PROJECT RESEARCH

KEY POINTS ON NON-REVENUE WATER REDUCTION PROJECTS

FINAL REPORT SUMMARY

FEBURARY 2020

JAPAN INTERNATIONAL COOPERATION AGENY (JICA)

NIPPON KOEI CO., LTD.
YOKOHAMA WATER CO., LTD.

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Abbreviations

C/P	Counterpart
DMA	District Metered Area
GIS	Geographical Information System
IWA	International Water Association
JICA	Japan International Cooperation Agency
NRW	Non-Revenue Water
ODA	Official Development Assistance
OJT	On Job Training
PBC	Performance-Based Contract
PDM	Project Design Matrix
PIs	Performance Indicators
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedures
UfW	Un-accounted for Water
USAID	US Agency for International Development

1. Background Fundamentals of Non-Revenue Water

1.1 Definition of Non-revenue Water

Definition of non-revenue water (NRW) and related terms endorsed by the International Water Association (IWA) are given in Table 1.1. They are widely adopted by international aid organizations.

Table 1.1 Water Balance Sheet Based on IWA Definition

<table>
<tr><td rowspan="8">System Input Volume (SIV)</td><td rowspan="3">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed metered water consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed unmetered water consumption (Water meter not installed, estimated water consumption due to water meter failure)</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered water consumption (Settled water consumption)</td><td rowspan="6">Non-revenue Water (NRW)</td></tr>
<tr><td>Unbilled unmetered water consumption (Free water from public tap, pipeline cleaning water from water utility)</td></tr>
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<tr><td rowspan="3">Real Losses (Physical Loss)</td><td>Leakage on transmission and distribution mains</td></tr>
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<tr><td>Leakage on service connections up to point of customer metering</td></tr>
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Source: Management of Non-revenue Water, Shozo Yamazaki, 2011

NRW means "water that was distributed but not billed". It is often confused with "water that was billed, but the tariff could not be collected for it." But IWA classifies revenue-water (RW) and NRW based on whether the water is subject to billing. It is important to understand correctly how these terms are defined. NRW is further categorized as follows:

Table 1.2 Sub-Categories and Typical Cases of NRW

Sub-category	Typical Case
[1] Physical loss	Water leakage
[2] Commercial loss	Water theft (illegal connection) and/or loss due to measurement error (meter error, meter reading error, data processing error, etc.
[3] Unbilled authorized consumption	Public or non-public water usages that are not subject to billing.

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1.2 Significance and Benefits of NRW Reduction

In Japan, the objectives of water utility services are, as articulated in Article 1 of the Water Supply Act in Japan, "to supply clean, ample, and affordable water, and to contribute to the improvement of public health and living environment." These objectives are universal and are also relevant to water supply services in developing countries. To fulfill these objectives, a water utility company has to operate a water supply system, which incurs a cost. The cost has to be recovered by collecting water tariffs as revenue. But NRW does not generate revenue. It merely puts pressure on the financial management of the operation, making it difficult to provide the services. Therefore, efforts must be made to minimize

NRW as much as possible – "the water produced and distributed with costs should not be wasted." The significance and benefits of reducing NRW are explained below by the sub-category of NRW:

(1) Significance and Benefits of Reducing Physical Loss

- In case the water supply is short of the demand and the supply has to be increased, the reduction of physical loss helps increase the supply without investing in new water supply infrastructure or without limiting water usage. The saved water can be supplied to the customers, billed, and contribute to increasing the revenue.
- In case the water supply is meeting the demand, reduction of leakage helps reduce the amount of water to be supplied. This reduces the operation cost, such as electricity and chemicals. Moreover, leakage reduction saves precious water resources.
- When water pressure in the pipes are not enogh, water leakage could cause water contamination by drawing wastewater into the pipeline. Such problems are likely to occur if the water supply is intermittent, the leakage point is at the end of the network, or if the elevation of the network is high. Water leakage can also cause low water pressure in the pipes downstream. Reducing leakages improves these issues related to water quality and pressure, and improves customer satisfaction.
- Leakage reduction prevents other problems related to leakage, such as a traffic accident at a caved-in road caused by the leakage.

(2) Significance and Benefits of Reducing Commercial Loss

- By reducing illegal connection and metering errors, it becomes possible to increase the amount of billable water, and thus increase the revenue.
- Reducing illegal connections and verifying/renewing malfunctioning meters contribute to building trust with customers.
- Reducing illegal connections could also reduce the leakage from the illegal connection sites.

(3) Significance and Benefits of Reducing Unbilled Authorized Consumption

- Unbilled authorized consumption is usually not a target for reduction, unlike the reduction of physical and commercial losses. However, in theory, revenue can be increased by reducing unbilled authorized water. Moreover, the amount of unbilled authorized water must be monitored correctly in order to carry out water balance analysis (water distribution analysis). Therefore, water meters should be installed even for unbilled authorized water.

As described above, NRW reduction brings various benefits to water utility services, and each water utility company has different views on what benefit of reducing NRW is considered a priority. Thus, before implementing NRW reduction activities, it is essential to clearly define the objectives of the NRW reduction, such as conservation of water resources, improvement of financial conditions, or improvement of water services (water quality, water pressure, water supply time, etc.). In addition, measures other than NRW reduction may also be required to achieve the objective. For example, if the improvement of financial conditions is the objective, reduction of costs for electricity and chemicals, and improvement of bill collection, should also be considered important, in addition to NRW reduction.

2. Lessons Learned and Key Messages for Future Initiatives

This chapter summarizes the lessons learned through JICA's NRW reduction projects and key messages for future initiatives.

2.1 Key Messages for Future Initiatives

<Key Message 1> NRW reduction is an approach to achieve an objective, not an objective itself.

NRW reduction is an approach to achieve an objective and is not an objective itself. Before examining the ways to reduce NRW, a capacity assessment targeting the whole water supply sector or the target water utility company should be implemented first. Then, based on the results of the assessment, a goal to comprehensively improve the sector or the company and the program to accomplish the goal should be developed. NRW reduction becomes a part of the program to achieve the goal. To implement effective international cooperation, the top management of the counterpart agency needs to clearly understand the comprehensive goal and the objective of and the need for reducing the NRW. He/she should be committed to reducing NRW, and has the will to prepare, approve, and implement a long-term plan for NRW reduction.

The NRW reduction is not an objective itself. It is implemented to accomplish a more comprehensive goal, such as "effective utilization of water resources" or "improvement of the financial condition of a water utility company". Therefore, it is important to clarify the goal of improving the targeted water supply sector or the utility company, and then design the program to accomplish the goal. NRW reduction is a part of the program. The requirements for NRW reduction are dependent on whether the goal is to improve the financial condition of the water utility company or to effectively utilize water resources (reduction of leakage). In the former case, the program should adopt a wide range of approaches, such as saving energy and chemical expenses, setting an appropriate tariff, and improving the collection rate of the water tariff and accounts receivable. NRW reduction should be viewed as one component of a comprehensive program. It is wrong to start conceiving a project by assuming NRW reduction is the only goal and confining the scope of the project to NRW reduction alone, or to merely follow the contents of past NRW reduction projects. The project should be designed and formulated considering the future vision of the targeted water supply sector or the water utility company as well as the required outcomes and impacts of the project.

In order to enhance the effectiveness and sustainability of cooperation, the top management of the counterpart agency needs to recognize the goal and the necessity of improving the sector or the water utility company and where NRW reduction stands in the whole package. The top management should also educate the staff, lead the whole organization to accomplish the goal.

<Key Message 2> NRW reduction project should be designed according to the local context.

An inflexible, one-fits-all design is not appropriate for NRW reduction projects. They should be designed considering the actual NRW situation, capacity, available facilities, and future of the target sector or the water utility company. Designing a program that couples a technical cooperation project with a facility development project is an effective approach to achieve the goal.

Many NRW reduction projects in the past were designed and implemented in a rather uniform and inflexible manner. As a result, some projects contained activities too demanding for the targeted water utility companies, while others could not accomplish the expected outcomes because of the limitation of the available facilities. These experiences showed that an NRW reduction project should not be designed by simply replicating previous projects. The program or projects should be designed and tailored to fit the actual capacity of the target water supply sector or the water utility company. When

required, it is effective to design a program that combines a technical cooperation project with a facility development project.

Prior to formulating an NRW reduction project, a data collection survey should be carried out to obtain information on: policies and targets envisaged by the counterpart organization, the counterpart organization's understandings of objectives and activities of NRW reduction measures, actual conditions of NRW, financing of the water utility services, facility development, and sustainability of activities for improvement of water supply services in the future. The results of the data collection survey help clarify the contents and the starting level of cooperation activities.

If the target water utility company has an elementary capacity to supply water, the NRW project should start from basic activities, such as awareness-raising, water flow measurements, and collection of data and information on water distribution networks and customers' inventory. A company that can supply water only during limited hours of a day due to a serious shortage of water supply capacity is likely to face difficulty in carrying out measures to control water leakage. As a result, one cannot expect much improvement in performance through the project. In such cases, the shortage of water supply capacity should be improved first by facility development. This will improve the service hours and the water pressures in the system. Then, the countermeasures against water leakage could become more effective. Similarly, it is more effective to strengthen water tariff collection after the improvement of water supply services.

In Japan, the foundations for efficient water supply services, including accurate water meters, quality assurance of construction works, and financial autonomy of a water utility company, are already in place. Thus, it is possible to focus on further reduction of leakage. However, many water utility companies in developing countries are still facing apparent loss due to water stealing or malfunctioning meters and visible leakage from the network on the ground. Under such a situation, priority countermeasures are different from those carried out in Japan, such as the detection and repair of underground leakage. In developing countries, countermeasures against apparent losses and visible leakage are often more cost-effective in reducing the NRW. Moreover, the importance of preventive measures, in addition to responsive measures, should not be overlooked. Improvement of pipe installation work technique, strict enforcement of standards for structure and materials of water supply facilities, and establishment of the registration system and training programs for plumbers, are among the preventive measures that need more attention.

To scale up the improvement of water supply services through combining technical cooperation and facility development, coordination with other development partners is effective. However, it should be noted that there is a potential risk of unforeseeable delay of one project due to the delay of another project.

<Key Message 3> A NRW reduction project should pay attention to the water supply sector entirely.

Even if the project focuses only on the improvement of a water utility company, it is important to understand the policy, institutional, and regulatory implications of the whole water supply sector, and to appeal to sector-level issues in the project, because such issues could become the driving force to control NRW at the utility company level, especially if the utility company is financially independent and/or there is a well-developed regulatory framework to oversee the operation of the utility company.

JICA's policy on capacity development acknowledges the need to enhance capacity on three levels: individual, organizational, and the enabling environment. The enabling environment encompasses policy, institutional system, and regulations that shape the sector. The management of the counterpart agency could be strongly motivated to reduce the NRW if there is an enabling environment that gives them a reason or a justification to do so, such as (i) the central government agency has the clear policies and targets for NRW reduction, and is keen to enforce regulations to control NRW; (ii) the water utilities

are financially autonomous and there are incentives to reduce cost and to increase water revenues; and (iii) there is a system of evaluating the performance of each water utility company against the NRW benchmark. The project could achieve the expected outcomes when there is such an enabling environment. For these reasons, it is important to understand the existing policy, institutional systems, or regulations, and to consider how to shape the enabling environment that drives NRW reduction forward.

<Key Message 4> Motivation highly matters to the sustainability of activities.

In order to attain the program goals, it is important to sustain NRW reduction activities by keeping the motivations of parties concerned high. For enhancing the motivation, it is important to introduce activities that reveal cost-effectiveness, make officers aware of the importance of cost recovery, make outcomes visible, and provide incentives.

A water utility company should continuously reduce NRW through its daily operation and maintenance. In order to achieve this after a technical cooperation project, various mechanisms and ideas that make NRW reduction sustainable should be built into the activities through the finding, formation, and implementation stages of the projects. The counterpart should recognize that "it is themselves, and not the Japanese experts, who reduce NRW" and the project is the opportunity to develop their own capacity to sustainably reduce NRW in the future.

One of the essential tactics to ensure sustainability is to enhance and sustain the motivation of those involved in the activities. The following approaches should be considered during a technical cooperation project:

- To clarify the financial and economic significance of NRW reduction by showing the cost-effectiveness of NRW reduction. Also, to clarify the significance of reducing NRW in a wider sense, such as benefits for citizen's living environment and hygiene as well as improved sustainability of water supply services.
- To make the counterparts to pay attention to the cost recovery of the water utility company.
- To improve the performance of the water utility company by setting an achievable short-term target and revising the target based on actual achievements, in addition to the long-term targets.
- To make it possible to "visualize" the progress and outcomes of the project by continuously monitoring relevant information and by using indicators. If applicable, to encourage healthy competition among parties concerned by using the visualized indicators.
- To give incentives to parties concerned.
- To develop a workable system for NRW reduction considering the workload and motivation of the staff. Adding new NRW reduction tasks to daily activities could significantly increase the workload of each staff and could make the staff lose motivation. Establishing a section dedicated to NRW reduction activities may be a sensible approach to avoid this.

<Key Message 5> Long-term plan and annual plan ensure the cycle of NRW reduction activities.

In order to establish an operational structure that reduces NRW continuously, it is a good idea to prepare an achievable long-term plan and an annual plan. The annual plan should be revised year by year based on the annual budget. The long-term plan should also be updated periodically, considering the actual progress of the activities. The work should be organized in such a way to accommodate disruptions by the transfer of personnel, which is often unavoidable in an organization.

To ensure the sustainable implementation of the NRW reduction activities, the water utility company should prepare a long-term plan that enables the company to engage in NRW reduction in a continuous and self-motivated manner after the completion of the project. The long-term plan should clearly present a realistic target for NRW reduction, priority measures to achieve the target that is effective and

achievable with the resources of the organization, a strategy to secure the staff, methods and the organization for monitoring and evaluation of performance, an approach to systematic data collection, the costs required to operate, cost-effectiveness, and the directions and contents of the activities in the future. The long-term plan should be feasible in terms of budget, human resources, and technical capacity, and worth investing the limited resources of the company.

Following the development of the long-term plan, an annual plan for NRW reduction should be prepared considering the available resources from the annual budget and human resources year by year. Depending on the progress of the NRW reduction, the activities should be adjusted. For this, periodic updating of the long-term plan is required based on the monitoring of the activities and their impacts. In a technical cooperation project, a long-term plan is often developed at the end of the project. However, this is not effective. To ensure sustainability, it is better to support implementation and revision of the long-term plan, or to evaluate the need for a follow-up cooperation based on how the counterpart organization is following up the project activities, making it a condition to extend further support.

To avoid a gradual decline in the outcome of the cooperation due to the leaving or transfer of the trained staff, it is advised to adopt measures, such as providing training to as many staff as possible, developing manuals so that the outcome could remain in the organization after the project, and establishing an internal training system.

<Key Message 6> Pilot activity is a practical tool to identify the most effective measures.

Based on the results of the pilot activities, effective approaches to NRW reduction should be identified and incorporated into the long-term plan. The contents of pilot activities should not be uniform but designed specifically considering the situation of the target area and the specific needs for capacity development.

Pilot activities under JICA technical cooperation projects in the past were often standardized and inflexible. They typically created hydraulically isolated blocks in the water distribution networks for the measurement of NRW and the detection of underground leakage. However, such an approach has not always been successful. First, they tend to make the reduction of the NRW rate in the pilot area the main objective of the activity, diverting the attention from the more important objective of identifying cost-effective approaches to reduce NRW for the whole area. Also, in many activities, much time was lost for creating the isolated blocks. Moreover, some counterparts wrongly believed that an isolated block is always required for NRW reduction, and as isolating a block is not easy, the NRW reduction measures did not spread to other areas of the network.

The pilot activities should not be generalized but tailored to identify the most cost-effective measures and important issues in implementing such measures in the target country or the target water utility. Also, they should be utilized as an opportunity for on-the-job training (OJT) to introduce a long-term plan or other future plans. Data accumulated and lessons learned through a pilot activity should be utilized for enhancing the implementability of and justifying the future plan. A pilot activity is not necessarily meant to be replicated in other locations. A pilot activity is implemented to gain practical experiences to identify a suitable measure based on the characteristics of each area. Measures in other service areas are to be designed using such experiences and by modifying the design of the pilot activity. It seems the term "pilot activities" is creating the misunderstanding that such activities can be readily replicated in different areas. Perhaps another term, such as "priority measures identification" should be used for describing the objective more precisely.

In implementing a pilot activity, it is important: (i) to pay attention to the objective as mentioned above; (ii) to measure the actual NRW rate, which becomes the baseline; (iii) to implement NRW reduction measures step by step, and to monitor the NRW rate at each step, in order to identify the most cost-effective countermeasures to accomplish NRW reduction; (iv) to implement the countermeasures considering the general cost-effectiveness, in the order of: basic measures other than reduction of

leakage → reduction of visible leakage → reduction of underground leakage; and (v) to keep the conditions, such as the water pressure and extent of the target area, unchanged so that the effectiveness of different measures can be compared.

A District Metered Area (DMA) is an effective approach to NRW reduction. It establishes hydraulically isolated blocks in the whole service area. Each block is equipped with bulk flow meters to monitor leakage, and the data are used to identify priority areas for NRW reduction. However, the introduction of DMA is sometimes unrealistic in developing countries due to the following: (1) it is hard to create hydraulically isolated blocks due to incorrect network data and unexpected complexity of the network; (2) meters and gate valves for establishing DMA are too costly; and (3) there are other NRW countermeasures to be introduced before DMA, which requires considerable labor forces and costs. The necessity of introducing DMA should be assessed carefully, depending on the capacity of the target water supply utility.

<Key Message 7> Give innovative approaches and technologies positive considerations.

There are no fixed methods and technologies for NRW reduction. Thus, innovative methods and technologies should be given positive considerations, in addition to conventional measures.

Besides approaches applied in previous projects or those prevailing in Japan, different approaches to NRW reduction, such as innovative technologies in other countries, should be taken into consideration. A performance-based contract for NRW reduction has already been practiced in many countries in the world. JICA's schemes of public-private partnership and support for Japanese SMEs Overseas Business Development have been used to propose and test out various technologies to control NRW reduction. Some trial and error should be allowed in a technical cooperation project. It is important to look out for innovative technologies, carry out experimental applications, and accumulate and share lessons learned. It is an idea to launch a platform for the introduction and experimental application of innovative technologies, products, and approaches, as part of the cooperation.

<Key Message 8> Successful project implementation requires the cooperation of stakeholders, sharing of the project purpose, well-considered schedule, and assignment of local human resources.

For operating the activities of the technical cooperation project effectively, the concerned persons should take account of things such as 1) enhancement of understanding by various stakeholders, 2) sharing of understanding on overall goal and project purpose, 3) set up of appropriate project period after considering the required time for collection of information and data and the procurement schedule of equipment, and 4) assignments of local coordinators and consultants.

NRW reduction requires inter-departmental cooperation and coordination. Managers and staff in both administrative and technical departments should share the targets and work together in carrying out the activities. Setting a proper project schedule is also important. In many of the past technical cooperation projects, the project periods were extended mainly because it took a long time to verify incorrect data of water distribution network and customers' inventory and to procure equipment.

A technical cooperation project for NRW reduction often involves various organizations, including different departments of the counterpart organization and other organizations in the water utility sector. Good communication among the people involved in the project, from the top managers to the field workers, is essential. Thus, it is often effective to assign local coordinators and consultants, and ensure good communication in the project.

<Key Message 9> Effective assignment of staff and arrangement of budget are critical.

In order to implement a technical cooperation project smoothly and to ensure the sustainability of the outcomes, the counterpart organization needs to assign counterparts, clarify responsibilities of organizations and personnel in charge of NRW reduction, and make budgetary arrangements for the project.

Staff assignment and budgetary arrangements are crucial to implement project activities and to continue the NRW reduction after the completion of the project. Furthermore, it is important to raise priorities of project-related activities within the organization by raising the awareness of the managers, clarifying the priority of the NRW reduction plan in the overall business plan of the organization, and to quantitatively show the NRW reduction measures bring sufficient benefits that match the investment.

Since the NRW reduction is implemented across the border of departments, there must be a highly authorized "control tower" who can oversee the overall activities, monitor and facilitate activities through the PDCA cycle, and give directions and allocate resources to different departments.
When a full-scale NRW reduction is initiated, the workload of staff would increase significantly. For example, activities, such as a measurement of leaks using the minimum night flow method, often require long fieldwork and overtime works. To minimize the concentration of the burden to some staff, and to clarify the purpose of promoting NRW reduction, it is advised to establish, if appropriate, a dedicated unit within the department in charge.

2.2 Summary of Lessons Learned

The lessons learned from previous NRW reduction projects and the key messages drawn from them are shown in Table 2.1.

Table 2.1 Lessons Learned and Key Messages

Subject	Lessons Learned	Key Message
<1> Program Target and Project Purpose		
Setting Targets	1. A program with a goal to comprehensively improve the water supply sector should be proposed first. The NRW reduction measures should be incorporated in this program .	Key Message 1
	2. The top management of the counterpart agency needs to recognize the objectives and necessity of NRW reduction.	
Project Formation	3. In many cases, it is effective to combine technical cooperation with financial cooperation.	Key Message 2
	4. Priority issues of the organization in the water supply service sector should be identified.	
	5. Coordination with another donor is usually synergetic, but it is also important to give attention to potential risks.	
	6. Approaches to the policy, institutional, and regulatory aspects of water supply services should be incorporated into the project.	Key Message 3
	7. An introduction of an independent accounting system and autonomy of water utility should be taken into consideration.	
	8. A well-developed regulatory framework often raises the utility company's awareness for NRW reduction.	
<2> Project Activities and Implementation Methods		
Motivation	1. Clarification of financial implication (cost-effectiveness) often helps understanding of the top management regarding the need to control NRW and allocation of the necessary budget.	Key Message 4

Subject	Lessons Learned	Key Message
	2. Consciousness about cost recovery often raises the motivation to continue NRW reduction..	
	3. The target of a technical cooperation project should be set flexibly through the activities so that it can be achieved.	
	4. Progress and effects of NRW reduction activities should be visualized through regular monitoring. The information would help justify budgetary arrangements and enhance the motivation of the staff.	
	5. Giving incentives is important for raising the motivation of the staff.	
Long-term Approaches	6. The plans (long term, middle term, and short term) for NRW reduction should be prepared and officially approved. They should be within the available budget.	Key Message 5
	7. In order to ensure the sustainability of NRW reduction, recruiting and transfer of staff should be taken into consideration.	
Pilot Project and DMA	8. The pilot activities should be designed specifically considering the local situation.	Key Message 6
	9. The necessity of the introduction of DMA should be assessed carefully considering the situation.	
Innovative Technologies and Methods	10. Experimental applications of innovative technologies developed in Japan or tried by other donors should be taken into consideration.	Key Message 7
Effective Work Operation	11. Because many parties are involved in NRW reduction, it is important to promote their understanding of the project.	Key Message 8
	12. The understanding of the overall goals and the project purpose should be shared among counterpart members.	
	13. The project period should be set appropriately considering the time needed to procure equipment, collect data, and other activities of the project.	
	14. Local coordinators and local consultants often help improve the effectiveness of project implementation.	
<3> Responsibility of Counterpart Agency		
Assignment of Staff	1. Responsibilities of the manager in charge and the departments involved in NRW reduction should be clarified .	Key Message 9
Budgetary Arrangement	2. The budget for NRW reduction should be available in a sustainable manner.	

Source: Project Research Team

3. Key Points at Project Finding Stage and Project Formulation Stage

3.1 Key Points at the Project Finding Stage

3.1.1 Steps of Project Finding Stage

At the project finding stage, the current performance level of the water supply sector, and the target levels of the services and financial condition of water utilities in the future should be firstly examined. Next, the goal of the program for the improvement of the sector shall be set up. Then, cooperation projectsshould be identified as well as activities to be implemented by the own efforts of the counterpart organization to achieve the program goal. As NRW reduction may not be the only issue, it is not wise to limit the activities to NRW reduction. The need to tackle broader issues of the sector and measures to resolve such issues should be taken into consideration.

【STEP-1】 Capacity Assessment of the Water Sector and Setting of Program Target

Capacity Assessment of the target water utility should be carried out. Table 3.1 shows the key evaluation items to identify issues of a water utility.

Table 3.1 Key Evaluation Items of Water Utility Capacity Assessment

Major Category	Medium Category	Minor Category	Indicator
Items to be solved/improved mainly by facility development	General	Continuous Water Supply	Average water supply time (hours/day)
	Expansion	Coverage of Water Service	Water service rate (%)
Items to be solved/improved mainly by capacity development	Technical aspects	NRW Reduction	NRW rate (%), leakage rate (%)
		Water Quality Management	Rate of the residual chlorine testing at the water supply point (%) Compliance with water quality standards (%)
	Non-technical aspects	Financial Management	Tariff collection rate (%)
			Operating revenue and expenditure ratio: ratio of billing amount to operation and maintenance costs (%)
		Business Efficiency	Number of staff of water utility per 1,000 connections (person)

Source: "Handbook for Capacity Assessment for Urban Water Sector and Water Supply Operation in Developing Countries"

After the assessment of the current performance level of the water utility company using the indicators in Table 3.1, examine what should be improved in the company and for what objectives. Then, the goal of the program to improve water supply services should be set up tentatively. The program goal may include the following items:

- Expansion of water service area (indicator: water service rate)
- Improvement of water service level (indicators: average water supply hours, water quality standard compliance rate)
- Promotion of effective usage of water resources (indicator: water leakage rate)
- Improvement of financial conditions (indicators: operating revenue and expenditure ratio, water tariff collection rate, number of employees per number of connections, non-revenue water rate)

It is important to evaluate priorities of such goals based on the performance of the water utility, the regulatory framework of the water sector, and other circumstances, through discussions with the counterpart organization. In developing countries, water utilities tend to give a top priority to the "expansion of water service area," which can bring the most visible result in the water sector. Thus, there is a risk that the counterpart is not interested in reducing NRW, and an NRW project becomes less sustainable, even supported by a donor.

Another point is that the performance level of the water utility company determines the achievable level of NRW measures. If the performance level is very low, it is often difficult to achieve a sizable reduction of NRW. For example, a water supply utility that can provide water only for limited hours per day can hardly take measures against underground leakage because there is no water flow in pipes for an extended period, though they can still take measures against visual leakage on the ground. If the turbidity of the supplied water is high due to insufficient treatment, there is no point in replacing water meters frequently as the meters go out of order quickly. As these examples indicate, the level of NRW reduction measures should be raised step by step as the performance of the water utility company improves.

Yet another point is whether the main objective of NRW reduction is the "promotion of effective use of water resources" or the "improvement of financial conditions" of the water utility company. If the main objective is the "promotion of effective use of water resources", the priority should be given to water leakage reduction measures. In addition, there are other measures to be implemented, such as public awareness raising to promote water-saving, prevention of wasteful water usage by installing suitable water taps or by introducing a volume-based tariff system, and introduction of a progressive tariff system to encourage major water users to save water. If the main objective is the "improvement of financial conditions", the priority should be given to the reduction of apparent loss. In addition, other measures should be considered, such as increase of tariff collection rate, reduction of O&M cost, especially variable costs for electricity and chemicals, restructuring of the water tariff system, and introduction of an independent accounting system. As these examples explained, the focus of NRW reduction is dependent on the objective, and in order to achieve the objective, measures other than NRW reduction may also be required.

【STEP-2】 Examination of Required Projects and Their Feasibilities

In Step-2, the scope of projects and activities necessary to achieve the program goal are identified. Table 3.2 shows the types of program goals and necessary projects. The scope of the projects is determined by the capacity of the target water sector and the level of the program goal.

If the program goal is the "expansion of water supply services", a facility development project should be implemented first to expand the network to the required scale. This may require financial cooperation. Then a technical cooperation project will be required to strengthen the O&M capacity of the expanded water supply system. As for NRW reduction, the facility development project should include measures to keep the NRW rate low in the new network and to make NRW monitoring and maintenance easy, such as isolation of water service blocks, the establishment of DMA, water pressure management, quality control of pipe installation, installation of water meters, etc. Then, the technical cooperation project can follow this up in the areas of water distribution management (water pressure management), monitoring and control of NRW in the new network, and if applicable, NRW control in the existing network.

If the program goal is the "improvement of the level of the water supply service", the contents of the program should reflect the performance level of the water sector, the target area, and the target level of the program. For example, if the goal of the program is an improvement of water quality by the construction of a WTP, extension of water service hours or optimization of water pressure through the reconstruction of the existing pipe networks or the replacement of existing old pipes, some facility development is essential. Most likely this will require a financial cooperation project. Generally speaking, an extension of water service hours requires water resource development and construction of a water treatment plant. Nevertheless, some water utility companies have achieved the extension of water service hours (including 24-hour service) by isolating the water service blocks, establishing

DMAs, optimizing water pressure, reducing leakage and installing water meters for monitoring water usage. Similarly, a technical cooperation project may be able to make a significant impact if facilities have been already developed to some level, and the program is seeking a gradual improvement of the services, such as through capacity development for O&M of a WTP and water quality management, a pilot-scale reconstruction of network and improvement of water distribution management in a limited area, etc. Even in such cases, it is necessary to prepare a certain amount of budget for the installation of valves and water meters for the reconstruction of a network, procurement of equipment for chemical treatment at the WTP and equipment for water quality analysis, among others. A technical cooperation project can also make a significant impact when a "prescription" for improvement has to be identified with the counterpart organization prior to facility development. In such a circumstance, a technical cooperation project can implement a pilot project to test out potential approaches to improve services and to examine impacts and issues of such approaches. Then a financial cooperation project is implemented for full-scale implementation of the identified approaches, considering the results of the pilot activity.

When the goal is the "effective use of water resources" or the "improvement of financial conditions", a technical cooperation project is generally highly relevant, and widely utilized. However, if the pipe network is too old, the impact of a technical cooperation project (such as capacity development of leak detection and repair) tends to diminish. Even if leakages can be detected and repaired well, new leakage will often occur at another location in the network. Similarly, if many meters have to be replaced, the budget of a technical cooperation project may be insufficient. Improvement of water pressure management also requires investment for new pipes and valves in order to reconstruct water distribution blocks. While some issues can be effectively resolved within a technical cooperation project and some investment can be done within the budget of a technical cooperation project, financial cooperation may be needed to deal with the issue. Thus, it is important to consider such limitations of different cooperation schemes. As an example of a program, it is suggested to implement a technical cooperation project to demonstrate the effectiveness of NRW reduction measures in a certain block (pilot area), then implement a financial cooperation project to expand the measures to wider areas. Another idea is to introduce NRW measures step by step in different phases of technical cooperation project, from the preliminary, the basic, and more advanced levels, depending on the progress of NRW reduction.

Table 3.2 Program Targets and Necessary Projects

Necessary Measures		Program Target			
		Expansion of Water Supply Service Area	Improvement of Water Supply Service Level (existing area)	Effective Use of Water Resources	Improvement of Financial Conditions
1. Facility Development Project					
Expansion of water supply facilities	Expansion of pipe network	◎	-	-	-
	Expansion of water intake and purification facilities	◎	-	-	-
Restructuring and repair of water supply facilities	Restructuring of a pipe network	-	◎	◎	◎
	Rehabilitation of water intake and water treatment plant	-	◎	-	○
Procurement of water meters, monitoring equipment, etc.		○	○	◎	◎
2. Technical Cooperation Project					
Capacity Development (Technical Aspects)	O&M of a water supply facility	○	◎	-	○
	Management of water distribution network	○	◎	◎	○
	NRW: Water leakage reduction	-	◎	◎	◎
	NRW: Commercial loss reduction	-	-	-	◎
	Water quality management	-	◎	-	-
Capacity Development (Non-technical Aspects)	Financial status	○	○	○	◎
	Organizational development	○	○	○	◎
	Public relation	○	○	-	○
3. Undertakings of Counterpart Agency					
Preparation of Resources for Project Implementation	Fund preparation, budget arrangement	◎	◎	◎	◎
	Staff assignment for project implementation	◎	◎	◎	◎

Note: "◎": Important, "○": Necessary, "-": Limited relevance, NRW reduction measures

Source: Project Research Team

As mentioned above, the program often consists of a combination of a technical cooperation project and a facility development project. At this STEP, it is important to estimate the necessary scale of the facility development project from the viewpoint of financial arrangement.

【STEP-3】Decision on Whether to Extend JICA Cooperation for the Program

In order to make the decision on whether JICA could extend cooperation, it is very important to confirm the level of "motivation" of the counterpart organization to implement the program. The following points are relevant:

- Is there any legal, regulatory or other supervisory pressure to achieve the goal? For example, whether the target levels of water supply service or NRW rate are determined by the supervising agency, the current status and the progress are published, and the water utilities

are under pressure to take actions to achieve the goal. Or the improvement of performance affects the financial subsidy for the water utility.

- Is there any pressure to achieve the goal because of the leader's intention or public pressure? For example, a top official of a supervising agency could be a strong advocate for reform and taking leadership in the improvement of water supply service and financial conditions. Or there is a strong public opinion for the improvement of water supply services that has resulted in public demonstrations and petitions. Or public pressure is growing due to water supply restriction caused by drought or an outbreak of water-borne diseases.
- Do the top officials or executives of the counterpart agency have a strong will for the improvement and have been taken actions to address it? It is necessary to confirm whether they are taking real action and not only talking.
- Is the utility company being operated under an independent accounting system? This is not a prerequisite for support. Nevertheless, if an independent accounting system is adopted by the utility company, the improvement of water supply service and NRW reduction could directly affect the profitability of the business operation, and the staff has the motivation to improve the service and reduce NRW. However, even if an independent accounting system is adopted, the deficit of water utilities is often subsidized from the general account of the government. Thus, it is necessary to assess the actual situation.
- Can the counterpart provide enough funds and human resources for the implementation of the project as undertakings? If there are not enough staff members for capacity development or if they are too busy, it is difficult to implement a technical cooperation project.

3.1.2 Survey Items for the Data Collection Survey during Program Formulation

(1) Survey to Collect General Information of the Water Sector

These are typical items to understand the overview of the water sector.

1) Basic Data and Information of the Water Sector and General Information of NRW

- Basic Data and Information of the Water Sector

  Upper level plan, budget/financial statement, number of meters installed/meter installation rate, various kinds of water capacity (water intake/water treatment/water distribution/water supply), water pressure, pipe network drawings, pipe length/pipe material/pipe diameter, pipe replacement, number of complaints, etc.
- General Information on NRW

  Number of claims/estimated leak amount, number of leakages detected and repaired, type and number of leakage detection equipment, number of illegal connections, year of meter installation, number of meter replacements, etc.
- Cost Data on NRW Reduction Measures

  Budget for water leakage reduction, budget for pipeline replacement (number of staff in charge, salary level, working hours, materials and equipment costs, construction costs, etc.)
- Organization Data and Information

  Organizational system, capacity development (training) status and level, higher-level organization, related organizations, etc.

2) Social Conditions and Infrastructure

   Population, residential classificatin, regional development plan, security, etc.

3) Natural Conditions such as Topography and Weather

   Topography and elevation difference (whether it is difficult to control the water pressure due to a large elevation difference), soil condition, rainfall amount, etc.

4) Legal System and Regulatory Administration Related to Water Utilities

Legal system, enforcement of the legal system (actual situation of enforcement) and organization, accounting system (whether a water utility company adopts an independent accounting system), monitoring system, benchmarking, technical standards, subsidy system, quality of water supply equipment and quality control system, key persons and decision-making mechanisms of higher authority and related organizations, private sector involvement, technology level and quality control ability of local private companies, etc.

(2) Survey Items for Capacity Assessment and Setting of Program Goals

- Capacity assessment of target water utility (evaluation by using numerical indicators such as average water supply hours, water service rate, NRW rate, water leakage rate, water quality standard compliance rate, etc.)
- Data collection to understand the performance of water utility (basic data on water supply operation, data related to NRW measures, information on social conditions and infrastructure conditions, natural conditions such as topography and weather, existing plans for water utilities and their background data, legal systems related to water utilities, regulatory supervision)
- Discussion and confirmation of the objectives and contents of the improvement of water utility
- The setting of program goals (setting of the targets such as an expansion of water service area, improvement of water service levels, promotion of effective use of water resources, and improvement of financial conditions)
- Determination of the objective of NRW reduction measures, whether it is the "promotion of effective use of water resources" or the "improvement of financial conditions".

(3) Survey Items for Confirmation of the Required Project Components and Feasibility

- Clarification of necessary measures for each item of the program goals (facility development projects, technical cooperation projects, and undertaking of the counterpart organization, see Table 6.2.2)
- Study on the financial scale and financial sources (including various donor funds) from the viewpoint of funding possibility, if a facility development project is absolutely required.

(4) Survey Items for Judging whether to Implement the Project

- Confirmation on: whether the implementation of the project is required from the viewpoint of regulations and organizational supervision, whether there is a momentum for the implementation of the project such as the intentions of the central government or the top management, whether the financial conditions should be improved after adopting an independent accounting system, whether there is a sense of project ownership in the counterpart organization, such that they have already taken actions by themselves. Based on the confirmation, it is necessary to judge whether there is enough willingness in the counterpart organization to implement the project.
- The availability of funds for necessary projects needs to be confirmed.

3.2 Key Points at the Project Formulation Stage for a Technical Cooperation Project

3.2.1 Steps of the Detailed Planning Survey

A detailed planning survey is a survey to formulate a concrete project. It is required to determine the objectives, results, activities, indicators, inputs (experts, training, equipment, overseas activities costs), resource mobilization methods, undertakings of the counterpart organization, implementation organization, and project period.

【STEP-1】Clarification of Objectives of Cooperation

First, it is necessary to clarify the objectives of the cooperation program as a whole. Regarding NRW reduction, if the objective is to "promote effective use of water resources," it should mainly focus on the measures for water leakage reduction. If the objective is to "improve financial conditions", it should focus on the measures against apparent loss. In addition, if the objective is the former, it should consider other measures, such as the promotion of water-saving and prevention of wasted water. If the objective is the latter, it should consider the improvement of the water tariff collection rate and reduction of the O&M costs. NRW reduction is just an approach to accomplish the objective. Considering the objective, the project should include, if appropriate, a wide range of measures without limiting the scope to NRW reduction.

【STEP-2】Confirmation of the Current and the Target Levels of NRW Measures in the Target Water Sector

To clarify the necessary projects and activities, both the current and the target levels of NRW reduction activities in the water supply sector should be clarified using Table 3.3.

For example, if the current level of the counterpart organization is at the Preliminary Stage (Level 1), there is almost no NRW reduction activity. In this case, the priority activities are 1) to raise the awareness of executives on the significance and necessity of NRW measures, 2) to establish an organization and to appoint the staff, 3) to provide basic training to the staff to raise awareness on the concept and necessity of NRW reduction measures, 4) to carry out some measures, like the visible leakage control, which work effectively without a huge amount of cost, equipment and technical capacity, 5) to install flow meters and customer meters for the establishment of a monitoring system. A water utility company at this level of maturity usually does not keep customer ledgers and pipe network drawings. Thus, collection of such basic data is a priority. It is too early to commence surveys of underground leakage. In many cases, water leakage is so serious that the replacement of old transmission and distribution pipes is absolutely required. In such cases, it is necessary to consider synchronizing a technical cooperation project with a financial cooperation project.

If the current status of the organization is at the Initial Measure Stage (Level 2), some NRW reduction measures have already been introduced. Thus, it is necessary to figure out what is needed to complement ongoing activities and how they can be improved. At this stage, the high priority measures are almost the same as at the Preliminary Stage (Level 1), but at the Initial Measure Stage (Level 2), the measures are to be implemented at a higher level than at the Preliminary Stage (Level 1), aiming at around 30% of NRW rate.

If the current status has reached the Full-scale Measure Stage (Level 3), the staff members already know the basic concept of NRW reduction, and they have already implemented basic NRW reduction measures. The major activities to be implemented at this stage are the full-scale NRW reduction measures beyond the basic measures. Among such measures are underground leakage control, advanced leak detection with the training program, isolation of water service blocks in the target area, improvement of meter accuracy, and promotion of advanced management system of facility data and customer data. To allow full-fledged underground leakage control, the water service should be available almost 24 hours with an appropriate level of water pressure.

The Advanced Measure Stage (Level 4) is the stage where the NRW ratio has already been reduced to

around 20%. The aim at this level is to reduce the NRW rate to less than 20%. At this stage, the NRW reduction measures are not fully effective anymore due to recurrent leakage. In many cases, more elaborate measures are required. The measures at this stage include strengthening of pipe materials, the introduction of DMA, thorough underground leak detection, and advanced leak monitoring using telemeter systems or SCADA. These measures require both high technologies and high costs.

In order to achieve the target level, a facility development project may be required, in addition to a technical cooperation project. It is necessary to examine what measures are required to secure enough water resources and to achieve 24-hour water supply.

【STEP-3】Consideration of Contents of Technical Cooperation Project for NRW Reduction

After confirmation of the current level and the target level of NRW reduction, determine the contents of the technical cooperation project for NRW reduction by using Table 3.3 and 3.4.

【STEP-4】Consideration of the Implementation Plan of Technical Cooperation Project for NRW Reduction

In Step 4, the implementation plan for the proposed NRW reduction project is prepared.

Table 3.3 Level of Activities and Measures for Non-revenue Water Reduction

Items		Preliminary Stage (Level 1)	Initial Measure Stage (Level 2)	Full-scale Measure Stage (Level 3)	Advanced Measure Stage (Level 4)
Outline		No measure for NRW reduction has been carried out. At this stage, it is required to understand existing problems and confirm the commitment of the executives.	Technically easy and relatively cost-effective measures can be commenced at this stage, such as the measures to control visible leakage on the ground and apparent loss.	More elaborate measures can be introduced at this stage, such as underground leak detection and isolation of water distribution blocks.	At this stage, all types of standard measures have been introduced. Ready to introduce more advanced measures adopted by the Tokyo Metropolitan Government in the later stage, including strengthening of pipe materials, the establishment of DMA, and more advanced underground leak detection.
Typical level of NRW reduction measures					
Target NRW rate (rough indication)		More than 40% at present with no active control No target so far	Much more than 30% at present The target is 30%.	Around 30% at present The target is 20%.	Around 20% at present The target is less than 10%.
Staff for NRW reduction activities		No staff has been assigned for NRW reduction activities.	The staff has been assigned for NRW reduction activities.	The staff has been assigned for NRW reduction activities.	The staff is working actively on NRW reduction activities.
Measures for leakage reduction	Leakage detection survey and repair	Not enough repair has been done even for visible leakage.	Visible leakage can be repaired and stopped.	Visible leakage can be controlled appropriately, and some measures against underground leakage are being implemented.	Measures against underground leakage (detection and repair) are being implemented appropriately.
	Replacement of old pipes, selection of pipe materials	Due to very old pipes, visible leakage occurs frequently, and the pipes cannot be repaired appropriately. (Pressures of the piped water could not reach the designed pressure level because of the leakage)	Even if visible leakage occurs frequently, the leakage could be repaired appropriately and stopped.	Replacement of very old pipes has been completed. Serious visible leakage does not occur frequently.	The replacement of old pipes has been completed, and the pipe materials are suitable. Installing more resilient pipes and establishment of DMA are being implemented.
Meter installation and monitoring		Not enough flow meters and customer meters have been installed or functioning. The NRW rate and the amount are difficult to measure.	Flow meters and customer meters have been installed. However, they are not working properly. The measurement of the NRW rate and amount is not accurate.	Accurate flow meters and customer meters have been or are being installed nearly at all locations. The NRW rate and amount can be measured accurately.	Same as left
Level of water supply service as a prerequisite for NRW reduction measures					
Adequacy of water resources, water supply hours		-	The water resources are adequate to supply water for 24 hours in the limited areas even though there is a seasonal water shortage. Though the service is intermittent sometimes, 24-hour water supply is possible with some support.	The water resources are available to supply water for 24 hours in most area. Basically, 24-hour water supply is provided, even if the service becomes intermittent temporarily.	24-hour water supply
Expected contents of corporation					
Expected contents of corporation		- Awareness building on the necessity of NRW reduction measures, and a demonstration of the measures. - Measurement of NRW and establishment of a monitoring system. - Preparation of basic data, such as pipe network drawings and customer ledgers. - Preparation of an NRW reduction plan, the establishment of the organization - Visible leakage control (Before NRW reduction, other measures, such as securing water resources, are often required to improve water supply services)	- Measurement of NRW and establishment of the monitoring system. - Preparation of basic data such as pipe network drawings and customer ledgers - Preparation of NRW reduction plan, the establishment of the organization. - Comprehensive measures against visible leakage, replacement of old pipes (high-priority), improvement of construction and repair technology - Measures against apparent loss - Shift to measures against underground leakage if visible leakages are not frequent.	- Improvement of the accuracy of NRW measurement by isolation of water distribution blocks - Measures against underground leakage - Comprehensive measures against visible leakage and apparent loss - Replacement of pipes based on plan - Further improvement of construction and repair technology	- Precise monitoring through the establishment of DMA and identification of service zones to be prioritized NRW measures - Systematic measures against underground leakage - Improvement of pipe materials and construction technology - Implementation of various highly accurate measures

Note: The above is a description of typical cases and is not applicable to all water utilities. In addition, it is not always necessary to follow the above steps. The contents of cooperation should be determined according to the situation of the target water utility company. For example, there is an example where the project for a Preliminary Stage utility company included advanced activities, such as the installation of DMA and measures against underground leakage, because the counterpart members were deeply aware of the issue of NRW, and the target area was only one small water supply block. (Capacity Enhancement Project for Samoa Water Authority in Cooperation with Okinawa)

Table 3.4 List of NRW Reduction Measures and Their Selection by Situation

List of NRW Reduction Measures				Implementation Status of NRW Measures				Priority Project	
No.	Contents		Remarks	Preliminary Stage	Initial Measure Stage	Full-scale Measure Stage	Advanced Measure Stage	Effective Use of Water Resources	Improvement of Financial Conditions
(1) Technical Cooperation Project									
1	Establishment of Organization for NRW Reduction Activities	Assignment of staff	Prerequisite for NRW reduction activities	◎	◎	○		○	○
		Establishment of the responsible department	Necessary for effective activities	○	◎	○		○	○
2	Implementation of Pilot Activities		Required to confirm effective approaches	◎	◎	○	△	○	○
3	Installation of Meters in Target Areas	Installation of flow meters	Prerequisite for NRW reduction activities	◎	◎			○	○
		Installation of customer meters		◎	◎			○	◎
4-1	Capacity Development (Management Level)	Lecture on NRW reduction measures	Top priority, if the management level does not understand issues well	◎	◎	○		○	○
		Lecture on the significance of the measures		◎	◎	○		○	○
		Lecture on the improvement of financial conditions		◎	○	○	○		◎
4-2	Capacity Development (Staff Level)	On-site training for measures against visible leakage	Top priority	◎	◎	△		◎	○
		On-site training for measures against underground leakage	High priority following the measures against visible leakage		○	◎	◎	◎	○
		On-site training for measures against leakage at reservoirs, etc.	Important	◎	◎	△		◎	○
		Training for pipe repair methods	Top priority	◎	◎	△		○	○
		Training for construction supervision of pipe installation	Important, if use contractor	◎	◎	○		○	○
		Training for customer meter reading	For commercial loss (apparent loss)	○	○	△			◎
		Training for customer meter testing		○	○	△			◎
		Training for water pressure control	For water leakage		○	○		○	○
		Training for the introduction of DMA	Depend on the level of capacity			○	◎	○	○
		Training for measure against water theft	For commercial loss (apparent loss)	○	○	○			○
		Analysis of cost-effectiveness	For improvement of motivation	◎	◎	○			
		Training on the strengthening of pipe material	Measure for the final stage			○	◎		○
		Training for capacity development of planning	Required to ensure continuity	◎	◎	○			○
4-3	Capacity Development (Outsourcing)	Improvement of business capability	For pipe repair, meter reading, leak detection, etc.	○	○	○	○	○	○
		Training for qualification exam, certification system	Securing the capability	○	○	○	○	○	
5	Data Management	Management of customer data	Required for the effectiveness of the activities	○	◎	○			◎
		Management of asset ledger		○	◎	○		○	○
		Management of pipe network drawings		○	◎	○		○	○
6	Preparation of NRW Reduction Plan	Preparation of long/middle term plans	Required to ensure continuity	◎	◎	○	○	○	○
		Preparation of annual plan		◎	◎	○	○	○	○
7	Public Awareness Activities for Residents		Necessary for effective implementation of the measures	○	○	○		○	○

(2) Technical Cooperation Project (Except for NRW Reduction Measures)									
8	Training for Improvement of Financial Conditions	Introduction of the independent accounting system and separation of the organization	For improvement of financial conditions, not for NRW reduction		○	○			○
		Water tariff setting			○	○			○
		Subsidy system			○	○			○
		Reduction of O&M cost			○	○			○
		Appropriate staff allocation			○	○			○
		Improvement of water tariff collection rate			○	○			○
(3) Financial Cooperation Project									
9	Measures for Leakage Reduction	Replacement of old pipes	Prerequisite for NRW reduction activities	◎	◎	○	○	◎	◎
		Reallocation of water service blocks	Optimization of water pressure		○	◎	○	○	○
	Management of NRW Reduction Activities	Procurement of flow meters and customer meters	Prerequisite for NRW reduction activities	◎	◎	○		◎	◎

Note: "◎": Important, "○": Necessary, "△": Limited relevance,

Source: Project Research Team

3.2.2 Key Points for Detailed Planning Survey

(1) Understanding of the Current Situation

- To understand the related national policies and the system of regulatory supervision.
- To identify the major factors affecting NRW as much as possible.
- To confirm the level of involvement of the private sector, e.g., whether some works, such as pipe installation or meter reading, are outsourced to private companies. To confirm the existence of registration, certification, qualification system, etc. for private companies, engineers and craftsmen. If the project is going to include a component to support the utilization of the private sector, it will be effective to use these systems.
- To confirm the situations of human resource development and transfer of personnel, the existence of incentives, such as overtime payment and performance-based salary, and the existence of allowances for night works and compensation day off.
- To understand the financial situation of the target water utility company and the process of budget formulation and decision, in order to confirm whether the counterpart organization can fulfill the undertakings of the project as well as whether the project is likely to be sustainable after its implementation.

(2) Objectives, Outcomes and Activity Plan

- For a given project, some NRW measures are appropriate and effective while others may be premature. This depends on the present levels of NRW control, water service, and situation of the facilities of the target water utility company. There was a case in one of the past projects that a project team tried to complete hydraulic isolation of a pilot area even though there were too many problems for hydraulic isolation. This happened because the team set up the activity plan that did not match the situation of the site and the counterpart organization. Similarly, the minimum night flow method, which is carried out for estimating leakage amount, can not be applied to an area where the water is supplied intermittently at night.
- There are two types of NRW reduction projects; one is formulated only for NRW reduction, and the other is targeting a wider scope with NRW reduction as one of the components. The former is appropriate when NRW reduction is definitely the priority issue, or when the target utility company is relatively large, and the project needs to focus on NRW reduction to produce a meaningful result. The latter is appropriate when the capacity of the target utility company is limited, and there are many priority issues, requiring a step-by-step and comprehensive capacity development of the whole organization and its staff.
- Even if the request for cooperation is specifically for NRW reduction, it is important to clarify what is the goal for improvement, how is the current capacity level of the organization, and what are the priority issues. Then, the project should include appropriate outputs and activities to achieve the goal.
- It is important to incorporate ideas to enhance the sustainability of the project. For example, preparing training materials and training courses may not be sufficient. It is better to devise a mechanism to ensure that the training is implemented and continued. With respect to an NRW reduction plan, the project should support not only the preparation of the plan, but also its approval and implementation during the project period, or make the effort of the counterpart organization a condition to start the next phase of the project. Another idea is to extend the scope of the project until the counterpart organization builds enough capacity for continuous monitoring and NRW reduction measures by itself.
- Ideas to raise motivations should be incorporated into the project, such as "visualization" of results of the NRW reduction measures, estimation of cost-effectiveness, the introduction of an award system, etc.
- Future expansion and development of NRW reduction activities by the counterpart organization after completion of the project should be envisioned. Among the ideas are: to share the outcomes of the activities widely beyond the direct counterpart members; to actively promote the project outcomes to the top management of the target utility company;

to integrate the targets and future action plans into the official plans of the organization, systems of operation, budgets, etc.; to make the preparation and initial implementation of the future plan a part of the project; to create a competitive environment by making the performance of each section/branch of the organization visual; and, to make the counterpart members to recognize that, once the project is completed, they become the ones to teach and lead others and expand the activities.

- NRW reduction measures are related to many dimensions of the water utility, and in-depth observation is essential to reveal the actual situation on the site. Since a detailed planning survey is too short for such observation, a baseline survey and capacity assessment should be conducted in the early stage of the main project to define the details of the project activities, baseline, target level, capacity development plan, etc. The project plan such as the Project Design Matrix (PDM) should be modified flexibly based on the results of such activities.
- Typical documents to be delivered during the project period include 1) an NRW reduction plan, 2) guidelines, 3) manuals, 4) SOPs, and 5) training curriculum and training materials. These deliverables are supposed to be used in the project activities, revised based on the results of the use, and to be updated by incorporating ideas and recommendations to sustain activities. They are not meant to be delivered just before the completion of the project. The contents should be short and concise, showing only the key points. It is also important to make the content and language suitable for the level of the person who uses them. It is best if the users themselves can revise the deliverables for their own use reflecting their experiences through the project activities.

(3) Plan for Indicators

- In some projects, outcome indicators, such as "NRW Rate" have been used as the indicators of the overall goal and the project purpose. However, it is necessary to examine whether such indicators can be measured or achieved.

(4) General Design of Pilot Activities

- In NRW reduction projects, it has become a standard practice to include a pilot activity in which NRW reduction measures are demonstrated in an isolated small water service block as a pilot area. But the contents of the pilot activity should not be uniform and inflexible. They should be formulated flexibly according to the level of performance of the target water utility company and the measures to be prioritized.
- In many cases, pilot activities are planned for the objective of identifying effective and efficient NRW reduction measures. This is usually done by selecting a certain water service block as a pilot area and analyzing the main causes of NRW and the cost-effectiveness of each measure for NRW reduction. To expand the activities to other areas in the future, it is desirable to select an area representative of the whole service area and not a special section in the service area.

(5) Plan for the Input of Experts

- In Japan, NRW reduction measures are carried out regularly by a water utility of a local government, and the local government has accumulated a lot of know-how. For this reason, the dispatch of an expert from a local government is effective.

- However, the dispatch of experts from a local government has become more difficult recently due to the constant reduction of the number of employees in local governments and the retirement of veteran experts. Local governments cannot dispatch enough experts to all JICA projects. For this reason, particularly in South Asia and Africa, most of the experts are assigned by development consulting firms on a contract basis. Even in this case, it is desirable to recommend in the request for proposal the utilization of the local government's know-how. The development consulting firms are making various efforts to stay competitive, for example, by formulating a joint venture with a non-profit third sector organization of a local

government or by recruiting local government retirees.

- For technical cooperation projects, it is desirable to assign long-term experts who can stay on-site for consultations, observation of the actual situation, and carrying out activities appropriate for the site. The development consulting firms tend to assign experts in a shuttle type manner, and it is difficult to dispatch long-term experts. For these reasons, the following ways to dispatch long-term experts can be considered: 1) to get support from local governments, 2) to dispatch a local government retiree registered with the Japan Water Works Association's Water Works Senior International Cooperation Expert Registration System, as recommended by the Ministry of Health, Labor and Welfare, and 3) to dispatch an expert who is active as a JICA junior expert or a freelance retiree with working experience in JICA water sector or in a local government.
- If long-term experts cannot be dispatched and a shuttle-type, contract-based short-term experts are to be dispatched, it is suggested to extend the assignment period of the core members as much as possible or to adjust the assignment schedules of the experts so that at least one of the experts can stay on the site for a long time.

(6) Plan for Training Abroad

- Training in Japan targeting the executives of the counterpart organization is an effective way to start a project. The executives often become more understanding and cooperative toward the project, as they deepen their understanding of ideal water service operations and gain trust in Japan's technical capabilities. Training in a third country is useful to learn innovative activities in a country with similar conditions to the target country, or to learn initiatives in a country ahead of the target country, but not as advanced as Japan.
- In some projects, persons not related to the project or staff close to retirement are shortlisted as candidates for training abroad. In order to avoid this, the selection criteria for trainees should be agreed upon in the detailed planning survey. Also, at the implementation stage, it is important to select people who can utilize the results of the training for actual activities, such as the counterpart staff and the leader of the counterpart staff.

(7) Plan of Equipment Input

- Table 3.5 shows a list of necessary equipment corresponding to the four levels of NRW reduction activities as explained in Table 3.3.
- Some leak detectors, such as correlation leak detectors, are expensive. Also, a small set of equipment procured for training in a technical cooperation project may not be enough to expand the activities to the entire area. In such a situation, the staff may not be able to apply what they have learned because of the shortage of equipment, even if they have received the training. Hence, in planning the number and the timing of equipment procurement, it is necessary to consider the objective of the procurement, such as whether it is necessary to procure enough equipment for the entire area, or whether the main objective is to demonstrate and to confirm local applicability of an NRW measure. If the equipment is essential and should be used widely, it should be decided whether the JICA can procure a large number, or JICA procures a part, and the rest is procured by the counterpart organization. If the equipment is expensive, sharing the burden with financial cooperation is an option.
- The procurement of some equipment requires a long time to clear related local regulations and customs. There was a case where it took a long time to obtain the permission to use the radio frequency used by a correlation leak detector that emits radio waves. In another case, obtaining approval for import took time. In another case, a local regulation required a burglar-proof chain to be attached to meters, and it took time for a vendor in Japan to deal with this requirement.
- When introducing a telemeter system or SCADA, it is necessary to connect individual devices to exchange signals and to function as a system, and this brings an additional difficulty to procurement. Since the cost is high, it is not recommended to obtain such a system in a technical cooperation project. Even if the necessity is extremely high, and the system should be procured, it is not recommended to place a simple procurement order. For

this type of system, it is better to place a turnkey order that includes installation, operation test, and handover of the system after confirmation that the system is operating normally.

(8) Plan of Organizational Set-up for Project Implementation

- NRW reduction measures involve many departments, and responsibility tends to become ambiguous. Thus, the organizational plan of the project should clarify the department responsible for the supervision of the entire activities, including the tasks of leading, coordinating, planning, and monitoring activities across the boundary of departments. This can be done by establishing a new department or appointing an existing department, but it is essential to make the person in charge clear.
- The commitment of top management and executives is critical. In setting up the project implementation plan, a senior manager who is in the position to make decisions for the organization should participate in the project as a project director or a similar position. Leakage control usually involves technical departments responsible for onsite water supply and pipe maintenance management as well as sales offices responsible for billing and tariff collection. Thus, the leadership of senior executives whose positions are higher than these departments and offices is indispensable.
- Introducing full-scale NRW measures to a water utility company that has hardly implemented such measures in the past adds a significant new workload to the field engineers and workers. In order to relieve the sense of burden, it may be possible to establish a dedicated full-time unit independent of the conventional routine works. This way, the staff can clearly identify their responsibility and concentrate on NRW reduction measures.
- An organization established solely for project implementation often becomes dissolved after the end of the project, and as a result, countermeasures become unsustainable. To avoid this, the project should include an activity to promote the newly established organization responsible for promoting NRW reduction to become an officially recognized organization and last long. Similarly, the mechanism to coordinate NRW reduction activities across different departments should become a part of the official coordination mechanisms in the organization.

(9) Plan to Promote Fulfilment of the Undertakings of the Counterparts

- In previous projects, the following undertakings were expected from the counterpart organizations: 1) assignment of the counterpart staff, 2) provision of necessary data and information, 3) setting up the project implementation system (usually called the NRW countermeasure management team or NRW countermeasure action team), 4) arrangement of the budget required for the activities (counterpart overtime allowance, travel expenses, daily allowance, etc.)
- Regarding the assignment of counterparts, various problems occurred in the past projects, such as the number of the assigned counterparts was too few, the counterpart members were transferred, or they were too busy because of their regular works and did not have enough time for the project activities. To avoid such issues to arise, these issues should be discussed with the counterpart organization during the detailed planning survey. There was a case where the project commencement was postponed until the recruitment of the counterpart staff. In other cases, a "core team" of permanent members was established to ensure the members are not lost to transfer. Perhaps the counterpart organization is requested to submit a list of counterparts to JICA before the start of the project and make their availability a condition for the dispatch of international experts.
- There are examples where the provision of valves, pipes, etc. necessary for hydraulic separation was the responsibility of the counterpart organizations. However, such an arrangement often affects the project execution as the budgeting and procurement of the equipment are delayed. A contingency plan (e.g., should the delay occurred, procuring the equipment with the project budget) and timing of intervention should be planned in advance.

(10) Planning of Project Period

- In the past technical cooperation projects, the procurement of material for the pilot activities and the hydraulic separation of pilot areas often became the critical path of project implementation and caused the delay and extension of the project. One should anticipate these issues if the procurement of such equipment and hydraulic separation are envisaged. In such cases, a longer project period is advised.

(11) Others

- Measurement of a leakage volume and detection of underground leakage with the minimum night flow method have to be done at night, so it is necessary to pay enough attention to security. For cities with poor security, it is better to consider an alternative approach that does not require night work.
- Donor collaboration should be actively promoted, but the activities of another project do not necessarily progress as planned. Therefore, it is important to avoid a plan in which other project imposes a fatal impact on the proposed JICA project. It is important to prepare a contingency plan against a delay or cancellation of another project.

Table 3.5 Necessary Equipment for NRW Reduction Activities at Different Stages

Items	Preliminary Stage (Level 1)	Initial Measure Stage (Level 2)	Full-scale Measure Stage (Level 3)	Advanced Measure Stage (Level 4)
Overview	No measure for NRW reduction has been carried out. At this stage, it is required to understand existing problems and confirm the commitment of the executives.	Technically easy and relatively cost-effective measures could be commenced at this stage, such as the measures to control visible leakage and apparent loss.	More elaborate measures can be introduced at this stage, such as underground leak detection and isolation of water distribution block.	At this stage, all types of standard measures have been introduced. Ready to introduce more advanced measures adopted by the Tokyo Metropolitan Government in the later stage, including strengthening of pipe materials, the establishment of DMA, and more elaborate underground leak detection.
Necessary Equipment for the Implementation of Technical Cooperation Project				
Equipment required for hydraulic separation	Although it is not necessary at this stage, as an initial-stage demonstration, it is possible to select a small section of the network and place a flow meter and/or valve to measure the effectiveness of the countermeasure.	Although it is not essential, flow meters and valves are required if a pilot area is created to confirm the cost-effectiveness of various countermeasures.	Although it is not essential, in many projects, pilot areas are established and flow meters and valves are installed to confirm the cost-effectiveness of various countermeasures.	Flow meters and valves are required for the demonstration of DMA construction and verification of its effectiveness.
Equipment required to study the baseline of NRW and/or equipment required for monitoring	Install flow meters at the outlets of the water treatment plant and distribution reservoirs.	Install flow meters at the outlets of the water treatment plant and distribution reservoir. If a pilot area is established, install customer meters.	Usually, flow meters and customer meters have already been installed, but they should be replaced or newly installed as necessary.	Usually, flow meters and customer meters have already been installed.
Equipment for water leakage investigation	It is not necessary at this level because there are many issues to be addressed prior to the measures against underground leakage.	It is not always necessary at this level, but equipment becomes necessary if the surface leakage is limited and the counterpart is ready to start countermeasures against underground water leakage. (Refer to Chapter 2 for the details of the equipment for water leakage investigation.)	It is highly necessary in order to proceed with the underground leakage countermeasures. (Refer to Chapter 2 for the details of the equipment for water leakage investigation.)	It is highly necessary in order to proceed with the underground leakage countermeasures. (Refer to Chapter 2 for the details of the equipment for water leakage investigation.)
Equipment necessary for water leakage repair and pipe installation	Materials and equipment necessary for the rapid and accurate repair of surface water leakage.	Materials and equipment necessary for the rapid and accurate repair of surface water leakage and for improvement of pipe installation skills.	The equipment is available in many cases. Introduce better material and equipment if necessary.	In many cases, the equipment has been installed, and principally, it is not necessary.
Equipment necessary for apparent loss countermeasures	PCs for customer ledger, etc.	Meter test bench, PCs for the customer ledger, etc.	The equipment is available in many cases. Introduce better material and equipment if necessary.	The equipment is usually available, and most likely not necessary.
Equipment necessary for conducting training	Basic equipment, such as a projector and PCs.	Basic equipment, such as a projector and PCs. In order to efficiently conduct training on pipe connection and countermeasures against underground leakage, a training yard should be prepared.	Basic equipment such as a projector and PCs. In order to efficiently conduct training on pipe connection and countermeasures against underground leakage, a training yard should be prepared.	The equipment is usually available, and most likely not necessary.
Others	Tools for preparing pipeline drawings, such as GIS.	Tools for preparing pipeline drawings, such as GIS.	There may be a demand for SCADA. However, since it is expensive and may be difficult to procure, it is necessary to study carefully whether it is possible to be procured through the technical cooperation project.	There may be a demand for SCADA. However, at this level, it has to be established comprehensively, and the cost becomes formidable. So, procurement in a technical cooperation project is unrealistic.

Note: The above is only a guideline and is not strictly divided by stage. It is necessary to select appropriate materials and equipment regardless of this table. It should depend on the status of the target water utility and the assumed activities of the project.

3.3 Key Points for Financial Cooperation Projects at the Project Formulation Stage

3.3.1 Key Points before Confirmation of the Contents of the Preparatory Survey

Typically the following contents are assumed for a non-revenue water reduction project as a financial cooperation project. In many cases, a preparatory survey is conducted for a broader water supply project that includes not only these three items but also other items (e.g., new pipe installations, rehabilitation of water treatment plants and pumping stations, etc.).

(1) Replacement of Pipes and Reconstruction of a Water Distribution Pipe Network

Pipe replacement is effective in reducing water leakage because old pipes that cause recurrent leakage are replaced to new ones. Moreover, it becomes an opportunity to rebuild the pipe network for the future.

If the amount of supplied water increases due to the development of a new water source or development of a water treatment plant, and the water pressure rises, the existing pipe network with old pipes does not withstand the water pressure, and water leakage increases. In addition, ex-post evaluations of financial cooperation projects often reveal problems related to insufficient rehabilitation of a pipe network, despite new core facilities, such as a water treatment plant, were built with the projects. Among the problems are the NRW rate remained high, water distribution was uneven, or the problem of the restricted service hours could not be resolved. Considering these lessons, it is often advised to formulate a project that includes a replacement of pipes and reconstruction of a water distribution pipe network.

(2) Meter Installation and Replacement

Installation and replacement of flow meters and customer meters are indispensable for "visualization" and monitoring of the NRW rate, reducing apparent loss, preventing wasteful use of water, billing and collecting appropriate water tariffs, etc. Installation and replacement of meters should be done routinely. Both types of meters require continuous quality control. Customer meters need to be renewed at the time of failure or every certain number of years (in Japan, every eight years as defined by the Measurement Law). Therefore, it is necessary to estimate the number of meters to be installed in the short-term in a financial cooperation project. Moreover, if the counterpart organization is not able to properly maintain meters, the financial cooperation project may be implemented in combination with technical assistance or a technical cooperation project.

(3) Introduction of SCADA

SCADA aims to improve the ability of the water utility to operate and maintain the entire water supply network, including NRW management and distribution management. While reducing NRW is not the sole aim of introducing SCADA, it is highly effective in reducing NRW because it makes it possible to monitor flow rate and water pressure, and thus monitor the NRW rate and the leakage rate in each management zone, such as water distribution blocks and DMA. This helps the water utility to identify priority management zones for NRW control and priority measures. Originally, SCADA is a system that includes both remote monitoring and remote control. However, since remote control requires expensive electric valves, there are not many examples in developing countries. As a tool to control NRW, only the remote monitoring function of the system (telemeter system) is sufficient.

(4) Other

If water with high turbidity is supplied because there is no water treatment plant or water treatment is insufficient, there will be many meter failures. If a water treatment plant is improved and the water quality (especially turbidity) becomes better, the failures of the meters will also decrease. In this sense, the improvement of the water treatment plant can also contribute to reducing NRW.

3.3.2 Key Points to Consider in the Preparatory Survey

(1) Replacement of Pipes and Reconstruction of Water Distribution Pipe Network

[Collection of basic data and information]

Basic data and information on pipes, such as the material of target pipes to be replaced, year of installation, accurate information on pipe location (GIS, mapping), and leakage history, are fundamental for NRW reduction. To collect such basic data and information, it is necessary to conduct a thorough investigation in the preparatory survey.

[Points to note regarding pipe materials: Water distribution pipes]

The pipe materials should be selected carefully. In Japan, ductile cast iron pipes are often used for the water distribution mains, but in developing countries, polyethylene pipes are common. Ductile cast iron pipes are expensive, but they have a number of advantages, such as 1) they have a long service life, 2) water cannot be stolen easily without a dedicated drilling tool, and 3) joints designed to prevent water leakage and detachment are available. Meanwhile, polyethylene pipes have issues, such as 1) making holes and stealing water are easy, 2) the service life is shorter than ductile pipes, and 3) it is prone to leakage from the connection in case connection work is inappropriate, though leakage can be prevented with proper electrical welding.

[Points to note about pipe materials: Water supply pipes]

In developing countries, cast iron pipes and PVC pipes are often used, but polyethylene pipes are becoming popular. Polyethylene pipes are flexible, can reduce the number of joints, and have good workability. Water leakage from a polyethylene pipe can be reduced if electrical fusion is performed appropriately.

[Points to note regarding water pipe connection]

Care should also be taken when connecting distribution pipes. There are many cases where the responsibility of the water supply pipe connection is borne by the counterpart organization because the project budget is limited, and it takes a lot of supervision work as the work volume is high. However, unless the work is done properly, it becomes the reason why the service population does not increase as planned. When the qualities of construction work, materials, or the meters are compromised in water pipe connection work, water leakage or apparent loss could occur. To avoid such problems to arise, it is effective, e.g., to include the procurement of water supply equipment and materials with appropriate quality as a component of the financial cooperation, to include the construction within the scope of the Japanese side, or to supervise the construction of the water pipe connection work in a soft component of the project.

[Consideration of water pressure management]

In many projects, the entire pipe network system is renewed or reconstructed when the pipes are replaced. This is highly effective to control NRW provided that the replacement is done considering water pressure management.

In developing countries, water pressure is generally too low. But on undulating terrain with many high and low areas, the water pressure is often low in the high area and high in the low area. Thus, in implementing a financial cooperation project in a city where water leakage due to high water pressure occurs frequently, it is necessary to not only renew the pipelines, but also 1) to configure the pipeline so that appropriate water pressure management can be performed, 2) to set up distribution blocks according to the altitude, and 3) to prevent high water pressure with surge tanks and pressure reducing valves.

[Notes on blocking and DMA]

The establishment of DMA is an effective measure for NRW reduction, but it takes a lot of time and cost to construct it. So, other measures might have higher priorities from the viewpoint of cost-effectiveness. In addition, hydraulic isolation for DMA construction may be difficult due to underdeveloped or inaccurate pipeline drawings and the existence of many unknown pipes.

The establishment of distribution block is similar to DMA in that they both divide the distribution area, but the main difference is that blocking is done for distribution management and the size of

the block is therefore free. It is a system that keeps the water pressure and the water supply population in the block within certain ranges so that each block can be connected and backed up during an accident.

(2) Meter Installation and Replacement

Customer meters are essential for tariff revenue and are indispensable equipment (facility) for quantifying the amount of revenue water. In order to accurately measure the amount of revenue water, it is necessary to improve the rate of meter reading, check the meter accuracy, replace the failed meters, among others. When installing a meter, it is necessary to consider whether the location is suitable for installation and whether the meter itself is appropriate. Inappropriate meter installation may lead to frequent meter replacement and affect the financing of the water utility company.

(3) Introduction of SCADA

In introducing SCADA, it is important to consider what parameters are monitored and controlled and how they are done. The possible circumstances for introducing SCADA are described below.

- In order to keep track of the water volume of the entire water supply system and to identify the water leakage in the water reservoir, monitor the flow rate at the outlet of the water treatment plant and the inflow/outflow of the water reservoir. An electromagnetic/ultrasonic flow meter and a data transfer device are installed at each measurement point. In addition, a water level monitoring device/inflow control device is installed at the reservoir to prevent overflow.
- In order to measure the amount of inflow/outflow in a certain area (distribution block or DMA), install a gate valve for hydraulic separation of the area, and a flow meter and data transfer equipment at each inflow/outflow point.
- When considering only NRW measures, a remote monitoring system is important, but the remote control is not essential. Remote control requires an electric valve and actuator, which is expensive and difficult to maintain. There were limited cases where the remote control was required in developing countries.
- SCADA is simply a system for monitoring and controlling. The situation does not improve unless the facilities and the operations are improved using the system. There are cases where SCADA was introduced, but the data could not be used, and it did not improve the services because the capacities of the facilities were inadequate, and the management of the water service was unsatisfactory. If the capacity of the facility and the capacity of the utility company are insufficient, the implementation of a facility development project and a technical cooperation project should be considered.

SCADA requires not only the initial investment, but also a large O&M cost. To use SCADA, it is necessary to confirm data transmission, power supply, compatibility with existing facilities, and availability of the necessary budget. The following points are extracted from the SCADA case studies.

- All equipment related to SCADA (flow meters, pressure gauges, water level gauges, valves, etc.) must be electrical. Therefore, all manual or mechanical devices that have been used in the past need to be replaced with electric devices, and this will incur significant costs. The counterpart organization has to understand this. The system does not have to be full-scale from the start. For example, the locations of sensor installation can be added or expanded in the future. Thus, JICA's assistance often proposes an initial system that matches the level of the target water supply utility. This can be done by limiting the number of installations and limiting the measurement items to water volume and water pressure.
- To use the system sustainably, the utility company must be able to perform the minimum inspection and maintenance. If the capacity of the utility company is deemed insufficient, the utility company has to understand that an additional budget becomes necessary to outsource the tasks of inspection and maintenance to an external contractor.

4. Key Points during the Implementation Stage of NRW Reduction Projects

4.1 Key Points during implementation of the Program

At the implementation stage, it is important to review the contents of the program periodically (around once every half year) and to confirm whether the program is progressing towards the goals, considering changes in internal and external conditions. Then, the formulation of subsequent cooperation projects is considered by following the patterns of programs described in Table 3.2 in Chapter 3 of this report. To improve water supply, both facility development and capacity development have to be pursued in parallel. Thus, the timing of inputs and contents of the technical cooperation and financial cooperation should be considered carefully.

As another point, it is important to consider the overall directions of the activities, such as stepping up the level of NRW reduction measures mentioned in Chapter 3, promoting the establishment of the institutional framework for NRW reduction, scaling up activities from the pilot area to the entire area or to other water utilities, etc.

4.2 Key Points during Implementation of Technical Cooperation Project

4.2.1 General Considerations

Technical cooperation projects often encounter unexpected problems during implementation, such as projects do not proceed as planned, or the actual capabilities of the counterpart organization are not the same as expected. This is particularly true for NRW reduction projects because NRW reduction is related to a wide range of water utility operations, and it is difficult to thoroughly examine all aspects of operations in the detailed planning survey is not possible. Therefore, the contents, inputs, and schedules of the project activities should be reviewed as the project progresses, and adjusted to the situation of the site.

Although the reduction of NRW is the principal outcome of an NRW reduction project, such improvement in performance should be the result of the improvement of the operational capacity of the target water utility company. If the reduction of NRW were achieved by the JICA experts, the activities would be neither sustainable nor possible to expand to other areas after the completion of the project. Thus, what is important is the improvement of the capacity of the organization and human resources of the target water utility company, legal framework, and regulatory oversight mechanisms.

4.2.2 Baseline Survey and Capacity Assessment

In a technical cooperation project, a baseline survey and/or capacity assessments should be carried out in line with the objectives and the desired outcomes of the project in order to understand the latest situation of the water utility company. Among the important points to note are: 1) to analyze the problems in detail, 2) to understand the capacities from three dimensions: legal frameworks/regulatory supervision, organization, human resources, 3) to confirm the current level (baseline) of capacities, considering what capacities can be improved and up to what level, the contents of the project activities, and items of training and instruction to raise capacities, and 4) to confirm the current level (baseline) of the overall performance of the target water utility company.

4.2.3 Formulation of a Detailed Plan of Project Activities

Based on the results of the baseline survey and capacity assessment, the project activities, training items, target levels, and inputs of resources are planned. The details of the activities for NRW reduction should be carefully determined by coordinating with the target organization, considering the site situation. The following items are important in the process of formulating a detailed plan of the project activities.

(1) Revision of PDM

- Revise the PDM (Project Design Matrix) prepared during the detailed planning survey as necessary.
- Set the level of achievement concretely. PDM often uses ambiguous indicators, such as "Improvement of XYZ", without defining, for example, what becomes possible by the improvement of XYZ, or what activities and what understandings are required to say XYZ has improved. Such matters should be clarified here.
- Clarify when the indicator value should be determined and what kinds of surveys and data are required for the determination, if no indicator value has been set in the PDM.

(2) Capacity Development Plan

- Prepare the capacity development plan based on the results of the capacity assessment. Prepare a list of items to be learned and skills to be gained through training and OJT activities, then clarify the current level and target level of such items.
- Clarify who is the target of the development: executives and managers, engineers, site workers, private subcontractors (pipe-fitting companies, etc.).
- Determine the monitoring methods for the capacity development activities, after the formulation of the capacity development plan.

4.2.4 Motivation Raising

In order to sustain and expand the outcomes of the NRW reduction project, it is important to maintain and raise the motivation of the staff, and to secure enough funds. With respect to maintaining and raising motivation, the following points should be taken into consideration:

(1) Visualization of Progress and Impact Using Indicators and Sharing Awareness

The staff gets more motivated if the results of the efforts are quantified using an indicator, and the indicator shows their effort is contributing to the reduction of the NRW rate.

- Make use of numerical indicators related to the progress and impact of NRW reduction activities. Motivation is highly influenced by visible impressions.
- Provide opportunities for many stakeholders to know how the work is progressing and the indicators are changing.
- Make the indicators readily available for the staff working at leak sites, leak repair sites, and meter readers, etc. It will make the staff feel that they are a part of the effort to reduce NRW.
- Disclose the indicators to not only executives and staff of the target water utility company but widely to the public, in ways that can easily promote customer understanding.

(2) Introduction of Competition

Once the progress is visualized with the indicators, it becomes possible to encourage the staff to actively engage in activities through healthy competition. Benchmarking techniques are often used for stimulating competition by disclosing and comparing performance indicators collected from various water utility companies. Even within one water utility company, it is possible to let regional offices and different departments to compete and promote voluntary innovations and initiatives if indicators for each regional office or department are introduced.

(3) Evaluation of Cost-Effectiveness

If the NRW reduction brings more tariff income than the costs of procurement of the equipment and the construction works, one can prove that the measures are financially effective. Even if the equipment for measuring leakage rates is not available, it is still possible to estimate leakage rate using bucket and stopwatch, and then estimate the financial benefit of leakage repair by multiplying the leakage volume by the unit water production cost.

Showing the cost-effectiveness is important for gaining an understanding of the executives and for

motivating the staff. In addition to direct financial benefits, NRW reduction also brings other development benefits, such as the improvement of water supply services (water service hours and water pressure) through the improvement of distribution management, postponement of the water source development to meet the future demand, and improvement of relationship with the customers based on trust.

(4) Recognition and Awards

NRW reduction activities, such as night-time leakage detection works, are often time-consuming, low-profile and thankless. Thus, it is important to make good efforts and outcomes visible to the executives for recognition of the importance of the work and for the awarding of staff.

(5) System Trainee Becomes Trainer

The introduction of a trainer certificate system could be a motivation factor. When a trainee becomes a trainer, the remaining trainees understand that they too can become trainers and motivation of the counterpart organization is improved overall. A deep understanding is needed to become a trainer so trainees may become more eager and dedicated to learning.

(6) Incentives

It is generally believed that monetary incentive is temporary, has sometimes the opposite effect if not continued, and thus, is not a good way to raise overall motivation. Nevertheless, NRW reduction activities include night works and holiday works, which may reduce the willingness of the staff to work if there is no overtime allowance or compensation day-off system. Thus, the introduction of monetary incentives, such as overtime allowance, should be considered provided that they are properly institutionalized and continued. If training in Japan is included in a project, the participants should be selected based on their performance in the NRW reduction activities. This should be informed to the candidates, as it is one of the incentives to continue the activity.

4.2.5 NRW Reduction Measures in the Pilot Area

The objective of the pilot activities is not to reduce NRW, but to identify the appropriate techniques and measures to reduce NRW at the lowest cost or the shortest time for the entire water service area, and to transfer such techniques to the counterpart for implementation. Through the pilot activities, the cost and time required for each measure, points to be considered for efficient and effective implementation, and organizational structure required to expand and continue the countermeasures, should be clarified. These results should be incorporated into the long-term NRW reduction plan.

The pilot area needs to be an area where experts and water service personnel can work safely. In order to reduce time loss, it is better if the pilot area is close to where the experts live. To ensure safety, it is advised to avoid an area where theft, unexpected accidents, or incidences of violence occur frequently. Reducing the risk of traffic accidents is also important by avoiding an area with narrow and heavily trafficked roads. An area that has many stray dogs should also be avoided.

Testing with minimum night flow method, step tests, underground leak detection, etc. should be carried out at night because water consumption is low at night. The night works should not be done if security and cooperation from the local staff are not adequate. If the conditions of security and cooperation cannot be satisfied, NRW measures that do not require night work should be prioritized. For example, underground leak detection is not useful for water utility companies that cannot provide water 24 hours a day including the night. For such water utility, training for other measures should be adopted. In principle, a pilot area should not be selected near a confidential facility, such as a military facility, because information about pipelines and customers may not be available, and there is a risk that the working staff may be deemed as suspicious and be detained.

4.2.6 Leakage Detection and Repair

- For water utility companies with a high NRW rate, the measures against visible leakage tend to be more cost-effective than the measures against underground leakage. An underground leakage under a low-pressure condition might become a sizable, visible leakage once the water pressure increases.
- Many leakages occur on household connection pipes around the joints with water distribution pipes. The importance of leak detection and repair for house connection pipes should not be overlooked.
- Leak detection and repair is a reactive approach to contain existing leakage problems. To minimize leakage at a more fundamental level, the quality of pipe installation work should be improved. This requires improvement of the technical capabilities of workers and private companies, the establishment of standards for structures and materials, and the establishment of a qualification system for private companies. These conditions have already been well established in Japan, and thus Japanese water utilities can concentrate mainly on the leak detection/repair. However, this may not be the case in many developing countries.
- Even though leakage detection/repair is implemented well, old pipes may leak again in one to two years. Replacing old pipes is a fundamental solution.

4.2.7 Measures for Apparent Loss Reduction

(1) Water Meter Accuracy Verification Method

1) Accuracy Verification Method

Water meter accuracy is often measured with a portable mechanical test meter or a high accuracy electromagnetic meter.

2) Error Tolerance

- Error tolerance of new water meters is generally ±2%. In the case of meters in use, error tolerance ranges ±5%, 7% and as high as 10%. Information about the meters should be collected so that the decision can be made. It is usually the water utility company that decides the acceptable error tolerance of water meters.
- Setting accuracy requirements too high could make a large number of meters to be unacceptable, and require them to be replaced. Considering the importance of setting accuracy requirements, it is necessary to confirm the protocol or agreement regarding how to make the decision on the acceptable range of error, and how the cost for the replacement of meters is handled.

(2) Measures for Unauthorized Water Usage

There are a number of different approaches to deal with unauthorized connections, such as establishing a penalty, or recognizing unauthorized users as customers and collecting the tariff. Poor communities sometimes use water from fire hydrants or leakages from water pipe joints. Such users do not have the ability to pay for the cost of new connections or water bills. Simply punishing these users will not solve the issue. Probably it is more sensible to engage communities to use water properly through government efforts for low-income persons, such as the installation of public taps and education for correct water use.

(3) Errors on Billing

The cause of the error and the countermeasures should be identified. If the NRW rate is high due to billing errors, it could be possible to correct the problem with almost no cost. The common causes are meter reading errors, recording errors, and inputting errors to electronic media.

4.2.8 Preparation of a Long-term NRW Reduction Plan

(1) Selection of the Measures, Securing Financial Resources, and Consistency with High-level Plan

1) Selection of measures that are sustainable and have a high possibility of further expansion

- Water utility companies that have high needs for NRW reduction are often facing financial difficulty as well. They are aware that, reduction of NRW can bring a reasonable return on investment for NRW reduction, and the investment may be recovered quickly. However, such companies often have difficulty in coming up with the initial investment. For this reason, the company cannot realize the long-term plan even if the plan is formulated in the project.
- In developing a long-term plan, thus, many options should be explored, and realistic NRW reduction measures should be selected considering the agency's technical and financial capacity. DMA construction, which requires high investment cost, is not the only option. The lessons learned in the pilot activity are expected to be applied widely to the whole service area.
- It is important to have a plan that incorporates training for the organization and individuals so that the knowledge and skills of NRW reduction measures can be properly passed on in the future.
- Easy-to-understand reports, manuals, and SOPs can facilitate the transfer of knowledge to other water utilities. However, since conditions of facilities, management capacities, and other factors are not the same, the long-term plan cannot simply be copied for other utilities. It is necessary to revise the contents in the plan to meet the local situation based on the results of the analysis of the target utility.
- Some projects have prepared an "Expansion and Development Plan" for the objective of expanding the project activities to other regions and agencies.

2) Consistency with High-level Planning

- In order to secure a budget for a project that requires large expenses, such as pipe replacement works, it is necessary to ensure consistency with other projects and plans. Securing the fund becomes difficult if it is not possible to explain clearly the significance of the proposed NRW reduction project and the position of the projects in a high-level plan.

3) Securing Financial Sources

- Whether a project can be realized or not is highly dependent on the availability of financial resources. Since operation based on water tariff revenue is an important aim of a water utility company, the operation target for revenue generation should be set.
- If an investment for facility development, such as pipe replacement or water meter procurement, is required, the possibility of obtaining funding from outside, such as subsidies from higher-level organizations, related organizations and departments, and assistance from donors, should be examined.
- When costs for necessary measures are simply added, the total cost estimate often becomes unrealistic for the target organization. Thus the measures should be proposed within the realistic budget scale, which should be estimated from relevant information, such as the realistic cost considering the scale of the water utility company, and possible amount of subsidy and assistance based on the recent trends.
- The persons responsible for the budgetary request/approval procedure should be confirmed so that the significance, return benefits, and long-term outlook of the NRW reduction plan can be explained to the responsible persons. Their understanding is paramount for securing the financial resources.

4) Target Setting and Possibility of Realization

- The water supply sector is rarely developing alone, or faster than in other sectors. It is usually developing along with overall social development. The water sector target should not be set

too ideally without considering the overall social framework.

(2) Confirmation of the Approval Procedure

Before the implementation, the plan should be formally approved by high-level decision-makers and communicated to both inside and outside the organization. Many organization have informal approval procedures such as step-by-step consensus building from the bottom up and unofficial negotiations with a person of influence. Thus, the responsible persons for such approval procedures and the process of decision making should be confirmed in advance. Development of the schedule for project approval, reporting of progress and other communication with these persons should be done considering such procedures.

The decision-making process does not always follow a simple structure like a pyramid within the organizational structure. The actual process is often more complicated. After confirming the decision-making processes with the counterpart, it is necessary to approach the persons responsible for the approval procedures (note that several people/organizations may be involved).

The following conditions are essential to get the plan approved smoothly: a strong motivation of the top manager for NRW reduction, the proof of the cost-effectiveness of NRW reduction measures based on the results of pilot activities or other works, and the plan that is convincing and is backed by knowledge and experience obtained through the pilot activities or other works.

(3) Ensuring and Supporting Execution

In order to ensure the implementation of the plan, some projects formulate the plan during the intermediate stages of the project. This way, implementation of the prioritized measures can be supported in the later stage of the project. Similarly, the plan can be formulated during Phase 1 of the project. Then, preparation for the implementation of the plan (approve the plan, establish the organization, prepare human resources, etc.) by the target organization is made a condition to start Phase 2. This makes it possible to support the implementation of the plan in Phase 2.

4.2.9 Training

As for the training of the counterparts, the trainees and organizations accepting the trainees should be selected in such a way that the effects of the training can be maximized. A single training course is not enough to have a long-term impact. In order to ensure that training is continued in a systematic manner after the completion of the project, it is advised to establish and continuously use the PDCA process for the training, to make attendance to the training mandatory by institutionalizing the training, and to update and improve the instructors, training text, and training facilities.

4.2.10 Procurement of Equipment

(1) Procurement Procedures

- Before the procurement of the equipment, review and confirm whether the equipment proposed in the proposal is appropriately based on the results of the baseline survey and capacity assessment.
- Select a supplier for procurement among candidates with proven experience and reliability.
- The time required for preparation of the specifications, shipping, transport of the equipment, etc., is often longer than expected and causes disruption or delays of project activities. It is important to allocate enough time and closely monitor and manage the progress of the procurement. An idea to reduce the risk of delay is to make a limited order in advance for materials required at the initial stage of the project. The procurement included in the consultant contract generally takes less time compared with the procurement done by JICA directly.

(2) Management of Procured Equipment

- Prepare easy to understand manuals that clearly show how to operate and maintain the equipment with photos and figures in a language that can be understood by local workers and engineers.

- The equipment should be maintained properly and stored in an appropriate environment during and after the project period in order to avoid loss, theft, or mechanical trouble.
- It is necessary to monitor the usage and condition of the equipment. The inventory of equipment should be updated regularly. Preparation of a checklist and a regular checking of the inventory are recommended.
- Because the equipment could go out of order, it is necessary to clarify in advance who takes what actions for the situation. The responsible person should be appointed, and the contact address of the local agents for equipment maintenance may be made visible on storage cabinets.

4.2.11 Progress Management of the Project

In order to implement the project smoothly, it is necessary to regularly monitor the progress of the project, and review and adjust the implementation schedule if necessary, considering the progress and the target. The JICA headquarters staff should keep in close contact with the expert team and make site visits at least once a year to understand the local situation which cannot be understood through e-mails or in writing.

(1) Key Points to be Confirmed for Progress Management by Stage

1) Commencement of Project
   - Reconfirmation of objectives and outcomes of the project, sharing of awareness among stakeholders.
   - Establishment of organizational structure for implementation.
   - Confirmation of the progress of the undertakings of the counterpart.
2) Initial Stage
   - Capacity assessment, reconfirmation of issues to be resolved.
   - Formulation of the activity plan and capacity development plan based on the results of the assessment.
   - Early mobilization of project inputs that may take a long time and have significant impacts on the progress of the project, such as procurement of equipment.
3) Intermediate Stage
   - Interim review, confirmation of progress of the project and issues to be solved.
4) Final Stage
   - Assessment of progress towards achievement of project purposes and outputs.
   - Promotion of initiatives to ensure sustainability and to contribute to overall goals.
5) End of the Project
   - The final evaluation, confirmation of achievement of project purposes and outcomes.
   - Confirmation of activities to be implemented from the final evaluation until the close of the project (usually about six months).
   - Promotion of initiatives to ensure the sustainability of the activities and achievement of overall goals.
   - Compilation of knowledge gained from the achievements and lessons learned.

(2) Flexible Revision of Plan

In technical cooperation projects, the plan and scope should change flexibly according to the changing situation, in order to achieve the objectives of the project. Both the PDM and the contract should be reviewed and adjusted flexibly as the situation changes. If changes are required, it is necessary to keep records of the reason, background, contents of the change, and comparison of before and after, so that the history of changes can be traced clearly during the final evaluation.

(3) Joint Coordinating Committee (JCC)

- The JCC has several important functions such as, to provide opportunities for common understanding of significance and outcomes of the project among the decision-makers and responsible officers of the projects and other stakeholders, to request necessary actions for the undertakings of the counterpart, to get support for implementation of the project from them, and to encourage counterpart's self-motivated efforts and initiatives based on the sense of their project ownership.
- It is necessary to consider how to organize the JCC, such as, to request high-level managers to attend, to invite media to provide publicity opportunities, and to let the counterparts manage the meeting. These are expected to increase the motivation of the counterpart members.
- The benefits of NRW reduction activities should be presented in an easily understandable manner with numerical indicators, such as reduced NRW rates and the financial indicators of saving water. By using such figures and graphs, the attendees of the JCC can easily understand the effectiveness of the project.
- The JCC should be used as a place to monitor the overall progress of project implementation. The typical monitoring items are the following: progress of the project, problems, outcomes, expectation of achievement of project purposes, and necessary actions to achieve the overall goals. The JCC is the place to discuss and reconfirm the targets of the project and the progress to achieve the targets based on the PDM. A JCC is not just held to present the results of the activities.

(4) Publicity

- Publicity of the project is an important activity to let local residents in the counterpart country know about Japan's cooperation activities, and also let Japanese taxpayers recognize the outcomes and effectiveness of the ODA project.
- In the case of NRW reduction projects, publicity plays a major role to get cooperation from the residents in reporting water leaks, reporting water theft, paying water bills, and getting support for managing water meters appropriately. Furthermore, if awareness is raised through publicity, the motivation of counterparts will improve, and it becomes easier to receive support from higher-level organizations and executives.

4.3 Points Regarding the Supervision of the Financial Cooperation Projects

This section discusses important points for supervising a financial cooperation project for NRW reduction, especially in the following three components that strongly affect NRW reduction: 1) the replacement of pipes, 2) installation and replacement of meters, and 3) introduction of SCADA.

4.3.1 General Considerations

In the case of financial cooperation projects, it is important to monitor the effective usage of the facilities, improvement of performance and the generation of impacts after the completion of the project. Since the target water utility company has the responsibility for the operation after project completion, a follow-up mechanism for the target organization should be established before the completion of the project.

The schedule is often delayed and the scope is changed due to unsuccessful bidding or design modification. If a project is planned to be implemented in cooperation with another project, changes in one project will have an impact on the other. Since many departments of JICA are involved in many projects, the information should be shared in a timely manner.

Quality control and inspection of construction works are also necessary because the quality of the facility construction affects the operation, water distribution management, and leakages after the completion of the project.

4.3.2 Pipe Replacement

(1) Confirmation of the Overall Plan

1) Basic Policy of Design

"The Design Criteria for Water Supply Facilities" issued by the Japan Waterworks Association (JWWA) can be used as a reference for the design of water supply facilities. However, these are just "guidelines" and are not absolute requirements even in Japan. In developing countries, the national government, local government or a water utility company sometimes have their own guidelines. In such cases, both the Japanese and local guidelines should be referred to. The Japanese guidelines may be used to supplement the insufficiencies of the local guidelines for design works. The design should be examined carefully based on the details of the local conditions, keeping the Japanese guidelines in mind.

2) Restructuring of the Pipeline Network

When replacing pipes for NRW reduction, it is effective to establish water distribution blocks or DMAs, and restructure the pipeline network in order to control the water pressure to remain within an appropriate range.

3) Pipe Diameter

When a pipe network is developed in a large area under the financial cooperation project, the contracted consultant should re-confirm whether the design, such as pipe sizes, etc., are suitable for proper water supply under the appropriate water pressure and flow. Pipe sizes should be determined after pipe network calculations. For the calculation, the coefficient of velocity is set for each pipe size and each material. The coefficient affects the required pipe sizes and may have an impact on the project costs. If the pipe size is inappropriate, water pressure may increase, leading to an increase of water leakage.

(2) Confirmation of Materials and Equipment

- Pipe material (ductile iron, steel, PVC, PE resin, etc) should be selected to meet the site and usage conditions.
  - ✧ The site conditions include earth covering, groundwater level, traffic on the roads, soil type, conditions of soft ground such as filled ground, tunnels, and other factors.
  - ✧ The usage conditions include flowing water volume, pressure, etc., in the pipes.
  - ✧ Asbestos concrete pipes should never be used because it is easily broken and has a health risk.
- Construction machinery and equipment should be checked in terms of safety, proper maintenance, and appropriate size for the construction scale.
- Fitting equipment should be suitable for the pipe type, pipe diameter, and the joint.
- As for construction materials such as backfill material, pavement material, and concrete, it is necessary to confirm whether the materials meet the standards and that they are approved by the water utility company. Backfill materials require special attention. If stones are included in the backfill soil for pipe installation, it will damage the pipes and lead to leakage. Pipes must be backfilled with good quality soil and sand.
- During the construction of roads, water pipes are sometimes damaged by the operations of heavy machinery. This results in serious water leakages. To avoid such accidents for important pipes, it is necessary to consider the installation of an underground warning sheet 30 cm to 60 cm above the top of the pipes under the ground.

(3) Construction

- Construction supervisors and workers should have enough skills, knowledge and qualifications appropriate for the type and scale of the construction works.

- If the specifications state that pipes and fittings can only be used after passing inspection, it is necessary to make sure that the inspections are done before the installation. The products which do not meet the requirements of pressure resistance and/or without certification of qualities could cause serious water leakage.
- It is necessary to confirm if the construction procedures are appropriate and whether the types of construction equipment and machines are selected properly as recommended by the manufacturer. As for tube cutter in particular, if the type of the cutter is not selected properly for each pipe material, it will cause accidents or lower the quality of pipe cutting sections, leading to water leakage.
- Soil or other materials should not be put in the pipes during construction.
- After the pipe installation, it is necessary to conduct a water pressure test as requested by the water utility company in order to confirm if there is a water leakage of the pipes or pipe fittings.

(4) Data Management

- Detailed design drawings for pipe installation work, including built drawings, location data of each valve, etc., should be recorded and submitted in a predetermined format. In developing countries, drawings of pipes are often missing or inaccurate, and this causes problems for the management works of pipe networks. For example, during the implementation of hydrological isolation of a water service block as part of an NRW reduction project, the progress of the works will be delayed significantly if the exact pipe location could not be identified. These drawings should be organized properly in the water utility company, so that necessary information could be found at any time. If GIS is adopted, construction data should be accurately reflected in the GIS. In addition, if any errors are found in the existing pipe data at the sites during construction works, these errors and information should be transferred immediately to the GIS section in the water utility, so that the GIS data can be corrected.

4.3.3 Meter Installation and Replacement

(1) General Considerations

- In Japan, water meters are installed for each user, and the tariff is collected by a meter-rate charge system based on the volume of usage. In developing countries, a flat-rate charge system is also adopted by many water utilities. If the meter-rate charge system is adopted and residents accept such a system, the installation and/or replacement of water meters in a financial cooperation project will have a great impact on establishing a suitable tariff charge and collection system based on the meter-rate charge system. However, before deciding whether to install meters and to adopt a meter-rate charge system, it is necessary to consider what are the benefits of meter installation and whether the meters should be installed. If the result of evaluation supports the installation of meters, then, a management system should be established to carry out the detailed inspection of meter installations, regular replacement of meters, inspections of meter accuracy, early detection and replacement of defective meters, etc.. Otherwise, the accuracy of the installed meters can be easily compromised. In order to establish such a system, the soft component to address these issues may be added to the financial cooperation project. A technical cooperation project to follow up on the meter installation is also effective. If the metered-rate charge system has not been adopted, and the residents prefer a flat-rate charge system or free water supply system, it is not easy to transfer to the metered-rate charge system. If a successful transition to the metered-rate charge system is to be sought, having only a financial cooperation project with a soft component is not enough. It will require a more comprehensive approach, such as the inclusion of assistance for awareness building activities and institutional development by a technical cooperation project.
- Understanding of residents is essential for the introduction of a metered-rate charge system. To install customer meters at the locations where reading a meter is easy and to prevent intentional meter breaking (vandalism), public relations activities are required.

(2) Data Management

- Information, such as the number of meters installed, the serial number of the meters, list of customers, and detailed drawings of pipe installation, should be recorded, submitted, and stored appropriately in the water utility. Information on the meters installed should be accurately reflected in the customer ledger and GIS mapping.

4.3.4 SCADA

(1) General Considerations

- A SCADA system including its installation and construction is expensive. Therefore, before the introduction, the cost-effectiveness and operation method/system of the SCADA to be introduced should be analyzed fully.
- Monitoring systems such as SCADA demand capacities of the organization (including staff capacity) to analyze and use data for the improvement of the operation and maintenance. Thus, it is advised to consider follow-up activities to strengthen such capacities through soft components or a subsequent technical cooperation project.
- Sensors need to be installed in pipes. However, the pipe information is often inaccurate, and the actual pipe conditions are different from the existing information. This is often discovered during the excavation of pipes. In such cases, the design should be modified flexibly during the construction stage.

(2) SCADA Equipment

- The SCADA system generally collects data on water flow, water pressure and water quality (mostly, residual chlorine). Water quality sensors are expensive and can increase the equipment cost. In addition, many water utilities cannot perform advanced water quality management that requires constant monitoring with SCADA, and they often require only regular residual chlorine monitoring at water taps. In many cases, only water flow and water pressure sensors are required at the initial stage. Thus, whether the required data collection system is appropriate or not should be verified.
- For selecting the equipment, another site study should be conducted, and the design specification should be re-evaluated and re-confirmed. Power availability, the occurrence of power failures, availability of wireless data transfer channels (for wireless communication), the suitability of telephone line for data transfer (for wired communication), and data transmission costs, should be considered for the decision. The required data volume is highly dependent on the frequency of data collection. If external facilities such as telephone lines are proposed for data transfer, the frequency of data collection should be considered, since data transfer cost may be too expensive. Technologies of electronic devices are devolving on a daily basis, and data could be sent to mobile phones for emergency purposes. It should be considered carefully on how far the functions of SCADA should be used in the system.

(3) Construction Works

1) Technical level of contractors

Same as mentioned in 4.3.2 (3) for pipe replacement.

2) Delivery and installation of equipment

If one contractor procures and the other contractor installs the equipment, the responsibility of each contractor becomes ambiguous and when a problem occurs, it may take a long time to solve. It is desirable that the same contractor procures and installs the equipment.

3) Quality control

It is always necessary to confirm whether the data is collected and transmitted properly in each process such as sensor, logger, data transmitter, receiver, data collector, and analyzer. How to deal with missing data should be considered. A manual for daily maintenance works and data collection/analysis should be prepared for the counterpart organization.

4.4 Points on Follow-up Activities after Project Completion

The ex-post evaluation should focus on the outcomes of the project, state of the utilization of the technologies and techniques introduced by the project, the sustainability of the activities carried out in the project, and any ripple effects (impacts) such as expansion and development of the activities after completion of the project. In addition to ex-post evaluation, monitoring and encouragement of further activities are occasionally required in order to ensure the continuity and expansion of the outcomes of the project. The worst situation after the completion of the project is that the budget allocation and personnel allocation are stopped for the activities and the equipment introduced is no longer in use. In such a case, the causes and the measures to put the activities back on track should be evaluated. The points on follow-up activities after the completion of the project are described below.

- Evaluate the effects of the NRW reduction project, from the viewpoints of not only the water utility company, but also from the water user, particularly on the improvement of the water services.
- Conduct interview surveys and data collection on the changes of NRW rate after completion of the project, the statuses of indicators of the program, implementation of NRW reduction measures, utilization of the project deliverables. These data are used for the evaluation.
- If the proposed activities are no longer implemented as planned, it is important to analyze the causes of the problems thoroughly and propose possible countermeasures to address them.
- After project completion, the target water utility company is expected to continue the activities toward the overall goals (or the targets of the program). This point should be emphasized repeatedly to increase awareness of the counterpart organization. To confirm the statuses of the overall goals, it is necessary to confirm the targets and achievements of the long-term plan and annual plans.
- In order to consider how the project could be sustained and expanded further, visit and inspect similar ongoing projects if there are such projects in neighboring countries or nearby water utilities. By having a continuous relationship with other water utilities that share similar experiences, it becomes possible to obtain information useful for the evaluation of the target water utility company. Holding a periodical forum is a good approach to get in touch with other utility companies. They can give presentations on their activities. Such an opportunity give the counterpart organization motivation as they have to present their activities, and also pressure to continue their activities even after completion of the projects.
- If a project has achieved remarkable outcomes, the outcomes should be reported to the central government and other donors or at international conferences. It will raise the motivation of related parties, and raise the awareness of the counterpart organization to further improve its performance.

Appendix：International Discussion on Non-Revenue Water Reduction

(1) Performance-based Contract (PBC)

Performance-based Contract (PBC) is a type of contract, in which the client and the contractor discuss the work contents and numerical targets as the indicators of achievement of the contract contents, and the payment is made based on the degree of achievement. The IWA and the World Bank are leading projects of this form, and attempts are being made to share the lessons that they have learned.
In a PBC for NRW management, the reduction of apparent and real water loss (number of customer meters installed, rate of water revenue increase, accounts due rate, number of repaired leaks, water leakage rate, number of people with 24 hours water supply) become the indicators. The amount to be paid is set according to the achievement of each indicator. Thus, the contractor strives to achieve the target value in order to obtain more rewards, and the water utility can reduce NRW by mobilizing the private sector's technical expertise as much as possible.
There are different types of PBC contracts, such as ones that cover a comprehensive NRW reduction, and special contracts that cover only leak detection and repair or only the accuracy control of meters for large customers. It is important to note that a contract for a comprehensive NRW reduction tends to be complicated as the contents of the contract and monitoring of performance become complex, and so as the contract design and supervision. Many organizations are interested in NRW reduction with a PBC as there is a high need for NRW countermeasures. However, a comprehensive NRW reduction with a PBC contract requires a certain capacity of monitoring NRW, and without the monitoring capacity, it is impossible to manage the PBC contract. In this regard, a specialized PBC contract targeting only a part of NRW reduction measures, such as meter accuracy control for large customers, is easier to design a contract that does not require a high level of performance monitoring, and thus easier to introduce in water utilities in developing countries.

(2) 24/7 Water Supply from Intermittent Water Supply

Intermittent water supply means that the water supply is less than 24 hours per day and is not continuous. This forces the residents to regularly store the necessary water in underground tanks or outdoor tanks.

The causes of intermittent water supply are often complex and convoluted, including lack of water sources as well as increased water leakage at night when water usage is low and the water pressure in the pipe rises, which occurs especially when 24/7 water supply is introduced.

For this reason, the IWA has established a specialist group on intermittent water supply and is studying the issues and countermeasures. Donors such as the World Bank and Asian Development Bank are also working on projects to eliminate intermittent water supply.

Eliminating intermittent water supply and shifting to a 24/7 water supply service will allow customers to directly feel the improvement in water service quality. In addition, it will lead to an improvement in the collection rate for water tariffs.

A 24/7 water supply project entails the same activities as NRW reduction measures, such as reducing water leakage by renewing old pipes, thoroughly repairing water leakage, and preventing unnecessary water use by shifting from a flat rate charge to a metered charge. Reducing NRW is often difficult to maintain motivation because the focus of the attention is the benefit of the water utility company. However, the goal of achieving a 24/7 water supply is easier to get support from citizens and politicians, as the improvement is intuitive to the residents. In addition, it can also increase motivation within the water supply utilities, since the benefit is visible and easy-to-understand.

(3) Establishment of District Metered Area (DMA)

The District Metered Area or District Metering Area (DMA) is a method of tackling NRW problems from the hydraulic blocks with a large amount of NRW. Hydraulic blocks of DMA are created by dividing the water supply area managed by a water utility company into small blocks (IWA recommends 500-3,000 connections), and a flow meter is installed at the entrance of each block to monitor flow.
The establishment of DMA is one of the most common measures in the NRW reduction menu. The "Manager's Non-revenue Water Handbook for Africa" (2010) developed jointly by USAID and the World Bank describes it a "Best Practice" and also elaborates on the DMA establishment standards and methods.
DMA is the hydraulic separation of the entire water supply area into smaller areas. Pilot projects that have been implemented in JICA's technical cooperation projects, such as "building of a few hydraulically separated small blocks" are sometimes referred to as "DMA construction". However, it should be called "Pilot Area" because the original meaning of DMA is subdivisions of the entire water supply area into small blocks metered with flow meters.

(4) Relation between NRW Management and SDGs

The United Nations lists 17 goals and 169 targets to be achieved by 2030 as "Sustainable Development Goals (SDGs)".
Measures for NRW are related to the following targets.

[Goal 6]
Ensure availability and sustainable management of water and sanitation for all.

[Target 6.4] Water Use and Scarcity
By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

Reducing leakage out of NRW is an activity that contributes to efficient water use required by Target 6.4, as underlined above.

[Target 6.1] Drinking Water
By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

Improving the management of water utilities through the NRW reduction will lead to the generation of funds necessary for the expansion of water supply services and the improvement of service levels by water utilities. In addition, reducing water leakage contributes to the improvement of the quality of tap water reaching the faucet. Reducing water loss by reducing NRW leads to keep water tariffs at a reasonable and affordable level.

Reference Materials

(1) List of NRW Projects by Region

Table R1.1 List of Non-Revenue Water Related Projects (Asia)

No.	Country/Region	Project Name	Scheme	Year※
1	India	Bisalpur Jaipur Water Supply Project (Transfer System)	Yen Loan	2004-2013
2		Capacity Development Project for Non-Revenue Water Reduction in Jaipur	Technical Assistance for Loan Project	2013-2017
3		The Assistance related to Delhi Water Supply Improvement Project	Technical Cooperation	2013-2018
4		Delhi Water Supply Improvement Project	Yen Loan	2012-2021
5		Capacity Development Project for Non-Revenue Water Reduction in Goa	Technical Assistance for Loan Project	2011-2014
6		Goa Water Supply and Sewerage Project	Yen Loan	2007-2014
7		Bangalore Water Supply and Sewerage Project	Yen Loan	1996-2005
8		Bangalore Water Supply and Sewerage Project (II-1)	Yen Loan	2005-2013
		Bangalore Water Supply and Sewerage Project (II-2)	Yen Loan	2006-2013
9		Agra Water Supply Project	Yen Loan	2007-2014
		Agra Water Supply Project (II)	Yen Loan	2014-2017
10		Guwahati Water Supply Project	Yen Loan	2009-2017
11		Kerala Water Supply Project	Yen Loan	1997-2010
12	Indonesia	Jakarta Water Supply Distribution Pipeline Project	Yen Loan	1990-1997
13		The Project for Water Supply Service Improvement in the Mamminasata Metropolitan Area	Technical Assistance for Loan Project	2009-2012
14		The Project on Strengthening COE（Center of Excellence）Program for PDAMs in the Republic of Indonesia	Technical Cooperation	2015-2018
15		Ujung Pandang Water Supply Development Project	Yen Loan	1993-2002
16		Jakarta Water Supply Development Project (Phase 2)	Yen Loan	1985-1995
17		Technologies for Operation & Maintenance of Distribution Pipelines, Utilizing Water Leakage Detection Focused on Resin Pipes	Dissemination / Verification	2013-2015
18	Cambodia	The Project for Improvement of Water Supply System in Siem Reap Town	Grant Aid	2004-2006
19		Project on Capacity Building for Urban Water Supply System in Cambodia	Technical Cooperation	2003-2006
		Project on Capacity Building for Urban Water Supply System in Cambodia (Phase 2)	Technical Cooperation	2007-2011
		Project on Capacity Building for Urban Water Supply System in Cambodia (Phase 3)	Technical Cooperation	2012-2017
20		Siem Reap Water Supply Expansion Project	Yen Loan	2012-2018
21		The Project for Replacement and Expansion of Water Distribution Systems in Provincial Capitals	Grant Aid	2011-2013
22		Development Study on Re-Master Plan of Phnom Penh Water Supply System	Master Plan	1993

No.	Country/Region	Project Name	Scheme	Year※
		Development Study on Re-Master Plan of Phnom Penh Water Supply System (Phase 2)	Master Plan	2004-2006
23		Re-Master Plan of Phnom Penh Water Supply System	Grant Aid	1993-1994
24		Project for improvement of water supply facilities in Phnom Penh, (phase 2)	Grant Aid	1997-1999
25		Project for Improvement of Management Capacity of Water Supply Facility in Siem Reap City	Partnership Program	2013-2015
26	Sri Lanka	The Capacity Development Project for Non Revenue Water (NRW) Reduction in Colombo City	Technical Cooperation	2009-2012
27		The Project for Enhancement of Operational Efficiency and Asset Management Capacity of Regional Support Center-Western South of NWSDB	Technical Cooperation	2018-2021
28		Verification survey with the private sector for disseminating Japanese technologies for non-revenue water reduction program	Dissemination /Verification	2015-2017
29		Dispatching lecturer of follow-up seminar in group study "non-revenue water reduction in water supply system"	Other	2013-2014
30		"Project for Strengthening construction supervision of water pipe" (Project for strengthening design and construction supervision of water supply facilities)	Partnership Program	2014-2017
31		The Project for Improvement of Water Supply System in Matara District	Grant Aid	2003-2006
32		Towns North of Colombo Water Supply Project	Yen Loan	1996-2007
33		Greater Kandy Water Supply Project	Yen Loan	2001-2008
34		Eastern Province Water Supply Development Project	Yen Loan	2010-2013
35	Thailand	Networks System Improvement Project	Yen Loan	1993-2001
36		Seventh Bangkok Water Supply Improvement Project (I)	Yen Loan	1999-2006
		Seventh Bangkok Water Supply Improvement Project (II)	Yen Loan	2000-2013
		Eighth Bangkok Water Supply Improvement Project	Yen Loan	2009-2014
37		Study on Distribution Pipe Maintenance Work collaborated with Provincial Waterworks Authority (PWA)	Study	2014
38	Tajikistan	The Project for Strengthening the Water Service Management of Pyanj and Khamadoni Vodokanals	Technical Cooperation	2017-2020
39	Pakistan	The project for water supply, sewerage and drainage master plan of Faisalabad	Technical Cooperation	2016-2019
40	Bangladesh	The Project for Advancing NRW reduction Initiative (PANI) of Chittagong WASA	Technical Cooperation	2009-2014
41		Project for Advancing Improvement of Chittagong Water Supply and Sewage (CWASA) and NRW Reduction	Technical Assistance for Loan Project	2014-2017
42		Karnaphuli Water Supply Project	Yen Loan	2006-2010
		Karnaphuli Water Supply Project (Phase 2)	Yen Loan	2013-2021
43	Philippines	Water Supply Operation and Management for Metropolitan Cebu Water District	Technical Cooperation	2012-2013
44		The Project for the Improvement of Water Supply System in Metropolitan Cebu Water District	Grant Aid	2014-2016
45		The Project for Improvement of Water Quality in Local Areas	Grant Aid	2002-2005
46		Provincial Cities Water Supply and Sewerage Improvement and Expansion Project (Iquitos, Cusco and Sicuani) (Phase III, IV, V)	Yen Loan	1994-2005
47	Vietnam	The Project on Capacity Development for Urban Water Supply Utilities in the Central Region	Technical Cooperation	2010-2013
48		NRW（Non-Revenue Water）Reduction Technology Training and Capacity Building Project in Hanoi	Partnership Program	2016-2019

No.	Country/Region	Project Name	Scheme	Year※
49		Improvement of HPWSCO's Capacity on Distribution Network Management	Partnership Program	2013-2016
50		JICA Partnership Program for Vietnam-Yokohama Safety Water Supply Management Project	Partnership Program	2014-2016
51	Malaysia	NRW（Non-Revenue Water）Reduction Technology Training and Capacity Building Project in Malaysia	Partnership Program	2014-2016
52	Myanmar	The Project for Improvement of Water Supply Management of Yangon City Development Committee（YCDC）	Technical Cooperation	2015-2020
53		The Project for Urgent Improvement of Water Supply System in Yangon City	Grant Aid	2013-2015
54		Greater Yangon Water Supply Improvement Project	Yen Loan	2014-2021
		Greater Yangon Water Supply Improvement Project (Phase 2)	Yen Loan	2017-2026
55		The Project for Improvement of Water Supply System in Mandalay City	Grant Aid	2015-2018
56	Laos	Project for Capacity Development of Urban Water Supply Authorities in the Lao PDR	Technical Cooperation	2003-2006
57		The Project for the Vientiane Water Supply Development	Grant Aid	2006-2009
39		Capacity Development Project for Improvement of Management Ability of Water Supply Authorities	Technical Cooperation	2012-2017

※For projects that have not been completed, the scheduled end year is indicated. (As of December 2018) In addition, for ODA loan projects, from the year when the Loan Agreement (L / A) was signed to the year when the loan was completed, for grant aid projects, the year when the Grant Agreement (G / A) was signed The project completion year is indicated. Table R1.2 to Table R1.7 are likewise.

Source: Project Research Team

Table R1.2 List of Non-Revenue Water Related Projects (Oceania)

No.	Country/Region	Project Name	Scheme	Year
59	Samoa	Capacity Enhancement Project for Samoa Water Authority in Cooperation with Okinawa	Technical Cooperation	2014-2019
60		The Project for Improvement of Urban Untreated Water Supply Schemes	Grant Aid	2014-2016
61		Waterworks Operation Assistance to the Samoan Water Authority (Miyakojima Model)	Partnership Program	2010-2012
62	Solomon Islands	The Project for Improvement of Non Revenue Water Reduction Capacity for Solomon Islands Water Authority	Technical Cooperation	2012-2016
63	Palau	The Project for Improvement of Water Supply System	Grant Aid	2015-2017
64	Fiji	Nadi-Lautoka Regional Water Supply Project	Yen Loan	1998-2004
65		Project to Support Reduction of Non-Revenue Water on Nadi/Lautoka Regional Supply	Partnership Program	2014-2017

Source: Project Research Team

Table R1.3 List of Non-Revenue Water Related Projects (Middle East & North Africa)

No.	Country/Region	Project Name	Scheme	Year
66	Egypt	The Project for Improvement of Water Supply System at the Northern Pyramids Aria in Giza City	Grant Aid	2003-2005
67		The Project for Water Supply Development in Northwestern Part of Sharqiya Governorate	Grant Aid	2004-2007
68		The Project for Improvement of Management Capacity of Operation and Maintenance for SHAPWASCO	Technical Cooperation	2006-2009
69		The Project for Improvement of Management Capacity of Operation and Maintenance for Water Supply Facilities in Nile Delta Area	Technical Cooperation	2011-2014
70	Palestine	The Project for Strengthening the Capacity of Water Service Management in Jenin Municipality	Technical Cooperation	2017-2020
71	Jordan	Capacity Development Project for Non-Revenue Water Reduction in Jordan Phase 1	Technical Cooperation	2005-2008

No.	Country/Region	Project Name	Scheme	Year
72		Capacity Development Project for Non-Revenue Water Reduction in Jordan Phase 2	Technical Cooperation	2009-2011
73		The Project for Improvement of the Water Supply System for the Zarqa District (Phase I)	Grant Aid	2002-2004
		The Project for Improvement of the Water Supply System for the Zarqa District (Phase II)	Grant Aid	2003-2005
74		The Project for Improvement of the Water Supply for the Zarqa District (Phase 2)	Grant Aid	2006-2010
75		The Project for the Improvement and Expansion of the Water Supply Networks in North／Middle Jordan Valley	Grant Aid	2005-2008
76		The Project for Rehabilitation and Expansion of the Water Networks in Balqa Governorate	Grant Aid	2014-2017
77		The Project for Rehabilitation and Improvement of Water Facilities in Tafieleh Governorate	Grant Aid	2011-2013
78		Project for Energy Conservation through Upgrading Water Supply Network in the Hashemite Kingdom of Jordan	Grant Aid	2010-2013

Source: Project Research Team

Table R1.4 List of Non-Revenue Water Related Projects (Africa)

No.	Country/Region	Project Name	Scheme	Year
79	Kenya	The Project for Augmentation of Water Supply System in Kapsabet Town	Grant Aid	2009-2011
80		The Project for Management of Non-Revenue Water in Kenya	Technical Cooperation	2010-2014
81		The Project for Strengthening Capacity in Non-Revenue Water Reduction	Technical Cooperation	2016-2021
82		The Meru Water Supply Project (Phase I)	Grant Aid	2001-2003
		The Meru Water Supply Project	Grant Aid	2003-2004
83		Greater Nakuru Water Supply Project	Yen Loan	1987-1994
84		The Project for Augmentation of Water Supply System in Narok	Grant Aid	2013-2016
85		The Project for Improvement of the Water Supply System in Embu and the Surrounding Area	Grant Aid	2010-2013
86	Tanzania	Project for Enhancement of Water Supply Management of Zanzibar Water Supply Authority (Phase 1, Phase 2)	Technical Cooperation	2008-2015
87	Nigeria	Federal Capital Territory Reduction of Non-Revenue Water Project	Technical Cooperation	2014-2018
88	Rwanda	Project for Strengthening Non-Revenue Water Control in Kigali City Water Network	Technical Cooperation	2016-2020

Source: Project Research Team

Table R1.5 List of Non-Revenue Water Related Projects (South America)

No.	Country/Region	Project Name	Scheme	Year
89	Ecuador	Project for Improvement of Water Supply System in Ibarra City El Proyecto para el Mejoramiento del Sistema de Agua Potable para el Cantón Ibarra	Grant Aid	2005-2008
90		Project for Improvement of Water Supply System for Cities of Huaquillas and Arenillas Proyecto para el Mejoramiento del Sistema de Agua Potable para las Ciudades de Huaquillas y Arenillas	Grant Aid	2006-2009
91	Brazil	The Project for Capacity Development on Non-Revenue Water Control for Sanitation Company of the State of Sao Paulo (SABESP)	Technical Cooperation	2006-2010
92		Non-Revenue Water Control Project in Sao Paulo State	Yen Loan	2012-2016
93	Paraguay	Asuncion Metropolitan Area Portable Water Project	Yen Loan	1995-2002
94		Project for Capacity Development of Distribution Network Management of ESSAP	Technical Cooperation	2011-2014
95	Peru	Project for Capacity Strengthening for Non-Revenue Water of SEDAPAL	Technical Cooperation	2012-2015
95 96		North Lima Metropoli Water Supply and Sewerage Optimization (I)	Yen Loan	2009-2013

No.	Country/Region	Project Name	Scheme	Year
		North Lima Metropoli Water Supply and Sewerage Optimization (II)	Yen Loan	2013-2018
97		Lima Marginal Areas Sanitary Improvement Project (I), (II)	Yen Loan	2000-2012
98		Lima-Callao Metropolitan Area Water Supply & Sewerage Improvement Project	Yen Loan	1995-2006
99		Provincial Cities Water Supply and Sewerage Improvement and Expansion Project (Iquitos, Cusco and Sicuani)	Yen Loan	2000-2013

Source: Project Research Team

Table R1.6 List of Non-Revenue Water Related Projects (Central America)

No.	Country/Region	Project Name	Scheme	Year
100	El Salvador	Capacity Development Project for the Operational Improvement of ANDA	Technical Cooperation	2009-2011
101	Guatemala	Quetzaltenango Municipality Urban Area Drinking Water Supply Project	Grant Aid	2004-2007
102	Nicaragua	Project for Strengthening Non-Revenue Water Management Capacity in Managua City	Technical Cooperation	2017-2020
103	Honduras	Tegucigalpa Urgent Water Supply Project	Grant Aid	2007-2010
104		Water Supply Facility Restoration Project in Tegucigalpa City	Grant Aid	2000-2004
105		The Project for Improvement and Extension of Water Supply System in Comayagua City	Grant Aid	2017-2020

Source: Project Research Team

Table R1.7 List of Non-Revenue Water Related Projects (Europe)

No.	Country/Region	Project Name	Scheme	Year
106	Montenegro	The Project for Urgent Rehabilitation of Water Supply System in the Capital City of Podgorica	Grant Aid	2010-2011
107	Serbia	The Project for the Improvement of Water Supply System in Belgrade City	Grant Aid	2005-2008

Source: Project Research Team

The following countries (projects) were not included in the target countries but the post-evaluation reports and other documents of the projects were referenced for the further analysis on lessons learned from NRW related projects by grant aid and loan projects.

Table R1.8 List of Non-Revenue Water Related Projects (Supplement)

No.	Country/Region	Project Name	Scheme	Year
1	Morocco	Water Supply Improvement Project	Yen Loan	1995-2002
2	Costa Rica	Urban Potable Water Supply Project	Yen Loan	1993-2001
3	Jamaica	Montego Bay Water Supply (Great River) Project	Yen Loan	1988-1997

Source: Project Research Team

(2) Equipment List

1) Survey Equipment

a) Equipment for Physical Loss (Leakage) Investigation

The main set of equipment used to investigate physical loss is described below.

Table R2.1 Survey Methods and Equipment (Physical Loss Investigation)

Equipment list by investigation method		Method											
		Surface Leakage survey	Manhole Survey	Door-to-door Listening Survey	Valve Listening Survey	Road surface listening survey	Leakage location confirmation survey	Leak noise correlator Survey	Flow Measurement	Pressure Measurement	Pipe Detection Survey	Valve Detection Survey	Tracer Gas Leak Survey
Equipment	Flow Meter (portable type/fixed type)								○				
	Water Pressure Gauge (Self-recording type)									○			
	Listening Stick			○	○		○						
	Electronic Listening Stick			○	○								
	Leak Detector					○	○						
	Noise Correlation Leak Detector							○					
	Logger type multi-point leakage detector							○					
	Generator, Hammer Drill, Boring Bar						○						
	Residual Chlorine Analyzer	○	○										
	Metal Pipe Detector										○		
	Non-metal Pipe Detector										○		
	Metal Detector											○	
	Gas Tracer/detector												○

Source: Project Research Team

b) Commercial Loss Investigation Equipment

Equipment used to investigate commercial loss (apparent loss) is summarized in Table R2.2.

Table R2.2 Survey Methods and Equipment (Commercial Loss Investigation)

Equipment list by investigation method		Method	
		Theft Survey	Meter Accuracy Survey
	Water Leak Survey Equipment	○	
	Test Meter		○
	Test Bench		○

Source: Project Research Team

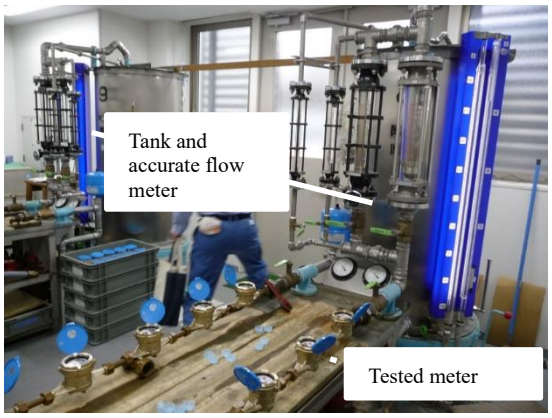

Figure R2.2 Test Bench for Meter Accurary Survey

2) Equipment Procured in JICA Projects

A wide variety of equipment has been procured in past technical cooperation projects. A list of equipment that has been successfully procured 5 to 10 times is given below. In selecting equipment for surveys, there is no single correct answer. It is important to select equipment that suits the purpose and local conditions.

Table R2.3 Procured Equipment

No.	Item	Usage
1	Flow Meter (Portable type/Fixed type)	For measuring water flow rate inside distribution pipes. Two main types exist. Portable types (ultrasonic types) are installed on the outside of distribution pipes. Fixed types (electromagnetic and mechanical types) are inserted and installed inside of the pipe. Portable types do not require special construction and are easy to install and uninstall. Fixed types require construction but are more accurate.
2	Pressure Gauge (Self-recording type)	For measuring pressure in pipes. When the pressure of the water applies force to the detection mechanism, the force applied is displayed as pressure.
3	Listening Stick	This is a type of stethoscope with a diaphragm attached to the end of a brass rod, without electronic amplification. It is used to investigate the presence or absence of water leaks by directly contacting the tip of the rod to water meters, pipes or accessories. Noise caused by leaks resonates through the rod and is transmitted to the ear via the diaphragm. A certain level of skill is needed to distinguish leakage noise from other noises.
4	Electronic Listening Stick	Same as a regular listening stick but with electronic amplification of noise. Very slight leakage noises can be amplified and detected. Less skill is needed for leakage detection.
5	Leak Detector	Consists of the main body, pickup, headphones and remote-control unit. The pickup is placed on the ground surface and detects leakage vibration noises. The signal is amplified in the main body and sent to the headphones. The pickup is moved to the point where leakage sound is greatest to determine leakage location.
6	Non-metal pipe (resin pipe) leak detector	Uses electromagnetic induction to search for resin pipes and leak locations. Since it is an electromagnetic induction type detector, it is possible to detect pipes and leaks without interference from water pressure or ambient noise.
7	Time Integration Type Leak Detector	The continuous noise of water leakage and ambient noise are distinguished by the time integration rate and presence or absence of nearby water leakage is determined.
8	Noise correlation leak detector	Leakage noise is detected by sensors installed at two locations on a span of pipe that includes the leakage point. Detected noise is analyzed by the correlator to determine the leakage location, displayed as a peak waveform on the monitor.
9	Logger type multi-point leakage detector	Multi-point leakage detectors are installed on pipes and leakage noises are detected. This device differs from the noise correlation leak detector in that it detects the presence or absence of leaks only.
10	Generator, Hammer Drill, Boring Bar	The generator powers the hammer drill in the field. By drilling through road surfaces, inserting the boring bar deep into the ground and attaching the pickup of the leak detector to the boring bar, leakage noise from deeply buried pipes can be detected.
11	Residual Chlorine Analyzer	Measure for the presence of residual chlorine in water appearing on the ground. Residual chlorine indicates that the water is tap water and confirms nearby leakage. Tap water can also be determined by examining water temperature, conductivity, pH, trihalomethane, etc.
12	Metal Pipe Detector	A high-frequency current is transmitted through a buried pipeline to induce a magnetic field in the pipeline. The equipment detects the location of the pipe by receiving this magnetic field. When detection conditions are good, detection distance of up to 200 m from the transmitter is possible.
13	Non-metal Pipe Detector	For detecting non-metallic pipes buried in the ground. Electromagnetic induction type, sound wave type, vibration type (tapping/pinging type) are available.
14	Metal Detector	For verifying the position of valves and fire hydrants underground. The equipment uses electromagnetic induction to detect the presence of metal buried underground.
15	Gas Tracer/detector	Water diffused with inert gas is pumped into the water distribution system from a fire hydrant or spigot using a special attachment. When water containing the inert gas leaks from a pipe, the water and gas separate. The gas permeates the soil and pavement layers and can be detected by an analyzer. Leakage location can be elucidated.
16	Test meter	For verifying the performance of installed water meters (mainly 13mm ~ 25mm meters). Consists of a metering water meter and a water stop ball valve.
17	Pulse output water meter	For reading and monitoring water meters located far away or in inaccessible places such as in buildings, condominiums, factories, etc.
18	Car battery for ultrasonic leak detector	For powering ultrasonic flowmeter where regular power is not available. Use battery with appropriate voltage for the flowmeter being used.

Source: Project Research Team