.4)	(1)			1.47
	Numbers inside ( ) is indicated in "days".													Sub total	Plan			9.40
															Actual			19.90
														Total	Plan			36.60
															Actual			36.60

Fig. 3.3.1 Inputs of JICA Experts in Term 1 (2/2)

	Field	Name	Plan/ Actual	Yr 2022 (4–12) / Yr 2023 (1–12) / Yr 2024 (1–3)	MM
Work in Pakistan	Chief Advisor/Training Management / Water and Sewage Facility Management	Nobuyuki Sato	Plan	(60) (60) (60) (60) (60) (75) (60)	14.50
			Actual	(71) (66) (44) (60) (80) (32) (55)	13.60
	Human Resource Development Specialist / Training Planner	Mikiko Azuma	Plan	(30) (45) (42)	3.90
			Actual	(36) (39) (47)	4.07
	Sewer Pipe and Drainage Cleaning Specialist	Tatsuo Tomidokoro	Plan	(45) (60) (45) (30)	6.00
			Actual	(45) (72) (29) (19) (15)	6.00
	Cleaning Equipment Instructor	Takafumi Sato	Plan	(15)	0.50
			Actual	(14)	0.47
	Civil Engineer (Pipe Replacement Planning)	Shuntaro Kinno	Plan	(30) (30)	2.00
			Actual	(45) (45)	3.00
	Plumbing Specialist 1	Toshimichi Naganuma	Plan	(51) (48) (48) (48)	6.50
			Actual	(41)	1.37
		Ryo Yamane / Kotomi Suguyama	Plan		3.00
			Actual	(44) (32) (23) (29)	4.27
	Plumbing Specialist 2	Hiroyuki Morita	Plan	(15) (15)	1.00
			Actual	(16) (14)	1.00
	Mechanical Engineer	Yusaku Numajiri/ Ryuta Kudo	Plan	(45) (45) (45) (36) (36)	6.90
			Actual	(45) (22) (30) (57) (45)	6.63
	Electrical Engineer	Tabusa Hiroyuki	Plan	(45) (39) (30) (30)	4.80
			Actual	(51) (44) (45)	4.67
	Leakage Control Specialist	Hiroyuki Morita/ Kazuhiro Kayanoma	Plan	(45) (45) (45) (45)	6.00
			Actual	(52) (53) (34) (41)	6.00
	Numbers inside ( ) is indicated in "days".			Sub total Plan	52.10
				Sub total Actual	51.07
Work in Japan	Chief Advisor/Training Management / Water and Sewage Facility Management	Nobuyuki Sato	Plan	(6)	0.30
			Actual	(2) (2) (2) (18)	1.20
	Human Resource Development Specialist / Training Planner	Mikiko Azuma	Plan		0.50
			Actual	(2)	0.10
	Cleaning Equipment Instructor	Takafumi Sato	Plan	(10)	0.50
			Actual	(4) (6.60)	0.53
	Numbers inside ( ) is indicated in "days".			Sub total Plan	0.80
				Sub total Actual	1.83
				Total Plan	52.90
				Total Actual	52.90

Fig. 3.3.2 Inputs of JICA Experts in Term 2

3-4 Revision of Project Implementation Plan and Reasons

(1) Fewer Inputs of JICA Experts for Activities in Pakistan

The original plan for activities in Pakistan by JET was to start in June 2021. However, the activities started in September 2021 due to COVID-19. Table 3.4.1 presents the revision of activities in Pakistan.

Table 3.4.1 Start of Activities in Pakistan

Original Plan	Revised Plan
June 2021	September 2021

Due to safety considerations with respect to General Elections in Pakistan, JET had to end the activities in Pakistan as indicated in Table 3.4.2.

Table 3.4.2 End of Activities in Pakistan

Original Plan	Revised Plan
15 February 2024	17 January 2024

(2) Revision of Terms in PDM and PO

The terms in PDM and PO were modified to avoid misunderstanding. Table 3.4.3 presents the modifications.

Table 3.4.3 Revision of Terms in PDM and PO

Original Plan	Revision	Activities in PDM and PO applied to revision
Training coordinator	WASA Coordinator	Activity 1-12, 1-13, 3-1, 3-2, 3-4, 3-5, 4-3
trainer	WASA Trainer	Activity 3-3, 4-1, 4-2, 4-3, 4-4

In order to keep things as simple as possible, it was decided not to form a group named "Training management group". Regardless of formulating or not formulating "Training management group", WASA coordinator and other staff members would play the role of "Training management group". There would be no particular problem in planning and implementing in-house training. The activities in PDM and PO related to this revision are Activities 3-1 to 3-5.

The revisions were the results of discussions with the Pakistani side and agreed in the 1st JCC (see Annex 8.1.1).

(3) Replacement of "Plumbing Specialist 1"

Mr. Toshimichi Naganuma, "Plumbing Specialist 1" passed away in October 2022. Due to this reason, "Plumbing Specialist 1" was replaced by Mr. Ryo Yamane / Ms. Kotomi Suguyama.

4. Progress of Activities in Term 1 (February 2021 to March 2022)

4-1 Activities related to Output 1

4-1-1 Conduct training assessment (needs, capacity) including interviews to WASAs [Activity 1-1]

Since JET could not travel to Pakistan due to the spread of COVID-19 at the time of the project launch, JET conducted online meetings with 5 WASAs from May to June 2021 to assess the training needs of WASA staff and their capacities regarding the operation and maintenance of water supply and sewerage services. This activity was combined with Activity 3-2 to identify training needs on the professional training and Training of Trainers (ToT) at AJWA and in-house training at WASAs.

The survey employed online interviews between JET and representatives of each WASA who were related to the training subject areas, i.e., 1) Mechanical Equipment, 2) Electrical Equipment, 3) Plumbing, Leakage Control, and Pipe Replacement, and 4) Sewerage and Drainage. While JICA Experts were operating the project activities from Japan, JICA Coordinators conducted the follow-up survey in Pakistan to collect relevant data and information from WASAs, including field visits to existing facilities operated by WASAs. JICA Coordinators had experience working for WASA or as JICA Coordinators in Phase 1, in the fields of three in mechanical and one in electricalThe roles of JICA Coordinators were to provide technical support to JICA Experts in terms of information gathering, facilitation and coordination of the project activities, especially at each WASA, regardless of whether or not there were field activities by the experts.

To improve the enabling environment for the in-house training, WASAs had high expectations for technical support from the project to develop the training content and train WASA Trainers. Salient points of findings from the assessment were as follows:

- Main items identified as training needs by subject areas are summarized in Table 4.1.1 (see details in Annex 4.1.1). While some of the needs were the same as those addressed in the professional training in Phase 1, WASAs requested that many of these training topics be covered in the in-house training in the Project.

Table 4.1.1 Summary of Training Topics Identified as WASAs' Needs

Subject Area	Major Items Identified as Training Needs
1) Mechanical Equipment	• Selection of pumps • Water treatment process and technology • O&M of mechanical equipment (pumps for tube wells and disposal stations, valves, chlorinator, water filtration plant, and heavy machines) • Energy audit, improvement of operating efficiency of mechanical

Subject Area	Major Items Identified as Training Needs
	equipment • Safety measures during installation and inspection of pumps
2) Electrical Equipment	• O&M of electrical equipment (electrical panels, Motor Control Units (MCU), generators) • Wiring • Energy audit, improvement of efficiency of electrical equipment • Work safety and health management
3) Leakage Control, Plumbing, Pipe Replacement Plan	• Pipe installation/ jointing technique • Selection and procurement of proper materials • Proper installation of water meters • Maintenance of pipelines, valves, and water meters • Leakage detection and proper handling of leakages from valves and connections • Observation/measurement of pressure in pipelines • Use of equipment (leak detector, metal locator, pipe locator, pressure recorder, etc.)
4) Sewerage and Drainage	• Cleaning of sewerage and drainage pipelines • Maintenance of sewerage and drainage system • Wastewater treatment technologies • O&M of wastewater treatment plant • Flow measurement of open channels and disposal pumping stations • Manhole detection
5) Business Plan	• Measures for revenue increase and cost reduction • Introduction of updated billing software
6) Asset Management	• Evaluation of conditions of assets of water supply facilities and disposal stations • Data collection

- WASA categorized the expected acquisition level of capacities at different grades, the nature of the work involved, the scope of responsibilities, and the competencies required (see Table 4.1.2).

Table 4.1.2 Categorization of Target Group of Training

Grade	Main Target Group of Training	Expected Acquisition Level of Capacities
BPS1-10 (field workers, field supervisors)	Pump Operator, Pipe Fitter, Sewer Worker, Supervisor, Electrician, Mechanics	• Implementation of daily operation and checkup of facilities • Implementation of SOPs • Application of work safety and health measures
BPS11-16 (superintendents, clerks, assistants)	Sub Engineer, Senior Sub Engineer, Senior Supervisor	• Planning of preventive and corrective maintenance of facilities/equipment with the application of appropriate technologies • Supervision of field staff on adherence to SOPs • Supervision of contractors involved in O&M of facilities • Supervision of utilization and proper handling of equipment
BPS17-19 (senior management)	Director, Deputy Director, Executive Engineer, Sub Divisional Officer, Assistant Director, GIS Analyst	• Verification of planning and designing of water supply and sewerage facilities • Planning of preventive and corrective maintenance, rehabilitation, and replacement of facilities/equipment • Facilitation of utilization of relevant software for designing of facilities, information management, and decision-making • Facilitation of energy audit

- WASA envisaged that the target groups of the in-house training were frontline staff in BPS 1-10 and middle-level management staff in BPS 11-16 who were in supervisory positions. While the staff in BPS11-16 are eligible to participate in the professional training, WASAs indicated that the in-house training would also be used as part of the capacity development opportunities for the staff in BPS11-16.
- Based on the implementation status of the professional training at AJWA in Phase 1 and the Project's approach in Phase 2 on establishing a training system of the in-house training, WASAs requested an improvement in the training content and methods as follows:
  - The structure of each training module should be reviewed to reduce the explanation of academic concepts and increase time allocation for hands-on training.
  - Training programs should be designed to enhance understanding and application of the proper and standard operation of various activities that trainees are tasked with. The training content should incorporate practical content and materials that take into account WASAs' business practices and challenges they have been facing.
  - The volume of training materials should be reduced and more concise in content. The use of SOPs describing main points is also preferable to facilitate understanding of the staff at BPS1-10.
  - In consideration of WASAs' daily workload, the duration of the training should be two to six days per course and not more than five hours per day.
  - For trainers for the in-house training, WASAs could make effective use of retired or soon-to-be-retired personnel who have worked at WASAs for a long time and had experience in field operations.

Based on information collected through the training needs assessment, JET discussed with AJWA and WASAs, respectively, the proposed thematic areas where the Project put high priority among the identified training needs. The training topics with the first and second priorities were agreed upon among AJWA, WASAs, and JET, as shown in Annex 4.1.2. The training topics with the first priority were dealt with in the professional training, Training of Trainers (hereinafter referred to as "ToT"), and in-house training in 2022. Then, the training content on these topics with the first priority was to be further improved in implementing the training in 2022.

Those with the second priority were considered potential subject areas for training to be covered in 2023. AJWA and JET planned to review how many additional topics would be implemented in 2023 as new modules based on the training implementation in 2022. TAC would then approve the additional content for the second priority topic during 2022.

The following are the salient points of discussion with AJWA with regard to the reflection of results of the training needs assessment to the professional training and ToT:

- Sewerage and Drainage

  AJWA expected to develop a full-fledged training program on sewerage treatment plants, including all the basics. However, JET did not plan to provide technical support regarding sewerage treatment plants, as this subject area was not included in R/D. Therefore, this subject area was addressed in training within the scope that JET could handle, specifically, basic methods in selecting a treatment process and sludge removal at a sewage treatment plant of WASA-M. JET and AJWA confirmed that they would consult with WASAs on this point adequately before presenting the proposed training content to TAC for approval.

- Electrical and Mechanical Equipment

  Most of the high-priority training topics are already included in the professional training developed in Phase 1. Meanwhile, the wiring and energy audit will be added to the course as new contents. It is expected that the implementation of the energy audit will contribute to energy efficiency improvement, hence the reduction of electricity costs. This is an urgent issue for WASAs, and AJWA is also well aware of its importance. AJWA further agreed with a suggestion by JET that the training should also focus on the methods and procedures for diagnosing the operational status of electrical equipment, which is the basic information for taking energy efficiency measures. JET also confirmed that AJWA had agreed upon the training topics related to the mechanical equipment.

- Leakage Control, Plumbing, and Pipe Replacement Plan

  AJWA generally agreed on the priority training topics proposed by JET. The following suggestions made by AJWA are to be considered in planning the training module and contents of the professional training:

  - The course should be divided into three modules: leakage control, plumbing, and pipe replacement plan.
  - AJWA will provide WASAs with their training course on the use of analysis and design software such as EPA NET, WaterGEM, WaterCAD, etc.
  - AJWA requested the cooperation of the Project in procuring the necessary training equipment in plumbing as the institution does not have some items.

4-1-2 Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules [Activity 1-2]

The second JCC meeting of 1st November 2021 approved the following three courses to be assisted by the Project for the professional training at AJWA and in-house trainings at WASAs. AJWA and JET confirmed that they would implement the two types of the ToT components: 1) technical guidance for each of these three courses (technical training) and 2) training on training design and pedagogy/instruction skills for in-house training in general, regardless of the course (training on training design and pedagogy/instruction skills). ToT (technical training) is expected to last two days for each course, for about five hours per day, and will be conducted at different times from the professional training, as described in Activity 1-5.

- O&M on mechanical and electrical equipment
- O&M on sewerage and drainage
- Leakage control, plumbing, and pipe replacement plan

4-1-3 Update or revise training modules and materials of thematic sectors where ToT will be incorporated [Activity 1-3]

AJWA and JET prepared training modules and materials for ToT for each course. As the preparation of training modules/contents for in-house and professional training was prioritized, ToT (Technical Training) for mechanical/electrical and sewerage/drainage was scheduled to be implemented around July 2022. The ToT for leakage control, plumbing, and pipe replacement plan was expected to be implemented around November 2022.

The in-house training was scheduled to start at the end of May 2022 in WASA-G and in June 2022 in WASA-F, WASA-M, and WASA-R. It was unlikely that all preparations for ToT content would be completed before the commencement of in-house training. Pilot in-house training was conducted in WASAs at the end of January towards February 2022 to ensure that WASA trainers could conduct in-house training by themselves with a certain level of standard even before they attend ToT. (Refer to Activity 4-2.)

4-1-4 Conduct pilot ToT and evaluate the training [Activity 1-4]

The pilot ToT was conducted at WASAs, as shown in Table 4.1.3 below.

Table 4.1.3 Pilot ToT Schedule

	Site Selection	Preparation of Training	Implementation of Training
WASA-G	10 Dec 2021	27-29 Dec 2021	30 Dec 2021
WASA-F	17 Dec 2021	03-05 Jan 2022	06 Jan 2022
WASA-R	23 Dec 2021	19 Jan 2022	20 Jan 2022

Objectives of this pilot activity are i) to check whether the training process and methods planned in the training outlines are effective for the expected trainees and manageable by WASA trainers, and ii) to allow trainers of ToT to become familiar with the environment and field conditions where the in-house training will be conducted. From the perspective of understanding the environment and constraints for conducting in-house training, including checking the status of candidate sites for field practices, and proposing more practical training implementation methods, it was decided that the pilot ToT would be conducted at WASAs rather than at AJWA.

Using the module on energy audit in O&M of Mechanical and Electrical Equipment course as a case, where the preparation of training is in progress, the contents and methods of instruction in ToT were confirmed by practicing the series of processes of site selection, training preparation, implementation, and review in collaboration among JET, AJWA, and WASA trainers. In the pilot ToT, WASA trainers demonstrated the actual training delivery process with the participation of some trainees after JET provided orientation on the training objectives, the process to be involved, and points to which the trainers should pay attention.

4-1-5 Formulate ToT training schedules [Activity 1-5]

There are two types of ToT. One is ToT (Training Design and Instruction Skills). The other is ToT (Technical). For effective implementation, ToT (Training Design and Instruction Skills) and ToT (Technical) were scheduled to be implemented at AJWA and respective WASA, respectively. The reasons are described as follows.

- ToT (Training Design and Instruction Skills) is common contents to all WASAs. Therefore, it is efficient to be implemented as AJWA.
- The detailed contents or approach of the in-house training at each WASA may be different even though the name of training topic is the same. If the ToT (Technical) is conducted at each WASA, the ToT (Technical) can be provided to each WASA complied with the detail demand.
- If the ToT (Technical) is conducted at each WASA, the same facility for in-house training can be used. As a result, WASA Trainers can obtain the technical knowledge and skills effectively and efficiently.

As soon as ToT was ready, ToT was scheduled to be implemented. As a result, ToT presented in Table 4.1.4 was scheduled.

Table 4.1.4 Schedule of ToT

ToT	Venue	Date
ToT (Training Design and Instruction Skills)	AJWA	24-25 Jan 2022
ToT (Technical)		
- Energy Audit	WASA-F	26 Jan 2022
- Energy Audit	WASA-G	9-10 Dec 2021
- Energy Audit	WASA-R	18-20 Jan 2022
- Other ToT (Technical)	4WASAs	Scheduled in Term 2 (see Table 5.1.9)

4-1-6 Conduct ToT [Activity 1-6]

AJWA organized ToT (Training Design and Instruction Skills), as shown in Table 4.1.5. Both WASA Coordinators and Trainers were invited to this training as they work together to facilitate in-house training in each WASA, and, in some cases, WASA Coordinators also serve as WASA Trainers. Therefore, this training combines with the training of WASA Coordinators for the implementation of training needs assessment in WASAs in Activity 1-12.

Table 4.1.5 Program of ToT (Training Design and Instruction Skills)

Training Course	:	ToT (Training in Training Design and Pedagogy/Instruction Skills)
Date	:	January 24-25, 2022
Venue	:	Al-Jazari Water and Sanitation Academy
Target Group	:	WASA Coordinators and WASA Trainers from 5 WASAs (total: 10)
Trainer	:	Pedagogy Officers and Human Resources Manager of AJWA
Objectives	:	Enhancement of knowledge, skills, and attitudes related to the management of training cycle and effective instructional strategies for in-house training
Main Topics	:	- Pedagogy and instructional design - Learning objectives, Bloom's Taxonomy - Training cycle – ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model - How to perform the training needs assessments - Course designing - Communication skills and presentation skills - Effective training methods, how to conduct active engagement - The layout of training classroom, time management - Training evaluation (reaction, learning, behavior, and results), the importance of feedback from trainees

In preparing the training plan, the following points were taken into consideration based on the results of interviews with WASA Coordinators and WASA Trainers by JET and AJWA:

- Bearing in mind that WASA is not an educational or training institution and, therefore, cannot assign a full-time training coordinator or curriculum development specialist, AJWA will advise WASA on how to implement the training in a way that can be implemented within WASA's organizational culture, structure, and personnel.
- WASA Trainers have expressed the need for ToT to be more than a one-time training and to provide follow-up training and opportunities for mutual learning and experience sharing among WASAs. To address these needs, WASA Coordinators have a plan to meet every six months as described in Activity 1-13, and WASA Trainers will be invited to participate in the meeting to share the status of internal trainings, challenges, and best practices, and to discuss ways to

improve the training.

- ToT is intended for WASA Coordinators, WASA Trainers, and staff who assist WASA Coordinators in training management. AJWA will suggest the target group of the training, and each WASA will decide who will participate.

According to Table 4.1.4, ToT (Technical) for energy audit at WASA-F, WASA-G, and WASA-R was conducted. Before conducting technical assistance to WASA Trainers sufficiently, ToT was conducted smoothly. However, an important outcome was to realize the "first step" for implementing in-house training more than smooth implementation of ToT.

4-1-7 Conduct review of ToT regularly and update or revise contents [Activity 1-7]

The activity is scheduled in Term 2.

4-1-8 TAC reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements [Activity 1-8]

TAC meetings were held on 14th September 2021 and 17th January 2022 to review the professional training content developed in Phase 1. The following are the outcomes of the meetings:

- JET reported the training needs assessment results and priority training topics for the professional training, ToT, and in-house training of WASAs. TAC agreed upon the proposal on training topics to be supported by the Project.
- TAC agreed to the following:
  - The focus should be put on making training more practical by reducing the ratio of lectures and increasing time allocation for exercises and field activities.
  - The contents and methods of the in-house training at WASAs should be effectively used to improve the professional training.
  - The professional training content should include the introduction of WASA's good practices, for example, the efforts to improve water supply services through the pilot activities conducted at WASA Faisalabad in the Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.

  As for the revision of the professional training content, AJWA and JET reviewed the training timetables and materials developed in Phase 1 to identify the subjects to be improved in the training content, methods, time allocation, and venue. Annex 4.1.3 and 4.1.4 describe the revisions of professional training from Phase 1 to Phase 2 and the timetables. TAC approved the documents presented in the meeting on 17th January 2022. Table 4.1.6 summarizes revisions proposed by the Project on the professional training of Phase 1.

Table 4.1.6 Summary of Proposed Revisions on Professional Training of Phase 1

Course	Major Revisions
O&M of Mechanical and Electrical Equipment	• The training topics of "energy audit" and "wiring" are added to the course. • Contents of "electrical panels" and "selection of pumps" cover more details. • "Generator" is grouped into the topics of second priority and included in training topics for the course for FY2023.
O&M of Sewerage and Drainage	• The training topics of "flow measurement of open channels", "wastewater treatment technology", and "O&M of wastewater treatment plant" are added to the course. • "Sewer pipe inspection camera" is added under the training topic of "cleaning of sewerage and drainage pipelines". • "Manhole detection" is moved to the second priority and included in the training topics for the course of FY2023.
Leakage Control, Plumbing, and Pipe Replacement Plan	• The training topics of "water meter for house connections", "proper handling of leakage from valves and connections", "data collection method at the leakage repairing site", "joint/connection/replacement, including welding from fusion", and "pressure test" are added to the course. • "On-site leakage detection" is considered into the second priority and included in the course for FY2023. • "Repairing of leakage and burst pipelines" is removed from the training topics of the course in Phase 2.
Training Methods and Process (applicable to all courses)	• While reducing the time allocated for lectures, more time is to be secured at the site to perform activities by applying theories/rules to different cases and ensuring proper work procedures.

4-1-9 Based on the recommendations, revise or update the professional training contents [Activity 1-9]

AJWA and JET revised and updated the professional training content and materials for the three courses based on the training topics agreed upon in TAC. As AJWA had planned the professional training as shown in Section 4-1-11 below, AJWA and JET decided to complete the preparation and obtain approval from TAC by the end of May 2022 at least for the training content for the Sewage and Drainage, and Mechanical and Electrical courses to be held in May-June 2022.

4-1-10 TAC approves revised and updated professional training content [Activity 1-10]

The activity is scheduled in Term 2.

4-1-11 Conduct professional training with approved training content [Activity 1-11]

The activity is scheduled in Term 2.

4-1-12 Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators [Activity 1-12]

For the training of WASA Coordinators, advice on the process of practicing needs assessment for in-house training was provided in Activity 3-2 and ToT (Training in Training Design and Instruction Skills) in Activity 1-6.

In the process of training needs assessment, an orientation on the assessment process was provided for WASA Coordinators before the activity started. WASA Coordinators worked with JET to identify the issues that need to be addressed in the implementation of the work and the capacity development of the staff in each area. In collaboration with JET, WASA Coordinators i) identified issues related to the service provision by WASA and capacity development of the staff, and ii) considered training topics and target groups for issues that could be addressed in training. The training topics and target groups identified by each WASA were reflected in selecting priority training areas for in-house training (Activities 3-3) and the development of training plans by WASA (Activity 3-4).

4-1-13 Organize semi-annual WASA coordinators meetings [Activity 1-13]

The activity is scheduled in Term 2.

4-2 Activities related to Output 2

4-2-1 Assess and evaluate current training of WASA Training Center [Activity 2-1]

JET consolidated the training implementation status of WASA-L Training Center for 2019 and 2020 (see Annex 4.2.1) and confirmed the following points from the management of WASA Training Center:

- WASA-L provides its staff with opportunities to attend in-house training organized by WASA Training Center and training programs offered by local and foreign training institutions. The in-house training is broadly categorized into regular, need-based, and post-induction training. Twelve modules are available for the regular training and 27 modules for the need-based training (Table 4.2.1). Most of the regular training and needs-based training is targeted at technical staff involved in the planning, operating, and maintaining of water and sewerage facilities. The contents of these training modules cover the professional knowledge and skills as well as behavioral requirements that the staff in each position should have for the service provision of WASA.
- Most of the proposed training programs for 2020 were canceled due to the spread of COVID-19. Nevertheless, WASA Training Center managed to conduct six training modules in the 1st and 4th quarters of 2020. A total of 990 staff were trained in the regular training, namely "quality

control management", "energy-saving techniques", "chlorination at tube wells", "water supply lines and their O&M", "leakage detection & repair", and "occupational health & worksite safety" in 2020.

- WASA Training Center provided two modules of "human resources management information system", "O&M of disposal stations", "cost estimation, technical sanction, measurement book, surveying & leveling", and "quality assurance & quality control of materials & construction materials" in 2021.

Further, based on discussions with WASA Training Center, JET assessed the training content and methods of ten modules dealing with subjects in technical/engineering fields, those indicated in boldface with underlines in Table 4.2.1, among the present 12 regular training modules. These ten regular training modules are required to be taken by all technical staff in the target positions. Since the training content and implementation methods have been established, they can be regarded as the standard training programs of WASA Training Center and appropriate as samples to assess and draw recommendations for improving the overall training program.

Table 4.2.1 Existing Training Modules of WASA Training Center

Training Module*	Category	Target Group	BPS
O&M of Electrical Equipment	Regular	Sub Engineer, SDO (O&M)/Ads	14, 16, 17
Quality Control Management	Regular	Sub Engineer, SDO (O&M)	14, 16, 17
Energy Saving Techniques	Regular	Sub Engineer, SDO (O&M)	14, 16, 17
Functions of Valves	Regular	Sub Engineer, SDO (O&M)	14, 16, 17
Chlorination at Tube Wells	Regular	Junior Pump Operator, Senior Pump Operator, SGPO	2-7
O&M of Generators	Regular	Junior Pump Operator, Senior Pump Operator, SGPO	2-7
Water Supply Lines and Their O&M	Regular	Head Pipe Fitter, Pipe Fitter, Assistant Pipe Fitter	1-6
Leakage Detection & Repair	Regular	Sub-Engineers	14, 16
Occupational Health & Worksite Safety	Regular	Sanitation Worker, Asst. Supervisor, Supervisor	1-4
O&M of Disposal Stations	Regular	Sub Engineer, SDO	14, 16, 17
Documents & Staff Handling	Regular	PS, SO, Sr. Clerk, Jr. Clerk, Asst. Stenographer, Data Entry Operators	11-17
PPRA Rules	Regular	SDO, XEN, Director	16, 17, 18, 19
Policies, Laws, Rules & Regulations	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Delegation of Powers	Need-Based	SDO, XEN, Director	16, 17, 18, 19
B & R (Buildings & Roads) Codes	Need-Based	SDO, XEN, Director	16, 17, 18, 19
PEEDA Act-2006	Need-Based	SDO, XEN, Director	16, 17, 18, 19
ESTA Code, 1974	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Land Acquisition Process	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Leave Rules & Travel Allowances	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Approval of Schemes & personal matters	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Financial Audit Rules & Regulations	Need-Based	SDO, XEN, Director	16, 17, 18, 19

Training Module*	Category	Target Group	BPS
Business Management	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Financial Management	Need-Based	SDO, XEN, Director	16, 17, 18, 19
Reduction of NWR	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Project Construction Management	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Hydrology	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Cost Management	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Asset Management	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Team Building & Efficient Use of Human Resource	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Stress Management	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
First Aid	Need-Based	Sub Engineer, SDO, XEN	14, 16, 17, 18
Drilling & Boring of Tube Wells	Need-Based	Sub Engineer, SDO	14, 16, 17
O&M of Drainage Systems	Need-Based	Sub Engineer, SDO	14, 16, 17
Technical Sanction, Measurement Book, Leveling & Surveying	Need-Based	Sub Engineer	14, 16
Operation of Dewatering Sets	Need-Based	Dewatering Set Operator	1-5
Detection of Illegal Water Connections and Issuance of Challans regarding Amnesty Scheme	Need-Based	SDO (O&M), AD (Revenue)	16, 17
Human Resource Management Information System	Need-Based	Clerical Staff, AD, DD	11-18
Workplace Ethics and Table Serving Manners	Need-Based	All Naib Qasids	1, 2, 3
Water Conservation Awareness	Need-Based	All Staff (Random)	16, 17, 18, 19
Multiple Modules	Induction	AD, SDO, Junior Engineer	17
Multiple Modules	Induction	Sub Engineer	14, 16

* The Project assessed the syllabus and materials of the training modules indicated in boldface with underlines.

Findings from the assessment are as follows:

- Each module is designed as a three-hour training program with 20 participants per class.
- The program mainly consists of lectures in a training room and site visits with lecturers' demonstrations.
- The lectures cover daily activities that the target groups are responsible for.
- Only two modules among those listed above include exercises by trainees on the training topics in the training room.
- None of the modules provide opportunities for the trainees to conduct field activities on-site as practical training.
- The training content and method need to be adjusted to give more emphasis on practical application.

4-2-2 Based on the results of evaluation, list up thematic areas and methodologies requires revisions or improvements [Activity 2-2]

While maintaining the existing modules, WASA Training Center needed to develop new training modules in the areas of i) wastewater treatment technology, ii) water purification technology, iii) flow measurement in drainage canals and wastewater pumping stations, and iv) O&M of wells and pumps, which WASA-L had identified as the priority issues to be addressed. A training needs and capacity assessment was also conducted for WASA-L to confirm the details of their training needs. As a result, it was found that the areas of training needs of WASA-L were those that WASA had not experienced before and were being planned. Specifically, the training needs include methods for selecting wastewater treatment processes, and methods for selecting pumps to be installed in tube wells and disposal pump stations (see Table 4.2.2). While some topics, such as the selection method for pumps to be installed in tube wells and disposal pump stations, are basic to WASA's work, they were not included in the existing modules. The results of this assessment were compiled together with those of the survey in Activities 1-1 and 3-1 (see Annex 4.2.2).

In addition, from the perspective of improving the quality of training, WASA Training Center needed to select the training content and methods, monitor and evaluate training effectiveness, and revise the training content appropriately based on the results of such monitoring and evaluation. The Project provided technical support to WASA Training Center to improve quality management of training activities by practicing planning, implementation, and evaluation of new training modules. The Project also facilitated that the quality management practiced through the new modules would be applied to existing ones. As for the training content of existing modules, the Project supported the Training Center in improving the contents by themselves during the second term of the Project.

Table 4.2.2 Training Needs of WASA Training Center

Subject Area	Training Subject	Target Group
Mechanical and Electrical Equipment	• Selection of pumps for tube wells and disposal pump stations	Directors/XENs/ADs (Eng.)
	• O&M of tube wells and pumps (scheduled maintenance, troubleshooting of deep well turbine pumps and tube wells, instruction and supervision of contractors providing maintenance of tube wells)	ADs/SDOs (BS-17) & Sub Engineers (BS-14 & BS-16)
	• Selection of water treatment technology (O&M of the membrane treatment plant at tube wells and surface water treatment plant)	Directors/XENs/ADs (Eng.)
Sewerage and Drainage	• Wastewater treatment basics, wastewater treatment technologies, criteria for selection of wastewater treatment technology for local conditions in Pakistan, financial comparison of different technologies regarding CAPEX and OPEX	Directors/XENs/ADs (Eng.)
	• Flow measurement of open channels and disposal pumping stations (transient time flow meters, Doppler Ultrasonic flow meters)	XENs/DDs, ADs/SDOs
	• Improvement of designs of disposal pumping stations (Adoption of designs that consider ease of O&M)	XENs/DDs, ADs/SDOs

Subject Area	Training Subject	Target Group
	• Inspection & testing of sewerage system, selection of sewer cleaning machinery & safety equipment as per local conditions (choosing best possible specifications), safety measures	ADs/SDOs (BS-17) & Sub Engineers (BS-14 & BS-16)
	• Designing of sewerage schemes by using the latest IT and software (SewerCAD, StormCAD, SewerGEM)	XENs/DDs, ADs/SDOs
Leakage Control, Plumbing, and Pipe Replacement Plan	• Choosing specifications and international standards for water supply control valves	XENs/DDs, ADs/SDOs
	• Designing of water supply schemes by using the latest IT and software (EPA NET, WaterGEM, WaterCAD)	XENs/DDs, ADs/SDOs

Following consultations with JET on the training needs assessment and review of existing training modules, the Training Center decided to develop and implement the first priority training topics (see Table 4.2.3 and Annex 4.1.2) as a new training module for 2022, and prepared the annual plan and schedule for 2022 (see Annex 4.2.3). WASA-L also appointed the Director (Planning & Evaluation) who oversees the Training Center as WASA Coordinator.

Table 4.2.3 First Priority Training Topics of WASA Training Center

No.	Training Topic	Main Contents
Area: O&M of Mechanical and Electrical Equipment		
1	Energy Audit (Saving Operation Cost)	• How to check/evaluate operating efficiency of mechanical equipment • How to improve operating efficiency
2	O&M of Pump (Tube Well and Disposal Station)	• SOPs for pump and motor • Daily and periodic inspection • Preventive maintenance
3	Selection of Pump	• How to select suitable pumps for tube well and disposal station • How to decide/check the specifications
4	Electrical panels	• O&M of electrical panels
5	MCU	• How to read Electrical drawings of motor starters and electrical panels • O&M (Recordkeeping, SOP, Routine and Preventive Maintenance) • Design (Selection criteria for appropriate protective devices)
6	Wiring	• Inspection and repair • Wire size
Area: O&M of Sewerage and Drainage		
1	Cleaning of sewerage and drainage pipelines	• How to clean sewer and drainage lines properly • Latest cleaning techniques of sewerage and drainage pipelines (Camera) • Removal of blockages in sewer lines
1'	Maintenance of sewerage and drainage system (including NO.1)	• Repair and maintenance of sewerage and drainage pipeline • Leakage issues and methods of repair • Modern technique to fix crown failures • How to avoid crown failures • Latest different techniques for testing sewerage and drainage system
2	Flow measurement of open channels	• How to use flow velocity meter • How to calculate the flow rate • How to estimate at various depths

No.	Training Topic	Main Contents
3	Wastewater treatment technologies	• Wastewater treatment basics • Wastewater treatment technologies • Criteria for selection of the most suitable technology for local conditions • Financial comparison of different technologies regarding CAPEX and OPEX
Area: Leakage Control, Plumbing, and Pipe Replacement Plan		
1	Water Meter for house connection	• Proper Installation • Basic knowledge
2	Proper handling of leakages from valves and connections (including pressure testing between branch saddle and meter)	• Type of meters and proper selection • Proper installation • Repair work • Pressure recording at the end of network for consumer
3	Pressure test	• Pressure test of proper and improper material, torque, different dimension

4-2-3 Update and revise training contents, modules and methodologies [Activity 2-3]

WASA Trainers prepared programs and materials for the new module with the technical support of JET. The activities are outlined below:

(1) Mechanical Equipment

On 9th and 14th December 2021, an energy audit of the pumps was conducted at WASA's facilities. Based on the audit, the team guided in calculating the pump efficiency and power consumption.

Picture 4.2.1 Support to Implementation of Energy Audit

(2) Plumbing

As a result of the discussions with WASA Training Center on 7th and 30th December 2021, JET confirmed that risks associated with pressure testing should be included in the training topics as WASA Training Center observed that WASA staff did not have sufficient knowledge of the issues. In addition, JET checked the training site for pressure testing as well as other training facilities.

Picture 4.2.2 Pressure Test Equipment and Pipes at WASA Training Center

4-2-4 Conduct training with revised contents, modules and methodologies [Activity 2-4]

The activity is scheduled in Term 2.

4-2-5 Reevaluate training and update or revise the training contents, modules and methodologies regularly [Activity 2-5]

The activity is scheduled in Term 2.

4-3 Activities related to Output 3

4-3-1 Notify WASA coordinator in each WASA [Activity 3-1]

All WASAs appointed WASA Coordinators by May 2021, as shown in Annex 4.3.1.

4-3-2 WASA coordinator conducts training assessment for in-house training needs and training capacity [Activity 3-2]

This activity was conducted in conjunction with Activity 1-1.

4-3-3 Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers [Activity 3-3]

Each WASA decided on in-house training courses and priority training topics based on the results of the training needs assessment and outlines of in-house training they discussed with JET (Table 4.3.1 - 4.3.3, Annex 4.3.2). In terms of training areas, all 4 WASAs expressed their preference to implement the three project-supported courses, i.e., O&M of mechanical and electrical equipment, O&M of sewerage and drainage, and plumbing, leakage control, and pipe replacement plan) starting with in-house training in 2022.

4 WASAs also nominated candidates of WASA Trainers to be responsible for each training course, as shown in Annex 4.3.1.

Table 4.3.1 First Priority Topics of In-House Training at 4 WASAs (O&M of Mechanical and Electrical Equipment Course)

No.	Training Topic	Main Content	WASA-F	WASA-G	WASA-M	WASA-R
1	Energy Audit (Saving Operation Cost)	• How to check/evaluate operating efficiency of mechanical equipment • How to improve operating efficiency	✓	✓	✓	✓
2	O&M of Pump (Tube Well and Disposal Station)	• SOPs for pump and motor • Daily and periodic inspection • Preventive maintenance	✓	✓	✓	✓
4	Electrical panels	• O&M of electrical panels	✓	✓	✓	✓
5	MCU	• How to read Electrical drawings of motor starters and electrical panels • O&M (Recordkeeping, SOP, Routine and Preventive Maintenance) • Design (Selection criteria for appropriate protective devices)	✓	✓	✓	
6	Wiring	• Inspection and repair • Wire size	✓	✓	✓	✓

Table 4.3.2 First Priority Topics of In-House Training at 4 WASAs (O&M of Sewerage and Drainage Course)

No.	Training Topic	Main Content	WASA-F	WASA-G	WASA-M	WASA-R
1	Cleaning of sewerage and drainage pipelines	• How to clean sewer and drainage lines properly • Latest cleaning techniques of sewerage and drainage pipelines (Camera) • Removal of blockages in sewer lines	✓	✓	✓	✓
1'	Maintenance of sewerage and drainage system (including NO.1)	• Repair and maintenance of sewerage and drainage pipeline • Leakage issues and methods of repair • Modern technique to fix crown failures • How to avoid crown failures • Latest different techniques for testing sewerage and drainage system	✓	✓	✓	✓
2	Flow measurement of open channels	• How to use flow velocity meter • How to calculate the flow rate • How to estimate at various depths	✓	✓	✓	
3	O&M of the wastewater treatment plant	• Maintenance/How to increase the efficiency of existing WWTP(WSP) • How to clean and maintain ponds of WWTP(WSP)	✓		✓	

No.	Training Topic	Main Content	WASA-F	WASA-G	WASA-M	WASA-R
4	Wastewater treatment technologies	• Wastewater treatment basics • Wastewater treatment technologies • Criteria for selection of the most suitable technology for local conditions • Financial comparison of different technologies regarding CAPEX and OPEX		✓	✓	✓

Table 4.3.3 First Priority Topics of In-House Training at 4 WASAs (Leakage Control, Plumbing, and Pipe Replacement Plan Course)

No.	Training Topic	Main Content	WASA-F	WASA-G	WASA-M	WASA-R
1	Water Meter for house connection	• Proper Installation • Basic knowledge			✓	
2	Proper handling of leakages from valves and connections (including pressure testing between branch saddle and meter)	• Type of meter and proper selection • Proper installation • Repair work • Pressure recording at the end of network for consumer			✓	✓
3	Data collection method at leakage repairing site	• Creation of Data collection format • Risk/condition evaluation method • Application of the format in actual works	✓	✓	✓	✓
4	Joint/Connection/Replacement including welding and fusion	• Physical property different types of pipe/ size of pipes • Type of connections Gibault joint, Mechanical joint, Flange, Valve, Dismantling joint • Type of External/Internal lining - proper selection of lining - the type of External/Internal lining like epoxy, polyethylene, bitumen, etc. • Standard and instruction Standard and instruction of the manufacturer of the material,	✓	✓	✓	✓
5	Pressure test	• Pressure test of proper and improper material, torque, different dimension		✓	✓	✓

4-3-4 WASA coordinator formulates in-house training plans semiannually [Activity 3-4]

Based on the training courses and topics determined in Activity 3-3, each WASA has prepared an annual in-house training plan and schedule for FY2022 (see Annex 5.3.1-5.3.4). The training plan includes training modules for each course, designations and BPS of the target groups, the number of relevant staff employed, and the planned number of staff to be trained in FY2022. The training schedule also summarizes the frequency, timing, and duration of each training module, the target group and the number of trainees for each batch, and WASA Trainer in charge. WASA-F, WASA-G, and WASA-R planned to pilot the in-house training at the end of January or early February 2022 for the energy audit training module that was in an advanced stage of preparation. The full launch of in-house training was anticipated in June 2022 for 4 WASAs. Tables 4.3.4 to 4.3.7 show the structure of the in-house training modules for each WASA.

Table 4.3.4 In-House Training Modules of WASA-F

Course	Module	Target Cadre (BPS)	Duration
O&M of Mechanical and Electrical Equipment	Energy Audit	DD (Technical)(18), AD (technical)(17), Senior Sub Eng. (16), Sub Eng (14), Water Supply Supervisor (4/5/6), Work Supervisor (10), Motor Mechanic (7/8), Mechanic (5), Electrician (4/5/6), Pump Operator (2/3/4/5), Plumber (3/4/5/6), Helper Electrician (1)	1 day
	O&M of Pump	DD (Technical)(18), AD (technical)(17), Senior Sub Eng. (16), Sub Eng (14), Water Supply Supervisor (4/5/6), Work Supervisor (10), Motor Mechanic (7/8), Mechanic (5), Electrician (4/5/6), Pump Operator (2/3/4/5), Plumber (3/4/5/6)	1 day
	Electric Panel, MCU, and Wiring	DD (Technical)(18), AD (technical)(17), Senior Sub Eng. (16), Sub Eng (14), Water Supply Supervisor (4/5/6), Work Supervisor (10), Motor Mechanic (7/8), Mechanic (5), Electrician (4/5/6), Pump Operator (2/3/4/5), Plumber (3/4/5/6), Helper Electrician (1)	2 days
O&M of Sewerage and Drainage	Cleaning of Sewerage and Drainage Pipelines	DD (Technical) (18), AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Senior Sewer Supervisor (10), Sanitation Supervisor (7), Sewer Cleaning Machine Operator (6), Sewer Supervisor (4/5)	1 day
	O&M of Wastewater Treatment Plan	AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Senior Sewer Supervisor (10), Sanitation Supervisor (7), Sewer Cleaning Machine Operator (6), Sewer Supervisor (4/5)	1 day
	Flow Measurement of Open Channels	AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Senior Sewer Supervisor (10)	1 day
Leakage Control, Plumbing, and Pipe Replacement Plan	Replacement Planning Using GIS	DD (Technical/GIS)(18), GIS Analyst (17), AD (Drawing/Technical)(17), Senior Sub Eng. (17), Sub Eng. (14)	1 day
	Distribution Pipe	DD (Technical/GIS)(18), AD (Technical)(17), Senior Sub Eng. (17), Sub Eng. (14), Supervisor (Water Supply) (5/6), Plumber (6)	1 day

Table 4.3.5 In-House Training Modules of WASA-M

Course	Module	Target Cadre (BPS)	Duration
O&M of Mechanical and Electrical Equipment	Energy Audit	Senior Sub Eng. (16), Sub Eng. (14), Plumber (5), Fitter (5), Tube Well Operator (1), Helper (Tube Well Operator) (1)	1 day
	O&M of Pump	Senior Sub Eng. (16), Sub Eng. (14), Plumber (5),	1 day

Course	Module	Target Cadre (BPS)	Duration
		Fitter (5), Tube Well Operator (1), Helper (Tube Well Operator) (1)	
	Electric Panel, MCU, and Wiring	Senior Sub Eng. (16), Sub Eng. (14), Tube Well Operator (1), Helper (Tube Well Operator) (1), Operator (Disposal Station) (6), Helper (Disposal Station) (1)	1 day
O&M of Sewerage and Drainage	Cleaning of Sewerage and Drainage Pipelines	Senior Sub Eng. (16), Sub Eng. (14), Sewer Supervisor (4), Senior Sewer man (4), Helper (Sewer Cleaning Machinery (1), Sewer Man (1)	1 day
	O&M of Wastewater Treatment Plan	Senior Sub Eng. (16), Sub Eng. (14), Sewer Supervisor (4), Senior Sewer man (4), Helper (Sewer Cleaning Machinery (1), Sewer Man (1)	1 day
	Flow Measurement of Open Channels	Senior Sub Eng. (16), Sub Eng. (14), Sewer Supervisor (4), Senior Sewer man (4), Helper (Sewer Cleaning Machinery (1), Sewer Man (1)	1 day
Leakage Control, Plumbing, and Pipe Replacement Plan	Replacement Planning Using GIS	AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Leakage Supervisor (7), Plumber (5), Fitter (4)	1 day
	Leakage Control and Plumbing with Service Pipe	AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Leakage Supervisor (7), Plumber (5), Fitter (4)	1 day
	Distribution Pipe	AD (Technical) (17), Senior Sub Eng. (16), Sub Eng. (14), Leakage Supervisor (7), Plumber (5), Fitter (4)	1 day

Table 4.3.6 In-House Training Modules of WASA-G

Course	Module	Target Cadre (BPS)	Duration
O&M of Mechanical and Electrical Equipment	Energy Audit	AD (Civil) (17), Sub Eng. (Civil) (14/16), Sub Eng. (Electrical/Mechanical) (14), Tube Well Operator (5), Electrician (5), Plumber (5), Assistant Pump Operator (2)	1 day
	O&M of Pump	Sub Eng. (Civil) (14/16), Sub Eng. (Electrical/Mechanical) (14), Tube Well Operator (5), Plumber (5), Assistant Pump Operator (2)	1 day
	Electric Panel, MCU, and Wiring	Sub Eng. (Civil) (14/16), Sub Eng. (Electrical/Mechanical) (14), Tube Well Operator (5), Electrician (5), Assistant Pump Operator (2)	1 day
O&M of Sewerage and Drainage	Cleaning of Sewerage and Drainage Pipelines	Sub Eng. (Civil) (14/16), Supervisor (11), Excavating Operator (8), Sewer Supervisor (5), Sewer Man (1)	1 day
	Flow Measurement of Open Channels	Sub Eng (Technical) (17), Sub Eng. (Civil) (14/16), Supervisor (11)	1 day
Leakage Control, Plumbing, and Pipe Replacement Plan	Replacement Planning Using GIS	AD (Civil/ Mechanical) (17), Sub Eng. (Civil) (14/16), Sub Eng. (Electrical/Mechanical) (14), Supervisor (11)	1 day
	Distribution Pipe	Sub Eng. (Civil) (14/16), Supervisor (11), Plumber (5)	1 day

Table 4.3.7 In-House Training Modules of WASA-R

Course	Module	Target Cadre (BPS)	Duration
O&M of Mechanical and Electrical Equipment	Energy Audit	AD (17), Sub Eng (14), Supervisor (Water Supply) (11), Inspector Tube Well (9), Electrician (6), Filter/Tube Well Mechanic (5), Plumber (5), Tube Well Operator (4), Pump Operator (4)	1 day
	O&M of Pump	AD (Water Supply/ Monitoring & Evaluation/ Planning & Development) (17), Sub Eng. (14), Supervisor (Water Supply) (11), Inspector Tube Well (9), Filter/Tube Well Mechanic (5), Plumber (5), Tube Well Operator (4), Pump Operator (4)	1 day
	Electric Panel, MCU, and Wiring	Sub Eng. (14), Supervisor (Water Supply) (11), Inspector Tube Well (9), Electrician (6), Filter/Tube Well Mechanic (5), Plumber (5), Tube Well Operator (4), Pump Operator (4)	1 day
O&M of Sewerage and Drainage	Cleaning of Sewerage and Drainage Pipelines	AD (Sewerage & Drainage) (17), Sub Eng. (14), Supervisor (Sewerage & Drainage) (11), Sewer Man (1)	1 day
Leakage Control, Plumbing, and Pipe Replacement Plan	Replacement Planning Using GIS	AD (Water Supply) (17), Sub Eng. (14), Supervisor (Water Supply) (11), Filter/Tube Well Mechanic (5), Plumber (5), Valve Man (1)	1 day
	Leakage Control and Plumbing with Service Pipe	AD (Water Supply) (17), Sub Eng. (14), Supervisor (Water Supply) (11), Filter/Tube Well Mechanic (5), Plumber (5), Valve Man (1)	1 day
	Distribution Pipe	AD (Water Supply) (17), Sub Eng. (14), Supervisor (Water Supply) (11), Filter/Tube Well Mechanic (5), Plumber (5), Valve Man (1)	1 day

JET participated in the planning process by WASA Coordinators and WASA Trainers, providing advice on the organization of the training course into modules, setting the target groups and the number of trainees, and reviewing the proposed schedule. In developing the training plan, WASAs took into consideration the following points:

- During the monsoon season (June to mid-September), the frequency of in-house training will be reduced as the staff will be busy with their work.
- In-house training programs are expected to be conducted for about two hours each (roughly one-hour lecture and exercises in a training room and one-hour field practices).
- The details of the training schedule will be adjusted according to the operation status of WASA, and the schedule will be updated by WASA Coordinator from time to time.

JET advised mainly on the following points:

- WASA Coordinators and Trainers need to ensure that the number of trainees in each batch is not too large so that each participant/group of participants has the opportunity to experience the field practices and/or exercises in a training room, and WASA Trainers can provide the necessary guidance and assistance to their learning. Also, the number of trainees in each batch/training module should be adjusted by WASA based on observations on the appropriate size of participants that WASA Trainers can handle.

- To promote the practical application of what trainees learn, it is also important to obtain the understanding and support of the training content from their supervisors. If WASA Trainer is not the direct supervisor of the trainees, the supervisor can be included in the target group of the training, or WASA Trainer and the supervisor can work together to monitor how trainees apply what they learned in training to their work.
- It is necessary to decide how to manage and share documents and data to be accumulated through in-house training, such as training outlines, timetables, and training materials/tools, within WASAs. PCs procured by the Project should also be utilized for this purpose.

4-3-5 WASA coordinator reviews implementation of in-house training plans and budget annually and revises the plans and budget if necessary [Activity 3-5]

The activity is scheduled in Term 2.

4-4 Activities related to Output 4

4-4-1 Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules [Activity 4-1]

The in-house training modules are shown in the annual training plan for each WASA. The training is mainly based on exercises and field practice. Therefore, the training procedures and supporting materials for each module were designed in consideration that i) WASA trainers can learn how to conduct the training with the technical support of JET, and ii) WASA trainers will be able to conduct the training by themselves gradually by the end of the Project. With this aim, JET drafted a training outline consisting of the training objectives, contents and procedures for each module. The outlines were reviewed among WASA trainers, AJWA, and JET (see Annex 4.4.1 - 4.4.3).

AJWA faculty and JET visited each WASA, as shown in Table 4.4.1. During the visit, they discussed the training modules and detailed contents on in-house training to prepare the training.

Table 4.4.1 Visit to Each WASA

Field of Expert	WASA-F	WASA-M	WASA-G	WASA-R
Mechanical	16,17 Dec 2021	-	9,10 Dec 2021	21,22 Dec 2021
Sewerage & drainage	17 Dec 2021	22,23,24 Dec 2021	27,28,29 Dec 2021	31 Dec 2021
Plumbing	-	23-25 Dec 2021	8,9,27-30 Dec 2021	-

The activities of each subject area of training are summarized as follows.

(1) Sewerage and Drainage

JET and AJWA faculty visited 4WASAs, discussed with WASA trainers, and visited candidate sites for field practices to be conducted in in-house training. At WASA-M and WASA-R, the sewer camera was used to take videos inside sewer pipes. The demonstration was conducted without major problems. At WASA-M, JICA conducted a preparatory survey for a grant aid project for the procurement of equipment in parallel with this project. In order to enhance the outcome of the grant aid project, Mr. Muhammad Nadeem, a primary officer of WASA-M for the grant aid project, was assigned as one of the WASA Trainers.

WASAs perform cleaning of sewer pipes mainly by sticking the nozzle through the blockage with the guide of a bamboo pole. When the water level begins to drop, a high-pressure sewer jetting truck leaves the site, and then a sludge suction truck sucks out the accumulated sewage. After the water level falls into the manhole, the work is completed and the manhole lid is closed to leave the site. However, this cleaning method does not remove the sediment in the sewer pipes and will result in another overflow.

In order to support proper cleaning of the sewer pipes, the Project facilitated the management of WASA and persons in charge of cleaning the sewer pipes to understand the problems with the current cleaning process and encouraged them to employ appropriate measures. The field practices in in-house training were designed to provide WASA staff with opportunities to use a sewer inspection camera to check the remaining sediments through video images after cleaning sewer pipes with the current procedures and to understand the causes of frequent overflows. The training content also included a session for WASA staff, AJWA faculty, and JET to discuss future countermeasures based on the field exercise and take actions accordingly.

Picture 4.4.1 Demonstration of sewer camera at WASA-M and surrounding area

Picture 4.4.2 Demonstration of sewer camera at WASA-R

(2) Mechanical Equipment

The site visit was conducted to confirm i) current conditions of on-site facilities required for in-house training and ii) the expected training sites. The result was that the performance curves of the pumps, important information for analyzing the adequacy of the pump operation, were not available or not properly kept at WASA. The technical assistance for measuring various data such as flow rate was also conducted.

Measurement of water level at a tube well

Measurement of flowrate at a tube well

Picture 4.4.3 Technical assistance on energy audit at WASA-R

(3) Plumbing

To determine the training details, JET interviewed WASA staff to assess the extent to which they are familiar with the basics related to the training topics. As a result, the specific training needs were confirmed for i) pressure resistance during replacement, ii) pipe specifications, iii) screw standards, and iv) pipe fittings.

Connection between PVC and HDPE

Connection of saddle to HDPE

Picture 4.4.4 Pipe connection at WASA-G

4-4-2 WASA trainers conduct pilot in-house training at each WASA [Activity 4-2]

The pilot in-house training was conducted at WASA- F, G, and R. AJWA faculty and JET attended the training to observe the facilitation process and instruction methods by WASA trainers and provided technical assistance to the training and advice to WASA trainers.

Table 4.4.2 Implementation of Pilot In-house Training

WASA	Training course	Module	Implemented date	Number of Trainees
WASA-F	O&M of Mechanical & Electrical Equipment	Energy Audit	27 Jan 2022	11
WASA-G	O&M of Mechanical & Electrical Equipment	Energy Audit	10 Feb 2022	4
WASA-R	O&M of Mechanical & Electrical Equipment	Energy Audit	3 Feb 2022	9

4-4-3 WASA trainers and WASA coordinator review pilot in-house training and update the training contents and modules [Activity 4-3]

After the pilot in-house training, the training review was conducted among WASA Trainers, WASA Coordinators, AJWA faculty, and JET. It was confirmed that WASA Trainers have sufficient technical knowledge to conduct in-house training. The parties identified the contents to be enhanced in preparation and facilitation of training activities to realize in-house training at full-scale. For instance, there was a need to improve the preparation of materials and equipment necessary for the smooth implementation of training. In addition, WASA Trainers could facilitate training by asking trainees questions to check their understanding and obtain their contributions to the discussion.

4-4-4 WASA trainers conduct in-house training [Activity 4-4]

The activity is scheduled in Term 2.

4-4-5 Regularly, review and update in-house training contents, modules, and methods [Activity 4-5]

The activity is scheduled in Term 2.

4-5 Other Activities

4-5-1 Baseline Survey for Measuring the Effect of the Project

A simple baseline survey was conducted to collect data on the indicators of PDM. Table 4.5.1 and Table 4.5.2 show the basic information of each WASA compiled from the baseline survey results. In addition, information on cleaning equipment was collected from 5WASAs for planning sewer cleaning activities (see Annex 4.5.1-4.5.5).

Table 4.5.1 Basic Information of WASAs

	WASA-L	WASA-F	WASA-M	WASA-G	WASA-R
Number of staff	6,838	1,699	1,377	781	1,235
Water Supply					
Total population in service area (million)	8	3.4	2.2	2.0	1.6
Service population (million)	8	2.38	1.2	0.74	1.4
Service rate (%)	100	70	55	37	85
Service hour (hr/day)	11	6	6	10 - 12	2 - 3
WTP (nos)	0	2	0	0	1
Length of water supply pipeline (km)	5,864	1,510	1,448	617	1,000
Non-revenue water (%)	30	40	28	32	30
Collection rate of tariff (%)	92	65	54	47	60 - 65
Sewerage					
Total population in service area (million)	8	3.4	2.2	2.0	1.6
Sewerage connection population (million)	8	2.45	1.4	1.4	0.56
Service rate (%)	100	72	65	70	35
Length of sewage pipeline (km)	4,974	1,957	1,774	1,280	364
Length of storm drainage (km)	482	62	156	39	8
Total number of disposal stations and lift stations (nos)	126	38	25	37	4
WWTP (nos)	0	1	1	0	0

(Source: WASA-L, WASA-F, WASA-M, WASA-G, WASA-R)

Table 4.5.2 Staff Distribution by BPS in WASAs

	BPS1-10	BPS11-16	> BPS17	Total
WASA-L	6,021	582	235	6,838
WASA-F	1,438	171	90	1,699
WASA-M	1,174	165	38	1,377
WASA-G	690	72	19	781
WASA-R	991	118	30	1,139

(Source: WASA-L, WASA-F, WASA-M, WASA-G, WASA-R)

Table 4.5.3 summarizes the baseline of indicators for the project output in PDM.

Table 4.5.3 Baseline of Indicators for Project Output

Output	Indicator	Baseline
Output 1: Capacity for Al-Jazari Academy to conduct practical training to WASAs is strengthened.	1-1 ToT components are included in training contents/materials of three thematic areas.	ToT component has not been developed.
	1-2 All of the selected training contents are revised/updated based on the Technical Advisory Committee's recommendations.	The professional training content has not been revised/updated.
Output 2: Capacity to plan and conduct training at WASA Training Center is improved.	2-1 Training contents, modules, and methodologies that require revisions or improvements are fulfilled.	Revisions have not been made.
Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.	3-1 Priority sectors for in-house training at WASAs were identified by the end of Year 1.	Priority sectors for in-house training have not been identified.
	3-2 Training plans are updated every year at 4 WASAs from Year 2.	In-house training plans have not been formulated.
Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.	4-1 Each WASA achieves three thematic areas that in-house training is conducted.	In-house training has never been conducted at 4 WASAs.
	4-2 More than 50% of in-house training participants feel their skills are improved by training.	In-house training has never been conducted at 4 WASAs.

4-5-2 Activities as Countermeasures against the Spread of COVID-19

Activities as countermeasures against the spread of COVID-19 was discussed with WASAs. As a result, the formulation of a Business Continuity Plan (hereinafter referred to as "BCP") was selected and agreed upon in the first JCC meeting. To proceed with the preparation of BCP, JET collected information on cases of COVID-19 infection at each WASA (see Table 4.5.4 - 4.5.8). After that, JET discussed with WASAs the problems in daily work when a staff member became COVID-19 positive, and confirmed the chain of instructions for emergencies in the organization. As a result, it was confirmed that it would be the same as usual operation, and that instructions would be issued to subordinates from superiors in the same department.

Although BCP was initially planned to be completed in the first term of the Project, it could not be realized due to the inadequate period of assignment in Pakistan caused by the spread of COVID-19, which made JET difficult to work with WASAs for the preparation of BCP directly. This activity was, therefore, planned to be completed in the second term of the Project.

Table 4.5.4 Number of Confirmed COVID-19 Cases among Staff of WASA-L

BPS	Directorate				Total
	O&M[1)]	Eng[2)]	FAR[3)]	other	
1-10	23	3	5	0	31
11-16	6	0	8	0	14
17 or above	11	13	10	2	36
Total	40	16	23	2	81

Note: 1) Operation and Maintenance, 2) Engineering, 3) Finance, Administration, and Revenue
Source: WASA-L

Table 4.5.5 Number of Confirmed COVID-19 Cases among Staff of WASA-F

BPS	Directorate				Total
	Service	Eng[1)]	FAR[2)]	other	
1-10	0	0	0	1	1
11-16	0	0	0	0	0
17 or above	3	3	3	1	10
Total	3	3	3	2	11

Note: 1) Engineering, 2) Finance, Administration, and Revenue
Source: WASA-F

Table 4.5.6 Number of Confirmed COVID-19 Cases among Staff of WASA-M

BPS	Directorate				Total
	Operation	Eng[1)]	FAR[2)]	other	
1-10	9	0	2	0	11
11-16	3	0	4	0	7
17 or above	1	1	3	1	6
Total	13	1	9	1	24

Note: 1) Engineering, 2) Finance, Administration, Revenue
Source: WASA-M

Table 4.5.7 Number of Confirmed COVID-19 Cases among Staff of WASA-G

BPS	Directorate				Total
	P&D[1)]	Eng[2)]	A&F[3)]	other	
1-10	0	1	0	0	1
11-16	0	1	0	0	1
17 or above	1	3	1	1	6
Total	1	5	1	1	8

Note: 1) Planning and Development, 2) Engineering, 3) Administration and Finance
Source: WASA-G

Table 4.5.8 Number of Confirmed COVID-19 Cases among Staff of WASA-R

BPS	Directorate			Total
	Eng[1)]	A&F[2)]	other	
1-10	4	0	0	4
11-16	0	1	0	1
17 or above	2	1	1	4
Total	6	2	1	9

Note: 1) Engineering, 2) Administration and Finance

Source: WASA-R

4-5-3 Procurement of Equipment

Table 4.5.9 shows equipment procured in the Project and handed over to the Pakistani side. The record of handing over of the equipment is attached in Annex 4.5.6.

Table 4.5.9 List of Equipment Procured

Date of Handing Over	Item
15 Oct 2021	Personal Computer (15 units)
24 Dec 2021	Sewer Inspection Camera (1 unit)
3 Feb 2022	Vibration Meter (6 units)

5. Progress of Activities in Term 2 (April 2022 to February 2024)

5-1 Activities related to Output 1

5-1-1 Conduct training assessment (needs, capacity) including interviews to WASAs [Activity 1-1]

The activity was completed in Term 1.

5-1-2 Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules [Activity 1-2]

The activity was completed in Term 1.

5-1-3 Update or revise training modules and materials of thematic sectors where ToT will be incorporated [Activity 1-3]

Each WASA prepared materials for ToT (Technical Training), pilot in-house training, and in-house training through assistance of JET. These materials are summarized in Table 5.1.1 to 5.1.4. There are cases that a material for ToT is the same as pilot in-house training in the training topic. But some training topics are required to be changed. The contents of materials in the training topics were decided through discussions between WASA Trainers and JET.

Table 5.1.1 Outline and Training Materials for ToT, Pilot In-house Training, and In-house Training at WASA Faisalabad

<table>
<tr><th>Training topic</th><th>Outline</th><th>ToT
(Activity 1-6)</th><th>Pilot in-house training
(Activity 4-3)</th><th>In-house training
(Activity 4-4)</th></tr>
<tr><td colspan="5">O&M on Mechanical and Electrical Equipment</td></tr>
<tr><td>Energy Audit</td><td rowspan="3">Annex 5.1.1</td><td colspan="2">Annex 5.1.2</td><td>Annex 5.1.2 (1st-3rd)*
Annex 5.1.3 (4th-7th)*</td></tr>
<tr><td>O&M on pumps and motors (Efficient pumping machinery)</td><td>Annex 5.1.4</td><td colspan="2">Annex 5.1.5</td></tr>
<tr><td>Electrical Panel, MCU and wiring</td><td colspan="3">Annex 5.1.6</td></tr>
<tr><td colspan="5">O&M on Sewerage and Drainage</td></tr>
<tr><td>Cleaning of sewerage and drainage pipelines</td><td colspan="2" rowspan="2">Annex 5.1.7</td><td colspan="2" rowspan="2">Annex 5.1.8</td></tr>
<tr><td>O&M of waste water</td></tr>
</table>

treatment plant				
Flow measurement of open channels				
Leakage Control, Plumbing and Pipe Replacement Plan				
Pipe replacement planning	Annex 5.1.9	Annex 5.1.10		Annex 5.1.10 (1st,2nd)* Annex 5.1.11 (3rd,4th)*
Plumbing (HDPE jointing, pressure test etc.)		Annex 5.1.12	Annex 5.1.13	Annex 5.1.14 (1st)* Annex 5.1.15 (2nd-3rd)*
Leakage control		Annex 5.1.16		Annex 5.1.16 (1st,2nd)*, Annex 5.1.17 (3rd)* Annex 5.1.18 (4th)*

Note: "1st" means "1st In-house training". "2nd" means "2nd In-house training". See Table 5.1.5.

Table 5.1.2 Outline and Training Materials for ToT, Pilot In-house Training, and In-house Training at WASA Multan

Training topic	Outline	ToT (Activity 1-6)	Pilot In-house training (Activity 4-3)	In-house training (Activity 4-4)
O&M on Mechanical and Electrical Equipment				
Energy Audit	Annex 5.1.1	Annex 5.1.19		Annex 5.1.20
O&M on Pump		Annex 5.1.21	Annex 5.1.22	
Electrical Panel, MCU and wiring		Annex 5.1.23	Annex 5.1.24	
O&M on Sewerage and Drainage				
Cleaning of sewerage and drainage pipelines	Annex 5.1.7		Annex 5.1.8	
O&M of wastewater treatment plant				
Flow measurement of open channels				
Leakage Control, Plumbing and Pipe Replacement Plan				
Pipe replacement planning	Annex 5.1.9	Annex 5.1.10		Annex 5.1.10 (1st)* Annex 5.1.11 (2nd-4th)*
Plumbing (HDPE jointing, pressure test etc.)		Annex 5.1.12	Annex 5.1.13	Annex 5.1.14
Leakage control		Annex 5.1.16		Annex 5.1.16 (1st)* Annex 5.1.17 (2nd)*

Note: "1st" means "1st In-house training". "2nd" means "2nd In-house training". See Table 5.1.6.

Table 5.1.3 Outline and Training Materials for ToT, Pilot In-house Training, and In-house Training at WASA Gujranwala

<table>
<tr><th>Training topic</th><th>Outline</th><th>ToT
(Activity 1-6)</th><th>Pilot In-house training
(Activity 4-3)</th><th>In-house training
(Activity 4-4)</th></tr>
<tr><td colspan="5">O&M on Mechanical and Electrical Equipment</td></tr>
<tr><td>Energy Audit</td><td rowspan="3">Annex 5.1.1</td><td colspan="3">Annex 5.1.25</td></tr>
<tr><td>O&M on Pump</td><td>Annex 5.1.26</td><td colspan="2">Annex 5.1.27</td></tr>
<tr><td>Electrical Panel, MCU and wiring</td><td colspan="3">Annex 5.1.24</td></tr>
<tr><td colspan="5">O&M on Sewerage and Drainage</td></tr>
<tr><td>Cleaning of sewerage and drainage pipelines</td><td colspan="2" rowspan="2">Annex 5.1.7</td><td colspan="2" rowspan="2">Annex 5.1.8</td></tr>
<tr><td>Flow measurement of open channels</td></tr>
<tr><td colspan="5">Leakage Control, Plumbing and Pipe Replacement Plan</td></tr>
<tr><td>Pipe replacement planning</td><td rowspan="3">Annex 5.1.9</td><td colspan="2">Annex 5.1.10</td><td>Annex 5.1.10 (1st)*
Annex 5.1.11 (2nd)*</td></tr>
<tr><td>Plumbing (HDPE jointing, pressure test etc.)</td><td>Annex 5.1.12</td><td>Annex 5.1.13</td><td>Annex 5.1.14 (1st-3rd)*
Annex 5.1.15 (4th)*</td></tr>
<tr><td>Leakage control</td><td colspan="2">Annex 5.1.16</td><td>Annex 5.1.16 (1st)*
Annex 5.1.17 (2nd)*
Annex 5.1.18 (3rd)*</td></tr>
</table>

Note: "1st" means "1st In-house training". "2nd" means "2nd In-house training". See Table 5.1.7.

Table 5.1.4 Outline and Training Materials for ToT, Pilot In-house Training, and In-house Training at WASA Rawalpindi

<table>
<tr><th>Training topic</th><th>Outline</th><th>ToT
(Activity 1-6)</th><th>Pilot In-house training
(Activity 4-3)</th><th>In-house training
(Activity 4-4)</th></tr>
<tr><td colspan="5">O&M on Mechanical and Electrical Equipment</td></tr>
<tr><td>Energy Audit</td><td rowspan="3">Annex 5.1.1</td><td colspan="3">Annex 5.1.28</td></tr>
<tr><td>O&M on Pump</td><td>Annex 5.1.29</td><td colspan="2">Annex 5.1.30</td></tr>
<tr><td>Electrical Panel, MCU and wiring</td><td colspan="3">Annex 5.1.24</td></tr>
<tr><td colspan="5">Supplemental material for WTP: Annex 5.1.31
Major Points of O&M
Supplemental materials for tubewell operation: Annex 5.1.32
Checklist for Tube Well Operation (Submersible)
Troubleshooting of Tubewell
Pump Selection</td></tr>
<tr><td colspan="5">O&M on Sewerage and Drainage</td></tr>
<tr><td>Cleaning of sewerage and drainage pipelines</td><td colspan="2" rowspan="2">Annex 5.1.7</td><td colspan="2" rowspan="2">Annex 5.1.8</td></tr>
<tr><td>Flow measurement of open channels / sludge</td></tr>
</table>

volume measurement				
Leakage Control, Plumbing and Pipe Replacement Plan				
Pipe replacement planning	Annex 5.1.9	Annex 5.1.10		Annex 5.1.10 (1st)* Annex 5.1.11 (2nd,3rd)*
Plumbing (HDPE jointing, pressure test etc.)		Annex 5.1.12	Annex 5.1.13	Annex 5.1.14 (1st,2nd)* Annex 5.1.15 (3rd)*
Leakage control		Annex 5.1.16		Annex 5.1.16 (1st)* Annex 5.1.17 (2nd)* Annex 5.1.18 (3rd)*

Note: "1st" means "1st In-house training". "2nd" means "2nd In-house training". See Table 5.1.8.

5-1-4 Conduct pilot ToT and evaluate the training [Activity 1-4]

The activity was completed in Term 1.

5-1-5 Formulate ToT training schedules [Activity 1-5]

The activity was completed in Term 1.

5-1-6 Conduct ToT [Activity 1-6]

There are two types of ToT. One is ToT (Training Design and Instruction Skills). The other is ToT (Technical). ToT (Training Design and Instruction Skills) was conducted at AJWA on January 24-25, 2022. However, ToT (Technical) was conducted at each WASA because of the following advantages.

- The detailed contents or approach on the in-house training at each WASA may be different even though the name of the training topic is the same. If the ToT (Technical) is conducted at each WASA, the ToT (Technical) is able to be provided to each WASA complied with the detail demand.
- If the ToT (Technical) is conducted at each WASA, the same facility for in-house training is able to be used. As a result, WASA Trainers can obtain the technical knowledge and skills effectively and efficiently.

The implementation of "ToT (Technical)" (Activity 1-6), "Pilot In-house training" (Activity 4-3), and "In-house training" (Activity 4-4) at each WASA are summarized in Tables 5.1.5 to 5.1.8.

Table 5.1.5 ToT, Pilot In-house Training and In-house Training at WASA Faisalabad

Training topic	ToT (Activity 1-6)	Pilot In-house training (Activity 4-3)	In-house training (Activity 4-4)
O&M on Mechanical and Electrical Equipment			
Energy Audit	26 Jan 2022	27 Jan 2022	24 Jun 2022 17 Nov 2022 18 Feb 2023 3 Jun 2023 4-6 Jul 2023 (3 days) 24-25 Aug 2023 (2 days) 16-17 Oct 2023 (2 days)
O&M on pumps and motors (Efficient pumping machinery)	23 Jun 2022	24 Jun 2022	20 Oct 2022 17 Nov 2022 18 Feb 2023 3 Jun 2023 23-24 Aug 2023 (2 days)
Electrical Panel, MCU and wiring	16-17 Nov 2023	18 Nov 2023	3 Jan 2024
O&M on Sewerage and Drainage			
Cleaning of sewerage and drainage pipelines	28-30 Jun 2022	8-Dec 2022	1 Feb 2023 29 Mar 2023 3 Nov 2023
O&M of waste water treatment plant	28-30 Jun 2022	8-Dec 2022	2 Feb 2023
Flow measurement of open channels	28-30 Jun 2022	8-Dec 2022	2 Feb 2023 30 Mar 2023
Leakage Control, Plumbing and Pipe Replacement Plan			
Pipe replacement planning	10-12 Aug 2022	20 Oct 2022	17 Nov 2022 4 Jan 2023 17 Jun 2023 26 Sep 2023
Plumbing (HDPE jointing, pressure test etc.)	3-5 Aug 2022	19 May 2023	11 Jul 2023 30 Aug 2023 6 Dec 2023
Leakage control	7-8 Feb 2023	9 Feb 2023	11 Jul 2023 30 Aug 2023 27 Sep 2023 22 Dec 2023

Table 5.1.6 ToT, Pilot In-house Training and In-house Training at WASA Multan

Training topic	ToT (Activity 1-6)	Pilot In-house training (Activity 4-3)	1st In-house training (Activity 4-4)
O&M on Mechanical and Electrical Equipment			
Energy Audit	28 Jun 2022	29 Jun 2022	18 Mar 2023 3-4 Aug 2023 (2 days)
O&M on Pump	28-29 Jun 2022	30 Jun 2022	2 Nov 2022 2-3 Aug 2023 (2 days)
Electrical Panel, MCU and wiring	1-3 Nov 2022, 13-14 Dec 2022	16 Mar 2023	21 Jun 2023
O&M on Sewerage and Drainage			
Cleaning of sewerage and drainage pipelines	21-23 Jun 2022	1 Dec 2022	4 May 2023
O&M of waste water treatment plant	21-23 Jun 2022	2 Dec 2022	6 May 2023
Flow measurement of open channels	21-23 Jun 2022	3 Dec 2022	27 Jun 2023
Leakage Control, Plumbing and Pipe Replacement Plan			
Replacement planning using GIS	16-19 Aug 2022	6 Oct 2022	2 Nov 2022 22 Jun 2023 20-21 Sep 2023 (2 days) 15 Nov 2023
Plumbing (HDPE jointing, pressure test etc.)	16-19 Aug 2022	17 Mar 2023	25 May 2023 19 Jul 2023
Leakage control	31 Jan - 1 Feb 2023	2 Feb 2023	20 Jul 2023 24 Aug 2023

Table 5.1.7 ToT, Pilot In-house Training and In-house Training at WASA Gujranwala

Training topic	ToT (Activity 1-6)	Pilot In-house training (Activity 4-3)	In-house training (Activity 4-4)
O&M on Mechanical and Electrical Equipment			
Energy Audit	9-10 Dec 2021	10 Feb 2022	9 Jun 2022 18-19 Jul 2023 (2 days) 19-20 Oct 2023 (2 days) 16-17 Nov 2023 (2 days) 28-30 Nov 2023 (3 days)
O&M on Pump	20 Jun 2022	21 Jun 2022	20 Oct 2022 24 Nov 2022 19-20 Jul 2023 (2 days) 18-19 Oct 2023 (2 days) 28-30 Nov 2023 (3 days)
Electrical Panel, MCU and wiring	24-26 Oct 2022	25 Nov 2022	2 Mar 2023 12 Jul 2023 16 Nov 2023

O&M on Sewerage and Drainage			
Cleaning of sewerage and drainage pipelines	7 Jul 2022	29 Dec 2022	27 Jan 2023 3 Apr 2023
Flow measurement of open channels	7 Jul 2022	29 Dec 2022	25 Jan 2023 4 Apr 2023 14 Jun 2023
Leakage Control, Plumbing and Pipe Replacement Plan			
Replacement planning using GIS	3-5 Aug 2022	14 Oct 2022	23 Nov 2022 14 Jun 2023
Plumbing (HDPE jointing, pressure test etc.)	10-12 Aug 2022	2 Mar 2023	1 Jun 2023 8 Aug 2023 6 Sep 2023 23 Nov 2023
Leakage control	25 Jan 2023	26 Jan 2023	30 Mar 2023 3 Aug 2023 8 Nov 2023

Table 5.1.8 ToT, Pilot In-house Training and In-house Training at WASA Rawalpindi

Training topic	ToT (Activity 1-6)	Pilot In-house training (Activity 4-3)	In-house training (Activity 4-4)
O&M on Mechanical and Electrical Equipment			
Energy Audit	18-20 Jan 2022	3 Feb 2022	8 Dec 2022 15 May 2023 9-10 Aug 2023 (2 days) 25-27 Oct 2023 (3 days)
O&M on Pump	5 Jul 2022	6 Jul 2022	7 Dec 2022 15 May 2023 10-11 Aug 2023 (2 days) 25-26 Oct 2023 (2 days)
Electrical Panel, MCU and wiring	6-7 Dec 2022	8 Dec 2022	24 Feb 2023
O&M on Sewerage and Drainage			
Cleaning of sewerage and drainage pipelines	5-6 Jul 2022	17 Dec 2022	22 March 2023
Flow measurement of open channels	5-6 Jul 2022	17 Dec 2022	22 March 2023
Leakage Control, Plumbing and Pipe Replacement Plan			
Replacement planning using GIS	28-29 Aug 2022	7 Dec 2022	16 March 2023 8 Jun 2023 26 Oct 2023
Plumbing (HDPE jointing, pressure test etc.)	9 May 2023	12 May 2023	7 Jun 2023 17 Aug 2023 30 Nov 2023
Leakage control	15 Feb 2023	16 Feb 2023	15 Mar 2023 16 Aug 2023 16 Nov 2023

Table 5.1.9 presents ToT (Technical) in Term 2, extracted from Table 5.1.5-5.1.8.

Table 5.1.9 ToT (Technical) in Term 2

WASA	Training course	Training topic	ToT
WASA Faisalabad	O&M on Mechanical and Electrical Equipment	O&M on pumps and motors (Efficient pumping machinery)	23 Jun 2022
		Electrical Panel, MCU and wiring	16-17 Nov 2023
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	28-30 Jun 2022
		O&M of waste water treatment plant	28-30 Jun 2022
		Flow measurement of open channels	28-30 Jun 2022
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	10-12 Aug 2022
		Plumbing (HDPE jointing, pressure test etc.)	3-5 Aug 2022
		Leakage control	7-8 Feb 2023
WASA Multan	O&M on Mechanical and Electrical Equipment	Energy Audit	28 Jun 2022
		O&M on Pump	28-29 Jun 2022
		Electrical Panel, MCU and wiring	1-3 Nov 2022 13-14 Dec 2022
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	21-23 Jun 2022
		O&M of waste water treatment plant	21-23 Jun 2022
		Flow measurement of open channels	21-23 Jun 2022
	Leakage Control, Plumbing and Pipe Replacement Plan	Replacement planning using GIS	16-19 Aug 2022
		Plumbing (HDPE jointing, pressure test etc.)	16-19 Aug 2022
		Leakage control	31 Jan - 1 Feb 2023
WASA Gujranwala	O&M on Mechanical and Electrical Equipment	O&M on Pump	20 Jun 2022
		Electrical Panel, MCU and wiring	24-26 Oct 2022
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	7 Jul 2022
		Flow measurement of open channels	7 Jul 2022
	Leakage Control, Plumbing and Pipe Replacement Plan	Replacement planning using GIS	3-5 Aug 2022
		Plumbing (HDPE jointing, pressure test etc.)	10-12 Aug 2022
		Leakage control	25 Jan 2023
WASA Rawalpindi	O&M on Mechanical and Electrical Equipment	O&M on Pump	5 Jul 2022
		Electrical Panel, MCU and wiring	6-7 Dec 2022
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	5-6 Jul 2022
		Flow measurement of open channels / sludge volume measurement	5-6 Jul 2022
	Leakage Control, Plumbing and Pipe Replacement Plan	Replacement planning using GIS	28-29 Aug 2022
		Plumbing (HDPE jointing, pressure test etc.)	9 May 2023
		Leakage control	15 Feb 2023

5-1-7 Conduct review of ToT regularly and update or revise contents [Activity 1-7]

It was observed that WASA Trainers at 4 WASAs understood and obtained necessary knowledge and skills for conducting the in-house training through Activity 1-6. However, through Activity 1-6, the necessity for revision/improvement on the training content was found. The details are as follows:

(1) WASA Faisalabad

General

WASA Faisalabad built their own training center, and practically started the training at the training center in January 2022. Since the training center is located about 15 km away from the center of Faisalabad city, it may be difficult to reach the training center especially for BPS 1-10. Some of them may not have a motor bike. In addition, when it rains, many puddles form on the access road to the training center. Therefore, the transportation arrangements need to be considered.

Training topic: Leakage control

The following items were decided to be included in in-house training for better understanding of water meters after a review of ToT.

- Explanation on a function of impeller as conversion from rotation of impeller to an amount of water flow.
- Accuracy of water meter among rotary piston, multi-jet, and single-jet type.

(2) WASA Multan

General

WASA Trainer is very busy for daily work and received many phone calls due to shortage of staff. If another staff could provide the training as trainer, this situation would be improved.

Training topic: Leakage control

The following items were decided to be included in in-house training for better understanding of water meters and leak detection after a review of ToT.

- Explanation on various diameters of water meters for various flowrates
- Explanation on location of bulk meters
- Explanation on suitable time for leak detection survey

(3) WASA Gujranwala

General

WASA Trainer is very busy for daily work and received many phone calls due to shortage of staff. If another staff could provide the training as trainer, this situation would be improved.

Training topic: Electrical Panel, MCU and wiring

The following items were decided to be included in in-house training for better understanding of insulation measurement after a review of ToT.

- Explanation and measurement of insulation at various locations with power factor
- Explanation on proper installation of earth for insulation measurement
- Explanation and measurement of insulation at various intervals of time with power factor

Training topic: Leakage control

Through a review of ToT, the following items were decided to be included in in-house training for better understanding of water meter.

- Explanation on right direction for installing a water meter
- Explanation on result of installing a water meter in the wrong direction
- Explanation on a function of impeller as converting an amount of water flow by the rotation.

(4) WASA Rawalpindi

Training topic: Electrical Panel, MCU and wiring

The following items were decided to be included in in-house training for better understanding of insulation measurement after a review of ToT.

- Explanation and measurement of insulation at various locations with power factor
- Explanation on proper installation of earth for insulation measurement
- Explanation and measurement of insulation at various intervals of time with power factor

Training topic: Leakage control

Through a review of ToT, the following items were decided to be included in in-house training for better understanding of water meter and leak detection.

- Explanation on avoidance of reverse flow by installing non-return valve
- Explanation on a change of flowrate unit for ultrasonic flow meter
- Explanation on suitable time for leak detection survey

5-1-8 TAC reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements [Activity 1-8]

The activity was completed in Term 1.

5-1-9 Based on the recommendations, revise or update the professional training contents [Activity 1-9]

According to the recommendation by Technical Advisory Committee (TAC) held on 17th January, 2022, more practical activities were included. As per recommendation, the training of "O&M on Mechanical and Electrical Equipment" was conducted. The result of the training was applied to the other training. The details are as follows.

(1) Training course: O&M on Mechanical and Electrical Equipment

The training on "Energy Audit", one of the training topics under "O&M on Mechanical and Electrical Equipment" was conducted on 15th-16th February, 2022 as a pilot professional training (see Picture 5.1.1).

Training on utilization of "Pump model"

Training on preparation of electrical panel

Picture 5.1.1 Practical training on "Energy Audit" under training course of "O&M on Mechanical and Electrical Equipment"

It was observed that the practical training was very effective for the trainees to learn the actual function of each equipment / parts. In addition, the trainees thought by themselves or learned interactively through discussions among trainees. Such phenomenon is considered as occurrence of "deep learning mode". Therefore, this approach was extensively applied to the other courses of "O&M on Sewerage and Drainage" and "Leakage Control, Plumbing and Pipe Replacement Plan" as follows.

(2) Training course: O&M on Sewerage and Drainage

The practical training was planned as follows:

i) The equipment (flow velocity meter, sewer camera) is used in the lecture room at first, then on-site by all trainees

ii) Sufficient time for operating the equipment by their own hands is allocated.

(3) Training course: Leakage Control, Plumbing and Pipe Replacement Plan

Pipe network model and NRW model were prepared for conducting the practical training (see Picture 5.1.2, 5.1.3). Initially "Pipe network model" was prepared simply for the same size of diameter for the entire model. However, TAC recommended that it would be much more realistic if a diameter of the main pipe, connected to a bulk meter, is larger than the service pipe connected to the water meter. According to the recommendation, "Pipe network model" was modified.

For "pipe replacement plan", a free software named on "mWater" is extensively used. If leakage repair data is registered by "mWater", data is accumulated. Based on the accumulated data, the prioritization for pipe replacement plan is effectively developed. Therefore, the training was prepared to include the practical activity on i) installation of App to smart phone owned by the trainees, and ii) registration of data.

Original　　　　　　　　　　After improvement

Picture 5.1.2　Pipe network model

Picture 5.1.3　NRW model

5-1-10 TAC approves revised and updated professional training contents [Activity 1-10]

TAC was held for approval of new / revised contents for the professional training every time before conducting the training. Table 5.1.10 indicates i) training course including the implementation date, ii) date of TAC and its MM, iii) time schedule of training, and iv) training material etc.. The revision of each training content is described in Activity 1-11.

Table 5.1.10 Professional Trainings in Term 2
- Time Schedule, Training Material -

No	Training Course	Duration	Date	TAC approval	MM on TAC	Training schedule	Training Materials
Summer 2022							
1	O&M on Sewerage and Drainage	3 days	13-15 Jun 2022	10 Jun 2022	Annex 5.1.33	Annex 5.1.41	Annex 5.1.46
2	O&M on Mechanical and Electrical Equipment	2 days	16-17 Jun 2022	10 Jun 2022	Annex 5.1.33	Annex 5.1.41	Annex 5.1.47
Fall 2022							
3	Leakage Control, Plumbing and Pipe Replacement Plan	3 days	25 - 27 Oct 2022	14 Oct 2022	Annex 5.1.34	Annex 5.1.42	Annex 5.1.48
4	O&M on Mechanical and Electrical Equipment	3 days	8,10,11 Nov 2022	14 Oct 2022	Annex 5.1.34	Annex 5.1.42	Annex 5.1.49
5	O&M on Sewerage and Drainage	3 days	22 - 24 Nov 2022	2 Nov 2022	Annex 5.1.35	Annex 5.1.42	Annex 5.1.50
6	O&M on Mechanical and Electrical Equipment	3 days	26 - 28 Dec 2022	21 Dec 2022	Annex 5.1.36	Annex 5.1.42	Annex 5.1.51
Spring 2023							
7	Leakage Control, Plumbing and Pipe Replacement Plan	3 days	17 - 19 Jan 2023	21 Dec 2022	Annex 5.1.36	Annex 5.1.43	Annex 5.1.52
8	O&M on Sewerage and Drainage	3 days	14 - 16 Feb 2023	n/a*	n/a*	Annex 5.1.43	Annex 5.1.53
9	O&M on Mechanical and Electrical Equipment	3 days	7-9 Mar 2023	3 Mar 2023	Annex 5.1.37	Annex 5.1.43	Annex 5.1.54
Summer 2023							

10	O&M on Mechanical and Electrical Equipment	3 days	2 - 4 May 2023	5 Apr 2023	Annex 5.1.38.	Annex 5.1.44.	Annex 5.1.55
11	Leakage Control, Plumbing and Pipe Replacement Plan	3 days	29 - 31 May 2023	5 Apr 2023	Annex 5.1.38	Annex 5.1.44	Annex 5.1.56
Fall 2023							
12	Leakage Control, Plumbing and Pipe Replacement Plan	3 days	18-20 Oct 2023	5 Oct 2023	Annex 5.1.39	Annex 5.1.45	Annex 5.1.57
13	O&M on Mechanical and Electrical Equipment	3 days	21-23 Nov 2023	5 Oct 2023	Annex 5.1.39.	Annex 5.1.45	Annex 5.1.58
14	O&M on Sewerage and Drainage	3 days	12-14 Dec 2023	1 Dec 2023	Annex 5.1.40	Annex 5.1.45	Annex 5.1.59

Note *: This training is almost the same as "O&M of Sewerage and Drainage" held on 22nd-24th November, 2022. As a result, TAC was not held.

5-1-11 Conduct professional training with approved training contents [Activity 1-11]

The trainings were conducted as per the time schedules and the training materials indicated in Table 5.1.10. Table 5.1.11 presents number of participants for the professional training. The professional trainings were planned at a maximum participants of 20. The list of participants for all professional training is presented in Annex 5.1.60.

Table 5.1.11 Professional Trainings in Term 2
- Number of Participants -

No	Training course	Number of Participants						
		WASA -L1)	WASA -F2)	WASA -M3)	WASA -G4)	WASA -R5)	Other	Total
Summer 2022								
1	O&M on Sewerage and Drainage	7	1	1	1	1	1	12
2	O&M on Mechanical and Electrical Equipment	5	2	0	2	3	0	12
Fall 2022								
3	Leakage Control, Plumbing and Pipe Replacement Plan	5	2	0	1	1	5	14
4	O&M on Mechanical and Electrical Equipment	7	2	0	1	0	4	14

5	O&M on Sewerage and Drainage	0	2	1	2	2	4	11
6	O&M on Mechanical and Electrical Equipment	2	2	0	1	2	0	7
Spring 2023								
7	Leakage Control, Plumbing and Pipe Replacement Plan	3	2	1	2	2	0	10
8	O&M on Sewerage and Drainage	2	2	1	1	1	5	12
9	O&M on Mechanical and Electrical Equipment	5	2	0	1	0	0	8
Summer 2023								
10	O&M on Mechanical and Electrical Equipment	5	2	0	1	0	3	11
11	Leakage Control, Plumbing and Pipe Replacement Plan	7	2	0	0	0	4	13
Fall 2023								
12	Leakage Control, Plumbing and Pipe Replacement Plan	3	2	1	2	2	4	14
13	O&M on Mechanical and Electrical Equipment	4	2	0	1	1	7	15
14	O&M on Sewerage and Drainage	4	2	0	1	0	2	9
	Total	59	27	5	17	15	39	162

Note: 1) WASA Lahore, 2) WASA Faisalabad, 3) WASA Multan, 4) WASA Gujranwala, 5) WASA Rawalpindi

After completion of each training, AJWA and JET reviewed and revised the contents for the improvement. The following describes main points of the revisions in the trainings described in Table 5.1.10.

(1) O&M on Mechanical and Electrical Equipment

Revision from Summer 2022 to Fall (November) 2022

Before conducting the training in November 2022, AJWA and JET reviewed the training in June 2022. As a result, the training in November 2022 was revised as follows:

- Since the training in June 2022 was focused on more mechanical component, more electrical component was included for the training in November 2022.
- The measurement on O&M parameters at tube well by power analyzer and ultrasonic flow meter, etc. was included in November 2022 for enhancing the understanding of the on-site measurement.
- "Scenarios based on learning activity" were added. The detail of "Scenarios based on learning activity" is to think and plan actions to minimize the recovery period when i) a motor is burned or ii) an issue on an electrical panel is observed.
- "Energy Development Plan" were added. The detail of "Energy Development Plan" is to think and discuss on improvements of energy efficiency at tubewell from current conditions.

Revision from Fall (November) 2022 to Fall (December) 2022

Before conducting the training of December 2022, AJWA and JET reviewed the training in November 2022. As a result, the training in December 2022 was revised as follows:

- Since the training in November 2022 was focused on more electrical component, more mechanical component was included for the training in December 2022.
- The training on mWATER and QGIS for mechanical component was added to enhance the development of database.
- Since on-site measurements at different sites provides more practical understanding, the disposal station was selected for on-site measurement in the training of December 2022 instead of tube well selected in the training of November 2022.

Revision from Fall (December) 2022 to Spring 2023

Before conducting the training in March 2023, AJWA and JET reviewed the training in December 2022. As a result, the training in March 2023 was revised as follows:

- Since the training in December 2022 was focused on more mechanical components, more electrical components were included for the training in March 2023.
- The training on mWATER for electrical component was added to enhance the development of database.
- For enhancement of understanding on electrical panel, a visit to a manufacturing company for electrical panel was added.
- WASA Lahore started using solar panel. It may be introduced to the other WASAs. For enhancement of understanding, a site visit to the disposal station where the solar panel has been installed was added.

Revision of the training from Spring 2023 to Summer 2023

Before conducting the training in May 2023, AJWA and JET reviewed the training in March 2023. As a result, the training in May 2023 was revised as follows:

- Since the training in March 2023 was focused on more electrical components, more mechanical components were included for the training in May 2023.
- The pump model was extensively used during the entire period of the training in May 2023.
- The preparation of Q-H curve by Excel was newly added to the training in May 2023.
- The comparison of distribution pressure between overhead reservoir (OHR) and direct distribution by pump was newly added.
- An inclusion of formula to mWATER was newly added to the training in May 2023.

Revision of the training from Summer 2023 to Fall 2023

Before conducting the training in November 2023, AJWA and JET reviewed the training in May 2023.

As a result, the training in November 2023 was revised as follows:

- The training content was focused on more mechanical or more electrical components until May 2023. The training in November 2023 was implemented for almost equal time allocation to mechanical and electrical components.
- All training was conducted by a practical activity with "Pump model" at inside building of AJWA for focusing on an operation of the entire facility, which is not an independent approach on mechanical and electrical components.
- KSB, a pump manufacturer, conducted the survey on energy audit for pump facility at tubewell in Lahore. An explanation by KSB as a guest speaker regarding the procedure, results, and improvement on survey was added.

(2) Leakage Control, Plumbing and Pipe Replacement Plan

Revision from Fall 2022 to Spring 2023

Before conducting the training in January 2023, AJWA and JET reviewed the training in October 2022. As a result, the training in January 2023 was revised as follows:

- OHR was added to "Pipe network model" for enhancement of understanding on distribution pressure.
- The measurement on flowrate of pipes at "Pipe network model" by ultrasonic flow meter was added for enhancement of understanding on how to use ultrasonic flow meter.
- A free software "EPANET" for hydraulic analysis was added. The learning objective on using "EPANET" in the training is to design pipe network when a replacement of pipes is planned. The training in January 2023 included a general explanation of "EPANET" and the hydraulic parameters for the analysis.
- Jointing of HDPE pipes by "Butt fusion welding machine" was added for proper understating on jointing HDPE pipes.
- The field activity on registering data by mWATER and QGIS was added for enhancement of understanding on mWATER and QGIS.

Revision of the training from Spring 2023 to Summer 2023

Before conducting the training in May 2023, AJWA and JET reviewed the training in January 2023. As a result, the training in May 2023 was revised as follows:

- The dashboard creation by mWATER was newly added to the training in May 2023.
- The analysis on actual data of leakage locations developed by WASA Faisalabad was newly added to the training in May 2023.
- The analysis on pipe network developed by each trainee through software "EPANET" was newly added to the training in May 2023.

Revision from Summer 2023 to Fall 2023

Before conducting the training in October 2023, AJWA and JET reviewed the training in May 2023. As a result, the training in October 2023 was revised as follows:

- WASA Multan has developed the database of leakage repair. An explanation by Mr. Nadeem, WASA Multan as a guest speaker regarding the findings or assumptions from the database was added.
- The field activity on leakage detection survey was newly added.

(3) O&M on Sewerage and Drainage

Revision from Summer 2022 to Fall 2022

Before conducting the training in November 2022, AJWA and JET reviewed the training in June 2022. As a result, the training in November 2022 was revised as follows:

- It was observed that a comparison of wastewater treatment processes was not easy for the trainees to understand based on the prepared training material. Therefore, the training material was required to be revised for better understanding. The revision was to include an item by item explanation, and examples with different required conditions of site availability and effluent quality for selecting the recommended processes.
- The training in November 2022 included public awareness. The students at the elementary school were invited for raising awareness of issues on overflow from manholes. The overflow, a major issue in the daily work of WASAs, needs to be reduced by an improvement of public's behavior such as not throwing garbage to a manhole. For understanding the issue visibly, "Manhole model" and the sewer camera were used for this training.

Revision from Fall 2022 to Spring 2023

Before conducting the training in February 2023, AJWA and JET reviewed the training in November 2022. As a result, the training in February 2023 was not required for the revision. However, before the training, very minor revision was made as follows.

- Introduction of database development by mWATER and QGIS was added for enhancement of understanding on database development in sewerage sector.

Revision from Spring 2023 to Fall 2023

Before conducting the training in December 2023, AJWA and JET reviewed the training in February 2023. As a result, the training in December 2023 revised as follows:

- WASA Multan has developed the database of crown failure. An explanation by Mr. Nadeem, WASA Multan as a guest speaker regarding the findings or assumptions from the database was added.
- An explanation of mWATER form for crown failure was newly added.

- The metal locator for finding a buried manhole cover was newly added.

5-1-12 Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators [Activity 1-12]

The activity was completed in Term 1.

5-1-13 Organize semi-annual WASA coordinators meetings [Activity 1-13]

The first "WASA Coordinators meeting" was held on 21st December, 2022 together with TAC. In the meeting, each WASA coordinator presented the progress on in-house training (see Annex 5.1.61). It would be more effective if WASA coordinators could explain the outcome of in-house training. Such effectiveness was observed in the second "WASA Coordinators meeting".

The second "WASA Coordinators meeting" was held on 1st August, 2023 together with PCC. In the meeting, each WASA coordinator presented the progress on in-house training mainly through database from web site. It was the first time to share and present database by each WASA. By that moment, the number of the data might not be sufficient for analysis. Therefore, there was not so much discussion regarding analysis on database. However, such sharing on the database is very important for WASA to know a variety of database because each WASA develops different types of database.

The meeting titled "WASA Coordinators' Meeting" was held only twice as mentioned above. However, WASA Coordinators attended TAC, PCC, and JCC. In addition, WASA Coordinators presented schedules of in-house trainings for respective WASAs at JCC in February and August 2022. Therefore, it is considered that the same function of "WASA Coordinators' Meeting" was frequently held under another name of meetings.

5-2 Activities related to Output 2

5-2-1 Assess and evaluate current training of WASA Training Center [Activity 2-1]

The activity was completed in Term 1.

5-2-2 Based on the results of evaluation, list up thematic areas and methodologies requires revisions or improvements [Activity 2-2]

The activity was completed in Term 1.

5-2-3 Update and revise training contents, modules and methodologies [Activity 2-3]

Through Activities 2-1 and 2-2, the training materials for the selected training modules at WASA Training Center of WASA Lahore are presented in Table 5.2.1.

Table 5.2.1 In-house Training at WASA Training Center of WASA Lahore
- Training Materials -

No	Training module	Material
O&M of Sewerage and Drainage		
1	Cleaning of Sewerage and Drainage Pipelines: Cleaning	Annex 5.2.1
2	Cleaning of Sewerage and Drainage Pipelines: Crown failure	Annex 5.2.2
3	Flow Measurement of Open Channels	Annex 5.2.3
4	Wastewater Treatment Technologies	Annex 5.2.4
O&M of Mechanical & Electrical Equipment		
5	Selection of Suitable Pump	Annex 5.2.5
6	Designing of Star-Delta Control Panel	Annex 5.2.6
7	Slip Ring Motors and starters	Annex 5.2.7
8	Practical Training on Energy Audit and Pump Efficiency	Annex 5.2.8
9	Energy Audit	Annex 5.2.9
10	Tube wells performance monitoring and rehabilitation	Annex 5.2.10
11	Relationship of Head, Motor capacity, and Delivery size with Pump flow	Annex 5.2.11
Leakage Control, Plumbing and Pipe Replacement Plan		
12	Plumbing (Distribution Pipe), Jointing / Welding and Pressure Test	Annex 5.2.12
13	Proper Handling of Leakages from Valves & Connections	Annex 5.2.13
14	Water meters selection and installation	Annex 5.2.14
15	Pressure Testing of Water Distribution Model	Annex 5.2.15
16	Working of a water supply network (water Supply Model)	Annex 5.2.16
17	Leakage Control, Plumbing and Pipe Replacement Plan	Annex 5.2.17
18	Construction management for Pipe installation	Annex 5.2.18
19	Utilization of mWater app and Web Portal for field data collection	Annex 5.2.19

5-2-4 Conduct training with revised contents, modules and methodologies [Activity 2-4]

In-house training at WASA Training Center of WASA Lahore was implemented as presented in Table 5.2.2.

Table 5.2.2 In-house Training at WASA Training Center in Term 2

No	Training module	Date	No. of participants
O&M of Sewerage and Drainage			
1	Cleaning of Sewerage and Drainage Pipelines: Cleaning	01-02 Jun 2022	22
		13-14 Jun 2022	34
		25 Nov 2022	13
		18 Feb 2023	6
		27 Mar 2023	18
2	Cleaning of Sewerage and Drainage Pipelines: Crown failure	24 Feb 2023	7
		23 Dec 2023	24
3	Flow Measurement of Open Channels	27-28 Jun 2022	24
		18 Nov 2022	11
4	Wastewater Treatment Technologies	04 Jul 2022	17
		16 Nov 2022	10
		17 May 2023	10
O&M of Mechanical & Electrical Equipment			
5	Selection of Suitable Pump	02 Jul 2022	18
		27 Apr 2023	13
		5 Aug 2023	15
6	Designing of Star-Delta Control Panel	12 Nov 2022	16
7	Slip Ring Motors and starters	01 Nov 2023	11
8	Practical Training on Energy Audit and Pump Efficiency	19 Dec 2022	11
		08 Aug 2023	15
9	Energy Audit	08 Mar 2023	15
10	Tube wells performance monitoring and rehabilitation	04 Dec 2023	31
11	Relationship of Head, Motor capacity, and Delivery size with Pump flow	28 Dec 2023	12
Leakage Control, Plumbing and Pipe Replacement Plan			
12	Plumbing (Distribution Pipe), Jointing / Welding and Pressure Test	26-27 Jul 2022	20
		07 Mar 2023	14
13	Proper Handling of Leakages from Valves & Connections	29 Oct 2022	10
		10 Jan 2023	8
		11 Jan 2023	6
		07 Mar 2023	14
14	Water meters selection and installation	06 Aug 2022	10
15	Pressure Testing of Water Distribution Model	13 Jul 2023	15
16	Working of a water supply network (water Supply Model)	03 Oct 2023	13
17	Leakage Control, Plumbing and Pipe Replacement Plan	11-12 Jan 2023	9
18	Construction Management for Pipe Installation	14 Jul 2023	13
19	Utilization of mWATER app and Web Portal for field data collection	24-26 Jan 2023	55
		23 Oct 2023	8
Total			548

5-2-5 Reevaluate training and update or revise the training contents, modules and methodologies regularly [Activity 2-5]

It was observed that all trainings were conducted smoothly. According to the discussion between trainers and trainees, trainees said that they acquired knowledge on respective subjects. Under such circumstances, WASA Training Center intended to use the same training materials until all targeted staff participated in the training. Instead, the focus by WASA Training Center was more towards increasing the training module as much as possible during the project period under the support of JET. As a result, 19 modules were developed as presented in Table 5.2.2. The most important is considered as the continuous implementation of the training. It was confirmed that WASA Training Center understands it according to the discussions between trainers of WASA Training Center and JICA Experts.

JET conducted a follow-up survey with WASA Training Center in November 2023 to verify the effects of in-house training conducted from 2022 to October 2023 at WASA-L with the support of the Project. Using a questionnaire, the team collected feedback from trainees about their perceptions on the improvement of their skills through attending the training and those on the application of what they learned in the training to their work. Tables 5.2.3 and 5.2.4 summarize the questionnaire survey, and Annex 5.4.2 provides details of the survey results.

Table 5.2.3 Distribution of Responses to the Questionnaire (WASA Lahore)

BPS	Number of Respondents
BPS1-10	0
BPS11-16	80
BPS17 or above	72
Work Charge	0
Total	152

Table 5.2.4 Responses on Outcome of In-House Training

WASA	Question 1[1)]		Question 2[2)]	
	Agree[3)]	Disagree[4)]	Agree[3)]	Disagree[4)]
WASA Lahore	89%	11%	79%	21%

Note:

1) Question 1 is "I feel the skills required for my job have improved by attending the training." The answer to the question was selected from "Strongly agree", "Agree", "Neutral", "Disagree", and "Strongly disagree".
2) Question 2 is "I have fully applied on the job what I learned in the training." The answer options for Question 2 are the same as those for Question 1.
3) Sum of responses "Strongly agree" and "Agree"
4) Sum of responses "Neutral", "Disagree", and "Strongly disagree"

As shown in Table 5.2.4, 89% of the respondents agreed that their skills had improved by attending the training. In addition, 79% of the respondents confirmed that they had applied what they learned in the training to their jobs. This high rate of achievement is attributed to the following:

i) WASA Lahore has already established the in-house training system at the Training Center, and the capacity development of staff through attending training is institutionalized as an organizational practice.

ii) The training content met the needs of trainees.

iii) The training methods employed were effective in helping the trainees learn.

5-3 Activities related to Output 3

5-3-1 Notify WASA coordinator in each WASA [Activity 3-1]

The activity was completed in Term 1.

5-3-2 WASA coordinator conducts training assessment for in-house training needs and training capacity [Activity 3-2]

The activity was completed in Term 1.

5-3-3 Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers [Activity 3-3]

The activity was completed in Term 1.

5-3-4 WASA coordinator formulates in-house training plans semiannually [Activity 3-4]

In Activity 3-4, the plan and actual implementation of in-house training including pilot in-house training are discussed. The details are as follows.

The plan and actual implementation at 4 WASAs are compared in Table 5.3.1. In-house training plans (including pilot in-house training) at each WASA were prepared in January, August, and December 2022, and August 2023 as shown in Annexes 5.3.1-5.3.4. The actual implementation presented in Table 5.3.1 is a summary of "Pilot in-house training" and "In-house training" in Tables 5.1.5 to 5.1.8.

Table 5.3.1 Number of "Pilot In-house Training" and "In-house Training" at 4 WASAs

Month/Year	WASA-F		WASA-M		WASA-G		WASA-R	
	Plan	Done	Plan	Done	Plan	Done	Plan	Done
Jun 2022	7	2	3	2	5	2	3	0
Jul 2022	0	0	0	0	0	0	0	1
Aug 2022	0	0	0	0	0	0	0	0
Sep 2022	1	0	0	0	0	0	0	0
Oct 2022	2	2	9	1	3	2	5	0
Nov 2022	2	3	7	2	5	3	7	0
Dec 2022	3	3	9	3	5	2	8	6
Jan 2023	2	1	0	0	2	3	2	0
Feb 2023	2	6	6	1	4	0	2	2
Mar 2023	2	2	3	3	2	3	5	4
Apr 2023	0	0	0	0	0	2	0	0
May 2023	n/a	1	n/a	3	n/a	0	n/a	3
Jun 2023	n/a	3	n/a	3	n/a	3	n/a	2
Jul 2023	n/a	3	n/a	2	n/a	3	n/a	0
Aug 2023	n/a	4	n/a	3	n/a	2	n/a	4
Sep 2023	1	2	0	1	0	1	0	0
Oct 2023	3	1	9	0	5	2	5	3
Nov 2023	3	2	9	1	6	6	8	2
Dec 2023	4	2	8	0	8	0	8	0
Jan 2024	n/a	1	n/a	0	n/a	0	n/a	0
Total (Jun - Sep 2022) in 4 months	8	2	3	2	5	2	3	1
Total (Oct 2022 - Jan 2024) in 16 months	24	36	60	23	40	32	50	26
Total (All)	32	38	63	25	45	34	53	27

Note:
"Plan" from June to July 2022 was prepared in January 2022.
"Plan" from August to December 2022 was prepared in August 2022.
"Plan" from January to April 2023 was prepared in December 2022.
"Plan" from May to mid-September 2023 was not prepared.
"Plan" from mid-September to December 2023 was prepared in August 2023.
"Plan" in Jan 2024 was not prepared.
"n/a" refers to "Not Applicable" because no plan was developed.

The comparison between "Plan" and "Done" is focused on the frequency of the training "Done" rather than the comparison on each training topic of "Plan" and "Done". The reasons are as follows:

- It was practically new for 4WASAs to conduct "In-house training".

- Until accustomed to conducting in-house training, the progress of in-house training at 4 WASAs relies more on the presence of a JICA expert at the respective WASA.
- JET was not allowed to change its intercity travel within the three-week schedule according to the security instructions which JICA Pakistan Office prepared based on the security arrangements by the Pakistani side. The confirmation of the next three-week schedule is not easy because i) WASAs may have an urgent or prioritized requirement of daily activities, and ii) the security consideration may be changed due to the political movement such as marching or gathering etc.
- JICA experts sometimes changed the schedule of visiting WASAs.
- WASAs were required to postpone an implementation of in-house training when JICA experts changed the schedule of visiting WASAs.
- JICA Experts sometimes came to Pakistan not as scheduled at the beginning of the project.

It is important to prepare the plan. However, as mentioned above, "Plan" shall be considered as images of implementing in-house training. This "image" varied from one WASA to another. In addition, as mentioned above, a change in JICA Experts schedule and the urgent or priority requirements at each WASA resulted in different ratios of "Done" against "Plan". Therefore, discussions on "Done" is more appropriate after October 2022 (or after the Monsoon). The reasons are as follows:

- It was June 2022 that JICA experts returned to Pakistan in Term 2 after leaving Pakistan in February 2022, the closing month of Term 1.
- The period of Monsoon is from mid-June to mid-September.
- WASAs must concentrate on drainage when it rains during the Monsoon period.
- AJWA avoids conducting the professional training during the Monsoon period.

Therefore, "Done" after October 2022 in Table 5.3.1 is discussed in Activity 3-4. Regarding the frequency of "Done" for in-house training at 4 WASAs is rated as "highly appropriate". The frequency of in-house training at about 1.5 times to twice per month is considered as the almost upper limit because WASA trainers conduct their daily work in addition to providing the training.

The following are the reasons why in-house training plan after May 2023 was not prepared until August 2023. The reasons were that i) WASA becomes busy during the Monsoon period (mid-June - mid-September), and ii) the period between the first working day after Eid holiday on 26th April 2023 and the start of Monsoon in mid-June 2023 was too short to plan in-house training from May to mid-June, and iii) in-house training after Monsoon was expected to be planned in August or September. It is noted that even though the plan was not prepared, in-house training at 4 WASAs were conducted from May to September 2023 as presented in Table 5.3.1.

5-3-5 WASA coordinator reviews implementation of in-house training plans and budget annually and revises the plans and budget if necessary [Activity 3-5]

As mentioned in Activity 3-4, the plan for in-house training was prepared (see Annex 5.3.1-5.3.4). In-house training was reviewed and updated/revised by the addition of contents and increase/decrease in the training duration. The details are described in Table 5.4.3.
Regarding budget, no major expenditures were required for implementing in-house training. In-house training was conducted mainly at WASA's own site with available equipment. In addition, the trainers were employees of respective WASA. Therefore, the budget was not an issue to be considered.

5-4 Activities related to Output 4

5-4-1 Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules [Activity 4-1]

The activity was completed in Term 1.

5-4-2 WASA trainers conduct pilot in-house training at each WASA [Activity 4-2]

WASA Trainers at each WASA conducted pilot in-house training. Table 5.4.1 presents the topic, date, and number of participants for pilot in-house training.

Table 5.4.1 Pilot In-House Training Conducted in Term 2

WASA	Course	Topic	Date	Number of participants
WASA-F[1)]	O&M of Mechanical & Electrical Equipment	O&M on pumps and motors (Efficient pumping machinery)	24 Jun 2022	8
		Electrical Panel, MCU and wiring	18 Nov 2023	12
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	8 Dec 2022	10
		O&M of wastewater treatment plant	8 Dec 2022	10
		Flow measurement of open channels	8 Dec 2022	13
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	20 Oct 2022	14
		Plumbing (HDPE jointing, pressure test etc.)	19 May 2023	11
		Leakage control	9 Feb 2023	13
WASA-M[2)]	O&M of Mechanical	Energy Audit	29 Jun 2022	6

WASA	Course	Topic	Date	Number of participants
	& Electrical Equipment	O&M on Pump	30 Jun 2022	10
		Electrical Panel, MCU and wiring	16 Mar 2023	5
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	1 Dec 2022	5
		O&M of wastewater treatment plant	2 Dec 2022	5
		Flow measurement of open channels	3 Dec 2022	5
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe Replacement planning using GIS	6 Oct 2022	8
		Plumbing (HDPE jointing, pressure test etc.)	17 Mar 2023	8
		Leakage control	2 Feb 2023	8
WASA-G[3)]	O&M of Mechanical & Electrical Equipment	O&M on Pump	21 Jun 2022	5
		Electrical Panel, MCU and wiring	25 Nov 2022	6
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	29 Dec 2022	5
		Flow measurement of open channels	29 Dec 2022	5
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe Replacement planning using GIS	14 Oct 2022	4
		Plumbing (HDPE jointing, pressure test etc.)	2 Mar 2023	7
		Leakage control	26 Jan 2023	6
WASA-R[4)]	O&M of Mechanical & Electrical Equipment	O&M on Pump	6 Jul 2022	7
		Electrical Panel, MCU and wiring	8 Dec 2022	10
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	17 Dec 2022	7
		Flow measurement of open channels / Sludge volume measurement	17 Dec 2022	5
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe Replacement planning using GIS	7 Dec 2022	7
		Plumbing (HDPE jointing, pressure test etc.)	12 May 2023	7
		Leakage control	16 Feb 2023	10

Note: 1) WASA Faisalabad, 2) WASA Multan, 3) WASA Gujranwala, 4) WASA Rawalpindi

5-4-3 WASA trainers and WASA coordinator review pilot in-house training and update the training content and modules [Activity 4-3]

After the completion of each pilot in-house training, WASA trainers, WASA coordinator, faculty of AJWA, and JICA Experts discussed the necessary revisions of the training content from pilot in-house training to in-house training. The results of discussions were that all pilot in-house trainings in Table 5.4.1 were i) conducted smoothly, ii) considered technically as "ready to conduct in-house training", and iii) to use the same contents. However, the following topics were revised from pilot in-house training.

"Energy Audit" at WASA Multan

WASA Multan expressed more interest to database development in the training topic "Energy Audit", which was not included in the pilot in-house training. Therefore, WASA Multan included database development in the training material of "Energy Audit" for in-house training.

"Plumbing (HDPE jointing, pressure test etc.)" at 4WASAs

4WASAs expressed more interest to butt fusion jointing of HDPE in the training topic "Plumbing (HDPE jointing, pressure test etc.)", which was not included in the pilot in-house training. Therefore, 4WASAs included butt fusion jointing of HDPE in the training material for in-house training.

5-4-4 WASA trainers conduct in-house training [Activity 4-4]

Table 5.4.2 summarizes the in-house training conducted at 4 WASAs in Term 2. The list of participants for in-house training is presented in Annex 5.4.1.

Table 5.4.2 In-House Training Conducted in Term 2

WASA	Course	Module	Date	Number of trainees
WASA-F[1)]	O&M of Mechanical & Electrical Equipment	Energy Audit	24 Jun 2022 17 Nov 2022 18 Feb 2023 3 Jun 2023 4-6 Jul 2023 (3 days) 24-25 Aug 2023 (2 days) 16-17 Oct 2023 (2 days)	8 11 12 18 10 12 9
		O&M on pumps and motors (Efficient pumping machinery)	20 Oct 2022 17 Nov 2022 18 Feb 2023 3 Jun 2023 23-24 Aug 2023 (2 days)	12 12 11 18 12
		Electrical Panel, MCU and wiring	3 Jan 2024	11
		Cleaning of sewerage and drainage pipelines	1 Feb 2023	6

WASA	Course	Module	Date	Number of trainees
	O&M on Sewerage and Drainage		29 Mar 2023 3 Nov 2023	10 4
		O&M of waste water treatment plant	2 Feb 2023	6
		Flow measurement of open channels	2 Feb 2023 30 Mar 2023	6 11
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	17 Nov 2022 4 Jan 2023 17 Jun 2023 26 Sep 2023	9 8 12 15
		Plumbing (HDPE jointing, pressure test etc.)	11 Jul 2023 30 Aug 2023 6 Dec 2023	12 16 8
		Leakage control	11 Jul 2023 30 Aug 2023 27 Sep 2023 22 Dec 2023	12 15 11 10
WASA-M[2]	O&M of Mechanical & Electrical Equipment	Energy Audit	18 Mar 2023 3-4 Aug 2023 (2 days)	5 7
		O&M on pump	2 Nov 2022 2-3 Aug 2023	6 7
		Electrical Panel, MCU and wiring	21 Jun 2023	4
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	4 May 2023	8
		O&M of wastewater treatment plant	6 May 2023	8
		Flow measurement of open channels	27 Jun 2023	8
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	2 Nov 2022 22 Jun 2023 20-21 Sep 2023 (2 days) 15 Nov 2023	7 11 6 12
		Plumbing (HDPE jointing, pressure test etc.)	25 May 2023 19 Jul 2023	10 10
		Leakage control	20 Jul 2023 24 Aug 2023	15 7
WASA-G[3]	O&M of Mechanical & Electrical Equipment	Energy Audit	9 Jun 2022 18-19 Jul 2023 (2 days) 19-20 Oct 2023 (2 days) 16-17 Nov 2023 (2 days) 28-30 Nov 2023 (3 days)	6 7 9 9 9
		O&M on pump	20 Oct 2022 24 Nov 2022 19-20 Jul 2023 (2 days)	6 7 5

WASA	Course	Module	Date	Number of trainees
			18-19 Oct 2023 (2 days) 28-30 Nov 2023 (3 days)	8 9
		Electrical Panel, MCU and wiring	2 Mar 2023 12 Jul 2023 16 Nov 2023	8 6 9
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	27 Jan 2023 3 Apr 2023	8 7
		Flow measurement of open channels	25 Jan 2023 4 Apr 2023 14 Jun 2023	8 7 9
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	23 Nov 2022 14 Jun 2023	6 7
		Plumbing (HDPE jointing, pressure test etc.)	1 Jun 2023 8 Aug 2023 6 Sep 2023 23 Nov 2023	7 8 4 8
		Leakage control	30 Mar 2023 3 Aug 2023 8 Nov 2023	5 8 6
WASA-R[4)]	O&M of Mechanical & Electrical Equipment	Energy Audit	8 Dec 2022 15 May 2023 9-10 Aug 2023 (2 days) 25-27 Oct 2023 (3 days)	10 9 7 5
		O&M on pump	7 Dec 2022 15 May 2023 10-11 Aug 2023 (2 days) 25-26 Oct 2023 (2 days)	10 9 7 5
		Electrical Panel, MCU and wiring	24 Feb 2023	15
	O&M on Sewerage and Drainage	Cleaning of sewerage and drainage pipelines	22 March 2023	10
		Flow measurement of open channels	22 March 2023	10
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	16 March 2023 8 Jun 2023 26 Oct 2023	4 9 10
		Plumbing (HDPE jointing, pressure test etc.)	7 Jun 2023 17 Aug 2023 30 Nov 2023	15 6 9
		Leakage control	15 Mar 2023 16 Aug 2023 16 Nov 2023	8 6 7

Note: 1) WASA Faisalabad, 2) WASA Multan, 3) WASA Gujranwala, 4) WASA Rawalpindi

5-4-5 Regularly, review and update in-house training contents, modules, and methods [Activity 4-5]

In-house trainings were conducted smoothly. The approach by WASAs was to minimize the lecture and focus more on practical activities inside the building and on site. Since it was practically new for WASAs to conduct in-house training, the same contents, modules and methods were used for in-house training, which was the understanding of WASAs, AJWA, and JET. However, the following contents were updated after the review.

Table 5.4.3 Contents of In-house Training Updated

WASA	Course	Topic	Timing of update	Major revision	Reasons	Reason No
WASA Faisalabad	O&M on Mechanical and Electrical Equipment	Energy Audit	3rd to 4th in-house training	Material	Because paper based forms were used for data management, database development through free application "mWater" was introduced. Due to that reason, the training included data collection and analysis by mWater.	1
			4th to 5th in-house training	Training duration	The training duration was extended to 3 days from 1 day by i) inclusion of database development using mWater, and ii) site visit of multiple tubewells and a disposal/ pumping station, instead of one tubewell.	2
			5th to 6th in-house training	Training duration	The training duration was reduced to 2 days from 3 days. The training content remained the same but field activities were carried out at different locations of tubewells and disposal/ pumping stations. Since know-how was obtained in the previous in-house training, the duration was reduced.	3
		O&M on pumps and motors	4th to 5th in-house training	Training duration	Basically, the reason is the same as "Reason No. 2" except the extension duration was 2 days instead of 3 days	4
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	2nd to 3rd in-house training	Material	The creation of "dashboard" in mWATER was included for the upgrading analysis. "Dashboard" is a realm where an analyzer selects and indicates graphs or tables for the detail analysis. Editing the GIS maps of water supply network for accurate and precise entries of points and lines using QGIS was also included.	5
		Plumbing (HDPE jointing, pressure test etc.)	1st to 2nd in-house training	Material	Necessary parameters and quality control for HDPE joints using butt furoin machine were added.	6
		Leakage control	2nd to 3rd in-house training	Material	The comparison of an amount of water flow measured by bulk meter and power consumption by electrical meter at tube well was included. "Energy Audit" in "O&M on Mechanical and Electrical Equipment" conducts the detailed comparison of these meters. However, WASAs considered that it is important for non-mechanical/ electrical engineers to start to learn the pump operation from this type of comparison. Furthermore, SOPs for installation of water meters were also included.	7
			3rd to 4th in-house training	Material	Details explanation of Non-Revenue-Water and SOPs regarding investigation of water leakage through field survey were included.	8

WASA	Course	Topic	Timing of update	Major revision	Reasons	Reason No
WASA Multan	O&M on Mechanical and Electrical Equipment	Energy Audit	1st to 2nd in-house training	Training duration	Same as "Reason No. 4"	
		O&M on pumps and motors	1st to 2nd in-house training	Training duration	Same as "Reason No. 4"	
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	1st to 2nd in-house training	Material	Same as "Reason No. 5"	
			2nd to 3rd in-house training	Training duration	An additional day was allocated to carry out further analysis of the leakage database and crown failure database using mWater and QGIS.	9
			3rd to 4th in-house training	Training duration	The training duration was reduced to 1 day from 2 days. The training content remained the same. Since mWater was included on the other trainings and understood, the duration was reduced.	10
		Leakage control	1st to 2nd in-house training	Material	Same as "Reason No. 7"	
WASA Gujranwala	O&M on Mechanical and Electrical Equipment	Energy Audit	1st to 2nd in-house training	Training duration	Same as "Reason No. 4"	
			4th to 5th in-house training	Training duration	The training duration was extended to 3 days from 2 days. The training content remained the same but the field activities were conducted at different locations of tubewells and disposal/ pumping stations.	11
		O&M on pumps and motors	2nd to 3rd in-house training	Training duration	Same as "Reason No. 4"	
			4th to 5th in-house training	Training duration	Same as "Reason No. 11"	
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	1st to 2nd in-house training	Material	Same as "Reason No. 5"	
		Plumbing (HDPE jointing, pressure test etc.)	3rd to 4th in-house training	Material	Same as "Reason No. 6"	
		Leakage control	1st to 2nd in-house training	Material	Same as "Reason No. 7"	

WASA	Course	Topic	Timing of update	Major revision	Reasons	Reason No
			2nd to 3rd in-house training	Material	Same as "Reason No. 8"	
WASA Rawalpindi	O&M on Mechanical and Electrical Equipment	Energy Audit	2nd to 3rd in-house training	Training duration	Same as "Reason No. 4"	
			3rd to 4th in-house training	Training duration	Same as "Reason No. 11"	
		O&M on pumps and motors	2nd to 3rd in-house training	Training duration	Same as "Reason No. 4"	
	Leakage Control, Plumbing and Pipe Replacement Plan	Pipe replacement planning	1st to 2nd in-house training	Material	Same as "Reason No. 5"	
		Plumbing (HDPE jointing, pressure test etc.)	2nd to 3rd in-house training	Material	Same as "Reason No. 6"	
		Leakage control	1st to 2nd in-house training	Material	Same as "Reason No. 7"	
			2nd to 3rd in-house training	Material	Same as "Reason No. 8"	

JET conducted a follow-up survey with 4WASAs during October – November 2023 to verify the effects of in-house training conducted from 2022 to September 2023 at 4 WASAs with the support of the Project. Using a questionnaire, the team collected feedback from trainees about their perceptions on the improvement of their skills through attending the training and those of the application of what they learned in the training to their work. The results are summarized in Tables 5.4.4 and 5.4.5. The details of the results are presented in Annex 5.4.2.

Table 5.4.4 Number of Responses to Questionnaire (4 WASAs)

WASA	BPS1-10	BPS11-16	BPS17 or above	Work Charge	Total
WASA Faisalabad	34	18	11	30	93
WASA Multan	31	21	13	4	69
WASA Gujranwala	13	18	1	19	51
WASA Rawalpindi	10	22	7	2	41
Total	88	79	32	55	254

Table 5.4.5 Responses on Outcome of In-House Training

WASA	Question No. 1[1)]		Question No. 2[2)]	
	Agree[3)]	Disagree[4)]	Agree[3)]	Disagree[4)]
WASA Faisalabad	97 %	3 %	86 %	14 %
WASA Multan	94 %	6 %	78 %	22 %
WASA Gujranwala	100 %	0 %	90 %	10 %
WASA Rawalpindi	88 %	12 %	59 %	42 %
Total in 4 WASAs	95 %	5 %	80 %	20 %

Note:
1) Question 1 is "I feel the skills required for my job have improved by attending the training." The answer for the question was selected from "Strongly agree", "Agree", "Neutral", "Disagree", and "Strongly disagree".
2) Question 2 is "I have fully applied on the job what I learned in the training." The answer options for Question 2 are the same as those for Question 1.
3) Sum of responses "Strongly agree" and "Agree"
4) Sum of responses "Neutral", "Disagree", and "Strongly disagree"

As indicated in Table 5.4.5, 95 % of the respondents at 4 WASAs agreed that their skills had improved by attending the training. In addition, 80% of the respondents confirmed that they have applied on the job what they learned. This high rate of achievement is attributed to the following:

i) The training content met the needs of trainees.
ii) The establishment of the in-house training system has motivated WASA staff to improve their performance in their day-to-day work.

Meanwhile, those who responded that they could not apply on the job what they had learned in the training, i.e. the response group of “Disagree” for Question 2 in Table 5.4.5, explained the reasons as listed below:

i) I do not think what I learned will work.
ii) The training did not give me the confidence to apply what I learned.
iii) I have other higher priorities in my job.
iv) I do not clearly understand what is expected of me.
v) I do not have the support to apply what I learned.

With regard to items i) to v) above, the following points were confirmed with the WASA coordinators and WASA trainers as areas that need further attention.

- Agreeing with trainees about the operational issues that training is going to address and expected training objectives and goals that should be achieved at the end and after the training.
- Motivating staff for attending the training.
- Allocating priority for attendance of staff whose duties are closely related to the training content.
- Ensuring that each trainee has sufficient opportunities for hands-on exercises and mutual learning among participants.
- Introducing cases in which work procedures and technologies addressed in the training have improved performance in actual daily operations.
- Agreeing upon post-training action plans among trainees, their supervisors, and WASA trainers
- Obtaining approval and support of the management of WASA for the introduction of the work procedures and technologies proposed in the training into daily operations.

5-5 Other Activities

5-5-1 Activities as Countermeasures against the Spread of COVID-19

Countermeasure activities against the spread of COVID-19 was discussed with WASAs and JET. The result was to prepare a Business Continuity Plan (BCP), which was agreed at the 1st JCC. BCP was prepared according to the following Table of Contents (see Annex 5.5.1).

Table of Contents for BCP

1 Purpose
2 Situation before emergency
2.1 Field installations
2.2 Operational field offices
2.3 Operation of tubewells and disposal/lift stations
2.4 Process of emergency contact
2.5 Maintenance Directorate
2.6 Customer Service/Bill distribution

3 Training requirement
4 Action after emergency situation is confirmed
    4.1 Action when the Government announces lock down
    4.2 Action when office and field work is allowed with certain precautions

BCP for each WASA was prepared with collaborations between each WASA and JET, and explained to WASA staff when the in-house training was conducted (see Table 5.5.1). During an emergency, directions were mainly informed verbally based on common understanding without written documents. Therefore, each WASA considered that BCP consists of actions to be taken during emergency which is a valuable document.

Table 5.5.1 Explanation on BCP at Each WASA

WASA	Date	Number of Participants
WASA Lahore	14 Jul 2023	15
WASA Faisalabad	6 Jul 2023	10
WASA Multan	22 Jun 2023	11
WASA Gujranwala	7 Jul 2023	6
WASA Rawalpindi	27 Jun 2023	6

5-5-2 Workshop

A workshop was held on 20th December 2023. Table 5.5.2 summarizes the workshop.

Table 5.5.2 Workshop

Item	Content
Date	20th December 2023
Place	Al Jazari Academy
Purpose	To share results of the project for both Phase 1 and 2
Main participants	Pakistani side - HUD&PHED Tayyab Farid (Special Secretary), Souman Khalid (Deputy Secretary (Technical)) - P&D Board Rehana Anwer (Deputy Project Director) - WASA Lahore Abdul Latif (Director (Planning and Evaluation)), Hisham Yaseer (Project Director), Fiza Anjum (Deputy Director (Planning and Evaluation)), Zaeema Aman (Deputy Director (Training)) - WASA Faisalabad Hafiz Hassan Nasir (Director (Planning and Design) - WASA Multan M. Nadeem (Deputy Director (Planning and Design)) - WASA Gujranwala M. Khurram (Director) - WASA Rawalpindi

Item	Content
	Azizullah Khan (Deputy Director) - Al Jazari Academy Abid Hussainy (Principal), Jawad Shahid (Vice Principal) - ADB PMU for PICIIP Talha Zubair (Deputy Program Director), Salman Yusuf (Technical Advisor (ADB)) - LG & CD M. Tariq (Director PLGA (Lala Musa Training Center)) - P&DC Pvt. Ltd. Umar Farooq (CEO) Japanese side JICA Headquarter: Ryuji Ogata, Hajime Sakai (online) JICA Pakistan Office: Koki Sawa, Takeru Endo, Naila Almas JET: Nobuyuki Sato, Yusaku Numajiri

In the workshop, several representatives from Pakistani and Japanese sides gave speeches/presentations on achievement of the professional training and in-house training etc. The following are pictures of the workshop.

Speech by Special Secretary HUD&PHED

Presentation by Principal AJWA

Presentation by WASA Lahore

Presentation by Mr Ogata, JICA HQ

Picture 5.5.1 Workshop

5-5-3 Procurement of Equipment

Table 5.5.3 shows equipment procured in the Project and handed over to the Pakistani side. The record of handing over of the equipment is attached in Annex 5.5.2

Table 5.5.3 List of Equipment Procured

Date of Handing Over	Item
19 September 2022	Velocity Meter (1 unit)
10 January 2024	Computers (5 units)

5-5-4 Training in Japan

The counterpart personnel attended training conducted in Japan in three batches. This section summarizes the training programs and outcomes.

(1) First Training

Table 5.5.4 and Table 5.5.5 show an outline and curriculum of the first training.

Table 5.5.4 Training Outline (First Batch)

Course Title	O&M on Water and Sewerage Sector
Expected Outcomes	To obtain knowledge on O&M of water supply and sewerage systems.
Duration of the Course	24 January – 1 February 2023
Number of Participants	12 participants (Refer to Annex 5.5.3.)

Table 5.5.5 Training Curriculum (First Batch)

Date	Contents		Venue
Jan 24 (Tue)		Opening ceremony JICA training briefing and orientation	JICA Chugoku (Hiroshima)
Jan 25 (Wed)	AM PM	O&M planning of waterworks Digitalization of O&M	JICA Chugoku (Hiroshima)
Jan 26 (Thu)	AM PM	O&M of WTP Courtesy visit to Onomichi Water and Sewage Bureau O&M of WWTP	Onomichi City
Jan 27 (Fri)	AM PM	O&M of waterworks: water distribution and leakage control Public relations: waste disposal plant	Hatsukaichi City
Jan 30 (Mon)	AM PM	Water resources conservation O&M of sewerage system: sewer pipe, manhole	Hiroshima City
Jan 31 (Tue)	AM PM	Improvement of work efficiency 5S Methodology: visit to a factory of a private company	Hiroshima City
Feb 1 (Wed)	AM	Evaluation Closing ceremony	JICA Chugoku (Hiroshima)

The training program was designed to address operational management and digitalization of business processes as well as O&M of facilities, a chronic challenge for WASAs. With regard to the issues of crown failure of sewer pipes, which pose a serious concern in the service areas of WASAs, the program included a visit to a sewer pipe manufacturing plant to gain a deeper understanding of the structure and components of the sewer pipes. In addition, since the workplace in WASAs is often observed for the requirement of the proper arrangement or recording of equipment including stock, the participants had an opportunity to learn about 5S through a visit to a factory. These programs were designed to help participants consider how they could apply Japanese technical management methods to the operations of their water supply and sewerage systems.

In the evaluation meeting on the last day of training, the participants commented that the training content w well organized. Meanwhile, it was observed that the time allocation in some programs would need to be adjusted in the subsequent batches to deliver training more effectively. Time was especially limited at a water treatment plant (WTP) and wastewater treatment plant (WWTP) for the participants to learn about only the outline of the facilities. In addition, there was not enough time for training on digitalization, which was included in the training topics in the light of the situation where WASA did not establish various databases. It was concluded that training at WTP and WWTP should allow sufficient time for the participants to further learn about the maintenance of mechanical and electrical equipment as well. The necessity to allocate more time to training on the utilization of data was also observed.

(2) Second Training

Table 5.5.6 and Table 5.5.7 show an outline and curriculum of the second training.

Table 5.5.6 Training Outline (Second Batch)

Course Title	O&M on Water and Sewerage Sector
Expected Outcomes	To obtain knowledge on O&M of water supply and sewerage systems.
Duration of the Course	23 May – 1 June 2023
Number of Participants	13 participants (Refer to Annex 5.5.3.)

Table 5.5.7 Training Curriculum (Second Batch)

Date		Contents	Venue
May 23 (Tue)		Opening ceremony JICA training briefing and orientation	JICA Chugoku (Hiroshima)
May 24 (Wed)	AM PM	Water supply services: roles of the local authorities O&M planning of waterworks: overview of O&M	JICA Chugoku (Hiroshima)
May 25 (Thu)	AM PM	O&M of waterworks: facilities of WTP O&M of waterworks: daily operations of WTP	Mihara City
May 26 (Fri)	AM	O&M of sewerage system: facilities of WWTP	Etajima City

Date	Contents		Venue
	PM	O&M of sewerage system: daily operations of WWTP Courtesy visit to the Mayor of Etajima	
May 29 (Mon)	AM PM	Field visit to Yasaka Dam O&M of sewerage system: sewer pipe, manhole	Otake City Iwakuni City, Yamaguchi
May 30 (Tue)	AM/ PM	O&M of waterworks: data management	Hiroshima City
May 31 (Wed)	AM PM	O&M of sewerage system: stormwater control Approach to technology improvement: visit to a factory of a private company	Hiroshima City
Jun 1 (Thu)	AM	Evaluation Closing ceremony	JICA Chugoku (Hiroshima)

As with the first training, the program covered O&M, operational management, and digitalization. In addition, to address the issues of crown failure of sewer pipes, the participants visited a sewer pipe manufacturing plant to learn about the structure and components of sewer pipes. The training also included a visit to a factory of a private company to foster a deeper understanding of the technologies and facilities introduced in their country and to develop a more proactive mindset toward technical improvement. In connection with these programs, the trainees commented on the importance of improving the quality of work in water supply and sewerage.

The training content covered a wide range of topics, and trainees gave positive feedback on this point. Meanwhile, some issues were observed as the areas that required improvement in the subsequent training batch. First, the training on NRW, which was included in the second batch based on the feedback from the participants of the first training, should have been delivered through both lectures and field visits, as classroom lectures alone pose limitations in facilitating the understanding of trainees. It was concluded that the participants in the third training should have field visits to actual sites of plumbing work and leakage investigations to observe responses to NRW.

Second, demonstrations of emergency responses could also have been incorporated into the program, as it is important to help participants fully understand the O&M process. While the second training provided an opportunity to observe daily inspection procedures of mechanical and electrical equipment at WTP and WWTP and directly interact with the staff at these facilities, the topic of emergency responses was not touched on in the program. It was suggested that the site visit program in the third training should consider further practicality of the topics and include demonstrations in handling broken pumps.

(3) Third Training

Table 5.5.8 and Table 5.5.9 show an outline and curriculum of the third training.

Table 5.5.8 Training Outline (Third Batch)

Course Title	O&M on Water and Sewerage Sector
Expected Outcomes	To obtain knowledge on O&M of water supply and sewerage systems.
Duration of the Course	19-28 September 2023
Number of Participants	11 participants (Refer to Annex 5.5.3.)

Table 5.5.9 Training Curriculum (Third Batch)

Date		Contents	Venue
Sep 19 (Tue)		Opening ceremony JICA training briefing and orientation	JICA Chugoku (Hiroshima)
Sep 20 (Wed)	AM PM	O&M of waterworks: facilities of WTP O&M of waterworks: water leakage	Mihara City
Sep 21 (Thu)	AM/ PM	O&M of waterworks: maintenance of mechanical equipment (pump)	Mihara City
Sep 22 (Fri)	AM/ PM	O&M of waterworks: maintenance of mechanical equipment (valve)	Mihara City
Sep 25 (Mon)	AM PM	O&M of sewerage system: facilities of WWTP O&M of sewerage system: treatment of sewage sludge and solid waste	Hiroshima City
Sep 26 (Tue)	AM/ PM	O&M of waterworks: maintenance of WTP (mechanical and electrical equipment, pipeline) Courtesy visit to Kure City Waterworks and Sewerage Bureau	Kure City
Sep 27 (Wed)	AM PM	O&M of waterworks: training program for waterworks professionals O&M of sewerage system: stormwater control	Hiroshima City
Sep 28 (Thu)	AM	Evaluation Closing ceremony	JICA Chugoku (Hiroshima)

As with the first and second training rounds, the program focused on O&M and operational management. The contents of the third training also reflected the improvements suggested from the results of the first and second trainings: First, a field visit program on NRW was provided where emergency water sealing work and leak detection were demonstrated and practiced. Second, practical training in disassembling and reassembling pumps and motors was conducted to enhance participants' understanding of the equipment.

The participants commented that the hands-on training stimulated discussions among the trainees and helped them better understand O&M work in their country. They also expressed their satisfaction with the relevance of the training content, which addressed the current situation and issues in water supply and sewerage services in Pakistan. Further, appreciating the practical training program on mechanical equipment, the trainees requested similar training methods for other topics. This suggests that hands-on training should be adopted where possible in similar training courses in the future.

6. Achievement on Outputs of PDM

6-1 Achievement on Output

Table 6.1.1 summarizes the achievements of output at the end of the project. The endline of each output indicator is detailed in Section 6-1-1 to 6-1-4.

Table 6.1.1 Endline of Indicators for Project Output

Output	Indicator	Endline
Output 1: Capacity for Al-Jazari Academy to conduct practical training to WASAs is strengthened.	1-1 ToT components are included in training contents/materials of three thematic areas.	Achievement: 100% TOT components were developed and implemented for three thematic areas, namely O&M of mechanical and electrical equipment, O&M of sewerage and drainage, and leakage control, plumbing and pipe replacement plan.
	1-2 All of the selected training contents are revised/updated based on the Technical Advisory Committee's recommendations.	Achievement: 100% The training content of the three thematic areas was revised and updated prior to the first batch of each professional training course. For the second and subsequent batches of the training, AJWA proposed revision of the training content based on the review of the preceding training event and obtained approval of TAC.
Output 2: Capacity to plan and conduct training at WASA Training Center is improved.	2-1 Training contents, modules, and methodologies that require revisions or improvements are fulfilled.	Achievement: 100% Based on discussions with WASA Training Centre, the project supported in developing new training modules to strengthen capacities of the staff to cope with identified operational issues of WASA-L.
Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.	3-1 Priority sectors for in-house training at WASAs were identified by the end of Year 1.	Achievement: 100% Each WASA identified priority sectors for in-house training by the end of Year 1 of the project. Training topics were selected based on these priorities.
	3-2 Training plans are updated every year at 4 WASAs from Year 2.	Achievement: 100% Each WASA prepared the first in-house training plan in January 2022 and updated it about every six months thereafter.
Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.	4-1 Each WASA achieves three thematic areas that in-house training is conducted.	Achievement: 100% Each WASA covered all planned training topics in the three thematic areas in-house training. More than half of the planned training topics were addressed several times in order to maximize the participation of target staff as much as possible.
	4-2 More than 50% of in-house	Achievement: 100%

Output	Indicator	Endline
	training participants feel their skills are improved by training.	Of the trainees who responded to a questionnaire for the follow-up of the in-house training, more than 90% indicated that they felt their skills had improved as a result of attending the training.

6-1-1 Output 1: Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.

Indicator 1-1 ToT component are included in training contents/materials of 3 thematic areas.

Achievement: 100%

There are two types of ToT, ToT (training management and instruction skills) and ToT (technical). ToT (training management and instruction skills) was implemented as described in Section 4-1-6 (Activity 1-6). ToT (technical) was implemented as described in Section 5-1-6 (Activity 1-6). The number of ToT (technical) topics is summarized in Table 6.1.2.

Table 6.1.2 ToT (technical), Prepared and Conducted

WASA	Number of ToT topics, prepared	Number of ToT topics, conducted
WASA Faisalabad	9	9
WASA Multan	9	9
WASA Gujranwala	8	8
WASA Rawalpindi	8	8

Indicator 1-2 All of the selected training contents are revised/updated based on technical advisory committee's recommendations.

Achievement: 100%

As shown in Table 4.1.5, the first batch professional training was revised/updated as follows.

i) O&M of Mechanical and Electrical Equipment

- The training topics of "energy audit" and "wiring" were added to the course.
- Contents of "electrical panels" and "selection of pumps" were revised to include more details.

ii) O&M of Sewerage and Drainage

- The training topics of "flow measurement of open channels", "wastewater treatment technology", and "O&M of wastewater treatment plant" were added to the course.
- "Sewer pipe inspection camera" was added under the training topic of "cleaning of sewerage and drainage pipelines".

iii) Leakage Control, Plumbing, and Pipe Replacement Plan

- The training topics of "water meter for house connections", "proper handling of leakage from valves and connections", "data collection method at the leakage repairing site", "joint/connection/replacement, including welding from fusion", and "pressure test" were added to the course.

After the second batch professional training, AJWA and JET reviewed and discussed the revision/upgrade for the next training. The revision/upgrade after the second batch was proposed by AJWA and approved. If TAC recommended the revision of the revised/upgraded version, the training content and schedule were revised according to the recommendations. The details are described in 5-1-11 (Activity 1-11).

6-1-2 Output 2: Capacity to plan and conduct training at WASA Training Center is improved.

Indicator 2-1 Training contents, modules and methodologies that required revisions or improvements are fulfilled.

Achievement: 100%

WASA Training Center developed 19 new training modules with the training materials as presented in Table 5.2.1, and conducted the training as presented in Table 5.2.2.

6-1-3 Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.

Indicator 3-1 Priority sectors for in-houses training at WASAs were identified by the end of Year 1.

Achievement: 100%

The priority sectors for in-house training at WASAs were identified as presented in Tables 4.3.1 to 4.3.3. Based on the priority sectors, training topics at each WASA were formulated as presented in Tables 5.1.5 to 5.1.8.

Indicator 3-2 Training plans are updated every year at 4 WASAs* from Year 2.

Achievement: 100%

4 WASAs formulated in-house training plans as follows.

"In-house training plan" from June to July 2022 was prepared in January 2022.

"In-house training plan" from August to December 2022 was prepared in August 2022.

"In-house training plan" from January to April 2023 was prepared in December 2022.

"In-house training plan" from May to mid-September 2023 was not prepared.

"In-house training plan" from mid-September to December 2023 was prepared in August 2023.

"In-house training plan" in Jan 2024 was not prepared.

During the monsoon, every WASA becomes busy and cannot predict whether in-house training can be conducted or not. Therefore, "In-house training plan" from May to mid-September 2023 was not prepared. The details are described in 5-3-4.

6-1-4 Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.

Indicator 4-1 Each WASA achieves 3 of thematic areas that in-house training is conducted.

Achievement: 100%

Based on Tables 5.1.5 to 5.1.8, Table 6.1.3 summarizes the implementation of In-house training.

Table 6.1.3 Implementation of Pilot In-house Training and In-house Training at WASA

WASA	Number of topics planned	Number of topics for in-house training, implemented	Number of topics for in-house training, implemented twice or more
WASA Faisalabad	9	9	7
WASA Multan	9	9	5
WASA Gujranwala	8	8	8
WASA Rawalpindi	8	8	5

As indicated in Table 6.1.2, each WASA conducted in-house training for all training topics. In addition, many of topics were conducted twice or more as indicated in Table 6.1.2.

Indicator 4-2 More than 50% of in-house training participants feel their skills are improved by training.

Achievement: 100%

The follow-up survey on in-house training was conducted during October - November 2023 at 4 WASAs. Table 6.1.4 summarizes the results that more than 90% of the respondents felt their skills have improved by attending the training. The details are shown in Tables 5.4.4 and 5.4.5.

Table 6.1.4 Outcomes of In-house Training

WASA	Number of Responses	Number of responses agreeing on the improvement of skills	% of responses agreeing on the improvement of skills
WASA Faisalabad	93	90	97%
WASA Multan	69	65	94%
WASA Gujranwala	51	51	100%
WASA Rawalpindi	41	36	88%
4 WASAs	254	242	95%

6-2 Achievement of Project Purpose

Project Purpose is "Training systems for 5 WASAs in Punjab province are established". The following is the achievements of Project Purpose.

Indicator 1: 4 WASAs conduct in-house training.

Achievement: 100%

All training topics of in-house training at 4WASAs were conducted as described in Tables 5.1.5-5.1.8. The following is supplemental information for positive support to the achievements of in-house trainings at 4 WASAs.

- Many of the training topics have been conducted twice or more as indicated in Table 6.1.2.
- The average frequency for monthly implementation of in-house training is about 1.5 - 2 times a month as mentioned in Section 5-3-4.
- The training content has been revised / upgraded according to the progress or target outcome as indicated in Table 5.4.3.

Indicator 2: Recommendations for training are presented to the Project Coordination Committee.

Achievement: 100%

Recommendations for professional trainings were presented at PCC held on 15th January, 2024.

- AJWA's management and operation including financial responsibility will be transferred from Urban Unit to HUD&PHED. The recommendation is to finalize the transition plan by HUD&PHED.
- The function of PCC will be transferred to PSC (hereinafter referred to as "Project Steering Committee"), which was established in September 2023 under the leadership of HUD&PHED. Therefore, it is recommended that PSC monitor the progress of the professional training. The outline of PSC is presented in Table 6.2.1.

Table 6.2.1 Outline of PSC

Item	Detail
Members	Chair: Additional Secretary (Tech), HUD&PHED Member / Secretary: Principal AJWA (Secretary) Member: MD / representatives from 5 WASAs in Punjab
Function	・To review overall progress, management, and functioning of the academy ・To review the progress and participation of the training program ・To review and finalize the curriculum and topics ・To carry out project appraisal / evaluation of the training program ・The Secretary of the committee is responsible to submit request for convening meeting on a quarterly basis or as desired by the Chair, table agendas with working papers and conduct all affairs of the meeting and implementation of decisions.

6-3 Suggestion to Achieving Overall Goal

Overall Goal is "Training systems for 5 WASAs in Punjab Province continue to function". The following are the suggestions to achieving Overall Goal.

6-3-1 Indicator 1: All WASAs continue conducting in-house training.

WASA Trainers conducted many in-house trainings in the project. Therefore, it is considered that WASAs developed the internal system and obtained skills to conduct the trainings, which were developed during the project period. However, each WASA has a wide variety of issues. The more the issues included in the training are solved or minimized, the more the other types of issues may arise. The other issues may require higher or other types of technical knowledge / skills, which were not included in the training. In that case, the training with new contents shall be developed and provided to WASA staff. The point to be considered is whether WASA itself could conduct such training or not. If it is difficult to develop new contents of the training, it is important that WASAs rely on AJWA to develop the training with the required contents. For smooth movement against such situation, there may be two approaches at least. The first one is that the cooperation system between AJWA and WASAs shall be developed. The second is that AJWA needs to have sufficient capacity to fulfill the request from WASAs.

Against the first, it could be smoothly implemented if a function of PSC includes the monitoring of progress on in-house training. In addition, it is also important that WASA Lahore or any other WASA which has capacity for specific topic shall support AJWA. Against the second, it could be implemented if AJWA establishes a R&D (Research and Development) section, working for new issues. These two items were discussed at PCC held on 15th January 2024. The importance of those two approaches were understood by both committees. In order to implement this approach, HUD&PHED becomes a main role after taking administrative control of AJWA. HUD&PHED can help in achieving this indicator due to having sufficient in-house capacity.

6-3-2 Indicator 2: Recommendations presented by the project are implemented.

The recommendations are described as Indicator 2 of Project Purpose in "6-2 Achievement of Project Purpose". For implementation of the recommendations, the importance is considered as an extensive activation of PSC. For the activation, PSC shall be held regularly, and held at any time if the Chair observes the necessity. These recommendations are described from experience in Phase 2 as follows.

One of the required improvements from Phase 1 to Phase 2 was to improve the professional training. As a result, TAC was established in Phase 2, and held 8 times for revision/approval of the professional training (see Table 5.1.10). It has positive impact on achieving the requirement.

7. Challenges, Approach, and Lessons learned in Project Implementation

The following are challenges, approach, and lessons learned in this project.

(1) Effectiveness of TAC

One of the challenges in Phase 2 was to improve the professional trainings implemented in AJWA from the training in Phase 1. The "improvement" intended to improve the training content, which is more directly applicable to improve the daily work of WASA. For including the opinions from WASAs smoothly, TAC, chaired by DMD WASA Lahore was established in Phase 2. The functions of TAC are not only to give advice to the contents of professional training, but also to approve it. Therefore, reflecting the opinions from WASA became easier than Phase 1. Since the training content was revised almost every time, TAC was held almost every time before each training was conducted. Frequent holding of TAC resulted in frequent opportunities for discussions between AJWA and WASA. This can be the result of the frequent discussions where the details of technical discussions were increased more and more, such as the diameter of distribution pipe on pipe network model and calculation of sludge volume in drainage. Thus, TAC played an important role for improvement of the contents in the professional training.

(2) Effectiveness of in-house training

WASAs face a wide variety of difficulties in daily work such as complaints from customers, a decrease in operation efficiency due to aging facilities etc. Each WASA understands the requirements for service improvement. However, only WASA Lahore implemented its own training to the officers.

Through this project, each WASA established the platform for implementation of in-house training. After this platform was established, each WASA positively implemented in-house training. As well as the professional training, the contents of in-house training was also revised when the necessity was observed. The addition of "database development", described in "(4) Database development" below was considered as one of the major upgrades in in-house training.

The lesson learned was that WASAs implement in-house training with an establishment of the platform by a third party with an assistance for obtaining necessary skills/knowledge.

(3) Training implemented by learning mode of "constructive" and "interactive"

Ms. Micheene Chi et al., cognitive and learning scientists, proposed four stages of the learning mode as "passive", "active", "constructive", and "interactive"[1]. This project targeted on the implementation methodology of the training by the learning modes of "constructive" and "interactive" because the

[1] Michelene T. H. Chi & Ruth Wylie (2014) The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes, Educational Psychologist, 49:4, 219-243

outcome of learning is deeper than the other learning modes such as "passive" or "active". In Pakistan, most of trainings are implemented by "passive" mode. In case of "passive" mode, the trainees obtain the same training content at maximum. However, the issue on the field may vary. If the situation is different, the training could not solve the issue. In order to solve such an issue, the trainees themselves need to obtain additional knowledge/skills from what the trainer teaches. This learning mode is proposed as "constructive" and "interactive". This was considered as quite a new approach to implement the training by the learning modes of "constructive" or "interactive".

In detail, the models for practical training were extensively utilized for enhancing the understanding through using the hands. As a result, the trainees i) used their hands, ii) took notes, and iii) learned through discussions with other trainees. This phenomenon is considered as the deep learning modes of "constructive" and "interactive", which the trainees add knowledge by themselves in addition to information from the trainers.

In Phase 1, a similar model was used. However, the model was not prepared with the purpose of obtaining new knowledge through using hands of the trainees. This issue was improved in Phase 2. The models in Phase 2 were arranged to enable learning through physical touch by hands of the trainees. The lesson learned is that the learning modes of "constructive" and "interactive" were achieved in the training mainly by the use of the improved models.

(4) Database development

The approach and contents of technical cooperation was developed from the viewpoint of an improvement on WASA's services. On the other hand, as a reality, many facilities require to be rehabilitated/renewed. However, the scarcity of budget faces difficulty to realize this. Under such a difficult situation, one of the effective approaches is to prioritize and implement the prioritized plan. For the prioritization, database on daily activity is required. However, such database was not developed. In the project, initially the training related to database development was only for "pipe replacement plan". In this cooperation, a free App "mWATER" (hereinafter referred to as "the App") was used for the database development. Since the App is installed into the mobile phone, it was easily and positively accepted by WASA staff.

Database is also applicable to the other fields of "pipe replacement plan" for analysis of the current operational conditions and development of the improvement plan. After this potential was explained to WASAs, WASAs understood the effectiveness and applied to the other fields such as monitoring the efficiency of pumps in "O&M on Mechanical and Electrical Equipment" and recording the crown failures of sewer pipes in "O&M on Sewerage and Drainage". The following are examples applied for the other courses.

At the moment, the field information at WASAs is recorded on paper base. Due to the paper base recording for all types of information, it takes a considerable amount of time make access to the required information through several members of WASA's staff. If database is developed, the required information can be accessed immediately. This advantage was also to generate WASA's interest in developing database in various fields.

General image of database is to be developed by Excel. However, PCs are provided only to limited staff of WASAs. In addition, in Pakistan, Excel is not used with its advantageous functions. Under such circumstances, the lesson learned was that App installable into smart phone is an easily acceptable tool to WASAs.

(5) Effectiveness of JICA Coordinators

JICA Experts did not stay continuously in Pakistan. A visit to Pakistan by each expert was mainly twice a year and 1 to 1.5 months per each trip. Therefore, this made it difficult for the experts to visit 5 WASAs during each trip. Even if the experts visited the WASAs, the assistance day in one WASA is 5 days at maximum during one trip to Pakistan. Since the absent period of experts in Pakistan is much longer than the staying period in Pakistan, the assistance activities during the absence period was very important for maximizing the outcome in the project. JET employed coordinators the same as Phase 1. Among the 4 coordinators in Phase 2, 3 coordinators were employed in Phase 1 by JET. The coordinators learned the knowledge and skills from respective JICA Experts during the expert's visit in Pakistan. Through such a learning process, the coordinators visited WASAs and assisted the implementation of in-house trainings even during the absence of JICA Experts. As a result, it is considered that many in-house trainings were implemented (see Table 5.4.2).

(6) Participation of Sub Engineer to training program in Japan

The Sub Engineer is responsible to supervise O&M activities directly to the actual workers in the field. Therefore, the capacity development to Sub Engineers is very important in terms of an improvement of O&M activities. This focus was clearly described on R/D as "The half of the trainees shall be nominated from the junior level (BPS11 to 16) at least."

It was a very rare case for staff of BPS 11-16 to participate in the foreign training. Therefore, the training program in Japan gave a significant impact to the Sub Engineers. It was confirmed that the trainees changed their attitude positively to their daily work.

(7) Minimization of negative impact on online meetings due to COVID-19

Due to the spread of COVID-19, the activities were mainly through online meetings from February to September 2021. The online meetings had some limitations in depth of discussions as compared to face to face meetings. Therefore, JET thought that it would be important to conduct TNA, which is the most fundamental part of this project, with repeated discussions instead of extending the activities. As a result, JET conducted i) interviews with each WASA twice, ii) one time discussion based on the evaluation by JET, and iii) meeting with all stakeholders of 5WASAs and AJWA with agenda of implementation approach on in-house training. The purpose of holding the meeting with all stakeholders was to reconfirm the training content which were discussed multiple times. As a result, from the first activity in Pakistan, the detail contents of the training were discussed. The start of activities in Pakistan was delayed for 3 months from the original plan. However, the delay was minimized since the result of TNA survey was re-confirmed through multiple meetings.

8. JCC

JCC was held as indicated in Table 8.1.1.

Table 8.1.1　JCC

JCC	Date	Main decisions	Minutes of Meeting
1st JCC	26 May 2021	• Work plan for Term 1 • Contents of the Project Monitoring Sheet • Formulation of BCP for the activity on countermeasures against the spread of COVID-19 • Revision of terms in PDM/PO • Equipment to be procured in the Project (sewer inspection camera, PC)	Annex 8.1.1
2nd JCC	1 Nov 2021	• Courses of AJWA's professional training and WASA's in-house training to be assisted by the Project • Equipment to be procured additionally in the Project (velocity meter, vibration meters)	Annex 8.1.2
3rd JCC	7 Feb 2022	• Project Progress Report (1) • Plan of Operation of the Project 2nd term • Courses, topics, and schedules of training to be organized by AJWA and WASAs • Progress of the indicators in PDM	Annex 8.1.3
4th JCC	2 Aug 2022	• Work plan for Term 2 • Review of sustainability framework (management, budget, faculty, training quality, participation)	Annex 8.1.4
5th JCC	9 Aug 2023	• Progress of Project • Shifting to HUD&PHED for an administrative control of AJWA from July 2024	Annex 8.1.5

Annex

Annex 5.1.5 Training Material: "O&M on Pumps and Motors (Efficient Pumping Machinery)" for Pilot In-house Training, and In-house Training at WASA Faisalabad

Annex 5.1.6 Training Material: "Electrical panel, MCU, and wiring" for ToT, Pilot In-house Training, and In-house Training at WASA Faisalabad

Annex 5.1.7 Outline of In-house Training and Training Material of ToT for "O&M of Sewerage and Drainage" at 4 WASAs

Annex 5.1.8 Training Material: "O&M of Sewerage and Drainage" for Pilot In-house Training and In-house Training at 4 WASAs

Annex 5.1.9 Outline of In-house Training for "Leakage Control, Plumbing and Pipe Replacement Plan" at 4 WASAs

Annex 5.1.10 Training Material on "Pipe Replacement Planning"
- WASA Faisalabad for ToT, Pilot In-house Training, In-house Training (1st, 2nd)
- WASA Multan for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training (1st)

Annex 5.1.11 Training Material on "Pipe Replacement Planning"
- WASA Faisalabad for In-house Training (3rd, 4th)
- WASA Multan for In-house Training (2nd-4th)
- WASA Gujranwala for In-house Training (2nd)
- WASA Rawalpindi for In-house Training (2nd, 3rd)

Annex 5.1.12 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)" for ToT at 4 WASAs:

Annex 5.1.13 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)" for Pilot In-house Training at 4 WASAs

Annex 5.1.14 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)"
- WASA Faisalabad for In-house Training (1st)
- WASA Multan for In-house Training
- WASA Gujranwala for In-house Training (1st-3rd)
- WASA Rawalpindi for In-house Training (1st, 2nd)

Annex 5.1.15 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)"
- WASA Faisalabad for In-house Training (2nd, 3rd)
- WASA Gujranwala for In-house Training (4th)
- WASA Rawalpindi for In-house Training (3rd)

Annex 5.1.16 Training Material on "Leakage Control"
- WASA Faisalabad for ToT, Pilot In-house Training, In-house Training (1st, 2nd)
- WASA Multan for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training (1st)

Annex 5.1.17 Training Material on "Leakage Control"
- WASA Faisalabad for In-house Training (3rd)
- WASA Multan for In-house Training (2nd)
- WASA Gujranwala for In-house Training (2nd)
- WASA Rawalpindi for In-house Training (2nd)

Annex 5.1.18 Training Material on "Leakage Control"
- WASA Faisalabad for In-house Training (4th)
- WASA Gujranwala for In-house Training (3rd)
- WASA Rawalpindi for In-house Training (3rd)

Annex 5.1.19 Training Material: "Energy Audit" for ToT and Pilot In-house Training at WASA Multan

Annex 5.1.20 Training Material: "Energy Audit" for In-house Training at WASA Multan

Annex 5.1.21 Training Material: "O&M on Pump" for ToT at WASA Multan

Annex 5.1.22 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Multan

Annex 5.1.23 Training Material: "Electrical panel, MCU, and wiring" for ToT at WASA Multan

Annex 5.1.24 Training Material on "Electrical panel, MCU, and wiring":
- WASA Multan for Pilot In-house Training, In-house Training
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training

Annex 5.1.25 Training Material: "Energy Audit" for ToT, Pilot In-house Training, and In-house Training at WASA Gujranwala

Annex 5.1.26 Training Material: "O&M on Pump" for ToT at WASA Gujranwala

Annex 5.1.27 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Gujranwala

Annex 5.1.28 Training Material: "Energy Audit" for ToT, Pilot In-house Training, and In-house Training at WASA Rawalpindi

Annex 5.1.29 Training Material: "O&M on Pump" for ToT at WASA Rawalpindi

Annex 5.1.30 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Rawalpindi

Annex 5.1.31 Supplemental Material for WTP at WASA Rawalpindi: Major Points of O&M

Annex 5.1.32 Supplemental materials for tubewell operation at WASA Rawalpindi
- Checklist for Tube Well Operation (Submersible)
- Troubleshooting of Tubewell
- Pump Selection

Annex 5.1.33 MM on 2nd TAC held on 10th June, 2022

Annex 5.1.34 MM on 3rd TAC held on 14th October, 2022

Annex 5.1.35 MM on 4th TAC held on 2nd November, 2022

Annex 5.1.36 MM on 5th TAC held on 21st December, 2022

Annex 5.1.37 MM on 6th TAC held on 3rd March, 2023

Annex 5.1.38 MM on 7th TAC held on 5th April, 2023

Annex 5.1.39 MM on 8th TAC held on 5th October, 2023

Annex 5.1.40 MM on 9th TAC held on 1st December, 2023

Annex 5.1.41 Time Schedule for Training in Summer 2022

Annex 5.1.42 Time Schedule for Training in Fall 2022

Annex 5.1.43 Time Schedule for Training in Spring 2023

Annex 5.1.44 Time Schedule for Training in Summer 2023

Annex 5.1.45 Time Schedule for Training in Fall 2023

Annex 5.1.46 Training Material for "O&M of Sewerage and Drainage" in Summer 2022

Annex 5.1.47 Training Material for "O&M of Mechanical and Electrical Equipment" in Summer 2022

Annex 5.1.48 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Fall 2022

Annex 5.1.49 Training Material for "O&M of Mechanical and Electrical Equipment" in Fall (November) 2022

Annex 5.1.50 Training Material for "O&M of Sewerage and Drainage" in Fall 2022

Annex 5.1.51 Training Material for "O&M of Mechanical and Electrical Equipment" in Fall (December) 2022

Annex 5.1.52 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Spring 2023

Annex 5.1.53 Training Material for "O&M of Sewerage and Drainage" in Spring 2023

Annex 5.1.54 Training Material for "O&M of Mechanical and Electrical Equipment" in Spring 2023

Annex 5.1.55 Training Material for "O&M of Mechanical and Electrical Equipment" in Summer 2023

Annex 5.1.56 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Summer 2023

Annex 5.1.57 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" in Fall 2023

Annex 5.1.58 Training Material for "O&M of Mechanical and Electrical Equipment" in Fall 2023

Annex 5.1.59 Training Material for "O&M of Sewerage and Drainage" in Fall 2023

Annex 5.1.60 Participant list for Professional Training

Annex 5.1.61 Presentation Material by 4 WASAs at WASA Coordinators Meeting on 21st December 2022

Annex 5.2.1 Training Material for "Cleaning of Sewerage and Drainage Pipelines: Cleaning" at WASA Lahore

Annex 5.2.2 Training Material for "Cleaning of Sewerage and Drainage Pipelines: Crown failure" at WASA Lahore

Annex 5.2.3 Training Material for "Flow Measurement of Open Channels" at WASA Lahore

Annex 5.2.4 Training Material for "Wastewater Treatment Technologies" at WASA Lahore

Annex 5.2.5 Training Material for "Selection of Suitable Pump" at WASA Lahore

Annex 5.2.6 Training Material for "Designing of Star-Delta Control Panel" at WASA Lahore

Annex 5.2.7 Training Material for "Slip Ring Motors and starters" at WASA Lahore

Annex 5.2.8 Training Material for "Practical Training on Energy Audit and Pump Efficiency" at WASA Lahore

Annex 5.2.9 Training Material for "Energy Audit" at WASA Lahore

Annex 5.2.10 Training Material for "Tube wells performance monitoring and rehabilitation" at WASA Lahore

Annex 5.2.11 Training Material for "Relationship of Head, Motor capacity, and Delivery size with Pump flow" at WASA Lahore

Annex 5.2.12 Training Material for "Plumbing (Distribution Pipe), Jointing / Welding and Pressure Test" at WASA Lahore

Annex 5.2.13 Training Material for "Proper Handling of Leakages from Valves & Connections" at WASA Lahore

Annex 5.2.14 Training Material for "Water meters selection and installation" at WASA Lahore

Annex 5.2.15 Training Material for "Pressure Testing of Water Distribution Model" at WASA Lahore

Annex 5.2.16 Training Material for "Working of a water supply network (water Supply Model)" at WASA Lahore

Annex 5.2.17 Training Material for "Leakage Control, Plumbing and Pipe Replacement Plan" at WASA Lahore

Annex 5.2.18	Training Material for "Construction management for Pipe installation" at WASA Lahore
Annex 5.2.19	Training Material for "Utilization of mWater app and Web Portal for field data collection" at WASA Lahore
Annex 5.3.1	In-house Training plan at WASA Faisalabad
Annex 5.3.2	In-house Training plan at WASA Multan
Annex 5.3.3	In-house Training plan at WASA Gujranwala
Annex 5.3.4	In-house Training plan at WASA Rawalpindi
Annex 5.4.1	Participant list for In-house Training at 4WASAs
Annex 5.4.2	Survey on Outcome by In-house Training at 4WASAs
Annex 5.5.1	Business Continuity Plan for 4 WASAs
Annex 5.5.2	Letters for Transferring Ownership of Equipment in Term 2

Annex 8.1.1	MM on 1st JCC held on 26th May, 2021
Annex 8.1.2	MM on 2nd JCC held on 1st November, 2021
Annex 8.1.3	MM on 3rd JCC held on 7th February, 2022
Annex 8.1.4	MM on 4th JCC held on 2nd August, 2022
Annex 8.1.5	MM on 5th JCC held on 9th August, 2023

Annex 1.2.1 PDM

PM Form 3-2 Project Monitoring Sheet I

Project Design Matrix

Project Title: The Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Implementing Organization: Al Jazari Academy, WASA Faisalabad, WASA Gujranwala, WASA Lahore, WASA Multan and WASA Rawalpindi

Version 2 (7th February, 2022)

Final Report (February 2024)

Target Groups: Managers and staff of implementation organizations

Period of Project: Feb. 2021-Feb..2024 (3 years)

Project Site: Punjab Province (Faisalabad, Gujranwala, Lahore, Multan, and Rawalpindi)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Training systems for 5 WASAs in Punjab province continue to function.	1. All WASAs continue conducting in-house training. 2. Recommendations presented by the project are implemented.	Record of trainings Interviews, questionnaire and observation			
Project Purpose Training systems for 5 WASAs in Punjab province are established.	1. 4 WASAs* conduct in-house trainings. 2. Recommendations for trainings are presented to the Project Coordination Committee	1. Training records/interviews, project documents 2. Recommendations, project documents			
Outputs 1. Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.	1-1 ToT component are included in training contents/materials of 3 thematic areas. 1-2 All of the selected training contents are revised/updated based on technical advisory committee's recommendations.	1-1 List of thematic areas, updated training materials, project document 1-2 Recommendation, updated contents		1-1: Achieved. 1-2: Achieved.	
2. Capacity to plan and conduct training at WASA Training Center is improved.	2-1 Training contents, modules and methodologies that required revisions or improvements are fulfilled.	2-1 List of revisions or improvements		2-1: Achieved.	
3. Capacity to formulate and implement training plans is strengthened in 4 WASAs*.	3-1 Priority sectors for in-houses training at WASAs were identified by the end of Year 1. 3-2 Training plans are updated every year at 4 WASAs* from Year 2.	3-1 Project document, list of sectors for in-house training 3-2 Training plans (original and revised)		3-1: Achieved. 3-2: Achieved.	
4. Capacity to conduct in-house training is strengthened in 4 WASAs*.	4-1 Each WASA achieves 3 of thematic areas that in-house training is conducted. 4-2 More than 50% of in-house training participants feel their skills are improved by training.	4-1 Training record, Project document 4-2 Evaluation by participants (interview or questionnaire), project document		4-1: Achieved. 4-2: Achieved.	

Activities	Inputs	Important Assumption
1-1. Conduct training assessment (needs, capacity) including interviews to WASAs. 1-2. Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules. 1-3. Update or revise training modules and materials of thematic sectors where ToT will be incorporated. 1-4. Conduct pilot ToT and evaluate the training. 1-5.Formulate ToT training schedules. 1-6.Conduct ToT. 1-7.Conduct review of ToT regularly and update or revise contents. 1-8.Technical advisory committee (TAC) reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements. 1-9. Based on the recommendations, revise or update the professional training contents. 1-10. Technical advisory committee approves revised and updated professional training contents. 1-11. Conduct professional training with approved training contents. 1-12. Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators. 1-13. Organize semi-annual WASA coordinators meetings. 2-1. Assess and evaluate current training of WASA Training Center. 2-2. Based on the results of evaluation, list up thematic areas and methodologies that require revisions or improvements. 2-3.Update and revise training contents, modules and methodologies. 2-4. Conduct training with revised contents, modules and methodologies. 2-5. Reevaluate training and update or revise the training contents, modules and methodologies regularly. 3-1. Notify WASA coordinator in each WASA. 3-2. WASA coordinator conducts training assessment for in-house training needs and training capacity. 3-3. Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers. 3-4. WASA coordinator formulates in-house training plans semiannually. 3-5. WASA coordinator reviews implementation of in-house training plans and budget annually and revises the plans and budget if necessary. 4-1. Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules. 4-2. WASA trainers conduct pilot training at each WASA 4-3. WASA trainers and WASA coordinator review pilot in-house training and update the training contents and modules. 4-4. WASA trainers conduct in-house training. 4-5. Regularly, review and update in-house training contents, modules, and methods.	(Japanese side) (1) Expert 1) Chief Advisor/Training Management / Water and Sewage Facility Management 2) Human Resource Development Specialist/ Training Planner 3) Sewer Pipe and Drainage Cleaning Specialist 4) Cleaning Equipment Specialist 5) Civil Engineer (Pipe Replacement Planning) 6) Plumbing Specialist 1 7) Plumbing Specialist 2 8) Mechanical Engineer 9) Electrical Engineer 10) Leakage Control Specialist 11) Training Coordinator (Training in Japan) (2) Trainings in Japan (3) Equipment (Training facility, Personal Computer, Sewer Inspection Camera) (Pakistan side) 1) Counterpart personnel 2) Project office 3) Equipment mutually agreed by Japanese and Pakistani sides 4) Necessary budget for project management (Water, electricity, secured internet, etc.) 5) Salary and necessary cost of project participants	Extraordinary natural disasters that affect WASA's operation adversely do not occur. **Pre-Conditions** - Enough number of counterparts (Al Jazari Academy and WASAs) participate in the project. - Budget for project activities of Al Jazari Academy is secured. **<Issues and countermeasures>**

*: 4 WASAs indicate Faisalabad, Gujranwala, Multan, and Rawalpindi

Annex 1.2.2 PO

PM Form 3-3 Project Monitoring Sheet II

Version 2 (7th February, 2022)

Plan of Operation

Timeline: 2021 (1 2 3 4 5 6 7 8 9 10 11 12), 2022 (1 2 3 4 5 6 7 8 9 10 11 12), 2023 (1 2 3 4 5 6 7 8 9 10 11 12), 2024 (1 2 3); Term 1, Term 2

Inputs		Remarks	Monitoring: Issue	Monitoring: Solution
Expert				
Chief Advisor/Training Management/Water and Sewage Facility Management	Plan			
	Actual			
Human Resource Development Specialist/ Training Planner	Plan			
	Actual			
Sewer Pipe and Drainage Cleaning Specialist	Plan			
	Actual			
Cleaning Equipment Specialist	Plan			
	Actual			
Civil Engineer (Pipe Replacement Planning)	Plan			
	Actual			
Plumbing Specialist 1	Plan			
	Actual			
Plumbing Specialist 2	Plan			
	Actual			
Mechanical Engineer	Plan			
	Actual			
Electrical Engineer	Plan			
	Actual			
Leakage Control Specialist	Plan			
	Actual			
Training in Japan				
Training of counterpart personnel	Plan			
	Actual			
Equipment				
Sewer Inspection Camera	Plan			
	Actual			
Personal Computer	Plan			
	Actual			
Vibration Meter	Plan			
	Actual			
Velocity Meter	Plan			
	Actual			

Timeline: 2021 (1 2 3 4 5 6 7 8 9 10 11 12), 2022 (1 2 3 4 5 6 7 8 9 10 11 12), 2023 (1 2 3 4 5 6 7 8 9 10 11 12), 2024 (1 2 3); Term 1, Term 2

Activities		Responsible Organization	Achievement	Issue & Countermeasure
Output 1: Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.				
1-1. Conduct training assessment (needs, capacity) including interviews to WASAs.	Plan	Academy	100%	
	Actual			
1-2. Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules.	Plan	Academy	100%	
	Actual			
1-3. Update or revise training modules and materials of thematic sectors where ToT will be incorporated.	Plan	Academy	100%	
	Actual			
1-4. Conduct pilot ToT and evaluate the training.	Plan	Academy	100%	
	Actual			
1-5.Formulate ToT training schedules.	Plan	Academy	100%	
	Actual			
1-6.Conduct ToT.	Plan	Academy	100%	
	Actual			
1-7.Conduct review of ToT regularly and update or revise contents.	Plan	Academy	100%	
	Actual			

Inputs		2021–2024 (Term 1 / Term 2)	Remarks	Issue	Solution
1-8.TAC reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements.	Plan / Actual		TAC	100%	
1-9. Based on the recommendations, revise or update the professional training contents.	Plan / Actual		Academy	100%	
1-10. TAC approves revised and updated professional training contents.	Plan / Actual		TAC	100%	
1-11. Conduct professional training with approved training contents.	Plan / Actual		Academy	100%	
1-12. Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators	Plan / Actual		Academy	100%	
1-13. Organize semi-annual WASA coordinators meetings.	Plan / Actual		Academy	100%	
Output 2: Capacity to plan and conduct trainings at WASA Training Center is improved.					
2-1. Assess and evaluate current training of WASA Training Center.	Plan / Actual		WASA Training Center	100%	
2-2. Based on the results of evaluation, list up thematic areas and methodologies requires revisions or improvements	Plan / Actual		WASA Training Center	100%	
2-3.Update and revise training contents, modules and methodologies.	Plan / Actual		WASA Training Center	100%	
2-4. Conduct training with revised contents, modules and methodologies.	Plan / Actual		WASA Training Center	100%	
2-5. Reevaluate training and update or revise the training contents, modules and methodologies regularly.	Plan / Actual		WASA Training Center	100%	
Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.					
3-1. Notify WASA coordinator in each WASA.	Plan / Actual		4 WASAs	100%	
3-2. WASA coordinator conducts training assessment for in-house training needs and training capacity.	Plan / Actual		4 WASAs	100%	
3-3. Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers.	Plan / Actual		4 WASAs	100%	
3-4. WASA coordinator formulates in-house training plans semiannually.	Plan / Actual		4 WASAs	100%	
3-5 WASA coordinator reviews implementation of in-house training plans and budget annually and revises the plans and budget if necessary.	Plan / Actual		4 WASAs	100%	
Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.					
4-1. Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules.	Plan / Actual		4 WASAs	100%	
4-2. WASA trainers conduct pilot in-house training at each WASA	Plan / Actual		4 WASAs	100%	
4-3. WASA trainers and WASA coordinator review pilot in-house training and update the training contents and modules.	Plan / Actual		4 WASAs	100%	
4-4. WASA trainers conduct in-house training.	Plan / Actual		4 WASAs	100%	
4-5. Regularly, review and update in-house training contents, modules, and methods.	Plan / Actual		4 WASAs	100%	

Inputs		2021												2022												2023												2024			Remarks	Issue	Solution
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
		Term 1															Term 2																										
Monitoring Plan		2021												2022												2023												2024			Remarks	Issue	Solution
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
		Term 1															Term 2																										
Monitoring																																											
Joint Coordinating Committee (JCC)	Plan				▲			▲							▲								▲									▲						▲					
	Actual					▲						▲			▲						▲												▲					▲					
Submission of the Work Plans (Term 1 & 2).	Plan					▲													▲																								
	Actual					▲															▲																						
Submission of Monitoring Sheet	Plan								▲						▲								▲						▲						▲								
	Actual								▲						▲								▲						▲						▲								
Reporting																																											
Progress Report (1) (2)	Plan														▲													▲															
	Actual														▲														▲														
Project Completion Report	Plan																																						▲				
	Actual																																						▲				
JICA Project Brief Note (Term1 & 2)	Plan														▲																								▲				
	Actual														▲																								▲				

Annex 3.2.1 Flowchart

	Term 1		Term 2
	February 2021 - August 2021 Activities in Japan	September 2021 - February 2022 Activities in Pakistan	
Overall project	Baseline survey for measuring the effect of the project JCC Discuss adding activities in consideration of the status of COVID-19 pandemic		
Output 1: Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.	**TOT at Al-Jazari Academy and Professional training** Activity 1-1: Conduct training assessment (needs, capacity) including interviews to WASAs.	Activity 1-2: Based on the results of assessment, identify thematic sectors where ToT components will be incorporated into the existing training modules. Activity 1-3: Update or revise training modules and materials of thematic sectors where ToT will be incorporated. Activity 1-4: Conduct pilot ToT and evaluate the training. Activity 1-5: Formulate ToT training schedules. Activity 1-6: Conduct ToT. Activity 1-7: Conduct review of ToT regularly and update or revise contents. Activity 1-8: Technical advisory committee reviews professional training contents to include case studies and practical skills, and make recommendations for contents' improvements. Activity 1-9: Based on the recommendations, revise or update the professional training contents. Activity 1-10: Technical advisory committee approves revised and updated professional training contents.	Activity 1-6 Activity 1-11
	Activity 1-12: Conduct trainings for how to conduct assessment (Needs study) for WASA coordinators	**Establishment and operational support of In-house training in 4WASAs**	
Output 2: Capacity to plan and conduct training at WASA Training Center is improved.		Activity 2-1: Assess and evaluate current training of WASA Training Center. Activity 2-2: Based on the results of evaluation, list up thematic areas and methodologies requires revisions or improvements Activity 2-3: Update and revise training contents, modules and methodologies.	Activity 2-4
Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.	Activity 3-1: Notify WASA coordinator in each WASA.	Activity 3-2: WASA coordinator conducts training assessment for in-house training needs and training capacity. Activity 3-3: Based on the results of assessment, WASA coordinator identifies priority areas and candidate WASA trainers. Activity 3-4: WASA coordinator formulates in-house training plans semiannually.	Activity 3-4
Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.		Activity 4-1: Based on the training plans formulated in Output 3, WASA trainers produce in-house training contents and modules.	Activity 4-2
Report	Work Plan	Monitoring Sheet (1)(2) Project Progress Report (1) Project Briefing Note	

	Term 1	Term 2
		May 2022 - February 2024 Activities in Pakistan

Overall project

- Trainings in Japan
- JCC

Output 1: Capacity for Al-Jazari Academy to conduct practical trainings to WASAs is strengthened.

Term 1: Activity 1-4; Activity 1-6; Activity 1-10

TOT at Al-Jazari Academy and Professional training

Activity	Description
Activity 1-6	Conduct ToT.
Activity 1-7	Conduct review of ToT regularly and update or revise contents.
Activity 1-9	Based on the recommendations, revise or update the professional training contents.
Activity 1-11	Conduct professional training with approved training contents.
Activity 1-13	Organize semi-annual WASA coordinators meetings.

Establishment and operational support of In-house training in 4WASAs

Output 2: Capacity to plan and conduct training at WASA Training Center is improved.

Term 1: Activity 2-3

Activity	Description
Activity 2-4	Conduct training with revised contents, modules and methodologies.
Activity 2-5	Reevaluate training and update or revise the training contents, modules and methodologies regularly.

Output 3: Capacity to formulate and implement training plans is strengthened in 4 WASAs.

Term 1: Activity 3-4

Activity	Description
Activity 3-4	WASA coordinator formulates in-house training plans semiannually.
Activity 3-5	WASA coordinator reviews implementation of in-house training plans and budget annually and revise the plans and budget if necessary.

Output 4: Capacity to conduct in-house training is strengthened in 4 WASAs.

Term 1: Activity 4-1

Activity	Description
Activity 4-2	WASA trainers conduct pilot training at each WASA
Activity 4-3	WASA trainers and WASA coordinator review pilot in-house training and update the training contents and modules.
Activity 4-4	WASA trainers conduct in-house training.
Activity 4-5	Regularly, review and update in-house training contents, modules, and methods.

Report

Work Plan, Monitoring Sheet (3)(4)(5)
Project Progress Report (2), Project Briefing Note
Project Completion Report

Annex 4.1.1 Detail of Training Needs Assessment for 5WASAs

Summary of Training Needs of WASAs

WS: Water Supply
S&D: Sewerage & Drainage

AJWA: Training at Al-Jazari Academy
WASA: In-House Training at WASA

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
WS	Designining of intake facilities	Selection of pumps	- Selection parameters of pumps and mechanical equipment	✓		- Parameters to select pumps	✓		- Types of different pumps for water supply - Selection of pumps for tubewells - Relation between speed, head, discharge and power consumption of pumps		✓				- Pump selection criteria	✓	
WS	Designining of intake facilities	Alternative water sources	- Installation of new water sources (WASA needs discussion with the project team)														
WS	Desingning of water treatment plant	Water treatment technology							- Membrane treatment plant - Surface water treatment plant		✓				- Different methods/techniques of surface water treatment - Improvement in process - Improvement in parameters (How much settling time should be?)	✓	✓
WS	Designing of pipeline	Hydraulic modelling	- Pipeline profile about pressure and flow	✓													
WS	Designing of pipeline	Choosing specifications and International standards for water supply control valves							- Types of valves (Manual and Motor Controlled) - International standards and specifications for good quality valves		✓						

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
WS	O&M of tube wells	O&M of pumps and motors for tube wells	- SOPs for pump and motor - Preventive maintenance - Daily/ monthly inspection parameters - Usage of small equipment like thermometer, ampere meter	✓	✓	- Overall issues on preventive maintenance of mechanical system of tube wells - Preventive maintenance/ repair of pumps and motors - SOPs, guidelines, checklists/inspection sheets for preventive maintenance of pumps and motors	✓	✓	- Maintenance schedules (Daily, weekly, monthly, bi-annual and annual checks) - Trouble shooting of turbine pumps - Trouble shooting of tube well bore		✓	- Daily and routine maintenance* - Record keeping* - Pump and motor repalcement technique* - Impeller adjustment, flange adjustment* - Replacement of bearings and bearing seals* - How to reduce pump vibrations - How to avoid wear and tear in shaft - Software or format for recording on faults and repairs of pumps (* in-house training only)	✓	✓	- Daily and routine maintenance - Record keeping - Pump and motor repalcement technique - Daily inspection parameters	✓	✓
WS	O&M of water treatment facilities	Chlorination	- Chlorinator dosage adjustment - O&M of chlorinator		✓							- How to calculate chlorine dosage		✓	- Adjustment of chlorination	✓	
WS	O&M of water treatment facilities	Filtration										- O&M of filtration plant - Record keeping - SOPs for backwash technique - Selection of filters	✓	✓	- SOPs for changing filter media at filtration plant	✓	
WS	O&M of OHR	O&M of OHR										- Cleaning techniques - Reparing techniques - Disinfecting techniques		✓	- Cleaning techniques - Reparing techniques - Disinfecting techniques		✓
WS	Plumbing works	Water supply pipe connections	- Water supply lines connection joints	✓	✓	- Jointing of pipes made of different materials and in different size		✓				- Prevention of contaminations in pipeline - Proper pipe jointing - Proper level of pipes - SOPs for installation of new pipes and pipe jointing	✓	✓	- How to join diffferent types of pipes (HDPE and AC) - How to make proper joint to decrease leakage of connections - How to connect different size of pipes* - O&M of pipe connections* - advance technique of jointing of pipes* (* in-house training only)	✓	✓

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
WS	Plumbing works	House connection and accessories	- How to make proper house connection with main line		✓	- How to make proper house connection with main line - Leakage from house connections		✓							- Plungging with main line - Selection of proper accessories (materials for proper connection)* (* academy only)	✓	✓
WS	Plumbing works	Coupling joint/Sleeve joints	- How to make proper coupling/ sleeve joints		✓										- Proper installation of Tee joint of gate/sluice valves for water supply - Use of Tee joint for jointing different types of pipes		✓
WS	Plumbing works	Material selection				- Materials selection for joints, accessories, and pipes	✓	✓									
WS	Plumbing works	Pipe testing /Jointing yard	- Development of piping yard to demonstrate different types of pipes/ joints and provide training in plumbing works		✓										- Development of piping yard in WASA where different types of pipes and accessories available for training in plumbing works		✓
WS	Plumbing works	O&M of valves of water supply	- SOPs for valve operation - How to reduce valve leakage - Preventive Maintenance of valves	✓	✓	- Preventive maintenance/ repair of valves - SOPs for valve operation	✓	✓				- Types - Components - Repair and maintenance		✓	- Types and components of valves - Repair and maintenance of valves - Daily inspection parameters	✓	✓
WS	Installation and maintenance of bulk and consumer water meters	O&M of bulk meters/ water meters	- Usage of bulk and water meters - O&M of bulk/water meters	✓	✓	- SOPs for Installation and O&M of water/bulk flow meters		✓				- O& M of bulk meters - Calliberation of bulk meters - How to repair water meters - SOPs of installation of bulk meters	✓	✓	- Installation and O&M of bulk/water meters including SOPs	✓	
WS	Leakage control	NRW	- Reduction of NRW - Use of equipment for leakage detection		✓	- Leakage detection and proper handling of leakages from valves and connections - Use of leak detector/ metal locator/ pipe locator		✓				- How to reduce NRW	✓	✓			

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
WS	Leakage control	Leakage repair	- Depth leakage - Visible leakage - Low pressure of water	✓	✓	- Leakage issues and methods of repair		✓				- Detection of vigible/ underground leakage, exact pin point of leakage using equipment - Case study of leakage detection - Use of equipment for leakage detection	✓	✓	- How to find minor and major leakages, visible and invisible leakages - Leakages from valves and gland leakages - Fixing of leaking pipe joints - Latest methods of repair of leakage	✓	✓
WS	Leakage control	Removal of contamination in pipeline													- Pipe cleaning after repairing	✓	
WS	Leakage control	Pressure recording													- Observation/ measurement of pressure in pipeline in different areas - Use of pressure recorder		✓
WS	Leakage control	Use of equipment for basic trouble shooting and routine maintenance of pipes										- Use of existing equipment provided by JICA project (Phase 1) for basic troubleshooting and routine maintenance (e.g. ultrasonic flow meter, pressure recorder, pipe locators, etc.)		✓	- Use of existing equipment provided by JICA project (Phase 1) for basic troubleshooting and routine maintenance (e.g. ultrasonic flow meter, pressure recorder, pipe locators, etc.)		✓
WS	Pipe replacement planning	Pipe replacement planning	- Pipe replacement planning - Design of pipe - Types of pipes suitable for the system		✓	- Pipeline designing for water supply - Type of pipes - Pipe selection criteria	✓					- Pipe selection criteria - SOPs for pipe replacement techniques	✓	✓	- Pipe selection criteria - Pipe replacement techniques	✓	
WS	Asset management	Asset management	- Asset evaluation starting from pumps, motors and pipelines etc. - Format to collect necessary data from site		✓												
WS	Water quality management/test	Water quality management										- How to check water quality at consumer and source end - Latest eqiupment for water testing (ICP (Inductive couple plasma), atomic absorption, Spectro photo meter, flame photo meter etc.)	✓	✓	*WASA wants JICA expert to evaluate the performance of lab. (e.g. The parameters they are checking and equipment they are using are enough or not as per international standards?) Some major improvement are required at lab., in-house training is preferable.*		✓

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
WS	Energy audit	Energy audit, improvement of efficiency of electrical equipment	- Energy audit methodologies - Optimization of machinery		✓	- Energy audit of tube wells - How to use test tools to check efficiency of motors and transformers after repair		✓				- How to perform energy audit using equipment procured by JICA project (Phase 1) - Bearing temp., motor temp., - Gland dowry replacement & selection - Reduction of friction and energy losses - Pump performance curve		✓	- Checking of system efficiency	✓	✓
WS	Work safety and health management	Safety measures during installation and dismantling of pumps										- Safety measures during installation and dismantling of pumps	✓	✓			
WS	Work safety and health management	Safety measures during installation of pipes										- Safety equipment during installation of new pipes and O&M of water supply - SOPs for installation of new pipes	✓	✓			
WS	Work safety and health management	Safety measures when handling electrical equipment	- Dealing with electrical machines with proper PPEs and in accordance with SOPs		✓	- Understanding of electrical hazards - How to operate electrical machines with proper safety		✓				- Safety measures during inspection and O&M of electrical equipment		✓			
S&D	Planning for sewerage and drainage system	Expansion and augmentation of sewerage system													- Planning for expansion and augmentation of existing sewerage system to fill gaps in service level	✓	
S&D	Designing of disposal stations	Design problems at disposal pumping stations							- Improvements needed in intake structure & dry well structure. - Specifications, operation, repair & maintenance of Disposal/Lift Stations - Operating curves, duty point		✓						

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
S&D	Designing of disposal stations	Selection of pumps	- Selection parameters of pumps and mechanical equipment	✓					- Types of different pumps for wastewater - Selection of pumps for disposal pumping stations - Relation between speed, head, discharge and power consumption of pumps		✓				- Pump selection criteria	✓	
S&D	Designing of wastewater treatment plant	Wastewater treatment technologies							- Wastewater treatment basics - Wastewater treatment technologies - Criteria for selection of the most suitable technology for local conditions - Financial comparison of different technologies regarding CAPEX and OPEX		✓				- Study and methods of sewerage treatment plant	✓	
S&D	Designing of pipeline	Hydraulic modelling	- Pipeline profile about pressure and flow	✓													
S&D	Sewer pipe installation	Jointing of sewer pipes	- Sewer line connection joints	✓	✓	- Jointing of pipes made of different materials and in different size		✓				- O&M of sewer pipe connections - Advance technique of jointing of pipes		✓	- O&M of sewer pipe connections - advance technique of jointing of pipes		✓
S&D	Sewer pipe installation	Material selection				- Materials selection for joints, accessories, and pipes	✓	✓									
S&D	Sewer pipe installation	Total station levelling										- How to perform ground station levelling for installation of new pipelines	✓				
S&D	Mainteance of sewer and drainage	Cleaning of sewerage and drainage pipelines	- Removal of blockages in sewer lines - Latest cleaning techniques of sewerage and drainage pipelines (CCTV camera)		✓	- How to clean sewer and drainage lines properly - Latest techniques to clean sewer pipelines	✓	✓				- Modern sewer cleaning techniques - Modern sewer inspection techniques - Modern sewer repair - Modern manhole repair technique		✓	- Sewerage pipeline cleaning technique - Latest technique of cleaning sewerage system - Discharge system cleaning		✓
S&D	Mainteance of sewer and drainage	Maintenance of sewerage and drainage system	- Repair and maintenance of sewerage and drainage pipeline		✓	- Leakage issues and methods of repair		✓				- Modern technique to fix crown failures - How to avoid crown failures		✓	- Latest different techniques for testing sewerage and drainage system	✓	✓

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
S&D	Mainteance of sewer and drainage	Inspection and testing of sewerage system							- Inspection & maintenance of sewerage system - Selection of best possible specifications for sewer cleaning machinery and safety equipment suitable for local conditions - Use of pneumatic stoppers		✓	- How to install pneumatic plug	✓				
S&D	Mainteance of sewer and drainage	Manhole detection				- How to detect buried manhole - How to use metal detector		✓				- How to use metal detector, metal locator, and other equipment provided by JICA		✓	- How to use manhole detector, metal locator, and other equipment provided by JICA		✓
S&D	Mainteance of sewer and drainage	Flow measurement of open channels and disposal pumping stations							- Transient time flow meters - Doppler Ultrasonic flow meters - Any other latest technology		✓						
S&D	Pipe replacement planning	Pipe replacement planning	- Pipe replacement planning - Design of pipe - Types of pipes suitable for the system		✓	- Pipeline designing for sewerage system and disposal stations - Type of pipes - Pipe selection criteria	✓										
S&D	O&M of disposal stations	O&M of disposal stations	- O&M disposal station - Removal of solid waste at disposal stations		✓	- Collection of garbage at disposal stations		✓									
S&D	O&M of disposal stations	O&M of heavy machines				- Overall issues on preventive maintenance of mechanical system of disposal stations and heavy machines - SOPs, guidelines, checklists/inspection sheets for preventive maintenance		✓				- Daily and routine maintenance - Record keeping - Cleaning of Jetting machine & Sucker machine		✓	- Daily and routine maintenance of heavy machines (jetting, sucker, dewatering pumps, and other machines) - Record keeping - Cleaning of jetting machine	✓	✓
S&D	O&M of disposal stations	Plumbing works at disposal stations	- Plumbing work at suction, delivery points and screen of disposal station - Improve efficiencty of disposal station		✓												

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
S&D	O&M of disposal stations	O&M of valves at disposal stations	- SOPs for valve operation - How to reduce valve leakage - Preventive maintenance of valves	✓	✓	- Preventive maintenance/ repair of valves - SOPs for valve operation	✓	✓									
S&D	O&M of disposal stations	O&M of pumps and motors for disposal stations	- SOPs for pump and motor - Daily/ monthly inspection parameters - Usage of small equipment like thermometer, ampere meter - Preventive maintenance of motors* (* in-house training only)	✓	✓	- Preventive maintenance/ repair of pump and motors - SOPs for pump and motor	✓	✓				- Daily and routine maintenance* - Record keeping* - Pump and motor repalcement technique* - Impeller adjustment, flange adjustment* - Replacement of bearings and bearing seals* - How to reduce pump vibrations - How to avoid wear and tear in shaft (* in-house training only)	✓	✓	- O&M of pump - Daily inspection parameters - O&M of motors* - Basic parameters of motor* (* in-house training only)	✓	✓
S&D	O&M of wastewater treatment plant	O&M of wastewater treatment plant	- Maintenance of existing WWTP	✓	✓							- How to clean and maintain ponds of WWTP - How to increase efficiency of WWTP		✓			
S&D	Asset management	Asset management				- Evaluation of condition of assets at disposal stations		✓									
S&D	Environmental protection	Proper handling of the process for collecting and disposing solid waste	- Environmental protection in the process of collecting and disposing garbarge/wastes - Technology to recycle solid waste - Revenue generation from solid waste recycling	✓	✓												

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
S&D	Energy audit	Energy audit, improvement of efficiency of electrical equipment	- Energy audit methodologies - Optimization of machinery - How to improve system efficiency - How to use equipment for checking energy efficiency	✓	✓	- Energy audit of disposal stations - Energy audit/check parameters of heavy machines - How to use test tools to check efficiency of motors and transformers after repair		✓				- How to perform energy audit using equipment procured by JICA project (Phase 1)		✓	- Checking of system efficiency	✓	✓
S&D	Work safety and health management	Safety measures when handling electrical equipment	- Dealing with electrical machines with proper PPEs and in accordance with SOPs		✓	- Understanding of electrical hazards - How to operate electrical machines with proper safety		✓				- Safety measures during inspection and O&M of electrical equipment		✓			
S&D	Work safety and health management	Safety measures for sewer works	- Sewer man protection equipment (detection of hazardous gases in sewer lines, finding of man holes)	✓	✓							- How to use gas detector - Sewer inspection using portable kits and sewer cleaning camera before cleaning		✓	- How to use gas detector - Sewer inspection using portable kits and sewer cleaning camera before cleaning		✓
Both	Management of data and information on water supply, sewerage, and drainage systems	GIS	- General format for field staff to collect data at site - How to fill format at site - How to mark locations especially right and left side		✓	- Basic format to maintain digital data of water supply line and sewerage line including materials, installation year and size of pipes		✓				- Utilization of GIS for management of information on location and condition of pipelines, valves, and sewer manholes	✓	✓	- Collection and management of information on location and condition of pipelines and valves of distribution network * - Collection and management of information on location and condition of sewers and manholes (* in-house training only)	✓	✓
Both	Designing of water supply system	Designing of water supply schemes by using latest IT Techniques and softwares							- EPA NET - WaterGEM - WaterCAD		✓						
Both	Designing of sewerage system	Designing of sewerage schemes by using latest IT Techniques and softwares							- SewerCAD - StormCAD - SewerGEM		✓				- How to design sewerage system on CAD	✓	
Both	O&M of mechanical equipment	Improvement of efficiency of mechanical equipment													- Implementation of scheduled preventive maintenance of mechanical equipment	✓	✓

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
Both	O&M of electrical equipment	O&M of transformers	- Preventive maintenance of transformers		✓							- Maintenance and testing of transformer	✓	✓	- Maintenance and testing of transformer	✓	
Both	O&M of electrical equipment	O&M of generator				- Daily and routine inspection - Preventive maintenance - Efficiency test		✓									
Both	O&M of electrical equipment	Electrical drawings	- Electrical drawings, motor starters, electrical panels		✓												
Both	O&M of electrical equipment	SCADA	- O&M of existing SCADA system - Integration techniques of SCADA system for existing facilities	✓		- O&M of existing SCADA system	✓								- Basic information on modern electrical technologies, such as SCADA		✓
Both	O&M of electrical equipment	Design of MCU				- Selection criteria for protection devices like selection of suitable circuit breaker, magnetic contactor, over current relays, over/ under voltage relays etc.	✓	✓									
Both	O&M of electrical equipment	O&M of MCU				- O&M of MCU		✓				- O&M of MCU	✓	✓	- O&M of MCU	✓	
Both	O&M of electrical equipment	Electrical panels	- Purpose and components of different type of panels Motor Starters		✓	- Distribution panel - Changeover panel		✓				- O&M of electrical panel/ change over		✓	- O&M of electrical panel		✓
Both	O&M of electrical equipment	Wiring	- Wiring/ Cable sizing - Repair and maintenance - Jointing techniques - Fault detection		✓	- Jointing techniques of wires and cables		✓				- Selection of wire for motor rewinding		✓	- How to use wire gauge to select proper conductor		✓
Both	O&M of electrical equipment	Electrical codes for different buildings	- Codes for building used for water supply, disposal station and offices etc.	✓													
Both	O&M of electrical equipment	General electrical training	- Basics of O&M of electrical equipment for staff with non electrical background		✓							- Very basics of electrics for staff with non electrical background to do basic tasks and to check necessary parameters		✓	- Very basics of electrics for staff with non electrical background to do basic tasks and to check necessary parameters		✓

Category 1	Category 2 (WASA's Activity)	Training Topic	Faisalabad			Gujranwala			Lahore			Multan			Rawalpindi		
			Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA	Main contents	AJWA	WASA
Both	O&M of electrical equipment	Advance electrical training	- Advance level workshop and international good practices in the same field for staff with electrical background	✓													
Both	Financial management	Measures for increasing revenue	- Revenue increment techniques - Reduction of electricity costs			- Revenue increment techniques - Reduction of electricity costs									- Revenue increment techniques - Optimization of expenditures		
Both	Administration of billing	Billing software										Introduction of updated billing software (Fox Pro)					

Training Needs Assessment of WASAs (Sewerage and Drainage Cleaning)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs (to be discussed with Academy and WASAs)

: First priority

: Second priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results: Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Training Plan: Type	Venue	Remarks
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
1	Cleaning of sewerage and drainage pipelines	- Removal of blockages in sewer lines - Latest cleaning techniques of sewerage and drainage pipelines (CCTV camera) -How to clean sewer and drainage lines properly -Latest techniques to clean sewer pipelines		✓	✓	✓				✓		✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Latest techniques to clean sewer pipelines	
2	Maintenance of sewerage and drainage system	-Repair and maintenance of sewerage and drainage pipeline -Leakage issues and methods of repair -Modern technique to fix crown failures -How to avoid crown failures -Latest different techniques for testing sewerage and drainage system		✓		✓				✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Maintenance system for sewer and drain pipes	
3	Wastewater treatment technologies	- Wastewater treatment basics - Wastewater treatment technologies - Criteria for selection of the most suitable technology for local conditions - Financial comparison of different technologies regarding CAPEX and OPEX - Study and methods of sewerage treatment plant						✓			✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Wastewater treatment basics,Study and methods of sewerage treatment plant	
4	O&M of wastewater treatment plant	- Maintenance of existing WWTP - How to clean and maintain ponds of WWTP - How to increase efficiency of WWTP	✓	✓						✓			Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Maintenance of WWTP	
5	Manhole detection	- How to detect buried manhole -How to use metal detector -How to use metal detector, metal locator ,and othor equipment provided by JICA				✓				✓		✓	Lecture & Practical	・Lecture: WASA Office ・Practical: How to detect buried manhole	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
6	Flow measurement of open channels and disposal pumping stations	-Transient time flow meters -Doppler Ultrasonic flow meters -Any other Latest technology						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Flow measurement of open channels etc	
7	Expansion and augmentation of sewerage system	- Planning for expansion and augmentation of existing sewerage system to fill gaps in service level									✓		Lecture & Practical	・Lecture: Academy ・Practical:	
8	Total station levelling	- How to perform ground station levelling for installation of new pipelines							✓				Practical	・Lecture: Academy ・Practical: Total station levelling	
9	Inspection and testing of sewerage system	-Inspection & maintenance of sewerage system -Selection of best possible specifications for sewer cleaning machinery and safety equipment suitable for local conditions -Use of pneumatic stoppers -How to install pneumatic plug(Multan)		✓					✓				Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Inspection & maintenance of sewerage system	
10	O&M of disposal stations	- O&M disposal station - Removal of solid waste at disposal stations - Collection of gabage at disposal station		✓		✓							Practical	O&M of disposal stations	
11	Proper handling of the process for collecting and disposing solid waste	- Environmental protection in the process of collecting and disposing garbarge/wastes - Technology to recycle solid waste - Revenue generation from solid waste recycling	✓	✓											Not applicable in the field of "Sewerage and Drainage Cleaning" course.
12	Safety measures for sewer works	- Sewer man protection equipment (detection of hazardous gases in sewer lines, finding of man holes) - How to use gas detector - Sewer inspection using portable kits and sewer cleaning camera before cleaning	✓	✓						✓		✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Inspection of sewer pipes using a sewer camera	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		**Gujranwala**		**Lahore**		**Multan**		**Rawalpindi**		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
13	Designing of sewerage schemes by using latest IT Techniques and softwares	- How to design sewerage system on CAD - Sewer CAD - Storm CAD - Sewer GEM						✓			✓				

Training Needs Assessment of WASAs (Mechanical Field)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs
(to be discussed with Academy and WASAs)

: First priority

: Second priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results: Faisalabad AJWA	Faisalabad WASA	Gujranwala AJWA	Gujranwala WASA	Lahore AJWA	Lahore WASA	Multan AJWA	Multan WASA	Rawalpindi AJWA	Rawalpindi WASA	Training Plan: Type	Venue	Remarks
1	O&M of Pump (Tube Well and Disposal Station)	・SOPs for pump and motor ・Daily and periodic inspection ・Preventive maintenance	✓	✓	✓	✓		✓		✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
2	O&M of Valves	・SOPs for valve operation ・Repair of leakage ・Daily and periodic inspection ・Preventive maintenance	✓	✓							✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
3	Selection of Pump	・How to select suitable pump for tube well and disposal station ・How to decide/check specification	✓		✓			✓			✓		Lecture	Academy, WASA Office	
4	Energy Audit (Saving Operation Cost)	・How to check/evaluate operating efficiency of mechanical equipment ・How to improve operating efficiency	✓	✓		✓				✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
5	Chlorination	・O&M of chlorinator (including dosage adjustment) ・Daily and periodic inspection ・Preventive maintenance		✓							✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, OHT	
6	Installation and O&M of Water Meter	・Proper installation of bulk and water meter ・O&M of bulk and water meter ・Daily and periodic inspection	✓	✓		✓					✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, other site	
7	Design Problems at Disposal Station	・Points to be improved (intake structure, dry well structure etc.) ・How to reflect these points in design						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Disposal Station	
8	Troubleshooting of Turbine Pump and Tube-well Bore	・Trouble shooting of turbine pumps ・Trouble shooting of tubewell bore ・Check points during design and installation						✓					Practical	Tube well	
9	Troubleshooting of Pump (Vibration)	・How to reduce vibration ・How to avoid wear and tear in shaft							✓	✓			Practical	Tube well, Disposal station	

No.	Topic	Main Contents	TNA Results: Faisalabad AJWA	Faisalabad WASA	Gujranwala AJWA	Gujranwala WASA	Lahore AJWA	Lahore WASA	Multan AJWA	Multan WASA	Rawalpindi AJWA	Rawalpindi WASA	Training Plan: Type	Venue	Remarks
10	Safety Measures	・Safety measures during Installation and dismantle of pump ・Safety measures during daily/periodic inspection and O&M works							✓	✓			Practical	Tube well, Disposal station	
11	Water Treatment Process and Technology	・Outline of Surface Water Treatment ・Outline of Ground Water Treatment						✓				✓	Lecture	Academy, WASA Office	
12	O&M of Membrane Filtration Facility	・O&M of Membrane Filtration Facility ・Daily and periodic inspection ・Preventive maintenance						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Membrane filtration facility	
13	O&M of Water Filteration Plant	・O&M of Filteration plant (record keeping and back wash procedure etc.) ・Daily and periodic inspection ・Preventive maintenance ・Design/selection of filters (outline of filtration process)							✓	✓	✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Filtration plant	It is necesarry to clarify the component of filtration plant. If membrane filtration facility is included, No.12 can be combined with this topic.
14	O&M of Water Treatment Plant	・O&M of WTP (record keeping and back wash procedure etc.) ・Daily and periodic inspection of each facility/equipment ・Preventive maintenance of each facility/equipment									✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: WTP	
15	Heavy Machines	・O&M of jetting machine, sucker, dewatering pumps and other machines									✓	✓			It's better to teach in "Sewerage and Drainage Cleaning" cource.
16	Hydraulic Modelling	Pipeline profile about pressure and flow rate	✓										Lecture	Academy	
17	Alternative source of water	Installation of new water sources											Discussion	WASA Office	WASA Faisalabad want to discuss this topic with us.

Training Needs Assessment of WASAs (Electrical Field)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs (to be discussed with Academy and WASAs)

: First priority

: Second priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results: Faisalabad AJWA	Faisalabad WASA	Gujranwala AJWA	Gujranwala WASA	Lahore AJWA	Lahore WASA	Multan AJWA	Multan WASA	Rawalpindi AJWA	Rawalpindi WASA	Training Plan: Type	Training Plan: Venue	Remarks
1	Electrical panels	・O&M of electrical panels		✔		✔				✔		✔			
2	Wiring	・Inspection and repair ・Wire size		✔		✔				✔		✔			
3	Energy audit	・Energy audit, improvement of efficiency of electrical equipment	✔	✔		✔				✔	✔	✔			
4	MCU	・How to read Electrical drawings of motor starters and electrical panels ・O&M (Record keeping, SOP, Routine and Preventive Maintenance) ・Design (Selection criteria for appropriate protective devices)		✔	✓	✔			✓	✓	✓				
5	O&M of generator	・Daily and routine inspection, SOP ・Preventive maintenance ・Efficiency test ・User Manual				✔									
6	Work safety and health management	・Understanding of electrical hazards ・Safety measures		✔		✔				✔					
7	SCADA	・O&M of existing SCADA system	✔		✔						✔				
8	General electrical training	・Basics of O&M of electrical equipment		✔						✔		✔			
9	Electrical codes for different buildings	・Wiring method	✔												
10	O&M of transformers	・Preventive maintenance		✔					✔	✔	✔				
11	Advance electrical training	・Advance level workshop and international good practices in the same field for staff with electrical background	✔												
12	O&M of tube wells	・O&M of pumps and motors for tube wells	✔	✔	✔	✔		✔	✔	✔	✔	✔			

Training Needs Assessment of WASAs (Plumbing/Leakage Control/Pipe Replacement)

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		**Gujranwala**		**Lahore**		**Multan**		**Rawalpindi**		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
1	OHR	Cleaning techniques								✓		✓	Practical	Field	
		Repairing techniques								✓		✓	Practical	Field	
		Disinfecting techniques								✓		✓	Practical	Field	
2	Jointing/ Pipe installation technique	How to joint different types/ size of pipes (HDPE and AC)	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Use of Tee joint for jointing different types of pipes	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		How to make proper joint to decrease leakage of connections	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Plungging with main line													
		Proper installation of Tee joint of gate/sluice valves for water supply	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		How to make proper coupling/ sleeve joints													
		Advanced technique of jointing of pipes*	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		SOPs for installation of new pipes and pipe jointing, valve operation	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
		SOPs for pipe replacement techniques	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
3	Procurement & Design	Proper level of pipes	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Materials selection for joints, accessories, and pipes- Types of valves (Manual and Motor Controlled) - International standards and specifications for good quality valves	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Selection of proper accessories (materials for proper connection)*			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
4	O&M	O&M of pipe connections*	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Prevention of contaminations in pipeline	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
5	Monitoring, Planning	Format to collect necessary data from site (* in-house training only)	✓		✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		- EPA NET - Water GEM - Water CAD	✓										Practical	Academy	
		- Pipeline profile about pressure and flow	✓										Lecture	・Lecture: Academy, WASA Office ・Practical: Field	
		Reduction of NRW			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
6	Leakage Control	Leakage from house connections			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Water meter													
		Leakage detection and proper handling of leakages from valves and connections			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Use of leak detector/ metal locator/ pipe locator			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Use of equipment for leakage detection			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
		Pipe cleaning after repairing after leakage repaired									✓				
		- Observation/ measurement of pressure in pipeline in different areas - Use of pressure recorder										✓			

No.	Topic	Main Contents	TNA Results Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Training Plan Type	Venue	Remarks
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
		Use of existing equipment provided by JICA project (Phase 1) for basic troubleshooting and routine maintenance (e.g. ultrasonic flow meter, pressure recorder, pipe locators, etc.) (* academy only)			✓	✓	✓	✓	✓	✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	
7	Pipe yard (Sample model)	- Development of piping yard in WASA where different types of pipes and accessories available for training in plumbing works		✓								✓	Practical	Field	
8	Water quality	WASA wants JICA expert to evaluate the performance of labo. (e.g. The parameters they are checking and equipment they are using are enough or not as per international standards?) Some major improvement are required at labo, in-house training is preferable.- How to check water quality at consumer and source end - Latest equipment for water testing (ICP (Inductive couple plasma), atomic absorption, Spectro photo meter, flame photo meter etc.)							✓	✓		✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Field	

Annex 4.1.2 Prioritization of Training Topics

Training Needs Assessment of WASAs (Mechanical Equipment)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs
(to be discussed with Academy and WASAs)

: First priority

: Second priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
1	Energy Audit (Saving Operation Cost)	・How to check/evaluate operating efficiency of mechanical equipment ・How to improve operating efficiency	✓	✓		✓		✓		✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
2	O&M of Pump (Tube Well and Disposal Station)	・SOPs for pump and motor ・Daily and periodic inspection ・Preventive maintenance	✓	✓	✓	✓		✓		✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
3	Selection of Pump	・How to select suitable pump for tube well and disposal station ・How to decide/check specification	✓		✓			✓			✓		Lecture	Academy, WASA Office	
4	O&M of Valves	・SOPs for valve operation ・Repair of leakage ・Daily and periodic inspection ・Preventive maintenance	✓	✓	✓	✓				✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, Disposal station	
5	Chlorination	・O&M of chlorinator (including dosage adjustment) ・Daily and periodic inspection ・Preventive maintenance		✓	✓	✓				✓	✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, OHT	
6	Installation and O&M of Water Meter (Bulk)	・Proper installation of bulk meter ・O&M of bulk meter ・Daily and periodic inspection	✓	✓		✓					✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Tube well, other site	
7	O&M of Water Filteration Plant	・O&M of Filteration plant (record keeping and back wash procedure etc.) ・Daily and periodic inspection ・Preventive maintenance ・Design/selection of filters (outline of filtration process)							✓	✓*	✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Filtration plant	Since WASA Multan has membrane filtration facility, No.9 will be included in this topic for In-house Training at WASA Multan.
8	Water Treatment Process and Technology	・Outline of Surface Water Treatment ・Outline of Ground Water Treatment						✓				✓	Lecture	Academy, WASA Office	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
9	O&M of Membrane Filtration Facility	・O&M of Membrane Filtration Facility ・Daily and periodic inspection ・Preventive maintenance						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Membrane filtration facility	
10	Design Problems at Disposal Station	・Points to be improved (intake structure, dry well structure etc.) ・How to reflect these points in design						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Disposal Station	
11	Troubleshooting of Turbine Pump and Tube-well Bore	・Trouble shooting of turbine pumps ・Trouble shooting of tubewell bore ・Check points during design and installation						✓					Practical	Tube well	
12	Troubleshooting of Pump (Vibration)	・How to reduce vibration ・How to avoid wear and tear in shaft							✓	✓			Practical	Tube well, Disposal station	
13	Safety Measures	・Safety measures during Installation and dismantle of pump ・Safety measures during daily/periodic inspection and O&M works							✓	✓			Practical	Tube well, Disposal station	
14	O&M of Water Treatment Plant	・O&M of WTP (record keeping and back wash procedure etc.) ・Daily and periodic inspection of each facility/equipment ・Preventive maintenance of each facility/equipment									✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: WTP	
15	Heavy Machines	・O&M of jetting machine, sucker, dewatering pumps and other machines									✓	✓			It's better to teach in "Sewerage and Drainage Cleaning" cource.
16	Hydraulic Modelling	Pipeline profile about pressure and flow rate	✓										Lecture	Academy	
17	Alternative source of water	Installation of new water sources											Discussion	WASA Office	WASA Faisalabad want to discuss this topic with us.

Training Needs Assessment of WASAs (Electrical Equipment)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs
(to be discussed with Academy and WASAs)

: First priority
: Second priority
: Third priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
1	Energy audit	・Energy audit, improvement of efficiency of electrical equipment	✔	✔		✔		✓		✔	✔	✔			
2	Electrical panels	・O&M of electrical panels		✔		✔		✓		✓		✔			
3	MCU	・How to read Electrical drawings of motor starters and electrical panels ・O&M (Record keeping, SOP, Routine and Preventive Maintenance) ・Design (Selection criteria for appropriate protective devices)		✔	✓	✔		✓	✓	✓	✓				
4	Wiring	・Inspection and repair ・Wire size		✔		✔		✓		✔		✔			
5	O&M of generator	・Daily and routine inspection, SOP ・Preventive maintenance ・Efficiency test ・User Manual		✓		✔									
6	Work safety and health management	・Understanding of electrical hazards ・Safety measures		✔		✔				✔					
7	SCADA	・Analyzing SCADA data to improve equipment efficiency	✔		✔			✓			✔				
8	General electrical training	・Basics of O&M of electrical equipment		✔						✔		✔			
9	Electrical codes for different buildings	・Wiring method	✔												
10	O&M of transformers	・Preventive maintenance		✔					✔	✔	✔				
11	Advance electrical training	・Advance level workshop and international good practices in the same field for staff with electrical background	✔												
12	O&M of tube wells	・O&M of pumps and motors for tube wells	✔	✔	✔	✔		✔	✔	✔	✔	✔			

Training Needs Assessment of WASAs (Sewerage and Drainage)

Highlighted cells: proposed thematic areas where the project puts high priority among the identified training needs
(to be discussed with Academy and WASAs)

: First priority

: Second priority

AJWA: Training at Al-Jazari Academy

WASA: In-House Training at WASA

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
1	**Cleaning of sewerage and drainage pipelines**	-How to clean sewer and drainage lines properly -Latest cleaning techniques of sewerage and drainage pipelines (Camera) -Removal of blockages in sewer lines		✓	✓	✓		✓		✓		✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Latest techniques to clean sewer pipelines	
1'	Maintenance of sewerage and drainage system (including NO.1)	-Repair and maintenance of sewerage and drainage pipeline -Leakage issues and methods of repair -Modern technique to fix crown failures -How to avoid crown failures -Latest different techniques for testing sewerage and drainage system		✓		✓		✓		✓	✓	✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Maintenance system for sewer and drain pipes	
2	**Flow measurement of open channels**	-How to use flow velocity meter -How to calculate flow rate -How to estimate at various depths						✓					Lecture & Practical	・Lecture: WASA Office ・Practical: Flow measurement of open channels etc	
3	**O&M of wastewater treatment plant**	- Maintenance/How to increase efficiency of existing WWTP(WSP) - How to clean and maintain ponds of WWTP(WSP)	✓	✓						✓			Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Maintenance of WWTP	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
4	**Wastewater treatment technologies**	- Wastewater treatment basics - Wastewater treatment technologies - Criteria for selection of the most suitable technology for local conditions - Financial comparison of different technologies regarding CAPEX and OPEX						✓			✓		Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Wastewater treatment basics,Study and methods of sewerage treatment plant	
5	Manhole detection	- How to detect buried manhole -How to use metal detector				✓				✓		✓	Lecture & Practical	・Lecture: WASA Office ・Practical: How to detect buried manhole	
6	Safety measures for sewer works	- Sewer man protection equipment (detection of hazardous gases in sewer lines, finding of man holes) - How to use gas detector - Sewer inspection using portable kits and sewer cleaning camera before cleaning	✓	✓						✓		✓	Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Inspection of sewer pipes using a sewer camera	
7	Expansion and augmentation of sewerage system	- Planning for expansion and augmentation of existing sewerage system to fill gaps in service level									✓		Lecture & Practical	・Lecture: Academy ・Practical:	
8	Total station levelling	- How to perform ground station levelling for installation of new pipelines							✓				Practical	・Lecture: Academy ・Practical: Total station levelling	
9	Inspection and testing of sewerage system	-Inspection & maintenance of sewerage system -Selection of best possible specifications for sewer cleaning machinery and safety equipment suitable for local conditions -Use of pneumatic stoppers -How to install pneumatic plug(Multan)		✓				✓	✓				Lecture & Practical	・Lecture: Academy, WASA Office ・Practical: Inspection & maintenance of sewerage system	

No.	Topic	Main Contents	TNA Results										Training Plan		Remarks
			Faisalabad		Gujranwala		Lahore		Multan		Rawalpindi		Type	Venue	
			AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA	AJWA	WASA			
10	O&M of disposal stations	- O&M disposal station - Removal of solid waste at disposal stations - Collection of gabage at disposal station		✓		✓							Practical	O&M of disposal stations	
11	Proper handling of the process for collecting and disposing solid waste	- Environmental protection in the process of collecting and disposing garbarge/wastes - Technology to recycle solid waste - Revenue generation from solid waste recycling	✓	✓											Not applicable in the field of "Sewerage and Drainage Cleaning" course.
12	Designing of sewerage schemes by using latest IT Techniques and softwares	- How to design sewerage system on CAD - Sewer CAD - Storm CAD - Sewer GEM						✓			✓				

Training Needs Assessment of WASAs (Leakage control, plumbing, pipe replacement plan)

: First priority

: Second priority

Summary of TNA for 5 WASAs (WS)

No.	Topic	Main Contents	Detail	TNA Results									
				WASA Faisalabad		WASA Gujranwala		WASA Lahore		WASA Multan		WASA Rawalpindi	
				Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house
1	Leakage Control and Plumbing with service pipe	Water Meter for house connection	・Proper Installation ・Basic knowledge	✓		✓			✓	✓	✓		
2		Proper handling of leakages from valves and connections (including pressure testing between branch sadle and meter)	・Type of meter and proper selection ・Proper installation ・Repair work ・Pressure recording in end of network for consumer			✓			✓	✓	✓	✓	✓
3		Leak detection & NRW	・Leak detection from Distribution & house connection ・NRW reduction		✓	✓			✓	✓	✓	✓	✓
4		Use of equipment for leakage detection	・Use of equipment ・Basic troubleshooting ・Routine maintenance	✓		✓				✓		✓	✓
5	Replacement planning using GIS	Data collection method at leakage reparing site (* in-house training only)	・Creation of Data collection format ・Risk/condition evaluation method ・Application of the format in actual works		✓		✓						✓
6		Concept of pipe replacement planning	・Concept of pipe replacement planning using GIS will be taught in professional training at Academy.										

No.	Topic	Main Contents	Detail	TNA Results									
				WASA Faisalabad		WASA Gujranwala		WASA Lahore		WASA Multan		WASA Rawalpindi	
				Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house
7	Distribution pipe	Joint/Connection/Replacement including welding and fusion	1) Physical property different types of pipe/ size of pipes 2) Type of connections Gibault joint, Mechanical joint, Flange, Valve, Dismantling joint 3) Type of External/Internal lining - proper selection of lining - type of External/Internal lining like epoxy, polyethylene, bitumen, etc. 4) Standard and instruction Standard and instruction of manufacturer of material,	✓	✓		✓			✓	✓	✓	✓
8		Pressure test	Pressure test of proper and improper material, torque, different dimension We show behavior of inside of pipe, in the condition of private sucking booster pump										
9		Preparation of simple feasible SOP through practical training	Practical training of Preparation of SOP Referring several standard and manual of manufacturer 1) pipe connection 2) Pipe replacement 3) New pipe installation, 4) Flange jointing 5) Pressure test	✓	✓	✓	✓			✓	✓	✓	
10	Procurement of pipe materials	Selection of appropriate specification of materials (pipe, joint, valves)	･Knowledge about Proper standard ･Demonstration of Water tightness difference using proper and improper standard item. ･Procedure of procurement of materials			✓	✓		✓	✓	✓	✓	

No.	Topic	Main Contents	Detail	TNA Results									
				WASA Faisalabad		WASA Gujranwala		WASA Lahore		WASA Multan		WASA Rawalpindi	
				Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house
11	O&M	O&M of pipe connections*	Covered in the Topic "Distribution Pipe" (No.7)										✓
12		Prevention of contaminations in pipeline	Covered in the Topic "Distribution Pipe" (No.7 and 8)							✓	✓		
13	Hydraulic Modeling	Hydraulic modeling using EPA NET, Water GEM and Water CAD	These modeling softwares are not covered by the expertise of JICA experts of this project. However it may be covered by academy apart from Japanese assistance. It is encouraged for WASAs to request Academy to include this item in professional training.	✓					✓				
14	OHR	Cleaning techniques	This will not be included because there is no special, advanced technique, and ordinary work just needs to be conducted in a precise and continuas manner.								✓		✓
15		Repairing techniques	ditto								✓		✓
16		Disinfecting techniques	ditto								✓		✓
17	Pipe yard (Sample model)	Development of piping yard in WASA where different types of pipes and accessories available for training in plumbing works	This is not a training issue		✓								✓

No.	Topic	Main Contents	Detail	TNA Results									
				WASA Faisalabad		WASA Gujranwala		WASA Lahore		WASA Multan		WASA Rawalpindi	
				Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house	Academy	In-house
18	Water quality	WASA wants JICA expert to evaluate the performance of labo. (e.g. The parameters they are checking and equipment they are using are enough or not as per international standards?) Some major improvement are required at labo, in-house training is preferable.- How to check water quality at consumer and source end - Latest equipment for water testing (ICP (Inductive couple plasma), atomic absorption, Spectro photo meter, flame photo meter etc.)	This will not be covered because water quality is the issue of laboratory and outside of the expertise of the experts of this project.							✓	✓		✓

Annex 4.1.3 Revision of Training Contents from Phase 1 to Phase 2

Review of the Professional Training Courses Developed in the Project Phase 1

Course: Leakage Detection

Review Item	Revisions	Reason for Changes
Training Contents	1. The water meter for house connections is newly added. 2. Proper handling of leakage from valves and connections is newly added. 3. The data collection method at the leakage repairing site is newly added. 4. Joint/ connection/ replacement, including welding from fusion, is newly added. 5. The pressure test is newly added. 6. Repairing of leakage and burst pipelines are removed. 7. On-site leakage detection is considered the second priority. 8. On-site installation and operation of leakage detection equipment are considered the second priority.	1. Government of Punjab is recommending WASAs to install and maintain water meters for all house connections. WASAs only have less than 2% water meter connections, so proper techniques for water meter selection and installations will be introduced. 2. Most of the visible leakages are found at valves and connections. 3. The leakage record is not maintained properly. This training topic will help WASAs identify the areas with more leakages, so a better pipelines replacement plan can be prepared, resulting in a reduction in NRW. 4. The government recommends using HDPE pipe instead of A/C. WASAs have less knowledge in this field. So, proper techniques for butt fusion will be taught. 5. WASAs always use A/C pipes, and they do not conduct pressure tests. Due to health hazards, the government has recently changed the policy and emphasized using HDPE pipes instead of A/C pipes for water supply lines. Installation of HDPE pipes should be followed by a pressure test to make sure proper jointing and no leakage. Therefore, the pressure test for newly installed HDPE lines will be taught. Initially, there were very few HDPE lines, and pressure tests were very rarely done. 6. This training topic dealt with repairing leaking/burst distribution pipes. It is observed that most of the leakages occur at service pipelines, for which a new training topic will be added in the course as mentioned in No. 1 and No. 2 above. It may be reviewed when 2nd priority is discussed for support in Year 3. 7. In Phase 1, it was observed that WASAs have no mechanism to detect the leakages, so it was added considering the importance of the topic. Later, it was observed that WASAs also need to know the rectification of leakages in a proper manner. Currently, their methods for leakage repair are not as per any standard. They are not dealing properly with already detected leakages. Detecting new leakages and no proper rectification will not help the service level to improve. Therefore, focusing and rectifying already visible leakages become the first priority, and detection of leakages moved to the second priority. 8. As explained at No. 7, WASAs get complaints about visible leakages on a daily

Review Item	Revisions	Reason for Changes
		basis. At first priority, they shall be taught to rectify those leakages. They do not need to install the equipment for such complaints most of the time. Therefore, the focus will be given to the causes of already detected leakages and their repairing methods.
Training Methods and Process	More interactive and practical sessions will be introduced. All contents will have a lesser theory with more interactive exercises and on-field activities.	Teaching theory in detail did not work effectively for WASA staff in Phase 1. It is observed that equipment and techniques did not work most of the time at the site as mentioned in theories. One of the major reasons is pipelines, which are not laid in the recommended way. The installation and maintenance at most of the parts are done in an improper manner, resulting in each site behaving differently for the same equipment and technique. Therefore, spending more time at the site to perform activities by applying theories/rules to different cases and ensuring proper work procedures may be a better approach than maintaining the same training methods and process as Phase 1.
Time Allocation & Venue	20~25% time will be allotted to lectures at Al Jazari Academy and 75~80% time for on-field training at service lines in WASA Lahore.	In phase 1, lecture time was around 50%, and on-field time was also 50%. To spend more time on-field training, especially at a site similar to the trainees' workplace.

Course: O&M of Sewer and Storm Water Drainage

Review Item	Revisions	Reason for Changes
Training Contents	1. Flow measurement of open channels is newly added. 2. Wastewater technologies is newly added. 3. O&M of the wastewater treatment plant is newly added. 4. Manhole detection is moved to second priority. 5. Sewer pipe inspection camera is added under the training topic of cleaning of sewerage and drainage pipelines.	1. WASAs have never calculated the flow of sewage and stormwater in open channels. They just make a rough estimate for it. Considering the importance of the topic and highly requested by WASAs, this field has been newly added this time. 2. The government has recommended that all development authorities consider the installation of wastewater treatment plants. As WASAs possess very little knowledge in this field at present, different technologies suitable for the Pakistani environment for treating wastewater will be taught. 3. WASA Faisalabad and WASA Multan have wastewater treatment plants (Aerobic and anaerobic ponds etc.). Since other WASAs are also planning to have it in the near future, O&M of the wastewater treatment plant is highly requested by WASAs as a part of the training topics. 4. WASAs were well trained regarding this activity in Phase 1, and they are doing well so far. WASAs have very few manhole detectors, and enough staff is there to use the equipment. Therefore, this training topic has been moved to the second priority. 5. There is no concept of preventive maintenance of sewerage pipelines in WASAs. To introduce the idea, and especially to avoid crown failures, this component is upgraded by introducing the use of an inspection camera.
Training Methods and Process	More interactive and practical sessions will be introduced. All contents will have a lesser theory with more interactive exercises and on-field activities.	Teaching theory in detail did not work effectively for WASA staff in Phase 1. Equipment and techniques did not work most of the time at the site as mentioned in theories. The major reason is that in WASAs, the sewerage and drainage system is either very old or is not maintained properly. Most of the time different techniques for testing and maintenance are to be used at different sites. Therefore, spending more time at practical activities by applying theories/rules to different cases and ensuring proper work procedures may be a better approach rather than maintaining the same training methods and process as Phase 1.
Time Allocation & Venue	20~25% time will be allotted to lectures at Al Jazari Academy and 75~80% time for on-field training at sewerage and drainage sites in WASA Lahore.	In phase 1, lecture time was around 50%, and on-field time was also 50%. To spend more time on-field training, especially at a site similar to the trainees' workplace.

Course: O&M for Electrical Equipment

Review Item	Revisions	Reason for Changes
Training Contents	1. Energy Audit is newly added. 2. Wiring is newly added. 3. Generator is removed. 4. Electrical panels will be taught in detail.	1. As reducing electricity cost is the priority of WASAs, energy audit content is added to train the WASA staff to optimize the operating condition of the equipment. 2. Training for wiring is also included to consider the reduction of electrical cost and avoid the breakdown of machines due to lack of knowledge of wiring. 3. During phase 1, Punjab suffered from a serious power shortage, so services highly depended on generators. But now, they are used as a backup. Therefore, this topic is shifted to the second priority this time. 4. During Training Needs Assessment (TNA) of Phase 1, it was observed that WASAs possess very little knowledge of electrical panels. So, this topic was introduced very briefly. This time content of the course will be enhanced, and O&M of different panels, e.g., Changeover Panel, Distribution Panel, Power Factor Improvement panels, etc., will be added.
Training Methods and Process	More interactive and practical sessions will be introduced. All contents will have a lesser theory with more interactive exercises and on-field activities.	Teaching theory in detail did not work effectively for WASA staff in Phase 1. Equipment and techniques did not work most of the time at the site as mentioned in theories. The major reason is that in WASAs electrical equipment are either very old or are not maintained properly. Most of the time different techniques for testing are to be used at different sites. Therefore, spending more time at practical activities by applying theories/rules to different cases and ensuring proper work procedures may be a better approach rather than classroom-based training.
Time Allocation & Venue	20~25% time will be allotted to lectures at Aljazari Academy and 75~80% time for on-field training at a tube well in WASA Lahore.	In phase 1, lecture time was around 80% and on-field time was 20%. To spend more time on-field training, especially at a site similar to the trainees' workplace.

Course: O&M for Mechanical Equipment

Review Item	Revisions	Reason for Changes
Training Contents	1. The energy audit is newly added. 2. The selection of pumps will be taught in detail.	1. As reducing electricity cost is the priority of WASAs, energy audit content is added to train the WASA staff to optimize the operating condition of the equipment. 2. During Training Needs Assessment (TNA) of phase 1, it was observed that WASAs possess very little knowledge of the selection of pumps. So, this topic was introduced briefly. This time content of the course will be enhanced, and detail will be added.
Training Methods and Process	More interactive and practical sessions will be introduced. All contents will have a lesser theory with more interactive exercises and on-field activities.	Teaching theory in detail did not work effectively for WASA staff in Phase 1. Equipment and techniques did not work most of the time at the site as mentioned in theories. The major reason is that, in WASAs, equipment is either very old or is not maintained properly. Most of the time, different techniques for testing and maintenance are to be used at different sites. Therefore, spending more time at practical activities by applying theories/rules to different cases and ensuring proper work procedures may be a better approach than classroom-based training.
Time Allocation & Venue	20~25% time will be allotted to lectures at Aljazari Academy and 75~80% time for on-field training at a tube well in WASA Lahore.	In phase 1, lecture time was around 80%, and on-field time was 20%. To spend more time on-field training, especially at a site similar to the trainees' workplace.

Annex 4.1.4 Time table of Training Course (Draft)

Operation & Maintenance of Sewerage and Storm Water Drainage System
Training Schedule (JICA Phase-II) 2022

Sr. No.	Day and Date	Module Name	Session-1			Tea 10:45 am-11:00 am	Session-2			Lunch 1:15 pm-2:00 pm	Session-3	
			1st Lecture		2nd Lecture		3rd Lecture		4th Lecture		5th Lecture	6th Lecture
			09:00 am-9:15 am	9:15 am-10:00 am	10:00 am-10:45 am		11:00 am-11:45 am	11:45 am-12:15 pm	12:15 am - 1:15 pm		2:00 pm-3:30 pm	3:30 pm-4:00 pm
1	Monday May 31, 2022	**Module 01** **Cleaning of Sewerage & Drainage Pipelines**	• Welcoming Remarks • Participant Introduction • Course Overview • Training Expectations	• Removal of Blockages in Sewer Lines • Latest Cleaning Techniques of Sewerage & Drainage System	• Introduction to Sewer Camera (Parts + Working) **(Demonstration)** • Repair & Maintenance of Sewerage & Drainage Pipelines	**Tea Break** **(As per Site Visit Situation)**	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Manhole & Sewer & Inspection with Camera			**Lunch & Prayer Break** **(As per Site Visit Situation)**	**FIELD WORK** • Manhole & Sewer & Inspection with Camera (Evalution of Manhole & Sewer)	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	Tuesday Jun 01, 2022	**Module 02** **Flow Measurement of Open Channels**	• Recap of Previous Day Activities	• Objectives • Types of Drains • Methods & Formulae	**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Doppler Ultrsonic Flow Meters • Anemometer		**FIELD WORK** **(Unpack-Assemble-Install-Use-Packing)** • Doppler Ultrsonic Flow Meters • Anemometer				**FIELD WORK** • Measuring Flow Velocity in Open Chanel • Calculation of Flow Rate	• Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	Wednesday Jun 02, 2022	**Module 3 & 4** **Wastewater Treatment (WWT)**	• Basics of WWT • WWT Technologies	• Most Suitable Technology	• How to Clean & Maintain Ponds of WWTP		• Fianacial Comparison of Various Technology w.r.t. CAPEX & OPEX				• How to Increase the Efficiency of WWTP	• Reflections • Group Picture • Certificates

Training Schedule (Draft)

Training Course: O&M of Electrical and Mechanical Equipment used by WASAs

S-No.	Date	Topic	Session 1	Tea Break	Session 2	Lunch	Session 3
			9:30-11:00	11:00-11:20	11:20-12:50	12:50-13:50	13:50-15:20
1	14th June, 2022	Mechanical Equipment	**Lecture & Exercise (at Academy);** - Preventive Maintenance - O&M of Pumps, Valves and Related Items	Move to tube well site	**Practical Training (at Tube Well Site);** - Daily & Periodic Inspection of Pumps and Related Items		**Lecture & Exercise (at Academy);** - Selection of Pumps
2	15th June, 2022	Electrical Equipment	**Lecture & Exercise (at Academy);** - Inspection of electrical panels for the purpose of preventive maintenance - MCU drawings and the importance of safeguards and data management	Move to tube well site	**Practical Training (at Tube Well Site);** - Daily & Periodic Inspection of Electric Panel		**Lecture & Exercise (at Academy);** - proper safety measures and wiring methods
3	16th June, 2022	Energy Audit	**Lecture & Exercise (at Academy);** - Objective and Outline of Energy Audit - Procedure of Energy Audit - How to Use the Instruments	Move to tube well site	**Practical Training (at Tube Well Site);** - Energy Audit Activities		**Data Analysis & Discussion (at Academy);** - Analyzing the Energy Audit Results - Discussion & Short Presentation of the Measures (Group Work)

LEAKAGE CONTROL, PLUMBING & PIPE REPLACEMENT

Training Schedule (JICA Phase-II) 2022

Sr. No.	Day & Date	Module Name	Session-1			Tea 11:00 am-11:15 am	Session-2			Lunch 1:15 pm-2:00 pm	Session-3	
			1st Lecture		2nd Lecture		3rd Lecture		4th Lecture		5th Lecture	6th Lecture
			09:00 am-9:15 am	9:15 am-10:00 am	10:00 am-11:00 am		11:15 am-11:45 am	11:45 am-12:15 pm	12:15 am-1:15 pm		2:00 pm-3:00 pm	3:00 pm-4:00 pm
1	TBD	MODULE 01 Leakage Control	• Welcoming Remarks • Participant Introduction • Course Overview • Training Expectations	• Importance & Classification of Water Meter • Standrads for Water Meter • Water Meter Selection	• Installation of Water Meter for House Connection • Installation of Service Pipes • Repairing of Service Pipes, Joints & Clamp	Tea Break 11:00 am-11:15 am	FIELD WORK • Planning for Meter Installation • Water Meter Installation as per SOPs			Lunch & Prayer Break 01:15 pm-02:00 pm (As per Site Visit Situation)	FIELD WORK • Planning for Meter Installation • Water Meter Installation as per SOPs	• Fromative Quiz • Quick Win Measures (QWMs) • Conclusion on Day's Activities
2	TBD	MODULE 02 Plumbing	• Opening Remarks & Introduction • Contents & Course Objectives • Trainees Participation (Brainstorming)	• Introduction & Definition of Plumbing • Components of Plumbing Systems • Types of Pipes, Joints / Fixtures & Valves	• Standards & Instructions of Manufacture of Material (Valves, Pipes & Joints) • Installation of Pipes, Joints & Valves • Butt Fusion Joints of HDPE with Video Demonstration		FIELD WORK • Hydrostatic Pressure Testing of Laid Water Supply / Sewer Lines				• Hazards and Risk Assement in Plumbing Field with Preventive Measures • Case Studies	• Day's wrapup & Review • Evaluation / Formative Quiz • Quick Win Measures (QWMs) • Conclusion on Day's Activities
3	TBD	MODULE 03 Pipe Replacement	• Opening remarks • Introduction & Icebreaking • Contents & Course Objectives • Trainees Expectation	• Actual Monitoring & Replacement Practices at WASAs including Evaluation Techniques for Repair or Replacement of the Existing Pipes (Brainstorming)	• Data Collection Methods at Leakage Repair Site. • Risk / Condition Assessment / Evaluation Method		FIELD WORK • Application of the Data Collection during Actual / Field Works				• Short-Term & Long-Term Pipe Replacement Plan / Water Leakage Repair Plan	• Day's wrapup & Review • Evaluation Session / Summative Quiz • Certificates & Group Picture

Annex 4.2.1 Training at WASA Training Center in 2019 and 2020

In-House Training Modules of WASA Lahore Training Center

	Target Group	BPS	Training Subject: Technical	Legal	Financial	Admin	Managerial	Training Module	Training Type	2019 Planned	2019 Implemented	2019 # Trained	2020 Planned	2020 Implemented	2020 # Trained	Remarks
1	Sub Engineer, SDO (O&M)	14, 16, 17	1					O&M of Electrical Equipment	Regular	Y	Y	32	Y	N		
2	Sub Engineer, SDO (O&M)	14, 16, 17	1					Quality Control Management	Regular				Y	Y	129	
3	Sub Engineer, SDO (O&M)	14, 16, 17	1					Energy Saving Techniques	Regular				Y	Y	48	
4	Sub Engineer, SDO (O&M)	14, 16, 17	1					Functions of Valves	Regular				Y	N		
5	Junior Pump Operator, Senior Pump Operator, SGPO	2-7	1					Chlorination at Tube Wells	Regular	Y	Y	389	Y	Y	134	Trainees in 2020 are Sub Engineers.
6	Junior Pump Operator, Senior Pump Operator, SGPO	2-7	1					O&M of Generators	Regular				Y	N		
7	Head Pipe Fitter, Pipe Fitter, Assistant Pipe Fitte	1-6	1					Water Supply Lines and Their O&M	Regular	Y	Y	430	Y	Y	430	
8	Head Pipe Fitter, Pipe Fitter, Assistant Pipe Fitte	1-6	1					Leakage Detection & Repair	Regular				Y	Y	70	Trainees in 2020 are Sub Engineers.
9	Sanitation Worker, Asst. Supervisor, Supervisor	1-4	1			1		Occupational Health & Worksite Safety	Regular	Y	Y	179	Y	Y	179	
10	PS, SO, Sr. Clerk, Jr. Clerk, Asst. Stenographer, Data Entry Operators	11-17				1		Documents & Staff Handling	Regular				Y	N		
11	SDO, XEN, Director	16, 17, 18, 19	1	1		1		PPRA Rules	Regular	Y	N		Y	N		
12	SDO, XEN, Director	16, 17, 18, 19	1	1		1		Policies, Laws, Rules & Regulations	Need-Based				Y	N		
13	SDO, XEN, Director	16, 17, 18, 19		1		1		Delegation of Powers	Need-Based				Y	N		
14	SDO, XEN, Director	16, 17, 18, 19	1	1				B & R (Buildings & Roads) Codes	Need-Based				Y	N		
15	SDO, XEN, Director	16, 17, 18, 19		1		1		PEEDA Act-2006	Need-Based				Y	N		
16	SDO, XEN, Director	16, 17, 18, 19		1		1		ESTA Code, 1974	Need-Based				Y	N		
17	SDO, XEN, Director	16, 17, 18, 19	1	1		1		Land Acquisition Process	Need-Based				Y	N		
18	SDO, XEN, Director	16, 17, 18, 19				1		Leave Rules & Travel Allowances	Need-Based				Y	N		
19	SDO, XEN, Director	16, 17, 18, 19				1		Approval of Schemes & personal matters	Need-Based				Y	N		
20	SDO, XEN, Director	16, 17, 18, 19		1	1	1	1	Financial Audit Rules & Regulations	Need-Based				Y	N		
21	SDO, XEN, Director	16, 17, 18, 19			1	1	1	Business Management	Need-Based				Y	N		
22	SDO, XEN, Director	16, 17, 18, 19			1	1	1	Financial Management	Need-Based				Y	N		
23	Sub Engineer, SDO, XEN	14, 16, 17, 18	1					Reduction of NWR	Need-Based				Y	N		
24	Sub Engineer, SDO, XEN	14, 16, 17, 18	1					Project Construction Management	Need-Based				Y	N		
25	Sub Engineer, SDO, XEN	14, 16, 17, 18	1					Hydrology	Need-Based				Y	N		
26	Sub Engineer, SDO, XEN	14, 16, 17, 18	1		1			Cost Management	Need-Based				Y	N		

	Target Group	BPS	Training Subject: Technical	Legal	Financial	Admin	Managerial	Training Module	Training Type	2019: Planned	Implemented	# Trained	2020: Planned	Implemented	# Trained	Remarks
27	Sub Engineer, SDO, XEN	14, 16, 17, 18	1		1			Asset Management	Need-Based				Y	N		
28	Sub Engineer, SDO, XEN	14, 16, 17, 18				1	1	Team Building & Efficient Use of Human Resource	Need-Based				Y	N		
29	Sub Engineer, SDO, XEN	14, 16, 17, 18				1	1	Stress Management	Need-Based				Y	N		
30	Sub Engineer, SDO, XEN	14, 16, 17, 18				1		First Aid	Need-Based				Y	N		
31	Sub Engineer, SDO	14, 16, 17	1					Drilling & Boring of Tube Wells	Need-Based				Y	N		
32	Sub Engineer, SDO	14, 16, 17	1					O&M of Disposal Stations	Need-Based				Y	N		
33	Sub Engineer, SDO	14, 16, 17	1					O&M of Drainage Systems	Need-Based				Y	N		
34	Sub Engineer	14, 16	1					Technical Sanction, Measurement Book, Leveling & Surveying	Need-Based	Y	Y	111	Y	N		
35	Dewatering Set Operator	1-5	1					Operation of Dewatering Sets	Need-Based	Y	Y	97	Y	N		
36	SDO (O&M), AD (Revenue)	16, 17	1					Detection of Illegal Water Connections and Issuance of Challans regarding Amnesty Scheme	Need-Based	Y	N					
37	Clerical Staff, AD, DD	11-18				1	1	Human Resource Management Information System	Need-Based							
38	All Naib Qasids	1, 2, 3				1		Workplace Ethics and Table Serving Manners	Need-Based				Y	N		
39	All Staff (Random)	16, 17, 18, 19	1	1				Water Conservation Awareness	Need-Based				Y	N		
40	All WASA Officers	17-20	1	1				Water Conservation	Seminar	Y	N					
41	AD, SDO, Junior Engineer	17	1	1	1	1	1	Multiple Modules	Induction	Y	N		Y	N		
42	Sub Engineer	14, 16	1	1	1	1	1	Multiple Modules	Induction				Y	N		

Annex 4.2.2 Training Needs at WASA Training Center

Needs of WASA Lahore Training Center for Development of New In-House Training Modules

The following ten courses/subjects were identified as the new training modules to be developed as in-house training at WASA Lahore Training Center.

	Training Subject	Target Group	Main Topics	WASA's Current Capacity	Frequency *1	Urgency *2
1	Selection of Wastewater Treatment technology for local conditions in Pakistan.	Directors/XENs/ADs (Eng.)	• Wastewater treatment basics • Wastewater treatment technologies • Criteria for selection of the most suitable technology for local conditions • Financial comparison of different technologies regarding CAPEX and OPEX	There is no WWTP existing previously. WASA is at the stage of entering into this work as it has awarded consultancy services to a local consultant for designing of 3 treatment plants to be funded by AIIB.WASA has also awarded consultancy services for detailed design for another treatment plant. So training on this subject by JICA will be beneficial now.	2	1
2	Selection of water treatment technology i.e. Surface water treatment, membrane treatment etc.	Directors/XENs/ADs (Eng.)	• Membrane treatment plant • Surface water treatment plant	WASA has been dependent on groundwater so far. But due to rapidly depleting ground water table and Arsenic in it, they have decided to shift to Surface water gradually. Consultancy services for 1st surface water treatment plant has been awarded. Therefore it is right time to get training on this subject. Membrane filtration plants were installed at WASA tubewells about 2-3 years ago. Nobody has been trained in maintenance of membrane filtration other than practical working on the plants for maintenance. Training on this subject will be beneficial for WASA Staff.	2	1
3	Flow measurement of open channels and disposal pumping stations.	XENs/DDs, ADs/SDOs	• Transient time flow meters • Doppler Ultrasonic flow meters • Any other Latest Technology	There are 7 primary drainage channels and 15 secondary drainage channels maintained by WASA Lahore. These channels carry storm water as well as sewage of the intermediate lift stations. There is no proper measurement system for flow measurement. It is roughly estimated on the basis of size of the channel and speed of flow. An accurate method based upon Ultrasonic flow measurement may be a good choice for which a training course is proposed.	2	1

	Training Subject	Target Group	Main Topics	WASA's Current Capacity	Frequency *1	Urgency *2
4	Choosing specifications and International standards for water supply control valves.	XENs/DDs, ADs/SDOs	• Types of valves (Manual and Motor Controlled) • International standards and specifications for good quality valves	WASA has a huge water supply network consisting of 5,864 KM long pipelines and serving about 8 million people. Water supply valves of wide range have been installed to control the flow and to maintain pressure in all the areas. In most cases, locally made valves are installed but they malfunction after some time after installation. Durable and good quality valves are of key importance in the maintenance of water supply system. Therefore, it is felt that a training course on specifications based on international standards may be conducted to enable officers to procure better quality valves.	2	2
5	Design problems at disposal pumping stations.	XENs/DDs, ADs/SDOs	• Improvements needed in intake structure & dry well structure. • Specifications, operation, repair & maintenance of Disposal/Lift Stations. • Operating curves, duty point	There are more than 129 sewage disposal and intermediate lift pumping stations in WASA. During maintenance it is felt that certain improvements especially in the intake structure and dry well or level of pumping units are needed at some places which may be better to incorporate at designing stage. As such this training course is requested so that all concerned are trained to choose better design as per international practices and recommendations.	2	2
6	Selection of pumps for Water and Wastewater with respect to flow, head and efficiency etc.	Directors/XENs/ADs (Eng..)	.• Types of different pumps for water & wastewater •Selection of pumps for disposal pumping stations • Selection of pumps for tubewells •Relation between speed, head, discharge and power consumption of pumps	There is a huge network of 600 deep well ground water tubewells and 129 disposal pumping stations in the water supply and sewerage system of WASA Lahore. New pumping stations are added day by day due to increasing demand. For water supply system, the standard pumps for a particular head are used without considering the actual requirement in this respect therefore it will be beneficial if training on selection of pumps with respect to flow, head and efficiency is conducted.	2	2
7	Designing of water supply schemes by using latest IT Techniques and software.	XENs/DDs, ADs/SDOs	•EPA NET •WaterGEM •WaterCAD	WASA has qualified Engineers in the field of designing water supply schemes. However, as the IT Techniques are evolving rapidly, the staff of WASA needs to be trained to work on the latest software according to the technological advancements in this field. Existing staff is less familiar with latest IT software. Therefore, training on the use of these software will be quite beneficial for WASA staff.	2	2

	Training Subject	Target Group	Main Topics	WASA's Current Capacity	Frequency *1	Urgency *2
8	Designing of sewerage schemes by using latest IT Techniques and software.	XENs/DDs, ADs/SDOs	•SewerCAD •StormCAD •SewerGEM	WASA has qualified Engineers in the field of designing sewerage schemes. However, as the IT Techniques are evolving rapidly, the staff of WASA needs to be trained to work on the latest software according to the technological advancements in this field. Existing staff is less familiar with latest IT software. Therefore, training on the use of these software will be quite beneficial for WASA staff.	2	2
9	Inspection & Testing of Sewerage System. Selection of sewer cleaning machinery & safety equipment as per local conditions (Choosing best possible Specifications).	ADs/SDOs (BS-17) & Sub Engineers (BS-14 & BS-16)	•Inspection & Maintenance of sewerage system • Selection of best possible specifications for sewer cleaning machinery and safety equipment suitable for local conditions •Use of pneumatic stoppers	The sewerage system of WASA Lahore consists of about 5000 KM long sewerage lines of different diameter ranging from 225 mm to 2250 mm. The current practice is to clean the manholes mostly. WASA does not have sewer inspection cameras or other equipment to inspect the pipeline from inside to assess the actual cleaning requirement. Also the sewer cleaning machinery is used for maintenance purpose. It will be beneficial for WASA staff to have training course to select better machinery useful for their system..	2	2
10	Troubleshooting of deep well turbine pumps and Tube-well bore.	ADs/SDOs (BS-17) & Sub Engineers (BS-14 & BS-16)	•Maintenance Schedules (daily, weekly, monthly, bi-annual and annual checks) •Trouble shooting turbine pumps • Trouble shooting tubewell bore	About 600 groundwater tubewells are used to supply drinking water to about 8 million people of Lahore. Very few staff follow proper procedures. There has been less practice of preventive maintenance and advance diagnosis of problems on pumps and tubewells. Maintenance works of tubewells are now outsourced to private companies. Supervisory staff of WASA needs to have capacities to guide the private companies on SOP. Regular maintenance is required to keep them operative in a satisfactory manner. Training on trouble shooting will be beneficial for the maintenance staff.	2	1

*1 Frequency: How often are the target group expected to apply attained knowledge/skills/attitudes related to the training subject in their actual works?
1: once a month 2: 1-11 times a year 3: Less than once a year

*2 Urgency: How urgently should the target group acquire/improve knowledge/skills/attitudes related to the training subject to apply them in their actual works?
1: Immediately 2: In a six-month to two-year time 3: After two years or more

Annex 4.2.3 Training Plan and Schedule at WASA Lahore in 2022

(WASA Lahore) Annual In-House Training Plan for 2022 (Performance Sheet)

Training Course	Training Module	Cader of Trainees (Designation, BPS)	No. of Staff	No. of Staff Trained (Plan & Result)		Achievement	
			All	Total		% (Actual/ Plan)	% (Actual /All)
				Plan	Actual		
O&M of Sewerage & Drainage	Flow Measurement of Open Channels	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	Flow Measurement of Open Channels	Sub Engineer (BPS-14 & 16)	140	40			
	Wastewater Treatment technoloies	DDs & ADs (Engg.) / XENs & SDOs (O&M) (BPS-17 & 18)	110	30			
	Wastewater Treatment technoloies	Sub Engineer (BPS-14 & 16)	140	40			
	Cleaning of Sewerage and Drainage of Pipeliens	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	Cleaning of Sewerage and Drainage of Pipeliens	Sub Engineer (BPS-14 & 16) & supervisor (BPS-11)	200	40			
O&M of Mechanical & Electrical Equipment	Energy Audit	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	Energy Audit	Sub Engineer (BPS-14 & 16)	140	40			
	O&M of Electric Panels	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	O&M of Electric Panels	Sub Engineer (BPS-14 & 16)	140	40			
	Selection of suitable Pump	DDs & ADs (Engg.) / XENs & SDOs (O&M) (BPS-17 & 18)	110	30			
	Selection of suitable Pump	Sub Engineer (BPS-14 & 16)	140	40			
	Energy audit for pump efficiency	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	15			
	Energy audit for pump efficiency	Sub Engineer (BPS-14 & 16)	140	20			
Leakage Control, Plumbing & Pipe Replacement Plan	Proper Handling of Leakages from Valves and Connections	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	Proper Handling of Leakages from Valves and Connections	Sub Engineer (BPS-14 & 16)	140	40			
	Water meters selection and installation	ADs (Engg.)/SDOs (O&M) (BPS-17)	70	30			
	Water meters selection and installation	Sub Engineer (BPS-14 & 16)	140	40			

(WASA LAHORE) In-House Training Plan for 2022

Training Course	Training Module	Batch No.	Cader of Trainees (Designation, BPS)	No. of Trainees (Plan)	Date (MM-DD-YYYY)	Duration	Name & Designation of Trainer	Category of Training
O&M of Sewerage & Drainage	Flow measurement of open channels	1	ADs (Engg.)/SDOs (O&M) (BPS-17)	30	2022/6/1	3h (Theoretical + Practical)	Mr. Zuhaib Butt, Dy. Director (P&D)	Regular
		2			2022/6/2			
O&M of Sewerage & Drainage	Wastewater treatment technologies	1	ADs (Engg.) & SDOs (O&M) (BPS-17)	30	2022/6/13	3h (Theoretical + Practical)	Mr. Zeeshan Bilal, Director (P&S)	Regular
		2			2022/6/14			
O&M of Sewerage & Drainage	Wastewater treatment technologies	1	Sub Engineer (BPS-11,14 & 16)	40	2022/6/27	3h (Theoretical + Practical)	Mr. Zeeshan Bilal, Director (P&S)	Regular
		2			2022/6/28			
		3			2022/6/29			
O&M of Sewerage & Drainage	Cleaning of sewerage and Drainage pipelines	1	ADs (Engg.)/SDOs (O&M) (BPS-17)	30	2022/9/19	3h (Theoretical + Practical)	Mr. Usman Babar, Director Construction-II	Regular
		2			2022/9/20			
O&M of Sewerage & Drainage	Cleaning of sewerage and Drainage pipelines	1	Sub Engineer (BPS-11,14 & 16)	40	2022/9/26	3h (Theoretical + Practical)	Mr. Usman Babar, Director Construction-II	Regular
		2			2022/9/27			
		3			2022/9/28			
O&M of Mechanical & Electrical Equipment	Energy Audit	1	ADs (Engg.)/SDOs (O&M) (BPS-17)	30	2022/10/10	3hours (Theoretical + Practical)	Ms. Memoona Ishtiaq, SDO Electricity	Regular
		2			2022/10/11			
O&M of Mechanical & Electrical Equipment	Energy Audit	1	Sub Engineer (BPS-11,14 & 16)	40	2022/10/24	3h (Theoretical + Practical)	Ms. Memoona Ishtiaq, SDO Electricity	Regular
		2			2022/10/25			
O&M of Mechanical & Electrical Equipment	O&M of Electric Panels	1	ADs (Engg.) & SDOs (O&M) (BPS-17)	30	2022/10/26	3h (Theoretical + Practical)	Mr. Ammar Arshad, SDO Electricity	Regular
		2			2022/10/31			
O&M of Mechanical & Electrical Equipment	O&M of Electric Panels	1	Sub Engineer (BPS-11,14 & 16)	40	2022/11/1	3h (Theoretical + Practical)	Mr. Ammar Arshad, SDO Electricity	Regular
		2			2022/11/2			
O&M of Mechanical & Electrical Equipment	Selection of Suitable Pump	1	ADs (Engg.) & SDOs (O&M) (BPS-17)	30	2022/11/3	3h (Theoretical + Practical)	Mr. Waqas Liaqat, XEN Maintenance-I SOUTH	Regular
		2			2022/11/14			
O&M of Mechanical & Electrical Equipment	Energy audit for pump efficiency	1	ADs (Engg.) & SDOs (O&M) (BPS-17)	15	2022/11/15	3h (Theoretical + Practical)	Mr. Sufian Habib, XEN Maintenance-II	Regular
O&M of Mechanical & Electrical Equipment	Energy audit for pump efficiency	1	Sub Engineer (BPS-11,14 & 16)	20	2022/11/16	3h (Theoretical + Practical)	Mr. Sufian Habib, XEN Maintenance-II	Regular

Training Course	Training Module	Batch No.	Cader of Trainees (Designation, BPS)	No. of Trainees (Plan)	Date (MM-DD-YYYY)	Duration	Name & Designation of Trainer	Category of Training
Leakage Control, Plumbing & Pipe Replacement Plan	Proper Handling of leakages from Valves & Connections	1	ADs (Engg.)/SDOs (O&M) (BPS-17)	30	2022/11/17	3h (Theoretical + Practical)	Mr. Hisham Pervaiz, Director Electricity	Regular
		2			2022/12/5			
	Proper Handling of leakages from Valves & Connections	1	Sub Engineer (BPS-11,14 & 16)	40	2022/12/7	3h (Theoretical + Practical)	Mr. Hisham Pervaiz, Director Electricity	Regular
		2			2022/12/8			
	Water meters selection and installation	1	ADs (Engg.)/SDOs (O&M) (BPS-17)	30	2022/12/12	3h (Theoretical + Practical)	Mr. Hisham Pervaiz, Director Electricity	Regular
		2			2022/12/13			
	Water meters selection and installation	1	Sub Engineer (BPS-11,14 & 16)	40	2022/12/19	3h (Theoretical + Practical)	Mr. Hisham Pervaiz, Director Electricity	Regular
		2			2022/12/20			

Annex 4.3.1 List of WASA Coordinators and WASA Trainers from 5WASAs

WASA Coordinators

WASA	Name	Designation
WASA Lahore	Mr. Muhammad Ghufran	Deputy Managing Director
WASA Faisalabad	Mr. Roohan Javed	Director Water Resources (OPS)
WASA Multan	Mr. Muhammad Nadeem	Deputy Director Engineering
WASA Gujranwala	Mr. Khurram Nabeel	Deputy Director (P&D)
WASA Rawalpindi	Mr. Azizullah Khan	Deputy Director (P&D)

Master / WASA Trainers

WASA Lahore

No	Course	Name	Designation
1	O&M of Sewerage and drainage	Mr. Usman Babar	Director Contuction-II
		Mr. Zuhaib Butt	Deputy Director (P&D)
		Mr. Zeeshan Bilal	Director P&S
2	O&M of Mechanical and Electrical Equipment	Ms. Mamoona Ishtiaq	AD (Electricity)
		Mr. Ammar Arshad	AD (Electricity)
		Mr. Sufian Habib	XEN, Maintenance-II, North
		Mr. Waqas Liaqat	XEN, Maintenance-II, South
3	Leakage Control, Plumbing and pipe replacement plan.	Mr. Hisham Pervaiz	XEN (O&M-II), GBT
		Mr. Hafiz Ozair Ahmed	Deputy Director QCD
		Mr Arsalan Idrees	AD(Procurement)

WASA Faisalabad

No	**Course**	**Name**	**Designation**
1	O&M of sewerage and drainage	Mr. Muhammad Rafi	Director (P&D) OPS
		Mr. Shahid Iqbal Gill	Deputy Director (Drainage)

		Mr. Zain-ul-Abidin	Assistant Director (Construction & Operation) East
2	O&M of Mechanical and Electrical Equipment	Mr. Usman Zia	Director (Construction & Operation) West-II
		Mr. Roohan Javed	Director Water Resources (OPS)
		Mr. Nouman Noor	Assistant Director (Water Resources)
3	Leakage Control, Plumbing and pipe replacement plan.	Mr. Hayyat Randhawa	Assistant Director (QCD)
		Mr. Atiq-ur-Rehman	Sub-Engineer Water (D&M) East
		Mr. Rauf Ahmad	Sub-Engineer Water (D&M) East

WASA Multan

No	Course	Name	Designation
1	O&M of Sewerage and drainage	Mr. Muhammad Nadeem	Deputy Director, Planning and design
2	O&M of Mechanical and Electrical Equipment	Mr. Arif Abbas	Deputy Director, Disposal Station
		Ms. Rabia Mehfooz	Deputy Director, Water Supply
		Mr. Muhammad Sajid	Staff Officer (Tech)
3	Leakage Control, Plumbing and pipe replacement plan.	Ms. Rabia Mehfooz	Deputy Director Water, Water Supply
		Mr. Hafeez Laghari	Deputy Director Sewerage division (south)

WASA Gujranwala

No	Course	Name	Designation
1	O&M of Sewerage and drainage	Mr. Abdul Wahab	Assistant Director (Civil Engg)
2	O&M of Mechanical and Electrical	Mr. Sarmad Waheed	Assistant Director (Electrical Engg)

	Equipment	Mr. Ali Husnain	Assistant Director (Mech. Engg)
3	Leakage Control, Plumbing and pipe replacement plan.	Mr. Zain ul Abdain	Sub-Engineer (Civil)
		Mr. Rana Ilham Rabani	Sun-Engineer (Electrical)

WASA Rawalpindi

No	Course	Name	Designation
1	O&M of Sewerage and drainage	Mr. Muhammad Afzal	Assistant Director
		Mr. Noor Rabbani	Assistant Director
		Mr. Ali Gulraiz	Sub-Engineer
2	O&M of Mechanical and Electrical Equipment	Mr. Khaleeq Afzal	Assistant Director
		Mr. Umar Kaleem	Assistant Director
		Mr. Abdul Basit	Assistant Director
		Mr. Muhammad Haseeb	Sub-Engineer
3	Leakage Control, Plumbing and pipe replacement plan.	Mr. Muhammad Haseeb	Sub-Engineer
		Mr. Smran Zahid	Sub-Engineer
		Mr. Muhammad Amir Shah	Sub-Engineer

Annex 4.3.2 Training Module of In-house Training at 4WASAs

O&M of Electrical and Mechanical Equipment

No.	Topic	Main Contents	WASA-F	WASA-M	WASA-G	WASA-R
1	Energy Audit (Saving Operation Cost)	・How to check/evaluate operating efficiency of mechanical and electrical equipment ・How to improve operating efficiency	✓	✓	✓	✓
2	O&M of Pump (Tube Well and Disposal Station)	・SOPs for pump and motor ・Daily and periodic inspection ・Preventive maintenance	✓	✓	✓	✓
3	Selection of Pump	・How to select suitable pump for tube well and disposal station ・How to decide/check specification				
4	Electrical panels	・ O&M of electrical panels	✓	✓	✓	✓
5	MCU	・How to read Electrical drawings of motor starters and electrical panels ・O&M (Record keeping, SOP, Routine and Preventive Maintenance) ・Design (Selection criteria for appropriate protective devices)	✓	✓	✓	
6	Wiring	・ Inspection and repair ・ Wire size	✓	✓	✓	✓

O&M of Sewerage and Drainage

No.	Topic	Main Contents	WASA-F	WASA-M	WASA-G	WASA-R
1	Cleaning of sewerage and drainage pipelines	-How to clean sewer and drainage lines properly -Latest cleaning techniques of sewerage and drainage pipelines (Camera) -Removal of blockages in sewer lines	✓	✓	✓	✓
1'	Maintenance of sewerage and drainage system (including NO.1)	-Repair and maintenance of sewerage and drainage pipeline -Leakage issues and methods of repair -Modern technique to fix crown failures -How to avoid crown failures -Latest different techniques for testing sewerage and drainage system	✓	✓	✓	✓
2	Flow measurement of open channels	-How to use flow velocity meter -How to calculate flow rate -How to estimate at various depths	✓	✓	✓	
3	O&M of wastewater treatment plant	- Maintenance/How to increase efficiency of existing WWTP(WSP) - How to clean and maintain ponds of WWTP(WSP)	✓	✓		
4	Wastewater treatment technologies	- Wastewater treatment basics - Wastewater treatment technologies - Criteria for selection of the most suitable technology for local conditions - Financial comparison of different technologies regarding CAPEX and OPEX		✓	✓	✓

Leakage control, plumbing, and pipe replacement plan

No.	Topic	Main Contents	WASA-F	WASA-M	WASA-G	WASA-R
1	Water Meter for house connection	・Proper Installation ・Basic knowledge		✓		
2	Proper handling of leakages from valves and connections (including pressure testing between branch sadle and meter)	・Type of meter and proper selection ・Proper installation ・Repair work ・Pressure recording in end of network for consumer		✓		✓
3	Data collection method at leakage reparing site	・Creation of Data collection format ・Risk/condition evaluation method ・Application of the format in actual works	✓	✓	✓	✓
4	Joint/Connection/Replacement including welding and fusion	1) Physical property different types of pipe/ size of pipes 2) Type of connections Gibault joint, Mechanical joint, Flange, Valve, Dismantling joint 3) Type of External/Internal lining - proper selection of lining - type of External/Internal lining like epoxy, polyethylene, bitumen, etc. 4) Standard and instruction Standard and instruction of manufacturer of material,	✓	✓	✓	✓
5	Pressure test	Pressure test of proper and improper material, torque, different dimension		✓	✓	✓

Annex 4.4.1 Outline of In-house training for "O&M on Sewerage and Drainage"

Outline of In-house Training (Sewerage and Drainage Cleaning)

Outline of in-house Training for the four first priority item which was selected based on the TNA results of five WASAs is shown below.

1. Cleaning of sewerage and drainage pipelines (including NO.2)

（1） Objective

Learn proper cleaning methods and procedures for facilities as part of proper sewerage facility maintenance activities.

（2） Training Method and Venue

Training method: Practical training at site, Venue: sewerage pipeline facilities in suburban areas without dense houses.

（3） Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

（4） Contents

1) Prepare camera
2) Removal of earth, sand, sludge, etc. from inside the pipe using jetting machine, sucker machine, etc.
3) Carry in camera from manhole and take safety measures
4) Check the condition of the inside of the pipe using the camera
5) Removal of obstructions: such as, removal of obstructions with heavy equipment, replacement of the pipe itself, etc

2. Flow measurement of open channels

(1) Objective

Flow measurement using an anemometer

(2) Training Method and Venue

Training method: Practical training at site, Venue: small rivers

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Prepare an anemometer, measuring tape (50m), pole (red and white), and distance meter
2) Prepare the flow calculation sheet
3) Measure the width and depth of the open channel

4) Measure the flow velocity in the open channel
5) Calculate the flow rate based on flow velocity and area of cross section at open channel

3. O&M of wastewater treatment plant

(1) Objective

Learn proper methods and procedures by removing sludge from sewage treatment plants and use them in preventive maintenance activities.

(2) Training Method and Venue

Training method: Practical training at site, Venue: sewerage treatment plant (Faisalabad,Multan)

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Determine the sequence (order) to be cleaned
2) Stop the inflow of water
3) Drain the water
4) Wait until dry
5) Remove the sludge
6) Place the removed sludge in the site or dispose it at an appropriate dumping site
7) Move to the next series (repeat steps 1) to 6))

4. Wastewater treatment technologies

(1) Objective

The objective is to select a sewage treatment technology that is suitable for local conditions and learn its procedures.

(2) Training Method and Venue

Training method: Lecture including exercise, Venue: WASA Office

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Summary description
2) Section of technologies

-Site requirement

- Financial analysis (CAPEX, OPEX)

Annex 4.4.2 Outline of In-house training for "O&M on Mechanical and Electrical Equipment"

In-house Training (Electrical Field)

From the results of the five WASA TNAs, a summary of the In-house Training on the four First Priorities is provided below.

Topic：No.1 Electrical Panels

Training Goal: Learn how to inspect electrical panels for the purpose of preventive maintenance.

⇒Understand the necessary tools and how to use them
Understand safety equipment and measures
Understand inspection methods and necessity

1)Preparations

⇒Inspection tools
Tester, clamp meter, megger, earth tester, electroscope,
screwdrivers of various sizes (+, -)

⇒Protective equipment
Insulated gloves (Rubber material or military gloves, etc.)
Protective helmet (If you have an electrical protective cap, that's better)
Basically, long sleeves, long pants and safety shoes should be worn (to prevent electric shock and injury).

2)Visit the work site with preparations

3)Safety measures

⇒Understanding of safety equipment, notices, and the dangers of electric shock

4)External inspection

⇒Check for rusting and damage to the panel, indicator lights (lamp test, etc.)

5)Internal inspection

⇒Check for any abnormalities in heat, sound, or smell. (Check the situation)
(Check if there are any problems with equipment, wiring, or grounding.

6)Confirmation of basic values

⇒Check and record the current value (A), voltage value (V), etc.
In order to make it stick, record it on the record sheet used in Phase 1, and manage it in Excel.

Topic：No.2 Wiring
Training Goal: Learn proper safety measures and wiring methods
⇒Understand the necessary tools and how to use them
Understand safety equipment and measures
Understand wiring methods and their necessity
1)Preparations
⇒Protective equipment (same as No.1)
⇒Tools for wiring (No.1 inspection tools, screwdrivers, pliers, etc.)
2)Safety measures
⇒general safety measures, installation of protective tubes, etc.
Check to make sure that no electricity is flowing by measuring insulation, etc.
3)Turn off the power to the circuit you are working on.
⇒If possible, turn off the main power supply in addition to the power supply to the area being worked on.
4)Wiring corresponding to the crisis to be connected
⇒When the length and the capacity of the pump increase, the wire size will increase.
5)Connect to the terminal securely.
6) Final check
⇒Check for wiring errors and forgotten postings

Topic：No.3 Energy audit

Training Goal: To measure and evaluate the current operating conditions mechanically and electrically, and to examine measures and improvements to reduce electricity costs. (to be done together with the mechanical field)

⇒To understand the necessary tools and how to use them

Understand safety equipment and measures

Understand the measurement method and necessity

Use and consider the data obtained

1)Preparations

⇒Protective equipment (same as No.1)

⇒Inspection tools (same as No.1, plus other items needed)

2)Confirmation of the measurement method

⇒Using the materials used in Phase 1

3)Safety measures (general safety measures, markings, protective equipment, etc.)

4)Measurement (A, V, etc.)

5)Data collection (A, V, etc.)

6)Summarize the data

7)Make a graph in Excel

8)☆Compare and discuss data

⇒Consider using inverters (individualized for Lahore only) and OHRs.

Topic：No.4 MCU

Training Goal: Learn about drawings and the importance of safeguards and data management

⇒To understand the necessary tools and how to use them

Understand safety equipment and measures

Understand the measurement method and necessity

Understand the role of each device

1)Learn about drawings

⇒Continuation of Phase 1 or upgrade

2)Preparations

⇒Inspection tools

3)Safety measures

⇒Protective equipment

4)Data measurement　A

5)Data measurement　V

6)Data measurement　Insulation resistance

7)Data measurement　ground resistance

8)Check function of protective devices

⇒Using materials from Phase 1

Outline of In-house Training (Mechanical Field)

Outline of In-house Training for the three first priority items which was selected based on the TNA results of five WASAs is shown below.

1. O&M of Pump (Tube Well and Disposal Station)

(1) Objective

To learn proper O&M method/procedure of pumps installed at tube well and disposal station as preventive maintenance activities.

(2) Training Method and Venue

Training method: Practical training at site, Venue: Tube well and disposal station

(3) Trainee

All technical staffs including operators

(4) Contents

1) Safety measures before and during O&M activities
2) Outline of instruments to be used and its directions for use (Vibration Meter, Clamp Meter, Insulation Meter)
3) Daily inspection based on the record sheet (discharge amount, discharge pressure, ampere, voltage, leakage amount at grand packing, abnormal sound, and vibration)
4) Periodic inspection based on the record sheet (vibration measurement, ampere/voltage measurement, insulation measurement)
5) Detailed method of maintenance and minor repair (replacement of oil, refilling grease, repair coating, adjustment of leakage amount at grand packing etc.)

2. Selection of Pump

(1) Objective

To understand how to select proper pump type and determine specifications which meet the actual installation and operation conditions for tube well and disposal station.

(2) Training Method and Venue

Training method: Lecture including exercise, Venue: WASA Office

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Proper pump type for tube well and disposal station
2) Parameters and specifications to be considered for pump selection
3) Calculation of important parameters such as discharge diameter, total head, and motor capacity for pump selection (exercise by using EXCEL)
4) Examples of defects and points to be considered/noted for pump selection and installation

3. Energy Audit (Saving Operation Cost)

(1) Objective

To check and evaluate the current operation condition of pump mechanically and electrically, and to consider measures based on the results for saving electricity cost.

(2) Training Method and Venue

Training method: Practical training at site, Venue: Tube well and disposal station

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Understanding of performance curve (Q-H curve)
2) Outline of instruments to be used and its directions for use (Ultrasonic Flow Meter, Clamp Meter, Power Analyzer)
3) Data measurement based on the record sheet
4) Check and analysis of the obtained data
5) Consideration and plan of measures/actions for saving electricity cost

Annex 4.4.3 Outline of In-house training for "Leakage Control, Plumbing, and Pipe Replacement Plan"

In-House Training Outline
~Leakage control, Pipe replacement Planning and Plumbing~

1. Leakage Control

1.1 Installation of Water Meter for house connection

1.1.1 Objectives

Metering is not only the basis for collecting tariff, but also provides essential data for understanding the operational status of water utilities. In this course, WASA staffs will learn how to select appropriate equipment, installation methods, and maintenance as the basics for accurate metering.

1.1.2 Materials

Water meter for house connection used in each WASA
Ultrasonic flowmeter provided in the first phase

1.1.3 Methods（Bulk Meters）《conducted in the 3rd year if possible》

The program will consist mainly of practical training and a brief lecture.
(1) Types of bulk meters and their characteristics
(2) Selection of installation site suitable for the objectives
(3) Measurement in pilot area and analysis of water distribution volume
Ultrasonic flowmeter measurements will be taken in the pilot area selected by each WASA, and water distribution volume analysis will be carried out together with water supply volume data (as preparation for the future installation of meters).

Translated with www.DeepL.com/Translator (free version)

1.1.4 Methods（Meter for house connection）

The program will consist mainly of practical training and a brief lecture.
(1) Understanding the classification of water meters in use and to be introduced at WASA.
(2) Understanding of international standards for meters, differences in accuracy (measurement range), and selection of meters that are compatible with Pakistan (using general specification tables).
(3) Maintenance (replacement)
(4) What to consider when planning the installation location
(If each WASA has a different opinion on the location of the meter inside or outside the premises, the staff need to discuss it when necessary.)
(5) Installation practice
For proper meter installation technique, the SOPs of Faisalabad will be applied.

1) Understanding of SOPs

2) Conduct the installation following the SOPs, in the actual field or using model piping for training.

Translated with www.DeepL.com/Translator (free version)

1.2 Proper installation of service pipe materials

1.2.1 Objectives

Since leakages from service pipes are said to the largest number of leakages, the appropriate selection of materials, installation methods and use of equipment will be learned to help prevent leakage from the service pipe installation stage

1.2.2 Materials

Nothing to newly purchase

1.2.3 Methods

The program will consist mainly of practical training and a brief lecture.

(1) service pipe material selection (regarding materials currently used in each WASA)
(2) Methods of branching service pipe from distribution pipe
(3) Installation equipment and methods suitable for the materials
(4) Water pressure test methods
(5) Plumbing practice
  1) Preparation of appropriate materials (model piping for training or actual piping)
  2) Branching from distribution pipe
  3) Water pressure test using a hand pump in model and actual piping
  4) Verification of proper installation using a check sheet
  5) Confirm the procedure of Faisalabad SOP.

1.3 Repair of service pipes

1.3.1 Objectives

Learn the leakage repairing methods according to pipe type, diameter, leak point and size.

1.3.2 Materials

(1) Repair clamps for water supply pipes, joint accessories, packings
(2) Repair clamps for water distribution pipes, pipe joint accessories such as couplings, etc.
(Purchase if there is a lack of appropriate repair parts)

1.3.3 Methods

(1) Repair methods for each leak location

1) Service pipe branch: Replacement of saddle, ferrule and packing

2) Service pipe and meter: Replacement of rubber ring, replacement of joint accessories, pipe cutting

3) Distribution pipe: Repair clamps, pipe cutting

(2) Leakage from water distribution accessories

1) Sluice valve, fire hydrant, air valve

(3) Leakage repair records (described in detail in the next chapter)

1) Record format

2) Record and save in format

2. Pipe Replacement Planning

Establishment of data collection methods at leak repair sites

2.1.1 Objectives

・Leakage repair records are continuously reflected in the existing database.

・Areas for pipeline replacement are prioritized based on the collected data on the number of leaks.

2.1.2 Materials

None in particular, using existing smartphones, PCs, etc. used by WASA staff in their daily work.

2.1.3 Methods

—Preparation phase (until 2021.11) -

(1) PCGIP data (GIS data and Excel data) held by the Urban Unit will be shared with all WASA.

(2) Creation of data collection form

1) Digital input by smartphone will be assumed; based on discussions with WASA, easy-to-use forms such as Google Form, ODK, etc. will be selected. However, we will also consider step-by-step methods such as paper-based in the second year and digital in the third year (to be discussed with WASA).

2) It is assumed that point-vector layers showing leak repair points will be created on GIS.

3) Select data that will contribute to reducing water leakage such as:

- Date and time of repair,
- responsible person
- pipe ID
- date and time of repair, material
- town, district, tehsil
- repair method (tape only or clamp), and

・comments (leak condition, etc.).

＊In advance, JICA expert team (GIS, construction, leakage) and coordinator will discuss and have some ideas on what kind of data is needed (decide on potential record format), who to share it with, and how to use it.

—In-House Training—

(1) Inform staff of the need for each parameter and why it is important.

(2) Explain the structure of the form and instruct the data entry methods.

(3) Understand the evaluation methods for condition, risk, etc. among the input items.The evaluation methods are based on the Phase 1 materials.

(3) Understand the evaluation methods for condition, risk, etc. among the input items. The evaluation methods are based on the Phase 1 materials.

(4) Go to the actual leakage repair site and input data into the form. (Whether this will be done at the same time as the leak repair instruction will be discussed with each WASA)

(5) Check the collected data on the PC in the office and integrate it into the existing database.

WASA-F, L: Integrate into ArcGIS database and display mapping.

WASA-G, M, R: Merge into Excel file of existing data. In addition, in anticipation of the future introduction of Arc GIS, the data will be displayed in QGIS.

(6) Water leakage repair plan

How to plan pipe replacement, meter installation, leakage survey, and leakage repair will be discussed based on collected data .

*Items to be discussed in advance with WASA

1) Data collection method (paper or digital), and if digital, which software to use.

2) What kind of data flow should be used?

Example

Construction team: Keep records of repairs and construction, and if paper-based, send them to the supervising department (field branch office? headquarters?). If it is digital, it will be transferred automatically.

GIS team: Receive information from the supervising department and reflect it in GIS data.

Planning department: Review priority replacement areas based on GIS data.

Leakage team: Investigate in priority survey areas.

3) Data sharing methods

・Which department should have the data necessary for water supply management?

・Approval method: Method for managerial staff to swiftly recognize the survey result data significant for waterworks management.

3. Piping Work

Joint/Connection/Replacement including welding and fusion

3.1 Jointing and pressure test

3.1.1 Objectives

When a water distribution pipe is damaged, several meters of pipe are replaced. After the repair, there are cases where leakage recurs at the repaired section.

The objectives of this training help participants to understand the causes of leakage theoretically on the quality of pipe connections, which are possible.

1) Quality of joints
2) Use of non-compliant products
3) Understanding of standards

3.1.2 Materials

From WASA stock：

Asbestos pipe
MS pipe, HDPE and PVC pipe
Replaced old Gibault joint
Materials to close at one end of pipe for pressure test

To be purchased (high quality)

1) Tool

Hand pressure pump
Tools (right angled ruler, grinder, and any flat plate to check the shape of cross section of pipe)

2) Material

Gibault joint
Two MS single-flange pipes for pressure test (minimum of two Gibault joints are required to test AC pipe)
Blind flange
MS pipes, HDPE and PVC pipes if WASA doesn't have

3.1.3 Methods

(1) Prepare an existing Gibault joint that has a leak and a quality-assured Gibault joint.
(2) Compare the parts of both joints so that the staff can understand the differences.
(3) Prepare the pipe to be connected, and measure its outer diameter and then estimate pressure rating, referring standard.
(4) Have the staff check the verticality of the cut face of the pipe (is there a gap when the plate is applied? Is the end face right-angled to the pipe? If there is a gap, have the staff correct it.
(5) Referring to the installation manual provided by the manufacturer, check and compare the

applicable pipe type, applicable outside diameter and tightening torque If this information is not known for an existing joint, check how it was previously determined.

(6) Perform a 10-minute pressure test on the leaking Gibault joint.

(7) If there is no leak, place a weight on the joint and perform a pressure test for 10 minutes.

(8) Perform a 10-minute pressure test on the Gibault joint whose quality has been verified.

(9) If there are no leaks, place a weight on the joint and conduct a pressure test for 10 minutes.

(10) Evaluate the results of both tests (If there is no problem, it means that the installation work was not done properly. If there is a problem, you can suspect a problem with the product itself.

3.2 Flange jointing and pressure test

3.2.1 Objectives

There are various standards for flanges, such as ANSI (ASTM, API), ISO (DIN, BS), and JIS, and the dimensions, torque tightening force, etc. differ depending on the standard and pressure resistance. However, there are cases where staff do not have a sufficient understanding of these standards and are using improper flanges.

Therefore, the <u>Objectives are to understand the following.</u>

<u>1) Differences in dimensions according to standards</u>

<u>2) Points to keep in mind in assembling</u>

3.2.2 Materials

<u>From WASA's stock</u>:

Flange tube (PN6, PN10, PN16)

<u>To be purchased</u>:

Torque Wrench

Restraint Joint

Blind flange for pressure testing

Teflon sealing tape

Measure

3.2.3 Methods

(1) Prepare samples of three types of existing DN100 flanges (PN6 and PN10) for ISO, ANSI, and JIS.

(2) Have the staff look at the dimension tables of the standards and determine which sample fits which standard.

(3) Prepare connection materials (bolts) that are compatible with the three types of flanges, have the staff select a bolt from among them, and have them connect the flanges using it.

(4) The instructor gives a review of the connection work done by each staff member.

(5) After disassembling the connected flanges, use a torque wrench to control the torque and tighten them in the recommended order.

3.3 HDPE Fusion《conducted in 2nd year if we have time to spare, otherwise in 3rd year》

3.3.1 Objectives

HDPE pipes are mainly used in small-diameter pipes in water distribution systems and also in large-diameter (1m) pipes in sewage systems. While Butt fusion, which is usually applied in pipe joining, is simple in terms of mechanism, there is cases, it can't be achieved to fuse the pipes properly according to the specified parameters. The existence of such a problem may not be recognized except operator of fusion machine.

Therefore, <u>the Objectives of this section are to understand the following.</u>

<u>1) Fusion parmeters defined by standard like ISO</u>

<u>2) Relationship between the manufacturer's recommended values and the values in the standard.</u>

<u>3) Methods to verify the fusion quality.</u>

3.3.2 Materials

<u>From WASA's stock</u>

HDPE pipe of OD125 or OD110 (pressure resistance: PN10 (SDR17), PN16 (SDR11))

<u>To be purchased:</u>

Infrared temperature meter,
Welding gauge,
Fusion machine for HDPE (OD100 to OD250),
Generator 10kVA (depending on capacity of fusion splicer)
Tools: White pen (eraser)

3.3.3 Methods

(1) Prepare HDPE pipes (pressure resistance: PN10 and PN16, length: 0.5 m long and 6 m or more, total 4 types).
(2) Explain the fusion curve of the ISO standard.
(3) Compare the manufacturer's recommended setting values with the ISO values.
(4) To make the staff understand the principle of setting the fusion pressure.
(5) To perform two types of fusion welding, high pressure and low pressure.
(6) Evaluate the finished product. (Bead size, left-right balance, internal bead)

3.4 Others

In addition, lectures on flange adapters, dismantle joints, mechanical joints, and breakaway prevention joints are also available upon request, as long as they are classroom lectures that do not require the purchase of materials.

Annex 4.5.1 List of Sewer Cleaning Equipment at WASA Lahore

Sewer cleaning equipment in WASA Lahore.

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
1	Farrukhabad Sub Division	Muck Sucker MS-14	HINO	2002	2002	Working condition	-
2		Jetting Unit JU-09	ISUZU	2007	2007	Working condition	-
3		Jetting Unit JU-10	ISUZU	2006	2006	Working condition	-
4		Tractor Trolley	JHON-DEER	2007	2007	Working condition	-
5		Back Hoe	Fiat	2007	2007	Out Of order	Rs. 300,000 and 15-Days required
7		Loader Rickshaw	Super Asia	2018	2018	Poor	-
1	Shahdara	Muck Sucker	HINO	2009	2009	Good	Minor Repair & Suction Pipe etc Rs 290000.00 and 15 days required
2		Jetting Machine	ISUZU	2009	2009	Good	Minor Repair & Presure Pipe etc Rs 260000.00 and 15 days required
3		Water Bouzer	HINO	2007	2007	Poor	Back Engine and Pipe Required Rs 190000.00 and 07 days required
4		Tractor Trolley	John Deere	2008	2008	Poor	Repair of Body and Tyres Required Rs 200000.00 and 15 days required
5		Loader Rikshaw	Super Asia	2018	2018	Ok	Tyre and Clurch plate and Body Repair Rs 45000.00 and 10 days required
1	Data Nagar Sub Division	Muck Sucker CMCU-1	HINO	2008	2008	Ok	-
2		Muck Sucker MS-17	HINO	2008	2008	Ok	-
3		Jetting Unit No. 11	ISUZU	2008	2008	Ok	-
4		Jetting JU-17	ISUZU	2009	2009	Ok	-
5		Water Bouzer	HINO	2009	2009	Ok	-
6		Tractor Trolley NH-15	FIAT	2009	2009	Ok	-
7		Loader Rickshaw	Super Asia	2018	2018	Ok	-
1		Jetting Machine	ISUZU	2009	2009	Out of order	Rs 2 to 3 lacs minimum 15 days required
2		Muck Sucker	ISUZU	2002	2002	Ok	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
3	Misri Shah	Tractor Trolly	MESSEY FERGUSON	2001	2001	Ok	Minor Repair required 50 to 70 thousand rupees minimum 7 days required
4		Water Bowzer	HINO	2007	2007	Ok	
1	City	Muck Sucker	HINO	2009	2009	Ok	Minor Repair and Suction Pipe required Rs 230000.00 and 07 days required
2		Jetting Machine	ISUZU	2009	2009	Ok	Minor Repair & Presure Pipe Rs 260000.00 and 15 days required
3		Crane	NISSAN	2011	2011	Ok	Hydraulic syatem and body repair Rs 385000.00 and 15 days required
4		Water Bouzer	HINO	2009	2009	Ok	Delivery Pipe required Rs 82000.00 and 02 days required
5		Tractor Trolley	John Deere	2008	2008	Ok	Denting Painting and Mechanical repair Rs 240000.00 and 15 days required
1		Hitachi Excavator	HITACHI	2005	2005	Ok	Hydraulic system and minor Mechanical repair 250000.00 and 10 days
2		Long Boom No. 03	KOMATSO	2009	2009	Ok	Hydraulic System and Mechanicaly repair Rs 400000.00 and 15 days required
3		Case Poclain No. 01	CASE	N/A	N/A	Out of Order	Tyres and Minor Repair Rs 385000.00 and 15 days required
4		Dump Truck LEJ-1229	HINO	2009	2009	Ok	_ _ _
5		Dump Truck LEJ-1230	HINO	2009	2009	Ok	_ _ _
6		Dump Truck LEJ-1269	HINO	2009	2009	Ok	_ _ _
7		Dump Truck LEJ-1273	HINO	2009	2009	Ok	Denting and painting of body required 100000,00 and 07 days
8		Dump Truck LEJ-1274	HINO	2009	2009	Ok	_ _ _

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
9	Drainage Ravi Town	Dump Truck LEJ-1281	HINO	2009	2009	Ok	Denting and painting of body required Rs 200000.00 and 07 days required
10		Dump Truck LEJ-1283	HINO	2009	2009	Ok	_ _ _
11		Dump Truck LWC-5841	ISUZU	2005	2005	Out of Order	Denting and painting of body required Rs 300000.00 and 10 days required
12		Clam Shell Back Hoe LRT-5518	FIAT	2002	2002	Ok	Minor Repair Rs. 200000.00 and 07 days required
13		Back Hoe LRT-5523	FIAT	2002	2002	Ok	Minor Mechanicaly Repair Rs. 150000.00 amd 07 days required
14		Tractor Trolley TT-05	MASSEY FERGUSON	1998	1998	Ok	_ _ _
15		Front End Loader Trolley LOT-7920	MASSEY FERGUSON	1991	1991	Out of Order	Rs. 200000.00 and 07 days required
16		Front End Loader LEG-1017	MASSEY FERGUSON	1995	1995	Ok	Mechanicaly Labour Rs. 100000.00 and 07 days reuired
1	**Garden Town Sub Division**	Muck Sucker MS-25	Hino	2009	2009	Ok	
2		Jetting Unit JU-25	Isuzu	2009	2009	Ok	
3		Isuzu Mazada -I	Isuzu	2007	2007	Ok	
4		Water Bouser WB-04	Hino 500	2008	2008	Ok	
5		Tractor Trolley LET-1319	Jan Dear 50-Hp	2008	2008	Ok	
1	**Kahna Sub Division**	Jetter JU-01-06	Maraj	2006	2006	Ok	
2		Sucker LZB-9741	Kissan	2004	2004	Ok	
1	**Green Town Sub Division**	Jetting LEJ- 1292	Hino	2007	2007	Ok	
2		Sucker MS-02	Hino	2009	2009	Ok	
3		Water Tanker WB-17	Hino	2009	2009	Ok	
4		Tractor Trolley LES-9634	Jan Dear	2007	2007	Ok	
1		Excavator Long boom No 6	Komatsu	2009	2009	Ok	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
2	**Drainage Sub Division Nishtar Town**	Excavator Long Boom No 7	Komatsu	2009	2009	Ok	
3		Excavator LWC 5520	Hitachi	2005	2005	Ok	
4		Dragline HC 77	Link Belt Speeder	1960	1960	Ok	
5		Dump Truck LEJ 1223	Hino	2009	2009	Ok	
6		Dump Truck LEJ 1233	Hino	2009	2009	Ok	
7		Dump Truck LEJ 1284	Hino	2009	2009	Ok	
8		Dump Truck LEJ 1285	Hino	2009	2009	Ok	
9		Dump Truck LEJ 1286	Hino	2009	2009	Ok	
10		Dump Truck LEJ 1287	Hino	2009	2009	Ok	
11		Dump Truck LWC 5849	Isuzu	2005	2005	Ok	
12		Back Hoe BHT-04	Messey 265	2005	2005	Ok	
13		Back Hoe LEJ 1464	Ghazi	2005	2005	Ok	
14		Back Hoe LRT 5514	Fait 640	2005	2005	Out of Order	15-Days required, 05 Lacs
15		Back Hoe NH 10	Ghazi	2005	2005	Ok	
16		Tractor Trolly LEJ 1451	Ghazi	2005	2005	Ok	
17		Tractor Trolly LEJ 1466	Ghazi	2005	2005	Ok	
18		Wheel Loader LWC 5517	Hitachi	2005	2005	Ok	
19		Dump Truck LWC 5868	Isuzu	2005	2005	Ok	
20		Dump Truck LWC 5869	Isuzu	2005	2005	Ok	
21		Dump Truck LWC 5840	Isuzu	2005	2005	Out of Order	01-Month required, **2.5 Million**
22		Dump Truck LWC 5844	Isuzu	2005	2005	Out of Order	01-Month required, **2.3 Million**
23		Dump Truck LWC 5867	Isuzu	2005	2005	Out of Order	01-Month required, **2.5 Million**
24		Dump Truck LWC 5873	Isuzu	2005	2005	Ok	
1		Jetting Unit JUK-01	Isuzu	2016	2016	OK	
2		Jetting Unit JUK-02	Isuzu	2016	2016	OK	
3		Sucker MSK-01	Isuzu	2016	2016	OK	
4		Sucker MSK-02	Isuzu	2016	2016	OK	
5		Sucker MSK-04	Hino	2009	2009	OK	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
6	Industrial Area Sub Division	Jetting Unit-02	Isuzu	2009	2009	OK	
7		Water Tanker LZK-2102	Hino	1998	1998	Out of Order	10-Days Required Rs.2.5 Lac
8		Tractor Trolley LXK-2707	Massey Ferguson-240	1998	1998	Ok	
9		MAZDA T-2200 LOT-5174	Mazda	1996	1996	Ok	
1	Township Sub Division	Sucker Machine	Hino	2008	2008	Ok	
2		Jetting Machine JU-23	Isuzu	2008	2008	Ok	
3		Jetting Machine JU-1	Isuzu	2005	2005	Ok	
4		Water Bouzer WB-07	Hino	2008	2008	Out of Order	20 days required Rs. 03 Lac
5		Tractor Trolly LES-2656	Jon Deer	2008	2008	Ok	
1	Shadipura Subdivision	Jetting Unit No. LXC-9583	ISUZU	1997	1997	Ok	Machinery is very old, replacement/New required, if agreed
2		Muck Suker No. LOK-1802	ISUZU	1991	1991	Ok	Machinery is very old, replacement/New required, if agreed
3		T. Trolley No. LWN-2205	Massey Ferguson	2006	2006	Ok	
1	Fatehgarh Sub Division	Jetting Unit No. JU06-AWT	ISUZU	2009	2009	Ok	
2		Muck Suker No. MS07-AWT	HINO	2009	2009	Ok	
3		T. Trolly No. LES-2657	John Deere	2008	2008	Out of Order	Rs. 0.500 Million approx. 10 Days Major Repair Work Required
4		Water Tanker No. WB # 03	ISUZU	2006	2006	Out of Order	Rs. 1.00 Million approx. 20 Days Major Repair Work Required
1	Tajpura Sub	Sucker Machine No.MS-22	HINO	2009	2009	Ok	
2		Jetting Machine No.JU.19	ISUZU	2009	2009	Ok	

S.No.	Sub-Divisional Office Division	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
3		Water Bouzer No.01	HINO	2006	2006	Out of Order	Rs. 1.00 Million approx. 20 Days Major Repair Work Required
4		Tractor Trolly No.LES.9629	JOHAN DERE	2008	2008	Ok	
1	Mustafabad Sub Division	Muck Sucker No.LEJ.1502	Hino	2009	2009	Ok	Machinery is very old, replacement/New required, if agreed
2		Jetter Machine No.LXP.3641	ISUZU	2000	2000	Ok	Machinery is very old, replacement/New required, if agreed
3		Tractor Trolly No.LES.2667	Johndeer-720	2008	2008	Ok	
1	Drainage Sub Division Aziz Bhatti & Wahga Town	Clamshell Excavator CS-01	Komatsu	2009	2009	Ok	…..
2		Long Boom Excavator no 4	Komatsu	2009	2009	Ok	
3		Dump Truck No. LEJ-1224	Hino	2009	2009	Ok	…..
4		Dump Truck No. LEJ-1225	Hino	2009	2009	Ok	…..
5		Dump Truck No. LEJ-1226	Hino	2009	2009	Ok	…..
6		Dump Truck No. LEJ-1228	Hino	2009	2009	Ok	…..
7		Dump Truck No. LEJ-1268	Hino	2009	2009	Ok	…..
8		Dump Truck No. LEJ-1277	Hino	2009	2009	Ok	…..
9		Dump Truck No. LEJ-1288	Hino	2009	2009	Ok	
10		Prime mover LEJ 1433	Kamaz	2009	2009	Ok	…..
11		F.E. Loader LEJ 1434	Messy Ferguson	2009	2009	Out of Order	Rs. 0.20 Million approx. 7 days Major Repair work required

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
12		T / Trolley No. 1	Messy Ferguson	2002	2009	Ok	…..
13		F.E.L TT NO 03	Messy Ferguson	2009	2009	Out of Order	Rs. 0.40 Million approx. 10 days Major Repair work Required
14		Tractor LRT 5524	Fiat Ghazi	2002	2002	Out of Order	Rs. 0.40 Million approx. 10 days Major Repair work Required
15		Clam shell Back Hoe LEJ-1461	Fiat Ghazi	2009	2009	Ok	…..
16		Back Hoe No. LRT-5513	Fiat	2002	2002	Out of Order	Sent to transport division for repair …..
1	**Islam Pura Sub Division**	Jetting Unit No. LEJ-1485	ISUZU	2009	2009	Ok	
2		Muck Suker No. LEJ-1425	HINO	2009	2009	Ok	
3		T. Trolley No. LRT-5516	FIAT	2004	2004	Ok	
4		Water Tanker No. WB-06	HINO	2009	2009	Ok	
5		Mazda No. LOT-4429	MAZDA	1996	1996	Ok	
1	**Gulshan-e-Ravi Sub Division**	Jetting Unit No. LEJ-1481	ISUZU	2009	2009	Ok	
2		Muck Suker No. LEJ-1503	HINO	2009	2009	Ok	
3		T. Trolly No. LES-2672	John Deere	2008	2008	Ok	
4		Water Tanker No. LXP-2803	HINO	1997	1997	Ok	
1	**Ravi Road Sub Division**	Jetter Machine No. JU-18	ISUZU	2009	2009	Ok	
2		Muck Sucker No. MS-23	Hino	2009	2009	Ok	
1	**Anarkali Sub**	Jetter Machine No. LEJ-1473	ISZU	2010	2010	Ok	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
2	Anarkali Sub Division	Muck SuckerNo.LEJ-1446	Hino	2009	2009	Ok	
3		Muck Sucker No.SS-04	Nisan	2006	2006	Ok	
1	Drainage Sub Division Gunj Buksh Town	Excavator No. LET-3440	Daewoo	2006	2006	Ok	…..
2		Dump Truck No. LEJ-1271	Hino	2009	2009	Ok	…..
3		Dump Truck No. LEJ-1272	Hino	2009	2009	Ok	…..
4		Dump Truck No. LEJ-1227	Hino	2009	2009	Ok	…..
5		Dump Truck No. LEJ-1276	Hino	2009	2009	Ok	…..
6		Dump Truck No. LEJ-1282	Hino	2009	2009	Ok	…..
7		Dump Truck No. LWC-5842	Isuzu	2005	2005	Ok	…..
8		Dump Truck No. LWC-5857	Isuzu	2005	2005	Out of Order	Rs. 1.00 Million approx. Major Repair Required
9		Dump Truck No. LWC-5847	Isuzu	2005	2005	Ok	…..
10		F.E. Loader No. No.03	Messy Ferguson	2009	2009	Ok	…..
11		T / Trolley No. LEJ-1455	Fiat Ghazi	2009	2009	Ok	…..
12		T / Trolley No. LEJ-1460	Fiat Ghazi	2009	2009	Out of Order	Rs. 0.60 Million approx. Major Repair Required
13		Tractor No. LEJ-1427	Messy Ferguson	2009	2009	Ok	…..
14		Back Hoe No. LEJ-1468	Fiat Ghazi	2009	2009	Ok	…..

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
15		Back Hoe No. LRT-5517	Fiat	2004	2004	Ok	…..
16		Tractor Loader No. LEG-2882	Messy Ferguson	2006	2006	Out of Order	Rs. 0.60 Million approx. Required Major Repair
1	**Gulberg**	Jetting Machine LEJ-1477	ISUZU	2009	2009	Ok	But need minor repair completion time 10-days Amount Rs. 2,50,000/-
2		Sucker Machine LEJ-1489	ISUZU	2014	2014	Ok	But need minor repair completion time 5-daysAmount Rs.3,00,000/-
3		Sucker Machine GS-02	HINO	2006	2006	Out of Order	Amount Rs. 5,00,000/- Complition Time 20-days
4		Water Bowzer GT-I	HINO	2007	2007	Ok	But need minor repair completion time 5-days Amount Rs. 1,50,000/-
5		Tractor Trolly LES-2654	JONDIOR	2008	2008	Ok	But need minor repair completion time 5-days Amount Rs. 2,00,000/-
6		Tuk Tuk Riskshaw	SUPER ASIA	2018	2018	Ok	But need minor repair completion time 1-days Amount Rs. 25000/-
1	**Mozang**	Jetting Machine	SEZO	2009	2009	Ok	---
2		Mug Sucker	HINO	2009	2009	Ok	---
3		Water Tanker	HINO	2009	2009	Ok	---
4		Tractor Trolly	JOHNDEAR	2008	2008	Ok	---
1	**Shimla Hill**	Jetter Machine LEJ-1484	ISUZU	2009	2009	Ok	---
2		Sucker Machine LEJ-1504	HINO	2009	2009	Ok	---

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
3		Tractor LXP-2885	MASSEY FERGUSON	2000	2000	Ok	---
1	Drainage Sub Division Gulberg Town	Excavator No. LWC-5519	HITACHI	2005	2005	Ok	---
2		Dump Truck No. LEJ-1275	HINO	2009	2009	Ok	---
3		Dump Truck No. LWC-5862	ISUZU	2005	2005	Ok	---
4		Dump Truck No. LWC-5860	ISUZU	2005	2005	Ok	---
5		Dump Truck No. LWC-5864	ISUZU	2005	2005	Out of Order	Repair Cost Rs.10,00000/- PKR. Completion Time 30-Days
6		Dump Truck No. LWC-5846	ISUZU	2005	2005	Ok	---
7		Dump Truck No. LWC-5863	ISUZU	2005	2005	Ok	---
8		Dump Truck No. LWC-5854	ISUZU	2005	2005	Ok	---
9		Dump Truck No. LWC-5866	ISUZU	2005	2005	Out of Order	Repair Cost Rs.1,000,00/- PKR. Completion Time 25-Days
10		Back Hoe No. LEJ-1459	GHAZI	2009	2009	Out of Order	Repair Cost Rs.400,000/- PKR. Completion Time 15-Days
11		Tractor Trolley No. LEJ-1467	GHAZI	2009	2009	Out of Order	Repair Cost Rs.500,000/- PKR. Completion Time 15-Days
12		Loader No. L-02	MASSEY FERGUSON	2009	2009	Out of Order	Repair Cost Rs.200,000/- PKR. Completion Time 15-Days
1	Johar Town sub division	Jetter	Isuzu	2009	2009	Ok	-
2		Jetter	Isuzu	2004	2004	Ok	-
3		Muck Sucker	Hino	2009	2009	Ok	-
4		Muck Sucker	Isuzu	2004	2004	Ok	-
5		Water Bouzer	Hino	2007	2007	Ok	-
6		Tractor Trolley	John Deere	2008	2008	Ok	-

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
7		Back Hoe	Al ghazi	2005	2005	Ok	-
8		Loader	United	2018	2018	Ok	-
1	**LDA Avenue**	Muck Sucker	Hino Pak/ Kissan Engg.	2009	2009	Ok	-
2		Tractor Trolley	Ghazi	2014	2014	Ok	-
1	**Jubilee Town Sub division**	Jetter	Isuzu	2009	2009	Ok	-
1	**Baghbanpura**	Water Bowser	HINO	2009	2009	Ok	
2		Jetting Machine	ISUZU	2009	2009	Ok	
3		Muck Sucker	HINO	2009	2009	Ok	
4		Tactor Trolley	JHON-DEAR	2008	2008	Out of Order	Requirement of spare parts for functional of tractor trolly already submittedto Transport Division
5		Loader Rickshaw Tuk Tuk	Super Asia	2018	2018	Ok	
1	**Mughalpura**	Jetting Machine	ISUZU	2009	2009	Ok	
2		Muck Sucker	ISUZU	1993	1993	Out of Order	Work in Progress for Repairing of Pump and Engine.
3		Tractor Trolly	JHON-DEAR	2008	2008	Working condition	
5		Loader Rickshaw	Super Asia	2018	2018	Working condition	
1	**Gujjar Pura**	Jetter Machine	HINO EURO	2008	2008	Working condition	
2		Sucker Machine	HINO	2009	2009	Working condition	
1	**Shadbagh**	SUCKER MACHINE LOK-1801	ISUZU	1991	1991	Working condition	
2		JATTER MACHINE LEJ-1449	ISUZU FTR	2009	2009	Out of Order	Work in progress for repairing of pump and engine
3		WATER BOOZER PMU-2	NISSHAN	2007	2007	Working condition	
4		CRANE LEJ-1443	NISSHAN	2006	2006	Working condition	
5		TRACTOR TROLLY LES-2659	JOHN DEER	2008	2008	Working condition	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
6		MOTOR CYCLE RICKSHAW	SUPER ASIA	2017	2008	Working condition	
1	**Sabzazar**	Muck Sucker	Hino FG1	2013	2013	Working condition	
2		Jetting Machine	Hino FG1	2013	2013	Working condition	
3		Water Tanker	Hino FG1	2013	2013	Working condition	
1	**A.I. Town**	Jetter Machine	Isuzu	2009	2009	Working condition	
2		Sucker Machine	Hino	2005	2005	Working condition	
3		Sucker Machine	Hino	2005	2005	Working condition	
4		Back Hoe	Fiat	2005	2005	Working condition	
5		Tractor Trolley	John Deer	2008	2008	Working condition	
6		Rickshaw	Super Asia	2018	2018	Working condition	
1	**Samanabad**	Tactor Trally	Millat	1996	1996	Working condition	
2		Muck Sucker	HINO	2013	2013	Working condition	
3		Jeter Machine	ISUZU	2013	2013	Working condition	
4		Tuk Tuk Riskshaw	SUPER ASIA	2018	2018	Working condition	
5		Water Tanker	Hino	1991	1991	Out of Order	
1	**Ichhra**	JETTER MACHINE	(ISUZU) FTR	2009	2009	Working condition	
2		MUCK SUCKER BIG	(HINO)	2009	2009	Working condition	
3		MUCK SUCKER SMALL	(ISUZU) NPR	2004	2004	Working condition	
4		TRACTOR TROLLY	(JOHN DEER)	2008	2008	Working condition	
5		WATER BOUZER	(HINO)	2010	2010	Working condition	
6		Loder Rickshaw	Super Asia	2017	2017	Working condition	
1	**Mustafa Town**	Jetting Machine	Nissan	2004	2004	Working condition	
1	**Dholanwal**	Jetting	Nissan Diesel	2005	2005	Working condition	
1	**Drainage Sub**	Excavator	Hitachi	2005	2005	Working condition	
2		Long Boom	Komatsu	2009	2009	Working condition	
3		Clamshell (Excavator)	Komatsu	2009	2009	Working condition	
4		Dump Truck	Hino	2009	2009	Working condition	
5		Dump Truck	Hino	2009	2009	Working condition	
6		Dump Truck	Hino	2009	2009	Working condition	
7		Dump Truck	Isuzu	2004	2004	Working condition	

S.No.	Sub-Divisional Office	Type of Equipment	Manufacturer	Model	Year of Manufactu	Condition of Vehicle	If malfunctioned,how much PKR and how many days ar required in
8	Drainage Sub Division Allama Iqbal Town	Dump Truck	Isuzu	2004	2004	Working condition	
9		Dump Truck	Isuzu	2004	2004	Working condition	
10		Dump Truck	Isuzu	2004	2004	Working condition	
11		Dump Truck	Isuzu	2004	2004	Working condition	
12		Wheel Loader	Hitachi	2004	2004	Working condition	
13		Tractor Trolley	Ghazi	2014	2014	Working condition	
14		Back Hoe Tractor	Ghazi	2007	2007	Working condition	
15		Back Hoe Tractor	Fiat	2005	2005	Working condition	
16		Back Hoe Tractor	Ghazi	2007	2007	Out of Order	Rs. 300,000 and 15-Days required

Annex 4.5.2 List of Sewer Cleaning Equipment at WASA Faisalabad

Sewer cleaning equipment in WASA Faisalabad

Sr. No	Office	Type of equipment	Total	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	Parking yard and O&M (West)	Jetter Machine	4				All functional	Rs. 5 lac required for routine maintenance. (Time: One month)
2	Parking yard and O&M (West)	Sucker Machine	3				All functional	Rs. 10 lac required for routine maintenance. (Time: One month)
3	Parking yard and O&M (West)	Dumper Truck	7				4 functional, 3 non-functional	Rs. 15 lac required for routine maintenance. (Time: One month)
4	Parking yard and O&M (West)	Crane Cargo Truck	2				All functional	Rs. 5 lac required for routine maintenance. (Time: One month)
5	Parking yard and O&M (West)	JBC Excavator	2				2 non-functional	Rs. 10 lac required for routine maintenance. (Time: One month)
6	Parking yard and O&M (West)	Mini-I, II	2				All functional	Rs. 10 lac required for routine maintenance. (Time: One month)

7	Parking yard and O&M (West)	Fuel Bouser	1				Functional	Rs. 3 lac required for routine maintenance. (Time: One month)

Annex 4.5.3 List of Sewer Cleaning Equipment at WASA Multan

Sewer cleaning equipment in WASA Multan

Sr. No	Office	Type of equipment	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	H.P/G.T South WASA, Multan	Flusher HINO K	Hino	JO8CFM-14860	2004-05	in working Condition	
2	H.P/G.T South WASA, Multan	Sucker HINO K	Hino	14625	2004-05	in working Condition	
3	H.P/G.T South WASA, Multan	Flusher Mini II ISUZU	Isuzu	897147254	2004-05	in working Condition	
4	H.P/G.T South WASA, Multan	Flusher New HINO 500	Hino	JO8CFM24191	2012	in working Condition	
5	H.P/G.T South WASA, Multan	Flusher (Old) ISUZU	Isuzu	6HH1-B0118	2004	Replacement of Pump and overhauling required	2 million / 3 weeks
6	H.P/G.T South WASA, Multan	Flusher FTR ISUZU	Isuzu	6BGI-0198PS	1995	in working Condition	
7	H.P/G.T South WASA, Multan	Sucker (Old) FTR ISUZU	Isuzu	01807PS	1995	in working Condition	
8	H.P/G.T South WASA,	Sucker Mini I NPR	Isuzu	9971-47254	2004-05	in working	

	Multan	ISUZU				Condition	
9	W.A South WASA, Multan	Flusher Mini I		12378P	2004-05	in working Condition	
10	W.A South WASA, Multan	Sucker HINO K	Hino	24644	2012	in working Condition	
11	Qasimpur Sub division	Sucker Large	Hino	J08CFM-13430	2004-05	in working Condition	
12	Qasimpur Sub division	Flusher Large	Hino	J08CFM-13560	2004-05	in working Condition	
13	Mumtazabad Sub division	Flusher Mini II	Isuzu	02581P	2004-05	in working Condition	
14	Mumtazabad Sub division	Sucker Mini II	Isuzu	02568P	2004-05	in working Condition	
15	New Multan Sub division	Flusher Large	Hino	J08CFM-13562	2004-05	in working Condition	
16	New Multan Sub division	Sucker Large	Hino	J08CFM-13427	2004-05	in working Condition	
17	Sub Division Suraj Miani	Flusher	ISUZU		2007	In working but Poor condition	9.50 million / 4 weeks
18	Sub Division Suraj Miani	Sucker	HINO		2007	In working but Poor condition	10 million / 4 weeks
19	Sub Division Suraj Miani	Pickup	Suzuki		2009	In working but Poor condition	1.80 million / 4 weeks
20	Sub Division Gulgasht	Flusher	HINO		2007	In working but	9 million / 4 weeks

						Poor condition	
21	Sub Division Gulgasht	Sucker-I	HINO		1992	In working but Poor condition	10.5 million / 4 weeks
22	Sub Division Gulgasht	Sucker	ISUZU		2007	In working but Poor condition	11 million / 4 weeks
23	Sub Division Gulgasht	Toyota dala	Toyota		1992	In working but Poor condition	2 million / 4 weeks
24	Sub Division Eid Gah	Flusher	ISUZU		2007	In working but Poor condition	10 million / 4 weeks
25	Sub Division Eid Gah	Sucker	ISUZU		2007	In working but Poor condition	11 million / 4 weeks
26	Sub Division Eid Gah	Pickup	Suzuki		2009	In working but Poor condition	1.80 million / 4 weeks

Annex 4.5.4 List of Sewer Cleaning Equipment at WASA Gujranwala

Sewer cleaning equipment in WASA Gujranwala

Sr. No	Office	Type of equipment	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	Zone III (Model Town)	Jetting Machine (Heavy Duty)	NISSAN	GAJ-52	2007	Working	
2	Zone III (Model Town)	Jetting Machine (Medium Duty)	HINO	GAJ-54	2007	Working	
3	Zone III (Model Town)	Mobile 3 Cusec Pump (with Vehicle)	HINO(Vehicle), PERKIN		2007,2015	Working	
4	Zone III (Model Town)	Sucker Machine JICA (Heavy Duty)	MITSUBISHI	GAJ-26	2017	Working	
5	Zone III (Model Town)	Sucker Machine (Medium Duty)	HINO	GAJ-58	2007	Working	
6	Zone III (Model Town)	Dumper Truck	MITSUBISHI, FUSO	GAJ-24	2017	Working	
7	Zone III (Model Town)	Dumper Truck	MITSUBISHI, FUSO	GAJ-19	2017	Working	
8	Zone III (Model Town)	Excavator 200-W	HYUNDAI		2009	Working	

9	Zone III (Model Town)	De-Watering Set 5 Cusec (JICA)	PERKIN		2015	Working	
10	Zone III (Model Town)	De-Watering Set 3 Cusec (JICA)	PERKIN		2015	Working	
11	Zone III (Model Town)	De-Watering Set 3 Cusec (JICA)	PERKIN		2015	Working	
12	Zone III (Model Town)	De-Watering Set 16 HP	Golden Pumps		2011	Working	
13	Zone III (Model Town)	De-Watering Set 16 HP	Golden Pumps		2011	Working	
14	Zone III (Model Town)	De-Watering Set 16 HP	Golden Pumps		2011	Working	
15	Zone III (Model Town)	De-Watering Set 16 HP	Golden Pumps		2011	Working	
16	Zone III (Model Town)	De-Watering Set 16 HP	Golden Pumps		2011	Working	
17	Zone III (Model Town)	De-Watering Set 25 HP	Golden Pumps		2011	Working	
18	Zone III (Model Town)	De-Watering Set 34 HP	Golden Pumps		2011	Working	
19	Zone III (Model Town)	Jetting Machine (Heavy Duty)				Abundant	4 millions /3 Months

Sr. No	Office	Type of equipment	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	Zone II (Sheranwala Bagh)	Sucker Machine Heavy Duty	NISSAN DIESEL	GAJ-49	2007	Working	
2	Zone II (Sheranwala Bagh)	Sucker Machine Medium Duty	HINO DUTRO	GAJ-56	2007	Working	
3	Zone II (Sheranwala Bagh)	Jetting Machine Heavy Duty	NISSAN DIESEL	GAJ-51	2007	Working	
4	Zone II (Sheranwala Bagh)	Jetting Machine (JICA)	MITSUBISHI FUSO	GAJ-29	2015	Working	
5	Zone II (Sheranwala Bagh)	Sucker Machine (JICA)	MITSUBISHI FUSO	GAJ-27	2015	Working	
6	Zone II (Sheranwala Bagh)	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
7	Zone II	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	

	(Sheranwala Bagh)						
8	Zone II (Sheranwala Bagh)	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
9	Zone II (Sheranwala Bagh)	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
10	Zone II (Sheranwala Bagh)	Dewatering Set 16 HP	GOLDAMATIC		2003	Working	
11	Zone II (Sheranwala Bagh)	Dewatering Set 16 HP	GOLDAMATIC		2003	Working	
12	Zone II (Sheranwala Bagh)	Dewatering Set 25 HP	GOLDAMATIC		2007	Working	
13	Zone II (Sheranwala Bagh)	Dewatering Set 34 HP	GOLDAMATIC		2007	Working	
14	Zone II (Sheranwala Bagh)	Small Excavator	DOOSAN	NO:55	2006	Working	
15	Zone II	Mobile Pumping Set 3	Vehicle: HINO		2007,2015	Working	

	(Sheranwala Bagh	Cusec	DUTRO, Pump PERKIN				
16	Zone II (Sheranwala Bagh	Dewatering Set 3 Cusec (JICA)	PERKIN		2015	Working	
17	Zone II (Sheranwala Bagh	Dewatering Set 3 Cusec (JICA)	PERKIN		2015	Working	
18	Zone II (Sheranwala Bagh	Dumper Heavy Duty	MITSUBISHI FUSO	GAJ-34	2015	Working	
19	Zone II (Sheranwala Bagh	Mazda T-3500	MAZDA	GA6-5762	2000	Working	
20	Zone II (Sheranwala Bagh	Dumper	MITSUBISHI FUSO	GAJ-20	2015	Working	
21	Zone II (Sheranwala Bagh	JCB Clamshell/Excavator	JCB		2015	Working	

Sr. No	Office	Type of equipment	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	ZONE I Sector A (Liaqat Park)	Sucker Machine Medium Duty	HINO DUTRO	GAJ-59	2007	Working	
2	ZONE I Sector A (Liaqat Park)	Sucker Machine Heavy Duty (JICA)	MITSUBISHI FUSO	GAJ-25	2016	Working	
3	ZONE I Sector A (Liaqat Park)	Jetting Machine Heavy Duty	MITSUBISHI FUSO	FK 617H, GAJ-30	2016	Working	
4	ZONE I Sector A (Liaqat Park)	Excavator Heavy Duty	JCB	JCB-145	2016	Working	
5	ZONE I Sector A (Liaqat Park)	Dumper Truck 4-Ton	MITSUBISHI FUSO	GAJ-31	2016	Working	
6	ZONE I Sector A (Liaqat Park)	Dewatering Set 16 HP	GOLDAMATIC		2008	Working	
7	ZONE I Sector A (Liaqat Park)	Dewatering Set 16 HP	GOLDAMATIC		2008	Working	
8	ZONE I Sector A (Liaqat Park)	Dewatering Set 16 HP	GOLDAMATIC		2008	Working	
9	ZONE I Sector A (Liaqat Park)	Dewatering Set 25 HP	GOLDAMATIC		2008	Working	
10	ZONE I Sector A	Dewatering Set Auto	SYKES PRIMAX		2015	Working	

	(Liaqat Park)	Prime 3 Cusec (JICA)					
11	ZONE I Sector A (Liaqat Park)	Mobile Vehicle Dewatering Set 3 Cusec (JICA)	SYKES PRIMAX	CP150IC, GAJ-55	2015	Working	
12	ZONE I Sector A (Liaqat Park)	Dewatering Set Auto Prime 3 Cusec (JICA)	SYKES PRIMAX	CP150IC, GAJ-23	2015	Working	
13	ZONE I Sector A (Liaqat Park)	Dewatering Set Auto Prime 5 Cusec (JICA)	SYKES PRIMAX	CP150IC	2015	Working	

Sr. No	Office	Type of equipment	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	ZONE I Sector B	Sucker Machine Heavy Duty	NISSAN DISSEL	GAJ-50(2015)	2007	Working	
2	ZONE I Sector B	Sucker Machine (JICA)	MITSUBISHI FUSO	GAJ-28(2017)	2015	Working	
3	ZONE I Sector B	Dump Truck 4-Ton	MITSUBISHI FUSO	GAJ-32(2017)	2015	Working	
4	ZONE I Sector B	Dewatering Set 34 HP	GOLDAMATIC		2007	Working	
5	ZONE I Sector B	Dewatering Set Auto Prime 3 Cusec (JICA)	PERKIN		2015	Working	
6	ZONE I Sector B	Mobile Vehicle Dewatering Set 3 Cusec (JICA)	Vehicle: HINO DUTRO, Pump: PERKIN	GAJ-44	2007, 2015	Working	
7	ZONE I Sector B	Dewatering Set Auto Prime 3 Cusec (JICA)	PERKIN		2015	Working	
8	ZONE I Sector B	Tractor	MILLAT	MF-260	2017	Working	
9	ZONE I Sector B	Jetting Machine Medium	HINO DUTRO	GAJ-57	2007	Working	

		(OLD)		(2015)			
10	ZONE I Sector B	Excavator JCB(JICA)	JCB	JCB-145/2	2015	Working	
11	ZONE I Sector B	Small Dumper Truck	MITSUBISHI FUSO	GAJ-21	2015	Working	
12	ZONE I Sector B	Suction Machine Medium (OLD)	HINO DUTRO	GAJ-59	2015	Working	
13	ZONE I Sector B	Suction Machine Heavy (JICA)	MITSUBISHI FUSO	GAJ-25(2017)	2015	Working	
14	ZONE I Sector B	Jetting Machine (JICA)	MITSUBISHI FUSO	GAJ-30(2017)	2015	Working	
15	ZONE I Sector B	Excavator JCB-145/1 (JICA)	MITSUBISHI FUSO	JCB-145(2017)	2015	Working	
16	ZONE I Sector B	Dump Truck 4-Ton	MITSUBISHI FUSO	GAJ-31(2017)	2015	Working	
17	ZONE I Sector B	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
18	ZONE I Sector B	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
19	ZONE I Sector B	Dewatering Set 16 HP	GOLDAMATIC		2007	Working	
20	ZONE I Sector B	Dewatering Set 25 HP	GOLDAMATIC		2007	Working	
21	ZONE I Sector B	Dewatering Set Auto Prime 3 Cusec (JICA)	PERKIN		2015	Working	

22	ZONE I Sector B	Mobile Vehicle Dewater Set 3 Cusec (JICA)	PERKIN	GAJ-55	2015	Working	
23	ZONE I Sector B	Mobile Dewatering set Auto Prime 3 Cusec (JICA)	PERKIN	GAJ-23	2015	Working	
24	ZONE I Sector B	Dewatering Set Auto Prime 5 Cusec (JICA)	PERKIN		2015	Working	

All sewerage and drainage cleaning equipment/Machines repair or maintain before monsoon season. So, all machineries are in working condition.

Annex 4.5.5 List of Sewer Cleaning Equipment at WASA Rawalpindi

Sewer cleaning equipment in WASA Rawalpindi

Sr. No	Office	Type of equipment	Total	Manufacturer	Model	Year of manufacture	Condition	If malfunctioned, how much PKR and how many days are required in minimum to be functioned
1	Liaqat Bagh Office	Jetter Machine	5				Working Condition	Equipment are recently repaired to be used during Monsoon, so no major work is required
2	Liaqat Bagh Office	Sucker Machine	6				Working Condition	
3	Liaqat Bagh Office	Dewatering Sets					Working Condition	
4	Liaqat Bagh Office	Tractor Sucker Machine	1				Working Condition	
5	Liaqat Bagh Office	Tractor Trolly	2				Working Condition	
6	Liaqat Bagh Office	Trolly Mounted Sewer Roding Machine	4				Working Condition	
7	Liaqat Bagh Office	Dewatering Sets	5				Working Condition	

Annex 4.5.6 Letters for Transferring Ownership of Equipment in Term 1

Date: October 15, 2021
Ref # JAT/JICA-Aljazari/032

Mr. Azhar Ali,
Principal Al-Jazari Academy,
Lahore.

Subject: **Transferring Ownership of Equipment**

Dear Mr. Ali,

JICA is transferring ownership of the equipment listed below to Al-Jazari Academy, Lahore. In the process, the following conditions between JICA and Al-Jazari Academy were agreed:

1) The equipment will be used exclusively for training activities related to the "Project for Improving the Capacity of WASAs in Punjab Province in Islamic Republic of Pakistan Phase 2"
2) After the project, Al-Jazari Academy will provide information (location, operation, condition, etc.) about the equipment at request.

Item No.	Description of Equipment	Quantity
1.	HP ProDesk 400 G7 Microtower PC Processor: Intel Core i5-10400 Processor, 2.9 GHz Base frequency, up to 4.3 GHz maximum turbo frequency with Intel Turbo Boost Technology, 12 MB cache, 6 cores, and 12 threads, Integrated Intel UHD Graphics 630 RAM: 16GB DDR-4 2666 MHz RAM Memory Storage: 256 GB SATA SSD + 1TB SATA Hard Drive Optical Drive: DVD-RW, OS DOS HP M24f Full HD IPS LED Monitor	15

佐藤 伸幸

NOBUYUKI SATO
Chief Advisor
(The Project for Improving the Capacity of WASAs in Punjab Province Phase 2)
Japan Techno Co Ltd
nsato@jat.co.jp

Equipment received as per above specifications and distributed to all five WASAs of Punjab.

20-7-2022.

Date: December 24, 2021
Ref # JAT/JICA-Aljazari/039

Mr. Abid Hussainy
The Principal,
Al-Jazari Academy,
Lahore.

Subject: **Transferring Ownership of Equipment**

Dear Mr. Hussainy,

JICA is transferring ownership of the equipment listed below to Al-Jazari Academy, Lahore. In the process, the following conditions between JICA and Al-Jazari Academy were agreed:

1) The equipment will be used exclusively for training activities related to the "Project for Improving the Capacity of WASAs in Punjab Province in Islamic Republic of Pakistan Phase 2"
2) After the project, Al-Jazari Academy will provide information (location, operation, condition, etc.) about the equipment at request.

Item No.	Description of Equipment	Quantity
1.	Sewer Inspection Camera	1 Unit

佐藤伸幸

NOBUYUKI SATO
Chief Advisor
(The Project for Improving the Capacity of WASAs in Punjab Province Phase 2)
Japan Techno Co Ltd
nsato@jat.co.jp

Received
15/7.

PRINCIPAL
Al-Jazari Water & Sanitation Academy

15/7/2022.

Date: February 03, 2022
Ref # JAT/JICA-Aljazari/040

Mr. Abid Hussainy
The Principal,
Al-Jazari Academy,
Lahore.

Subject: **Transferring Ownership of Equipment**

Dear Mr. Hussainy,

JICA is transferring ownership of the equipment listed below to Al-Jazari Academy, Lahore. In the process, the following conditions between JICA and Al-Jazari Academy were agreed:

1) The equipment will be used exclusively for training activities related to the "Project for Improving the Capacity of WASAs in Punjab Province in Islamic Republic of Pakistan Phase 2"
2) After the project, Al-Jazari Academy will provide information (location, operation, condition, etc.) about the equipment at request.

Item No.	Description of Equipment	Quantity
1.	Vibration Meter	6 Units

佐藤伸幸

NOBUYUKI SATO
Chief Advisor
(The Project for Improving the Capacity of WASAs in Punjab Province Phase 2)
Japan Techno Co Ltd
nsato@jat.co.jp

PRINCIPAL
Al-Jazari Water &
Sanitation Academy

5 will be transfered to
5 WASAs
15/7

15/7/2022

Annex 5.1.1 Outline of In-house Training for "O&M of Mechanical and Electrical Equipment" at 4 WASAs

In-house Training (Electrical Field)

From the results of the five WASA TNAs, a summary of the In-house Training on the four First Priorities is provided below.

Topic：No.1 Electrical Panels

Training Goal: Learn how to inspect electrical panels for the purpose of preventive maintenance.

⇒Understand the necessary tools and how to use them
Understand safety equipment and measures
Understand inspection methods and necessity

1)Preparations
⇒Inspection tools
Tester, clamp meter, megger, earth tester, electroscope,
screwdrivers of various sizes (+, -)
⇒Protective equipment
Insulated gloves (Rubber material or military gloves, etc.)
Protective helmet (If you have an electrical protective cap, that's better)
Basically, long sleeves, long pants and safety shoes should be worn (to prevent electric shock and injury).

2)Visit the work site with preparations

3)Safety measures
⇒Understanding of safety equipment, notices, and the dangers of electric shock

4)External inspection
⇒Check for rusting and damage to the panel, indicator lights (lamp test, etc.)

5)Internal inspection
⇒Check for any abnormalities in heat, sound, or smell. (Check the situation)
(Check if there are any problems with equipment, wiring, or grounding.

6)Confirmation of basic values
⇒Check and record the current value (A), voltage value (V), etc.
In order to make it stick, record it on the record sheet used in Phase 1, and manage it in Excel.

Topic：No.2 Wiring

Training Goal: Learn proper safety measures and wiring methods

⇒Understand the necessary tools and how to use them

Understand safety equipment and measures

Understand wiring methods and their necessity

1)Preparations

⇒Protective equipment (same as No.1)

⇒Tools for wiring (No.1 inspection tools, screwdrivers, pliers, etc.)

2)Safety measures

⇒general safety measures, installation of protective tubes, etc.

Check to make sure that no electricity is flowing by measuring insulation, etc.

3)Turn off the power to the circuit you are working on.

⇒If possible, turn off the main power supply in addition to the power supply to the area being worked on.

4)Wiring corresponding to the crisis to be connected

⇒When the length and the capacity of the pump increase, the wire size will increase.

5)Connect to the terminal securely.

6) Final check

⇒Check for wiring errors and forgotten postings

Topic：No.3 Energy audit

Training Goal: To measure and evaluate the current operating conditions mechanically and electrically, and to examine measures and improvements to reduce electricity costs. (to be done together with the mechanical field)

⇒To understand the necessary tools and how to use them

Understand safety equipment and measures

Understand the measurement method and necessity

Use and consider the data obtained

1)Preparations

⇒Protective equipment (same as No.1)

⇒Inspection tools (same as No.1, plus other items needed)

2)Confirmation of the measurement method

⇒Using the materials used in Phase 1

3)Safety measures (general safety measures, markings, protective equipment, etc.)

4)Measurement (A, V, etc.)

5)Data collection (A, V, etc.)

6)Summarize the data

7)Make a graph in Excel

8)☆Compare and discuss data

⇒Consider using inverters (individualized for Lahore only) and OHRs.

Topic：No.4 MCU

Training Goal: Learn about drawings and the importance of safeguards and data management

⇒To understand the necessary tools and how to use them

Understand safety equipment and measures

Understand the measurement method and necessity

Understand the role of each device

1)Learn about drawings

⇒Continuation of Phase 1 or upgrade

2)Preparations

⇒Inspection tools

3)Safety measures

⇒Protective equipment

4)Data measurement　A

5)Data measurement　V

6)Data measurement　Insulation resistance

7)Data measurement　ground resistance

8)Check function of protective devices

⇒Using materials from Phase 1

Outline of In-house Training (Mechanical Field)

Outline of In-house Training for the three first priority items which was selected based on the TNA results of five WASAs is shown below.

1. O&M of Pump (Tube Well and Disposal Station)

(1) Objective

To learn proper O&M method/procedure of pumps installed at tube well and disposal station as preventive maintenance activities.

(2) Training Method and Venue

Training method: Practical training at site, Venue: Tube well and disposal station

(3) Trainee

All technical staffs including operators

(4) Contents

1) Safety measures before and during O&M activities
2) Outline of instruments to be used and its directions for use (Vibration Meter, Clamp Meter, Insulation Meter)
3) Daily inspection based on the record sheet (discharge amount, discharge pressure, ampere, voltage, leakage amount at grand packing, abnormal sound, and vibration)
4) Periodic inspection based on the record sheet (vibration measurement, ampere/voltage measurement, insulation measurement)
5) Detailed method of maintenance and minor repair (replacement of oil, refilling grease, repair coating, adjustment of leakage amount at grand packing etc.)

2. Selection of Pump

(1) Objective

To understand how to select proper pump type and determine specifications which meet the actual installation and operation conditions for tube well and disposal station.

(2) Training Method and Venue

Training method: Lecture including exercise, Venue: WASA Office

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Proper pump type for tube well and disposal station
2) Parameters and specifications to be considered for pump selection
3) Calculation of important parameters such as discharge diameter, total head, and motor capacity for pump selection (exercise by using EXCEL)
4) Examples of defects and points to be considered/noted for pump selection and installation

3. Energy Audit (Saving Operation Cost)

(1) Objective

To check and evaluate the current operation condition of pump mechanically and electrically, and to consider measures based on the results for saving electricity cost.

(2) Training Method and Venue

Training method: Practical training at site, Venue: Tube well and disposal station

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Understanding of performance curve (Q-H curve)
2) Outline of instruments to be used and its directions for use (Ultrasonic Flow Meter, Clamp Meter, Power Analyzer)
3) Data measurement based on the record sheet
4) Check and analysis of the obtained data
5) Consideration and plan of measures/actions for saving electricity cost

Annex 5.1.2 Training Material: "Energy Audit" for ToT, Pilot In-house Training, and In-house Training (1st-3rd) at WASA Faisalabad

Energy Audit
Tube well station

Training By:

Mr.Roohan Javaid
Director Water Resources, WASA Faisalabad

Importance of Energy Audit

- Minimize the energy cost
- Minimize the electricity losses
- Improve the O&M of machinery
- Improve the pump-motor operation

Parameters for Energy audit

- Basic information about machinery
- Flow Rate(Q)
- Discharge Pressure(P_d)
- Dynamic water level(h_d)

Equipment Required

Ultrasonic Flow Meter	
Pressure gauge (Digital, Analog)	 
Water level indicator(Rope type)	
Tool Box(Spanner set,Wrench,Teflon Tape ,etc.)	

Preparation for Site before Energy Audit

- **Can we Install Pressure Gauge?**

- **Location of point near discharge pipe, where pressure gauge can be installed.**

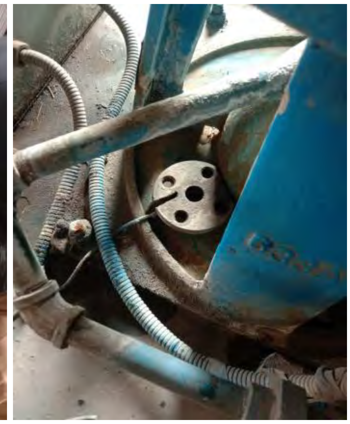
Preparation for Site before Energy Audit

- **Can we Install ultrasonic flow meter?**

Energy Audit Activity

- check water level?





- Measuring dynamic level(Hd) with Water level meter.

Energy Audit Activity

- Install pressure gauge and check Discharge Pressure(P_d)
- We can check pressure in Mpa,Bar,Psi etc.


Energy Audit Activity

- Install Ultrasonic flow meter and check Flow Rate(Q)



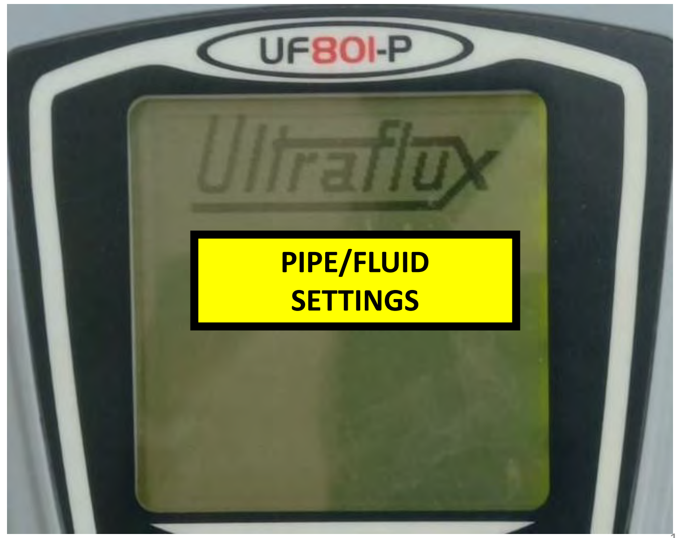

- On Tube well if we have bulk flow meter than we can take reading from their and compare reading of ultrasonic flow meter and bulk flow meter.


Use of Ultrasonic Flow Meter

- **After switching ON the ultrasonic flow meter press "F" button.**

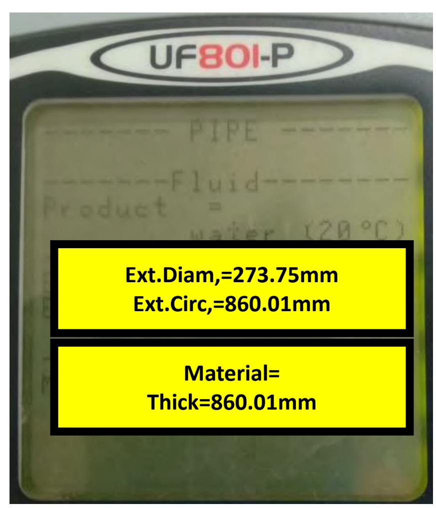
Use of Ultrasonic Flow Meter

- Again Press **"F"** its showing pipe fluid setting.



Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.



- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

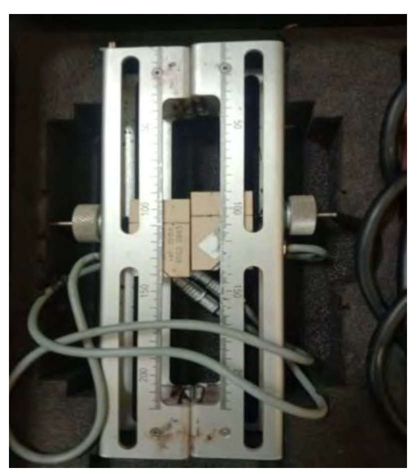
Use of Ultrasonic Flow Meter

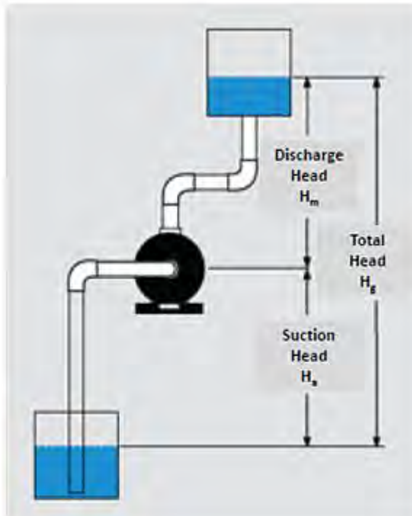
- **Press and hold "F"** **and its show probe distance and type of probes.**

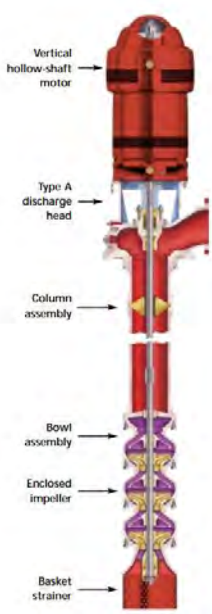
- **Flow rate in m3/hr will be shown.**

Use of Ultrasonic Flow Meter

- **Probes**
- For upto 100mm, use single probe, for more than 100mm, use double probe.




Discharge
Head
H_m
Total
Head
H_g
Suction
Head
H_s


Vertical
hollow-shaft
motor
Type A
discharge
head
Column
assembly
Bowl
assembly
Enclosed
impeller
Basket
strainer


shutterstock

Basic Information			
Date		Time	
Target Equipment Name			
Location			
Date of Installation			
Pump Details	Manufacturer:	Model/Type:	
	Design Capacity: cusec	Design Head: m	
Motor Details	Manufacturer:	Model/Type:	
	Frequency: Hz	Rated Output: kW	
	Rated Voltage: V	Rated Ampere: A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. **($P_d \times 10.197 + h_d$)**
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Power Consumption	kWh/day		Read the watt-hour meter in case that it is installed.
9	Operation Time	hour/day		Check the record book.
10	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

Findings & Comments:

Conducted by: Checked/Approved by:

Formulas for Energy Audit

- **1 bar=10 meter**
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=m^3/hr,**
- **1 cusec=102 m^3/hr**
- **1 m^3/min = 60 m^3/hr (Bulk Flow meter)**
- **H_{Total}=P_dx10.197+hd**
- **Lw=**Available Energy (output)
- **Lw =** $\frac{\rho \times g \times Q \times H}{60 \times 1,000}$
- **Pump Efficiency,ηp =**Lw /L × 100
- **L=**Shaft Power (input)

Analysis after Audit Parameters

- **1. Definition**

Pump Efficiency (ηp) is the ratio of Liquid Power to Shaft Power.

Pump Efficiency,ηp = Lw /L × 100

Liquid Power (Lw) is the available energy of pump which is given to liquid per unit time.

Lw = $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000}$ =1000x10x3.4x34/60x1000 =19.26Kw

ρ : Liquid Density (kg/m3)

g : Gravity Acceleration (m/s2)

Q: Discharge Quantity (m3/min)

H: Total Head (m)

Shaft Power (L) is the power which is transmitted to pump shaft by electrical motor.

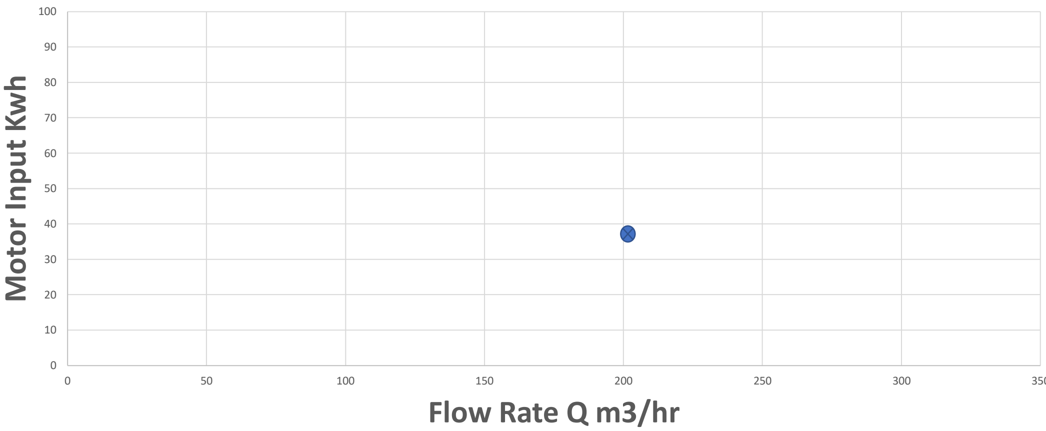
Finding and Analysis

- **At JBC(Jhal Branch Canal) TW 18 Site:**
- **Design head 132.874 feet** 40.50 meter
- calculated head Static 6.6 meter
- Calculated head dynamic 11.90 meter
- Pressure P 2.2 bar, 0.22 Mpa
- Total =

$H_{Total=}P_d x10.197+hd$

Head, H = 34 meter

- **Design Discharge flow rate** 2 Cusec(204 m3/hr)
- Ultrasonic flow meter reading 172 m3/hr (average)



KSB

The Expansion Project for Improvement of Water Supply System in Faisalabad

Tubewell # 18
Project: CSZ-2061
Doc #: KSB-TC-PR-061/018 (R1)

PUMP ANALYSIS REPORT

Specified Items	Density	Capacity	Driver power	Speed
	1000.00 kg/m3	200 M³/hr	37 kw	1475 rpm

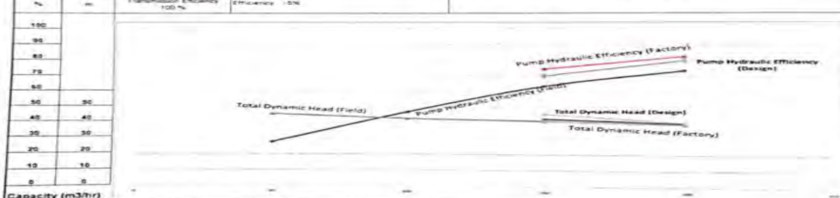
Motor Items	Maker	LPK #	Out Put	Voltage	Current	Speed	Trans.
Attached	Siemens	91132547	37Kw	415 V	64.3 A	1475 rpm	Direct coupled

Reading	Speed	Capacity	Total Dynamic Head: Disch Head	[illegible]	Total Head Loss	Total Head Field	Total Dynamic Head (Factory)	Total Dynamic Head (Design)	Variance	Pump Hydraulic Power Output	Electric Motor (415V 50Hz): Current	Volts	Power input	Efficiency	Output	Pump Hydraulic Efficiency Field	Pump Hydraulic Efficiency Factory	Pump Hydraulic Efficiency Design	Variance
No	RPM	(m3/hr)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kW)	(A)	(V)	(kW)	(%)	(Kw)	(%)	(%)	(%)	(%)
1	1,468	50	36.18	9.45	0.14	45.77			0.000	6.2	38.6	422.3	25.2	91.5	22.5	27.70			
2	1,467	100	32.16	9.89	0.73	42.78			0.000	11.7	41.5	422.0	27.6	91.9	24.9	46.91			
3	1,462	150	29.15	10.34	1.66	41.15	42.5	45.6	-9.751	16.8	43.8	422.0	29.5	91.9	25.8	63.34	74.40	70.00	-9.51
4	1,461	200	25.13	11.02	2.97	39.12	39.9	40.39	-3.152	21.3	46.8	425.7	32.0	92.1	29.0	73.48	82.61	80.00	-8.15

Measuring Device: Flap Vane Flow Meter - DN200
Transmission Efficiency 100 %

Standard: ISO 9906
Tolerance Factor
Head ±5%
Flow ±8%
Efficiency -5%

Result:
Efficiency at rated flow is out of tolerance limit.
Field data needs to be measured again, to eliminate any reading error.



Flow	Noise Level	Vibration (mm/s): Motor DE Bearing E/W	Motor DE Bearing N/S	Motor NDE Bearing E/W	Motor NDE Bearing N/S	Pump Base	Temprature (°C): Motor Body	Bearing	Coupling	Humidity	Ambient Temp	Remarks
m³/h	dB									%	°C	
No Load	80	1.4	1	0.8	0.8	0						
50	78.6	1.3	1.3	1.8	1.3	0	39.3	38.4/37.3	38.7	20	34	
100	78.8	1.1	1.1	1.8	1.1	0	41.3	39.6/37.9	39.6	20	35	
150	79	1.1	1.1	1.4	1.6	0	42.7	39.9/38.7	40.1	20	35	
200	80	1.8	1.8	1.4	1.9	0	43.1	39.8/38.3	39.3	20	34.8	

Recommendation(s) for long term operation: Every mechanical parameter is quite normal. Vibration Level should be checked once a month for Two months for KSB Pumps

	Prepared by	Checked by	Approved by
Name	Kamran Abid	SHAHBAZ KHALID	Mamoon Rashid
Signature	[signature]	MSE [signature]	[signature]
Date	16-06-12	18-06-12	

How to improve condition?

- Energy
- Flow
- On time

Electrical Parameters for **Energy Audit**

Nauman Noor – Assistant Director (Water Resource)

Topics we'll cover

1. Activities before Energy Audit
2. Setting up Power Analyzer
3. Installation of Power Analyzer
4. Measurements by Power Analyzer
5. Site Introduction

1. **Before** energy audit (1/5)

- Site preparation
  - Site cleaning
  - Fix the intrusion paths

1. **Before** energy audit (2/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5			8		
3			6					

1. **Before** energy audit (3/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		4	Helmet		7	Post Stamp	
2	Tape		5	Shoes		8	Glasses	
3	Gloves		6	Vest				

1. **Before** energy audit (4/5)

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5					
3			6					

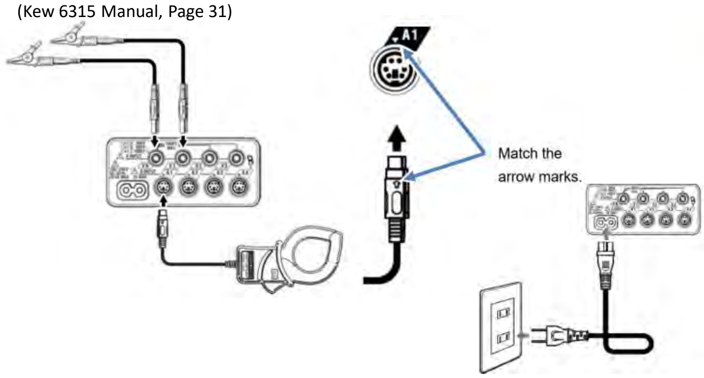
1. **Before** energy audit (5/5)

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Power Analyzer		4	Screw Driver Set		7	Insulation Tape	
2	Clamp meter		5	Voltage Tester				
3	Pliers		6	Wrench				

2. Setting up **Power Analyzer** (1/1)

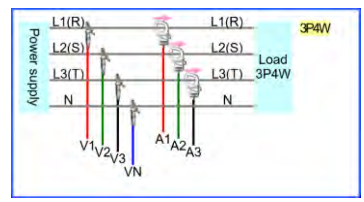
- Max rated voltage of supplied Power cord MODEL7169: AC125V
(Kew 6315 Manual, Page 31)



Power supply rating

Rating of power supply is as follows.

Rated supply voltage	100 to 240V AC (±10%)
Rated power supply frequency	45 to 65Hz
Max power consumption	7VA max



3. Installation of **Power Analyzer** (1/3)
(پاور اینالائزر کو لگانا)

- Cutoff the power by turning OFF circuit breaker (CB)
- Cross check the electricity continuity using clamp meter

سرکٹ بریکر کو آف کر کے بجلی کاٹ دیں۔

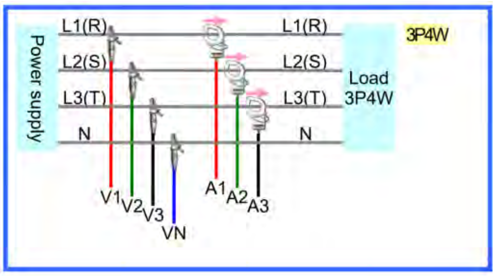
کلیمپ میٹر کا استعمال کرتے ہوئے بجلی کے تسلسل کو چیک کریں۔

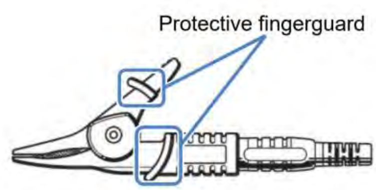
3. Installation of **Power Analyzer** (2/3)

(پاور اینالائزر کو لگانا)

- Install the voltage test leads and flexible clamp sensors on the secondary side of CB

سرکٹ بریکر کی سیکنڈری سائیڈ پر ٹیسٹ لیڈز کلیمپ سینسرز انسٹال کریں۔



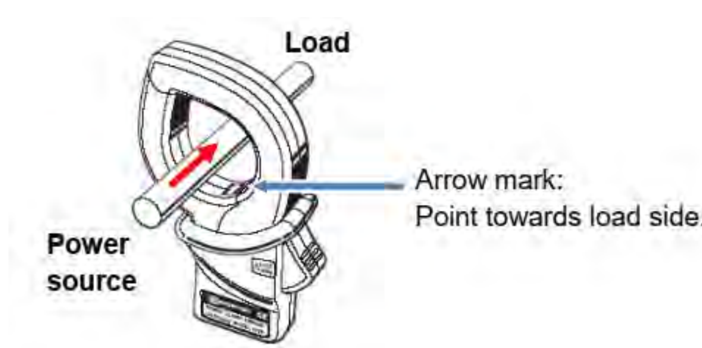


3. Installation of **Power Analyzer** (3/3)

(پاور اینالائزر کو لگانا)

(Note: don’t forget to follow the current direction as recommended)

نوٹ: تجویز کردہ کرنٹ کی سمت پر عمل کرنا نہ بھولیں



4. Measurements by **Power Analyzer** (1/3)

- Fill the given format

Energy Audit Form				
Basic Information				
Date		Time		
Target Equipment Name				
Location / Code				
Year of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity: cuse		Design Head: m	
Motor Details	Manufacturer:		Model/Type:	
	Frequency: Hz		Rated Output: kW	
	Rated Voltage: V		Rated Ampere: A	

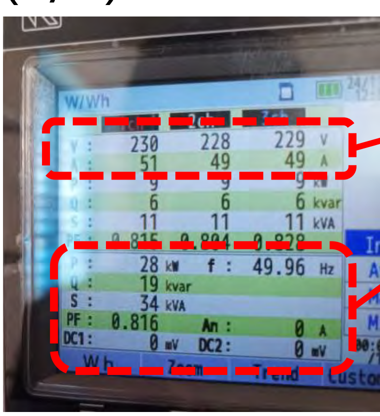
S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter or check the drawing. (between SWL to PG)
4	Total Head	m	0	To be calculated. ($P_d \times 10.19 + h_d$)
5	Voltage	V		Measure by power analyzer.
6	Ampere	A		Measure by power analyzer.
7	Power Factor	-		Measure by power analyzer.
8	Power	kW		Measure by power analyzer.
9	Operation Time	hour/day		Check the record book.
10	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

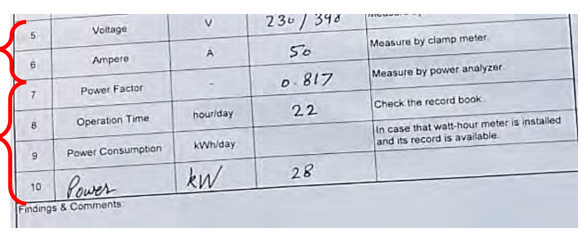
Findings & Comments:

Conducted by: Checked/Approved by:

5	Voltage	V		Measure by power analyzer.
6	Ampere	A		Measure by power analyzer.
7	Power Factor	-		Measure by power analyzer.
8	Power	kW		Measure by power analyzer.
9	Operation Time	hour/day		Check the record book.
10	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

4. Measurements by **Power Analyzer** (2/3)





5	Voltage	V	230 / 398	Measure by clamp meter.
6	Ampere	A	50	Measure by power analyzer.
7	Power Factor	-	0.817	Check the record book.
8	Operation Time	hour/day	22	In case that watt-hour meter is installed and its record is available.
9	Power Consumption	kWh/day		
10	Power	kW	28	

Findings & Comments:

(Get the Values)

(Fill the Form)

4. Measurements by **Power Analyzer** (3/3)

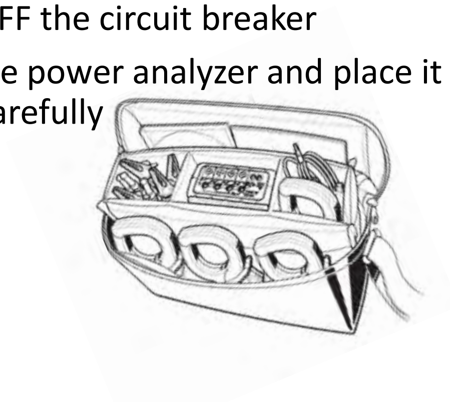
- Switch OFF the motor
- Stop recording on Power Analyzer
- Turn OFF the circuit breaker
- Remove power analyzer and place it back carefully

موٹر کو بند کریں

پاور اینالائزر پر ریکارڈنگ بند کریں۔

سرکٹ بریکر کو آف کردیں۔

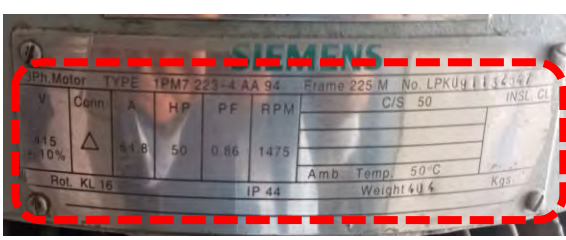
پاور اینالائزر کو ہٹائیں اور اسے احتیاط سے واپس رکھیں



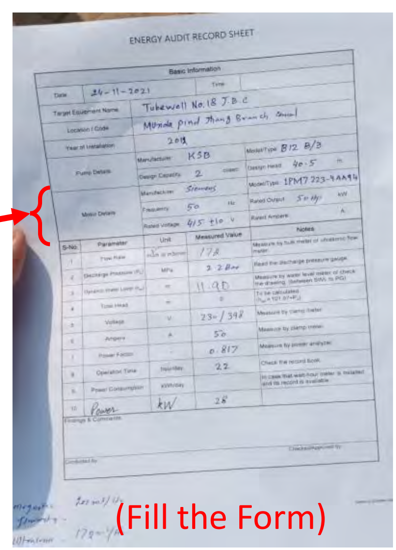
5. Site Introduction (1/3)

5. Site Introduction (2/3)

5. Site Introduction (3/3)



(Get the Values)


ENERGY AUDIT RECORD SHEET

Basic Information			
Date	24-11-2021	Time	
Target Equipment Name	Tubewell No.18 J.B.C		
Location / Code	Munda pind Jhang Branch Canal		
Year of Installation	201[illegible]		
Pump Details	Manufacturer KSB	Model/Type B12 B/3	
	Design Capacity 2 cusec	Design Head 40.5 m	
Motor Details	Manufacturer Siemens	Model/Type 1PM7 223-4AA94	
	Frequency 50 Hz	Rated Output 50 Hp kW	
	Rated Voltage 415 ±10 V	Rated Ampere A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	[illegible]	178	Measure by bulk meter or ultrasonic flow meter
2	Discharge Pressure	MPa	2.2 Bar	Read the discharge pressure gauge
3	Dynamic Water Level	m	11.90	Measure by water level meter or check the drawing (between SWL to PG)
4	Total Head	m	0	To be calculated
5	Voltage	V	230 / 398	Measure by clamp meter
6	Ampere	A	56	Measure by clamp meter
7	Power Factor	-	0.817	Measure by power analyzer
8	Operation Time	hour/day	22	Check the record book
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available
10	Power	kW	28	

Findings & Comments

Conducted By

Checked/Approved By

THANK YOU!!!

Let's go to the site!!!

Annex 5.1.3 Training Material: "Energy Audit" for In-house Training (4th-7th) at WASA Faisalabad

Energy Audit
Tube Well Station
03-06-2023

Training By:

1. Mr. Roohan Javaid
Director Water Resources, WASA Faisalabad
2. Mr. Muhammad Nauman Noor
Assistant Director Water Resources, WASA Faisalabad

Training **Goals**

- Evaluate the current operating condition of equipment and upgrade the site condition to:
  - Optimize the performance
  - Reduce the electricity cost

Skills YOU learn

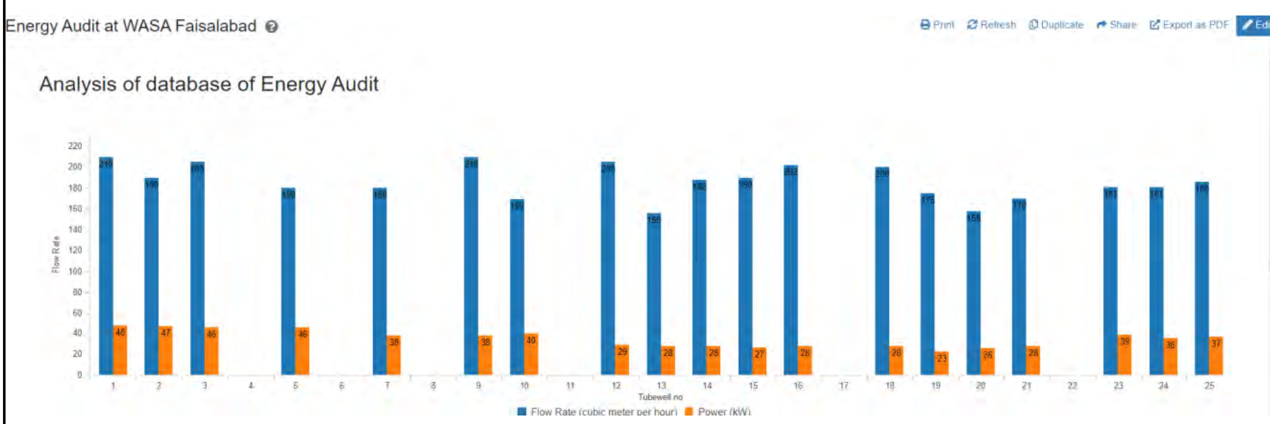
- Safety measures to work with electricity
- Use of equipment i.e. Power Analyzer, Ultrasonic flow meter, water level indicator and clamp meter etc.
- Tools and techniques to analyze data i.e. MS Excel and mWater

Topics we'll cover

1. Parameters for Energy Audit
2. Introduction of Equipment
3. Formulas and calculations
4. Site Introduction
5. Record keeping using mWater app.
6. Action Plan/ Implementation Plan

1. Parameters for Energy Audit

Data of Tube wells at JBC



Basic Information				
Date			Time	
Target Equipment Name				
Location				
Date of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity:	cusec	Design Head:	m
Motor Details	Manufacturer:		Model/Type:	
	Frequency:	Hz	Rated Output:	kW
	Rated Voltage:	V	Rated Ampere:	A

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. **($P_d \times 10.197 + H_d$)**
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Power Consumption	kWh/day		Read the watt-hour meter in case that it is installed.
9	Operation Time	hour/day		Check the record book.

Findings & Comments:

Conducted by: Checked/Approved by:

2. Introduction of Equipment

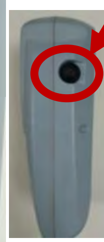
Equipment Required

Ultrasonic Flow Meter	
Pressure gauge (Digital, Analog)	
Water level indicator(Rope type)	
Power Analyzer	

Use of Ultrasonic Flow Meter

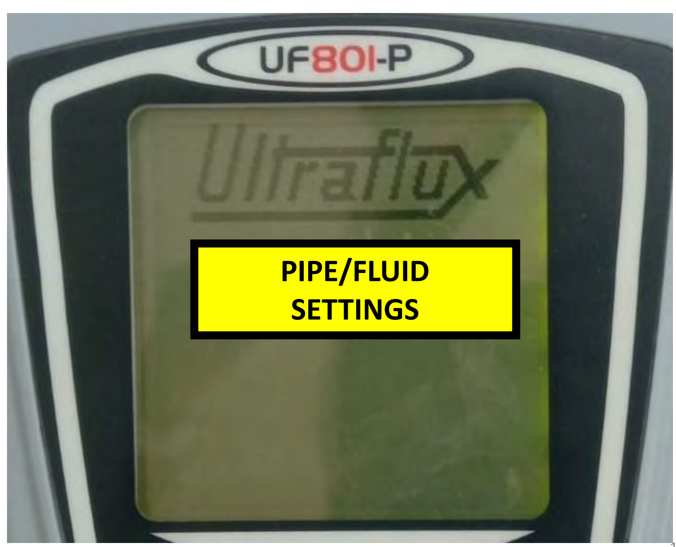
- After switching **ON** the ultrasonic flow meter press **“F”** button.

Press ON Button



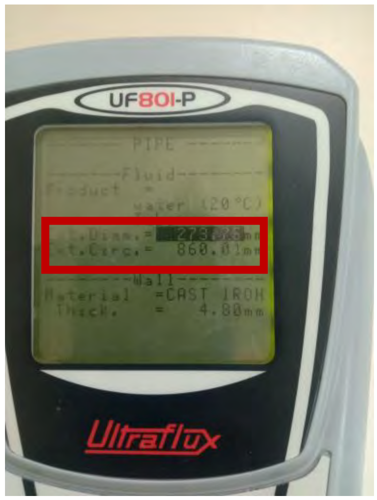
Use of Ultrasonic Flow Meter

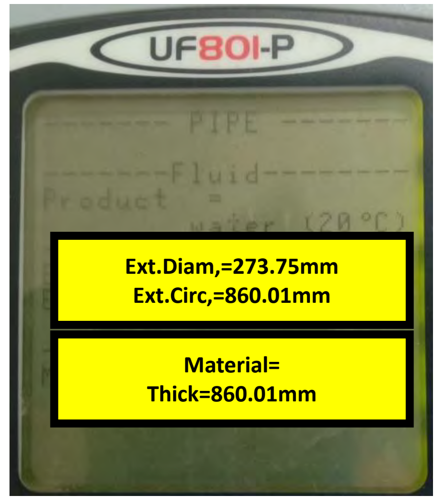
- Again Press **“F”** its showing pipe fluid setting.



Use of Ultrasonic Flow Meter

- **Press downward Key and check the parameters.**





- **Put the data circumference, material of pipe and thickness of pipe wall**

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

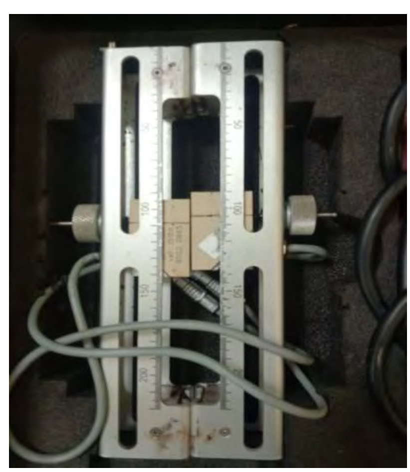
Use of Ultrasonic Flow Meter

- **Press and hold "F"** **and its show probe distance and type of probes.**

- **Flow rate in m3/hr will be shown.**

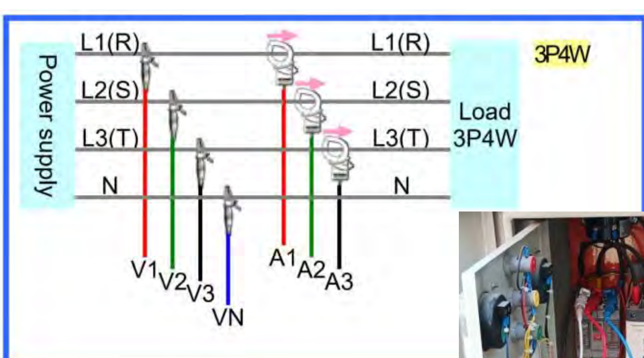
Use of Ultrasonic Flow Meter

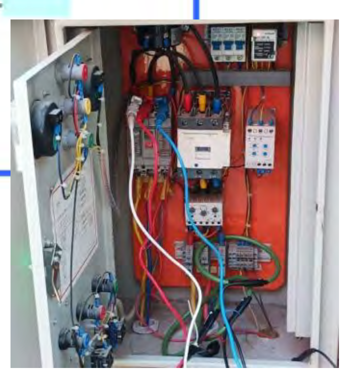
- **Probes**
- For upto 100mm, use single probe, for more than 100mm, use double probe.

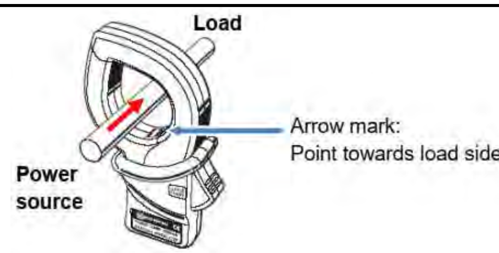


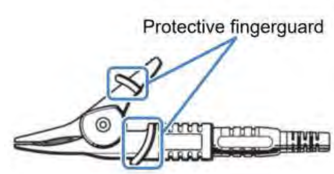
Electrical Power

- Use of Power Analyzer to measure
  - To measure 3 phase quantities
    - Voltage (V)
    - Current (A)
    - Power Factor
    - Power (KW,KVA,KVAR)
    - Energy (KWh)









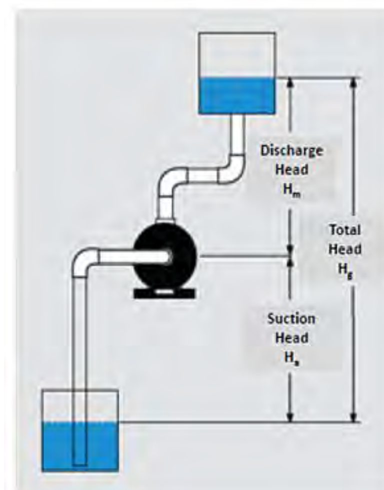
5	Voltage	V		Measure by power analyzer.
6	Ampere	A		Measure by power analyzer.
7	Power Factor	-		Measure by power analyzer.
8	Power	kW		Measure by power analyzer.
9	Operation Time	hour/day		Check the record book.
10	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

3. Formulas and calculations

Head Calculations

- Dynamic Head will be measured by Level indicator H_d .
- Discharge Head will be measured by Pressure Gauge in Bar P_d .

H_{Total}= P_dx10.197+ H_d



Formulas for Energy Audit

- **H_{Total}=** P_dx10.197+hd
- **1 bar=**10 meter
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=**m^3/hr,
- **1 cusec=**102 m^3/hr
- **1 m^3/min =** 60 m^3/hr (**Bulk Flow meter**)
- **Pump Efficiency,ηp =**Lw /L × 100
- **Lw =** $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000} = \frac{Q \times H}{6}$
- **Lw=**Available Energy (output)
- **L=**Shaft Power (input) or Electrical Power

Finding and Analysis

- **At JBC(Jhal Branch Canal) TW 18 Site:**
- H_{Total}=P_dx10.197+hd
- **Design head 132.874 feet** 40.50 meter
- calculated head Static 6.6 meter
- Calculated head dynamic 11.90 meter
- Discharge Head 2.2 bar, 0.22 Mpa
- Total calculated Head 34 meter

- **Design Discharge flow rate** 2 Cusec(204 m3/hr)
- Ultrasonic flow meter reading 172 m3/hr (average)

Analysis after Audit Parameters

- **1. Definition**

Pump Efficiency (ηp) is the ratio of Liquid Power (Ep) to Shaft Power (Em).

$$\eta p = Ep / Em \times 100$$

Liquid Power (Ep) is the available energy of pump which is given to liquid per unit time.

$$Ep = \frac{\rho \times g \times Q \times H}{60 \times 1{,}000}$$

ρ : Liquid Density (kg/m3)

g : Gravity Acceleration (m/s2)

Q: Discharge Quantity (m3/min)

H: Total Head (m)

Shaft Power (Em) is the power which is transmitted to pump shaft by electrical motor.

4. Site Introduction

Basic Information

Date			Time	
Target Equipment Name				
Location				
Date of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity:	cusec	Design Head:	m
Motor Details	Manufacturer:		Model/Type:	
	Frequency:	Hz	Rated Output:	kW
	Rated Voltage:	V	Rated Ampere:	A

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. (**$P_d \times 10.197 + H_d$**)
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Power Consumption	kWh/day		Read the watt-hour meter in case that it is installed.
9	Operation Time	hour/day		Check the record book.

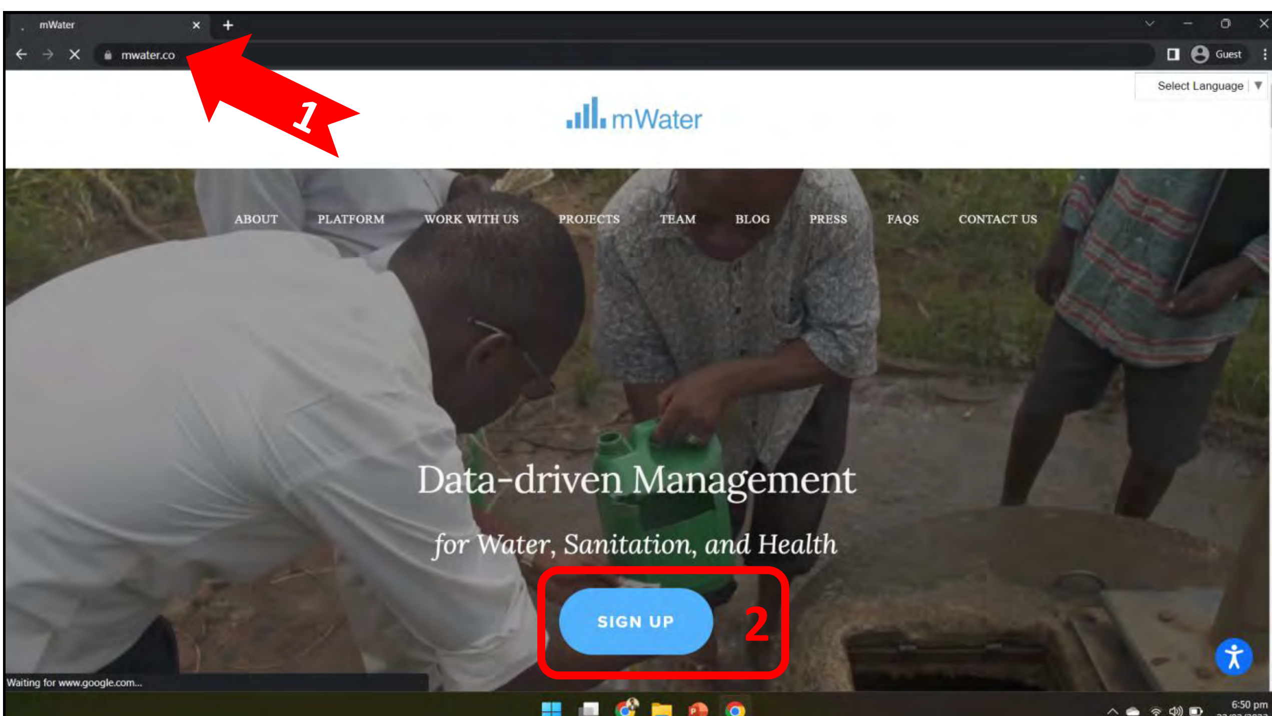
Findings & Comments:

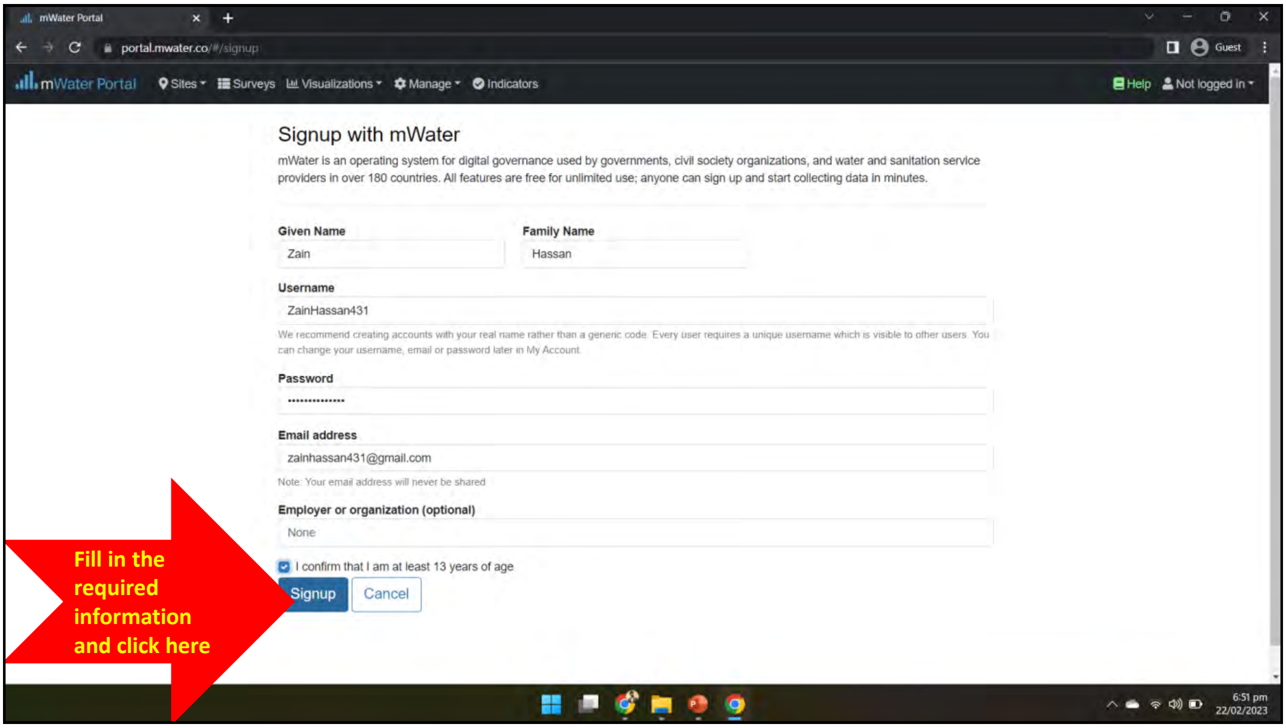
Conducted by: Checked/Approved by:

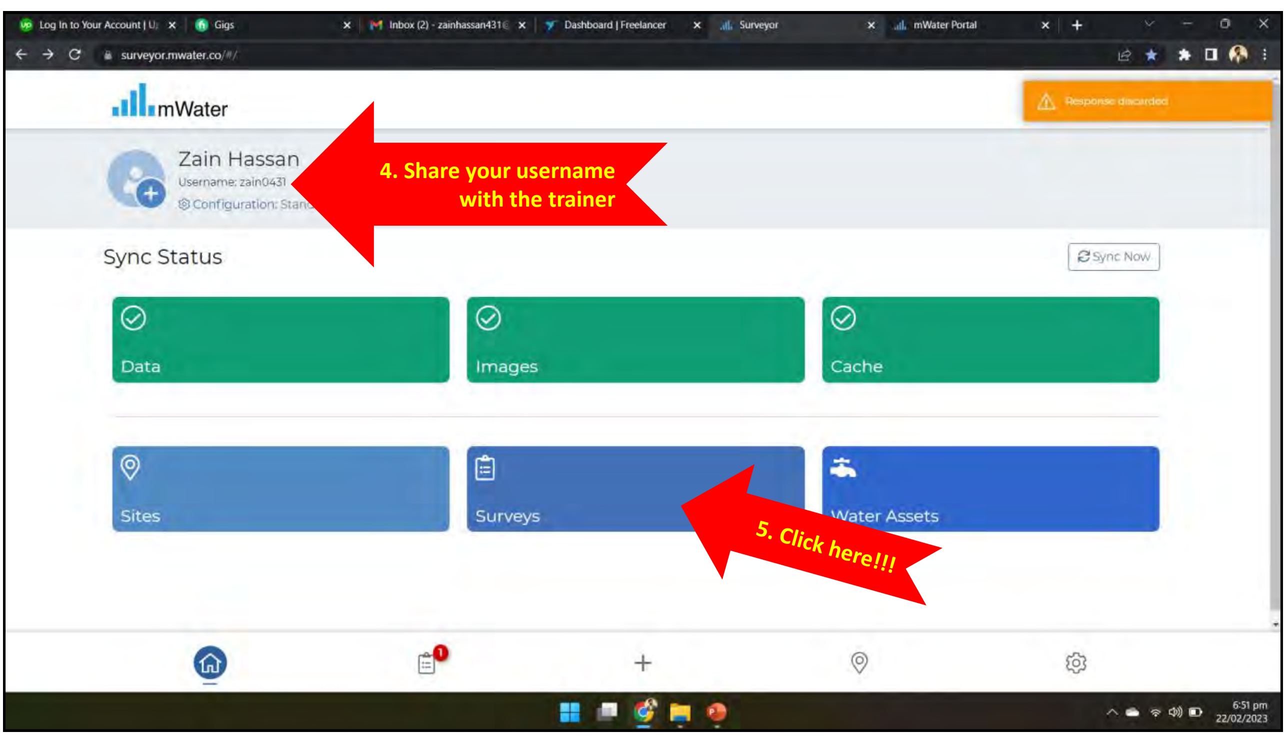
Preparation for Site before Energy Audit

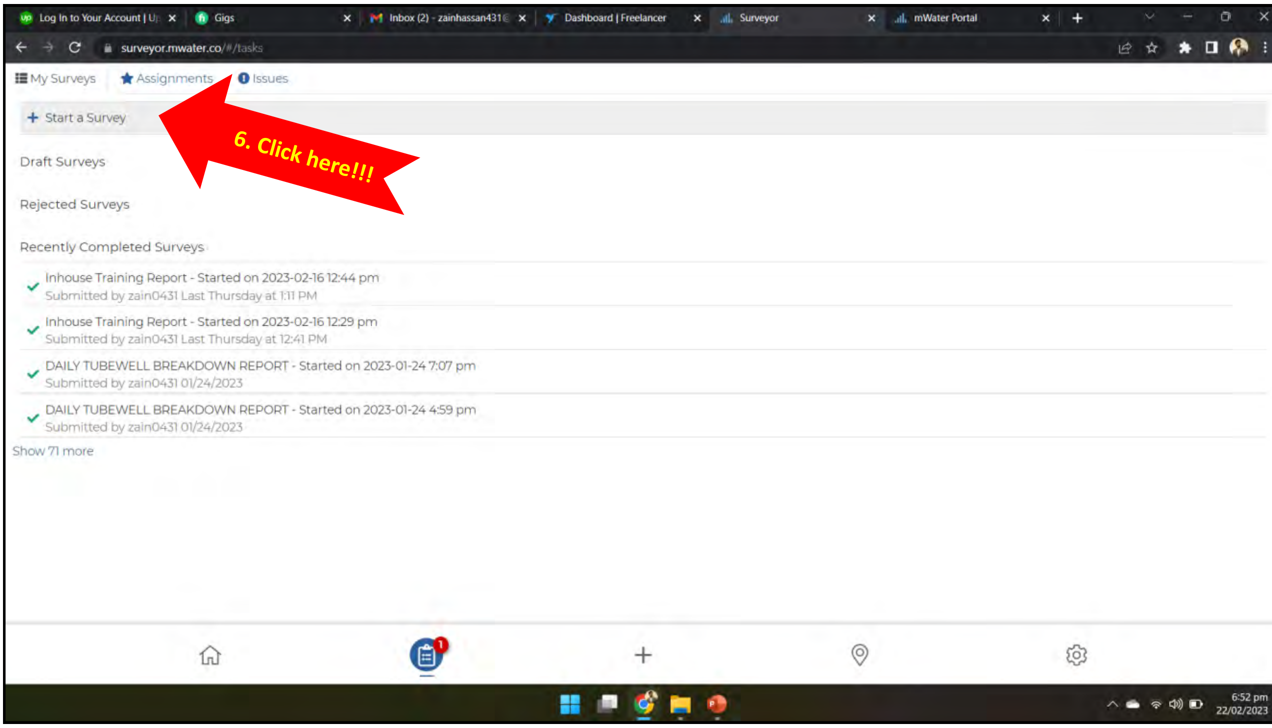
Preparation for Site before Energy Audit

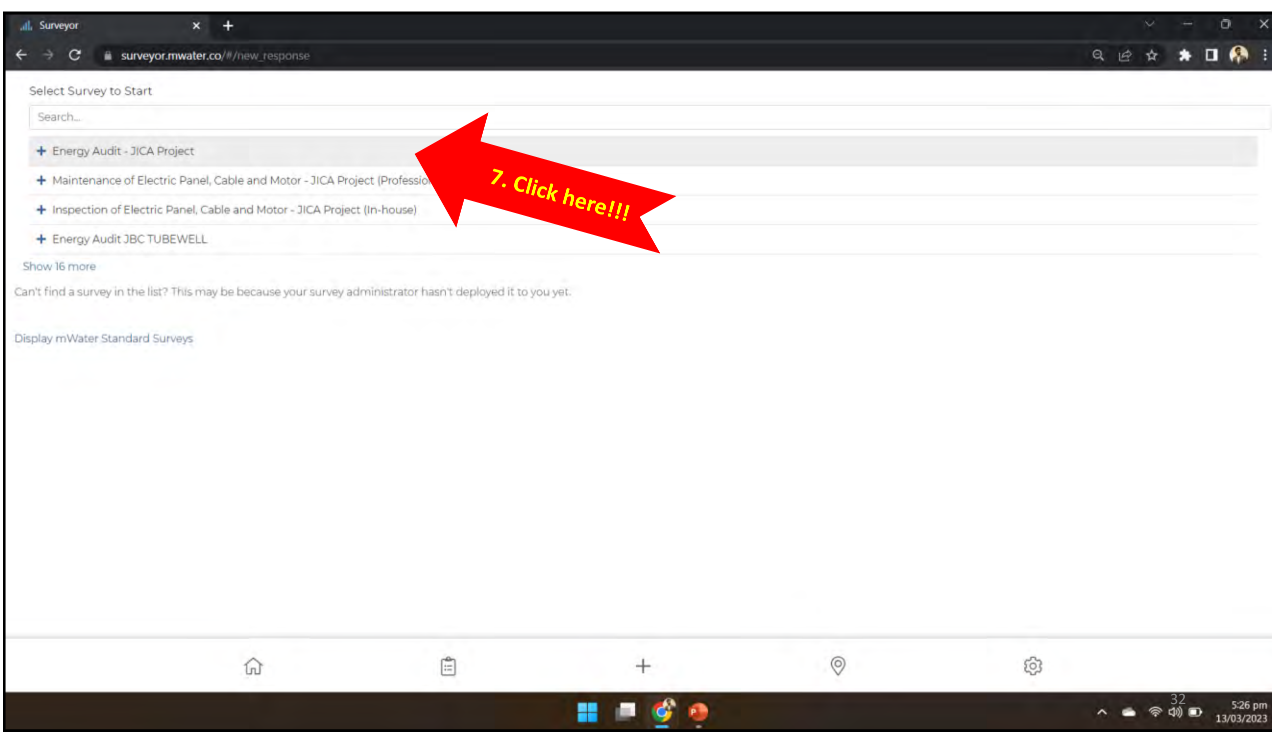
5. Record keeping using mWater app.

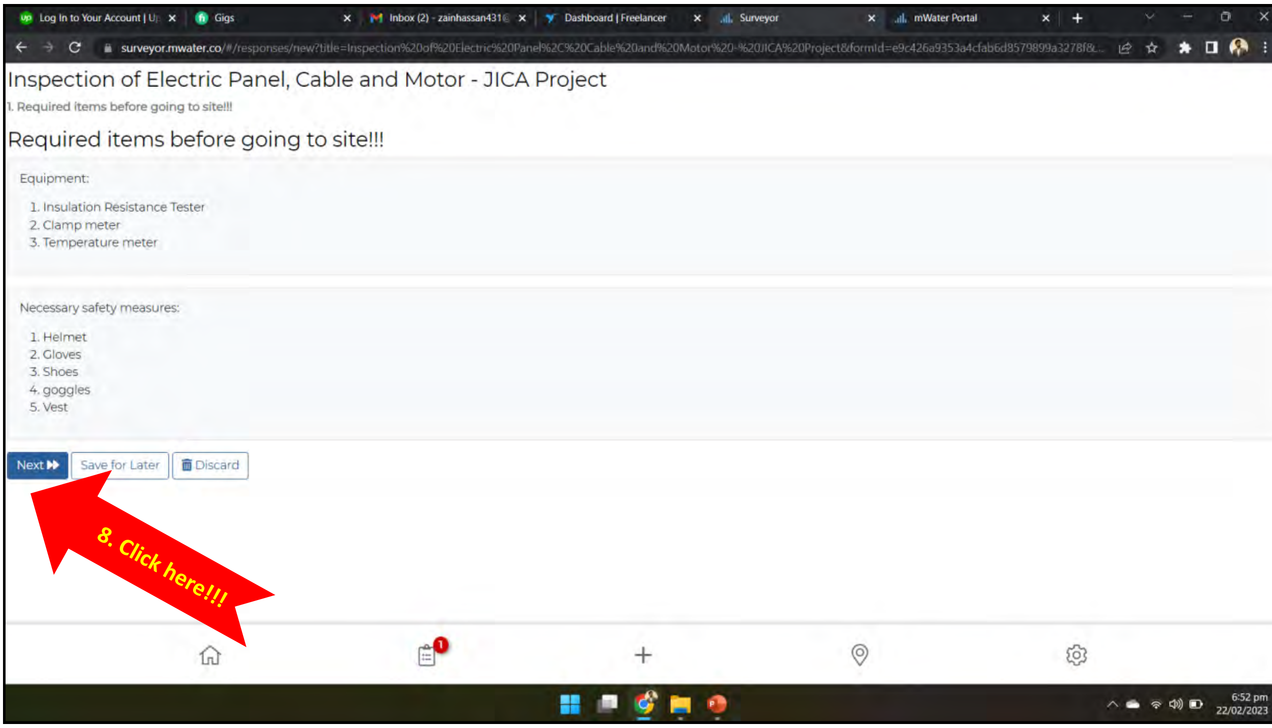


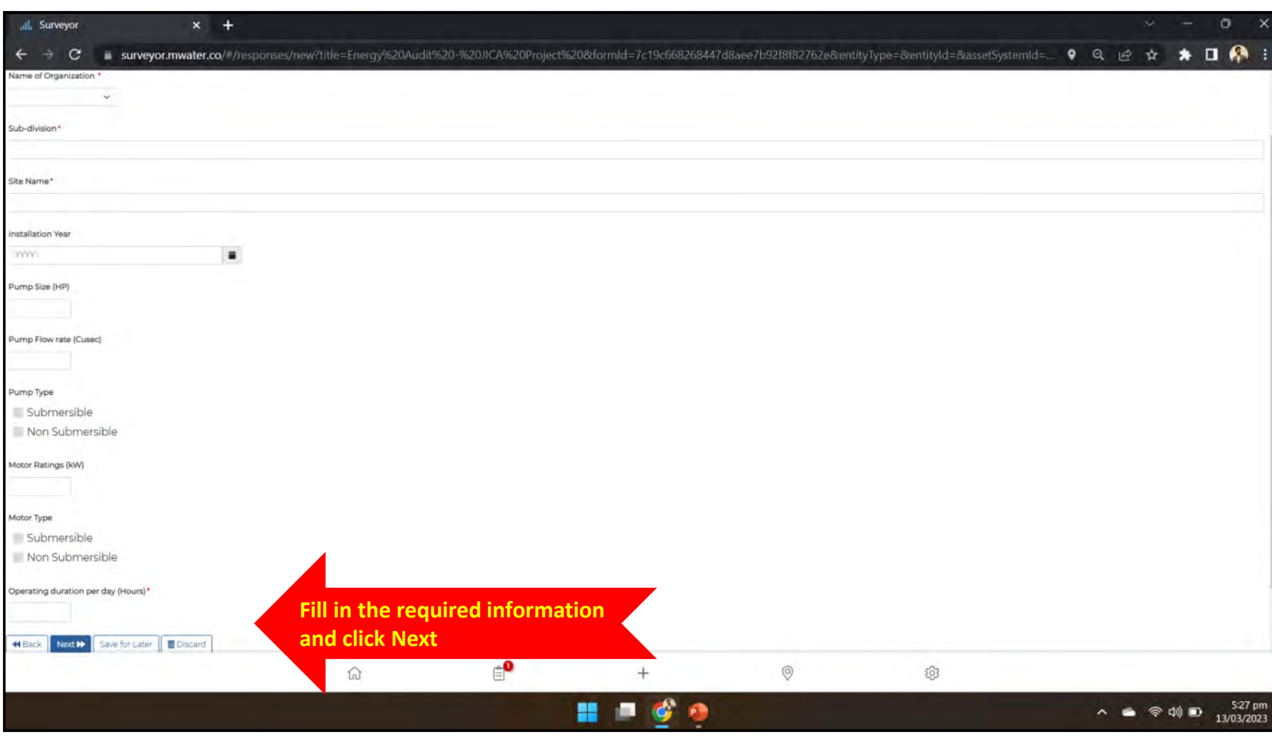

mWater Portal
portal.mwater.co/#/signup
Signup with mWater
mWater is an operating system for digital governance used by governments, civil society organizations, and water and sanitation service providers in over 180 countries. All features are free for unlimited use; anyone can sign up and start collecting data in minutes.
Given Name
Zain
Family Name
Hassan
Username
ZainHassan431
We recommend creating accounts with your real name rather than a generic code. Every user requires a unique username which is visible to other users. You can change your username, email or password later in My Account.
Password
Email address
zainhassan431@gmail.com
Note: Your email address will never be shared
Employer or organization (optional)
None
I confirm that I am at least 13 years of age
Signup
Cancel
Fill in the required information and click here

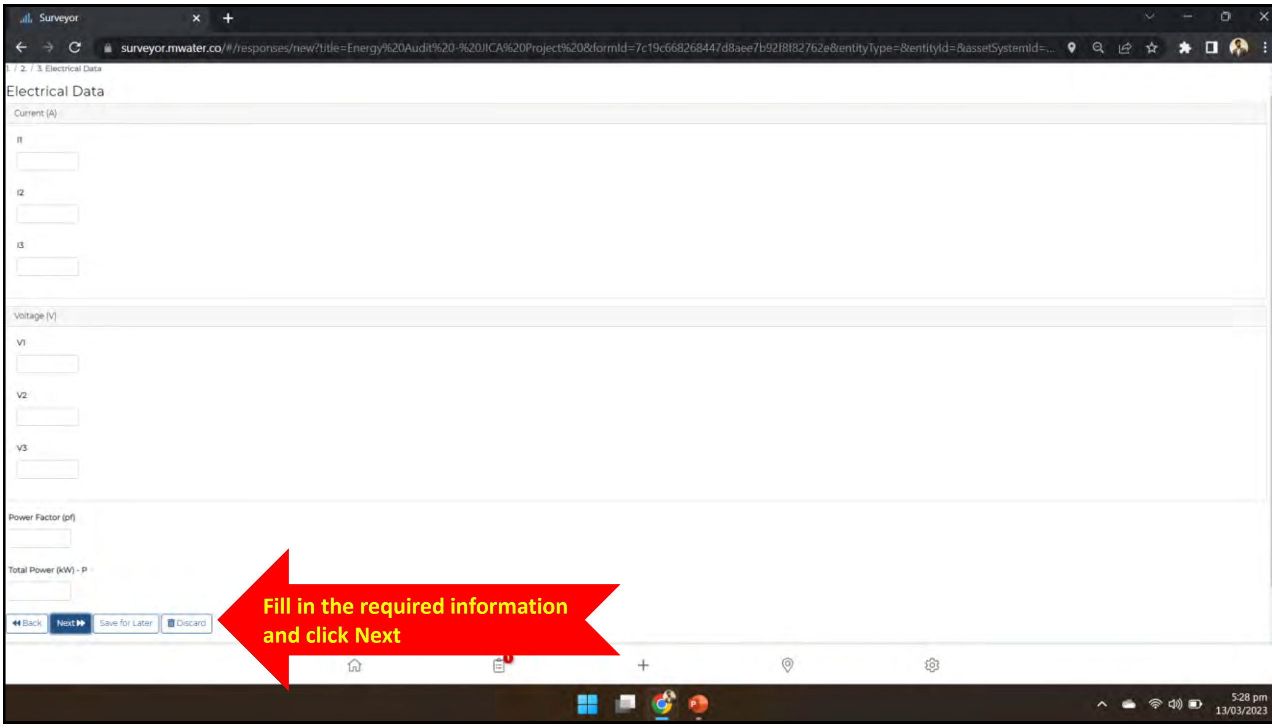

surveyor.mwater.co/#/
mWater
Zain Hassan
Username: zain0431
4. Share your username with the trainer
Sync Status
Sync Now
Data
Images
Cache
Sites
Surveys
Water Assets
5. Click here!!!

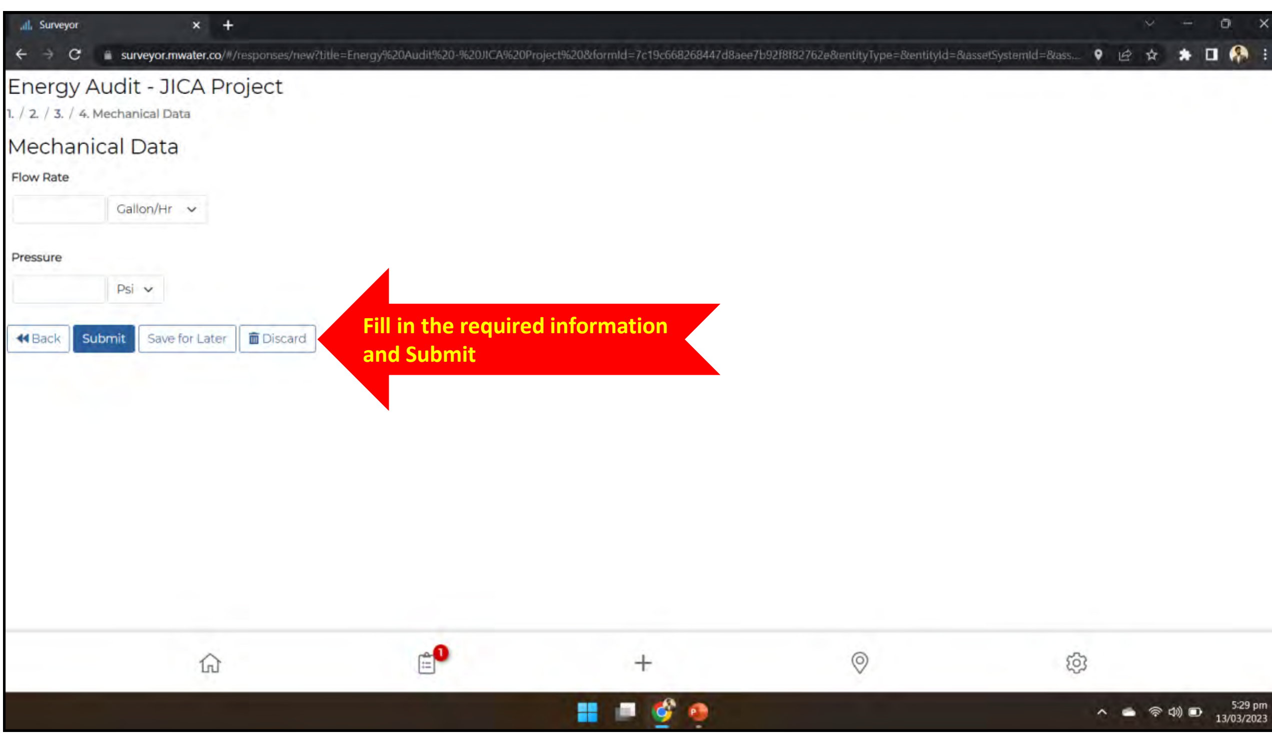

Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/tasks
My Surveys
Assignments
Issues
Start a Survey
6. Click here!!!
Draft Surveys
Rejected Surveys
Recently Completed Surveys
Inhouse Training Report - Started on 2023-02-16 12:44 pm
Submitted by zain0431 Last Thursday at 1:11 PM
Inhouse Training Report - Started on 2023-02-16 12:29 pm
Submitted by zain0431 Last Thursday at 12:41 PM
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 7:07 pm
Submitted by zain0431 01/24/2023
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 4:59 pm
Submitted by zain0431 01/24/2023
Show 71 more
6:52 pm
22/02/2023


Surveyor
surveyor.mwater.co/#/new_response
Select Survey to Start
Search...
Energy Audit - JICA Project
Maintenance of Electric Panel, Cable and Motor - JICA Project (Professio
Inspection of Electric Panel, Cable and Motor - JICA Project (In-house)
Energy Audit JBC TUBEWELL
7. Click here!!!
Show 16 more
Can't find a survey in the list? This may be because your survey administrator hasn't deployed it to you yet.
Display mWater Standard Surveys
5:26 pm
13/03/2023


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
Inspection of Electric Panel, Cable and Motor - JICA Project
1. Required items before going to site!!!
Required items before going to site!!!
Equipment:
1. Insulation Resistance Tester
2. Clamp meter
3. Temperature meter
Necessary safety measures:
1. Helmet
2. Gloves
3. Shoes
4. goggles
5. Vest
Next
Save for Later
Discard
8. Click here!!!
6:52 pm
22/02/2023


Surveyor
Name of Organization *
Sub-division *
Site Name *
Installation Year
YYYY
Pump Size (HP)
Pump Flow rate (Cusec)
Pump Type
Submersible
Non Submersible
Motor Ratings (kW)
Motor Type
Submersible
Non Submersible
Operating duration per day (Hours) *
Back
Next
Save for Later
Discard
Fill in the required information and click Next
5:27 pm
13/03/2023


Surveyor
Electrical Data
Current (A)
I1
I2
I3
Voltage (V)
V1
V2
V3
Power Factor (pf)
Total Power (kW) - P
Back
Next
Save for Later
Discard
Fill in the required information and click Next


Surveyor
Energy Audit - JICA Project
1. / 2. / 3. / 4. Mechanical Data
Mechanical Data
Flow Rate
Gallon/Hr
Pressure
Psi
Back
Submit
Save for Later
Discard
Fill in the required information and Submit

6. Action Plan/ Implementation Plan

Action Plan/ Implementation Plan (Sample)

• Energy Audit members	---	1. Assistant Director	x 1
		2. Sub Engineer	x 1
		3. Electrician	x 1
		4. Plumber	x 1
• No. of energy audits done	---	Three (03) sites a day	
• Database development	---	Sub Engineer (Daily)	
• Observations and Result	---	By Assistant Director (Weekly)	
• Start date	---	June 12th, 2023	

THANK YOU!!!

Let's go to the site!!!

Annex 5.1.4 Training Material: "O&M on Pumps and Motors (Efficient Pumping Machinery)" for ToT at WASA Faisalabad

Operation and Maintenance (O&M) OF PUMP

Table of Contents

Purpose and Outline of O&M Activity

1. Purpose of O&M Activity

- To **provide satisfactory and sustainable services** of water supply and sewerage for consumers.
- To **continue efficient and safe operational management** of pump facilities.
- To **conduct necessary inspection and maintenance**.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

O&M of Water Supply and Sewerage Facilities/Equipment consists of the following two elements.

- **Operation Management**
- **Maintenance Management**

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Operation Management is

- ✓ To operate and control each facility/equipment.
- ✓ To operate and control related facility/equipment as an integrated system effectively.
- ✓ To fulfill its function sufficiently.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is

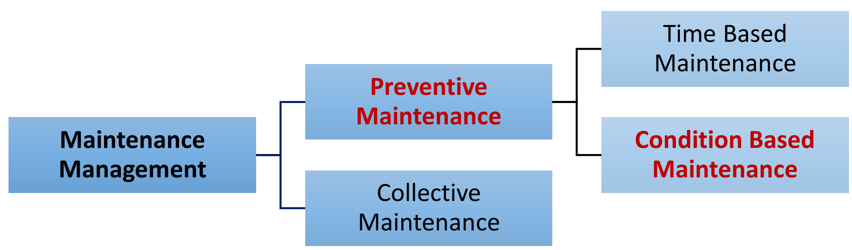
- ✓ To complement function degradation of equipment and maintain its original function.
- ✓ To decrease **Life Cycle Cost (LCC)** of equipment by prolongation of its lifetime etc.

LCC means the total cost which includes;
- Initial Cost (Construction Cost)
- Running Cost (Total O&M Cost during the Life Time)
- Disposal / Demolition Cost

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is categorized into the following items;



Purpose and Outline of O&M Activity

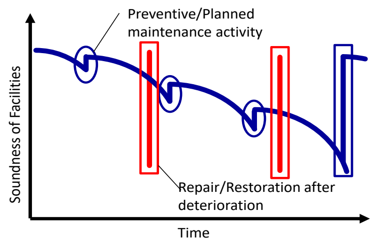
2. Outline of O&M Activity

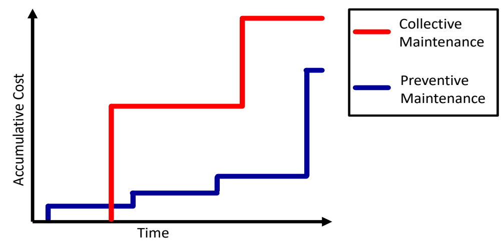
- **Preventive Maintenance** is preliminary maintenance activities to prevent from malfunction of equipment. It can be categorized into the followings.
  - ✓ **Time Based Maintenance (TBM):**

    Maintenance activities are performed based on the **planned period**.
  - ✓ **Condition Based Maintenance (CBM):**

    Maintenance activities are performed through the **planned inspection to check deterioration/operation condition**.
- **Collective Maintenance** is repair / restoration work after malfunction.

Importance of Preventive Maintenance





Source: Japan's Experiences on Water Supply Development (JICA)

Merits of Preventive Maintenance are

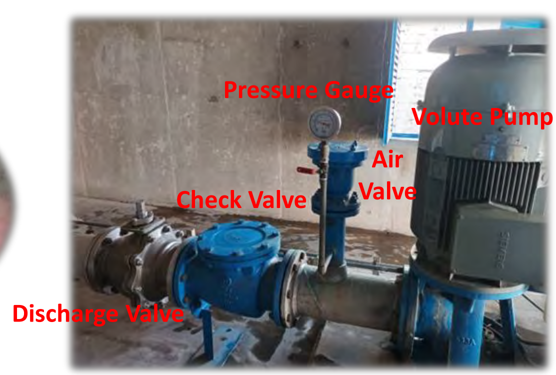
- To **minimize the LCC** of equipment
- To **prolong the lifetime** of equipment

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Volute Pump (Vertical Turbine)

Flow Meter
(Electro Magnetic Type)



Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Mixed Flow Pump

Mixed Flow Pump (Vertical)

Inlet Gate

Discharge Valve &
Check Valve

Screen

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the lubricate water tank is filled with water.

v. Check the pressure gauge indicates the original/zero value.

vi. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vii. Check/record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the flow meter reading and stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the pressure gauge indicates the original/zero value.

v. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vi. Check / record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, suction/discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the stop time.

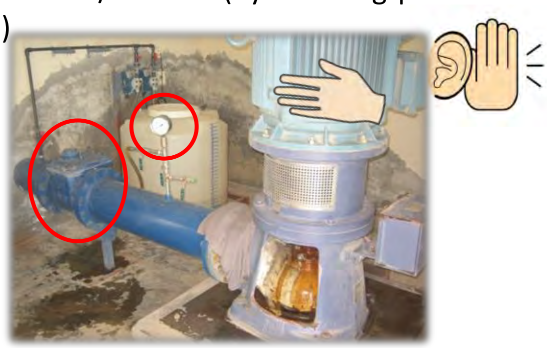
iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Abnormal noise and vibration (by hearing/touching)
- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage



How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

Excessive heat generation of motor can be checked by sense of touch.

Surface Temperature	Sense of Touch	Remarks
40 ℃	Somewhat warm	Feel slightly warm.
45 ℃	Warm	Feel comfortably warm.
50 ℃	Somewhat hot	Your palm turns red if you touch it for a few minutes.
60 ℃	Hot	Can hold your hand for a few seconds.
70 ℃	Extremely hot	Can hold one finger for a few seconds.
80 ℃	Extremely hot	Can hold one finger for only one second.

Normal condition

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

How to Conduct Daily Inspection

2. Daily Inspection Points of Mixed Flow Pump

- ✓ Same points as Volute Pump
- ✓ Suction pressure (if suction pressure gauge is installed.)

How to Conduct Daily Inspection

3. Record Keeping

Daily inspection results and other operation records shall be noted down in the Record Sheet surely and properly.

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Vibration	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

How to Conduct Periodic Inspection

1. Monthly Inspection Points of Volute/Mixed Flow Pump

- ✓ Leakage amount at Grand Packing
  - ➢ Criterion: q [mL/min] = 0.5 × d (mm, shaft dia.)
  - ➢ In case leakage amount is excess, retightening shall be done.
- ✓ Dosing amount of chlorine solution
  - ➢ In case the measured value doesn't meet the target value, it is necessary to adjust the setting value of Chlorinator.

- ✓ Oil level
  - ➢ In case oil level is low, refilling shall be done.
- ✓ Operation of Discharge Valve

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

- ✓ Vibration measurement
- ✓ Insulation measurement
- ✓ Retightening of Anchor Bolts
- ✓ Replace of Grand Packing
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Replace of Oil/Grease
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Overhaul
  - ➢ every 4 to 7 years (depending on the condition)

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Purpose**
  To check/evaluate whether a pump is functioning in desirable condition.
- **Standard/Regulation**
  ISO 10816-7 (2009)
- **Feature**
  Vibration measurement is used for fault diagnosis of pump. **Unbalance** and **misalignment** can be detected by measuring **vibration velocity**, and **abnormality of bearing** can be detected by measuring **vibration acceleration**.

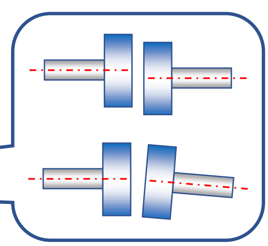
How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Major Causes of Vibration**

✓ Unbalance
✓ Misalignment
✓ Abnormality of Bearing
✓ Cavitation
✓ Loosening of Anchor (Foundation) Bolt



Source: Website of NTN Corporation, Japan

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

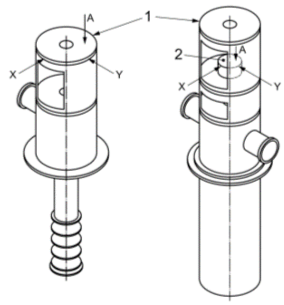
< Vibration Measurement >

- **Procedure**

i. Prepare/set up a vibration meter. (Basically magnet type sensor shall be used.)

ii. Select/decide the measurement locations based on the right figure.

iii. Measure/record vibration velocity value [mm/s] at the selected locations with three directions (axial, vertical, horizontal).



Notes)
Location 1: Driver mounting surface/lower motor bearing
Location 2: Pump bearing housing

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Evaluation**

The results shall be evaluated according to the below table.

Zone	Description	Vibration Velocity Limit*	
		≤ 200 kW**	> 200kW**
A	Newly commissioned machine	3.2	4.2
B	Unrestricted long-term operation	5.1	6.1
C	Limited operation	8.5	9.5
D	Risk of damage	> 8.5	> 9.5

Notes)
* *The root-mean-square (r.m.s) value in mm/s*
** *The applicable motor capacity of industrial pump, which is categorized into Category II (pumps for general or less critical application), is above 1 kW.*

How to Conduct Periodic Inspection

3. Record Keeping

Monthly and yearly inspection results shall be noted down in the Record Sheet surely and properly.

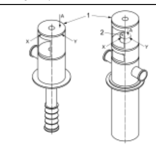
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:		cusec	Rated Ampere:		A	Location / Code:	
Total Head:		m	Rated Rotation Speed:		rpm	Inspection Date:	/ /
Rated Motor Output:		kW	Chlorinator Capacity: (only for Tube Well)		L/hr	Approved by (signature)	
Rated Voltage:		V	Chlorinator Setting: (only for Tube Well)		%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet			* Figure (Reference: ISO10816-7)	

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 4 to 7 years (depending on the condition)

< Comments / Findings>

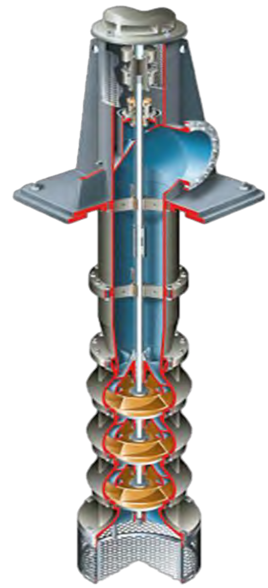


Planning of Periodic Inspection & Maintenance

- Periodic inspection and maintenance shall be conducted for all pumps surely and properly.
- Plan of periodic inspection and maintenance shall be made in the previous year considering the following points.
  - ✓ **Installation year** (Aged pump shall be checked carefully.)
  - ✓ **Importance/Priority** (Pumps have big impacts in case of malfunction/shutdown.)
  - ✓ **Location** (Moving time shall be minimized.)
  - ✓ **Time required** (Monthly inspection: within one hour, Yearly inspection: depending on the condition)
  - ✓ **Cost** (In case of overhaul, replace of major parts etc.)

Operation and Maintenance of Pump

WASA Tube well/Disposal Station



Operation and Maintenance of Pump

- **Operation of system**
- Ensuring effective routine running of system timely and daily.
- Stability
- Efficient
- Safely

- **Maintenance**
- Keep of structures/system including planned
- Preventive or Corrective maintenance
- Repair

Operation and Maintenance plan

Operation Record and Manual	• Keep a operational record continuously. • Prepare a O&M Manual (SOP).
Improvement of Operational Control	• Understand / follow the O&M Manual (SOP). • Detect any abnormalities and take measures.
Control of Water Amount and Pressure	• Establish a proper control method of equipment. • Prevent from water leakage.

Operation and Maintenance Plan

- **Preparation of O&M Plan**
- Preparation of a plan involves list of routine tasks, specific tasks at regular intervals including inspection of system (Daily, Weekly, Quarterly, Annually etc.)
- Plan also involves a checklist for operation, supervision and maintenance.

Standard Operating Procedure for Pump

- **1.**Check on the panel door the 3 indicator lights are illuminated. If the indicator lights are off check the position of Main breaker. Turning the main breaker On will illuminate the indicator lights. But if the situation remains the same then there will be shut off from Wapda's side.
- پینل کے دروازے پر چیک کریں کہ 3 انڈیکیٹر لائٹس روشن ہیں۔اگر اشارے کی لائٹس بند ہیں تو مین بریکر کی پوزیشن چیک کریں مین بریکر کو آن کرنے سے اشارے کی روشنی روشن ہو جائیگی۔لیکن اگر صورتحال یہی رہی تو واپڈا کی طرف سے بجلی بند کر دی گئی۔

- **2.**Check the indicator light status of (Over Load Trip).

2. (اوورلوڈ ٹرپ) کے اشارے کی روشنی کو چیک کریں۔

- **3.** Check the indicator light status of(Dry Running trip).

(Dry Running trip) کے اشارے کی روشنی کو چیک کریں ۔

Standard operating procedure

- **4.**Check the indicator light status of (Earth leakage trip).

(Earth Leakage Trip) اشارے کی روشنی کو چیک کریں۔

- **5.**You can only start the pump if all the above four indicator lights are in off state.In case anyone of above light is in on state do inform the respective operation supervisor.
- آپ پمپ کو صرف اس صورت میں شروع کرسکتے ہیں جب اوپر دیئے گئے چاروں اشارے کی لائٹس بند ہوں۔ اگر اوپر کی کوئی روشنی چل رہی ہو تو متعلقہ آپریشن سپروائزر کو مطلع کریں۔
- **6.** Before Pump start check main braker on or not?

مین بریکر آن ہے یا نہیں؟

- **7.**The (Duty selector switch) is in ON position.

ڈیوٹی سلیکٹر سوئچ آن ہو۔

Standard operating procedure

- **8.**Power Factor switch should be on Auto position.

8پاور فیکٹر سوئچ آٹو پوزیشن پر ہونا چاہئے۔

- **9.**Before Starting the pump open valve of water lubrication tank and close it after it goes empty.

پمپ کو چلانے سے پہلے بلکسس سے پانی کھولیں اور خالی ہونے کے بعد اسے بند کر دیں۔

- **10.**Press ON(Green) button pump will start.

ON(سبز) بٹن کو دبائیں پمپ چلنا شروع ہو جائے گا۔

Standard operating procedure

- **11.**After starting the pump, ON the Chlorine dosing pump to start the dosing of Chlorine.

پمپ چلانے کے بعد کلورین پمپ چلائیں۔

- **12.**After starting the main pump make sure the complete absence of abnormal noise or vibration in motor and pump. In occurrence of any such behavior immediately inform the respective site supervisor.

پمپ شروع کرنے کے بعد موٹر اور پمپ میں غیر معمولی شور یا وائبریشن کی چیک کریں ایسے
کسی بھی رویے کی صورت میں فوری طور پر متعلقہ سائٹ سپروائزر کو مطلع کریں۔

Daily operation Record

- **Daily operation record Parameters**
- Pump capacity
- Total Head
- Discharge pressure
- Chlorinator setting
- Motor heating, Noise
- Voltage(V),Ampere(A),Motor Output(KW)
- Leakage

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Noise	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

Daily Operation Record Sheet (Disposal Pumping Station)

11

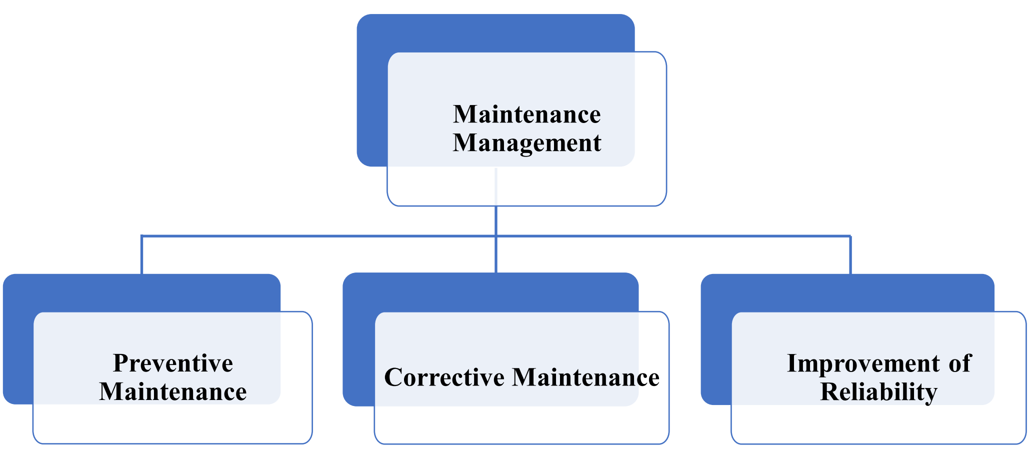
Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW			Approved by (Engineer)	
Rated Voltage:	V			Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Suction Pressure	Bar / MPa									
6	Discharge Pressure	Bar / MPa									
7	Voltage	V									
8	Ampere	A									
9	Motor Heating	Normal / High									
10	Abnormal Sound/Noise	Yes / No									
11	Leakage (except pump)	Yes / No									
12	Cleaning of Screen	Done / Not									
13	Remarks										

Maintenance Management of Pump

12

- Maintenance Management is categorized into the following items;



Parameters for Monthly/Yearly inspection(Preventive maintenance)

- Pump capacity
- Total Head
- Chlorinator capacity/setting
- Gland packing leakage
- Voltage(V),Ampere(A),Motor Output(KW)
- Oil Level/Grease
- Operation of discharge valve
- Vibration
- Insulation
- Connections
- Overhaul

Monthly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Result	Standard	Remarks
1	Leakage Amount at Grand Packing	mL/min	Proper / Not	q = 0.5 × d (mm, shaft dia.)	
2	Dosing Amount of Chlorine Solution	L/hr	Proper / Not	According to the caluculation sheet	Only for Tube Well
3	Oil Level	-	Proper / Not	According to the level gauge	

S-No.	Check / Maintenance Items	Unit	Result	Remarks
4	Retightening of Grand Packing	-	Done / Not	In case that leakage amount is excess.
5	Adjusting the setting value of Chlorinator	-	Done / Not	In case that the measured value does't meet the calculated value.
6	Refilling Oil	-	Done / Not	In case that oil level is low.
7	Operation of Discharge Valve	-	Functioning / Not	

< Comments / Findings>

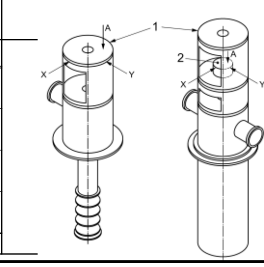
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet				

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 1 to 4 years (depending on the condition)

< Comments / Findings>



Instruments use for Inspection

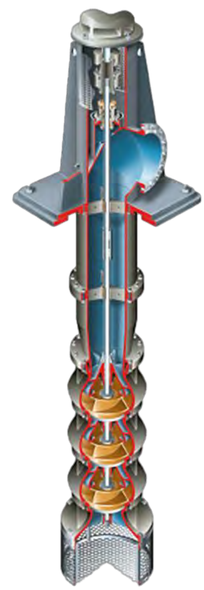
- Vibration meter
- Clamp meter
- Insulation meter

Troubleshooting of Pump

Annex 5.1.5 Training Material: "O&M on Pumps and Motors (Efficient Pumping Machinery)" for Pilot In-house Training, and In-house Training at WASA Faisalabad

Operation and Maintenance of Pump

WASA Tube well/Disposal Station



Parameters for Monthly inspection(Preventive maintenance)

- Pump capacity
- Total Head
- Chlorinator capacity/setting
- Gland packing leakage
- Voltage(V),Ampere(A)
- Oil Level/Grease
- Operation of discharge valve
- Vibration
- Insulation

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Noise	Yes / No									
14	Leakage	Yes / No									
	Overload/phase failure	yes/no									

Monthly Inspection Record Sheet (Vertical Pump)

4

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Result	Standard	Remarks
1	Leakage Amount at Grand Packing	mL/min	Proper / Not	q = 0.5 × d (mm, shaft dia.)	
2	Dosing Amount of Chlorine Solution	L/hr	Proper / Not	According to the caluculation sheet	Only for Tube Well

S-No.	Check / Maintenance Items	Unit	Result	Remarks
4	Retightening of Grand Packing	-	Done / Not	In case that leakage amount is excess.
7	Operation of Discharge Valve	-	Functioning / Not	

< Comments / Findings>

Monthly Inspection Record Sheet (Vertical Pump)

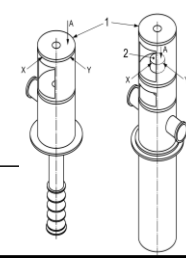
5

Pump Capacity:		cusec	Rated Ampere:		A	Location / Code:	
Total Head:		m	Rated Rotation Speed:		rpm	Inspection Date:	/ /
Rated Motor Output:		kW	Chlorinator Capacity: (only for Tube Well)		L/hr	Approved by (signature)	
Rated Voltage:		V	Chlorinator Setting: (only for Tube Well)		%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Gland Packing	Done / Not	
5	Replace of Oil/Grease	Done / Not	

< Comments / Findings>

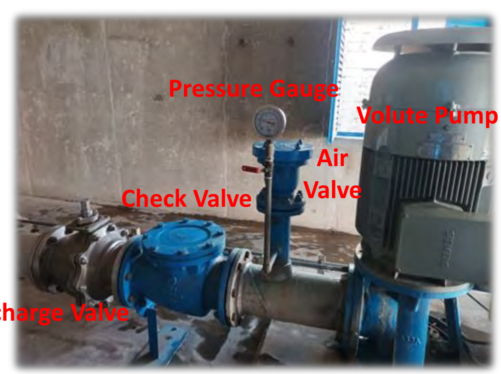


Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Volute Pump (Vertical Turbine)

Flow Meter
(Electro Magnetic Type)



How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Abnormal noise and vibration (by hearing/touching)
- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

How to Conduct Daily Inspection

2. Daily Inspection Points of Mixed Flow Pump

- ✓ Same points as Volute Pump
- ✓ Suction pressure (if suction pressure gauge is installed.)

Annex 5.1.6 Training Material: "Electrical panel, MCU, and wiring" for ToT, Pilot In-house Training, and In-house Training at WASA Faisalabad

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Electrical Panel, Motor Control Unit (MCU) and Wiring

WASA Trainer:

1. **Nauman Noor – Deputy Director**
2. **Tariq Hafeez – Assistant Director**

Water and Sanitation Agency (WASA), Faisalabad

Training **Goals**

- Learn about safety of panel, cable and motor by using equipment
- Preventive maintenance of electrical installations

Skills YOU learn

- Understating the operation of relays used in MCU
- Use of electrical equipment i.e., Insulation & Continuity Tester, Earth resistance Tester, Voltage detector and Clamp meter
- Maintenance work for panels and cables using Electrical Drawings

Activities YOU perform!

- At Class room
  - Introduction to main components of electrical panel and MCU
  - Wiring of electrical panel
  - Introduction to Insulation Resistance (Tester) to inspect electrical panel, cable and motor
- At site
  - Motor Inspection
  - Preventive Maintenance for panel, cable & motor

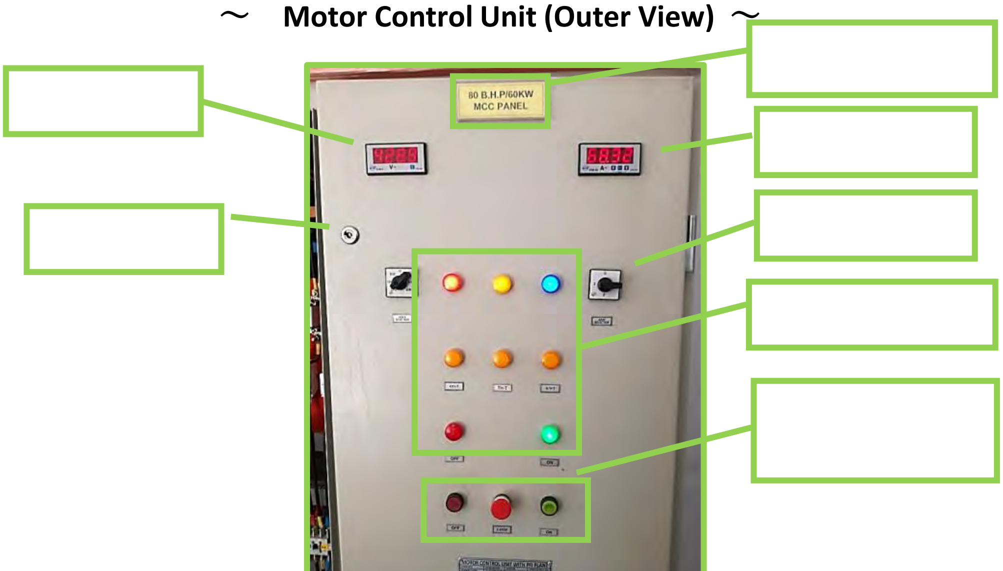
Training **Topics**

A. COMPONENTS OF THE ELECTRICAL PANEL/ MCU
B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU
C. SAFETY MEASURES, EQUIPMENT AND TOOLS
D. RECORD KEEPING USING mWATER APP

A. COMPONENTS OF THE ELECTRICAL PANEL/ MCU

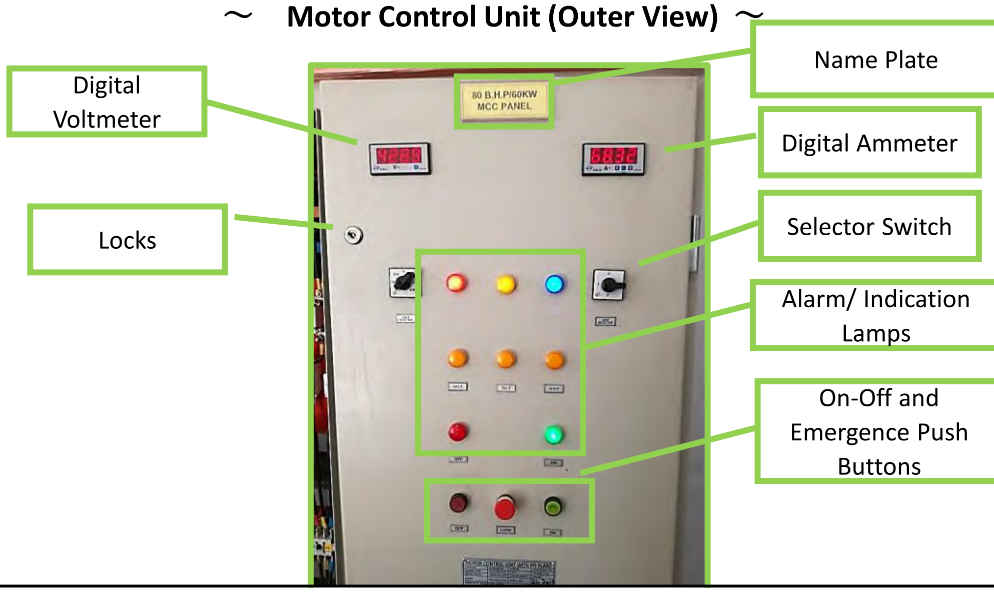
Components of Electrical Panel (1/x)

~ Motor Control Unit (Outer View) ~



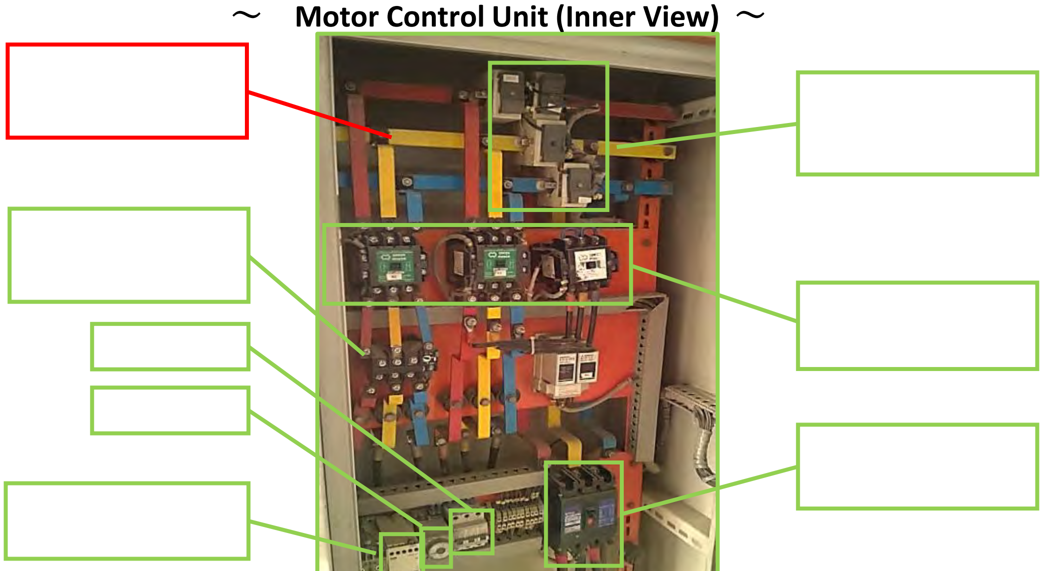
Components of Electrical Panel (2/x)

~ **Motor Control Unit (Outer View)** ~



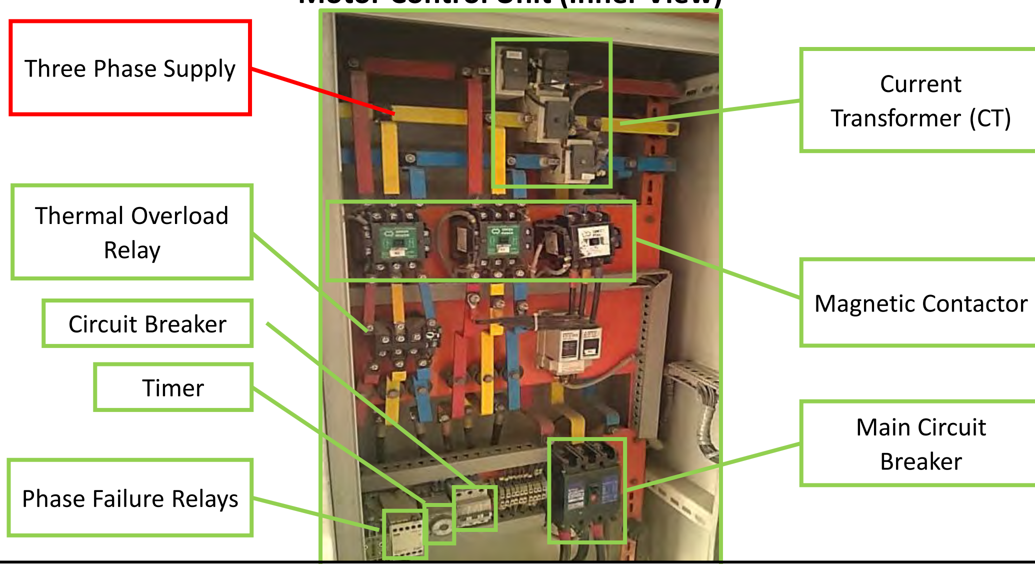
Components of Electrical Panel (3/x)

~ **Motor Control Unit (Inner View)** ~



Components of Electrical Panel (4/x)

~ **Motor Control Unit (Inner View)** ~

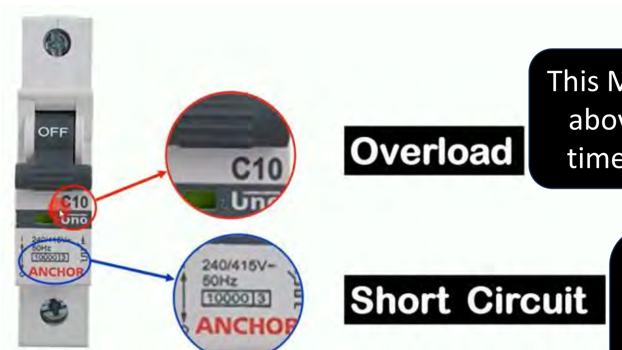


Difference Between Isolator and MCB (5/x)

Isolator Uses:
1. Switching

MCB Uses:
1. Switching
2. Overload Protection
3. Short Circuit Protection

Rating of Circuit Breaker (6/x)



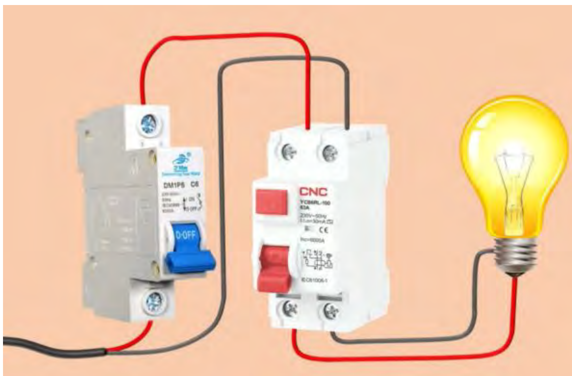
This MCB shall trip at a current above 10 Amp. But tripping time depends upon this "C"

This MCB shall trip in 3 milliseconds if a short circuit current occurs. The maximum bearable short circuit current is 10,000 amps. Above this value, the circuit breaker shall burn.

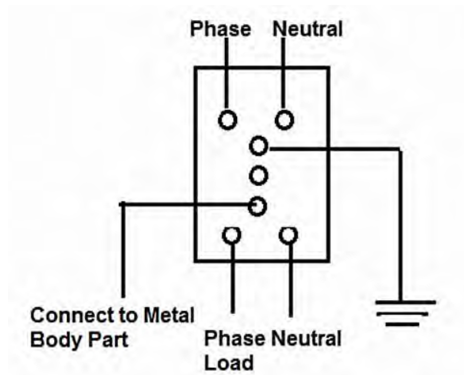
Tripping Characteristics of MCB (7/x)

Characteristic	Type B	Type C	Type D	Type K	Type Z
Application	Circuits with resistive loads	Circuits with higher inrush currents	Circuits with very high inrush currents	Circuits with high inrush currents	Sensitive electronic equipment
Tripping Curve	Relatively flat	Steeper	Steep	Steep	Steep
Response to Short Circuits	3 to 5 times In	2 to 5 times In	2 to 5 times In	2 to 5 times In	5 to 10 times In
Response to Overloads	5 to 20 seconds	1 to 5 seconds	1 to 5 seconds	2 to 10 seconds	1 to 3 seconds
Inrush Current Sensitivity	Low (e.g., 1.5 In)	Moderate (e.g., 3 In)	High (e.g., 5 In)	High (e.g., 4 In)	Very Low (e.g., 0.1 In)
Typical Use	Residential and light commercial	Industrial	High-powered equipment	Motors and Transformers	Sensitive electronic circuits

RCCB Vs ELCB (8/x)



No Earth connection is required for RCCB



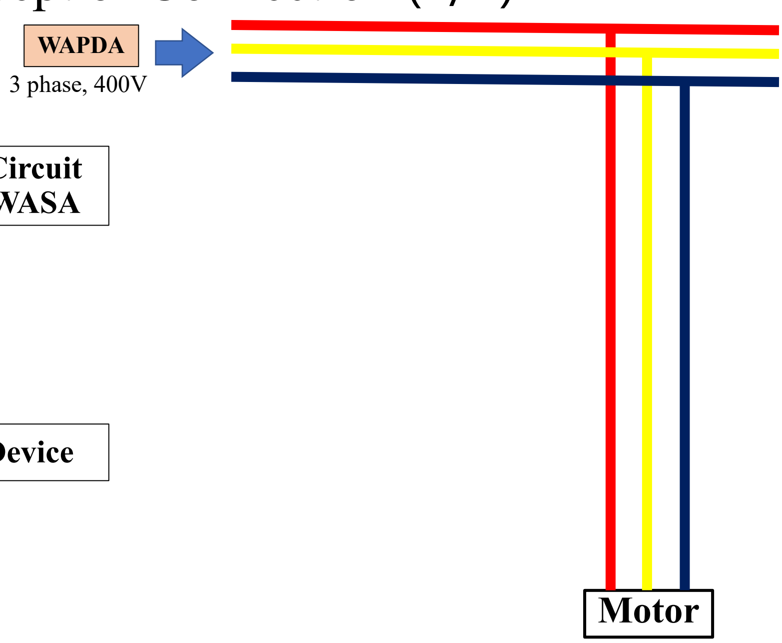
ELCB

RCCB Vs ELCB (9/x)

S.No	RCCB	ELCB
1.	RCCB refers to ear stands for Residual Current Circuit Breaker.	ELCB stands for Electric Leakage Circuit Breaker.
2.	It is a new name and refers to current operated devices.	ELCB refers to voltage operated earth leakage device.
3	It ensures 100% detection of leakage current & is available to sense the AC as well as DC leakage current.	It is not preferable as it can only detect current that flow back through the main earth wire.
4	RCCB has no connection with the earth wire and that's why it can trip when both currents (phase and neutral) are different and it withstands up to both the currents are same.	ELCB is working based on Earth leakage current. These devices measured the voltage on the earth conductor; if this voltage was not zero this indicated a current leakage to earth.

B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU

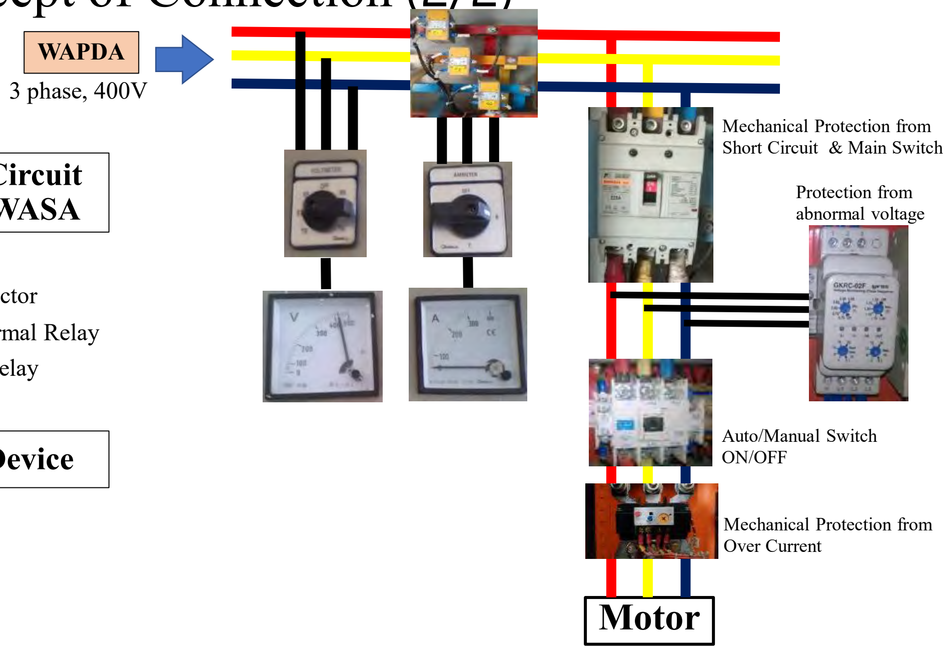
Basic Concept of Connection (1/2)



Basic Power Circuit for Motor in WASA

Monitoring Device

Basic Concept of Connection (2/2)



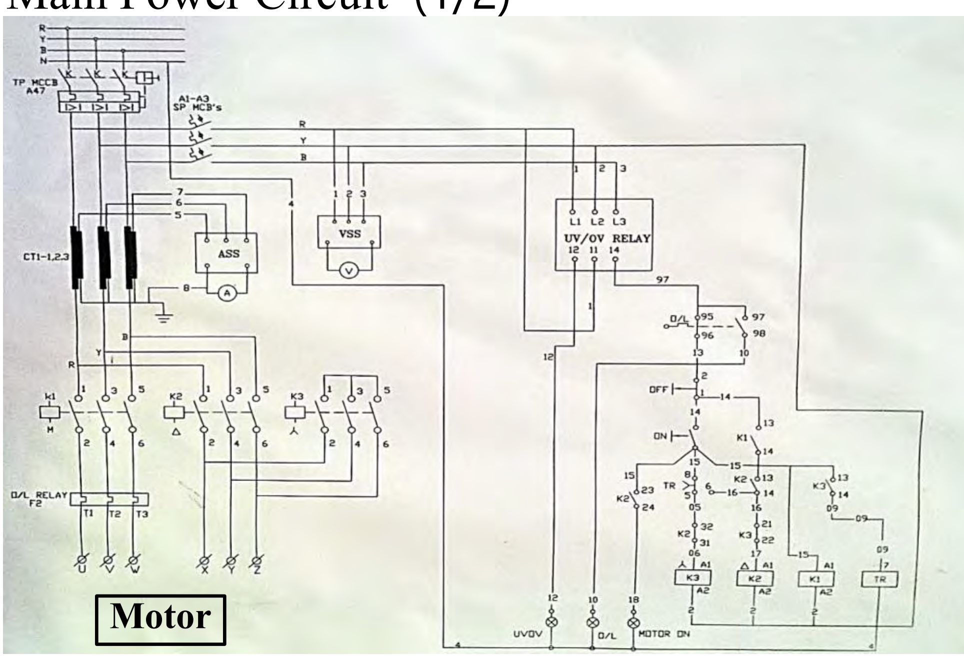
Basic Power Circuit for Motor in WASA

- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Phase Failure Relay

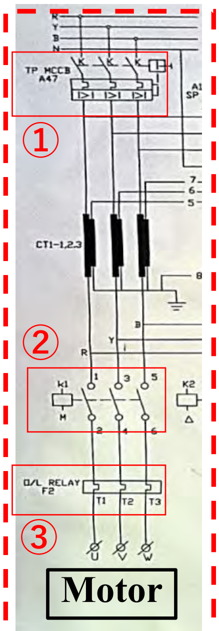
Monitoring Device

- Voltage Meter
- Ampere Meter

Main Power Circuit (1/2)



Main Power Circuit (2/2)



- ✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices

Direct On Line

Basic Power Circuit for Motor

C. SAFETY MEASURES, EQUIPMENT AND TOOLS

Before site activity (1/7)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5			8		
3			6					

Before site activity (2/7)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		2	Helmet		3	Post Stamp	
4	Tape		5	Shoes		6	Glasses	
7	Gloves		8	Vest				

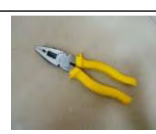
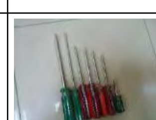
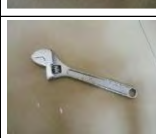
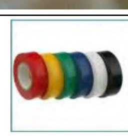
Before site activity (3/7)

• Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			2			3		
4			5			6		

Before site activity (4/7)

• Preparation of Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Voltage Tester		2	Pliers		3	Screw Driver Set	
4	Wrench		5	Insulation Tape				

Before site activity (5/7)

- Preparation of Equipment

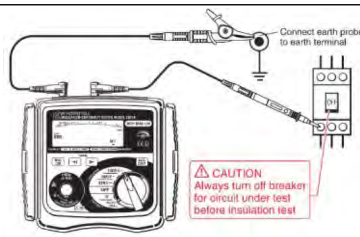
Sr. #	Item	Image	Sr. #	Item	Image
1	Clamp meter		2	Insulation Resistance Tester	

Voltage and Current measurements (6/7)

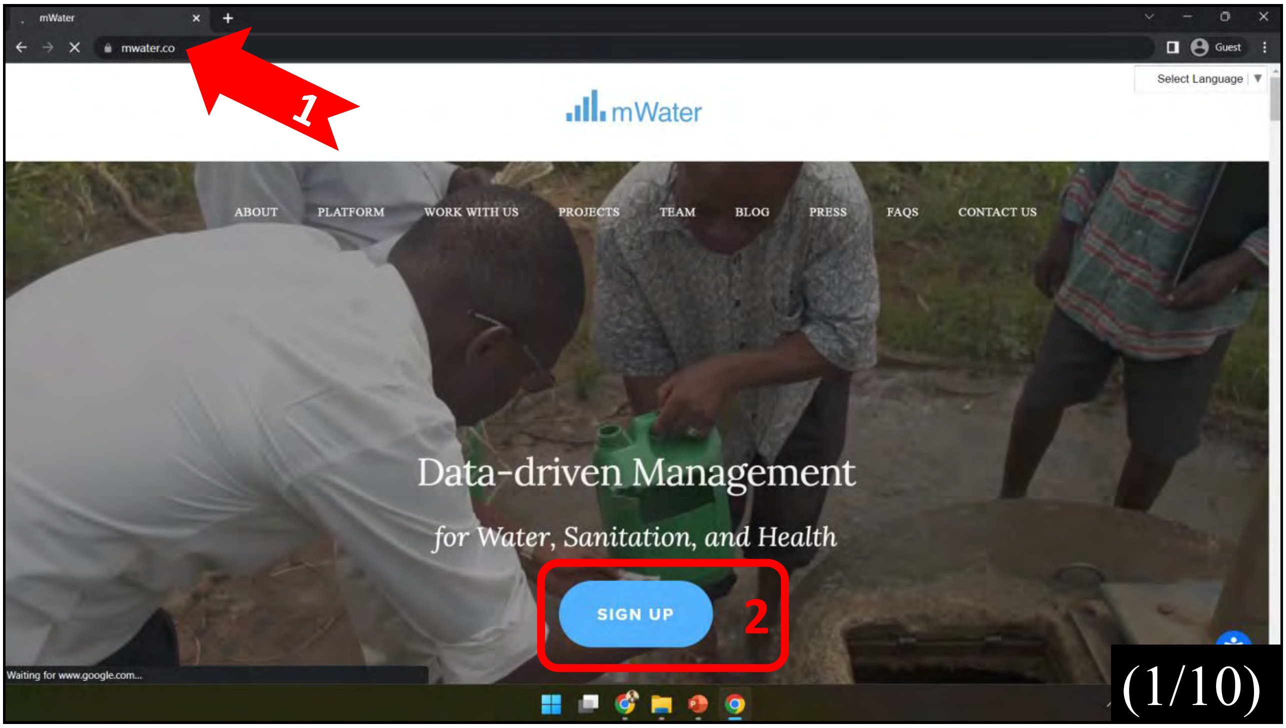
Measurement of Current

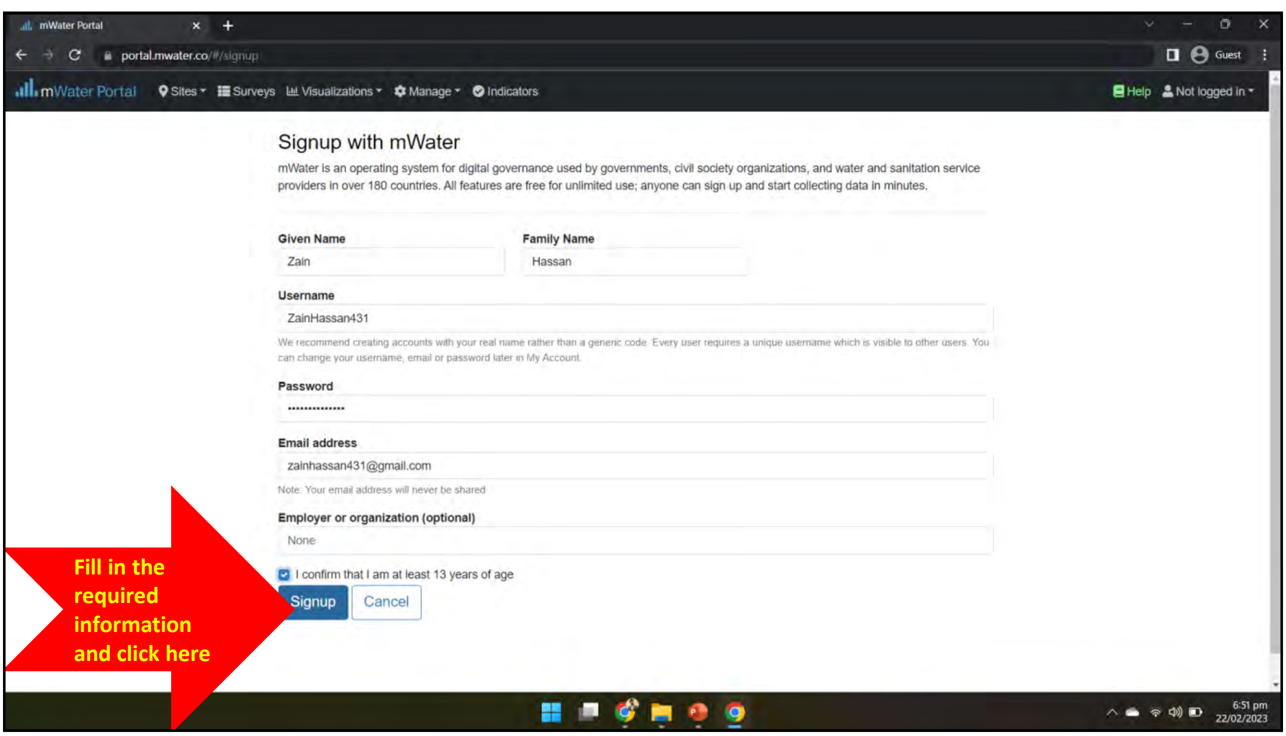
Measurement of Voltages

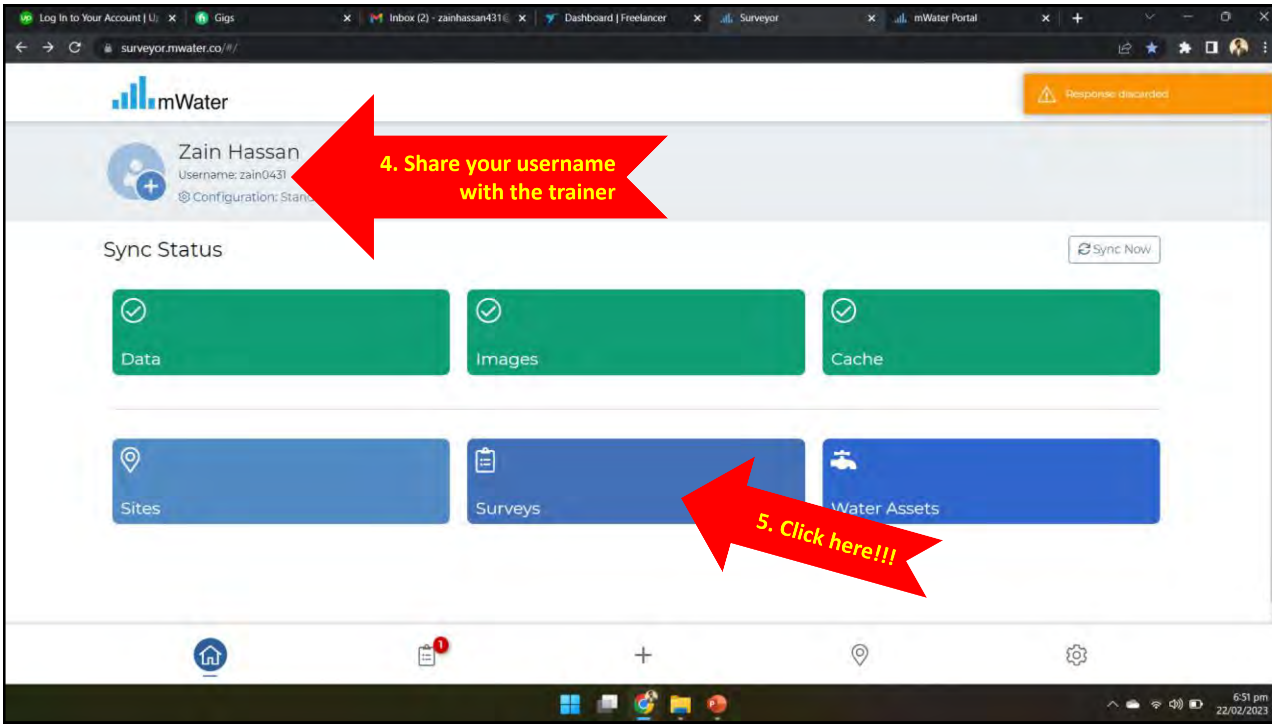
Insulation Resistance Test (7/7)

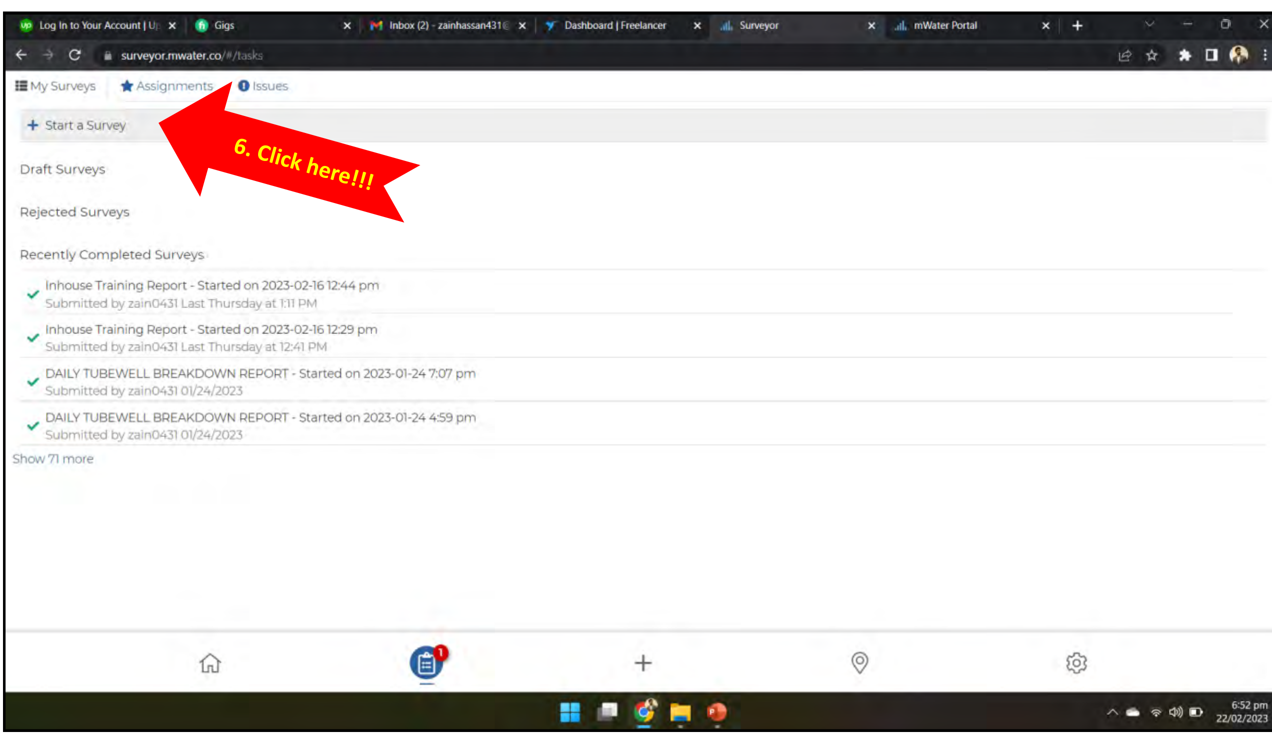
<table>
<tr>
<td>Step 1:
Check the "Zero Ohm" resistance between the test leads</td>
<td></td>
<td>Step 3:
Set the voltages to 500V</td>
<td rowspan="2">Larger insulation value is better.
<u>1MΩ< Value</u>
→Good. Please compare it with the previous value as well.
<u>0.4MΩ<Value <1MΩ</u>
→Caution. Need to find out fault part and prepare necessary action
<u>Value < 0.4MΩ</u>
→Dangerous. Take a necessary action immediately referring to "Fault Detect Procedure" shown in the later section.</td>
</tr>
<tr>
<td>Step 2:
Turn OFF the electrical supply</td>
<td>
</td>
<td>Step 4:
Rotate the test button and check the value of insulation resistance as per given format</td>
</tr>
</table>

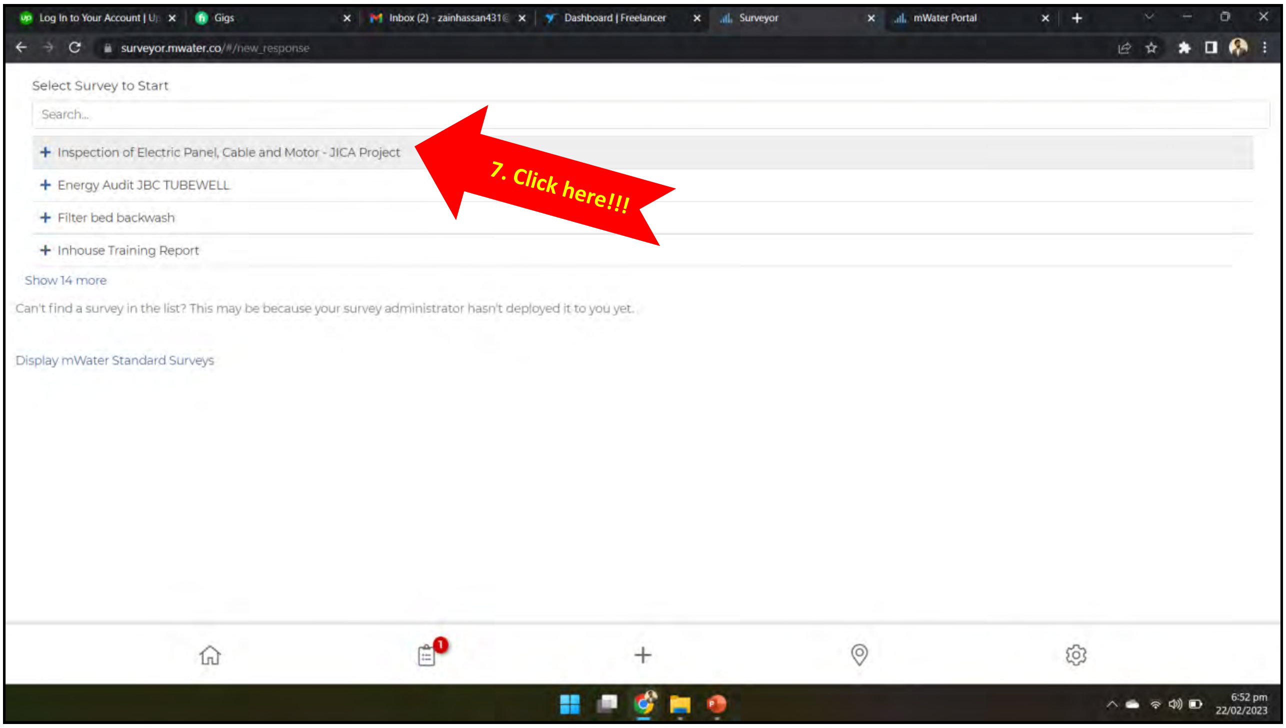
D. RECORD KEEPING USING mWATER APP.

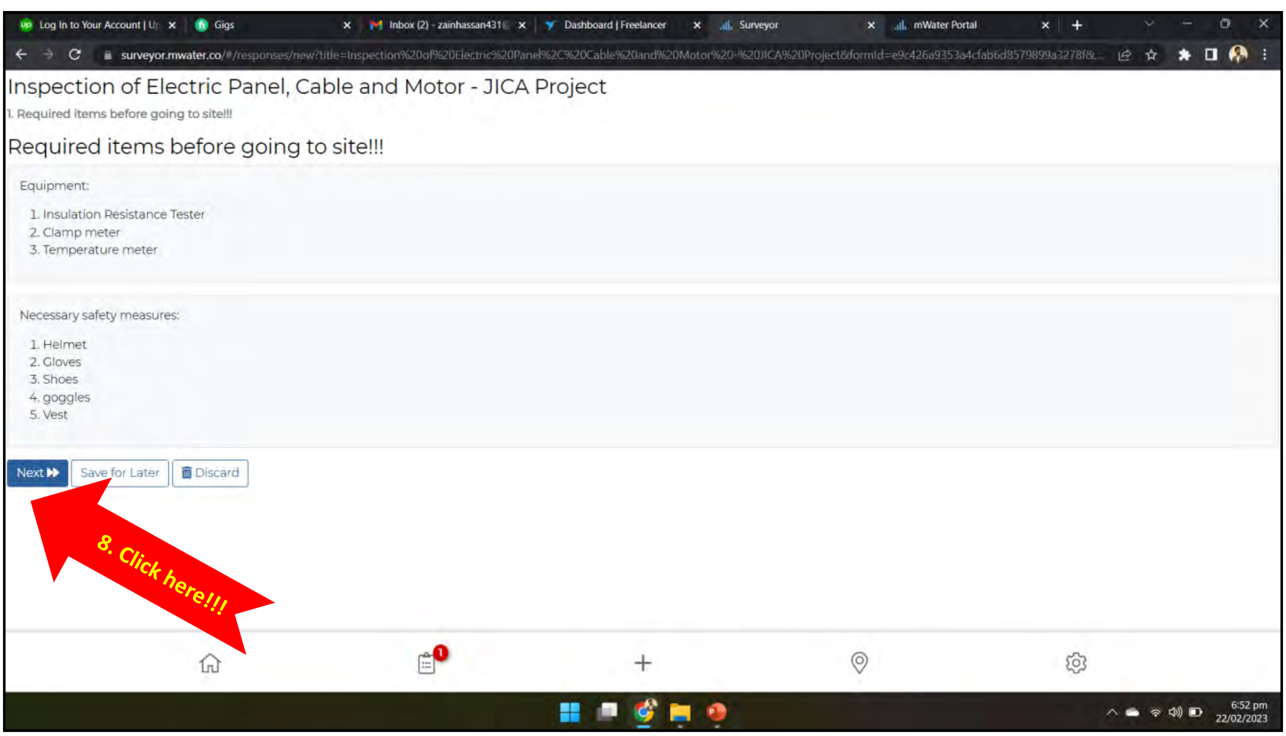

mWater
mwater.co
1
Select Language
mWater
ABOUT
PLATFORM
WORK WITH US
PROJECTS
TEAM
BLOG
PRESS
FAQS
CONTACT US
Data-driven Management
for Water, Sanitation, and Health
SIGN UP
2
Waiting for www.google.com...
(1/10)

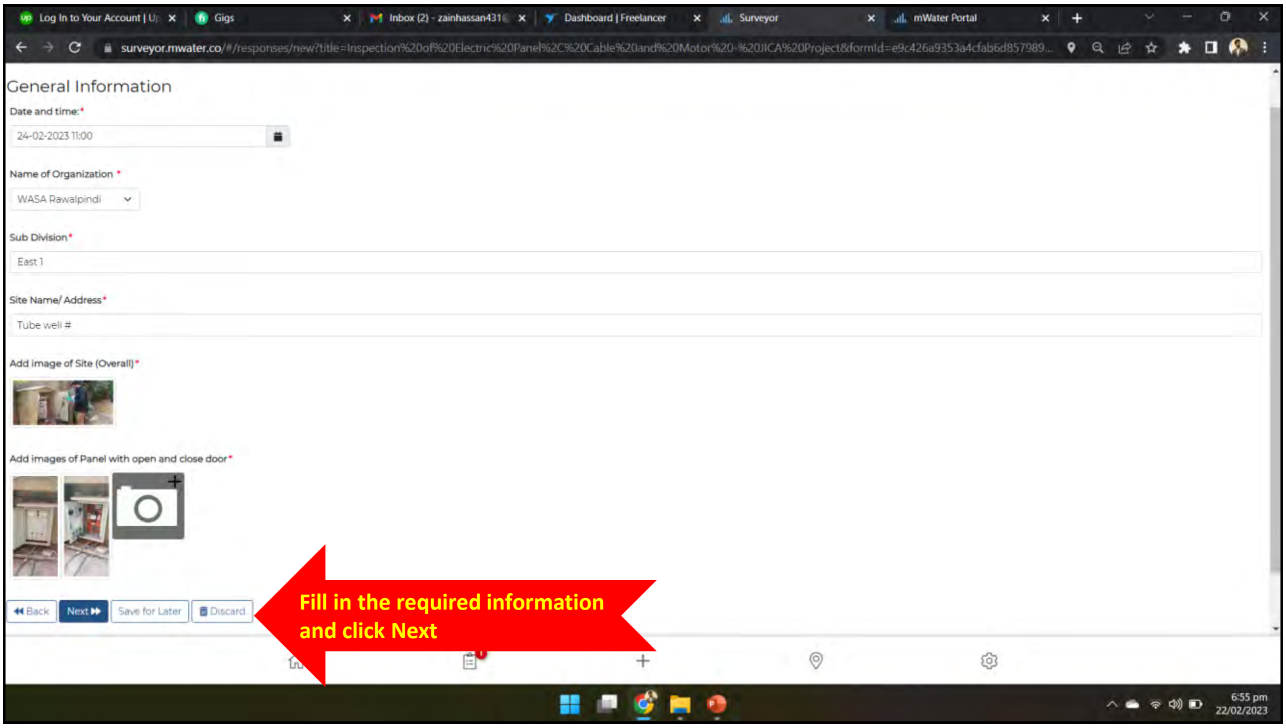

mWater Portal
portal.mwater.co/#/signup
mWater Portal
Sites
Surveys
Visualizations
Manage
Indicators
Help
Not logged in
Signup with mWater
mWater is an operating system for digital governance used by governments, civil society organizations, and water and sanitation service providers in over 180 countries. All features are free for unlimited use; anyone can sign up and start collecting data in minutes.
Given Name
Zain
Family Name
Hassan
Username
ZainHassan431
We recommend creating accounts with your real name rather than a generic code. Every user requires a unique username which is visible to other users. You can change your username, email or password later in My Account.
Password
Email address
zainhassan431@gmail.com
Note: Your email address will never be shared
Employer or organization (optional)
None
I confirm that I am at least 13 years of age
Signup
Cancel
Fill in the required information and click here
6:51 pm
22/02/2023

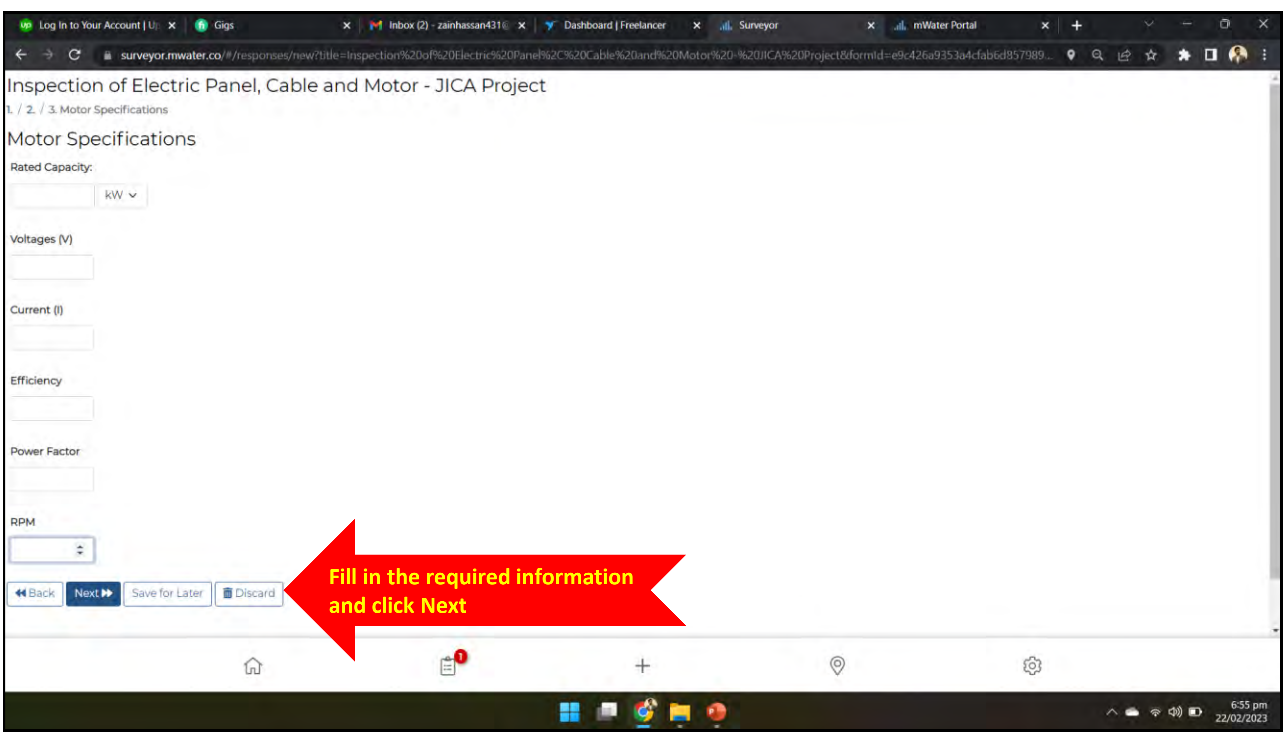

Log In to Your Account | U
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/
mWater
Response discarded
Zain Hassan
Username: zain0431
Configuration: Stan
4. Share your username
with the trainer
Sync Status
Sync Now
Data
Images
Cache
Sites
Surveys
Water Assets
5. Click here!!!
6:51 pm
22/02/2023

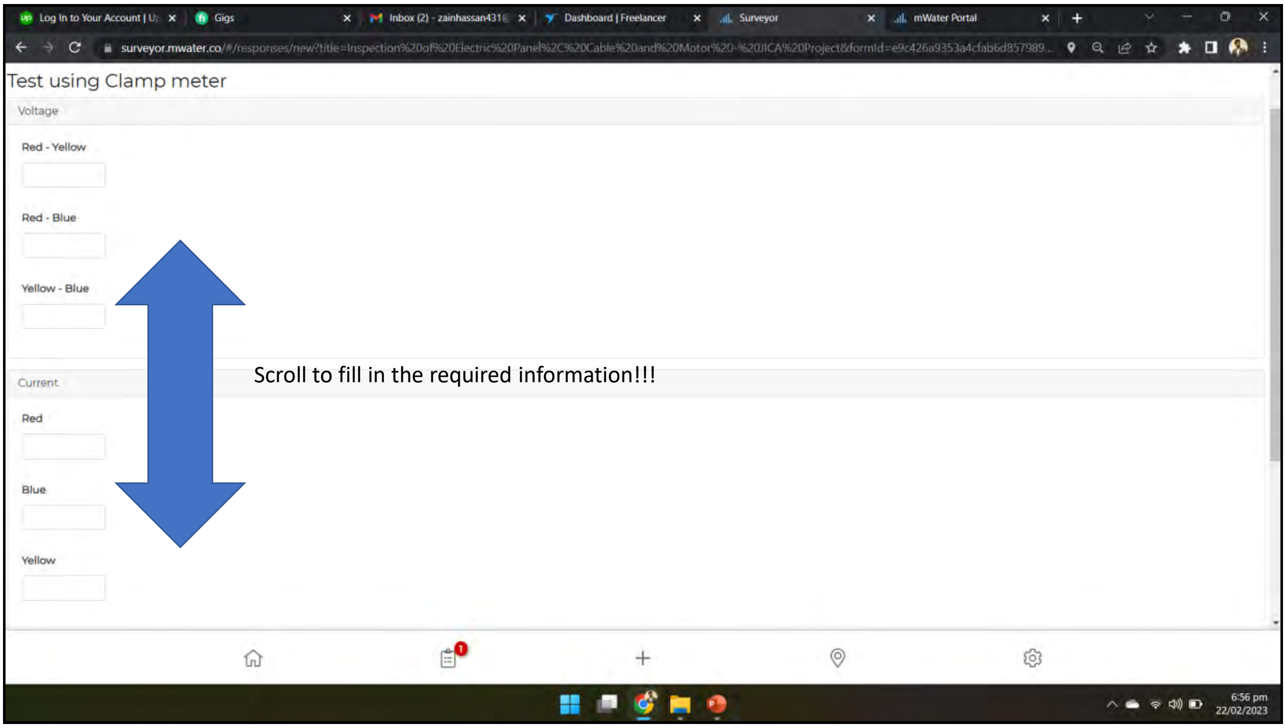

Log In to Your Account | U
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/tasks
My Surveys
Assignments
Issues
Start a Survey
6. Click here!!!
Draft Surveys
Rejected Surveys
Recently Completed Surveys
Inhouse Training Report - Started on 2023-02-16 12:44 pm
Submitted by zain0431 Last Thursday at 1:11 PM
Inhouse Training Report - Started on 2023-02-16 12:29 pm
Submitted by zain0431 Last Thursday at 12:41 PM
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 7:07 pm
Submitted by zain0431 01/24/2023
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 4:59 pm
Submitted by zain0431 01/24/2023
Show 71 more
6:52 pm
22/02/2023

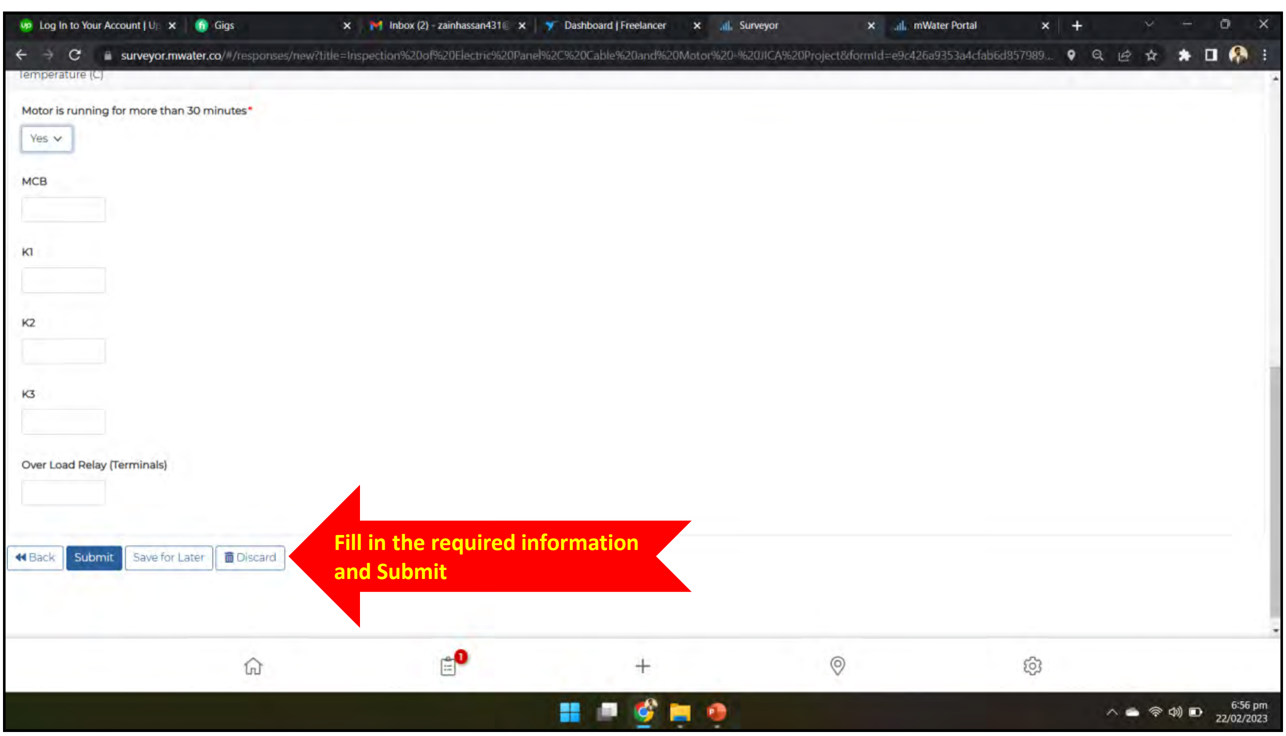

Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/new_response
Select Survey to Start
Search...
+ Inspection of Electric Panel, Cable and Motor - JICA Project
+ Energy Audit JBC TUBEWELL
+ Filter bed backwash
+ Inhouse Training Report
Show 14 more
Can't find a survey in the list? This may be because your survey administrator hasn't deployed it to you yet.
Display mWater Standard Surveys
7. Click here!!!
6:52 pm
22/02/2023


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
Inspection of Electric Panel, Cable and Motor - JICA Project
1. Required items before going to site!!!
Required items before going to site!!!
Equipment:
1. Insulation Resistance Tester
2. Clamp meter
3. Temperature meter
Necessary safety measures:
1. Helmet
2. Gloves
3. Shoes
4. goggles
5. Vest
Next
Save for Later
Discard
8. Click here!!!
6:52 pm
22/02/2023


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/responses/new?title=Inspection%20of%20Electric%20Panel%2C%20Cable%20and%20Motor%20-%20JICA%20Project&formId=e9c426a9353a4cfab6d857989...
General Information
Date and time:*
24-02-2023 11:00
Name of Organization *
WASA Rawalpindi
Sub Division*
East 1
Site Name/ Address*
Tube well #
Add image of Site (Overall)*
Add images of Panel with open and close door*
Back
Next
Save for Later
Discard
Fill in the required information and click Next
6:55 pm
22/02/2023


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/responses/new?title=Inspection%20of%20Electric%20Panel%2C%20Cable%20and%20Motor%20-%20JICA%20Project&formId=e9c426a9353a4cfab6d857989...
Inspection of Electric Panel, Cable and Motor - JICA Project
1. / 2. / 3. Motor Specifications
Motor Specifications
Rated Capacity:
kW
Voltages (V)
Current (I)
Efficiency
Power Factor
RPM
Back
Next
Save for Later
Discard
Fill in the required information and click Next
6:55 pm
22/02/2023


Test using Clamp meter
Voltage
Red - Yellow
Red - Blue
Yellow - Blue
Current
Red
Blue
Yellow
Scroll to fill in the required information!!!


Motor is running for more than 30 minutes*
Yes
MCB
K1
K2
K3
Over Load Relay (Terminals)
Back
Submit
Save for Later
Discard
Fill in the required information and Submit

سوال و جواب !!!

THANK YOU!!!

Annex 5.1.7 Outline of In-house Training and Training Material of ToT for "O&M of Sewerage and Drainage" at 4 WASAs

Outline of In-house Training (Sewerage and Drainage Cleaning)

Outline of in-house Training for the four first priority item which was selected based on the TNA results of five WASAs is shown below.

1. Cleaning of sewerage and drainage pipelines (including NO.2)

(1) Objective

Learn proper cleaning methods and procedures for facilities as part of proper sewerage facility maintenance activities.

(2) Training Method and Venue

Training method: Practical training at site, Venue: sewerage pipeline facilities in suburban areas without dense houses.

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Prepare camera
2) Removal of earth, sand, sludge, etc. from inside the pipe using jetting machine, sucker machine, etc.
3) Carry in camera from manhole and take safety measures
4) Check the condition of the inside of the pipe using the camera
5) Removal of obstructions: such as, removal of obstructions with heavy equipment, replacement of the pipe itself, etc

2. Flow measurement of open channels

(1) Objective

Flow measurement using an anemometer

(2) Training Method and Venue

Training method: Practical training at site, Venue: small rivers

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Prepare an anemometer, measuring tape (50m), pole (red and white), and distance meter
2) Prepare the flow calculation sheet
3) Measure the width and depth of the open channel

4) Measure the flow velocity in the open channel
5) Calculate the flow rate based on flow velocity and area of cross section at open channel

3. O&M of wastewater treatment plant

(1) Objective

Learn proper methods and procedures by removing sludge from sewage treatment plants and use them in preventive maintenance activities.

(2) Training Method and Venue

Training method: Practical training at site, Venue: sewerage treatment plant (Faisalabad,Multan)

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Determine the sequence (order) to be cleaned
2) Stop the inflow of water
3) Drain the water
4) Wait until dry
5) Remove the sludge
6) Place the removed sludge in the site or dispose it at an appropriate dumping site
7) Move to the next series (repeat steps 1) to 6))

4. Wastewater treatment technologies

(1) Objective

The objective is to select a sewage treatment technology that is suitable for local conditions and learn its procedures.

(2) Training Method and Venue

Training method: Lecture including exercise, Venue: WASA Office

(3) Trainee

Engineers in charge of planning, design, supervising and O&M (more than BPS-11)

(4) Contents

1) Summary description
2) Section of technologies

-Site requirement

- Financial analysis (CAPEX, OPEX)

Measurement of Discharge in Channel / Drain

	Left	cm/s	Center	cm/s	Right	cm/s
	V1		V4		V7	
	V2		V5		V8	
	V3		V6		V9	
	Avg.		Avg.		Avg.	
Avg of 9 Points (cm/s)						
Avg of 9 Points (m/s)						
Avg of 9 Points (ft/s)						

Marks	**25**	
	m	**ft**
Width		
Depth		

Q = A X V	

Name	
Designation	
Organization	
Obtained Marks	

Annex 5.1.8 Training Material: "O&M of Sewerage and Drainage" for Pilot In-house Training and In-house Training at 4 WASAs

INSPECTION OF SEWER / MANHOLE

JICA

WASA
MULTAN DEVELOPMENT AUTHORITY

OBJECTIVES OF SEWER/MANHOLE INSPECTION

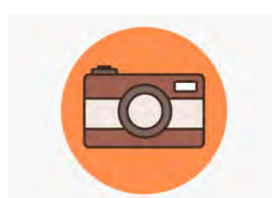
- To identify existing or potential problems in Sewer / Manhole
- To examine structure of the Sewer / manhole
- To observe functional capacity of Sewer / manhole




INSPECTION METHODS

- **Visual**

- **Camera**



VISUAL INSPECTION

Arrangements before Inspection:

• Map of the Collection System	• Scrapers and Wire Brushes for Cleaning the Manhole Ring
• Metal Detector	• Powerful Flashlight
• Warning Devices, Safety Cones and Traffic Safety Devices	• Gas Detection Devices
• Manhole Lid Removal Device	• Blower and Hose for Ventilating Manhole
• Leather Gloves	










SAFETY CONTROL DURING INSPECTION





CATEGORIES OF VISUAL INSPECTION

Initial Inspection

- Location
- Manhole Cover
- Ring & Frame
- Manhole Material
- Sizes

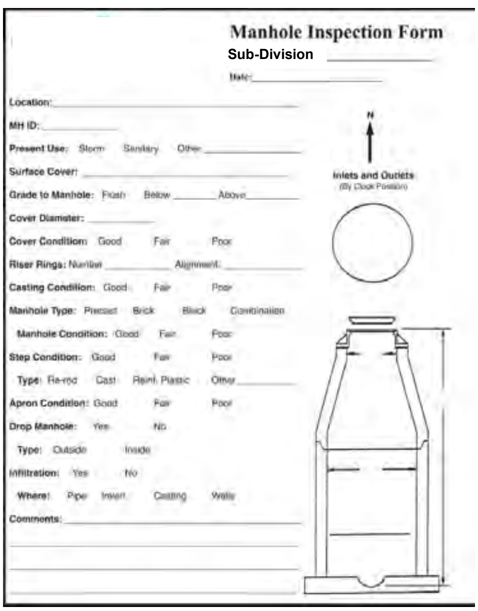
Structural Inspection

- Steps
- Cone
- Riser
- Channel

Hydraulic Inspection

- Inflow
- Clarity
- Flow
- Flow Depth
- Vermin

MANHOLE INSPECTIONFORM



Screening Camera For Sewer Inspection

OBJECTIVES OF SCREENING CAMERA

1. To look for damages / breaks in sewer line
2. To locate root intrusion
3. To find unrecorded connection
4. To locate protruding laterals
5. To locate cracks / inflow sources
6. To search lost / buried lines
7. To verify alignment

COMPONENTS OF CAMERA

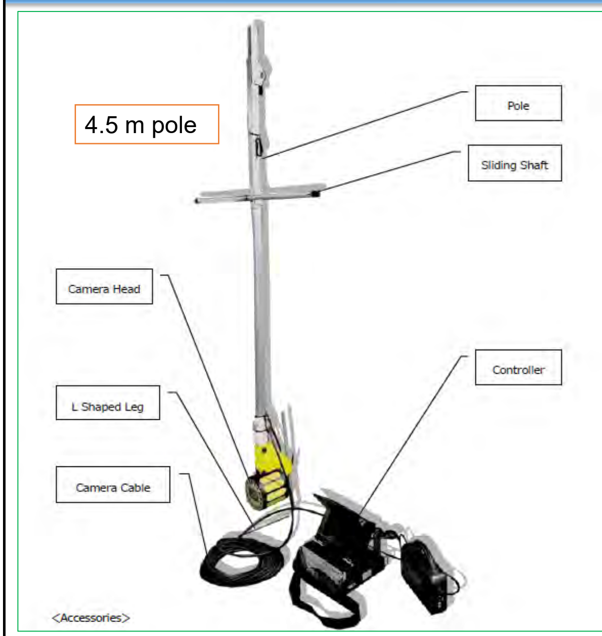
System

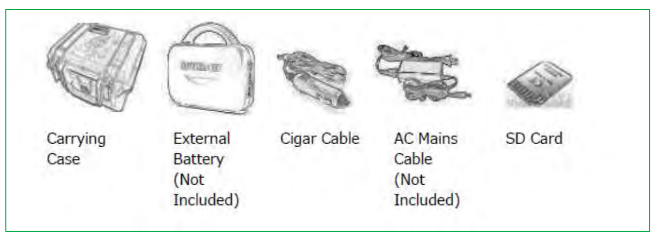
1)	Camera Head	…………	1 pc
2)	Camera Cable (10m)	…………	1 pc
3)	Controller	…………	1 pc
4)	Pole (4.5m : 3-stage telescopic)	…………	1 pc

Accessories

1)	Carrying Case	…………	1 pc
2)	SD Card	…………	1 pc
3)	Cigar Cable	…………	1 pc
4)	AC Mains Cable	…………	1 pc
5)	Instruction Manual (this document)	…………	1 pc

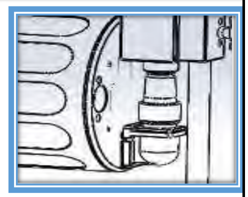
COMPONENTS OF CAMERA

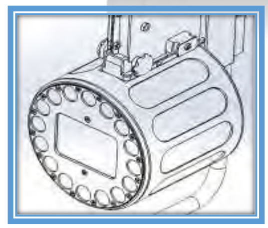




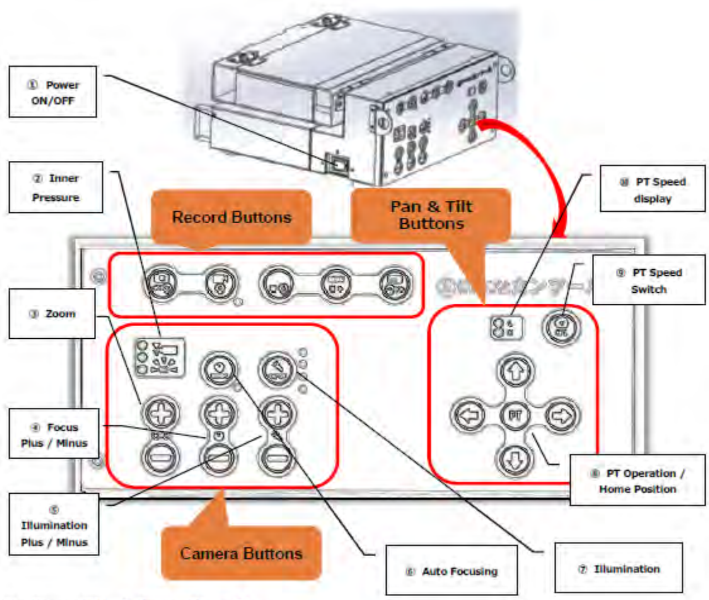
HOW TO CONNECT DEVICE

1. Take out the camera head and the camera cable from the carrying case.
2. Connect the camera head to the camera cable
3. Take out the controller from the carrying case.
4. Connect the controller to the camera cable.
5. Connect the pole to the camera head



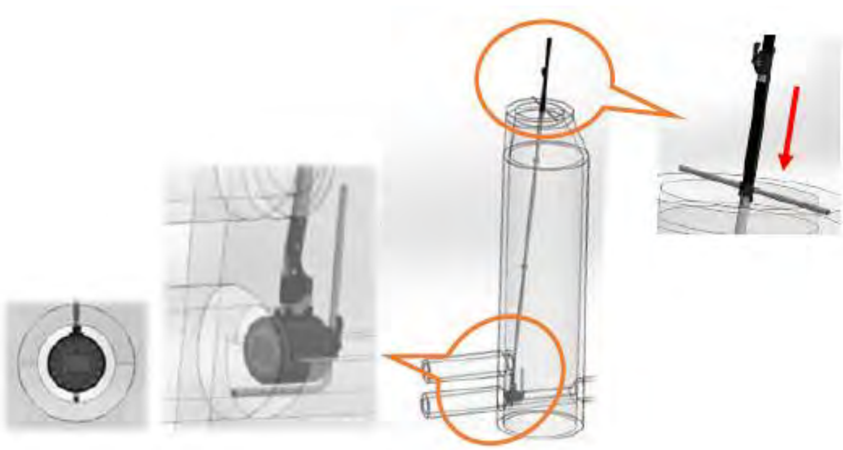


HOW TO OPERATE (OVERVIEW)



① Power ON: I Power OFF: O

INSTALLATION INTO THE MANHOLE



RECORDING (VIDEO/STILL IMAGE)

Video recording time (estimate)

Picture quality	4GB	8GB	16GB	32GB
Highest	About 48 min	About 96 min	About 190 min	About 380 min
High	About 60 min	About 120 min	About 240 min	About 480 min
Normal	About 80 min	About 160 min	About 320 min	About 640 min

AT WASA,S SITE (PICTURES)

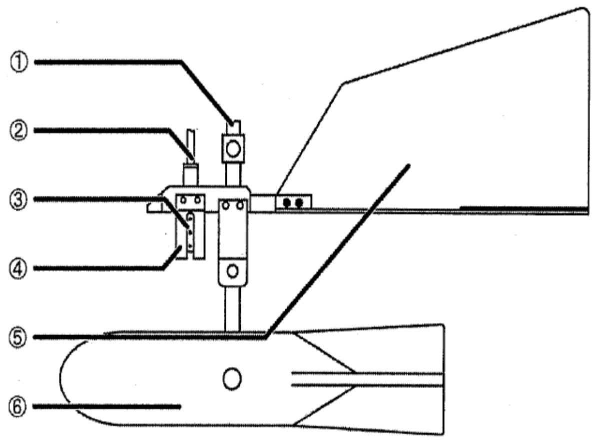
THANKS

Propeller Type Velocity Meter

Operational Principle

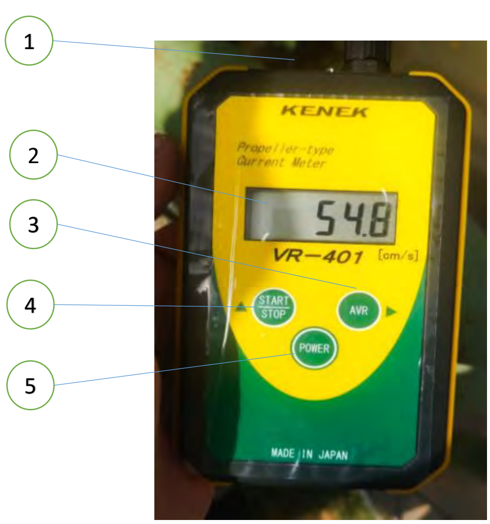
Propeller rotational speed is detected by means of magnet embedded in the propeller which is then converted into velocity by the main unit and displayed

Operational Principle



1. **Mounting Bracket**
2. **Connector Holder**
3. **Propeller**
4. **Protective Ring**
5. **Flowing Wing**
6. **Weight**

Operational Principle



1. **Output Connector**
2. **Display Window**
3. **Avg Time Button**
4. **Start / Stop Button**
5. **Power Button**

Foot Bridges

Measuring Width of Drain

Measuring Depth of Drain

Inlet Point to WWTP

Using Velocity Meter

Measuring Left side of Drain

Measuring Right side of Drain

Inlet Point to WWTP

Issues Using Velocity Meter

Garbage usually plastic or hair which blocks the rotation of propeller which results in "No value"

Remove Garbage with the help of Tweezer

Calculations

Calculations for Channel Avergae Flow Velosity (cm / sec)					
Left Point	**cm/s**	**Mid Point**	**cm/s**	**Right Point**	**cm/s**
V1		V4		V7	
V2		V5		V8	
V3		V6		V9	
Avg. 1		**Avg. 2**		**Avg. 3**	
Final Avg.					
Avg. Velocity (cm/s)			X 0.0328		
Avg. Velocity (ft/s)					

Calculations for Channnel X-Sectional Area 'A'		
Dimensions	**Feet**	
Width of Channel		
Depth of Channel	D1(Left)	
	D2(Mid)	
	D3(Right)	
Average Depth		
X-Sectional Area 'A' (W X D)		
Area	**SQF**	

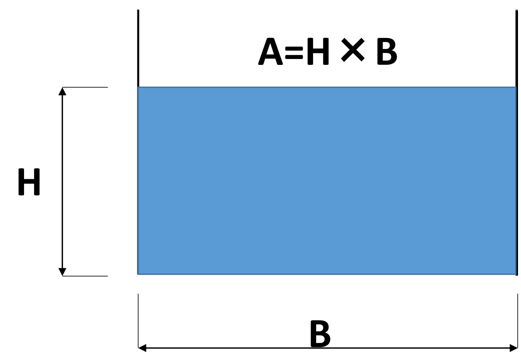
Discharge in Drain / Channel (cft/sec)	
Q = A X V	**x**

Name	
Designation	
Organization	
Location of Site	

Flow Measurement of Open Channels

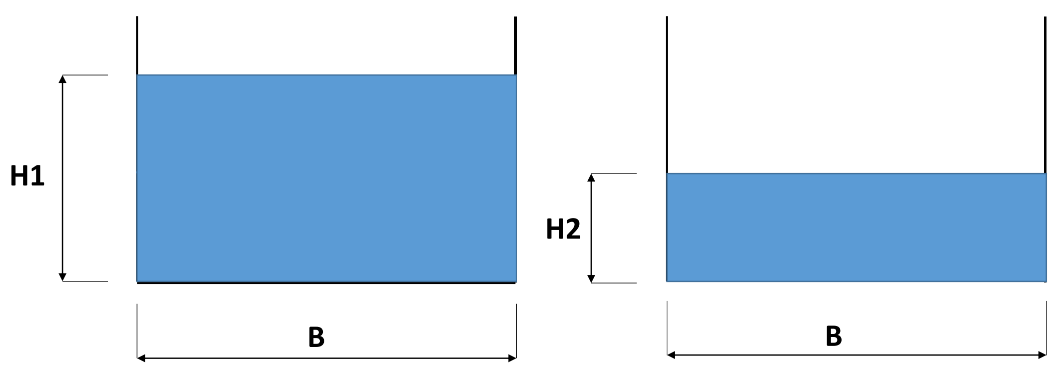
Q=A*V

- Q : Flow Rate
- A : Area
- V : Velocity



Open Channel : Area & Velocity

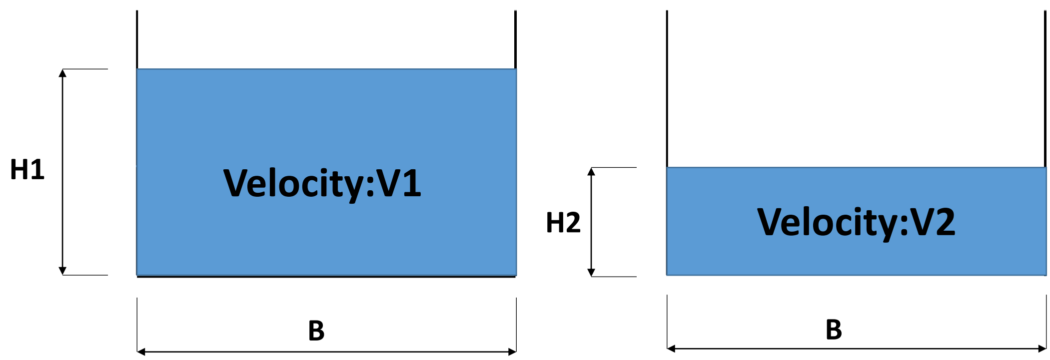
1) Area



A1=H1 × B

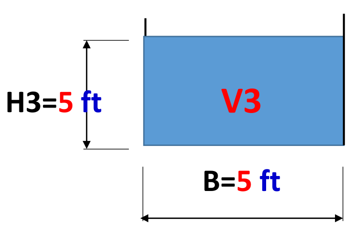
A2=H2 × B

2) Velocity

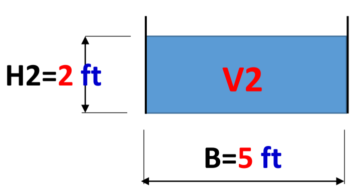


※ Flow velocity depends on the water level position to be measured.

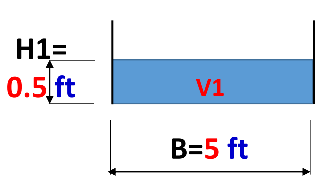
Flow Measurement of Open Channels



A3=5*5＝25 ft2
V3=4.36 ft/s
Q3=25*4.36
=109 ft3/s
(cusec)

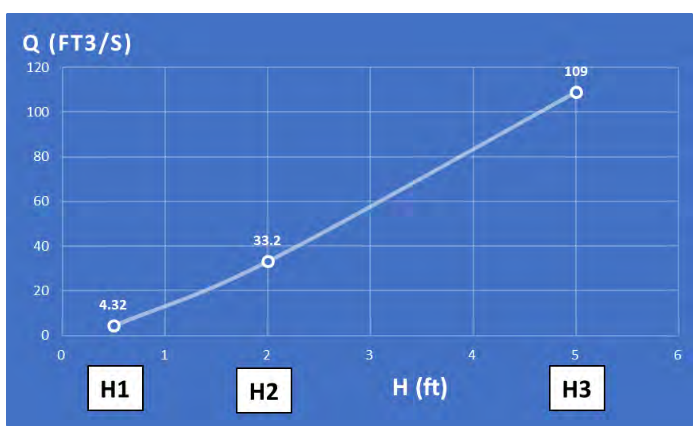


A2=5*2＝10 ft2
V2=3.32 ft/s
Q2=10*3.32
=33.2ft3/s
(cusec)



A1=5*0.5＝2.5 ft2
V1=1.73 ft/s
Q1=2.5*1.73
=4.32 ft3/s
(cusec)

H-Q(Height-Quantity) Curve



※ft3/s＝cusec

Operation & Maintenance of Sewerage and Drainage System
Training Course

29th & 30th March, 2023

To Reduce overflow and crown failure

Database development

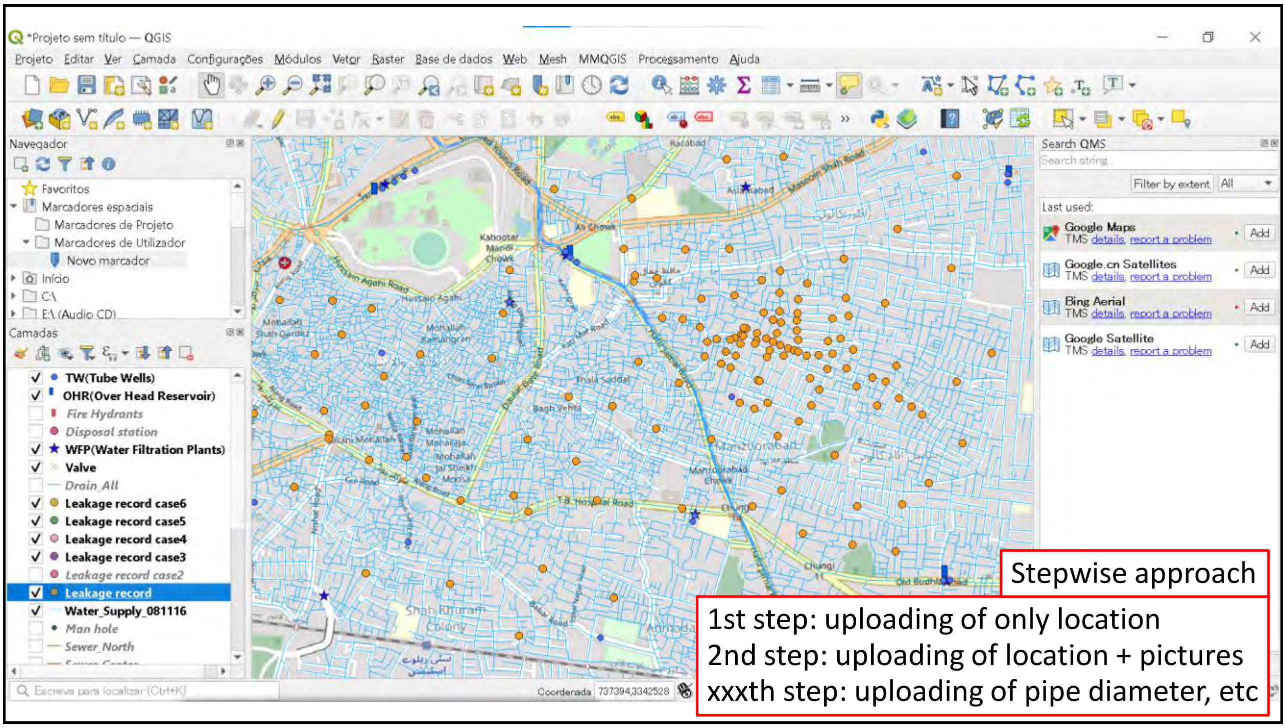
- mWATER

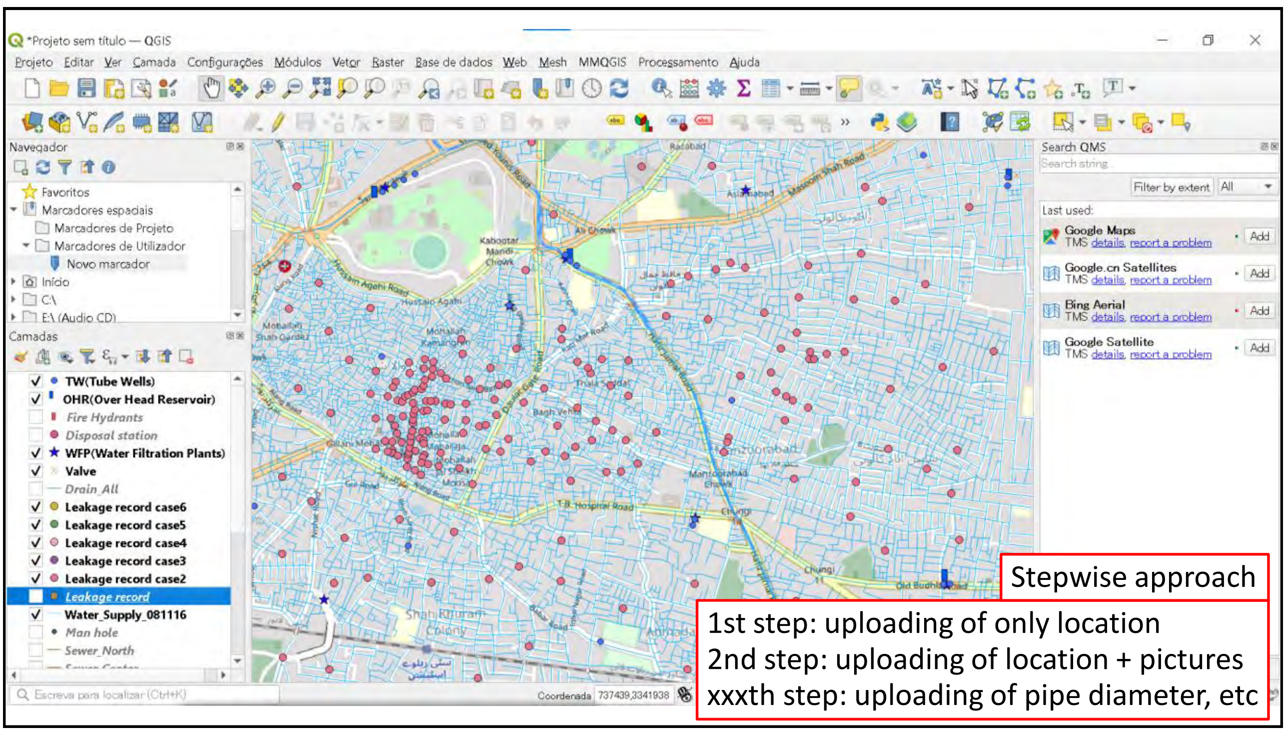
  ex. overflow, clown failure, etc

- QGIS

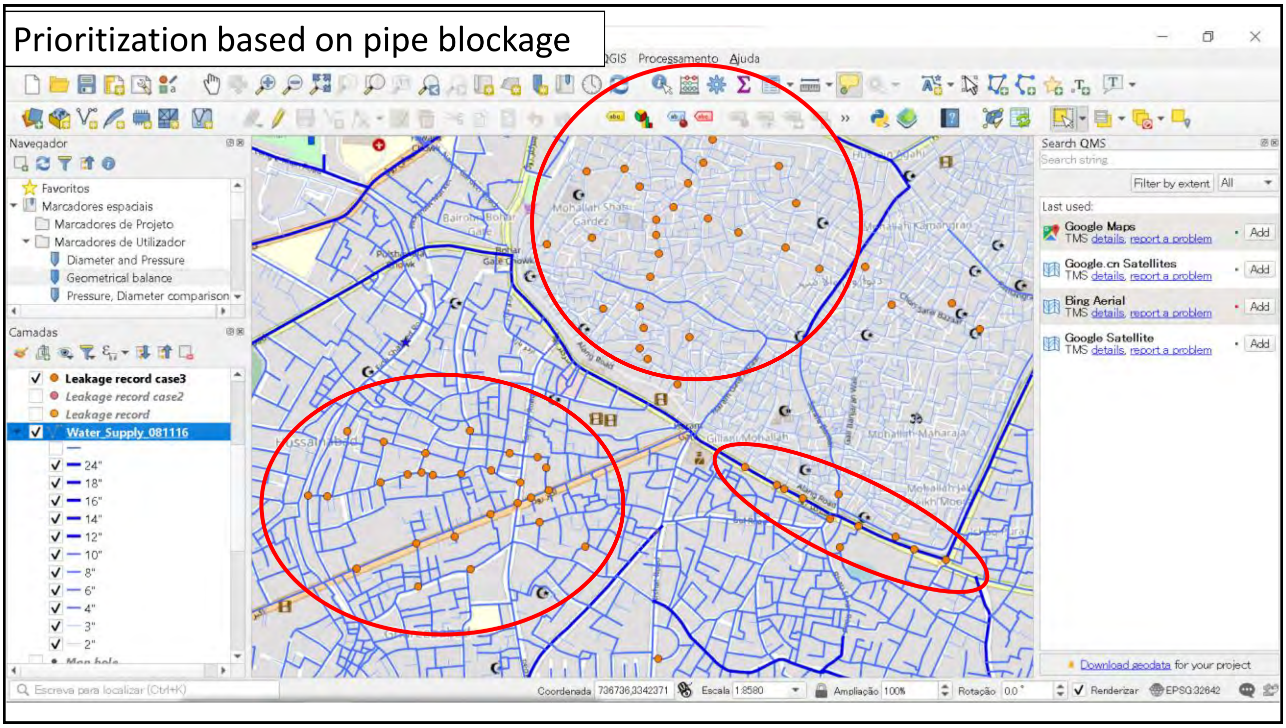
  ex. Background map of mWATER, calculation of length, area,etc

Verification by flow measurement

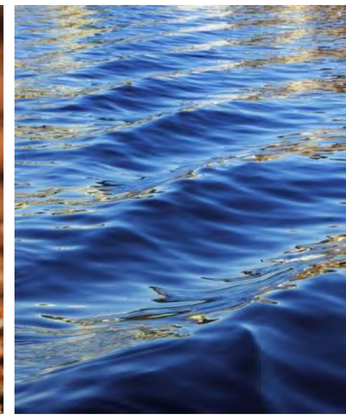

*Projeto sem título — QGIS
TW(Tube Wells)
OHR(Over Head Reservoir)
Fire Hydrants
Disposal station
WFP(Water Filtration Plants)
Valve
Drain_All
Leakage record case6
Leakage record case5
Leakage record case4
Leakage record case3
Leakage record case2
Leakage record
Water_Supply_081116
Man hole
Sewer_North
Stepwise approach
1st step: uploading of only location
2nd step: uploading of location + pictures
xxxth step: uploading of pipe diameter, etc


*Projeto sem título — QGIS
TW(Tube Wells)
OHR(Over Head Reservoir)
Fire Hydrants
Disposal station
WFP(Water Filtration Plants)
Valve
Drain_All
Leakage record case6
Leakage record case5
Leakage record case4
Leakage record case3
Leakage record case2
Leakage record
Water_Supply_081116
Man hole
Sewer_North
Stepwise approach
1st step: uploading of only location
2nd step: uploading of location + pictures
xxxth step: uploading of pipe diameter, etc

Prioritization based on pipe blockage



Wastewater Treatment



PACK Test Procedure

1.

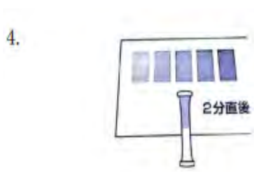
Pull out the line at the end of the tube

2.

With the hole up, pinch the bottom half of the tube tightly with your finger and push out the air inside

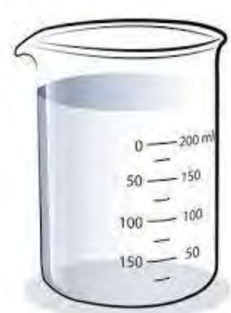
PACK Test Procedure

Continue to place the hole in the test water, loosen the pinching fingers, and wait until half of the water is absorbed. Shake the tube gently 15 times to prevent leakage



Immediately after 2 minutes, place the tube on top of the standard color and compare the colors.

Testing

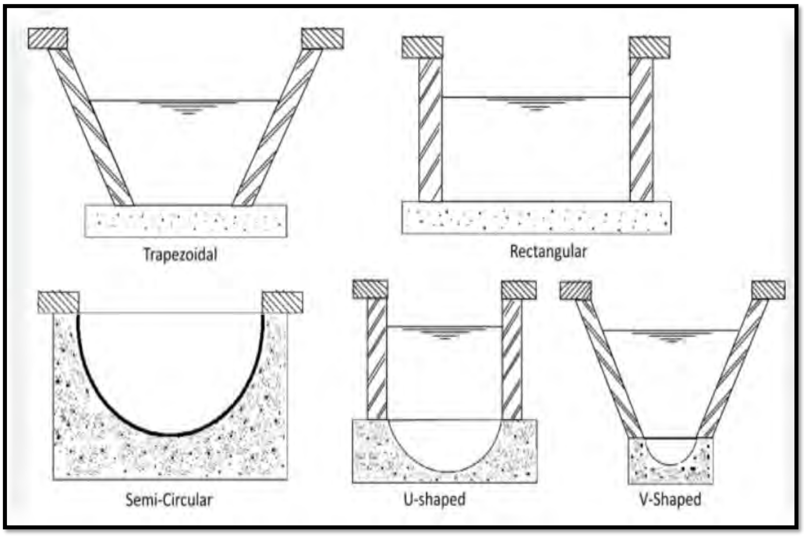
Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
				
Oil	Sugar mix with water	Sand Water	Algae Water	Water

Basics of Drainage System

Classification of Drains

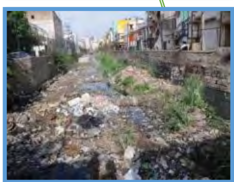
Based on Shapes of Drains:

- Trapezoidal Drain
- Rectangular Drain
- Semi Circular Drain
- U shape Drain
- Vee shape Drain



Critical Issues

Encroachment of drains



Silting of drains due to constant blockages

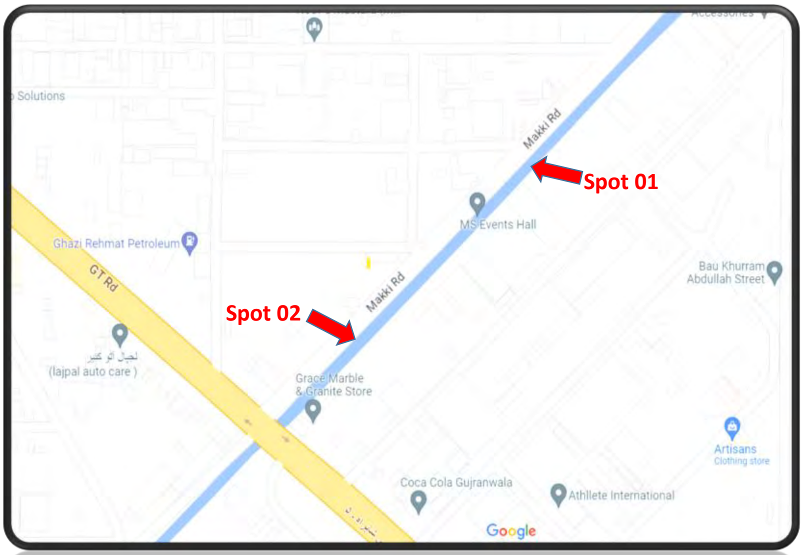
Stability of drainage cross-sections dislocated and damaged old lining of the drains

O&M of Drainage System

Departments should devise maintenance procedures including:

- Frequency of inspection
- Programme for dredging
- Necessary repair works
- Documentation for maintenance records

Using of Velocity meter



Top View of Field Work Area (Sludge Measurement Site)

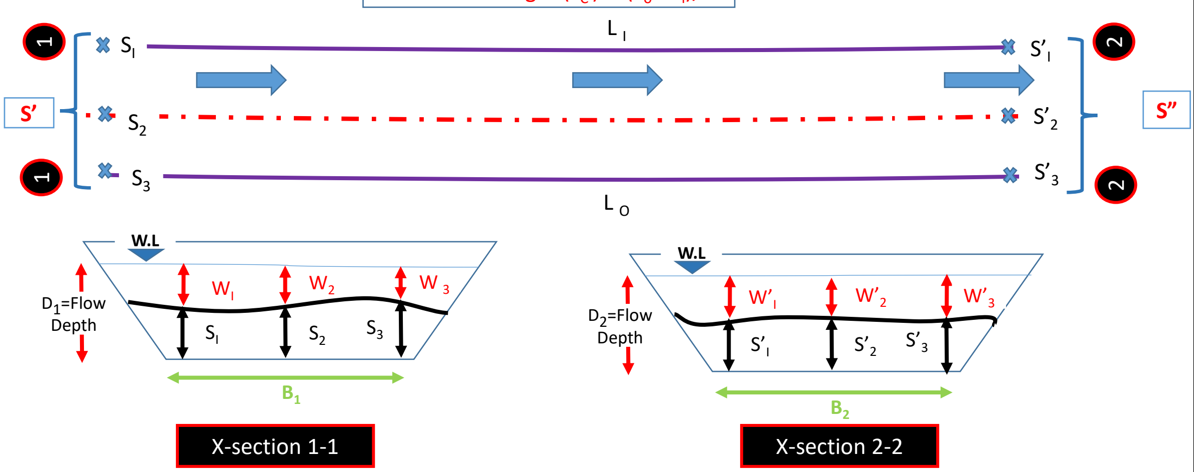
Makki Drain on Makki Road (Near GT Road)

(Measurement of Sludge Quantity in Drains)

Sketches (Layout and X-Section)

Estimated Sludge Quantity = (L_C x $B_{avg.}$ X $D_{avg.}$)

Centerline Length (L_C) = (L_o+ L_i)/2



Sludge Volume Calculation

Depth at Foot 1 S_n= (D- W_n)		Avg. Depth at Foot 1 S_{avg}	Depth at Foot 2 S_n= (D- W_n)		Avg. Depth at Foot 2 S'_{avg}	Overall Avg. Depth D_{avg}	Width at Foot 1 B_1	Width at Foot 2 B_2	Avg. Width B_{avg}	Length Inner L_i	Length Outer L_o	L_c	Sludge Volume V
S_1			S'_1										
S_2			S'_2										
S_3			S'_3										

D_1=

D_2=

Estimated Sludge Quantity (Vol.)
= (L_C X $B_{avg.}$ X $D_{avg.}$)
CUM or CFT

Estimated Sludge Quantity (Vol)
= (X X)
CUM or CFT

L_C = (L_O + L_I) / 2 (if drain stretch is curved)
S' = (S_1 +S_2 +S_3 + …) / n
S'' = (S'_1 +S'_2 +S'_3 + …) / n
$D_{avg.}$ = (S' + S'' + S'''+ …) / n
$B_{avg.}$ = (B_1 + B_2 + B_3 + …) / n

Annex 5.1.9 Outline of In-house Training for "Leakage Control, Plumbing and Pipe Replacement Plan" at 4 WASAs

In-House Training Outline
~Leakage control, Pipe replacement Planning and Plumbing~

1. Leakage Control

1.1 Installation of Water Meter for house connection

1.1.1 Objectives

Metering is not only the basis for collecting tariff, but also provides essential data for understanding the operational status of water utilities. In this course, WASA staffs will learn how to select appropriate equipment, installation methods, and maintenance as the basics for accurate metering.

1.1.2 Materials

Water meter for house connection used in each WASA
Ultrasonic flowmeter provided in the first phase

1.1.3 Methods（Bulk Meters）《conducted in the 3rd year if possible》

The program will consist mainly of practical training and a brief lecture.
(1) Types of bulk meters and their characteristics
(2) Selection of installation site suitable for the objectives
(3) Measurement in pilot area and analysis of water distribution volume
Ultrasonic flowmeter measurements will be taken in the pilot area selected by each WASA, and water distribution volume analysis will be carried out together with water supply volume data (as preparation for the future installation of meters).

Translated with www.DeepL.com/Translator (free version)

1.1.4 Methods（Meter for house connection）

The program will consist mainly of practical training and a brief lecture.
(1) Understanding the classification of water meters in use and to be introduced at WASA.
(2) Understanding of international standards for meters, differences in accuracy (measurement range), and selection of meters that are compatible with Pakistan (using general specification tables).
(3) Maintenance (replacement)
(4) What to consider when planning the installation location
(If each WASA has a different opinion on the location of the meter inside or outside the premises, the staff need to discuss it when necessary.)
(5) Installation practice
For proper meter installation technique, the SOPs of Faisalabad will be applied.

1) Understanding of SOPs

2) Conduct the installation following the SOPs, in the actual field or using model piping for training.

Translated with www.DeepL.com/Translator (free version)

1.2 Proper installation of service pipe materials

1.2.1 Objectives

Since leakages from service pipes are said to the largest number of leakages, the appropriate selection of materials, installation methods and use of equipment will be learned to help prevent leakage from the service pipe installation stage

1.2.2 Materials

Nothing to newly purchase

1.2.3 Methods

The program will consist mainly of practical training and a brief lecture.

(1) service pipe material selection (regarding materials currently used in each WASA)

(2) Methods of branching service pipe from distribution pipe

(3) Installation equipment and methods suitable for the materials

(4) Water pressure test methods

(5) Plumbing practice

1) Preparation of appropriate materials (model piping for training or actual piping)

2) Branching from distribution pipe

3) Water pressure test using a hand pump in model and actual piping

4) Verification of proper installation using a check sheet

5) Confirm the procedure of Faisalabad SOP.

1.3 Repair of service pipes

1.3.1 Objectives

Learn the leakage repairing methods according to pipe type, diameter, leak point and size.

1.3.2 Materials

(1) Repair clamps for water supply pipes, joint accessories, packings

(2) Repair clamps for water distribution pipes, pipe joint accessories such as couplings, etc.

(Purchase if there is a lack of appropriate repair parts)

1.3.3 Methods

(1) Repair methods for each leak location

1) Service pipe branch: Replacement of saddle, ferrule and packing

2) Service pipe and meter: Replacement of rubber ring, replacement of joint accessories, pipe cutting

3) Distribution pipe: Repair clamps, pipe cutting

(2) Leakage from water distribution accessories

1) Sluice valve, fire hydrant, air valve

(3) Leakage repair records (described in detail in the next chapter)

1) Record format

2) Record and save in format

2. Pipe Replacement Planning

Establishment of data collection methods at leak repair sites

2.1.1 Objectives

・Leakage repair records are continuously reflected in the existing database.

・Areas for pipeline replacement are prioritized based on the collected data on the number of leaks.

2.1.2 Materials

None in particular, using existing smartphones, PCs, etc. used by WASA staff in their daily work.

2.1.3 Methods

－Preparation phase (until 2021.11) -

(1) PCGIP data (GIS data and Excel data) held by the Urban Unit will be shared with all WASA.

(2) Creation of data collection form

1) Digital input by smartphone will be assumed; based on discussions with WASA, easy-to-use forms such as Google Form, ODK, etc. will be selected. However, we will also consider step-by-step methods such as paper-based in the second year and digital in the third year (to be discussed with WASA).

2) It is assumed that point-vector layers showing leak repair points will be created on GIS.

3) Select data that will contribute to reducing water leakage such as:

- Date and time of repair,
- responsible person
- pipe ID
- date and time of repair, material
- town, district, tehsil
- repair method (tape only or clamp), and

・comments (leak condition, etc.).

＊In advance, JICA expert team (GIS, construction, leakage) and coordinator will discuss and have some ideas on what kind of data is needed (decide on potential record format), who to share it with, and how to use it.

—In-House Training—

(1) Inform staff of the need for each parameter and why it is important.

(2) Explain the structure of the form and instruct the data entry methods.

(3) Understand the evaluation methods for condition, risk, etc. among the input items.The evaluation methods are based on the Phase 1 materials.

(3) Understand the evaluation methods for condition, risk, etc. among the input items. The evaluation methods are based on the Phase 1 materials.

(4) Go to the actual leakage repair site and input data into the form. (Whether this will be done at the same time as the leak repair instruction will be discussed with each WASA)

(5) Check the collected data on the PC in the office and integrate it into the existing database.

WASA-F, L: Integrate into ArcGIS database and display mapping.

WASA-G, M, R: Merge into Excel file of existing data. In addition, in anticipation of the future introduction of Arc GIS, the data will be displayed in QGIS.

(6) Water leakage repair plan

How to plan pipe replacement, meter installation, leakage survey, and leakage repair will be discussed based on collected data .

*Items to be discussed in advance with WASA

1) Data collection method (paper or digital), and if digital, which software to use.

2) What kind of data flow should be used?

Example

Construction team: Keep records of repairs and construction, and if paper-based, send them to the supervising department (field branch office? headquarters?). If it is digital, it will be transferred automatically.

GIS team: Receive information from the supervising department and reflect it in GIS data.

Planning department: Review priority replacement areas based on GIS data.

Leakage team: Investigate in priority survey areas.

3) Data sharing methods

・Which department should have the data necessary for water supply management?

・Approval method: Method for managerial staff to swiftly recognize the survey result data significant for waterworks management.

3. Piping Work

Joint/Connection/Replacement including welding and fusion

3.1 Jointing and pressure test

3.1.1 Objectives

When a water distribution pipe is damaged, several meters of pipe are replaced. After the repair, there are cases where leakage recurs at the repaired section.

The objectives of this training help participants to understand the causes of leakage theoretically on the quality of pipe connections, which are possible.

1) Quality of joints
2) Use of non-compliant products
3) Understanding of standards

3.1.2 Materials

From WASA stock：

Asbestos pipe
MS pipe, HDPE and PVC pipe
Replaced old Gibault joint
Materials to close at one end of pipe for pressure test

To be purchased (high quality)

1) Tool

Hand pressure pump
Tools (right angled ruler, grinder, and any flat plate to check the shape of cross section of pipe)

2) Material

Gibault joint
Two MS single-flange pipes for pressure test (minimum of two Gibault joints are required to test AC pipe)
Blind flange
MS pipes, HDPE and PVC pipes if WASA doesn't have

3.1.3 Methods

(1) Prepare an existing Gibault joint that has a leak and a quality-assured Gibault joint.
(2) Compare the parts of both joints so that the staff can understand the differences.
(3) Prepare the pipe to be connected, and measure its outer diameter and then estimate pressure rating, referring standard.
(4) Have the staff check the verticality of the cut face of the pipe (is there a gap when the plate is applied? Is the end face right-angled to the pipe? If there is a gap, have the staff correct it.
(5) Referring to the installation manual provided by the manufacturer, check and compare the

applicable pipe type, applicable outside diameter and tightening torque If this information is not known for an existing joint, check how it was previously determined.

(6) Perform a 10-minute pressure test on the leaking Gibault joint.

(7) If there is no leak, place a weight on the joint and perform a pressure test for 10 minutes.

(8) Perform a 10-minute pressure test on the Gibault joint whose quality has been verified.

(9) If there are no leaks, place a weight on the joint and conduct a pressure test for 10 minutes.

(10) Evaluate the results of both tests (If there is no problem, it means that the installation work was not done properly. If there is a problem, you can suspect a problem with the product itself.

3.2 Flange jointing and pressure test

3.2.1 Objectives

There are various standards for flanges, such as ANSI (ASTM, API), ISO (DIN, BS), and JIS, and the dimensions, torque tightening force, etc. differ depending on the standard and pressure resistance. However, there are cases where staff do not have a sufficient understanding of these standards and are using improper flanges.

Therefore, the Objectives are to understand the following.

1) Differences in dimensions according to standards

2) Points to keep in mind in assembling

3.2.2 Materials

From WASA's stock:

Flange tube (PN6, PN10, PN16)

To be purchased:

Torque Wrench

Restraint Joint

Blind flange for pressure testing

Teflon sealing tape

Measure

3.2.3 Methods

(1) Prepare samples of three types of existing DN100 flanges (PN6 and PN10) for ISO, ANSI, and JIS.

(2) Have the staff look at the dimension tables of the standards and determine which sample fits which standard.

(3) Prepare connection materials (bolts) that are compatible with the three types of flanges, have the staff select a bolt from among them, and have them connect the flanges using it.

(4) The instructor gives a review of the connection work done by each staff member.

(5) After disassembling the connected flanges, use a torque wrench to control the torque and tighten them in the recommended order.

3.3 HDPE Fusion 《conducted in 2nd year if we have time to spare, otherwise in 3rd year》

3.3.1 Objectives

HDPE pipes are mainly used in small-diameter pipes in water distribution systems and also in large-diameter (1m) pipes in sewage systems. While Butt fusion, which is usually applied in pipe joining, is simple in terms of mechanism, there is cases, it can't be achieved to fuse the pipes properly according to the specified parameters. The existence of such a problem may not be recognized except operator of fusion machine.

Therefore, the Objectives of this section are to understand the following.

1) Fusion parmeters defined by standard like ISO

2) Relationship between the manufacturer's recommended values and the values in the standard.

3) Methods to verify the fusion quality.

3.3.2 Materials

From WASA's stock

HDPE pipe of OD125 or OD110 (pressure resistance: PN10 (SDR17), PN16 (SDR11))

To be purchased:

Infrared temperature meter,
Welding gauge,
Fusion machine for HDPE (OD100 to OD250),
Generator 10kVA (depending on capacity of fusion splicer)
Tools: White pen (eraser)

3.3.3 Methods

(1) Prepare HDPE pipes (pressure resistance: PN10 and PN16, length: 0.5 m long and 6 m or more, total 4 types).
(2) Explain the fusion curve of the ISO standard.
(3) Compare the manufacturer's recommended setting values with the ISO values.
(4) To make the staff understand the principle of setting the fusion pressure.
(5) To perform two types of fusion welding, high pressure and low pressure.
(6) Evaluate the finished product. (Bead size, left-right balance, internal bead)

3.4 Others

In addition, lectures on flange adapters, dismantle joints, mechanical joints, and breakaway prevention joints are also available upon request, as long as they are classroom lectures that do not require the purchase of materials.

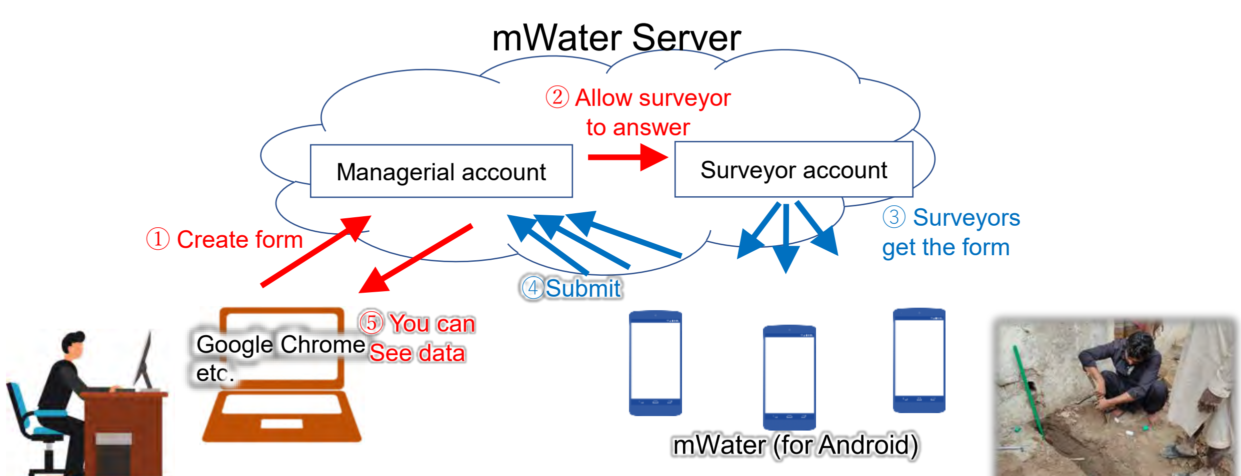
Annex 5.1.10 Training Material on "Pipe Replacement Planning"

- WASA Faisalabad for ToT, Pilot In-house Training, In-house Training (1st, 2nd)
- WASA Multan for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training (1st)

mWater App

(for Android)

mWater Data Collection

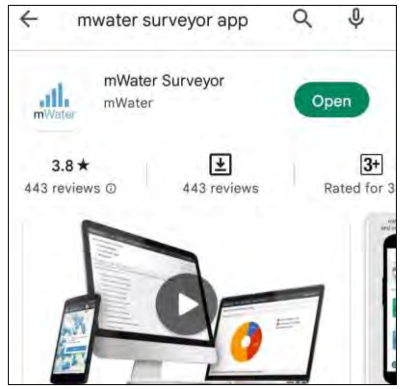


mWater Portal
(Office)

mWater App
(Field)

mWater App

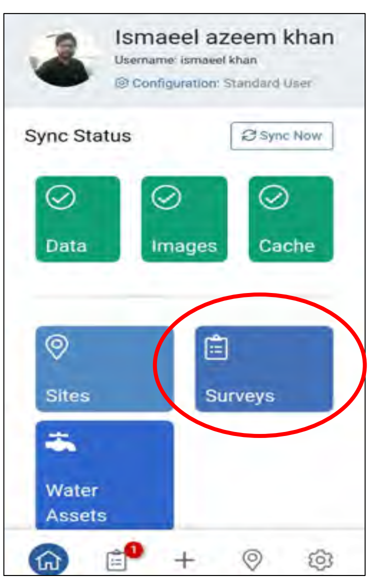
- Download from Play store with the name of **(mWater surveyor)**



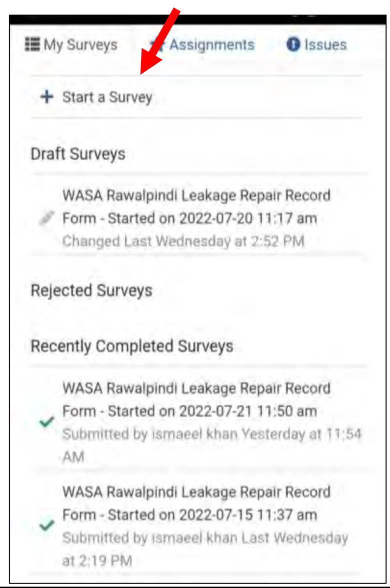
- Made Log-In ID on App and use it for Portal on PC.

mWater App

- After logging in, Click "Survey" icon

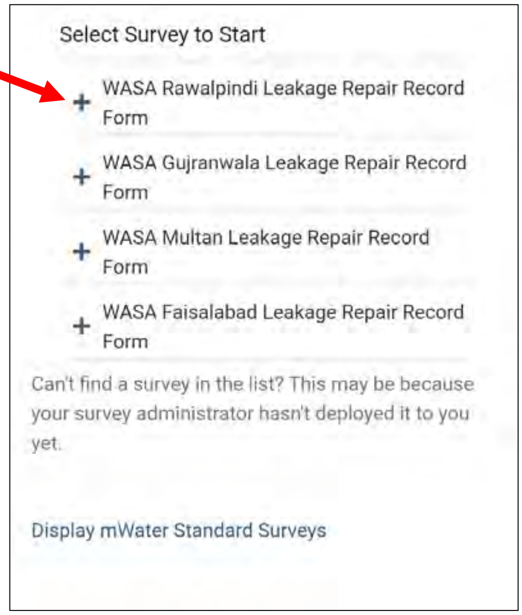


- Click icon "Start Survey"



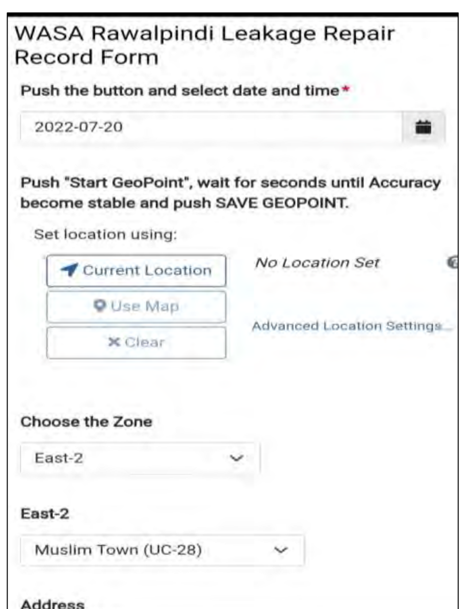
mWater App

- Select Form



mWater App

Put the information on the site, the repair situation etc.



mWater app

- Take photo

  and

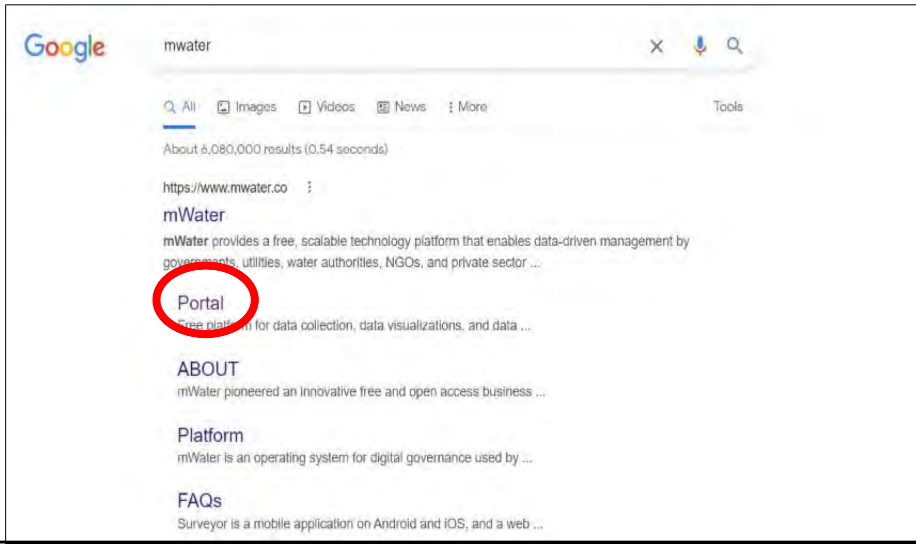
- Click “Submit”.

- When Internet is not available, Click “Save for Later”

mWater Portal

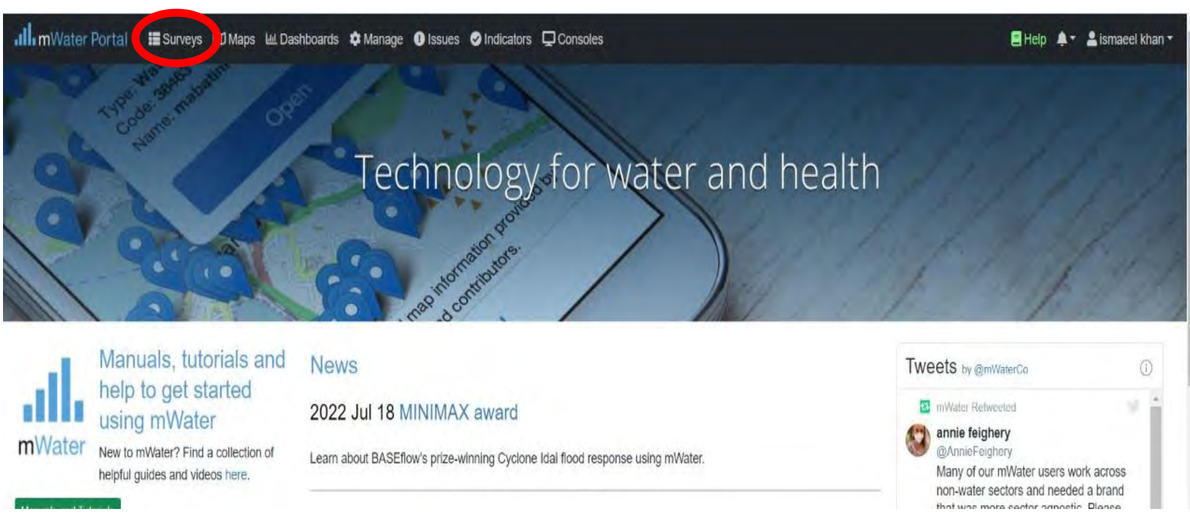
mWater Portal

- After the submission from mWater app, we can see the results on our PC or browser on smartphone or tablet, and analyze the results.



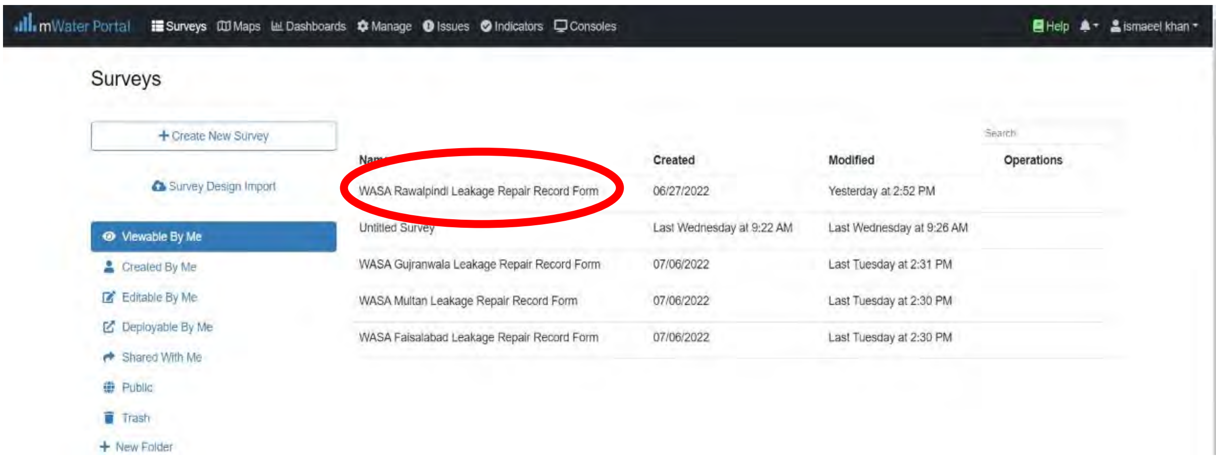
mWater Portal

- After Log in, click on “Survey” ICON.



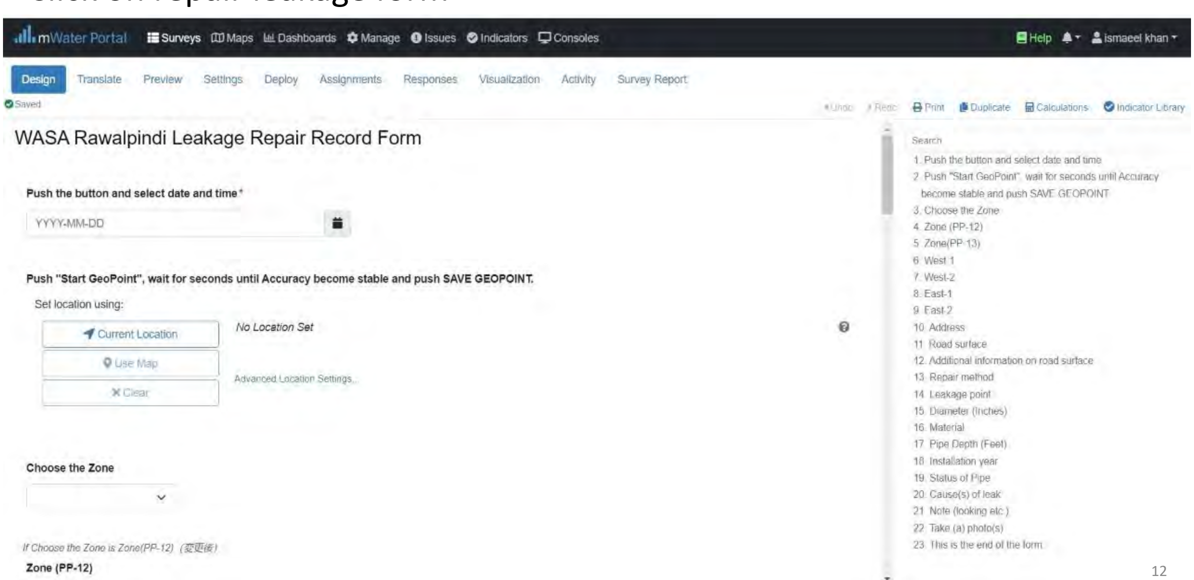
mWater Portal

- We can either use prepared form or create new survey



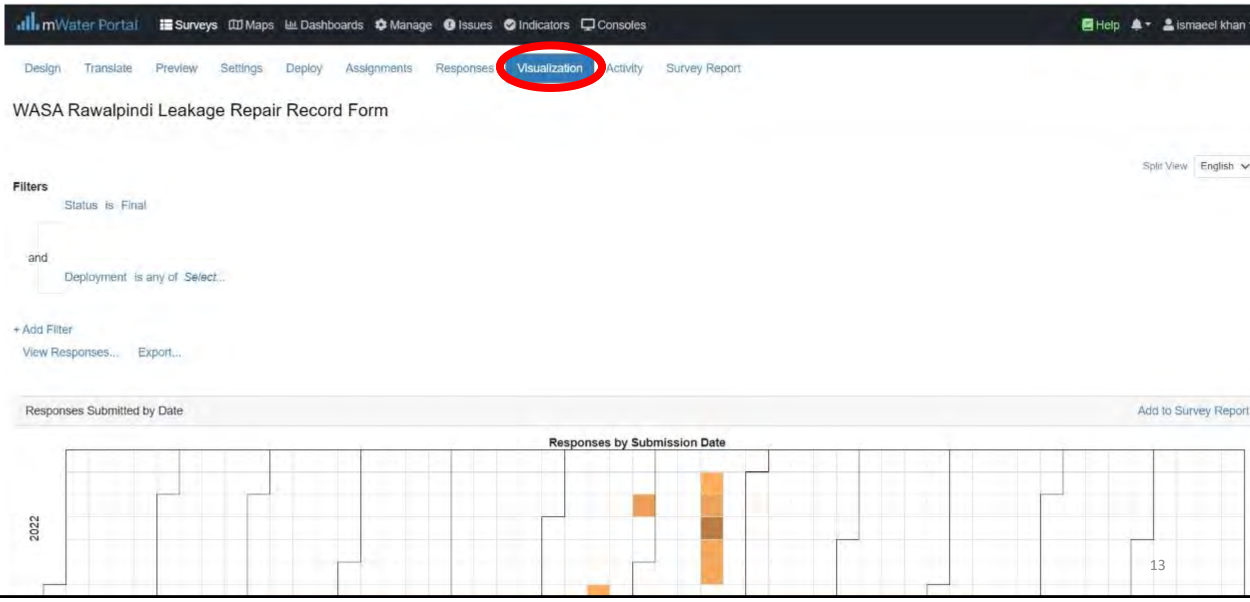
mWater Portal

- Click on repair leakage form



mWater Portal

- To see the form click on visualization



mWater Portal

- Example of Visualized data

Push "Start GeoPoint", wait for seconds until Accuracy become stable and push SAVE GEOPOINT

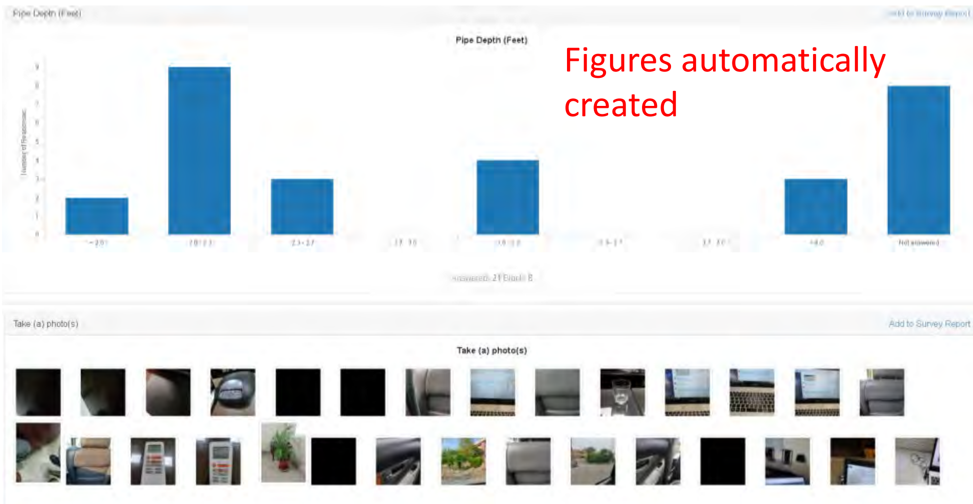
Mapping of the cases

Choose the Zone

Figures automatically created

mWater Portal

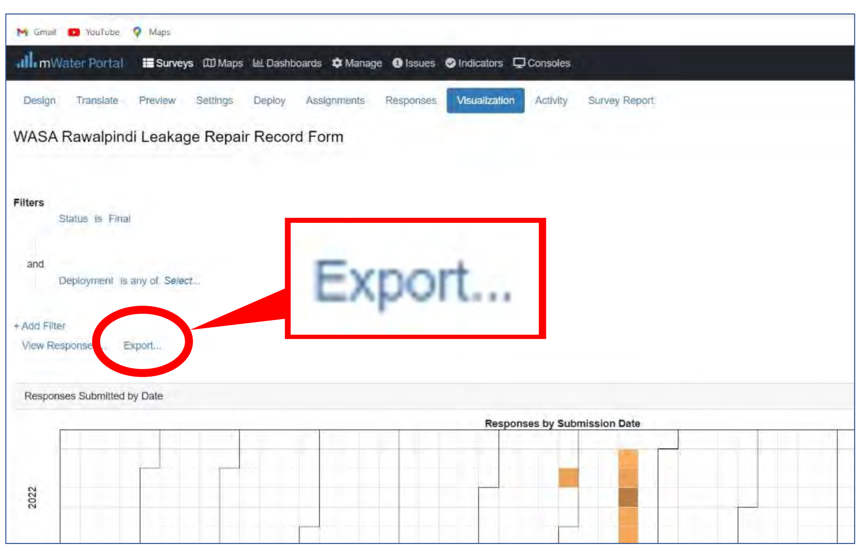
- Example of Visualized data



Photos

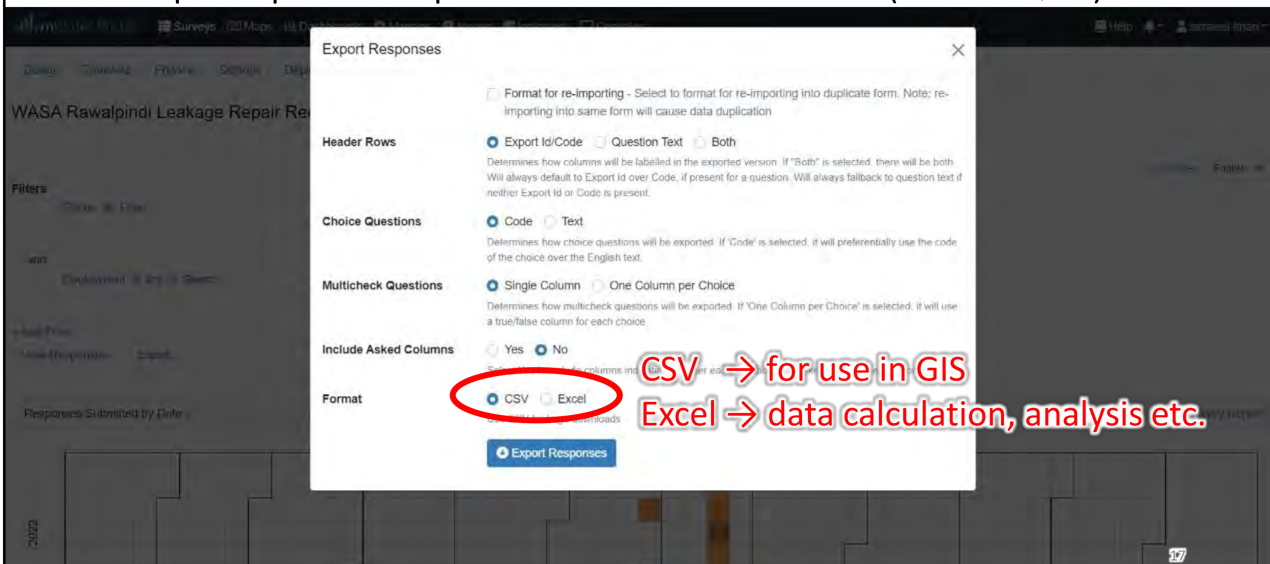
mWater Portal

- We can export file by clicking "Export" option.



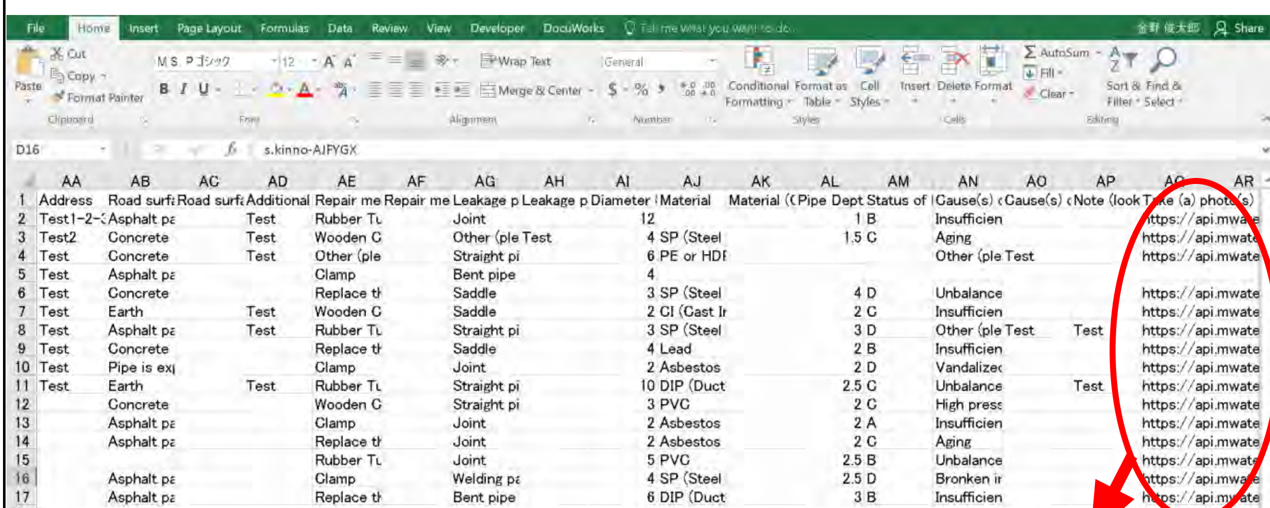
mWater Portal

Click on Export Option to export this file into Excel or CSV (used in QGIS)



Downloaded Excel sheet

(.xlsx or .csv)



D16 s.kinno-AJFYGX

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1	Address	Road surfa	Road surfa	Additional	Repair me	Repair me	Leakage p	Leakage p	Diameter	Material	Material (	Pipe Dept	Status of	Cause(s) c	Cause(s) c	Note (look	Take (a) photo(s)	
2	Test1-2-3	Asphalt pa		Test	Rubber Tu		Joint		12			1	B	Insufficien			https://api.mwate	
3	Test2	Concrete		Test	Wooden C		Other (ple	Test	4	SP (Steel		1.5	C	Aging			https://api.mwate	
4	Test	Concrete		Test	Other (ple		Straight pi		6	PE or HDI				Other (ple	Test		https://api.mwate	
5	Test	Asphalt pa			Clamp		Bent pipe		4									
6	Test	Concrete			Replace th		Saddle		3	SP (Steel		4	D	Unbalance			https://api.mwate	
7	Test	Earth		Test	Wooden C		Saddle		2	CI (Cast Ir		2	C	Insufficien			https://api.mwate	
8	Test	Asphalt pa		Test	Rubber Tu		Straight pi		3	SP (Steel		3	D	Other (ple	Test	Test	https://api.mwate	
9	Test	Concrete			Replace th		Saddle		4	Lead		2	B	Insufficien			https://api.mwate	
10	Test	Pipe is ex			Clamp		Joint		2	Asbestos		2	D	Vandalized			https://api.mwate	
11	Test	Earth		Test	Rubber Tu		Straight pi		10	DIP (Duct		2.5	C	Unbalance		Test	https://api.mwate	
12		Concrete			Wooden C		Straight pi		3	PVC		2	C	High press			https://api.mwate	
13		Asphalt pa			Clamp		Joint		2	Asbestos		2	A	Insufficien			https://api.mwate	
14		Asphalt pa			Replace th		Joint		2	Asbestos		2	C	Aging			https://api.mwate	
15					Rubber Tu		Joint		5	PVC		2.5	B	Unbalance			https://api.mwate	
16		Asphalt pa			Clamp		Welding pa		4	SP (Steel		2.5	D	Bronken ir			https://api.mwate	
17		Asphalt pa			Replace th		Bent pipe		6	DIP (Duct		3	B	Insufficien			https://api.mwate	
18																		

All the answers are shown in the table

Open the image on web browser

QGIS

(PC Software)

QGIS Software

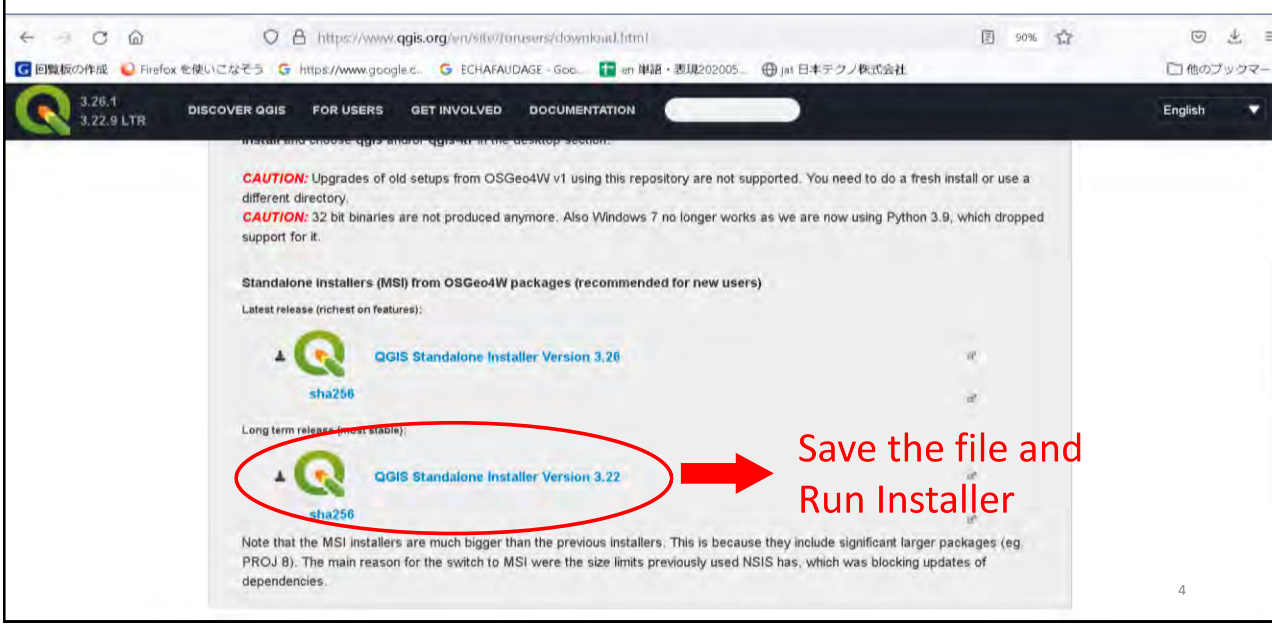
Index

- Use of QGIS software
- How to see mWater data and show them on **QGIS**.
- How to utilize the data

Step-1: How to install QGIS

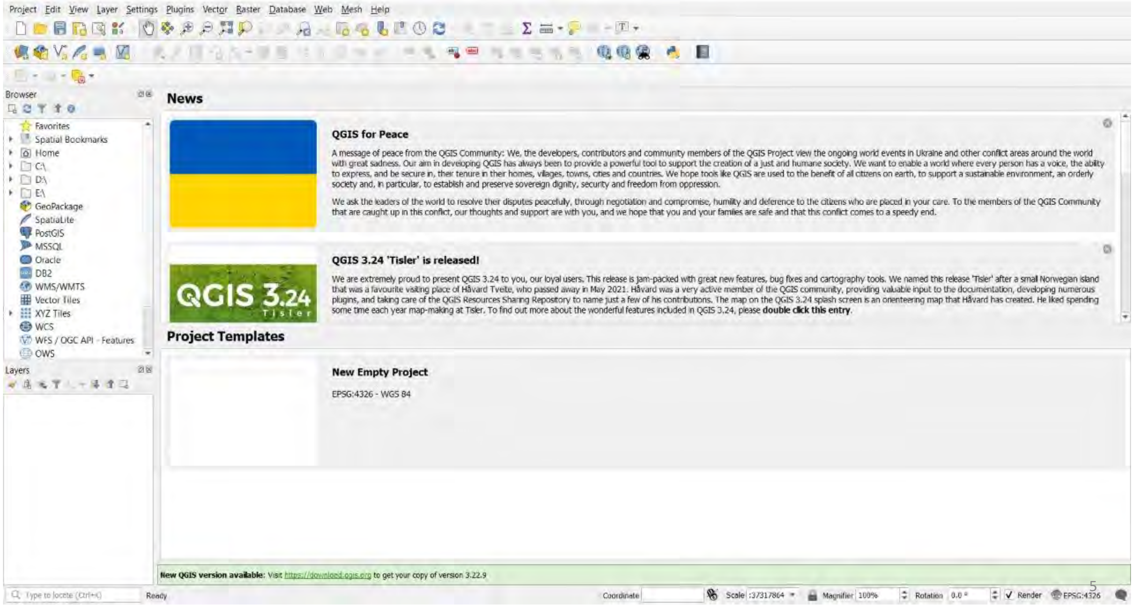
3

Step 2: How to install QGIS

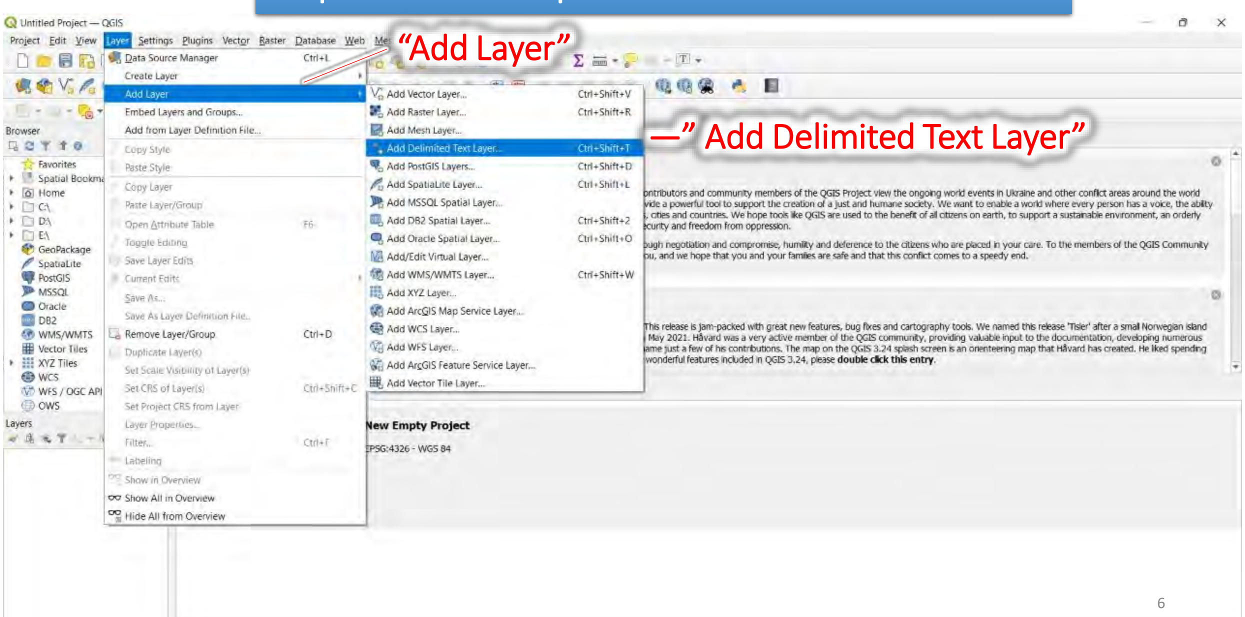


4

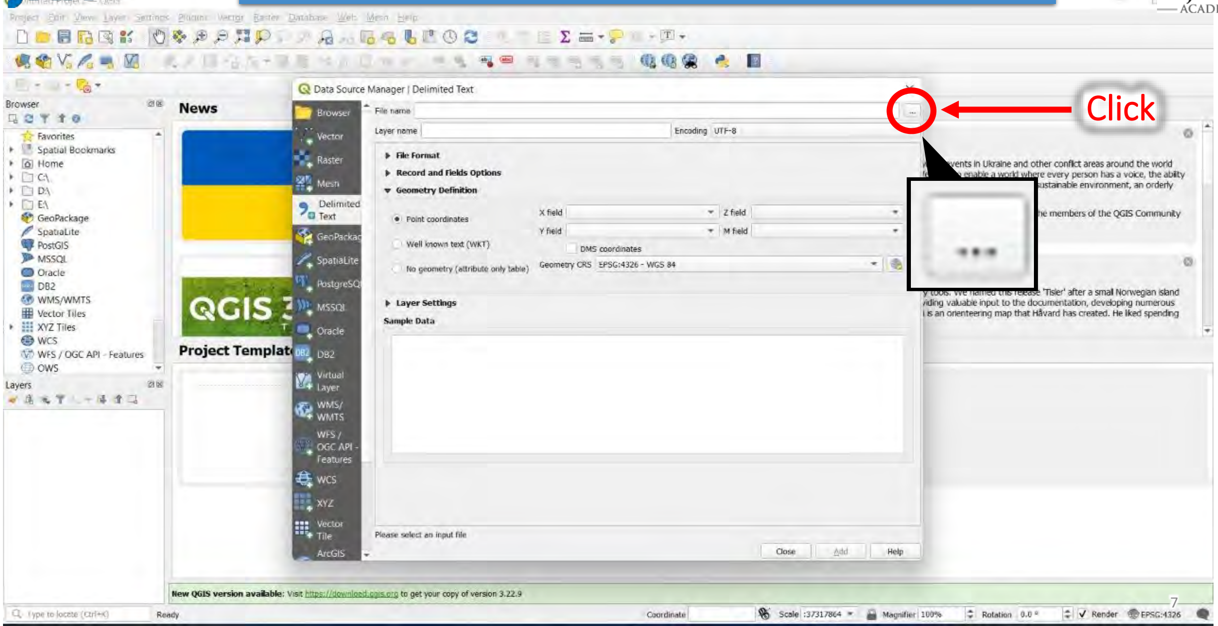
Step 1: How to import mWater data to QGIS



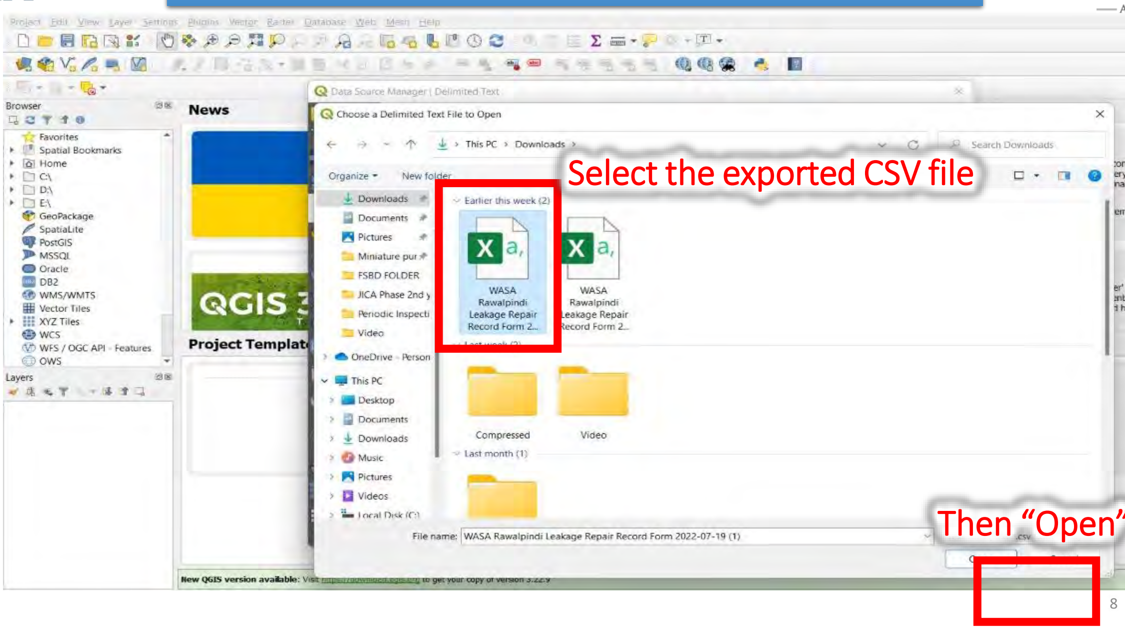
Step 2: How to import mWater data to QGIS



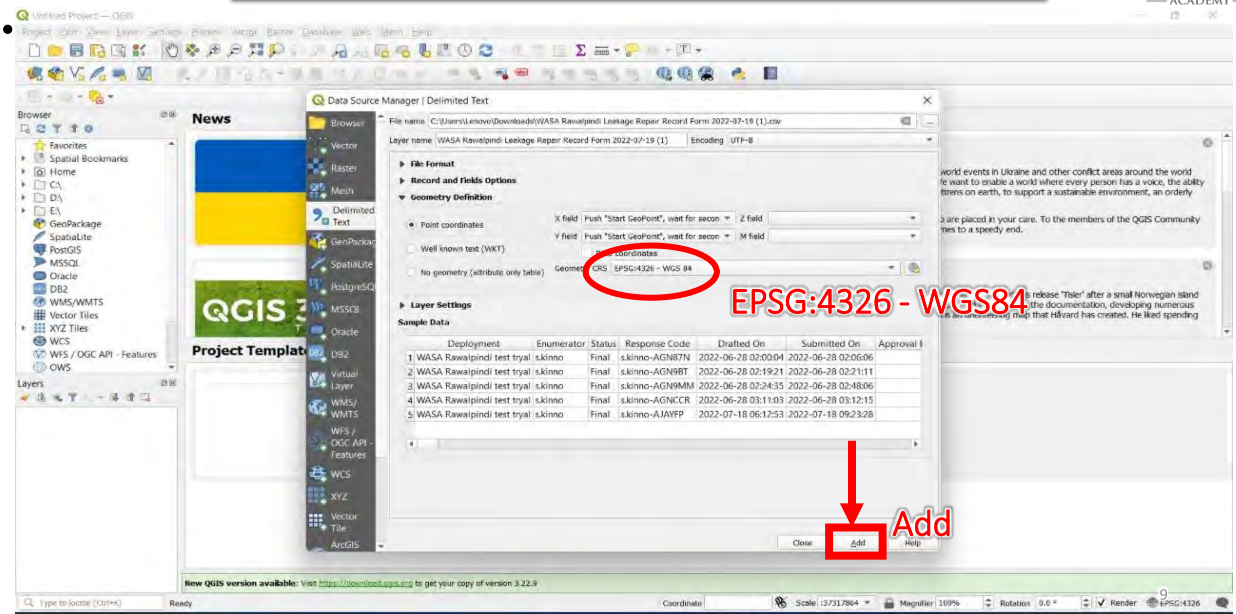
Step 3: How to import mWater data to QGIS



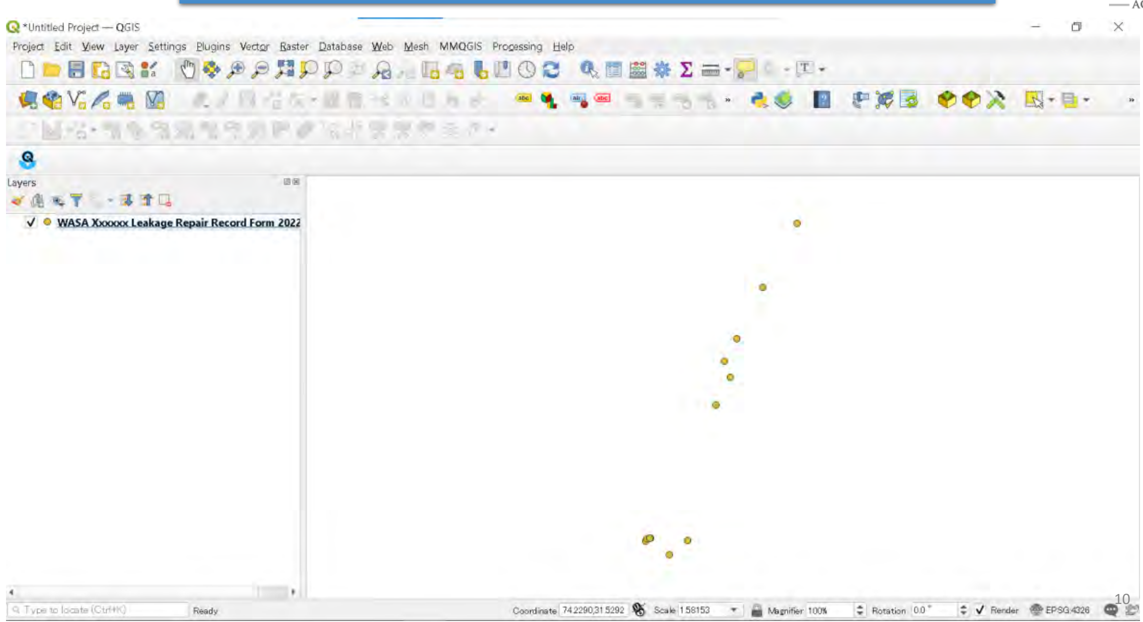
Step 4: How to import mWater data to QGIS

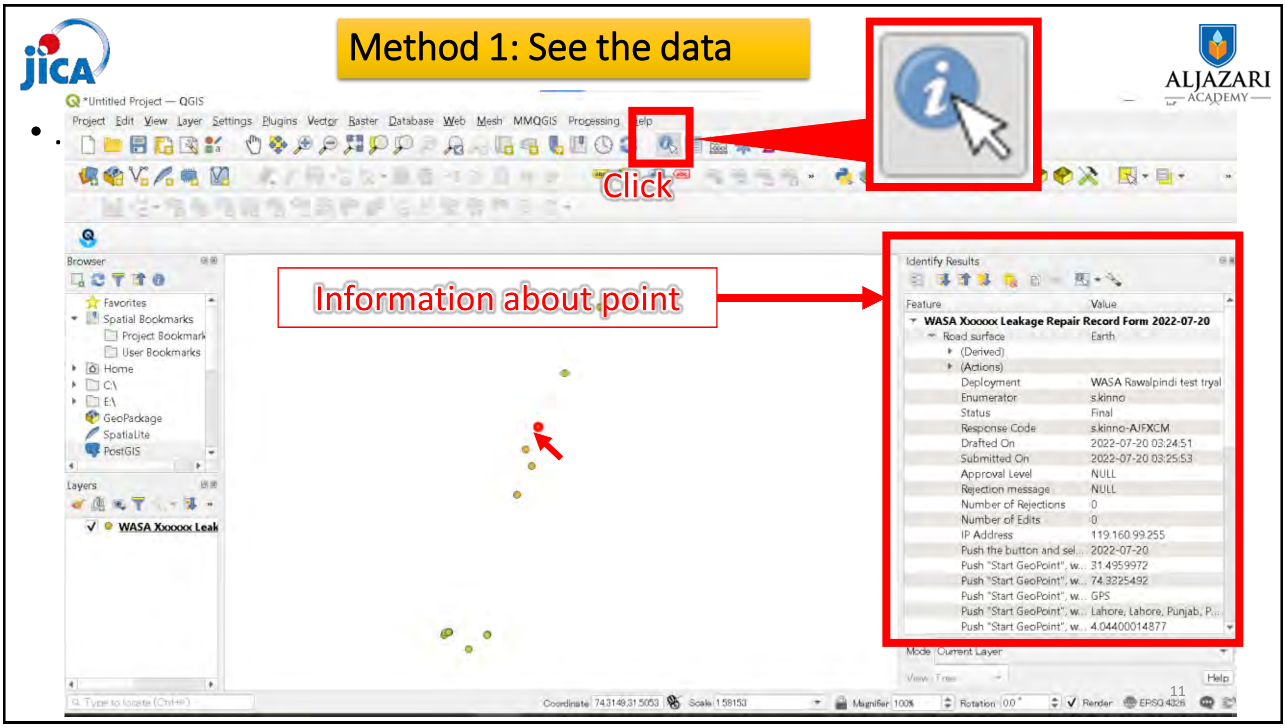


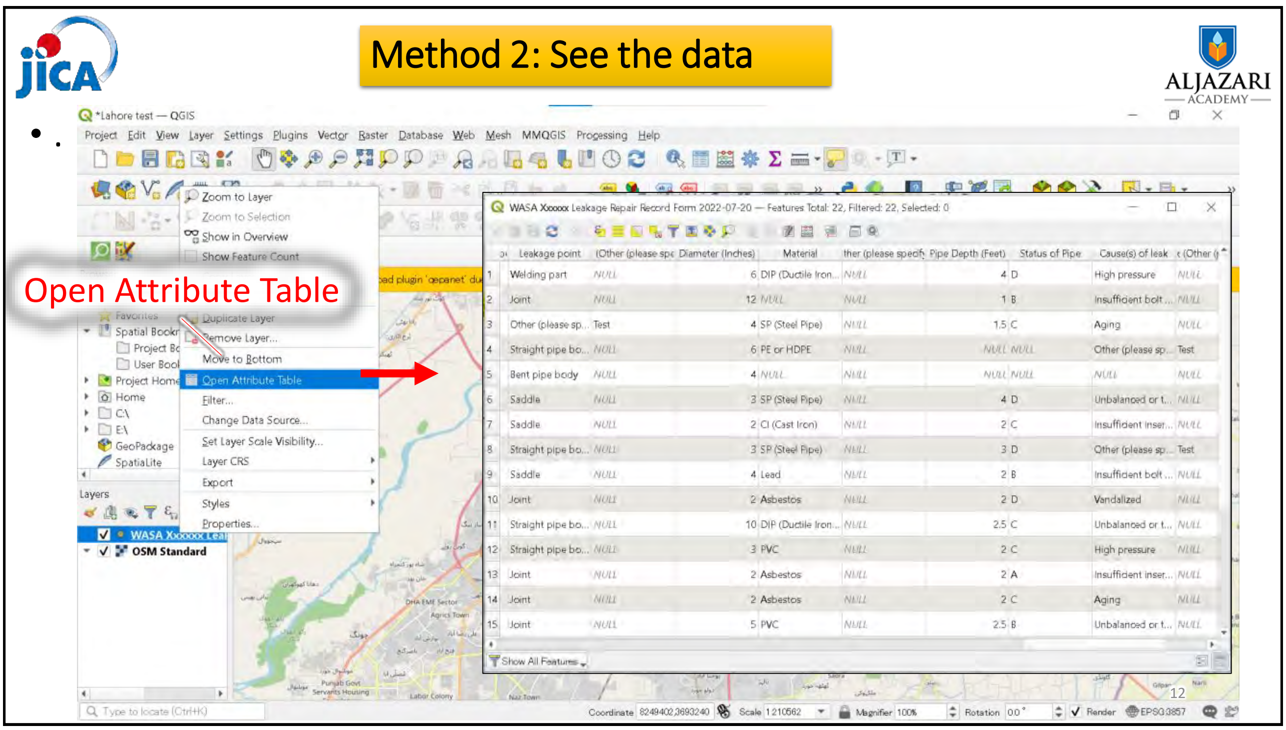
Step 5: How to import mWater data to QGIS



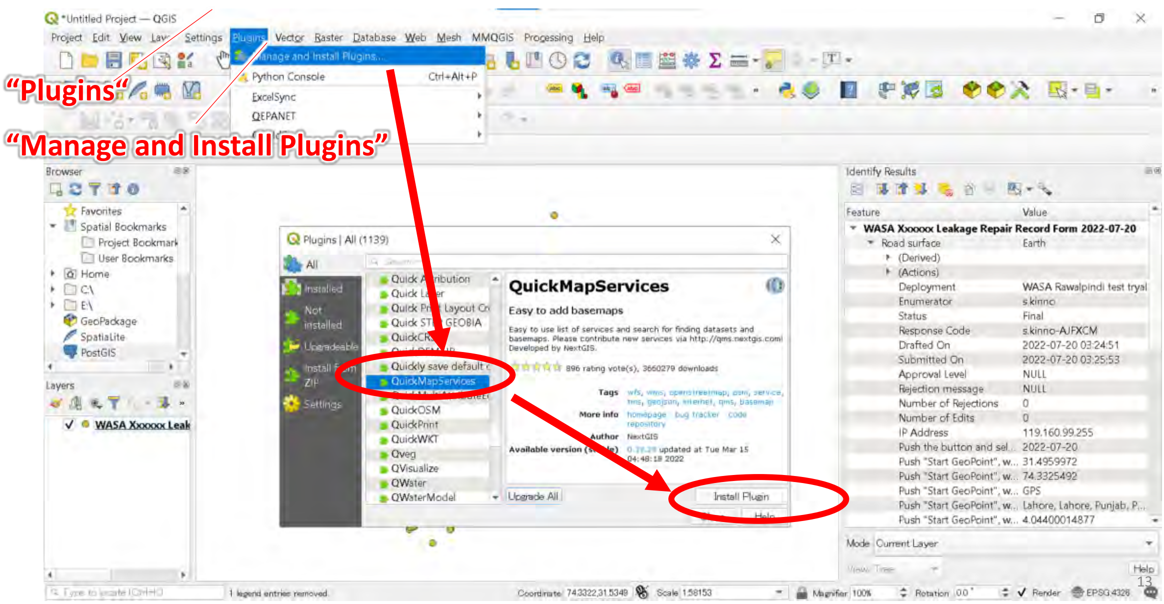
Step 6: How to import mWater data to QGIS



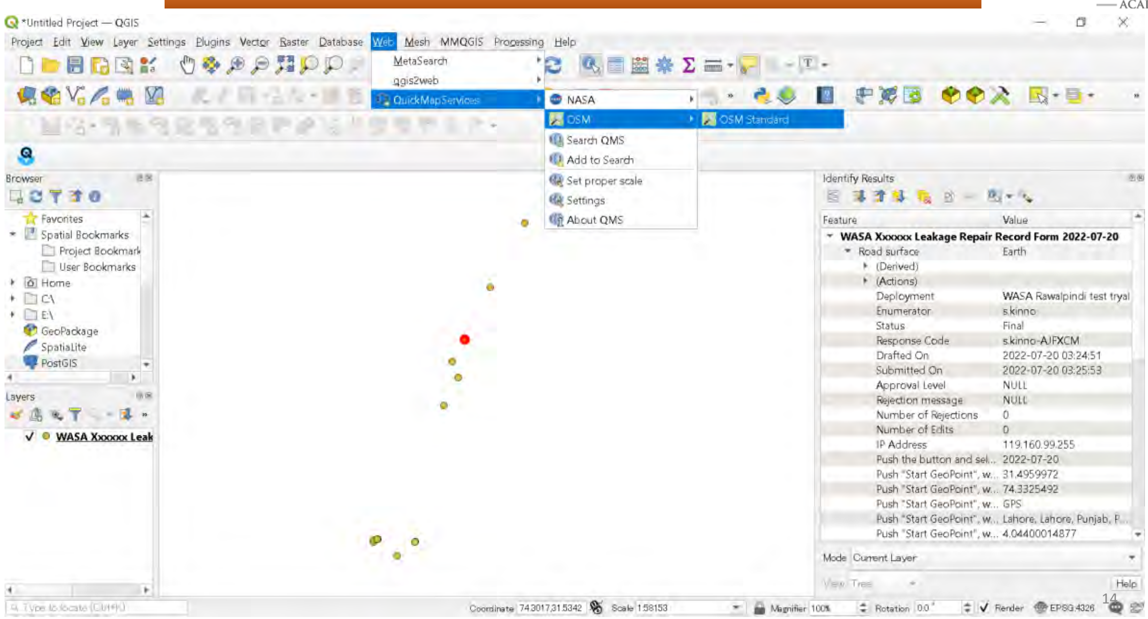

Method 1: See the data
Click
Information about point
Identify Results
11


Method 2: See the data
Open Attribute Table
Open Attribute Table
12

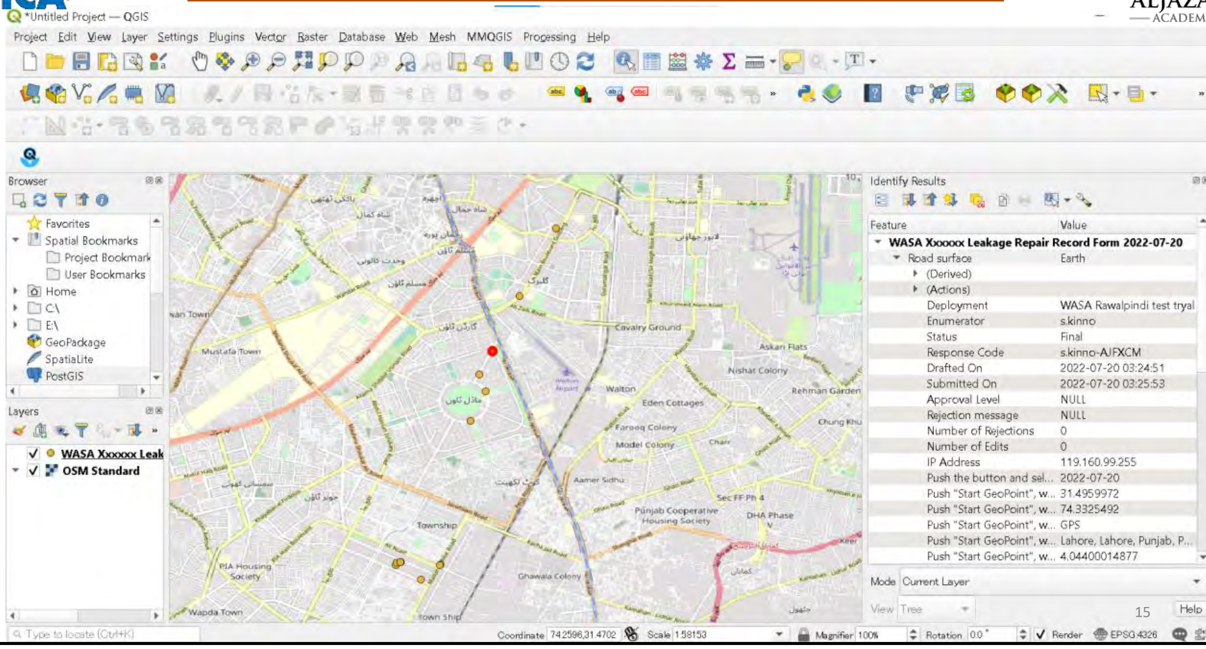
Step 1: How to show Background Map



Step 2: How to show Background Map



Step 3: How to show Background Map



Take full advantage of the data

Visualization in mWater Portal

- Quick check of the data

Excel

- Integrate and conserve all the data, calculate and analyze etc..

QGIS

- Visualize data on map and express the parameter as you like
- Prioritize the area for budget allocation of pipe replacement etc..
- Analyze the main cause of leakage and take effective measure

→ **Exhibit the leakage situation effectively**

- Request budget from the Government
- Attract international fund

Annex 5.1.11 Training Material on "Pipe Replacement Planning"

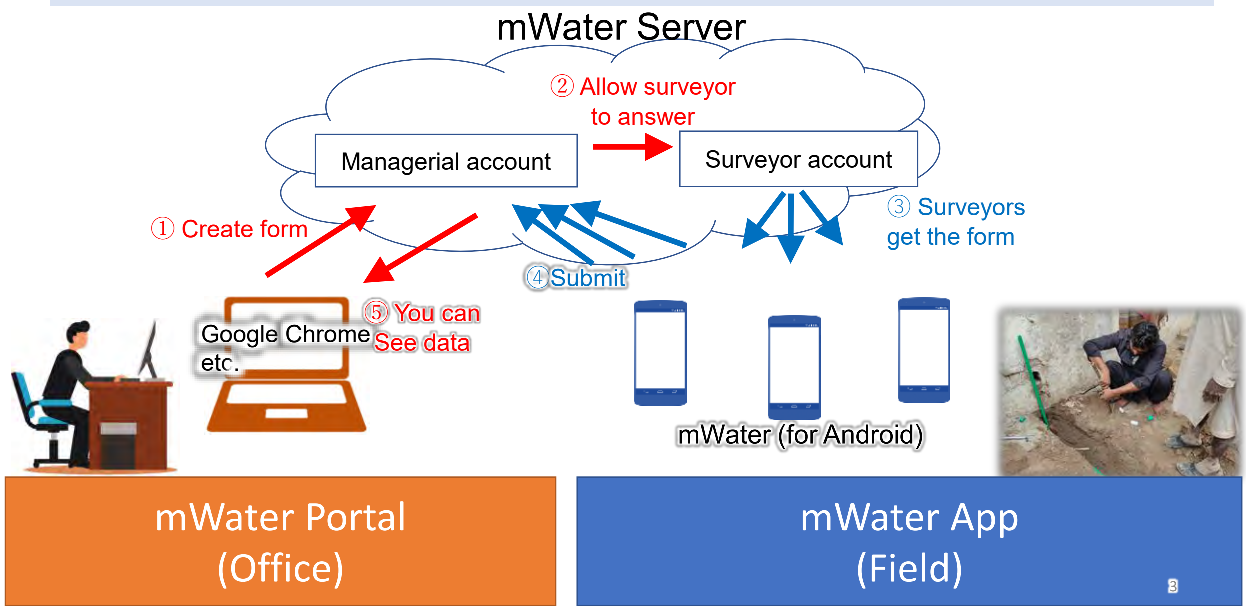
- WASA Faisalabad for In-house Training (3rd, 4th)
- WASA Multan for In-house Training (2nd-4th)
- WASA Gujranwala for In-house Training (2nd)
- WASA Rawalpindi for In-house Training (2nd, 3rd)

mWater App
&
QGIS Software

Learning Outcomes

- **Understand** key features of M-Water App and Q-GIS software
- **Create** data collection forms related to different assets of water utility
- **Use** of M-Water App for Data Collection and Management
- **Able** to keep record of Data (Leakage/Assets)
- **Know** importance of using Data Collection and Monitoring using Dashboard in mWater Portal
- **Present** recorded data in Q-GIS Program

mWater data collection

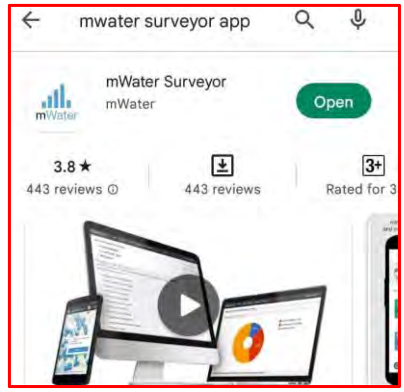


mWater App

(for Android)

mWater App

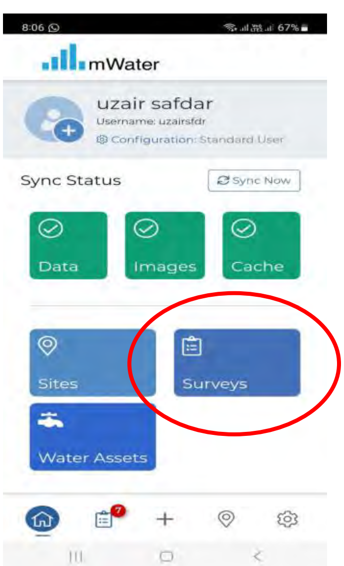
- Download from Play store with the name of (**mWater surveyor**)



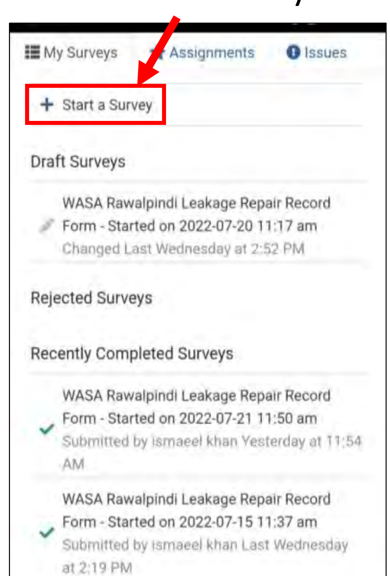
- Made Log-In ID on App and use it for Portal on PC.

mWater App

- After logging in, Click "Survey" icon

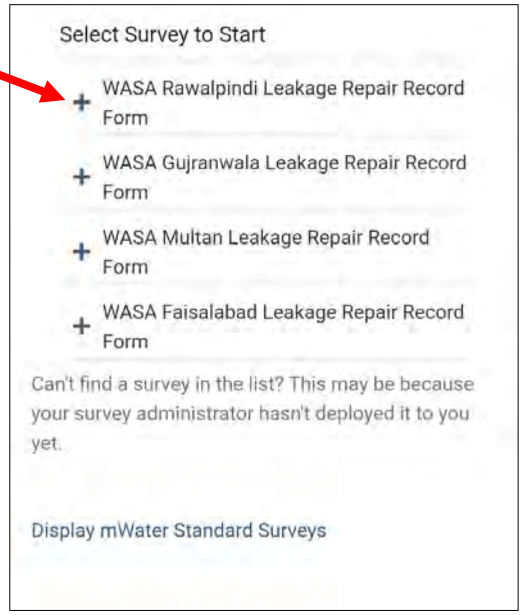


- Click icon "Start Survey"



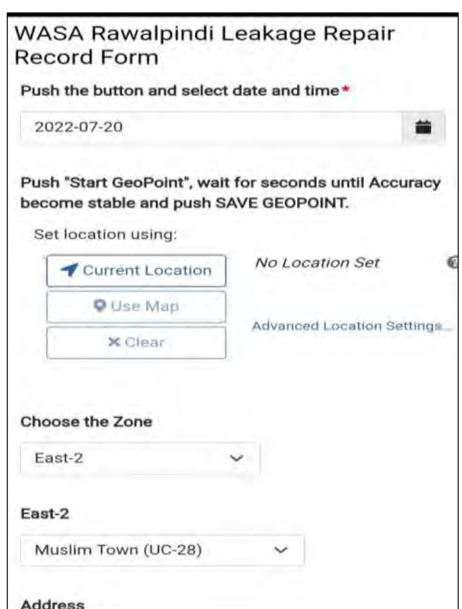
mWater App

- Select Form



mWater App

Put the information on the site, the repair situation etc.



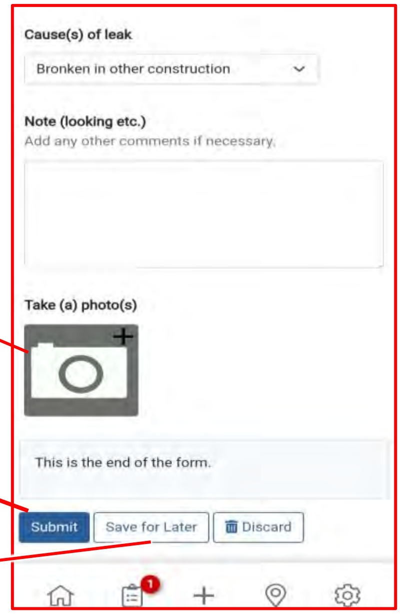
mWater app

- Take photo

  and

- Click “Submit”.

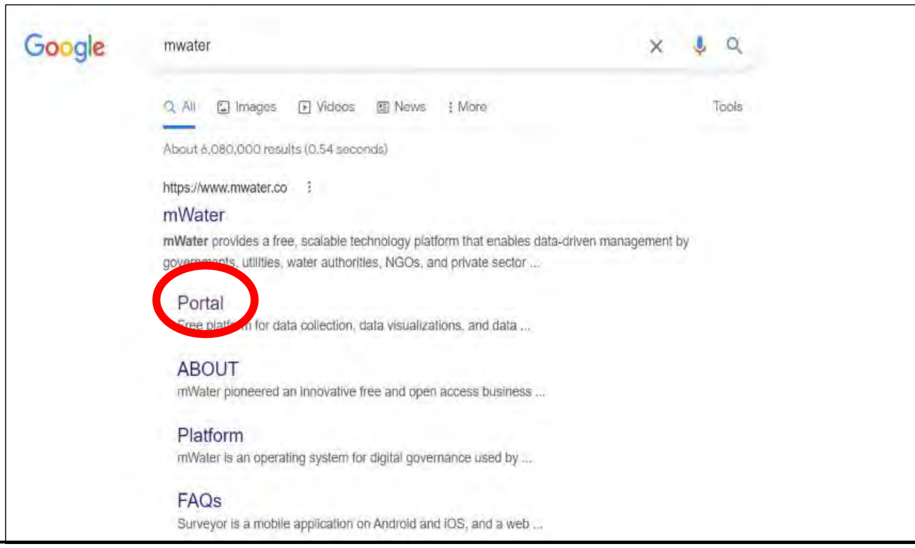
- When Internet is not available,
  Click “Save for Later”



mWater Portal

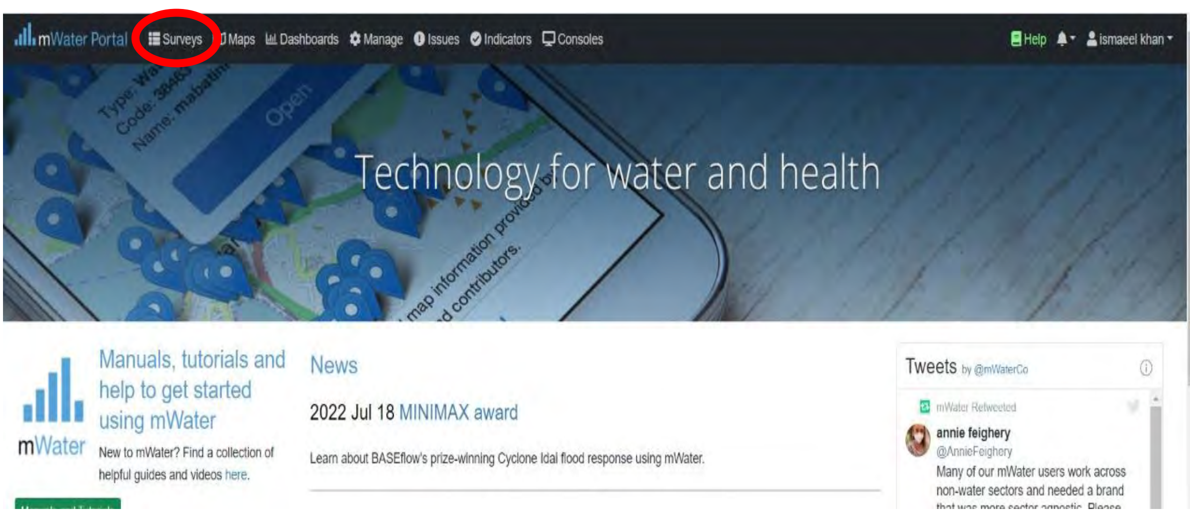
mWater Portal

- After the submission from mWater app, we can see the results on our PC or browser on smartphone or tablet, and analyze the results.



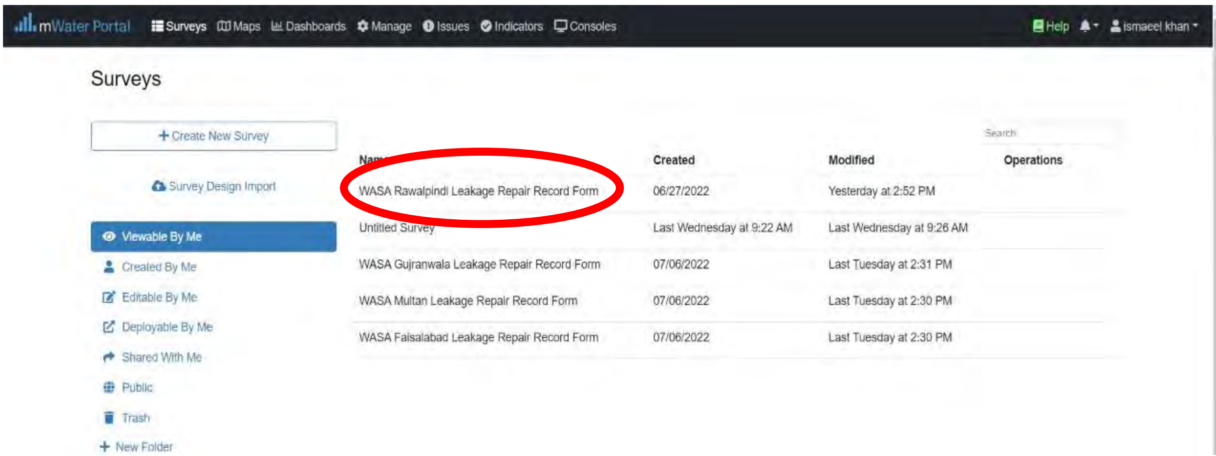
mWater Portal

- After Log in, click on "Survey" ICON.



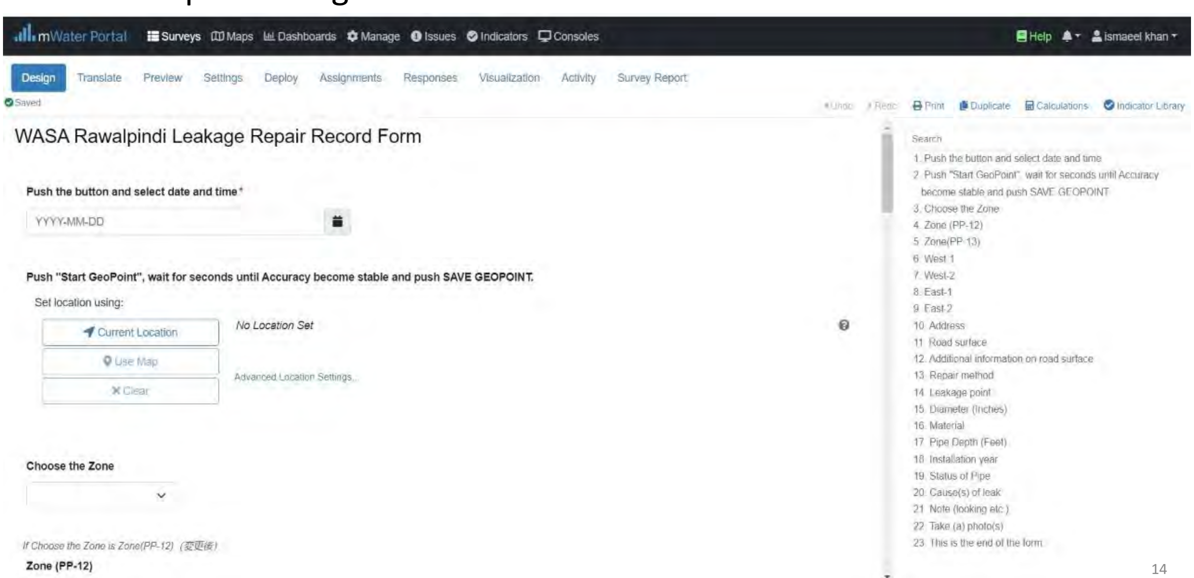
mWater Portal

- We can either use prepared form or create new survey



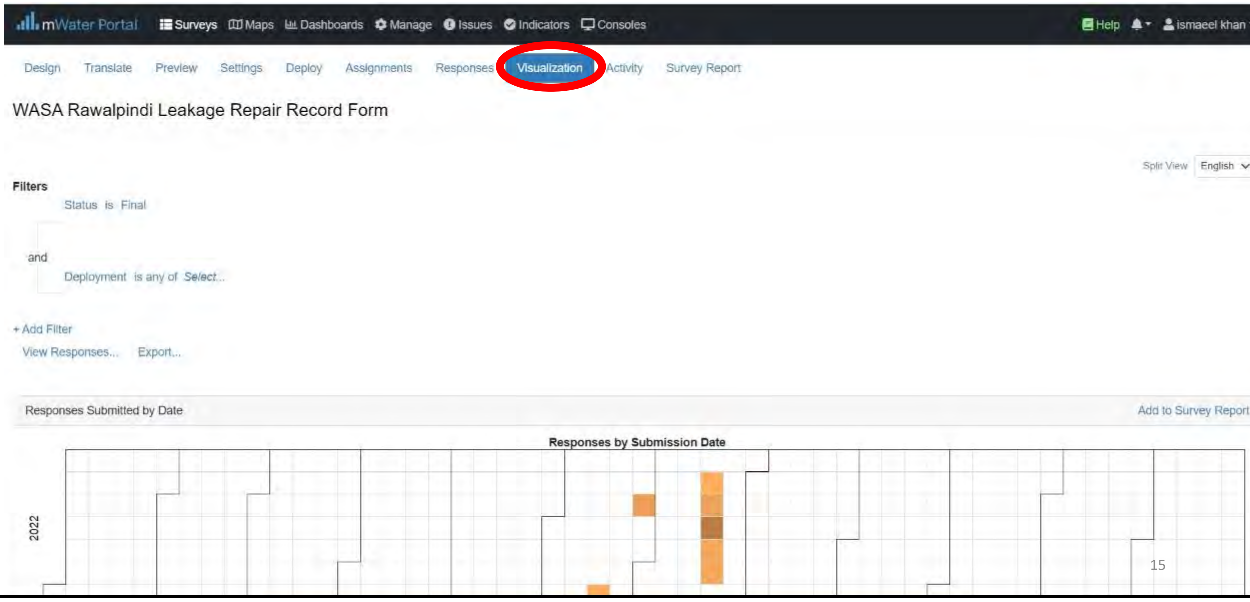
mWater Portal

- Click on repair leakage form



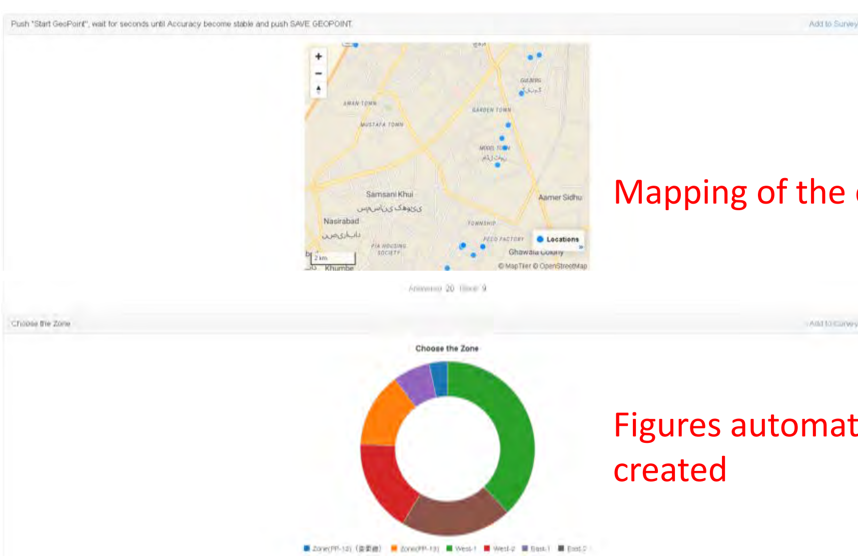
mWater Portal

- To see the form click on visualization



mWater Portal

- Example of Visualized data

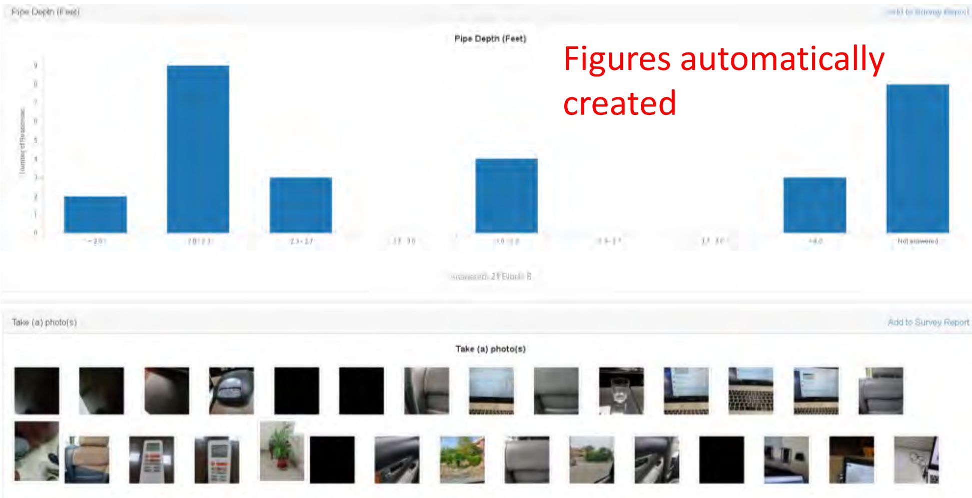


Mapping of the cases

Figures automatically created

mWater Portal

- Example of Visualized data

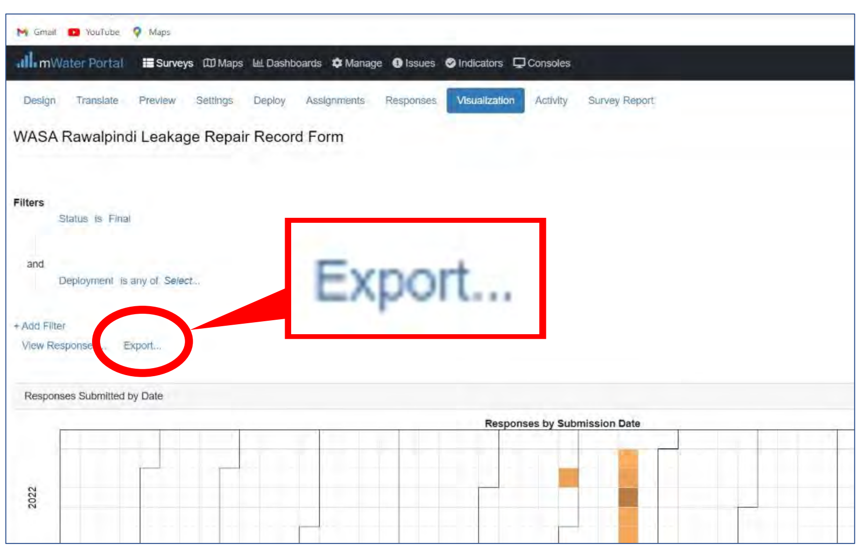


Figures automatically created

Photos

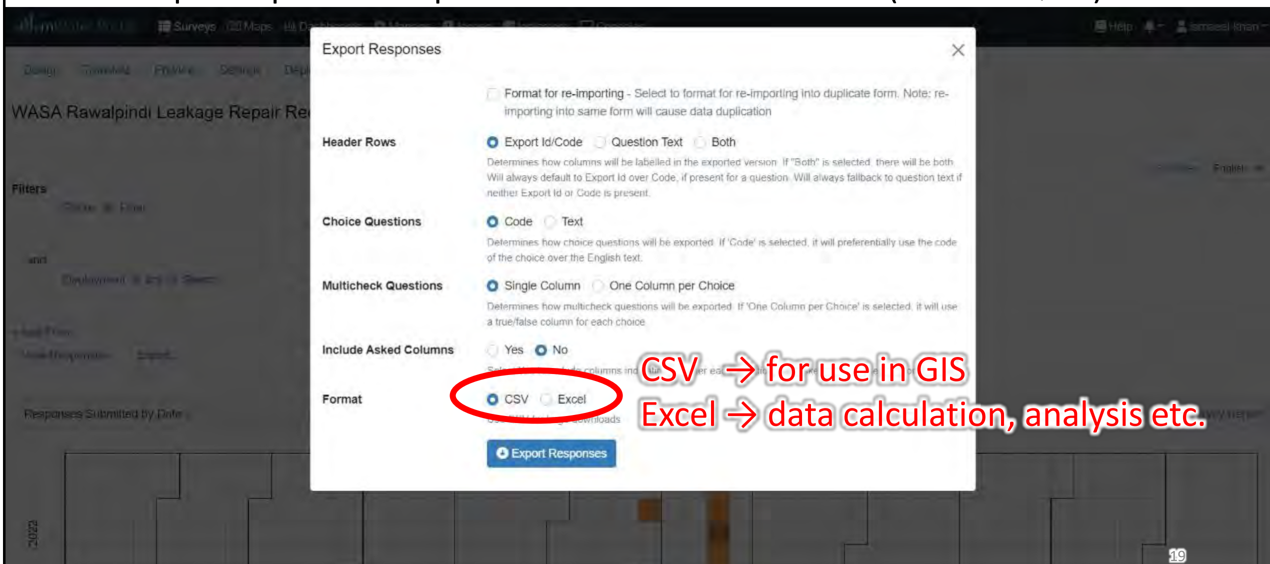
mWater Portal

- We can export file by clicking “Export” option.



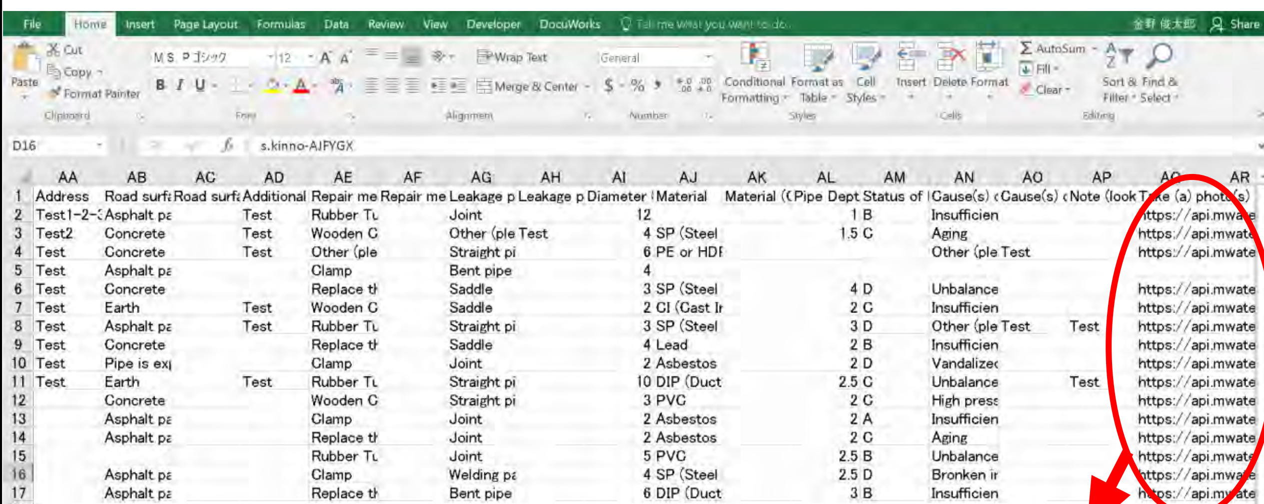
mWater Portal

Click on Export Option to export this file into Excel or CSV (used in QGIS)



Downloaded Excel sheet

(.xlsx or .csv)



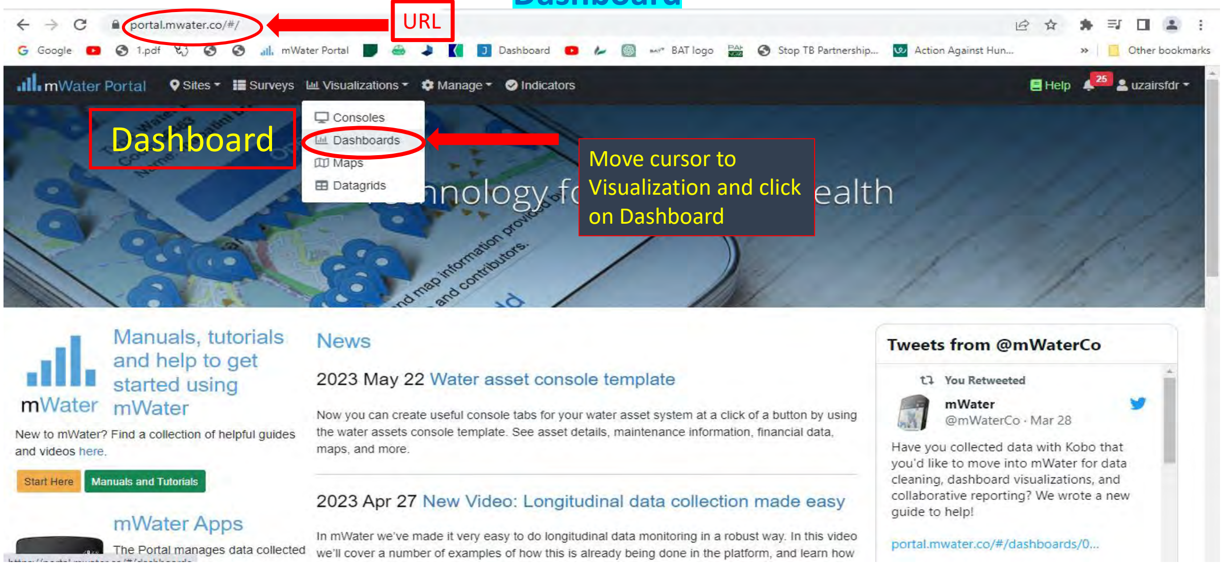
	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1	Address	Road surfa	Road surfa	Additional	Repair me	Repair me	Leakage p	Leakage p	Diameter	Material	Material (	Pipe Dept	Status of	Cause(s) c	Cause(s) c	Note (look	Take (a) photo(s)	
2	Test1-2-3	Asphalt pa		Test	Rubber Tu		Joint		12			1	B	Insufficien			https://api.mwate	
3	Test2	Concrete		Test	Wooden C		Other (ple	Test	4	SP (Steel		1.5	C	Aging			https://api.mwate	
4	Test	Concrete		Test	Other (ple		Straight pi		6	PE or HDF				Other (ple	Test		https://api.mwate	
5	Test	Asphalt pa			Clamp		Bent pipe		4									
6	Test	Concrete			Replace th		Saddle		3	SP (Steel		4	D	Unbalance			https://api.mwate	
7	Test	Earth		Test	Wooden C		Saddle		2	CI (Cast Ir		2	C	Insufficien			https://api.mwate	
8	Test	Asphalt pa		Test	Rubber Tu		Straight pi		3	SP (Steel		3	D	Other (ple	Test	Test	https://api.mwate	
9	Test	Concrete			Replace th		Saddle		4	Lead		2	B	Insufficien			https://api.mwate	
10	Test	Pipe is ex			Clamp		Joint		2	Asbestos		2	D	Vandalizec			https://api.mwate	
11	Test	Earth		Test	Rubber Tu		Straight pi		10	DIP (Duct		2.5	C	Unbalance		Test	https://api.mwate	
12		Concrete			Wooden C		Straight pi		3	PVC		2	C	High press			https://api.mwate	
13		Asphalt pa			Clamp		Joint		2	Asbestos		2	A	Insufficien			https://api.mwate	
14		Asphalt pa			Replace th		Joint		2	Asbestos		2	C	Aging			https://api.mwate	
15					Rubber Tu		Joint		5	PVC		2.5	B	Unbalance			https://api.mwate	
16		Asphalt pa			Clamp		Welding pa		4	SP (Steel		2.5	D	Bronken ir			https://api.mwate	
17		Asphalt pa			Replace th		Bent pipe		6	DIP (Duct		3	B	Insufficien			https://api.mwate	
18																		

All the answers are shown in the table

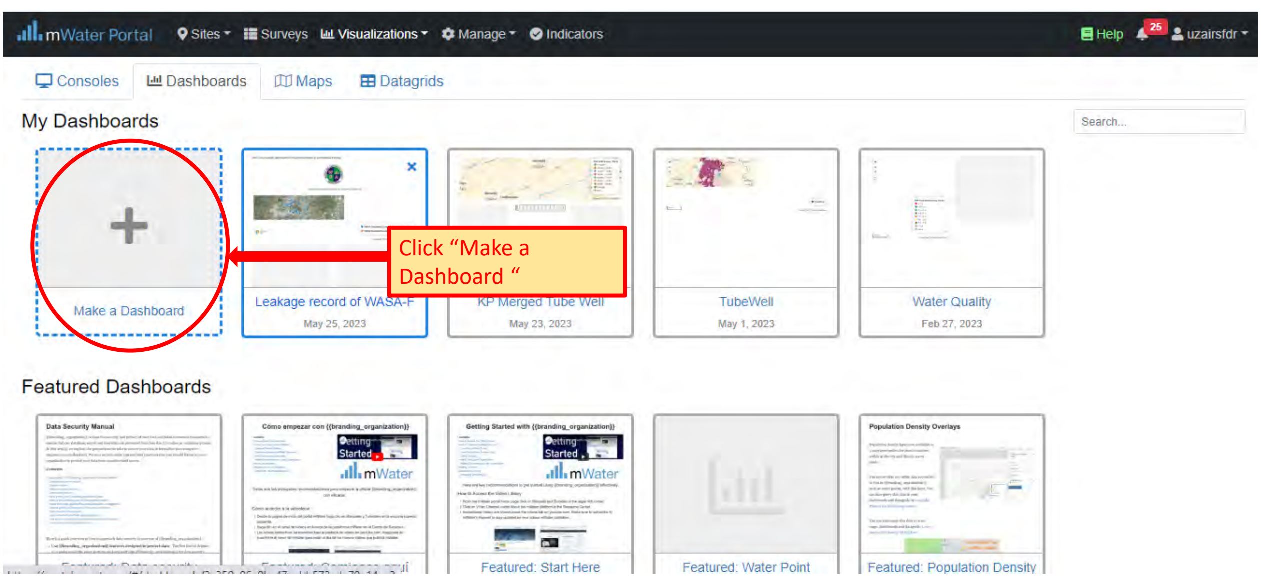
Open the image on web browser

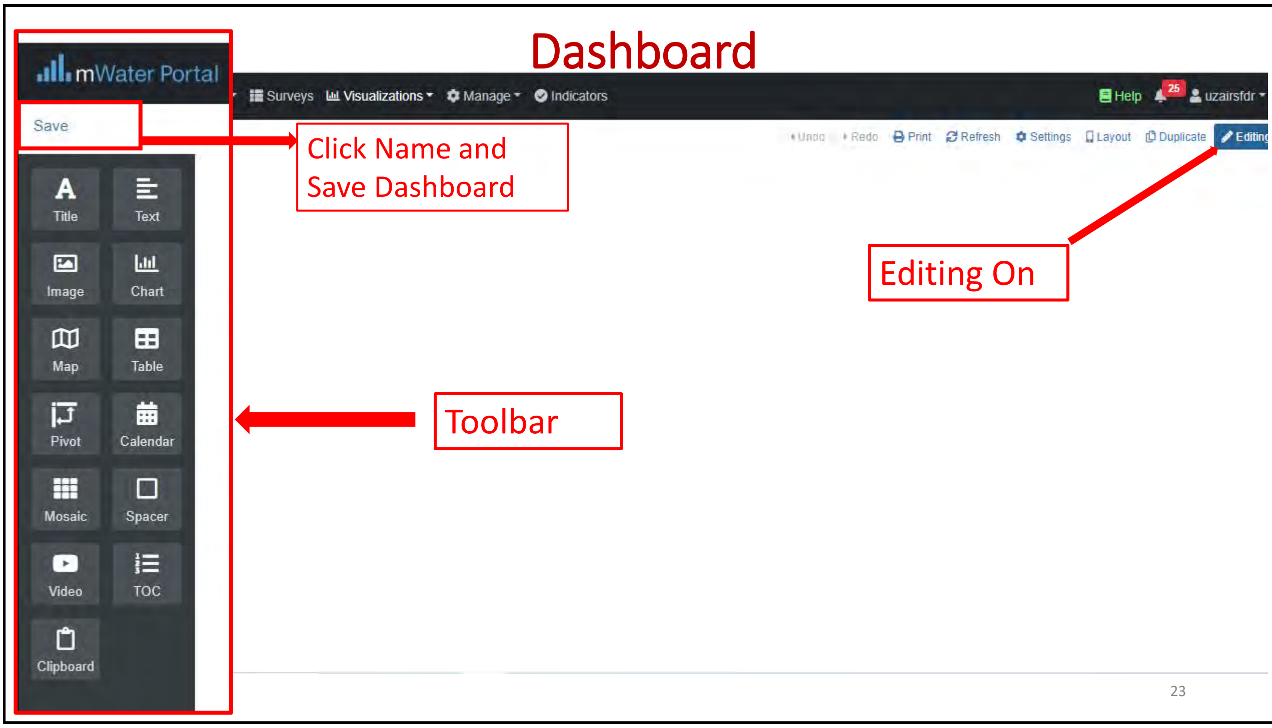
mWater Portal

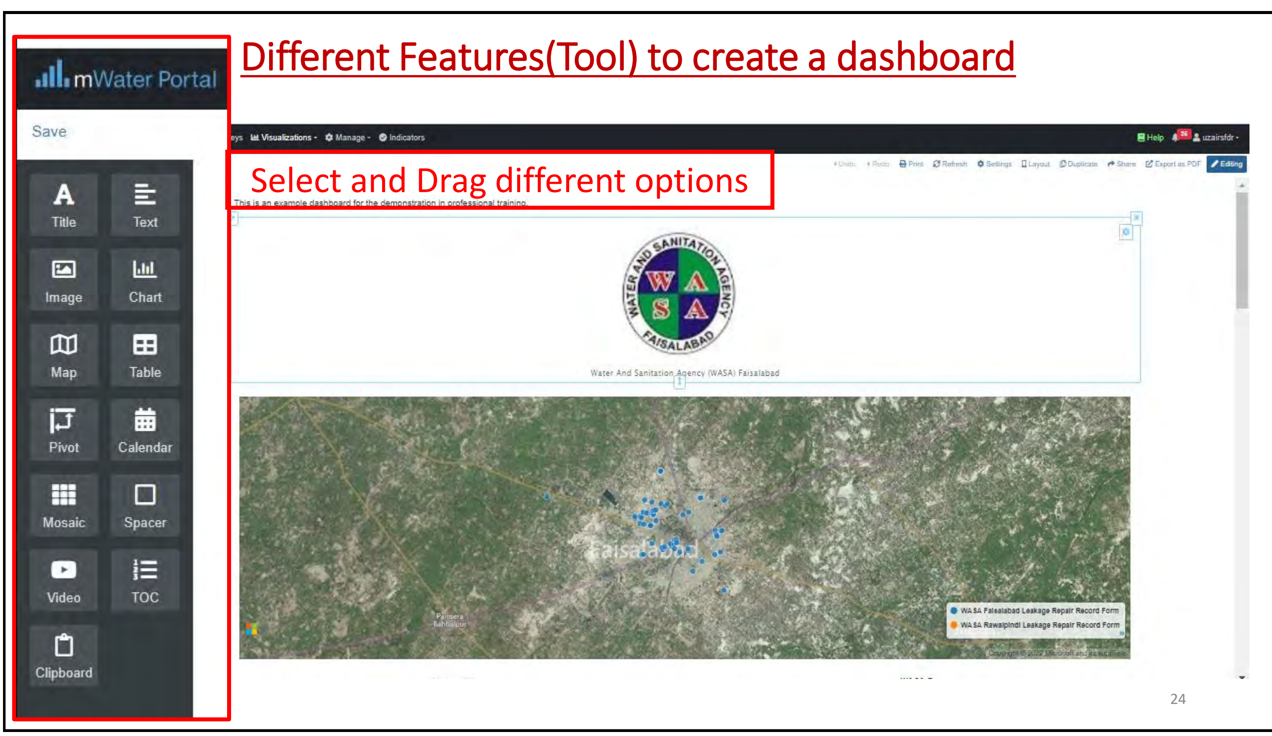
Dashboard



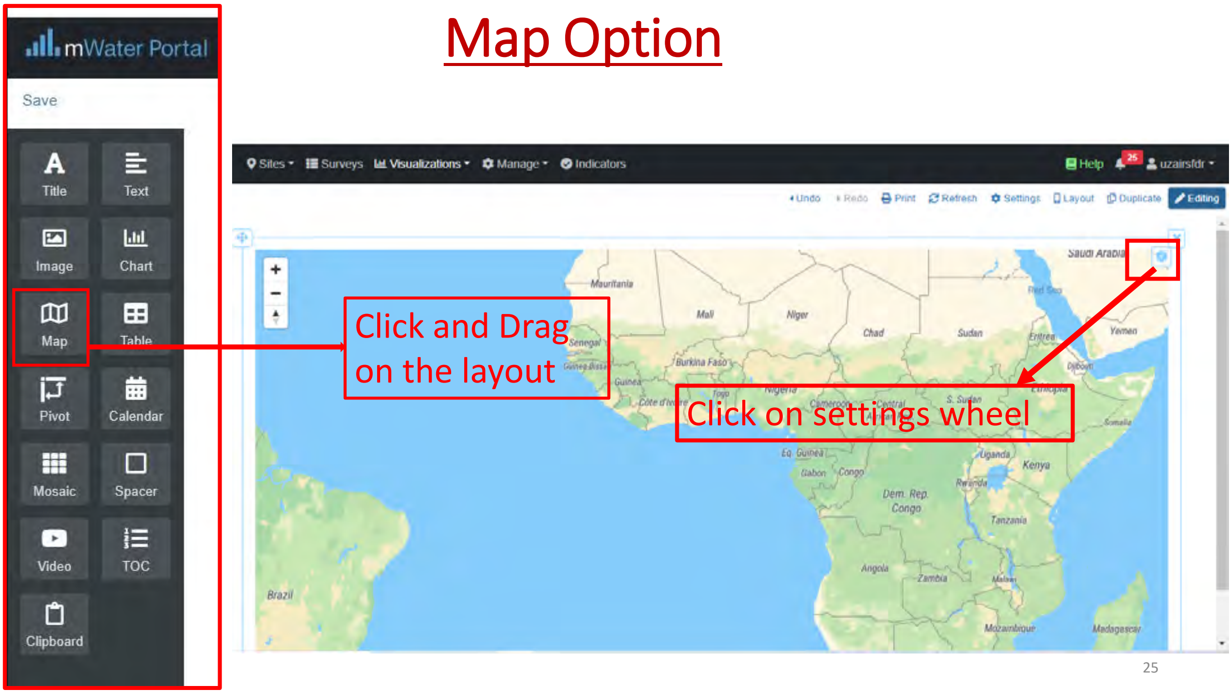
Dashboard




Dashboard
mWater Portal
Save
Surveys
Visualizations
Manage
Indicators
Help
25
uzairsfdr
Undo
Redo
Print
Refresh
Settings
Layout
Duplicate
Editing
Click Name and Save Dashboard
Editing On
Toolbar
Title
Text
Image
Chart
Map
Table
Pivot
Calendar
Mosaic
Spacer
Video
TOC
Clipboard
23

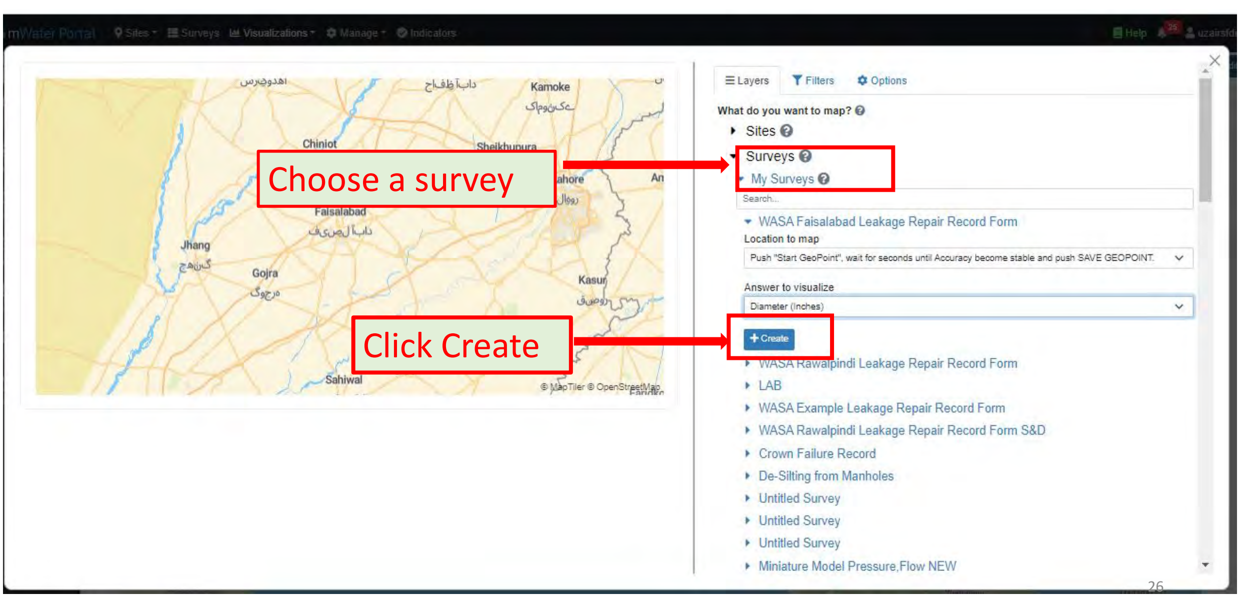

Different Features(Tool) to create a dashboard
mWater Portal
Save
Select and Drag different options
Title
Text
Image
Chart
Map
Table
Pivot
Calendar
Mosaic
Spacer
Video
TOC
Clipboard
Visualizations
Manage
Indicators
Help
uzairsfdr
Print
Refresh
Settings
Layout
Duplicate
Share
Export as PDF
Editing
This is an example dashboard for the demonstration in professional training
WATER AND SANITATION AGENCY
W A S A
FAISALABAD
Water And Sanitation Agency (WASA) Faisalabad
WASA Faisalabad Leakage Repair Record Form
WASA Rawalpindi Leakage Repair Record Form
24

Map Option

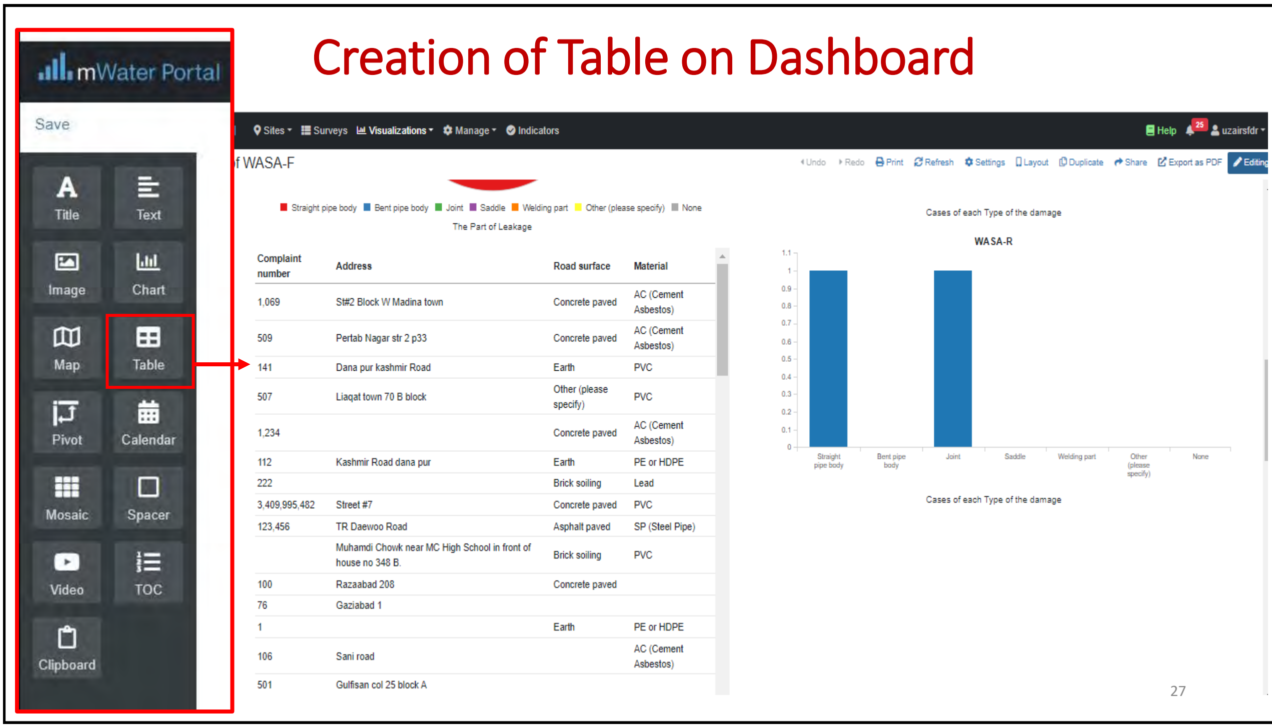


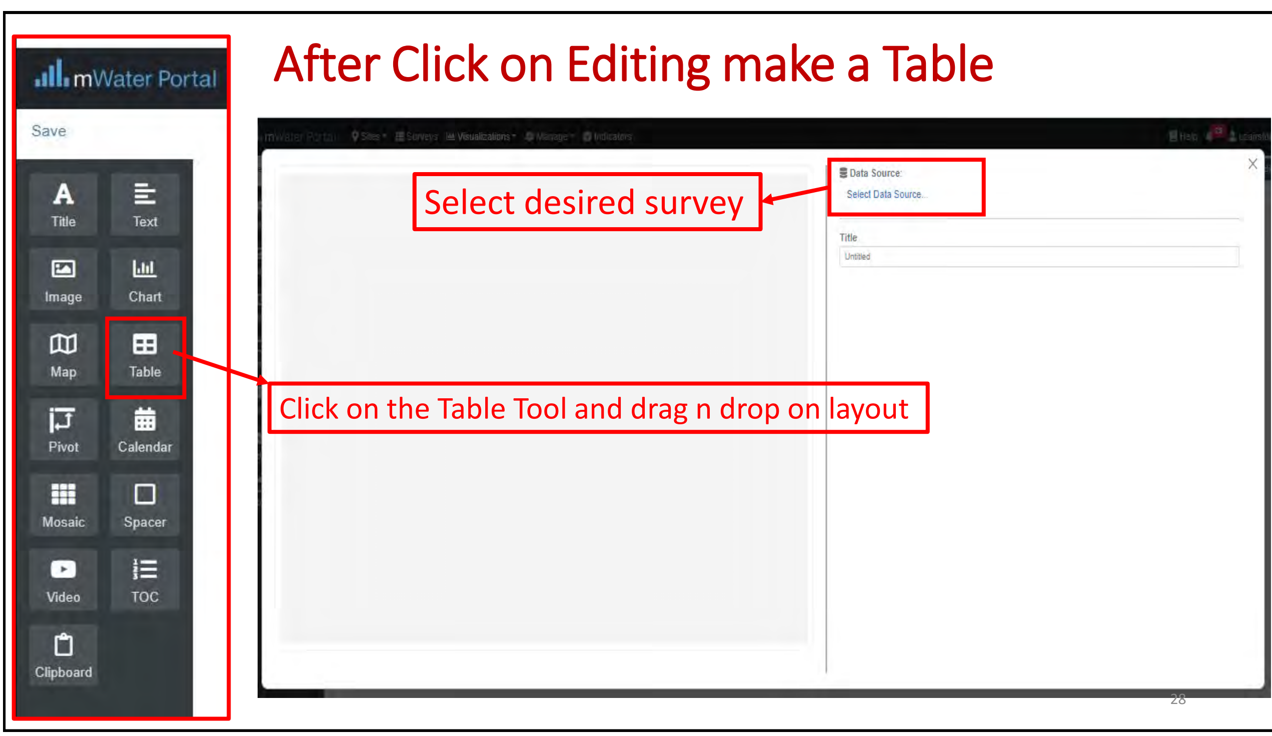
25

Click on Editing Different Options

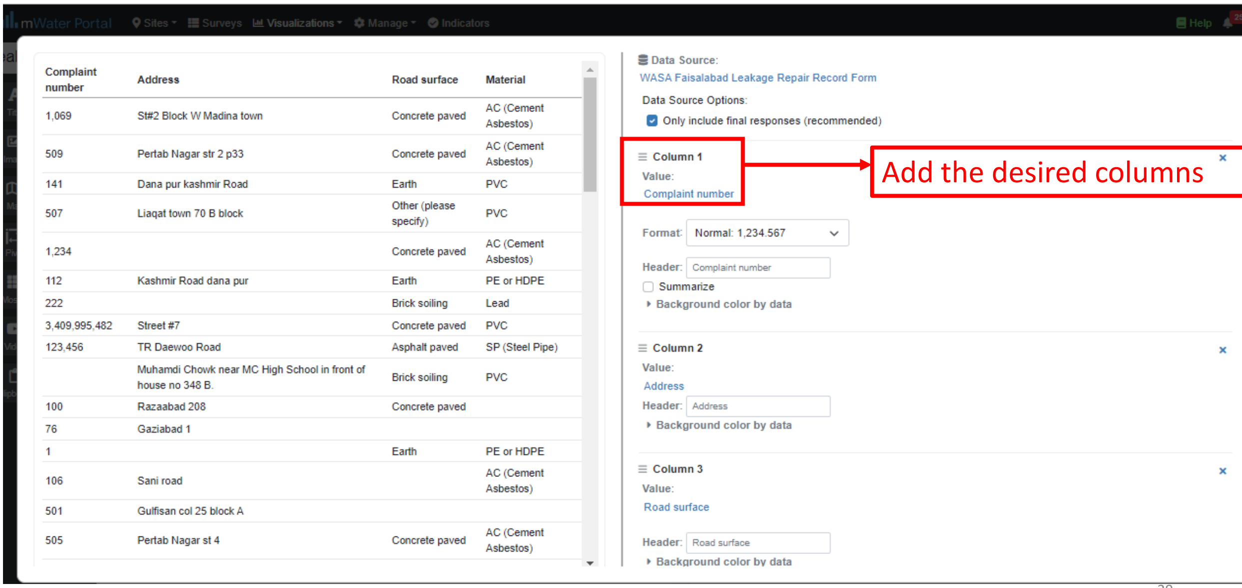


26


Creation of Table on Dashboard
mWater Portal
Save
Title
Text
Image
Chart
Map
Table
Pivot
Calendar
Mosaic
Spacer
Video
TOC
Clipboard
Sites Surveys Visualizations Manage Indicators
Help uzairsfdr
f WASA-F
Undo Redo Print Refresh Settings Layout Duplicate Share Export as PDF Editing
Straight pipe body Bent pipe body Joint Saddle Welding part Other (please specify) None
The Part of Leakage
Complaint number
Address
Road surface
Material
1,069 St#2 Block W Madina town Concrete paved AC (Cement Asbestos)
509 Pertab Nagar str 2 p33 Concrete paved AC (Cement Asbestos)
141 Dana pur kashmir Road Earth PVC
507 Liaqat town 70 B block Other (please specify) PVC
1,234 Concrete paved AC (Cement Asbestos)
112 Kashmir Road dana pur Earth PE or HDPE
222 Brick soiling Lead
3,409,995,482 Street #7 Concrete paved PVC
123,456 TR Daewoo Road Asphalt paved SP (Steel Pipe)
Muhamdi Chowk near MC High School in front of house no 348 B. Brick soiling PVC
100 Razaabad 208 Concrete paved
76 Gaziabad 1
1 Earth PE or HDPE
106 Sani road AC (Cement Asbestos)
501 Gulfisan col 25 block A
Cases of each Type of the damage
WASA-R
Straight pipe body
Bent pipe body
Joint
Saddle
Welding part
Other (please specify)
None
Cases of each Type of the damage
27

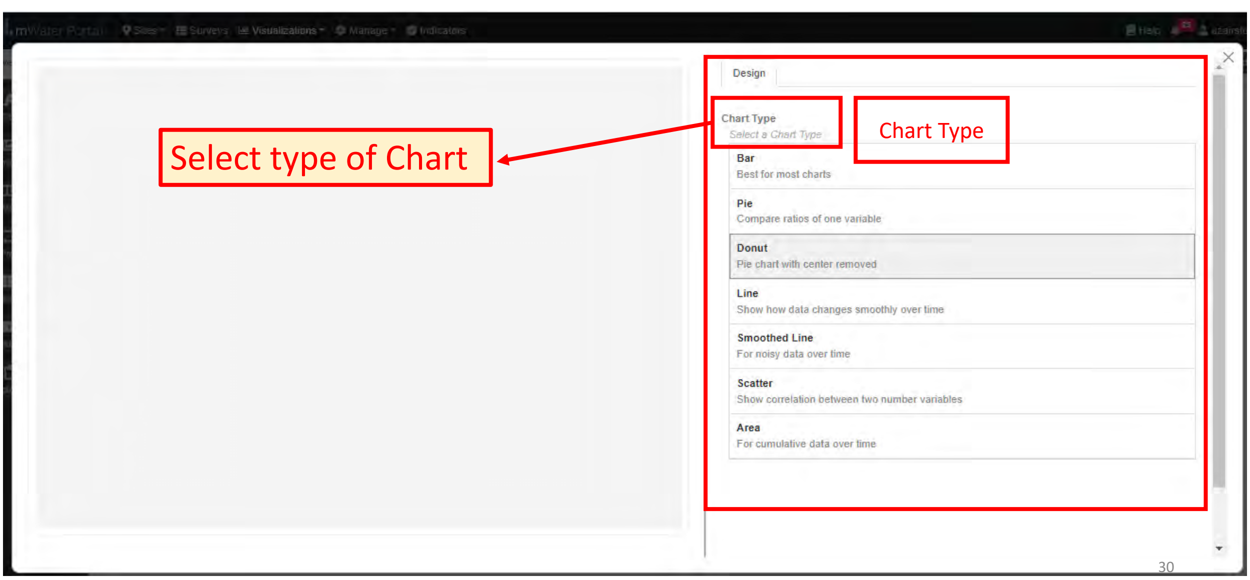

After Click on Editing make a Table
mWater Portal
Save
Title
Text
Image
Chart
Map
Table
Pivot
Calendar
Mosaic
Spacer
Video
TOC
Clipboard
Select desired survey
Data Source:
Select Data Source...
Title
Untitled
Click on the Table Tool and drag n drop on layout
28

Adjust the Table

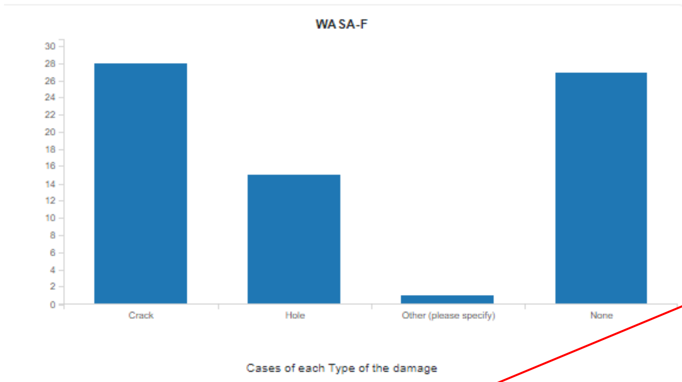


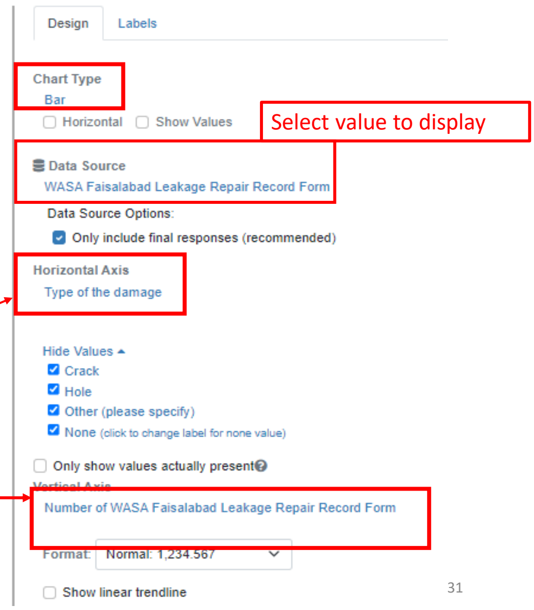
Complaint number	Address	Road surface	Material
1,069	St#2 Block W Madina town	Concrete paved	AC (Cement Asbestos)
509	Pertab Nagar str 2 p33	Concrete paved	AC (Cement Asbestos)
141	Dana pur kashmir Road	Earth	PVC
507	Liaqat town 70 B block	Other (please specify)	PVC
1,234		Concrete paved	AC (Cement Asbestos)
112	Kashmir Road dana pur	Earth	PE or HDPE
222		Brick soiling	Lead
3,409,995,482	Street #7	Concrete paved	PVC
123,456	TR Daewoo Road	Asphalt paved	SP (Steel Pipe)
	Muhamdi Chowk near MC High School in front of house no 348 B.	Brick soiling	PVC
100	Razaabad 208	Concrete paved	
76	Gaziabad 1		
1		Earth	PE or HDPE
106	Sani road		AC (Cement Asbestos)
501	Gulfisan col 25 block A		
505	Pertab Nagar st 4	Concrete paved	AC (Cement Asbestos)

Can Select Different types of Chart



Display of Bar Chart





Select value to display

Select values on Horizontal and Vertical Axis as per Demand

QGIS

(PC Software)

QGIS Software

Index

- Use of QGIS software
- How to see mWater data and show them on **QGIS**.
- How to utilize the data

Step-1: How to install QGIS

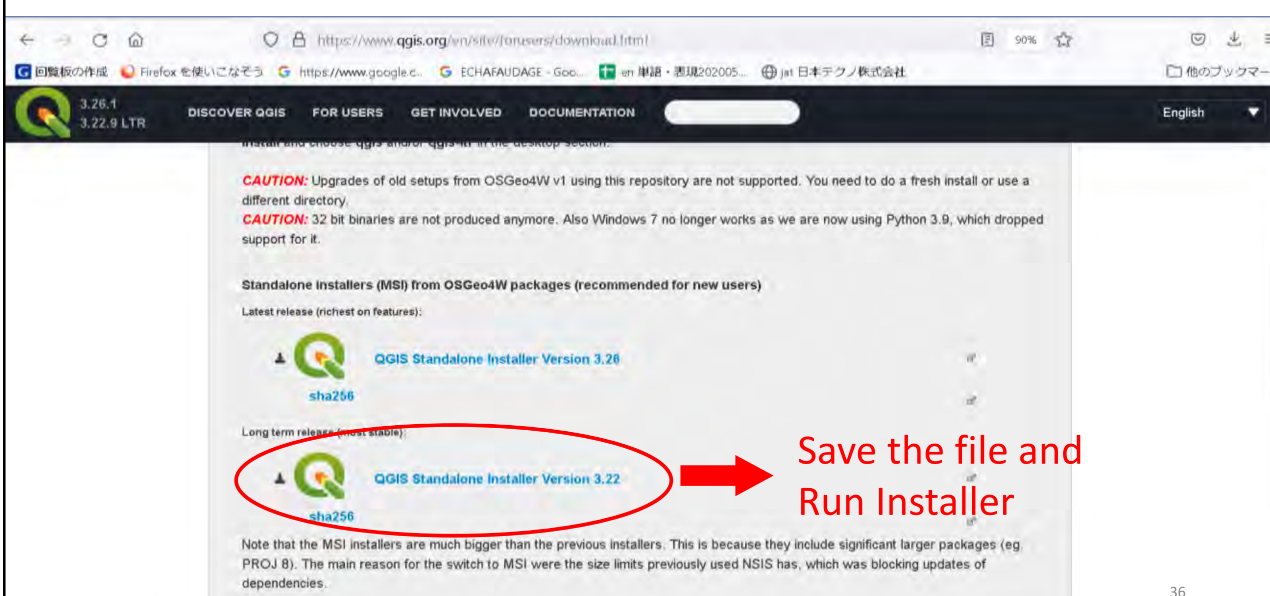
Geographic Information System GIS

A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there).

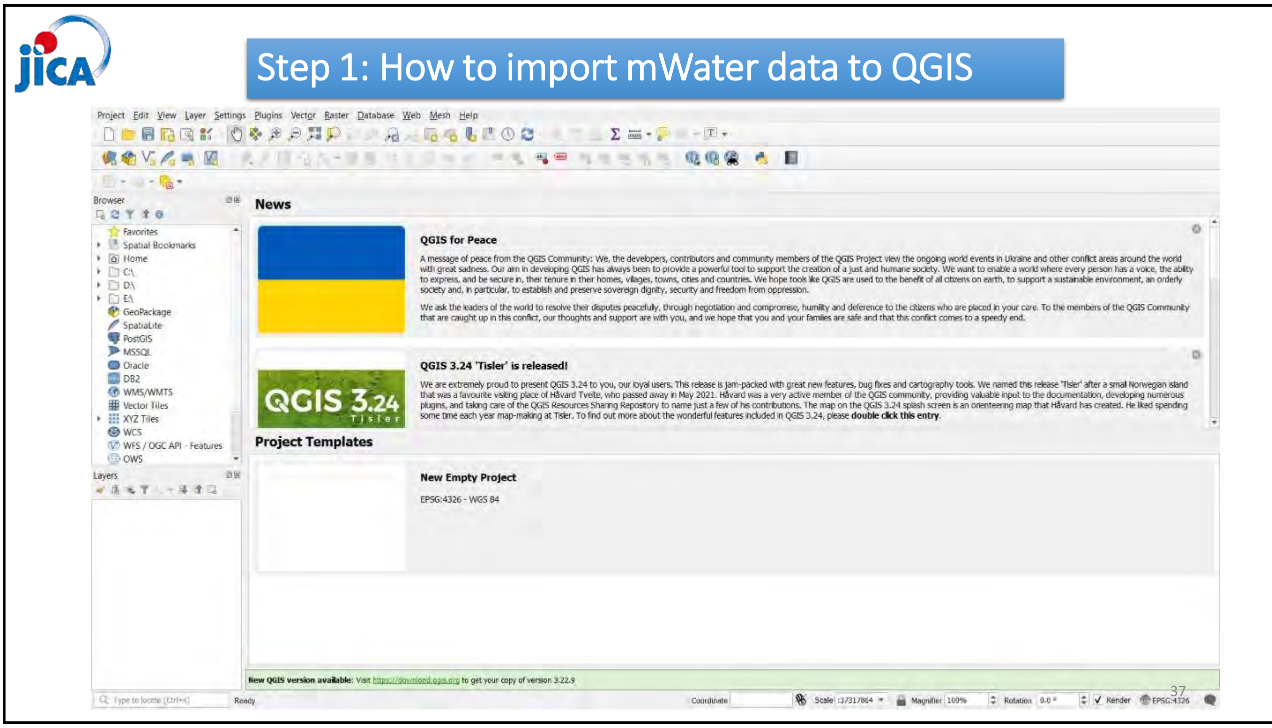
Types of Data Inputs in **GIS**

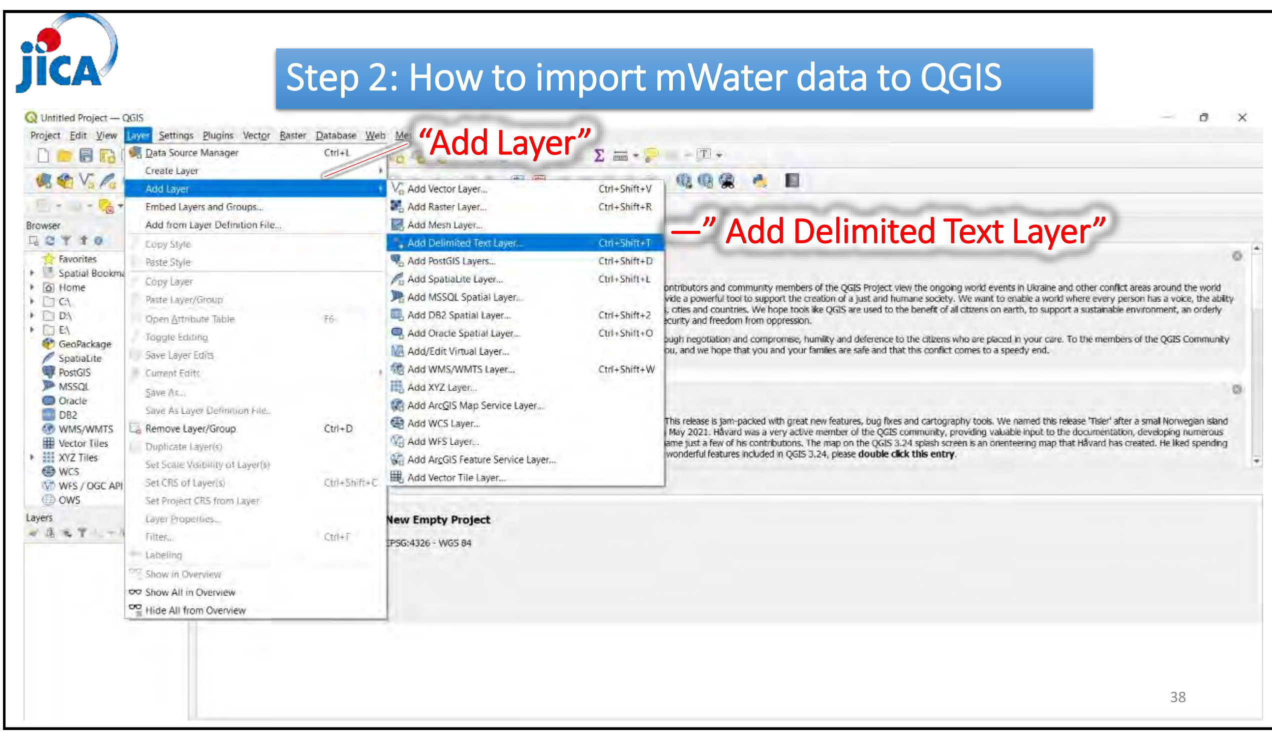
1. Vector Data
2. Raster data
3. Excel Data

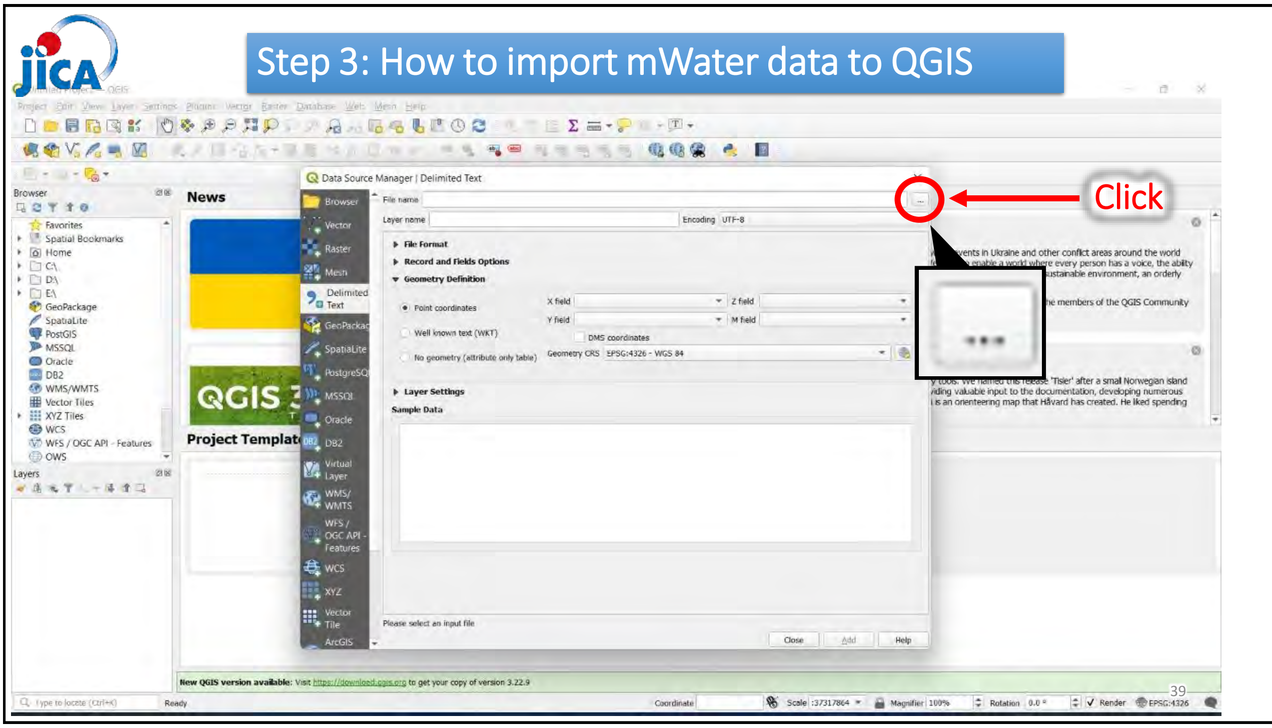
Step 2: How to install QGIS

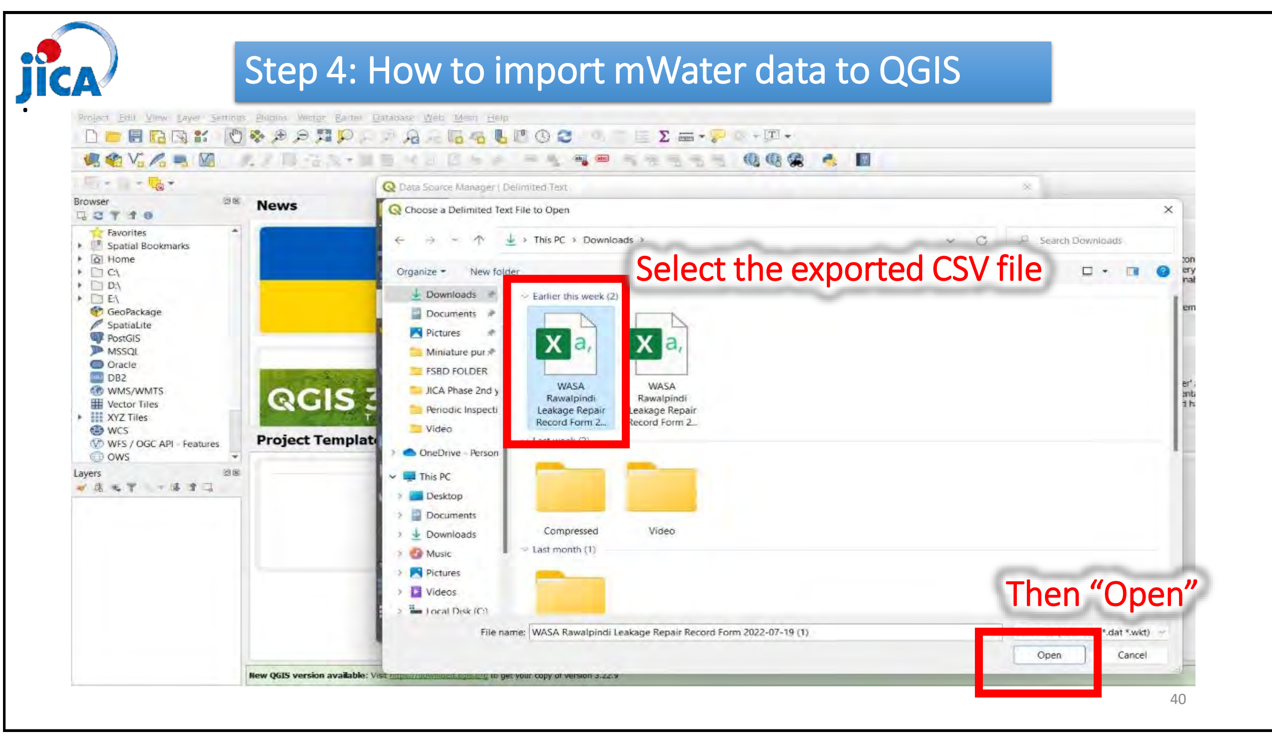


Save the file and Run Installer

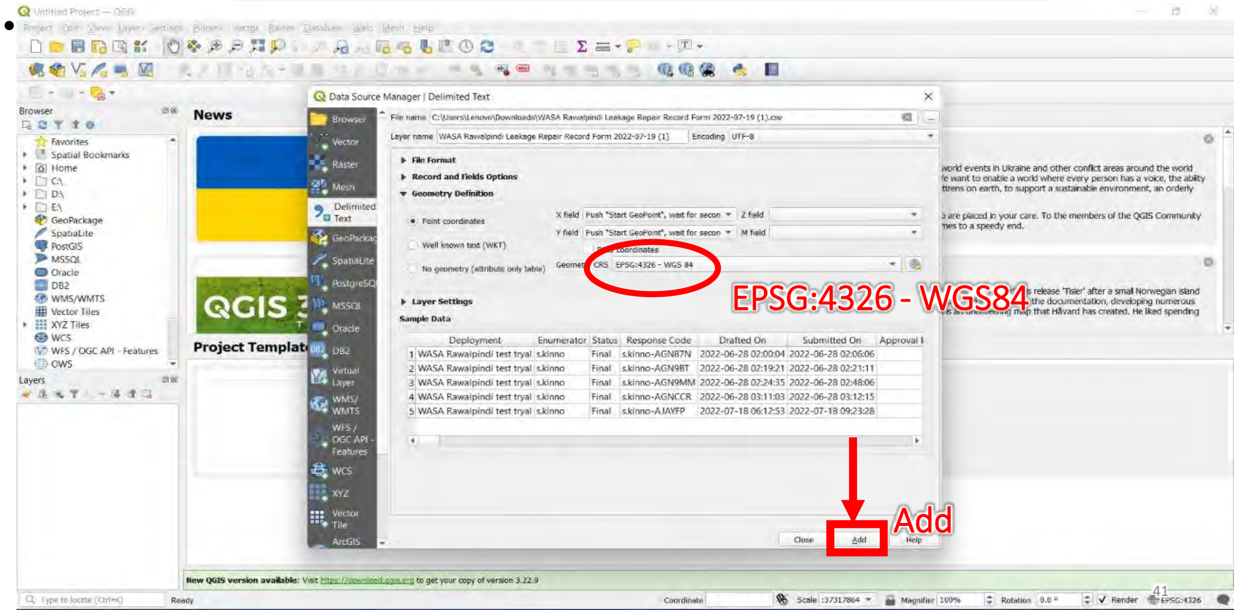

Step 1: How to import mWater data to QGIS
News
QGIS for Peace
QGIS 3.24 'Tisler' is released!
Project Templates
New Empty Project
EPSG:4326 - WGS 84
37


Step 2: How to import mWater data to QGIS
"Add Layer"
" Add Delimited Text Layer"
Add Vector Layer...
Add Raster Layer...
Add Mesh Layer...
Add Delimited Text Layer...
New Empty Project
EPSG:4326 - WGS 84
38

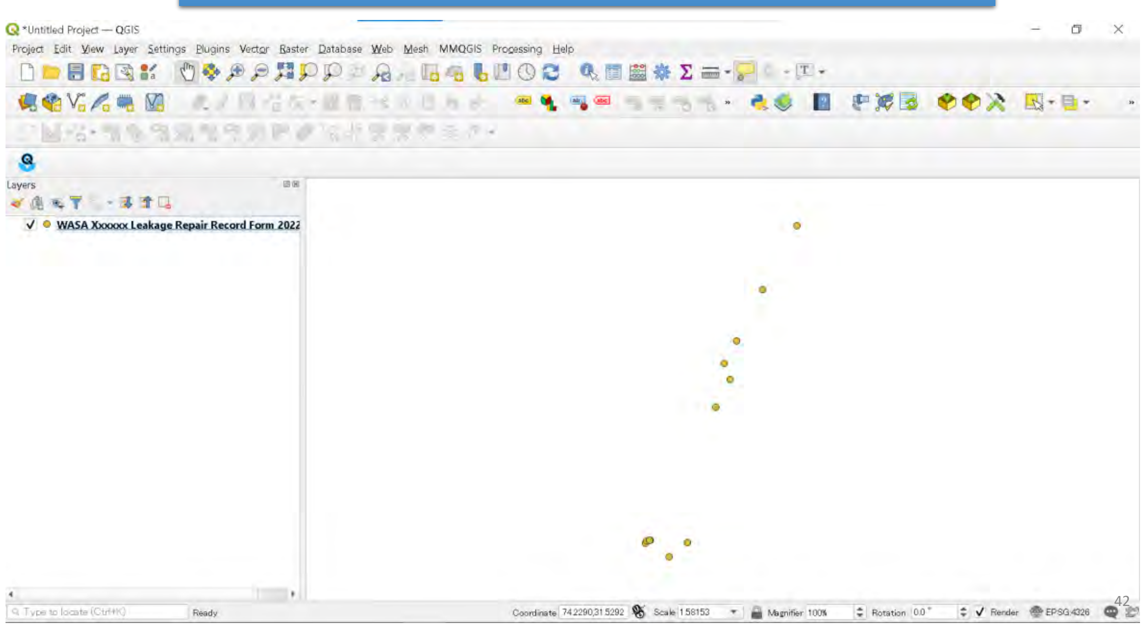

Step 3: How to import mWater data to QGIS
Click
Data Source Manager | Delimited Text
News
Project Templates
Please select an input file
39

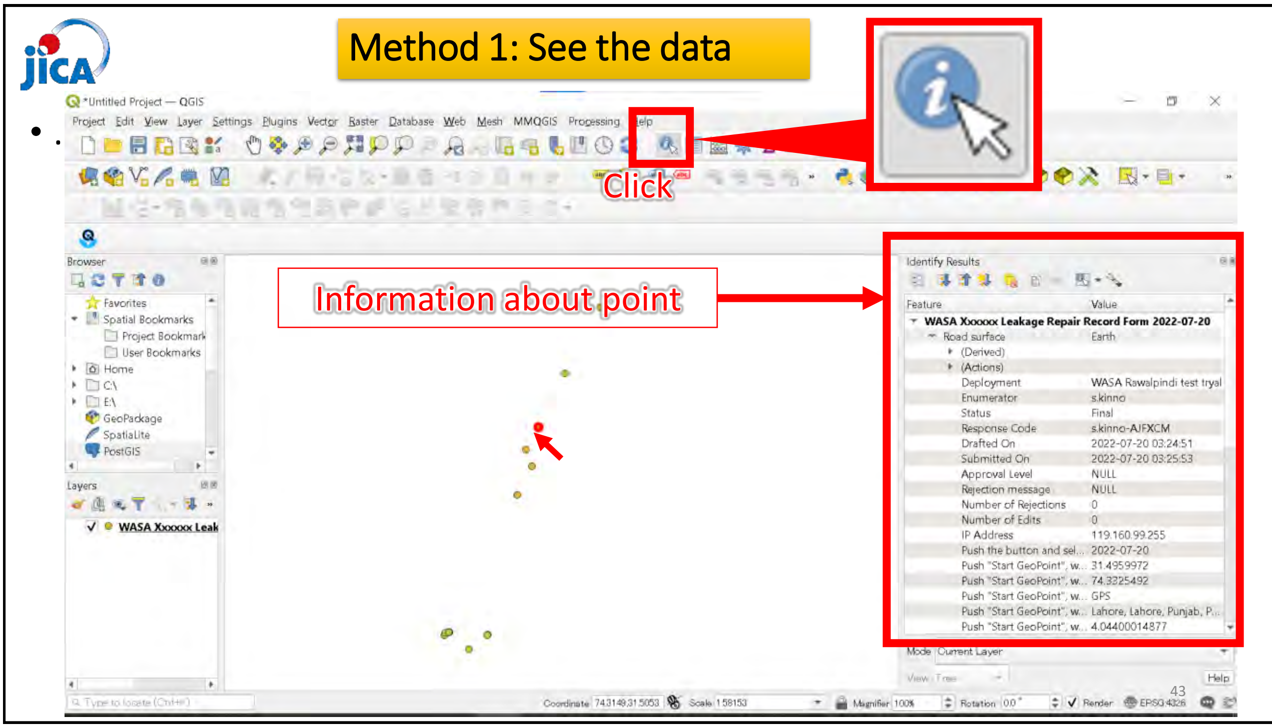

Step 4: How to import mWater data to QGIS
Choose a Delimited Text File to Open
Select the exported CSV file
WASA Rawalpindi Leakage Repair Record Form 2...
File name: WASA Rawalpindi Leakage Repair Record Form 2022-07-19 (1)
Then "Open"
Open
Cancel
40

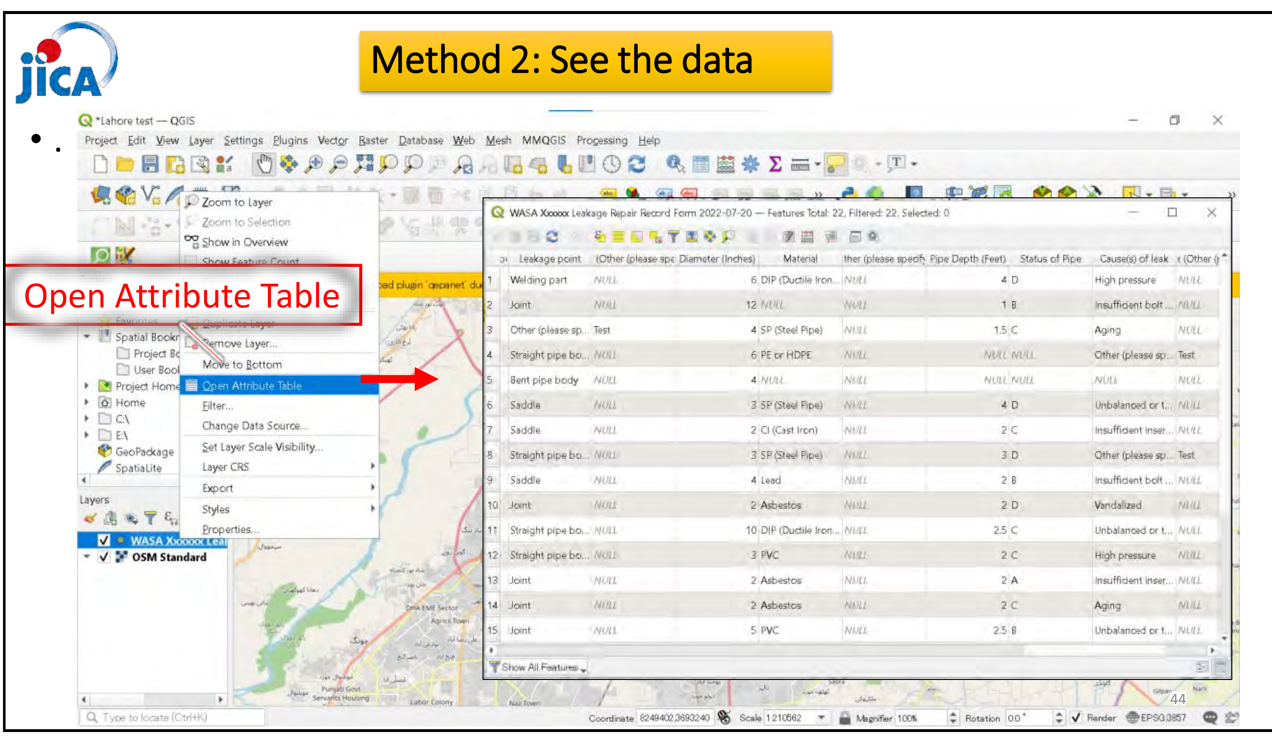
Step 5: How to import mWater data to QGIS



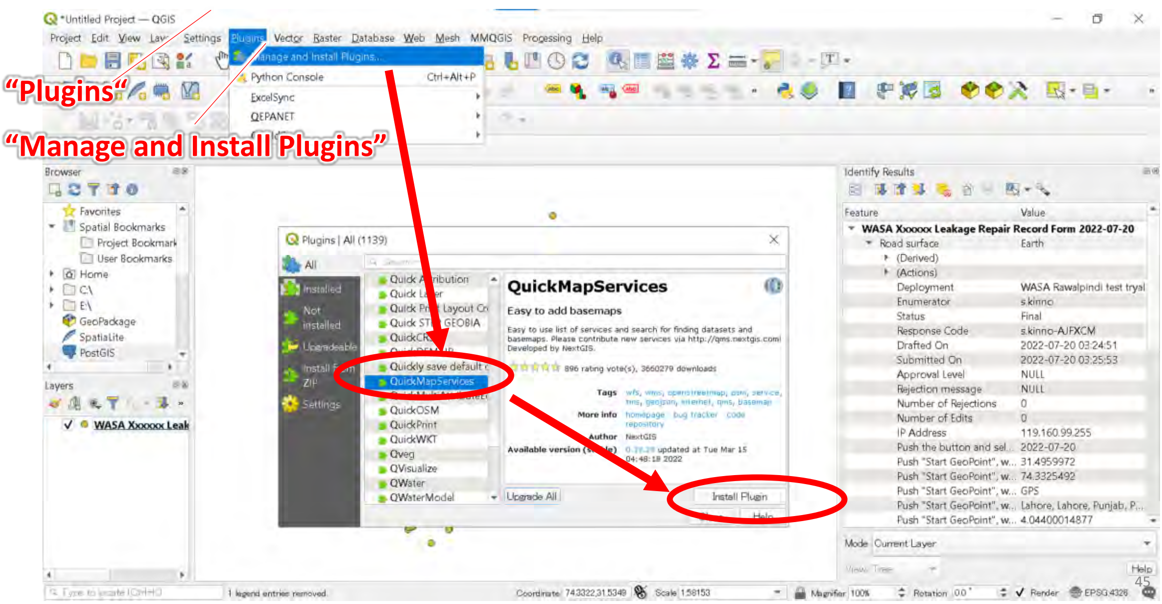
Step 6: How to import mWater data to QGIS




Method 1: See the data
Click
Information about point
Identify Results
WASA Xxxxxx Leakage Repair Record Form 2022-07-20
43


Method 2: See the data
Open Attribute Table
WASA Xxxxxx Leakage Repair Record Form 2022-07-20 — Features Total: 22, Filtered: 22, Selected: 0
44

Step 1: How to show Background Map



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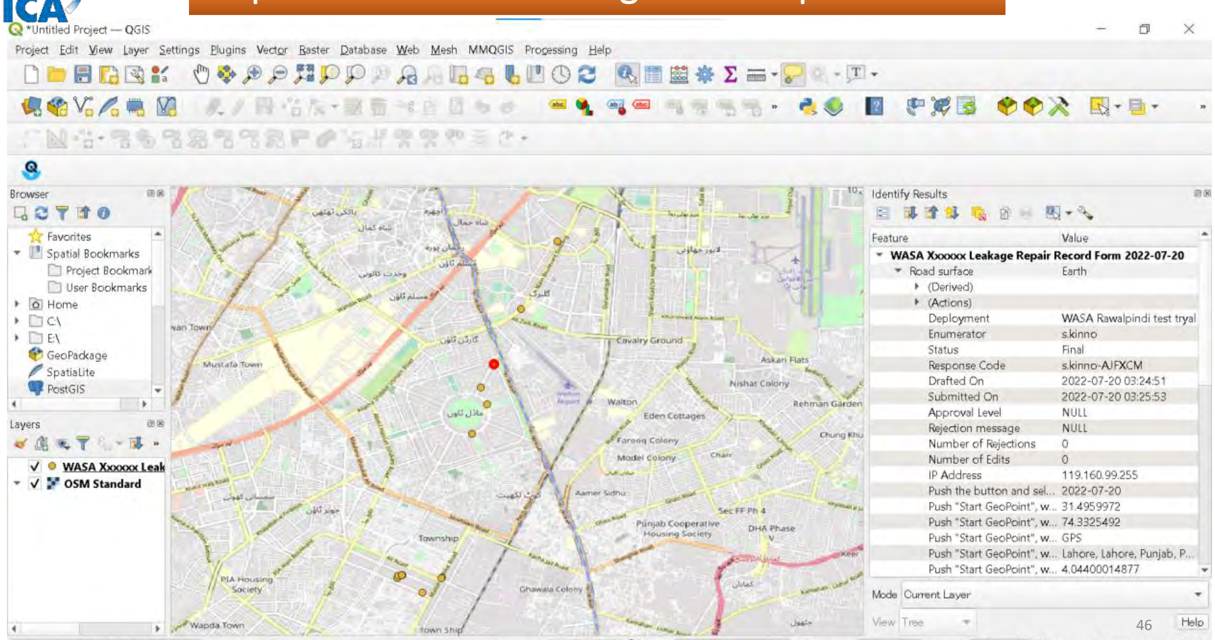
Step 3: How to show Background Map



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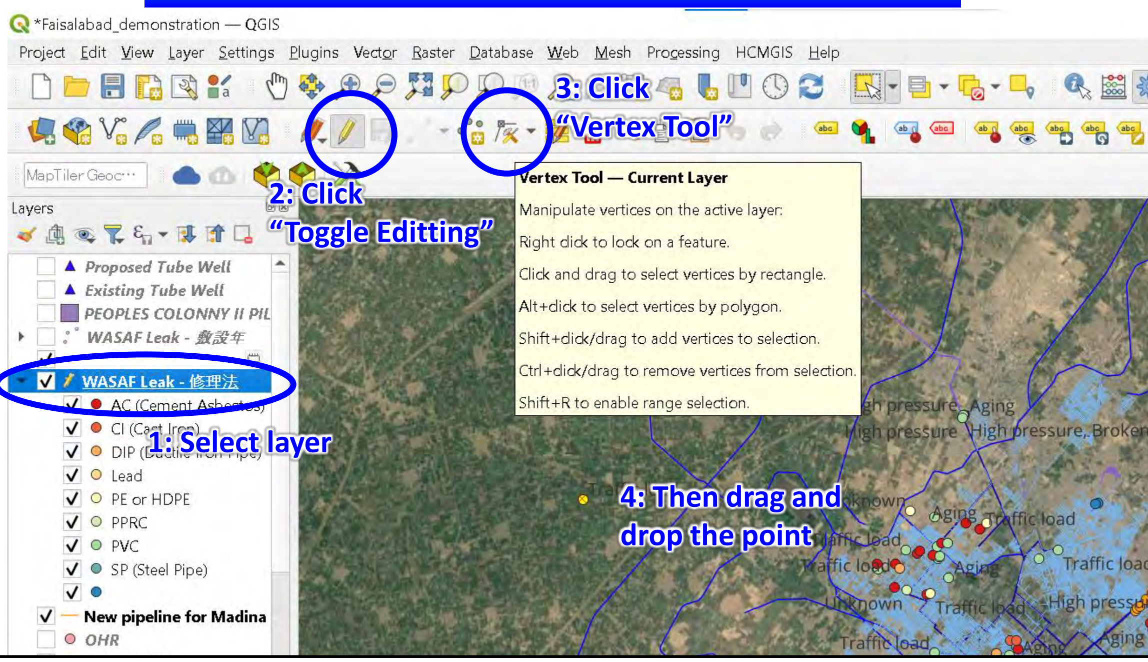
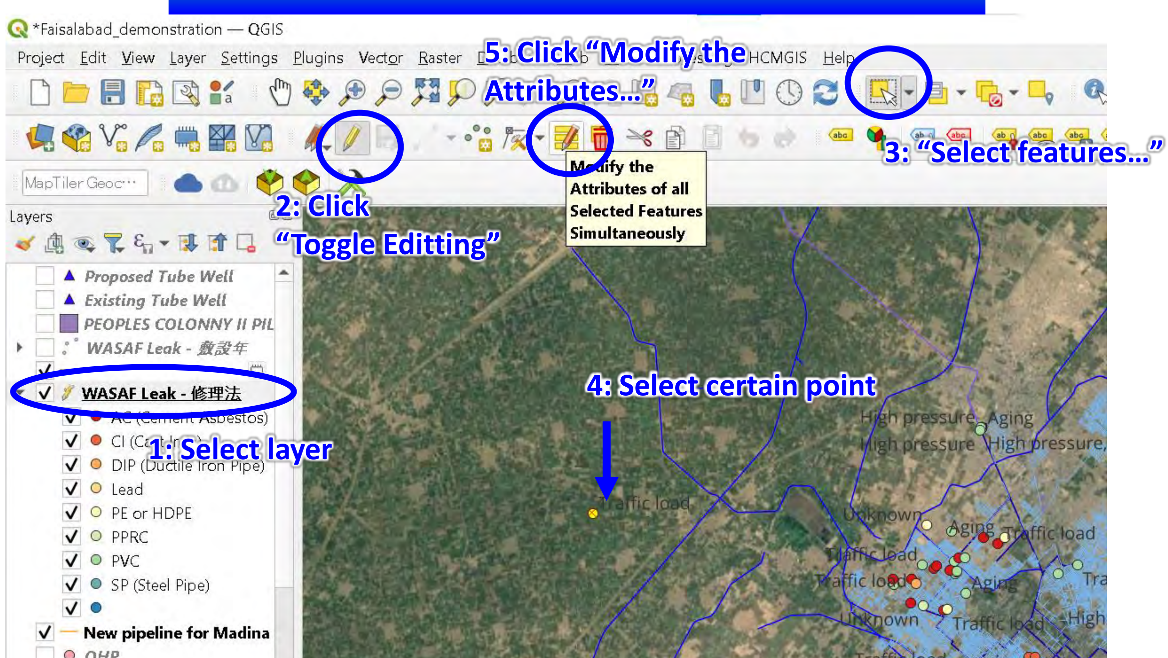
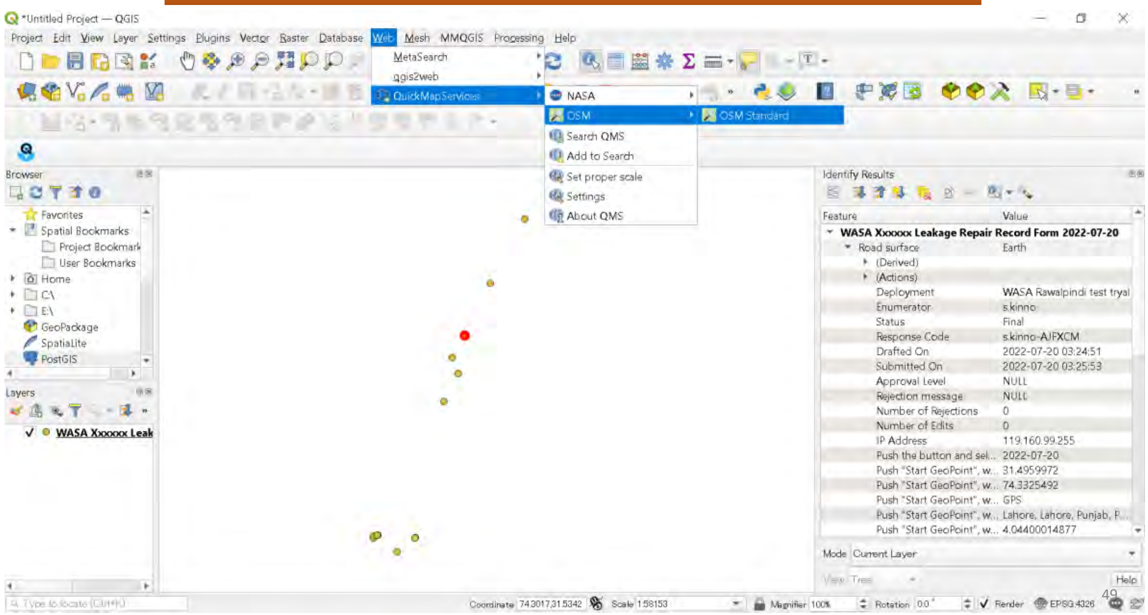
Edit data - Modify the location of points



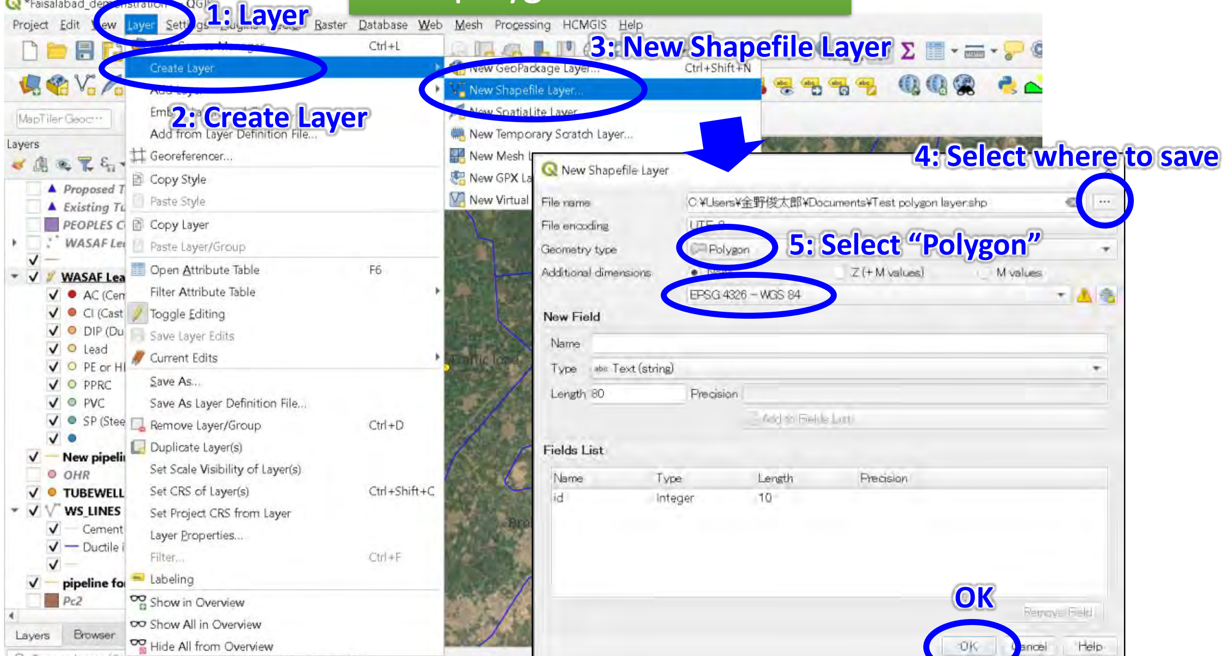
Edit data - Edit the attributes

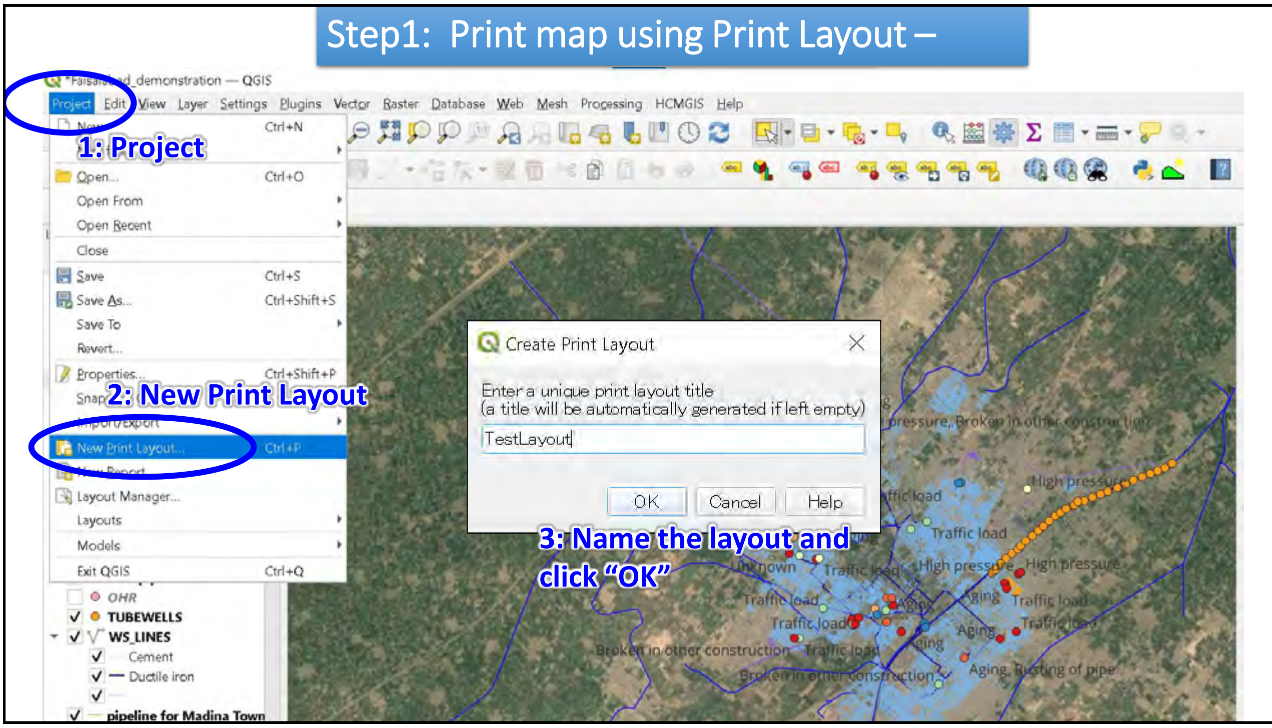


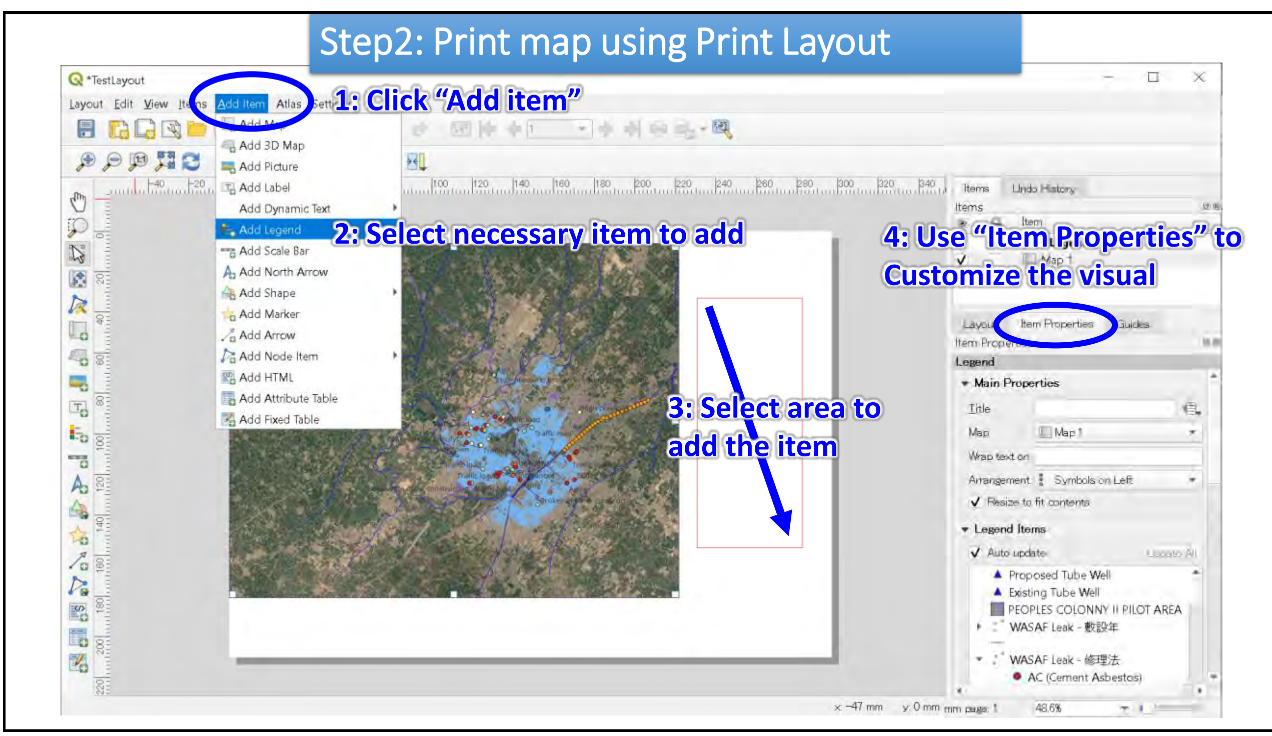
Step 2: How to show Background Map



Draw polygon




Step1: Print map using Print Layout –
1: Project
2: New Print Layout
3: Name the layout and click "OK"
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing HCMGIS Help
Open... Ctrl+O
Open From
Open Recent
Close
Save Ctrl+S
Save As... Ctrl+Shift+S
Save To
Revert...
Properties... Ctrl+Shift+P
New Print Layout... Ctrl+P
Layout Manager...
Layouts
Models
Exit QGIS Ctrl+Q
Create Print Layout
Enter a unique print layout title
(a title will be automatically generated if left empty)
TestLayout
OK
Cancel
Help
TUBEWELLS
WS_LINES
Cement
Ductile iron
pipeline for Madina Town


Step2: Print map using Print Layout
1: Click "Add item"
2: Select necessary item to add
3: Select area to add the item
4: Use "Item Properties" to Customize the visual
*TestLayout
Layout Edit View Items Add Item Atlas
Add 3D Map
Add Picture
Add Label
Add Dynamic Text
Add Legend
Add Scale Bar
Add North Arrow
Add Shape
Add Marker
Add Arrow
Add Node Item
Add HTML
Add Attribute Table
Add Fixed Table
Items
Undo History
Item Properties
Guides
Legend
Main Properties
Title
Map
Map 1
Wrap text on
Arrangement
Symbols on Left
Resize to fit contents
Legend Items
Auto update
Proposed Tube Well
Existing Tube Well
PEOPLES COLONNY II PILOT AREA
WASAF Leak - 数設年
WASAF Leak - 修理法
AC (Cement Asbestos)

Take full advantage of the data

Visualization in mWater Portal

- Quick check of the data

Excel

- Integrate and conserve all the data, calculate and analyze etc..

QGIS

- Visualize data on map and express the parameter as you like
- Prioritize the area for budget allocation of pipe replacement etc.

→ **Exhibit the leakage situation effectively**

- Request budget from the Government
- Attract international fund

Annex 5.1.12 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)" for ToT at 4 WASAs:

Plumbing Module

VALVES

Gate Valves (Also Sluice Valves)

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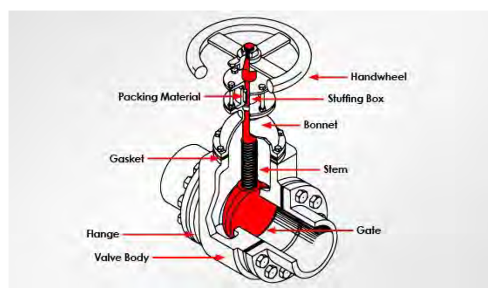

Advantages:
- Gate valves opens or closes slowly, which prevents fluid hammer and Subsequent damage to the piping system.
- Good choice for on-off service.
- Full flow, low pressure drop.
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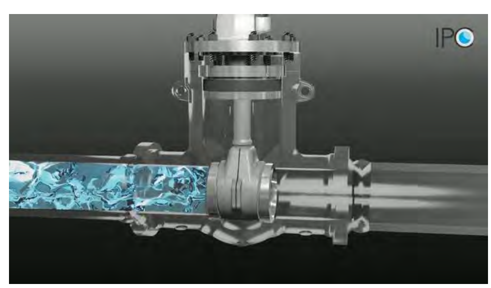

Disadvantages:
- It is not suitable for throttling applications.
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- It is more subject to seat and disk wear.
- Repairs are generally more difficult to accomplish.

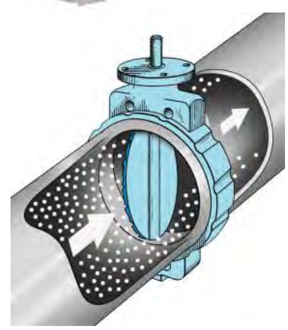
VALVES

Butterfly Valve

Butterfly valves are rotary motion valve that is used to stop, regulate, and start fluid flow.

Advantages:
- They are suitable for large valve applications.
- Compact, lightweight design.
- The maintenance costs are usually low.
- Pressure drop across a butterfly valve is small.
- Used with chemical or corrosive media.

Disadvantages:
- Difficult to clean
- Throttling limited to low differential pressure
- Potential for cavitation and choke
- Unguided disc movement is affected by flow turbulence



VALVES

Check Valve (Non-Return Valve)

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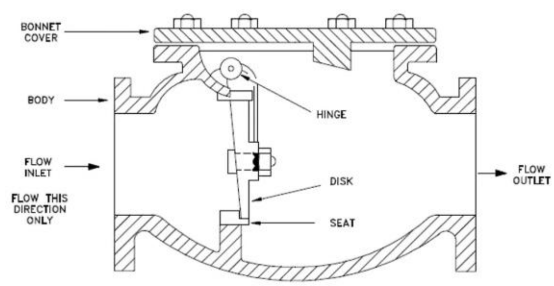

Advantages:
- Backflow should be avoided.
- Capable of withstanding both high and low pressures.
- Reduce the likelihood of unexpected valve failure.

Disadvantages:
- When there is a pressure difference between two sides, then it can cause leakage through the valve.
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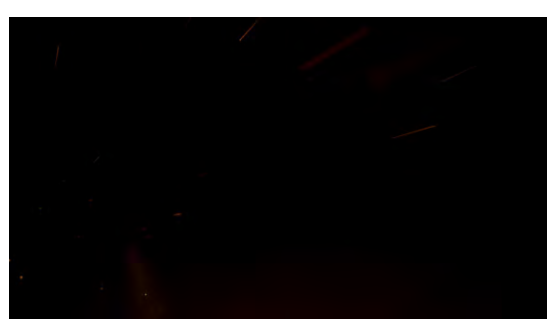

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Air Release Valve

An air release valve is generally a self-actuated valve that automatically vents small pockets of air that accumulate at the high point in a water distribution system when the system is operating under pressure.

Advantages:

- Air release valves protect the pipeline system and maintain its efficiency.
- These valves are perfect for quickly venting large volumes of air during filling or startup.
- This is important because some pipe materials can collapse under negative pressure.

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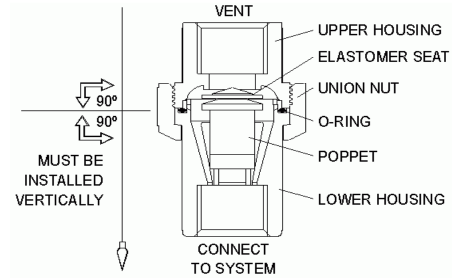

HIGH DENSITY POLYETHYLENE PIPE (HDPE)

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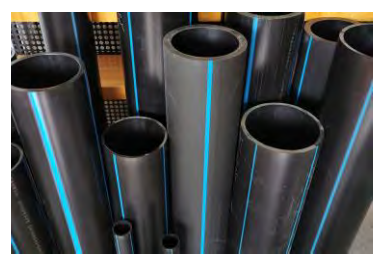


Salient Features of HDPE Pipes

- **Safe** for drinking water with no toxic or chemical contamination.
- **High flexibility.** Can be bent as much as 25-40 times of the pipe diameters. Thus reducing unnecessary pipe joint.
- **Light weight** with only 0.95 grams/cm2. Weight only 1/5 of steel pipes of the same size.
- **Rust proof** and high resistance to damaged chemicals, making the product last up to 50 years.
- **Super smooth** internal surface, reducing the chance of pipe cloggage.

BUTT FUSION WELDING

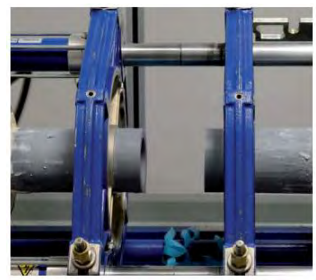
Butt Fusion Welding is a Thermo-fusion process.

It involves the simultaneous heating of the ends of two pipe/fitting components which are to be joined, until a molten state is attained on each contact surface. After its removal, joints are axially (butt) joined by applying pressure.

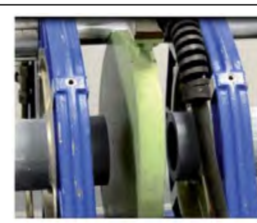
Like Poly-fusion and Electro-fusion, with butt fusion welding there is no additional contribution or use of filler materials (i.e. welding rod or flux) required to complete the weld.

BUTT FUSION WELDING MACHINE

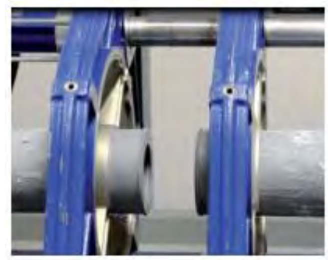
BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 1	**Preparation for welding** i. Select the operation area that is suitable for the work. ii. Set up the welding machine with all the accessories. iii. Before positioning the parts to be welded, clean the welding area to remove any dust, grease or dirt.	
Step 2	**Locking the ends** i. Insert two pipes ends on both side of the machine clamps, protrude approx. 3-5 cm from each side. ii. Adjust the alignment of pipe line by tightening or losing the nuts provided on the clamps. iii. Secure longitudinal movement of the parts to be welded by taking appropriate measures.	

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 3	**Milling the edges to be welded** i. Insert the facing tool or trimmer between the two pipe ends into the lock position on the welding machine. ii. Start the facing tool and slowly approach the pipe ends towards the tool by keep a control pressure. iii. The cutter will cut the surface of both pipe ends making them plane and parallel. iv. Chips shall be removed from the inner surface and the surrounding area.	
Step 4	i. Bring the two ends into contact, the space between the two edges must not exceed the value of 0.02 inches (0.5 mm). ii. Heating plate to be prepared by turning on heating until it reaches the desired temperature (220C – 240C)	

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 5	**Welding Process** i. Once the heating element reaches the desired temperature, place it between the pipe ends and ensure it's alignment & stability on machine base. ii. Place the edges in contact to the heating element and apply the initial welding force [pressure (P1 + Pt)] for a time t1 and maintain until the bead has reached height h on both welding edges. iii. Continue to the heating-up stage by reducing pressure and maintaining the heating-up pressure level (P2) along heating-up time (t2). iv. Open both pipe ends, carefully remove the heating plate and make sure the removal time should not be longer than the changeover time (t3).	 

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 6	**Welding Process** i. Once the heating element has been removed, bring the edges into contact. Gradually increase pressure until the value (P5 + Pt) is reached. ii. Reaching the final welding force [welding pressure (P3 + Pt)] must take the amount of time t4. iii. Maintain or Keep the joining pressure constant throughout the cooling time (T5) or until the welding joint cools down.	
Step 7	**Cooling Process:** i. Avoid forced cooling down by applying water. ii. Once the welding time is over, the welded joint can be removed from the welding machine, without being subjected to significant stress.	

BUTT FUSION WELDING DEMONSTRATION

Hands on Practice of Pressure Testing Model - 1

Module: Plumbing (Leakage, Plumbing & Pipe Replacement Course)

JICA Expert: Mr. T Naganuma

Team: Farhan Riaz, Rebia Suhail, Uzair Safdar, Haris Bin Khawar & Talha Rashid

Model Specifications: HDPE Pipe PN8 (Main Pipe) with four branches installed.

Branch 1: Gibault Joint; **Branch 2:** Flared Joint; **Branch 3:** Rubber Wrapped Joint; **Branch 4:** Bolted Clamp Joint

The course team performed a hands-on activity on the pressure test model at Aljazari Academy. It is a pilot activity to get practical experience of the model and figure out the unwanted issues and their solutions. The observations are listed as follows:

Steps Performed	Observations
1) Fill the testing model with water and release the trapped air inside.	Initially no leakage observed from any joint or valve. 
2) Injected the water with the help of hand pump to build a pressure inside pipes up to desired pressure rating. (We tested at 10 Bar)	Hand pump has leakages while injecting the water.
3) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 2.5 Bar,** rubber tube wrapped repair showed leakage. (Branch 3)  

<table>
<tr>
<td>4) While pressurizing leakage observed, stopped operation and checked the pressure.</td>
<td>At 4.5 Bar, bolted clamp showed leakage. (branch 4)
 </td>
</tr>
<tr>
<td>5) While pressurizing leakage observed, stopped operation and checked the pressure.</td>
<td>At 8 Bar, leakage from sluice valve of branch 2 observed.
</td>
</tr>
<tr>
<td>6) While pressurizing leakage observed, stopped operation and checked the pressure.</td>
<td>At 9 Bar, leakage from flange of branch 1 observed.
</td>
</tr>
<tr>
<td colspan="2">Action: Model was de-pressurized due to excessive leakages through saddle joint and hand pump. Minor repairs are required in the model to avoid any unwanted leakages.</td>
</tr>
</table>

Annex 5.1.13 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)" for Pilot In-house Training at 4 WASAs

PLUMBING COURSE

Batch - 1st

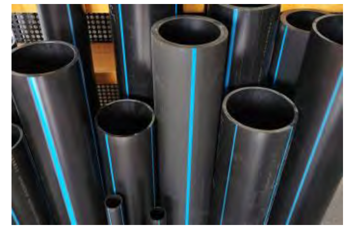
Plumbing Module

CONTENTS

1. **HDPE Pipes, Features, Standards, Color codes**
2. **HDPE Pipes SDR & MOP with class activity**
3. **Types of Valves, working principle and uses**

HIGH DENSITY POLYETHYLENE PIPE (HDPE)

HDPE pipe is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines.



Salient Features of HDPE Pipes

- **Safe** for drinking water with no toxic or chemical contamination.
- **High flexibility.** Can be bent as much as 25-40 times of the pipe diameters. Thus reducing unnecessary pipe joint.
- **Light weight** with only 0.95 grams/cm2. Weight only 1/5 of steel pipes of the same size.
- **Rust proof** and high resistance to damaged chemicals, making the product last up to 50 years.
- **Super smooth** internal surface, reducing the chance of pipe cloggage.

HDPE COLOR GUIDE

Red	Electric power lines, cable, conduit and lighting cables
Orange	Telecommunication, alarm or signal lines, cables or conduit
Yellow	Fuel gas (methane or propane), oil, petroleum, steam or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Violet (Purple)	Reclaimed water, irrigation and slurry lines

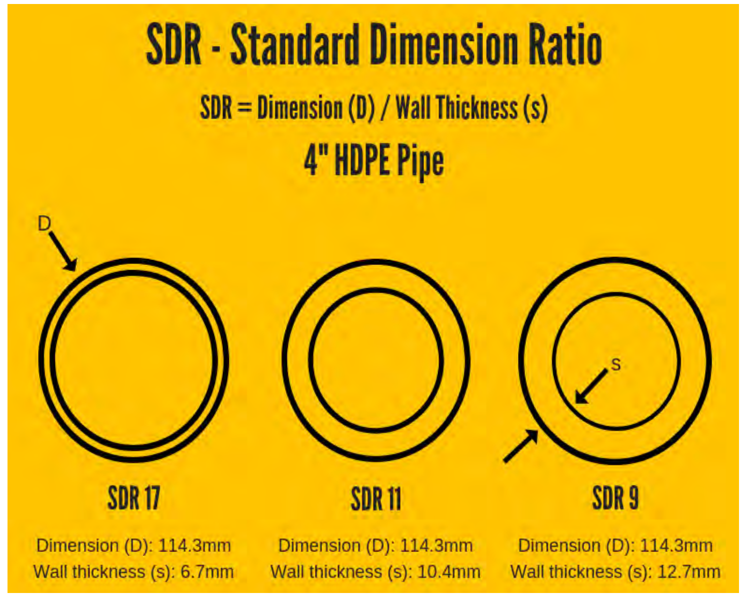
STANDARD DIMENSION RATIO (SDR)

SDR stands for **"Standard Dimension Ratio"**

SDR= D/s

Where;
D= Outside diameter of pipe
S= Thickness of pipe

It's an inverse relationship. **The higher the SDR, the lower the pressure rating**.



MAXIMUM OPERATING PRESSURE (MOP)

This pressure is defined as the 'Maximum Operating Pressure' MOP, or the pressure rating of the pipe.

MOP = 2 x MRS / C (SDR - 1) ---- Where MRS and MOP are in MPa

MOP = 20 x MRS / C (SDR - 1) ----- Where MRS is in MPa and MOP is in bar.

Where C is the 'overall service (design) coefficient, or Safety Factor.
For water applications the minimum value of **C** is **1.25**

In HDPE Pipe terms, MRS stands for "Minimum Required Strength" (MRS).
The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

Material Designation	Minimum Required Strength (MRS)MPa
PE100	10.0
PE80	8.0

M.O.D EXAMPLE

Example : What is the MOP or pressure rating of an SDR11 PE100 water pipe?

Given:
For PE100, MRS = 10 MPa.
Service design coefficient 'C' = 1.25

Formula: MOP = 20 x MRS / C (SDR - 1)

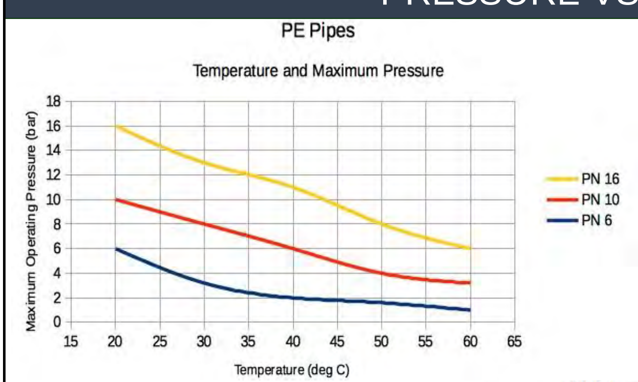
Solution:

MOP = 20 * 10 / 1.25 (11 - 1)
MOP = 16 bar

CLASS ACTIVITY

What is the MOP or pressure rating of an SDR17, PE100 water pipe?

PRESSURE VS TEMPRETURE



The maximum operating pressure of a HDPE pipe depends on the temperature of fluid and pipe.

Pressure reduction factors according to ISO Standards

Pressure reduction factors for temperatures between 20 °C and 50 °C

Material classification	Pressure reduction factors[a b]						
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
PE 100 PE 80	1,00	0,92	0,85	0,79	0,73	0,67	0,63
PE 63	1,00	0,92	0,85	0,79	0,73		
PE 40	1,00	0,92	0,85	0,77	0,70		

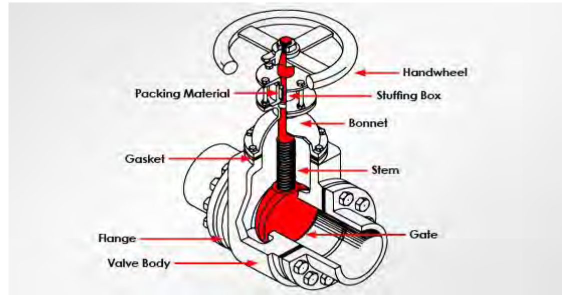
[a] Reference to ISO 9080:2012 shall be made for extrapolation time limits, see 5.3.

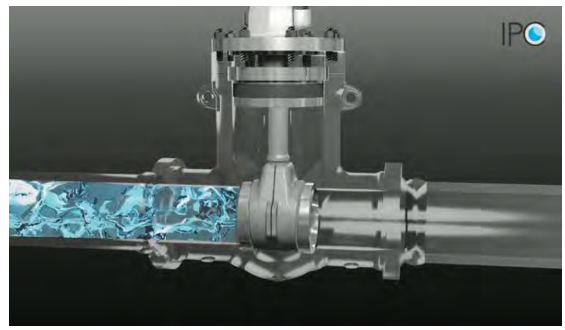
[b] The ISO 9080:2012 extrapolation factors are 50 for 40 °C, 30 for 45 °C and 18 for 50 °C when the material is tested at a maximum temperature of 80 °C. If the material is tested at a higher temperature than 80 °C then other extrapolation factors may apply.

VALVES

Gate Valves (Also Sluice Valves)

Flow is controlled by raising or lowering the disk. Gate valves are not usually used to regulate flow because the valving element can be damaged when in the partially open position.





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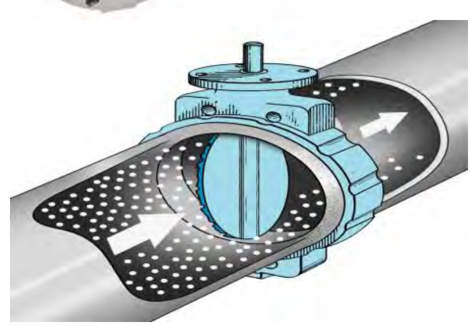

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- Compact, lightweight design.
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Disadvantages:
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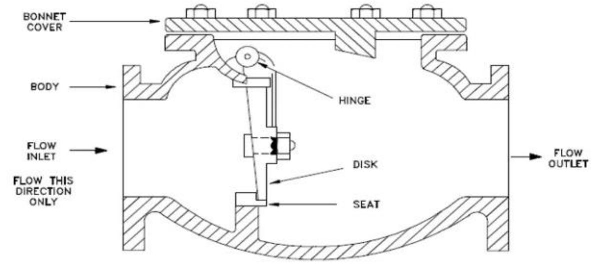

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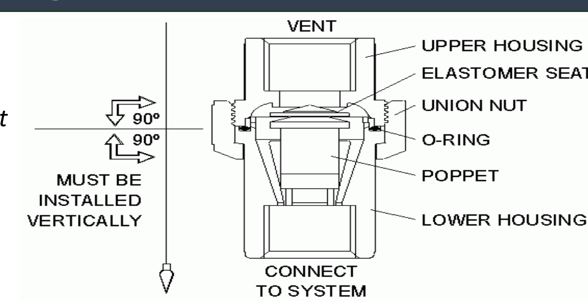

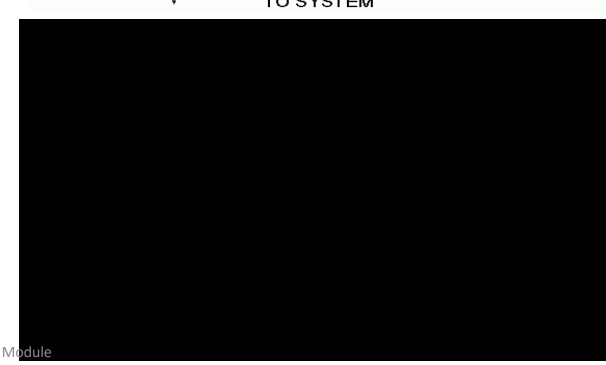

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Disadvantages:
- If a pipeline is filled or emptied too quickly, an air release valve does not always keep up with the air flow demands.
- You must size the valve correctly for your application.

VALVE STANDARDS

Type of valves	Standard for valves	Remarks
Gate valves	**BS EN-1171**	Used for isolation only.
Check Valves	**BSEN 1563**	Used to prevent reverse flow (non-return).
Butterfly valves	**ISO 10631, BS 5155, EN-593,**	Used for isolation as well as throttling.
Air valves	**ISO 4126-1, EN-1074**	Used to release the air entrapped in the pipelines.

Water And Sanitation Agency Gujranwala

WASA

THANK YOU!!!

Hands on Practice of Pressure Testing Model - 1

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Annex 5.1.14 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)"

- WASA Faisalabad for In-house Training (1st)
- WASA Multan for In-house Training
- WASA Gujranwala for In-house Training (1st-3rd)
- WASA Rawalpindi for In-house Training (1st, 2nd)

PLUMBING COURSE

Batch - 1st

Plumbing Module

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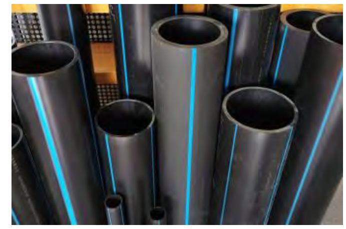

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HDPE COLOR GUIDE

Red	Electric power lines, cable, conduit and lighting cables
Orange	Telecommunication, alarm or signal lines, cables or conduit
Yellow	Fuel gas (methane or propane), oil, petroleum, steam or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Violet (Purple)	Reclaimed water, irrigation and slurry lines

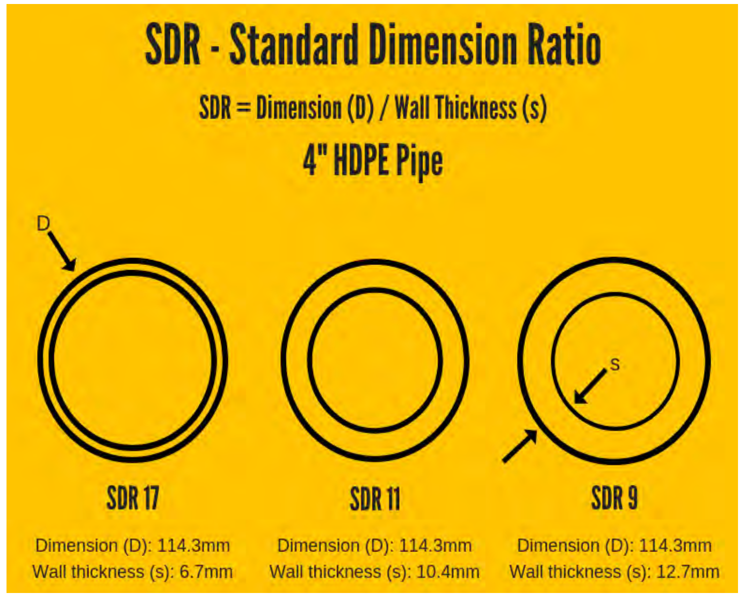
STANDARD DIMENSION RATIO (SDR)

SDR stands for **"Standard Dimension Ratio"**

SDR= D/s

Where;
D= Outside diameter of pipe
S= Thickness of pipe

It's an inverse relationship. **The higher the SDR, the lower the pressure rating**.



MAXIMUM OPERATING PRESSURE (MOP)

This pressure is defined as the 'Maximum Operating Pressure' MOP, or the pressure rating of the pipe.

MOP = 2 x MRS / C (SDR - 1) ---- Where MRS and MOP are in MPa

MOP = 20 x MRS / C (SDR - 1) ----- Where MRS is in MPa and MOP is in bar.

Where C is the 'overall service (design) coefficient, or Safety Factor.
For water applications the minimum value of **C** is **1.25**

In HDPE Pipe terms, MRS stands for "Minimum Required Strength" (MRS).
The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

Material Designation	Minimum Required Strength (MRS)MPa
PE100	10.0
PE80	8.0

M.O.D EXAMPLE

Example : What is the MOP or pressure rating of an SDR11 PE100 water pipe?

Given:
For PE100, MRS = 10 MPa.
Service design coefficient 'C' = 1.25

Formula: MOP = 20 x MRS / C (SDR - 1)

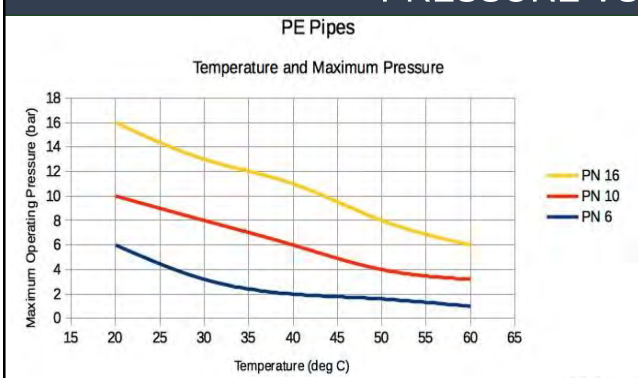
Solution:

MOP = 20 * 10 / 1.25 (11 - 1)
MOP = 16 bar

CLASS ACTIVITY

What is the MOP or pressure rating of an SDR17, PE100 water pipe?

PRESSURE VS TEMPRETURE



The maximum operating pressure of a HDPE pipe depends on the temperature of fluid and pipe.

Pressure reduction factors according to ISO Standards

Pressure reduction factors for temperatures between 20 °C and 50 °C

Material classification	Pressure reduction factors[a b]						
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
PE 100 PE 80	1,00	0,92	0,85	0,79	0,73	0,67	0,63
PE 63	1,00	0,92	0,85	0,79	0,73		
PE 40	1,00	0,92	0,85	0,77	0,70		

[a] Reference to ISO 9080:2012 shall be made for extrapolation time limits, see 5.3.

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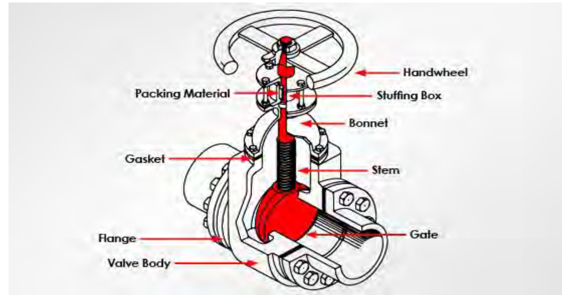
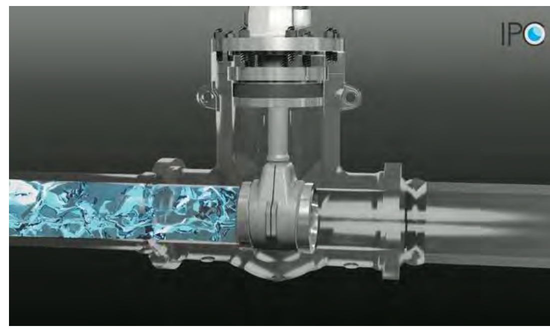
Gate Valves (Also Sluice Valves)

Flow is controlled by raising or lowering the disk. Gate valves are not usually used to regulate flow because the valving element can be damaged when in the partially open position.





Advantages:

- Gate valves opens or closes slowly, which prevents fluid hammer and Subsequent damage to the piping system.
- Good choice for on-off service.
- Full flow, low pressure drop.
- Bidirectional.

Disadvantages:

- It is not suitable for throttling applications.
- It is prone to vibration in the partially open state.
- It is more subject to seat and disk wear.
- Repairs are generally more difficult to accomplish.

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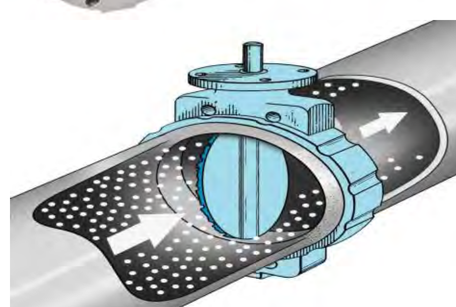
Butterfly Valve

Butterfly valves are rotary motion valve that is used to stop, regulate, and start fluid flow.



Advantages:

- They are suitable for large valve applications.
- Compact, lightweight design.
- The maintenance costs are usually low.
- Pressure drop across a butterfly valve is small.
- Used with chemical or corrosive media.

Disadvantages:

- Difficult to clean
- Throttling limited to low differential pressure
- Potential for cavitation and choke
- Unguided disc movement is affected by flow turbulence

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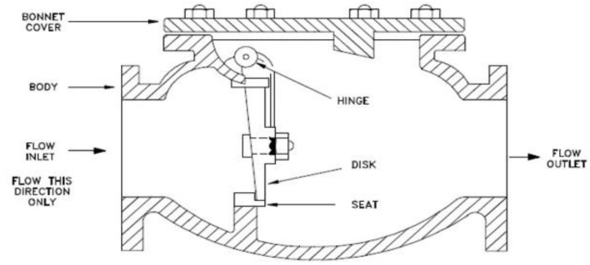

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Check valves are designed to prevent the reversal of flow in a piping system. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve.

Advantages:
- Backflow should be avoided.
- Capable of withstanding both high and low pressures.
- Reduce the likelihood of unexpected valve failure.

Disadvantages:
- When there is a pressure difference between two sides, then it can cause leakage through the valve.
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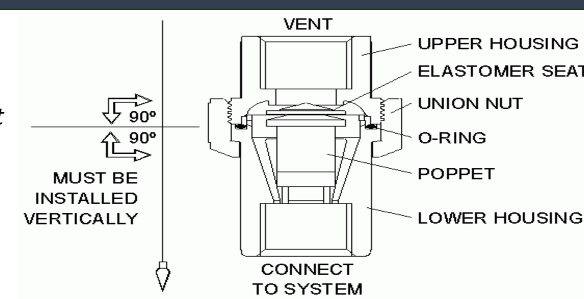
VALVES



Air Release Valve

An air release valve is generally a self-actuated valve that automatically vents small pockets of air that accumulate at the high point in a water distribution system when the system is operating under pressure.

Advantages:
- Air release valves protect the pipeline system and maintain its efficiency.
- These valves are perfect for quickly venting large volumes of air during filling or startup.
- This is important because some pipe materials can collapse under negative pressure.

Disadvantages:
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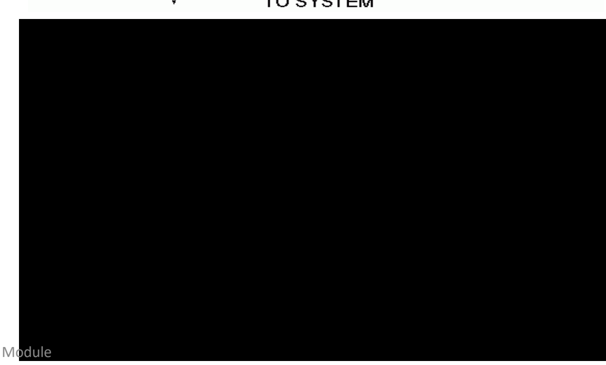

VALVE STANDARDS

Type of valves	Standard for valves	Remarks
Gate valves	**BS EN-1171**	Used for isolation only.
Check Valves	**BSEN 1563**	Used to prevent reverse flow (non-return).
Butterfly valves	**ISO 10631, BS 5155, EN-593,**	Used for isolation as well as throttling.
Air valves	**ISO 4126-1, EN-1074**	Used to release the air entrapped in the pipelines.

Water And Sanitation Agency Gujranwala
WASA

THANK YOU!!!

Hands on Practice of Pressure Testing Model - 1

Module: Plumbing (Leakage, Plumbing & Pipe Replacement Course)

JICA Expert: Mr. T Naganuma

Team: Farhan Riaz, Rebia Suhail, Uzair Safdar, Haris Bin Khawar & Talha Rashid

Model Specifications: HDPE Pipe PN8 (Main Pipe) with four branches installed.

Branch 1: Gibault Joint; **Branch 2:** Flared Joint; **Branch 3:** Rubber Wrapped Joint; **Branch 4:** Bolted Clamp Joint

The course team performed a hands-on activity on the pressure test model at Aljazari Academy. It is a pilot activity to get practical experience of the model and figure out the unwanted issues and their solutions. The observations are listed as follows:

Steps Performed	Observations
1) Fill the testing model with water and release the trapped air inside.	Initially no leakage observed from any joint or valve. 
2) Injected the water with the help of hand pump to build a pressure inside pipes up to desired pressure rating. (We tested at 10 Bar)	Hand pump has leakages while injecting the water.
3) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 2.5 Bar,** rubber tube wrapped repair showed leakage. (Branch 3)  

4) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 4.5 Bar,** bolted clamp showed leakage. (branch 4)  
5) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 8 Bar,** leakage from sluice valve of branch 2 observed. 
6) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 9 Bar,** leakage from flange of branch 1 observed. 
Action: Model was de-pressurized due to excessive leakages through saddle joint and hand pump. Minor repairs are required in the model to avoid any unwanted leakages.	

Plumbing Module

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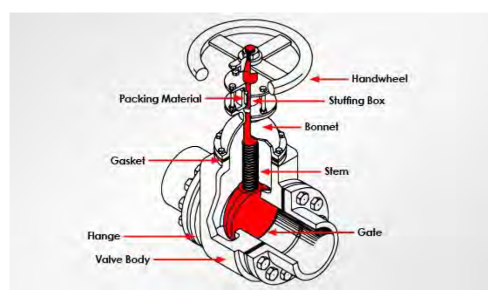

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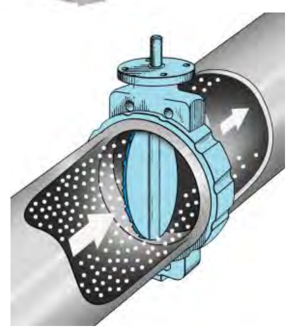

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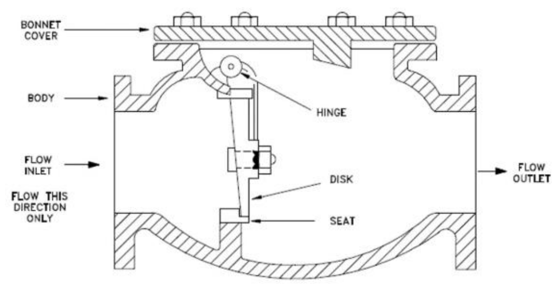

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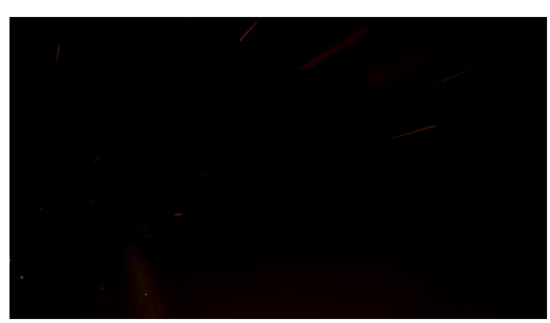

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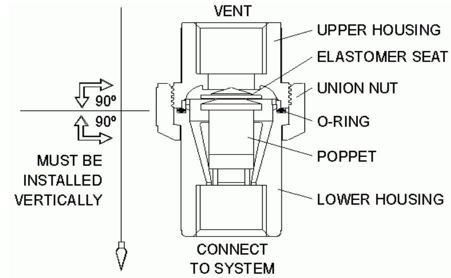
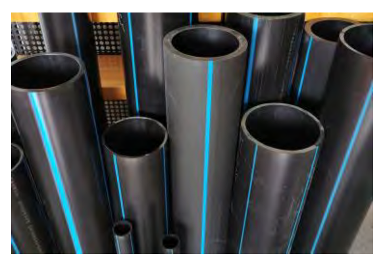


HIGH DENSITY POLYETHYLENE PIPE (HDPE)

HDPE pipe is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines.



Salient Features of HDPE Pipes

- **Safe** for drinking water with no toxic or chemical contamination.
- **High flexibility.** Can be bent as much as 25-40 times of the pipe diameters. Thus reducing unnecessary pipe joint.
- **Light weight** with only 0.95 grams/cm2. Weight only 1/5 of steel pipes of the same size.
- **Rust proof** and high resistance to damaged chemicals, making the product last up to 50 years.
- **Super smooth** internal surface, reducing the chance of pipe cloggage.

BUTT FUSION WELDING

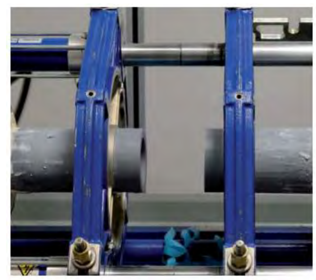
Butt Fusion Welding is a Thermo-fusion process.

It involves the simultaneous heating of the ends of two pipe/fitting components which are to be joined, until a molten state is attained on each contact surface. After its removal, joints are axially (butt) joined by applying pressure.

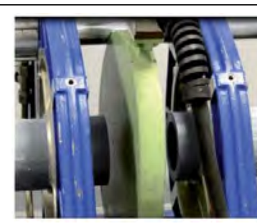
Like Poly-fusion and Electro-fusion, with butt fusion welding there is no additional contribution or use of filler materials (i.e. welding rod or flux) required to complete the weld.

BUTT FUSION WELDING MACHINE

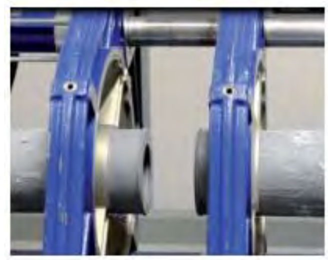
BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 1	**Preparation for welding** i. Select the operation area that is suitable for the work. ii. Set up the welding machine with all the accessories. iii. Before positioning the parts to be welded, clean the welding area to remove any dust, grease or dirt.	
Step 2	**Locking the ends** i. Insert two pipes ends on both side of the machine clamps, protrude approx. 3-5 cm from each side. ii. Adjust the alignment of pipe line by tightening or losing the nuts provided on the clamps. iii. Secure longitudinal movement of the parts to be welded by taking appropriate measures.	

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 3	**Milling the edges to be welded** i. Insert the facing tool or trimmer between the two pipe ends into the lock position on the welding machine. ii. Start the facing tool and slowly approach the pipe ends towards the tool by keep a control pressure. iii. The cutter will cut the surface of both pipe ends making them plane and parallel. iv. Chips shall be removed from the inner surface and the surrounding area.	
Step 4	i. Bring the two ends into contact, the space between the two edges must not exceed the value of 0.02 inches (0.5 mm). ii. Heating plate to be prepared by turning on heating until it reaches the desired temperature (220C – 240C)	

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 5	**Welding Process** i. Once the heating element reaches the desired temperature, place it between the pipe ends and ensure it's alignment & stability on machine base. ii. Place the edges in contact to the heating element and apply the initial welding force [pressure (P1 + Pt)] for a time t1 and maintain until the bead has reached height h on both welding edges. iii. Continue to the heating-up stage by reducing pressure and maintaining the heating-up pressure level (P2) along heating-up time (t2). iv. Open both pipe ends, carefully remove the heating plate and make sure the removal time should not be longer than the changeover time (t3).	 

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 6	**Welding Process** i. Once the heating element has been removed, bring the edges into contact. Gradually increase pressure until the value (P5 + Pt) is reached. ii. Reaching the final welding force [welding pressure (P3 + Pt)] must take the amount of time t4. iii. Maintain or Keep the joining pressure constant throughout the cooling time (T5) or until the welding joint cools down.	
Step 7	**Cooling Process:** i. Avoid forced cooling down by applying water. ii. Once the welding time is over, the welded joint can be removed from the welding machine, without being subjected to significant stress.	

BUTT FUSION WELDING DEMONSTRATION

Annex 5.1.15 Training Material: "Plumbing (HDPE jointing, pressure test, etc.)"

- WASA Faisalabad for In-house Training (2nd, 3rd)
- WASA Gujranwala for In-house Training (4th)
- WASA Rawalpindi for In-house Training (3rd)

PLUMBING COURSE

Batch - 1st

Plumbing Module

CONTENTS

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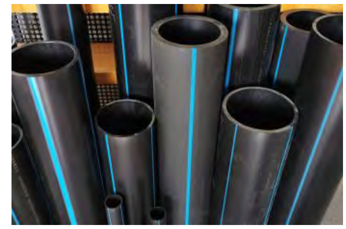

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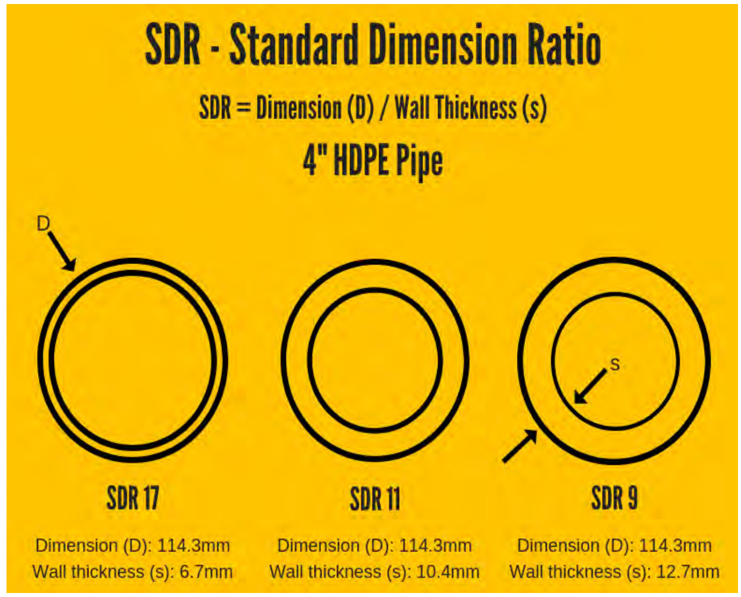

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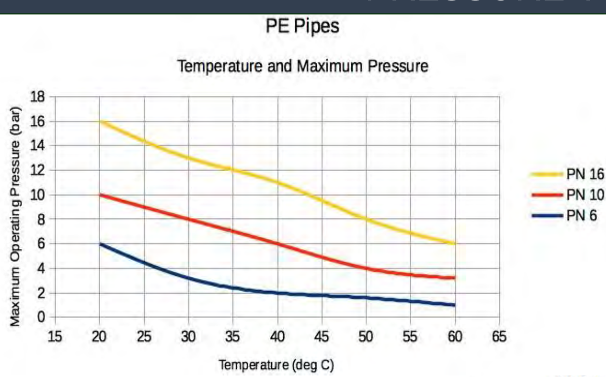

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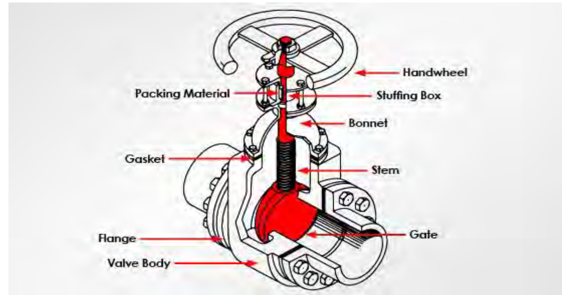

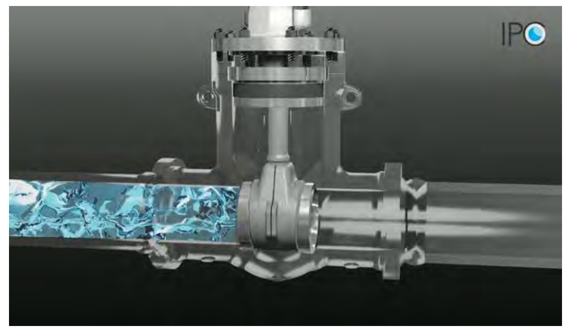

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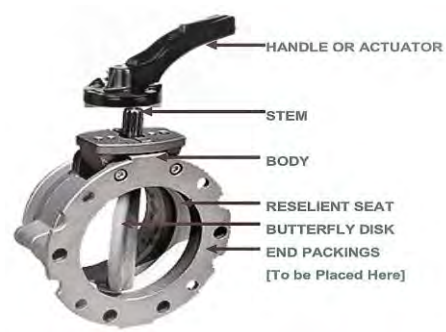

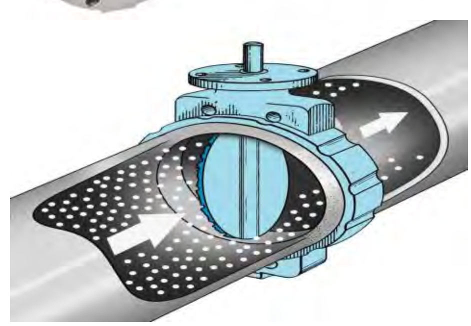

Plumbing Module

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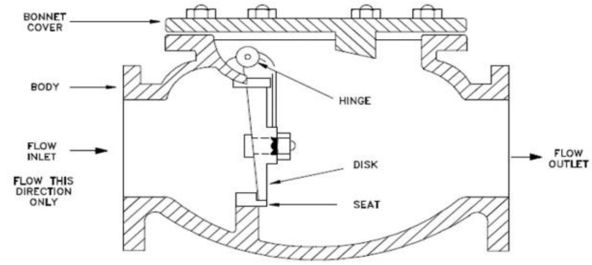

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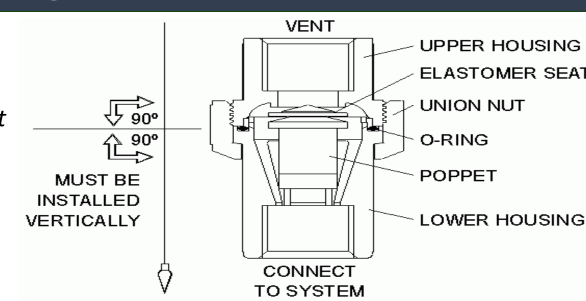

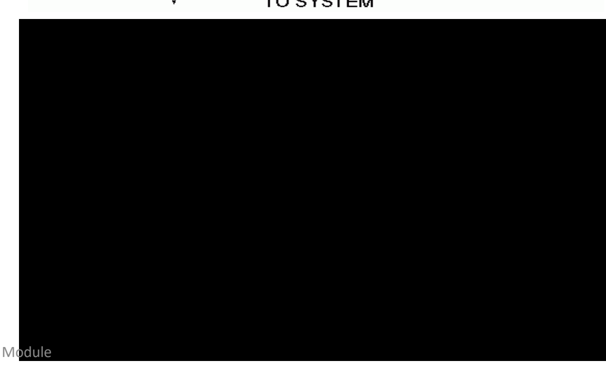

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- You must size the valve correctly for your application.

VALVE STANDARDS

Type of valves	Standard for valves	Remarks
Gate valves	**BS EN-1171**	Used for isolation only.
Check Valves	**BSEN 1563**	Used to prevent reverse flow (non-return).
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THANK YOU!!!

Hands on Practice of Pressure Testing Model - 1

Module: Plumbing (Leakage, Plumbing & Pipe Replacement Course)

JICA Expert: Mr. T Naganuma

Team: Farhan Riaz, Rebia Suhail, Uzair Safdar, Haris Bin Khawar & Talha Rashid

Model Specifications: HDPE Pipe PN8 (Main Pipe) with four branches installed.

Branch 1: Gibault Joint; **Branch 2:** Flared Joint; **Branch 3:** Rubber Wrapped Joint; **Branch 4:** Bolted Clamp Joint

The course team performed a hands-on activity on the pressure test model at Aljazari Academy. It is a pilot activity to get practical experience of the model and figure out the unwanted issues and their solutions. The observations are listed as follows:

Steps Performed	Observations
1) Fill the testing model with water and release the trapped air inside.	Initially no leakage observed from any joint or valve. 
2) Injected the water with the help of hand pump to build a pressure inside pipes up to desired pressure rating. (We tested at 10 Bar)	Hand pump has leakages while injecting the water.
3) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 2.5 Bar,** rubber tube wrapped repair showed leakage. (Branch 3)  

4) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 4.5 Bar,** bolted clamp showed leakage. (branch 4)  
5) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 8 Bar,** leakage from sluice valve of branch 2 observed. 
6) While pressurizing leakage observed, stopped operation and checked the pressure.	**At 9 Bar,** leakage from flange of branch 1 observed. 
Action: Model was de-pressurized due to excessive leakages through saddle joint and hand pump. Minor repairs are required in the model to avoid any unwanted leakages.	

Plumbing Module

VALVES

Gate Valves (Also Sluice Valves)

Flow is controlled by raising or lowering the disk. Gate valves are not usually used to regulate flow because the valving element can be damaged when in the partially open position.

Advantages:

- Gate valves opens or closes slowly, which prevents fluid hammer and Subsequent damage to the piping system.
- Good choice for on-off service.
- Full flow, low pressure drop.
- Bidirectional.

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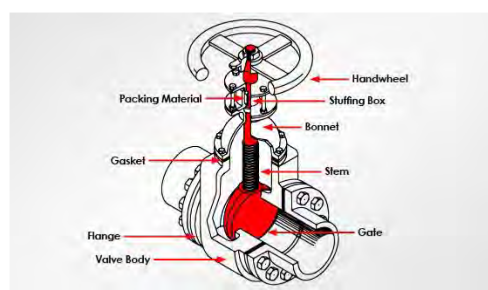

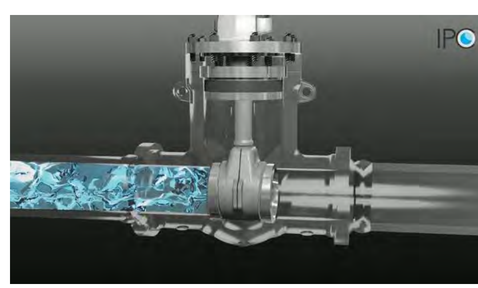

VALVES

Butterfly Valve

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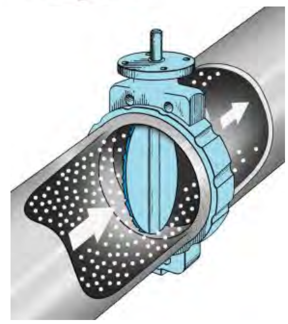

Advantages:
- They are suitable for large valve applications.
- Compact, lightweight design.
- The maintenance costs are usually low.
- Pressure drop across a butterfly valve is small.
- Used with chemical or corrosive media.

Disadvantages:
- Difficult to clean
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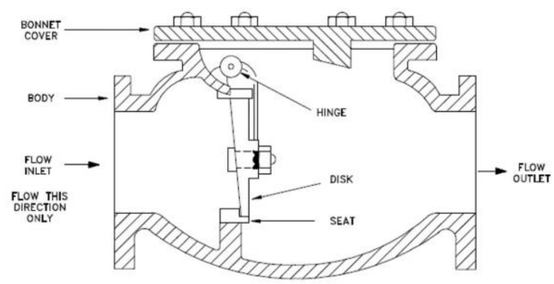
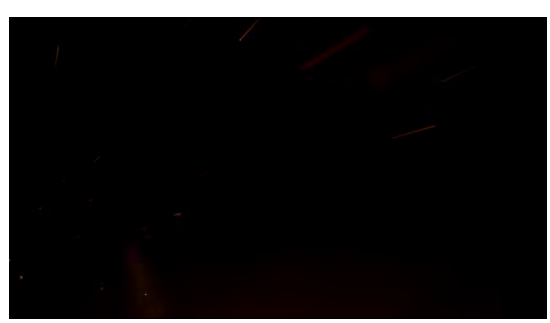
Check Valve (Non-Return Valve)

Check valves are designed to prevent the reversal of flow in a piping system. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve.





Advantages:
- Backflow should be avoided.
- Capable of withstanding both high and low pressures.
- Reduce the likelihood of unexpected valve failure.

Disadvantages:
- When there is a pressure difference between two sides, then it can cause leakage through the valve.
- Check valves cannot be used for fluids having a high viscosity or density.
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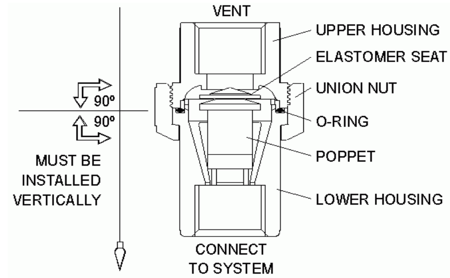


Advantages:

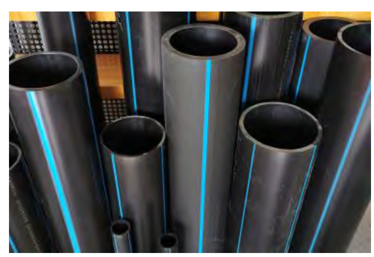
- Air release valves protect the pipeline system and maintain its efficiency.
- These valves are perfect for quickly venting large volumes of air during filling or startup.
- This is important because some pipe materials can collapse under negative pressure.

Disadvantages:

- If a pipeline is filled or emptied too quickly, an air release valve does not always keep up with the air flow demands.
- You must size the valve correctly for your application.

HIGH DENSITY POLYETHYLENE PIPE (HDPE)

HDPE pipe is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines.



Salient Features of HDPE Pipes

- **Safe** for drinking water with no toxic or chemical contamination.
- **High flexibility.** Can be bent as much as 25-40 times of the pipe diameters. Thus reducing unnecessary pipe joint.
- **Light weight** with only 0.95 grams/cm2. Weight only 1/5 of steel pipes of the same size.
- **Rust proof** and high resistance to damaged chemicals, making the product last up to 50 years.
- **Super smooth** internal surface, reducing the chance of pipe cloggage.

BUTT FUSION WELDING

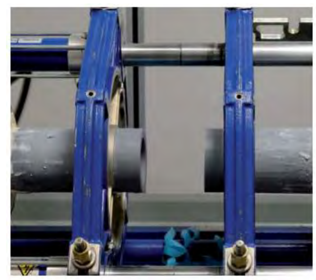
Butt Fusion Welding is a Thermo-fusion process.

It involves the simultaneous heating of the ends of two pipe/fitting components which are to be joined, until a molten state is attained on each contact surface. After its removal, joints are axially (butt) joined by applying pressure.

Like Poly-fusion and Electro-fusion, with butt fusion welding there is no additional contribution or use of filler materials (i.e. welding rod or flux) required to complete the weld.

BUTT FUSION WELDING MACHINE

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 1	**Preparation for welding** i. Select the operation area that is suitable for the work. ii. Set up the welding machine with all the accessories. iii. Before positioning the parts to be welded, clean the welding area to remove any dust, grease or dirt.	
Step 2	**Locking the ends** i. Insert two pipes ends on both side of the machine clamps, protrude approx. 3-5 cm from each side. ii. Adjust the alignment of pipe line by tightening or losing the nuts provided on the clamps. iii. Secure longitudinal movement of the parts to be welded by taking appropriate measures.	

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 3	**Milling the edges to be welded** i. Insert the facing tool or trimmer between the two pipe ends into the lock position on the welding machine. ii. Start the facing tool and slowly approach the pipe ends towards the tool by keep a control pressure. iii. The cutter will cut the surface of both pipe ends making them plane and parallel. iv. Chips shall be removed from the inner surface and the surrounding area.	
Step 4	i. Bring the two ends into contact, the space between the two edges must not exceed the value of 0.02 inches (0.5 mm). ii. Heating plate to be prepared by turning on heating until it reaches the desired temperature (220C – 240C)	

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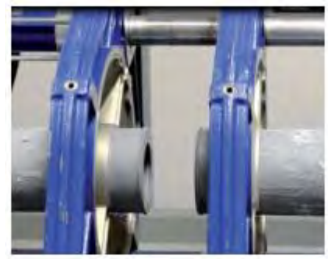
Step 5	**Welding Process** i. Once the heating element reaches the desired temperature, place it between the pipe ends and ensure it’s alignment & stability on machine base. ii. Place the edges in contact to the heating element and apply the initial welding force [pressure (P1 + Pt)] for a time t1 and maintain until the bead has reached height h on both welding edges. iii. Continue to the heating-up stage by reducing pressure and maintaining the heating-up pressure level (P2) along heating-up time (t2). iv. Open both pipe ends, carefully remove the heating plate and make sure the removal time should not be longer than the changeover time (t3).	 

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 6	**Welding Process** i. Once the heating element has been removed, bring the edges into contact. Gradually increase pressure until the value (P5 + Pt) is reached. ii. Reaching the final welding force [welding pressure (P3 + Pt)] must take the amount of time t4. iii. Maintain or Keep the joining pressure constant throughout the cooling time (T5) or until the welding joint cools down.	
Step 7	**Cooling Process:** i. Avoid forced cooling down by applying water. ii. Once the welding time is over, the welded joint can be removed from the welding machine, without being subjected to significant stress.	

BUTT FUSION WELDING DEMONSTRATION

PLUMBING COURSE

Batch – 4th

Master Trainer: Mr. Samran Zahid
Organization: WASA Rawalpindi

DATE: 30- 11- 2023
DAY: THURSDAY

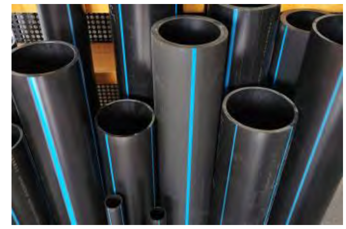
Plumbing Module

CONTENTS

1. **HDPE Pipes, Features, Standards, Color codes**
2. **HDPE Pipes SDR & MOP with class activity**
3. **Types of Valves, working principle and uses**

HIGH DENSITY POLYETHYLENE PIPE (HDPE)

HDPE pipe is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines.



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- **Rust proof** and high resistance to damaged chemicals, making the product last up to 50 years.
- **Super smooth** internal surface, reducing the chance of pipe cloggage.

HDPE COLOR GUIDE

Red	Electric power lines, cable, conduit and lighting cables
Orange	Telecommunication, alarm or signal lines, cables or conduit
Yellow	Fuel gas (methane or propane), oil, petroleum, steam or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Violet (Purple)	Reclaimed water, irrigation and slurry lines

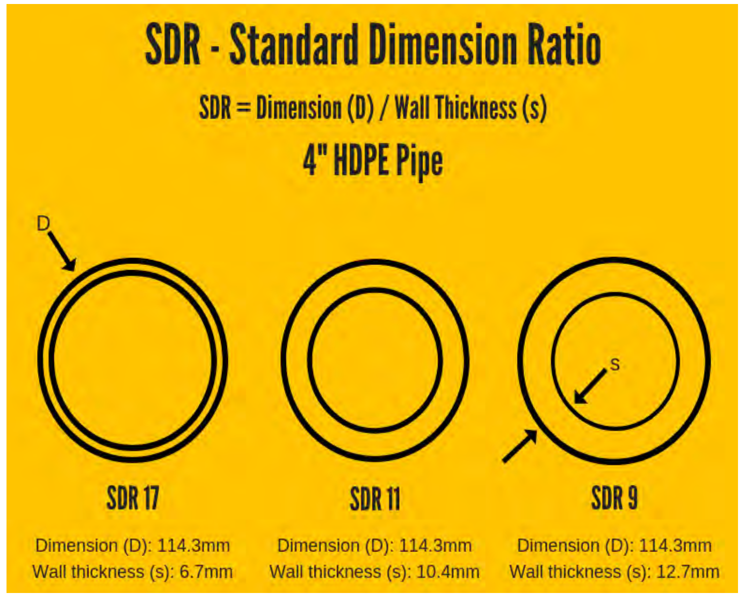
STANDARD DIMENSION RATIO (SDR)

SDR stands for **"Standard Dimension Ratio"**

SDR= D/s

Where;
D= Outside diameter of pipe
S= Thickness of pipe

It's an inverse relationship. **The higher the SDR, the lower the pressure rating**.



MAXIMUM OPERATING PRESSURE (MOP)

This pressure is defined as the 'Maximum Operating Pressure' MOP, or the pressure rating of the pipe.

MOP = 2 x MRS / C (SDR - 1) ---- Where MRS and MOP are in MPa

Note: 1 MPA = 10 bar

MOP = 20 x MRS / C (SDR - 1) ----- Where MRS is in MPa and MOP is in bar.

Where C is the 'overall service (design) coefficient, or Safety Factor.
For water applications the minimum value of **C** is **1.25**

In HDPE Pipe terms, MRS stands for "Minimum Required Strength" (MRS).
The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

Material Designation	Minimum Required Strength (MRS)MPa
PE100	10.0
PE80	8.0

M.O.D EXAMPLE

Example : What is the MOP or pressure rating of an SDR11 PE100 water pipe?

Given:
For PE100, MRS = 10 MPa.
Service design coefficient 'C' = 1.25

Formula: MOP = 20 x MRS / C (SDR - 1)

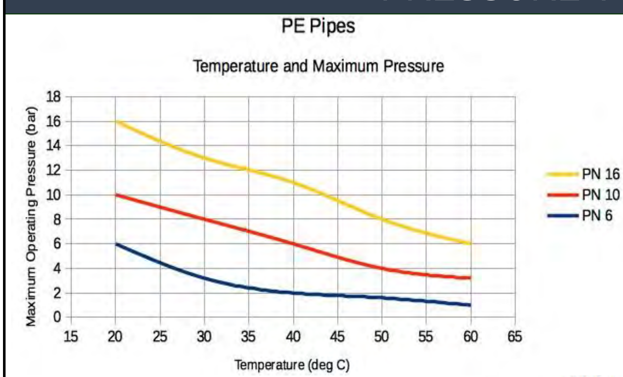
Solution:

MOP = 20 * 10 / 1.25 (11 - 1)
MOP = 16 bar

CLASS ACTIVITY

What is the MOP or pressure rating of an SDR17, PE100 water pipe?

PRESSURE VS TEMPRETURE



The maximum operating pressure of a HDPE pipe depends on the temperature of fluid and pipe.

Pressure reduction factors according to ISO Standards

Pressure reduction factors for temperatures between 20 °C and 50 °C

Material classification	Pressure reduction factors[a b]						
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
PE 100 PE 80	1,00	0,92	0,85	0,79	0,73	0,67	0,63
PE 63	1,00	0,92	0,85	0,79	0,73		
PE 40	1,00	0,92	0,85	0,77	0,70		

[a] Reference to ISO 9080:2012 shall be made for extrapolation time limits, see 5.3.

[b] The ISO 9080:2012 extrapolation factors are 50 for 40 °C, 30 for 45 °C and 18 for 50 °C when the material is tested at a maximum temperature of 80 °C. If the material is tested at a higher temperature than 80 °C then other extrapolation factors may apply.

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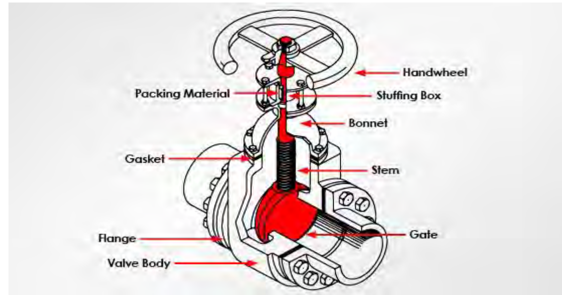

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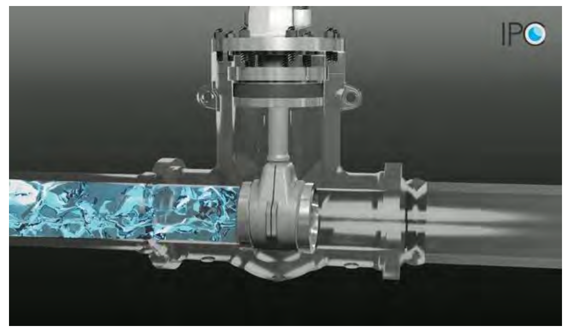

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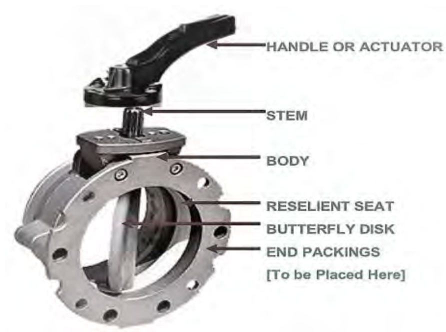

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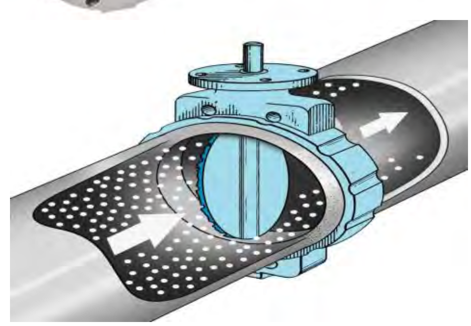

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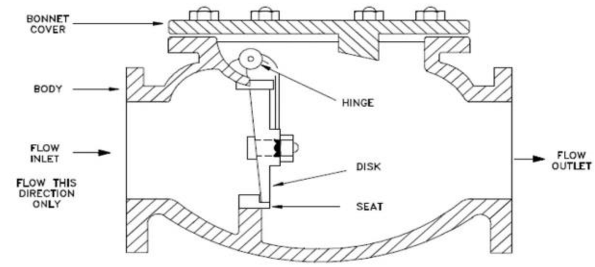

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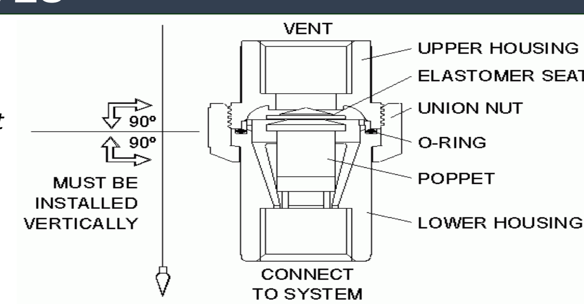

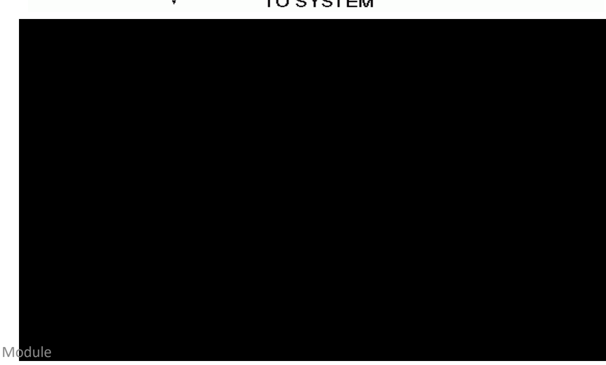

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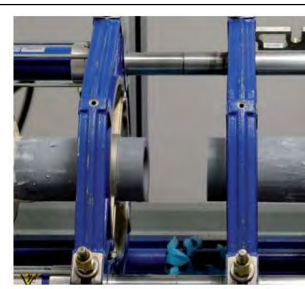
BUTT FUSION WELDING MACHINE

BUTT FUSION WELDING - PROCEDURE

Steps	Procedure	Demonstration
Step 1	**Preparation for welding** i. Select the operation area that is suitable for the work. ii. Set up the welding machine with all the accessories. iii. Before positioning the parts to be welded, clean the welding area to remove any dust, grease or dirt.	
Step 2	**Locking the ends** i. Insert two pipes ends on both side of the machine clamps, protrude approx. 3-5 cm from each side. ii. Adjust the alignment of pipe line by tightening or losing the nuts provided on the clamps. iii. Secure longitudinal movement of the parts to be welded by taking appropriate measures.	

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Steps	Procedure	Demonstration
Step 5	**Welding Process** i. Once the heating element reaches the desired temperature, place it between the pipe ends and ensure it's alignment & stability on machine base. ii. Place the edges in contact to the heating element and apply the initial welding force [pressure (P1 + Pt)] for a time t1 and maintain until the bead has reached height h on both welding edges. iii. Continue to the heating-up stage by reducing pressure and maintaining the heating-up pressure level (P2) along heating-up time (t2). iv. Open both pipe ends, carefully remove the heating plate and make sure the removal time should not be longer than the changeover time (t3).	 

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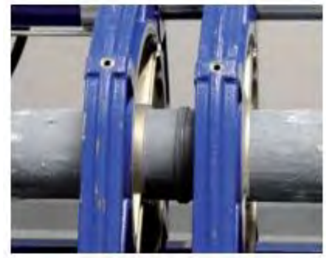
Steps	Procedure	Demonstration
Step 6	**Welding Process** i. Once the heating element has been removed, bring the edges into contact. Gradually increase pressure until the value (P5 + Pt) is reached. ii. Reaching the final welding force [welding pressure (P3 + Pt)] must take the amount of time t4. iii. Maintain or Keep the joining pressure constant throughout the cooling time (T5) or until the welding joint cools down.	
Step 7	**Cooling Process:** i. Avoid forced cooling down by applying water. ii. Once the welding time is over, the welded joint can be removed from the welding machine, without being subjected to significant stress.	

SINGLE HIGH PRESSURE WELDING - PARAMETERS

Annex C
(informative)

Examples of values of parameters for single high-pressure fusion jointing procedure

In Table C.1 examples of parameters for single high-pressure fusion jointing procedures are given.

Table C.1 — Examples of parameters for single high-pressure fusion jointing procedure

Nominal outside diameter d_n mm	Nominal wall thickness e_n mm	Minimum heat soak time[a] s	Minimum bead size after heating[b] mm	Maximum heater plate removal time[c] s	Minimum cooling time in machine under pressure min	Minimum cooling time out of the machine min
32	3,0	30 to 36	1	5	1	d
63	5,8	58 to 70	2	6	2	d
110	10,0	100 to 120	3	7	4	d
200	18,2	182 to 218	4	10	8	d
315	28,6	286 to 343	5	13	12	d
400	36,4	364 to 437	6	16	16	d
500	45,5	455 to 546	8	18	20	d
630	57,3	573 to 688	10	22	25	d
1 000	90,9	909 to 1 091	15	30	39	d

[a] The minimum heat soak time, in seconds, is $(11 \pm 1) \times e_n$. It is highly recommended that heat soak times and heater temperatures at the upper end of the range be used in low ambient conditions.

[b] The minimum bead size on the heater plate at the end of the bead-up time is $1 + 0{,}15 \times e_n$ and is generated through thermal expansion of the PE material only.

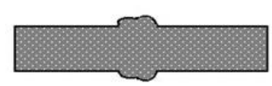
[c] The heater plate removal time, in seconds, is according to ISO 12176-1. These times are a maximum. Every effort should be made to reduce these times wherever possible, to protect molten surfaces against rapid cooling.

[d] A cooling time out of the machine and before rough handling may be recommended.

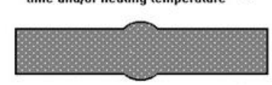
1: 5 mins.

BUTT FUSION WELDING – QUALITY CONTROL

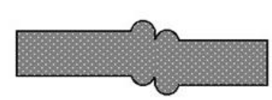
Observed Condition	Possible Cause
Excessive double bead width	Overheating; Excessive joining force
Double bead v-groove too deep	Excessive joining force; Insufficient heating; Pressure during heating
Flat top on bead	Excessive joining force; Overheating
Non-uniform bead size around pipe	Misalignment; Defective heating tool; Worn equipment; Incomplete facing
One bead larger than the other	Misalignment Component slipped in clamp; worn equipment Defective heating tool; Incomplete facing dissimilar material – see note above.
Beads too small	Insufficient heating; Insufficient joining force
Beads not rolled over to surface	Shallow v-groove – Insufficient heating & insufficient joining force Deep v-groove – Insufficient heating & excessive joining force
Beads too large	Excessive heating time
Squareish outer bead edge	Pressure during heating
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination



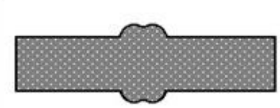
The materials have different heating time and/or heating temperature



Small welding bead,not enough pressure



Disalignment tollerance accepted 10% of pipe wall thickness



Correct welding

THANK YOU!!!

Annex 5.1.16 Training Material on "Leakage Control"

- WASA Faisalabad for ToT, Pilot In-house Training, In-house Training (1st, 2nd)
- WASA Multan for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training (1st)
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training (1st)

District Metered Area

What is DMA?

Importance of DMA

How DMA works

DMA

Water Block System and DMA

- It is necessary to grasp the water flow in the water distribution system to survey water leakage.
- However, water distribution pipes spread complicatedly, and it makes difficult to grasp water flow in a certain area of distribution system.
- Districted Metered Area (DMA) and step test can solve this problem by measuring inflow and outflow in districted area.

Water Supply Block System

Purpose

1) Control of distribution water pressure
2) Control of distribution water volume
3) Simplifying water distribution plan
4) Mitigating damage in disaster such as earthquake
5) Rational construction plan of distribution facilities
6) Efficiency improvement plan
7) Simplifying control of distribution flow

Water Supply Block System

Principles

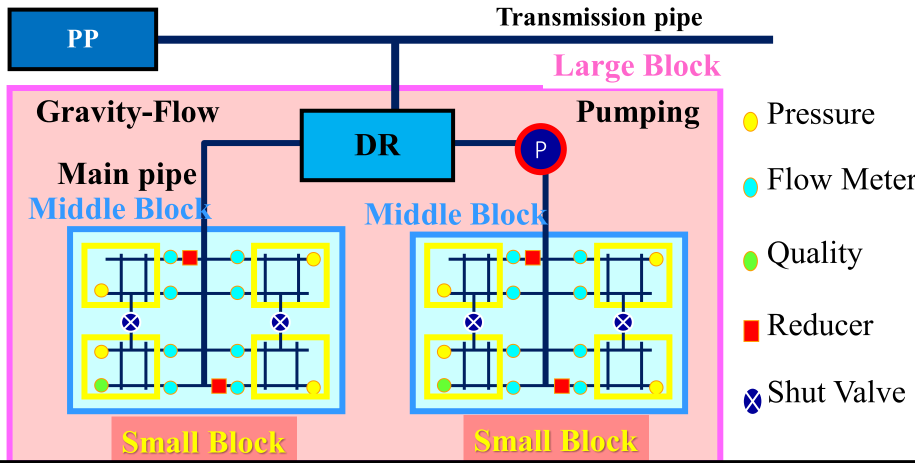
1) In principle every block has one distribution reservoir
2) Within the block, pumping stations are integrated
3) To classify blocks into two areas.

   In one area water is supplied through natural gravity, in the other area water is supplied by pumps.

4) To install pipelines in order to make flexible use of water among the blocks.

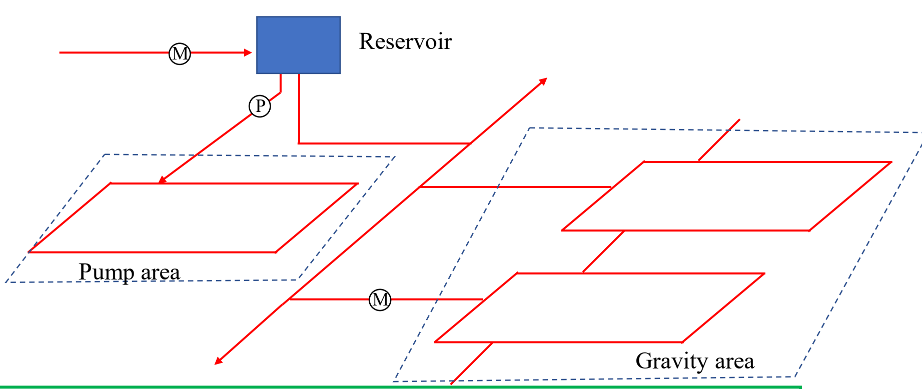
Water Supply Block System

Large Block: Distribution Reservoir Area
Middle Block: Gravity-Flow and Pumping Area
Small Block: District Metered Area



District Metered Area

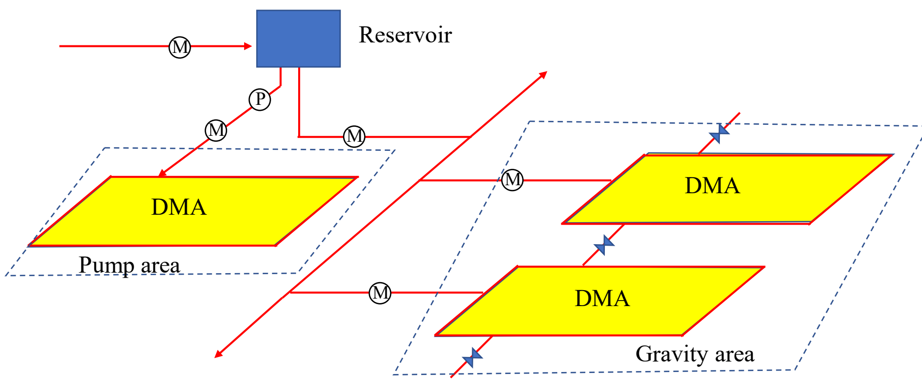
DMA



- To install
- flow meters and valves for isolation area

District Metered Area

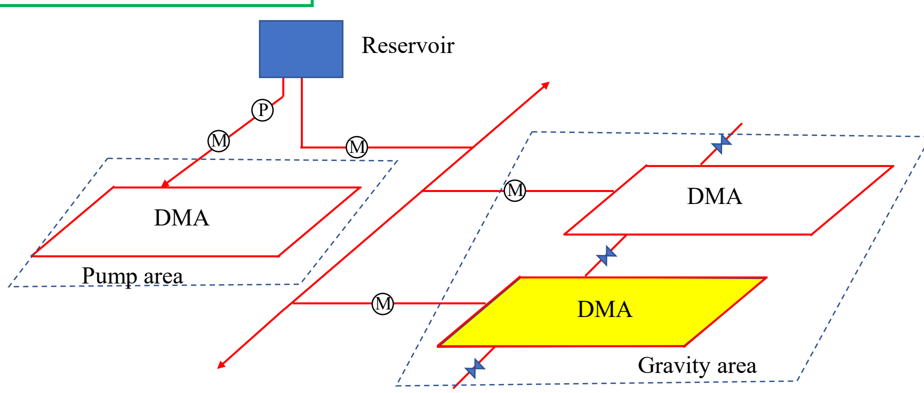
District Metered Area



- To install
  - flow meters and valves for isolation area

District Metered Area

What can we do at DMA?



- To analyze
  - Distribution water by measuring Minimum (Night) Flow

Water Meter

Content:

What is Water Meter?

- Water metering is the practice of measuring water usage.
- Water meters measure the volume of water used by residential and commercial building units that are supplied by a public water supply system.
- They are also used to determine flow through a particular portion of the system.

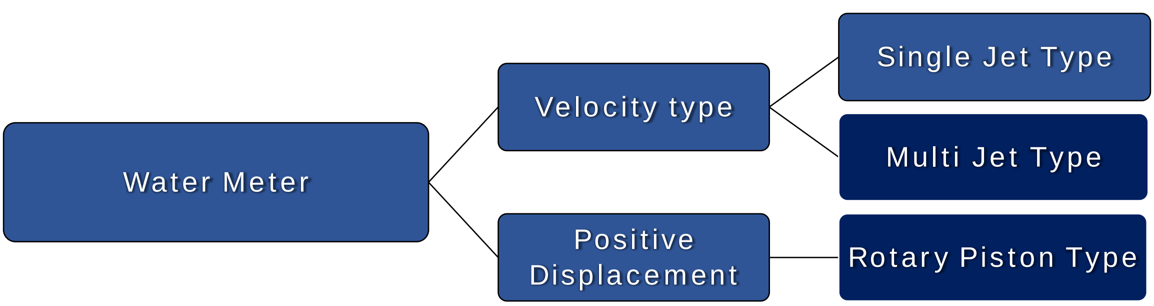
Importance of water meters

- ➢Helps in monitoring the volume of water in different areas
- ➢Help in water conservation
- ➢Allow the system to demonstrate accountability
- ➢Fair for all customers because they record specific usage
- ➢Aid in the detection of leaks and waterline breaks in the distribution system.
- ➢Monitor the volume of consumed water

Water Meter at House

Water Meter at Building

Major Water Meter Types in WASA (Consumer Meters)



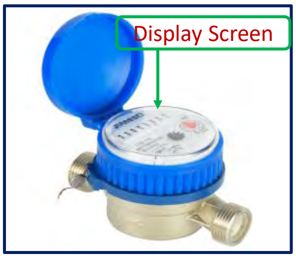
Single Jet Type

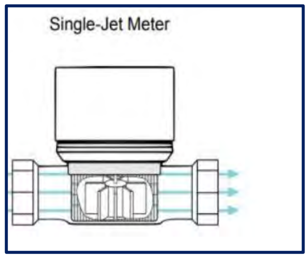
Multi Jet Type

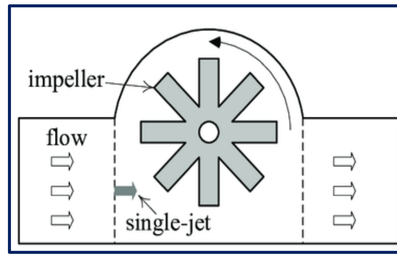
Rotary Piston Type

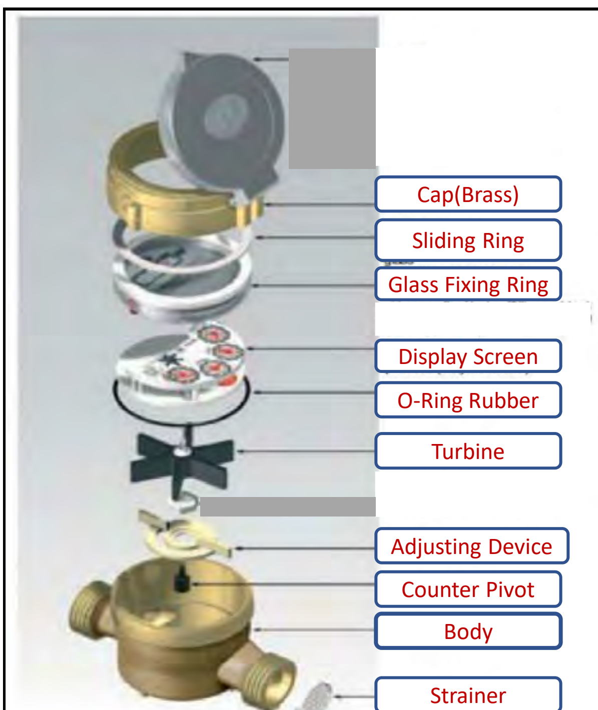
Single Jet water Meter

- Single jet water meters make use of only one port to create a jet of water, making the turbine rotate. There is a single stream of water directed towards a turbine mounted in a radial position within the meter. The turbine starts rotating and transmitting the motion to the display mechanism, which allows us to measure the volume of water passing through the meter.





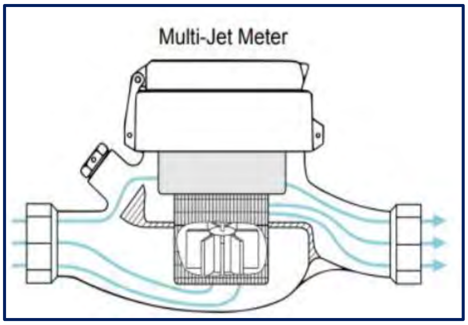


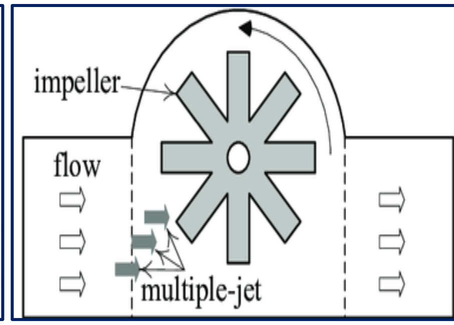


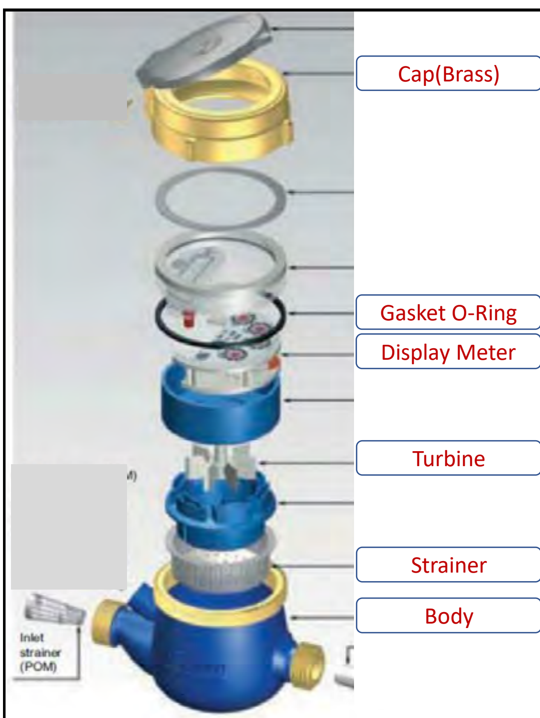
Main Parts of Water Meter

MultiJet Water Meter

➢Multi-jet meters have multiple ports that surround an internal chamber to create a flow of water against the turbine.Multi-jet meters retain accuracy even a lower flow rates and give a much longer life. Because of their design Multi-jet meters are ideal for diameters between 1-1/2" to 3" in diameter, for large water users, water utilities as well as for industrial water installations.







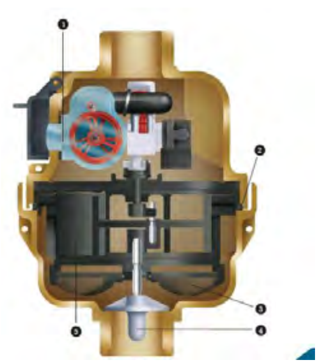
Main Parts of Water Meter

Rotary piston meters

- Rotary piston positive displacement meter records the flow rate according to the volumetric measuring principle.
- Rotary piston meters are popular for their combination of accuracy, long life and moderate cost so they are widely used.
- Sand or other suspended solids easily get stuck between the piston and chamber wall. Thus, it is important to be installed in the system with very good water quality and to install built-in strainer.

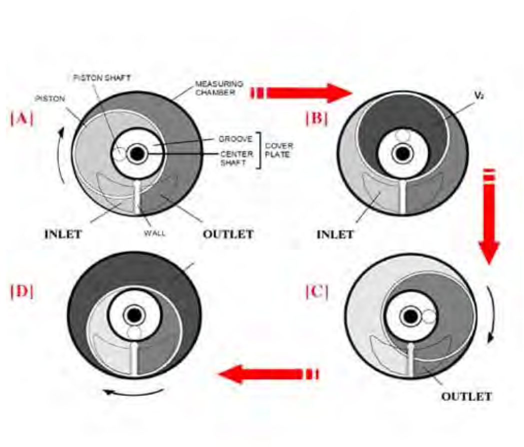
Mechanism

The piston and cylinder are alternately filled and emptied by the fluid passing through the meter. A slot in the sidewall of the piston is removed so that a partition extending inward from the bore of the working chamber can be inserted. This has the effect of restricting the movement of the piston to a sliding motion along the partition. The rotary movement of the piston is transmitted via a permanent-magnet coupling from the drive shaft to a mechanical register.



1. **Easy to read register**
2. **"O" ring seal**
3. **Stainer**
4. **Non-Return valve**
5. **Piston and cylinder**

Application and Installation

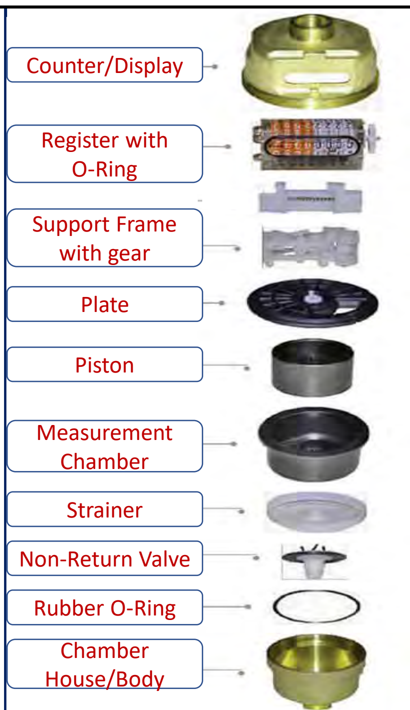


Rotary piston meters are commonly used most domestic applications up to diameter 25mm. They are not sensitive to the wide flow velocity profile.

Rotary piston meters can be installed in **any position** with stable accuracy and placed close to bend or pump.

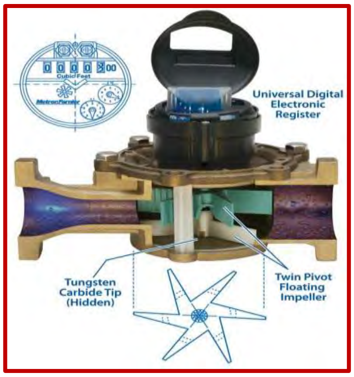
➢ Applicable pipe diameter: 13mm – 40mm

➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

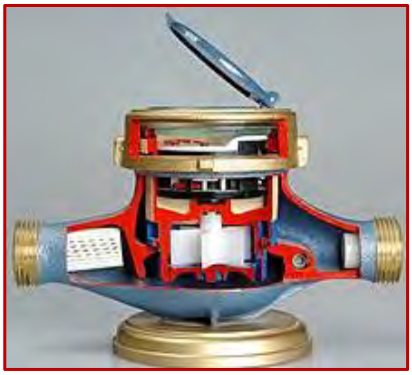


Main Parts of Water Meter

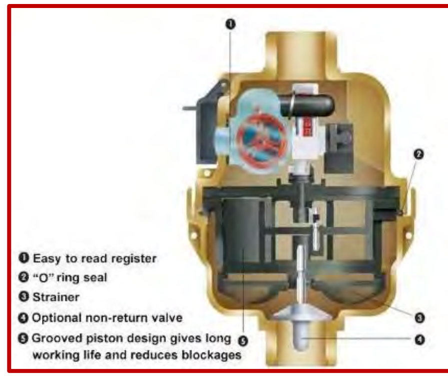
Cross Sectional View of water meters



Single-Jet Water Meter

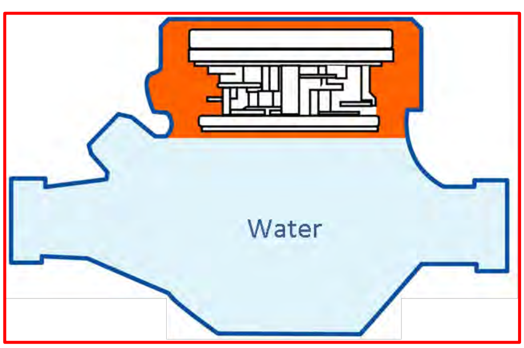


Multi-Jet Water Meter

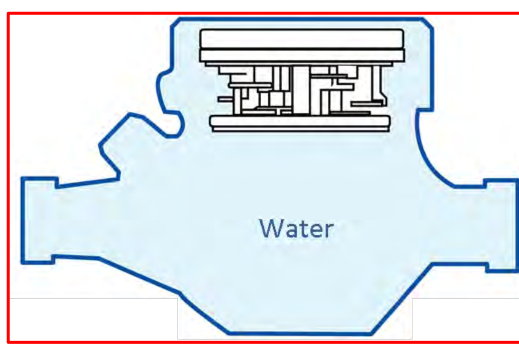


Rotary Piston/Vertical Meter

Difference between Dry and Wet Dial water meter

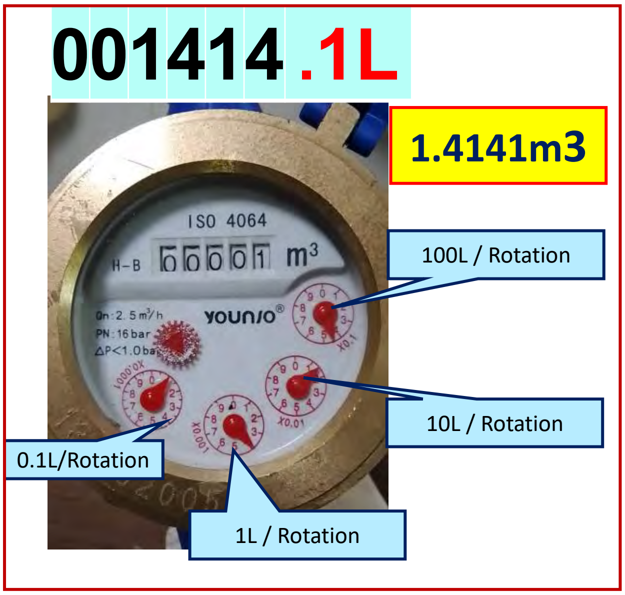


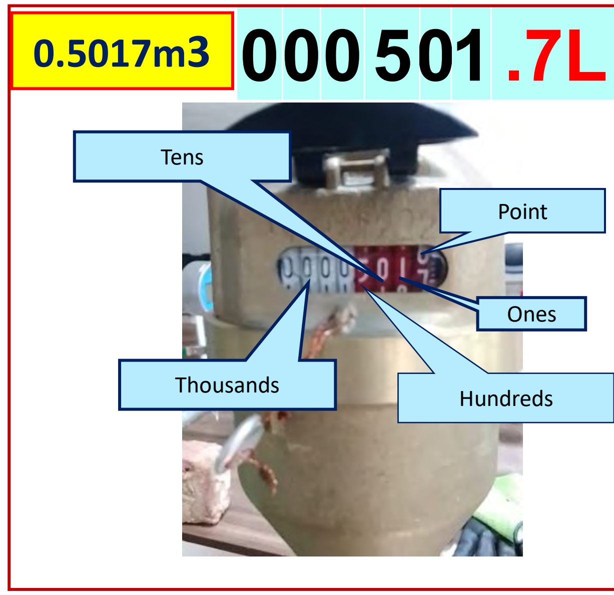
Dry Dial (Vacuum Register Unit)



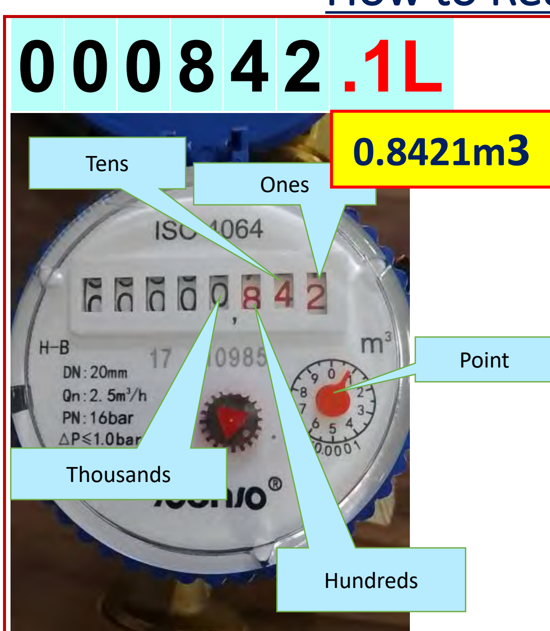
Wet Dial (Water Flow through Register Unit)

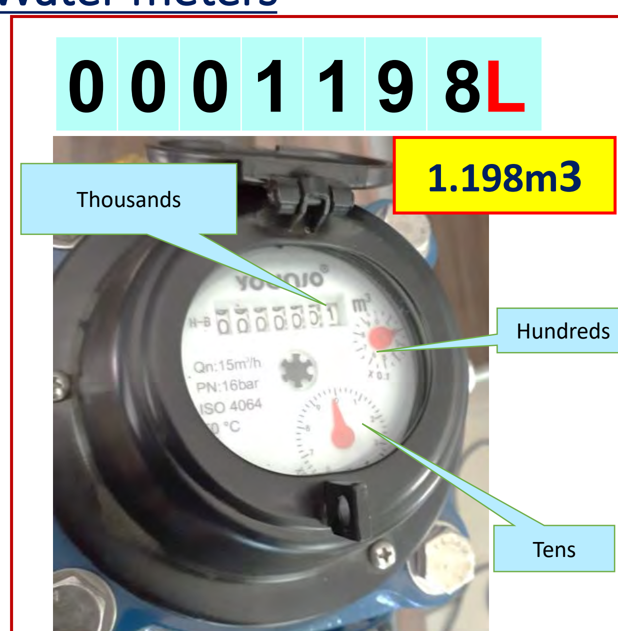
How to Read Water meters





How to Read Water meters

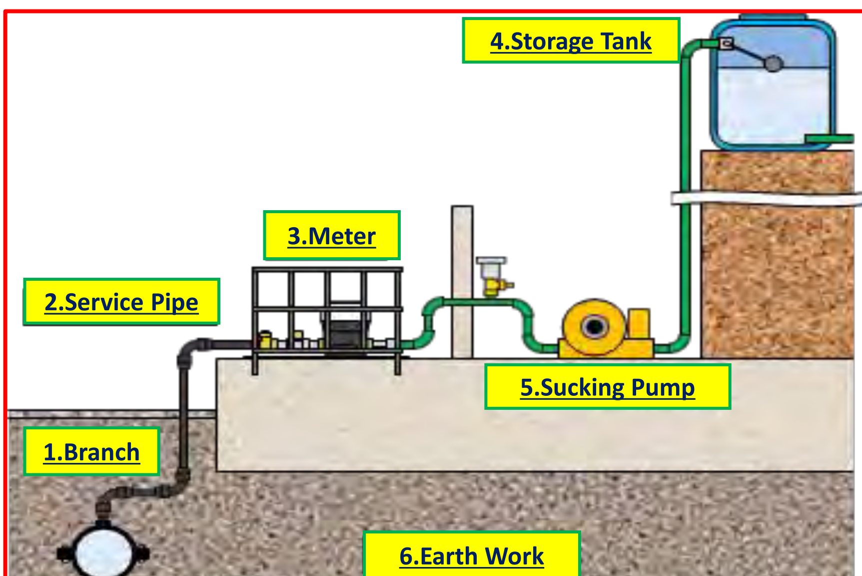


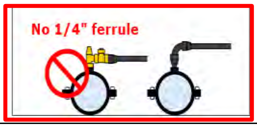


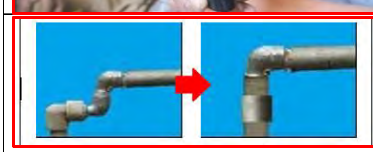
Comparison of water meters

	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance	 	 	 
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount of water can be measured accurately	High accuracy than others

SOP's for the Installation of Water Meter

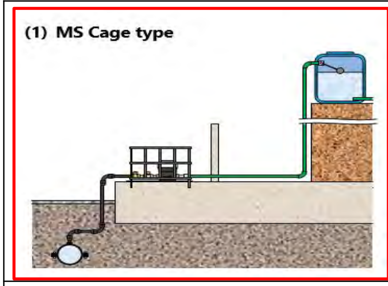
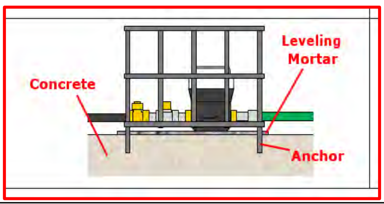
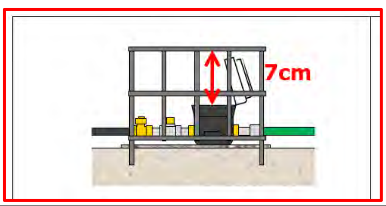


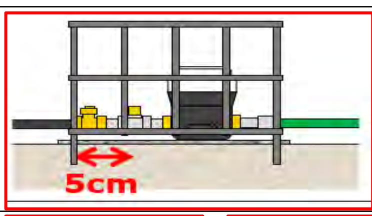
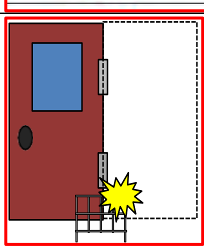
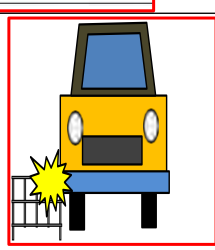
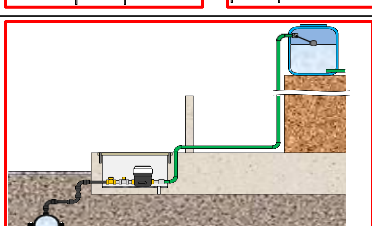
 **Branch**	It should be confirmed that rubber is set at branch point.
	Service connection should be branched directly from water distribution pipe by 1/2” and 90° of bent pipe is used instead of 1/4” ferrule.
 **Service Pipe**	When improving existing service pipe, it is necessary to confirm that pipe comes from WASA’s system.
	GI should be selected if pipe is installed above ground. If pipe is installed underground, UPVC/HDPE or non-corrosive pipe & fittings shall be used.
	The pipe should be cut with suitable equipment.

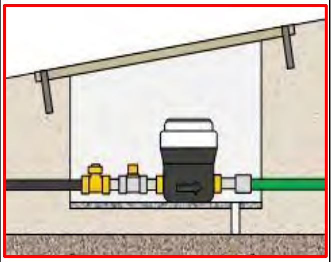
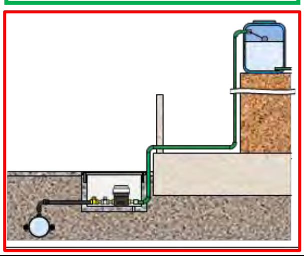
	The cut of the polyethylene pipe must be straight.
	Use of meaningless bend pipe should be avoided.
	Meter should be installed outside of customer’s premises within 50cm from boundary and without vehicle load. (If meter is installed inside the customer’s premises, it is difficult to read the meter for meter readers because of gate lock or customer absence).

Three types of meter cage for thief prevention measure of meter

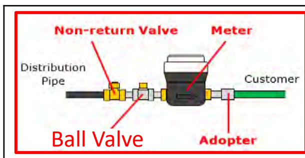
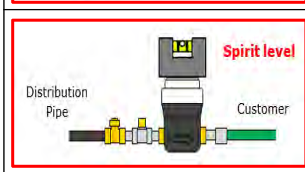
Measures to prevent theft of the meter are selected depending on the site situation, but in principle, installation of (1) **MS cage** should be adopted. Under difficult circumstances for various reasons, underground installation such as (2) **Steel lid** or (3) **Concrete Box** will be considered.

	In principle, MS cage should be selected with concrete base and meter should be installed on the ground.
	MS cage should be installed as left figure.
	For opening the meter cover, 7cm or more of interval is required at the top. At the site, meter cover should be opened and ease of meter reading should be confirmed.

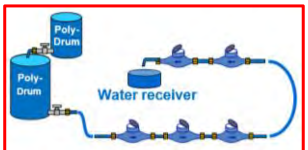
	For opening/closing the magnetic valve, 5cm or more of interval is required around magnetic valve. At the site, valve operation should be carried out and confirmed.
 	When the cage installed on the ground interferes with the opening and closing of the door or the passage of the vehicle, or when the space cannot be secured on the ground, underground installation should be selected for thief prevention measure of meter.
	If there is a concrete part where the lid can be fixed with the anchor, (2) **Steel lid** type should be selected instead of (1) **MS cage** type. The meter installation place is excavated. **Excavation range:** Width20cm x Length30cm x Depth20cm or more. Drainage function should be considered.

	Even on a slope, the lid can be installed as the left figure. However, it is necessary to pay attention to the lid installation location so that the anchor does not penetrate.
Concrete Box Type 	If there is no concrete to fix the lid with anchor, (3) Concrete Box Type should be selected for thief prevention measure of meter instead of (2) Steel Lid type. Drainage function should be considered(Installation of (1) and (2) is considered as much as possible, because (3) is expensive)

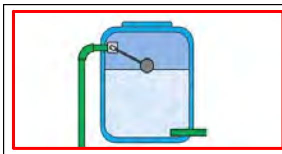
Basics for water Meter Installation

	Piping around the meter consists of non-return valve, Ball valve, meter and adopter.
	All water consumption should be captured. It is necessary to confirm that there is no water supply branch upstream of the meter.
	Meter should be installed horizontally, therefore horizontal should be confirmed using spirit level etc.
	It should be confirmed that the arrow on the side of the meter body with water flow direction.

Reuse of Existing water Meter

	Whether there is existing meter should be confirmed.
	If customer already has existing meter, meter should be read and recorded and this value should be reported to IT section.
	Removed meter should be brought the meter test yard and checked the accuracy. If meter has good accuracy, WASA can reuse it.
	If test meter is available, you can utilize it.

Storage Tank

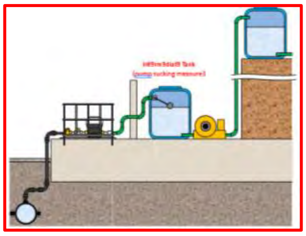
	It should be confirmed whether the customer has a storage tank. If customer has tank, it should be confirmed that the float valve is installed. If not, WASA should instruct customer to install it.

Sucking Pump:

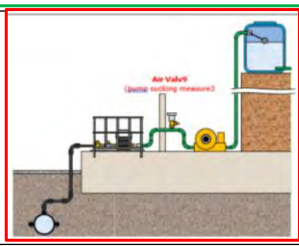
In principle, illegal sucking pump must be removed. If WASA cannot ensure the proper water pressure or customer denies removing it, for countermeasure of illegal pump sucking,

(1) Intermediate Tank or **(2) Air Valve** should be installed.

Intermediate Tank

	For one of the countermeasures of sucking pump, intermediate storage tank should be installed between meter and pump. When installing intermediate tank, float valve should be installed.

Air Valve

	For another countermeasure of sucking pump, air valve should be installed between meter and pump, and it should be installed at higher position than meter.
	It is confirmed that water does not come out from the air valve.

No.	Check items	Check
1	Meter is checked for proper functioning of low-flow dial before installing it.	
2	Meter is horizontally installed with correct flow direction.	
3	Ball valve is installed upstream and non-return valve is installed downstream of meter with no branches upstream of meter.	
4	Illegal sucking pump is not installed*1 and there are no suspected, illegal connections around customer's premises*2.	
5	If customer has storage tank, float valve is installed*3.	
6	Proper water pressure is secured at customer's tap.	
7	Meter is easy to read and remove by WASA maintenance workers.	
8	Meter is not an obstacle to traffic and has theft prevention.	

*1 If not, WASA should instruct and ask the customer to improve the situations (removal of pump/installation of intermediate tank/installation of air valve), and reconfirm later.

*2 If not, WASA should instruct and ask the customer to improve the situations (disconnect the connections) and reconfirm later.

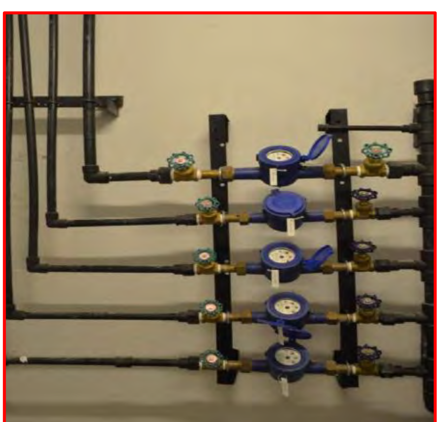
*3 If not, WASA should instruct and ask the customer to improve the situations (installation of float valve) and reconfirm at later date.

Installation of Water Meters

Above the Ground: The advantage is ease of maintenance and easy to read. Air tapping bubbles may occurs

Underground: In many countries it is installed below the floor level In this case meter box is required. Advantage-Reduces air tapping bubbles Disadvantage-High cost, difficult for maintenance

Installation of water Meters



Installation of water meters inside building/Commercial areas

Installation of Water Meters different places

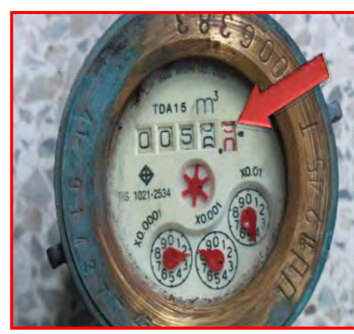
- .

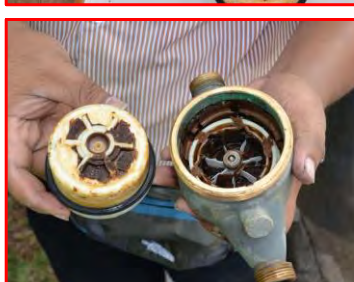
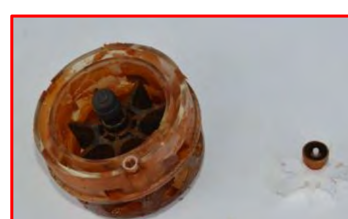





Maintenance of Water Meters(Different Problems)



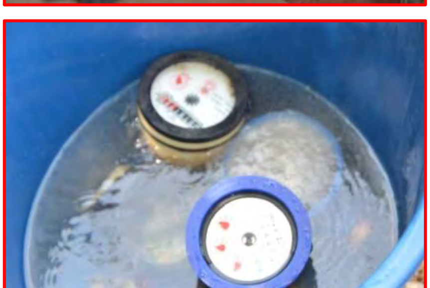


Maintenance of Water Meter(Different Problem)

Maintenance of Different Problems of water Meter

- 



Cleaning(Most of Problems can be solve by Cleaning parts of water meter)

Maintenance of Different Problems of water Meter

Rust Remover activity can also b more useful for maintenance of water meters

Selection of Water Meter

Nominal Size DN(mm)	Class of measurement	Overload Flow-rate Q4(m3/hr)	Permanent Flow-rate Q3(m3/hr)	Transitional Flow -rate Q2(m3/hr)	Minimum Flow-rate Q1(m3/hr)	Minimum Reading Min(m3)	Maximum Reading Max(m3)
15	R80	3.125	2.5	0.05	0.03125	0.0001	99999
	R100			0.04	0.025		
20	R80	5	4	0.08	0.05	0.0001	99999
	R100			0.064	0.04		
25	R80	7.875	6.3	0.126	0.063	0.0001	99999
	R100			0.1008	0.039375		
32	R80	12.5	10	0.2	0.125	0.0001	99999
	R100			0.16	0.1		
40	R80	20	16	0.32	0.2	0.0001	99999
	R100			0.256	0.16		
50	R80	31.25	25	0.5	0.3125	0.0001	99999
	R100			0.4	0.25		

Select
Too Small Water Meter

Easily worn out
-Inaccuracy
-Pressure lost

Select
Too Big Water Meter

-Inaccuracy
-High cost

Other Selection Parameters

- **Material:**

All materials in contact with the water passing through the water meter shall be made of materials which are harmless, non-contaminating and biologically inert.

- **Pressure test:**

The water meter shall conform to the pressure resistance performance.

Leakage and Accuracy Test

Meter error curve

- Water meters are designed for a specific flow rate, which is called as the permanent flow rate or Q3.The meter should be able to work at the permanent flow rate (or a lower flow rate) continuously for its design life without exceeding the permissible error.
- Although a meter is designed for the permanent flow rate, the actual flow through a meter is not constant. Thus, water meters should not only be accurate at the permanent flow rate, but also be accurate over a wide range of flow rates.
- It is useful to draw a graph of a meter's relative error. This curve is called the meter's error curve.

Meter error curve

- Q1 – Minimum flow rate:

The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance (± 5% error).

- Q2– Transitional flow rate:

The flow rate at which the maximum permissible error of the water changes in value from ±5% error to ± 2% error.

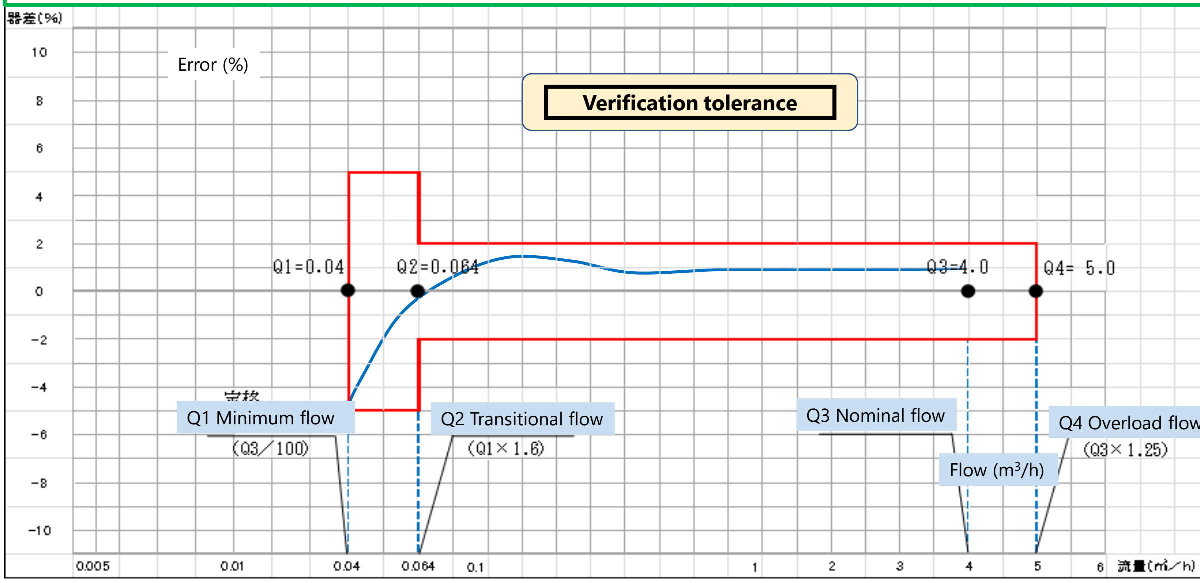
- Q3 – Permanent flow rate:

Permissible continuous load. Half the maximum flow rate (± 2% error).

- Q4 – Maximum flow rate (Overload Flow Rate):

The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period without deteriorating (± 2% error)

METER ERROR CURVE



ISO 4064: 2005 Standardization

- R=100 is the ratio of Normal Flow rate (Q3) the minimum flow rate(Q1).

$$R = \frac{Q3}{Q1} = 100$$

Q1= Qmin(Minimum Flow rate)

Q2= Qt(Transitional Flow rate)

Q3= Qn(Nominal Flow rate)

Q4= Qmax(Maximum Flow rate)

$$\frac{Q4}{Q3} = 1.25$$

$$\frac{Q2}{Q1} = 1.6$$

Definition of meter accuracy

The volume of water that passes through a water meter is called the **actual volume, or Va**.

No meter is 100% accurate, the meter will not register all the water passing through it but show a **indicated volume (Vi),** which is slightly lower or higher than the actual volume.

The difference between the indicated volume and actual volume **(Vi-Va)** is called the meter error. When the error is expressed as a fraction (percentage) of the actual volume, it is called as the relative error.

[Relative error]: (Vi - Va) / Va x 100 (%)

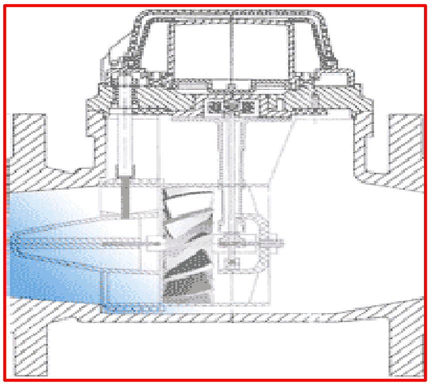
Definition of meter accuracy

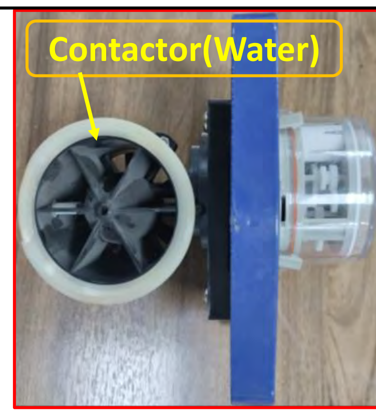
CALCULATION OF THE ERROR (%)

$$\text{Error (\%)} = \frac{\text{Indicated Volume (meter reading result)} - \text{Actual Volume}}{\text{Actual Water Volume}} \times 100$$

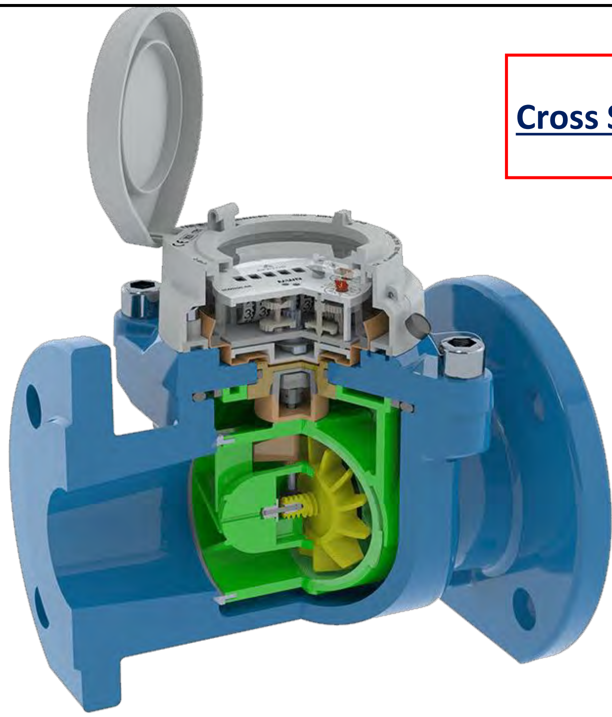
Bulk Flow meter(Woltman)

- The Woltman (Bulk) water meter with magnetic transmission and dry recording head, for measuring applications in water supply networks. A bulk meter is a large meter that we fit to pipes to measure water flow and help us find leaks.



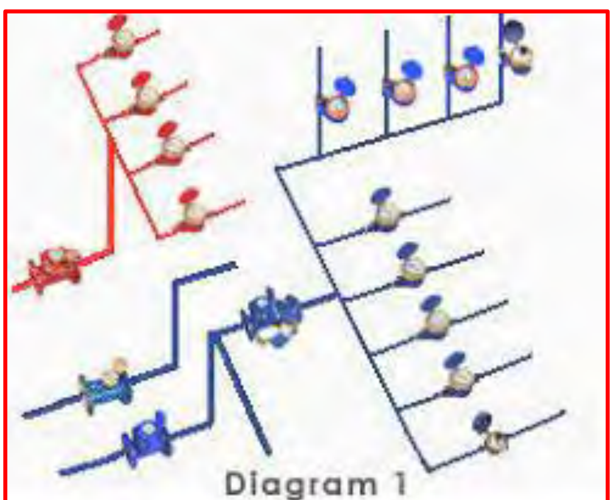


Main Parts of Bulk Water meter

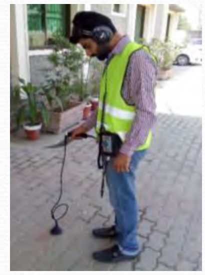


Cross Sectional-View of Woltman(Bulk Meter)

Bulk meter Installation



- Acoustic Rod
- Acoustic Leak Detector

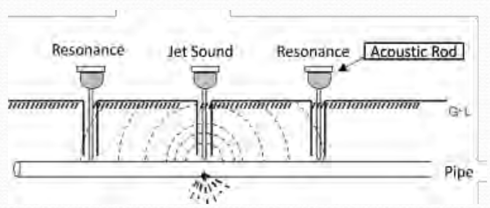


Acoustic Rod/Stick

Specification				
Type	**Cap dia.* Thickness (mm)**	**Total Length (mm)**	**Dia. of Iron Bar (mm)**	**Material**
LSP-1	ø 67x29	1,013	7	Stainless Steel

Use:

- Place the tip of acoustic rod at the point where doubt of leakage
- Catch the stick below the listening cap and place ear on the cap of acoustic rod
- Hear the sound of leaked water, if no leakage at that place repeat the same procedure aside this place
- Very useful to listen leaks sound at hydrants and valves



Factors affecting performance:

- Pressure
- Depth

Leak Detector

Operation:

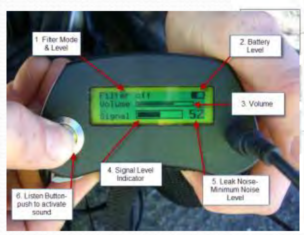
- Use head phones remember Left and Right direction.
- Turn volume up to half using the dial on the headphone cable.
- Ensure good contact of microphone and surface area.
- Press and hold silver button to listen sound.
- With every press and release of the silver button the noise level will be recorded in the memory.
- To see memory data for the last eight soundings, press and hold the "M" button on the amplifier.
- To turn filter on press and hold the sky blue + & - filter buttons simultaneously. The filter bandwidth is +/- 100Hz.

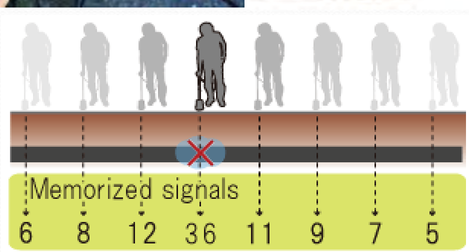
Components:

- Amplifier with waist belt
- Hand probe microphone
- Ground microphone plate
- Probe rods
- Stereo headphones
- Connecting cable

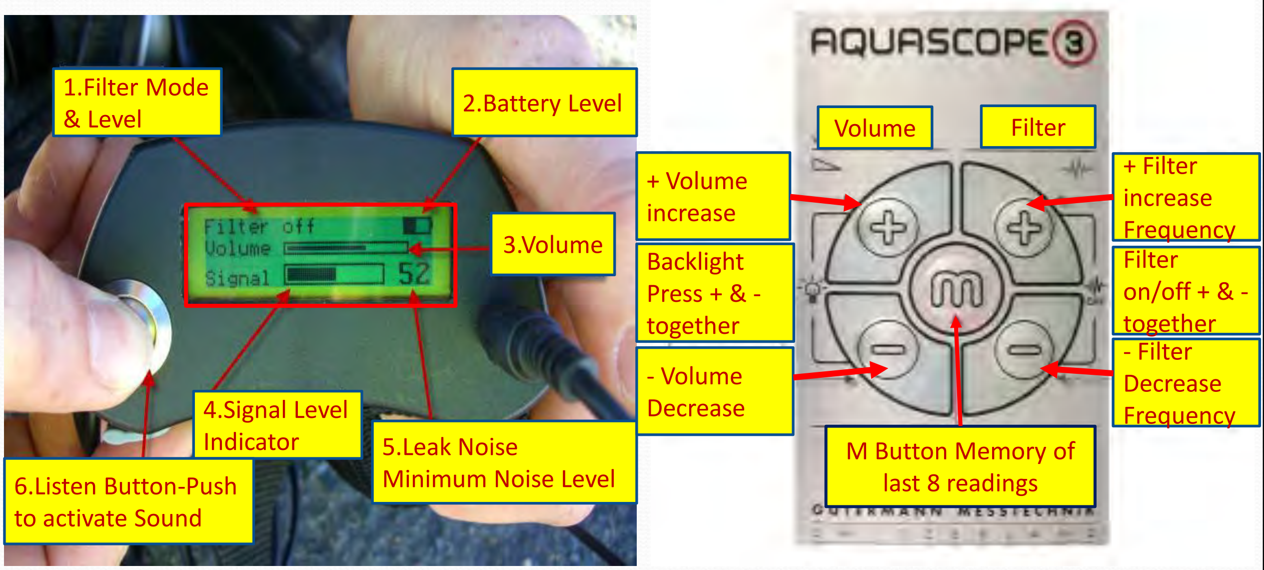
Leak Detector
Important Points & Precautions

- Use filter in case high background noises
- Leakage sound depends upon,
  - Water pressure
  - Crack or hole size
- Operator should stay stable during its use
- Required practice to pinpoint or identify leaks
- Don't use in rainy days and when speed is 6 m/s.
- Sensors are water resistant, but control unit and head phones are not resistive. Keep them away from water .





Use of Leak Detector



Understanding Leak Noise-Leak Frequency

Pipe Material	Frequency Range	Normal Frequency
Steel	400 Hz – 1500 Hz	800 Hz
Iron	300 Hz – 1200 Hz	700 Hz
Copper	700 Hz – 2500 Hz	1800 Hz
AC	300 Hz – 800 Hz	500 Hz
Lead	200 Hz – 700 Hz	400 Hz
PVC	200 Hz – 500 Hz	300 Hz
Polyethylene	100 Hz – 400 Hz	250 Hz

Factors Affecting Leak Noise

- Pipe Material (Hard is good - Soft is poor)
- Pipe Diameter (Small is good – Large is poor)
- Pressure (High is good – Low is poor)
- Background Noise can muffle or drown out leak noise (PRV's - throttled valves)
- Consumption (High levels of consumption can make it hard to hear the leak and you may have to return at low consumption times)

The best time to perform acoustic leak detection is when all these factors are at a minimum except for pressure, at a maximum

Recognizing Leak Noise

Track 1. No Leak Noise

Characteristics ,Normal flow in a steel pipe

Recognizing Leak Noise

Track 2. A Meter Turning fast then slow

Characteristics ,Normal flow in a Copper Service

Recognizing Leak Noise

Track 3. Steel Leak Noise

Characteristics are Clear, Mid Frequency and Loud

Recognizing Leak Noise

Track 4. PVC Leak Noise

Characteristics are Muffled, Low Frequency and Quiet

Recognizing Leak Noise

Track 5. Copper Leak Noise

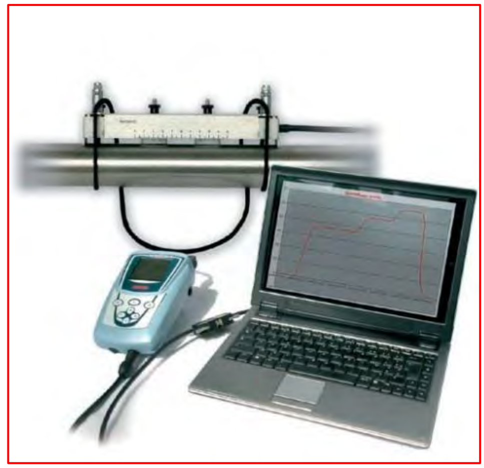
Characteristics are Clear, High Frequency and Loud

Recognizing Leak Noise

Track 6. Cast Iron Leak

Ultrasonic Flow Meter

Contents:



What Is Ultrasonic Flow Meter?

- Ultrasonic flow meter is a device to use measure the volume of flow per time.
- Portable ultrasonic flow meter is suitable for all conductive and non-conductive liquids such as water, chemicals, toxic media, hydrocarbons, etc.

Formula of Flow Rate:

- Q=V/t
- Q=Flow Rate
- V=Volume
- t=Time

- Unit

m3/hr, Cusec, Gpm

Working Principle

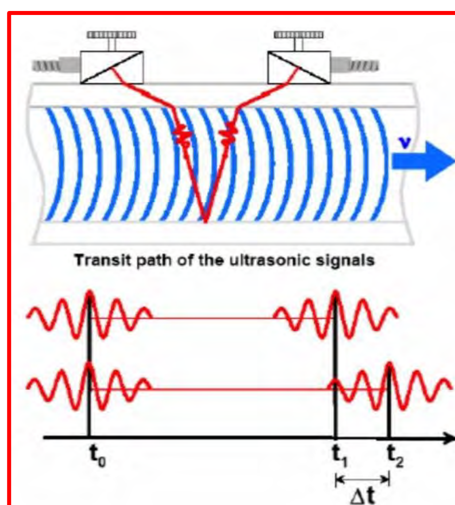
Ultrasonic technology(time of flight) to calculate the flow Velocity and volumetric flow rate of liquid. The flow meter Consist of two transducers that alternately send and receive ultrasonic signals to measure the flow rate.

Transducers/Probes

Ultrasonic Flow meter

Working Principle

The transit time difference between the transmitted and Received ultrasound signal. The difference in transit time Is a direct measure of liquid flow rate.



Advantages of Ultrasonic Flow meter

- 100% non-contact flow measurement (no liquid contact)
- Zero pressure drop created
- No moving parts and no wear and tear of flow transducers - long service life (+10 years)
- No re-calibration required - zero measurement drift
- No risk of pipe leaks - sensors installed externally on the pipe
- Suitable for a wide pipe size range - adaptable to future plant upgrades or pipe replacements
- Modular design - easy sensor and transmitter replacement requiring no system shutdown
- Accurate and repeatable: normally ±1..3% (±0.5..1% possible with advanced calibration)
- Easy installation and virtually zero maintenance costs
- Can measure conductive or non-conductive liquids
- Independent of liquid temperature, pressure, chemical properties, and viscosity.

Limitations

•Effected by concentration levels of suspended solids and aeration in the liquid (maximum allowable concentration 5%...10%).

•Highly affected by pipe condition (internal or external pipe rust, uneven surface etc.)

•Not as accurate as in-line meters such as magnetic or turbine meters.

•Accuracy highly affected by incorrect pipe dimensions and parameters.

Before Use of Ultrasonic Flow meter

- Before Using Ultrasonic flow meter we have to following basic information about,

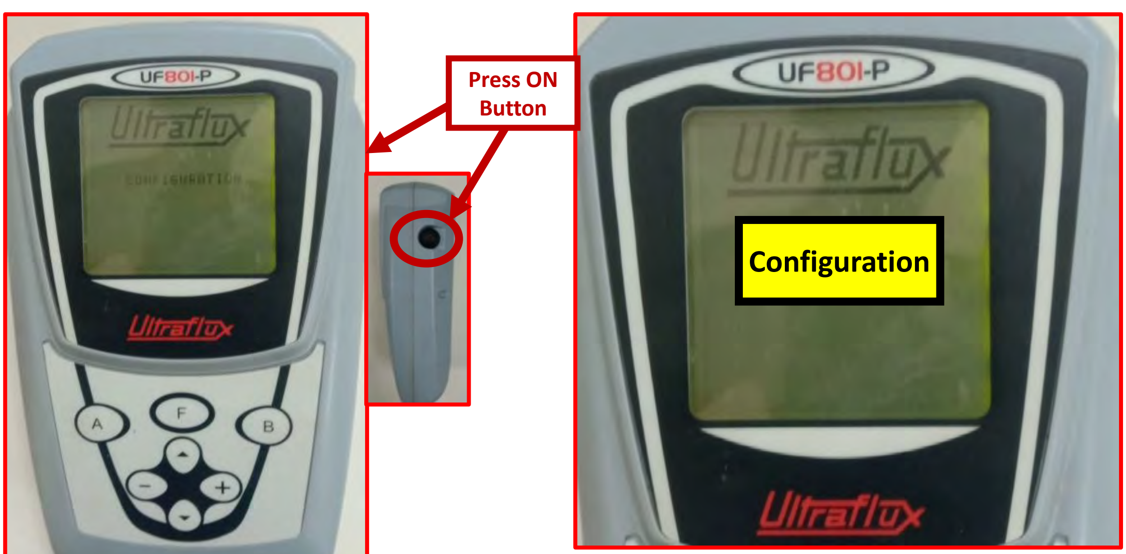
➢ Information of pipe material
➢ Diameter of Pipe
➢ Thickness of Pipe wall

Thickness of Pipe wall

Circumference of Pipe

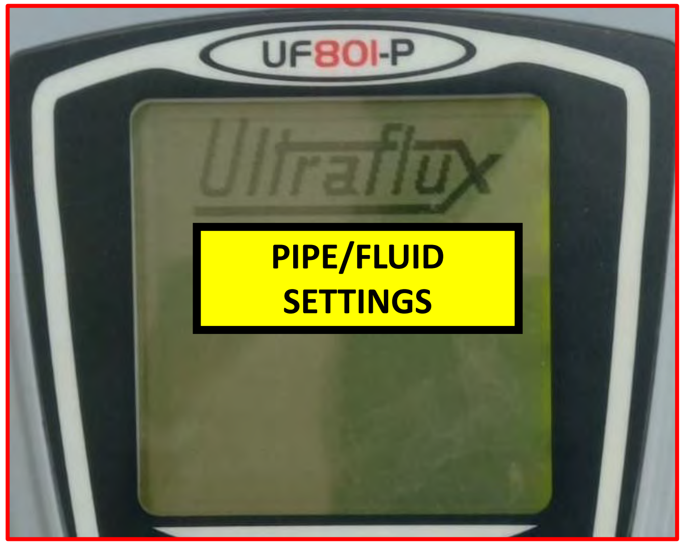
Use of Ultrasonic Flow Meter

- **After switching ON the ultrasonic flow meter press "F" button.**



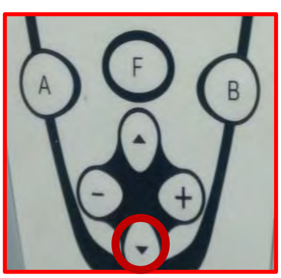
Use of Ultrasonic Flow Meter

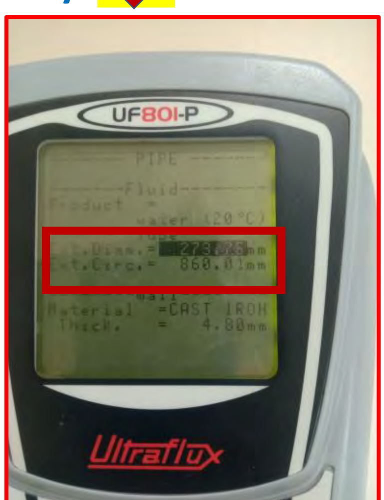
- Again Press **"F"** its showing pipe fluid setting.

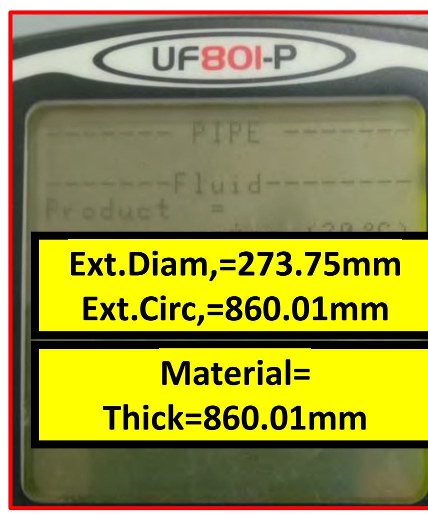


Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.







- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

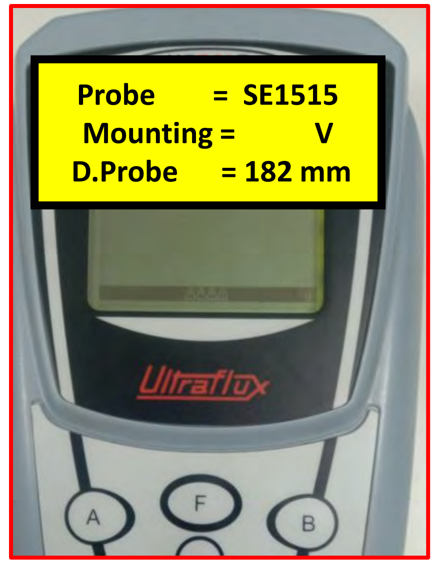
- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Use of Ultrasonic Flow Meter

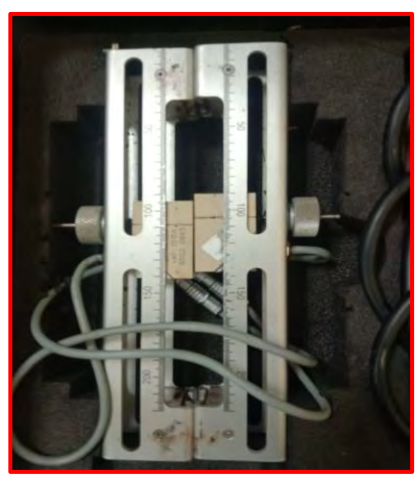
- **Press and hold "F"** and its show probe distance and type of probes.



- **Flow rate in m3/hr will be shown.**

Use of Ultrasonic Flow Meter

- **Probes**
- For up to 100mm, use single probe, for more than 100mm, use double probe.



EPANET Software

HYDRAULLIC MODELING

Application for Modeling Drinking Water Distribution Systems

What is EPANET

- EPANET performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks.
- Pipe network consists of pipes, nodes (pipe junctions), pumps, valves, storage tanks and reservoirs.
- EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank.
- EPANET use for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

How to Download

https://www.epa.gov › water-research › epanet

EPANET | US EPA

01-Feb-2022 — EPANET is **a software application used throughout the world to model water distribution systems**. It was developed as a tool for understanding ...

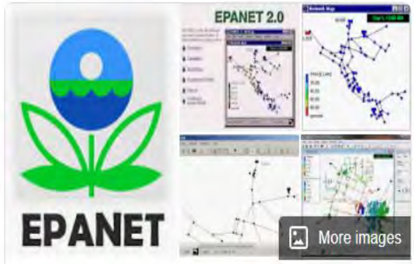
Software, Compatibility, and... · Capabilities · Applications

People also search for

is epanet free	epanet logo
epanet tutorial	epanet uses
epanet examples	epanet pdf

People also ask

What is EPANET software used for?



EPANET

System software

EPANET is a public domain, water distribution system modeling software package developed by the United States Environmental Protection Agency's Water Supply and Water Resources Division. Wikipedia

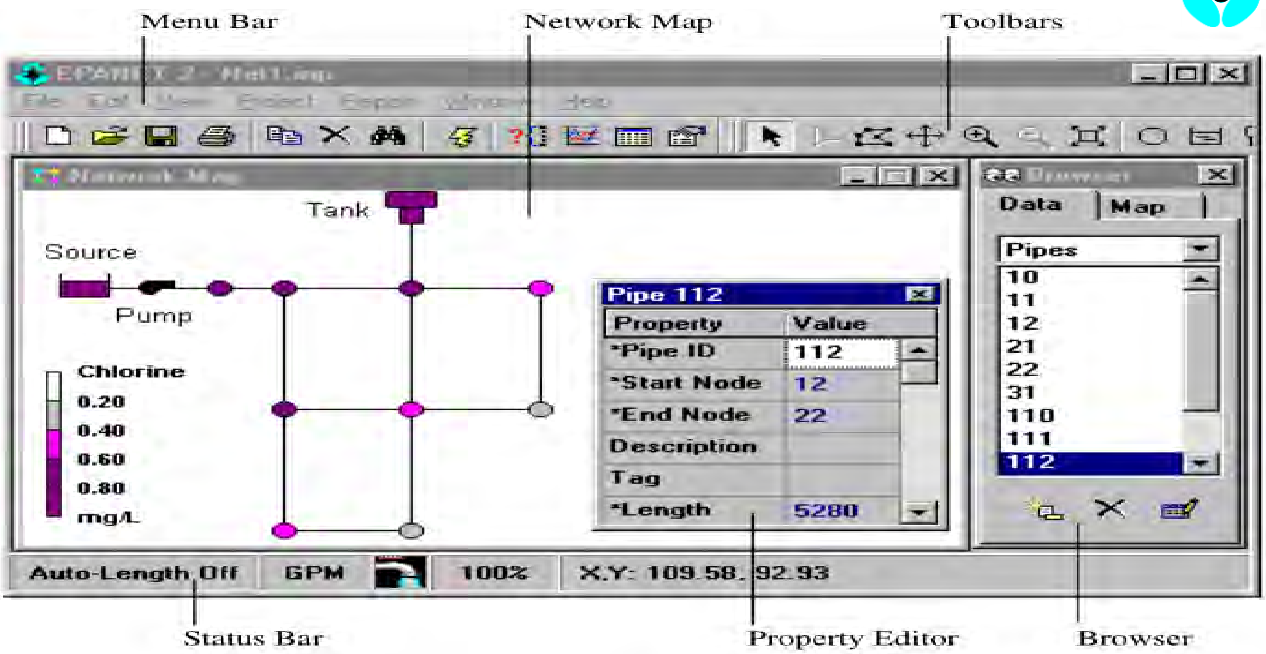
Download Software

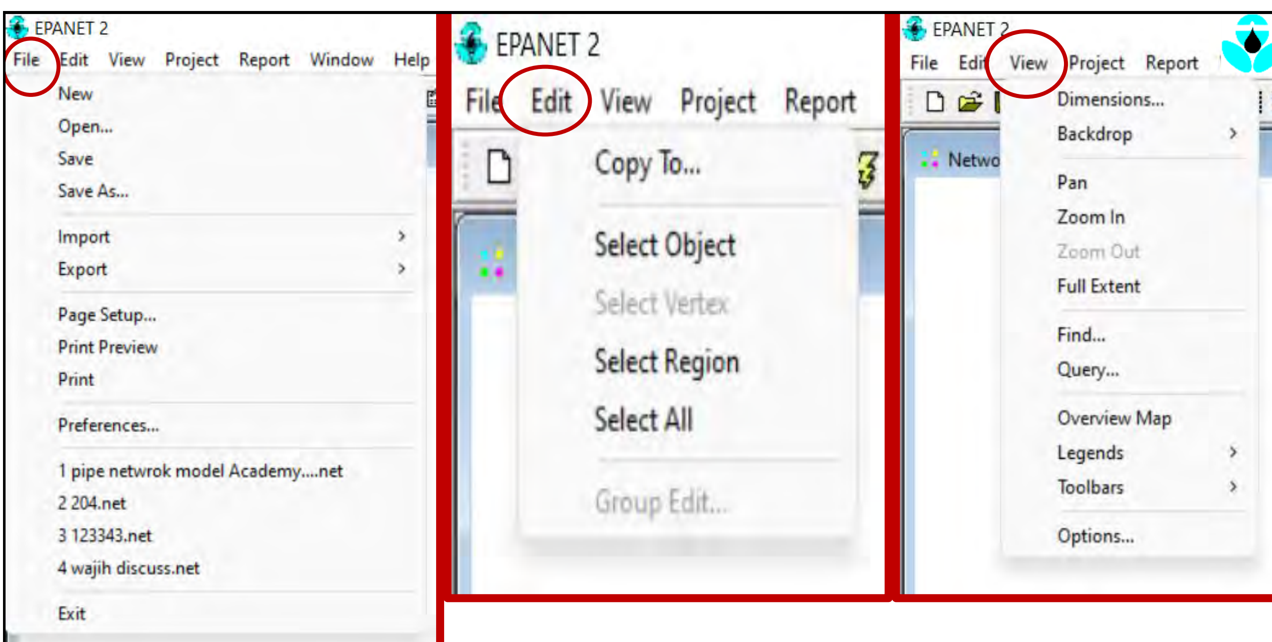
- EPA's GitHub site for EPANET 2.2 open source project

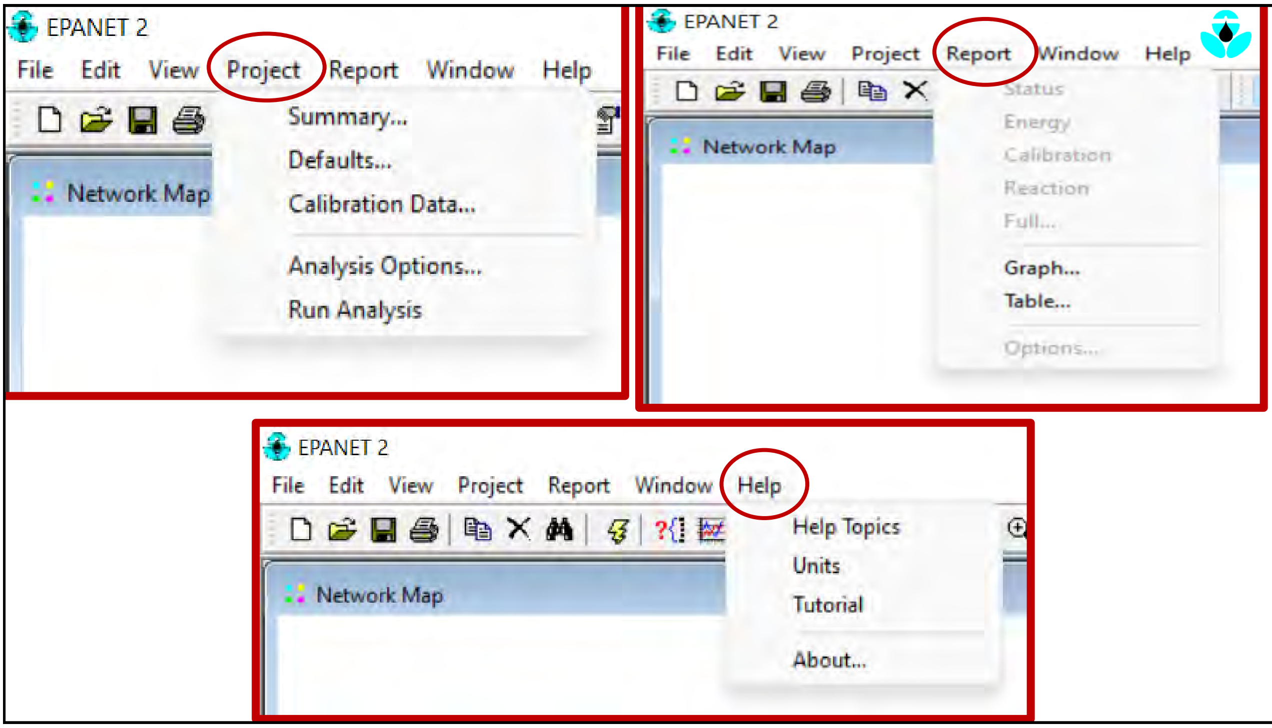
Software

Date	Description
07/23/2020	Self-Extracting Installation Program for EPANET 2.2 (EXE) (3.5 MB)
07/23/2020	Non-Installing Software for EPANET 2.2 (ZIP) (2.84 MB)
10/01/2018	Self-Extracting Installation Program for EPANET 2.00.12 (EXE) (exe)

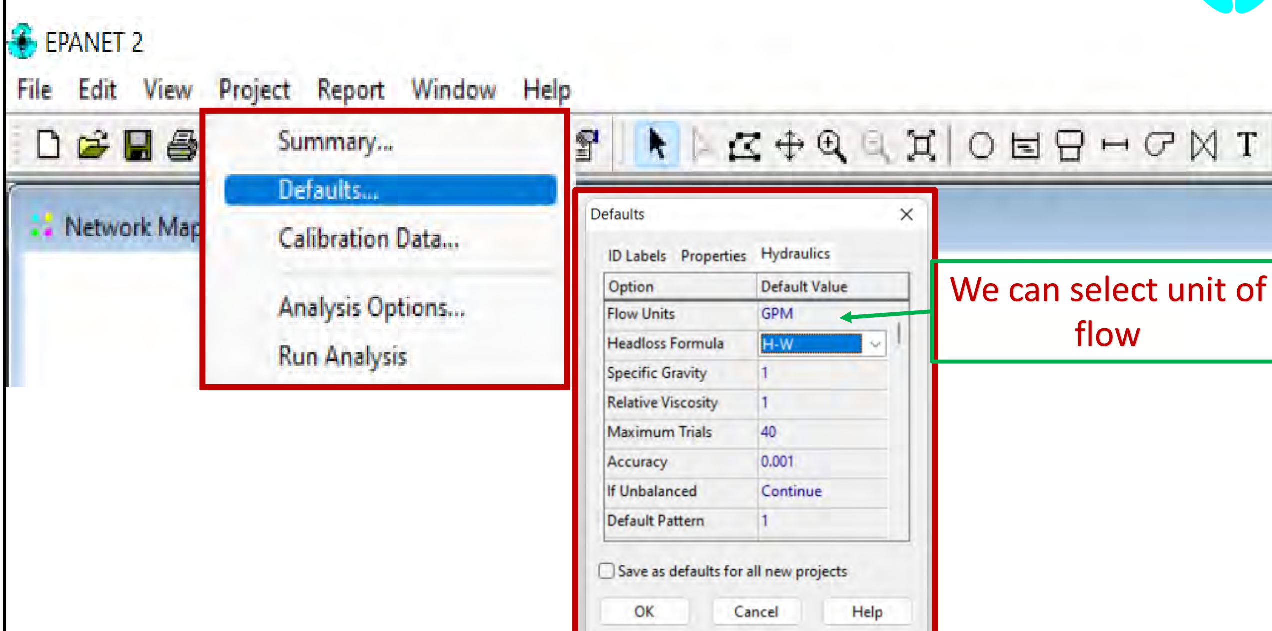
Interface


Menu Bar
Network Map
Toolbars
Tank
Source
Pump
Chlorine
0.20
0.40
0.60
0.80
mg/L
Pipe 112
Property
Value
*Pipe ID
112
*Start Node
12
*End Node
22
Description
Tag
*Length
5280
Data
Map
Pipes
10
11
12
21
22
31
110
111
112
Auto-Length Off
GPM
100%
X,Y: 109.58, 92.93
Status Bar
Property Editor
Browser

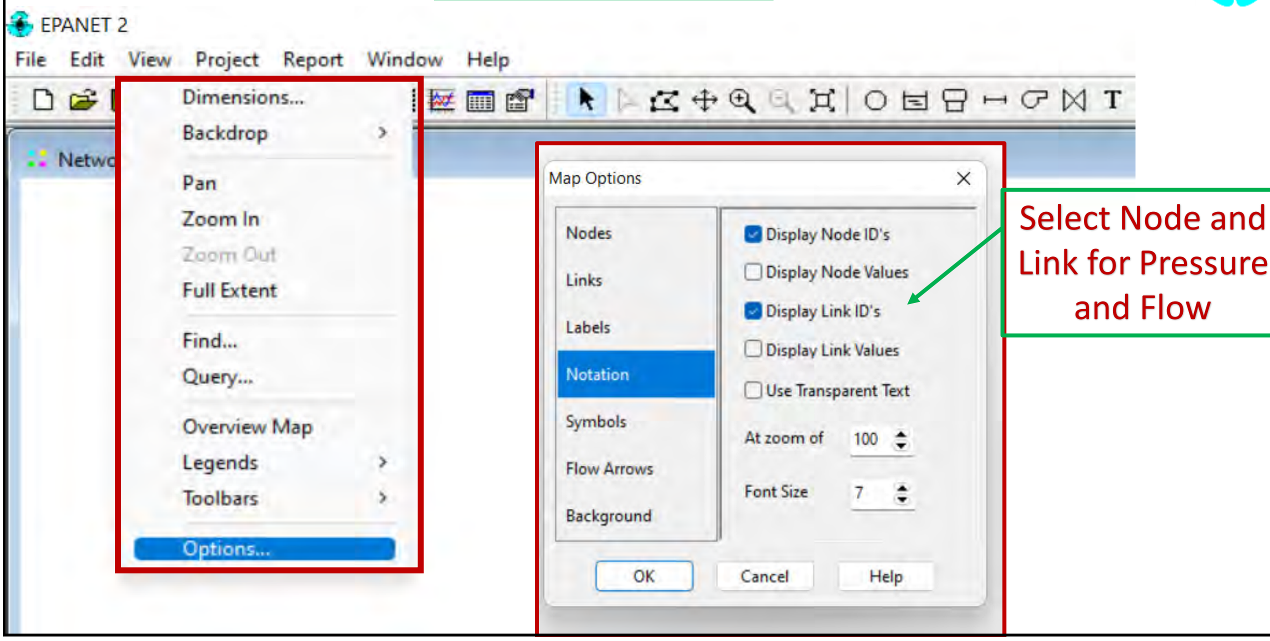

EPANET 2
File
Edit
View
Project
Report
Window
Help
New
Open...
Save
Save As...
Import
Export
Page Setup...
Print Preview
Print
Preferences...
1 pipe netwrok model Academy....net
2 204.net
3 123343.net
4 wajih discuss.net
Exit
EPANET 2
File
Edit
View
Project
Report
Copy To...
Select Object
Select Vertex
Select Region
Select All
Group Edit...
EPANET 2
File
Edit
View
Project
Report
Dimensions...
Backdrop
Pan
Zoom In
Zoom Out
Full Extent
Find...
Query...
Overview Map
Legends
Toolbars
Options...



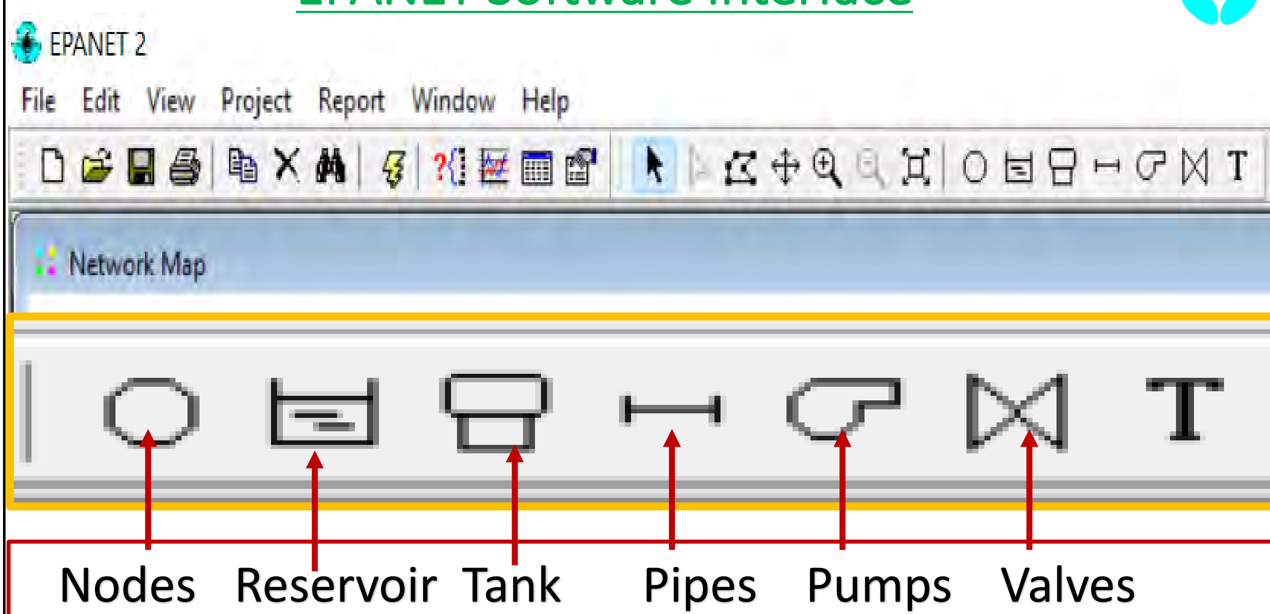
Use of EPANET



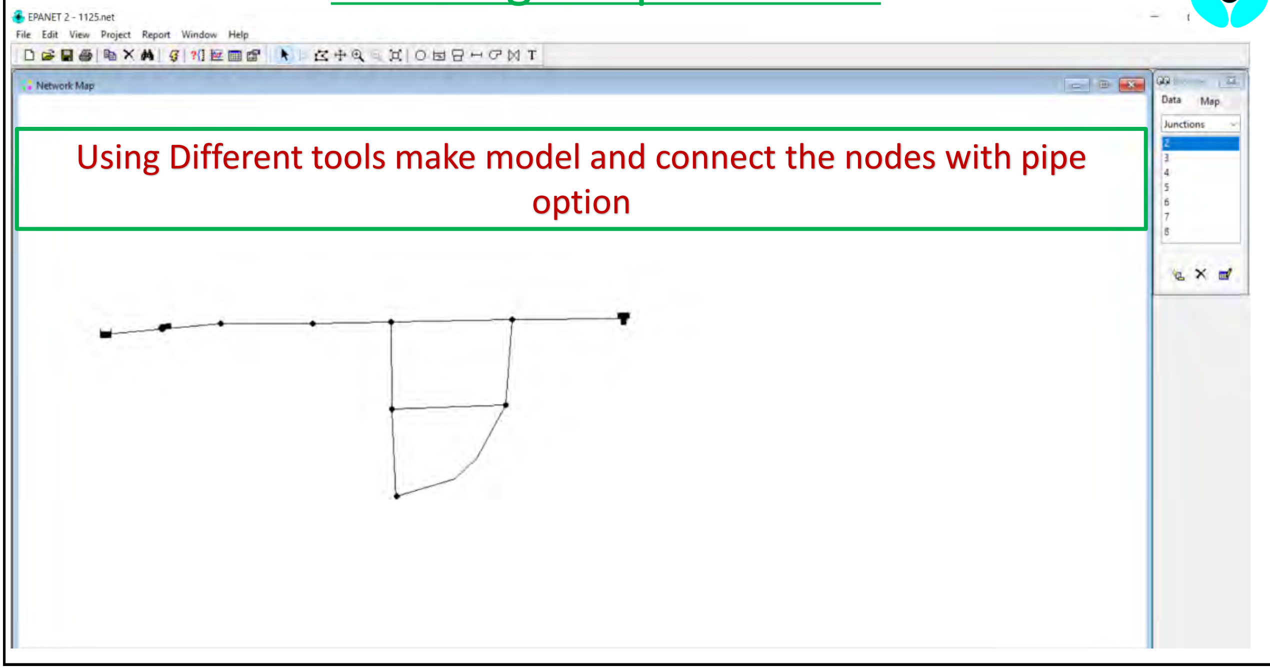
Use of EPANET

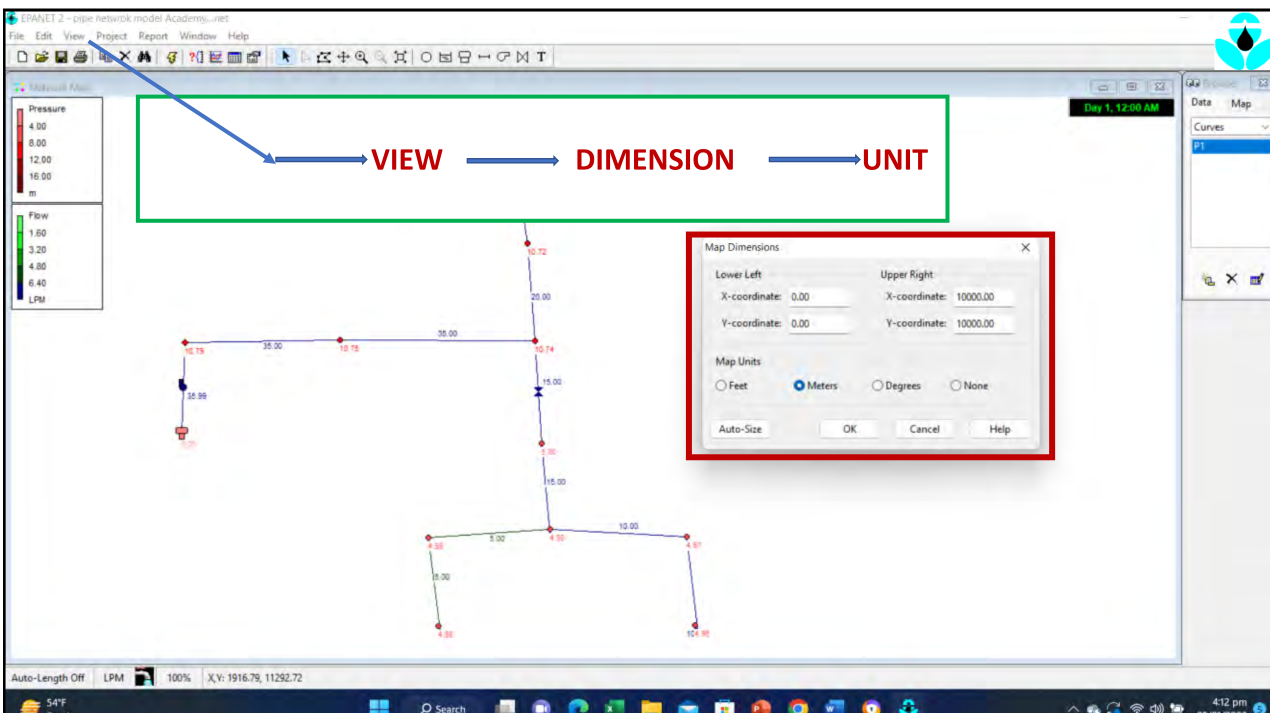


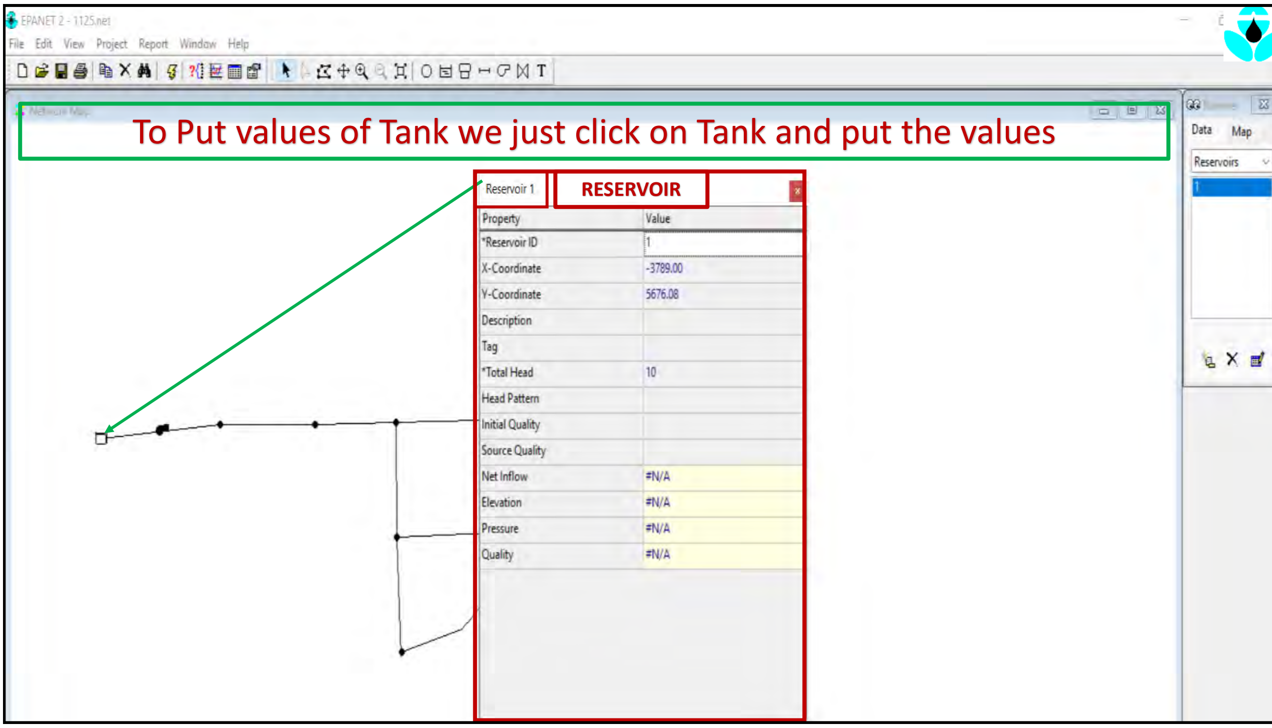
EPANET Software Interface

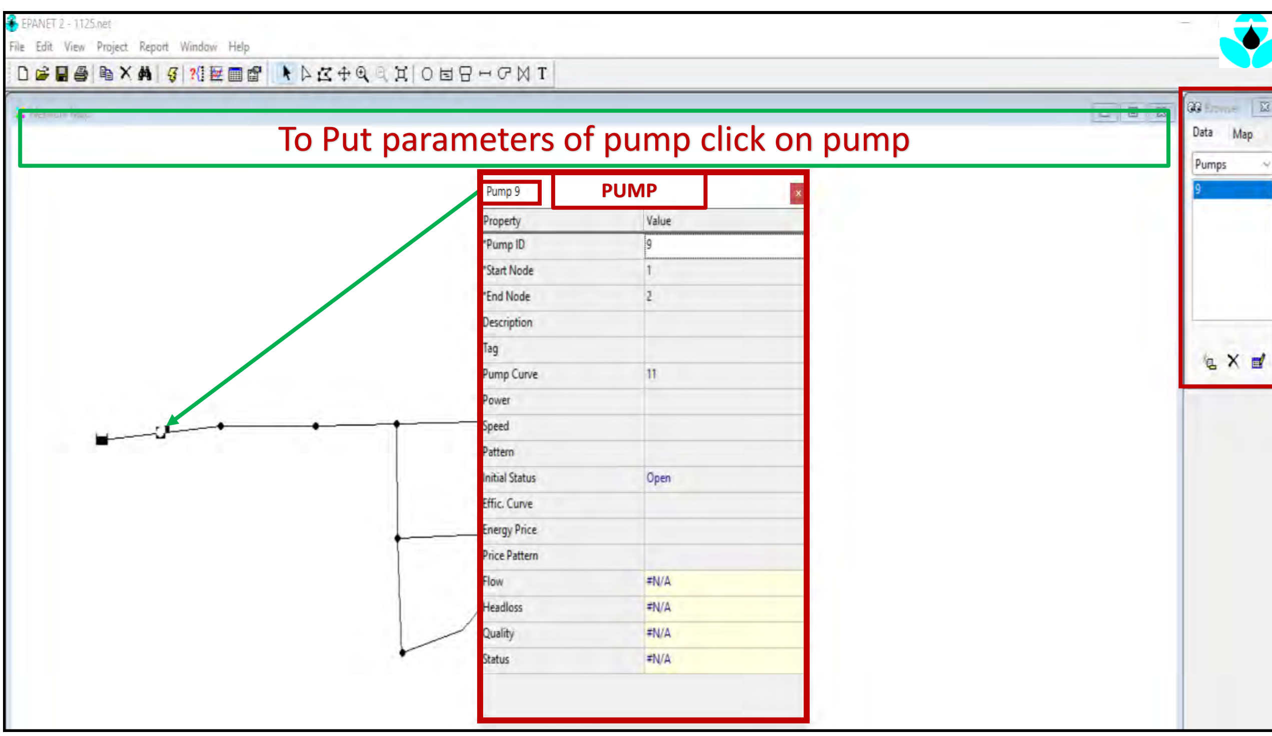


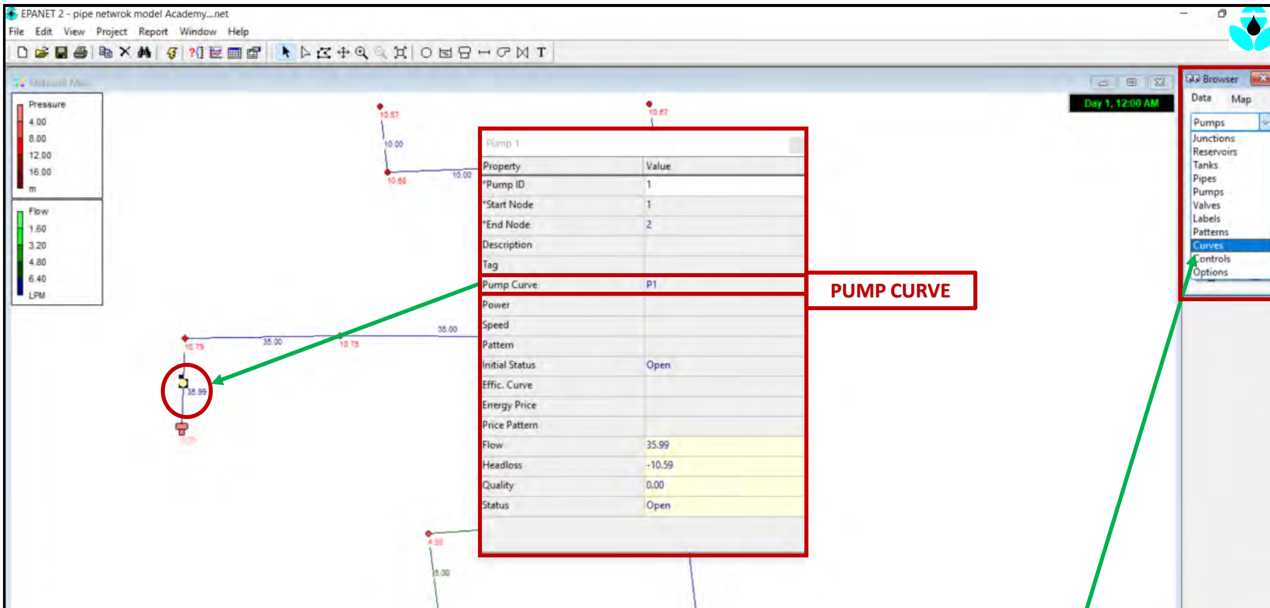
Modeling of Pipe Network



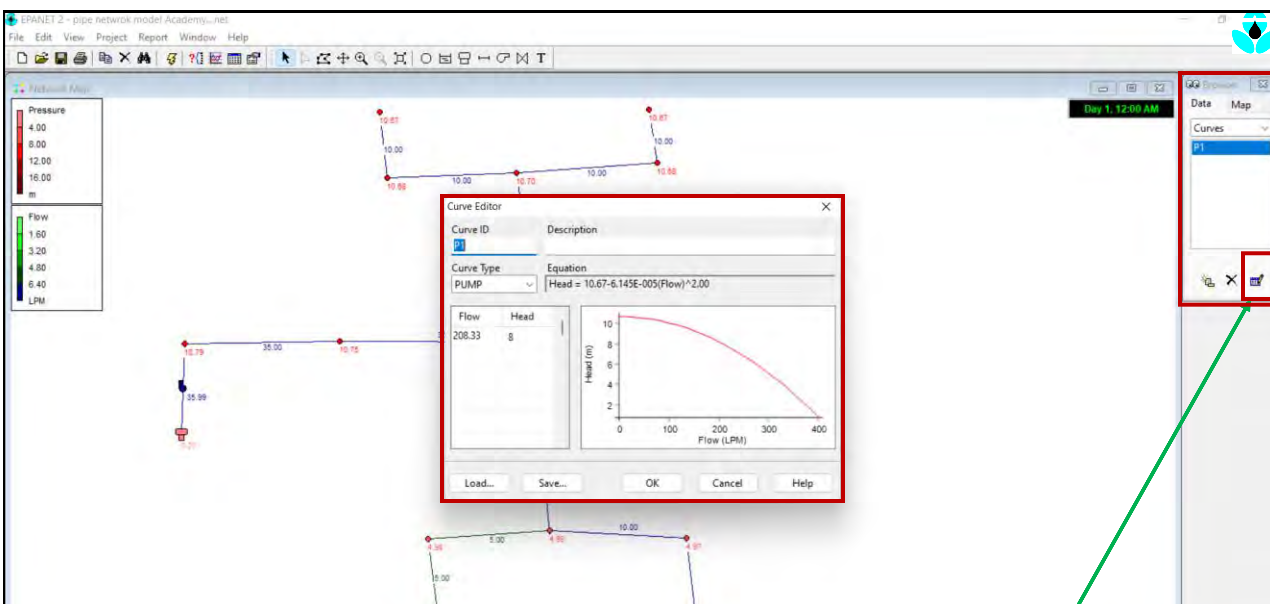



EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put values of Tank we just click on Tank and put the values
Reservoir 1
RESERVOIR
Property Value
*Reservoir ID 1
X-Coordinate -3789.00
Y-Coordinate 5676.08
Description
Tag
*Total Head 10
Head Pattern
Initial Quality
Source Quality
Net Inflow #N/A
Elevation #N/A
Pressure #N/A
Quality #N/A
Data Map
Reservoirs

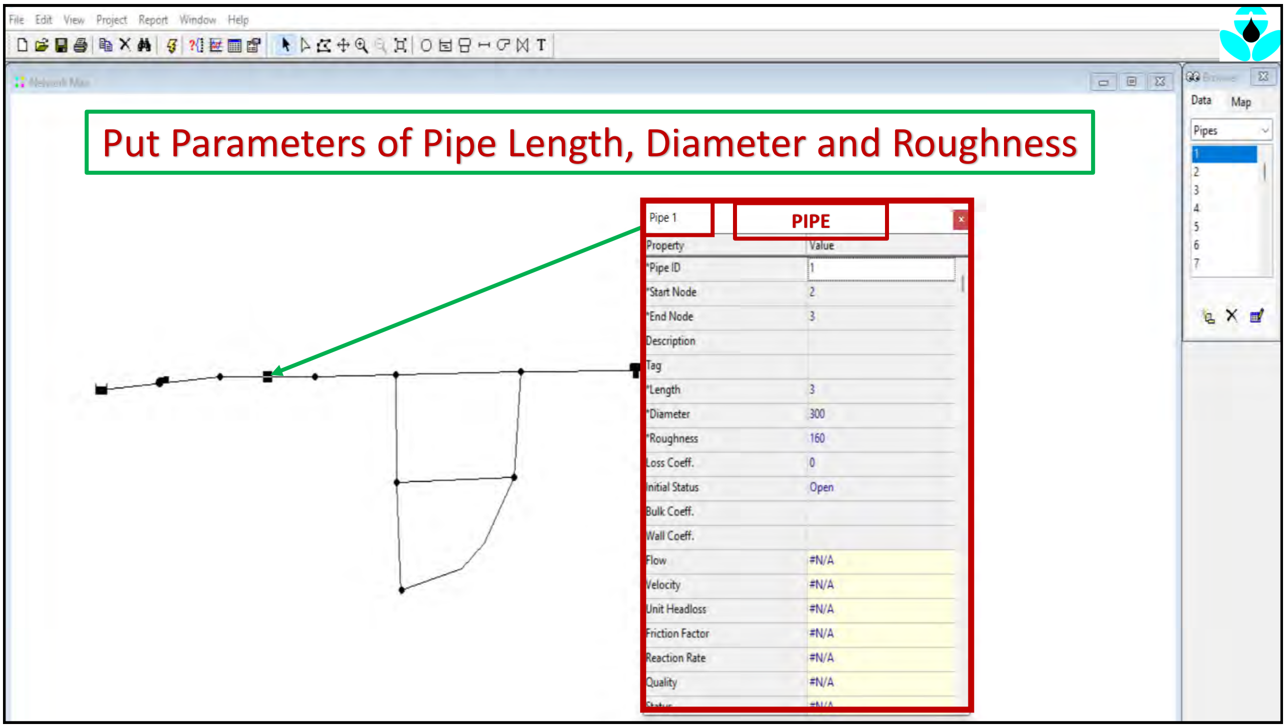

EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put parameters of pump click on pump
Pump 9
PUMP
Property Value
*Pump ID 9
*Start Node 1
*End Node 2
Description
Tag
Pump Curve 11
Power
Speed
Pattern
Initial Status Open
Effic. Curve
Energy Price
Price Pattern
Flow #N/A
Headloss #N/A
Quality #N/A
Status #N/A
Data Map
Pumps

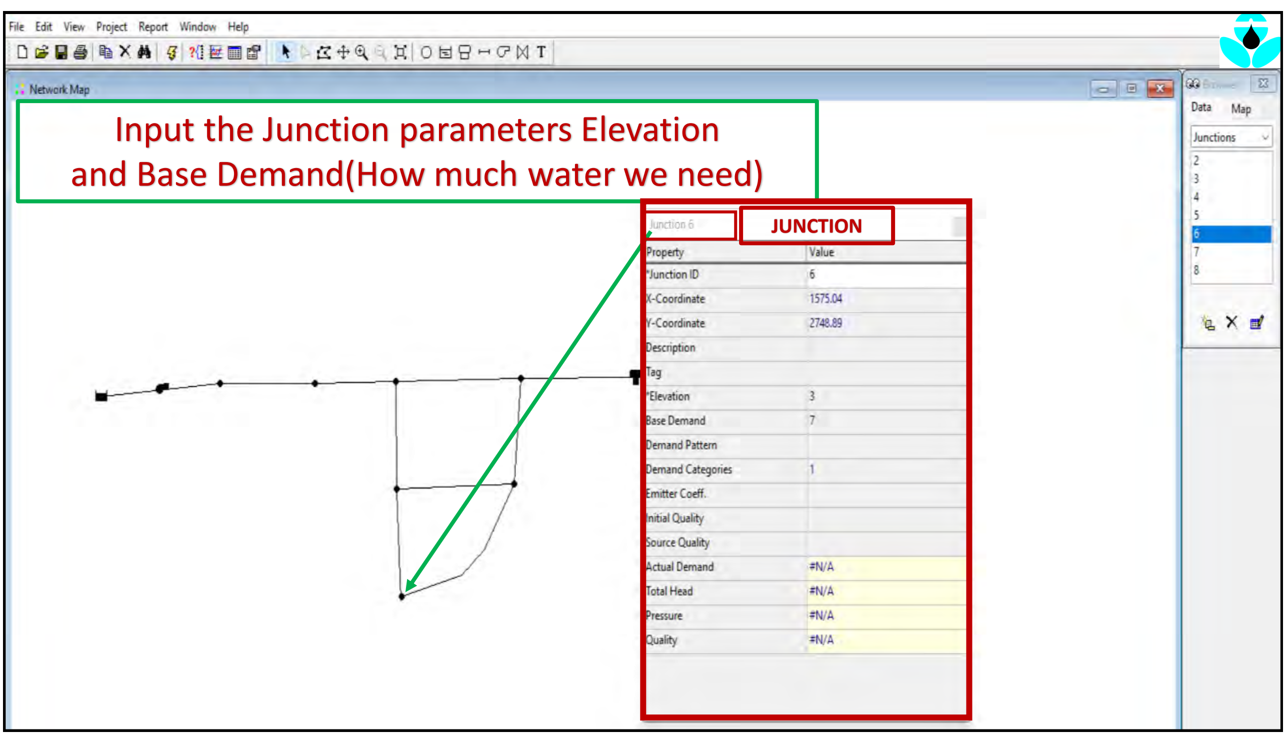


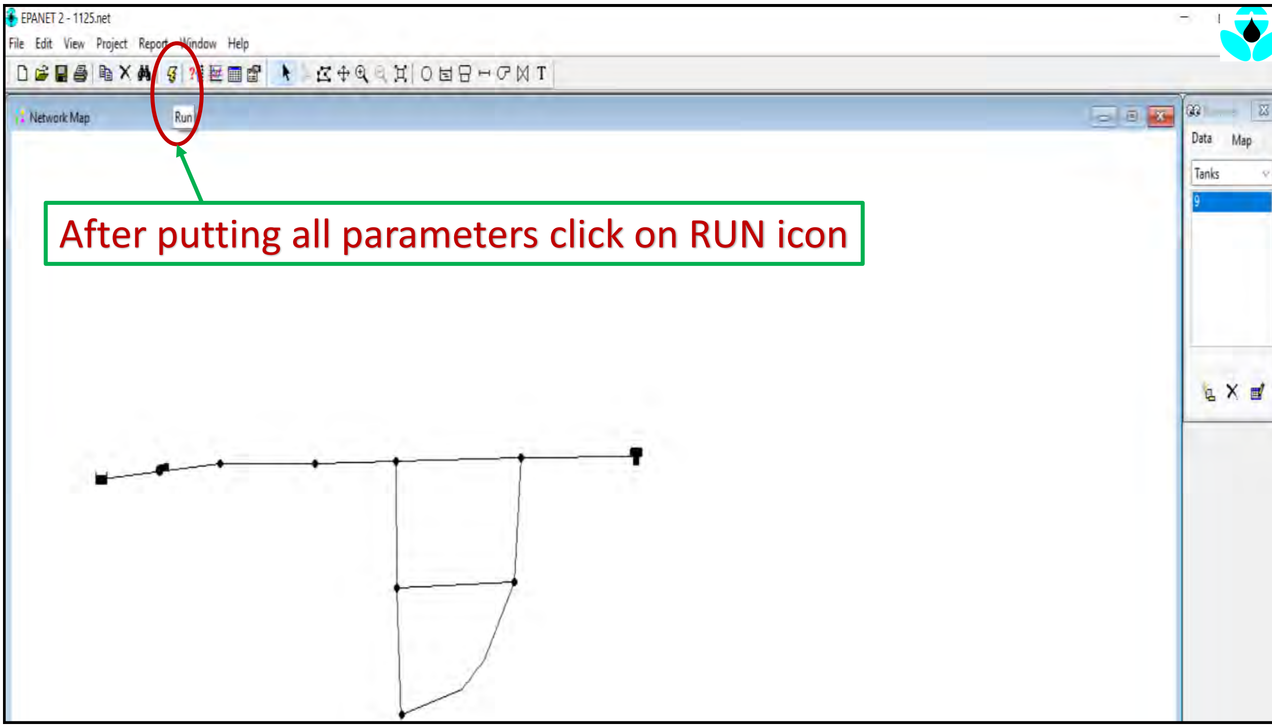
Add pump values, can add Pump curve, Power or Speed. On upper right side the different parameters we can put.

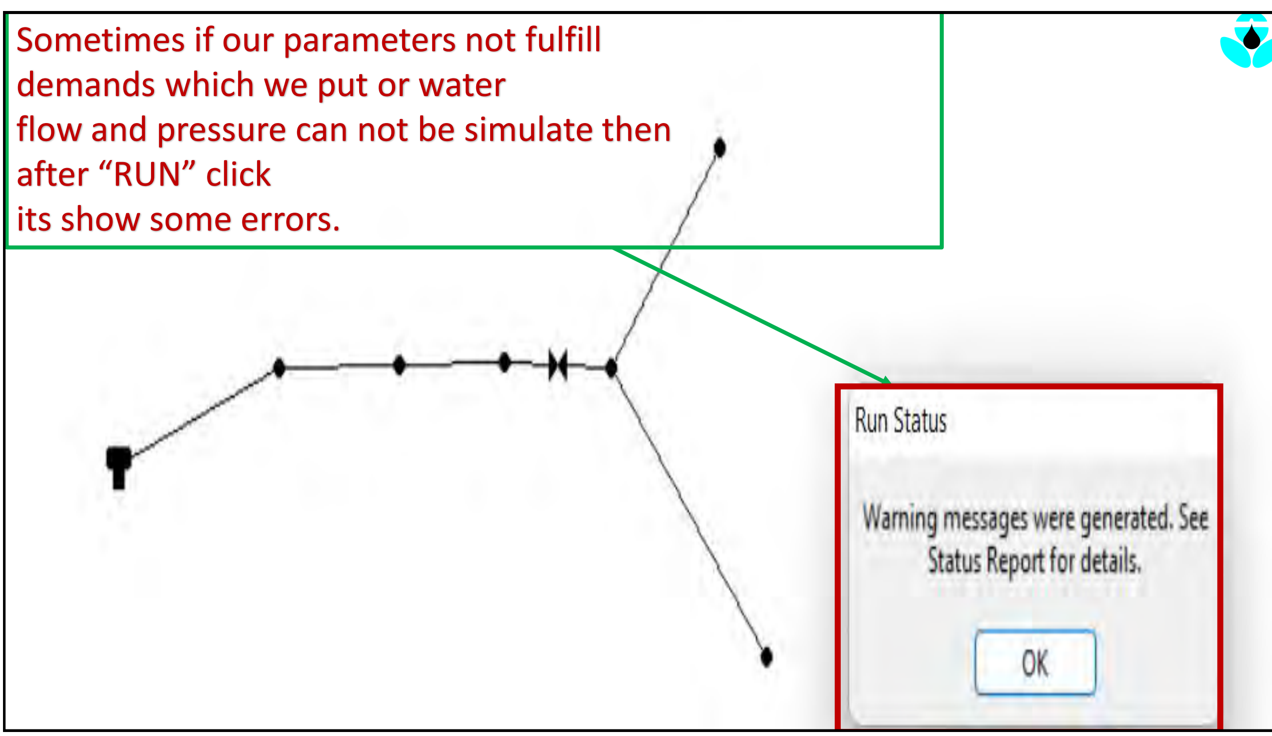


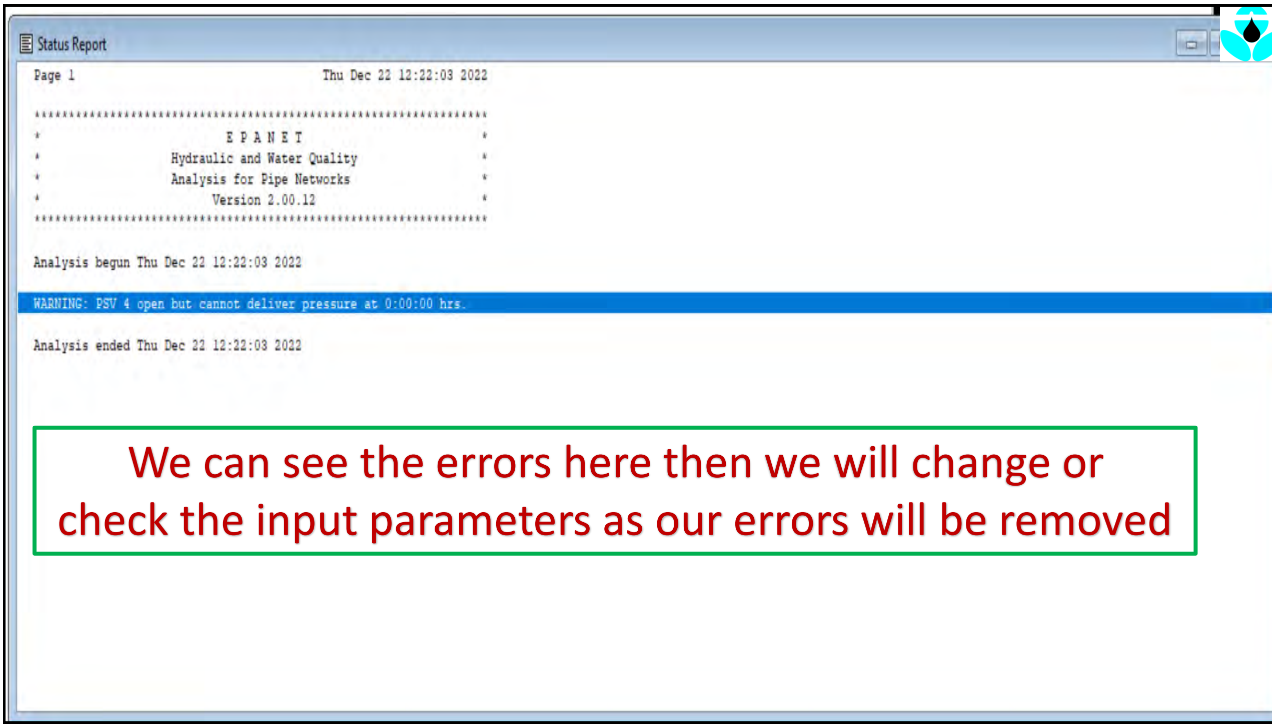
Add Pump curve, Put Flow and Head values. On upper right side click on icon and put the values.


Put Parameters of Pipe Length, Diameter and Roughness
Pipe 1
PIPE
Property
Value
*Pipe ID
1
*Start Node
2
*End Node
3
Description
Tag
*Length
3
*Diameter
300
*Roughness
160
Loss Coeff.
0
Initial Status
Open
Bulk Coeff.
Wall Coeff.
Flow
#N/A
Velocity
#N/A
Unit Headloss
#N/A
Friction Factor
#N/A
Reaction Rate
#N/A
Quality
#N/A
File Edit View Project Report Window Help
Data
Map
Pipes

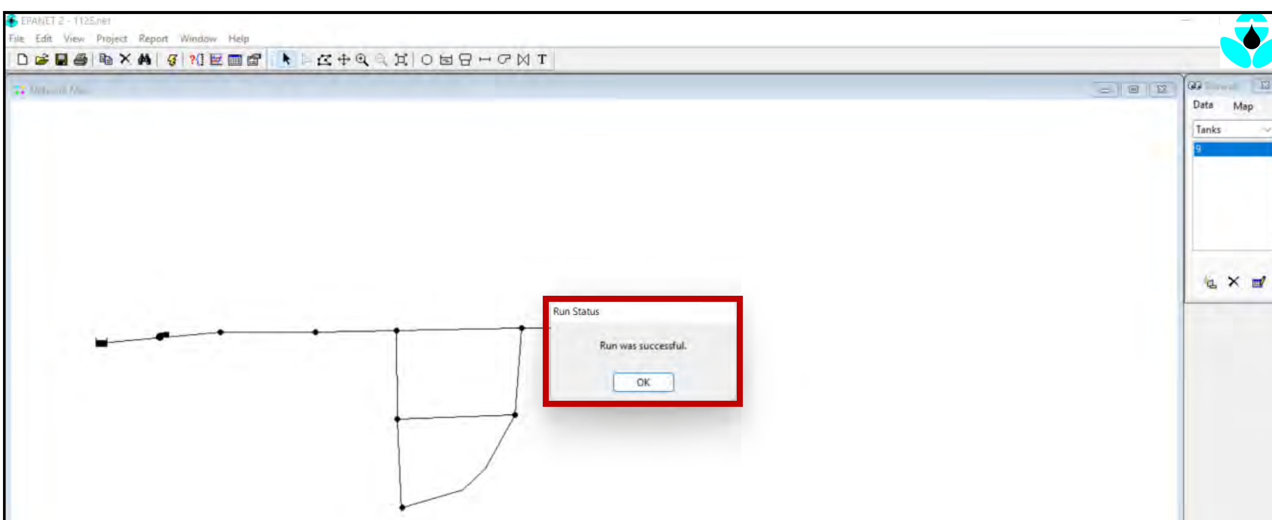

Input the Junction parameters Elevation
and Base Demand(How much water we need)
JUNCTION
Property
Value
*Junction ID
6
X-Coordinate
1575.04
Y-Coordinate
2748.89
Description
Tag
*Elevation
3
Base Demand
7
Demand Pattern
Demand Categories
1
Emitter Coeff.
Initial Quality
Source Quality
Actual Demand
#N/A
Total Head
#N/A
Pressure
#N/A
Quality
#N/A
File Edit View Project Report Window Help
Network Map
Data
Map
Junctions


EPANET 2 - 1125.net
File Edit View Project Report Window Help
Network Map
Run
Data Map
Tanks
After putting all parameters click on RUN icon

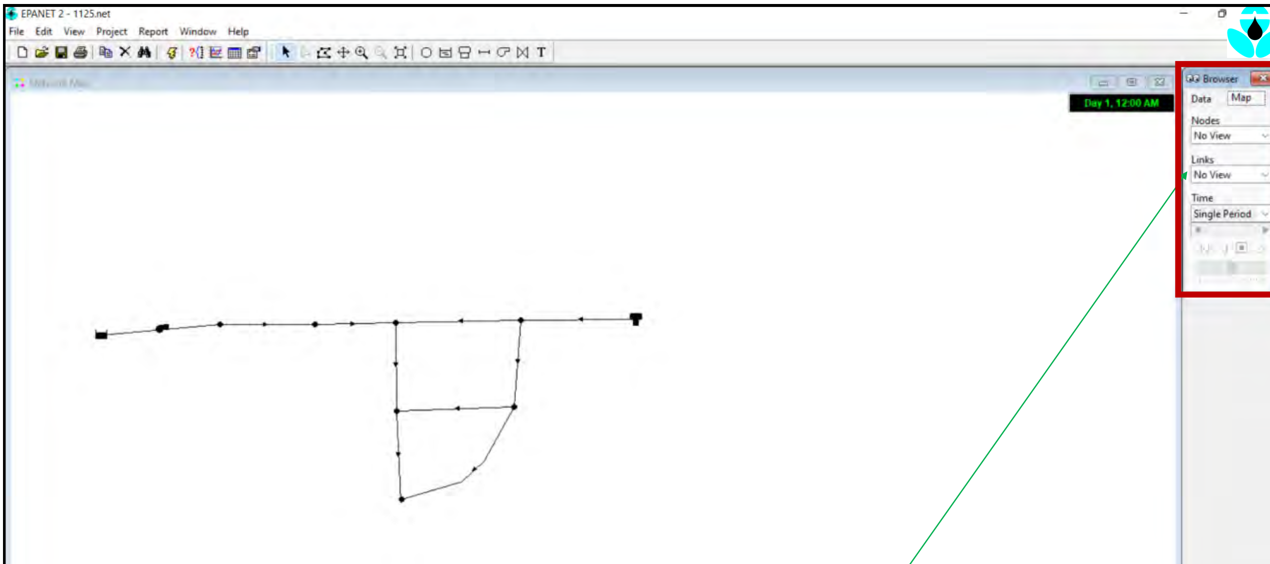

Sometimes if our parameters not fulfill
demands which we put or water
flow and pressure can not be simulate then
after “RUN” click
its show some errors.
Run Status
Warning messages were generated. See Status Report for details.
OK



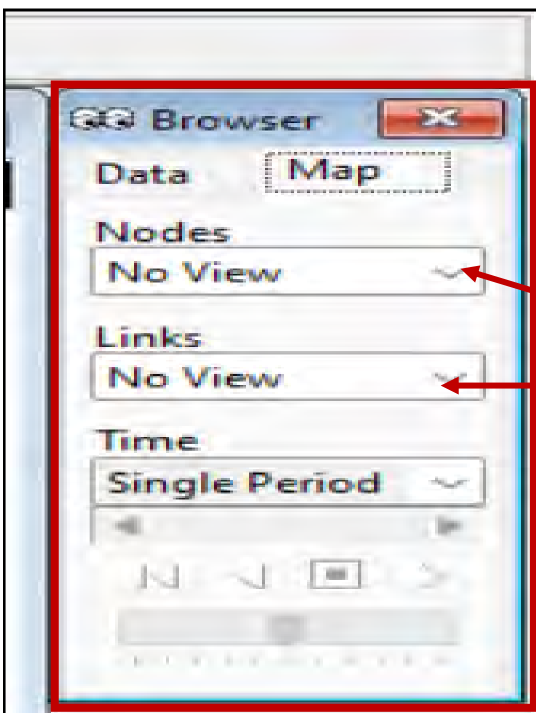
We can see the errors here then we will change or check the input parameters as our errors will be removed



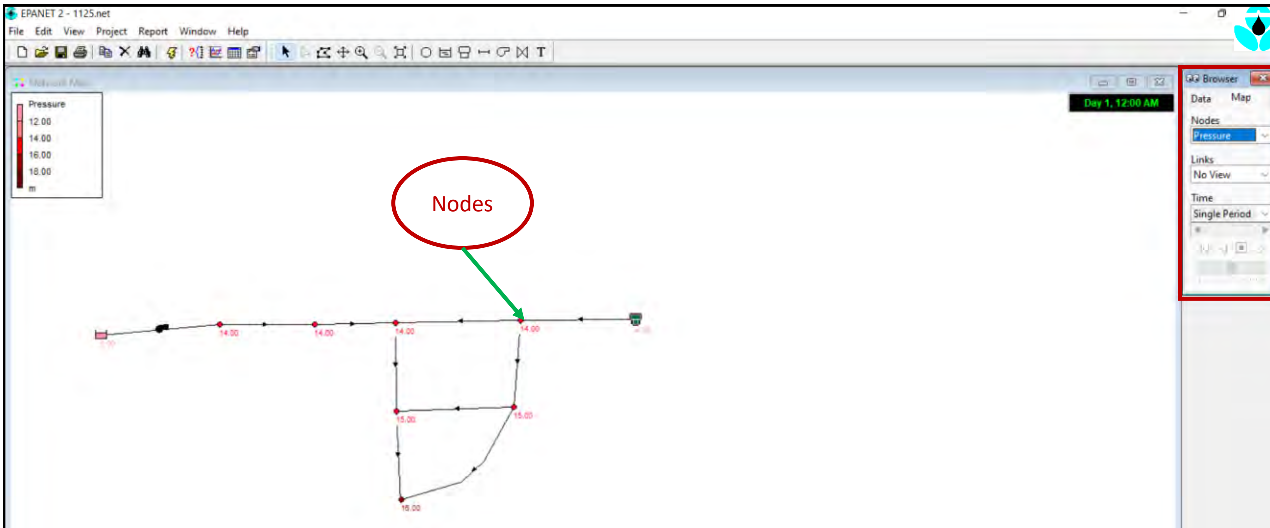
After checking input parameters and then again click on RUN Icon then status will be successful



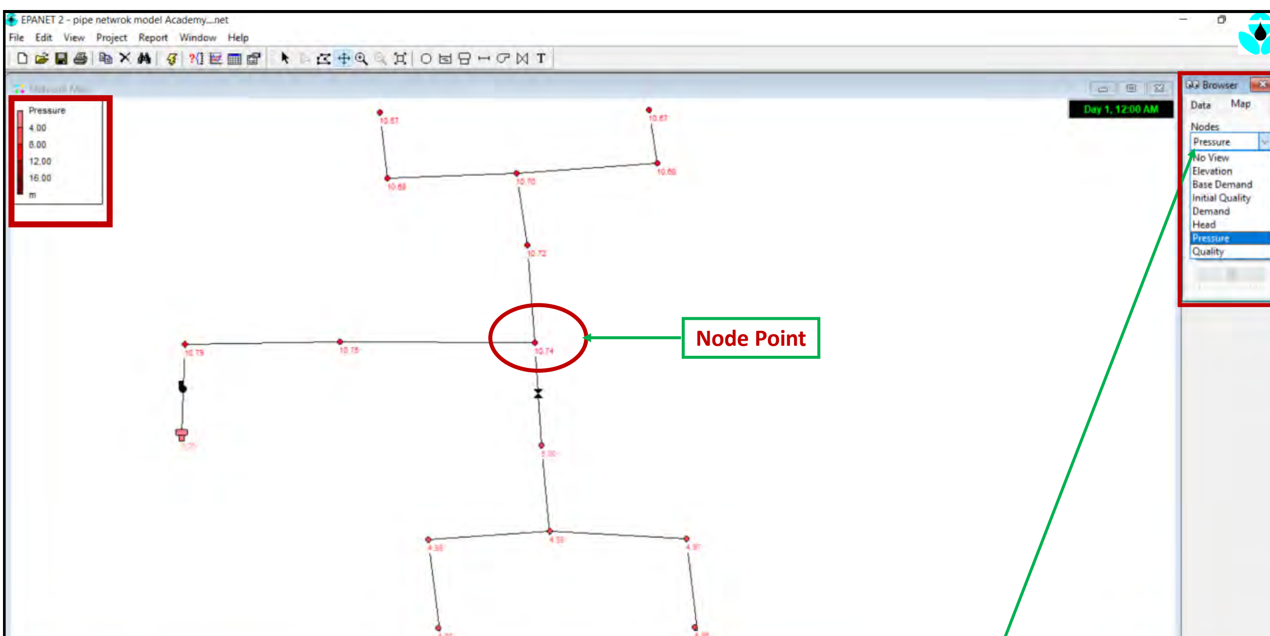
After Run Successful we have to add parameters which we want to observe



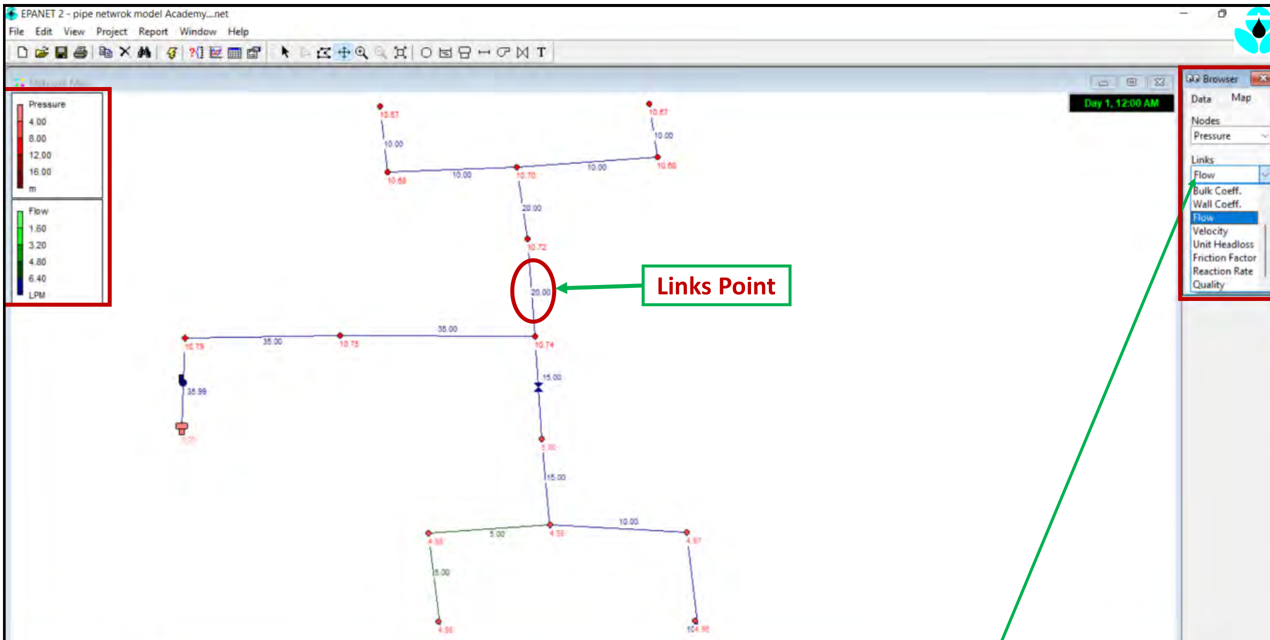
Select the Parameters of Nodes and Links and see the values



We Can observe the parameters values on "Nodes" point by clicking on right side browser Nodes



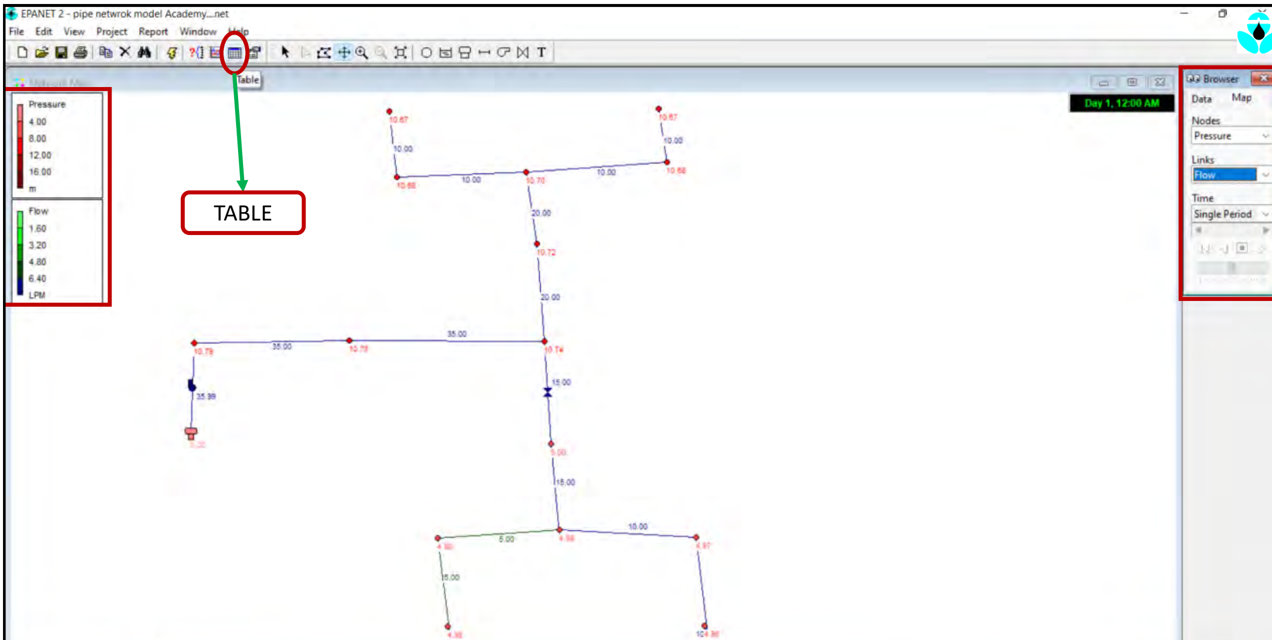
We Can observe the different parameters values on "Nodes" point by clicking on right side browser "Nodes"



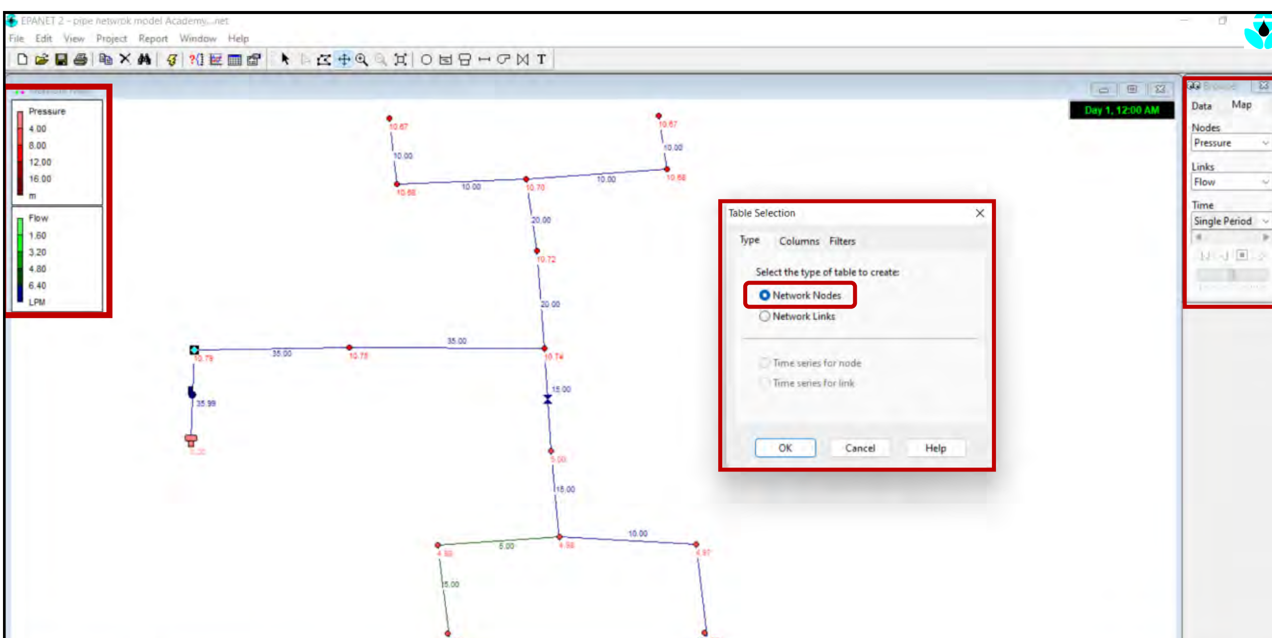
We Can observe the different parameters values on "Links" point by clicking on right side browser "Links"

Table and Charts

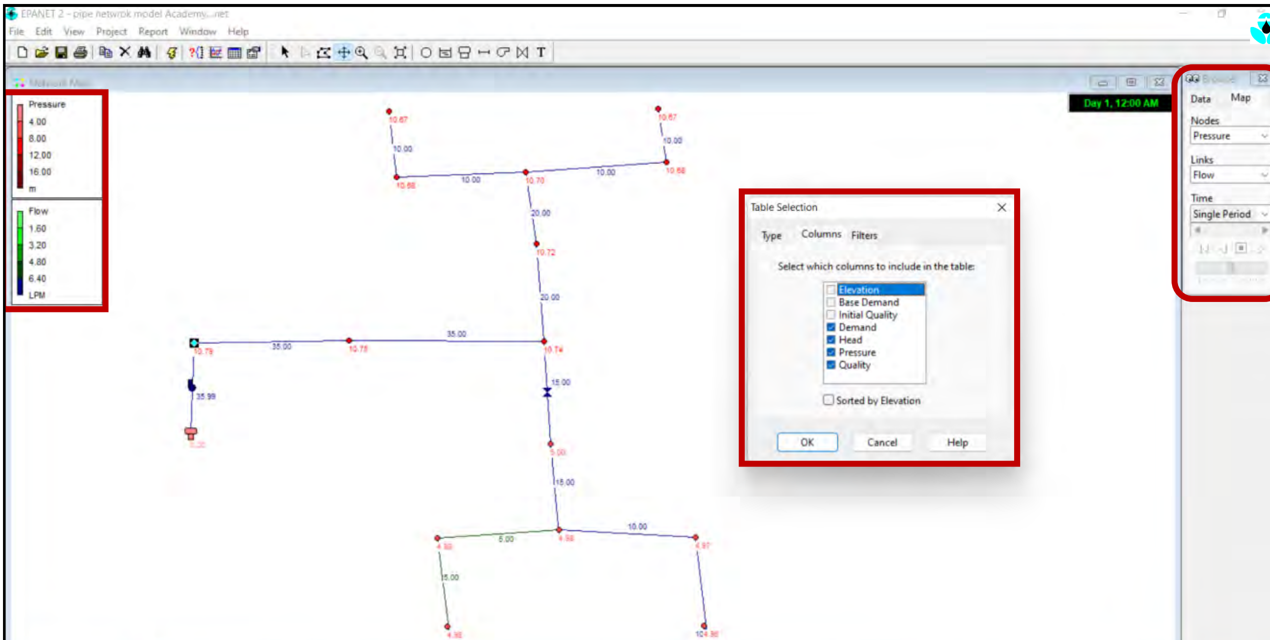
- After Successful Run and put the parameters on Node and Links point we can see results on Tables.



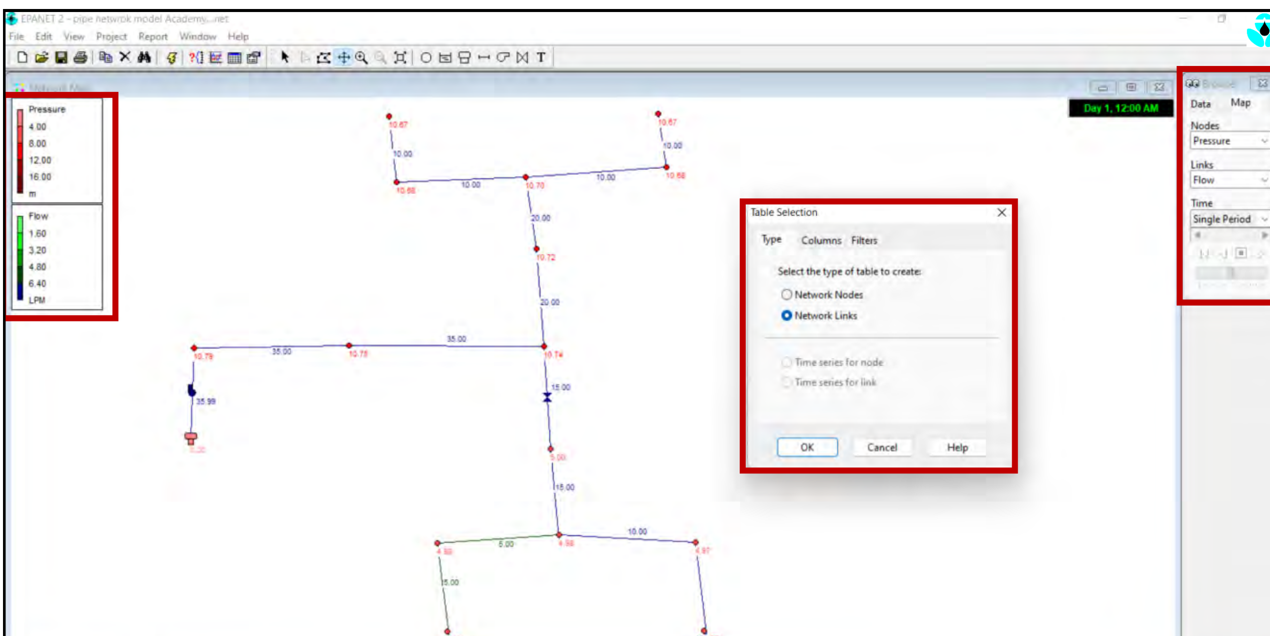
By clicking on Table ICON in toolbar a new Window will be open for Node and Links points



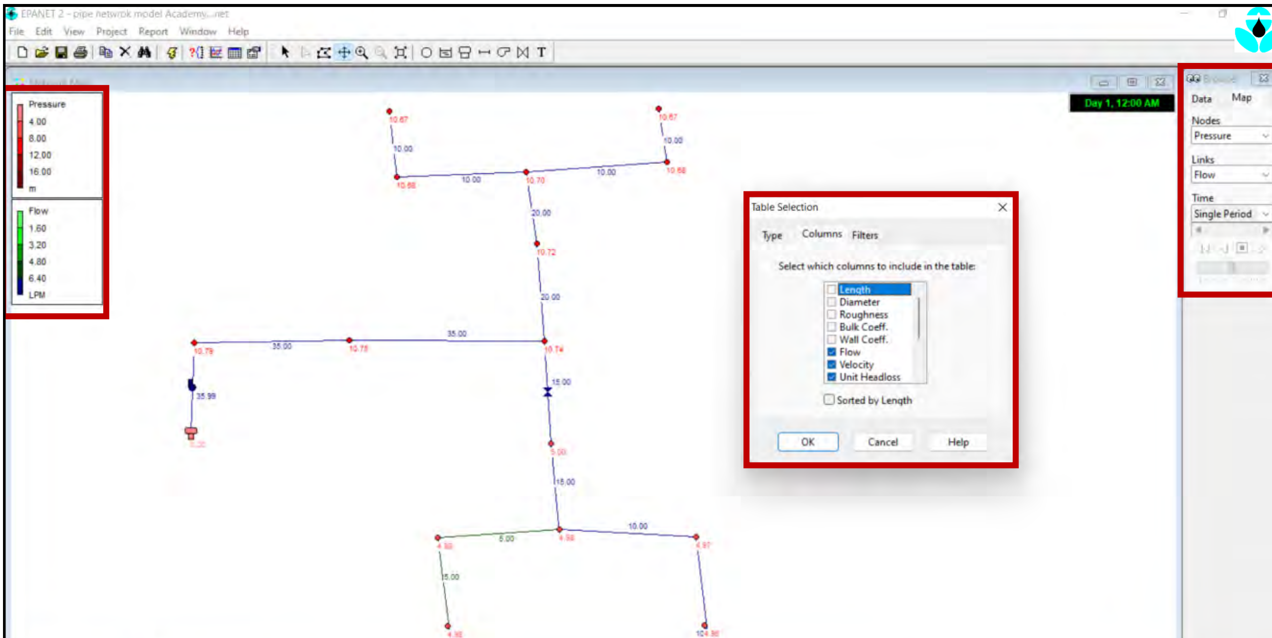
In new window we can see “Type of table creation” Can see Nodes and Links values on Table



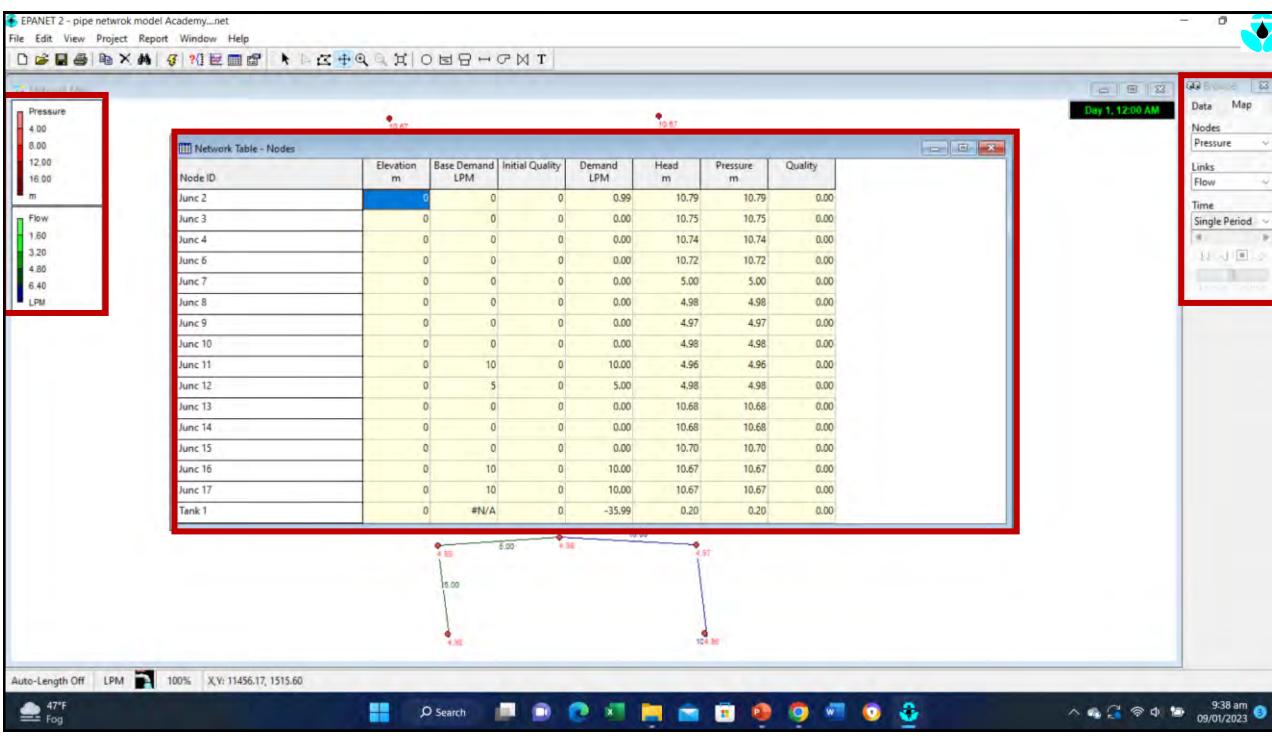
In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values



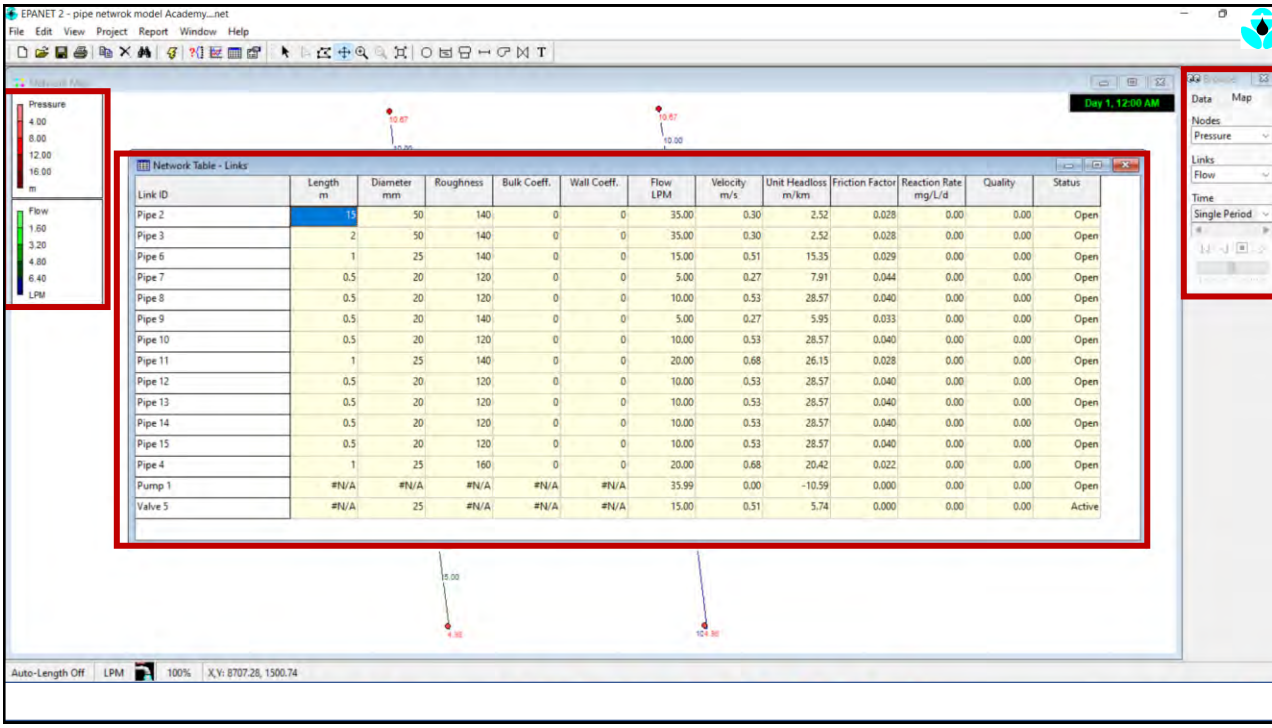
In new window we can see "Table Selection Parameters" Can select "LINKS" Points Values



In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values



Node ID	Elevation m	Base Demand LPM	Initial Quality	Demand LPM	Head m	Pressure m	Quality
Junc 2	0	0	0	0.99	10.79	10.79	0.00
Junc 3	0	0	0	0.00	10.75	10.75	0.00
Junc 4	0	0	0	0.00	10.74	10.74	0.00
Junc 6	0	0	0	0.00	10.72	10.72	0.00
Junc 7	0	0	0	0.00	5.00	5.00	0.00
Junc 8	0	0	0	0.00	4.98	4.98	0.00
Junc 9	0	0	0	0.00	4.97	4.97	0.00
Junc 10	0	0	0	0.00	4.98	4.98	0.00
Junc 11	0	10	0	10.00	4.96	4.96	0.00
Junc 12	0	5	0	5.00	4.98	4.98	0.00
Junc 13	0	0	0	0.00	10.68	10.68	0.00
Junc 14	0	0	0	0.00	10.68	10.68	0.00
Junc 15	0	0	0	0.00	10.70	10.70	0.00
Junc 16	0	10	0	10.00	10.67	10.67	0.00
Junc 17	0	10	0	10.00	10.67	10.67	0.00
Tank 1	0	#N/A	0	-35.99	0.20	0.20	0.00



Link ID	Length m	Diameter mm	Roughness	Bulk Coeff.	Wall Coeff.	Flow LPM	Velocity m/s	Unit Headloss m/km	Friction Factor	Reaction Rate mg/L/d	Quality	Status
Pipe 2	15	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 3	2	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 6	1	25	140	0	0	15.00	0.51	15.35	0.029	0.00	0.00	Open
Pipe 7	0.5	20	120	0	0	5.00	0.27	7.91	0.044	0.00	0.00	Open
Pipe 8	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 9	0.5	20	140	0	0	5.00	0.27	5.95	0.033	0.00	0.00	Open
Pipe 10	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 11	1	25	140	0	0	20.00	0.68	26.15	0.028	0.00	0.00	Open
Pipe 12	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 13	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 14	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 15	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 4	1	25	160	0	0	20.00	0.68	20.42	0.022	0.00	0.00	Open
Pump 1	#N/A	#N/A	#N/A	#N/A	#N/A	35.99	0.00	-10.59	0.000	0.00	0.00	Open
Valve 5	#N/A	25	#N/A	#N/A	#N/A	15.00	0.51	5.74	0.000	0.00	0.00	Active

Annex 5.1.17 Training Material on "Leakage Control"

- WASA Faisalabad for In-house Training (3rd)
- WASA Multan for In-house Training (2nd)
- WASA Gujranwala for In-house Training (2nd)
- WASA Rawalpindi for In-house Training (2nd)

District Metered Area

What is DMA?

Importance of DMA

How DMA works

DMA

Water Block System and DMA

- It is necessary to grasp the water flow in the water distribution system to survey water leakage.
- However, water distribution pipes spread complicatedly, and it makes difficult to grasp water flow in a certain area of distribution system.
- Districted Metered Area (DMA) and step test can solve this problem by measuring inflow and outflow in districted area.

Water Supply Block System

Purpose

1) Control of distribution water pressure
2) Control of distribution water volume
3) Simplifying water distribution plan
4) Mitigating damage in disaster such as earthquake
5) Rational construction plan of distribution facilities
6) Efficiency improvement plan
7) Simplifying control of distribution flow

Water Supply Block System

Principles

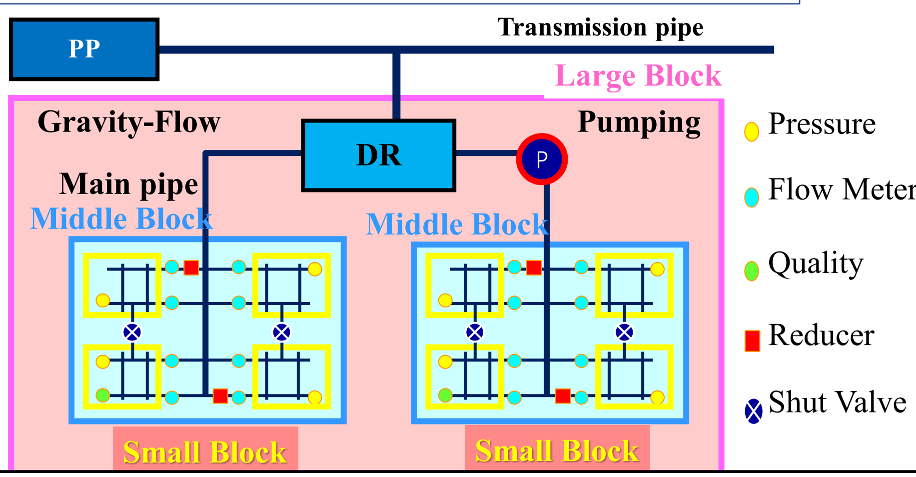
1) In principle every block has one distribution reservoir
2) Within the block, pumping stations are integrated
3) To classify blocks into two areas.

   In one area water is supplied through natural gravity, in the other area water is supplied by pumps.

4) To install pipelines in order to make flexible use of water among the blocks.

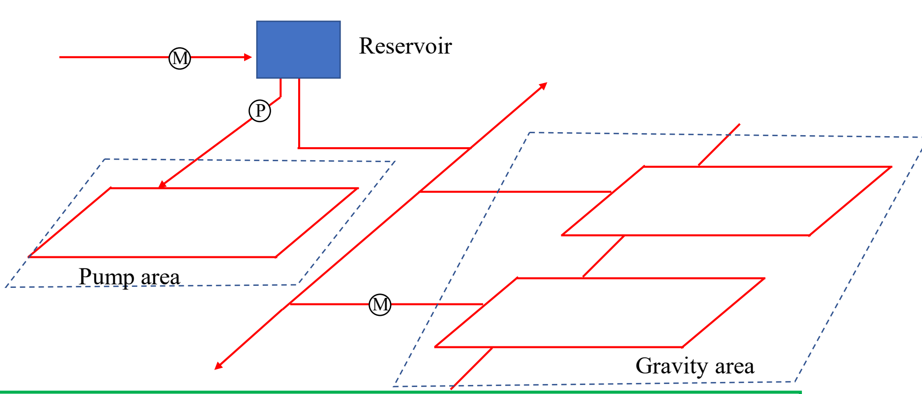
Water Supply Block System

Large Block: Distribution Reservoir Area
Middle Block: Gravity-Flow and Pumping Area
Small Block: District Metered Area



District Metered Area

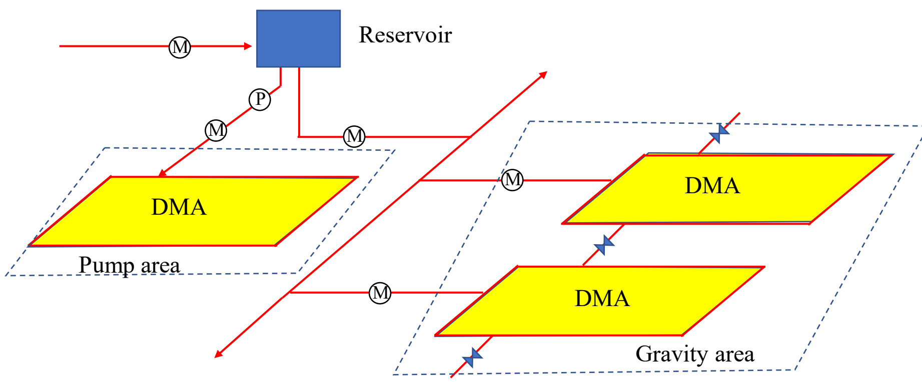
DMA



- ➢ To install
- • flow meters and valves for isolation area

District Metered Area

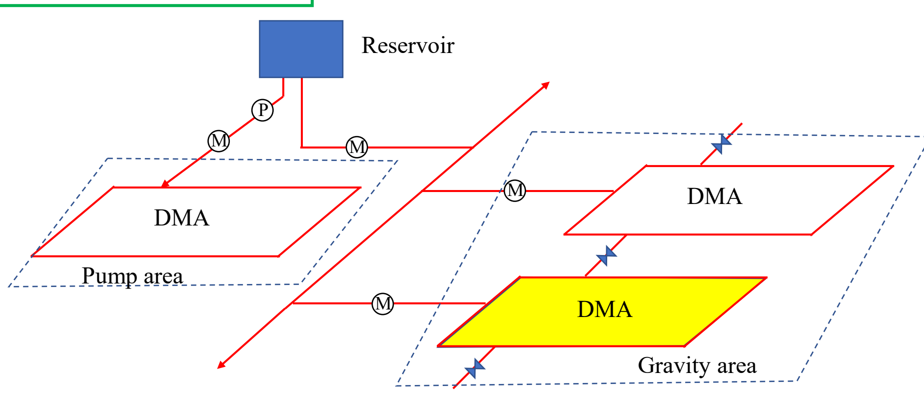
District Metered Area



➢ To install
- flow meters and valves for isolation area

District Metered Area

What can we do at DMA?



➢ To analyze
- Distribution water by measuring Minimum (Night) Flow

Water Meter

Content:

What is Water Meter?

➢Water metering is the practice of measuring water usage.

➢Water meters measure the volume of water used by residential and commercial building units that are supplied by a public water supply system.

➢They are also used to determine flow through a particular portion of the system.

Importance of water meters

- ➢Helps in monitoring the volume of water in different areas
- ➢Help in water conservation
- ➢Allow the system to demonstrate accountability
- ➢Fair for all customers because they record specific usage
- ➢Aid in the detection of leaks and waterline breaks in the distribution system.
- ➢Monitor the volume of consumed water

Water Meter at House

Water Meter at Building

Major Water Meter Types in WASA (Consumer Meters)

- Water Meter
  - Velocity type
    - Single Jet Type
    - Multi Jet Type
  - Positive Displacement
    - Rotary Piston Type

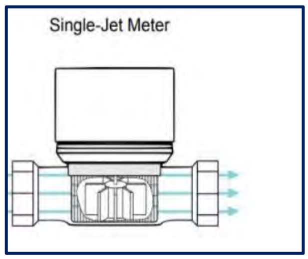
Single Jet Type

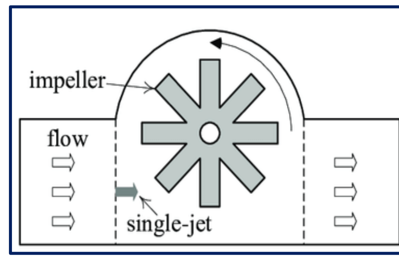
Multi Jet Type

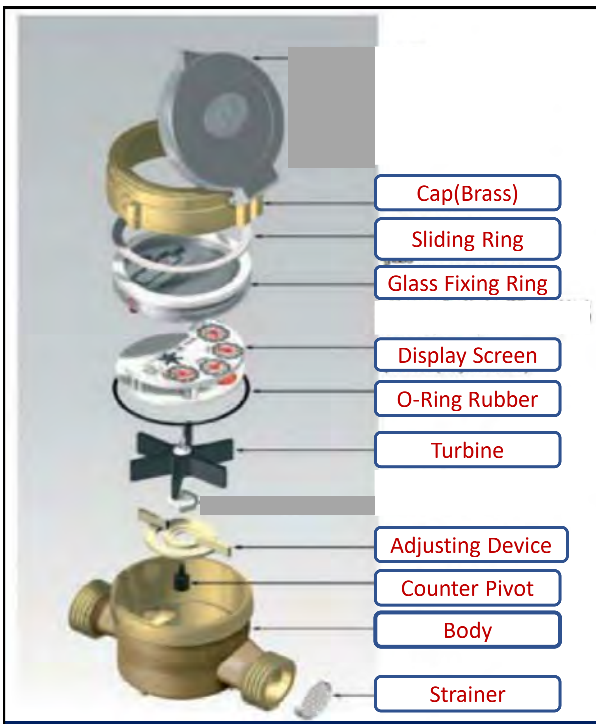
Rotary Piston Type

Single Jet water Meter

- Single jet water meters make use of only one port to create a jet of water, making the turbine rotate. There is a single stream of water directed towards a turbine mounted in a radial position within the meter. The turbine starts rotating and transmitting the motion to the display mechanism, which allows us to measure the volume of water passing through the meter.



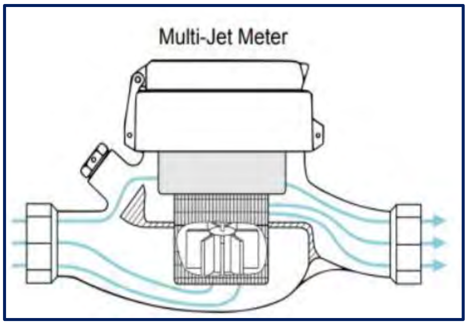


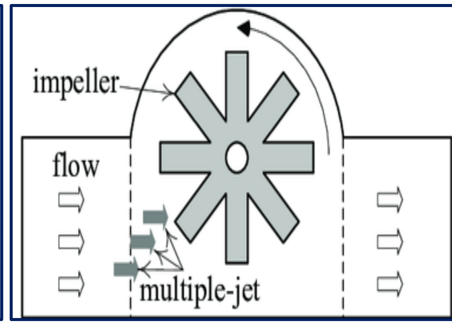


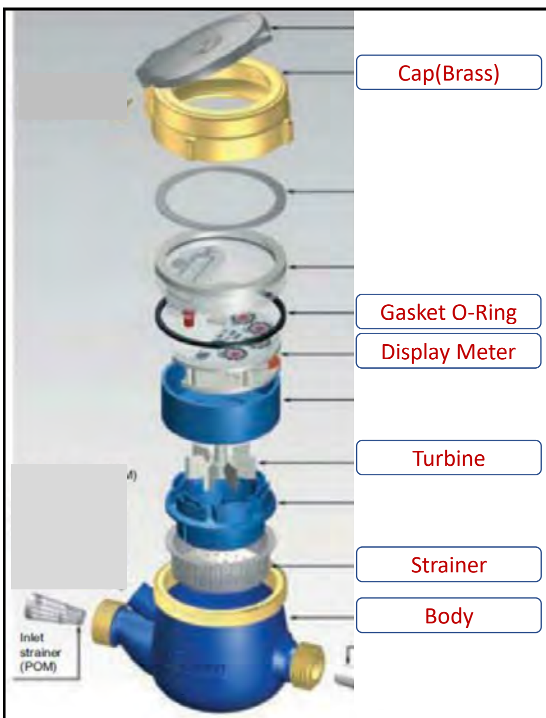
Main Parts of Water Meter

MultiJet Water Meter

- Multi-jet meters have multiple ports that surround an internal chamber to create a flow of water against the turbine.Multi-jet meters retain accuracy even a lower flow rates and give a much longer life. Because of their design Multi-jet meters are ideal for diameters between 1-1/2" to 3" in diameter, for large water users, water utilities as well as for industrial water installations.







Main Parts of Water Meter

Rotary piston meters

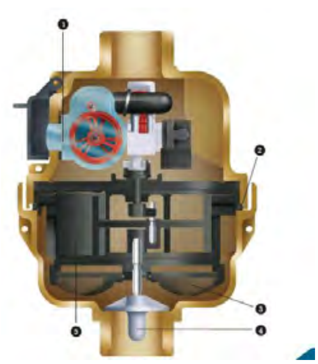
- ➢Rotary piston positive displacement meter records the flow rate according to the volumetric measuring principle.
- ➢Rotary piston meters are popular for their combination of accuracy, long life and moderate cost so they are widely used.
- ➢Sand or other suspended solids easily get stuck between the piston and chamber wall. Thus, it is important to be installed in the system with very good water quality and to install built-in strainer.



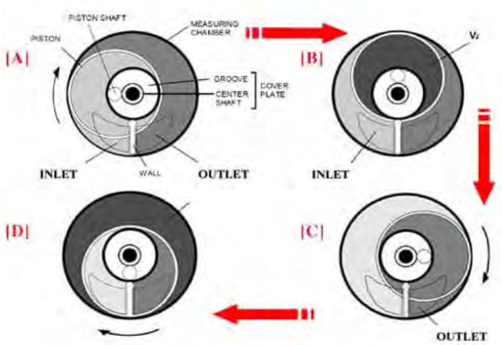
Mechanism

The piston and cylinder are alternately filled and emptied by the fluid passing through the meter. A slot in the sidewall of the piston is removed so that a partition extending inward from the bore of the working chamber can be inserted. This has the effect of restricting the movement of the piston to a sliding motion along the partition. The rotary movement of the piston is transmitted via a permanent-magnet coupling from the drive shaft to a mechanical register.

1. **Easy to read register**
2. **"O" ring seal**
3. **Stainer**
4. **Non-Return valve**
5. **Piston and cylinder**



Application and Installation

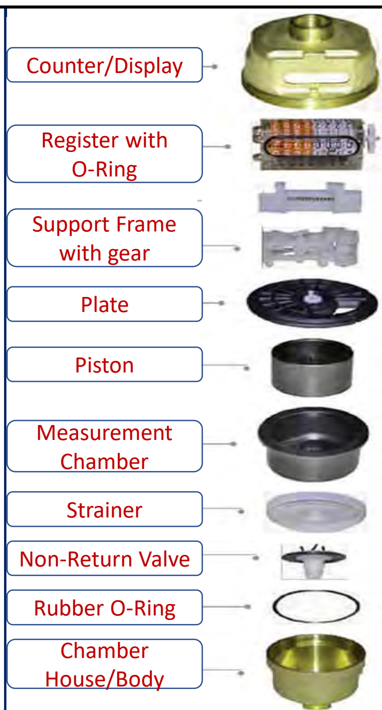


Rotary piston meters are commonly used most domestic applications up to diameter 25mm. They are not sensitive to the wide flow velocity profile.

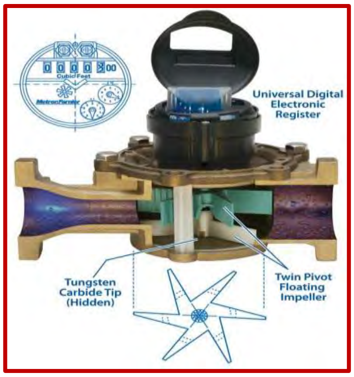
Rotary piston meters can be installed in **any position** with stable accuracy and placed close to bend or pump.

- ➢ Applicable pipe diameter: 13mm – 40mm
- ➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

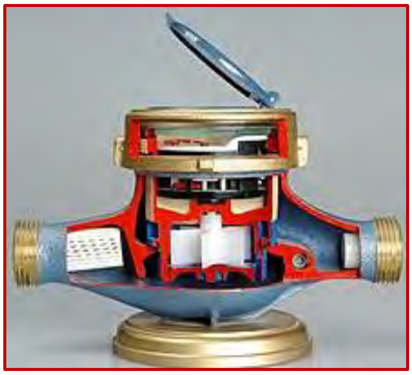
Main Parts of Water Meter



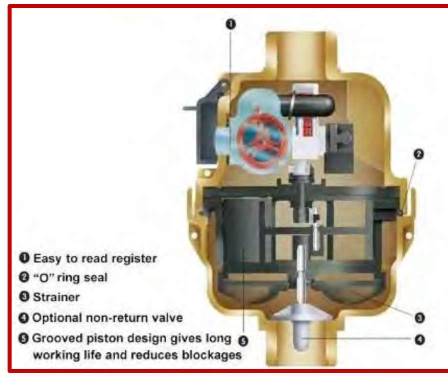
Cross Sectional View of water meters



Single-Jet Water Meter

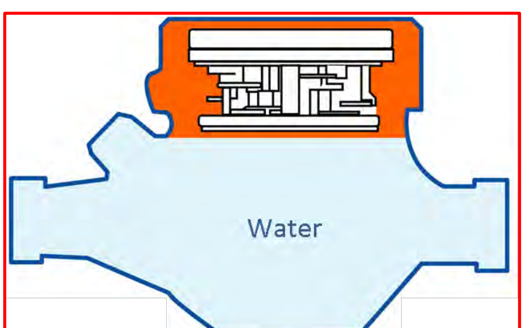


Multi-Jet Water Meter

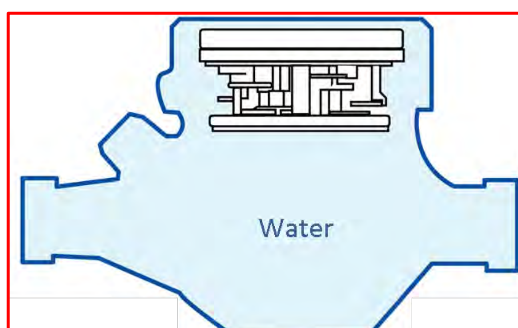


Rotary Piston/Vertical Meter

Difference between Dry and Wet Dial water meter

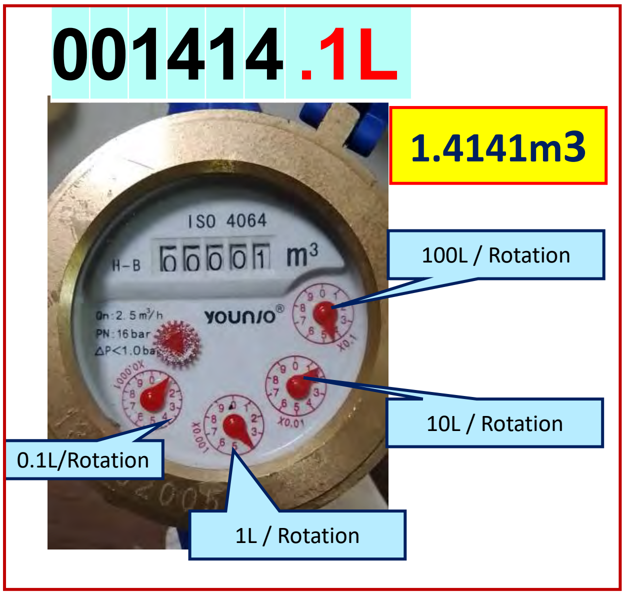


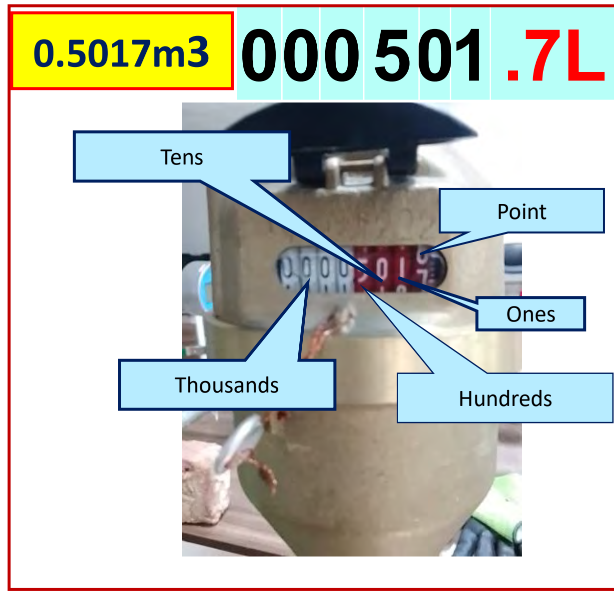
Dry Dial (Vacuum Register Unit)



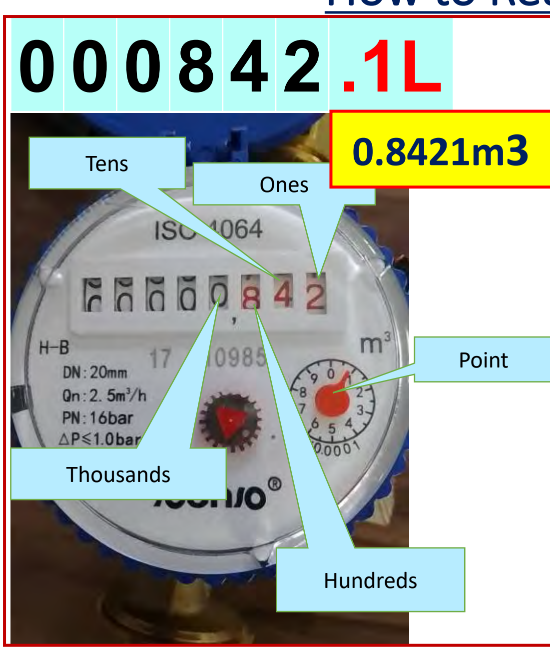
Wet Dial (Water Flow through Register Unit)

How to Read Water meters





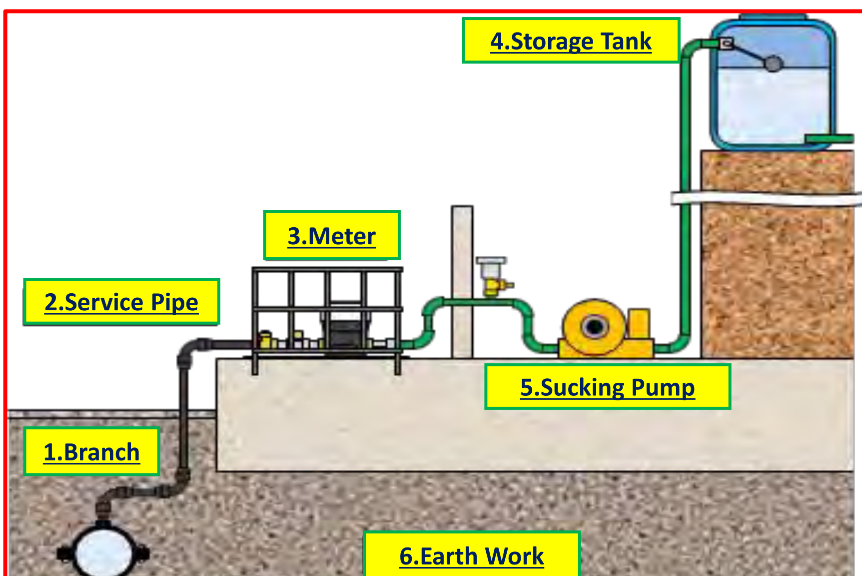
How to Read Water meters

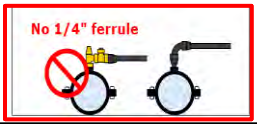


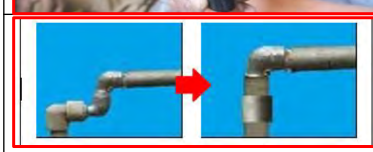
Comparison of water meters

	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance	 	 	 
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount of water can be measured accurately	High accuracy than others

SOP's for the Installation of Water Meter

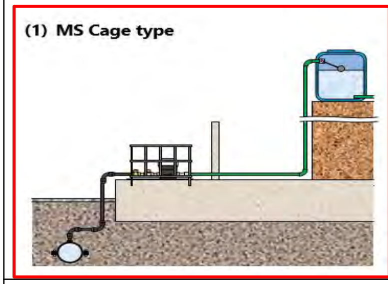
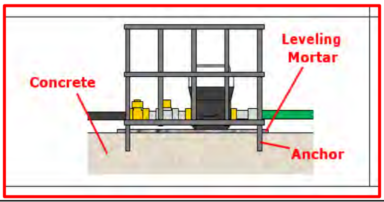
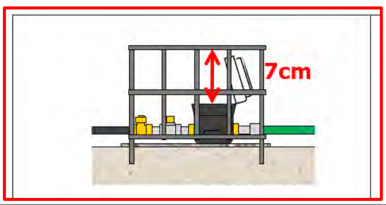


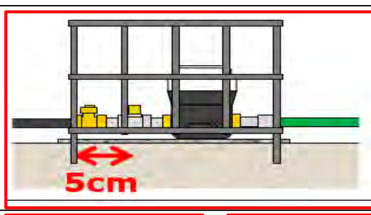
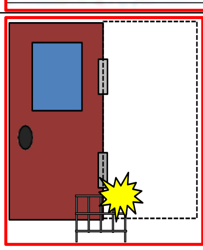
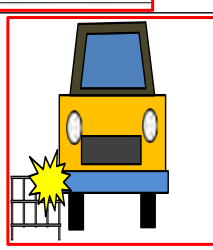
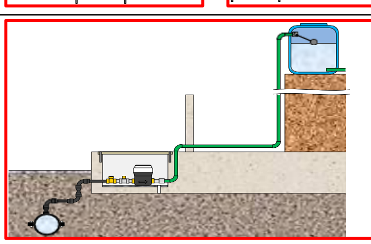
 **Branch**	It should be confirmed that rubber is set at branch point.
	Service connection should be branched directly from water distribution pipe by 1/2" and 90° of bent pipe is used instead of 1/4" ferrule.
 **Service Pipe**	When improving existing service pipe, it is necessary to confirm that pipe comes from WASA's system.
	GI should be selected if pipe is installed above ground. If pipe is installed underground, UPVC/HDPE or non-corrosive pipe & fittings shall be used.
	The pipe should be cut with suitable equipment.

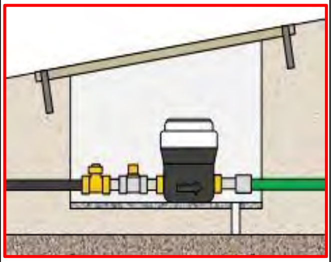
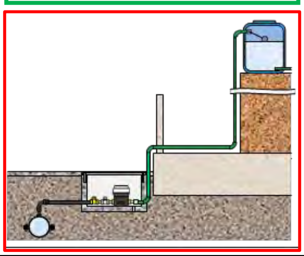
	The cut of the polyethylene pipe must be straight.
	Use of meaningless bend pipe should be avoided.
	Meter should be installed outside of customer's premises within 50cm from boundary and without vehicle load. (If meter is installed inside the customer's premises, it is difficult to read the meter for meter readers because of gate lock or customer absence).

Three types of meter cage for thief prevention measure of meter

Measures to prevent theft of the meter are selected depending on the site situation, but in principle, installation of (1) **MS cage** should be adopted. Under difficult circumstances for various reasons, underground installation such as (2) **Steel lid** or (3) **Concrete Box** will be considered.

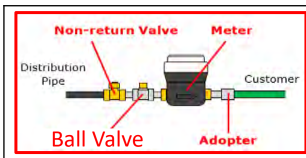
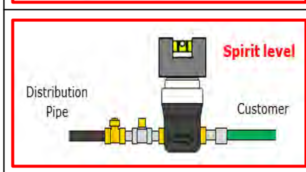
	In principle, MS cage should be selected with concrete base and meter should be installed on the ground.
	MS cage should be installed as left figure.
	For opening the meter cover, 7cm or more of interval is required at the top. At the site, meter cover should be opened and ease of meter reading should be confirmed.

	For opening/closing the magnetic valve, 5cm or more of interval is required around magnetic valve. At the site, valve operation should be carried out and confirmed.
 	When the cage installed on the ground interferes with the opening and closing of the door or the passage of the vehicle, or when the space cannot be secured on the ground, underground installation should be selected for thief prevention measure of meter.
	If there is a concrete part where the lid can be fixed with the anchor, (2) **Steel lid** type should be selected instead of (1) **MS cage** type. The meter installation place is excavated. **Excavation range:** Width20cm x Length30cm x Depth20cm or more. Drainage function should be considered.

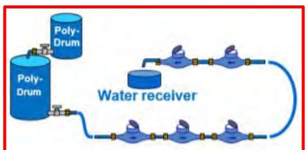
<table>
<tr><td></td><td>Even on a slope, the lid can be installed as the left figure. However, it is necessary to pay attention to the lid installation location so that the anchor does not penetrate.</td></tr>
<tr><td><u>Concrete Box Type</u>
</td><td>If there is no concrete to fix the lid with anchor, (3) Concrete Box Type should be selected for thief prevention measure of meter instead of (2) Steel Lid type.

Drainage function should be considered(Installation of (1) and (2) is considered as much as possible, because (3) is expensive)</td></tr>
</table>

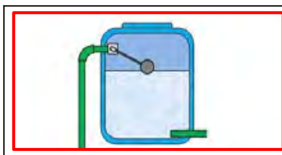
Basics for water Meter Installation

<table>
<tr><td>
</td><td>Piping around the meter consists of non-return valve, Ball valve, meter and adopter.</td></tr>
<tr><td>
</td><td>All water consumption should be captured. It is necessary to confirm that there is no water supply branch upstream of the meter.</td></tr>
<tr><td>
</td><td>Meter should be installed horizontally, therefore horizontal should be confirmed using spirit level etc.</td></tr>
<tr><td>
</td><td>It should be confirmed that the arrow on the side of the meter body with water flow direction.</td></tr>
</table>

Reuse of Existing water Meter

	Whether there is existing meter should be confirmed.
	If customer already has existing meter, meter should be read and recorded and this value should be reported to IT section.
	Removed meter should be brought the meter test yard and checked the accuracy. If meter has good accuracy, WASA can reuse it.
	If test meter is available, you can utilize it.

Storage Tank

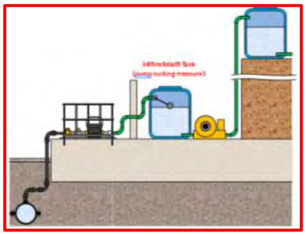
	It should be confirmed whether the customer has a storage tank. If customer has tank, it should be confirmed that the float valve is installed. If not, WASA should instruct customer to install it.

Sucking Pump:

In principle, illegal sucking pump must be removed. If WASA cannot ensure the proper water pressure or customer denies removing it, for countermeasure of illegal pump sucking,

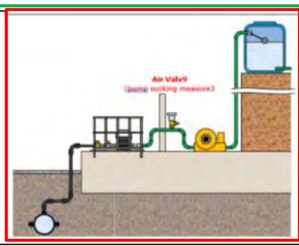
(1) Intermediate Tank or **(2) Air Valve** should be installed.

Intermediate Tank



For one of the countermeasures of sucking pump, intermediate storage tank should be installed between meter and pump. When installing intermediate tank, float valve should be installed.

Air Valve



For another countermeasure of sucking pump, air valve should be installed between meter and pump, and it should be installed at higher position than meter.

It is confirmed that water does not come out from the air valve.

No.	Check items	Check
1	Meter is checked for proper functioning of low-flow dial before installing it.	
2	Meter is horizontally installed with correct flow direction.	
3	Ball valve is installed upstream and non-return valve is installed downstream of meter with no branches upstream of meter.	
4	Illegal sucking pump is not installed*1 and there are no suspected, illegal connections around customer's premises*2.	
5	If customer has storage tank, float valve is installed*3.	
6	Proper water pressure is secured at customer's tap.	
7	Meter is easy to read and remove by WASA maintenance workers.	
8	Meter is not an obstacle to traffic and has theft prevention.	

*1 If not, WASA should instruct and ask the customer to improve the situations (removal of pump/installation of intermediate tank/installation of air valve), and reconfirm later.

*2 If not, WASA should instruct and ask the customer to improve the situations (disconnect the connections) and reconfirm later.

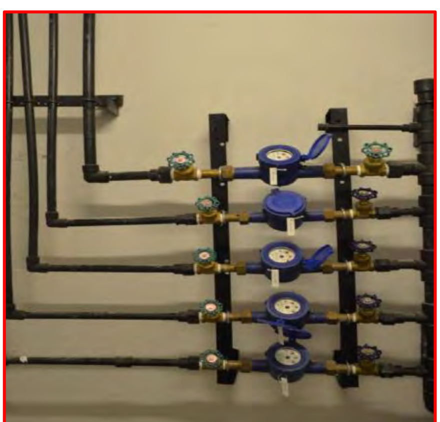
*3 If not, WASA should instruct and ask the customer to improve the situations (installation of float valve) and reconfirm at later date.

Installation of Water Meters

Above the Ground: The advantage is ease of maintenance and easy to read. Air tapping bubbles may occurs

Underground: In many countries it is installed below the floor level In this case meter box is required. Advantage-Reduces air tapping bubbles Disadvantage-High cost, difficult for maintenance

Installation of water Meters



Installation of water meters inside building/Commercial areas

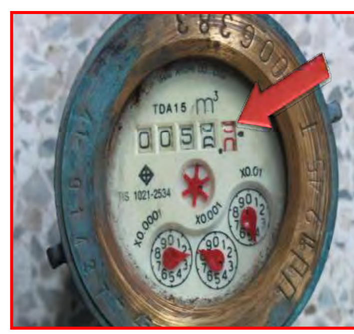
Installation of Water Meters different places

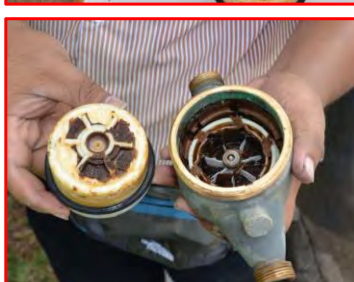
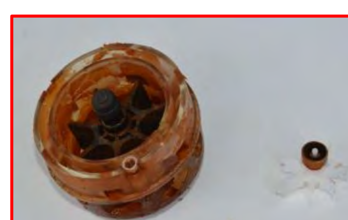





Maintenance of Water Meters(Different Problems)



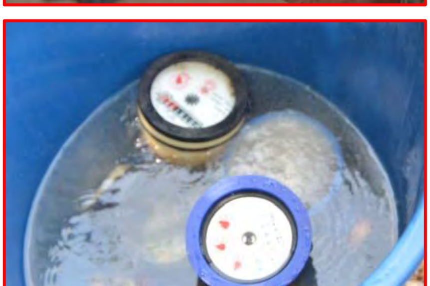


Maintenance of Water Meter(Different Problem)

Maintenance of Different Problems of water Meter

- 



Cleaning(Most of Problems can be solve by Cleaning parts of water meter)

Maintenance of Different Problems of water Meter

Rust Remover activity can also b more useful for maintenance of water meters

Selection of Water Meter

Nominal Size DN(mm)	Class of measurement	Overload Flow-rate Q4(m3/hr)	Permanent Flow-rate Q3(m3/hr)	Transitional Flow -rate Q2(m3/hr)	Minimum Flow-rate Q1(m3/hr)	Minimum Reading Min(m3)	Maximum Reading Max(m3)
15	R80	3.125	2.5	0.05	0.03125	0.0001	99999
	R100			0.04	0.025		
20	R80	5	4	0.08	0.05	0.0001	99999
	R100			0.064	0.04		
25	R80	7.875	6.3	0.126	0.063	0.0001	99999
	R100			0.1008	0.039375		
32	R80	12.5	10	0.2	0.125	0.0001	99999
	R100			0.16	0.1		
40	R80	20	16	0.32	0.2	0.0001	99999
	R100			0.256	0.16		
50	R80	31.25	25	0.5	0.3125	0.0001	99999
	R100			0.4	0.25		

Select
Too Small Water Meter

Easily worn out
-Inaccuracy
-Pressure lost

Select
Too Big Water Meter

-Inaccuracy
-High cost

Other Selection Parameters

- **Material:**

All materials in contact with the water passing through the water meter shall be made of materials which are harmless, non-contaminating and biologically inert.

- **Pressure test:**

The water meter shall conform to the pressure resistance performance.

Leakage and Accuracy Test

Meter error curve

- Water meters are designed for a specific flow rate, which is called as the permanent flow rate or Q3.The meter should be able to work at the permanent flow rate (or a lower flow rate) continuously for its design life without exceeding the permissible error.
- Although a meter is designed for the permanent flow rate, the actual flow through a meter is not constant. Thus, water meters should not only be accurate at the permanent flow rate, but also be accurate over a wide range of flow rates.
- It is useful to draw a graph of a meter's relative error. This curve is called the meter's error curve.

Meter error curve

- Q1 – Minimum flow rate:

The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance (± 5% error).

- Q2– Transitional flow rate:

The flow rate at which the maximum permissible error of the water changes in value from ±5% error to ± 2% error.

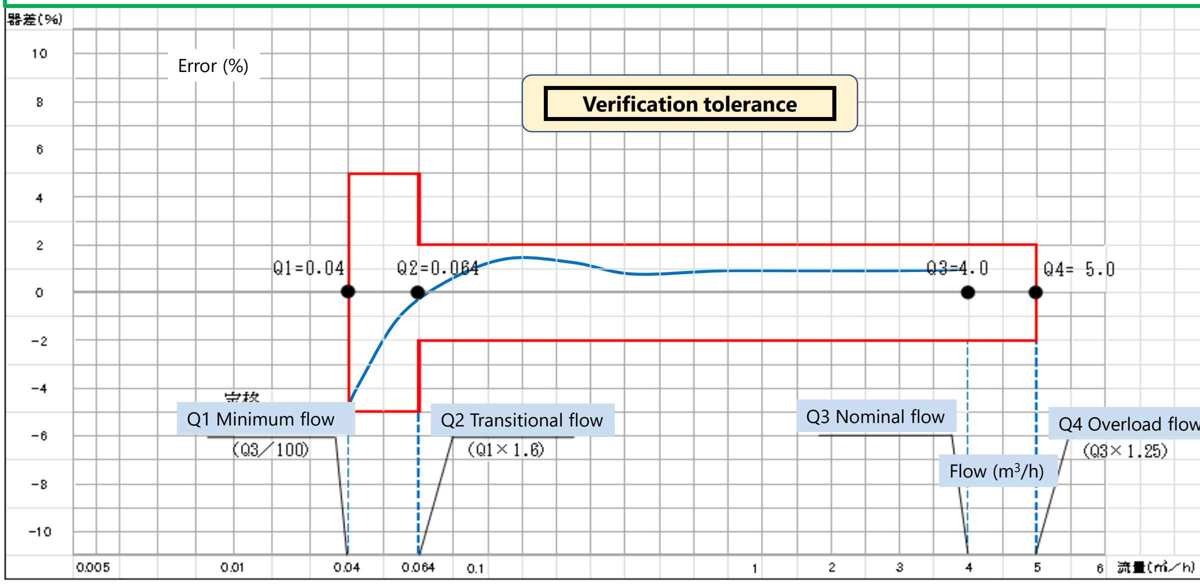
- Q3 – Permanent flow rate:

Permissible continuous load. Half the maximum flow rate (± 2% error).

- Q4 – Maximum flow rate (Overload Flow Rate):

The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period without deteriorating (± 2% error)

METER ERROR CURVE



ISO 4064: 2005 Standardization

- R=100 is the ratio of Normal Flow rate (Q3) the minimum flow rate(Q1).

$$R = \frac{Q3}{Q1} = 100$$

Q1= Qmin(Minimum Flow rate)

Q2= Qt(Transitional Flow rate)

Q3= Qn(Nominal Flow rate)

Q4= Qmax(Maximum Flow rate)

$$\frac{Q4}{Q3} = 1.25$$

$$\frac{Q2}{Q1} = 1.6$$

Definition of meter accuracy

The volume of water that passes through a water meter is called the **actual volume, or Va**.

No meter is 100% accurate, the meter will not register all the water passing through it but show a **indicated volume (Vi),** which is slightly lower or higher than the actual volume.

The difference between the indicated volume and actual volume **(Vi-Va)** is called the meter error. When the error is expressed as a fraction (percentage) of the actual volume, it is called as the relative error.

[Relative error]: (Vi - Va) / Va x 100 (%)

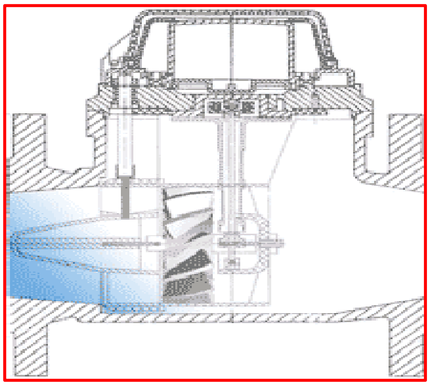
Definition of meter accuracy

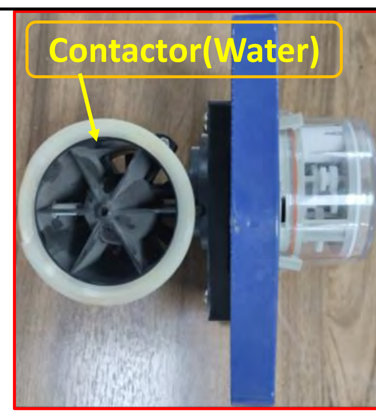
CALCULATION OF THE ERROR (%)

$$\text{Error (\%)} = \frac{\begin{matrix}\text{Indicated Volume} \\ \text{(meter reading result)}\end{matrix} - \text{Actual Volume}}{\text{Actual Water Volume}} \times 100$$

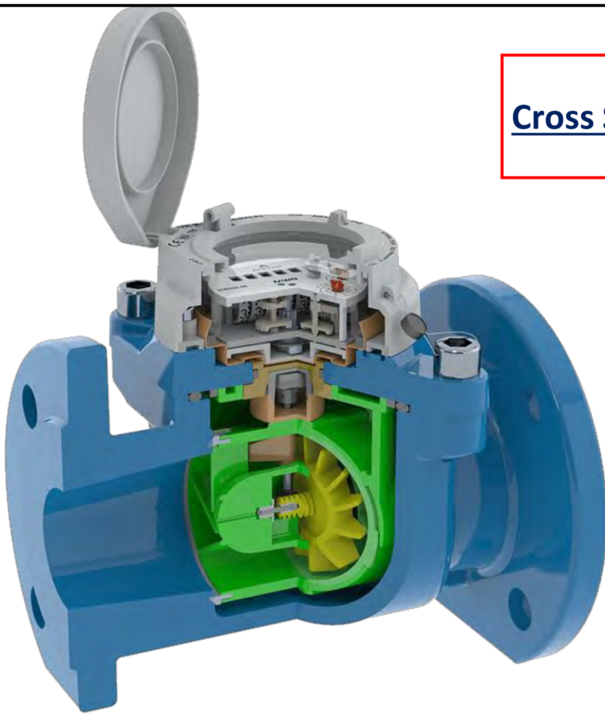
Bulk Flow meter(Woltman)

- The Woltman (Bulk) water meter with magnetic transmission and dry recording head, for measuring applications in water supply networks. A bulk meter is a large meter that we fit to pipes to measure water flow and help us find leaks.



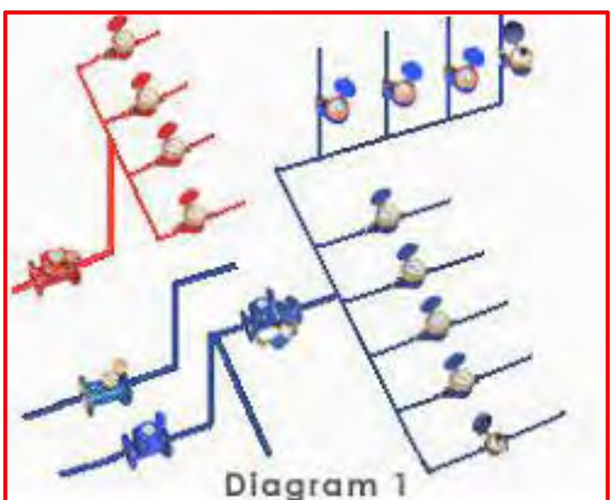


Main Parts of Bulk Water meter

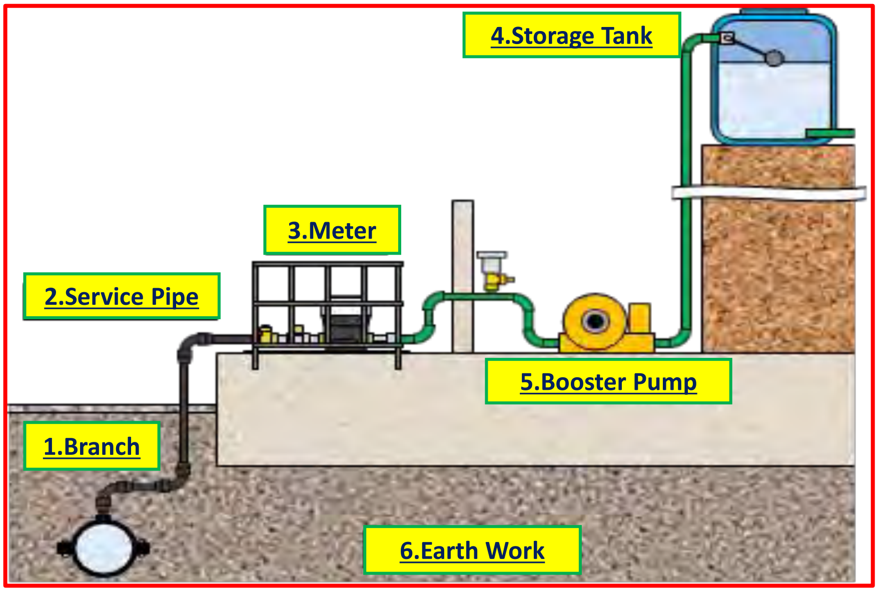


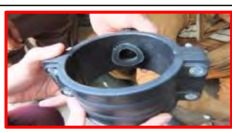
Cross Sectional-View of Woltman(Bulk Meter)

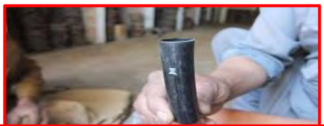
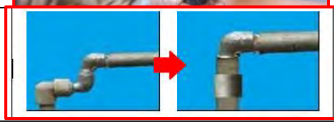
Bulk meter Installation



SOP's for the Installation of Water Meter

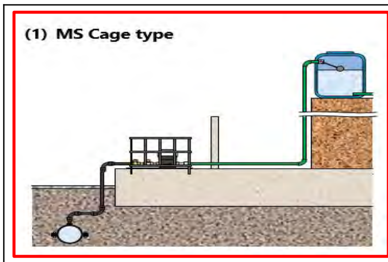
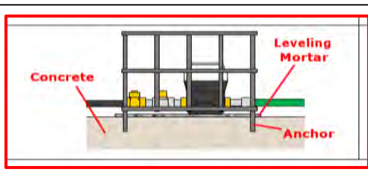
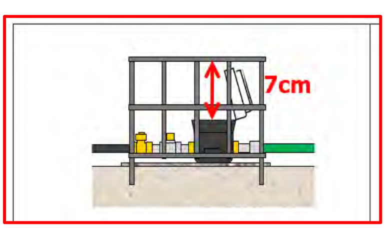


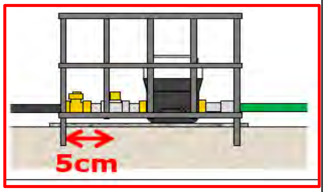
 Branch	It should be confirmed that rubber is set at branch point. اس بات کی تصدیق کی جانی چاہیے کہ ربڑ برانچ پوائنٹ پر سیٹ ہے۔
 Service Pipe	Service connection should be branched directly from water distribution pipe by 1/2" and 90° of bent pipe is used instead of 1/4" ferrule. سروس کنکشن کو پانی کی تقسیم کے پائپ سے براہ راست "2/1 تک برانچ کیا جاتا چاہئے اور "4/1 فیرول کی بجائے 90° جھکا ہوا پائپ استعمال کیا جاتا ہے۔
	When improving existing service pipe, it is necessary to confirm that pipe comes from WASA's system. موجودہ سروس پائپ کو بہتر کرتے وقت یہ تصدیق کرنا ضروری ہے کہ پائپ واسا کے سسٹم سے آیا ہے۔
	GI should be selected if pipe is installed above ground. If pipe is installed underground, UPVC/HDPE or non-corrosive pipe & fittings shall be used. اگر پائپ زمین کے اوپر نصب ہے تو GI کا انتخاب کیا جانا چاہیے۔ اگر پائپ زیر زمین نصب ہے تو، UPVC/HDPE یا نان کوروسیو پائپ اور فٹنگز استعمال کی جائیں گی۔

	The pipe should be cut with suitable equipment and must be straight. پائپ کو مناسب آلات کے ساتھ کاٹا جانا چاہئے اور اسے سیدھا کاٹا جانا چاہئے۔
	Use of meaningless bend pipe should be avoided. پائپ میں بے معنی موڑ کے استعمال سے گریز کیا جائے۔
	Meter should be installed outside of customer's premises within 50cm from boundary and without vehicle load. (If meter is installed inside the customer's premises, it is difficult to read the meter for meter readers because of gate lock or customer absence). میٹر گاہک کے احاطے سے باہر باؤنڈری سے 50 سینٹی میٹر کے اندر نصب کیا جائے اور ٹریفک سے بچیں۔ (اگر میٹر گاہک کے احاطے کے اندر نصب ہے تو گیٹ لاک یا گاہک کی غیر موجودگی کی وجہ سے میٹر ریڈرز کے لیے میٹر کو پڑھنا مشکل ہے)۔

Three types of meter cage for thief prevention measure of meter

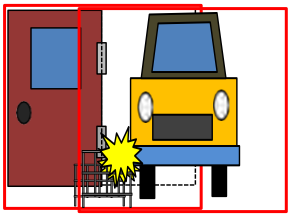
Measures to prevent theft of the meter are selected depending on the site situation, but in principle, installation of (1) **MS cage** should be adopted. Under difficult circumstances for various reasons, underground installation such as (2) **Steel lid** or (3) **Concrete Box** will be considered.

	In principle, MS cage should be selected with concrete base and meter should be installed on the ground. اصولی طور پر، ایم ایس کیج کو کنکریٹ کی بنیاد کے ساتھ منتخب کیا جانا چاہئے اور زمین پر میٹر لگانا چاہئے۔
	MS cage should be installed as left figure. ایم ایس کیج کو اس طرح انسٹال کرنا چاہیے جیسا کہ بائیں تصویر میں دکھایا گیا ہے۔
	For opening the meter cover, 7cm or more of interval is required at the top. At the site, meter cover should be opened and ease of meter reading should be confirmed. میٹر کور کھولنے کے لیے، اوپر 7 سینٹی میٹر یا اس سے زیادہ وقفہ درکار ہے۔ سائٹ پر، میٹر کا احاطہ کھولا جانا چاہیے اور میٹر ریڈنگ میں آسانی کی تصدیق کی جانی چاہیے۔



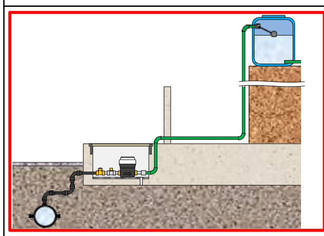
For opening/closing the magnetic valve, 5cm or more of interval is required around magnetic valve. At the site, valve operation should be carried out and confirmed.

مقناطیسی والو کو کھولنے/بند کرنے کے لیے،
مقناطیسی والو کے ارد گرد cm5 یا اس سے زیادہ
وقفہ درکار ہے۔ سائٹ پر، والو آپریشن کیا جانا
چاہئے اور اس کی تصدیق کی جانی چاہئے



Cage installed on the ground can be interferes with the opening and closing of the door or the passage of the vehicle. When meter is not secured on the ground, underground installation should be selected for thief prevention measure of meter.

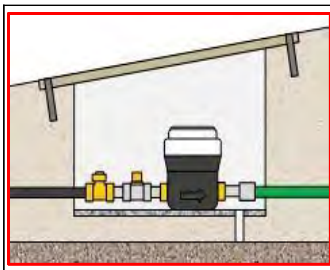
زمین پر نصب پنجرا دروازے کے کھلنے اور بند ہونے
یا گاڑی کے گزرنے میں مداخلت کر سکتا ہے۔ جب میٹر
زمین پر محفوظ نہ ہو تو میٹر کی چوری کی روک تھام
کے لیے زیر زمین تنصیب کا انتخاب کیا جانا چاہیے



If there is a concrete part where the lid can be fixed with the anchor, (2) **Steel lid** type should be selected instead of (1) **MS cage** type.
The meter installation place is excavated

Excavation range:
W 20cm x L 30cm x D 20cm or more.
Drainage function should be considered.

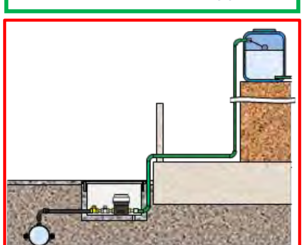
اگر کوئی کنکریٹ کا حصہ ہے جہاں لنگر کے ساتھ
ڈھکن لگایا جا سکتا ہے، (2) سٹیل کی پلیٹ (1)
ایم ایس کیج کی بجائے منتخب کی جائے۔
میٹر کی تنصیب کی جگہ کھدائی کرنی چاہیے۔



Even on a slope, the lid can be installed as the left figure. However, it is necessary to pay attention to the lid installation location so that the anchor does not penetrate.

ڈھلوان پر، ڈھکن بائیں شکل کے طور پر نصب
کیا جا سکتا ہے۔ تاہم، ڈھکن کی تنصیب پر
توجہ دینا ضروری ہے

Concrete Box Type



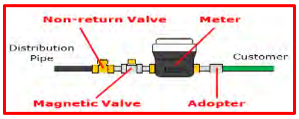
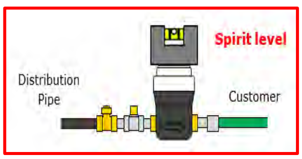
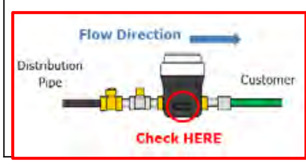
If there is no concrete to fix the lid with anchor, (3) Concrete Box Type should be selected for thief prevention measure of meter instead of (2) Steel Lid type.

اگر پیچ کے ساتھ ڈھکن لگانے کے لیے کوئی
کنکریٹ نہیں ہے، (3) میٹر کی چوری کی روک
تھام کے لیے کنکریٹ باکس کا انتخاب کیا
جانا چاہیے بجائے اسٹیل کے ڈھکن کی قسم۔

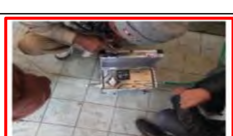
Drainage function should be considered(Installation of (1) and (2) is considered as much as possible, because (3) is expensive)

نکاسی کے فنکشن پر غور کیا جانا چاہئے (1)
اور (2) کی تنصیب پر غور کیا جانا چاہئے۔
جتنا ممکن ہو، کیونکہ (3) مہنگا ہے)

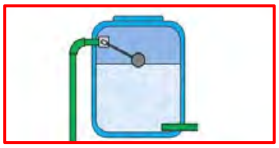
Basics for water Meter Installation

	Piping around the meter consists of non-return valve, Ball valve, meter and adopter. میٹر کے ارد گرد پائپنگ نان ریٹرن والو، بال والو، میٹر اور ساکٹ پر مشتمل ہے
	All water consumption should be captured. It is necessary to confirm that there is no water supply branch upstream of the meter. تمام پانی کی کھپت کو میٹر کیا جانا چاہئے. یہ تصدیق کرنا ضروری ہے کہ میٹر کے اوپر پانی کی فراہمی کی کوئی شاخ نہیں ہونی چاہیے
	Meter should be installed horizontally, therefore horizontal should be confirmed using spirit level etc. میٹر کو افقی طور پر نصب کیا جانا چاہیے، اس لیے اسپرٹ لیول وغیرہ کا استعمال کرتے ہوئے افقی کی تصدیق کی جانی چاہیے۔
	It should be confirmed that the arrow on the side of the meter body with water flow direction. میٹر کو پانی کے بہاؤ کی سمت میں نصب کیا جانا چاہئے اور پانی کے میٹر کے کیس میں بہاؤ کا تیر بھی ہے تاکہ آپ کی رہنمائی ہو سکے۔

Reuse of Existing water Meter

	Either there is existing water meter or not. It should be confirmed. پانی کا میٹر موجود ہے یا نہیں؟ اس کی تصدیق ہونی چاہیے۔
	If customer already has existing meter, meter should be read and recorded and this value should be reported to IT section. اگر گاہک کے پاس پہلے سے ہی میٹر موجود ہے تو میٹر کو پڑھنا چاہیے اور اس کی ریڈنگ کو ریکارڈ کرنا چاہیے اور آئی ٹی سیکشن کو رپورٹ کرنا چاہیے۔
	Removed meter should be brought the meter test yard and checked the accuracy. If meter has good accuracy, WASA can reuse it. ہٹائے گئے میٹر کو میٹر ٹیسٹ یارڈ میں لایا جائے اور درستگی کی جانچ کی جائے۔ اگر میٹر کی درستگی اچھی ہے تو واسا اسے دوبارہ استعمال کر سکتا ہے
	If test meter is available, you can utilize it. اگر ٹیسٹ میٹر دستیاب ہے، تو آپ اسے استعمال کر سکتے ہیں

Storage Tank



If Customer have storage tank. Float valve should be installed in it.

اگر گاہک کے پاس اسٹوریج ٹینک ہے۔ اس میں فلوٹ
والو لگانا چاہیے

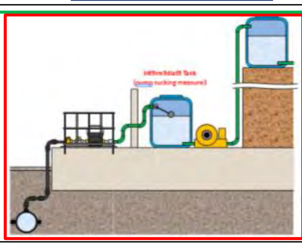
Sucking Pump:

Usually customers used illegal pumps to maintain water pressure that illegal pump must be removed.

عام طور پر صارفین پانی کے دباؤ کو برقرار رکھنے
کے لیے غیر قانونی پمپ استعمال کرتے ہیں۔ اس غیر
قانونی پمپ کو ہٹا دیا جانا چاہیے۔

(1) Intermediate Tank or **(2) Air Valve** should be installed.

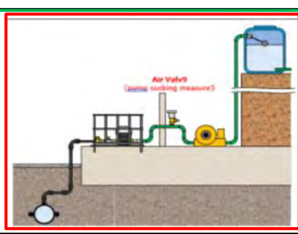
Intermediate Tank



For one of the countermeasures of sucking pump, intermediate storage tank should be installed between meter and pump. When installing intermediate tank, float valve should be installed.

پمپ کے انسدادی اقدامات، میٹر اور پمپ کے
درمیان انٹرمیڈیٹ سٹوریج ٹینک نصب کیا جانا
چاہیے۔ انٹرمیڈیٹ ٹینک نصب کرتے وقت، فلوٹ
والو نصب کیا جانا چاہئے

Air Valve



For another countermeasure of sucking pump, air valve should be installed between meter and pump, and it should be installed at higher position than meter.

پمپ کے انسداد کے لیے، ایئر والو کو میٹر اور پمپ
کے درمیان نصب کیا جانا چاہیے، اور اسے میٹر سے
اونچی پوزیشن پر نصب کیا جانا چاہیے

Their should be no leakage from air release valve.

چیک کریں، ایئر ریلیز والو سے پانی کا رساو
نہیں ہونا چاہیے

No.	Check items	Check
1	Check meter proper functioning at low-flow dial before installing it. واٹر میٹر کو انسٹال کرنے سے پہلے اسے کم بہاؤ پر کام کرنے کی جانچ کریں	
2	Meter is horizontally installed with correct flow direction. میٹر افقی طور پر درست بہاؤ کی سمت کے ساتھ نصب ہے	
3	Ball valve is installed upstream and non-return valve is installed downstream of meter with no branches upstream of meter. بال والو کو اپ اسٹریم پر نصب کیا جانا چاہئے اور میٹر کے بعد نان ریٹرن والو انسٹال کیا جانا چاہئے۔ میٹر سے پہلے کوئی برانچ لائن پائپ موجود نہیں ہونا چاہیے	
4	Illegal sucking pump is not installed and there are no suspected. illegal connections around customer's premises. غیر قانونی پمپ نہیں لگانا چاہیے، گاہک کے احاطے کے ارد گرد کوئی مشتبہ اور غیر قانونی پانی کے کنکشن نہیں ہونا چاہیے۔	
5	If customer has storage tank, it should have float valve. اگر گاہک کے پاس اسٹوریج ٹینک ہے تو اس میں فلوٹ والو ہونا چاہیے	
6	Check water pressure at customer's tap. گاہک کے نل پر پانی کا دباؤ چیک کریں	
7	Meter is easy to read and remove by WASA maintenance workers. کیا میٹر پڑھنا آسان ہے اور اسے واسا کے مینٹیننس ورکرز ہٹا سکتے ہیں	
8	Is meter is not being an obstacle to traffic and have meter prevention being theft کیا میٹر ٹریفک کی راہ میں رکاوٹ نہیں ہے اور میٹر چوری ہونے کی روک تھام ہے	

Water & Electricity Consumption

BEFORE TURN ON T.W:

- Note the reading of bulk flow meter

- Note the reading of Electricity meter

AFTER TURN OFF T.W:

- Note the reading of bulk flow meter

- Note the reading of Electricity meter

CALCULATION

- For Example:

Water produced = 300 m3

Electricity = 10 kwh (10 units)

Time = 30 min

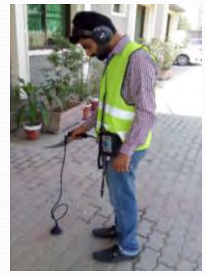
Per unit water produced = 300/10 = 30 m3

Per minute water produced = 30/30 = 1 m3

End Result:

So we are generating 1000 liters in one minute by consuming 1 kw power

- Acoustic Rod
- Acoustic Leak Detector

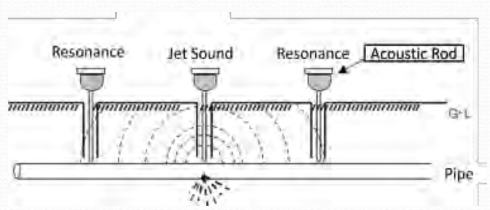


Acoustic Rod/Stick

Specification				
Type	**Cap dia.* Thickness (mm)**	**Total Length (mm)**	**Dia. of Iron Bar (mm)**	**Material**
LSP-1	ø 67x29	1,013	7	Stainless Steel

Use:

- Place the tip of acoustic rod at the point where doubt of leakage
- Catch the stick below the listening cap and place ear on the cap of acoustic rod
- Hear the sound of leaked water, if no leakage at that place repeat the same procedure aside this place
- Very useful to listen leaks sound at hydrants and valves



Factors affecting performance:

- Pressure
- Depth

Leak Detector

Operation:

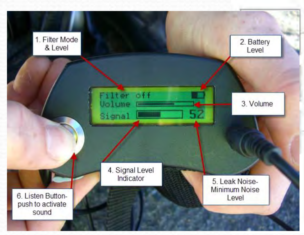
- Use head phones remember Left and Right direction.
- Turn volume up to half using the dial on the headphone cable.
- Ensure good contact of microphone and surface area.
- Press and hold silver button to listen sound.
- With every press and release of the silver button the noise level will be recorded in the memory.
- To see memory data for the last eight soundings, press and hold the "M" button on the amplifier.
- To turn filter on press and hold the sky blue + & - filter buttons simultaneously. The filter bandwidth is +/- 100Hz.

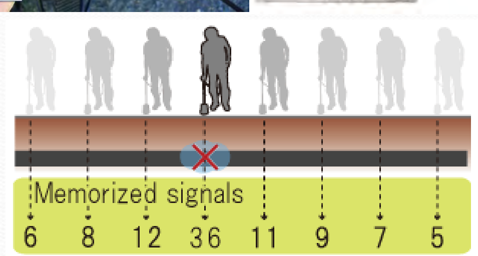
Components:

- Amplifier with waist belt
- Hand probe microphone
- Ground microphone plate
- Probe rods
- Stereo headphones
- Connecting cable

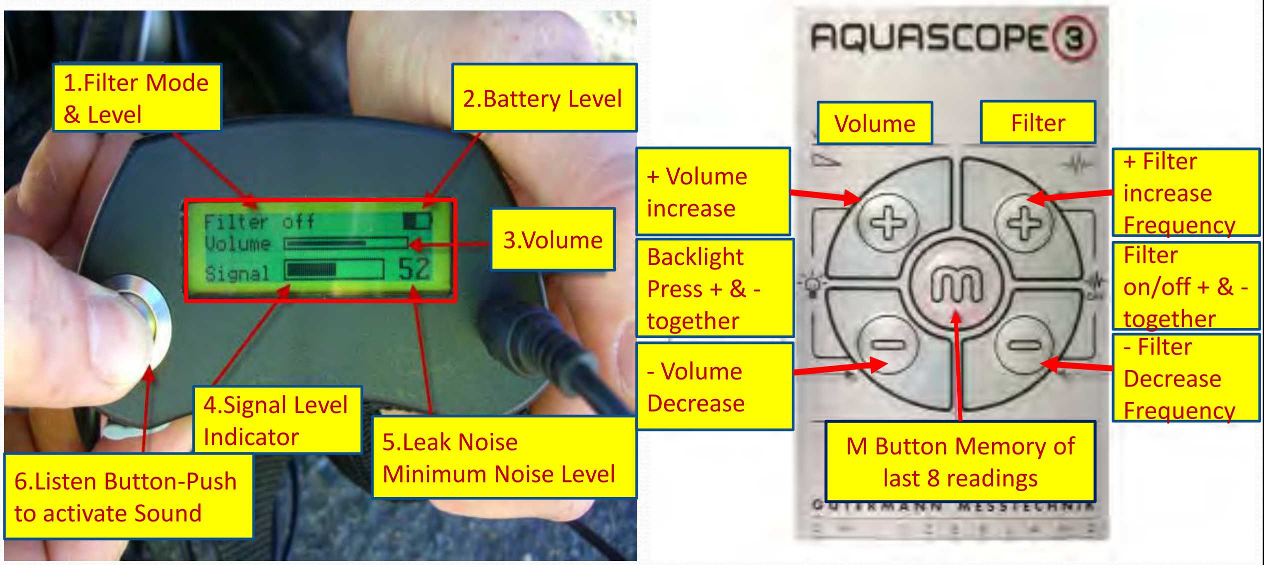
Leak Detector
Important Points & Precautions

- Use filter in case high background noises
- Leakage sound depends upon,
  - Water pressure
  - Crack or hole size
- Operator should stay stable during its use
- Required practice to pinpoint or identify leaks
- Don't use in rainy days and when speed is 6 m/s.
- Sensors are water resistant, but control unit and head phones are not resistive. Keep them away from water .





Use of Leak Detector



Understanding Leak Noise-Leak Frequency

Pipe Material	Frequency Range	Normal Frequency
Steel	400 Hz – 1500 Hz	800 Hz
Iron	300 Hz – 1200 Hz	700 Hz
Copper	700 Hz – 2500 Hz	1800 Hz
AC	300 Hz – 800 Hz	500 Hz
Lead	200 Hz – 700 Hz	400 Hz
PVC	200 Hz – 500 Hz	300 Hz
Polyethylene	100 Hz – 400 Hz	250 Hz

Factors Affecting Leak Noise

- Pipe Material (Hard is good - Soft is poor)
- Pipe Diameter (Small is good – Large is poor)
- Pressure (High is good – Low is poor)
- Background Noise can muffle or drown out leak noise (PRV's - throttled valves)
- Consumption (High levels of consumption can make it hard to hear the leak and you may have to return at low consumption times)

The best time to perform acoustic leak detection is when all these factors are at a minimum except for pressure, at a maximum

Recognizing Leak Noise

Track 1. No Leak Noise

Characteristics ,Normal flow in a steel pipe

Recognizing Leak Noise

Track 2. A Meter Turning fast then slow

Characteristics ,Normal flow in a Copper Service

Recognizing Leak Noise

Track 3. Steel Leak Noise

Characteristics are Clear, Mid Frequency and Loud

Recognizing Leak Noise

Track 4. PVC Leak Noise

Characteristics are Muffled, Low Frequency and Quiet

Recognizing Leak Noise

Track 5. Copper Leak Noise

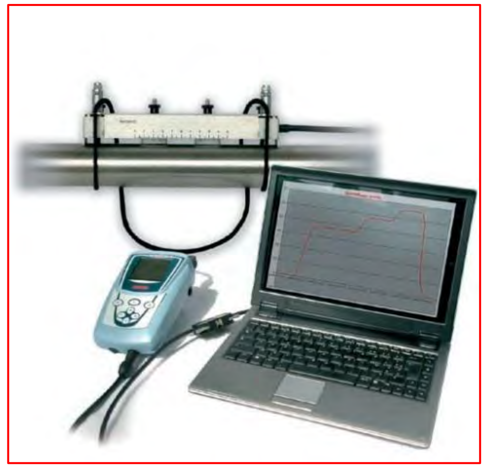
Characteristics are Clear, High Frequency and Loud

Recognizing Leak Noise

Track 6. Cast Iron Leak

Ultrasonic Flow Meter

Contents:



What Is Ultrasonic Flow Meter?

- Ultrasonic flow meter is a device to use measure the volume of flow per time.
- Portable ultrasonic flow meter is suitable for all conductive and non-conductive liquids such as water, chemicals, toxic media, hydrocarbons, etc.

Formula of Flow Rate:

- Q=V/t
- Q=Flow Rate
- V=Volume
- t=Time

- Unit

m3/hr, Cusec, Gpm

Working Principle

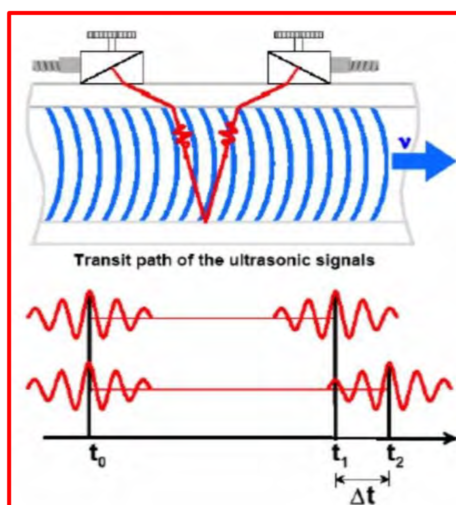
Ultrasonic technology(time of flight) to calculate the flow Velocity and volumetric flow rate of liquid. The flow meter Consist of two transducers that alternately send and receive ultrasonic signals to measure the flow rate.

Transducers/Probes

Ultrasonic Flow meter

Working Principle

The transit time difference between the transmitted and Received ultrasound signal. The difference in transit time Is a direct measure of liquid flow rate.



Advantages of Ultrasonic Flow meter

- 100% non-contact flow measurement (no liquid contact)
- Zero pressure drop created
- No moving parts and no wear and tear of flow transducers - long service life (+10 years)
- No re-calibration required - zero measurement drift
- No risk of pipe leaks - sensors installed externally on the pipe
- Suitable for a wide pipe size range - adaptable to future plant upgrades or pipe replacements
- Modular design - easy sensor and transmitter replacement requiring no system shutdown
- Accurate and repeatable: normally ±1..3% (±0.5..1% possible with advanced calibration)
- Easy installation and virtually zero maintenance costs
- Can measure conductive or non-conductive liquids
- Independent of liquid temperature, pressure, chemical properties, and viscosity.

Limitations

•Effected by concentration levels of suspended solids and aeration in the liquid (maximum allowable concentration 5%...10%).

•Highly affected by pipe condition (internal or external pipe rust, uneven surface etc.)

•Not as accurate as in-line meters such as magnetic or turbine meters.

•Accuracy highly affected by incorrect pipe dimensions and parameters.

Before Use of Ultrasonic Flow meter

- Before Using Ultrasonic flow meter we have to following basic information about,

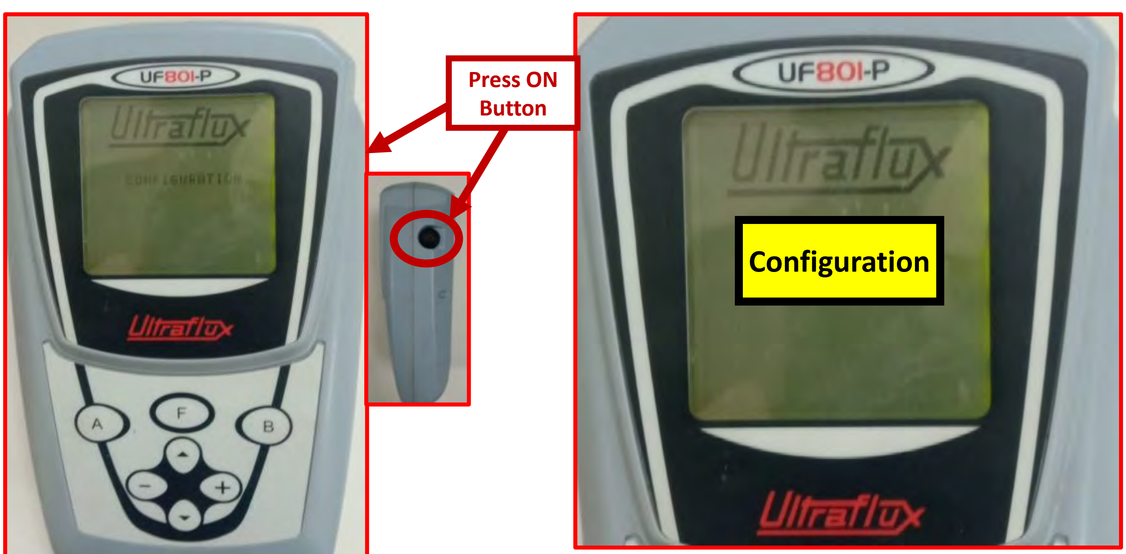
➢ Information of pipe material
➢ Diameter of Pipe
➢ Thickness of Pipe wall

Thickness of Pipe wall

Circumference of Pipe

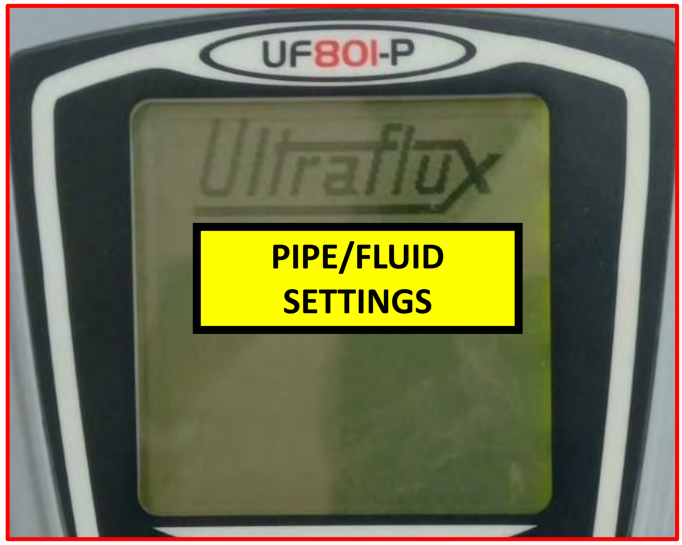
Use of Ultrasonic Flow Meter

- **After switching ON the ultrasonic flow meter press "F" button.**



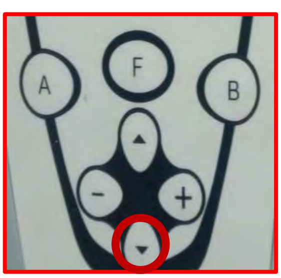
Use of Ultrasonic Flow Meter

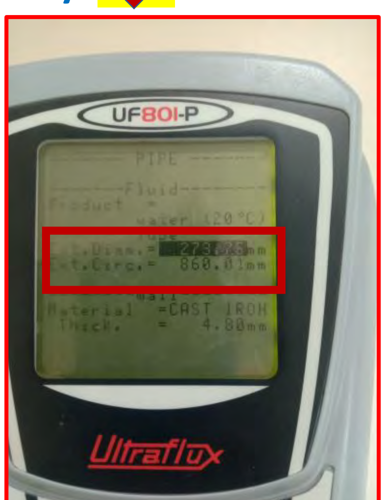
- Again Press **“F”** its showing pipe fluid setting.

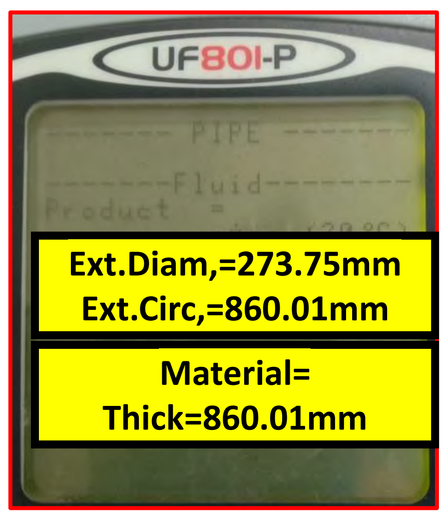


Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.







- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

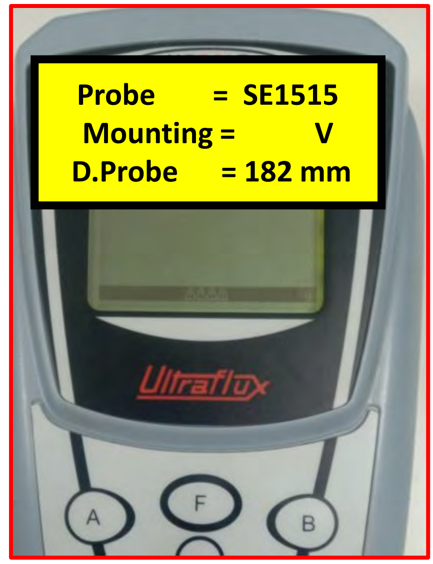
- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Use of Ultrasonic Flow Meter

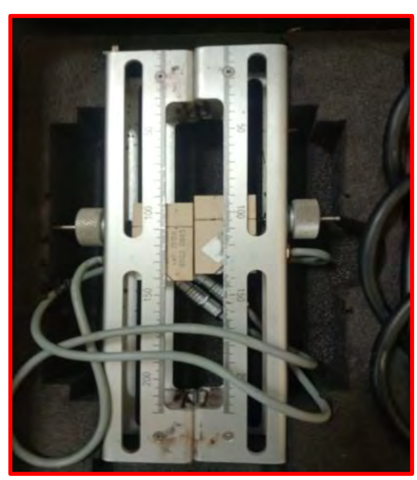
- **Press and hold "F"** and its show probe distance and type of probes.



- Flow rate in m3/hr will be shown.

Use of Ultrasonic Flow Meter

- **Probes**
- For up to 100mm, use single probe, for more than 100mm, use double probe.



EPANET Software

HYDRAULLIC MODELING

Application for Modeling Drinking Water Distribution Systems

What is EPANET

- EPANET performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks.
- Pipe network consists of pipes, nodes (pipe junctions), pumps, valves, storage tanks and reservoirs.
- EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank.
- EPANET use for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

How to Download

https://www.epa.gov › water-research › epanet

EPANET | US EPA

01-Feb-2022 — EPANET is **a software application used throughout the world to model water distribution systems**. It was developed as a tool for understanding ...

Software, Compatibility, and... · Capabilities · Applications

People also search for

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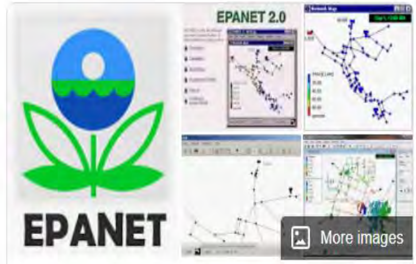
People also ask

What is EPANET software used for?



EPANET

System software

EPANET is a public domain, water distribution system modeling software package developed by the United States Environmental Protection Agency's Water Supply and Water Resources Division. Wikipedia

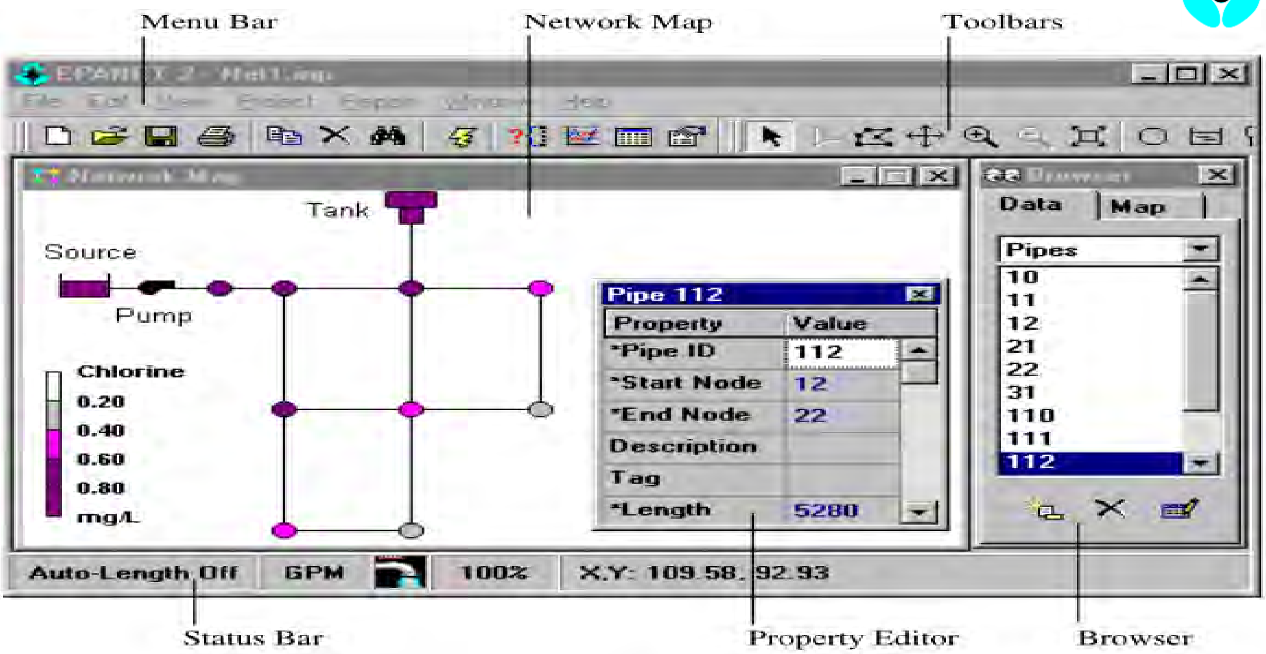
Download Software

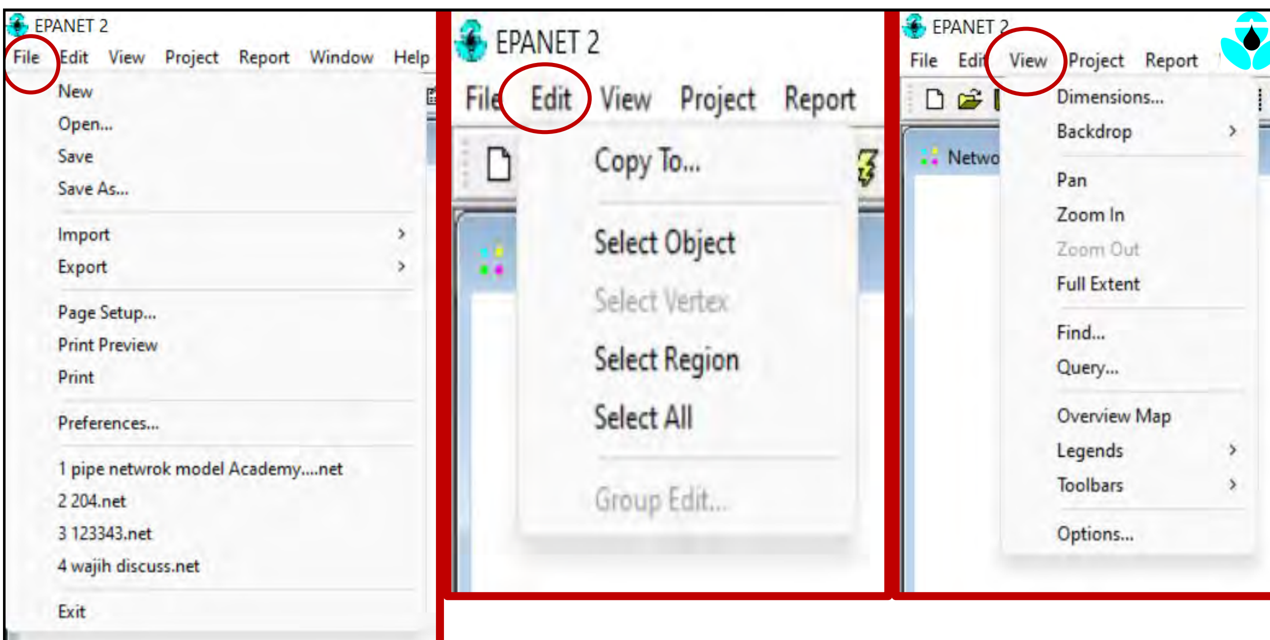
- EPA's GitHub site for EPANET 2.2 open source project

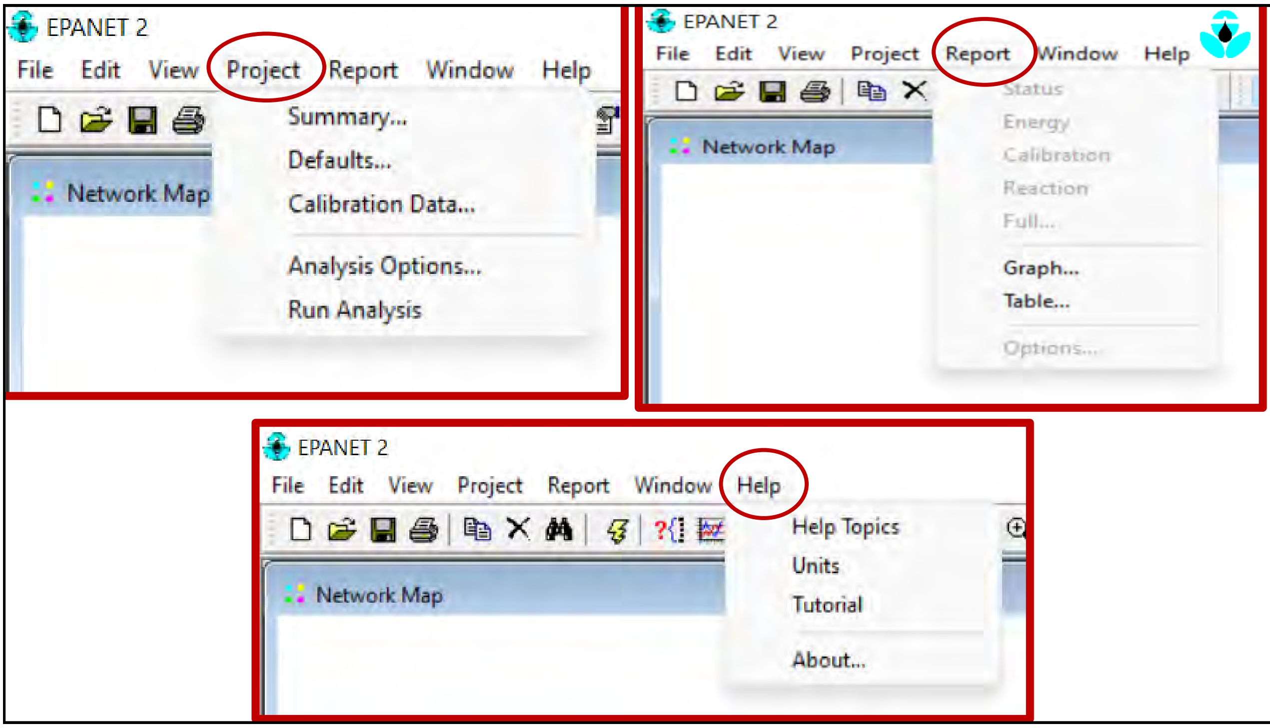
Software

Date	Description
07/23/2020	Self-Extracting Installation Program for EPANET 2.2 (EXE) (3.5 MB)
07/23/2020	Non-Installing Software for EPANET 2.2 (ZIP) (2.84 MB)
10/01/2018	Self-Extracting Installation Program for EPANET 2.00.12 (EXE) (exe)

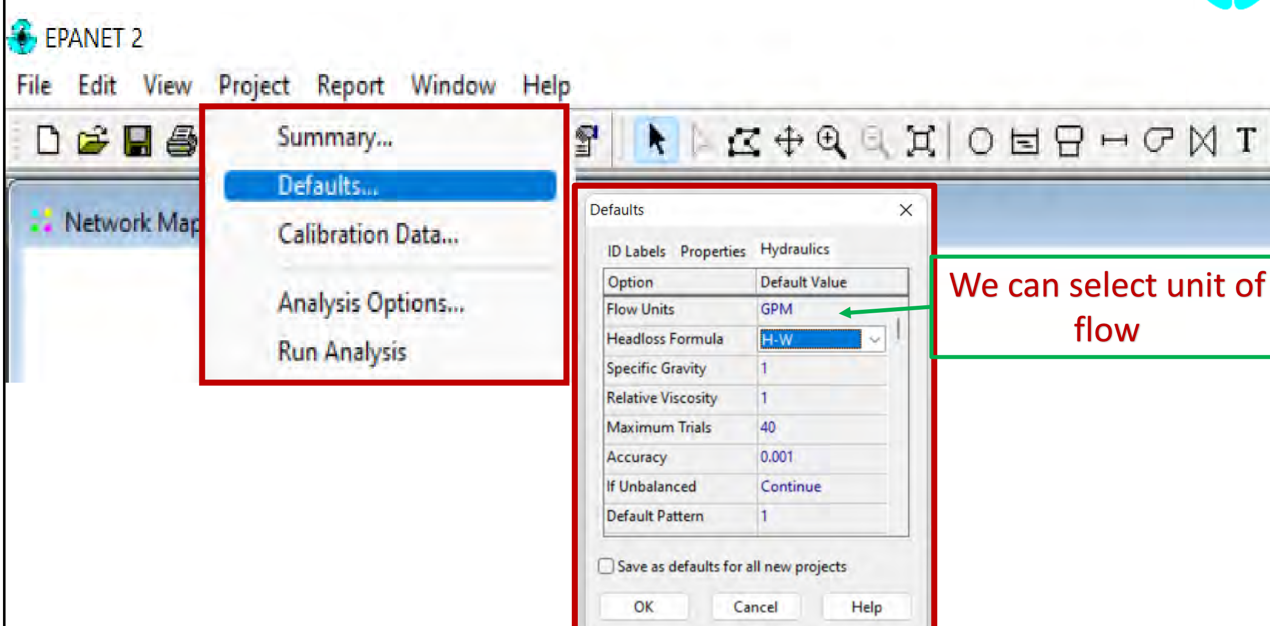
Interface


Menu Bar
Network Map
Toolbars
Tank
Source
Pump
Chlorine
0.20
0.40
0.60
0.80
mg/L
Pipe 112
Property
Value
*Pipe ID
112
*Start Node
12
*End Node
22
Description
Tag
*Length
5280
Data
Map
Pipes
10
11
12
21
22
31
110
111
112
Auto-Length Off
GPM
100%
X,Y: 109.58, 92.93
Status Bar
Property Editor
Browser

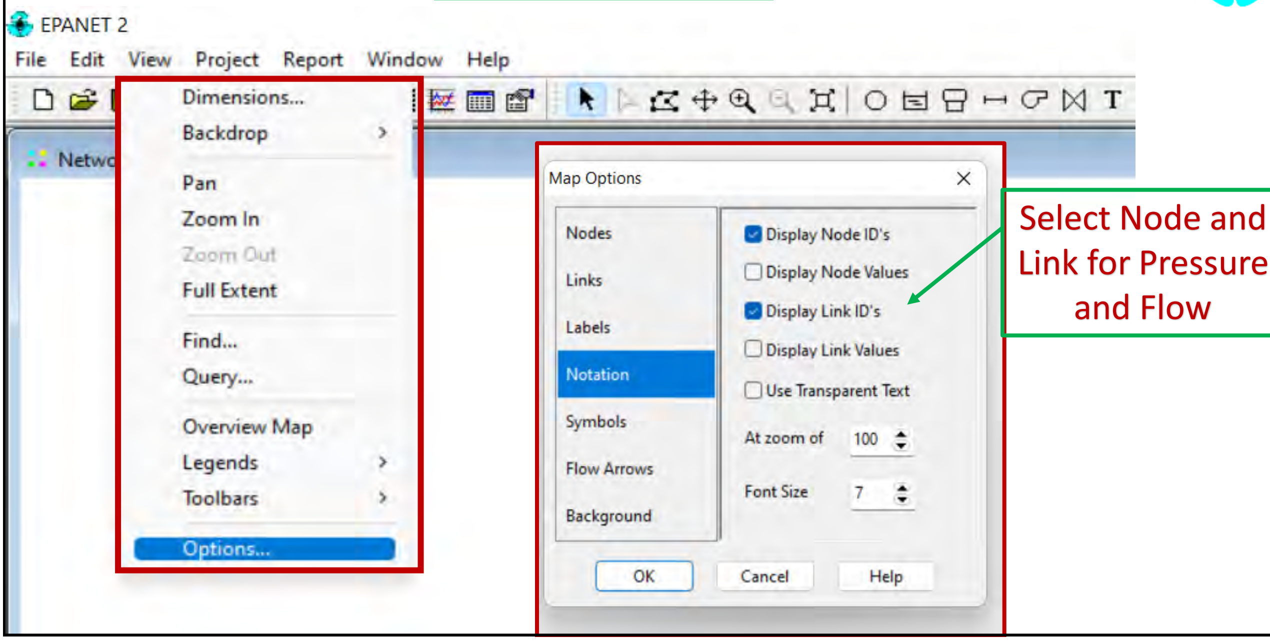

EPANET 2
File
Edit
View
Project
Report
Window
Help
New
Open...
Save
Save As...
Import
Export
Page Setup...
Print Preview
Print
Preferences...
1 pipe netwrok model Academy....net
2 204.net
3 123343.net
4 wajih discuss.net
Exit
EPANET 2
File
Edit
View
Project
Report
Copy To...
Select Object
Select Vertex
Select Region
Select All
Group Edit...
EPANET 2
File
Edit
View
Project
Report
Dimensions...
Backdrop
Pan
Zoom In
Zoom Out
Full Extent
Find...
Query...
Overview Map
Legends
Toolbars
Options...



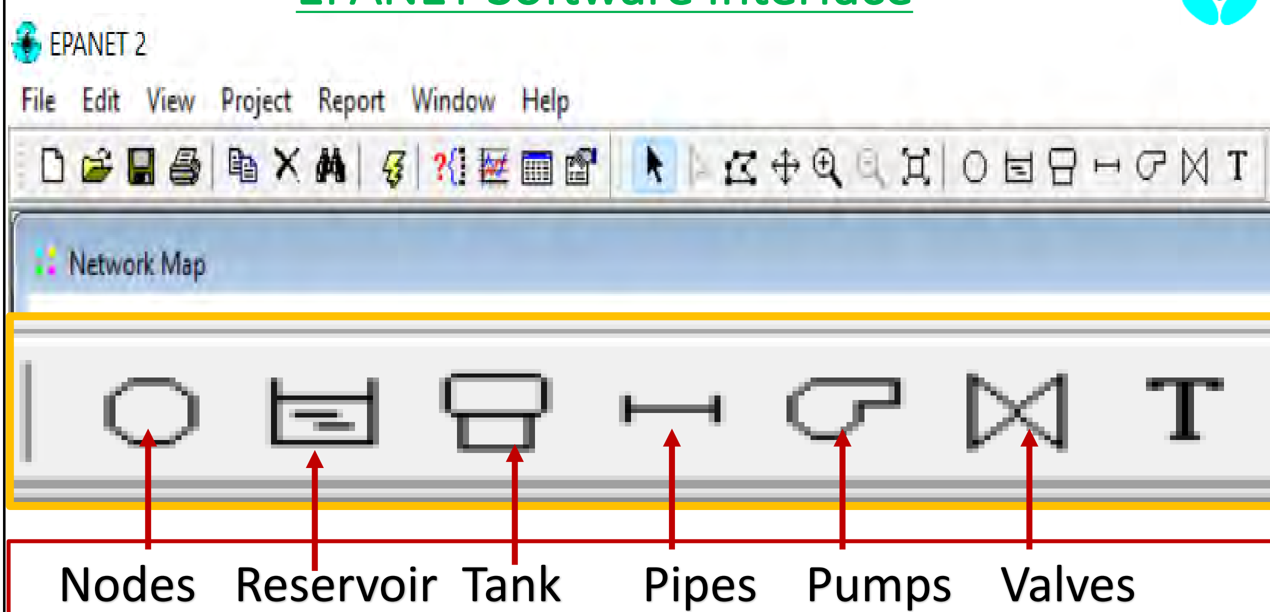
Use of EPANET



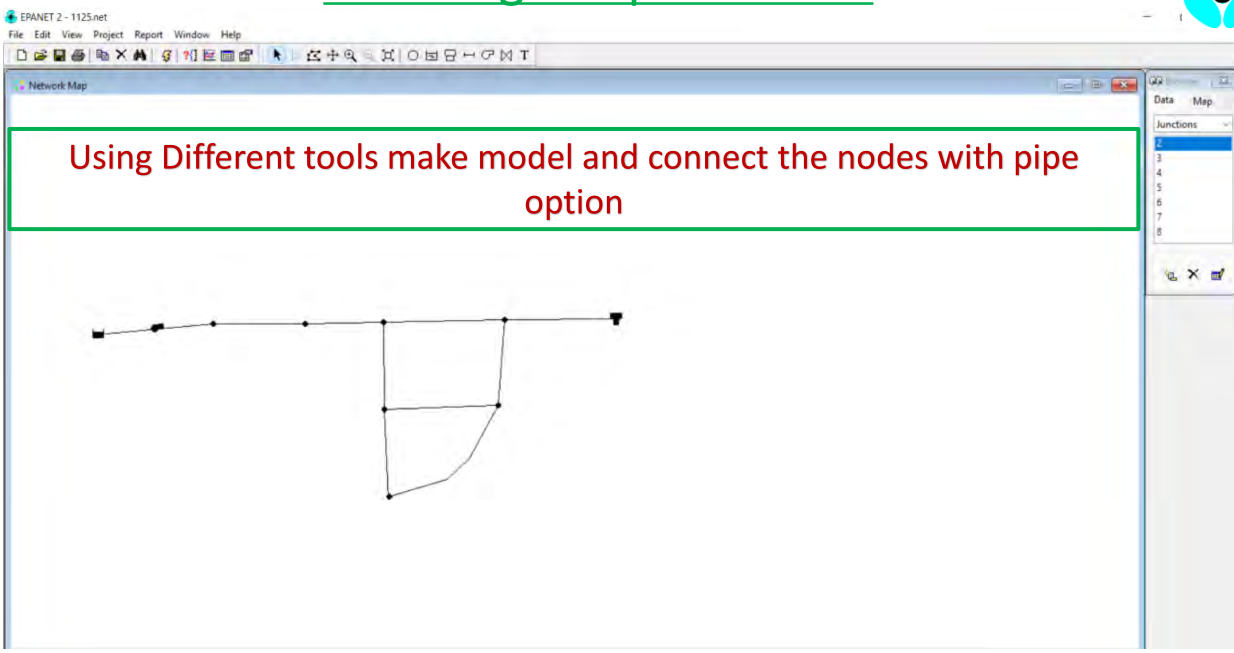
Use of EPANET

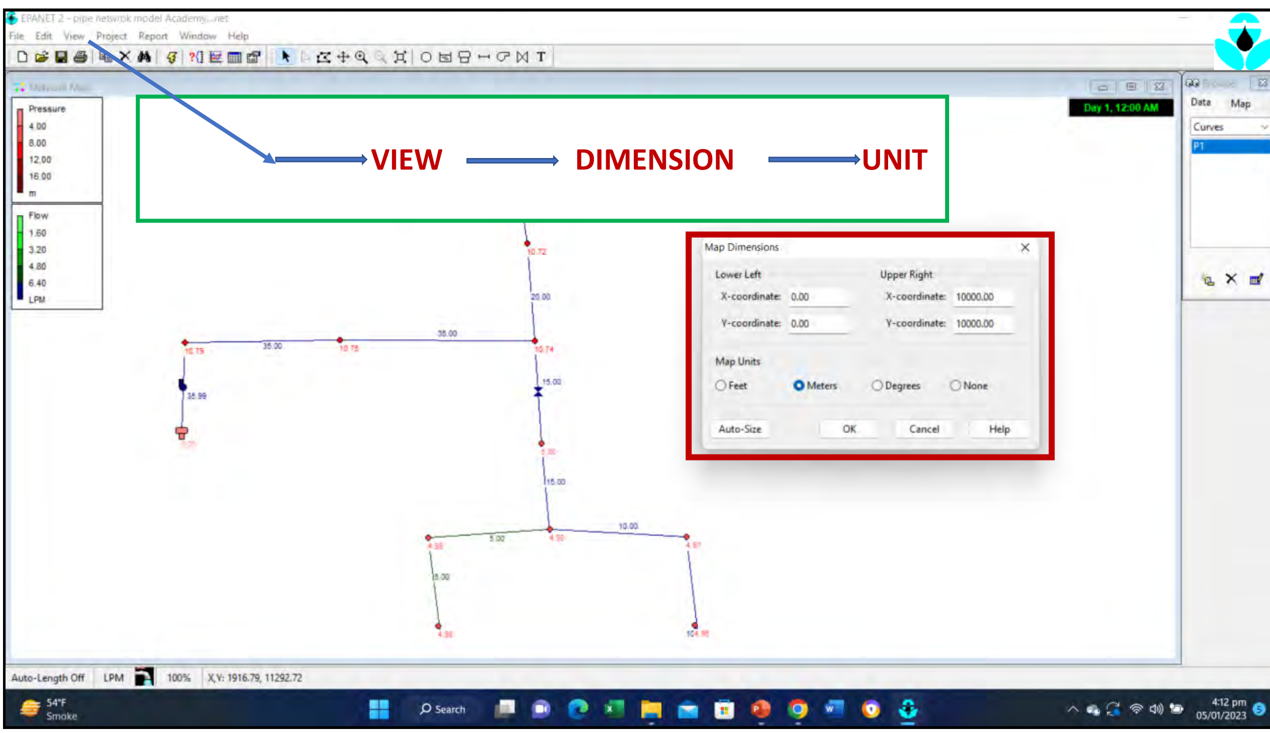


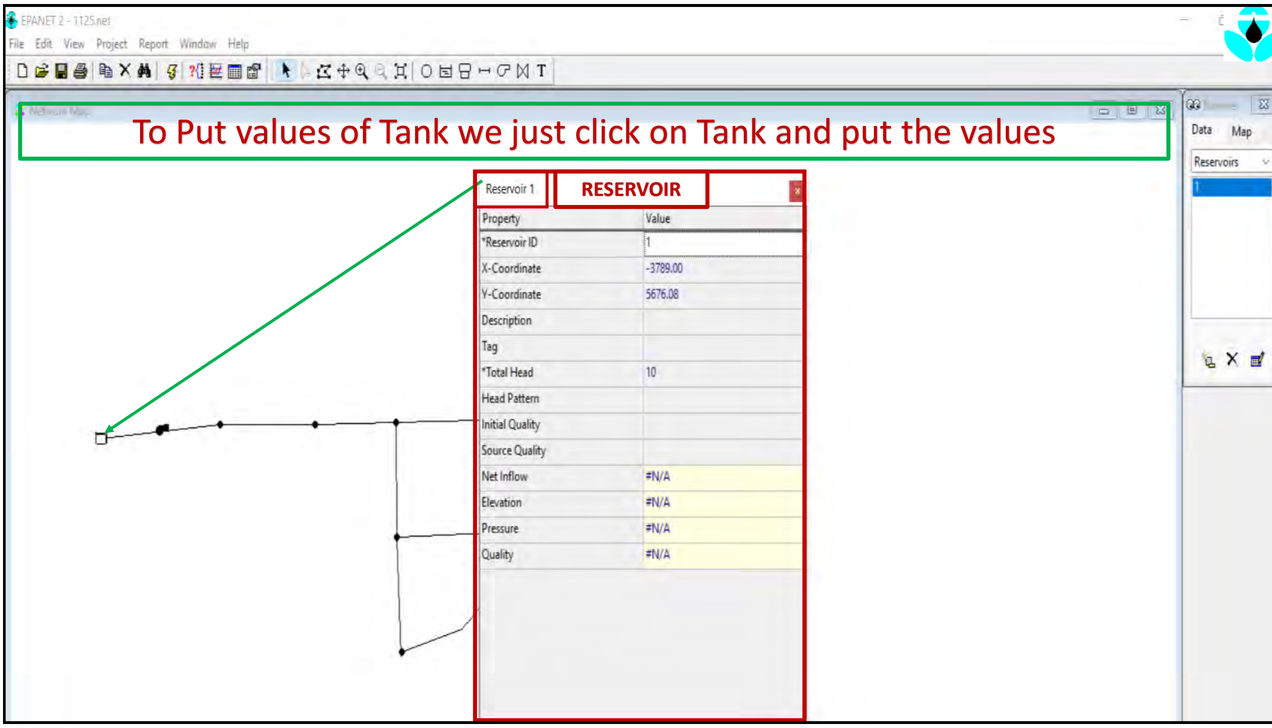
EPANET Software Interface

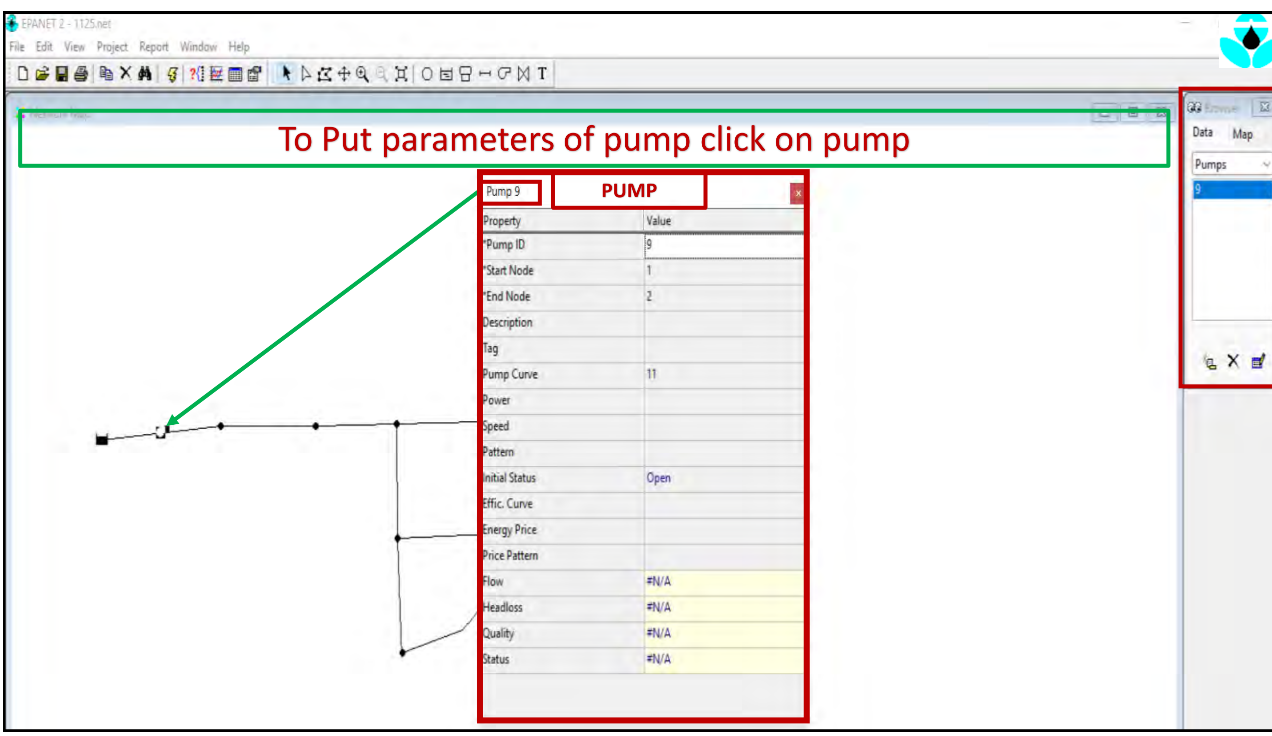


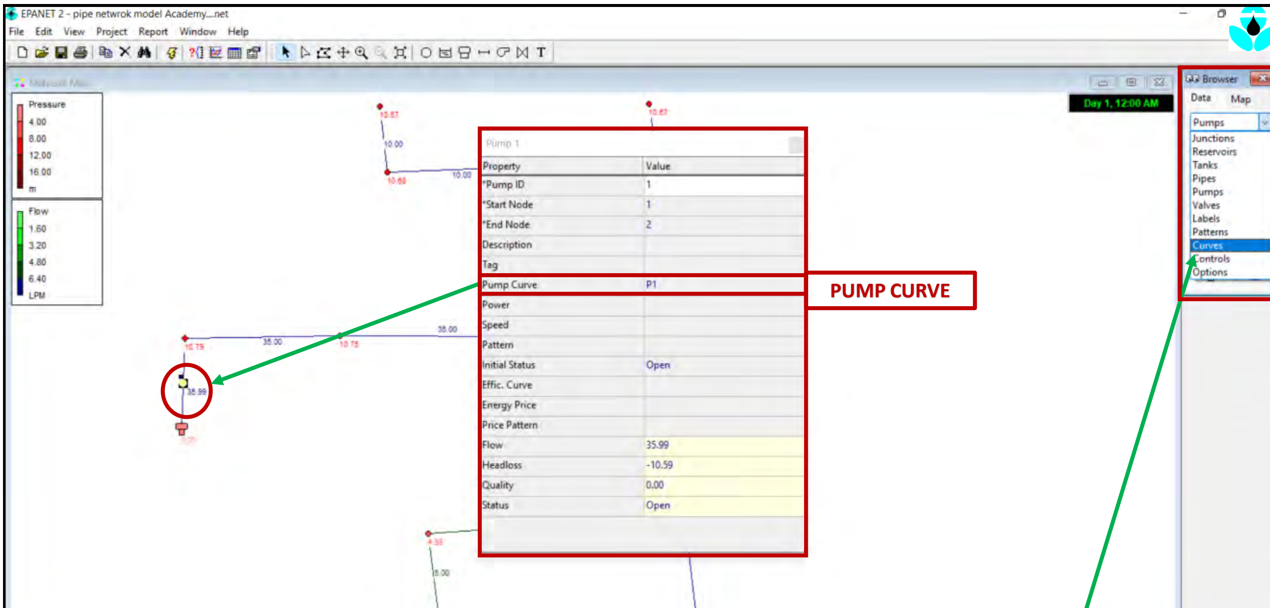
Modeling of Pipe Network



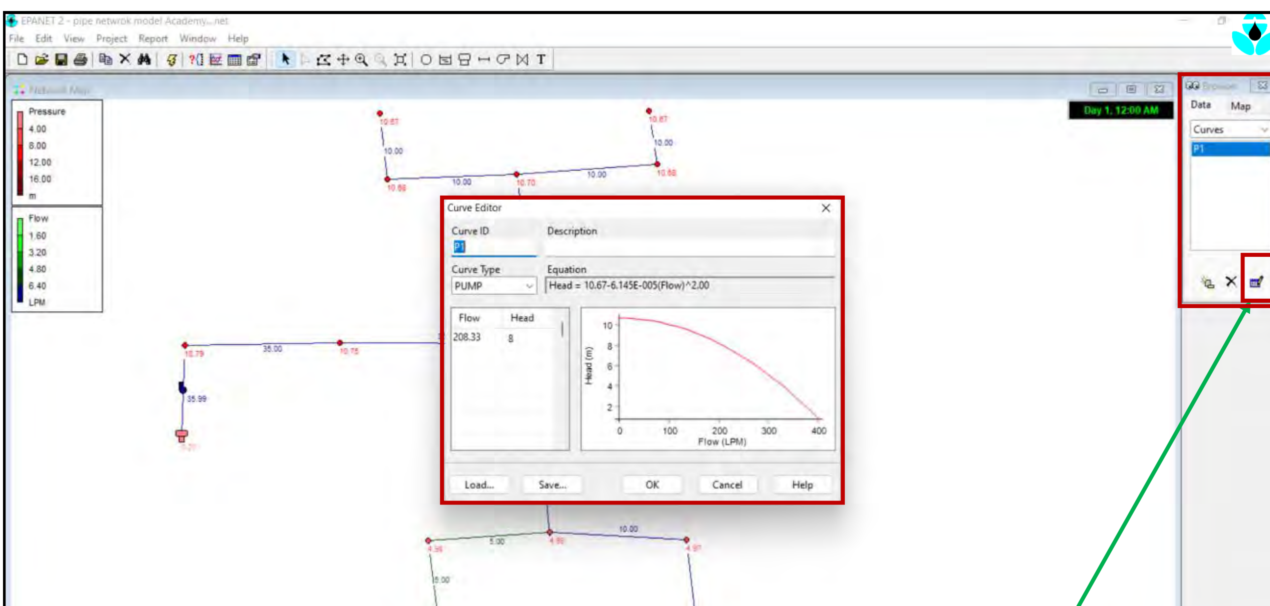



EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put values of Tank we just click on Tank and put the values
Reservoir 1
RESERVOIR
Property Value
*Reservoir ID 1
X-Coordinate -3789.00
Y-Coordinate 5676.08
Description
Tag
*Total Head 10
Head Pattern
Initial Quality
Source Quality
Net Inflow #N/A
Elevation #N/A
Pressure #N/A
Quality #N/A
Data Map
Reservoirs

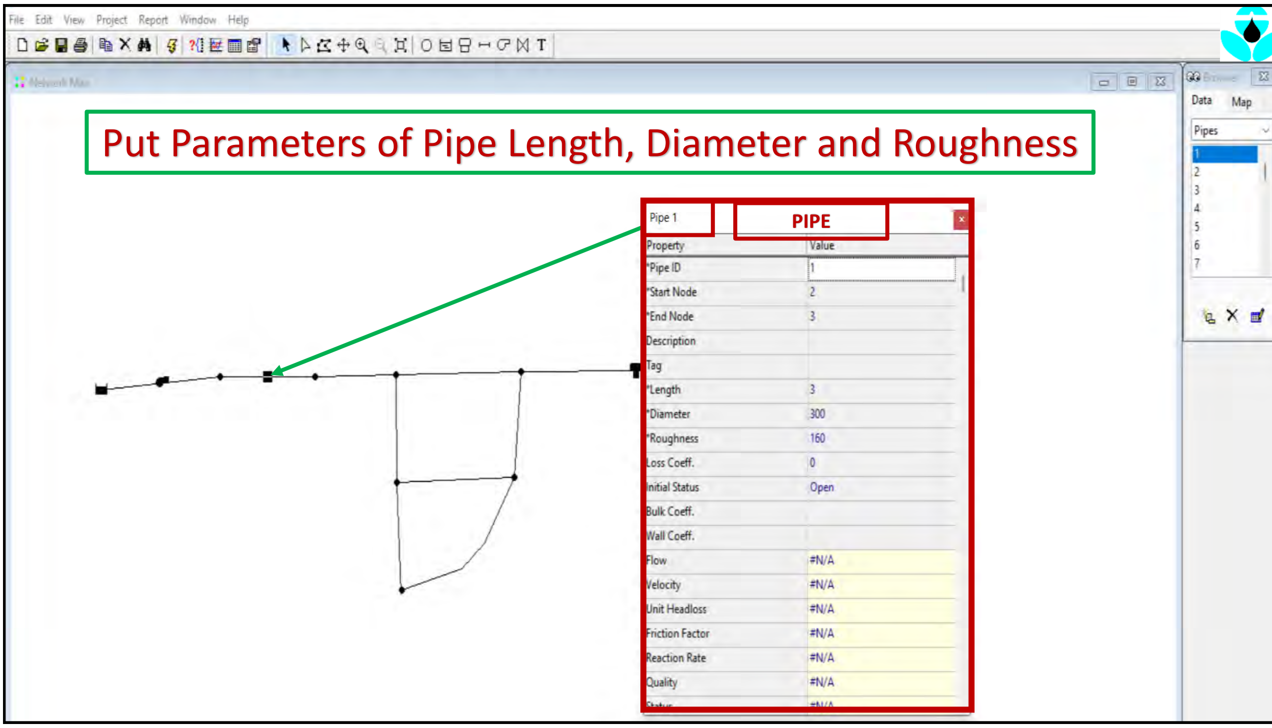

EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put parameters of pump click on pump
Pump 9
PUMP
Property Value
*Pump ID 9
*Start Node 1
*End Node 2
Description
Tag
Pump Curve 11
Power
Speed
Pattern
Initial Status Open
Effic. Curve
Energy Price
Price Pattern
Flow #N/A
Headloss #N/A
Quality #N/A
Status #N/A
Data Map
Pumps

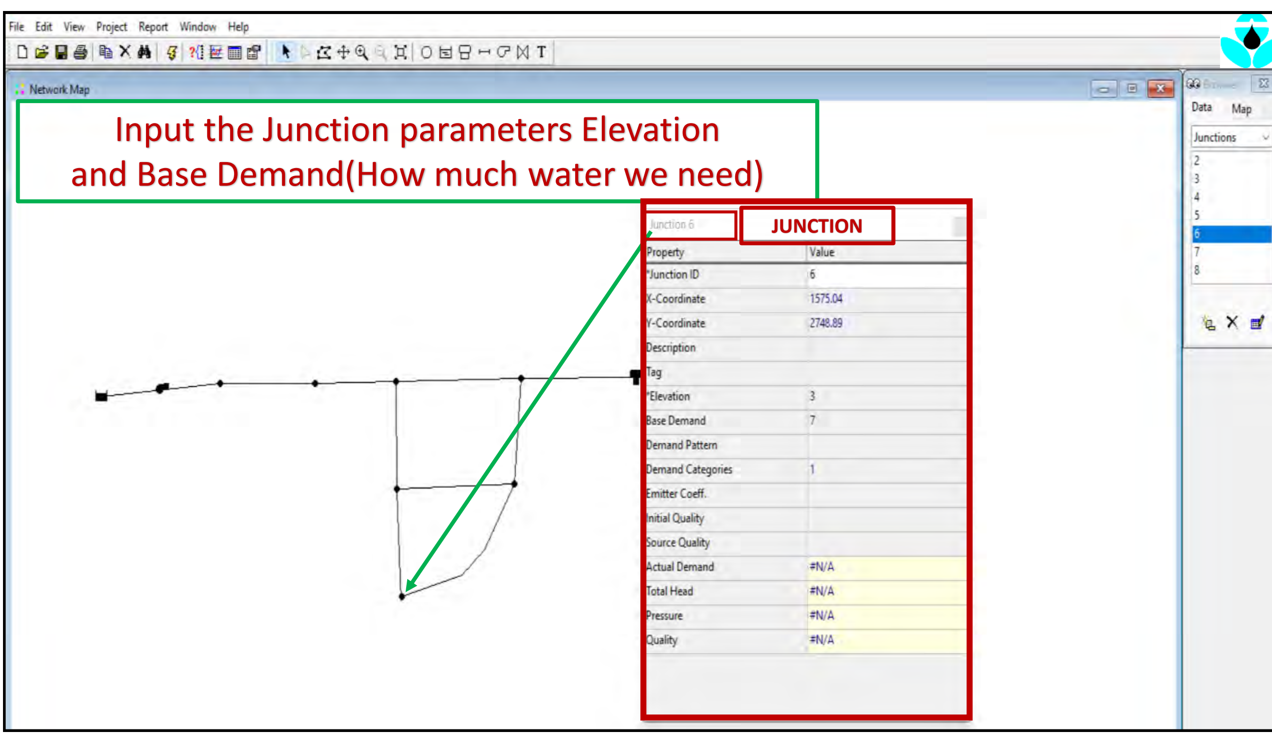


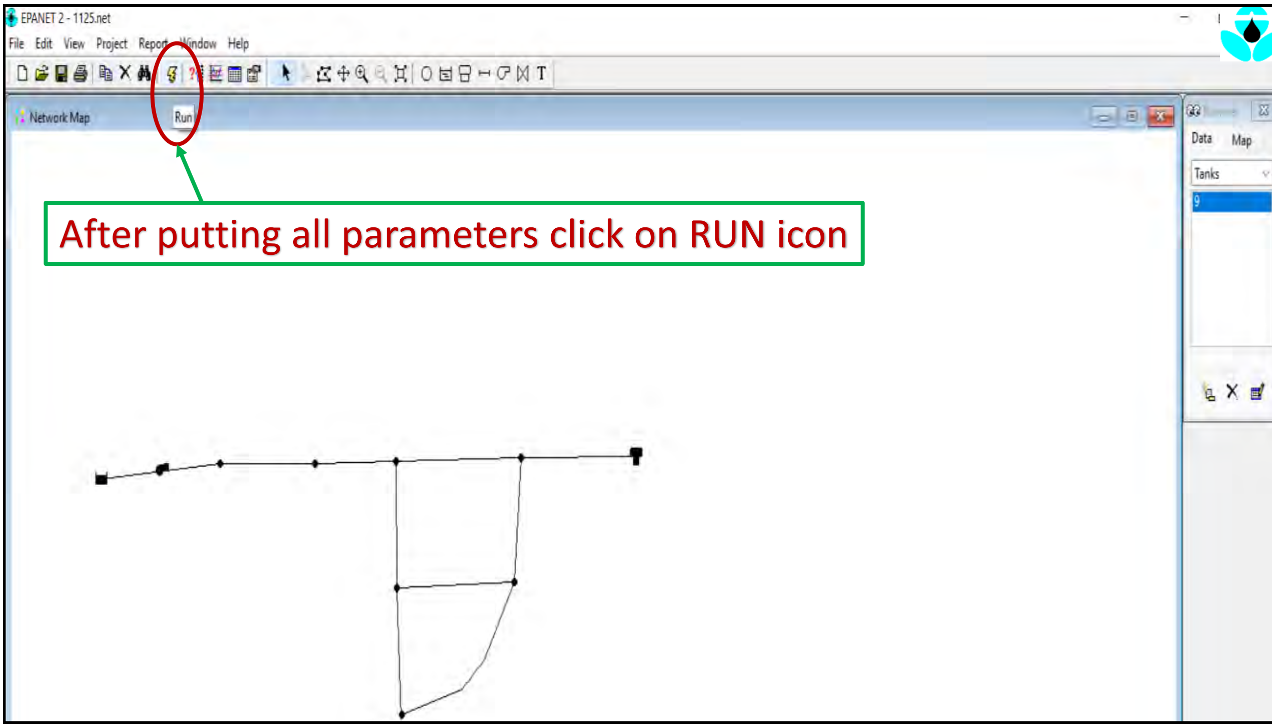
Add pump values, can add Pump curve, Power or Speed. On upper right side the different parameters we can put.

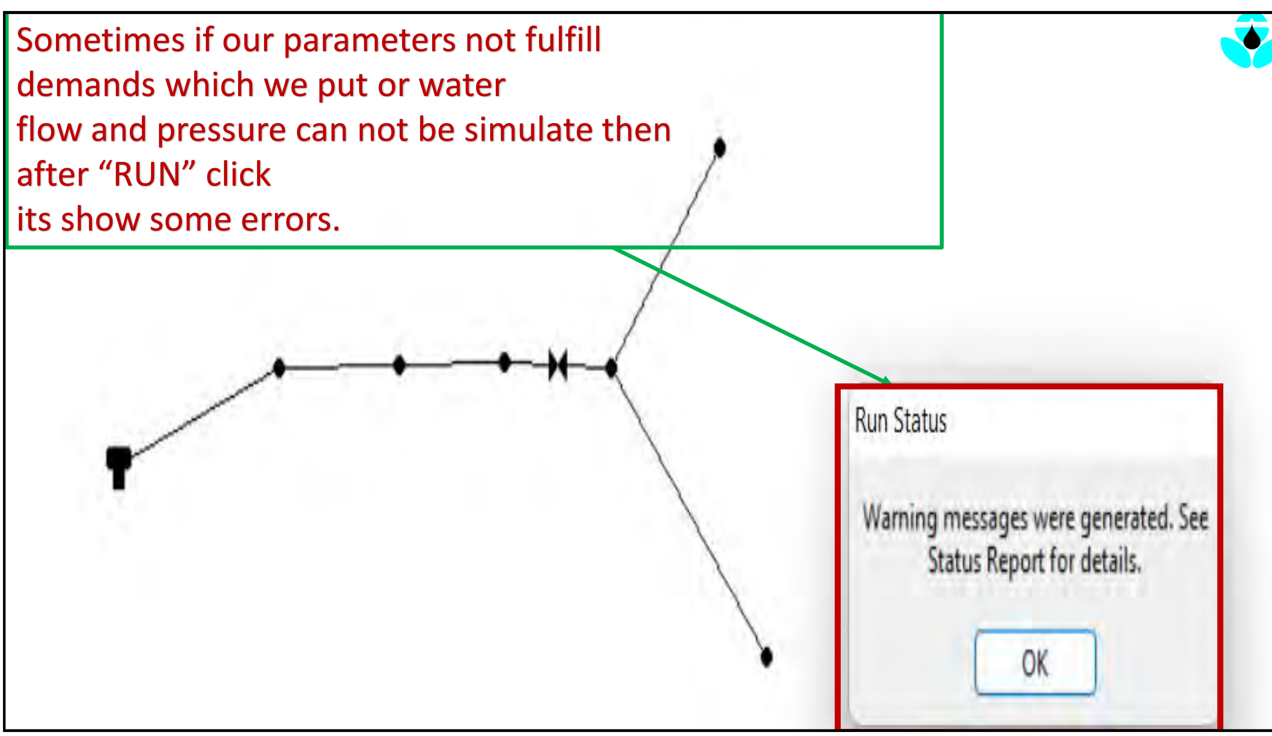


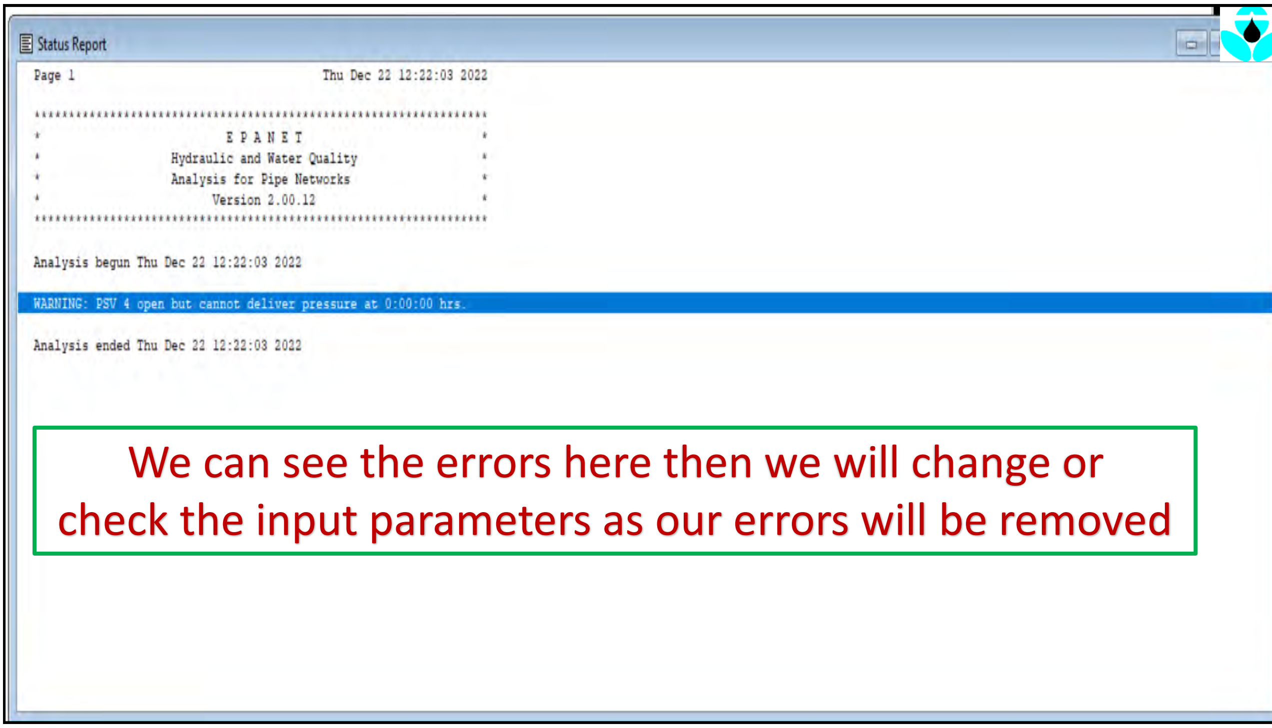
Add Pump curve, Put Flow and Head values. On upper right side click on icon and put the values.

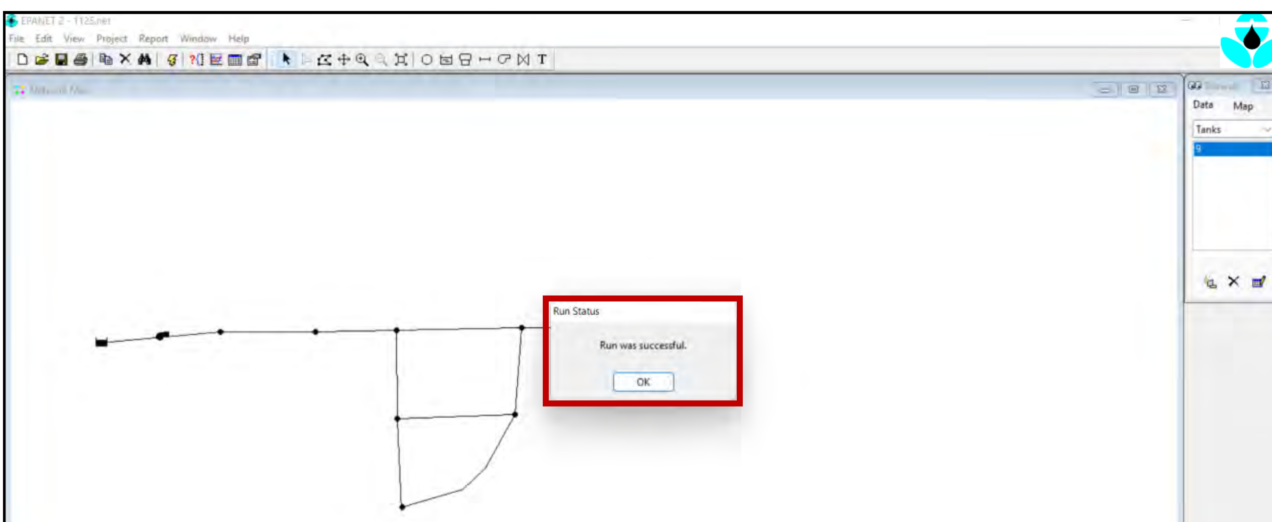

File Edit View Project Report Window Help
Put Parameters of Pipe Length, Diameter and Roughness
Pipe 1
PIPE
Property
Value
*Pipe ID
1
*Start Node
2
*End Node
3
Description
Tag
*Length
3
*Diameter
300
*Roughness
160
Loss Coeff.
0
Initial Status
Open
Bulk Coeff.
Wall Coeff.
Flow
#N/A
Velocity
#N/A
Unit Headloss
#N/A
Friction Factor
#N/A
Reaction Rate
#N/A
Quality
#N/A
Data
Map
Pipes


File Edit View Project Report Window Help
Network Map
Input the Junction parameters Elevation
and Base Demand(How much water we need)
Junction 6
JUNCTION
Property
Value
*Junction ID
6
X-Coordinate
1575.04
Y-Coordinate
2748.89
Description
Tag
*Elevation
3
Base Demand
7
Demand Pattern
Demand Categories
1
Emitter Coeff.
Initial Quality
Source Quality
Actual Demand
#N/A
Total Head
#N/A
Pressure
#N/A
Quality
#N/A
Data
Map
Junctions

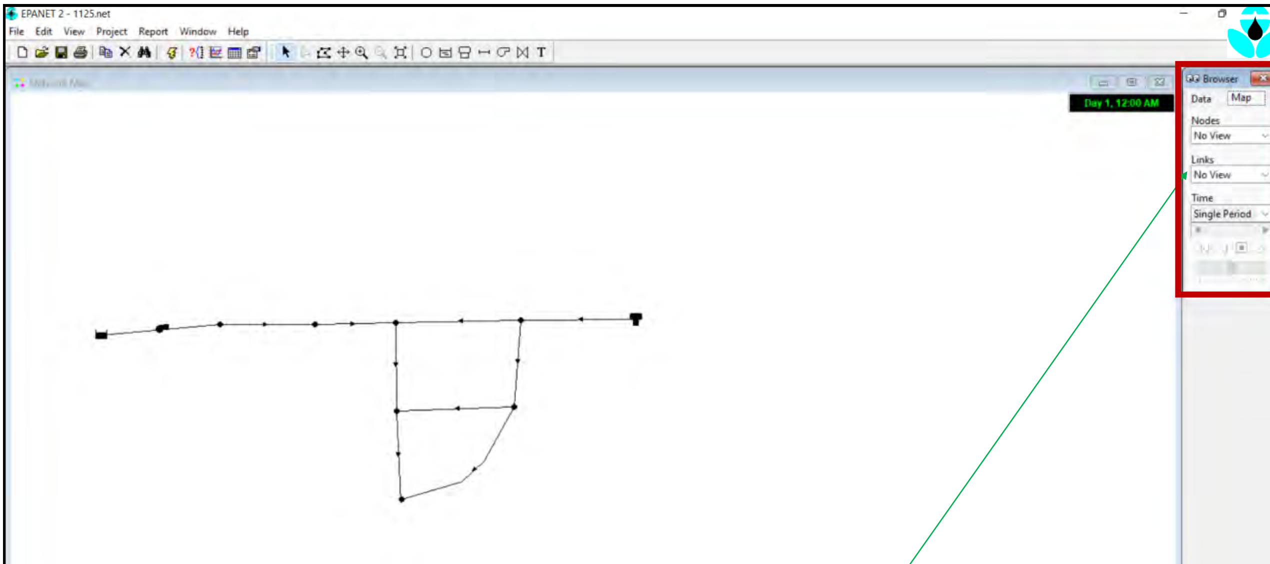

EPANET 2 - 1125.net
File Edit View Project Report Window Help
Network Map
Run
Data Map
Tanks
After putting all parameters click on RUN icon


Sometimes if our parameters not fulfill
demands which we put or water
flow and pressure can not be simulate then
after "RUN" click
its show some errors.
Run Status
Warning messages were generated. See Status Report for details.
OK

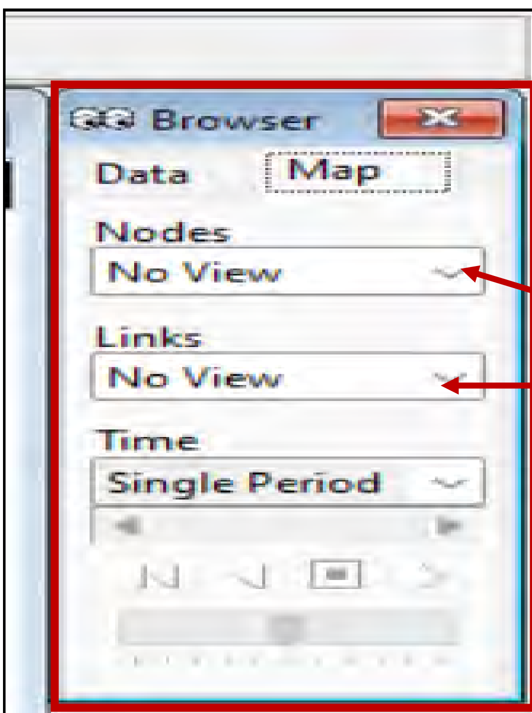




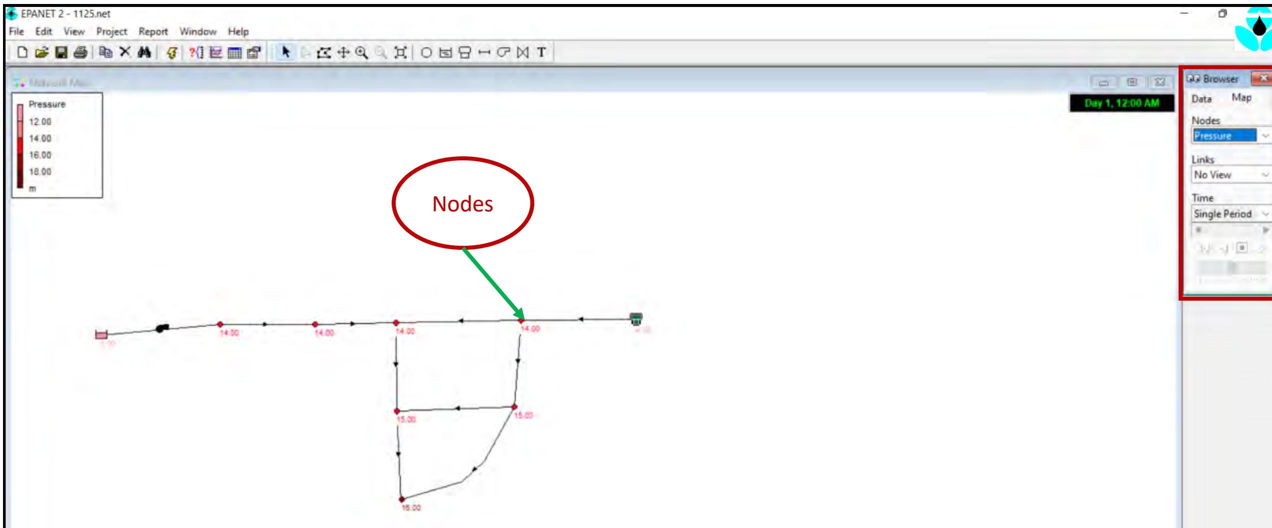
After checking input parameters and then again click on RUN Icon then status will be successful



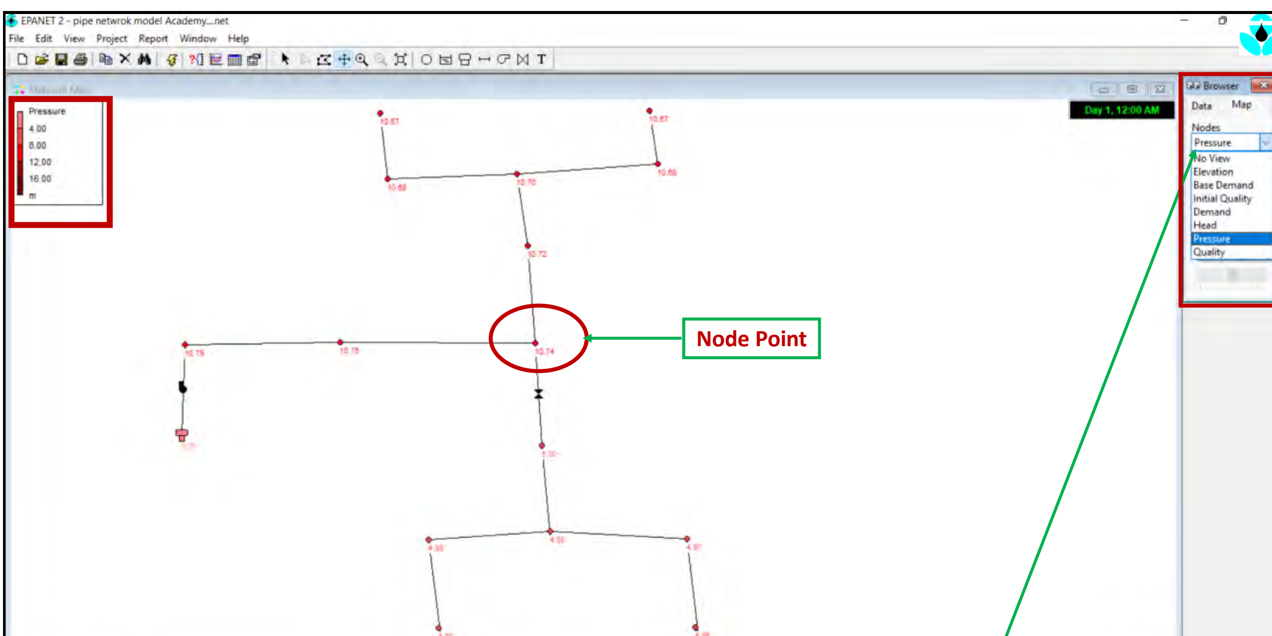
After Run Successful we have to add parameters which we want to observe



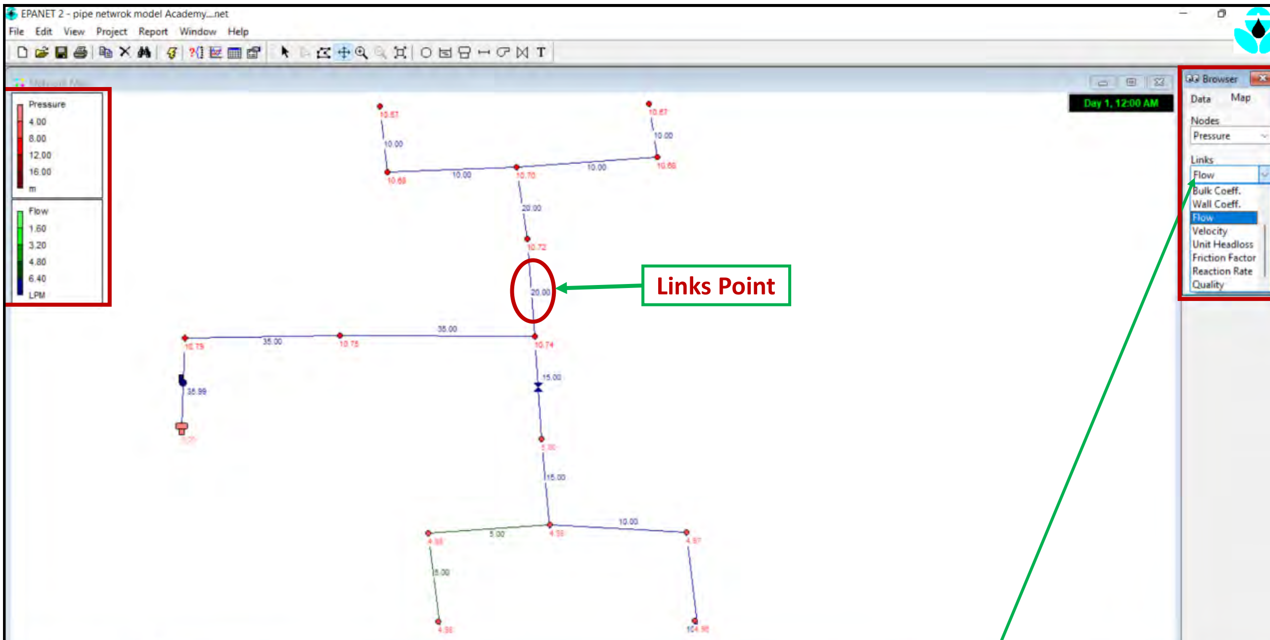
Select the Parameters of Nodes and Links and see the values



We Can observe the parameters values on “Nodes” point by clicking on right side browser Nodes



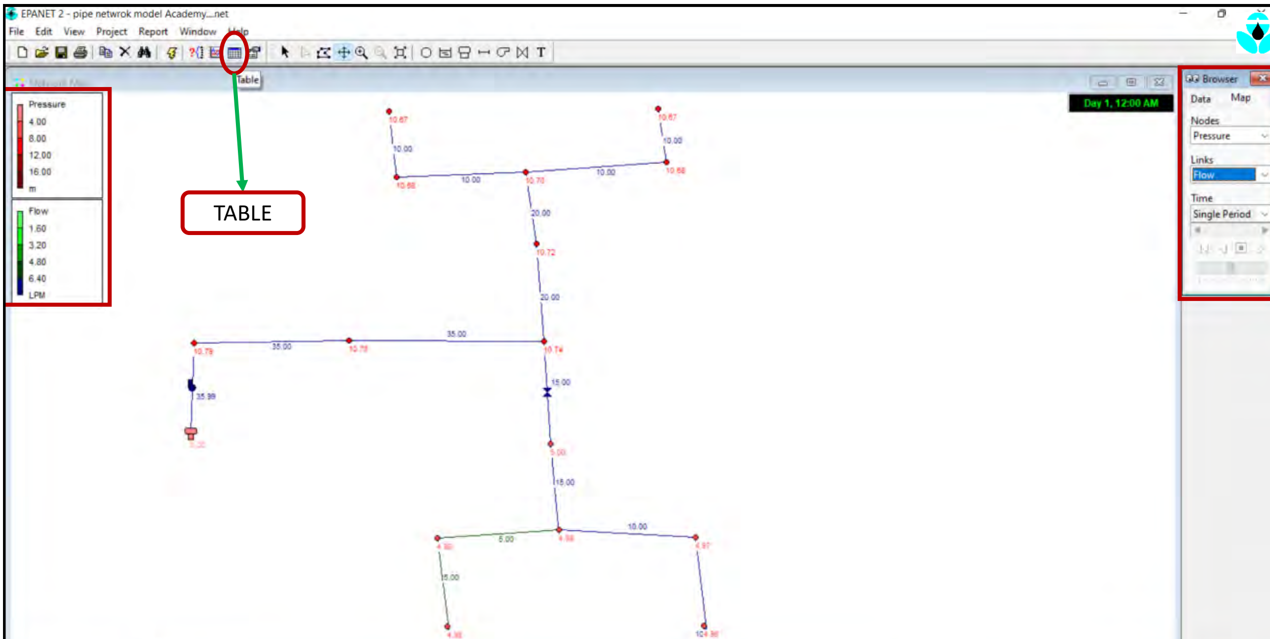
We Can observe the different parameters values on “Nodes” point by clicking on right side browser “Nodes”



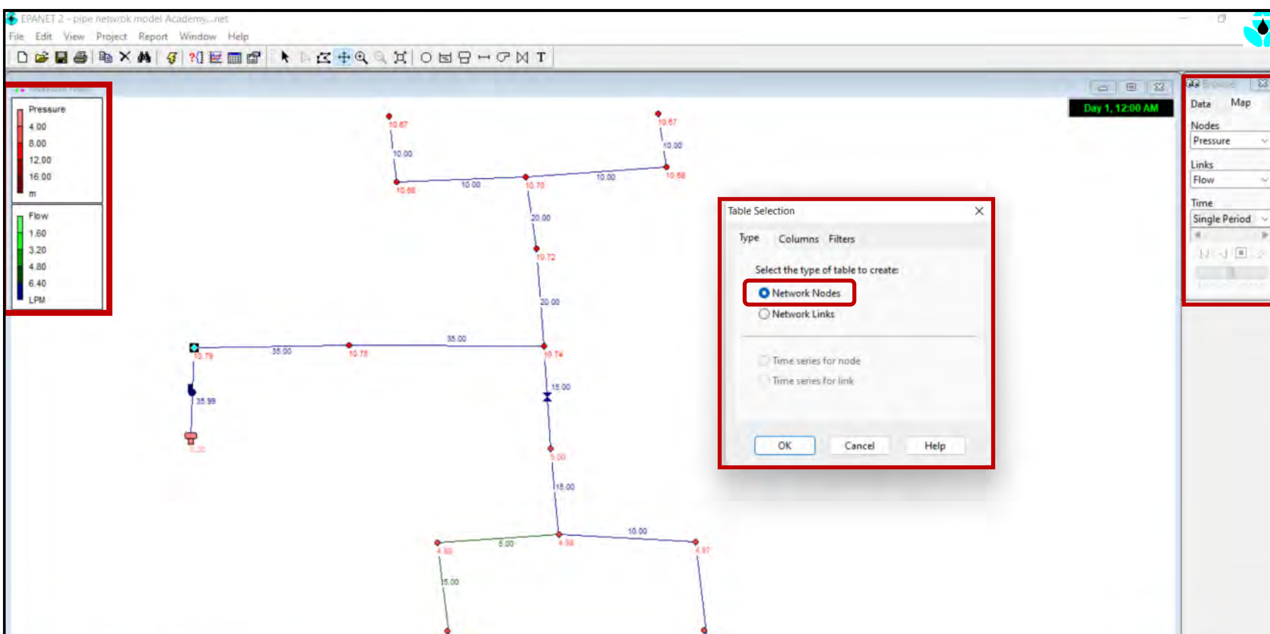
We Can observe the different parameters values on "Links" point by clicking on right side browser "Links"

Table and Charts

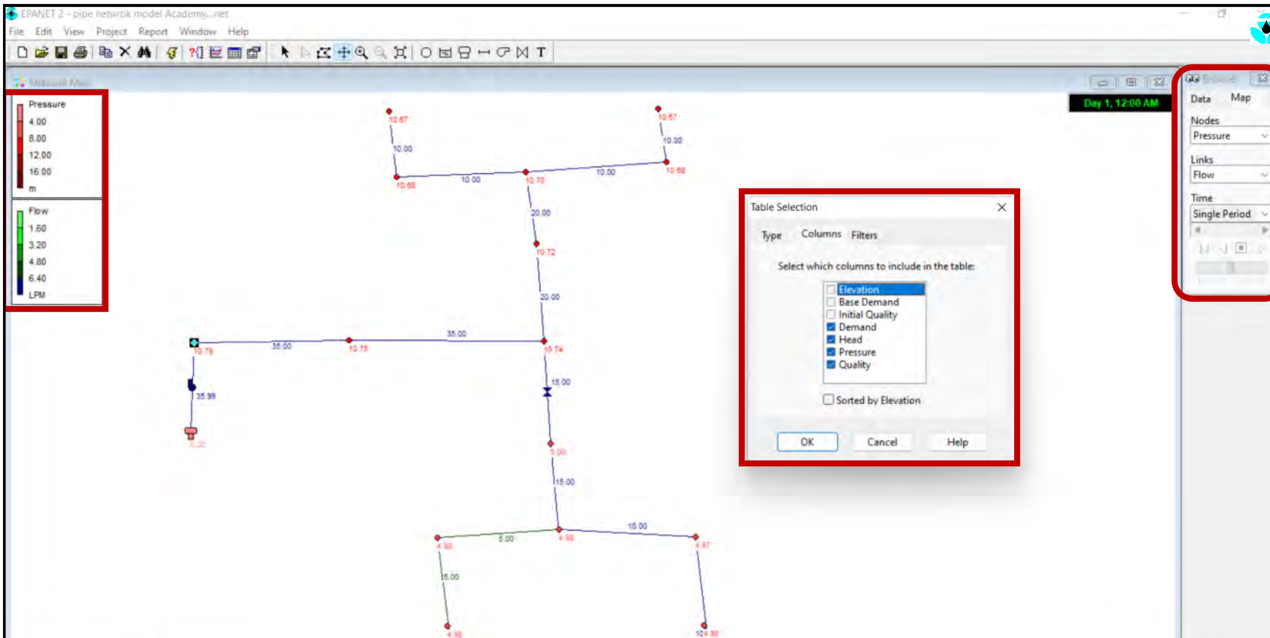
- After Successful Run and put the parameters on Node and Links point we can see results on Tables.



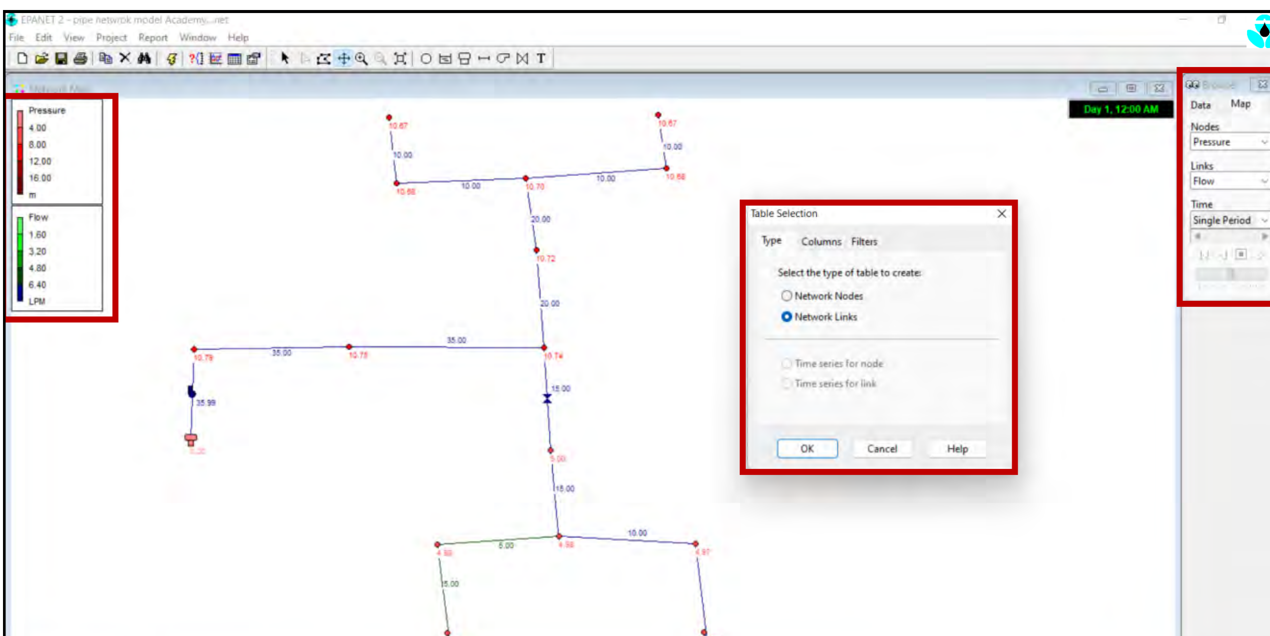
By clicking on Table ICON in toolbar a new Window will be open for Node and Links points



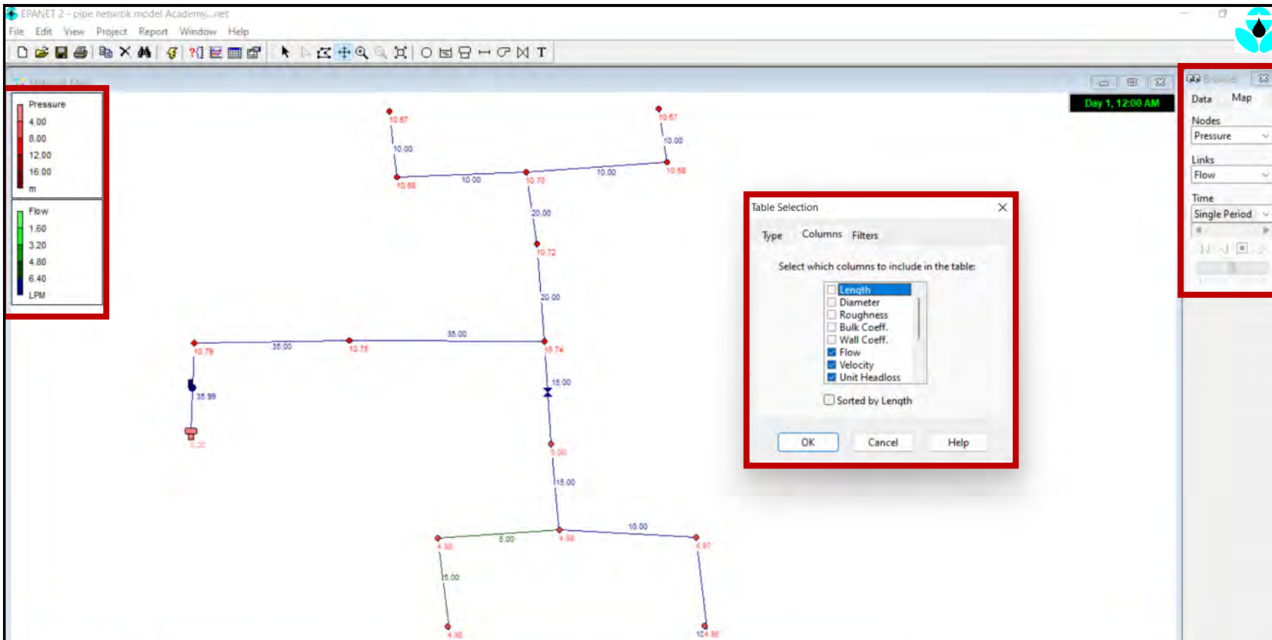
In new window we can see “Type of table creation” Can see Nodes and Links values on Table



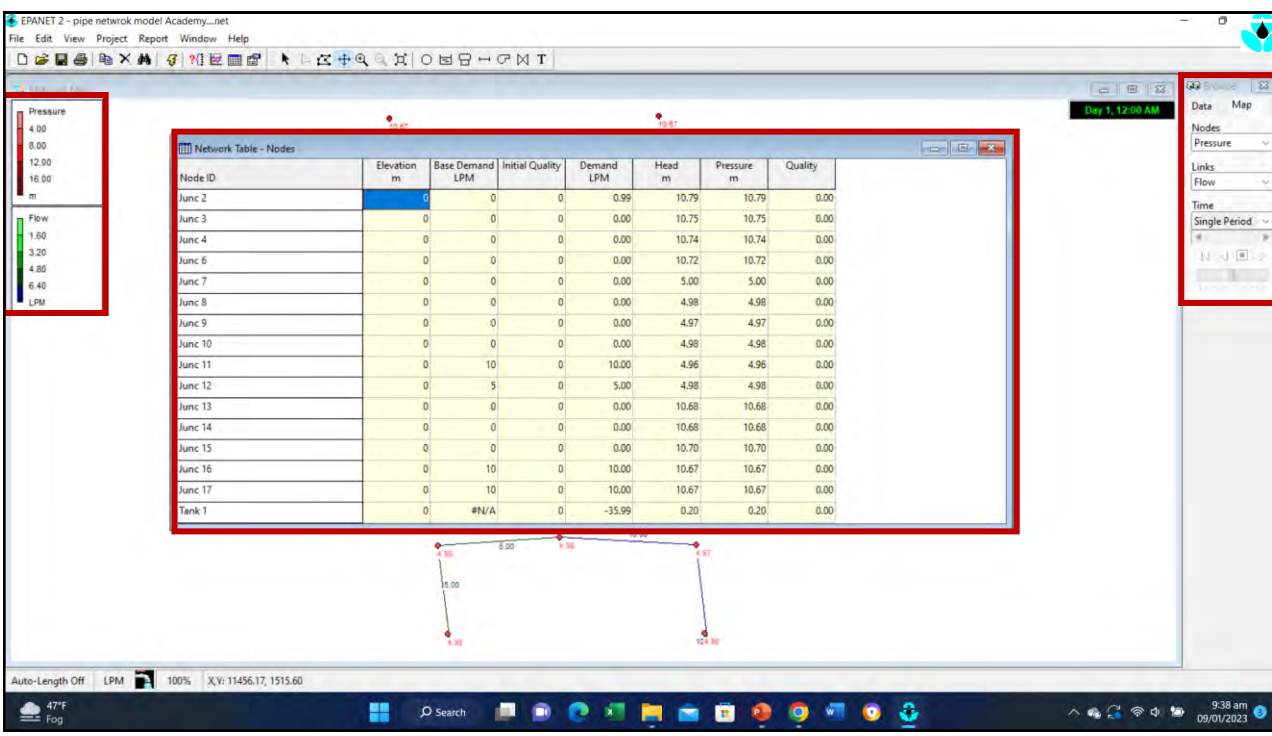
In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values

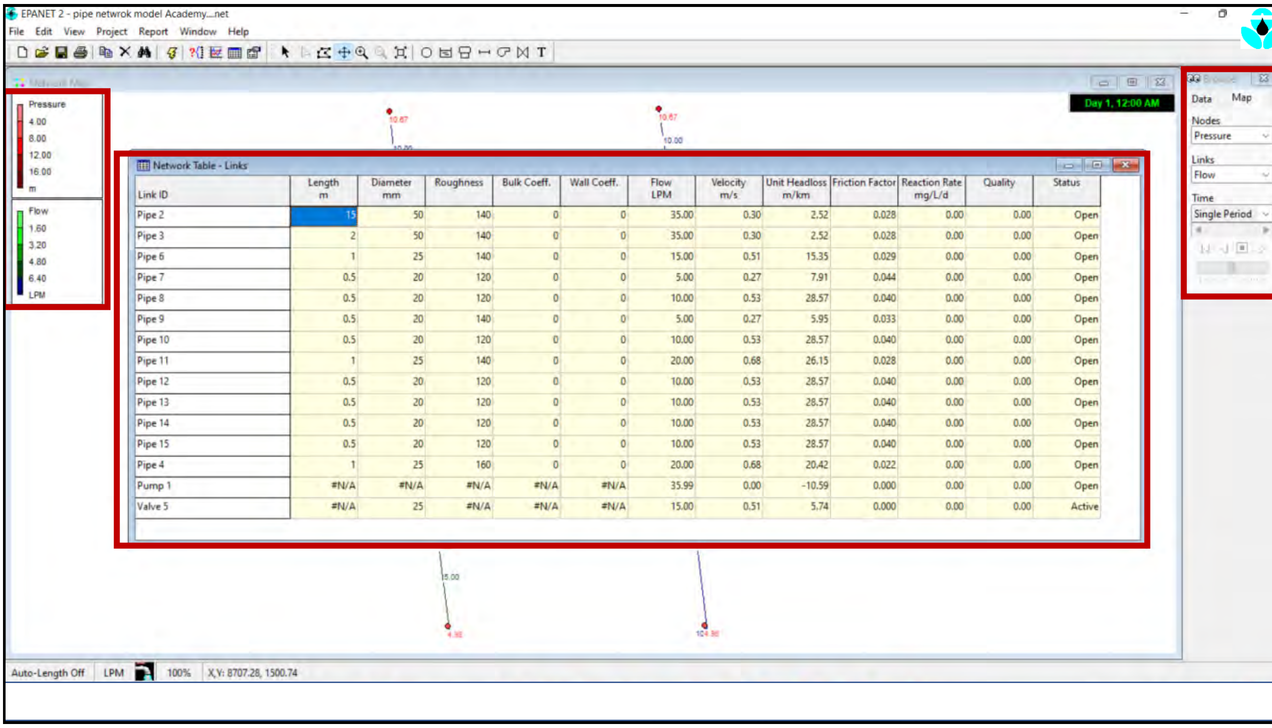


In new window we can see "Table Selection Parameters" Can select "LINKS" Points Values



In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values





Link ID	Length m	Diameter mm	Roughness	Bulk Coeff.	Wall Coeff.	Flow LPM	Velocity m/s	Unit Headloss m/km	Friction Factor	Reaction Rate mg/L/d	Quality	Status
Pipe 2	15	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 3	2	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 6	1	25	140	0	0	15.00	0.51	15.35	0.029	0.00	0.00	Open
Pipe 7	0.5	20	120	0	0	5.00	0.27	7.91	0.044	0.00	0.00	Open
Pipe 8	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 9	0.5	20	140	0	0	5.00	0.27	5.95	0.033	0.00	0.00	Open
Pipe 10	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 11	1	25	140	0	0	20.00	0.68	26.15	0.028	0.00	0.00	Open
Pipe 12	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 13	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 14	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 15	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 4	1	25	160	0	0	20.00	0.68	20.42	0.022	0.00	0.00	Open
Pump 1	#N/A	#N/A	#N/A	#N/A	#N/A	35.99	0.00	-10.59	0.000	0.00	0.00	Open
Valve 5	#N/A	25	#N/A	#N/A	#N/A	15.00	0.51	5.74	0.000	0.00	0.00	Active

Annex 5.1.18 Training Material on "Leakage Control"

- WASA Faisalabad for In-house Training (4th)
- WASA Gujranwala for In-house Training (3rd)
- WASA Rawalpindi for In-house Training (3rd)

District Metered Area

What is DMA?

Importance of DMA

How DMA works

DMA

Water Block System and DMA

- It is necessary to grasp the water flow in the water distribution system to survey water leakage.
- However, water distribution pipes spread complicatedly, and it makes difficult to grasp water flow in a certain area of distribution system.
- Districted Metered Area (DMA) and step test can solve this problem by measuring inflow and outflow in districted area.

Water Supply Block System

Purpose

1) Control of distribution water pressure
2) Control of distribution water volume
3) Simplifying water distribution plan
4) Mitigating damage in disaster such as earthquake
5) Rational construction plan of distribution facilities
6) Efficiency improvement plan
7) Simplifying control of distribution flow

Water Supply Block System

Principles

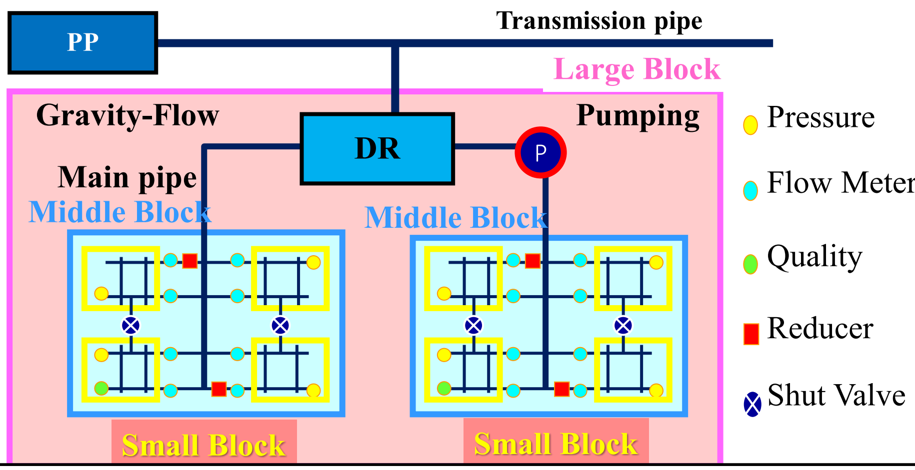
1) In principle every block has one distribution reservoir
2) Within the block, pumping stations are integrated
3) To classify blocks into two areas.

   In one area water is supplied through natural gravity, in the other area water is supplied by pumps.

4) To install pipelines in order to make flexible use of water among the blocks.

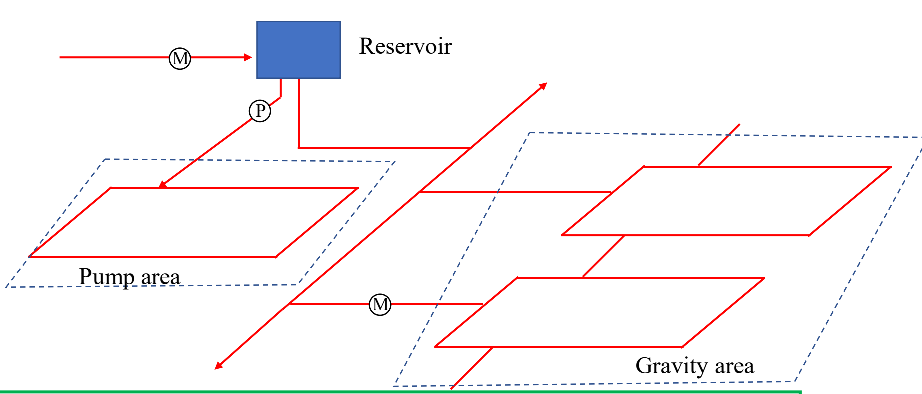
Water Supply Block System

Large Block: Distribution Reservoir Area
Middle Block: Gravity-Flow and Pumping Area
Small Block: District Metered Area



District Metered Area

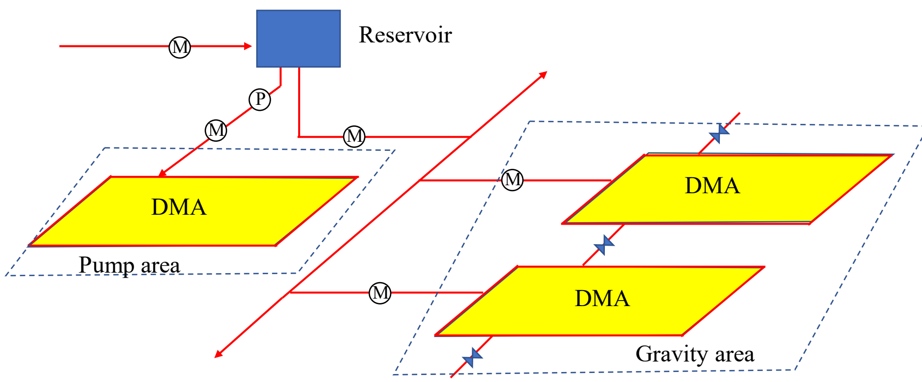
DMA



- To install
- flow meters and valves for isolation area

District Metered Area

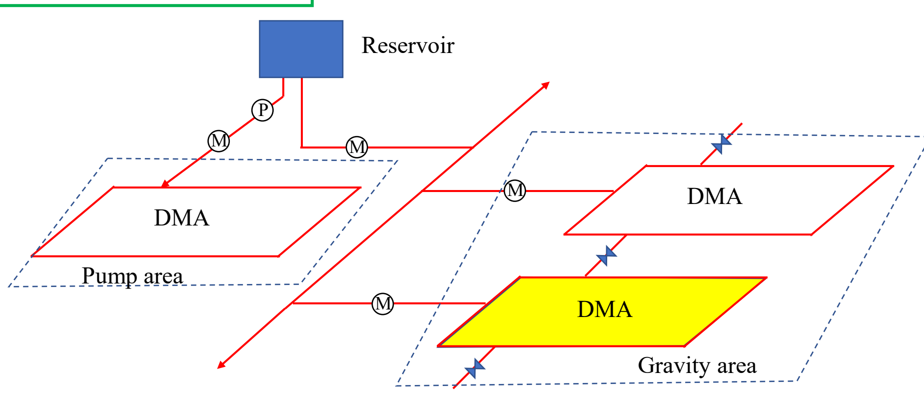
District Metered Area



- ➢ To install
- • flow meters and valves for isolation area

District Metered Area

What can we do at DMA?



- ➢ To analyze
- • Distribution water by measuring Minimum (Night) Flow

Water Meter

Content:

- Introduction, Importance
- Types and Explanation
- Assembly parts
- Cross sectional View
- Difference b/w Wet & Dry Dial
- How to Read
- Comparison
- SOP's for Installation
- Maintenance
- Selection
- Meter Error Curve
- Accuracy
- Woltman(Bulk Flow meter)

What is Water Meter?

➢Water metering is the practice of measuring water usage.

➢Water meters measure the volume of water used by residential and commercial building units that are supplied by a public water supply system.

➢They are also used to determine flow through a particular portion of the system.

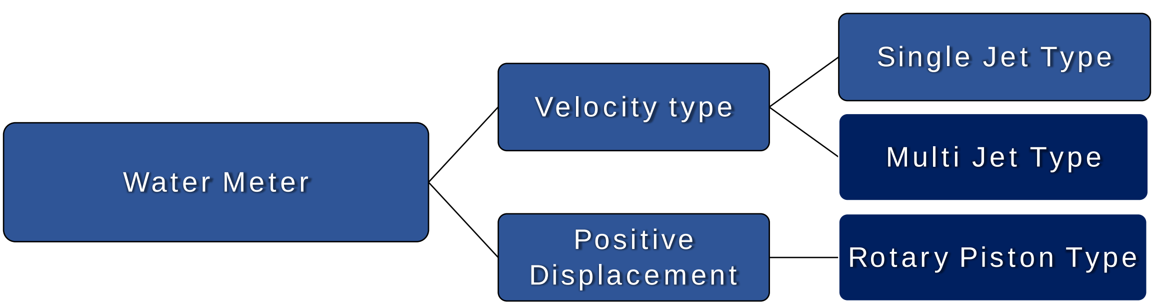
Importance of water meters

- ➢Helps in monitoring the volume of water in different areas
- ➢Help in water conservation
- ➢Allow the system to demonstrate accountability
- ➢Fair for all customers because they record specific usage
- ➢Aid in the detection of leaks and waterline breaks in the distribution system.
- ➢Monitor the volume of consumed water

Water Meter at House

Water Meter at Building

Major Water Meter Types in WASA (Consumer Meters)



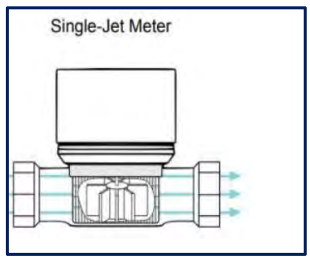
Single Jet Type

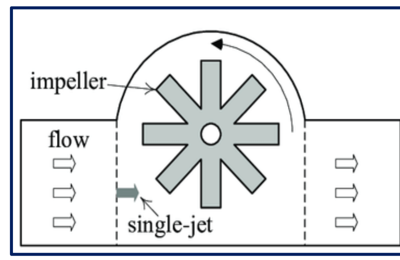
Multi Jet Type

Rotary Piston Type

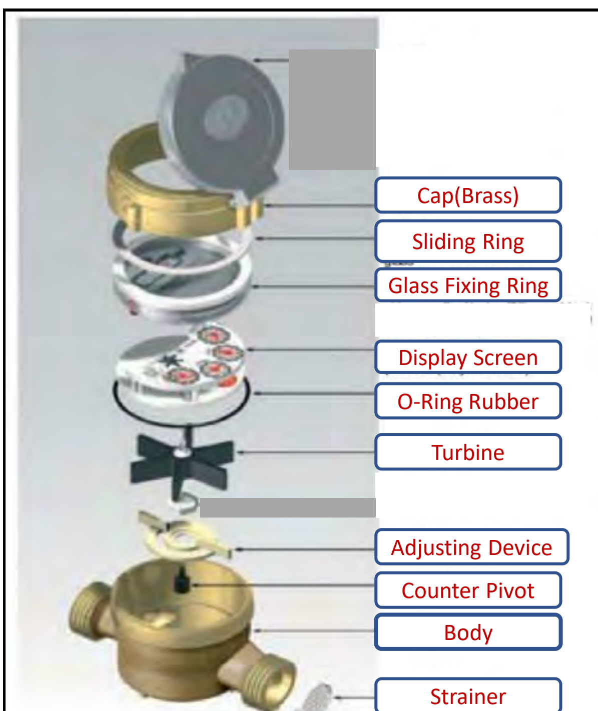
Single Jet water Meter

- Single jet water meters make use of only one port to create a jet of water, making the turbine rotate. There is a single stream of water directed towards a turbine mounted in a radial position within the meter. The turbine starts rotating and transmitting the motion to the display mechanism, which allows us to measure the volume of water passing through the meter.



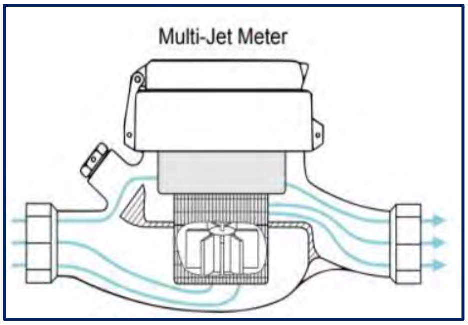


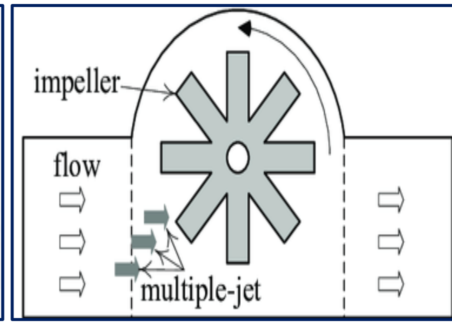
Main Parts of Water Meter

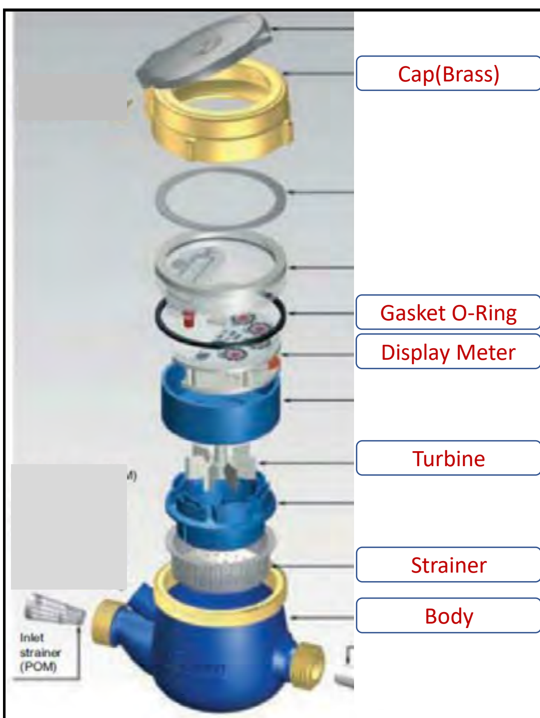


MultiJet Water Meter

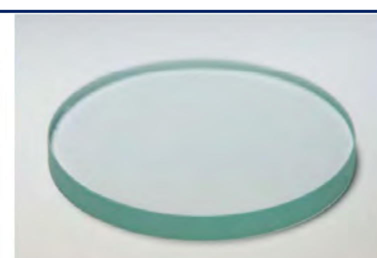
➢Multi-jet meters have multiple ports that surround an internal chamber to create a flow of water against the turbine.Multi-jet meters retain accuracy even a lower flow rates and give a much longer life. Because of their design Multi-jet meters are ideal for diameters between 1-1/2" to 3" in diameter, for large water users, water utilities as well as for industrial water installations.







Main Parts of Water Meter



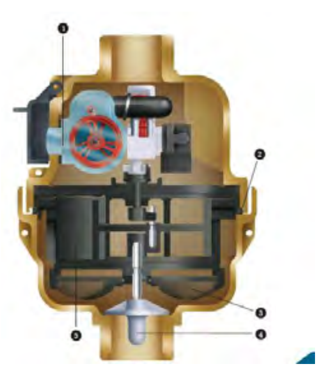
Rotary piston meters

- Rotary piston positive displacement meter records the flow rate according to the volumetric measuring principle.
- Rotary piston meters are popular for their combination of accuracy, long life and moderate cost so they are widely used.
- Sand or other suspended solids easily get stuck between the piston and chamber wall. Thus, it is important to be installed in the system with very good water quality and to install built-in strainer.

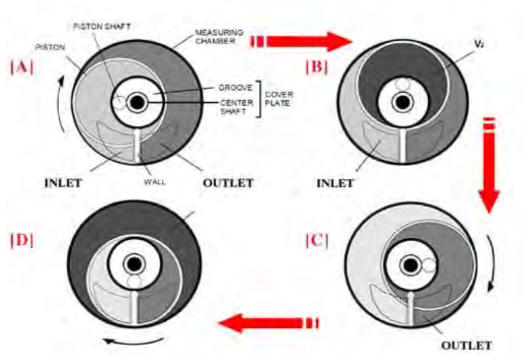
Mechanism

The piston and cylinder are alternately filled and emptied by the fluid passing through the meter. A slot in the sidewall of the piston is removed so that a partition extending inward from the bore of the working chamber can be inserted. This has the effect of restricting the movement of the piston to a sliding motion along the partition. The rotary movement of the piston is transmitted via a permanent-magnet coupling from the drive shaft to a mechanical register.

1. Easy to read register
2. "O" ring seal
3. Stainer
4. Non-Return valve
5. Piston and cylinder



Application and Installation

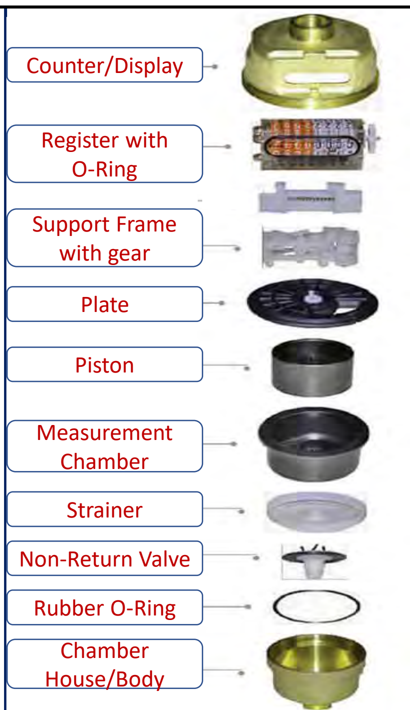


Rotary piston meters are commonly used most domestic applications up to diameter 25mm. They are not sensitive to the wide flow velocity profile.

Rotary piston meters can be installed in **any position** with stable accuracy and placed close to bend or pump.

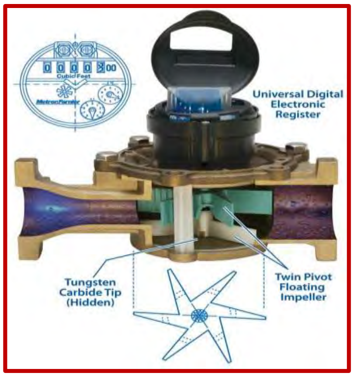
➢ Applicable pipe diameter: 13mm – 40mm

➢ Suitable installation location: Place where the power is out and there is no cover to protect rainwater

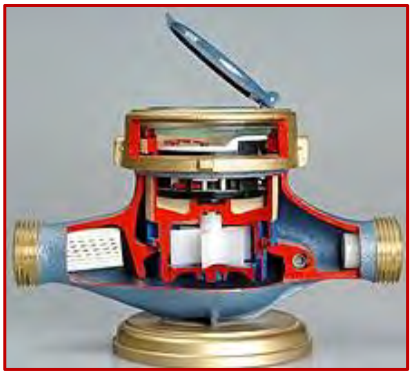


Main Parts of Water Meter

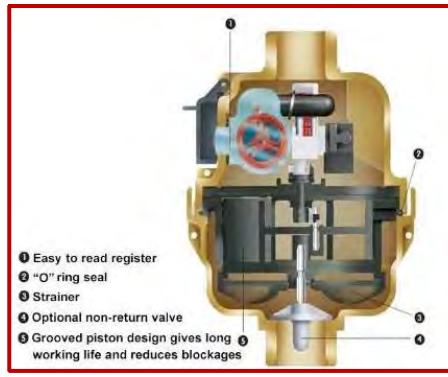
Cross Sectional View of water meters



Single-Jet Water Meter

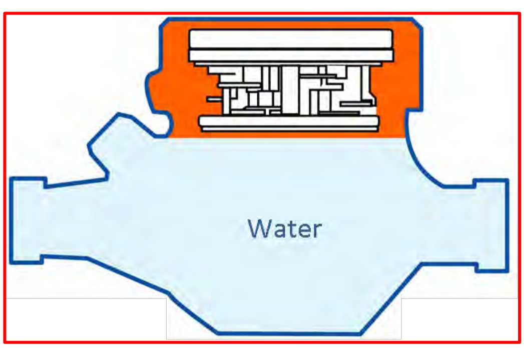


Multi-Jet Water Meter

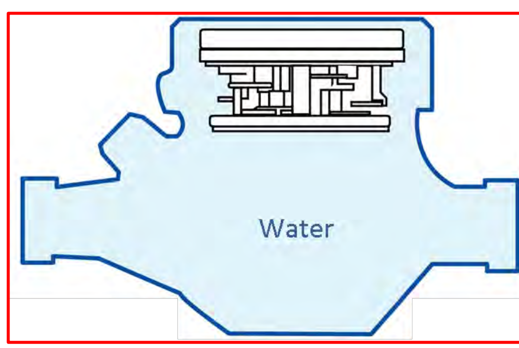


Rotary Piston/Vertical Meter

Difference between Dry and Wet Dial water meter

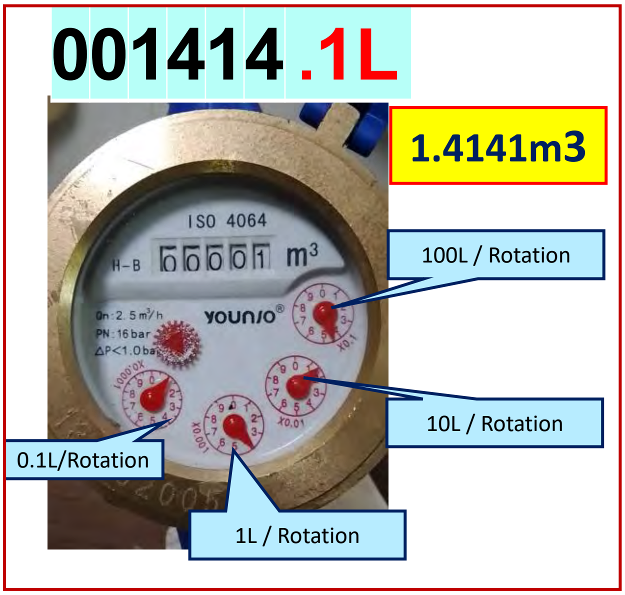


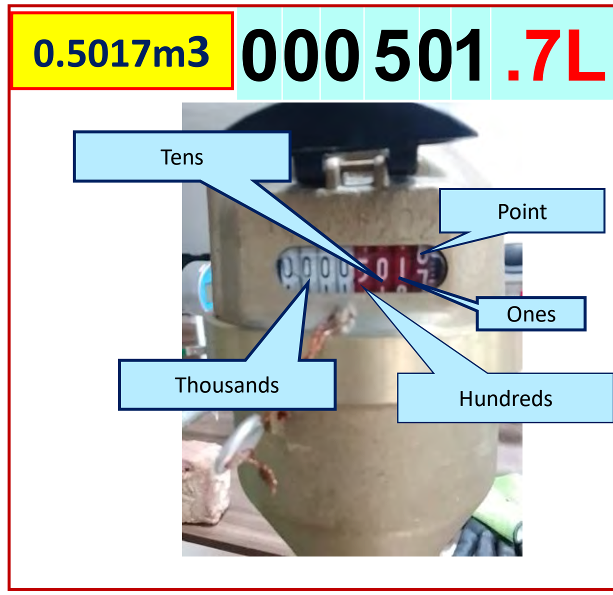
Dry Dial (Vacuum Register Unit)



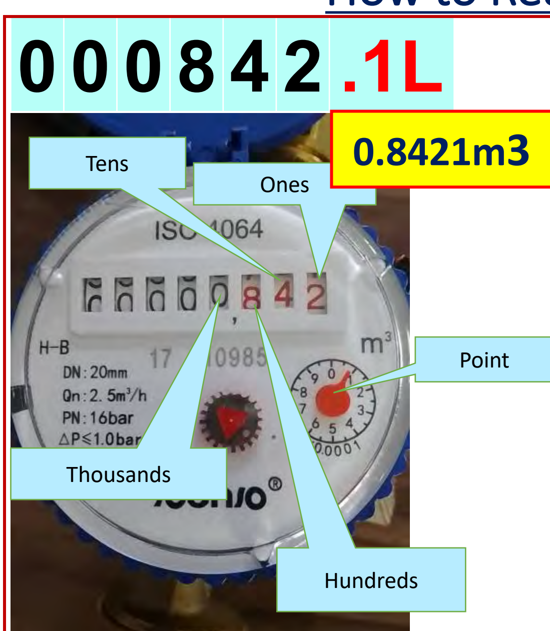
Wet Dial (Water Flow through Register Unit)

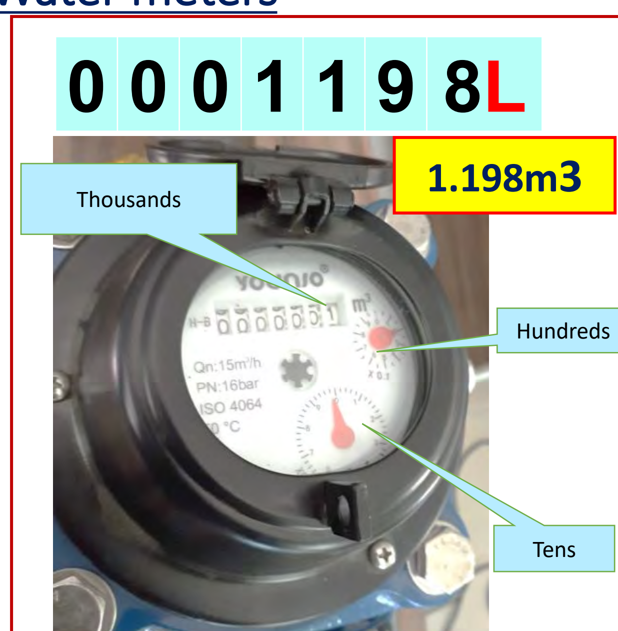
How to Read Water meters





How to Read Water meters

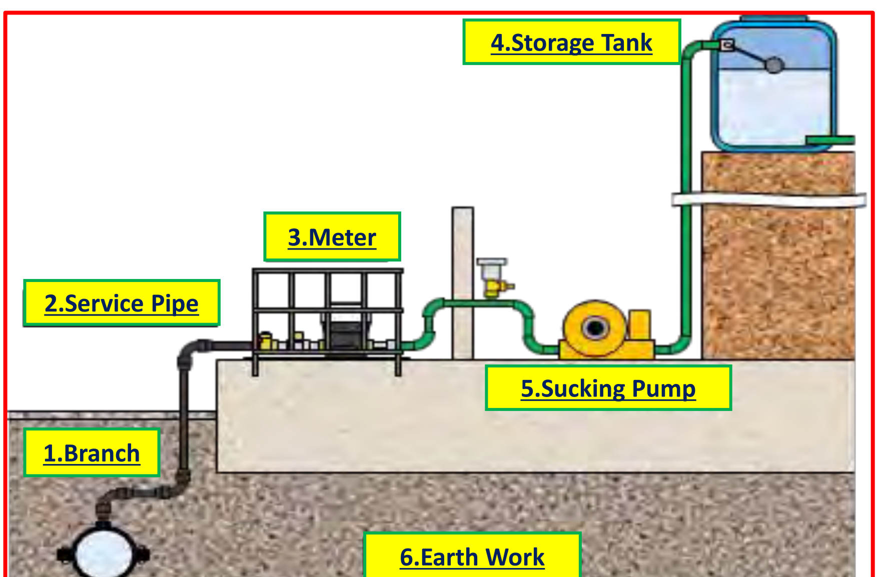


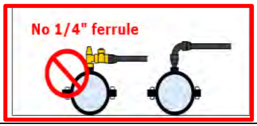


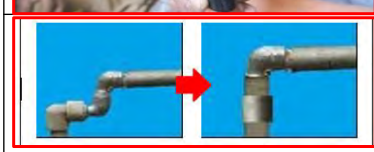
Comparison of water meters

	Single jet (dry)	Multi jet (wet)	Rotary piston (wet)
Appearance	 	 	 
Measuring method	Velocity	Velocity	Positive displacement
Structure	Simple structure	Complicated than Single jet	Complicated than others
Cost	Inexpensive	Inexpensive	More expensive than others
Others	Highly reliable operation	Small amount of water can be measured accurately	High accuracy than others

SOP's for the Installation of Water Meter

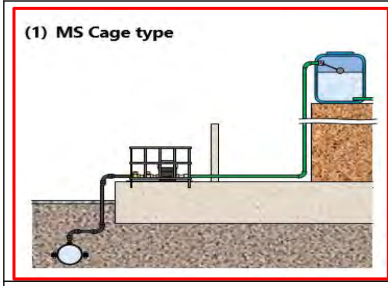


 **Branch**	It should be confirmed that rubber is set at branch point.
	Service connection should be branched directly from water distribution pipe by 1/2” and 90° of bent pipe is used instead of 1/4” ferrule.
 **Service Pipe**	When improving existing service pipe, it is necessary to confirm that pipe comes from WASA’s system.
	GI should be selected if pipe is installed above ground. If pipe is installed underground, UPVC/HDPE or non-corrosive pipe & fittings shall be used.
	The pipe should be cut with suitable equipment.

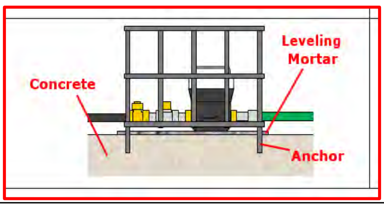
	The cut of the polyethylene pipe must be straight.
	Use of meaningless bend pipe should be avoided.
	Meter should be installed outside of customer’s premises within 50cm from boundary and without vehicle load. (If meter is installed inside the customer’s premises, it is difficult to read the meter for meter readers because of gate lock or customer absence).

Three types of meter cage for thief prevention measure of meter

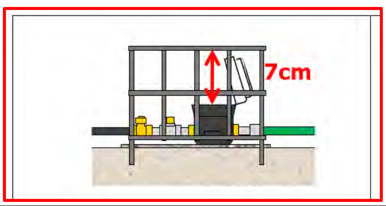
Measures to prevent theft of the meter are selected depending on the site situation, but in principle, installation of (1) **MS cage** should be adopted. Under difficult circumstances for various reasons, underground installation such as (2) **Steel lid** or (3) **Concrete Box** will be considered.



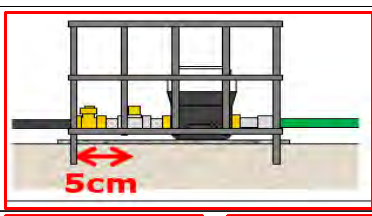
In principle, MS cage should be selected with concrete base and meter should be installed on the ground.



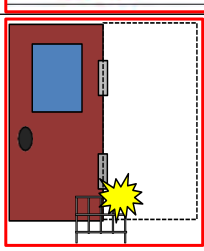
MS cage should be installed as left figure.

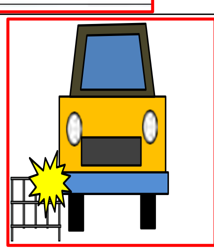


For opening the meter cover, 7cm or more of interval is required at the top. At the site, meter cover should be opened and ease of meter reading should be confirmed.

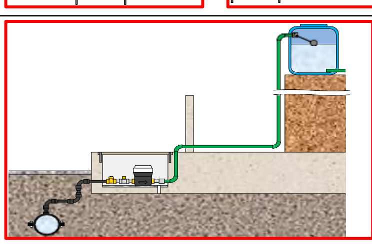


For opening/closing the magnetic valve, 5cm or more of interval is required around magnetic valve. At the site, valve operation should be carried out and confirmed.

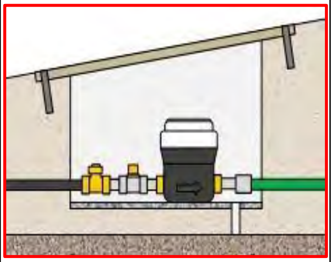
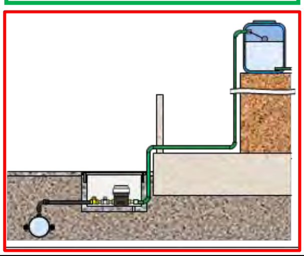




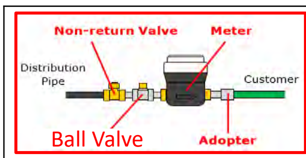
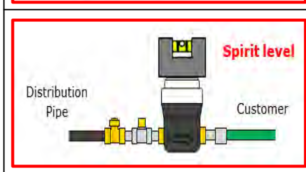
When the cage installed on the ground interferes with the opening and closing of the door or the passage of the vehicle, or when the space cannot be secured on the ground, underground installation should be selected for thief prevention measure of meter.



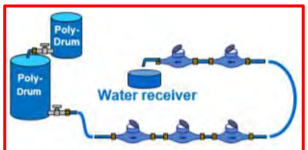
If there is a concrete part where the lid can be fixed with the anchor, (2) <u>**Steel lid**</u> type should be selected instead of (1) <u>**MS cage**</u> type.
The meter installation place is excavated.
<u>**Excavation range:**</u>
Width20cm x Length30cm x Depth20cm or more.
Drainage function should be considered.

	Even on a slope, the lid can be installed as the left figure. However, it is necessary to pay attention to the lid installation location so that the anchor does not penetrate.
Concrete Box Type 	If there is no concrete to fix the lid with anchor, (3) Concrete Box Type should be selected for thief prevention measure of meter instead of (2) Steel Lid type. Drainage function should be considered(Installation of (1) and (2) is considered as much as possible, because (3) is expensive)

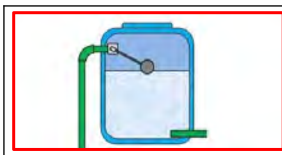
Basics for water Meter Installation

	Piping around the meter consists of non-return valve, Ball valve, meter and adopter.
	All water consumption should be captured. It is necessary to confirm that there is no water supply branch upstream of the meter.
	Meter should be installed horizontally, therefore horizontal should be confirmed using spirit level etc.
	It should be confirmed that the arrow on the side of the meter body with water flow direction.

Reuse of Existing water Meter

	Whether there is existing meter should be confirmed.
	If customer already has existing meter, meter should be read and recorded and this value should be reported to IT section.
	Removed meter should be brought the meter test yard and checked the accuracy. If meter has good accuracy, WASA can reuse it.
	If test meter is available, you can utilize it.

Storage Tank

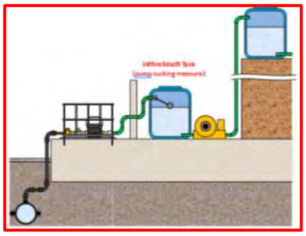
	It should be confirmed whether the customer has a storage tank. If customer has tank, it should be confirmed that the float valve is installed. If not, WASA should instruct customer to install it.

Sucking Pump:

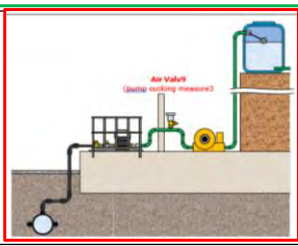
In principle, illegal sucking pump must be removed. If WASA cannot ensure the proper water pressure or customer denies removing it, for countermeasure of illegal pump sucking,

(1) Intermediate Tank or **(2) Air Valve** should be installed.

Intermediate Tank

	For one of the countermeasures of sucking pump, intermediate storage tank should be installed between meter and pump. When installing intermediate tank, float valve should be installed.

Air Valve

	For another countermeasure of sucking pump, air valve should be installed between meter and pump, and it should be installed at higher position than meter.
	It is confirmed that water does not come out from the air valve.

No.	Check items	Check
1	Meter is checked for proper functioning of low-flow dial before installing it.	
2	Meter is horizontally installed with correct flow direction.	
3	Ball valve is installed upstream and non-return valve is installed downstream of meter with no branches upstream of meter.	
4	Illegal sucking pump is not installed*1 and there are no suspected, illegal connections around customer’s premises*2.	
5	If customer has storage tank, float valve is installed*3.	
6	Proper water pressure is secured at customer’s tap.	
7	Meter is easy to read and remove by WASA maintenance workers.	
8	Meter is not an obstacle to traffic and has theft prevention.	

*1 If not, WASA should instruct and ask the customer to improve the situations (removal of pump/installation of intermediate tank/installation of air valve), and reconfirm later.

*2 If not, WASA should instruct and ask the customer to improve the situations (disconnect the connections) and reconfirm later.

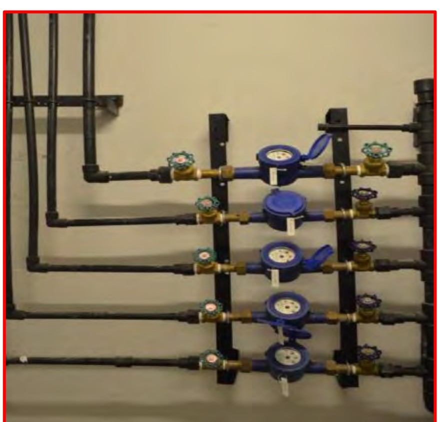
*3 If not, WASA should instruct and ask the customer to improve the situations (installation of float valve) and reconfirm at later date.

Installation of Water Meters

Above the Ground: The advantage is ease of maintenance and easy to read. Air tapping bubbles may occurs

Underground: In many countries it is installed below the floor level In this case meter box is required. Advantage-Reduces air tapping bubbles Disadvantage-High cost, difficult for maintenance

Installation of water Meters



Installation of water meters inside building/Commercial areas

Installation of Water Meters different places

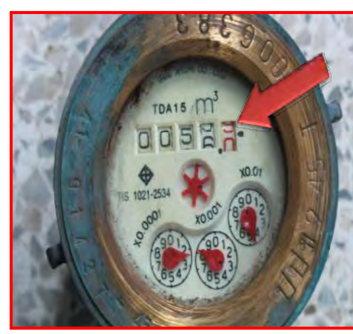
- .

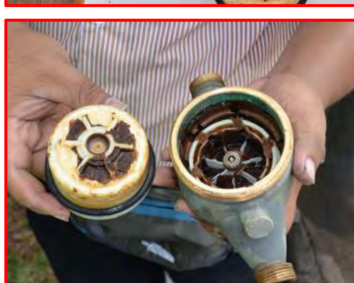
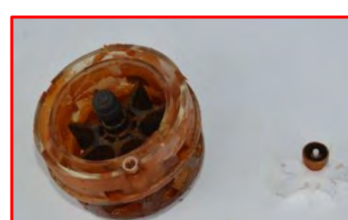





Maintenance of Water Meters(Different Problems)





Maintenance of Water Meter(Different Problem)

Maintenance of Different Problems of water Meter

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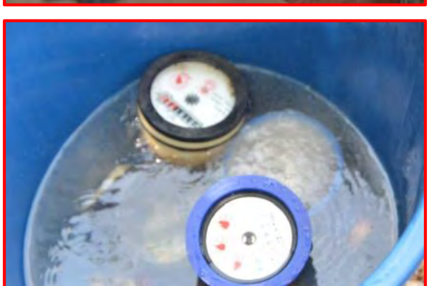


Cleaning(Most of Problems can be solve by Cleaning parts of water meter)

Maintenance of Different Problems of water Meter

Rust Remover activity can also b more useful for maintenance of water meters

Selection of Water Meter

Nominal Size DN(mm)	Class of measurement	Overload Flow-rate Q4(m3/hr)	Permanent Flow-rate Q3(m3/hr)	Transitional Flow -rate Q2(m3/hr)	Minimum Flow-rate Q1(m3/hr)	Minimum Reading Min(m3)	Maximum Reading Max(m3)
15	R80	3.125	2.5	0.05	0.03125	0.0001	99999
	R100			0.04	0.025		
20	R80	5	4	0.08	0.05	0.0001	99999
	R100			0.064	0.04		
25	R80	7.875	6.3	0.126	0.063	0.0001	99999
	R100			0.1008	0.039375		
32	R80	12.5	10	0.2	0.125	0.0001	99999
	R100			0.16	0.1		
40	R80	20	16	0.32	0.2	0.0001	99999
	R100			0.256	0.16		
50	R80	31.25	25	0.5	0.3125	0.0001	99999
	R100			0.4	0.25		

Select
Too Small Water Meter

Easily worn out
-Inaccuracy
-Pressure lost

Select
Too Big Water Meter

-Inaccuracy
-High cost

Other Selection Parameters

- **Material:**

All materials in contact with the water passing through the water meter shall be made of materials which are harmless, non-contaminating and biologically inert.

- **Pressure test:**

The water meter shall conform to the pressure resistance performance.

Leakage and Accuracy Test

Meter error curve

- Water meters are designed for a specific flow rate, which is called as the permanent flow rate or Q3.The meter should be able to work at the permanent flow rate (or a lower flow rate) continuously for its design life without exceeding the permissible error.
- Although a meter is designed for the permanent flow rate, the actual flow through a meter is not constant. Thus, water meters should not only be accurate at the permanent flow rate, but also be accurate over a wide range of flow rates.
- It is useful to draw a graph of a meter's relative error. This curve is called the meter's error curve.

Meter error curve

- Q1 – Minimum flow rate:

The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance (± 5% error).

- Q2– Transitional flow rate:

The flow rate at which the maximum permissible error of the water changes in value from ±5% error to ± 2% error.

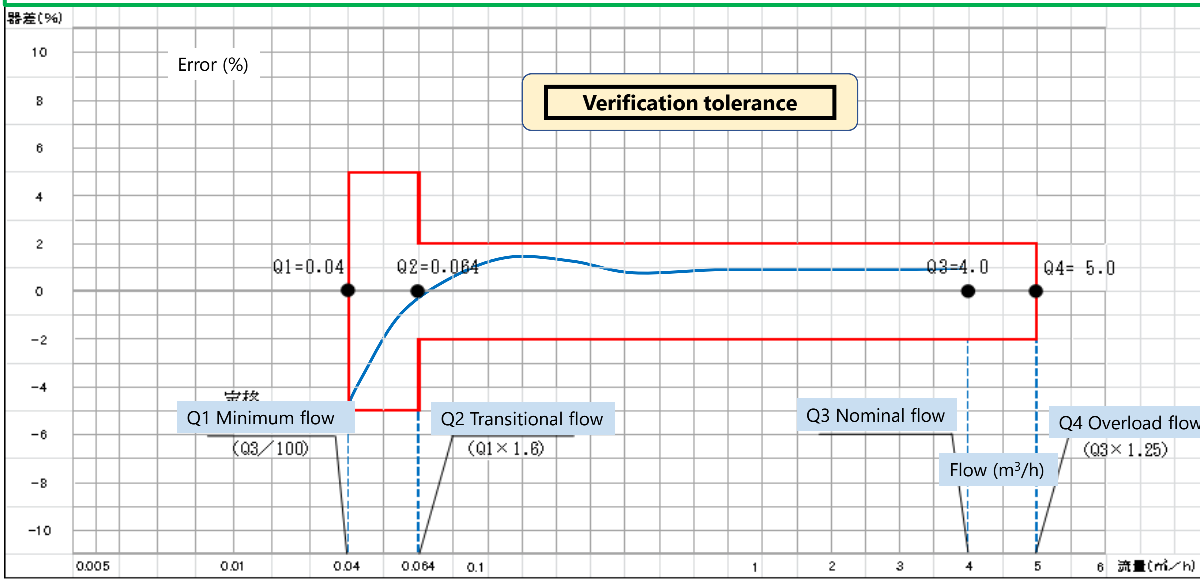
- Q3 – Permanent flow rate:

Permissible continuous load. Half the maximum flow rate (± 2% error).

- Q4 – Maximum flow rate (Overload Flow Rate):

The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period without deteriorating (± 2% error)

METER ERROR CURVE



ISO 4064: 2005 Standardization

- R=100 is the ratio of Normal Flow rate (Q3) the minimum flow rate(Q1).

$$R = \frac{Q3}{Q1} = 100$$

Q1= Qmin(Minimum Flow rate)

Q2= Qt(Transitional Flow rate)

Q3= Qn(Nominal Flow rate)

Q4= Qmax(Maximum Flow rate)

$$\frac{Q4}{Q3} = 1.25$$

$$\frac{Q2}{Q1} = 1.6$$

Definition of meter accuracy

The volume of water that passes through a water meter is called the **actual volume, or Va**.

No meter is 100% accurate, the meter will not register all the water passing through it but show a **indicated volume (Vi),** which is slightly lower or higher than the actual volume.

The difference between the indicated volume and actual volume **(Vi-Va)** is called the meter error. When the error is expressed as a fraction (percentage) of the actual volume, it is called as the relative error.

[Relative error]: (Vi - Va) / Va x 100 (%)

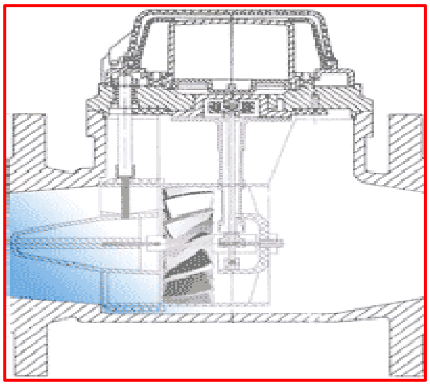
Definition of meter accuracy

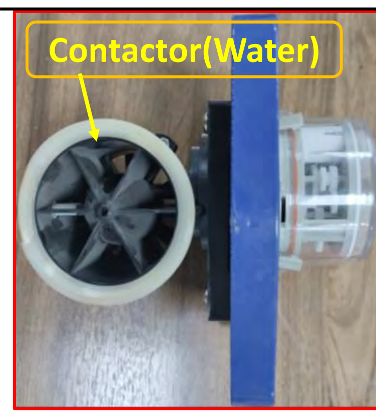
CALCULATION OF THE ERROR (%)

$$\text{Error (\%)} = \frac{\begin{array}{c}\text{Indicated Volume} \\ \text{(meter reading result)}\end{array} - \text{Actual Volume}}{\text{Actual Water Volume}} \times 100$$

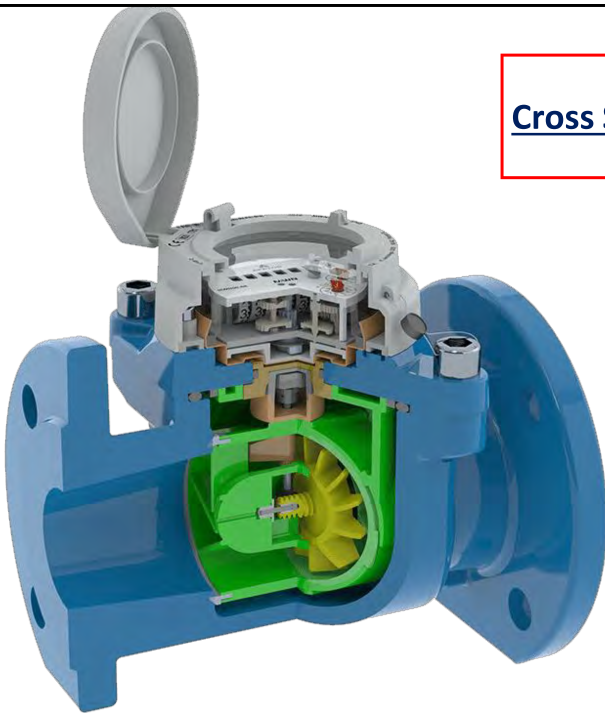
Bulk Flow meter(Woltman)

- The Woltman (Bulk) water meter with magnetic transmission and dry recording head, for measuring applications in water supply networks. A bulk meter is a large meter that we fit to pipes to measure water flow and help us find leaks.



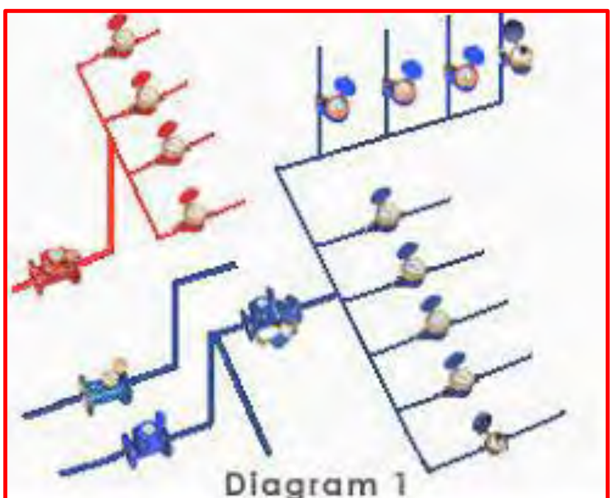


Main Parts of Bulk Water meter

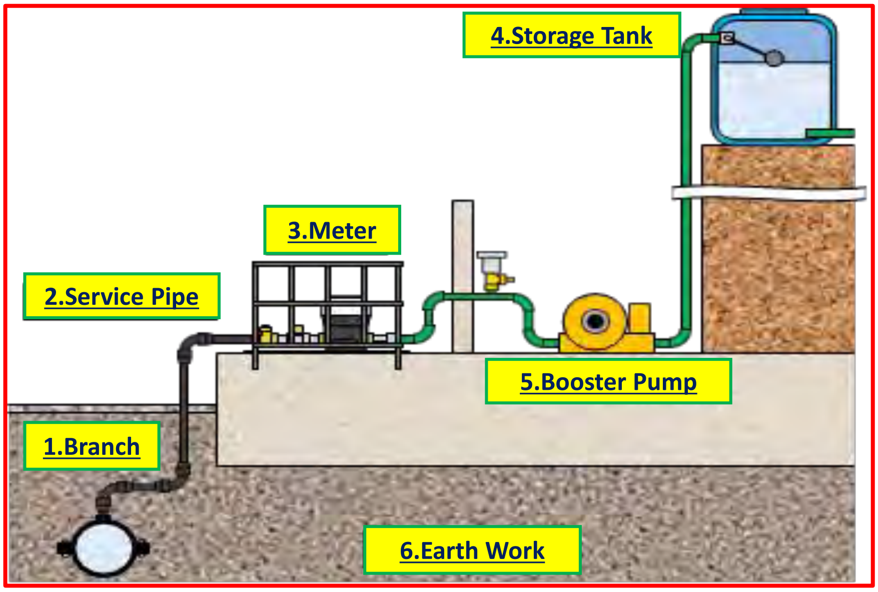


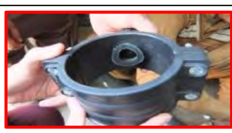
Cross Sectional-View of Woltman(Bulk Meter)

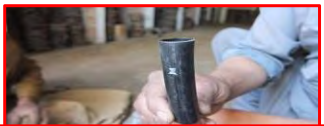
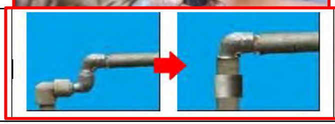
Bulk meter Installation



SOP's for the Installation of Water Meter

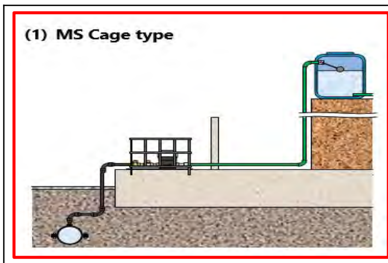
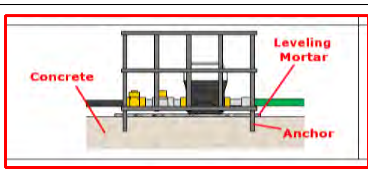
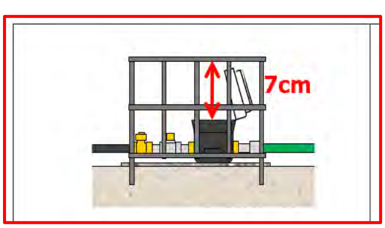


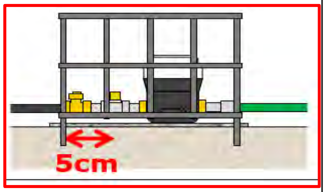
 Branch	It should be confirmed that rubber is set at branch point. اس بات کی تصدیق کی جانی چاہیے کہ ربڑ برانچ پوائنٹ پر سیٹ ہے۔
 Service Pipe	Service connection should be branched directly from water distribution pipe by 1/2" and 90° of bent pipe is used instead of 1/4" ferrule. سروس کنکشن کو پانی کی تقسیم کے پائپ سے براہ راست "2/1 تک برانچ کیا جاتا چاہئے اور "4/1 فیرول کی بجائے °90 جھکا ہوا پائپ استعمال کیا جاتا ہے۔
	When improving existing service pipe, it is necessary to confirm that pipe comes from WASA's system. موجودہ سروس پائپ کو بہتر کرتے وقت یہ تصدیق کرنا ضروری ہے کہ پائپ واسا کے سسٹم سے آیا ہے۔
	GI should be selected if pipe is installed above ground. If pipe is installed underground, UPVC/HDPE or non-corrosive pipe & fittings shall be used. اگر پائپ زمین کے اوپر نصب ہے تو GI کا انتخاب کیا جانا چاہیے۔ اگر پائپ زیر زمین نصب ہے تو، UPVC/HDPE یا نان کوروسیو پائپ اور فٹنگز استعمال کی جائیں گی۔

	The pipe should be cut with suitable equipment and must be straight. پائپ کو مناسب آلات کے ساتھ کاٹا جانا چاہئے اور اسے سیدھا کاٹا جانا چاہئے۔
	Use of meaningless bend pipe should be avoided. پائپ میں بے معنی موڑ کے استعمال سے گریز کیا جائے۔
	Meter should be installed outside of customer's premises within 50cm from boundary and without vehicle load. (If meter is installed inside the customer's premises, it is difficult to read the meter for meter readers because of gate lock or customer absence). میٹر گاہک کے احاطے سے باہر باؤنڈری سے 50 سینٹی میٹر کے اندر نصب کیا جائے اور ٹریفک سے بچیں۔ (اگر میٹر گاہک کے احاطے کے اندر نصب ہے تو گیٹ لاک یا گاہک کی غیر موجودگی کی وجہ سے میٹر ریڈرز کے لیے میٹر کو پڑھنا مشکل ہے)۔

Three types of meter cage for thief prevention measure of meter

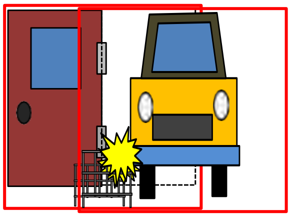
Measures to prevent theft of the meter are selected depending on the site situation, but in principle, installation of (1) **MS cage** should be adopted. Under difficult circumstances for various reasons, underground installation such as (2) **Steel lid** or (3) **Concrete Box** will be considered.

	In principle, MS cage should be selected with concrete base and meter should be installed on the ground. اصولی طور پر، ایم ایس کیج کو کنکریٹ کی بنیاد کے ساتھ منتخب کیا جانا چاہئے اور زمین پر میٹر لگانا چاہئے۔
	MS cage should be installed as left figure. ایم ایس کیج کو اس طرح انسٹال کرنا چاہیے جیسا کہ بائیں تصویر میں دکھایا گیا ہے۔
	For opening the meter cover, 7cm or more of interval is required at the top. At the site, meter cover should be opened and ease of meter reading should be confirmed. میٹر کور کھولنے کے لیے، اوپر 7 سینٹی میٹر یا اس سے زیادہ وقفہ درکار ہے۔ سائٹ پر، میٹر کا احاطہ کھولا جانا چاہیے اور میٹر ریڈنگ میں آسانی کی تصدیق کی جانی چاہیے۔



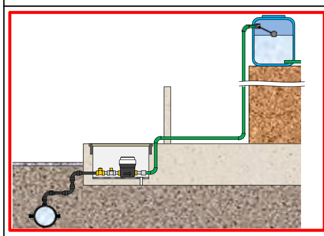
For opening/closing the magnetic valve, 5cm or more of interval is required around magnetic valve. At the site, valve operation should be carried out and confirmed.

مقناطیسی والو کو کھولنے/بند کرنے کے لیے،
مقناطیسی والو کے ارد گرد cm5 یا اس سے زیادہ
وقفہ درکار ہے۔ سائٹ پر، والو آپریشن کیا جانا
چاہئے اور اس کی تصدیق کی جانی چاہئے



Cage installed on the ground can be interferes with the opening and closing of the door or the passage of the vehicle. When meter is not secured on the ground, underground installation should be selected for thief prevention measure of meter.

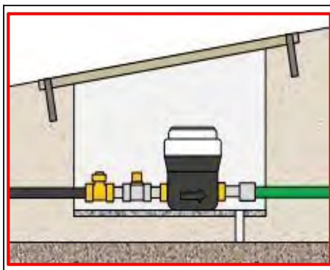
زمین پر نصب پنجرا دروازے کے کھلنے اور بند ہونے
یا گاڑی کے گزرنے میں مداخلت کر سکتا ہے۔ جب میٹر
زمین پر محفوظ نہ ہو تو میٹر کی چوری کی روک تھام
کے لیے زیر زمین تنصیب کا انتخاب کیا جانا چاہیے



If there is a concrete part where the lid can be fixed with the anchor, (2) **Steel lid** type should be selected instead of (1) **MS cage** type.
The meter installation place is excavated

Excavation range:
W 20cm x L 30cm x D 20cm or more.
Drainage function should be considered.

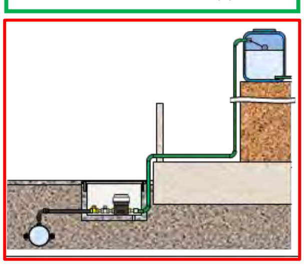
اگر کوئی کنکریٹ کا حصہ ہے جہاں لنگر کے ساتھ
ڈھکن لگایا جا سکتا ہے، (2) سٹیل کی پلیٹ (1)
ایم ایس کیج کی بجائے منتخب کی جائے۔
میٹر کی تنصیب کی جگہ کھدائی کرنی چاہیے۔



Even on a slope, the lid can be installed as the left figure. However, it is necessary to pay attention to the lid installation location so that the anchor does not penetrate.

ڈھلوان پر، ڑککن بائیں شکل کے طور پر نصب
کیا جا سکتا ہے۔ تاہم، ڑککن کی تنصیب پر
توجہ دینا ضروری ہے

Concrete Box Type



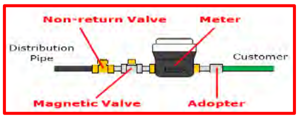
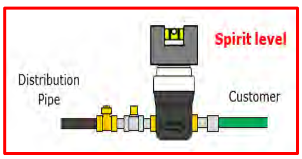
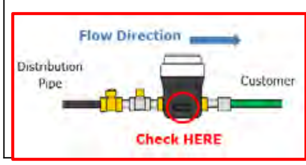
If there is no concrete to fix the lid with anchor, (3) Concrete Box Type should be selected for thief prevention measure of meter instead of (2) Steel Lid type.

اگر پیچ کے ساتھ ڈھکن لگانے کے لیے کوئی
کنکریٹ نہیں ہے، (3) میٹر کی چوری کی روک
تھام کے لیے کنکریٹ باکس کا انتخاب کیا
جانا چاہیے بجائے اسٹیل کے ڈھکن کی قسم۔

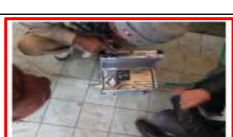
Drainage function should be considered(Installation of (1) and (2) is considered as much as possible, because (3) is expensive)

نکاسی کے فنکشن پر غور کیا جانا چاہئے (1)
اور (2) کی تنصیب پر غور کیا جانا چاہئے۔
جتنا ممکن ہو، کیونکہ (3) مہنگا ہے)

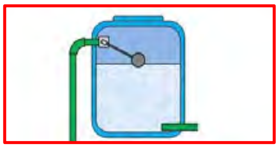
Basics for water Meter Installation

	Piping around the meter consists of non-return valve, Ball valve, meter and adopter. میٹر کے ارد گرد پائپنگ نان ریٹرن والو، بال والو، میٹر اور ساکٹ پر مشتمل ہے
	All water consumption should be captured. It is necessary to confirm that there is no water supply branch upstream of the meter. تمام پانی کی کھپت کو میٹر کیا جانا چاہئے۔ یہ تصدیق کرنا ضروری ہے کہ میٹر کے اوپر پانی کی فراہمی کی کوئی شاخ نہیں ہونی چاہیے
	Meter should be installed horizontally, therefore horizontal should be confirmed using spirit level etc. میٹر کو افقی طور پر نصب کیا جانا چاہیے، اس لیے اسپرٹ لیول وغیرہ کا استعمال کرتے ہوئے افقی کی تصدیق کی جانی چاہیے۔
	It should be confirmed that the arrow on the side of the meter body with water flow direction. میٹر کو پانی کے بہاؤ کی سمت میں نصب کیا جانا چاہئے اور پانی کے میٹر کے کیس میں بہاؤ کا تیر بھی ہے تاکہ آپ کی رہنمائی ہو سکے۔

Reuse of Existing water Meter

	Either there is existing water meter or not. It should be confirmed. پانی کا میٹر موجود ہے یا نہیں؟ اس کی تصدیق ہونی چاہیے۔
	If customer already has existing meter, meter should be read and recorded and this value should be reported to IT section. اگر گاہک کے پاس پہلے سے ہی میٹر موجود ہے تو میٹر کو پڑھنا چاہیے اور اس کی ریڈنگ کو ریکارڈ کرنا چاہیے اور آئی ٹی سیکشن کو رپورٹ کرنا چاہیے۔
	Removed meter should be brought the meter test yard and checked the accuracy. If meter has good accuracy, WASA can reuse it. ہٹائے گئے میٹر کو میٹر ٹیسٹ یارڈ میں لایا جائے اور درستگی کی جانچ کی جائے۔ اگر میٹر کی درستگی اچھی ہے تو واسا اسے دوبارہ استعمال کر سکتا ہے
	If test meter is available, you can utilize it. اگر ٹیسٹ میٹر دستیاب ہے، تو آپ اسے استعمال کر سکتے ہیں

Storage Tank

	If Customer have storage tank. Float valve should be installed in it. اگر گاہک کے پاس اسٹوریج ٹینک ہے۔ اس میں فلوٹ والو لگانا چاہیے

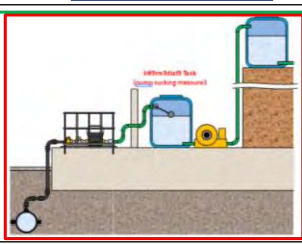
Sucking Pump:

Usually customers used illegal pumps to maintain water pressure that illegal pump must be removed.

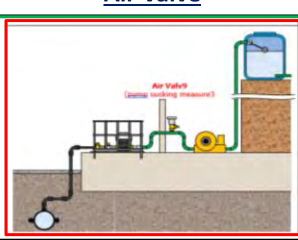
عام طور پر صارفین پانی کے دباؤ کو برقرار رکھنے کے لیے غیر قانونی پمپ استعمال کرتے ہیں۔ اس غیر قانونی پمپ کو ہٹا دیا جانا چاہیے۔

(1) Intermediate Tank or **(2) Air Valve** should be installed.

Intermediate Tank

	For one of the countermeasures of sucking pump, intermediate storage tank should be installed between meter and pump. When installing intermediate tank, float valve should be installed. پمپ کے انسدادی اقدامات، میٹر اور پمپ کے درمیان انٹرمیڈیٹ سٹوریج ٹینک نصب کیا جانا چاہیے۔ انٹرمیڈیٹ ٹینک نصب کرتے وقت، فلوٹ والو نصب کیا جانا چاہئے

Air Valve

	For another countermeasure of sucking pump, air valve should be installed between meter and pump, and it should be installed at higher position than meter. پمپ کے انسداد کے لیے، ایئر والو کو میٹر اور پمپ کے درمیان نصب کیا جانا چاہیے، اور اسے میٹر سے اونچی پوزیشن پر نصب کیا جانا چاہیے
	Their should be no leakage from air release valve. چیک کریں، ایئر ریلیز والو سے پانی کا رساو نہیں ہونا چاہیے

No.	Check items	Check
1	Check meter proper functioning at low-flow dial before installing it. واٹر میٹر کو انسٹال کرنے سے پہلے اسے کم بہاؤ پر کام کرنے کی جانچ کریں	
2	Meter is horizontally installed with correct flow direction. میٹر افقی طور پر درست بہاؤ کی سمت کے ساتھ نصب ہے	
3	Ball valve is installed upstream and non-return valve is installed downstream of meter with no branches upstream of meter. بال والو کو اپ اسٹریم پر نصب کیا جانا چاہئے اور میٹر کے بعد نان ریٹرن والو انسٹال کیا جانا چاہئے۔ میٹر سے پہلے کوئی برانچ لائن پائپ موجود نہیں ہونا چاہیے	
4	Illegal sucking pump is not installed and there are no suspected. illegal connections around customer's premises. غیر قانونی پمپ نہیں لگانا چاہیے، گاہک کے احاطے کے ارد گرد کوئی مشتبہ اور غیر قانونی پانی کے کنکشن نہیں ہونا چاہیے۔	
5	If customer has storage tank, it should have float valve. اگر گاہک کے پاس اسٹوریج ٹینک ہے تو اس میں فلوٹ والو ہونا چاہیے	
6	Check water pressure at customer's tap. گاہک کے نل پر پانی کا دباؤ چیک کریں	
7	Meter is easy to read and remove by WASA maintenance workers. کیا میٹر پڑھنا آسان ہے اور اسے واسا کے مینٹیننس ورکرز ہٹا سکتے ہیں	
8	Is meter is not being an obstacle to traffic and have meter prevention being theft کیا میٹر ٹریفک کی راہ میں رکاوٹ نہیں ہے اور میٹر چوری ہونے کی روک تھام ہے	

Water & Electricity Consumption

BEFORE TURN ON T.W:

- Note the reading of bulk flow meter

- Note the reading of Electricity meter

AFTER TURN OFF T.W:

- Note the reading of bulk flow meter

- Note the reading of Electricity meter

CALCULATION

- For Example:

Water produced = 300 m3

Electricity = 10 kwh (10 units)

Time = 30 min

Per unit water produced = 300/10 = 30 m3

Per minute water produced = 30/30 = 1 m3

End Result:

So we are generating 1000 liters in one minute by consuming 1 kw power

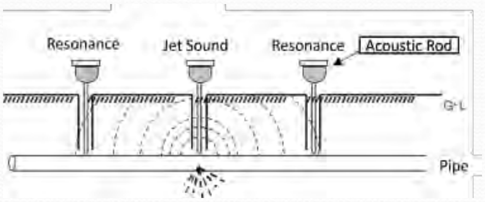
- Acoustic Rod
- Acoustic Leak Detector

Acoustic Rod/Stick

Specification				
Type	Cap dia.* Thickness (mm)	Total Length (mm)	Dia. of Iron Bar (mm)	Material
LSP-1	ø 67x29	1,013	7	Stainless Steel

Use:
- Place the tip of acoustic rod at the point where doubt of leakage
- Catch the stick below the listening cap and place ear on the cap of acoustic rod
- Hear the sound of leaked water, if no leakage at that place repeat the same procedure aside this place
- Very useful to listen leaks sound at hydrants and valves

Factors affecting performance:
- Pressure
- Depth



Leak Detector

Components:

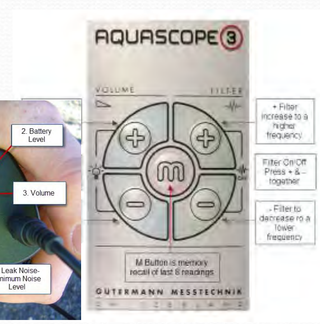
- Amplifier with waist belt
- Hand probe microphone
- Ground microphone plate
- Probe rods
- Stereo headphones
- Connecting cable

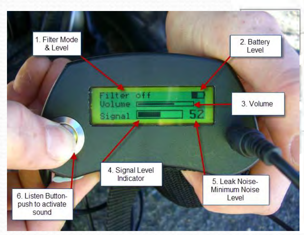
Operation:

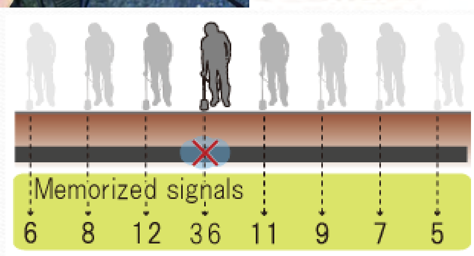
- Use head phones remember Left and Right direction.
- Turn volume up to half using the dial on the headphone cable.
- Ensure good contact of microphone and surface area.
- Press and hold silver button to listen sound.
- With every press and release of the silver button the noise level will be recorded in the memory.
- To see memory data for the last eight soundings, press and hold the "M" button on the amplifier.
- To turn filter on press and hold the sky blue + & - filter buttons simultaneously. The filter bandwidth is +/- 100Hz.

Leak Detector
Important Points & Precautions

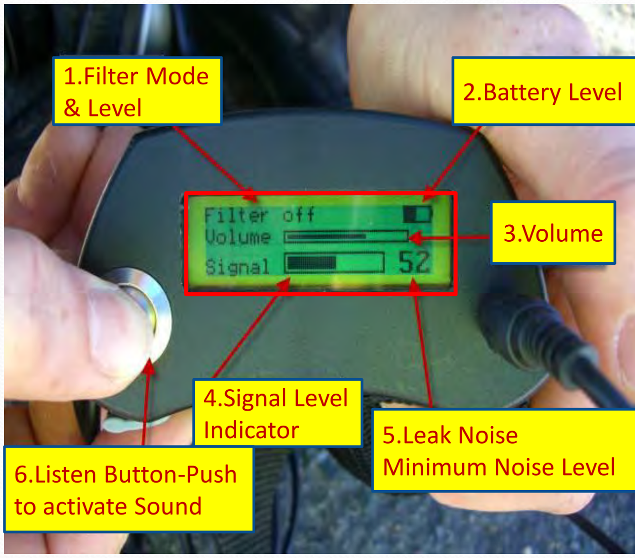
- Use filter in case high background noises
- Leakage sound depends upon,
  - Water pressure
  - Crack or hole size
- Operator should stay stable during its use
- Required practice to pinpoint or identify leaks
- Don't use in rainy days and when speed is 6 m/s.
- Sensors are water resistant, but control unit and head phones are not resistive. Keep them away from water .

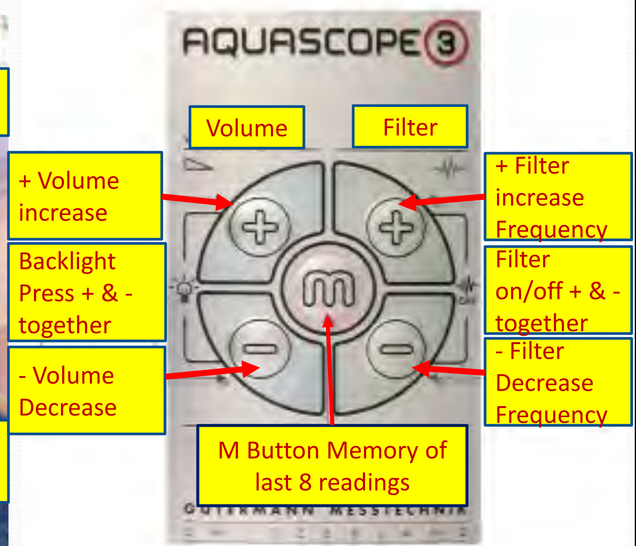






Use of Leak Detector





Understanding Leak Noise-Leak Frequency

Pipe Material	Frequency Range	Normal Frequency
Steel	400 Hz – 1500 Hz	800 Hz
Iron	300 Hz – 1200 Hz	700 Hz
Copper	700 Hz – 2500 Hz	1800 Hz
AC	300 Hz – 800 Hz	500 Hz
Lead	200 Hz – 700 Hz	400 Hz
PVC	200 Hz – 500 Hz	300 Hz
Polyethylene	100 Hz – 400 Hz	250 Hz

Factors Affecting Leak Noise

- Pipe Material (Hard is good - Soft is poor)
- Pipe Diameter (Small is good – Large is poor)
- Pressure (High is good – Low is poor)
- Background Noise can muffle or drown out leak noise (PRV's - throttled valves)
- Consumption (High levels of consumption can make it hard to hear the leak and you may have to return at low consumption times)

The best time to perform acoustic leak detection is when all these factors are at a minimum except for pressure, at a maximum

Recognizing Leak Noise

Track 1. No Leak Noise

Characteristics ,Normal flow in a steel pipe

Recognizing Leak Noise

Track 2. A Meter Turning fast then slow

Characteristics ,Normal flow in a Copper Service

Recognizing Leak Noise

Track 3. Steel Leak Noise

Characteristics are Clear, Mid Frequency and Loud

Recognizing Leak Noise

Track 4. PVC Leak Noise

Characteristics are Muffled, Low Frequency and Quiet

Recognizing Leak Noise

Track 5. Copper Leak Noise

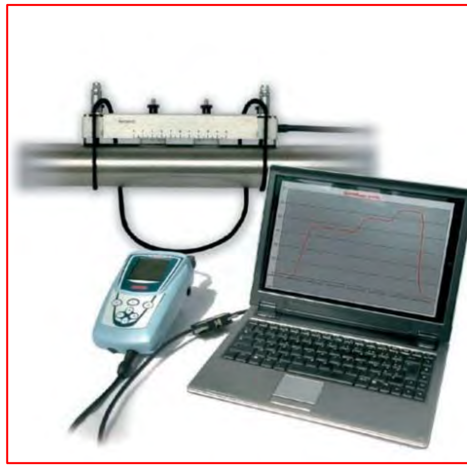
Characteristics are Clear, High Frequency and Loud

Recognizing Leak Noise

Track 6. Cast Iron Leak

Ultrasonic Flow Meter

Contents:



What Is Ultrasonic Flow Meter?

- Ultrasonic flow meter is a device to use measure the volume of flow per time.
- Portable ultrasonic flow meter is suitable for all conductive and non-conductive liquids such as water, chemicals, toxic media, hydrocarbons, etc.

Formula of Flow Rate:

- Q=V/t
- Q=Flow Rate
- V=Volume
- t=Time

- Unit

m3/hr, Cusec, Gpm

Working Principle

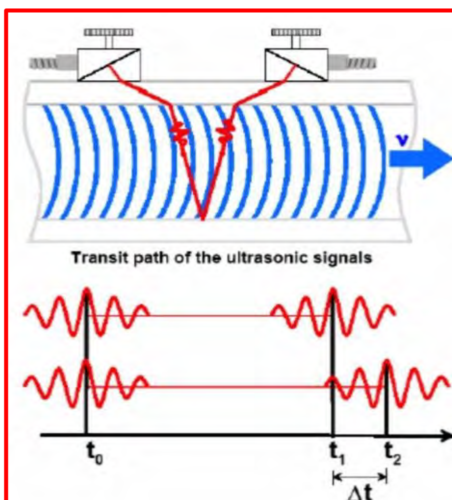
Ultrasonic technology(time of flight) to calculate the flow Velocity and volumetric flow rate of liquid. The flow meter Consist of two transducers that alternately send and receive ultrasonic signals to measure the flow rate.

Transducers/Probes

Ultrasonic Flow meter

Working Principle

The transit time difference between the transmitted and Received ultrasound signal. The difference in transit time Is a direct measure of liquid flow rate.



Advantages of Ultrasonic Flow meter

- 100% non-contact flow measurement (no liquid contact)
- Zero pressure drop created
- No moving parts and no wear and tear of flow transducers - long service life (+10 years)
- No re-calibration required - zero measurement drift
- No risk of pipe leaks - sensors installed externally on the pipe
- Suitable for a wide pipe size range - adaptable to future plant upgrades or pipe replacements
- Modular design - easy sensor and transmitter replacement requiring no system shutdown
- Accurate and repeatable: normally ±1..3% (±0.5..1% possible with advanced calibration)
- Easy installation and virtually zero maintenance costs
- Can measure conductive or non-conductive liquids
- Independent of liquid temperature, pressure, chemical properties, and viscosity.

Limitations

•Effected by concentration levels of suspended solids and

aeration in the liquid (maximum allowable concentration 5%...10%).

•Highly affected by pipe condition

(internal or external pipe rust, uneven surface etc.)

•Not as accurate as in-line meters such as magnetic

or turbine meters.

•Accuracy highly affected by incorrect pipe dimensions and parameters.

Before Use of Ultrasonic Flow meter

- Before Using Ultrasonic flow meter we have to following basic information about,

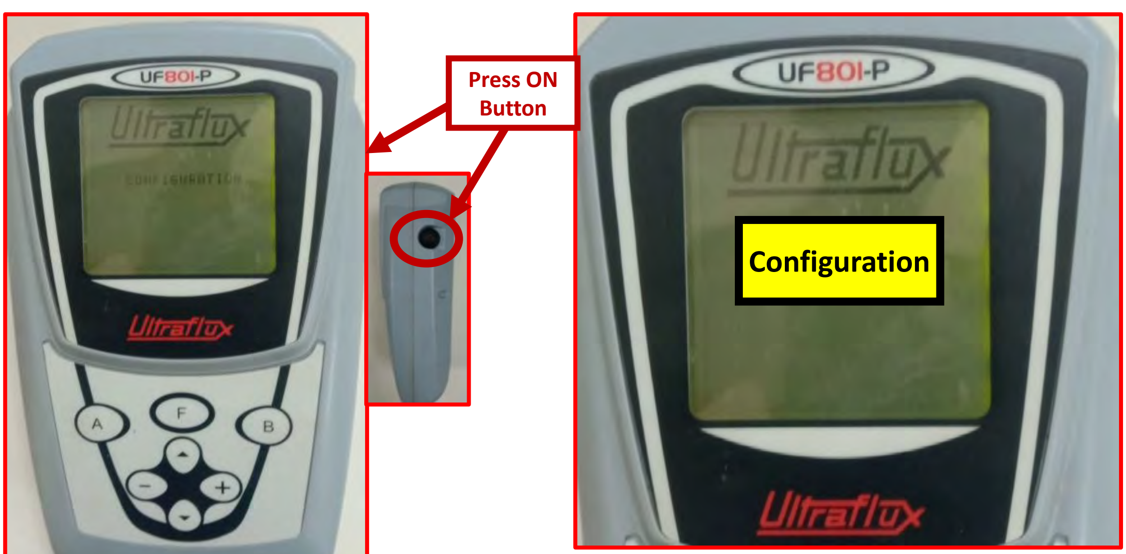
➢ Information of pipe material
➢ Diameter of Pipe
➢ Thickness of Pipe wall

Thickness of Pipe wall

Circumference of Pipe

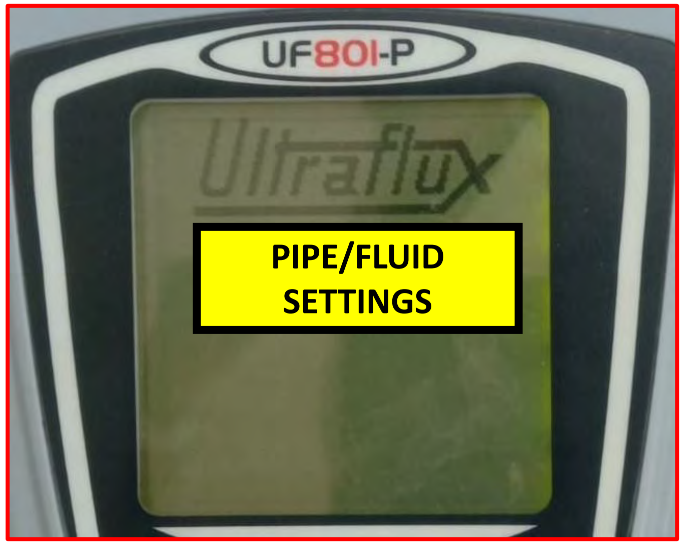
Use of Ultrasonic Flow Meter

- **After switching ON the ultrasonic flow meter press "F" button.**



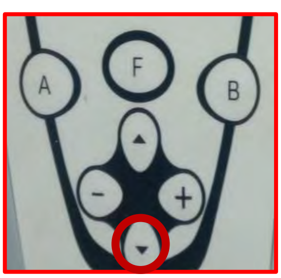
Use of Ultrasonic Flow Meter

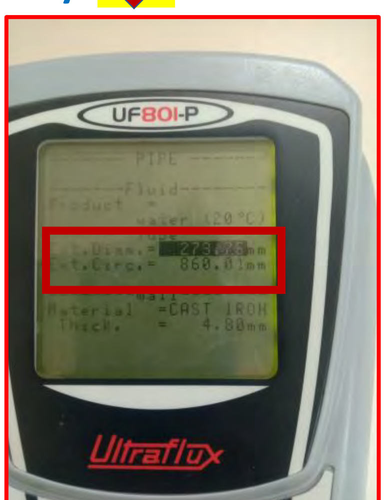
- Again Press **"F"** its showing pipe fluid setting.

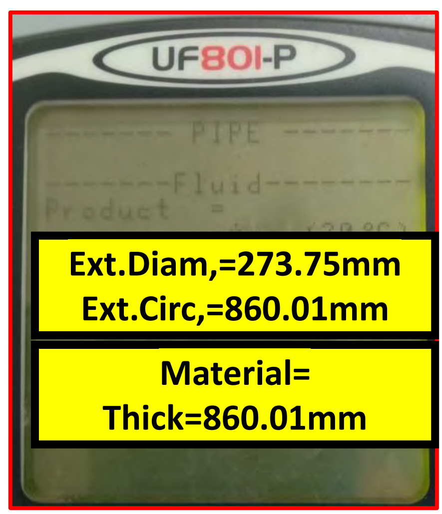


Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.







- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

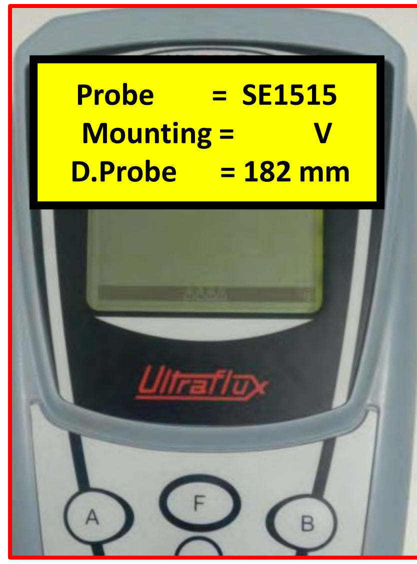
- Plus + or Minus – the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Use of Ultrasonic Flow Meter

- **Press and hold "F"** and its show probe distance and type of probes.



- **Flow rate in m3/hr will be shown.**

Use of Ultrasonic Flow Meter

- **Probes**
- For up to 100mm, use single probe, for more than 100mm, use double probe.

EPANET Software

HYDRAULLIC MODELING

Application for Modeling Drinking Water Distribution Systems

What is EPANET

- EPANET performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks.
- Pipe network consists of pipes, nodes (pipe junctions), pumps, valves, storage tanks and reservoirs.
- EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank.
- EPANET use for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

How to Download

https://www.epa.gov › water-research › epanet

EPANET | US EPA

01-Feb-2022 — EPANET is **a software application used throughout the world to model water distribution systems**. It was developed as a tool for understanding ...

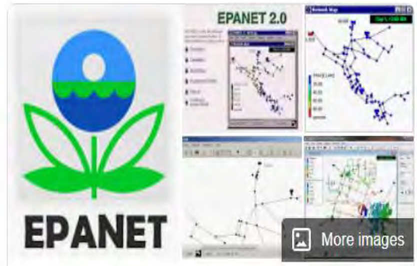
Software, Compatibility, and... · Capabilities · Applications

People also search for

is epanet free · epanet logo
epanet tutorial · epanet uses
epanet examples · epanet pdf

People also ask

What is EPANET software used for?



EPANET

System software

EPANET is a public domain, water distribution system modeling software package developed by the United States Environmental Protection Agency's Water Supply and Water Resources Division. Wikipedia

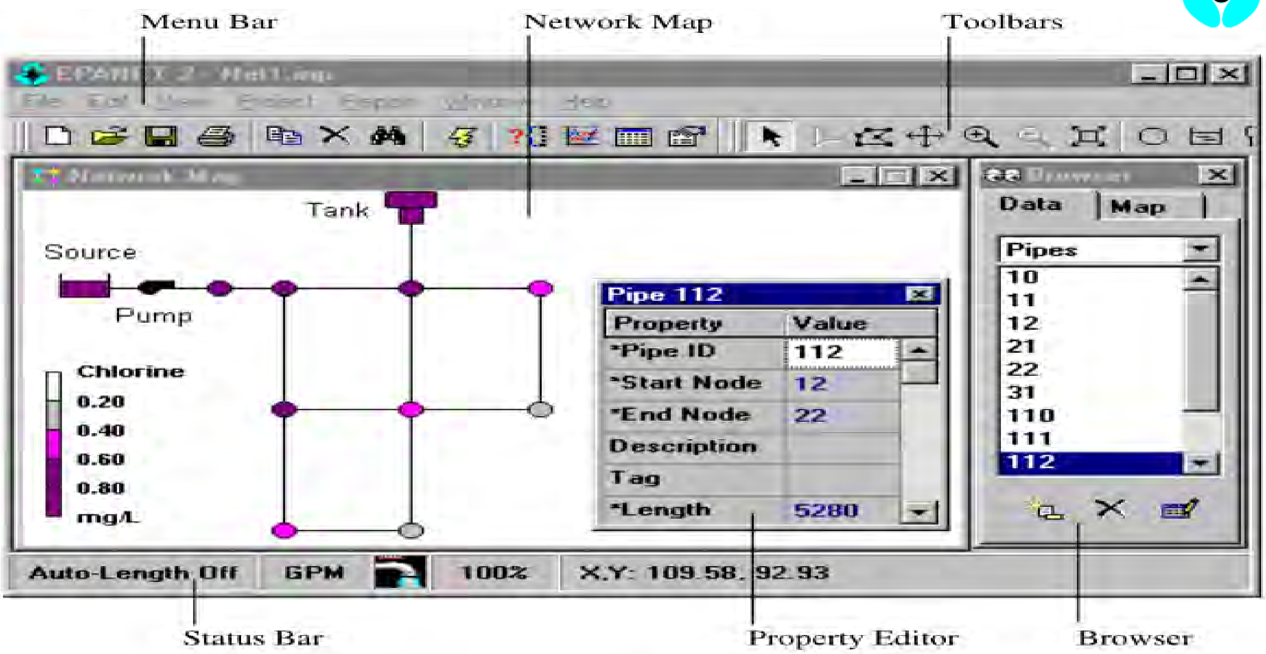
Download Software

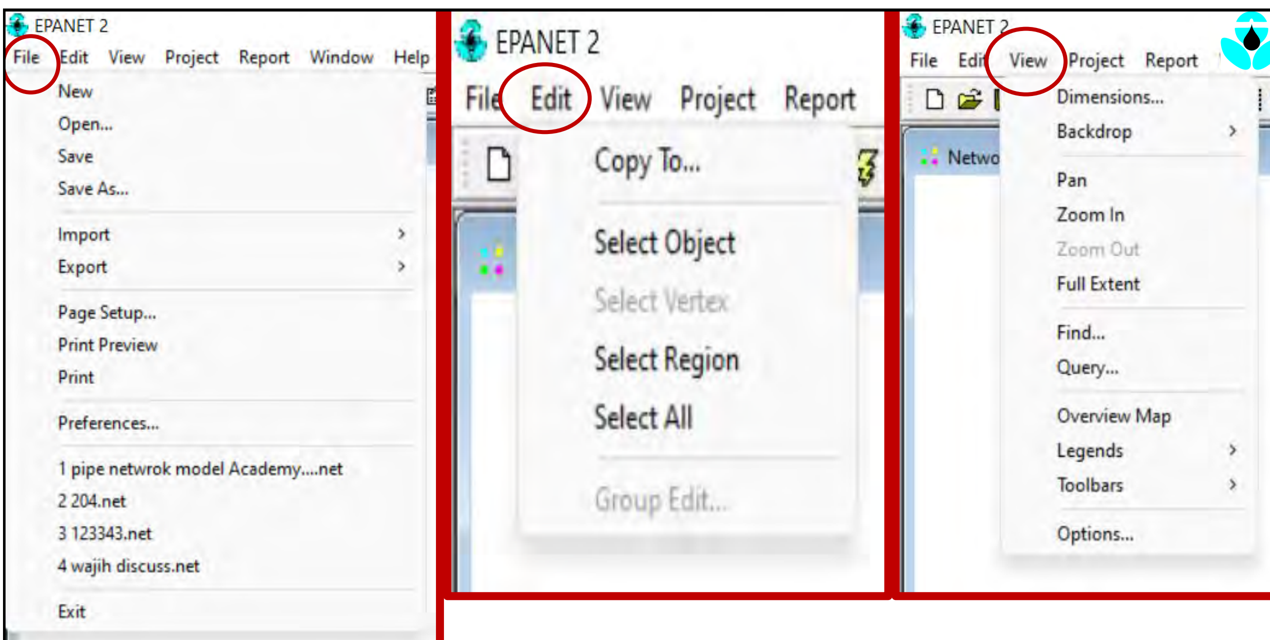
- EPA's GitHub site for EPANET 2.2 open source project

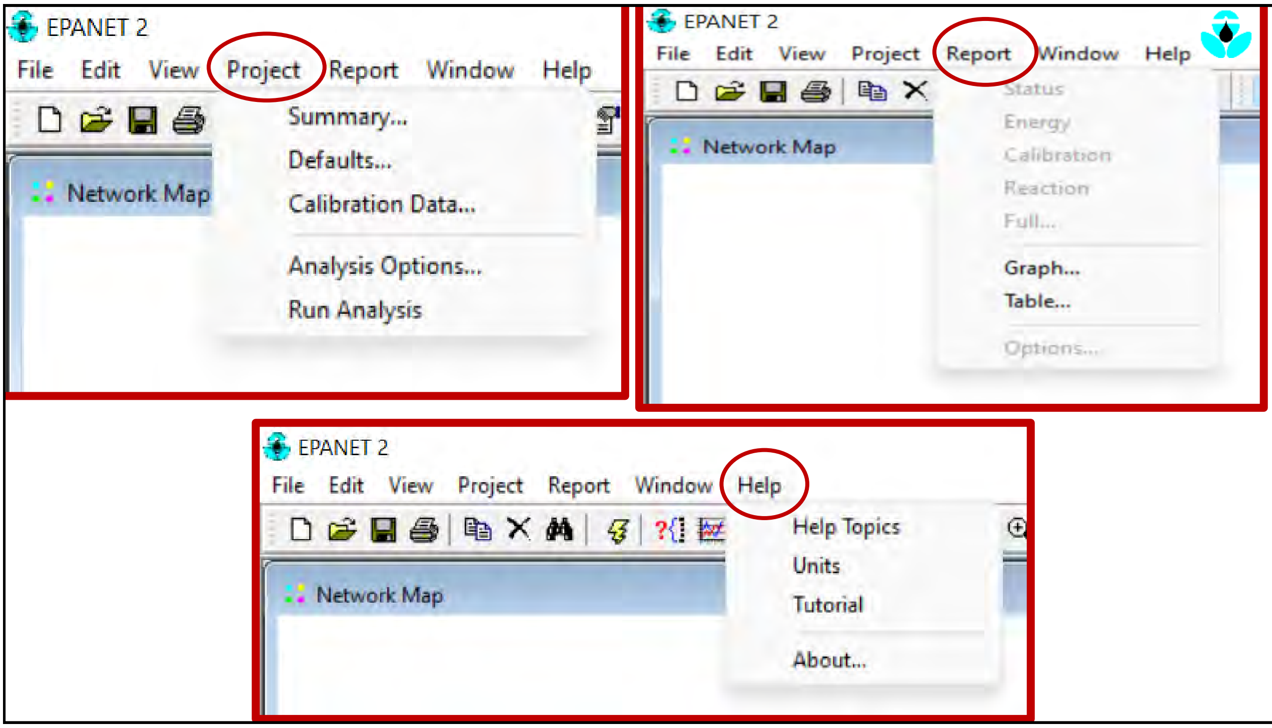
Software

Date	Description
07/23/2020	Self-Extracting Installation Program for EPANET 2.2 (EXE) (3.5 MB)
07/23/2020	Non-Installing Software for EPANET 2.2 (ZIP) (2.84 MB)
10/01/2018	Self-Extracting Installation Program for EPANET 2.00.12 (EXE) (exe)

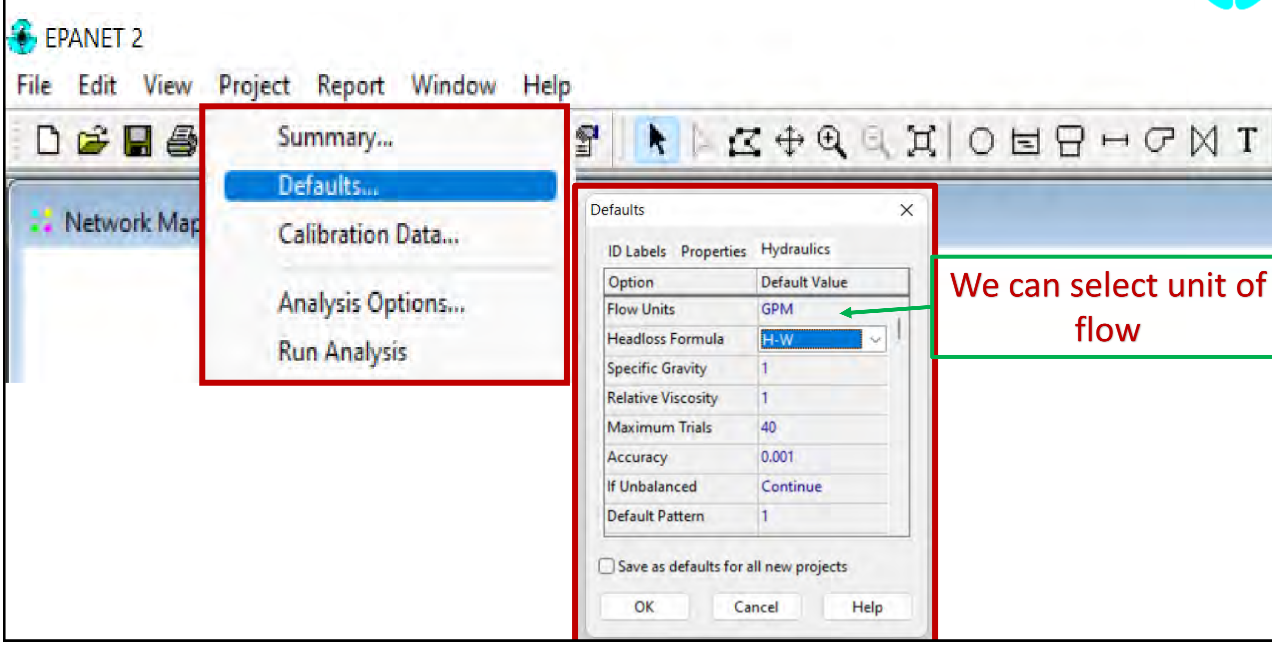
Interface


Menu Bar
Network Map
Toolbars
Tank
Source
Pump
Chlorine
0.20
0.40
0.60
0.80
mg/L
Pipe 112
Property
Value
*Pipe ID
112
*Start Node
12
*End Node
22
Description
Tag
*Length
5280
Data
Map
Pipes
10
11
12
21
22
31
110
111
112
Auto-Length Off
GPM
100%
X,Y: 109.58, 92.93
Status Bar
Property Editor
Browser

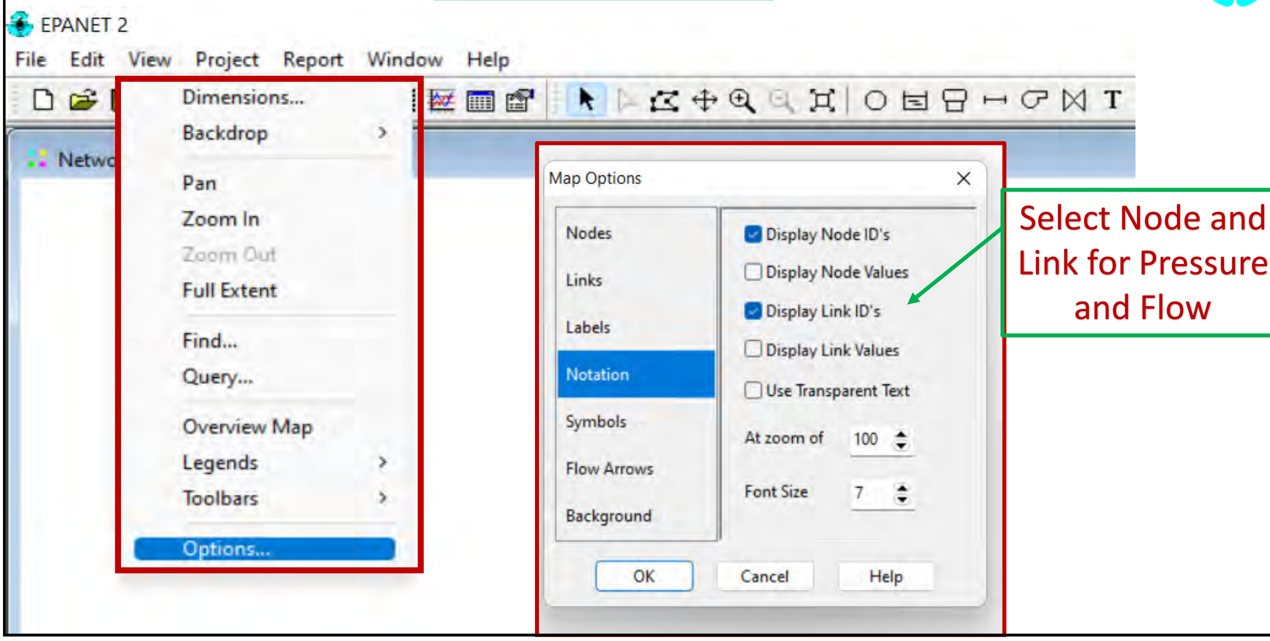

EPANET 2
File
Edit
View
Project
Report
Window
Help
New
Open...
Save
Save As...
Import
Export
Page Setup...
Print Preview
Print
Preferences...
1 pipe netwrok model Academy....net
2 204.net
3 123343.net
4 wajih discuss.net
Exit
EPANET 2
File
Edit
View
Project
Report
Copy To...
Select Object
Select Vertex
Select Region
Select All
Group Edit...
EPANET 2
File
View
Project
Report
Dimensions...
Backdrop
Pan
Zoom In
Zoom Out
Full Extent
Find...
Query...
Overview Map
Legends
Toolbars
Options...



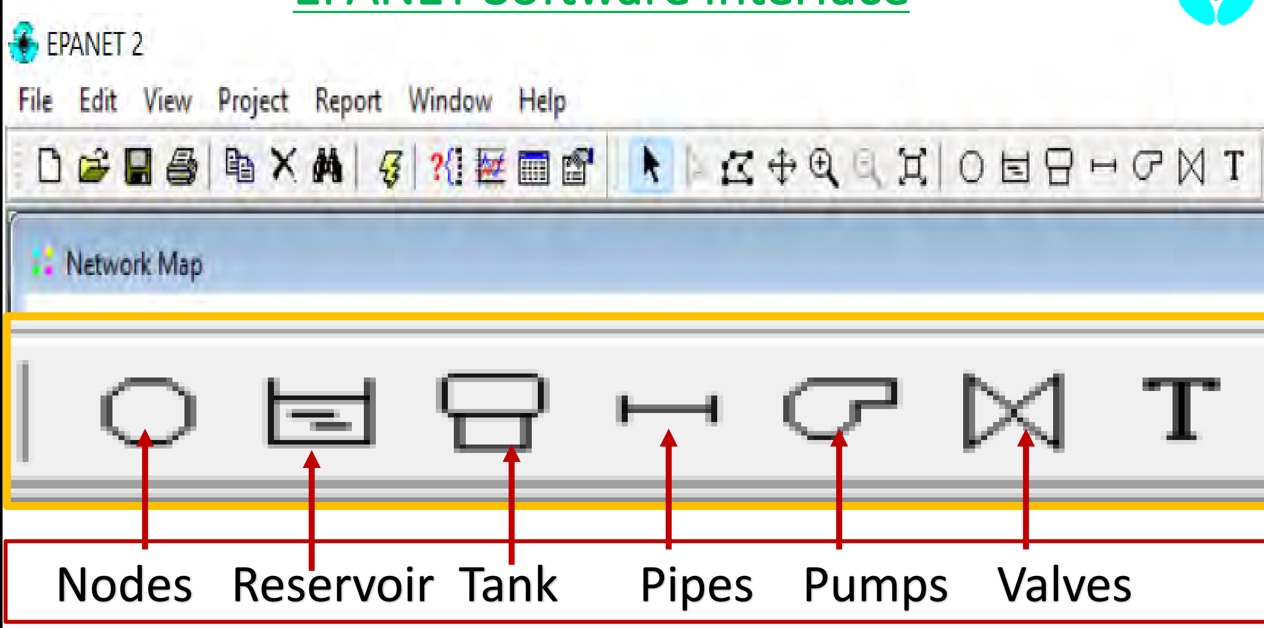
Use of EPANET



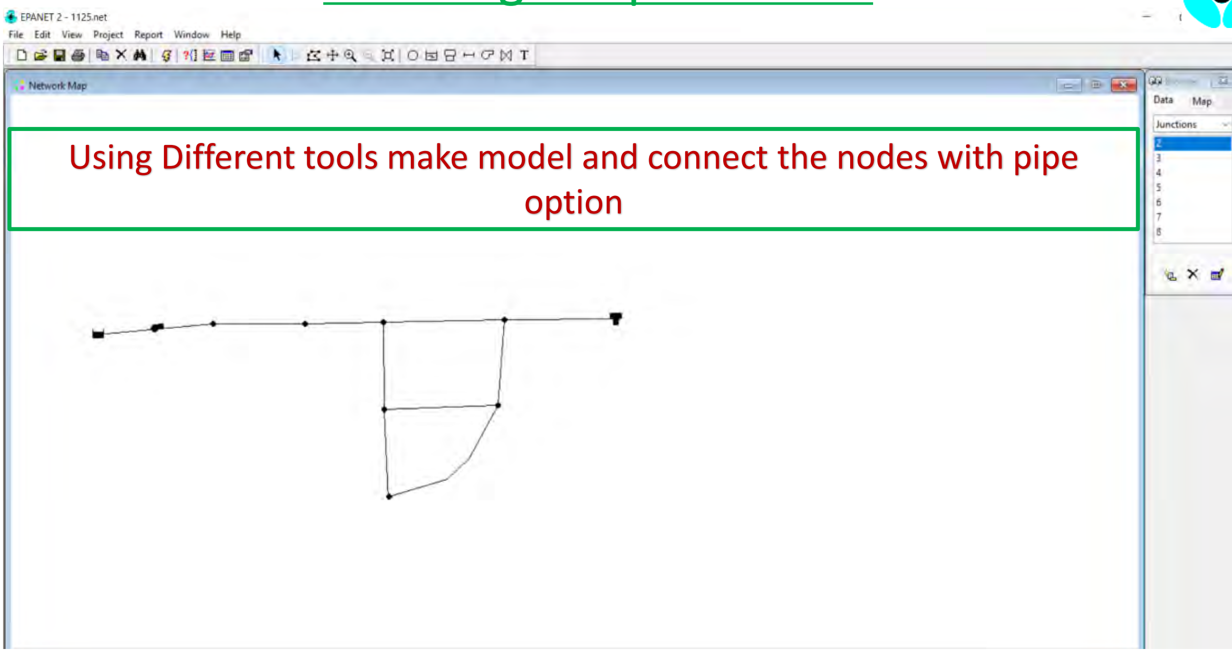
Use of EPANET

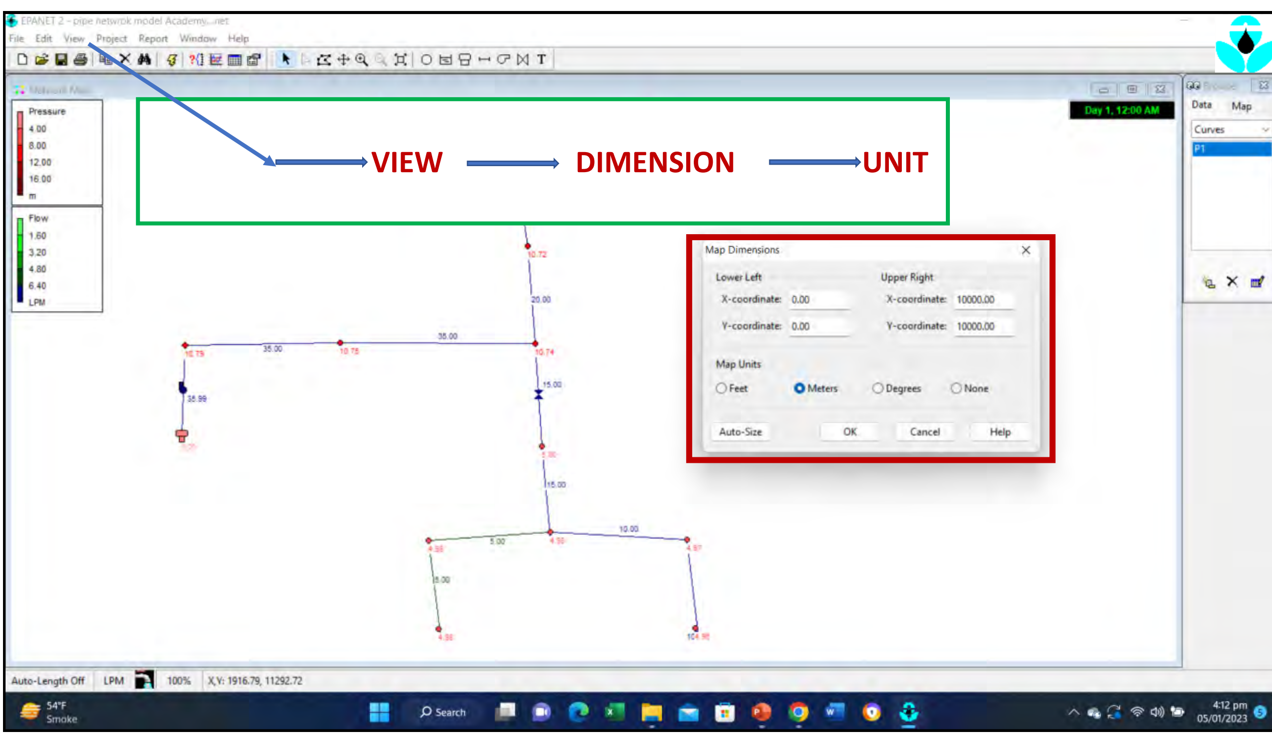


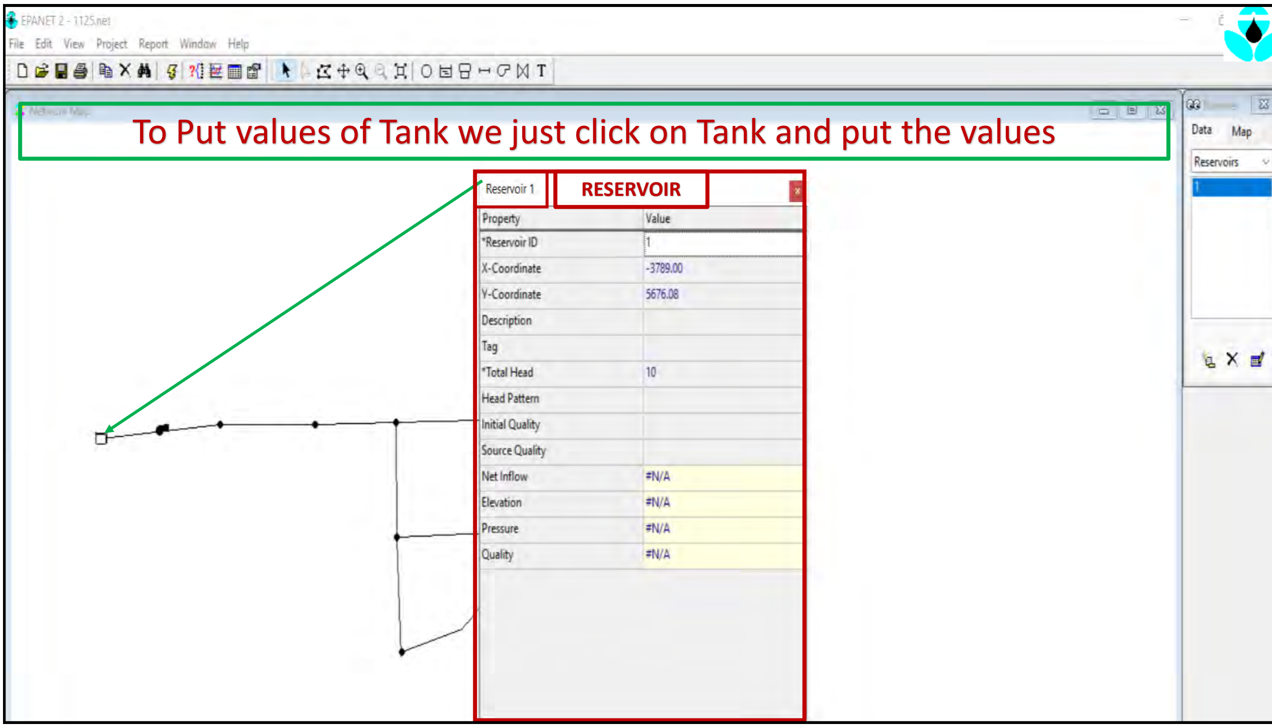
EPANET Software Interface

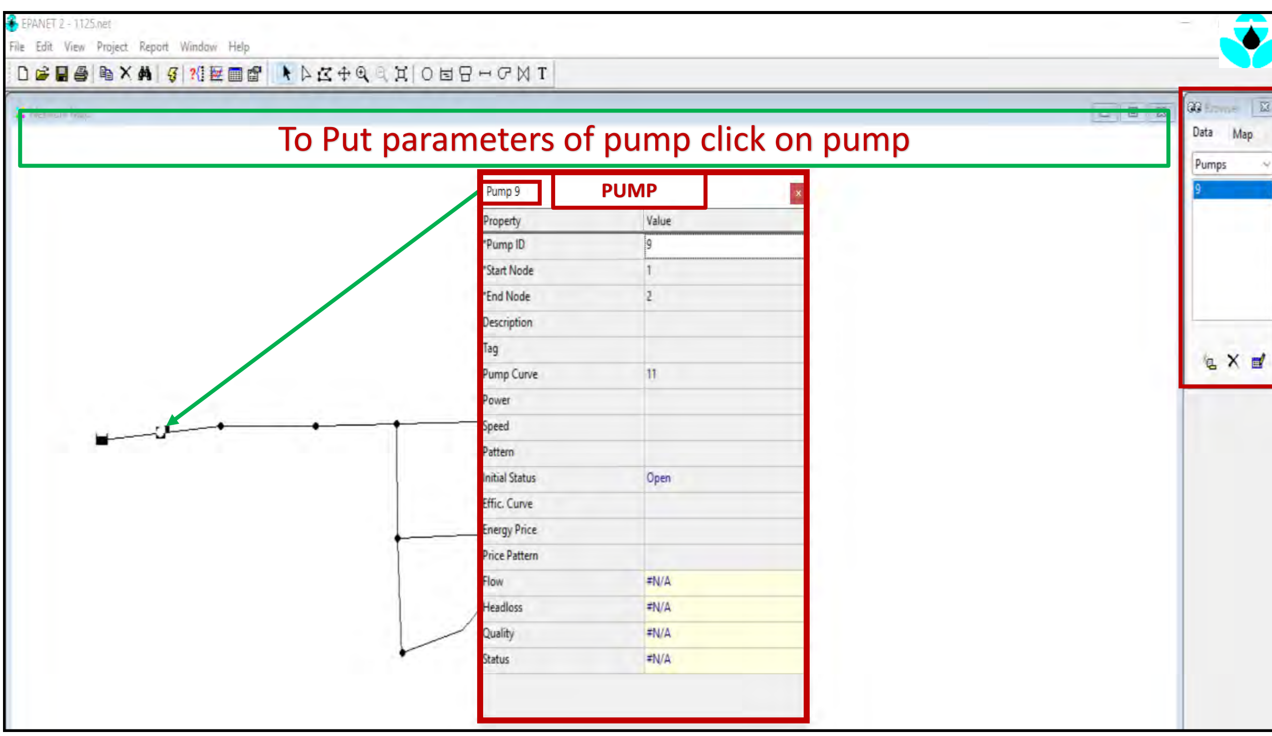


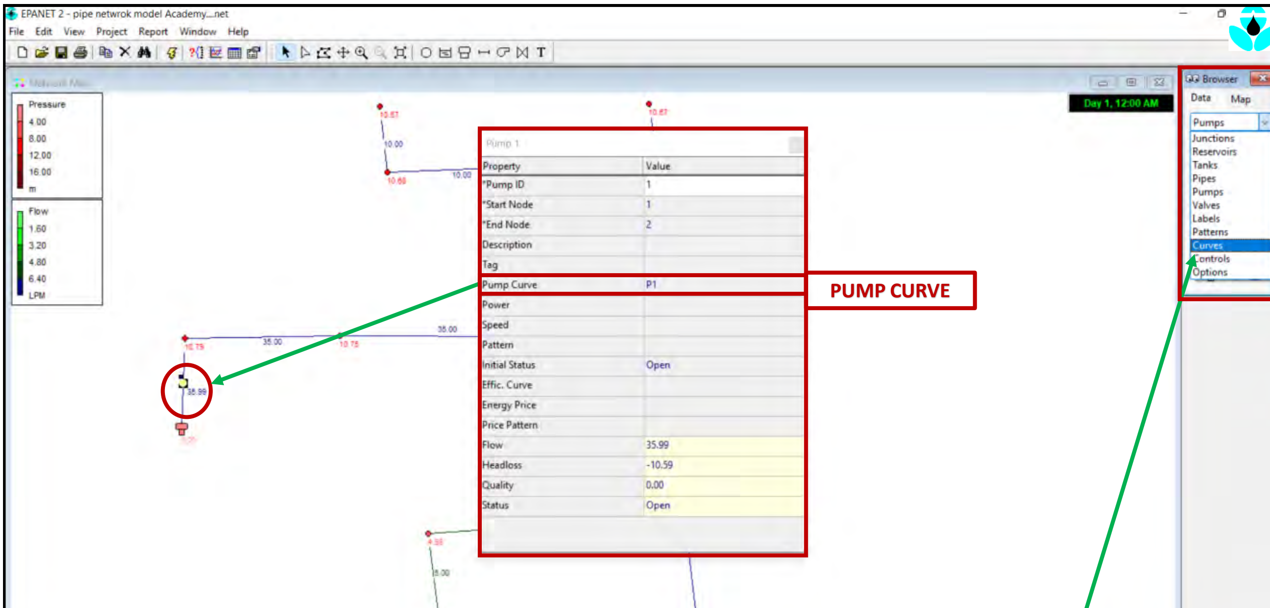
Modeling of Pipe Network



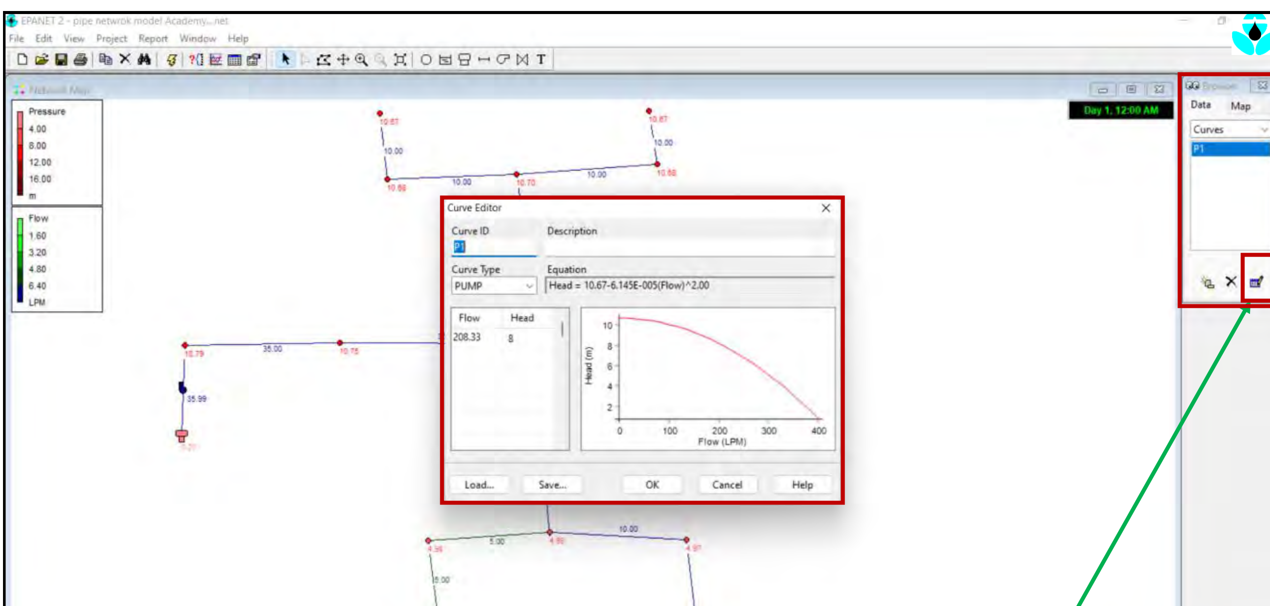



EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put values of Tank we just click on Tank and put the values
Reservoir 1
RESERVOIR
Property Value
*Reservoir ID 1
X-Coordinate -3789.00
Y-Coordinate 5676.08
Description
Tag
*Total Head 10
Head Pattern
Initial Quality
Source Quality
Net Inflow #N/A
Elevation #N/A
Pressure #N/A
Quality #N/A
Data Map
Reservoirs

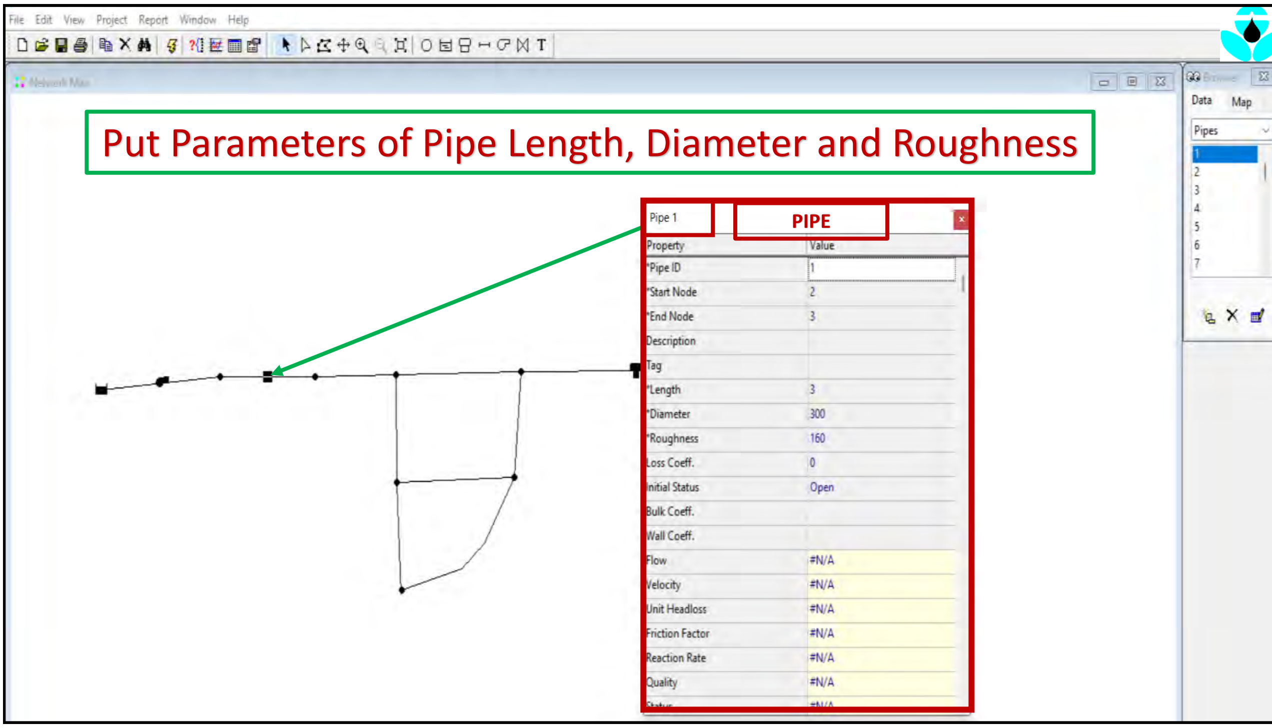

EPANET 2 - 1125.net
File Edit View Project Report Window Help
To Put parameters of pump click on pump
Pump 9
PUMP
Property Value
*Pump ID 9
*Start Node 1
*End Node 2
Description
Tag
Pump Curve 11
Power
Speed
Pattern
Initial Status Open
Effic. Curve
Energy Price
Price Pattern
Flow #N/A
Headloss #N/A
Quality #N/A
Status #N/A
Data Map
Pumps

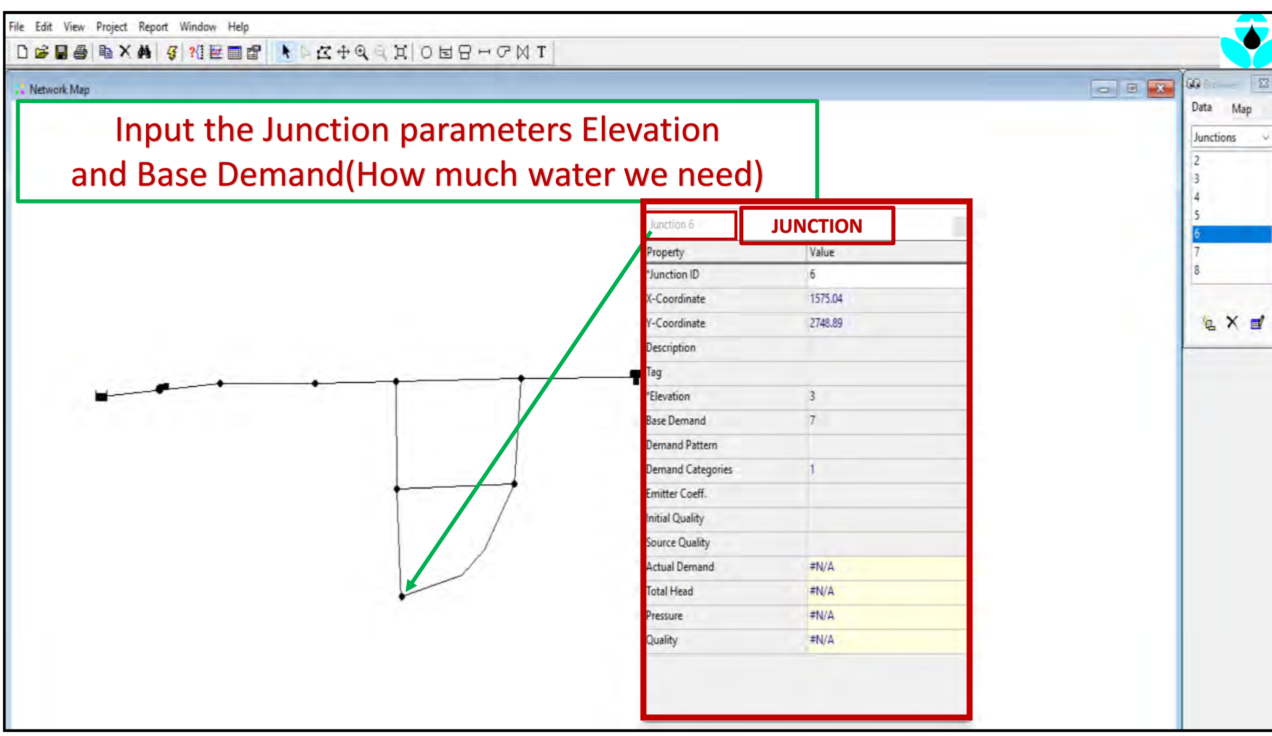


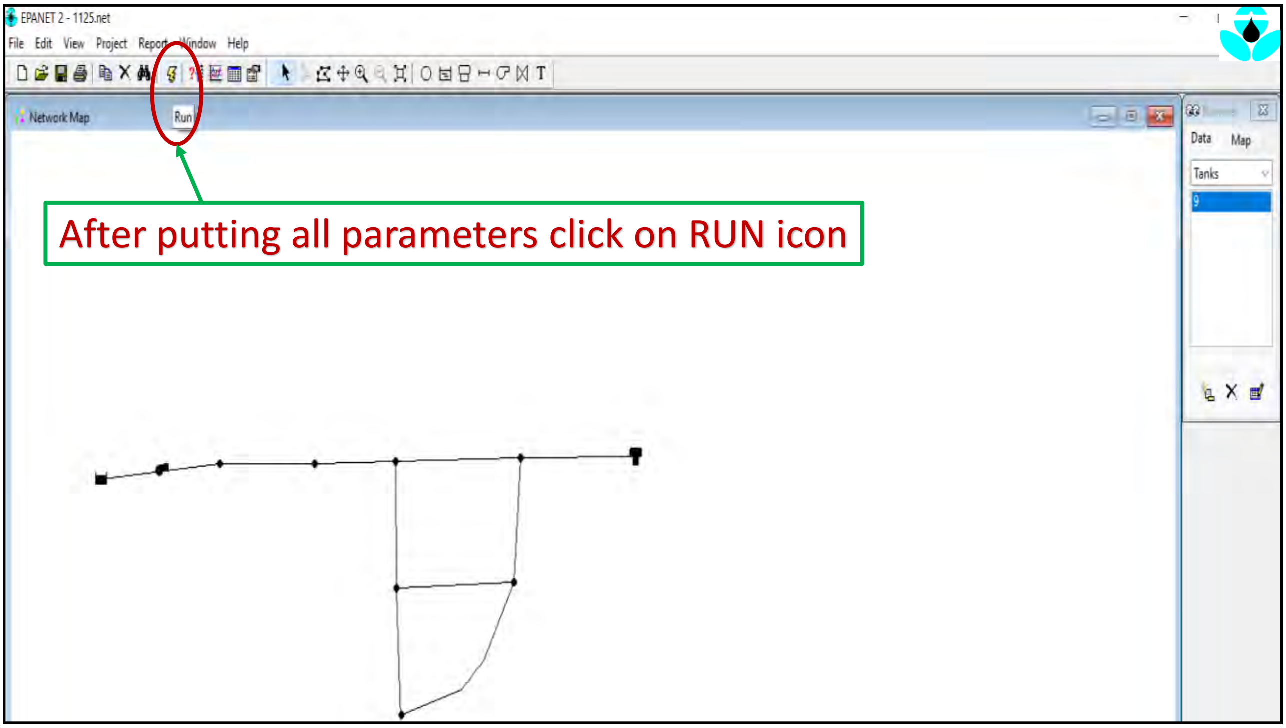
Add pump values, can add Pump curve, Power or Speed. On upper right side the different parameters we can put.

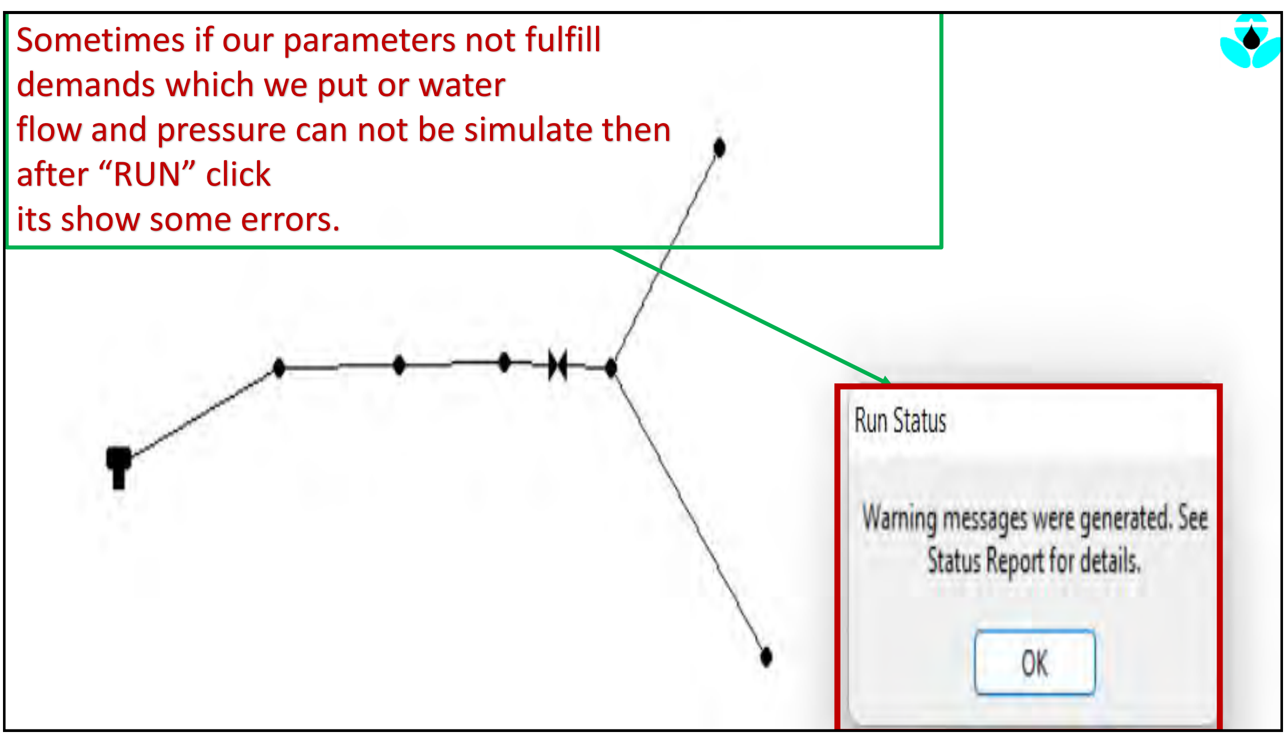


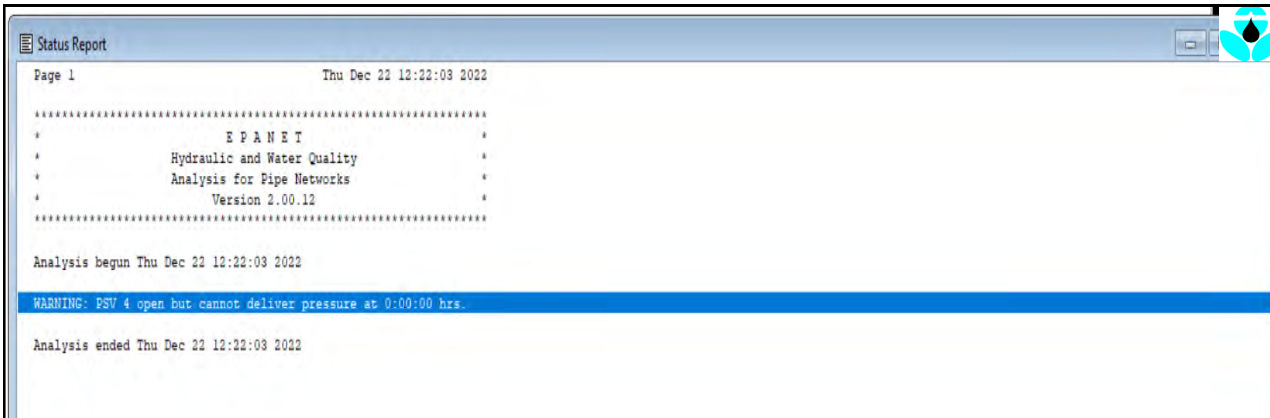
Add Pump curve, Put Flow and Head values. On upper right side click on icon and put the values.


File Edit View Project Report Window Help
Put Parameters of Pipe Length, Diameter and Roughness
Pipe 1
PIPE
Property
Value
*Pipe ID
1
*Start Node
2
*End Node
3
Description
Tag
*Length
3
*Diameter
300
*Roughness
160
Loss Coeff.
0
Initial Status
Open
Bulk Coeff.
Wall Coeff.
Flow
#N/A
Velocity
#N/A
Unit Headloss
#N/A
Friction Factor
#N/A
Reaction Rate
#N/A
Quality
#N/A
Data
Map
Pipes
1
2
3
4
5
6
7

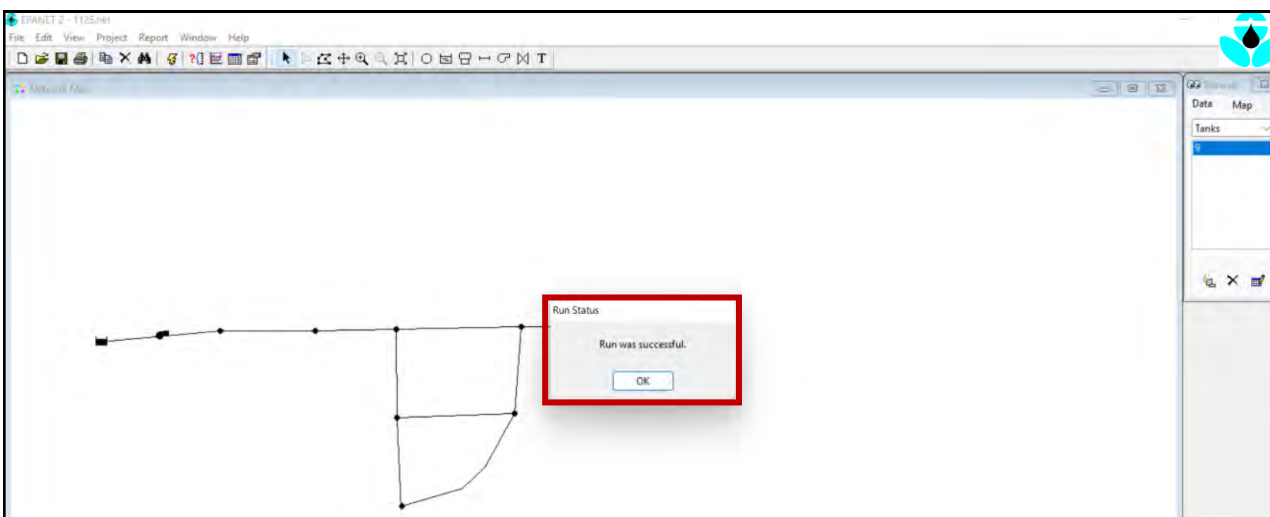

File Edit View Project Report Window Help
Network Map
Input the Junction parameters Elevation
and Base Demand(How much water we need)
Junction 6
JUNCTION
Property
Value
*Junction ID
6
X-Coordinate
1575.04
Y-Coordinate
2748.89
Description
Tag
*Elevation
3
Base Demand
7
Demand Pattern
Demand Categories
1
Emitter Coeff.
Initial Quality
Source Quality
Actual Demand
#N/A
Total Head
#N/A
Pressure
#N/A
Quality
#N/A
Data
Map
Junctions
2
3
4
5
6
7
8


EPANET 2 - 1125.net
File Edit View Project Report Window Help
Network Map
Run
Data Map
Tanks
After putting all parameters click on RUN icon

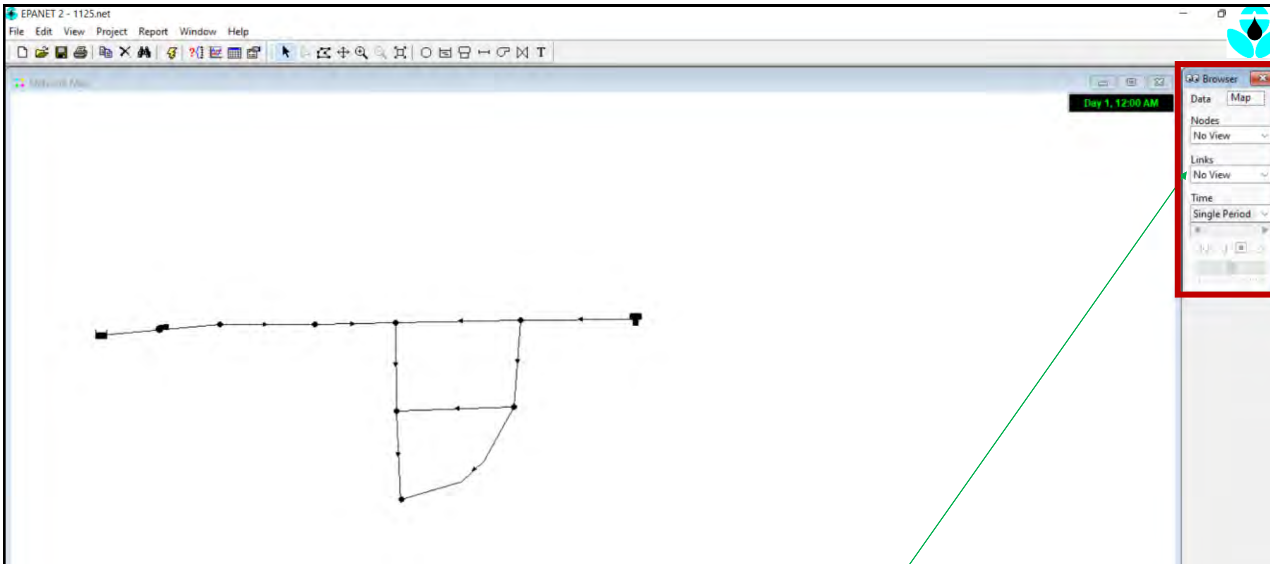

Sometimes if our parameters not fulfill
demands which we put or water
flow and pressure can not be simulate then
after “RUN” click
its show some errors.
Run Status
Warning messages were generated. See
Status Report for details.
OK



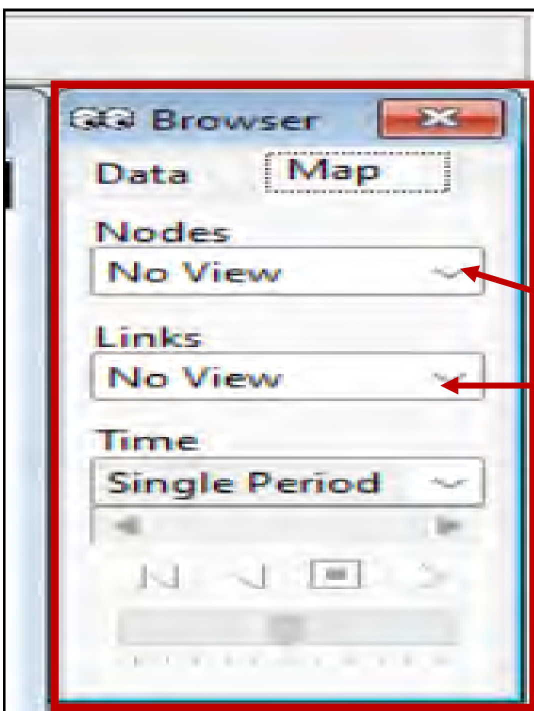
We can see the errors here then we will change or check the input parameters as our errors will be removed



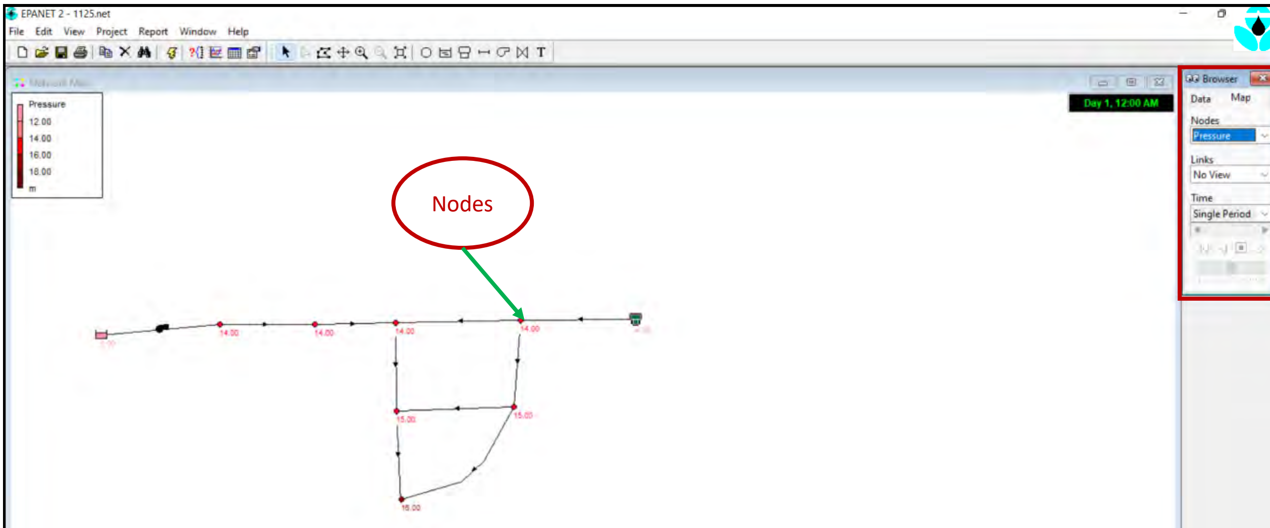
After checking input parameters and then again click on RUN Icon then status will be successful



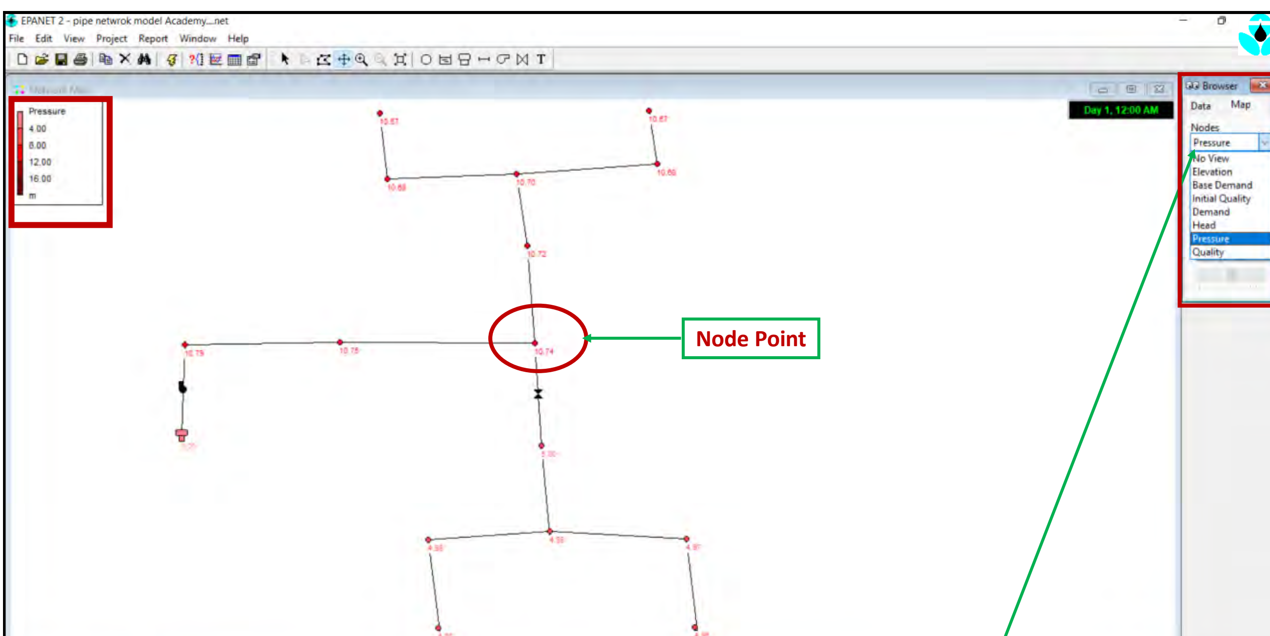
After Run Successful we have to add parameters which we want to observe



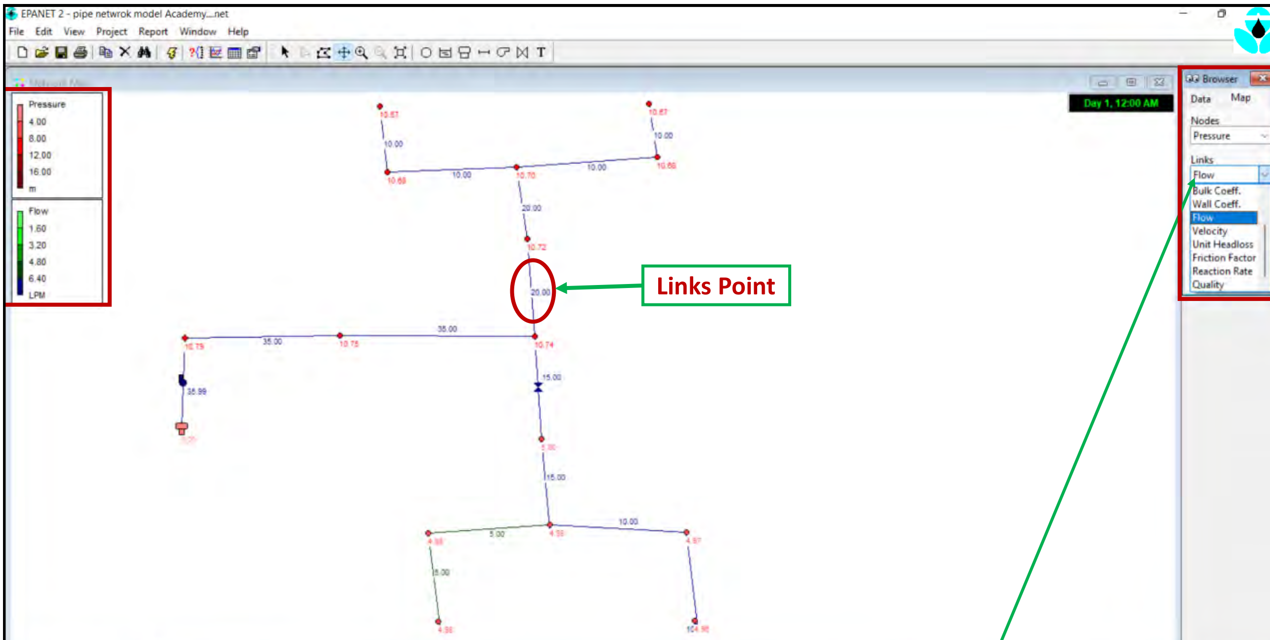
Select the Parameters of Nodes and Links and see the values



We Can observe the parameters values on "Nodes" point by clicking on right side browser Nodes



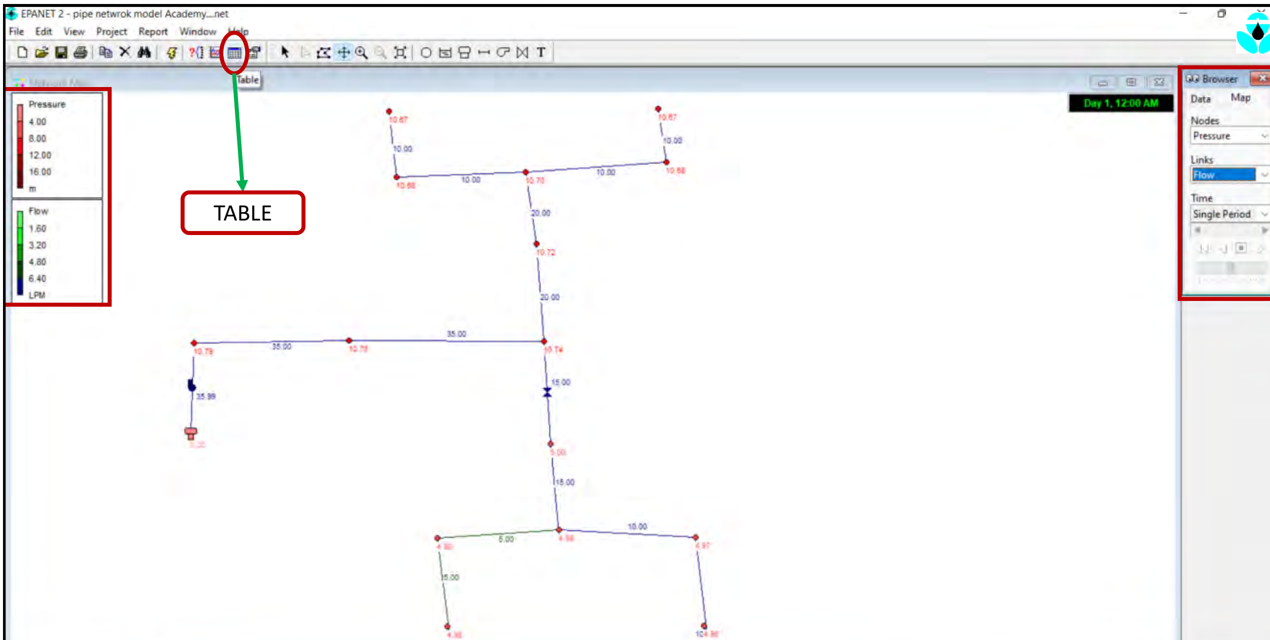
We Can observe the different parameters values on "Nodes" point by clicking on right side browser "Nodes"



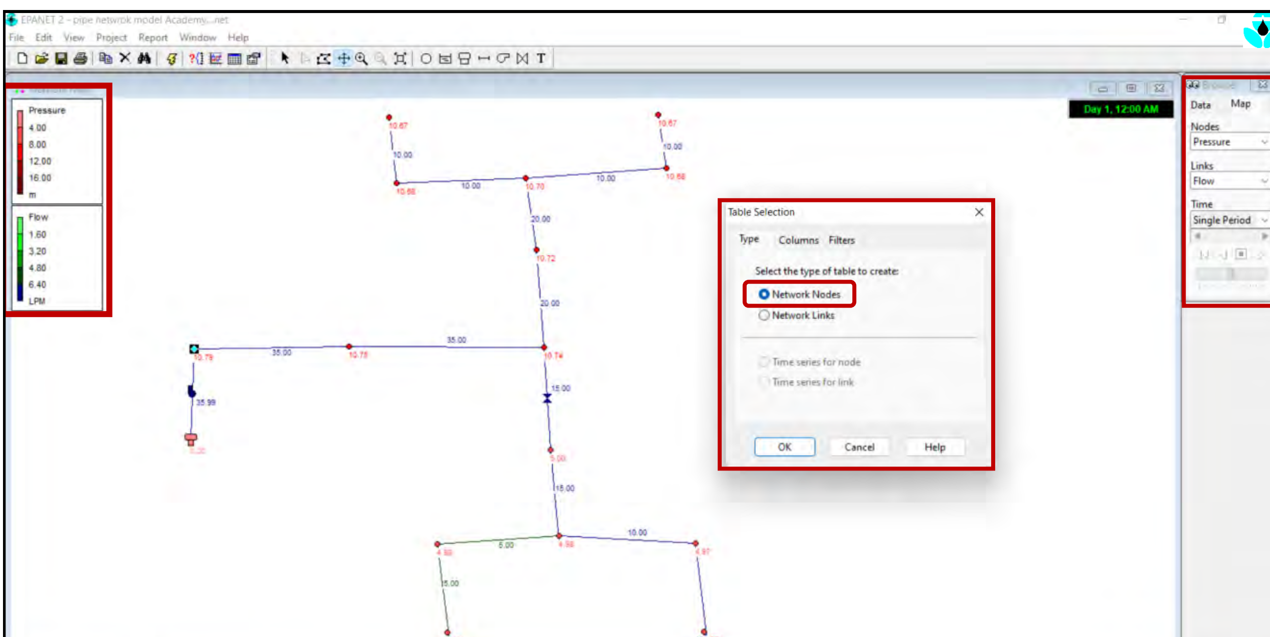
We Can observe the different parameters values on "Links" point by clicking on right side browser "Links"

Table and Charts

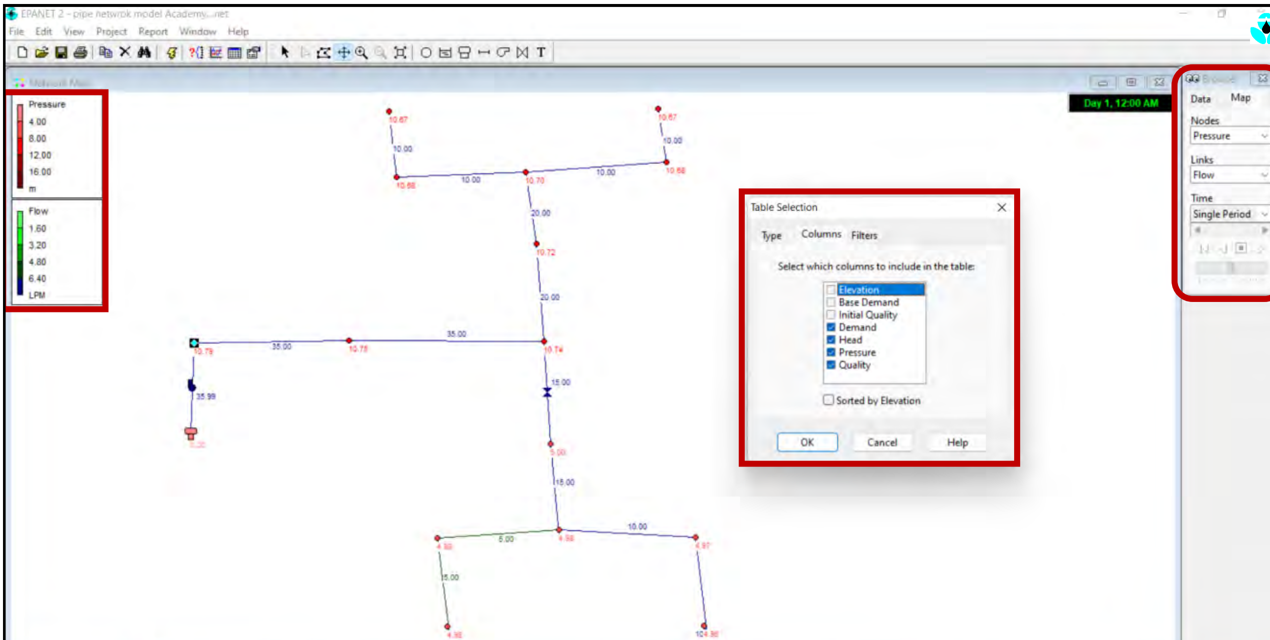
- After Successful Run and put the parameters on Node and Links point we can see results on Tables.



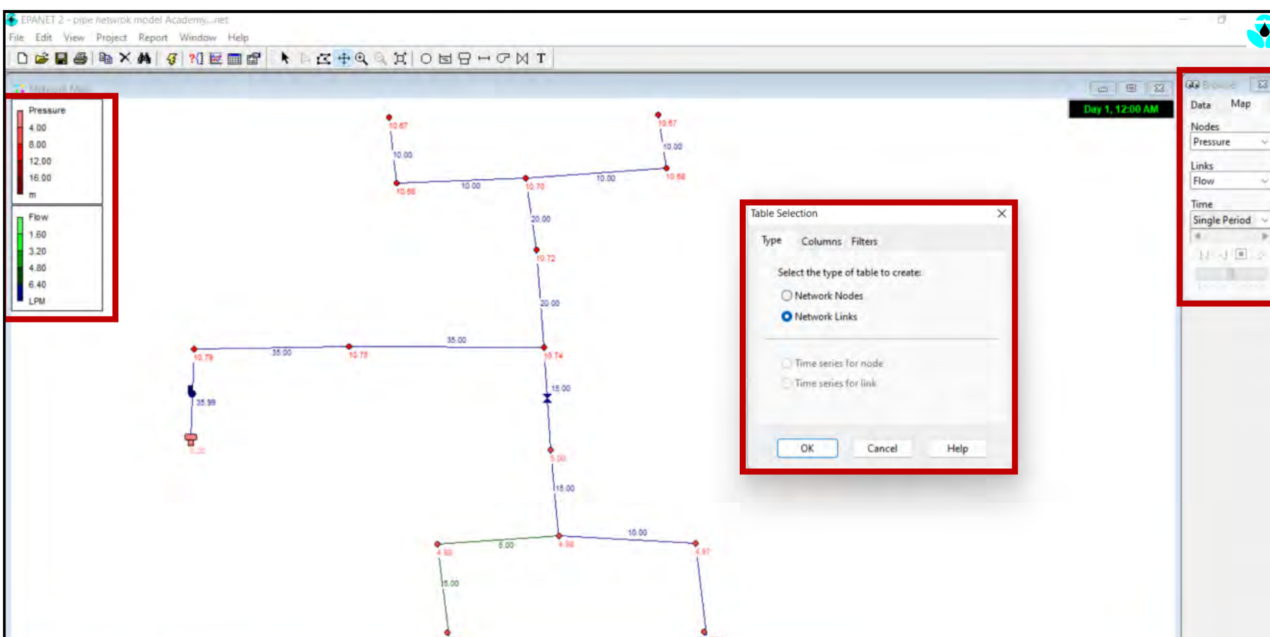
By clicking on Table ICON in toolbar a new Window will be open for Node and Links points



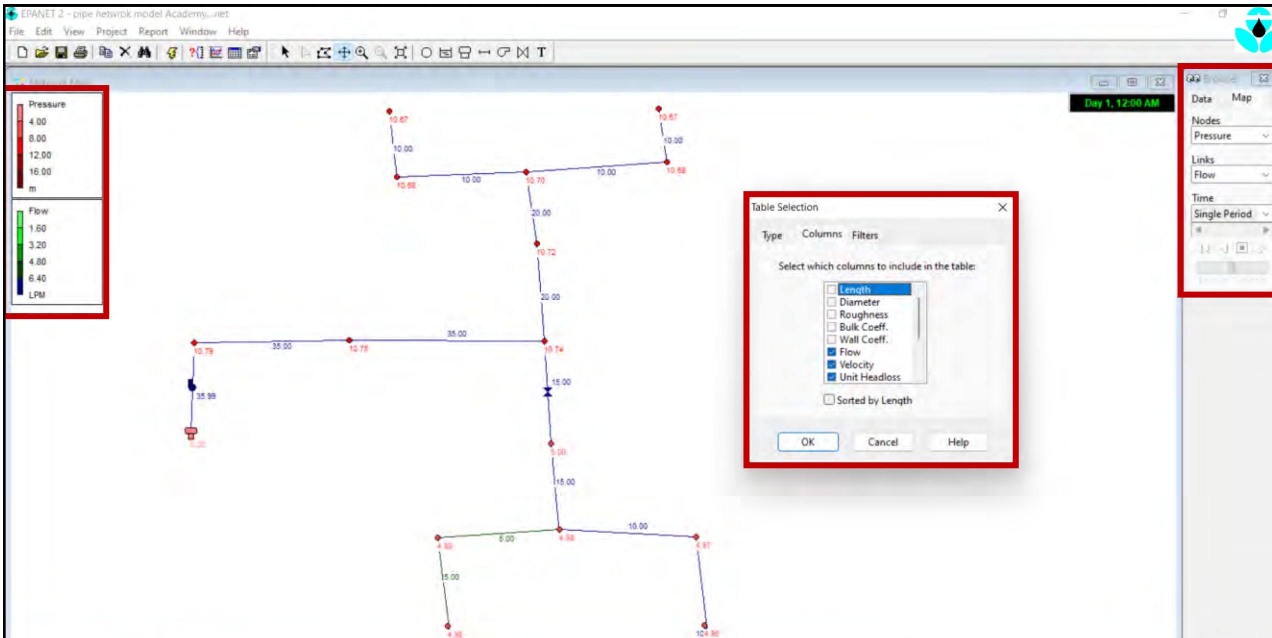
In new window we can see "Type of table creation" Can see Nodes and Links values on Table



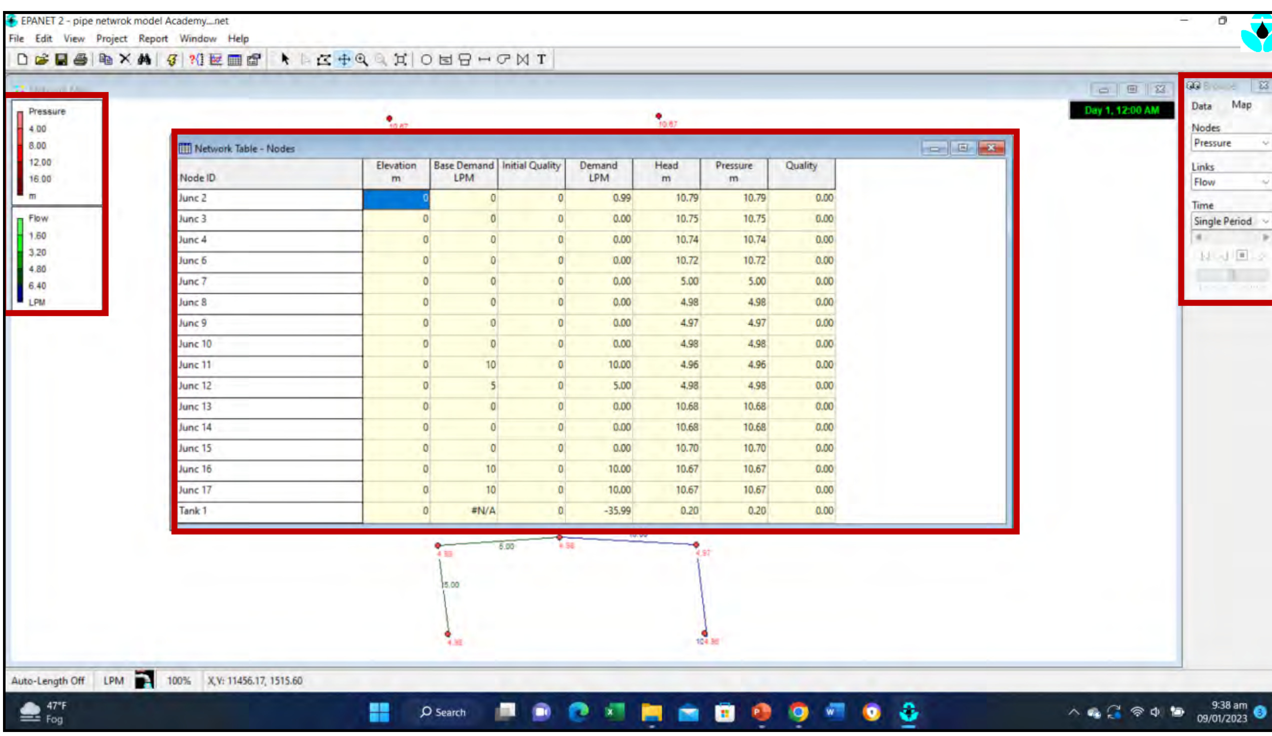
In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values



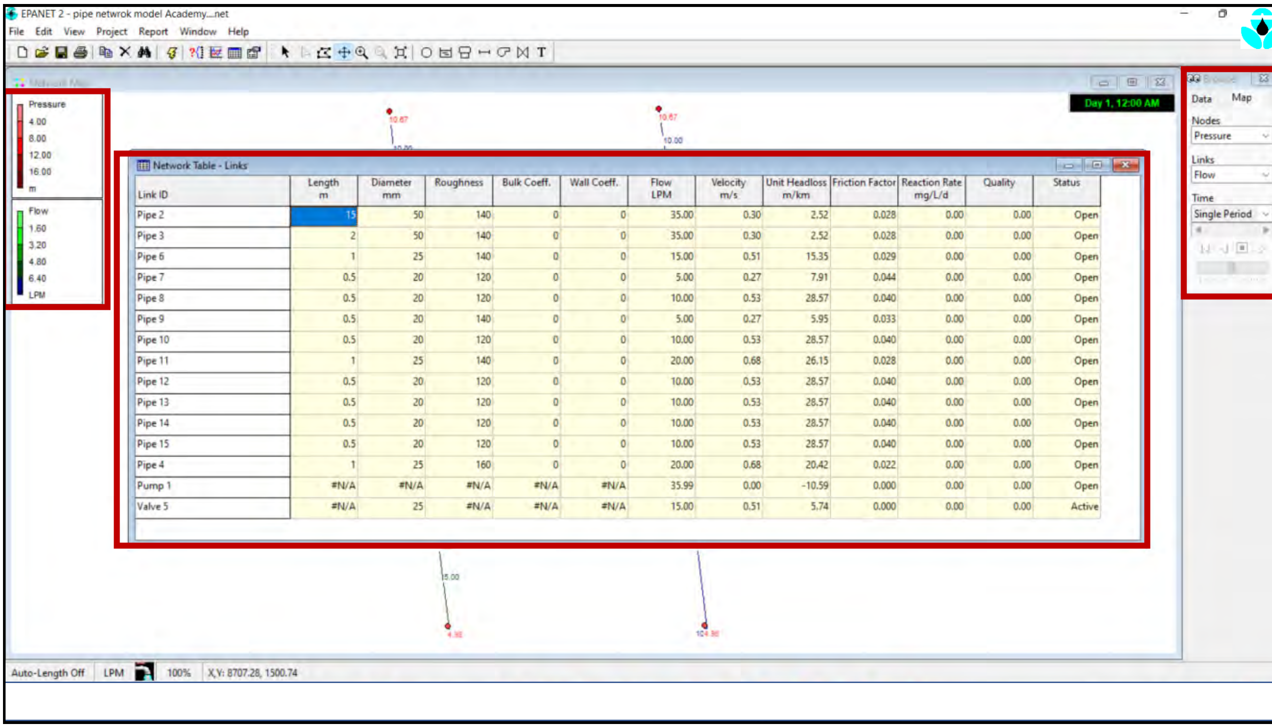
In new window we can see "Table Selection Parameters" Can select "LINKS" Points Values



In new window we can see "Table Selection Parameters" Can select "Nodes" Points Values



Node ID	Elevation m	Base Demand LPM	Initial Quality	Demand LPM	Head m	Pressure m	Quality
Junc 2	0	0	0	0.99	10.79	10.79	0.00
Junc 3	0	0	0	0.00	10.75	10.75	0.00
Junc 4	0	0	0	0.00	10.74	10.74	0.00
Junc 6	0	0	0	0.00	10.72	10.72	0.00
Junc 7	0	0	0	0.00	5.00	5.00	0.00
Junc 8	0	0	0	0.00	4.98	4.98	0.00
Junc 9	0	0	0	0.00	4.97	4.97	0.00
Junc 10	0	0	0	0.00	4.98	4.98	0.00
Junc 11	0	10	0	10.00	4.96	4.96	0.00
Junc 12	0	5	0	5.00	4.98	4.98	0.00
Junc 13	0	0	0	0.00	10.68	10.68	0.00
Junc 14	0	0	0	0.00	10.68	10.68	0.00
Junc 15	0	0	0	0.00	10.70	10.70	0.00
Junc 16	0	10	0	10.00	10.67	10.67	0.00
Junc 17	0	10	0	10.00	10.67	10.67	0.00
Tank 1	0	#N/A	0	-35.99	0.20	0.20	0.00



Link ID	Length m	Diameter mm	Roughness	Bulk Coeff.	Wall Coeff.	Flow LPM	Velocity m/s	Unit Headloss m/km	Friction Factor	Reaction Rate mg/L/d	Quality	Status
Pipe 2	15	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 3	2	50	140	0	0	35.00	0.30	2.52	0.028	0.00	0.00	Open
Pipe 6	1	25	140	0	0	15.00	0.51	15.35	0.029	0.00	0.00	Open
Pipe 7	0.5	20	120	0	0	5.00	0.27	7.91	0.044	0.00	0.00	Open
Pipe 8	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 9	0.5	20	140	0	0	5.00	0.27	5.95	0.033	0.00	0.00	Open
Pipe 10	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 11	1	25	140	0	0	20.00	0.68	26.15	0.028	0.00	0.00	Open
Pipe 12	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 13	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 14	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 15	0.5	20	120	0	0	10.00	0.53	28.57	0.040	0.00	0.00	Open
Pipe 4	1	25	160	0	0	20.00	0.68	20.42	0.022	0.00	0.00	Open
Pump 1	#N/A	#N/A	#N/A	#N/A	#N/A	35.99	0.00	-10.59	0.000	0.00	0.00	Open
Valve 5	#N/A	25	#N/A	#N/A	#N/A	15.00	0.51	5.74	0.000	0.00	0.00	Active

- Acoustic Rod
- Acoustic Leak Detector

Definition of NRW

- NRW (Non-Revenue Water) is defined as the amount of water which is not billed and does not earn revenue.
- This is the difference between the system input and billed authorized consumption in volume (m3).

<u>NRW = System Input Volume - Billed Authorized Consumption</u>

- System Input :

  The amount of water produced for distribution
- Billed Authorized Consumption:

  The amount of water billed to consumers

NRW Ratio

- NRW ratio is the percentage of the amount of water not billed against the total amount of water produced for distribution.

$$\text{NRW Ratio(\%)} = \frac{\text{System Input Volume - Billed Authorized Consumption}}{\text{Input Volume}} \times 100$$

Water Balance Analysis

System Input Volume	**Revenue Water**	Billed metered consumption (**metered**)
		Billed unmetered consumption (**flat-rate, estimated, compensation for damage**)
	Non Revenue Water	Unbilled metered consumption (**settlement discount, employees' houses, free water stations**)
		Unbilled unmetered consumption (**used by water utility, excess use of flat-rate, authorized unbilled**)
		Unauthorized consumption (**illegal connection, unregistered customer, vandalism**)
		Customer meter inaccuracies (**faulty meter, meter reading error**)
		Leakage / Overflow

	NRW Ratio	Main Purpose of NRW Reduction Measure	Recommended NRW Reduction Measure
1st	More than 35%	To find out visible leakage (surface leakage)	Fundamental leak detection, pipe pressure control
2nd	35% - 25%	To find out non-visible leakage (underground leakage) and theft water	Training workers, correct mapping of pipe network
3rd	30% - 25% (overlapping 2nd)	To prevent reoccurrence of leakage	Replacement of aged pipes
4th	25% - 15%	To implement thorough NRW management	Acceleration of pipe replacement
5th	15% - 10%	To finish up NRW management	Completion of pipe replacement
6th	Less than 5%	To maintain minimum NRW ratio	Constant monitoring

Ref: Mr. Shozo Yamazaki, Non-Revenue Water Management, 2011

Physical (Real) Losses

- This is water lost starting from the storage tank or tubewell to the point of customer use.
- The total annual volume of water lost through all types of leakages, breaks and overflows depends on the frequency, flow rate and average duration of individual leakages, breaks and overflows
- Note: Although leakages occurring after the point of customer use (tap) are not included as metered customers

Components of physical losses

Physical Losses (Real Loss) can be divided into visible leakage (surface leakage) and non-visible leakage (underground leakage).
Surface leakages occur in areas with high water pressure, whereas underground leakages occur in areas with low water pressure and therefore difficult to detect.
In general, there are more occurrences of leakages in service pipes compared to distribution pipes.

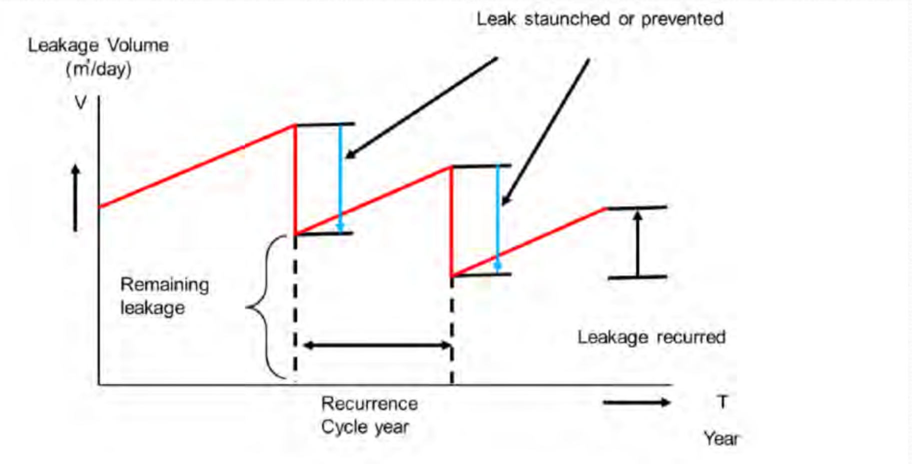
Main Causes of Physical Losses

Causes of Physical Losses	
Factors	Causes
Poor Quality of pipe material	• Material and/or mechanical defects • Lack of corrosion resistance • Age and/or deterioration • Galvanic corrosion
Technicality in pipe laying or poor workmanship	• Design errors • Poor jointing of pipes • Inappropriate back filling • Contact with other structural objects • Defective corrosion protection methods
Poor Conditions	• Unsuitable water pressure (usually high pressure) • Water Hammer • Water quality (internal corrosion)
Environment of underground pipes	• Increase in traffic loads • Corrosive soils such as marine clay • Ground subsidence caused by excessive pumping etc. • Effects of other construction works

Typical Measures for Physical Losses

Measures		Activities
Pipe Work	Pipe Mapping	・Preparation of accurate pipeline drawing
	Zoning	・Determination of DMA or measurement blocks ・Isolation of measurement blocks
	Leak Detection	・Detection of leakages by water leak investigation
	Leak Repair	・Adoption of optimum leakage repair method
Pipe Replacement	Planning	・Preparation of pipe replacement plan based on statistical analysis of the pipeline network ・Determine correct pipe type and pipe diameter
	Implementation	・Implementation of pipe replacement
Water Pressure Control	Pressure equalization	・Zoning of distribution network ・Installation of PRVs ・Installation of Flow Meters and Pressure Meters
	Setting up Pressure Control facilities	・Construction of distribution reservoirs and / or pumping station
	Pressure Control at pumping station	・Pressure control by controlling pump flow and number of pump rotation

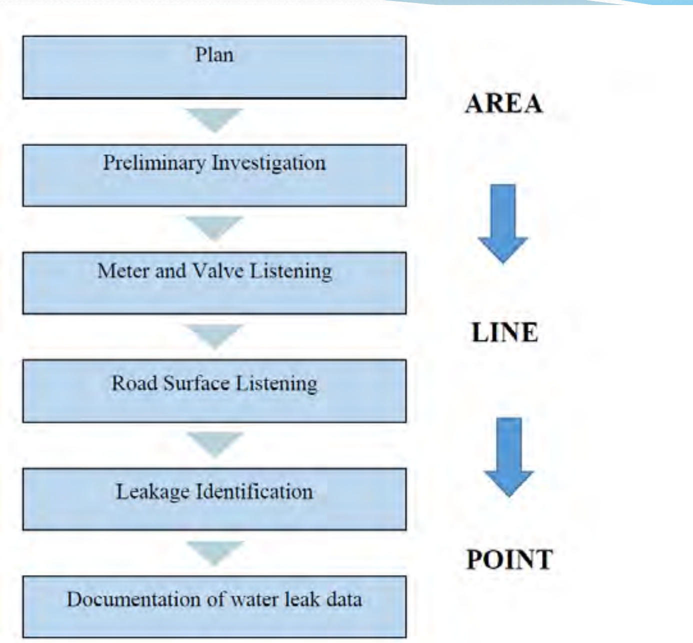
Recurrence of Leakage



- Water pipes tend to leak due to aging and other factors. Even if the leaking point is repaired, there is a high possibility that a new leak will occur in the same deteriorated pipe, "Recurrence". More pipes deteriorate, more the possibility of water leakage or recurrence increases, and leak detection and repair need to be carried out to overcome this risk.
- If water leakage is not prevented, the leakage volume increases over time. Although water leak investigation and repair helps to decrease the leakage volume, remaining leakage grows and new leakage occurs over time. It means water leak investigation should be repeated regularly, in order to keep lowering NRW.

Standard Procedure of Water Leak Investigation.

- This section describes the standard procedure of water leak investigation. In particular, Listening Investigations (Meter and Valve Listening, Road Surface Listening) and Leakage Identification are explained in detail.



Plan

Before investigation, make an investigation plan in order to implement an investigation smoothly and efficiently. The examples of check-points and tasks for plan are below.

- Selection of investigation area (DMA)
- Confirmation of investigation contents
- Consideration of members
- Confirmation of water supply time
- Determination of survey time
- Preparation of pipeline map
- Making a road map
- Inspection of equipment

Preliminary Investigation

Check a pipeline map and any other information relating to investigation against a field

- Location of buried pipes
- Location of valves
- Location of buried pipes other than water pipes (such as gas pipes, electricity pipes, pipes for communication facility)
- Write the preview results down on a map

Meter and Valve Listening

- At the beginning of investigation, investigation engineers listen to noises from meters, stop valves, gate valves and hydrants with a listening stick at a whole pilot area.
- The objective is to find leakage on water supply instruments (meters, valves, etc.), and to localize suspected leakage areas and points.
- When finding a noise doubtful of water leakage, write the location down on a map in order to implement listening investigation at ground surface and detect water leakage point later on.

Road Surface Listening

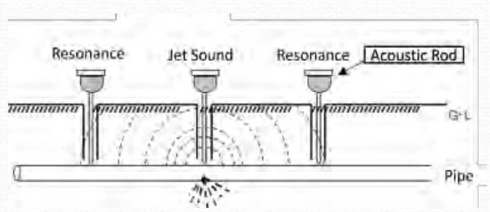
- Road Surface Listening is implemented to detect water leak sounds occurring in distribution pipes and service pipes. This is also further pursuance of locations of leaks detected through meter and valve listening.
- After finding suspected leakage areas by meter and valve listening, in order to pinpoint suspected leakage points.
- A leak detector is used in this method. In this step, engineers listen to noises from ground surface with an electronic leak detector every 0.5- 1 meter above the line of buried pipes and listen on hydrants and valves by listening stick in need.
- When it is difficult to locate pipelines accurately, shift the sensor to 0.3m each side from the estimated pipeline and listen to around sound.

Acoustic Rod/Stick

Specification				
Type	Cap dia.* Thickness (mm)	Total Length (mm)	Dia. of Iron Bar (mm)	Material
LSP-1	ø 67x29	1,013	7	Stainless Steel

Use:

- Place the tip of acoustic rod at the point where doubt of leakage
- Catch the stick below the listening cap and place ear on the cap of acoustic rod
- Hear the sound of leaked water, if no leakage at that place repeat the same procedure aside this place
- Very useful to listen leaks sound at hydrants and valves



Factors affecting performance:

- Pressure
- Depth

Leak Detector

Operation:

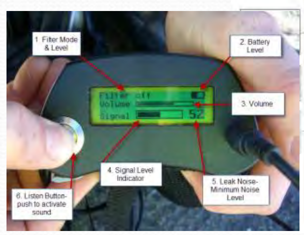
- Use head phones remember Left and Right direction.
- Turn volume up to half using the dial on the headphone cable.
- Ensure good contact of microphone and surface area.
- Press and hold silver button to listen sound.
- With every press and release of the silver button the noise level will be recorded in the memory.
- To see memory data for the last eight soundings, press and hold the "M" button on the amplifier.
- To turn filter on press and hold the sky blue + & - filter buttons simultaneously. The filter bandwidth is +/- 100Hz.

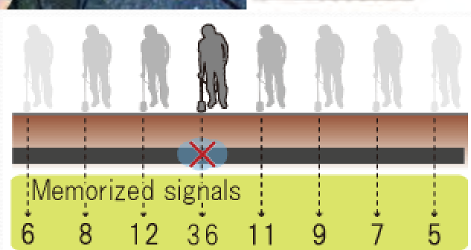
Components:

- Amplifier with waist belt
- Hand probe microphone
- Ground microphone plate
- Probe rods
- Stereo headphones
- Connecting cable

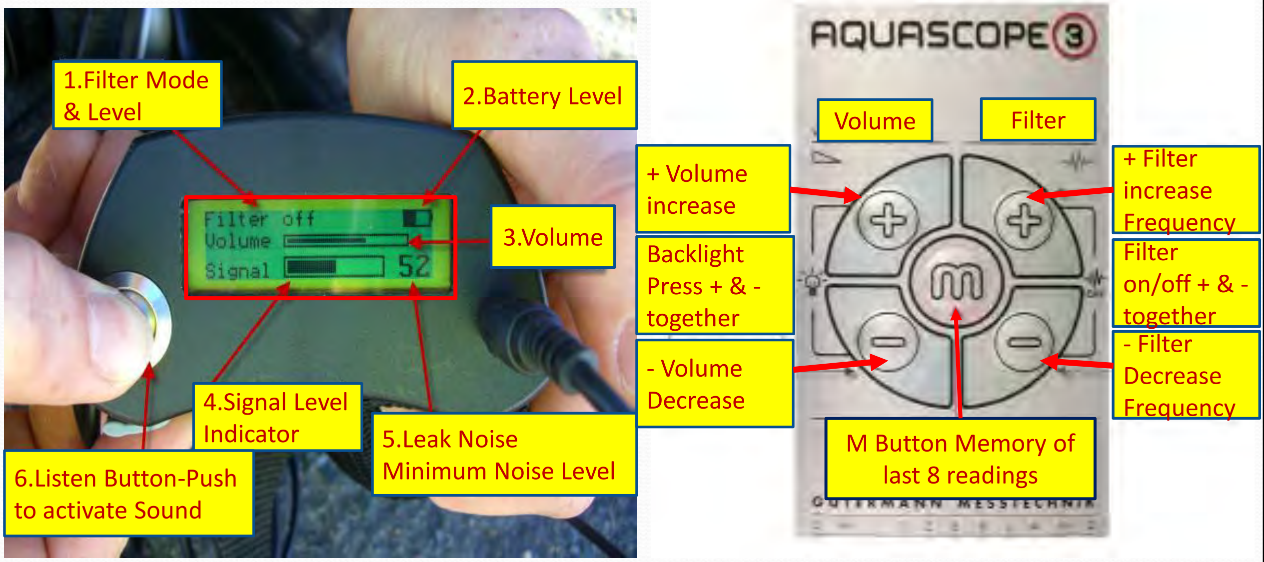
Leak Detector
Important Points & Precautions

- Use filter in case high background noises
- Leakage sound depends upon,
  - Water pressure
  - Crack or hole size
- Operator should stay stable during its use
- Required practice to pinpoint or identify leaks
- Don't use in rainy days and when speed is 6 m/s.
- Sensors are water resistant, but control unit and head phones are not resistive. Keep them away from water .





Use of Leak Detector



Understanding Leak Noise-Leak Frequency

Pipe Material	Frequency Range	Normal Frequency
Steel	400 Hz – 1500 Hz	800 Hz
Iron	300 Hz – 1200 Hz	700 Hz
Copper	700 Hz – 2500 Hz	1800 Hz
AC	300 Hz – 800 Hz	500 Hz
Lead	200 Hz – 700 Hz	400 Hz
PVC	200 Hz – 500 Hz	300 Hz
Polyethylene	100 Hz – 400 Hz	250 Hz

Factors Affecting Leak Noise

- Pipe Material (Hard is good - Soft is poor)
- Pipe Diameter (Small is good – Large is poor)
- Pressure (High is good – Low is poor)
- Background Noise can muffle or drown out leak noise (PRV's - throttled valves)
- Consumption (High levels of consumption can make it hard to hear the leak and you may have to return at low consumption times)

The best time to perform acoustic leak detection is when all these factors are at a minimum except for pressure, at a maximum

Annex 5.1.19 Training Material: "Energy Audit" for ToT and Pilot In-house Training at WASA Multan

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Energy Audit

Water and Sanitation Agency (WASA) Multan

WASA Trainer:

1. **M. Nadeem – WASA Coordinator**

Training **Goals**

- Evaluate the current operating condition of equipment and upgrade the site condition to:
  - Optimize the performance
  - Reduce the electricity cost

Skills YOU learn

- Safety measures to work with electricity
- Use of electrical equipment i.e. Power Analyzer and clamp meter etc.
- Tools and techniques to analyze data

Activities YOU perform!

- At site
  - Site Preparation
  - Site Inspection
  - Get required values using testing equipment
- At office
  - Collaboration of data
  - Data Analysis and energy optimization techniques
  - Preparation of site improvement plan
- Improve the site

Before energy audit

- Site preparation
  - Site cleaning
  - Fix the intrusion paths

Before energy audit

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		4	Helmet		7	Post Stamp	
2	Tape		5	Shoes		8	Glasses	
3	Gloves		6	Vest				

Before energy audit

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Power Analyzer		4	Screw Driver Set		7	Insulation Tape	
2	Clamp meter		5	Voltage Tester				
3	Pliers		6	Wrench				

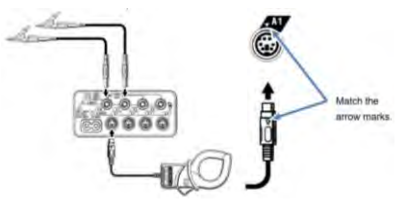
Setting up **Power Analyzer**

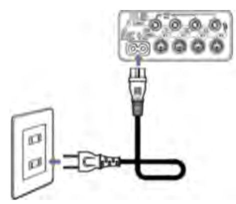
- Max rated voltage of supplied Power cord MODEL7169: AC125V
  (Kew 6315 Manual, Page 31)

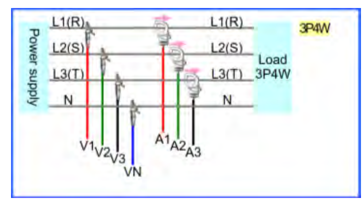
Power supply rating

Rating of power supply is as follows.

Rated supply voltage	100 to 240V AC (±10%)
Rated power supply frequency	45 to 65Hz
Max power consumption	7VA max





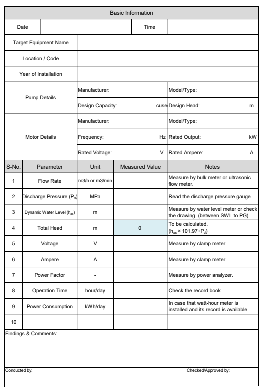


Measurements using **Power Analyzer**

- Installation of Power Analyzer
  - Cutoff the power by turning OFF circuit breaker (CB) or Changeover switch
  - Cross check the electricity continuity using clamp meter
  - Install the test leads and flexible clamp sensors on the secondary side of CB
    (Note: don't forget to follow the current direction as recommended)
- Turn ON power analyzer
- Turn ON the circuit breaker
- Start recording on Power Analyzer
- Switch ON the motor

Measurements using **Power Analyzer**

- Fill the given format

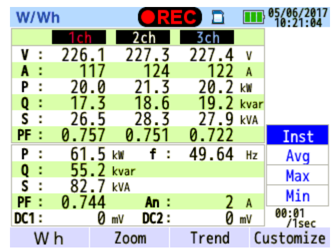


Basic Information				
Date		Time		
Target Equipment Name				
Location / Code				
Year of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity: cuse		Design Head: m	
Motor Details	Manufacturer:		Model/Type:	
	Frequency: Hz		Rated Output: kW	
	Rated Voltage: V		Rated Ampere: A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	MPa		Read the discharge pressure gauge.
3	Dynamic Water Level (h_{as})	m		Measure by water level meter or check the drawing. (between SWL to PG)
4	Total Head	m	0	To be calculated. ($h_{as} \times 101.97 + P_d$)
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.
10				

Findings & Comments:

Conducted by: Checked/Approved by:



5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

Measurements using **Power Analyzer**

- Switch OFF the motor
- Stop recording on Power Analyzer
- Turn OFF the circuit breaker
- Remove power analyzer
- Store the items after use as shown

ENERGY AUDIT OF TUBE WELS

WASA Mechanical Trainer

- **Muhammad Nadeem (Deputy Director P&D)**

GENERAL INFORMATION

ESTABLISHMENT OF WASA	April 1992
JURISDICTION AREA	584 Km^2
POPULATION OF MULTAN	2.2 MILLION
COVERAGE OF SEWERAGE	65% population (1.43 million) 117 Km^2
COVERAGE OF WATER SUPPLY	55% population (1.21 million) 58 Km^2
WATER DISTRIBUTION SYSTEM	Tube wells 84 (04 Cusec Each) Total Capacity = 336 Cfs Network 1448 km (02" to 24") (1016 Km life expired network) Filtration Plants 65 (1000 Gallons/hr) Functional = 65 No
SEWERAGE SYSTEM	2055 Km sewer (1236 Km life expired sewer) Lateral Sewer (9" to 21") = 1790 Km Trunk Sewer (24" to 72") = 265 Km Disposal Stations = 15 No Total Installed Capacity = 1309 Cfs Lift Stations = 10 No Working Capacity = 916 Cfs
TOPOGRAPHY	Plain/ Cup shaped (which is different from other major cities in Punjab) (Each and Every drop of sewage and rain water is disposed off with the help of Pumps)
MASTER PLAN (2015-40)	WASA Multan has prepared its Master Plan of Water Supply, Sewerage and Drainage(2015-40)

Table of Contents

Importance of Energy Audit

- **Help us to Minimize the energy cost through improved efficiency**
- **Helps to Minimize the losses**
- **Helps to Improve the operational/Efficiency work**
- **Helps to improve the pump condition**

Parameters for Energy audit

- **Basic information about site**
- **Flow Rate(Q)**
- **Discharge Pressure(P_d)**
- **Dynamic water level(h_d)**

Equipment Required

Ultrasonic Flow Meter	 
Pressure gauge (Digital, Analog)	 
Water level indicator(Rope type)	
Tool Box(Spanner set, Wrench, Teflon Tape ,etc.)	

Pre-Audit site information

Preparation for Site

- Site Information
- Can we install Pressure Gauge?
- Can we install ultrasonic flow meter?
- Can we check water level?

Pre-Audit site information

•

Energy Audit Form

Energy Audit Form			
Date		Time	
Target Equipment Name			
Location			
Date of Installation			
Pump Details	Manufacturer:	Model/Type:	
	Design Capacity: cusec	Design Head: m	
Motor Details	Manufacturer:	Model/Type:	
	Frequency: Hz	Rated Output: kW	
	Rated Voltage: V	Rated Ampere: A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. **($P_d \times 10.197 + h_d$)**
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.

Perform Energy Audit at Site

- Install pressure gauge and check Discharge Pressure(P_d)
- Using Water level indicator to check dynamic water level(h_d)
- Install Ultrasonic flow meter and check Flow Rate(Q)

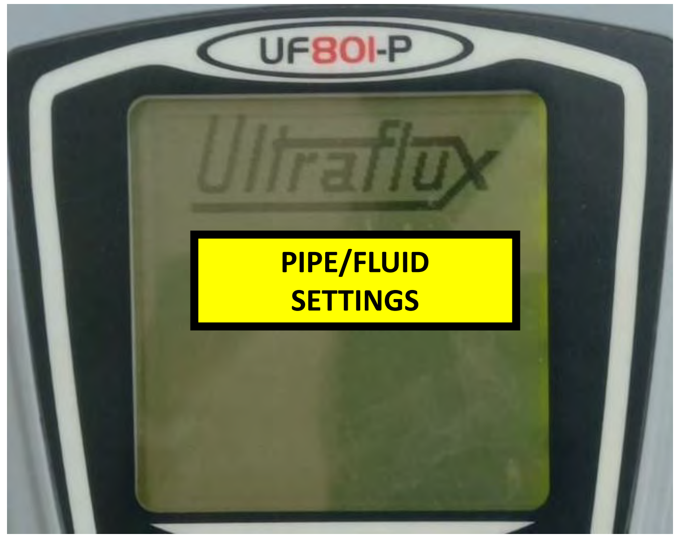
Equipment Installation

Use of Ultrasonic Flow Meter

- After switching ON the ultrasonic flow meter press "F" button.

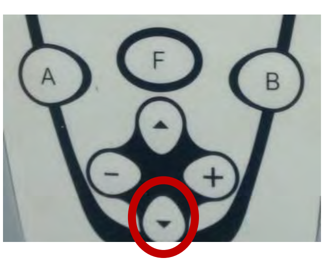
Use of Ultrasonic Flow Meter

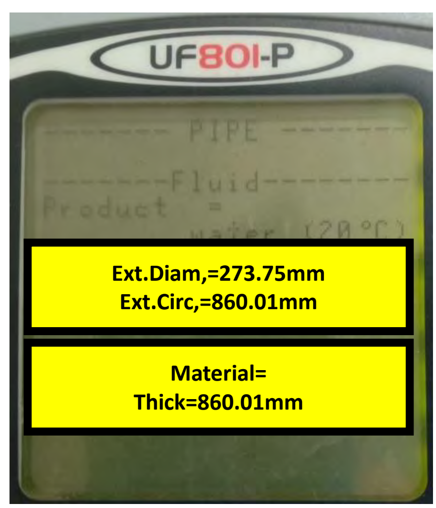
- Again Press **"F"** its showing pipe fluid setting.



Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.





- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Material	Sound Velocity
Mild Steel	5920
Stainless steel	5800
Iron	5900
Cast Iron	4600
HDPE	2460
PVC	2395

Use of Ultrasonic Flow Meter

- **Press and hold "F"** and its show probe distance and type of probes.

Use of Ultrasonic Flow Meter

- **Probes**

Formulas for Energy Audit

- **$H_{Total=}P_d x10.197+hd$**
- **1 bar=**10.19 meter
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=**m^3/hr,
- **1 cusec=**102 m^3/hr
- **1 m^3/min =** 60 m^3/hr (**Bulk Flow meter**)
- **Pump Efficiency,ηp =Ep /Em** × 100
- **Pump output E =** $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000} = \frac{QXH}{6}$
- **E pump(Mechanical power)=**Available Energy
- **E motor(Electrical Power)=**Shaft Power

Annex 5.1.20 Training Material: "Energy Audit" for In-house Training at WASA Multan

Operation and Maintenance of Electrical Equipment

Energy Audit

Water and Sanitation Agency (WASA)

WASA Trainers:

Training **Goals**

- Evaluate the current operating condition of equipment and upgrade the site condition to:
  - Optimize the performance
  - Reduce the electricity cost

Skills YOU learn

- Safety measures to work with electricity
- Use of electrical equipment i.e. Power Analyzer and clamp meter etc.
- Tools and techniques to analyze data

Activities YOU perform!

- At site
  - Site Preparation
  - Site Inspection
  - Get required values using testing equipment
- At office
  - Collaboration of data
  - Data Analysis and energy optimization techniques
  - Preparation of site improvement plan
- Improve the site

Topics we'll cover

1. Activities before Energy Audit
2. Setting up Power Analyzer
3. Installation of Power Analyzer
4. Measurements by Power Analyzer
5. Site Introduction
6. Record keeping using mWater app.

1. **Before** energy audit (1/5)

- Site preparation
  - Site cleaning
  - Fix the intrusion paths

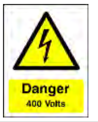
1. **Before** energy audit (2/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5			8		
3			6					

1. **Before** energy audit (3/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		4	Helmet		7	Post Stamp	
2	Tape		5	Shoes		8	Glasses	
3	Gloves		6	Vest				

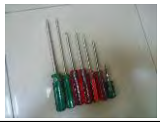
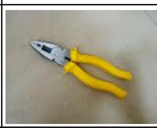
1. **Before** energy audit (4/5)

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5					
3			6					

1. **Before** energy audit (5/5)

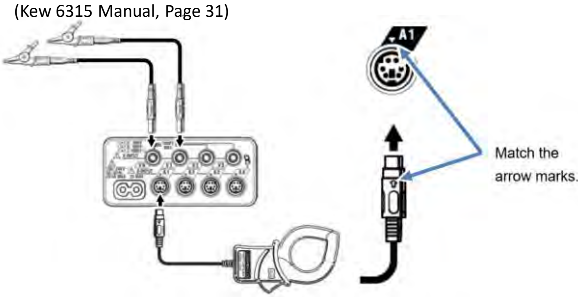
- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Power Analyzer		4	Screw Driver Set		7	Insulation Tape	
2	Clamp meter		5	Voltage Tester				
3	Pliers		6	Wrench				

2. Setting up **Power Analyzer** (1/1)

- Max rated voltage of supplied Power cord MODEL7169: AC125V

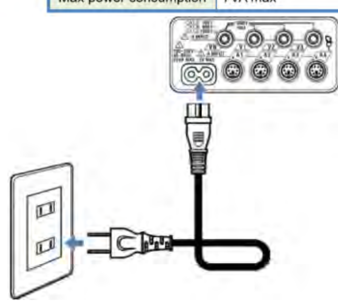
(Kew 6315 Manual, Page 31)



Power supply rating

Rating of power supply is as follows.

Rated supply voltage	100 to 240V AC (±10%)
Rated power supply frequency	45 to 65Hz
Max power consumption	7VA max



3. Installation of **Power Analyzer** (1/4)
(پاور اینالائزر کو لگانا)

- Cutoff the power by turning OFF circuit breaker (CB)
- Cross check the electricity continuity using clamp meter

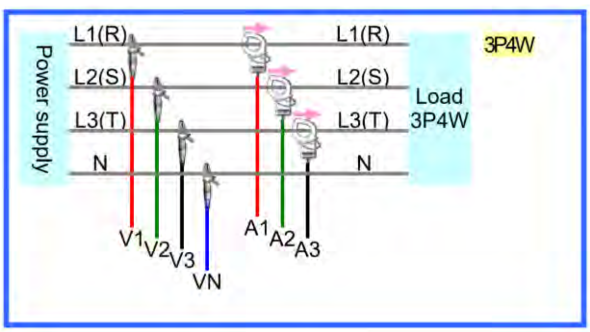
سرکٹ بریکر کو آف کرکے بجلی کاٹ دیں۔

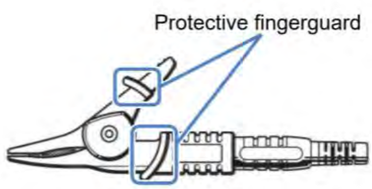
کلیمپ میٹر کا استعمال کرتے ہوئے بجلی کے تسلسل کو چیک کریں۔

3. Installation of **Power Analyzer** (2/4)
(پاور اینالائزر کو لگانا)

- Install the voltage test leads and flexible clamp sensors on the secondary side of CB

سرکٹ بریکر کی سیکنڈری سائیڈ پر ٹیسٹ لیڈز کلیمپ سینسرز انسٹال کریں۔



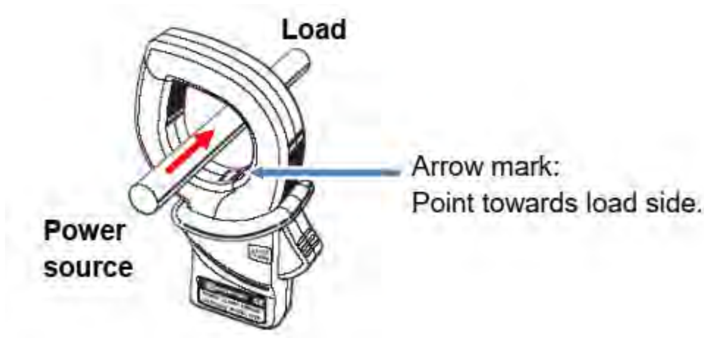


3. Installation of **Power Analyzer** (3/4)

(پاور اینالائزر کو لگانا)

(Note: don't forget to follow the current direction as recommended)

نوٹ: تجویز کردہ کرنٹ کی سمت پر عمل کرنا نہ بھولیں



3. Installation of **Power Analyzer** (4/4)

(پاور اینالائزر کو لگانا)

4. Measurements by **Power Analyzer** (1/2)

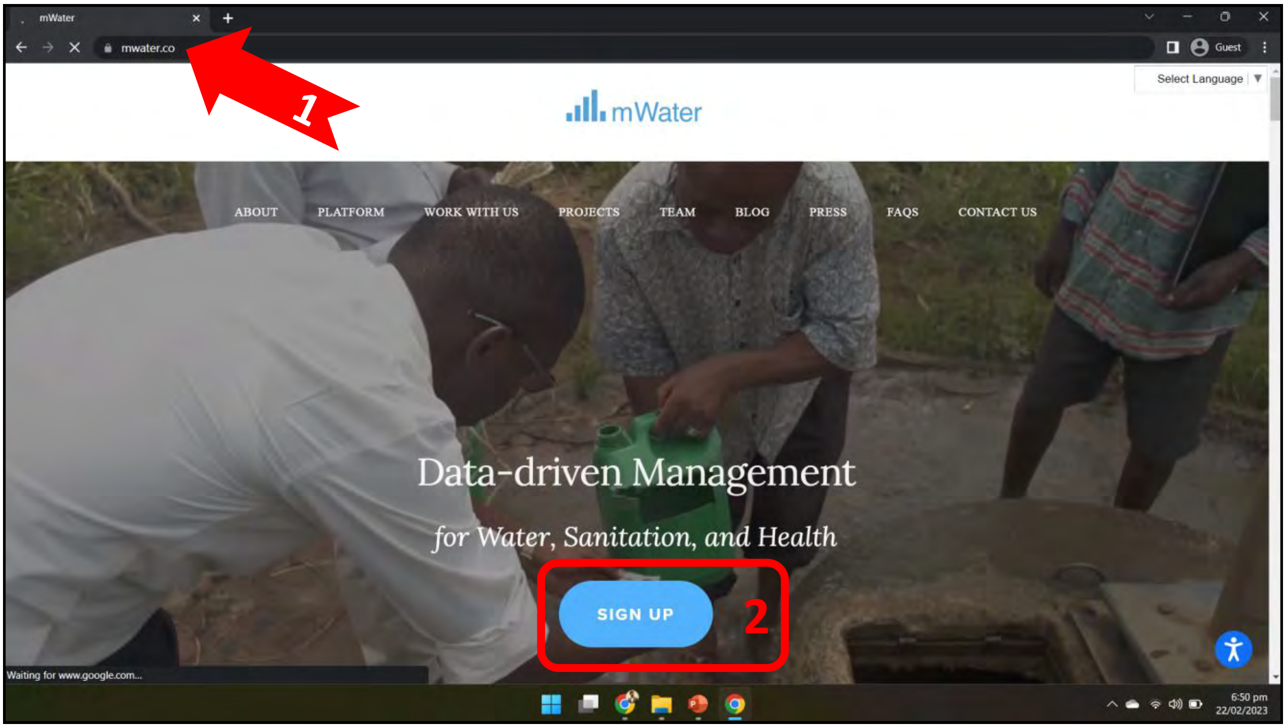
(Get the Values)

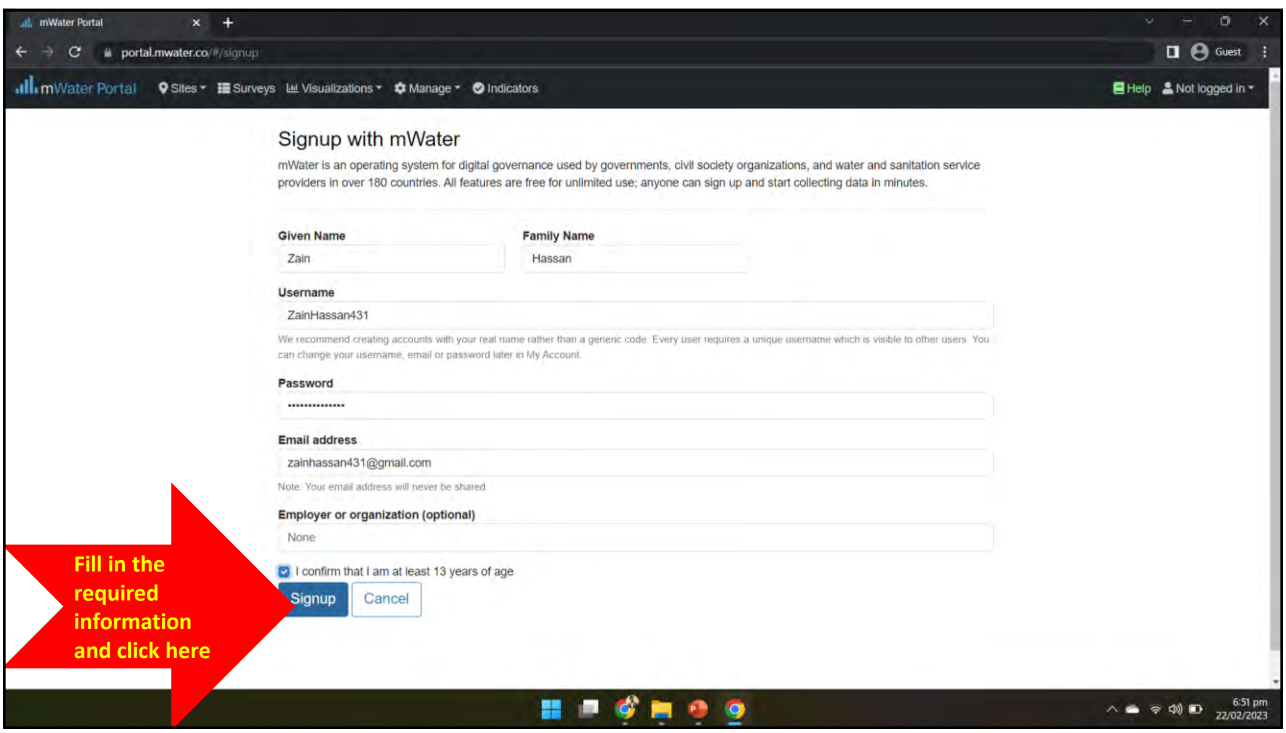
4. Measurements by **Power Analyzer** (2/2)

- Switch OFF the motor موٹر کو بند کریں
- Stop recording on Power Analyzer پاور اینالائزر پر ریکارڈنگ بند کریں۔
- Turn OFF the circuit breaker سرکٹ بریکر کو آف کر دیں۔
- Remove power analyzer and place it back carefully پاور اینالائزر کو ہٹا دیں اور اسے احتیاط سے واپس رکھیں

5. Site Introduction (1/1)

6. RECORD KEEPING USING mWATER APP.


mWater
mwater.co
Guest
1
Select Language
mWater
ABOUT
PLATFORM
WORK WITH US
PROJECTS
TEAM
BLOG
PRESS
FAQS
CONTACT US
Data-driven Management
for Water, Sanitation, and Health
SIGN UP
2
Waiting for www.google.com...
6:50 pm
22/02/2023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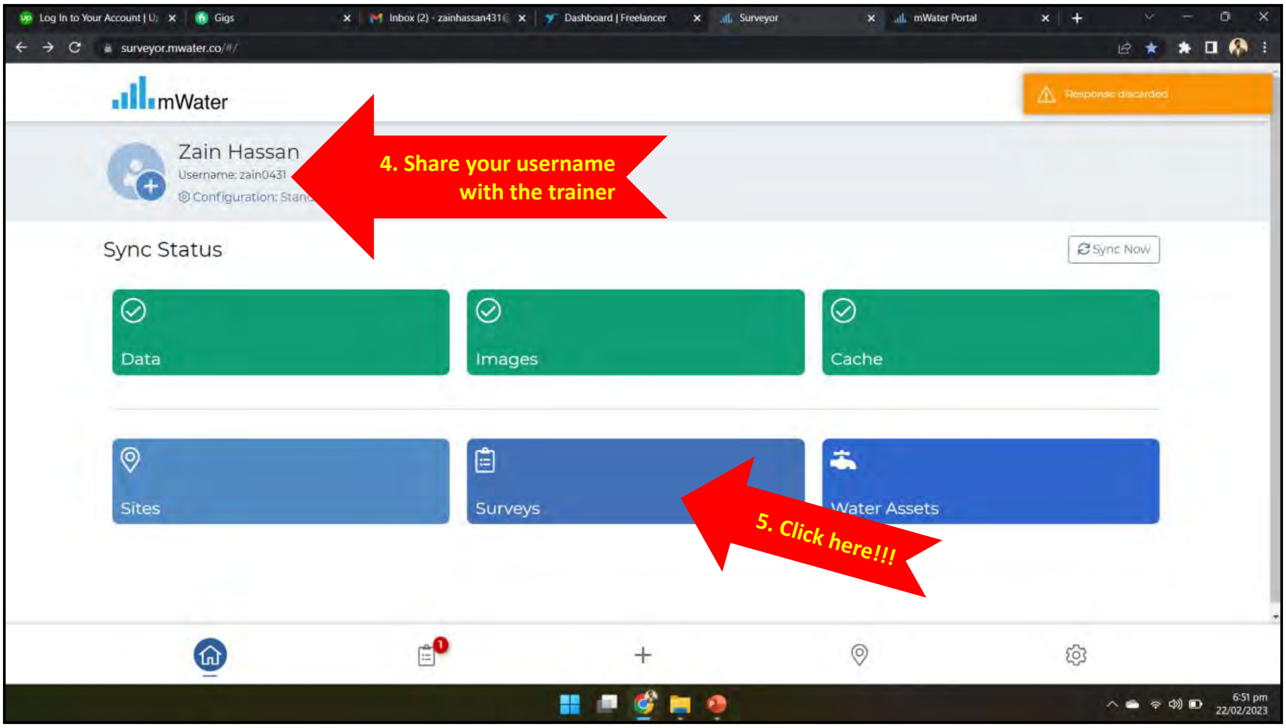
portal.mwater.co/#/signup
Guest
mWater Portal
Sites
Surveys
Visualizations
Manage
Indicators
Help
Not logged in
Signup with mWater
mWater is an operating system for digital governance used by governments, civil society organizations, and water and sanitation service providers in over 180 countries. All features are free for unlimited use; anyone can sign up and start collecting data in minutes.
Given Name
Zain
Family Name
Hassan
Username
ZainHassan431
We recommend creating accounts with your real name rather than a generic code. Every user requires a unique username which is visible to other users. You can change your username, email or password later in My Account.
Password
Email address
zainhassan431@gmail.com
Note: Your email address will never be shared
Employer or organization (optional)
None
I confirm that I am at least 13 years of age
Signup
Cancel
Fill in the required information and click here
6:51 pm
22/02/2023


Log In to Your Account | U
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/
mWater
Response discarded
Zain Hassan
Username: zain0431
Configuration: Stan
4. Share your username with the trainer
Sync Status
Sync Now
Data
Images
Cache
Sites
Surveys
Water Assets
5. Click here!!!
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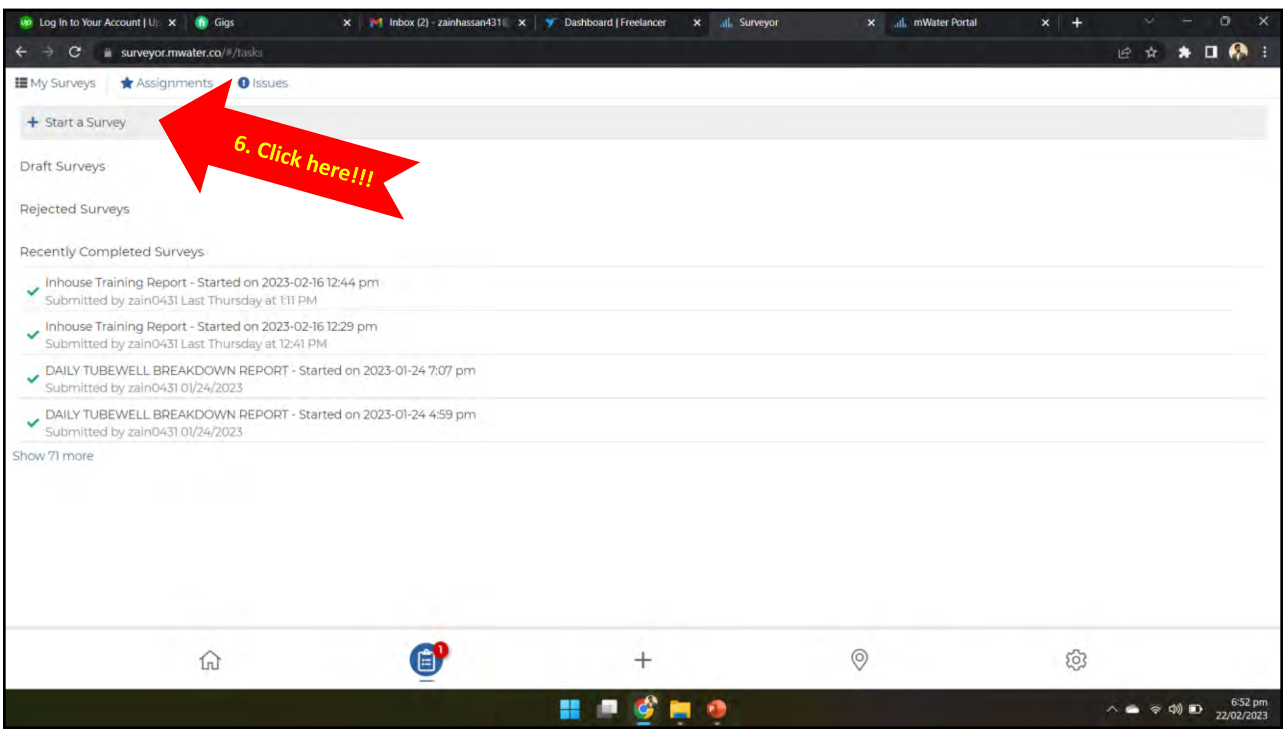
22/02/2023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Dashboard | Freelancer
Surveyor
mWater Portal
surveyor.mwater.co/#/tasks
My Surveys
Assignments
Issues
Start a Survey
6. Click here!!!
Draft Surveys
Rejected Surveys
Recently Completed Surveys
Inhouse Training Report - Started on 2023-02-16 12:44 pm
Submitted by zain0431 Last Thursday at 1:11 PM
Inhouse Training Report - Started on 2023-02-16 12:29 pm
Submitted by zain0431 Last Thursday at 12:41 PM
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 7:07 pm
Submitted by zain0431 01/24/2023
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Submitted by zain0431 01/24/2023
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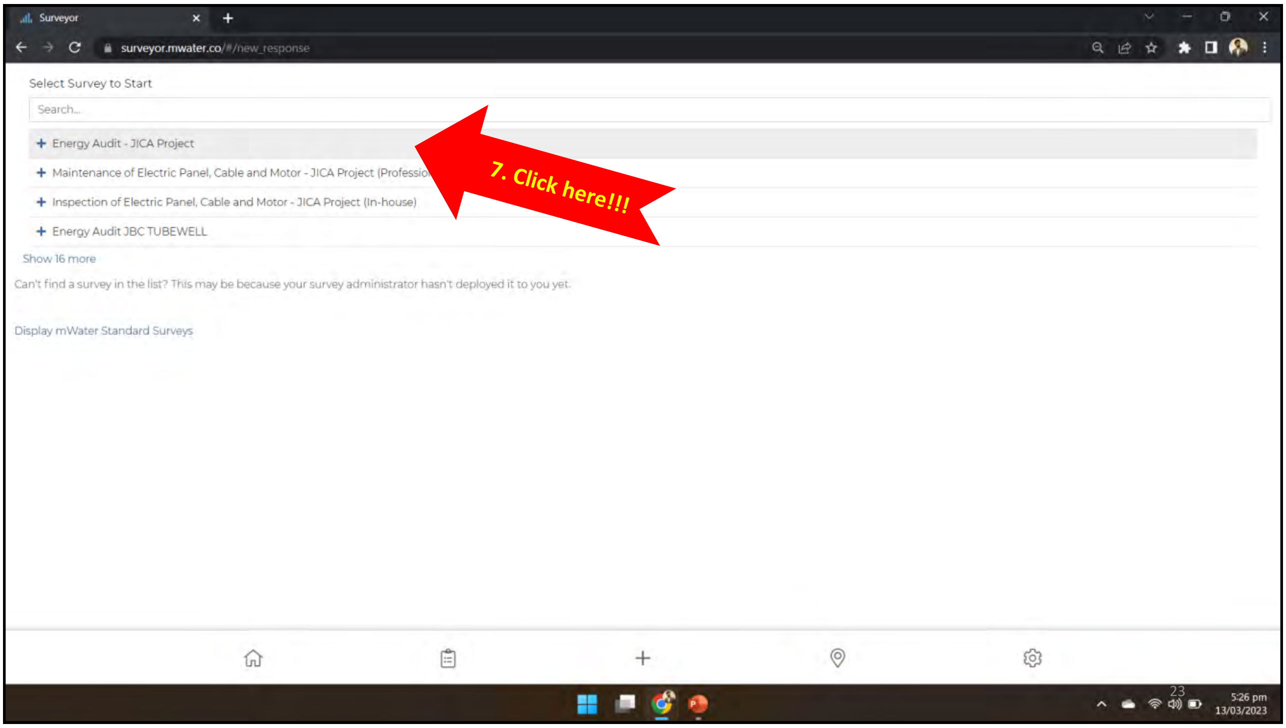
22/02/2023


Surveyor
surveyor.mwater.co/#/new_response
Select Survey to Start
Search...
Energy Audit - JICA Project
Maintenance of Electric Panel, Cable and Motor - JICA Project (Professio
Inspection of Electric Panel, Cable and Motor - JICA Project (In-house)
Energy Audit JBC TUBEWELL
Show 16 more
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Display mWater Standard Surveys
7. Click here!!!
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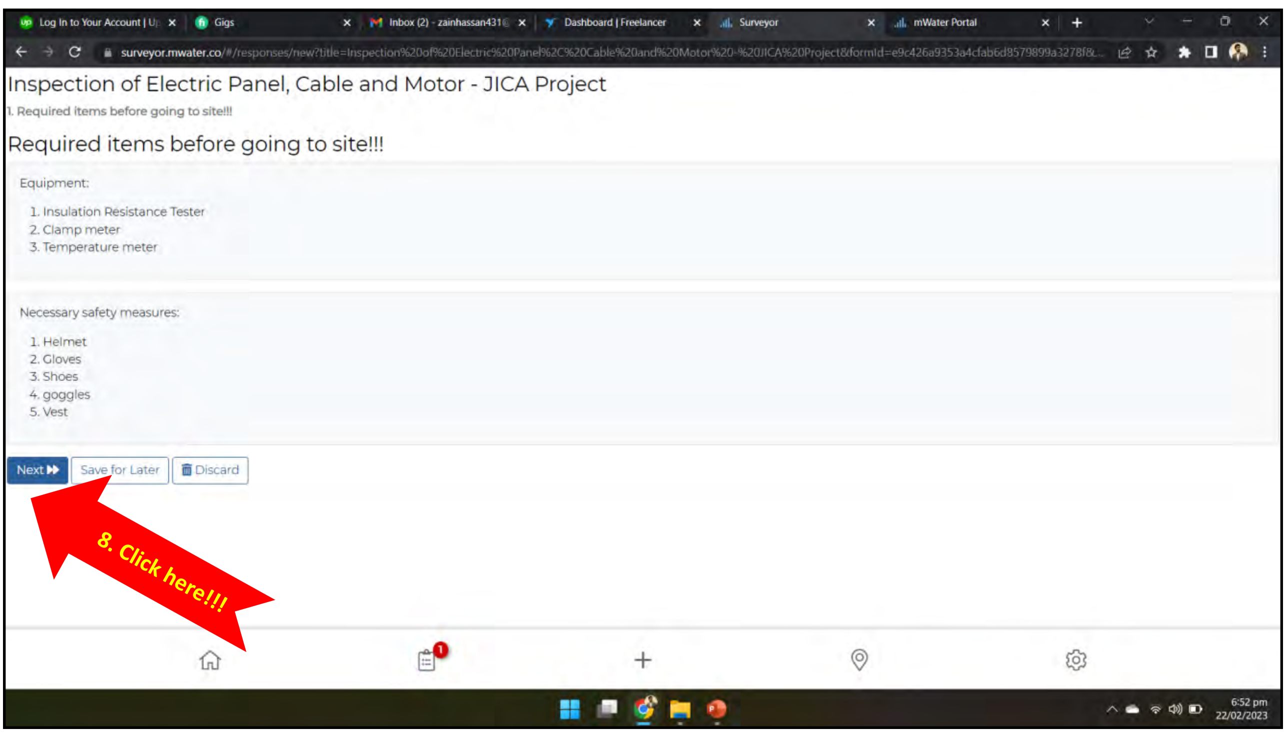
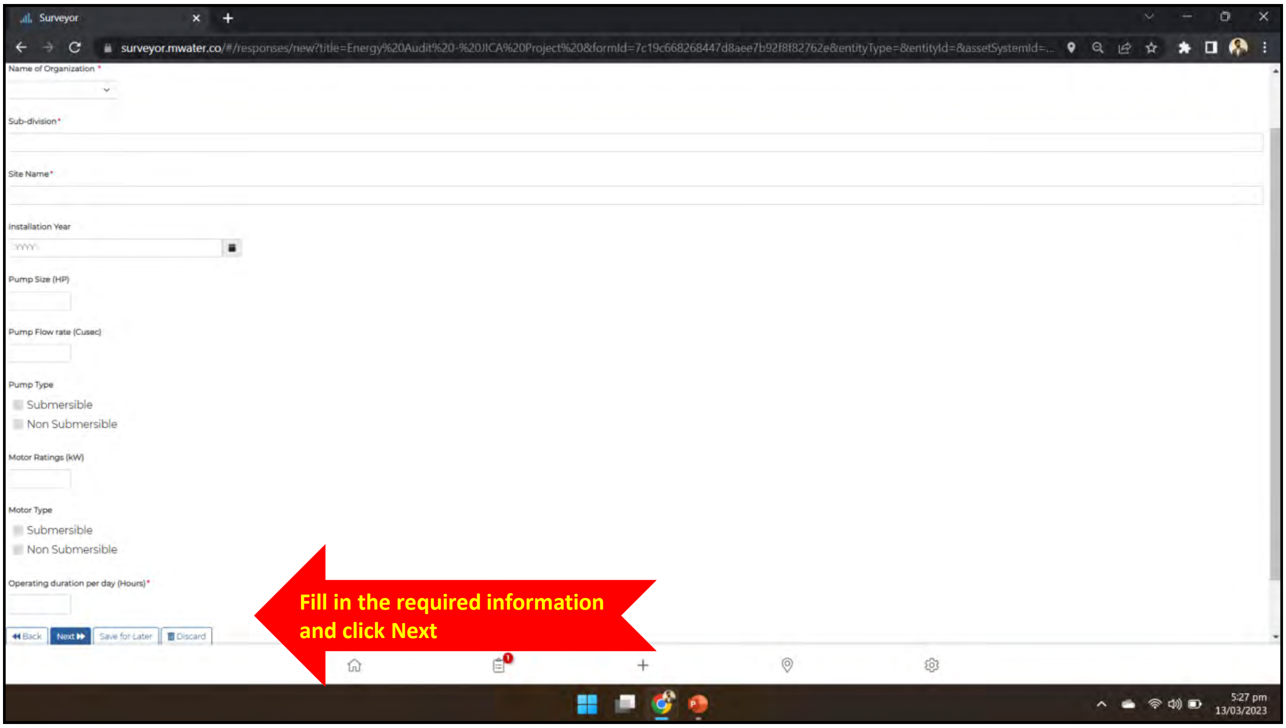
13/03/2023


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
Inspection of Electric Panel, Cable and Motor - JICA Project
1. Required items before going to site!!!
Required items before going to site!!!
Equipment:
1. Insulation Resistance Tester
2. Clamp meter
3. Temperature meter
Necessary safety measures:
1. Helmet
2. Gloves
3. Shoes
4. goggles
5. Vest
Next
Save for Later
Discard
8. Click here!!!
6:52 pm
22/02/2023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Name of Organization *
Sub-division *
Site Name *
Installation Year
YYYY
Pump Size (HP)
Pump Flow rate (Cusec)
Pump Type
Submersible
Non Submersible
Motor Ratings (kW)
Motor Type
Submersible
Non Submersible
Operating duration per day (Hours) *
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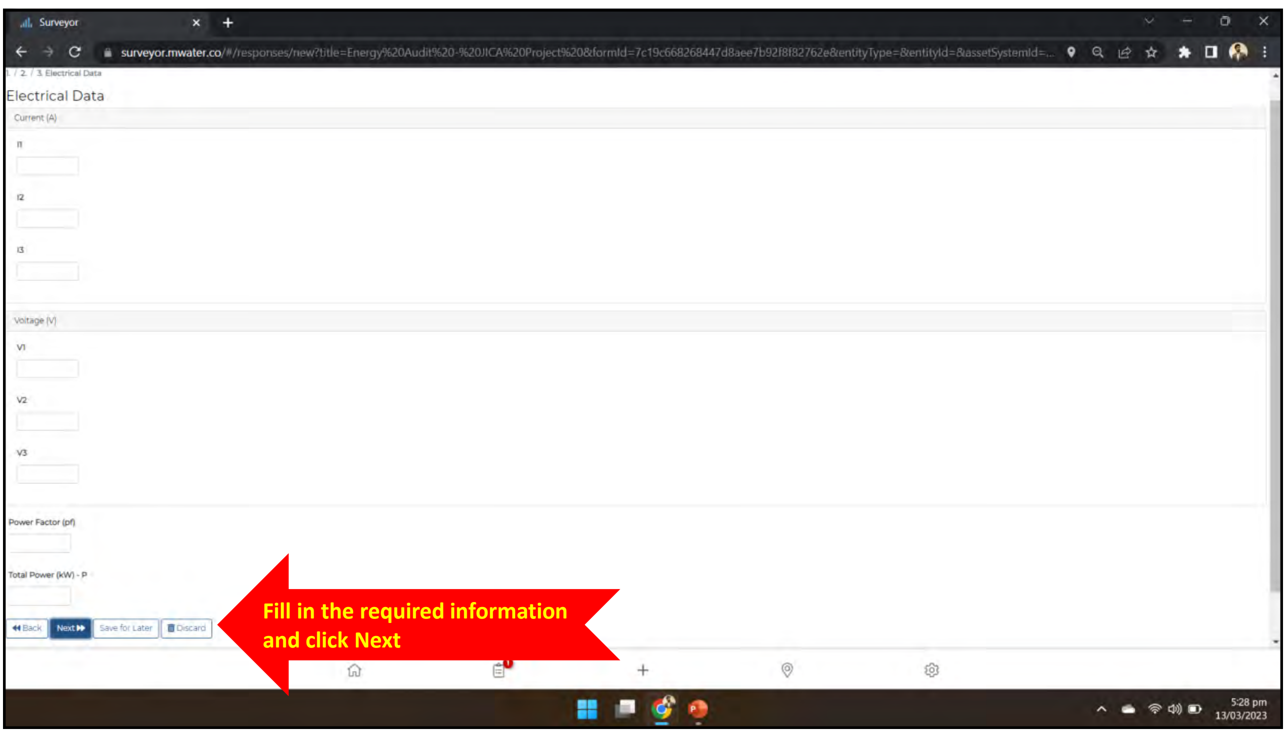
13/03/2023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1 / 2 / 3. Electrical Data
Electrical Data
Current (A)
I1
I2
I3
Voltage (V)
V1
V2
V3
Power Factor (pf)
Total Power (kW) - P
Back
Next
Save for Later
Discard
Fill in the required information and click Next
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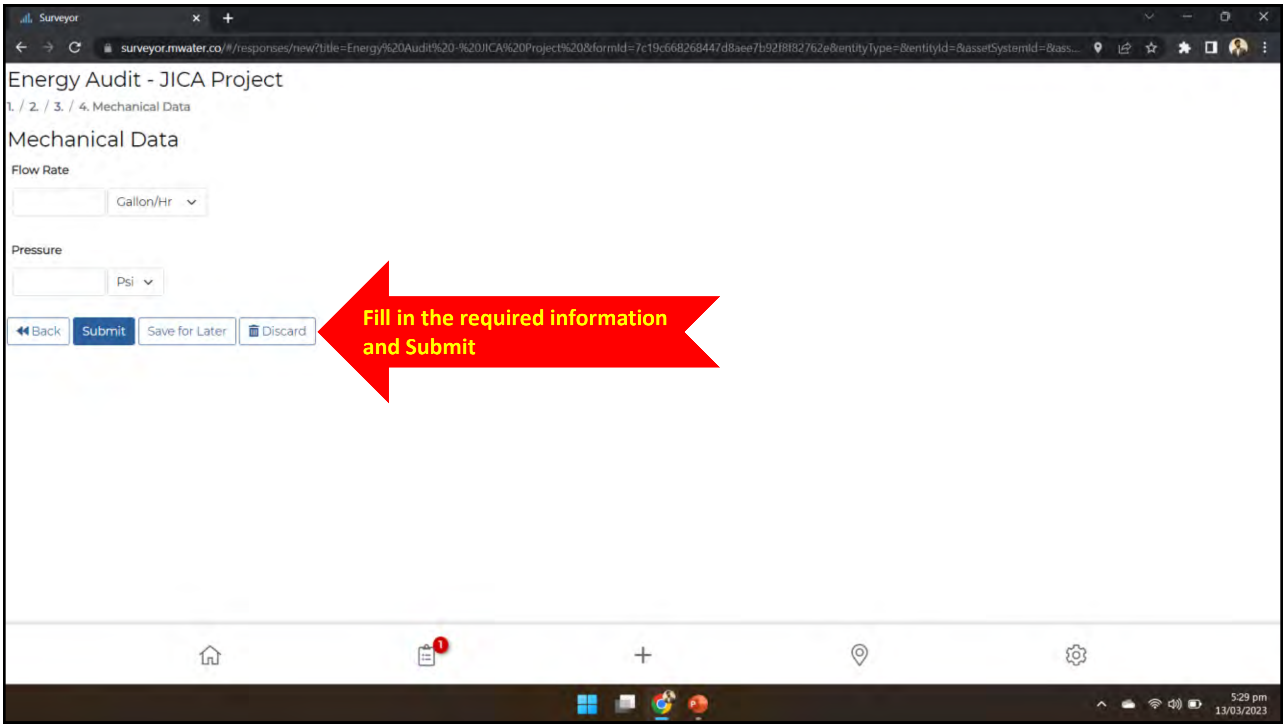
13/03/2023



Project for Improving the Capacity of WASAs in Punjab Province Phase 2

THANK YOU!!!

Let’s go to the site!!!

ENERGY AUDIT OF TUBE WELS

WASA Mechanical Trainer

- **Muhammad Nadeem (Deputy Director P&D)**

GENERAL INFORMATION

ESTABLISHMENT OF WASA	April 1992
JURISDICTION AREA	584 Km^2
POPULATION OF MULTAN	2.2 MILLION
COVERAGE OF SEWERAGE	65% population (1.43 million) 117 Km^2
COVERAGE OF WATER SUPPLY	55% population (1.21 million) 58 Km^2
WATER DISTRIBUTION SYSTEM	Tube wells 84 (04 Cusec Each) Total Capacity = 336 Cfs Network 1448 km (02” to 24”) (1016 Km life expired network) Filtration Plants 65 (1000 Gallons/hr) Functional = 65 No
SEWERAGE SYSTEM	2055 Km sewer (1236 Km life expired sewer) Lateral Sewer (9” to 21”) = 1790 Km Trunk Sewer (24” to 72”) = 265 Km Disposal Stations = 15 No Total Installed Capacity = 1309 Cfs Lift Stations = 10 No Working Capacity = 916 Cfs
TOPOGRAPHY	Plain/ Cup shaped (which is different from other major cities in Punjab) (Each and Every drop of sewage and rain water is disposed off with the help of Pumps)
MASTER PLAN (2015-40)	WASA Multan has prepared its Master Plan of Water Supply, Sewerage and Drainage(2015-40)

Table of Contents

Importance of Energy Audit

- **Help us to Minimize the energy cost through improved efficiency**
- **Helps to Minimize the losses**
- **Helps to Improve the operational/Efficiency work**
- **Helps to improve the pump condition**

Parameters for Energy audit

- **Basic information about site**
- **Flow Rate(Q)**
- **Discharge Pressure(P_d)**
- **Dynamic water level(h_d)**

Equipment Required

Ultrasonic Flow Meter	 
Pressure gauge (Digital, Analog)	 
Water level indicator(Rope type)	
Tool Box(Spanner set, Wrench, Teflon Tape ,etc.)	

Pre-Audit site information

Preparation for Site

- Site Information
- Can we install Pressure Gauge?
- Can we install ultrasonic flow meter?
- Can we check water level?

Pre-Audit site information

•

Energy Audit Form

Energy Audit Form					
Date			Time		
Target Equipment Name					
Location					
Date of Installation					
Pump Details	Manufacturer:		Model/Type:		
	Design Capacity:	cusec	Design Head:	m	
Motor Details	Manufacturer:		Model/Type:		
	Frequency:	Hz	Rated Output:	kW	
	Rated Voltage:	V	Rated Ampere:	A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. **($P_d \times 10.197 + h_d$)**
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.

Perform Energy Audit at Site

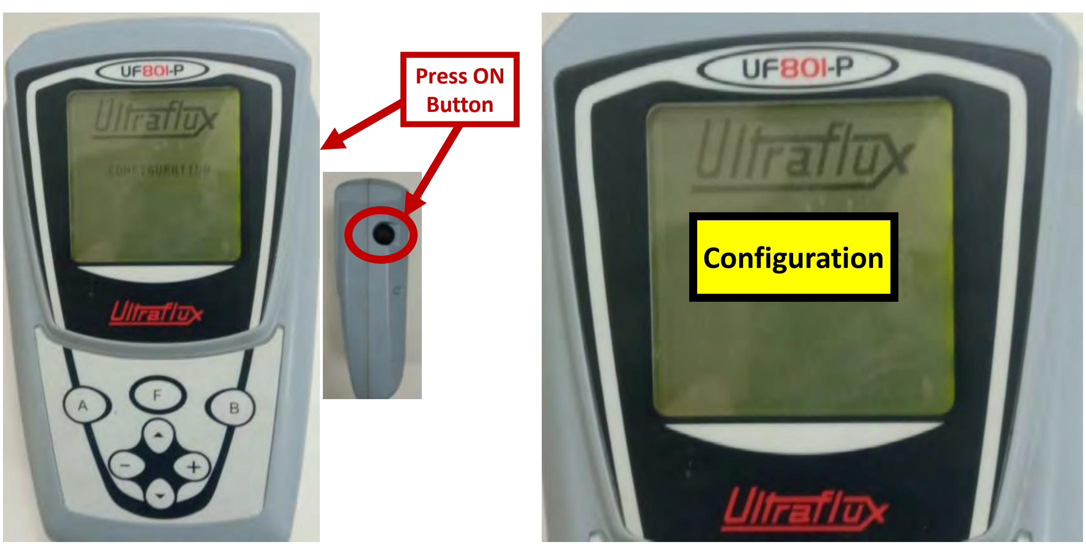
- Install pressure gauge and check Discharge Pressure(P_d)
- Using Water level indicator to check dynamic water level(h_d)
- Install Ultrasonic flow meter and check Flow Rate(Q)

Equipment Installation

11

Use of Ultrasonic Flow Meter

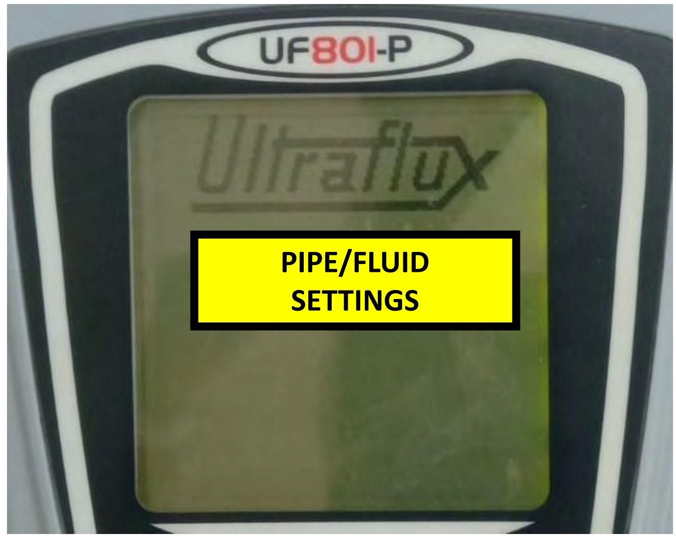
- After switching ON the ultrasonic flow meter press “F” button.



12

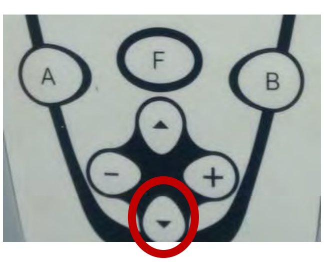
Use of Ultrasonic Flow Meter

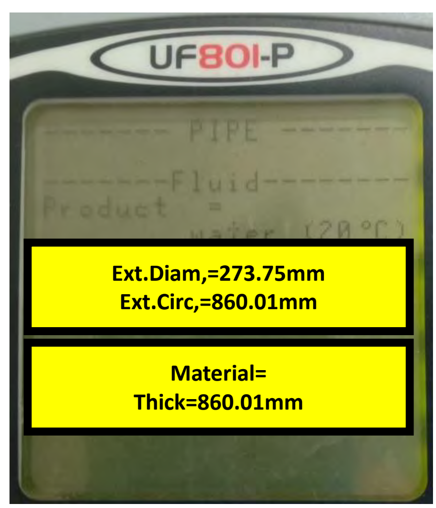
- Again Press **"F"** its showing pipe fluid setting.



Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.





- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Material	Sound Velocity
Mild Steel	5920
Stainless steel	5800
Iron	5900
Cast Iron	4600
HDPE	2460
PVC	2395

Use of Ultrasonic Flow Meter

- Press and hold “F” and its show probe distance and type of probes.

Use of Ultrasonic Flow Meter

- Probes

Formulas for Energy Audit

- **$H_{Total=}$ P_dx10.197+hd**
- **1 bar=**10.19 meter
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=**m^3/hr,
- **1 cusec=**102 m^3/hr
- **1 m^3/min =** 60 m^3/hr (**Bulk Flow meter**)
- **Pump Efficiency,ηp =Ep /Em** × 100
- **Pump output E =** $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000} = \frac{QXH}{6}$
- **E pump(Mechanical power)=**Available Energy
- **E motor(Electrical Power)=**Shaft Power

Annex 5.1.21 Training Material: "O&M on Pump" for ToT at WASA Multan

Operation and Maintenance (O&M) OF PUMP

Table of Contents

Purpose and Outline of O&M Activity

1. Purpose of O&M Activity

- To **provide satisfactory and sustainable services** of water supply and sewerage for consumers.
- To **continue efficient and safe operational management** of pump facilities.
- To **conduct necessary inspection and maintenance**.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

O&M of Water Supply and Sewerage Facilities/Equipment consists of the following two elements.

- **Operation Management**
- **Maintenance Management**

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Operation Management is

- ✓ To operate and control each facility/equipment.
- ✓ To operate and control related facility/equipment as an integrated system effectively.
- ✓ To fulfill its function sufficiently.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is

- ✓ To complement function degradation of equipment and maintain its original function.
- ✓ To decrease **Life Cycle Cost (LCC)** of equipment by prolongation of its lifetime etc.

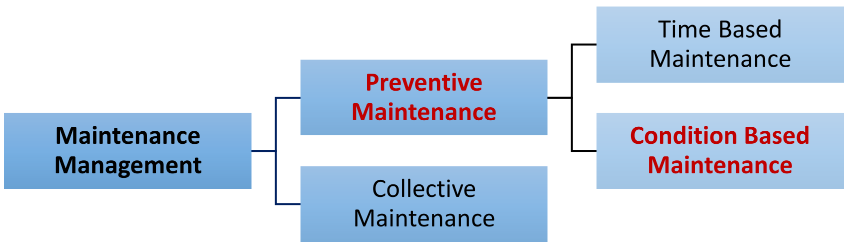
LCC means the total cost which includes;

- Initial Cost (Construction Cost)
- Running Cost (Total O&M Cost during the Life Time)
- Disposal / Demolition Cost

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is categorized into the following items;



Purpose and Outline of O&M Activity

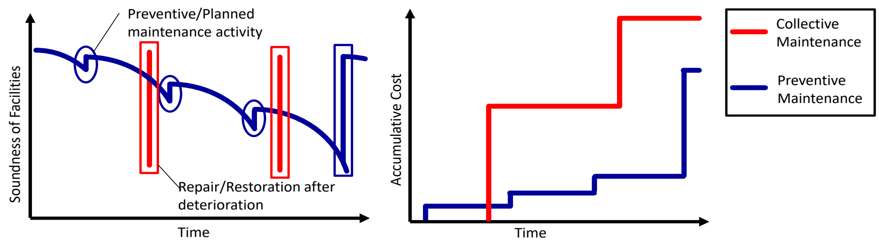
2. Outline of O&M Activity

- **Preventive Maintenance** is preliminary maintenance activities to prevent from malfunction of equipment. It can be categorized into the followings.
  - ✓ **Time Based Maintenance (TBM):**

    Maintenance activities are performed based on the **planned period**.
  - ✓ **Condition Based Maintenance (CBM):**

    Maintenance activities are performed through the **planned inspection to check deterioration/operation condition**.
- **Collective Maintenance** is repair / restoration work after malfunction.

Importance of Preventive Maintenance



Source: Japan's Experiences on Water Supply Development (JICA)

Merits of Preventive Maintenance are

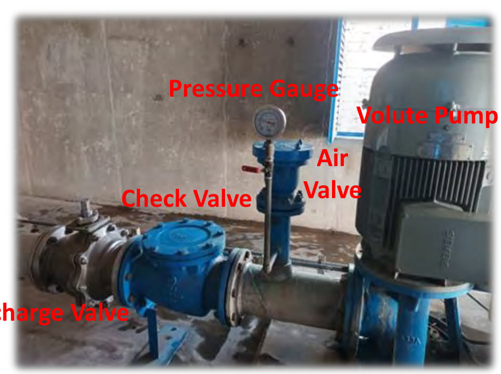
- To **minimize the LCC** of equipment
- To **prolong the lifetime** of equipment

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Volute Pump (Vertical Turbine)

Flow Meter
(Electro Magnetic Type)



Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Mixed Flow Pump

Mixed Flow Pump (Vertical)

Inlet Gate

Discharge Valve &
Check Valve

Screen

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.
ii. Select the pump to be operated.
iii. Check the related valves are at the proper position.
iv. Check the lubricate water tank is filled with water.
v. Check the pressure gauge indicates the original/zero value.
vi. Check/record the Voltage, Ampere of power incoming on the electrical panel.
vii. Check/record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the flow meter reading and stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the pressure gauge indicates the original/zero value.

v. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vi. Check / record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, suction/discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Abnormal noise and vibration (by hearing/touching)
- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

Excessive heat generation of motor can be checked by sense of touch.

Surface Temperature	Sense of Touch	Remarks
40 ℃	Somewhat warm	Feel slightly warm.
45 ℃	Warm	Feel comfortably warm.
50 ℃	Somewhat hot	Your palm turns red if you touch it for a few minutes.
60 ℃	Hot	Can hold your hand for a few seconds.
70 ℃	Extremely hot	Can hold one finger for a few seconds.
80 ℃	Extremely hot	Can hold one finger for only one second.

Normal condition

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

How to Conduct Daily Inspection

2. Daily Inspection Points of Mixed Flow Pump

- ✓ Same points as Volute Pump
- ✓ Suction pressure (if suction pressure gauge is installed.)

How to Conduct Daily Inspection

3. Record Keeping

Daily inspection results and other operation records shall be noted down in the Record Sheet surely and properly.

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Vibration	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

How to Conduct Periodic Inspection

1. Monthly Inspection Points of Volute/Mixed Flow Pump

- ✓ Leakage amount at Grand Packing
  - ➢ Criterion: q [mL/min] = 0.5 × d (mm, shaft dia.)
  - ➢ In case leakage amount is excess, retightening shall be done.
- ✓ Dosing amount of chlorine solution
  - ➢ In case the measured value doesn't meet the target value, it is necessary to adjust the setting value of Chlorinator.

- ✓ Oil level
  - ➢ In case oil level is low, refilling shall be done.
- ✓ Operation of Discharge Valve

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

- ✓ Vibration measurement
- ✓ Insulation measurement
- ✓ Retightening of Anchor Bolts
- ✓ Replace of Grand Packing
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Replace of Oil/Grease
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Overhaul
  - ➢ every 4 to 7 years (depending on the condition)

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Purpose**
  To check/evaluate whether a pump is functioning in desirable condition.
- **Standard/Regulation**
  ISO 10816-7 (2009)
- **Feature**
  Vibration measurement is used for fault diagnosis of pump. **Unbalance** and **misalignment** can be detected by measuring **vibration velocity**, and **abnormality of bearing** can be detected by measuring **vibration acceleration**.

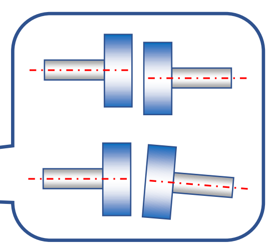
How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Major Causes of Vibration**

✓ Unbalance
✓ Misalignment
✓ Abnormality of Bearing
✓ Cavitation
✓ Loosening of Anchor (Foundation) Bolt



Source: Website of NTN Corporation, Japan

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

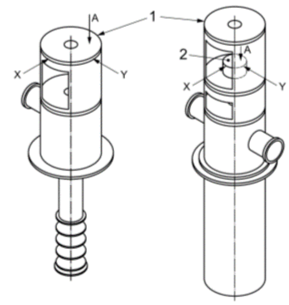
< Vibration Measurement >

- **Procedure**

i. Prepare/set up a vibration meter. (Basically magnet type sensor shall be used.)

ii. Select/decide the measurement locations based on the right figure.

iii. Measure/record vibration velocity value [mm/s] at the selected locations with three directions (axial, vertical, horizontal).



Notes)
Location 1: Driver mounting surface/lower motor bearing
Location 2: Pump bearing housing

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Evaluation**

The results shall be evaluated according to the below table.

Zone	Description	Vibration Velocity Limit*	
		≤ 200 kW**	> 200kW**
A	Newly commissioned machine	3.2	4.2
B	Unrestricted long-term operation	5.1	6.1
C	Limited operation	8.5	9.5
D	Risk of damage	> 8.5	> 9.5

Notes)
* *The root-mean-square (r.m.s) value in mm/s*
** *The applicable motor capacity of industrial pump, which is categorized into Category II (pumps for general or less critical application), is above 1 kW.*

How to Conduct Periodic Inspection

3. Record Keeping

Monthly and yearly inspection results shall be noted down in the Record Sheet surely and properly.

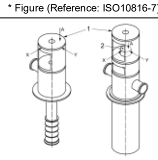
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet			* Figure (Reference: ISO10816-7)	

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 4 to 7 years (depending on the condition)

< Comments / Findings>

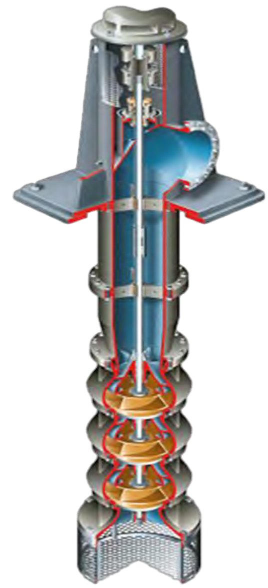


Planning of Periodic Inspection & Maintenance

- Periodic inspection and maintenance shall be conducted for all pumps surely and properly.
- Plan of periodic inspection and maintenance shall be made in the previous year considering the following points.
  - ✓ **Installation year** (Aged pump shall be checked carefully.)
  - ✓ **Importance/Priority** (Pumps have big impacts in case of malfunction/shutdown.)
  - ✓ **Location** (Moving time shall be minimized.)
  - ✓ **Time required** (Monthly inspection: within one hour, Yearly inspection: depending on the condition)
  - ✓ **Cost** (In case of overhaul, replace of major parts etc.)

Operation and Maintenance of Pump

WASA Tube well/Disposal Station



Operation and Maintenance of Pump

- **Operation of system**
- Ensuring effective routine running of system timely and daily.
- Stability
- Efficient
- Safely

- **Maintenance**
- Keep of structures/system including planned
- Preventive or Corrective maintenance
- Repair

Operation and Maintenance plan

Operation Record and Manual	• Keep a operational record continuously. • Prepare a O&M Manual (SOP).
Improvement of Operational Control	• Understand / follow the O&M Manual (SOP). • Detect any abnormalities and take measures.
Control of Water Amount and Pressure	• Establish a proper control method of equipment. • Prevent from water leakage.

Operation and Maintenance Plan

- **Preparation of O&M Plan**
- Preparation of a plan involves list of routine tasks, specific tasks at regular intervals including inspection of system (Daily, Weekly, Quarterly, Annually etc.)
- Plan also involves a checklist for operation, supervision and maintenance.

Standard Operating Procedure for Pump

- **1.**Check on the panel door the 3 indicator lights are illuminated. If the indicator lights are off check the position of Main breaker. Turning the main breaker On will illuminate the indicator lights. But if the situation remains the same then there will be shut off from Wapda's side.
- پینل کے دروازے پر چیک کریں کہ 3 انڈیکیٹر لائٹس روشن ہیں۔ اگر اشارے کی لائٹس بند ہیں تو مین بریکر کی پوزیشن چیک کریں۔ مین بریکر کو آن کرنے سے اشارے کی روشنیاں روشن ہو جائیں گی۔ لیکن اگر صورتحال یہی رہی تو واپڈا کی طرف سے بجلی بند کر دی گئی۔

- **2.**Check the indicator light status of (Over Load Trip).

2. (اوورلوڈ ٹرپ) کے اشارے کی روشنی کو چیک کریں۔

- **3.** Check the indicator light status of(Dry Running trip).

(Dry Running trip) کے اشارے کی روشنی کو چیک کریں۔

Standard operating procedure

- **4.**Check the indicator light status of (Earth leakage trip).

(Earth Leakage Trip) اشارے کی روشنی کو چیک کریں۔

- **5.**You can only start the pump if all the above four indicator lights are in off state.In case anyone of above light is in on state do inform the respective operation supervisor.
- آپ پمپ کو صرف اس صورت میں شروع کر سکتے ہیں جب اوپر دی گئی چاروں اشارے کی لائٹس بند ہوں۔ اگر اوپر کی کوئی روشنی چل رہی ہو تو متعلقہ آپریشن سپروائزر کو مطلع کریں۔

- **6.** Before Pump start check main braker on or not?

مین بریکر آن ہیں یا نہیں؟

- **7.**The (Duty selector switch) is in ON position.

ڈیوٹی سلیکٹر سوئچ آن ہو۔

Standard operating procedure

- **8.**Power Factor switch should be on Auto position.

8پاور فیکٹر سوئچ آٹو پوزیشن پر ہونا چاہئے۔

- **9.**Before Starting the pump open valve of water lubrication tank and close it after it goes empty.

پمپ کو چلانے سے پہلے بلک سسٹم سے پانی کھولیں اور خالی ہونے کے بعد اسے بند کر دیں۔

- **10.**Press ON(Green) button pump will start.

ON(سبز) بٹن کو دبائیں پمپ چلنا شروع ہو جائے گا۔

Standard operating procedure

- **11.**After starting the pump, ON the Chlorine dosing pump to start the dosing of Chlorine.

پمپ چلانے کے بعد کلورین پمپ چلائیں۔

- **12.**After starting the main pump make sure the complete absence of abnormal noise or vibration in motor and pump. In occurrence of any such behavior immediately inform the respective site supervisor.

پمپ شروع کرنے کے بعد موٹر اور پمپ میں غیر معمولی شور یا وائبریشن کی جانچ کریں۔ ایسے
کسی بھی ہونے کی صورت میں فوری طور پر متعلقہ سائٹ سپروائزر کو مطلع کریں۔

Daily operation Record

- **Daily operation record Parameters**
- Pump capacity
- Total Head
- Discharge pressure
- Chlorinator setting
- Motor heating, Noise
- Voltage(V),Ampere(A),Motor Output(KW)
- Leakage

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Noise	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

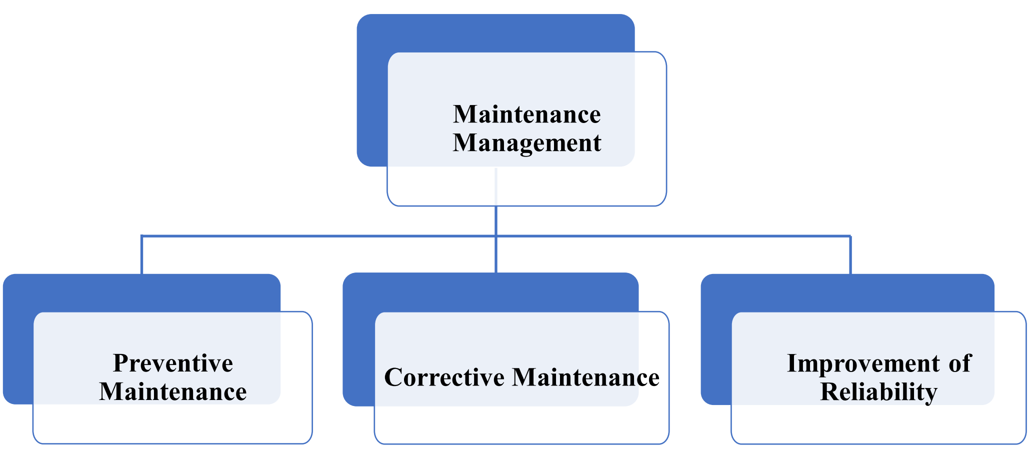
Daily Operation Record Sheet (Disposal Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW			Approved by (Engineer)	
Rated Voltage:	V			Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Suction Pressure	Bar / MPa									
6	Discharge Pressure	Bar / MPa									
7	Voltage	V									
8	Ampere	A									
9	Motor Heating	Normal / High									
10	Abnormal Sound/Noise	Yes / No									
11	Leakage (except pump)	Yes / No									
12	Cleaning of Screen	Done / Not									
13	Remarks										

Maintenance Management of Pump

- Maintenance Management is categorized into the following items;



Parameters for Monthly/Yearly inspection(Preventive maintenance)

- Pump capacity
- Total Head
- Chlorinator capacity/setting
- Gland packing leakage
- Voltage(V),Ampere(A),Motor Output(KW)
- Oil Level/Grease
- Operation of discharge valve
- Vibration
- Insulation
- Connections
- Overhaul

Monthly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Result	Standard	Remarks
1	Leakage Amount at Grand Packing	mL/min	Proper / Not	q = 0.5 × d (mm, shaft dia.)	
2	Dosing Amount of Chlorine Solution	L/hr	Proper / Not	According to the caluculation sheet	Only for Tube Well
3	Oil Level	-	Proper / Not	According to the level gauge	

S-No.	Check / Maintenance Items	Unit	Result	Remarks
4	Retightening of Grand Packing	-	Done / Not	In case that leakage amount is excess.
5	Adjusting the setting value of Chlorinator	-	Done / Not	In case that the measured value does't meet the calculated value.
6	Refilling Oil	-	Done / Not	In case that oil level is low.
7	Operation of Discharge Valve	-	Functioning / Not	

< Comments / Findings>

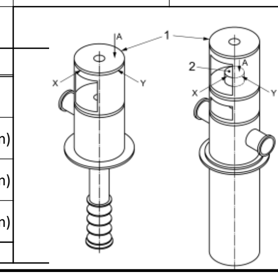
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet				

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 1 to 4 years (depending on the condition)

< Comments / Findings>



Instruments use for Inspection

- Vibration meter
- Clamp meter
- Insulation meter

Troubleshooting of Pump

Annex 5.1.22 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Multan

Operation and Maintenance

Trainer Name: Mr.Arif Abbass

(Deputy Director Disposal Station)

General Information

- **Total Number Pumping stations** **25**
- **Disposal stations** 15
- **Lift Stations** 10

Operation of Pump

- **SOP,s For Operation**
- Check gases specifically H_2S with gas detective meter in screen chamber & Pump house
- Confirm double source electric supply
- Electric Panel reading
- Any Abnormal leakages in suction/delivery/valves
- Select Pump to be operated after monitoring water level in Wet Well

Operation of Pump

- Check Pressure gauge in suction/delivery pipes
- Check voltage/Ampere status on display Panel (rated voltage/display voltage (+-10%)) (rated ampere/ display ampere (+-5%) Three phase motor normally operate on 400 volt
- Conversion factor 1 cusec=10 hp
- Start the pump and check noise leakages if any
- Check discharge flow with ultrasonic flow meter
- Check suction and discharge pressure on pressure gauge
- Note the daily operation record (Performa)

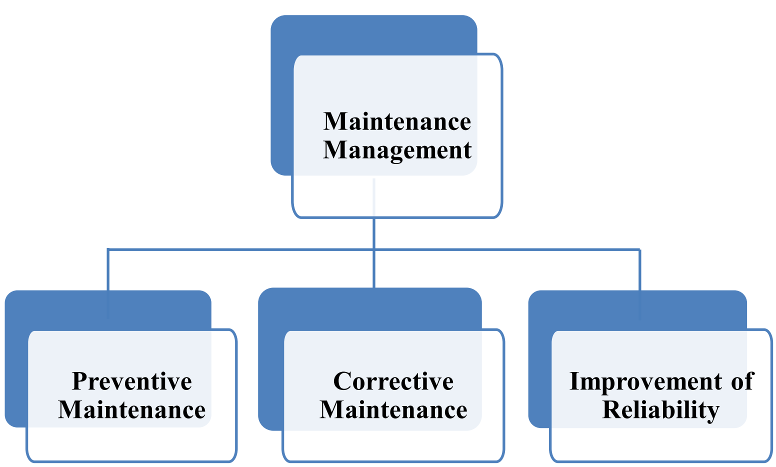
Daily Operation Record Sheet (Disposal Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW			Approved by (Engineer)	
Rated Voltage:	V			Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Suction Pressure	Bar / MPa									
6	Discharge Pressure	Bar / MPa									
7	Voltage	V									
8	Ampere	A									
9	Motor Heating	Normal / High									
10	Abnormal Sound/Noise	Yes / No									
11	Leakage (except pump)	Yes / No									
12	Cleaning of Screen	Done / Not									
13	Remarks										

Maintenance Management of Pump

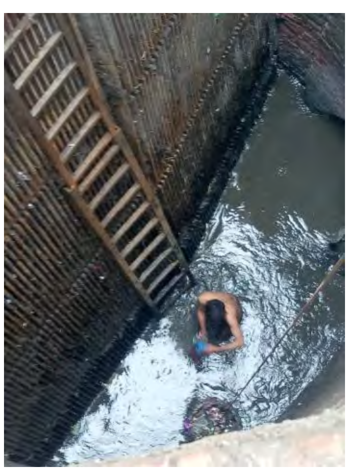
- Maintenance Management is categorized into the following items;



Preventive Maintenance

- Why it is necessary?
- How to avoid pump damages
- **Issues**
- Cordon shaft alignment and its Hz. Support
- Vibrations (bearing+shaft)
- Lubrication/greasing
- Leakages (valve+gland packing)
- Loose nut bolts

WASA Condition



Annex 5.1.23 Training Material: "Electrical panel, MCU, and wiring" for ToT at WASA Multan

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Electrical Panel, Motor Control Unit (MCU) and Wiring

WASA Trainer:

1. **M. Sajid– Deputy Director**

Water and Sanitation Agency (WASA), Multan.

Training **Goals**

- Learn about safety of panel, cable and motor by using equipment
- Preventive maintenance of electrical installations

Skills YOU learn

- Understating the operation of relays used in MCU
- Use of electrical equipment i.e., Insulation & Continuity Tester, Earth resistance Tester, Voltage detector and Clamp meter
- Maintenance work for panels and cables using Electrical Drawings

Training **Topics**

A. COMPONENTS OF ELECTRICAL PANEL/ MCU
B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU
C. SAFETY MEASURES, EQUIPMENT AND TOOLS
D. RECORD KEEPING

Activities YOU perform!

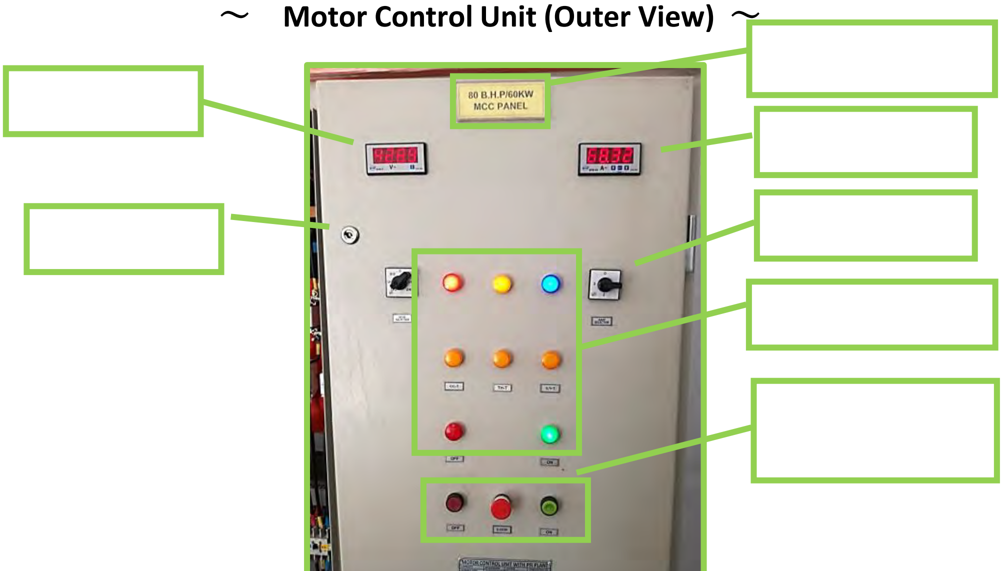
- At office
  - Introduction to main components of electrical panel and MCU
  - Wiring of electrical panel
  - Introduction to electrical panel inspection equipment

- At site
  - Panel Inspection
  - Preventive Maintenance for panel, cable & motor

A. COMPONENTS OF ELECTRICAL PANEL/ MCU

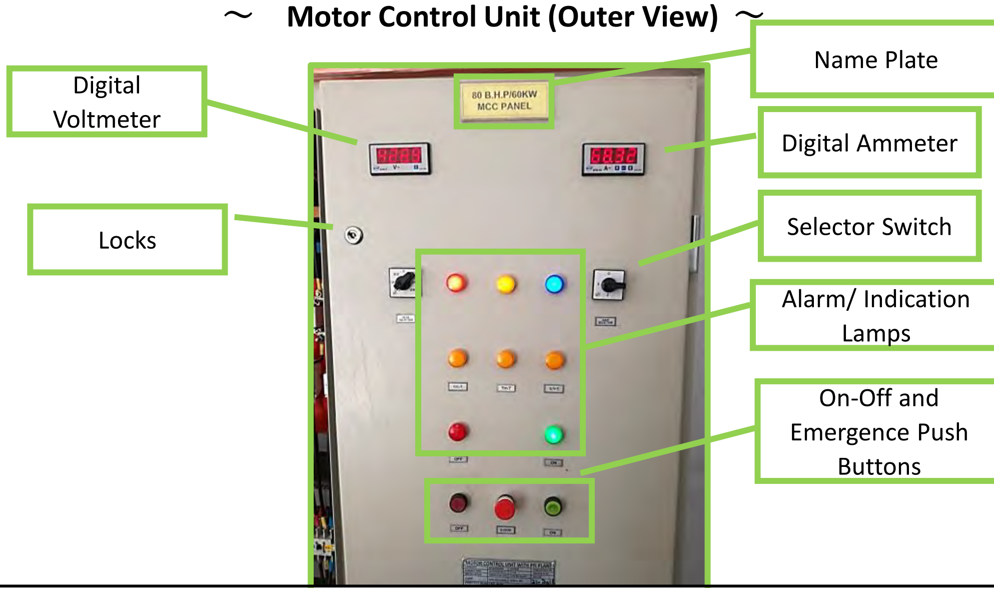
Components of Electrical Panel (1/4)

~ Motor Control Unit (Outer View) ~



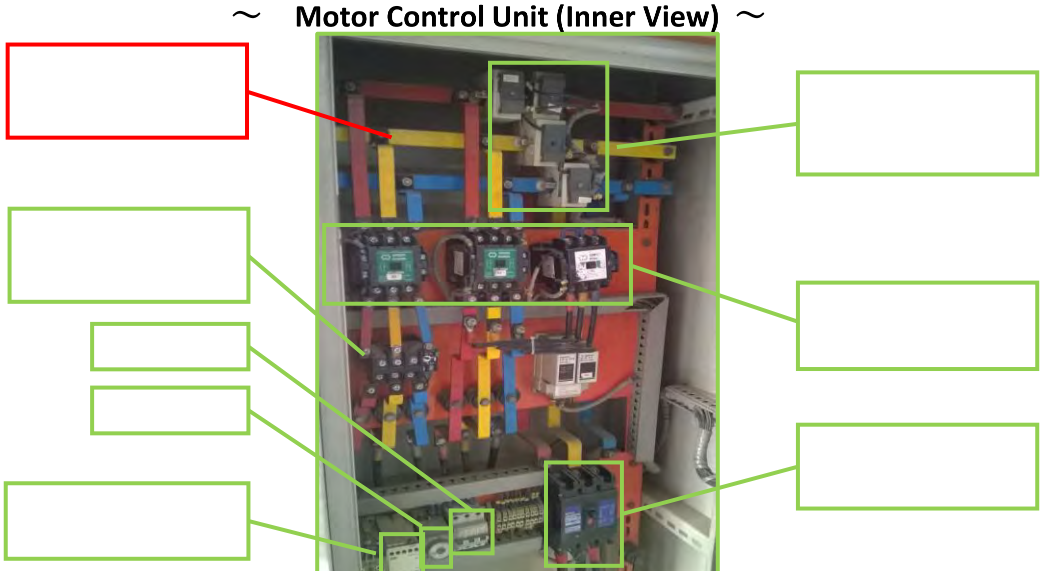
Components of Electrical Panel (2/4)

~ **Motor Control Unit (Outer View)** ~



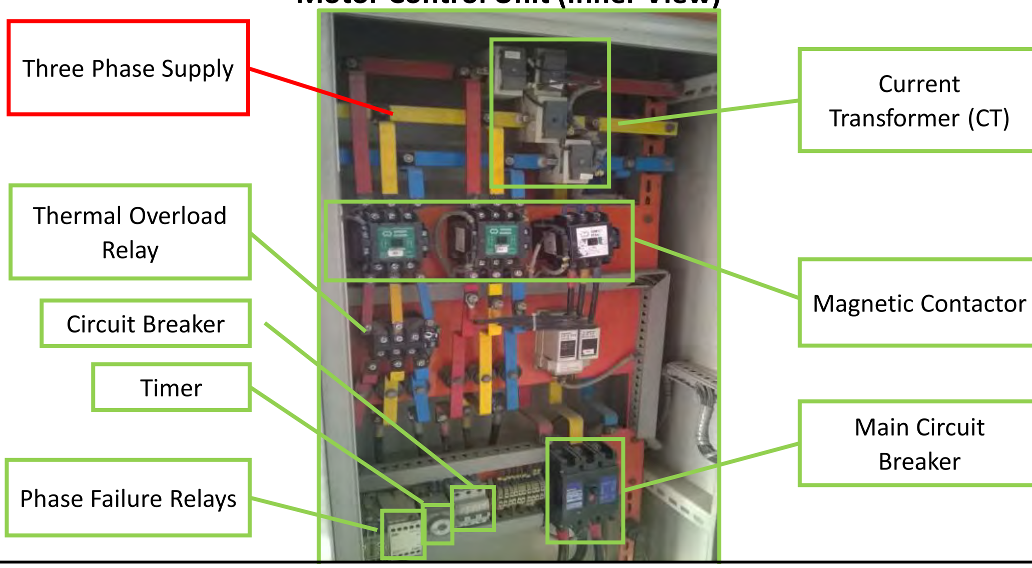
Components of Electrical Panel (3/4)

~ **Motor Control Unit (Inner View)** ~



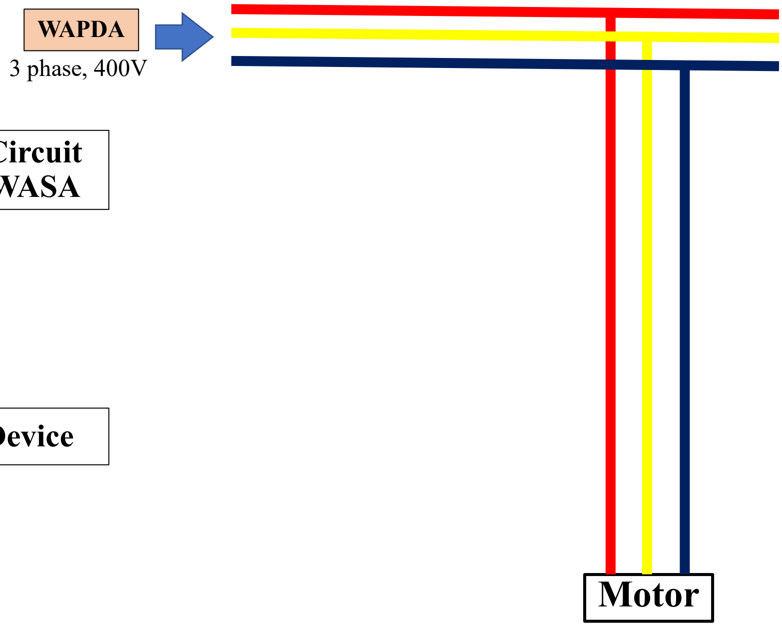
Components of Electrical Panel (4/4)

～ **Motor Control Unit (Inner View)** ～



B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU

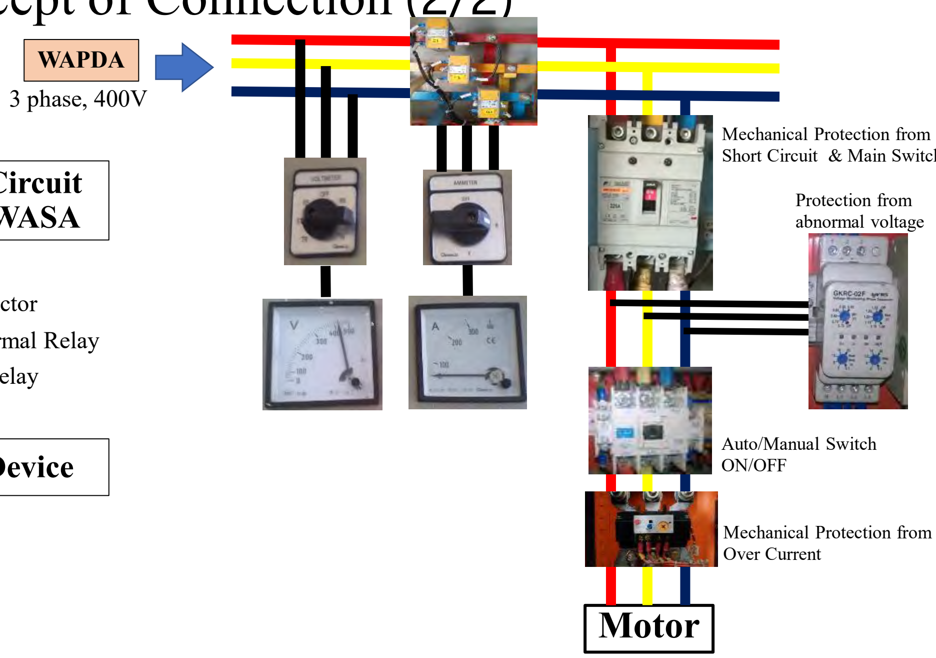
Basic Concept of Connection (1/2)



Basic Power Circuit for Motor in WASA

Monitoring Device

Basic Concept of Connection (2/2)



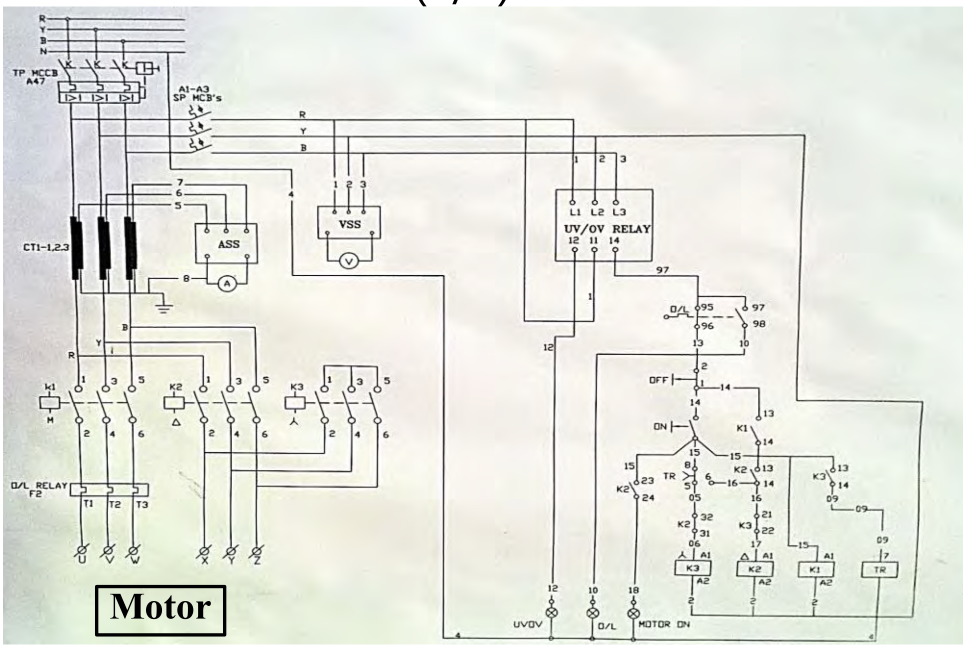
Basic Power Circuit for Motor in WASA

- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Phase Failure Relay

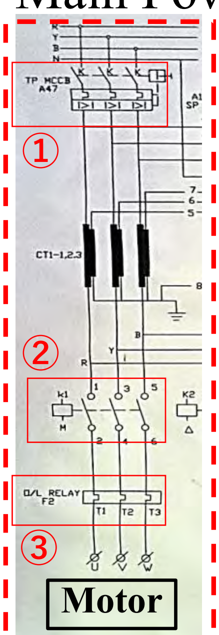
Monitoring Device

- Voltage Meter
- Ampere Meter

Main Power Circuit (1/2)



Main Power Circuit (2/2)



- ✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices

Direct On Line

Basic Power Circuit for Motor

C. SAFETY MEASURES, EQUIPMENT AND TOOLS

Before site activity (1/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5			8		
3			6					

Before site activity (2/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		2	Helmet		3	Post Stamp	
4	Tape		5	Shoes		6	Glasses	
7	Gloves		8	Vest				

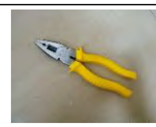
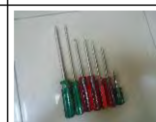
Before site activity (3/5)

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			2			3		
4			5			6		

Before site activity (4/5)

- Preparation of Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Voltage Tester		2	Pliers		3	Screw Driver Set	
4	Wrench		5	Insulation Tape				

Before site activity (5/5)

- Preparation of Equipment

Sr. #	Item	Image	Sr. #	Item	Image
1	Clamp meter		2	Insulation Resistance Tester	

D. RECORD KEEPING

Daily Operation Record (1/1)

Date	Start time	Stop time	Current	Voltage

Preventive Maintenance Record (1/4)

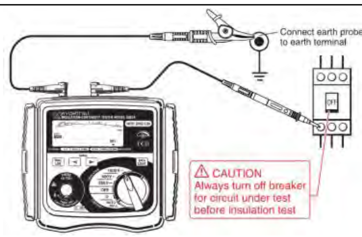
- Bolt tightening
- Insulation Resistance Test
- Voltage, Current and Temperature Check (Using Clamp meter)

Note: All above activities should be performed once in three months

Preventive Maintenance Record (2/4)

- Insulation Resistance Test
  - This test is used to check the quality of insulation of panel, wire, motor body and motor windings
  - This is an Off-load test so make sure the main supply is disconnected before the test
  - Connect Black alligator clip with the Earth terminal (If earth is not available then connect it to a body part i.e., screw etc.)
  - Use red probe to test each component as mentioned in the Device Inspection Sheet

Preventive Maintenance Record (3/4)

Step 1: Check the "Zero Ohm" resistance between the test leads		Step 3: Set the voltages to 500V	Larger insulation value is better. **1MΩ< Value** →**Good.** Please compare it with the previous value as well. **0.4MΩ<Value <1MΩ** →**Caution.** Need to find out fault part and prepare necessary action **Value < 0.4MΩ** →**Dangerous.** Take a necessary action immediately referring to "Fault Detect Procedure" shown in the later section.
Step 2: Turn OFF the electrical supply	 	Step 4: Rotate the test button and check the value of insulation resistance as per given format	

Preventive Maintenance Record (4/4)

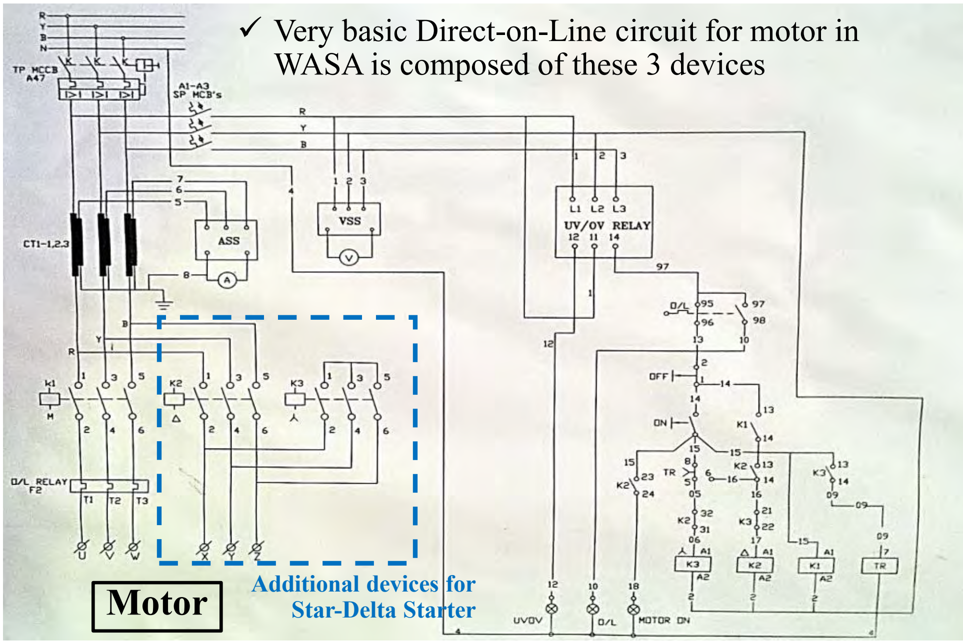
Sr. No.	Inspection Date	Bolt Tightening	Insulation Resistance Test ≥ 1 MΩ												Earth Resistance Test < 5 Ω		
			U1 - E	V1 - E	W1 - E	U2 - E	V2 - E	W2 - E	U1 - V1	U1 - W1	V1 - W1	U2 - V2	U2 - W2	V2 - W2	Earthing Pit	Motor	MCU
1																	
2																	
3																	
Sr. No.	**Inspection Date**	**Voltage (V) ± 10%**			**Current (A) ± 5%**			**Temperature (˚C)**									
								ON duration > 30 min, Upto 70˚C					**OFF duration > 30 min**				
		RY	**RB**	**YB**	**R**	**Y**	**B**	**MCB**	**K1**	**K2**	**K3**	**O/L Relay**	**MCB**	**K1**	**K2**	**K3**	**O/L Relay**
1																	
2																	
2																	

سوال و جواب !!!

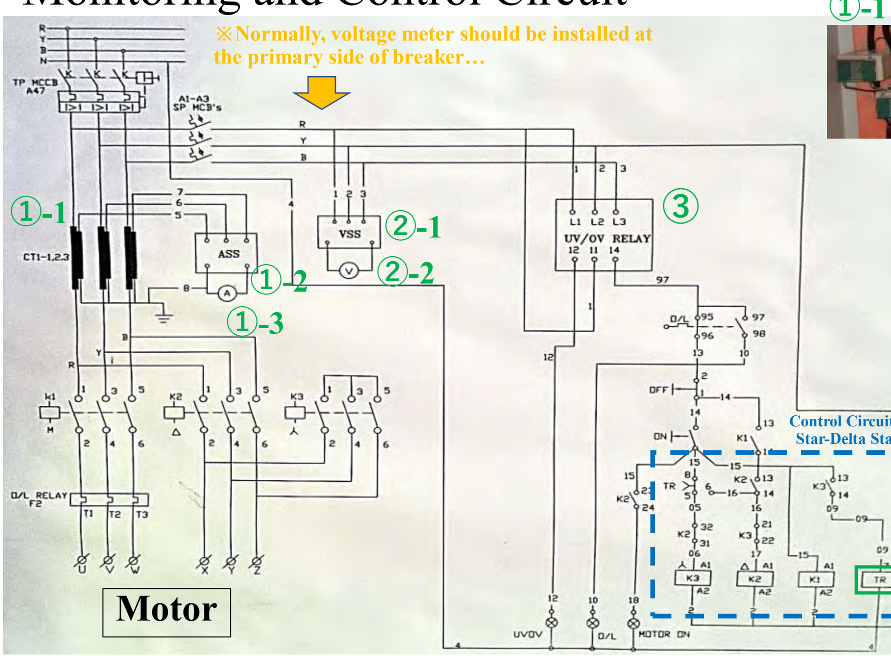
THANK YOU!!!

Main Power Circuit

✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices



Monitoring and Control Circuit



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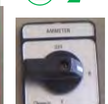
①-2



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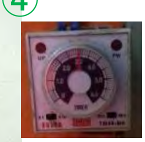


Annex 5.1.24 Training Material on "Electrical panel, MCU, and wiring":

- WASA Multan for Pilot In-house Training, In-house Training
- WASA Gujranwala for ToT, Pilot In-house Training, In-house Training
- WASA Rawalpindi for ToT, Pilot In-house Training, In-house Training

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Electrical Panel, Motor Control Unit (MCU) and Wiring

WASA Trainer:

1. **M. Sajid– Deputy Director**

Water and Sanitation Agency (WASA), Multan.

Training **Goals**

- Learn about safety of panel, cable and motor by using equipment
- Preventive maintenance of electrical installations

Skills YOU learn

- Understating the operation of relays used in MCU
- Use of electrical equipment i.e., Clamp meter
- Maintenance work for panels and cables using Electrical Drawings

Activities YOU perform!

- At office
  - Introduction to the main components of the electrical panel and MCU
  - Wiring of electrical panel
  - Introduction to electrical panel inspection equipment
  - Understanding the data recording through mWater App.

- At site
  - Panel Inspection
  - Preventive Maintenance
  - Data input through mWater App.

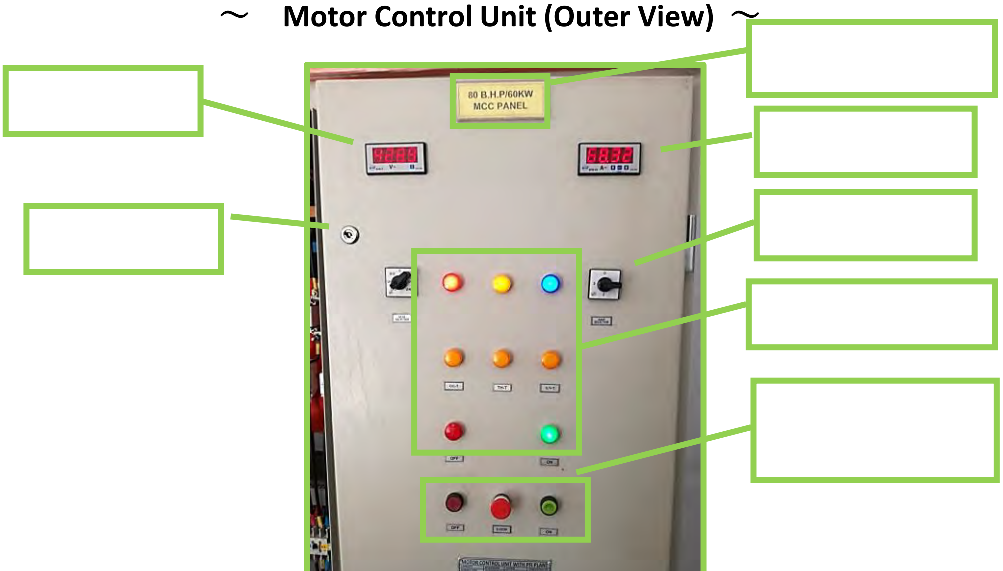
Training **Topics**

A. COMPONENTS OF THE ELECTRICAL PANEL/ MCU
B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU
C. SAFETY MEASURES, EQUIPMENT AND TOOLS
D. RECORD KEEPING USING mWATER APP

A. COMPONENTS OF THE ELECTRICAL PANEL/ MCU

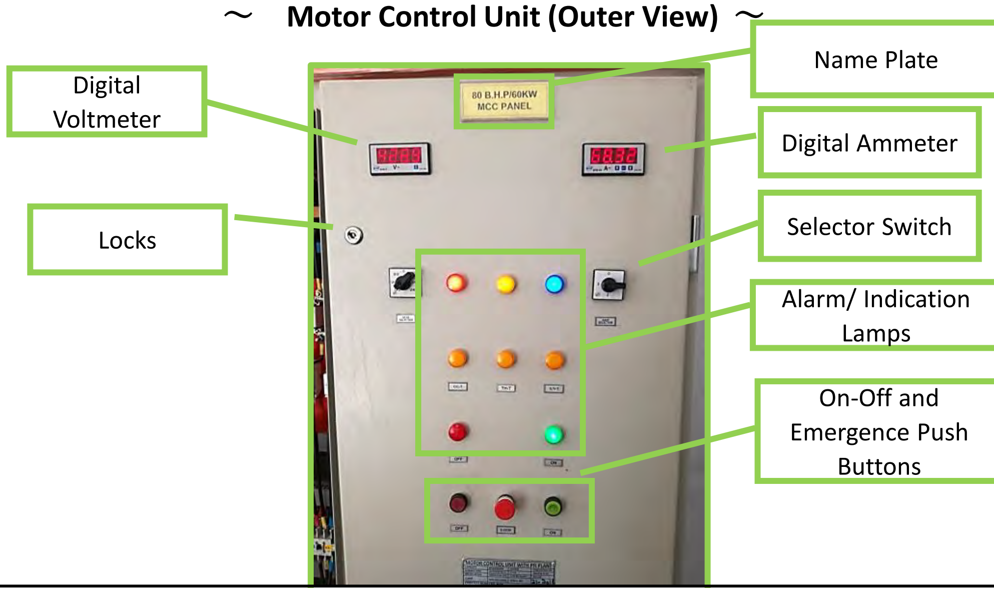
Components of Electrical Panel (1/4)

～ Motor Control Unit (Outer View) ～



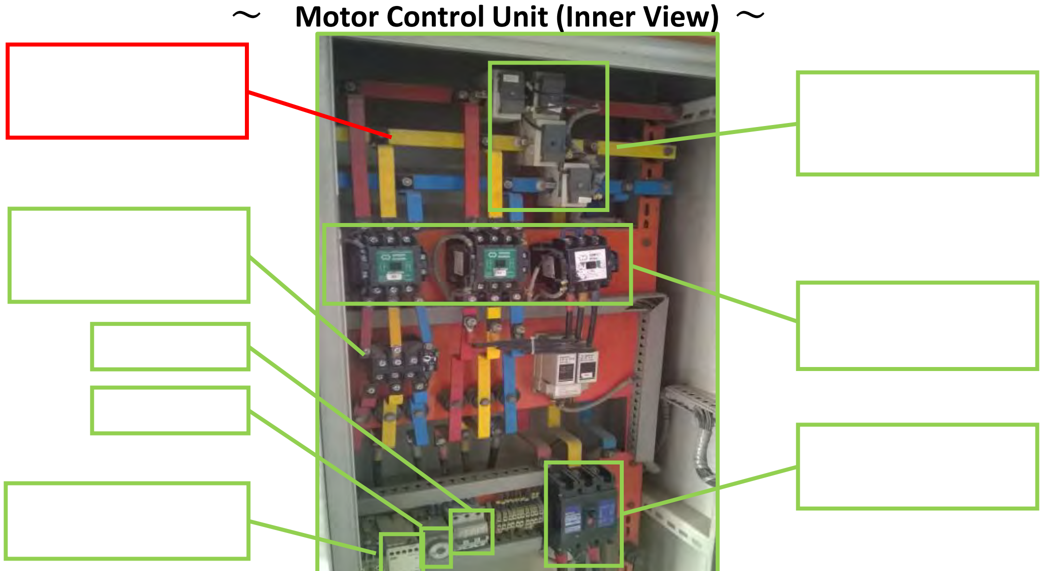
Components of Electrical Panel (2/4)

~ **Motor Control Unit (Outer View)** ~

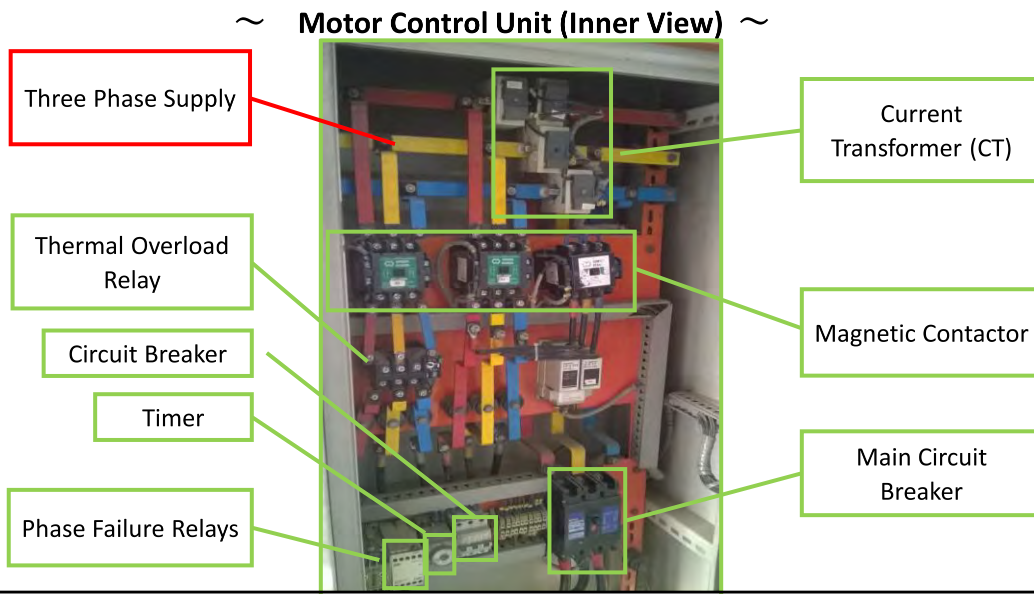


Components of Electrical Panel (3/4)

~ **Motor Control Unit (Inner View)** ~

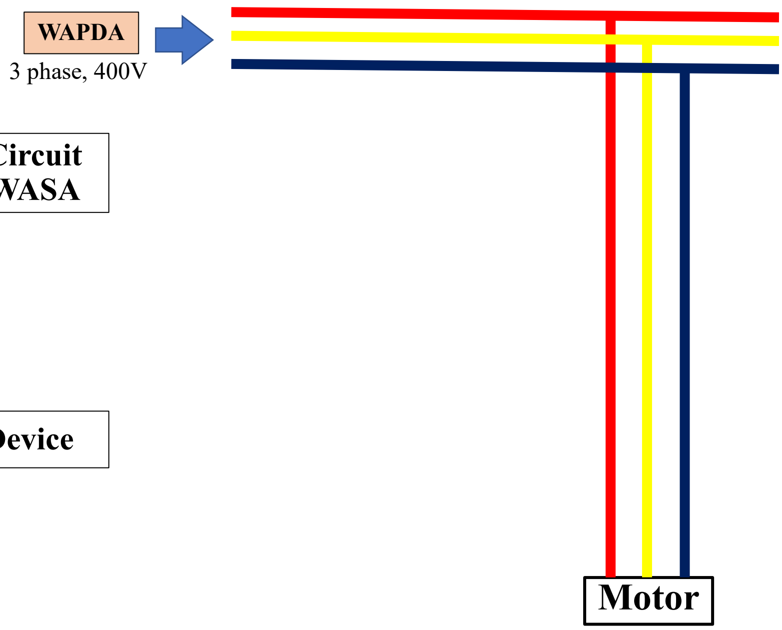


Components of Electrical Panel (4/4)



B. WIRING DIAGRAMS OF ELECTRICAL PANEL/ MCU

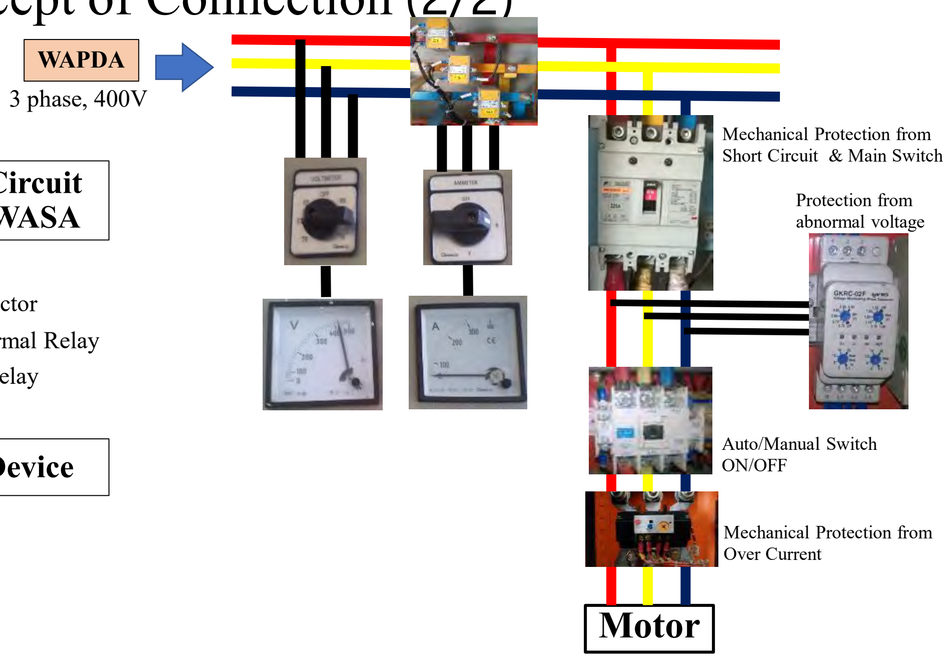
Basic Concept of Connection (1/2)



Basic Power Circuit for Motor in WASA

Monitoring Device

Basic Concept of Connection (2/2)



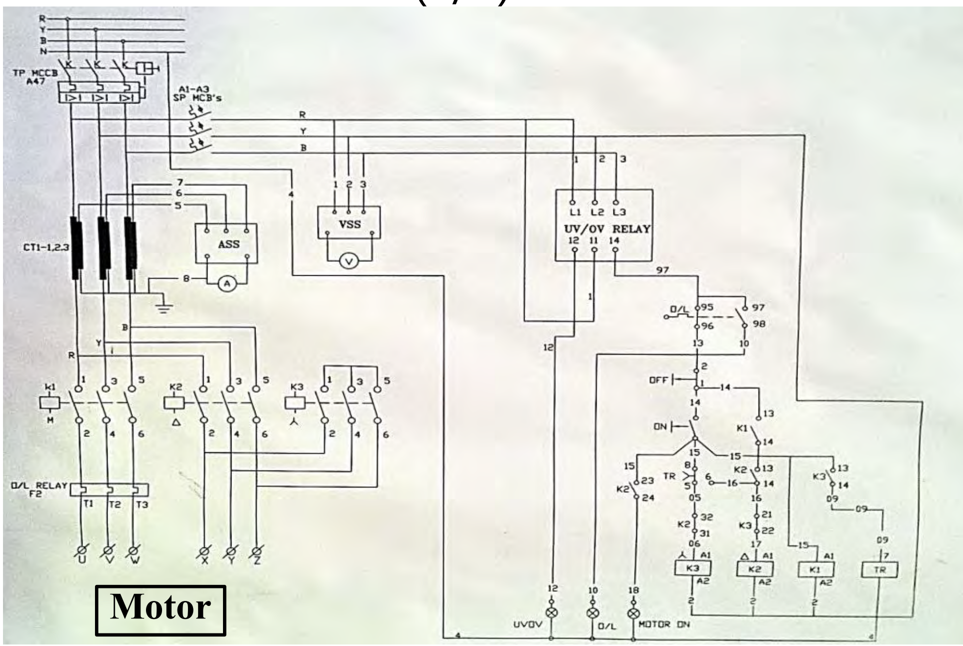
Basic Power Circuit for Motor in WASA

- Circuit Breaker
- Magnetic Contactor
- Over Load/Thermal Relay
- Phase Failure Relay

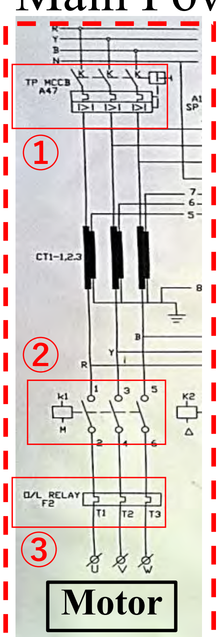
Monitoring Device

- Voltage Meter
- Ampere Meter

Main Power Circuit (1/2)



Main Power Circuit (2/2)



✓ Very basic Direct-on-Line circuit for motor in WASA is composed of these 3 devices

Basic Power Circuit for Motor

C. SAFETY MEASURES, EQUIPMENT AND TOOLS

Before site activity (1/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			4			7		
2			5			8		
3			6					

Before site activity (2/5)

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		2	Helmet		3	Post Stamp	
4	Tape		5	Shoes		6	Glasses	
7	Gloves		8	Vest				

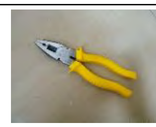
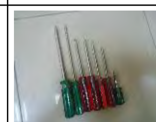
Before site activity (3/5)

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1			2			3		
4			5			6		

Before site activity (4/5)

- Preparation of Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Voltage Tester		2	Pliers		3	Screw Driver Set	
4	Wrench		5	Insulation Tape				

Before site activity (5/5)

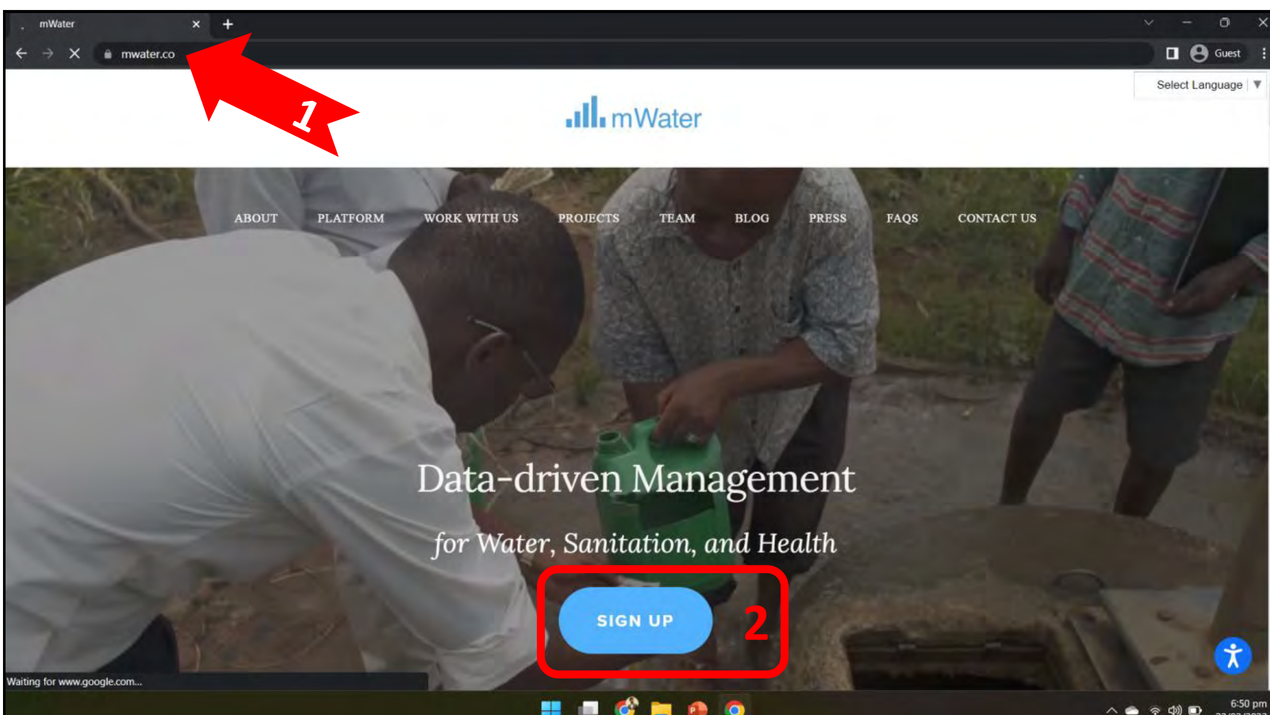
- Preparation of Equipment
  - AC/DA Digital Clamp meter

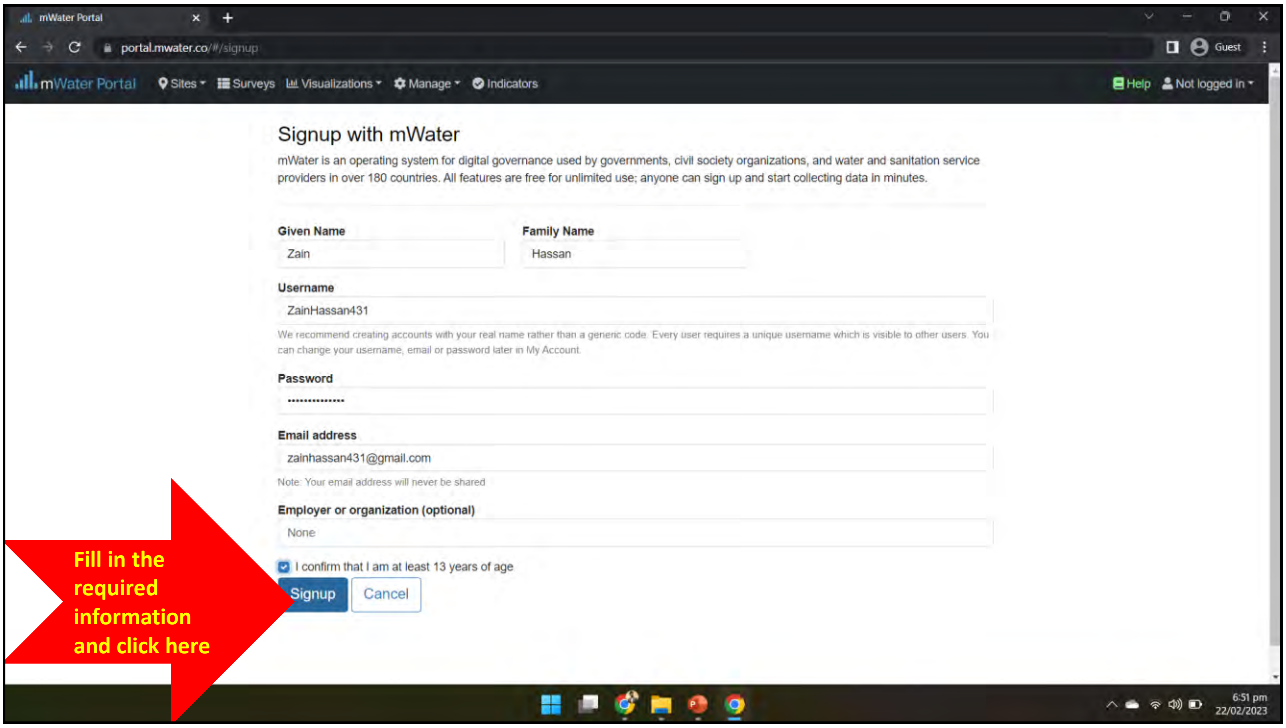
    Model: Kew 2046R

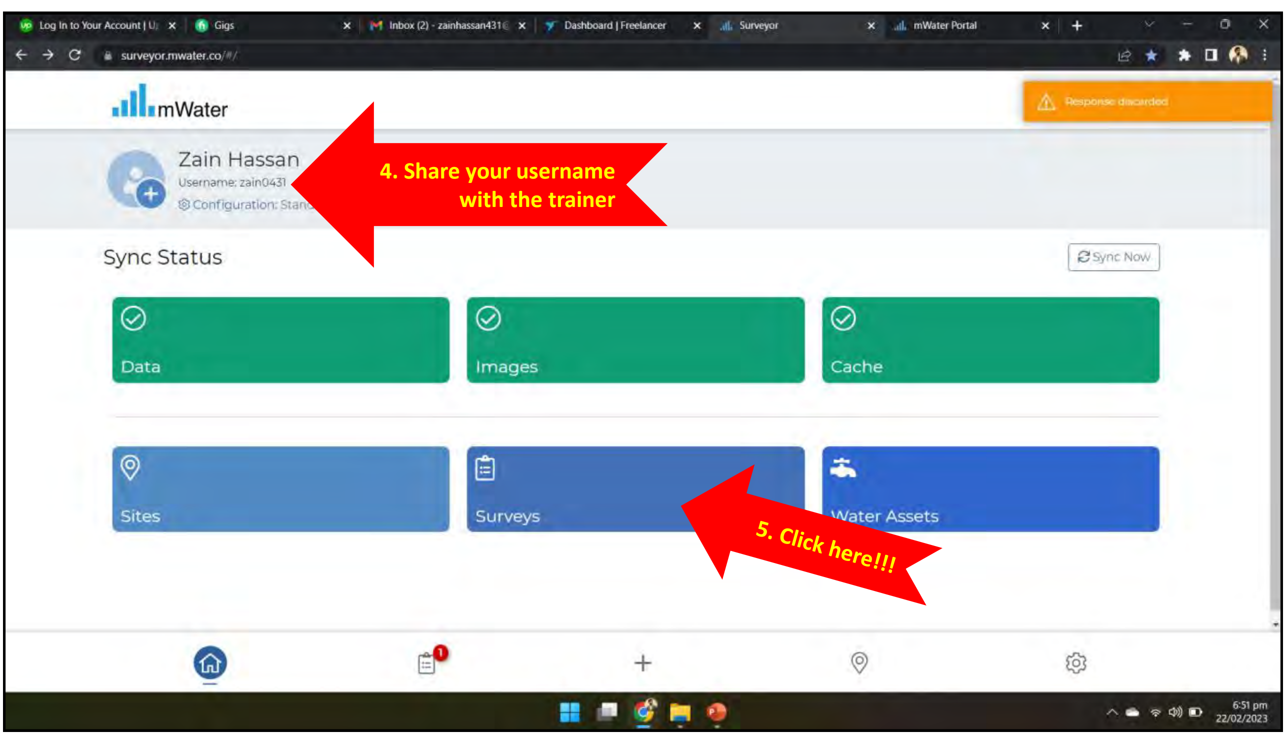
    Voltage Range: upto $600V_{AC}$

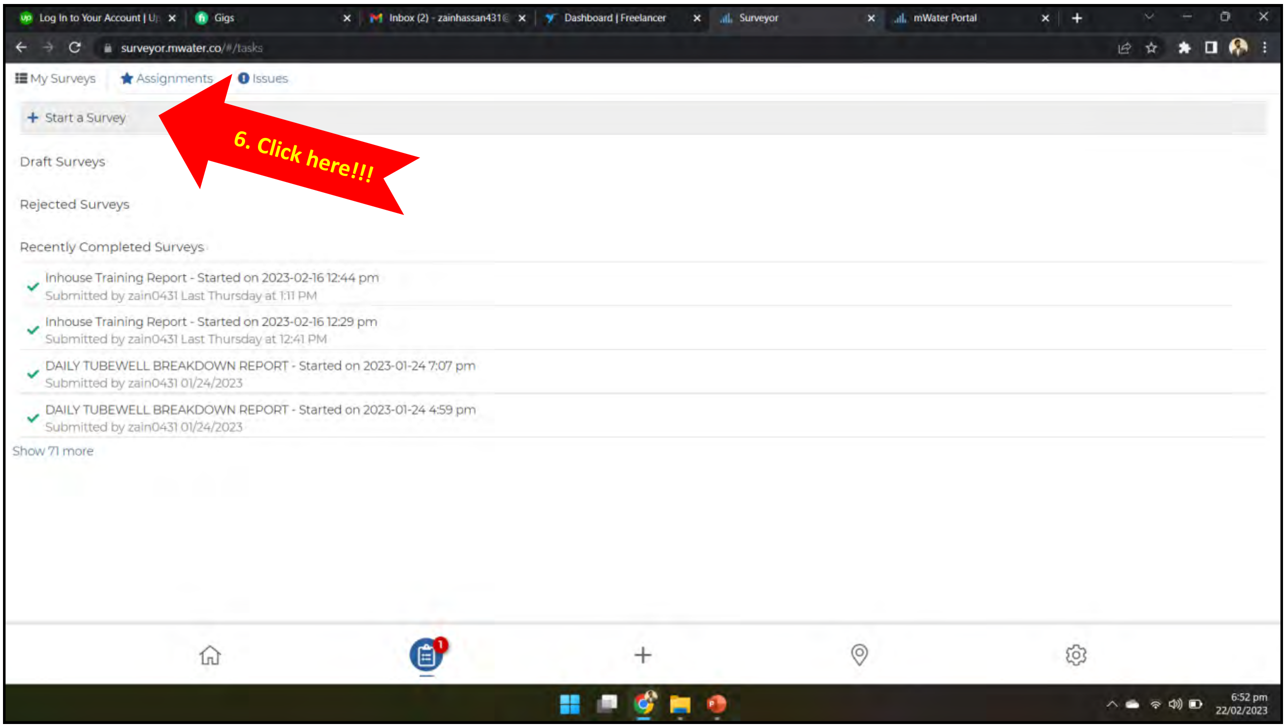
    Current Range: upto $600A_{AC}$

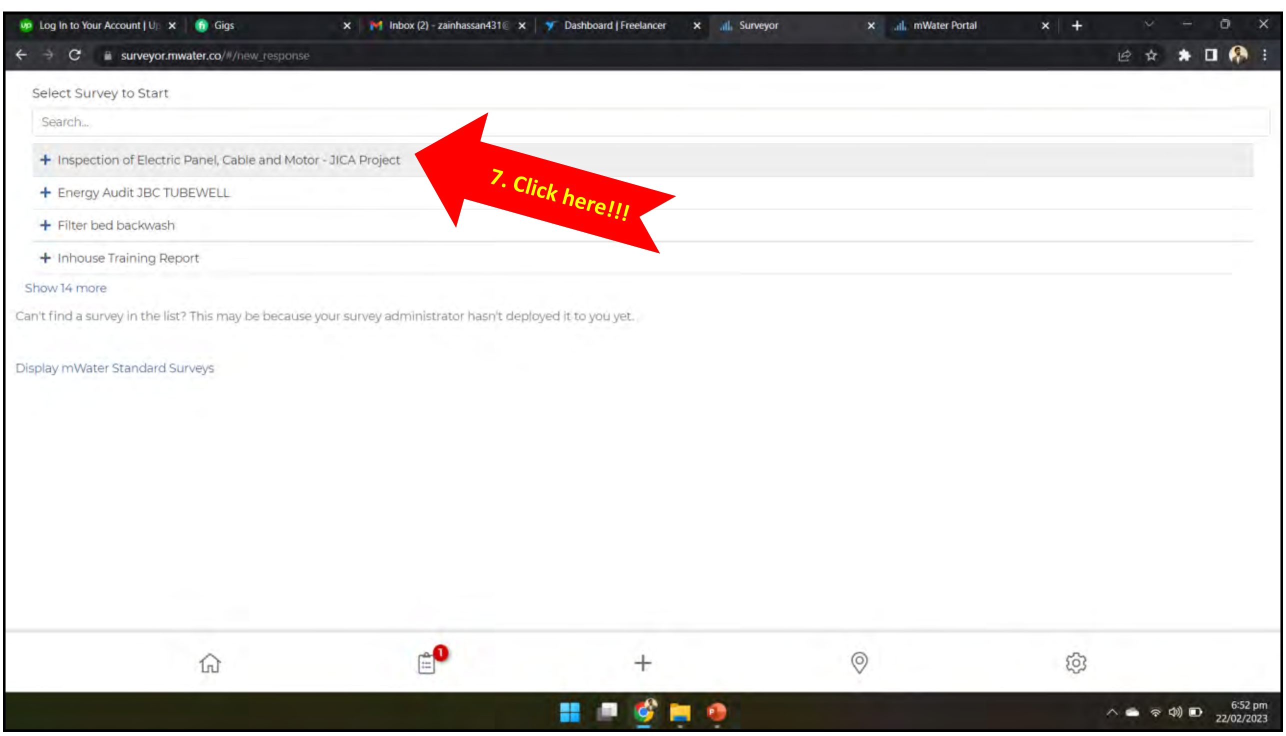
D. RECORD KEEPING USING mWATER APP.

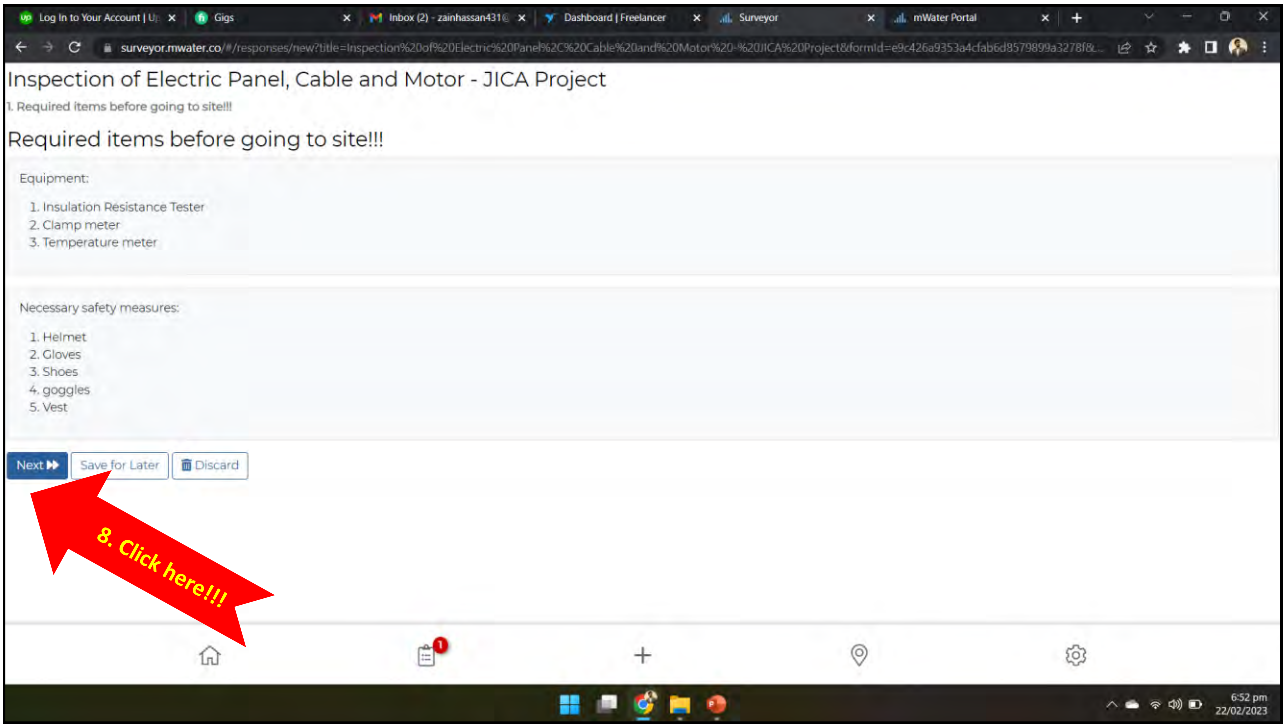


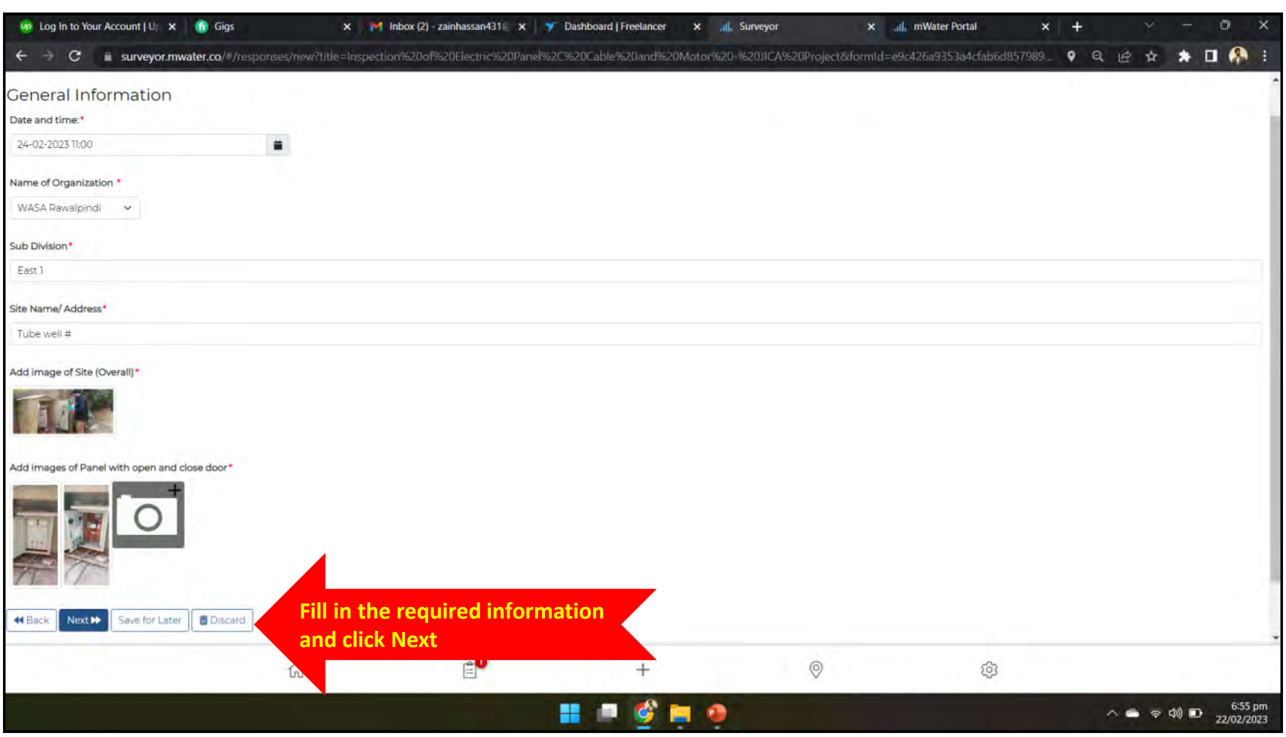

mWater Portal
portal.mwater.co/#/signup
mWater Portal
Sites
Surveys
Visualizations
Manage
Indicators
Help
Not logged in
Signup with mWater
mWater is an operating system for digital governance used by governments, civil society organizations, and water and sanitation service providers in over 180 countries. All features are free for unlimited use; anyone can sign up and start collecting data in minutes.
Given Name
Zain
Family Name
Hassan
Username
ZainHassan431
We recommend creating accounts with your real name rather than a generic code. Every user requires a unique username which is visible to other users. You can change your username, email or password later in My Account.
Password
Email address
zainhassan431@gmail.com
Note: Your email address will never be shared
Employer or organization (optional)
None
I confirm that I am at least 13 years of age
Signup
Cancel
Fill in the required information and click here
6:51 pm
22/02/2023

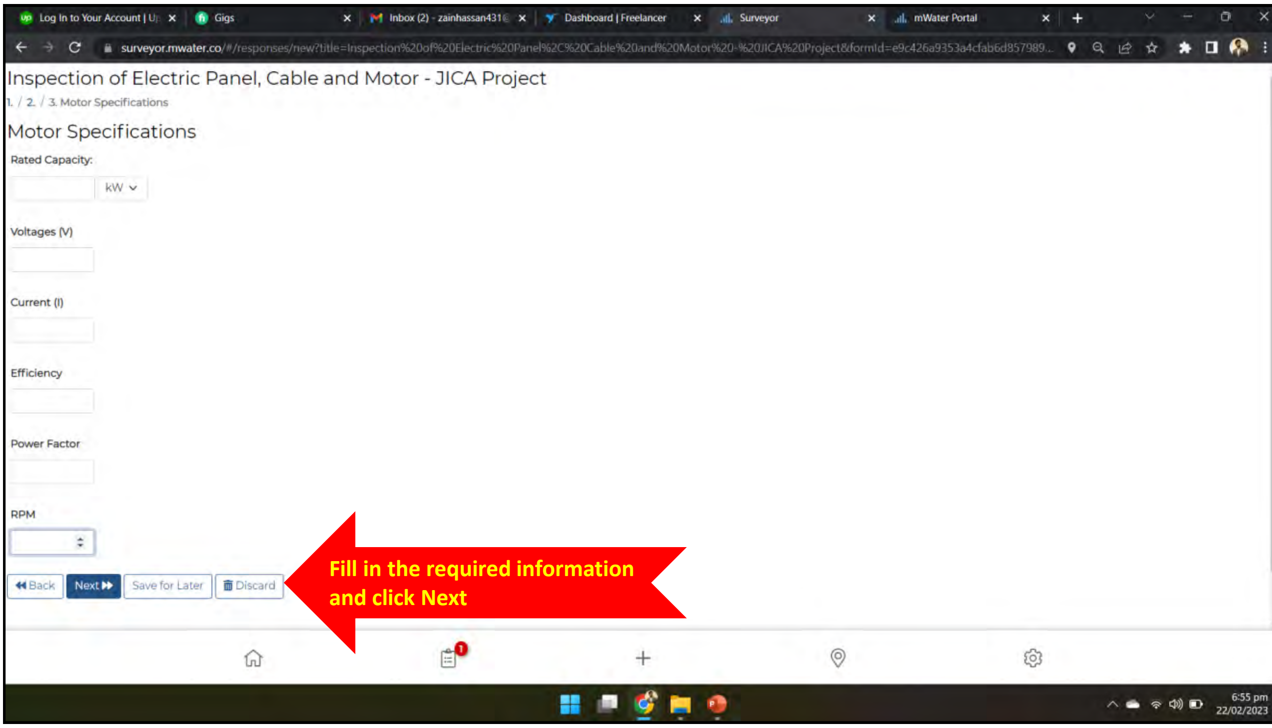

surveyor.mwater.co/#/
mWater
Response discarded
Zain Hassan
Username: zain0431
4. Share your username with the trainer
Sync Status
Sync Now
Data
Images
Cache
Sites
Surveys
Water Assets
5. Click here!!!
6:51 pm
22/02/2023

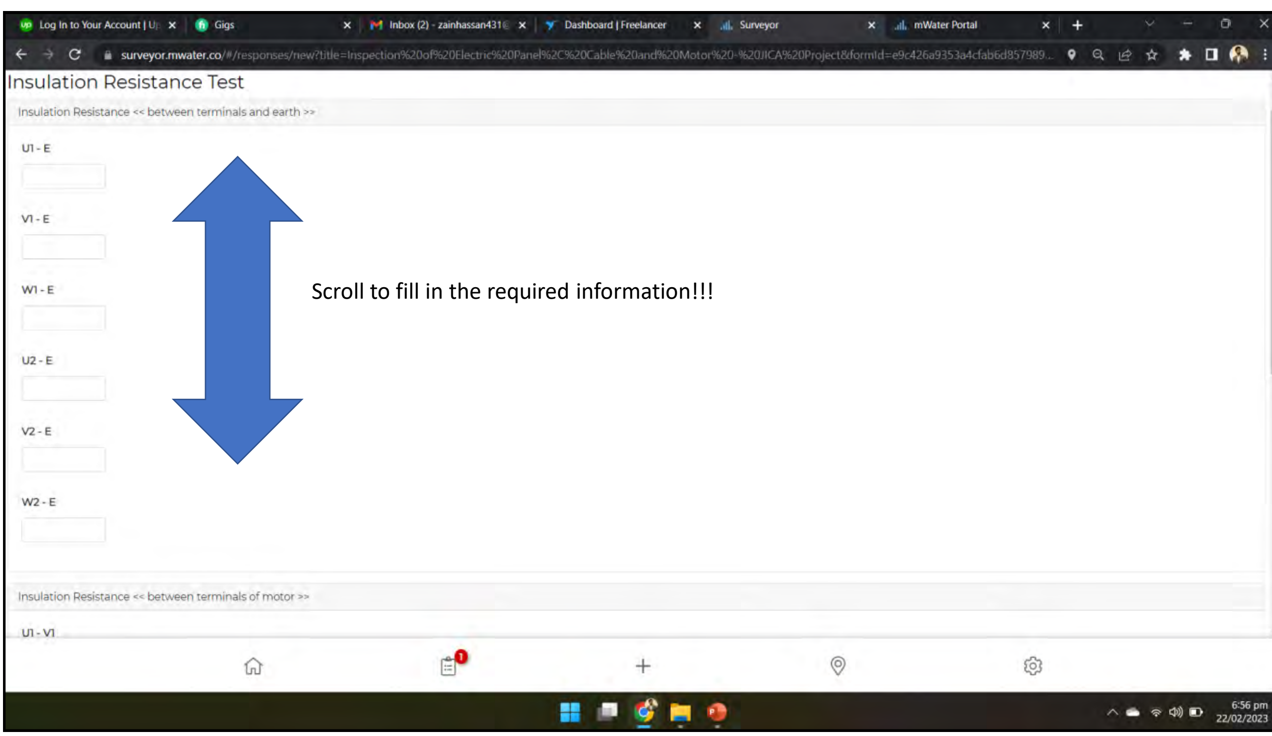

surveyor.mwater.co/#/tasks
My Surveys
Assignments
Issues
Start a Survey
6. Click here!!!
Draft Surveys
Rejected Surveys
Recently Completed Surveys
Inhouse Training Report - Started on 2023-02-16 12:44 pm
Submitted by zain0431 Last Thursday at 1:11 PM
Inhouse Training Report - Started on 2023-02-16 12:29 pm
Submitted by zain0431 Last Thursday at 12:41 PM
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 7:07 pm
Submitted by zain0431 01/24/2023
DAILY TUBEWELL BREAKDOWN REPORT - Started on 2023-01-24 4:59 pm
Submitted by zain0431 01/24/2023
Show 71 more

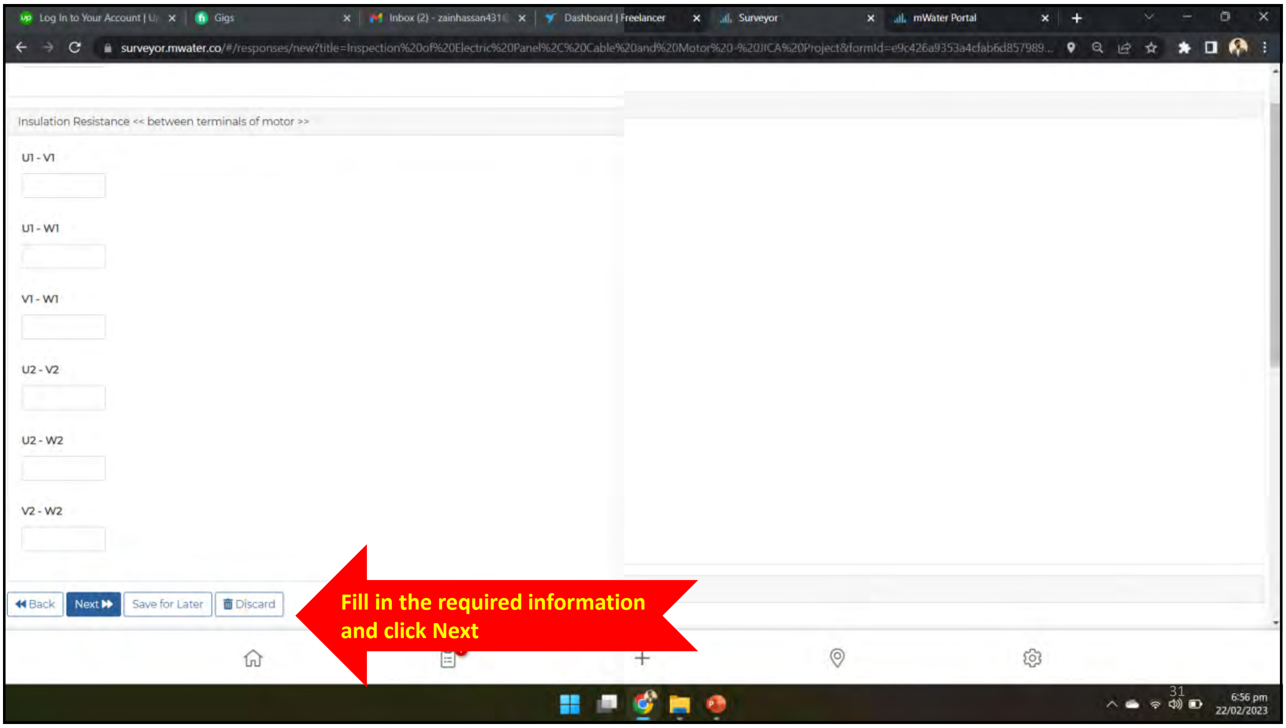

surveyor.mwater.co/#/new_response
Select Survey to Start
Search...
Inspection of Electric Panel, Cable and Motor - JICA Project
7. Click here!!!
Energy Audit JBC TUBEWELL
Filter bed backwash
Inhouse Training Report
Show 14 more
Can't find a survey in the list? This may be because your survey administrator hasn't deployed it to you yet.
Display mWater Standard Surveys

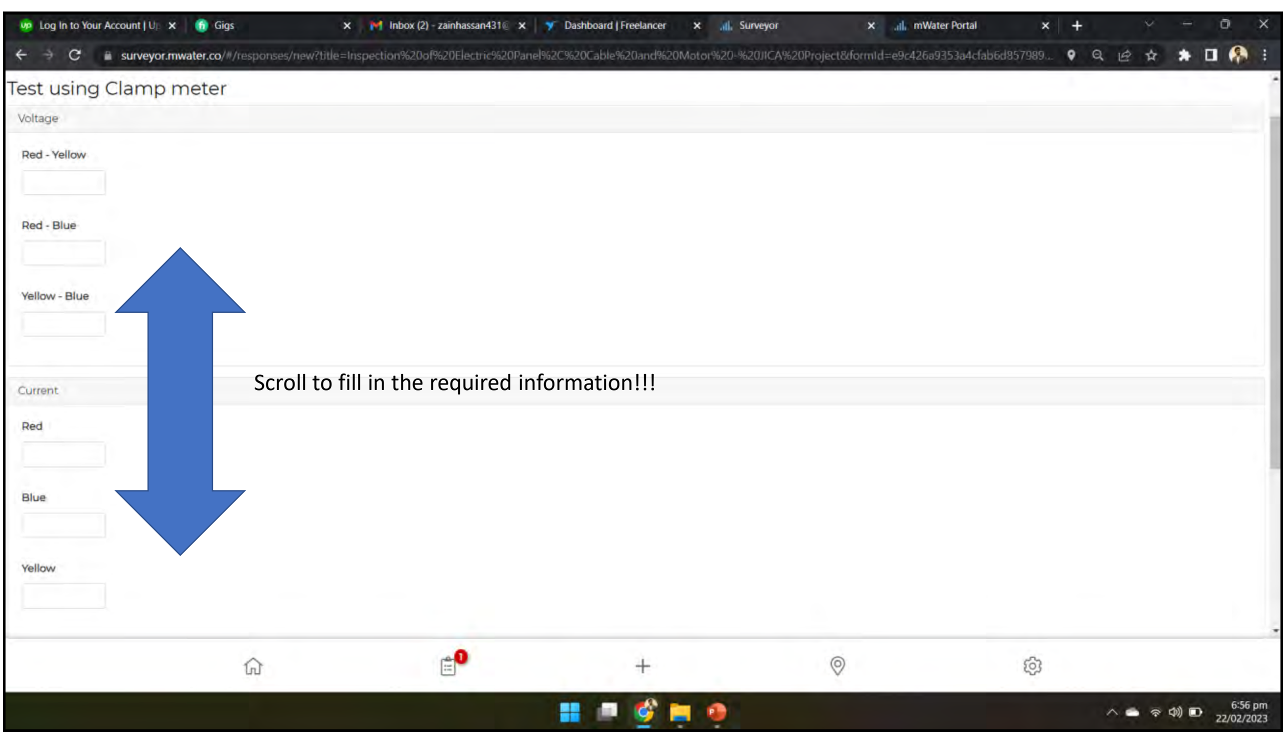

Inspection of Electric Panel, Cable and Motor - JICA Project
1. Required items before going to site!!!
Required items before going to site!!!
Equipment:
1. Insulation Resistance Tester
2. Clamp meter
3. Temperature meter
Necessary safety measures:
1. Helmet
2. Gloves
3. Shoes
4. goggles
5. Vest
Next
Save for Later
Discard
8. Click here!!!

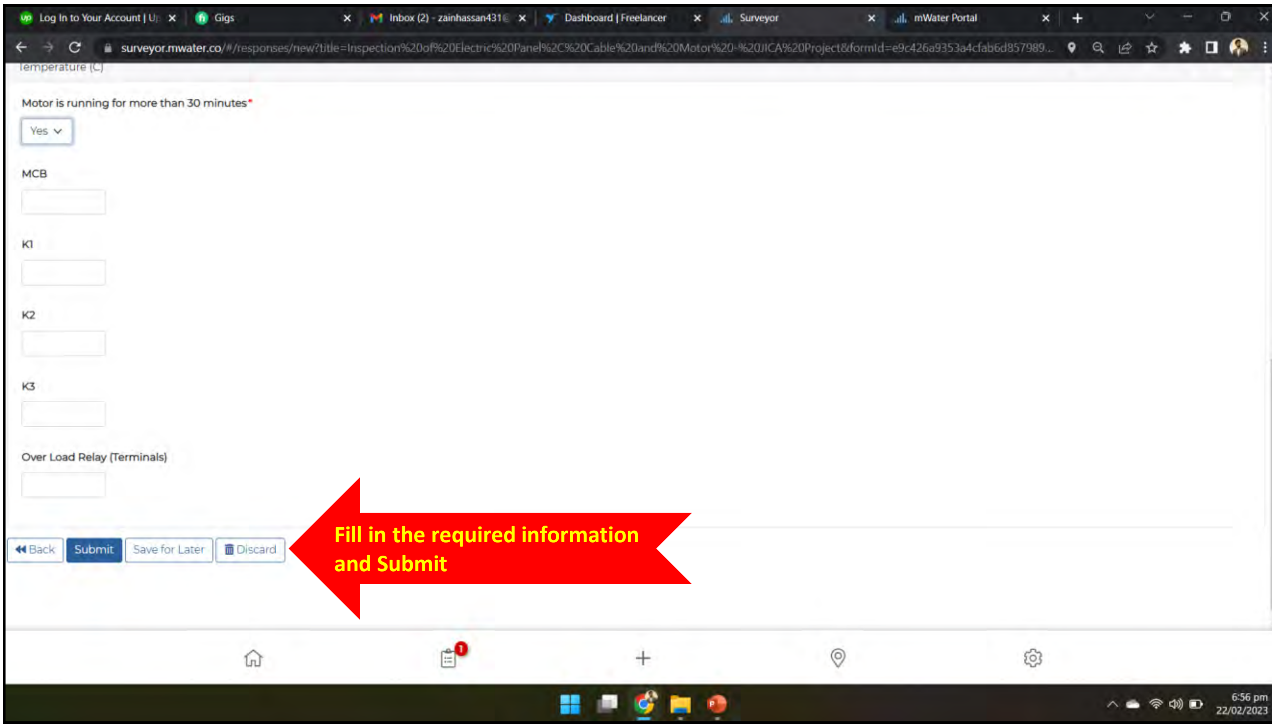

General Information
Date and time:*
24-02-2023 11:00
Name of Organization *
WASA Rawalpindi
Sub Division*
East 1
Site Name/ Address*
Tube well #
Add image of Site (Overall)*
Add images of Panel with open and close door*
Back
Next
Save for Later
Discard
Fill in the required information and click Next


Inspection of Electric Panel, Cable and Motor - JICA Project
1. / 2. / 3. Motor Specifications
Motor Specifications
Rated Capacity:
kW
Voltages (V)
Current (I)
Efficiency
Power Factor
RPM
Back
Next
Save for Later
Discard
Fill in the required information and click Next


Insulation Resistance Test
Insulation Resistance << between terminals and earth >>
U1 - E
V1 - E
W1 - E
U2 - E
V2 - E
W2 - E
Scroll to fill in the required information!!!
Insulation Resistance << between terminals of motor >>
U1 - V1


Insulation Resistance << between terminals of motor >>
U1 - V1
U1 - W1
V1 - W1
U2 - V2
U2 - W2
V2 - W2
Back
Next
Save for Later
Discard
Fill in the required information and click Next


Test using Clamp meter
Voltage
Red - Yellow
Red - Blue
Yellow - Blue
Current
Red
Blue
Yellow
Scroll to fill in the required information!!!


Log In to Your Account | Up
Gigs
Inbox (2) - zainhassan431
Dashboard | Freelancer
Surveyor
mWater Portal
Motor is running for more than 30 minutes*
Yes
MCB
K1
K2
K3
Over Load Relay (Terminals)
Back
Submit
Save for Later
Discard
Fill in the required information and Submit
6:56 pm
22/02/2023

سوال و جواب !!!

THANK YOU!!!

Annex 5.1.25 Training Material: "Energy Audit" for ToT, Pilot In-house Training, and In-house Training at WASA Gujranwala

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Energy Audit

Water and Sanitation Agency (WASA) Gujranwala

Training **Goals**

- Evaluate the current operating condition of equipment and upgrade the site condition to:
  - Optimize the performance
  - Reduce the electricity cost

Skills YOU learn

- Safety measures to work with electricity
- Use of electrical equipment i.e. Power Analyzer and clamp meter etc.
- Tools and techniques to analyze data

Activities YOU perform!

- At site
  - Site Preparation
  - Site Inspection
  - Get required values using testing equipment
- At office
  - Collaboration of data
  - Data Analysis and energy optimization techniques
  - Preparation of site improvement plan
- Improve the site

Before energy audit

- Site preparation
  - Site cleaning
  - Fix the intrusion paths

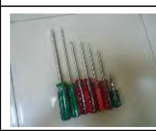
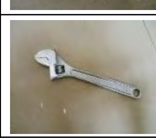
Before energy audit

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		4	Helmet		7	Post Stamp	
2	Tape		5	Shoes		8	Glasses	
3	Gloves		6	Vest				

Before energy audit

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Power Analyzer		4	Screw Driver Set		7	Insulation Tape	
2	Clamp meter		5	Voltage Tester				
3	Pliers		6	Wrench				

Measurements using **Power Analyzer**

- Installation of Power Analyzer
  - Cutoff the power by turning OFF circuit breaker (CB)
  - Cross check the electricity continuity using clamp meter
  - Install the test leads, flexible clamp sensors on the secondary side of CB
    (Note: don't forget to follow the current direction as recommended)
- Turn ON power analyzer
- Turn ON the circuit breaker
- Start recording on Power Analyzer
- Switch ON the motor

Measurements using **Power Analyzer**

- Fill the given format

Basic Information				
Date			Time	
Target Equipment Name				
Location / Code				
Year of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity: cuse		Design Head: m	
Motor Details	Manufacturer:		Model/Type:	
	Frequency: Hz		Rated Output: kW	
	Rated Voltage: V		Rated Ampere: A	
S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	MPa		Read the discharge pressure gauge.
3	Dynamic Water Level (h_{as})	m		Measure by water level meter or check the drawing. (between SWL to PG)
4	Total Head	m	0	To be calculated. (h_{as} × 101.97+P_d)
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.
10				
Findings & Comments:				
Conducted by:			Checked/Approved by:	

5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

Measurements using **Power Analyzer**

- Switch OFF the motor
- Stop recording on Power Analyzer
- Turn OFF the circuit breaker
- Remove power analyzer and place it back carefully

Collaboration of data

- Transferring data from power analyzer to the computer
- Use excel sheets to input the data collected from the site
- Collaborate the information of inspection from electrical and mechanical teams

Analyze data

- Analyzing data using formulas, WASA standards, GEPCO standards and equipment manufacturing standards
- Use of tools like MS Excel for in depth analysis and expected outcomes if site is rehabilitate etc.

Site Improvement Plan

- Prepare estimate for the expenditures required for the procurement of faulty parts
- Coordinate with technical staff i.e. sub engineer, supervisor and electrician etc. to perform site activities
- Prepare a time plan to perform activities at site

Energy Audit Training

WASA Tube well station

- WASA Mechanical Trainer
- Mr.Ali Hussain

Table of Contents

Importance of Energy Audit

- Minimize the energy cost
- Minimize the losses
- Improve the operational work
- Improve the pump condition

Parameters for Energy audit

- Basic information about site
- Flow Rate(Q)
- Discharge Pressure(P_d)
- Dynamic water level(h_d)

Equipment Required

Ultrasonic Flow Meter	
Pressure gauge (Digital, Analog)	 
Water level indicator(Rope type)	
Tool Box(Spanner set, Wrench, Teflon Tape ,etc.)	

Pre-Audit site information

Preparation for Site

- Site Information
- Can we install Pressure Gauge?
- Can we install ultrasonic flow meter?
- Can we check water level?

Pre-Audit site information

- .

Energy Audit Form

Energy Audit Form			
Date		Time	
Target Equipment Name			
Location			
Date of Installation			
Pump Details	Manufacturer:	Model/Type:	
	Design Capacity: cusec	Design Head: m	
Motor Details	Manufacturer:	Model/Type:	
	Frequency: Hz	Rated Output: kW	
	Rated Voltage: V	Rated Ampere: A	

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. ($P_d \times 10.197 + h_d$)
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.

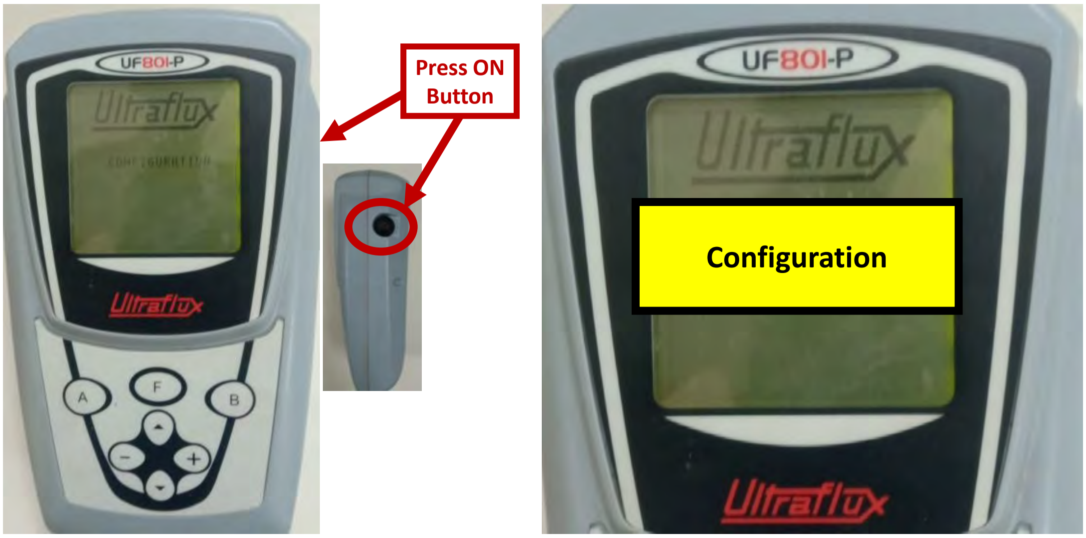
Perform Energy Audit at Site

- Install pressure gauge and check Discharge Pressure(P_d)
- Using Water level indicator to check dynamic water level(h_d)
- Install Ultrasonic flow meter and check Flow Rate(Q)

Equipment Installation

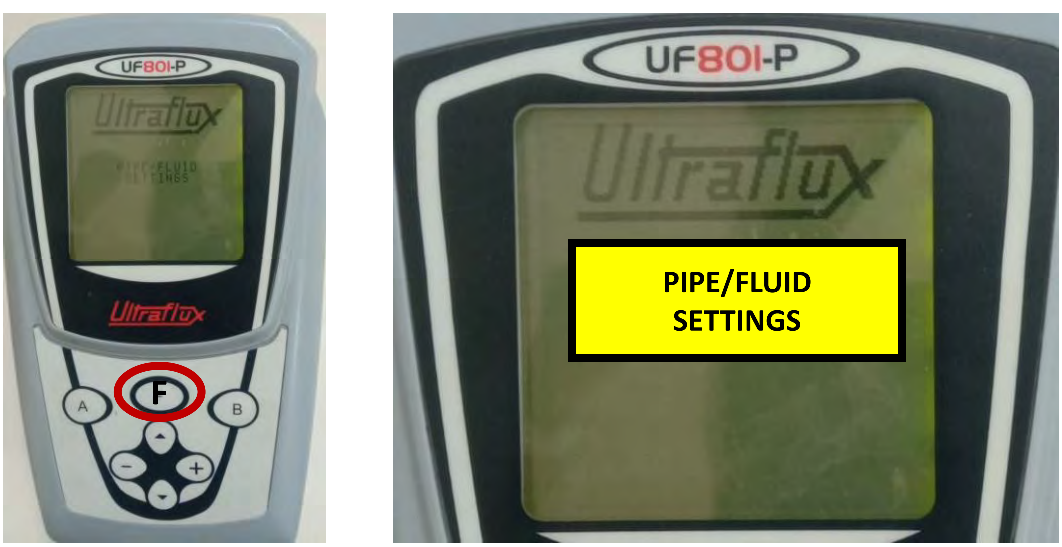
Use of Ultrasonic Flow Meter

- After switching ON the ultrasonic flow meter press “F” button.



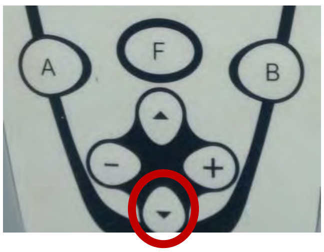
Use of Ultrasonic Flow Meter

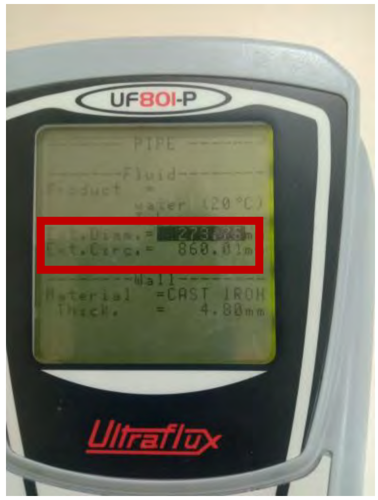
- Again Press **“F”** its showing pipe fluid setting.

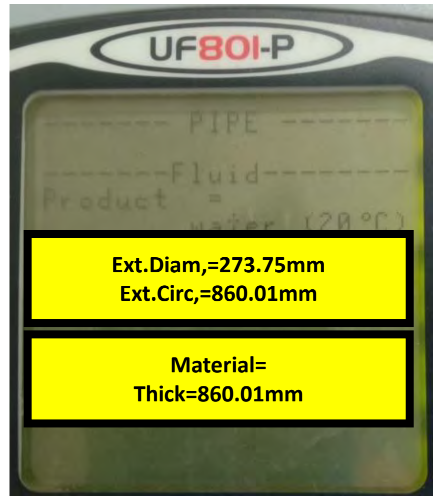


Use of Ultrasonic Flow Meter

- **Press downward Key and check the parameters.**







- **Put the data circumference, material of pipe and thickness of pipe wall**

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus **+** or Minus **–** the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- Select and put material of pipe
- Check wall thickness of pipe by using ultrasonic thickness probe

Material	Sound Velocity
Mild Steel	5920
Stainless steel	5800
Iron	5900
Cast Iron	4600
HDPE	2460
PVC	2395

Use of Ultrasonic Flow Meter

- Press and hold "F" and its show probe distance and type of probes.

Use of Ultrasonic Flow Meter

- **Probes**

Formulas for Energy Audit

- **H_{Total}= P_dx10.197+hd**
- **1 bar=**10.19 meter
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=**m^3/hr,
- **1 cusec=**102 m^3/hr
- **1 m^3/min =** 60 m^3/hr (**Bulk Flow meter**)
- **Pump Efficiency,ηp =Ep** /**Em** × 100
- **Pump output E =** $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000} = \frac{QXH}{6}$
- **E pump(Mechanical power)=**Available Energy
- **E motor(Electrical Power)=**Shaft Power

Finding of Site

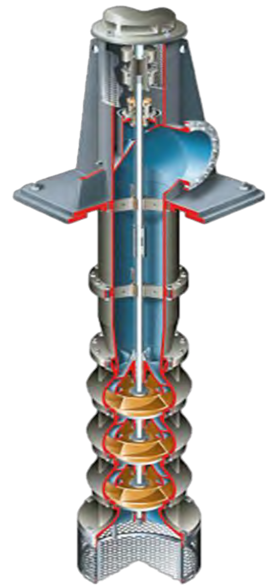
- **At Pasban Colony TW Site:**
- **Design head 155 feet** 47.24 meter
- calculated head Static 12 meter
- Calculated head dynamic 17.30 meter
- Discharge Head ________1.35 bar, 0.135 Mpa
- Total calculated Head 31 meter

- **Design Discharge flow rate** 2 Cusec(204 m3/hr)
- Ultrasonic flow meter reading 250 m3/hr (average)

Annex 5.1.26 Training Material: "O&M on Pump" for ToT at WASA Gujranwala

Operation and Maintenance of Pump

WASA Tube well/Disposal Station



Operation and Maintenance of Pump

- **Operation of system**
- Ensuring effective routine running of system timely and daily.
- Stability
- Efficient
- Safely

- **Maintenance**
- Keep of structures/system including planned
- Preventive or Corrective maintenance
- Repair

Operation and Maintenance plan

Operation Record and Manual	• Keep a operational record continuously. • Prepare a O&M Manual (SOP).
Improvement of Operational Control	• Understand / follow the O&M Manual (SOP). • Detect any abnormalities and take measures.
Control of Water Amount and Pressure	• Establish a proper control method of equipment. • Prevent from water leakage.

Operation and Maintenance Plan

- **Preparation of O&M Plan**
- Preparation of a plan involves list of routine tasks, specific tasks at regular intervals including inspection of system (Daily, Weekly, Quarterly, Annually etc.)
- Plan also involves a checklist for operation, supervision and maintenance.

Standard Operating Procedure for Pump

- **1.**Check on the panel door the 3 indicator lights are illuminated. If the indicator lights are off check the position of Main breaker. Turning the main breaker On will illuminate the indicator lights. But if the situation remains the same then there will be shut off from Wapda's side.
- پینل کے دروازے پر چیک کریں کہ 3 انڈیکیٹر لائٹس روشن ہیں اگر اشارے کی لائٹس بند ہیں تو مین بریکر کی پوزیشن چیک کریں مین بریکر کو آن کرنے سے اشارے کی روشنیاں روشن ہو جائیں گی۔ لیکن اگر صورتحال یہی رہی تو واپڈا کی طرف سے بجلی بند کر دی گئی۔

- **2.**Check the indicator light status of (Over Load Trip).

2. (اوورلوڈ ٹرپ) کے اشارے کی روشنی کو چیک کریں۔

- **3.** Check the indicator light status of(Dry Running trip).

(Dry Running trip) کے اشارے کی روشنی کو چیک کریں ۔

Standard operating procedure

- **4.**Check the indicator light status of (Earth leakage trip).

(Earth Leakage Trip) اشارے کی روشنی کو چیک کریں۔

- **5.**You can only start the pump if all the above four indicator lights are in off state.In case anyone of above light is in on state do inform the respective operation supervisor.
- آپ پمپ کو صرف اس صورت میں شروع کر سکتے ہیں جب اوپر دی گئی چاروں اشارے کی لائٹس بند ہوں۔
اگر اوپر کی کوئی روشنی چل رہی ہو تو متعلقہ آپریشن سپروائزر کو مطلع کریں۔
- **6.** Before Pump start check main braker on or not?

مین بریکر آن ہے یا نہیں؟

- **7.**The (Duty selector switch) is in ON position.

ڈیوٹی سلیکٹر سوئچ آن ہو۔

Standard operating procedure

- **8.**Power Factor switch should be on Auto position.

8پاور فیکٹر سوئچ آٹو پوزیشن پر ہونا چاہئے۔

- **9.**Before Starting the pump open valve of water lubrication tank and close it after it goes empty.

پمپ کو چلانے سے پہلے بلک سسٹم سے پانی نکالیں اور خالی ہونے کے بعد اسے بند کر دیں۔

- **10.**Press ON(Green) button pump will start.

ON(سبز) بٹن کو دبائیں پمپ چلنا شروع ہو جائے گا۔

Standard operating procedure

- **11.**After starting the pump, ON the Chlorine dosing pump to start the dosing of Chlorine.

پمپ چلانے کے بعد کلورین پمپ چلائیں۔

- **12.**After starting the main pump make sure the complete absence of abnormal noise or vibration in motor and pump. In occurrence of any such behavior immediately inform the respective site supervisor.

پمپ شروع کرنے کے بعد موٹر اور پمپ میں غیر معمولی شور یا وائبریشن کی جانچ کریں ایسے کسی بھی رویے کی صورت میں فوری طور پر متعلقہ سائٹ سپروائزر کو مطلع کریں۔

Daily operation Record

- **Daily operation record Parameters**
- Pump capacity
- Total Head
- Discharge pressure
- Chlorinator setting
- Motor heating, Noise
- Voltage(V),Ampere(A),Motor Output(KW)
- Leakage

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Noise	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

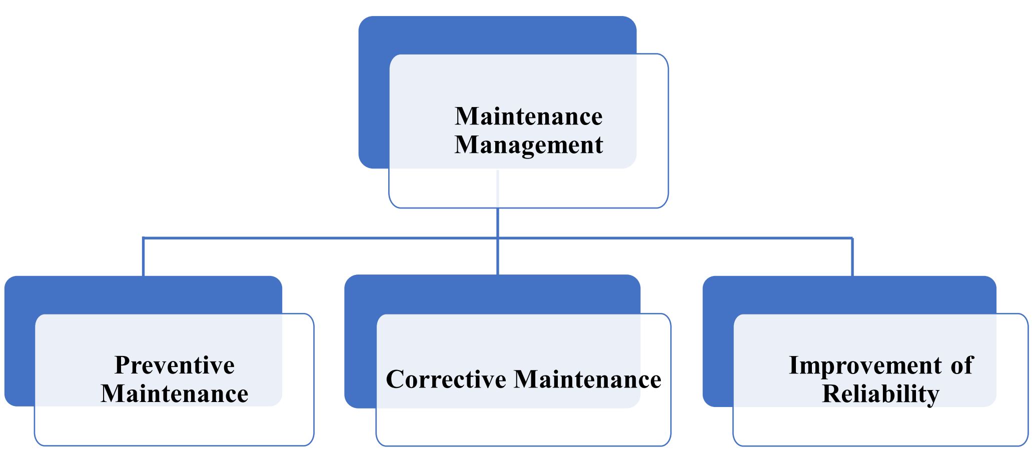
Daily Operation Record Sheet (Disposal Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW			Approved by (Engineer)	
Rated Voltage:	V			Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Suction Pressure	Bar / MPa									
6	Discharge Pressure	Bar / MPa									
7	Voltage	V									
8	Ampere	A									
9	Motor Heating	Normal / High									
10	Abnormal Sound/Noise	Yes / No									
11	Leakage (except pump)	Yes / No									
12	Cleaning of Screen	Done / Not									
13	Remarks										

Maintenance Management of Pump

- Maintenance Management is categorized into the following items;



Parameters for Monthly/Yearly inspection(Preventive maintenance)

- Pump capacity
- Total Head
- Chlorinator capacity/setting
- Gland packing leakage
- Voltage(V),Ampere(A),Motor Output(KW)
- Oil Level/Grease
- Operation of discharge valve
- Vibration
- Insulation
- Connections
- Overhaul

Monthly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Result	Standard	Remarks
1	Leakage Amount at Grand Packing	mL/min	Proper / Not	q = 0.5 × d (mm, shaft dia.)	
2	Dosing Amount of Chlorine Solution	L/hr	Proper / Not	According to the caluculation sheet	Only for Tube Well
3	Oil Level	-	Proper / Not	According to the level gauge	

S-No.	Check / Maintenance Items	Unit	Result	Remarks
4	Retightening of Grand Packing	-	Done / Not	In case that leakage amount is excess.
5	Adjusting the setting value of Chlorinator	-	Done / Not	In case that the measured value does't meet the calculated value.
6	Refilling Oil	-	Done / Not	In case that oil level is low.
7	Operation of Discharge Valve	-	Functioning / Not	

< Comments / Findings>

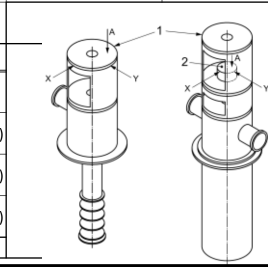
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet				

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 1 to 4 years (depending on the condition)

< Comments / Findings>



Instruments use for Inspection

- Vibration meter
- Clamp meter
- Insulation meter

Troubleshooting of Pump

Annex 5.1.27 Training Material: "O&M on Pump" for Pilot In-house Training and In-house Training at WASA Gujranwala

Operation and Maintenance (O&M) OF PUMP

Table of Contents

Purpose and Outline of O&M Activity

1. Purpose of O&M Activity

- To **provide satisfactory and sustainable services** of water supply and sewerage for consumers.
- To **continue efficient and safe operational management** of pump facilities.
- To **conduct necessary inspection and maintenance**.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

O&M of Water Supply and Sewerage Facilities/Equipment consists of the following two elements.

- **Operation Management**
- **Maintenance Management**

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Operation Management is

- ✓ To operate and control each facility/equipment.
- ✓ To operate and control related facility/equipment as an integrated system effectively.
- ✓ To fulfill its function sufficiently.

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is

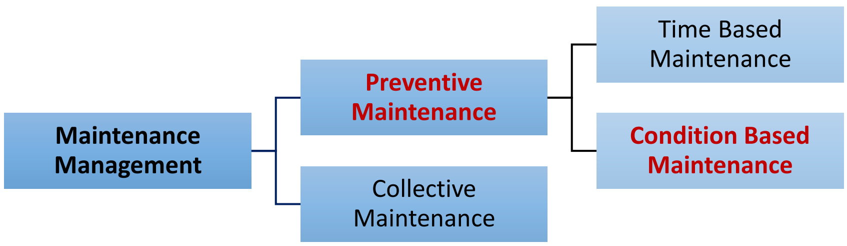
- ✓ To complement function degradation of equipment and maintain its original function.
- ✓ To decrease **Life Cycle Cost (LCC)** of equipment by prolongation of its lifetime etc.

LCC means the total cost which includes;
- Initial Cost (Construction Cost)
- Running Cost (Total O&M Cost during the Life Time)
- Disposal / Demolition Cost

Purpose and Outline of O&M Activity

2. Outline of O&M Activity

Maintenance Management is categorized into the following items;



Purpose and Outline of O&M Activity

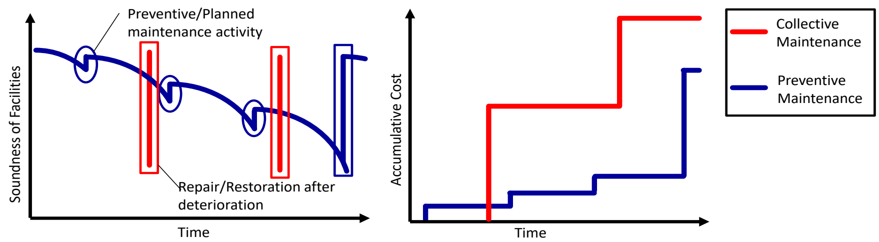
2. Outline of O&M Activity

- **Preventive Maintenance** is preliminary maintenance activities to prevent from malfunction of equipment. It can be categorized into the followings.
  - ✓ **Time Based Maintenance (TBM):**

    Maintenance activities are performed based on the **planned period**.
  - ✓ **Condition Based Maintenance (CBM):**

    Maintenance activities are performed through the **planned inspection to check deterioration/operation condition**.
- **Collective Maintenance** is repair / restoration work after malfunction.

Importance of Preventive Maintenance



Source: Japan's Experiences on Water Supply Development (JICA)

Merits of Preventive Maintenance are

- To **minimize the LCC** of equipment
- To **prolong the lifetime** of equipment

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Volute Pump (Vertical Turbine)

Flow Meter
(Electro Magnetic Type)

Standard Operation Procedure (SOP) of Pump

1. Typical System of Pump Equipment

Mixed Flow Pump

Discharge Valve & Check Valve

Mixed Flow Pump (Vertical)

Inlet Gate

Screen

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.
ii. Select the pump to be operated.
iii. Check the related valves are at the proper position.
iv. Check the lubricate water tank is filled with water.
v. Check the pressure gauge indicates the original/zero value.
vi. Check/record the Voltage, Ampere of power incoming on the electrical panel.
vii. Check/record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

2. SOP of Volute Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the flow meter reading and stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Before Operation

i. Check a leakage or other abnormality at the pump area.

ii. Select the pump to be operated.

iii. Check the related valves are at the proper position.

iv. Check the pressure gauge indicates the original/zero value.

v. Check/record the Voltage, Ampere of power incoming on the electrical panel.

vi. Check / record the flow meter reading and water level of the related tanks (if necessary).

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Start Operation

i. Push the start button at the electrical panel.

ii. Open the discharge valve slowly.

iii. Check/adjust the flow rate and discharge pressure to the design value (indicated in the specification).

iv. Check/record the start time, suction/discharge pressure, Voltage and Ampere etc. in accordance with the Record Sheet.

Note) In case the pump is operated frequently, keep open the discharge valve and skip the above procedure of ii.

Standard Operation Procedure (SOP) of Pump

3. SOP of Mixed Flow Pump / Stop Operation

i. Push the stop button on the electrical panel.

ii. Check/record the stop time.

iii. Close the discharge valve.

(In case the pump is stopped for a long time.)

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

- ✓ Abnormal noise and vibration (by hearing/touching)
- ✓ Heat generation of motor (by touching)
- ✓ Discharge pressure, flow rate/amount (by checking pressure gauge, flow meter etc.)
- ✓ Leakage

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

Excessive heat generation of motor can be checked by sense of touch.

Surface Temperature	Sense of Touch	Remarks
40 ℃	Somewhat warm	Feel slightly warm. Normal condition
45 ℃	Warm	Feel comfortably warm.
50 ℃	Somewhat hot	Your palm turns red if you touch it for a few minutes.
60 ℃	Hot	Can hold your hand for a few seconds.
70 ℃	Extremely hot	Can hold one finger for a few seconds.
80 ℃	Extremely hot	Can hold one finger for only one second.

How to Conduct Daily Inspection

1. Daily Inspection Points of Volute Pump

✓ Voltage and current (by checking voltage/ampere meter on the electrical panel)

How to Conduct Daily Inspection

2. Daily Inspection Points of Mixed Flow Pump

- ✓ Same points as Volute Pump
- ✓ Suction pressure (if suction pressure gauge is installed.)

How to Conduct Daily Inspection

3. Record Keeping

Daily inspection results and other operation records shall be noted down in the Record Sheet surely and properly.

Daily Operation Record Sheet (Tube Well Pumping Station)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Submission Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity:	L/hr	Approved by (Engineer)	
Rated Voltage:	V	Chlorinator Setting:	%	Prepared by (Operator)	

S-No.	Items	Unit	Results								Total
1	Date	-									
2	Start Time	-	:	:	:	:	:	:	:	:	
3	Stop Time	-	:	:	:	:	:	:	:	:	
4	Operating Hours	hour									
5	Flow Meter Reading (Start)	m^3									
6	Flow Meter Reading (Stop)	m^3									
7	Flow Amount (No.6 - No.5)	m^3									
8	Pressure Gauge Reading	Bar / MPa									
9	Voltage	V									
10	Ampere	A									
11	Operation of Chlorinator	Done / Not									
12	Motor Heating	Normal / High									
13	Abnormal Sound/Vibration	Yes / No									
14	Leakage	Yes / No									
15	Remarks										

How to Conduct Periodic Inspection

1. Monthly Inspection Points of Volute/Mixed Flow Pump

- ✓ Leakage amount at Grand Packing
  - ➢ Criterion: q [mL/min] = 0.5 × d (mm, shaft dia.)
  - ➢ In case leakage amount is excess, retightening shall be done.
- ✓ Dosing amount of chlorine solution
  - ➢ In case the measured value doesn't meet the target value, it is necessary to adjust the setting value of Chlorinator.
- ✓ Oil level
  - ➢ In case oil level is low, refilling shall be done.
- ✓ Operation of Discharge Valve

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

- ✓ Vibration measurement
- ✓ Insulation measurement
- ✓ Retightening of Anchor Bolts
- ✓ Replace of Grand Packing
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Replace of Oil/Grease
  - ➢ every 1 to 4 years (depending on the condition)
- ✓ Overhaul
  - ➢ every 4 to 7 years (depending on the condition)

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Purpose**
  To check/evaluate whether a pump is functioning in desirable condition.
- **Standard/Regulation**
  ISO 10816-7 (2009)
- **Feature**
  Vibration measurement is used for fault diagnosis of pump. **Unbalance** and **misalignmen**t can be detected by measuring **vibration velocity**, and **abnormality of bearing** can be detected by measuring **vibration acceleration**.

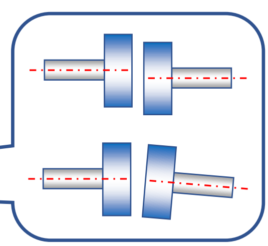
How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Major Causes of Vibration**

✓ Unbalance
✓ Misalignment
✓ Abnormality of Bearing
✓ Cavitation
✓ Loosening of Anchor (Foundation) Bolt



Source: Website of NTN Corporation, Japan

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

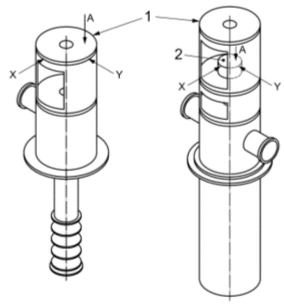
< Vibration Measurement >

- **Procedure**

i. Prepare/set up a vibration meter. (Basically magnet type sensor shall be used.)

ii. Select/decide the measurement locations based on the right figure.

iii. Measure/record vibration velocity value [mm/s] at the selected locations with three directions (axial, vertical, horizontal).



Notes)
Location 1: Driver mounting surface/lower motor bearing
Location 2: Pump bearing housing

How to Conduct Periodic Inspection

2. Yearly Inspection Points of Volute/Mixed Flow Pump

< Vibration Measurement >

- **Evaluation**

The results shall be evaluated according to the below table.

Zone	Description	Vibration Velocity Limit*	
		≤ 200 kW**	> 200kW**
A	Newly commissioned machine	3.2	4.2
B	Unrestricted long-term operation	5.1	6.1
C	Limited operation	8.5	9.5
D	Risk of damage	> 8.5	> 9.5

Notes)
* *The root-mean-square (r.m.s) value in mm/s*
** *The applicable motor capacity of industrial pump, which is categorized into Category II (pumps for general or less critical application), is above 1 kW.*

How to Conduct Periodic Inspection

3. Record Keeping

Monthly and yearly inspection results shall be noted down in the Record Sheet surely and properly.

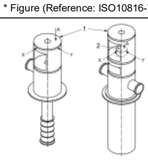
Yearly Inspection Record Sheet (Vertical Pump)

Pump Capacity:	cusec	Rated Ampere:	A	Location / Code:	
Total Head:	m	Rated Rotation Speed:	rpm	Inspection Date:	/ /
Rated Motor Output:	kW	Chlorinator Capacity: (only for Tube Well)	L/hr	Approved by (signature)	
Rated Voltage:	V	Chlorinator Setting: (only for Tube Well)	%	Prepared by (signature)	

S-No.	Measurement Items	Unit	Measurement Location/Direction*		Measured Value	Standard Value*	Remarks
1	Vibration	mm/s	1 (Drive Mounting Surface/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
			2 (Pump Bearing/Lower Motor Bearing)	Axial (A)		Upper Limit: 8.5 (less than 200kW), 9.5 (above 200kW)	
				Orthogonal (X)			
				Orthogonal (Y)			
2	Insulation	MΩ	** According to the electrical inspection sheet			* Figure (Reference: ISO10816-7)	

S-No.	Maintenance Items	Result	Remarks
3	Retightening of Anchor Bolts	Done / Not	
4	Replace of Grand Packing	Done / Not	every 1 to 4 years (depending on the condition)
5	Replace of Oil/Grease	Done / Not	every 1 to 4 years (depending on the condition)
6	Overhaul	Done / Not	every 4 to 7 years (depending on the condition)

< Comments / Findings>



Planning of Periodic Inspection & Maintenance

- Periodic inspection and maintenance shall be conducted for all pumps surely and properly.
- Plan of periodic inspection and maintenance shall be made in the previous year considering the following points.
  - ✓ **Installation year** (Aged pump shall be checked carefully.)
  - ✓ **Importance/Priority** (Pumps have big impacts in case of malfunction/shutdown.)
  - ✓ **Location** (Moving time shall be minimized.)
  - ✓ **Time required** (Monthly inspection: within one hour, Yearly inspection: depending on the condition)
  - ✓ **Cost** (In case of overhaul, replace of major parts etc.)

Annex 5.1.28 Training Material: "Energy Audit" for ToT, Pilot In-house Training, and In-house Training at WASA Rawalpindi

Project for Improving the Capacity of WASAs in Punjab Province Phase 2

Operation and Maintenance of Electrical Equipment

Energy Audit

Water and Sanitation Agency (WASA) Rawalpindi

WASA Trainers:

1. **Abdul Basit – Assistant Director**

Training **Goals**

- Evaluate the current operating condition of equipment and upgrade the site condition to:
  - Optimize the performance
  - Reduce the electricity cost

Skills YOU learn

- Safety measures to work with electricity
- Use of electrical equipment i.e. Power Analyzer and clamp meter etc.
- Tools and techniques to analyze data

Activities YOU perform!

- At site
  - Site Preparation
  - Site Inspection
  - Get required values using testing equipment
- At office
  - Collaboration of data
  - Data Analysis and energy optimization techniques
  - Preparation of site improvement plan
- Improve the site

Before energy audit

- Site preparation
  - Site cleaning
  - Fix the intrusion paths

Before energy audit

- Necessary safety measures

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Cone		4	Helmet		7	Post Stamp	
2	Tape		5	Shoes		8	Glasses	
3	Gloves		6	Vest				

Before energy audit

- Preparation of Equipment and Tools

Sr. #	Item	Image	Sr. #	Item	Image	Sr. #	Item	Image
1	Power Analyzer		4	Screw Driver Set		7	Insulation Tape	
2	Clamp meter		5	Voltage Tester				
3	Pliers		6	Wrench				

Measurements using **Power Analyzer**

- Installation of Power Analyzer
  - Cutoff the power by turning OFF circuit breaker (CB)
  - Cross check the electricity continuity using clamp meter
  - Install the test leads, flexible clamp sensors on the secondary side of CB
    (Note: don't forget to follow the current direction as recommended)
- Turn ON power analyzer
- Turn ON the circuit breaker
- Start recording on Power Analyzer
- Switch ON the motor

Measurements using **Power Analyzer**

- Fill the given format

Basic Information				
Date			Time	
Target Equipment Name				
Location / Code				
Year of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity: cuse		Design Head: m	
Motor Details	Manufacturer:		Model/Type:	
	Frequency: Hz		Rated Output: kW	
	Rated Voltage: V		Rated Ampere: A	
S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	MPa		Read the discharge pressure gauge.
3	Dynamic Water Level (h_{as})	m		Measure by water level meter or check the drawing. (between SWL to PG)
4	Total Head	m	0	To be calculated. ($h_{as} \times 101.97+P_d$)
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.
10				
Findings & Comments:				
Conducted by:			Checked/Approved by:	

5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.
7	Power Factor	-		Measure by power analyzer.
8	Operation Time	hour/day		Check the record book.
9	Power Consumption	kWh/day		In case that watt-hour meter is installed and its record is available.

Measurements using **Power Analyzer**

- Switch OFF the motor
- Stop recording on Power Analyzer
- Turn OFF the circuit breaker
- Remove power analyzer and place it back carefully

Collaboration of data

- Transferring data from power analyzer to the computer
- Use excel sheets to input the data collected from the site
- Collaborate the information of inspection from electrical and mechanical teams

Analyze data

- Analyzing data using formulas, WASA standards, GEPCO standards and equipment manufacturing standards
- Use of tools like MS Excel for in depth analysis and expected outcomes if site is rehabilitate etc.

Site Improvement Plan

- Prepare estimate for the expenditures required for the procurement of faulty parts
- Coordinate with technical staff i.e. sub engineer, supervisor and electrician etc. to perform site activities
- Prepare a time plan to perform activities at site

Water and Sanitation Agency (WASA)
Rawalpindi

Energy Audit Training

WASA Tube well station

- WASA Mechanical Trainer
- Mr.Khaleeq Afzal

Table of Contents

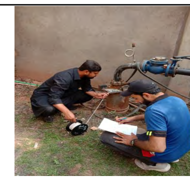
Importance of Energy Audit

- Minimize the energy cost
- Minimize the losses
- Improve the operational work
- Improve the pump condition

Parameters for Energy audit

- Basic information about site
- Flow Rate(Q)
- Discharge Pressure(P_d)
- Dynamic water level(h_d)

Equipment Required

Ultrasonic Flow Meter	
Pressure gauge (Digital, Analog)	 
Water level indicator(Rope type)	 
Tool Box(Spanner set,Wrench,Teflon Tape ,etc.)	

Pre-Audit site information

Preparation for Site

- Site Information
- Can we install Pressure Gauge?
- Can we install ultrasonic flow meter?
- Can we check water level?

Pre-Audit site information

- .

Energy Audit Form

Energy Audit Form				
Date			Time	
Target Equipment Name				
Location				
Date of Installation				
Pump Details	Manufacturer:		Model/Type:	
	Design Capacity:	cusec	Design Head:	m
Motor Details	Manufacturer:		Model/Type:	
	Frequency:	Hz	Rated Output:	kW
	Rated Voltage:	V	Rated Ampere:	A

S-No.	Parameter	Unit	Measured Value	Notes
1	Flow Rate	m3/h or m3/min		Measure by bulk meter or ultrasonic flow meter.
2	Discharge Pressure (P_d)	bar		Read the discharge pressure gauge.
3	Dynamic Water Level (h_d)	m		Measure by water level meter. (between GWL to PG)
4	Total Head	m	0	To be calculated. **($P_d \times 10.197 + h_d$)**
5	Voltage	V		Measure by clamp meter.
6	Ampere	A		Measure by clamp meter.

Perform Energy Audit at Site

- Install pressure gauge and check Discharge Pressure(P_d)
- Using Water level indicator to check dynamic water level(h_d)
- Install Ultrasonic flow meter and check Flow Rate(Q)

Equipment Installation

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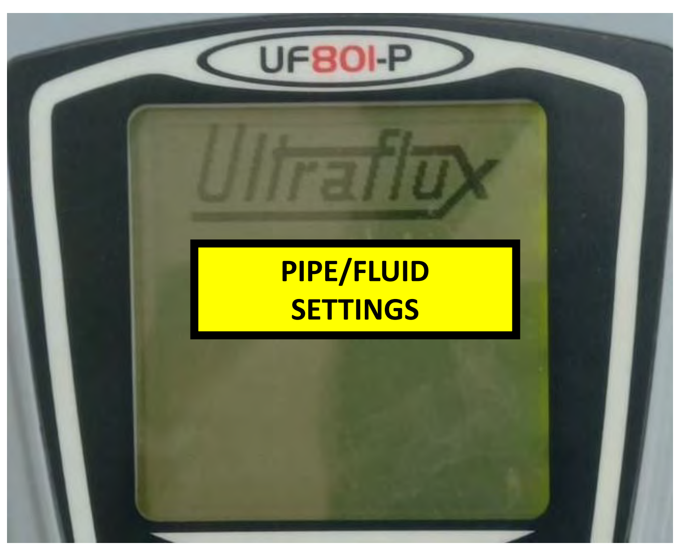
Use of Ultrasonic Flow Meter

- **After switching ON the ultrasonic flow meter press "F" button.**

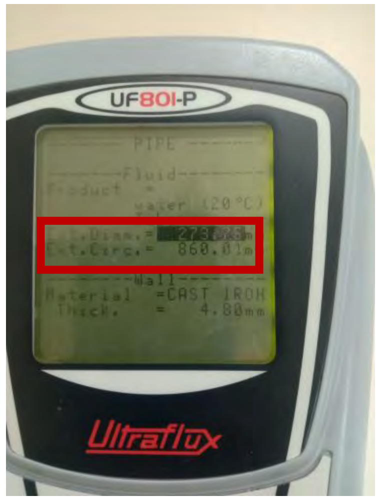
Use of Ultrasonic Flow Meter

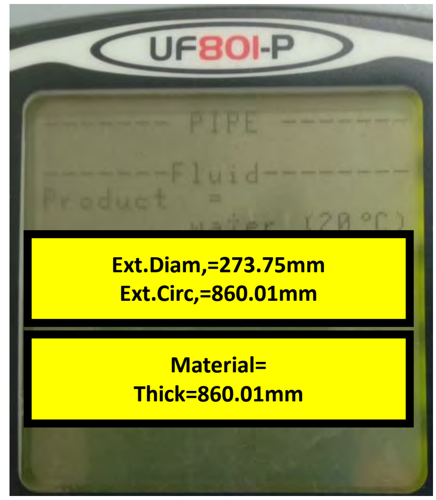
- **Again Press "F" its showing pipe fluid setting.**



Use of Ultrasonic Flow Meter

- Press downward Key and check the parameters.





- Put the data circumference, material of pipe and thickness of pipe wall

Use of Ultrasonic Flow Meter

After PIPE/FLUID SETTING press downward key.

Step1

- Measure the circumference of pipeline by measuring tape

Step2

- Plus + or Minus – the values of diameter to adjust the circumference values.

Use of Ultrasonic Flow Meter

- **Select and put material of pipe**
- **Check wall thickness of pipe by using ultrasonic thickness probe**

Material	Sound Velocity
Mild Steel	5920
Stainless steel	5800
Iron	5900
Cast Iron	4600
HDPE	2460
PVC	2395

Use of Ultrasonic Flow Meter

- **Press and hold "F" and its show probe distance and type of probes.**

Use of Ultrasonic Flow Meter

- **Probes**

Formulas for Energy Audit

- **$H_{Total} = P_d \times 10.197 + hd$**
- **1 bar=**10.19 meter
- **1 bar= 0.1 Mpa**
- **Flow Rate Q=**m^3/hr,
- **1 cusec=**102 m^3/hr
- **1 m^3/min =** 60 m^3/hr (**Bulk Flow meter**)
- **Pump Efficiency,ηp =Ep /Em** × 100
- **Pump output E =** $\frac{\rho \times g \times Q \times H}{60 \times 1{,}000}$
- **E pump=**Available Energy
- **E motor=**Shaft Power

Finding of Sites

- **At DAV School College Road TW Site:**
- **Design head 280 feet 85.3** meter
- calculated head Static 77.4 meter
- Calculated head dynamic 79 meter
- Discharge Head _______ 0.68 bar, 0.068 Mpa
- Total calculated Head 85.8 meter

- **Design Discharge flow rate 0.23** Cusec(6000g/hr)(23.5 m3/hr)
- Ultrasonic flow meter reading 22 m3/hr (average)