

The Total Water Supply System in Osaka Municipal Waterworks Bureau

T. Doyama*, K. Sakata** and M. Yagyu*

* Facilities Dept., Engineering Div., Osaka Municipal Waterworks Bureau, 1-14-16 Nanko-kita, Suminoe-ku, Osaka, Japan (E-mail: t-doyama@suido.city.osaka.jp; m-yagyu@suido.city.osaka.jp)

** Niwakubo Purification Plant, Engineering Div., Osaka Municipal Waterworks Bureau, 11-31 Yodoe-cho, Moriguchi city, Osaka, Japan (E-mail: k-sakata@suido.city.osaka.jp)

Abstract

Osaka Municipal Waterworks Bureau has three water purification plants. Until now, each purification plant makes water demand prospect corresponding to the distribution area, and controls total system from intake, purification to distribution of water by making water management plan. The total water supply system, planned to be introduced into the Kunijima Purification Plant, prospects water demand for whole city including the distribution area of three water purification plants, and calculates the amount of water which each purification plants have to make. By transmitting the results of the calculation to each plant, water adaptability among three purification plants and efficiency of the facilities will be improved.

By operating the total water supply system, the management of purification plants and distribution plants will be more efficient and more flexible. Energy saving effect is also expected. In addition, in case of emergency like disaster and accident, the ability of crisis-management will be enhanced by improving water adaptability among different purification plants and distribution plants.

In the future, extension of operating area to other waterworks bureaus will be expected. Therefore by introducing extensible system beforehand, OMWB can apply the total water supply system to other cities.

Keywords

Water Supply Operation; Total System; Water Demand Prospect; Water Adaptability; Crisis Management; Extension of Operating Area

INTRODUCTION

In Osaka City, all of the raw water for drinking water supply is drawn up from Yodo River, and water is supplied from the three water purification plants of Kunijima, Niwakubo, and Toyono to the whole city. As one of the largest water utilities in Japan, Osaka Municipal Waterworks Bureau has established a total system covering the entire route from water sources to the consumers' tap, and makes efforts for stable water supply in both terms of quality and quantity.

The Kunijima Purification Plant is the largest among the three water purification plants with a daily water supply capacity of 1,180,000 m³. This key plant has three pumping stations, which provide water through 15 distribution trunk lines, and also serves as the core water distribution

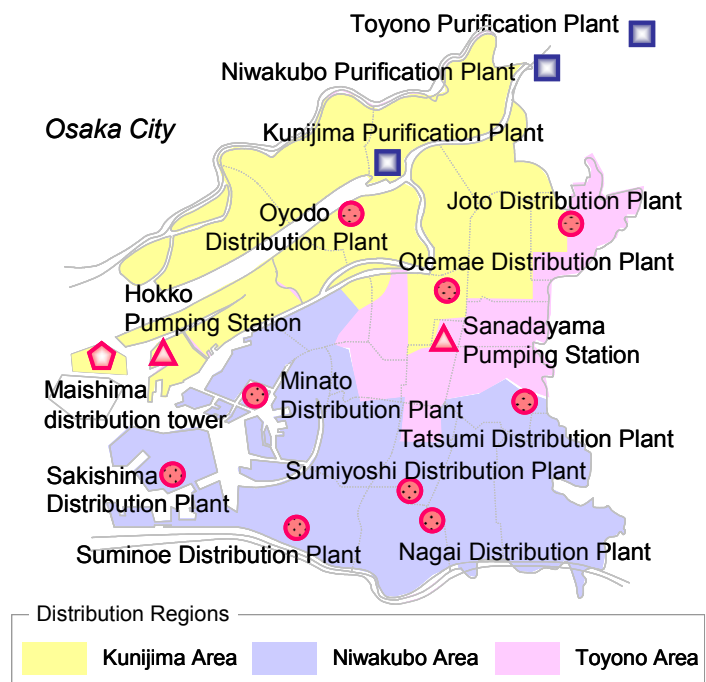


Figure 1 Water service facilities in Osaka City

management plant that controls the distribution reservoirs in the city remotely in a centralized manner.

This paper reports the establishment of the total water supply system being developed in the Kunijima Purification Plant. The total water supply system aims to enable water purification plants to share water more efficiently and improve the operation of facilities by prospecting water demand across the city, calculating the water volume necessary for the operation of each plant, and informing the plants of the results. With a comprehensive view of the three water purification plants and distribution reservoirs in the city, a more advanced total system can be established centering on the Kunijima plant. In addition, it is expected that the bureau can make effective use of its technologies including the total system by introducing a scalable system aimed at cross-jurisdictional cooperation with other local governments. The development of the total water supply system is positioned to be an important project anticipated to greatly contribute to the stable supply of safe and quality water as well as water utilities in Japan and other countries and environmental issues. The water service facilities in Osaka City are presented in Figure 1.

OPERATION AND MANAGEMENT OF WATER SERVICE FACILITIES IN THE PAST

Management facilities in early years

Since its foundation, the Kunijima Purification Plant had added new facilities at different times over long years in accordance with the expansion of the water service network. As a result, facilities with similar functions but different models and operation methods were mixed in the plant. The operation system was also inconsistent, as operators in the field controlled most of the facilities using control panels but some devices were operated remotely.

Then, during the period from 1972 to 1973, the facilities were remodeled to enable the purification plant to be operated and managed at multiple control rooms in a centralized matter. The key measure was the introduction of data processing equipment including computers. The equipment automatized the complex jobs that used to be performed manually such as the preparation of daily and monthly reports and the calculation of various control values. Furthermore, the full-scale introduction of a remote monitoring control system substantially reduced the work load for operators in the field under normal conditions.

Water purification

In the system, controllers were installed to adjust the amount of chemical and other inputs, and operators entered the target values calculated by the data processing equipment and other devices. The judgment of operators was reflected on the control.

The controllers were able to be added with a cascade control system so that the manual control could be replaced with automatic control in the future.

Water distribution

In the water distribution control system, operators manually controlled the flow rate or the opening of the valves. It was planned to introduce an automatic control system after the completion of the water distribution pressure control system covering the whole city.^[1]

Upgrading of the management facilities

The existing management facilities mentioned above were fully upgraded from 1990 to 1993. As it was the era of rapid progress in computers, latest technologies were employed in the monitoring control, information processing, instrumentation, and other devices installed in the management site, etc. This led to safer and more reliable and efficient operation control mainly through drastic automation and failure monitoring.

Most of the current functions for the operation management of water purification, namely the calculation and prediction of water demand by computers using such parameters as water supply in the past, season, temperature, and the day of the week to automatically determine filtration rate, chemical injection rate, and water intake volume based on the predicted results and make the water

supply plan, were established in this upgrade.

For the operation management of water distribution, the facilities were equipped with functions to change the number and rotation speed of pumps based on the water pressure measured by the telemeters installed in various points of the city to operate with a constant preset pressure.

Guidance functions were also adopted to allow easy replacement of power receiving and distributing equipment and water intake system. In addition, industrial television cameras were installed in the coagulation sedimentation basin to monitor the coagulation, and VDT monitoring control equipment and information processing terminals were set up in the office to check the situation in the water purification plant.

In comparison with the data processing equipment installed at the time of the introduction of the management facilities for the first time, the performance of the information processing system was dramatically improved, which enhanced the functionality of the whole management facilities. The functions of this information processing system were at a similar level to those of the current system except for the processing speed and storage capacity. Table 1 outlines the functions of the information processing system.

The demand prospect accuracy, which plays a pivotal part in the water volume operation plan, is especially high and contributes to stable water purification. Figure 2 shows a demand prospect trend displayed on the VDT monitoring screen. The red line represents the estimated water demand while the yellow line indicates the actual water demand, which demonstrates that the margin of error is limited.

Table 1: Outline of the functions of the information processing system in the management facilities^[2]

Function	Item	Description
Water volume operation plan	Demand prospect	Based on the demand trend up to the previous day, the trend on the day is prospect in consideration of such factors as weather conditions, the day of the week, and special features of the day.
	Distribution reservoir operation plan	To make the total filtration flow rate as constant as possible, water changes in the distribution reservoir are simulated based on the estimated distribution volume and the designated range of water level in the distribution reservoir. If the water level in the distribution reservoir is out of the designated range, the distribution reservoir operation will be replanned.
	Filter basin operation plan	The number of filter basins in service and cleaning schedule are set to make the total filtration rate as constant as possible.
	Water intake operation plan	Water intake volume is set based on the total infiltration flow rate and the return flow rate of the cleaning water.
Database	Data storage	Long-term storage and searches of information on the operation (warnings, operation records) are conducted.
	Preparation of records	Daily, monthly, and yearly reports are prepared automatically.
	Statistical processing	Documents are prepared using PCs for the equipment improvement plan and maintenance plan.
Training on operation	Simulation of operation	The operation of the VDT monitoring control equipment and other devices is acquired.
	Simulation of electrification	The electrification of the power receiving and distributing system is simulated to acquire how to respond to emergency situations.
Operation support	Switching of the power receiving and distributing system	Guidance on the operation of power receiving and distributing system switching is provided.
	Switching of the water intake system	Guidance on the operation of water intake system switching is provided to set the water intake flow rate for support to water intake.
Process diagnosis		The abnormality of meters and equipment is detected based on the process water level, water pressure and flow rate, the comparison of data between different points at the same time, chemical injection rate, and measurements of water quality.

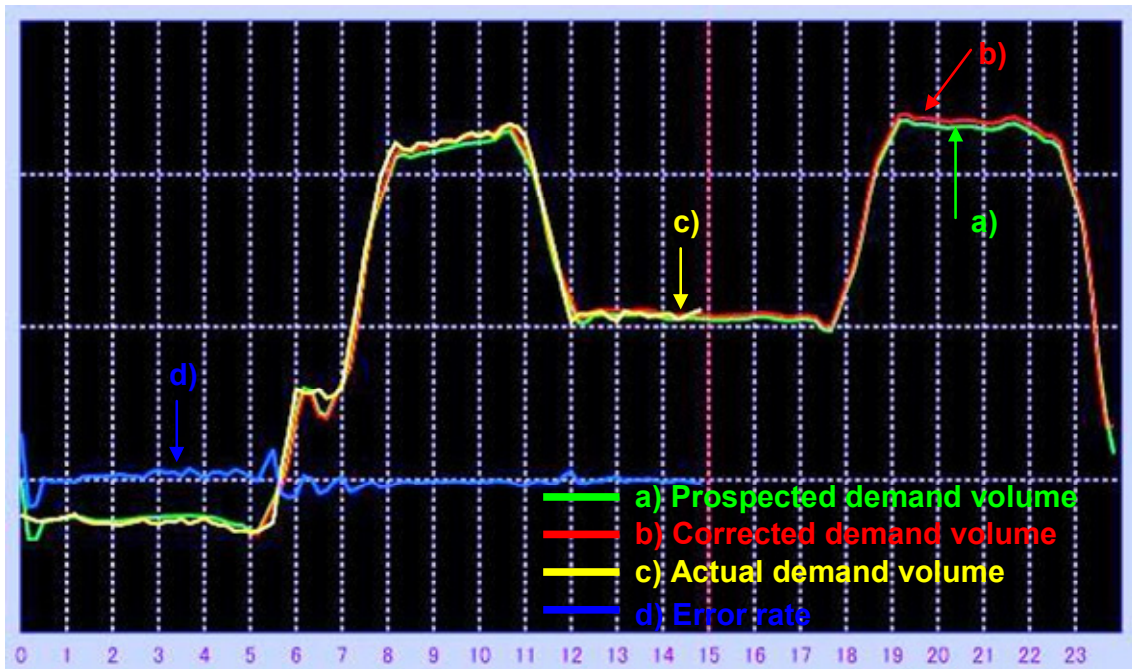


Figure 2 Example of a display on the demand prospect screen

INTRODUCTION OF A MORE ADVANCED WATER DISTRIBUTION MANAGEMENT SYSTEM

In Osaka Municipal Waterworks Bureau, the operation management of the process from water intake and purification to the delivery of the water to distribution reservoirs is called “water purification management,” and the operation management of the process of distributing the water from distribution reservoirs by distribution pumps to the city is called “water distribution management.”

An important role of water purification management is to make effective use of distribution reservoirs as a buffer to meet variations in water demand and maintain stable water purification treatment. Accordingly, the accuracy of the demand prospect mentioned above is indispensable for stable water purification treatment.

In the meantime, a crucial function of water distribution management is the control of the pressure in different points of Osaka City to maintain a constant level. To this end, water distribution telemeters are installed in more than 100 points of the city to monitor the distribution pressure. The rotation speed of pumps and the opening of discharge valves are also controlled to eliminate the gap between measurements and preset values (target pressure values). Since a wrong operation can result in cutoff of water supply or supply of muddy water, water distribution management is a significant operation that can have direct impact on the consumers. Therefore, for more stable and efficient water distribution management, more advanced water distribution management has been introduced to control the operation of all distribution pumping stations in the city from the water distribution management room in the Kunijima Purification Plant. The conventional method of controlling distribution reservoirs separately in each of the purification plant lines has been replaced with the system to remotely control them from the water distribution management room in the Kunijima plant, the core purification plant located in the city center, in a centralized manner, which has enabled the operation of water distribution based on a comprehensive view of the whole city. Figure 3 illustrates the water purification management and water distribution management.

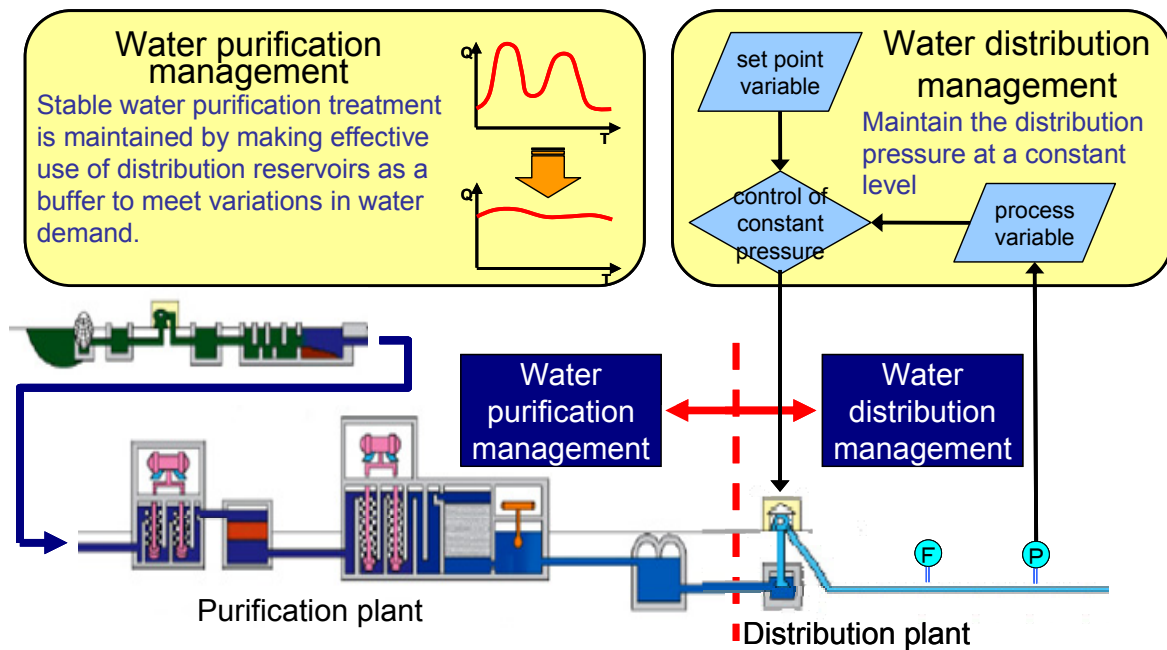


Figure 3 Water purification management and water distribution management

CURRENT WATER PURIFICATION AND DISTRIBUTION MANAGEMENT FACILITIES

The management facilities renovated in the early 1990s were upgraded to the current systems due to their aging between 2006 and 2009. With respect to the functions of operation control, the modification of the specifications was limited because they had already reached a certain level in the previous upgrade. The priority goal was the improvement of safety and reliability, which are different concepts. While safety places an emphasis on the prevention of risk to people, reliability focuses on the performance of functions. Still, because risks to people often occur when systems do not function as intended, less reliable systems present a lower level of safety, and the two factors are thus consistent.^[3]

System design for improved reliability

In the basic policy of the system design for improved reliability, the system configuration has employed a distributed monitoring control system, as well as dual structure in the key devices constituting the facilities and transmission lines. Fault tolerance technology is also used to the control units to make them autonomous and perform their functions independently even when they cannot communicate with other devices. It is generally said that, to ensure the safety of a system, the system has to be developed to be safe (technical aspect), used by people with attention to safety (human aspect), and managed to ensure safety in a proper manner (organizational aspect).^[4] At the design stage, it is particularly necessary to pay attention to the technical aspect.

Example of the application of reliability-improving technology

An example of the application of reliability-improving technology is the parallel input of signals into the control units in the distribution monitoring control system.

As the control units are installed to the facilities in a distributed manner, maintenance and inspection can be performed without the shutdown of the whole system. This also has a risk diversification effect because the affected area can be limited. Nevertheless, to ensure stable water purification treatment during maintenance and inspection or in case of failure, parallel input of important signals especially on chemical injection by other control units in addition to the original device is also employed, which allows degraded operation to be continued even in case of emergency.^[5] This is an example of the application of fail-soft.

With an increase in the signals subject to parallel input, the Kunijima Purification Plant now has more than 26,000 monitoring control items. The types and number of the monitoring control items in the plant are shown in Table 2.

Table 2 Number of monitoring control items in the Kunijima Purification Plant^[6]

Class	Main monitoring control items	No.
DI	Working status of equipment, failure signals	17,990
DO	Operation signals	4,521
AI	Water level, flow rate, pressure	2,709
AO	Preset control value, preset warning value	968
PI	Integral power use, integral flow rate	289
Total		26,477

Note: Backup signals are included in the number.

ESTABLISHMENT OF A TOTAL WATER SUPPLY SYSTEM

While a more advanced operation management system has been introduced to supply safer and more secure water in a stable way, it is also necessary to provide the water service that meets the demands of the time in a stable and sustainable way because the environment for water utilities is becoming increasingly stringent. Osaka Municipal Waterworks Bureau accordingly identifies two principles in its operation policy: to ensure stable supply of safe, secure, and quality water through steady promotion of the development of water service facilities and other measures; and to contribute to water service projects in Japan and other countries as well as the environment through the promotion of inter-jurisdictional cooperation with other local governments.

Under these operation principles, the bureau has decided to introduce a new total water supply system to the Kunijima Purification Plant as a water service measure. The basic concepts for the introduction are: to establish a new system based on the water service technologies acquired in the operation of the previous total systems in order to upgrade the facilities operation and enhance the risk management capacity; and to establish a system that can respond to inter-jurisdictional water service projects and serve as a core for cooperation with the facilities of other local governments. The system is currently under development with the target of completing it in March 2013. Figure 4 illustrates the functions of the total water supply system.

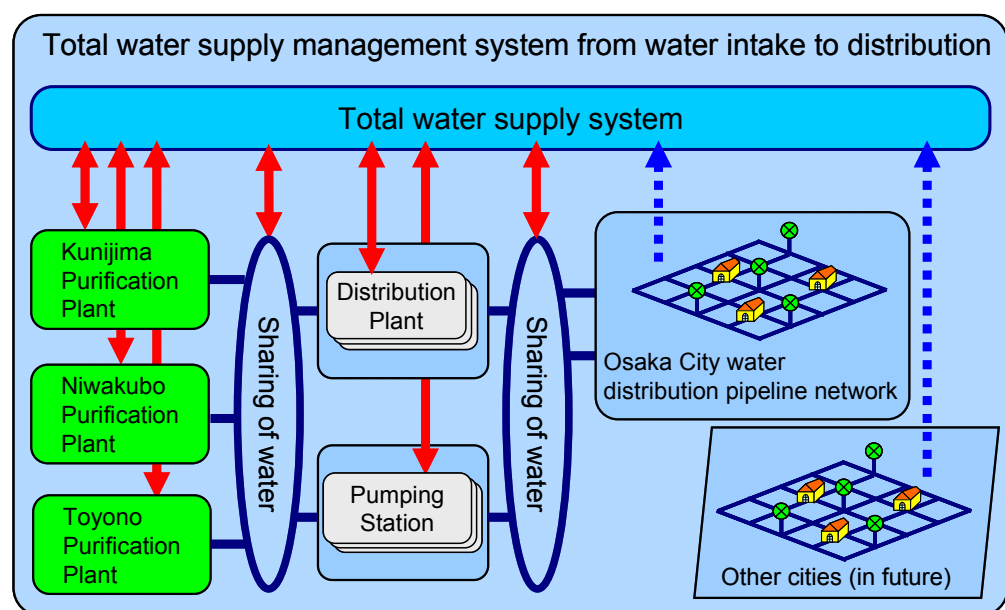


Figure 4 Conceptual diagram of the total water supply system

Objectives of the development of the total water system

The development of the system has two main objectives: the introduction of more advanced operation of water service facilities, or more specifically, the realization of more efficient and flexible operation of water purification and distribution facilities to meet water demand; and the improvement of the risk management capacity, or more specifically, sharing of water between purification and distribution facilities in case of failure to enhance the responsiveness.

The specific task to be performed first is to calculate and communicate the water volume necessary for the operation of the purification plants under the operation of the total system in an integrated way in order to improve the sharing of water between the purification plants and introduce more advanced operation of facilities. It is also expected that the improved sharing of water will reduce overall energy consumption by the water service facilities in Osaka City.

The second task is the monitoring of the three purification plants. In addition to the upgrading of the aged management facilities in the Toyono and Niwakubo Purification Plants, information on the three plants will be concentrated to enable the monitoring of them, which will enhance coordination between the plants as well as risk management capacity in case of failure. The upgrading of the management facilities in the Niwakubo Purification Plant is scheduled to be completed by March 2014, which will further improve the total water supply system.

The third task is to secure the scalability for inter-jurisdictional activities. The system will be made scalable so that Osaka Municipal Waterworks Bureau can operate and manage the facilities of other local governments in future. The bureau can also transfer its accumulated know-how on the total system to other cities in order not only to help the cities but also to contribute to the development of water services. The configuration of the total water supply system after improvement is shown in Figure 5.

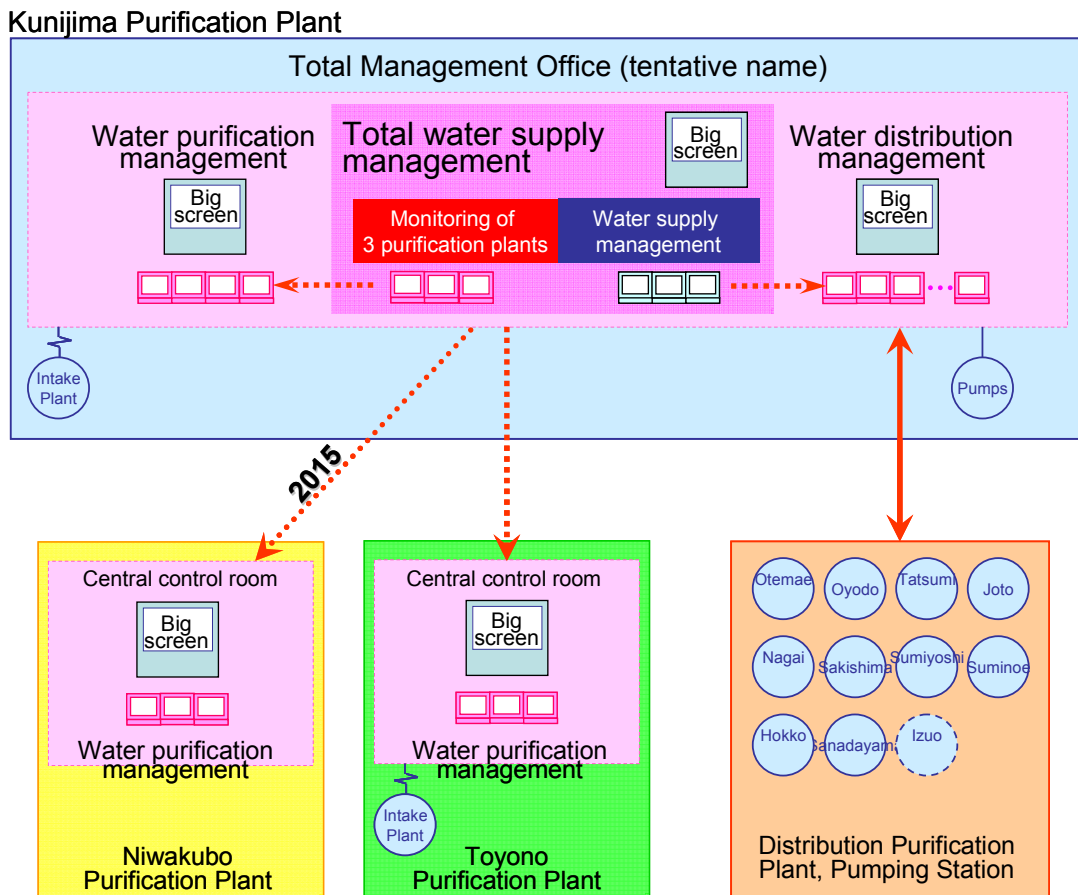


Figure 5 Configuration of the total water supply system after improvement

CONCLUSION

Osaka City has three water purification plants, which have separately managed the process from water intake to water purification and distribution by prospecting water demand for the respective water supply areas and making independent water supply plans. The new total water supply system to be established in the Kunijima Purification Plant will improve the sharing of water between the purification plants and introduce more advanced operation of facilities by estimating water demand for the city as a whole based on a comprehensive view of the entire area including the three purification plants, calculating the water volume needed for the operation of the plants, and communicating the results to the respective plants.

The operation of the total system in an integrated manner is expected to enable more efficient and flexible operation of water purification and distribution plants according to the water demand and also reduce overall energy consumption in the water service facilities. The new system also seeks to improve its responsiveness on the sharing of water between purification and distribution facilities in emergency situations such as disasters and accidents to enhance the risk management capacity from the perspective of business continuity.

In addition, if the scalability of the system is secured to seek inter-jurisdictional cooperation such as the operation and management of the facilities of other water utilities, Osaka Municipal Waterworks Bureau can also transfer its accumulated know-how on the total system to other cities and consequently contribute to the development of water services.

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