Front view of the Office of Waterworks, Seoul Metropolitan Government

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Healthy, Tasty, World's Best Tap Water

Arisu

Seoul Waterworks Authority
Seoul Metropolitan Government

2015

History of Best Policies for World-class Arisu

SEOUL METROPOLITAN GOVERNMENT

Seoul Together we stand

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History of Best Policies for World-class Arisu

Arisu: Seoul's Water Recognized by the World

Healthy and tasty water, Arisu, is loved by all citizens of Seoul!
We produce the best-quality tap water through rigorous water quality control systems.
We supply safe water in state-of-the-art water distribution settings.
We ensure health and taste with advanced purification facilities.
Finally, we provide the highest-quality service to our citizens.

For the past 107 years, water production in Seoul soared by 368 times, and service population grew by 83 times -- a remarkable achievement hardly found in any other country in the world. We have redoubled our efforts in improving both the quantity and quality of tap water through various policy mechanisms. Today, the Office of Waterworks has become the largest water utility provider in the country, fully capable of providing the world's best-quality, safe, and tasty water to 10 million people. Such recognition has prompted many countries and cities around the globe to reach out to us for advice so that they can learn from our accumulated experiences and know-how and benchmark them in configuring their own settings. To share our knowledge more effectively, we have decided to publish the "History of Best Policies for World-class Arisu" for all other municipalities and water sector, so that together, we can further develop the water industry both at home and abroad.

- excerpt from the preface -

SEOUL METROPOLITAN GOVERNMENT

History of Best Policies for
World-class Arisu

History of Best Policies for

World-class Arisu

SEOUL METROPOLITAN GOVERNMENT

Preface

On September 1, 1908, the first purification center in Seoul was built in Ttukdo, and the water treated here flowed to 125,000 residents within the “Four Great Gates” of Seoul and in the Yongsan area, marking the beginning of the modern water supply system in Korea. As of 2014, there are 6 purification stations throughout Seoul supplying 4.35 million m^3 of clean, safe water every day to 10 million Seoulites. Over the past 106 years, water production soared by 348 times, and service population grew by 83 times – a remarkable achievement hardly found in any other country in the world.

Of course, our water system suffered many blows over time. The Korean War destroyed the water facilities; the population surge during the 1960s to 1970s on the back of rapid economic growth led to serious water shortage. Production was finally stabilized in the 1980s thanks to the expansion of facilities; still, urbanization and industrialization gave rise to another issue: the quality of tap water.

Therefore, the Office of Waterworks devoted all its energy and resources to addressing the quality issue. Today, we perform one of the most stringent and thorough water quality checks: we have the “Arisu Verification System” wherein our staff visit households to check the water quality at the faucet level; we are equipped with an “Advanced Purification Facility”; we operate the “Arisu Integrated Information System,” which lets us manage the entire water supply process from intake stations to faucets at home, and; we provide tailored, integrated services to all citizens with our “Arisu Total Service.” These programs and mechanism have made Seoul’s Arisu clean and safe for anyone to drink anywhere.

No doubt, the Office of Waterworks has become the largest water utility provider in the country, fully capable of providing the world‘s best-quality, safe, and tasty water to 10 million people. Such recognition has led many countries and cities around the globe to reach out to us for advice so that they can learn from our accumulated experiences and know-how and benchmark them in configuring their own settings.

To share our knowledge more effectively, we have decided to publish the "History of Best Policies for World-class Arisu" for all other municipalities and water sector, so that together, we can further develop the water industry both at home and abroad.

The book details Seoul’s various policies as well as what propelled such policies to be introduced, including the implementation process, outcome, evaluation, and many other valuable information.

I extend my deepest gratitude to all citizens of Seoul who are genuinely interested in and supportive of our cause to advance Seoul’s water system. It is my sincere hope that this book will serve as valuable input in developing the water industry even further so that everyone in this country can drink healthy, tasty, and best-quality tap water and enjoy premium service, free of any and all concerns. Thank you.

January 2015

Won-joon NAM

President

Office of Waterworks, Seoul Metropolitan Government

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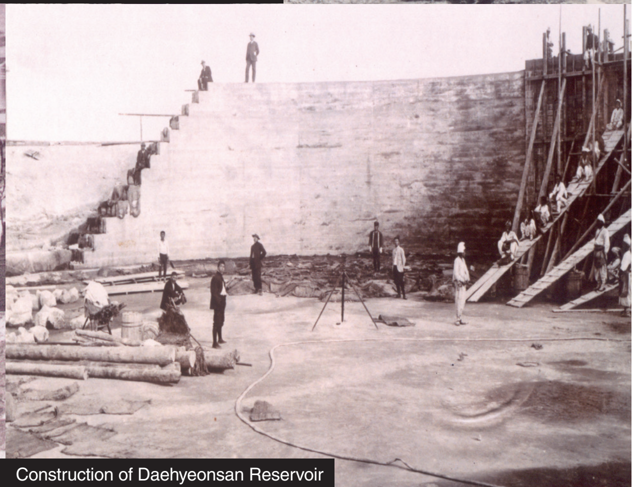
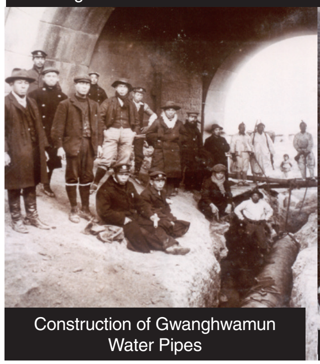
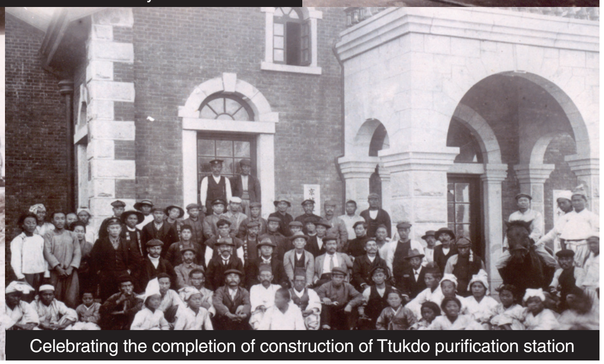
Fetching water with water buckets


Construction of Daehyeonsan Reservoir


Construction of Gwanghwamun Water Pipes


Celebrating the completion of construction of Ttukdo purification station

Arisu History

Past and Present of Seoul's Water Supply

World's best tap water provided to 10 million Seoul citizens

Committed to realizing its vision of **"Healthy, Tasty Water Loved by All Citizens of Seou"** and providing the best-quality, safe, and tasty tap water to 10 million Seoulites, the Office of Waterworks at Seoul Metropolitan Government has set four specific goals for Arisu: **"safe and tasty water production"; "stable and optimized water supply", "convenient, smart maintenance," and; "international competitiveness through improved management and innovation."**

Before the Policy Implementation	After the Policy Implementation
• Average life expectancy was 40 due to contagious water-borne diseases, among others. • The surge in demand for water called for the expansion of facilities. • Urbanization and industrialization caused water pollution. • There was growing public demand for better business management and high-quality service provision.	• Average life expectancy doubled, thanks to the water supply system in place. • Expansion of production facilities led to 100% water supply ratio. • Seoul Arisu passed tap water quality tests for 163 substances as recommended by WHO. • Tap water provision service was upgraded with the "Arisu Total Service."

Policy Vision for Arisu

Vision

Healthy,
Tasty Water Loved by
All Citizens of Seoul

Mission

Stable Supply of Safe,
Clean Water for Our Citizens'
Happiness and a Healthy
Environment

Goal

Production | Safe, tasty water production
Supply | Stable, optimized water supply
Maintenance | Convenient, smart maintenance
International competitiveness |
Through improved management and innovation

Summary of the Policy

- Constructing large-scale water production facilities
- Introducing rigorous water quality management to ensure the best water quality in keeping with the global standards
- Adopting an indirect water supply system with expanded reservoirs to guarantee stable water supply free of interruptions
- Replacing old water pipes and adopting a scientific water leak control mechanism to increase Seoul's revenue water ratio
- Enhancing the quality of water
- Providing the best-quality service to Seoul's citizens, genuinely impressing them with warmth

Background

Demand for water grew exponentially in Seoul

First introduced in 1908, Seoul's water supply system grew steadily over time. In the 1960s, however, the city experienced an exponential population growth accompanying the rapid industrialization and urbanization. Such change gave rise to an urgent need to expand the water supply facilities in Seoul.

To rationalize business, revenue water ratio (RWR) had to be improved

Since its establishment, the Office of Waterworks has continuously worked to expand water production facilities and to address water supply difficulties in the hilly areas of the city. Such efforts eventually contributed to achieving a 100% water supply system without water interruptions. Nonetheless, the city's revenue water ratio or RWR, which refers to the percentage of supplied water that is not lost due to leaks or other factors, was still low. Because a lot of water was lost in the supply process, more production facilities were required, and high direct production cost and leak recovery cost were involved such as raw water purchasing, chemicals, electricity consumption, and labor cost. All these hurt the financial situation of the Office of Waterworks.

The quality of tap water needed to be upgraded to encourage more people to drink tap water

To ensure the safety and pleasant taste of Seoul's tap water, several measures were necessary. First is the "Integrated Water Quality Management System," which reinforces each quality testing procedure and more efficiently manages the entire process in an integrated manner. In addition, the "Advanced Water Purification Facility" had to be introduced to treat thoroughly all micro-organic materials including disinfection byproducts (DBP) so that minerals can be kept intact throughout the treatment process. Lastly, the problem of unpleasant chlorine smell needed to be addressed so that more people would be willing to drink tap water.

An innovative, customer-centered approach to service provision was necessary

Extensive efforts have been made to improve water production and supply through better infrastructure, such as adopting the "Advanced Water Purification Facility" and the "Chlorine Re-dispersion System." Despite the improvements in the safety and taste of tap water, however, citizens still had complaints about the service they were receiving. In fact, customer satisfaction level decreased over time; it became evident that an innovative service delivery system was necessary to address this problem.

Process of Policy Implementation

Beginning of water supply in Seoul

The water supply system was first introduced to Seoul on December 9, 1903 when then Emperor Gojong of Chosun Dynasty gave two American entrepreneurs, Collbran and Bostwick, the right to build a water supply system for Seoul. In August 1905, the two Americans resold the rights to Korea Works Company, which handled facility building and management of the modern water supply system in Seoul. In August 1906, the company began the construction of slow sand filter in the Ttukdo purification station and completed it in August 1908. On September 1, 1908, 12,500m^3 of water began to flow through the pipes of the system to 125,000 people every day.

When the Ttukdo purification station, the 1st modern water facility in Seoul, began operation, it was equipped with 2 settling reservoirs, 5 filtering chambers, and 1 distribution reservoir. Water treated at the Ttukdo purification station flowed to the Daehyeonsan reservoir, which served residents within the "Four Great Gates" of Seoul and in the Yongsan area. This marked the beginning of the modern water supply system in Korea.

Water supply during the Japanese colonial period

As the country lost its sovereignty to imperialist Japan in 1910, administration also became subject to the Japanese rule, and water supply was no exception. The management right of Korea Works Company changed hands several times from private company, Japanese Governor-General, Gyeonggi Province, Seoul, and many more.

During this time, Seoul saw an explosive surge in demand for water since its population grew as the water supply system became widely popular for its convenience and hygiene. In response, from 1910 to 1945, Seoul, under Japanese rule, pushed through with 3 rounds of water pipe expansion projects, which increased the number of water taps or faucets by 15 times in just about 30 years, from around 4,000 in 1912, 21,121 in 1930, and all the way to 61,970 in 1945.

Recovery from post-Japanese occupation and Korean War

After the country won its independence in 1945, the focus was on water production to enhance the water supply rate, which means serving more people whose demand was not really being met. For example, expansion work for the Guui purification station, which halted during the war, resumed, and Seoul took over the Noryangjin reservoir from the City of Incheon in 1948. Such efforts hiked up Seoul's water production capacity to 177,300m^2 per day.

Note, however, that the Korean War that broke out in 1950 destroyed most of Seoul's water supply facilities; 30~90% of the purification stations were destroyed, and 90% of the communications facilities were ruined during the 3-year war.

Despite the odds, officials in the water supply system and the government did their best to continue operating water supply even during wartime. For the next 5 years from 1954, thanks to the assistance of the government and the US, repair & maintenance projects could be implemented. Water facility expansion took off in earnest with the construction of Guui purification station plant 2, which was done without any foreign technical assistance, in 1956. Since then, expansion and repair works continued, resulting in 3 times' increase in water supply per capita from 59ℓ in 1945 to 163ℓ in 1960.

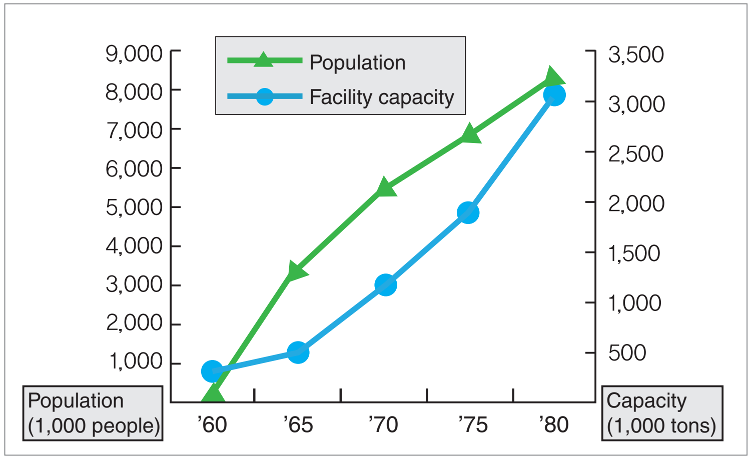
Facility expansion to address serious water shortage

The successive Korean governments during the period 1960~1970 made the 5-year economic development plan the highest agenda, which drove rapid industrialization, urbanization, and surge in Seoul's population. Such change inevitably gave rise to an explosive demand for water in the city, and the city had to use all its resources to address the problem of water shortage. For instance, Seoul used loans from overseas governments to expand production facilities and pipes as well as construct ancillary purification facilities.

With the 1st facility expansion & improvement project (1960~1963), the Guui and Noryangjin purification facilities were upgraded, and new purification stations were built in Shinchon, Mia, and Bulgwang to expand the service area to even the peripheral parts of Seoul. Such efforts increased production capacity by 71,000m^3/day to up to 348,600m^3/day.

During the 2nd facility expansion & improvement project (1964~1969), the Bogwang reservoir and Siheung ancillary purification station were newly built, and many other purification facilities were upgraded and expanded. From 1972 to 1981, large-scale purification stations such as Yeongdeungpo, Seonyu, and Gwangam were newly constructed, and Seoul took over the management right of the Gimpo purification station from Incheon. Such efforts resulted in the expansion of facility capacity to 3,070,000m^3/day. Thanks to such improvement, Seoul could maintain a stable water supply system despite the population surge from 2.45 million in 1960 to 8.37 million in 1980.

I Graph 1 I Changes in population and water production capacity in Seoul



Establishing the foundation for stable water supply

Thanks to the continuous expansion of production facilities and slowdown of population growth, demand for water finally subsided to a stable level during the period 1980-1990. Water supply rate reached almost 100%, with the water supply rate per capita in Seoul improving to a level that is on a par with advanced nations. To achieve the goal of interruption-free water supply, the Office of Waterworks never ceased to build new purification facilities and expand existing ones in times of emergency. For instance, the Amsa, Ttukdo, and Yeongdeungpo purification stations were expanded and improved, along with the new addition of the Gangbuk purification station. By 1999, daily water production capacity reached 7.3 million m, a level considered stable.

I Table 1 I Changes in Water Supply Rate and Water

Classification	1960	1965	1970	1975	1980	1985	1988
Water Supply Rate (%)	59.8	73.7	85.8	89.1	92.7	97.5	98.8
Water Supply Per Capita (ℓ)	163.0	187.0	171.0	290.0	305.0	382.0	415.0

Water quality issue

When the water quantity issue was finally resolved in the 1980s, the quality issue began to surface. Around this time, environmental pollution became a global issue. Likewise, with regard to water, the focus was shifting from quantity to quality.

Seoul's water system relies on Han River's surface water for its raw water; with urbanization and industrialization, however, concerns over the quality of this raw water grew. Such concerns became a nationwide social issue when the water quality of some local streams was called into question.

In response, the government issued a comprehensive plan along with the "Water Supply Facility Modernization Plan" in 1985, a move that resulted in the introduction of a computer system throughout the purification process and enabled remote monitoring/control system. In addition, to control water quality better, aluminum sulfate was replaced with poly-aluminum chloride as purification chemical.

Inauguration of the Office of Waterworks at the Seoul Metropolitan Government

Although quantitative growth was evident with the water supply rate reaching almost 99%, an amazingly satisfactory level, issues related to management efficiency and water quality persisted. To tackle such issues and offer safe, affordable tap water to all residents, Seoul launched the Office of Waterworks in 1989.

Improvement in production facilities to enhance productivity

The Office of Waterworks exerted contiguous efforts to prevent leaks including old pipe replacement, thereby enhancing the revenue water ratio. Since less water was lost, production level could also be decreased from the mid-1990s. In addition, some underperforming purification stations such as Seonyu, Shinwol, Noryangjin, and Bogwang could be closed down. By 2004, facility capacity of 5.4 million m3 -- a level deemed most proper -- was maintained. The closed purification stations were transformed into amenities for residents to enjoy in their leisure time.


Seonyudo Park


West Seoul Lake Park

Details of the Policy

Constructing large-scale production facilities

The first water purification plant was constructed in Ttukdo on September 1, 1908; with it, the modern-day history of Korean waterworks began as 12,500 tons of water was supplied to Seoul citizens every day.

After the country won its independence from the Japanese rule, 3 purification plants (Ttukdo, Noryangjin, and Guui: facility capacity of 1,521,000m^3/day) were built, and 2 more purification plants (Bogwang, Yeongdeungpo) were constructed in 1977 to bring the total to 5 (facility capacity of 2,166,000m^3/day).

Later, purification plants in Amsa, Ttukdo, and Yeongdeungpo were upgraded or expanded to avoid interruptions in times of emergency, with a new purification plant built in Gangbuk. By 1999, production facility capacity reached 7,300,000m^3/day. Due to a significant amount of water leaks in the supply process, however, Seoul had to have greater production facility capacity than what was required to meet the demand.

We at the Office of Waterworks responded by replacing old water pipes and taking other drastic measures to reduce leaks. Consequently, the revenue water ratio soared; from the late 1990s, production could be reduced. This meant that some production capacities were not in use. Therefore, we decided to close down some underperforming facilities such as the Seonyu, Sinwol, Noryangjin, and Bogwang purification plants.

By the end of 2013, production facility capacity stood at 4.35 million m3/day; the number of people serviced was 10.39 million, and the water supply rate was 100%.

Introducing rigorous water quality management to ensure the best water quality in keeping with the global standards

Water quality in every step of the entire process of water distribution — from raw water to faucet — is managed and assessed systematically. The results are disclosed to the public to build trust in the quality of water they are drinking.

As part of such trust-building effort, we introduced the “Seoul Water Now System,” a real-time, automatic water quality assessment and online data disclosure service. In addition, the “Algae Alert System” is in operation, with the “Advanced Water Purification Facility” and the “Chlorine Re-dispersion System” established to reduce odor in the water.

Adopting an indirect water supply system with the expanded reservoirs to guarantee stable water supply free of interruptions

With some of the production capacity found to be idle or unused, more efforts focused on creating large-scale reservoirs. This means switching from a “direct water supply scheme” (purification station → household consumers) to an “indirect water supply scheme” (purification station → reservoir → household consumers) to guarantee stable water supply without interruptions even in cases of emergency.

In 1990, the Suyu 5-dong(district) reservoir was expanded, and new ones were built in Gimpo and Naksungdae. Soon, construction of reservoirs followed in places such as Daehyeonsan, Naksungdae, Bugak, Jeungsan, Achasan, and Gaepo. By the end of 2013, there were 104 reservoirs with reservoir capacity of 2,318,000m^3, and water stayed in the reservoirs for 16 hours. Currently, the plan is to expand the hours of water stay to 17 by 2030 and increase the portion of indirect supply using the reservoir from 92.6% (in 2011) to 96.3%.

Replacing old water pipes and adopting scientific water leak control mechanism to increase Seoul's revenue water ratio

Back in 1989 when the Office of Waterworks was first launched, the revenue water ratio was only 55.2%. After our continuous efforts, the figure jumped to 94.4% at the end of 2013.

We also divided the entire Seoul region into 2,037 small blocks and adopted the GIS system to map out the priority districts that have had highest leaks for the past 3 years. Once targets were identified, we employed hi-tech, multi-point interaction leak detectors in 2004 to improve our detection precision. In addition, we established a system for calculating the flow of tap water during the night (from midnight to 4am) when tap water is used the least. This system allowed us to detect tap water pipeline leaks efficiently.

To avoid leaks and contamination, old pipe replacement was necessary. Instead of continuing the existing, small-scale replacement works, in 1984, Seoul formulated a comprehensive replacement project to move forward in full swing. By 2013, 13,192km (96.5%) out of the 13,668 km old pipes, or pipes past their life cycle, were replaced. The remaining 476km of pipes are slated to be replaced by 2018.

Moreover, by expanding reservoirs, the existing direct water supply system was switched to an indirect one. Instead of supplying or distributing water directly from purification centers or pressurizing stations, water is now supplied through reservoirs -- an additional step that reduces chances of leaks. Likewise, by maintaining the same level of water pressure all day long, a more stable water supply system is now established. Another measure to minimize leak was the water flux monitoring system. With this system, information on water flux and pressure is collected in real time, managed collectively, and stored, in order to be used as database to manage water flux systematically. Using this information, daily supply data for each source water can be analyzed; in times of surge or sharp drop in supply, we can readily identify the causes (such as leaks) and respond quickly.

Such extensive, large-scale efforts against leaks raised the revenue water ratio. In fact, from 1990 to 2013, 7.5 billion tons of water was saved; this is equivalent to the amount of tap water needed to supply 10 million people for 6~7 years. In monetary terms, it is equivalent to 4.2 trillion won.

During the same period, cases of leak dropped to 725,998 cases or 82.5%. This means 1.8 trillion won in budget savings.

Since we could reduce production, 4 out of 10 purification plants (capacity of 7.3m^3/day) were closed down, yet the remaining 6 are (435m^3/day) providing enough water for all consumers. The closed purification stations were transformed into amenities such as parks, thereby contributing to higher quality of life and community development.

Enhancing the quality of water

To advance the quality level of Arisu further, we acquired ISO14001 Certification and introduced various systems such as automatic water quality monitoring system, comprehensive information system, direct water supply scheme, advanced water purification facility, and chlorine re-dispersion system.

Today, Arisu undergoes tap water quality tests for 163 substances as recommended by WHO. Besides, every step from production to distribution is thoroughly tested, and the results are made public in real time; thus contributing to the public trust building on Arisu.

Providing the best-quality service to Seoul's citizens

Committed to producing and providing the world's best, safe, and tasty tap water to Seoulites and to providing the best-quality service to them, Seoul had adopted a wide range of services. For example, in 1990, the "121 Call Service" was set up to minimize the impact of water-related accidents and damages. In 1993, we also established the "Special Task Force," which was tasked with responding quickly to water interruptions. In 1998, the "Utility Bill Management System" was introduced to minimize civil complaints related to water bills. In 2000, we declared the "Customer Service Charter" as a way of enhancing the service satisfaction level and introduced the "Happy Call System" to monitor the customer satisfaction level. Finally, in 2005, the "Customer Support System" was put in place to check the entire process of how a civil complaint is handled.

Despite years of efforts and new systems, citizens continued to lodge complaints about tap water. Therefore, we introduced the “Arisu Total Service,” an innovative way of proactively and comprehensively dealing with civil complaints.

This system allowed us to identify potential complaints, solicit the opinions of all players involved, discuss solutions with employees, and hold discussion sessions to seek efficient complaint handling solutions. By combining it with the training programs for all employees at the Office on how to deliver the best-quality service, civil complaints on water supply dropped by 19.6% from the 2013 level.

Seoul’s Water Supply Today

Water Intake

The facility capacity of intake stations in Seoul is 7.12 m^{3}day, and the average intake per person is 3.25m3day. Of these, 230,000m^3/day (7.1%) is sourced from Paldang Lake, and 3.02m^3/day (92.9%), from the Upper Jamsil area.

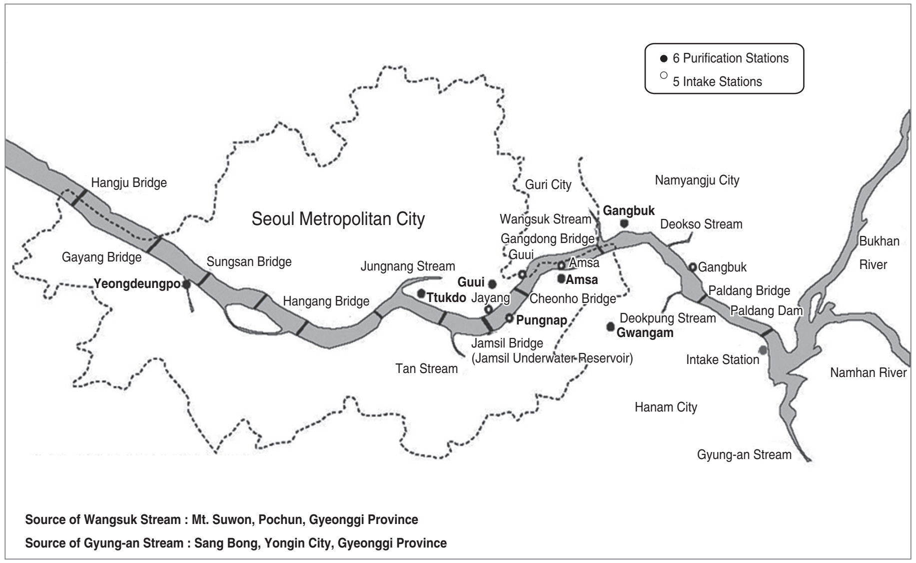
Purification

The purification capacity in Seoul was 12,500m^3/day in 1908, serving 125,000 people. By the end of 2013, it jumped to 4.35 million m^3/day, serving 10.39 million citizens. Such represented 348- and 83-fold increases, respectively. As of 2013, the total amount of water used per year was 1,164,636,000, and the daily average was 3,191,000m^3.

Although there were many operational difficulties until 1992 due to the lack of facility capacity, we have had sufficient purification facilities since 1998, becoming completely free from these issues.

At present, we are focused on upgrading the water supply system even further with the “Advanced Purification System” wherein ozone and GAC (granular activated carbon) are added to eliminate the unpleasant smell and taste in water as well as disinfection byproducts. The system was first introduced to the Yeongdeungpo Arisu Center in 2010 and is expected to be adopted in all purification centers in Seoul by 2015.

[Locations of Intake Stations in Seoul]



I Table 2 I Purification and Intake Stations in Seoul (as of 2013) (Unit : 1000㎥/day)

Purification Station	Location	Daily Production	Facility Capacity	Intake Facility		Intake Source		Branch Office in Charge
				Intake Station	Capacity	Jamsil	Paldang	
Total		3,191	4,350	5	7,120	3,950	400	
Gwangam	Hanam-si, Gyeonggi-do	220	400	Paldang raw water		-	400	Gangdong
Guui	Guui-dong, Gwangjin-gu	182	250	Guui	960	175	-	Dongbu
				Gangbuk (Guui watershed)	550	75	-	
Ttukdo	Sungsu-dong, Sungdong-gu	396	500	Jayang	1,450	350	-	Jungbu, Seobu, Dongbu
				Gangbuk (Ttukdo watershed)	700	150	-	
Yeong-deungpo	Yeouido-dong, Yeongdeungpo	440	600	Pungnap	700	600	-	Seobu, Gangseo, Nambu
Amsa	Gangdong-gu, Amsa-dong	1,145	1,600	Amsa	1,710	1,600	-	Jungbu, Dongbu, Gangseo, Nambu, Gangnam, Gangdong
Gangbuk	Gyeonggi-do, Namyangju-si	808	1,000	Gangbuk (Gangbuk watershed)	1,050	1,000	-	Jungbu, Seobu, Dongbu, Bukbu

I Table 3 I Statistics of Seoul's Water Supply

Classification	Unit	2007	2008	2009	2010	2011	2012	**2013**
Population	1000 people	10,422	10,456	10,464	10,575	10,528	10,442	**10,388**
Service population	1000 people	10,422	10,456	10,464	10,575	10,528	10,442	**10,388**
Water supply rate	%	99.99	100	100	100	100	100	**100**
Facility capacity	10,000㎥/day	510	510	510	455	460	435	**435**
Daily maximum production	10,000㎥/day	373	378	365	368	372	358	**351**
Daily average production	10,000㎥/day	334	331	327	327	325	322	**319**
Daily maximum water service per capita	ℓ	352	356	343	342	348	338	**332**
Daily average water service per capita	ℓ	315	311	307	304	303	303	**301**
Daily average water consumption	ℓ	288	285	285	284	284	286	**284**
Reservoir	10,000㎥	235	235	237	236	238	238	**242**
Water valve (faucet)	1000	1,960	1,957	1,961	1,917	1,992	2,024	**2,058**
RWR (revenue water ratio)	%	91.4	91.7	92.9	93.4	93.5	94.5	**94.4**

: Policy Outcome & Evaluation (awards)

[June 2009] Winner of the United Nations Public Service Awards

Seoul gained international recognition for the transparency and reliability of its water supply service. In particular, Seoul was recognized for its electronic water quality service that allows citizens of Seoul to access the latest information on the quality of water supplied to their homes and the free water quality verification service delivered to households upon their request.

[May 2010] Certificate in the Public Administration Service Section from the Korean Standard-Service Quality Index (KS-SQI)

Seoul was awarded the certificate by the Minister of Knowledge Economy based on the KS-SQI model, the only publicly certified service quality assessment model for the public administration sector in Korea.

[September 2010] 2010 Project Innovation Award

IWA (International Water Association), the world's largest water-related association composed of 85 countries, awarded Seoul the Project Innovation Award for producing premium tap water.

[September 2010] 2010 International Business Awards

Seoul was chosen as the Stevie Award recipient in recognition of its creativity and knowledge efficiency performance.

[September 2012] 2012 Project Innovation Award

Seoul was awarded the "Global Honor Award" for its contribution to research on technological standardization titled "combined remote metering system using electric lines as a medium of communication."

Applicability of the Policy

Seoul has over 100 years' experience in water supply, which has now become stable and best in quality. The know-how and insights can be shared and applied to other municipalities in Korea or other countries whose waterworks are outdated.

Q & A

How did the Office of Waterworks become capable of supplying water to such a huge population? What were the secrets to the success?

Clearly, the Office of Waterworks at the Seoul Metropolitan Government is the largest water provider in Korea whose history spans over 100 years and whose service population is well over 10 million people. Our achievements can be attributed to several factors. For instance, we entrusted some of the tasks such as water meter inspection and replacement; we integrated some affiliated agencies and introduced smart technology in billing and accounting. We also continued to rationalize our business operations. Through such efforts, we were able to downsize our staff from 4,300 members to 2,000 while remaining effective and capable. In addition, our employee training programs, knowledge-sharing practices, efforts to nurture specialists, focus on R&D and researchers' capacity building, and "Arisu Total Service" significantly contributed to our overall success.

Water Production

01 Water Quality Control
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Water Production 01

Raw and Purified Water Quality Testing

Testing the quality of both raw and purified water to ensure the highest quality of Arisu

To supply safe and tasty drinking water, the Office of Waterworks at the Seoul Metropolitan Government performs rigorous quality check at each stage of the water supply system from intake and purification to the distribution stage.

Before the Policy Implementation	After the Policy Implementation
• There was no real-time, inclusive water quality monitoring system in place; issues such as algal bloom and chlorine odor led to public distrust in the drinking water supplied to their homes.	• Real-time water quality monitoring at each stage of the water supply system • Proactive response to the unpleasant odor found in water • Real-time release of water quality information to the public • Reduction of chlorine odor and stability of water supply to households at the end of water mains

Overview of the Policy

- Setting up an automatic water quality monitoring system for both source water and raw water at intake points
- Assuring the optimal quality of purified water
- Performing water quality testing in the distribution system

Background

Climate change has led to a range of unexpected problems such as torrential rainfall and algae-induced odors. To address these issues and to prepare further against drinking water contaminants, a comprehensive water quality control system was necessary. The new system would strengthen the existing tests at each stage of the water supply system (raw water, purified water), tailored to different kinds of source water. In addition, the chlorine odor had to be removed to encourage more people to drink tap water.

Process of Policy Implementation

Since 1908 when the first modern water purification plant in Ttukdo began operation, Seoul Arisu has undergone tap water quality testing for 14 items such as turbidity, pH, and residues. After the detailed standards for water quality and testing items were stipulated by law on March 11, 1963, the testing has expanded to include a total of 29 substances such as ammoniac nitrogen.

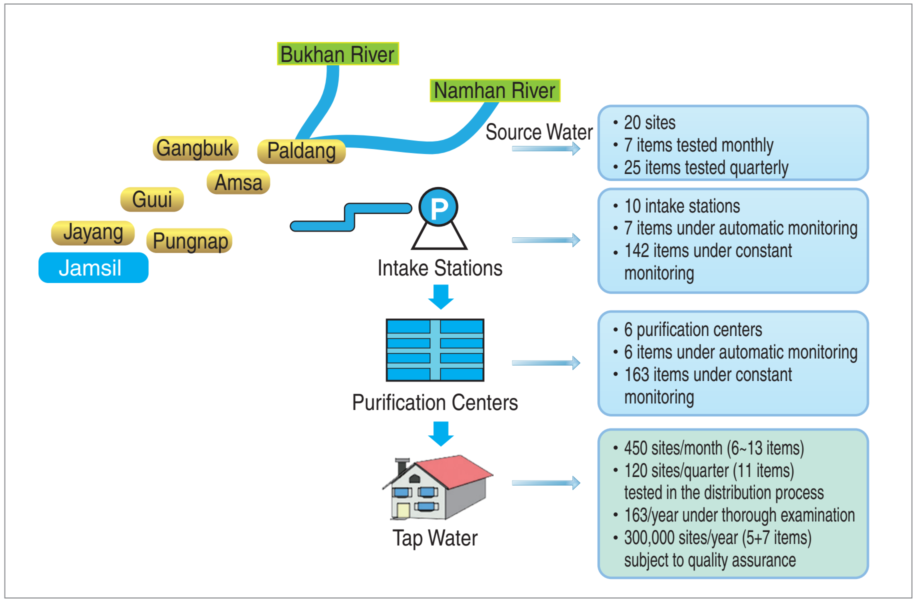
As of 2014, the law stipulates that 59 substances be tested for drinking water such as DBP (disinfection byproducts). On top of this, the Seoul Metropolitan Government has established separate guidelines for a more rigorous review. Expanding the number of regular water quality testing parameters, Seoul introduced 2 additional tests in July 1997 but has now expanded even further to bring the total to 104. The total number of tested items is 163 as recommended by WHO. The result of the stringent tests is made public so that the citizens can build trust in the water supplied to their homes.

Besides the water quality tests, we also introduced the algae alert system in 2000 as a means of reducing odor-causing materials. The system is now supplemented by the odor alert system introduced in 2012 to detect geosmin and 2-MIB. The two measures have been effective in proactively and efficiently tackling the odor issue in Arisu.

Details of the Policy

Water quality control tasks are divided by stages of the water supply process. The Waterworks Research Institute and purification centers undertake testing on raw and purified water, whereas both the Waterworks Research Institute and branch offices perform testing on water in the distribution process. The Office of Waterworks HQ takes charge of operating the Tap Water Assessment Committee, an advisory committee established as per Clause 1, Article 19 of the Enforcement Regulation of the Water Supply and Waterworks Installation Act, and supports the policymaking process.

[Map of the water quality control process by stage and source water]



Setting up an automatic water quality monitoring system for both source water and raw water at intake points

- Source water (20 points, monthly basis) and raw water (10 points, weekly basis) are subject to water quality testing.
- 7 items (phenol, ammoniac nitrogen, etc.) are automatically monitored.
- Biological early warning system (Gangbuk, Amsa, and Pungnap intake stations)

Among 6 reservoirs, the Gwangam reservoir gets water from Paldang (157.3km^2) as its source water; the rest including the Gangbuk reservoir get it from Jamsil (6.45km^2). We have focused on controlling the quality of Han River's main and branch streams, which directly affect the quality of raw water, and proactively responded to potential contaminants.

※ In 2013, Paldang and Jamsil recorded BOD of 1.2 ~ 1.6mg/L, which is classified as I-b grade (good).

The Waterworks Research Institute and purification centers conduct testing on both source water and raw water at intake points. In particular, 7 items including phenol and ammoniac nitrogen are subject to automatic, real-time testing.

Moreover, in the Gangbuk, Amsa, and Pungnap (Yeongdeungpo) intake stations, a biological alert system is in operation round the clock to monitor heavy metals and contaminants.

I Table 1-1 I Water Quality Testing in Source Water and Raw Water

<table>
<tr><th>Classification</th><th>Tested Sites/Target</th><th>Tested Items</th><th>Testing Agency</th><th>Testing Frequency</th></tr>
<tr><td rowspan="2">Source Water</td><td rowspan="2">20 sites
(Namhan River 5, Bukhan River 5,
Gyungan Stream,
Paldang Lower Branch Stream 9)</td><td rowspan="2">42 items</td><td rowspan="2">Waterworks Research Institute</td><td>17/month</td></tr>
<tr><td>25/quarter</td></tr>
<tr><td rowspan="3">Source Water</td><td rowspan="3">8 sites
Branch stream (6),
Main stream of Han River (2)
* Branch stream : Gungchon, Dosim,
Wolmun, Dukso, Hongneung, Sangok
* Main stream : Amsa, Guui</td><td rowspan="3">57 items
* branch stream:42
* main stream :15
(15 items overlapped)</td><td>Waterworks Research Institute</td><td>42/month</td></tr>
<tr><td rowspan="2">Amsa, Guui</td><td>4/day</td></tr>
<tr><td>11/month</td></tr>
<tr><td>Raw Water at Intake Stations</td><td>3 sites
* Gangbuk : Algae Closterium
(heavy metal, pesticides)
* Amsa : electroactive substances
(domestic sewage)
* Pungnap : water flea
(insecticide, heavy metal)</td><td>Bio Alert Device</td><td>Gangbuk, Amsa, Yeongdeungpo</td><td>Real time</td></tr>
<tr><td>Raw Water at Intake Stations</td><td>6 intake points
* CN, phenol, NH3-N, TOC, pH, turbidity
(chlorophyll-a)</td><td>Automatic Water Quality Control Device
(7 items)</td><td>Purification center</td><td>Real time</td></tr>
<tr><td rowspan="6">Raw Water at Intake Stations</td><td rowspan="6">10 sites
(6 intake points)
(Han River confluence 4)
* Namhan River : Bolpo-ri, Sinwon-ri
* Bukhan River : Sambong-ri, Jinjoong-ri</td><td rowspan="6">142
* by law : 31
* by Seoul: 111
(15 items overlapped)</td><td rowspan="4">Waterworks Research Institute
135</td><td>21/week</td></tr>
<tr><td>12/month</td></tr>
<tr><td>73/quarter</td></tr>
<tr><td>29/year</td></tr>
<tr><td rowspan="2">Purification center
22</td><td>10/day</td></tr>
<tr><td>12/week</td></tr>
</table>

Assuring the optimal quality of purified water

- Automatic water quality monitoring system tailored to each stage of the water supply process
- Alert system for algal bloom and odor in source water and raw water
- Expansive list of tests (59 stipulated by law + 104 on Seoul's own list)

We monitor the quality of raw water through analysis, strengthen our disinfection work, and control the turbidity level of filtered water. Through the multi-layered control system, water quality can meet the safety requirement even in the worst case scenario.

As one of the most important indicators of water quality, turbidity is measured round the clock throughout the entire process. We also have measures in place to cater to different needs during the water shortage period such as dry season, rainy season, and winter season.

※ Turbidity level is kept below 0.06 NTU (below 0.1 NTU during the rainy season)

Alongside the "Algae Alert System," the "Odor Alert System" was introduced to detect geosmin or 2-MB, both of which produce odor (an alert is issued when strange taste or odor is detected (geosmin-2-MIB).

When alert/warning is issued for either algae bloom or odor, we take a series of measures. First, we conduct water testing more frequently than usual (from every week to every day); we add powdered activated carbon, and then use interchlorination in purification stations instead of doing pre-chlorination at intake stations.

I Table 1-2 I Algae Alert System: Alert/Warning is issued when the indicated numbers have been reached for both categories for 2 consecutive times

Algae Warning Items	Alert	Warning	High-level Warning
Chlorophyll-a concentration (mg/m3)	15+	25+	100+
Blue-green algae cell count (cell/mL)	500+	5,000+	106+

I Table 1-3 I Odor Alert System: Alert/Warning is issued when the indicated numbers are reached for each category once — findings are reflected on the purification process

Malodor Warning Items	Alert	Warning	High-level Warning
Geosmin (ng/L)	20	500	1,000
2-MIB(ng/L)	20	50	100

Since 2012, we have been reducing the amount of chlorine added at reservoirs; instead, we disperse chlorine at several points -- especially in the later stage of process -- to eliminate the chlorine smell. Currently, the chlorine re-dispersion system is used at 17 sites, but the number will be expanded to keep the residual chlorine level between 0.1~0.3mg/L at every faucet.

Reducing the chlorine smell throughout the water supply system

Performing water quality testing in the distribution system

Before		After
Most of the chlorine was added at the purification centers, which led to the following: · Complaints from neighbors regarding the smell · Insufficient residual chlorine in distant areas	→	Chlorine dispersion is done at multiple points including purification centers and reservoirs, which led to the following: · Consistent level of chlorine added · Residual chlorine level between 0.1~0.3mg/L at faucets

- Real-time, automatic water quality monitoring at every step of the distribution system & public disclosure of water quality information
- "Arisu Quality Verification System"
- "Chlorine Re–dispersion System" at reservoirs

We have redoubled our efforts to improve water quality with a wide range of measures. Recognizing the need to take a step further beyond the legally required tests, we decided to test the water quality at every stage of the water supply process. In addition, we have been carrying out the "Arisu Quality Verification System" and other measures to keep an eye on water quality in the distribution systems. All of the efforts are designed to improve public perception of Arisu and encourage them to drink more tap water.

I Table 1-4 I Water Quality Testing in Purification Stations

	Tested Sites/Target	Tested Items	Testing Agency	Testing Frequency
Raw Water	6 purification centers	22	Purification center	10/day 12/week
Purified Water	6 purification centers	23	Purification center	10/day 13/month
Purified Water	6 purification centers 10 sites	163(59 legally set, 104 set by Seoul itself)	Waterworks Research Institute	63/month 61/quarter 39/year
Purified Water	Testing new variants of materials • Residual medical substances 3, chemicals for industrial use: 3	130 (6 in 2014)	Waterworks Research Institute	year-round

There is a legally required water quality test to be done at faucets in accordance with Article 4 of the Act on the Management of Drinking Water. A total of 450 sites throughout Seoul including households located at the end of the pipe networks are subject to the test. As the testing agency, the Waterworks Research Institute tests on 6 items (bacteria, turbidity, etc.). At least 6,500 sites that were tested in 2013 have all passed the tests.

In addition, every month, 20 old pipes deemed likely to affect water quality undergo testing on 13 items (bacteria, iron, turbidity, etc.). In 2013, 200 pipes went through the testing, and all of them met the requirements for drinking water.

The Waterworks Research Institute also performs quarterly testing on 11 items (bacteria, iron, THMs, turbidity, residual chlorine, etc.) on 120 points throughout Seoul's water supply system (including purification stations, reservoirs, pressurizing stations, etc.).

In 2013, Seoul's water met the requirements for all areas.

※ Purification Stations (8), pre-reservoir (26), post-reservoir (26), intersection of the water service area (26), pressurizing stations (8), faucets in households at the end of the pipe network (26), etc.

Furthermore, the residual chlorine level is measured and monitored every day for 113 reservoirs and pressurizing stations. In fact, 188 sites have real-time, automatic monitoring device for 5 items including turbidity and residual chlorine, with the results made public through the "Seoul Water Now System."

Seoul's water quality control is not affected by interruptions. When there is water supply facility construction (cleaning of reservoirs and pressurizing stations, pipe repair, etc.), we make sure we check the water quality once again before water is allowed to flow. We were able to ensure the quality of tap water by conducting 1,283 tests in 552 cases of such construction. Branch offices of the Waterworks and private testing agencies also conduct tests on 13,188 water tanks and pipes in large buildings. Equally important, 30,807 drinking fountains in 2,674 sites used widely by the public are subject to weekly checking (monthly for subway, quarterly for school) on 5 items including turbidity.

Our commitment to delivering safe and clean water also led to the introduction of the "Arisu Quality Verification Service," which is provided to over 300,000 households that are considered low-income, underprivileged, or with problematic water supply environment at home in Seoul every year. To implement this service, we employed 121 civilians (non-public officials) as inspecting agents who are fully trained and dispatched to visit the homes of Seoul citizens to do actual check of the faucets (1st: 5 items including turbidity, iron; 2nd: 7 items including bacteria, ammonia nitrogen). Agents identify the causes of the reported problem and continuously work with the households until the quality improves to the desired level. The service has been highly received by the public, enhancing the satisfaction level.

From 2008 to 2010, 2.6 million households in Seoul had their faucets tested; since 2011, 300,000 households have been having their homes tested every year. In 2013, of the 320,000 households that underwent testing, 450 were found to have poor water quality, and appropriate measures were taken for them.

※ Water quality improvement measures: indoor water pipe repair/replacement (389), switch to direct water supply (50), water tank cleaning (7), etc.

Aside from the various tests, we also run the "Tap Water Assessment Committee" as stipulated by Article 4 of the Water Supply and Waterworks Installation Act and the same ordinance by the Seoul Metropolitan Government. Composed of city council members, professors, and environment experts, among others, the advisory body takes samples of water from 10 points from the intake station to the faucets of homes on 2 purification centers of their choice. The samples are then sent to an independent testing center commissioned to test the water quality on 59 legally required items.

The result report is made available to the public on the website of the Seoul Metropolitan Government and the Committee. This system helped us gain public trust for Seoul's tap water.

In other words, Seoul has dedicated itself to serving its citizens with safe, healthy, and tasty tap water through multi-layered, stringent water quality tests from intake stations through the production process, all the way to the faucets at home.

| Table 1-5 | Water Quality Control in Distribution Process

Classification	Tested Sites/Target	Tested Items	Testing Agency	Test Frequency
Faucet	450 sites(419 legally required+basic test sites)	6 (4 required, 2 on our own)	Waterworks Research Institute	Monthly
Old pipes	20	13	Waterworks Research Institute	Monthly
Each supply stage	120(purification station 8, pre-reservoir 26 ·post-reservoir 26, intersection of water service 26, pressurizing station 8, end of pipe network 26)	11	Waterworks Research Institute	Quarterly
Reservoir pressurizing station	300,000	12 (5 on the 1st test, 7 on the 2nd)	Branch office	Randomly
Reservoir pressurizing station	113(reservoir 104,pressurizing station 9)	Residual chlorine	Branch office	Daily
			Branch office	Real-time (Seoul Now System)
Reservoir	104	12	Branch office	Quarterly
Before water is let out to flow (after construction works)	Reservoir, pressurizing station, pipes	4 (piping works 2)	Branch office	Randomly
Pipe water tank	1,079 pipes	7	Branch office	yearly
	12,089 water tanks	6	Independent (private) agency	yearly
Water fountain	2,674 sites (30,807units)	5	Branch office	subway : monthly school, gov't complex : quarterly
Monitored items	Faucets at 25 sites (1 site per district)	163 (59 by law +104 monitored)	Waterworks Research Institute	yearly(Sep)
Residual chlorine monitoring	Faucets at 90 sites for each source water's purification center	Residual chlorine	Branch office	weekly

Policy Outcome & Lessons

Today, Seoul is providing healthy and tasty water through systematic and comprehensive water quality testing and monitoring system through the entire process of the water supply system. It is complemented by the real-time automatic water quality monitoring devices and the transparent information disclosure service, all of which have contributed to building public trust in Arisu. The aforesaid measures are made even more effective with the 163 items recommended by WHO as well as the yearly check on the 130 harmful microorganisms that are otherwise not regulated.

We have adopted the "Algae Alert System" and the "Odor Alert System" to deal with problems that directly affect public perception the most and their willingness to drink tap water. The two complementary programs have allowed Seoul to respond preemptively to odor and disinfection taste issues. Another effective measure is the "Chlorine Re-dispersion System," which is designed to keep the chlorine level in reservoirs between the 0.1~0.3mg/L range. Furthermore, the "Advanced Water Purification Facility" will be completed in all 6 purification stations of Seoul by 2015; this will substantially reduce odor, especially algae-related odor, which in turn will make people more willing to drink tap water.

The relative evaluation method among purification centers has also been effective in upgrading facilities and improving water quality. Each purification center is tasked to do research on a topic of their choice, hold workshops on the research topic, and share their experiences and best practices. Such efforts have contributed to upgrading the purification technology and capacity of water quality experts and professionals.

Applicability of the Policy

Other municipalities have benchmarked Seoul's systematic, excellent, inclusive water quality control system, which is applied from the source water all the way to the faucets at homes. In particular, the Ministry of Environment and other municipalities have already adopted or are planning to adopt Seoul's "Odor Alert System," "Arisu Quality Verification System," "Chlorine Re-dispersion System," and harmful microorganisms monitoring practice.

Q&A

How is the standard of Arisu set?

In Korea, to meet the standards for drinking water, microorganism, harmful inorganic matter, harmful organic matter, disinfectants, disinfection byproducts, and aesthetic factors have to be tested. The standards protect public health by limiting the levels of contaminants in drinking water. For each contaminant, it sets a health goal, which is the level at which a person could drink 2 liters of water containing the contaminant every day for 70 years without suffering ill health effects; this basically means no health risk.

What are the grounds that dictate which items are chosen for testing and how they are tested?

Clause 3, Article 4 of the <Water Supply and Waterworks Installation Act> stipulates the following as subject to testing for water quality: harmful microorganisms; substances deemed to have high probability of being detected; substances that may cause social problems, and; items that raised issues internationally. As for the methods and testing guidelines, WHO produces international norms on water quality and human health in the form of guidelines that are used as basis for regulation and standard setting worldwide. We refer to this WHO guideline as well as the practices of other countries.

(We also use the 30 items included in the recommendations by the Ministry of Environment and 104 items stipulated by the Seoul Metropolitan Government).

How was the guideline for healthy and tasty water set?

It was set in December 2010 through sampling events, public survey, public hearing, expert panel, and advisory council as well as outside research, which all began in May of the same year.

| Table 1-6 | Guideline for Healthy and Tasty Water

	Items	Unit	Standard for drinking water	Guideline	Remarks
Health-related	Mineral (Ca,Mg,Na,K)	mg/L	-	20~100	Necessary for human health
	TOC (total organic carbons)	mg/L	5.0 (Seoul's own monitoring regulation)	Below 1.0	Reduction in residual chlorine is beneficial for health
	Turbidity	NTU	0.5	Below 0.3	Reduction in microorganisms (protozoan, virus, etc.) is beneficial for health
Taste-related	Residual chlorine	mg/L	4	0.1~0.3	Disinfection odor
	2-MIB	ng/L	20 (Ministry of Environment)	Below 8.0	Causes moldy odor
	Geosmin	ng/L	20 (Ministry of Environment)	Below 8.0	Causes earthly odor
	Copper	mg/L	1	Below 0.05	Causes blue water
	Iron	mg/L	0.3	Below 0.05	Causes blue water and metallic taste
	Temperature	°C	-	4~15	Suitable to drink with refreshing feel

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Water Production 02

Advanced Water Purification System

World-class water purification system

To deliver upgraded, premium-quality tap water to all citizens of Seoul, the Office of Waterworks has adopted the **"Advanced Water Purification System"** after years of thorough preparation. As we continue to expand the service, all households in Seoul will be provided with tap water treated by the advanced water purification system by 2015.
The system strengthens the current purification method by incorporating ozone and granular activated carbon (GAC, or charcoal), which perfectly remove unpleasant taste and odor caused by algae, disinfection byproducts, and other micro-organic matters. With the introduction of the advanced system, Seoul can now deliver cleaner, safe water in which minerals are kept intact.

Before the Policy Implementation	After the Policy Implementation
• Moldy odor was detected in tap water when raw water was affected by algae bloom and other phenomenon caused by climate change. • Citizens were suspicious of tap water due to unpleasant odor/taste, disinfection byproducts, agricultural pesticides, antibiotics, and microorganisms.	• Taste is improved by eliminating the unpleasant taste and odor. • Disinfection byproducts, agricultural pesticides, antibiotics, and microorganisms are eliminated, ensuring safety. • Even when raw water is affected by algae or other issues caused by climate change, countermeasures are in place.

Overview of the Policy

《 Adopting an advanced water purification process that utilizes ozone and activated carbon

– Ozone can effectively eliminate substances that cause unpleasant odor, taste, disinfection byproducts, and microorganisms.

– The GAC (granular activated carbon) process can reduce materials that cause unpleasant taste and odor.

Background

Recently, the unpleasant odor caused by algal bloom – one of the side effects of climate change -- and unexpected presence of unknown organic matter in tap water gave rise to concerns among the people. To deliver the finest-tasting water that is free of unknown matter, we needed to adopt a new, more advanced water purification system that can eliminate unknown organic matter and enhance taste at the same time.

Process of Policy Implementation

- 2007 : A plan to adopt the "Advanced Water Purification Facility" was formulated.
- 2010 : The construction of the advanced water purification facility was completed in the Yeongdeungpo purification center (450,000㎥/day).
- 2012 : Construction was completed in the Gwang-am purification center (700,000㎥/day).
- 2014 : Construction is set to be completed in Gangbuk, Amsa by October and Guui by December (3.2 million ㎥/day).
- 2015 : Construction is set to be completed in Ttukdo (3.8 million ㎥/day).

| Table 2-1 | Percentage of Purification Centers with the Advanced Purification Facility (Cumulative)

Classification	2011	2012	2013	2014	2015
Percentage	17.26%	24.61%	24.61%	90.31%	100%

Details of the Policy

Seoul's water purification plants for Arisu adopt the Advanced Water Purification Facility.

To provide premium Arisu to all Seoulites, we have been making aggressive investments; In fact, from 2007 to 2015, 528.5 billion won was spent on constructing advanced water purification facilities in 6 centers (capacity of 3.8 million m/day) and upgrading the existing purification plants in Seoul. The facility utilizes granular activated carbon and ozone on top of the standard purification process. The first construction was carried out in March 2007 in Yeongdeungpo, and the second one, in Gwang-am in 2014. The same facilities will be built for Amsa, Gangbuk, and Guui by the end of 2014 and Ttukdo by 2015.

We also adopted the "Ubiquitous Process Management System," which incorporates IT to control the entire process automatically by computer.

| Table 2-2 | Construction of the Advanced Purification Facility in Seoul

<table>
<tr><th colspan="2">Classification</th><th>Number</th><th>2007~2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td colspan="2">Completion</td><td>6 sites</td><td>Yeongdeungpo 1-2 purification stations (2010~2011), Gwangam (2012)</td><td>–</td><td>Gangbuk, Amsa, Guui</td><td>Ttukdo</td></tr>
<tr><td rowspan="2">Advanced Purification</td><td>Production (Cumulative)</td><td>380 (Million ton/ day)</td><td>70</td><td>70</td><td>320</td><td>380</td></tr>
<tr><td colspan="6">※ Capacity(3.8 million/day) : Yeongdeungpo 45, Gwangam 25, Gangbuk 95, Amsa 110, Guui 45, Ttukdo 60</td></tr>
<tr><td>Expenses</td><td colspan="6">52.85 billion won</td></tr>
</table>

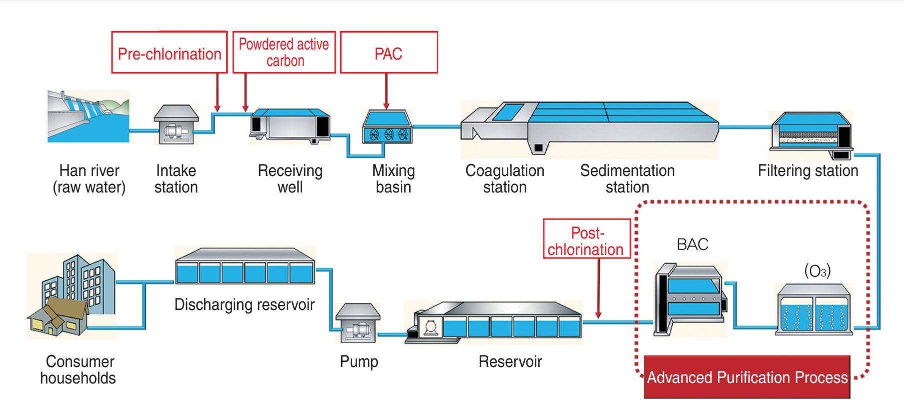
Yeongdeungpo

Gwang-am

Process of the Advanced Water Purification System

Tap water is provided to households after 6 different processes: mixing (blending), flocculation/coagulation, sedimentation, filtration, ozone treatment, and granular carbon treatment. Water taken from the intake stations go through the following steps before reaching the reservoirs:

[Process Map]



- Intake station: Water acquired from Han River's intake stations is released by pumps.
- Pre-chlorination: This process disinfects source water in advance to kill bacteria and improve water quality.
- Mixing basin: Source water and purifying chemicals, or coagulants, are mixed together in the basins.
- Coagulation station: Small impurities in the water, which are mixed with coagulants, are condensed into larger particles or lumps.
- Sedimentation station: Big, condensed lumps are deposited and allowed to settle.
- Filtering station: Fine particles that did not settle in the previous step are now filtered.
- Advanced water purification: The strong oxidation power of ozone and adsorptive power of GAC used in this process produce cleaner, safer water.

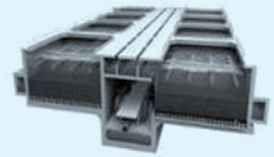
※ **Ozone Treatment**

Ozone's strong oxidation power is used to eliminate disinfection byproducts and micro-organic matter, which cause unpleasant taste and odor. Ozone is obtained and provided in reservoirs by liquid oxygen or ozone producer.

Transform oxygen in the atmosphere into ozone by applying strong electricity (8,000~20,000v)

※ **GAC (Granular Activated/Active Carbon)**

Activated carbon is a form of carbon usually derived from the carbonization of charcoal and timber at high temperature and processed to have small, low-volume pores that increase the surface area available for adsorption. The enhanced adsorptive power effectively filters air and water, especially the odor and taste of disinfectants in tap water. It is classified into powdered activated carbon (PAC) and granular activated carbon (GAC). PAC is generally added directly to the receiving well, whereas GAC is added in a structure or a fixture (refer to the image) through which water is allowed to flow. GAC is reusable.



- Post-chlorination: Chlorine is added to the water at this stage to eliminate any source of contaminants and make the effect of disinfectants reach the faucets.
- Reservoir: The purified water is stored here.
- Pump: Purified water flows to reservoir or households by pump.
- Discharging reservoir: Water is stored at a high location temporarily so that it can be delivered to each household in a stable manner.

Know-how & Insights

The Office of Waterworks adopted the "Ubiquitous Process Management System," which incorporates IT to control the entire process automatically by computer. The "Advanced Water Purification System" -- which utilizes ozone and GAC (granular activated carbon) -- ensures the safety and taste of tap water.

The system allows us to protect tap water against any possible unknown organic matter that may contaminate water and against any change in source water.

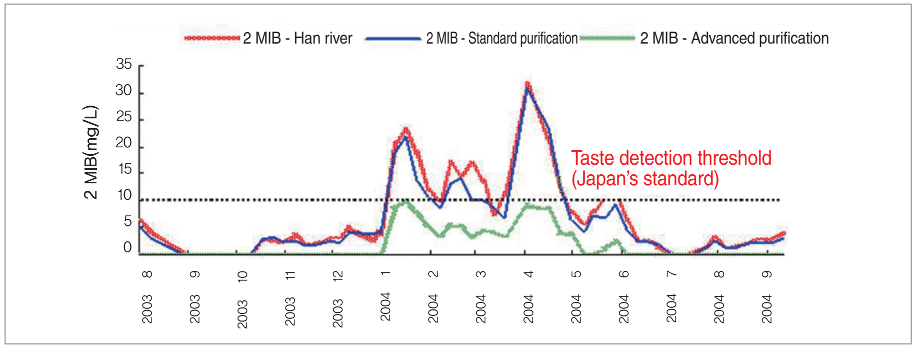
Policy Outcome & Evaluation

GAC absorbs and removes taste and odor from the water as well as unknown organic matter. Therefore, adding GAC can reduce the use of chlorine by up to 30~50%.

Because of its excellent disinfection and oxidation qualities, ozone is widely used for drinking water treatment -- especially to remove disinfection byproducts and remaining dissolved organic matter -- far more effectively than the traditional method.

This "Advanced Water Purification System" completely eliminates sandy or moldy taste caused by algal bloom. In fact, its effectiveness and safety were proven during algal blooms in Han River during the cold days of Nov. 2011 and warmer ones in August 2012; equipped with the system, the Yeongdeungpo purification station was found to have removed all algae and other organic/inorganic matter.

I Graph I Odor and Taste Removal Function of the Advanced Purification Facility



Applicability of the Policy

Areas subject to high level of industrialization, contamination of source water, algal blooms due to climate change, and/or concentrated use of agricultural pesticides can adopt the "Advanced Purification System" to eliminate concerns over the compromised quality of source water.

Q&A

What are the greatest strengths of Seoul's "Advanced Water Purification System"?

With the standard purification system, materials that give rise to odor and taste issues cannot be easily eliminated. The advanced purification system remedies this shortcoming by incorporating ozone and GAC and advanced oxidation process. The additional processes ensure that all odor/taste-causing materials are completely removed from the water including the remaining antibiotics and micro-organic matter. In other words, this system is an effective prevention mechanism to ensure thorough water treatment.

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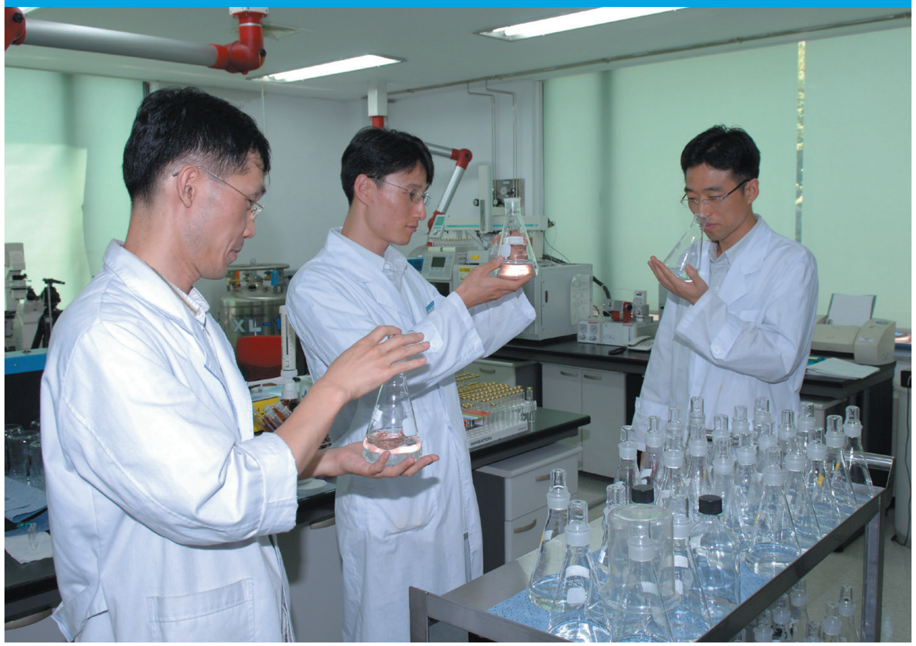
Seoul provides premium-quality, healthy, and tasty water to its citizens with quality control testing tailored to each step of the water supply system from intake and purification to distribution.



Water Production 03

Chlorine Re-dispersion Facility

Reduction of disinfection odor in tap water

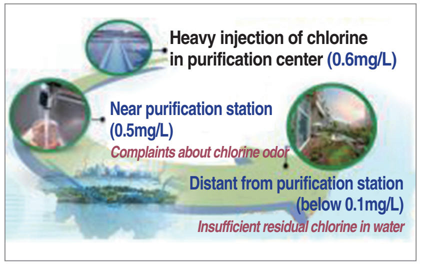
Tap water chlorination is a necessary step to ensure the hygiene and safety of tap water since it destroys harmful microorganisms; note, however, that it may also add an unpleasant odor to the drinking water. Before, most of the chlorine was usually added in purification stations; with the installation of hypochlorous acid producers, however, chlorine can now be added in multiple steps. In other words, only the minimum amount of chlorine was added at the purification plant, with a minimum amount added again at the water supply reservoir. This system, called **"Chlorine Re-dispersion,"** can significantly reduce unpleasant odor and related civil complaints. It also ensures that a sufficient amount of residual chlorine is maintained in areas located at the far end of the water pipe network. With the system, the same level of residual chlorine (0.1 ~0.3 mg/L) is maintained all throughout the water supply system while providing safe, odor-free water to our citizens.

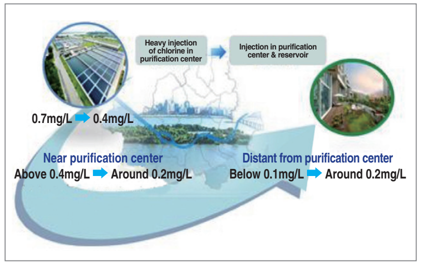
Before the Policy Implementation	After the Policy Implementation
• Because chlorine was added at the purification plants only, areas near the plants complained of unpleasant odor, whereas those at the end of the water pipe network suffered from insufficient residual chlorine.	• A smaller amount of chlorine is added at purification plants, reducing unpleasant odor coming from disinfection. • For distant districts, another round of chlorine is added to maintain an adequate amount of residual chlorine in the water.

: Overview of the Policy

- Installing a disinfection facility that forms hypochlorous acid at 18 reservoirs to allow multiple chlorine injection in the distribution system
- Reducing the strong chlorine odor near purification plants to address civil complaints and consequently increase the tap water drinking rate
- Ensuring safety from microorganisms in areas located at the end of the water pipe network by maintaining the proper level of chlorine

[Changes in the chlorine injection system]





Background

In the past, the main objective was to ensure the safety of drinking water by adding a substantial amount of chlorine in purification plants to kill microorganisms and bacteria. The side effect, however, was the too strong odor of chlorine in water, especially near purification plants; thus making people hesitant to drink the water or prompting them to lodge civil complaints. On the other hand, households located at the end of the water pipe network were provided water that did not have enough residual chlorine; thus raising concerns of the disinfection and safety of the water they are drinking.

Process of Policy Implementation

To reduce chlorine odor near purification plants and to provide the proper chlorine level to distant places, the "Chlorine Re-dispersion System" was formulated in 2009 and pilot-run from 2010 to 2011 in 3 reservoirs. Based on the analysis of the pilot results, from 2012 to 2013, 14 reservoirs adopted the system, bringing the total to 17.

[Installation of chlorine re-dispersion facilities]

Classification	Total	2010	2011	2012	2013
Installation completed	17	1 pilot	2 pilot	6 in Amsa source water	7 in Gangbuk source water
Expense (unit : million won)	2,873	70	267	948	1,726

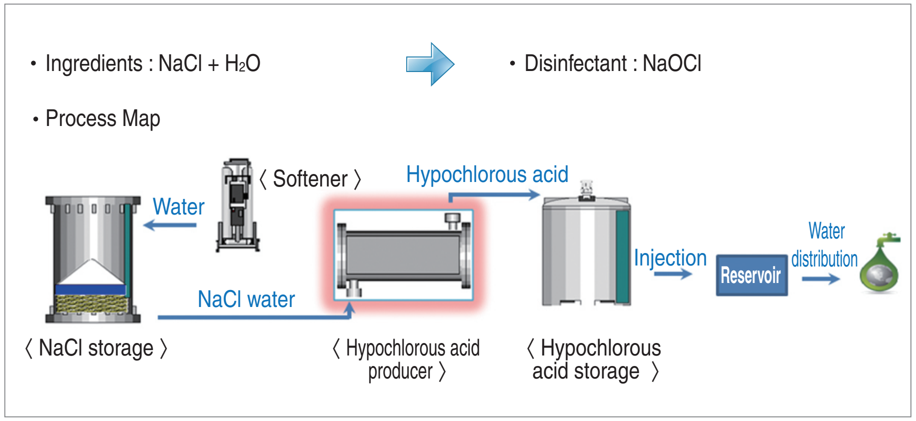
Details of the Policy

Installing a disinfection facility that forms hypochlorous acid at 18 reservoirs to allow multiple chlorine injections in the distribution system

Chlorine liquefied under high pressure is used; since disinfectants purification plants require safety devices and other protection facilities as per the High-pressure Gas Safety Control Act, which inevitably incurs higher costs such as hiring certified safety managers.

To reduce such high cost, we replaced high-pressure liquefied chlorine with equipment that generates hypochlorite through the electrolysis of NaCl. The system was first pilot-tested in 2009 at 1 site; after thorough analysis of the effectiveness, 17 reservoirs adopted this system by 2013. The system was complemented by electronic communication that enables remote controlling and monitoring system.

[Schematic Diagram for the Chlorine Re-dispersion System]





Chlorine Re-dispersion Facilities

Know-how & Insights

Using chlorine at purification centers incurs additional cost of safety control and specialized labor. In contrast, a system in which hypochlorite is generated through the electrolysis of NaCl reduces safety-related costs and extra labor needs.

Even better, through the electronic communication control system, operation can be monitored and remotely controlled at each Waterworks branch.

Policy Outcome & Evaluation

We were able to reduce the chlorine concentration of water by 10.3% (from 0.58-→52mg/L) at purification plants; this translates into a 21.1% reduction of the chlorine concentration level (0.33→0.26mg/L) at faucets in homes near the purification centers. This substantially eliminated the disinfectant odor to the extent that people do not detect the unpleasant odor at all. For distant areas where the residual chlorine level was too low, hypochlorite was added to keep it at least above 0.1mg/L of chlorine concentration at the faucets.

Applicability of the Policy

This system is absolutely necessary for cities with long water pipe network.

Q&A

Why did Seoul set the proper residual disinfectant level at 0.1~0.3ml/L when the maximum chlorine concentration allowed in drinking water is 4.0 mg/L?

Though differing among individuals, various tests including blind tests and satisfaction survey find that people hardly detect disinfectant odor when the chlorine concentration level is below 0.3mg/L. Note that 0.1mg/L is the level required to protect water against bacteria and microorganisms.

Contact Information	Division : Water Quality Division, Facility Department, Office of Waterworks, Seoul Metropolitan Government Director : Sung-jae LEE, 02-3146-1320, jae7461@seoul.go.kr Manager : Jong-pil LIM, 02-3146-1325, jplnim65@seoul.go.kr


Gwang-am Purification Station


Gangbuk Purification Station


Yeongdeungpo Purification Station

Water Production 04

Arisu Quality Verification System

Building trust with water faucet inspection

The **"Arisu Quality Verification System"** allows citizens to request inspecting agents to visit their houses to verify the water quality in their faucets. The system helps people build trust in the water they are drinking and creates employment opportunities by being hired as inspecting agents. In 2008, Seoul adopted such service for the first time in the country. Since then until 2013, 3.6 million households have benefited from the service, with which households can get free water quality assessment on 5 indicators (turbidity, pH, iron, copper, and residual chlorine). In 2013, 320,000 households had their water faucets inspected; of these, 4.5 million houses found to be in need of improvement received proper support. Assistance measures include old pipe replacement (389 cases), drain valve and shift to direct water supply (50 cases), water tank cleaning service (11 cases), etc. As such, we provided support to upgrade the water supply environment and provide tasty, clean tap water. Starting this year, the inspection includes not only quality but also taste and odor.

Before the Policy Implementation	After the Policy Implementation
• Citizens had unfounded mistrust in the water provided to their houses. • Citizens were suspicious of the safety of tap water.	• The system lets people check the water quality in their house, thereby building trust. • The system creates jobs as citizens participate in the process as inspecting agents.

Overview of the Policy

《 Every year, 300,000 households with low income and those whose tap water quality does not meet the basic guidelines receive free water quality inspection service.

《 Five basic indicators of tap water safety -- turbidity, ion density, iron, copper, and chlorine residue -- are examined to determine potability.

- In case the test results are not satisfactory, 7 additional items such as bacteria and colon bacterium are tested.

《 Citizens (non-public servants) are hired as inspecting agents who visit the inquiring houses.

Background

There was general public mistrust -- mostly unfounded -- in the quality of tap water, and many were uncomfortable drinking it. To address this issue, we decided to implement the "Arisu Water Quality Verification System," which allows citizens to check and evaluate the quality of tap water in their own homes.

Process of Policy Implementation

From 2001, we dispatched officials to conduct every year free water quality checks at 50,000 households that signed up to have their tap water tested. In 2008, in a bid to improve public perception of Arisu, we took a step further and implemented the plan to have all 2.6 million households in Seoul undergo free water quality checks by 2010. From 2011 to 2014, we have been expanding the service to 300,000 specially chosen households, mostly daycare centers, schools, and low-income families.

Details of the Policy

Every year, 300,000 households with low income and those whose tap water quality does not meet the basic guidelines receive free water quality inspection service

With the introduction of the service in 2013, 320,000 households underwent free water quality checks. Of those, 450 households were found to have poor-quality tap water; they receive assistance to replace worn-out pipelines in their houses (389 cases), eliminate small water tanks and switch to direct water supply (50 cases), and clean the water tank (11 cases). Beginning 2014, the inspection criteria were expanded to include water taste and odor.

Five basic indicators of tap water safety – turbidity, ion density, iron, copper, and chlorine residue – are examined to determine potability

Inspecting agents visit houses to check 5 indicators -- turbidity, pH, residual chorine, copper, and iron -- and explain the results clearly. When the quality passes the level, a "certificate" is given; when found to have poor quality, a sample is taken for further tests for 7 additional indicators: bacteria, coliform group, colon bacteria, ammonia nitrogen, zinc, manganese, and chlorine ion. We continue to take actions so that the quality of water used by citizens reaches the permissible level.

Citizens (non-public servants) are hired as inspecting agents who visit the inquiring houses

Citizens themselves participate in the program as inspecting agents who visit to check the tap water faucets. Such engagement enhances public trust in tap water and creates jobs as well.

- Citizens are hired as inspecting agents and trained on how to check water quality, how to handle civil complaints, and how to deliver quality service. After the training, they are dispatched to houses who inquired about the service.
- Quality check is done with both agents and users. When found poor, the quality is continuously checked until it passes the level.
- 1st testing: turbidity, ion density, copper, iron, and residual chlorine
- 2nd testing: bacteria, coliform group, colon bacteria, ammonia nitrogen, zinc, manganese, and chlorine ion


Turbidity tester


Residual chlorine tester


pH tester


Copper, iron tester

I Table 4-1 I Number of Inspecting Agents Hired by District (in 2014) : 121 persons in all (including 3 people with disability)

Classification	Jungbu	Seobu	Dongbu	Bukbu	Gangseo	Nambu	Gangnam	Gangdong
# hired	12	14	18	16	17	19	12	13

Know-how & Insights

First of all, the inspecting agents need proper training such as how to use the quality measuring device, provide excellent service, and have basic knowledge of the water treatment process and tap water in general. Second, there is a need to purchase water quality measuring devices that the agents will carry with them when visiting houses so that they can check the five indicators.

Policy Outcome & Evaluation

- [2001~2007] 50,000 households (per year) that signed up received free water quality check.
- [2008~2010] Free water quality check is provided for 2.6 million households.
- [2011~2013] Free water quality check is provided for 1 million households.

I Table 4-2 I Measures Taken to Improve Water Quality : old pipe replacement (1,283), drain valve (191), switch to direct water system (173), water tank cleaning service (60)

Classification	Cases Completed	Measures Taken
2011	663	Old pipe replacement 489, drain valve140
		Direct water system 2, water tank cleaning 32
2012	594	Old pipe replacement 405, drain valve 47
		Direct water system 121, water tank cleaning 21
2013	450	Old pipe replacement 389, drain valve 4
		Direct water system 50, water tank cleaning 7

Applicability of the Policy

First adopted in Seoul, the “Arisu Water Quality Verification System” is now being benchmarked by other municipalities such as Gwangju and Incheon. The Ministry of Environment benchmarked this program in 2014, and it has been adopting a similar service dubbed the “Tap Water Quality Check” program in all municipalities.

Q & A

How do I apply to receive free water quality check at my house?

Simply call the 120 Dasan Call Center, an information hotline for inquiries on life in Seoul, by dialing 120 or visit http://arisu.seoul.go.kr and sign up for the free faucet quality inspection service.

Contact Information

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Water Distribution

01 Water Supply Free of Interruption
Minimizing the impact of water supply interruptions through quick emergency response measures and adjustment of water supply system tailored to high/lowlands

02 Revenue Water Ratio & Leak Management
Achieving the highest revenue water ratio in the world

03 Water Supply Geographic Information System (GIS)
Building a smart water supply facility management system by providing high-quality spatial information of the facilities

04 Old Pipe Maintenance Project
Systemic Maintenance based on the "Comprehensive Old Pipe Maintenance Plan"

05 Shifting to the Direct Water Supply System
Ensuring the highest water quality by removing rooftop water tanks and applying direct water [supply system for buildings with up to 5 stories]

06 Frost Protection for Water Meters
Minimizing water supply interruptions by introducing measures to protect water meters from freezing and bursting

Water Distribution 01

Water Supply Free of Interruption and Emergency Water Supply System

Minimizing the impact of water supply interruptions through quick emergency response measures and adjustment of water supply system tailored to high/lowlands

Committed to providing the best water supply service to 10.39 million Seoul citizens, the Office of Waterworks of the Seoul Metropolitan Government has installed emergency water supply pipes between water purification plants and between water reservoirs, thereby eliminating the risk of water outages that may take place after leak, earthquake, or other natural disasters. In addition, we have effectively utilized the newly created suspension bridge pipelines on Han River bridges to connect the water supply networks of Gangnam and Gangbuk, making them complement one another in emergency situations.
Furthermore, to maintain the security of water supply, we have also introduced an emergency action plan with which we can rapidly alter source water in cases of isolated water outages caused by small-scale leaks.

Before the Policy Implementation	After the Policy Implementation
• Large-scale water interruption was unavoidable in the event of leak in a big water pipe. • Lowland areas suffered from water leaks due to high water pressure, whereas highland areas were plagued by water shortages caused by low water pressure. • During water interruptions, emergency water supply to the upper floors of high-rise buildings was most difficult.	• Emergency pipelines are installed to connect different water reservoirs as well as connect Gangnam and Gangbuk; thus eliminating the risk of water interruptions. • A more sustainable water supply system is created by changing the direct water supply system into the indirect one, allowing water to be supplied at adequate pressure in all areas. • By employing tanker trucks with pumps, it is now possible to supply water up to the 15th floor of tall buildings.

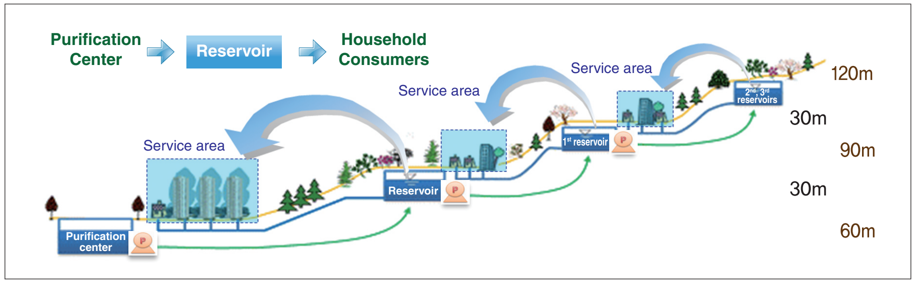
Overview of the Policy

« In lowlands with high water pressure, the indirect water supply system using reservoirs has replaced the direct method.

« Emergency water pipelines are now installed to connect large-scale purification plants in Gangbuk and Amsa.

« Tanker trucks are employed to enable water to be supplied to tall buildings.

[Water Supply System in Seoul]



Background

Differences in water pressure due to Seoul's topographic characteristics caused frequent water leaks

Seoul's mountainous terrain requires pressurizing stations to supply water to higher-lying areas. Nonetheless, such pressurizing stations proved to be insufficient in preventing water interruptions. In fact, high water pressure in the lowlands continued to cause water leaks, whereas water shortages plagued many highland areas. Therefore, there was a clear need to replace the direct water supply system using pressurizing stations with an indirect system whereby water is supplied through water reservoirs.

The combined application of direct and indirect water supply systems led to energy wastage and high water pressure

While water is supplied at normal pressure level in most parts of Seoul, lowlands suffered from various water interruption issues due to higher water pressure (5.0kgf/cm3).

Of the 16,634 cases of leaks that occurred in 2010, 3,904 occurred in high water pressure areas (lands supplied with water at high pressure); this is six times higher than the areas with normal water pressure levels. Such interruptions caused 8.5 billion won in losses and much inconvenience to the residents of the affected areas/districts.

- In areas where water is supplied to both high- and low-lying areas, higher head was used to lift water uphill, causing significant energy loss.
- After emergency recovery from water leak, water was supplied to the lowlands first, causing delays of recovery in the high-lying areas.
- In areas where water was supplied directly from its source, water supply was immediately cut off when pressurizing stations failed due to power outage, causing sudden water interruptions and much inconvenience to the community.

In case of water interruptions and other emergencies, upper floors of high-rise buildings had most difficulties with water supply

Since 60% of the residents in Seoul live in apartment buildings, it was necessary to enable water supply to higher floors in the event of an emergency.

- During water interruptions, bottles of Arisu water were distributed, and water supply trucks were mobilized (only for lower floors).

Process of Policy Implementation

The indirect water supply system, instead of the direct system, is utilized for high water pressure areas

- [Nov 30, 2011] A plan that would allow switching from direct water supply (using pressurizing stations) to indirect water supply (using reservoir) was formulated.
- [Nov 24, 2010] A plan to change the water supply system in the Namsan reservoir was formulated.

  [July 2012] The Bogwang reservoir & pressurizing station around Whoam-dong and Cheonyeon pressurizing station changed their system from direct to indirect using the Namsan reservoir.
- [June 01, 2011] A plan for the water flow of the Gaewoonsan reservoir was made.

  [Sep ~ Nov 2012]. Areas such as Jeungnung2, Seongbuk1, and Seougbuk2, which previously used pressurizing stations, now changed the system to use the indirect water distribution mechanism with a reservoir in Gaewoonsan.

• [As of June 2014] Efforts are underway to construct the water supply system for the Samsung, Bongeun, and Suseo reservoirs.

An emergency water supply system is in place, with emergency water pipes connecting large-scale purification stations in Gangbuk and Amsa

• [May 2007] Efforts to establish the <Basic Plan for Waterworks Improvement by 2020> began

• Emergency duct lines were installed to connect the purification stations of Gangnam and Gangbuk to ensure balance in the capacity of the stations in both regions.

• [2007 ~ 2009] : The #2 purification plant in Yeongdeungpo was rebuilt.
[2007 ~ present]: An alternative water source was newly introduced as supply during the construction period of advanced water treatment facilities (70,000 tons/day for Gangbuk, 135,000 tons/day for Amsa).

• [2010 ~ 2011] : The Guui purification plant was rebuilt, and an alternative source of water began to be made available during the construction period of advanced water treatment facilities.

• [2012 ~ 2014] : The Ttukdo purification plant was rebuilt, and efforts are underway to ensure an alternative water source during the construction period of advanced water treatment facilities.

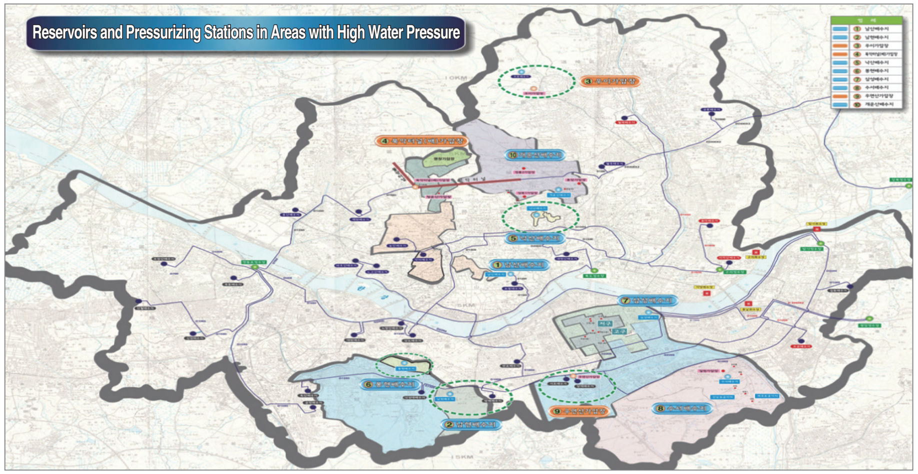
• Efforts are underway to install large-scale emergency water supply pipes connecting Gangbuk and Amsa, between different purification plants, between many reservoirs, and between the purification plant and the reservoir.

Facilities such as tanker truck are being effectively operated to supply water to high-rise buildings

• [Oct 18, 2011] A plan to improve water supply trucks was formulated.
The plan is implemented in full-scope feasibility studies of applying pumps on trucks and pilot project as well as several meetings with service providers and internal discussions.

Introduction of the Policy

Areas with high water pressure are designated as indirect water supply service areas, taking into consideration the characteristics of each region



• Major Projects

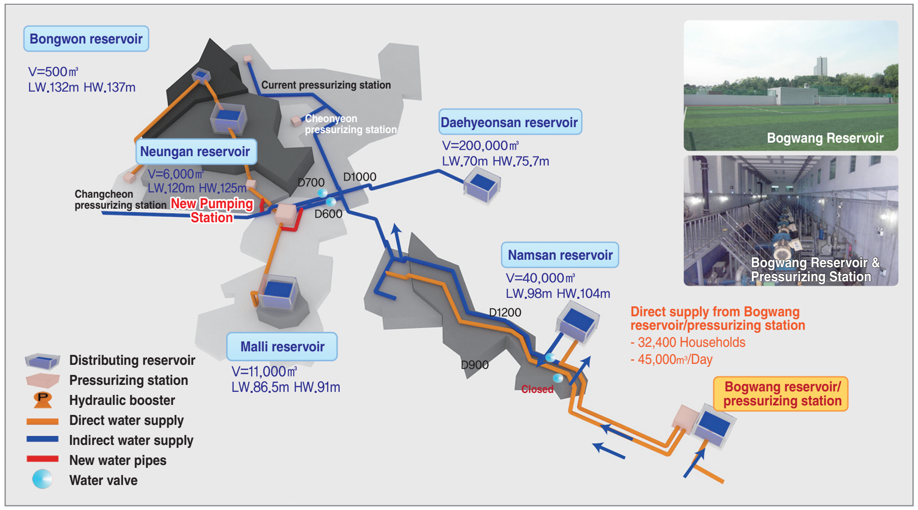
I Diagram 1-1 I Improvement of the Namsan Reservoir Water Supply System

Before	Bogwang reservoir →	Bogwang reservoir & pressurizing station <Head of fluid 108m> →	Pressurizing stations & Namsan reservoir	Combination of direct & indirect water supply
After	Bogwang reservoir →	Bogwang reservoir & pressurizing station <Head of fluid 104m> →	Namsan reservoir (only 10% supplied from pressurizing stations)	Indirect water supply

Among 32,400 households in 11 dongs of 3 administrative districts -- Jongno-gu, Yongsan-gu, and Seodaemun-gu – supplied with water from the Daehyeonsan reservoir and nearby areas (Malli and Neungan reservoirs), some were reclassified to receive water from the Namsan reservoir water supply system. At least 90% of the service area covered by direct water supply will now be covered by the indirect water supply system, whereas the remaining 10% will receive water supply from pressurizing stations.

As part of the project, we closed the Malli, Cheonyeon, and Changcheon pressurizing stations and Cheonyeon and Bongwon reservoirs.

As a result, the head of fluid at the Bogwang reservoir went down from 108m to 104m, enabling reduced electricity cost. In addition, we created more green spaces for the citizens by landscaping the site previously used for reservoirs and pressurizing stations.



I Table 1-2 I Improvement of the Namhyeon Reservoir's Water Supply System

Before	Amsa Water Purification Center <High-lift pump>	Bangbae service reservoir <Apply pressure>	Namhyeon service reservoir
			Pressurized, direct water supply
After	Amsa Water Purification Center <High-lift pump>	Bangbae service reservoir <Reapply pressure>	Namhyeon, Bangbae service reservoir
			Pressurized, direct water supply, Bongcheon 11 service reservoirs

We established a separate water supply system for different elevations (for below 30m and above 50m) to prevent water leak caused by overpressure and a two-track water supply system to ensure stable supply of water.

I Table 1-1 I Improvement of Gaeunsan Reservoir's Water Supply System

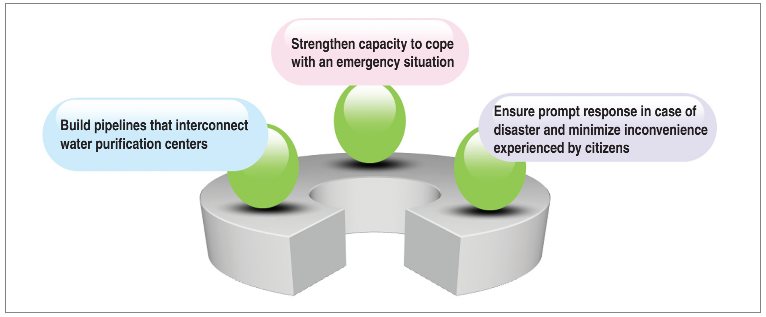
Classification	Pressurizing station	No. of households supplied with water	Improvements in Water Supply System	
			Before	After
Total		**73,200**		
Jeongneung area	Jeongneung 2	22,000	Jeongneung2 Pressurizing Station(40m)	Bugak tunnel pressurizing station(70m)
	Jeongneung 4	6,000	Jeongneung2 ⇨ Jeongneung4 Pressurizing Station	Bugak tunnel pressurizing station ⇨ Jeongneung4
Seongbuk area	Seongbuk 1, 2, Insoo	31,000	Bugak Tunnel ⇨ Seongbuk 1,2, Insoo	Integrate Bugak(Ga) with Gaewoonsan service reservoir
	Jongam	12,000	Wolgok ⇨ Jongam Pressurizing Station	
	Haemyung	2,200	Daehyunsan ⇨ Haemyung Pressurizing Station	

Service areas covered by Seongbuk 1, 2, Insoo, Jongam, and Haemyung pressurizing stations via direct water supply now receive water indirectly from the integrated Bugak tunnel pressurizing station. As a result, 3 pressurizing stations were closed down.

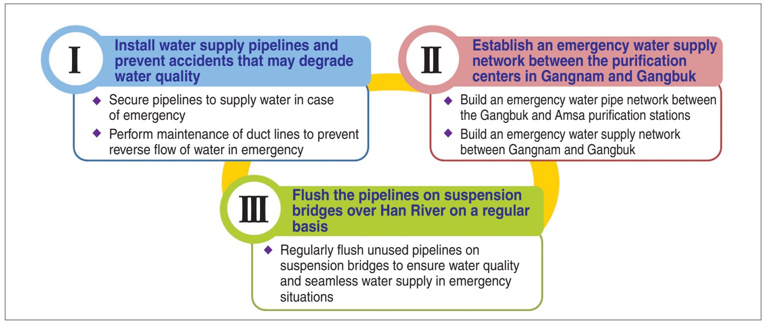
An emergency water supply scheme was put in place including installation of emergency water pipelines to connect large-scale purification plants in Gangbuk and Amsa

We built emergency water pipes connecting the Gangbuk and Amsa water purification centers so that each center serves as alternative source water in case of an emergency such as interruption of water supply due to the contamination of source water.

[Policy Objectives]



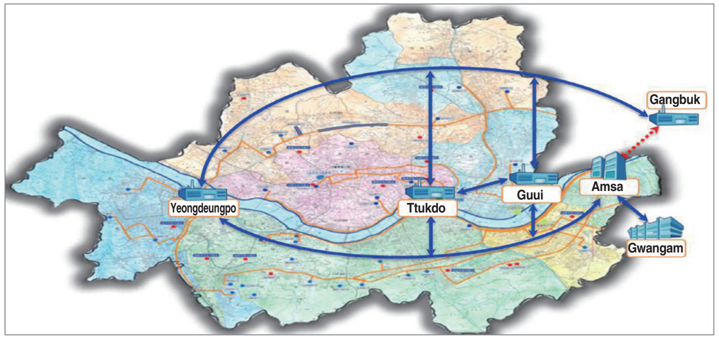
[Emergency Water Supply System]



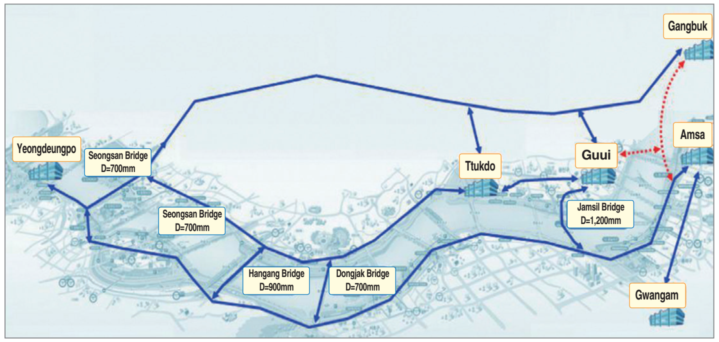
I Table 1-2 I Amount of Water Supply Provided by Supporting Purification Centers (Unit : 1,000㎥)

Water Purification Center	Service population (Unit: 1000 ppl)	Capacity	Average supply	Purification centers to support water supply
Total	10,388	4,350	3,250	
Gwangam	761	400	220	Amsa(220)
Guui	579	250	400	Ttukdo(50), Amsa(50), Gangbuk(300)
Ttukdo	1,016	500	470	Guui(150), Amsa(70), Yeongdeungpo(60), Gangbuk(190)
Yeongdeungpo	1,727	600	440	Amsa(290), Gangbuk(150)
Amsa	3,478	1,600	1,100	Gwangam(180), Guui(100), Ttukdo(280), Yeongdeungpo(160), Gangbuk(40) In case of shortage – supplied by Gangbuk(340)
Gangbuk	2,827	1,000	620	Guui(100), Ttukdo(280), Yeongdeungpo(60), In case of shortage – supplied by Amsa (180)

[Emergency water supply system for each water purification center]



[Emergency water supply system for each water purification center]

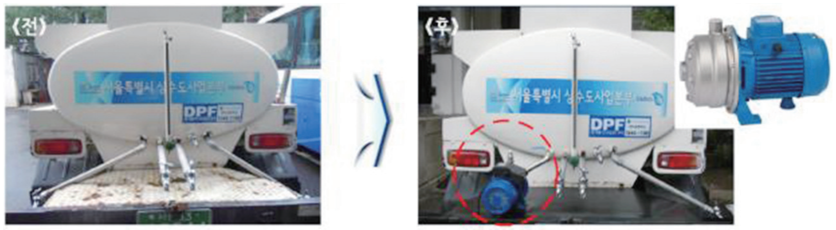


I Table 1-3 I Water Supply via Suspension Bridges of Han River

Bridge Name	Supply Pipes	Supporting purification center	Supply Amount (Unit: 1000 tons)
Seongsan Bridge	700mm×2 pipes	Yeongdengpo ⇔ Gangbuk	160 tons/day
Hangang Bridge	900mm×1 pipe	Amsa ⇔ Ttukdo	90 tons/day
Dongjak Bridge	700mm×1 pipe	Amsa ⇔ Ttukdo	70 tons/day
Jamsil Bridge	1,200mm×1 pipe	Amsa ⇔ Guui	150 tons/day

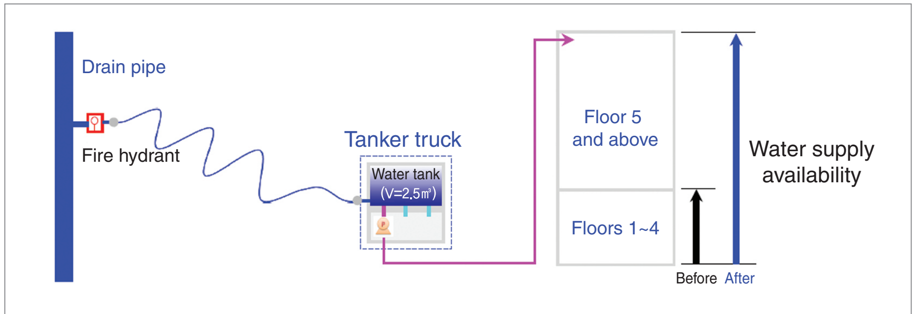
Establishing the infrastructure necessary to deploy tanker trucks for high-rise buildings

In case of emergency, water supply to the upper story of an apartment may be difficult. To address this issue, one electric booster pump (2HP, H=59m), which will be connected to the deployed water tanker for high-rise buildings, was installed for each of the water tankers owned by each Waterworks office.



Type	Voltage	Rated output	Total head	Maximum Pumping	Weight	Diameter of Inlet	Diameter of Outlet
2CDX(M)70/206	220V	2HP	59M	8,700(l/h)	19.4kg	32mm	25mm

[Illustration of how the pump is attached to the tanker truck]



Know-how & Insights

Overpressure regions were reclassified to receive water indirectly, taking into consideration the characteristics of each region.

To change the water supply source, we conducted due diligence to measure flow direction, flow velocity, and hydraulic pressure. Then, we coordinated schedules and determined the order of priority. To minimize the inconvenience experienced by the citizens, we held 10~15 meetings with interested parties and thoroughly prepared in advance.

An emergency water supply scheme that includes interconnected pipelines between large-scale purification plants in Gangbuk and Amsa was put in place.

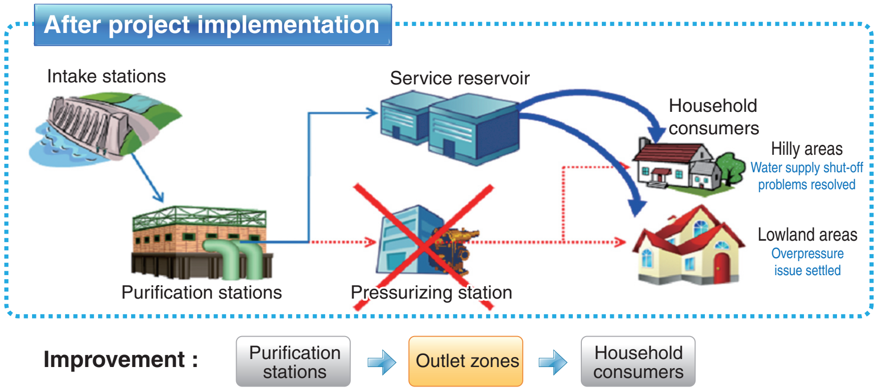
Projects including the construction of advanced water treatment facilities in Gangbuk and large-scale water pipeline construction such as establishment of dual pipeline system for Olympic Expressway require an emergency water supply plan that includes changing the source water. Thus, we initiated simulation to measure changes in flow direction, flow velocity, and hydraulic pressure resulting from source water changes, and then utilized this data during the actual construction project. Large-scale construction projects to build and connect water pipelines require a huge budget. Therefore, the budget for these construction projects is incorporated into both “2020 Basic Plan for Waterworks Improvement” and “2030 Basic Plan for Waterworks Improvement,” and we are making full preparation to ensure smooth water supply with zero interruption rate. The successful implementation of these projects requires a large budget and a contingency plan to respond to source water changes in case of an emergency including degradation of water quality.

By installing a pump, existing water tankers can be used to supply water to high-rise buildings without reconfiguring the vehicle.

Reconfiguration of the vehicle is costly, and it is difficult to install pressurizing facilities on a par with a fire truck. Therefore, instead of changing the structure of the vehicle, we installed a pump at the rear of the tanker truck to supply water to 15-story buildings.

Policy Outcome & Evaluation

Improved water supply system: Shifted from direct supply via pressurizing pump to indirect supply via service reservoirs



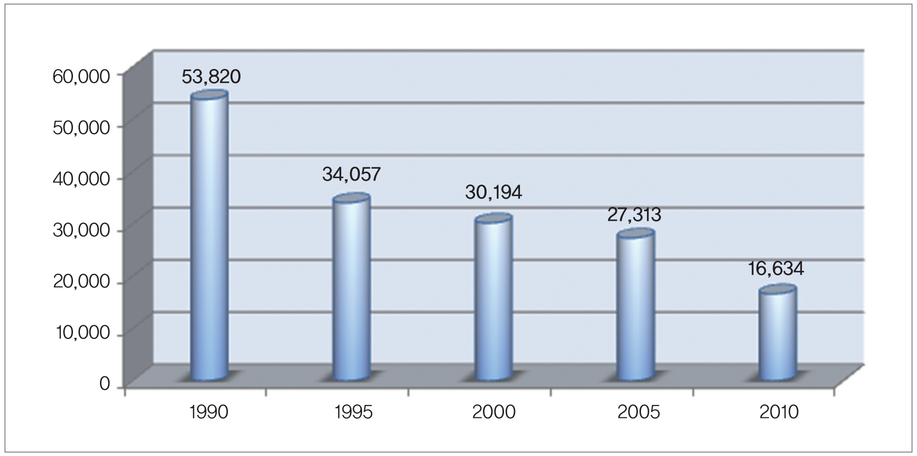
I Table 1-4 I Change in Rate of Water Supplied Indirectly

Year	1990	1995	2000	2005	2010
Reservoir Capacity (Unit: 10,000nf)	57	57	57	57	57
Indirect water supply rate(%)	25.8	25.8	25.8	25.8	25.8

I Table 1-5 I Decrease in the number of leaks due to pressure stabilization resulting from indirect water supply

In 1990	In 2000	In 2010
53,820(100%) cases	30,194 cases	16,634 cases (31%)

I Graph I Annual Leak Incidences



Establishing an emergency water supply management system in case of emergencies such as suspension of tap water supply at the purification plants

An emergency plan to change the source of water supply -- in case of water supply interruption at some purification plants or water interruptions due to natural disasters or leak -- was put in place and implemented. To this end, we installed emergency pipelines to connect the purification plants and service reservoirs.

Building the infrastructure needed to deploy tanker trucks to supply water to high-rise buildings

It is now possible to supply water to 15-story buildings in case of water interruptions.

: Applicability of the Policy

Seoul's policy on water supply networks can be replicated in cities in Central and South America, where there are many rivers and hillsides

- Seoul can share the know-how and experience in changing water supply systems and tackling problems that may arise in the process, thereby helping cities manage a stable water supply system.
- By minimizing the use of pressurizing stations, cities that adopt Seoul's policy can reduce energy consumption and save budget.

: Q & A

What was the greatest challenge in implementing the emergency plan to ensure all-year-round, reliable supply of tap water without any water interruption?

At the initial stage, it was not easy to conduct due diligence to measure flow direction, flow velocity, and hydraulic pressure, which were needed to change the water supply system.

Moreover, we faced difficulties in constructing duct lines, gate valves, and drain valves as well as changing the water supply source.

Has the emergency water supply scheme ever been utilized to supply water between purification centers?

Yes, the emergency water supply scheme was actually in use during the construction process of advanced water treatment facilities in Yeongdeungpo, which began in 2007. Likewise, for construction projects that began in the first half of 2014 including the installation of advanced water treatment facilities at the Gangbuk and Amsa purification centers and establishment of dual pipeline system for Olympic Expressway, we utilized interconnected pipelines and pipelines on suspension bridges to ensure the seamless supply of tap water. As a result, we avoided water interruptions despite suspension at the large-scale purification centers.

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Water Distribution 02

Revenue Water Ratio & Leak Management

Achieving the Highest Revenue Water Ratio in the World

The Office of Waterworks and its branch offices are public enterprises that have two tasks: to serve public good by supplying clean, safe water and to rationalize business management. The best way to achieve the latter is to improve the revenue water ratio (RWR), which cuts production cost and other expenses.
In 1989 when the Office of Waterworks of the Seoul Metropolitan Government was founded, RWR stood at a mere 55.2%. Our dedicated efforts for the past 25 years greatly rationalized management, hiking up RWR to as much as 94.4% in 2013.
Putting the impact of improved RWR enabled by rationalized management into context, the amount of water saved between 1990~2013 was 7,500,000,000nf, which was worth approximately KRW 4.2 trillion. This is equivalent to the amount used by 10 million Seoul citizens for 6~7 years. Leak cases also decreased by 725,998 (82.5%), saving KRW 1.8 trillion in budget.
As we became capable of cutting the amount of tap water production, we closed down 4 of our 10 purification plants (capacity of 7,300,000m3 per day); thus operating only 6 plants at present. The closed plant sites have been transformed into parks for citizens, contributing to the improvement of their quality of life and local economic development.

Before the Policy Implementation	After the Policy Implementation
• RWR in 1989: 55.2% • No. of purification plants: 10 (capacity of 7,300,000㎥ per day)	• RWR in 2013: 94.4% • No. of purification plants: 10 (capacity of 4,350,000㎥ per day)

Overview of the Policy

- Scientific and systematic IT-based leak detection
- Minimum night flow (MNF) measurement
- Old water pipe maintenance
- Establishment of gravity flow system using reservoirs
- Scientific management of water flow through the flow monitoring system
- Sharing of RWR know-how with other local governments and providing consulting

Background

Ever since the Office of Waterworks was founded in November 1989, improving RWR has been a necessary groundwork for us to achieve independent management

RWR refers to the percentage of billed water as a share of net water produced in purification plants. Thus, higher RWR means less water loss during the process of supplying tap water or, simply put, less leaks. Therefore, increased RWR allows the reduced production of tap water. This in turn brings down expenses for raw water purchases, chemicals, and power, thereby improving waterworks management. The benefits from such advanced management eventually go to the citizens.

Process of Policy Implementation

Phase 1: Initial phase of RWR improvement (1989 - 1995)

- Office of Waterworks established (November 21, 1989)
- District-level flow meter installed for the first time (1990s)
- Intensive maintenance of old water distribution/supply pipes (4,200km) (1991~1993)
- Measuring system using district flow meter fully put in place at each of the waterworks offices (1995)

Phase 2: Development phase of RWR improvement (1996 - 1999)

- RWR improvement team launched (October 12, 1998)
- District-level measurement of supplied amount and RWR initiated (1996 - 1997)
- Proper meters with smaller diameter installed, replaced inappropriate meters (1996 - 2000)
- MNF measured by dividing the Seoul pipeline network into 2,037 small blocks (1998)
- Official district-level RWR statistics produced for the first time (1998)
- Intensive management of waterworks facilities at the redevelopment and reconstruction sites (from 1999)

Phase 3: Settlement phase of RWR improvement (2000 - present)

- Shifted to indirect supply system after reservoir establishment (913,000nf)(2000 - 2003)
- Office reshuffled, RWR management responsibility transferred from waterworks task force to RWR division (January 8, 2001)
- Meter-reading works entrusted to private entities (July 22, 2001)
- Appropriate pressure of booster pumps managed in each time period (inverter) (from 2002)
- Systematic management of disused pipes (359km) (from 2003)
- Block-level RWR managed after introducing the medium block system (from 2004)
- Scientific leak detection started using the multi-point leak noise correlation system (from 2004)
- Supplied amount analyzed, flow controlled through the flow monitoring system (from 2005)

Details of the Policy

Scientific and systematic IT-based leak detection

Leak detection constitutes a crucial part in waterworks especially for RWR improvement.

To ensure systematic leak detection, Seoul divided the city‘s waterworks pipeline into 2,037 small blocks and sought to detect underground leaks focusing on those that recorded the most number of leak cases over the past three years based on the GIS system.

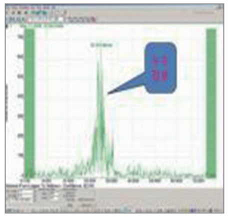
Since 1999, we have hired 60 - 70 leak detection specialists as fixed-term employees to enhance effectiveness and create jobs.

In 2004, we introduced the latest technological device to make leak detection more precise: the multi-point leak noise correlation system, which offers a comprehensive solution. This device collects leak noises through the high-sensitivity sound sensors attached on gate valves, fire hydrant, and meters. Using the installed program, the system conducts complete analysis of noises and pinpoints the locations of all leaks with high precision. These points are digitized and presented in 3D graphs.

Multi-point leak noise correlating logger (sensor)

Logger installed on gate valve

Computer analysis performed



Leaks determined

As for the number of leaks detected every year, it was 16,175 in 2004 but dropped dramatically to 2,601 in 2013 when maintenance of water distribution/supply pipes and disused pipes was successfully completed. The number is expected to go down further in the future.

I Table 2-1 I Leak Detection by Year

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Target for 2014
# of Detected Cases	16,175	17,657	5,317	5,493	4,934	5,561	5,472	5,326	4198	2,601	2,200

Minimum night flow (MNF) measurement

Minimum night flow refers to the minimum amount of water flow in a given block during the period of the lowest tap water consumption (midnight - 4 am on average). MNF measurement is designed to avoid leaks by evaluating whether a block exceeds the allowable leak, in which case active leak detection is initiated.

From 1998, we kept the leaks in all 2,037 small blocks in Seoul below the allowable leak limit (1m3/hr.km). From 2003 to 2005, we reinforced our detection work and set the allowable leak limit between 0.5m3/hr.km and 1m3/hr.km depending on the waterworks conditions of the blocks. Since 2006, the work has been performed partially on blocks presumed to have more leaks (allowable leak limit: 2.0m3/hr.km).

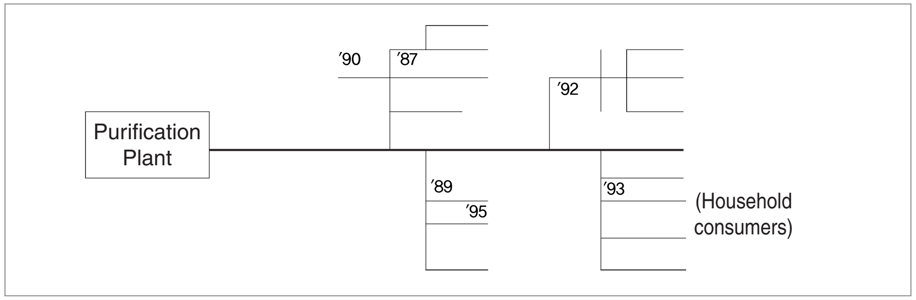
Old water pipe maintenance

Old water pipes refer to non-corrosion-resistant pipes that corroded both inside and outside after being used for a long time. These pipes result in frequent leaks, and the rust from corroded pipes breaks free and causes red water. Examples of non-corrosion-resistant pipes are as follows:

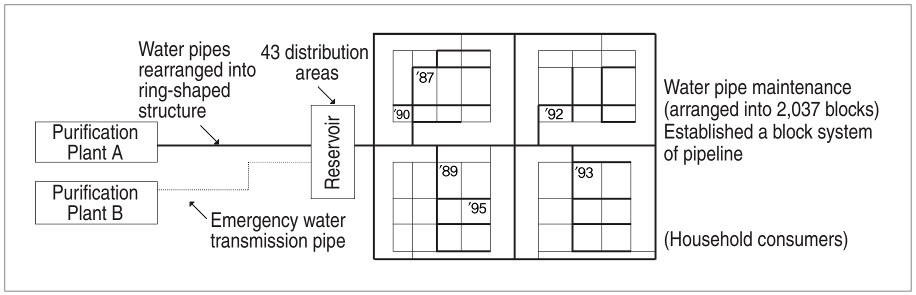
- Pipes made of gray case iron, steel, PVC, and galvanized steel and buried before 1984
- Corrosion-resistant pipes that have been in use for over 40 years and with frequent leaks

The maintenance of old pipes prevented tap water pollution and secured the quality of water during the entire process of supplying water to household faucets. Leaks from old pipes were also prevented in advance, which led to higher RWR. The pipe network, which changed from the branching system to the circular block system, also realized a more stable water supply system.

[Previous water supply system - Branching pipeline]



[Improved water supply system - Pipeline arranged into blocks]



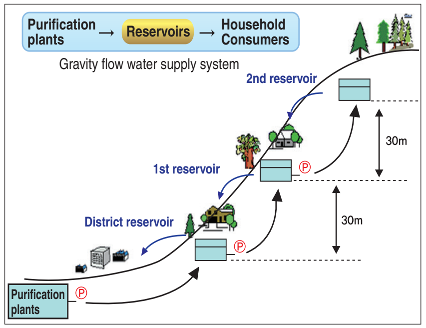
Over the 22-year period between 1962 and 1983, the old pipe maintenance project replaced around 1,821km of old pipes, which cost KRW 36.6 billion. In 1984, we performed extensive maintenance works on water distribution/supply pipes by formulating a comprehensive maintenance plan. As of 2013, we completed refurbishing 13,192km (96.5%) out of the 13,668km pipeline. The goal of this project is to finish maintenance for the remaining 476km by 2018.

Removal of old water pipes

After the replacement of old pipes

Gravity flow system establishment using reservoirs

[Water supply system from reservoirs]



We replaced the supply system that delivers tap water straight from purification plants or pressurizing stations with a gravity flow supply system that involves reservoirs. Through such change, the water supply system became more stable with less pressure-induced leaks and even pressure maintained 24/7.

To date, there are 104 reservoirs constructed and operated, with capacity of 2.38 million and retention time of around 16 hours.

Scientific management of water flow through the flow monitoring system

The water flow monitoring system performs comprehensive management of the collected real-time data on water flow and pressure created during the supply process for systematic flow control using the accumulated statistical information. The system employs a unique web feature that allows all officials at the Office of Waterworks to search for the necessary information at

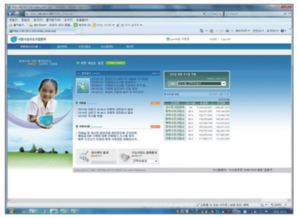
[Flow monitoring system chart (Flow meter — PC)]

On-site flow meter, pressure gauge, etc. → On-site controller and communication device → Computer and comm. device at waterworks offices → HQ server → Admin. computer network → PC (all officials)

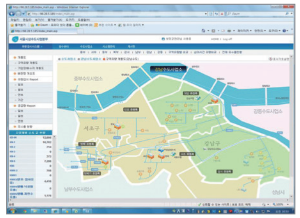
any time with their personal computers.

The basis of the monitoring system consists of 435 flow meters for water intake and transmission, for districts and medium blocks, and for pressurizing stations and reservoirs. To obtain an accurate amount of water supply, we have capped the margin of error at ±0.5% (Ministry of Environment standard: ±2.0%).

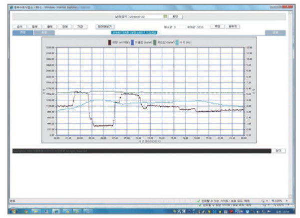
By utilizing the flow monitoring system, we analyze the daily supply of water from each source water. If sharp increase or decrease is detected, we identify the cause immediately to minimize leaks.



First page of the flow monitoring system webpage



Water flow of Seoul



Real-time water supply status

Sharing of RWR know-how with other local municipalities and providing consulting

The Office of Waterworks and the Korea Water and Wastewater Works Association have provided joint consulting services to local municipalities with low RWR to share know-how and technologies.

Since 2010, we have visited seven local cities to support them with our know-how on RWR improvement, thereby contributing significantly to the development of waterworks in the local districts.

I Table 2-2 I Technology Support to Other Municipalities

Classification	2010	2011	2012
Municipalities	Yeongju City Hwaju-Gun	Gyungsan City, Gunpo City, Hongcheon-Gun, Gyeongju City	Pocheon City Gochang-Gun

The major items that we set forth include detecting leaks, offering tailored solutions for RWR improvement, and educating the relevant officials on management methods to raise the ratio.


Yeongju City: Multi-point leak detection

Hongcheon-gun: RWR consulting


Hwasun-gun: Consulting on RWR


Gyeongju City: Employee training (lecture)

Know-hows & Insights

Underground Leak Detection

• Minimum flow measurement

A team of 4-5 workers (daily workers included) conducts (01:00 - 04:00) water leak detection for a day; 1 person measures the minimum flow at the flow meter-installed area, with the remaining 3-4 workers detecting the leaks with listening sticks, visual inspection of roads, and water meter boxes.

• Leak detection for drain pipeline

Leak detection teams each consisting of 3-4 workers performed daily leak visual inspection on water leaks from medium blocks with low RWR to drain pipelines as well as checking of the maintenance status of waterworks pipelines. In principle, detection is to be conducted during daytime; note, however, that certain sections require nighttime inspections. Under such circumstances, we plan for concentrated detection works so that the process could be completed within 1-2 days and to save cost.

• Acoustic water leak detection

For acoustic water leak detection, we first prioritized the water distribution/supply pipes near medium blocks with poor RWR by marking the pipes with diameter of 400mm or more on a detection plan drawing of each district (1/10,000 - 1/25,000). After performing detection works on the entire pipeline of the waterworks office following the order of priority as well as visually checking for leaks inside the drain pipes, we conducted precise detections on sections that showed signs of leaks.

With regard to sections where water flow changes, we continue to check for leak noises (vibration); if any noise if found, then we start precise water leak detection using acoustic detectors and inspect the interior of drain pipelines.

• Multi-point leak detection

Also known as a comprehensive system for leak diagnosis (SOUNDSENS), the system collects leak noises through high-sensitivity sound sensors installed on gate valves, fire hydrant, and water meters of water distribution/supply pipes. It then pins down the location by analyzing the collected noises using a program and displays the results in digitized version and 3D graphs.

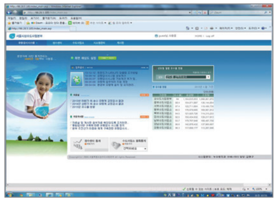
• MNF measurement

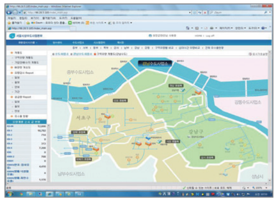
Minimum night flow refers to the minimum amount of water flow in a given block during the period when tap water consumption is lowest (midnight - 4 am on average). MNF measurement is a method of avoiding leaks by actively performing leak detection if the block exceeds the minimum flow.

• Old water distribution/supply pipes maintenance

○ Emphasis on improving water supply pipes
  - Galvanized steel pipes, PVC pipes → Stainless steel pipes
○ Maintenance of disused pipes

• Real-time management of water supply





- ㅇ Flow meter installed: 422 places
- ㅇ Routine inspection on flow meters
- ㅇ Real-time monitoring of water supply thru the flow monitoring system

Policy Outcome & Evaluation

As indicated in the tables below, Seoul's RWR in December 2013 stood at 94.4%, which increased drastically from 1999 and onward, after showing minimal upward trend between 1991 and 1998. This achievement, along with reduced leaks, has vastly improved the management of the office.

I Table 2-3 I RWR by year

	1989	1994	2000	2003	2006	2007	2008	2009	2010	2011	2013
RWR (%)	55.2	62.2	72	82.7	90	91.4	91.7	92.9	93.4	93.5	94.4

I Table 2-4 I Leak Cases by year

	1989	1994	2000	2003	2007	2008	2009	2010	2011	2012	2013
Leak Case	59,438	34,577	30.194	29,040	17,699	16,391	15,490	16,634	16,651	13,106	10,421

Production facilities and improved highland pipes completely resolved the issue of water interruptions. Major policy tasks for waterworks administration also shifted from supply-centered policies to management-centered ones, with the aim of advancing management through better water quality and higher RWR.

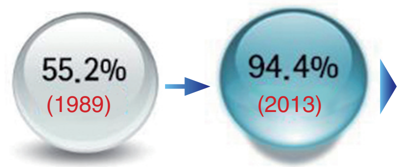
In the past, the city council and civic groups have repeatedly demanded measures to address low RWR. Today, big cities of the country not only maintain one of the highest RWRs; they are also on a par with advanced nations across the world.

I Table 2-5 I RWR in Korea and Other Countries

(Unit : %)

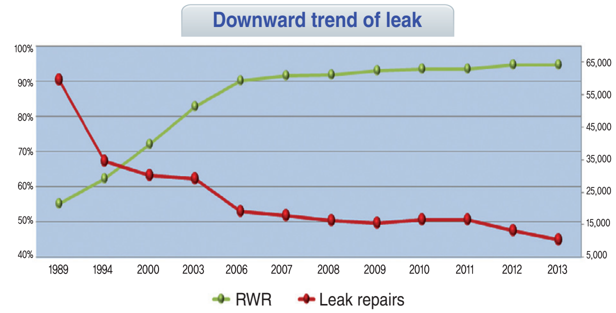
	Busan	Gwangju	Daegu	Incheon	Daejeon	Ulsan	Paris	New York	LA	London	Tokyo	Osaka	Yokohama
RWR (%)	92.2	84.5	91.3	87.7	89.1	88.8	91	79	94	74	96.8	87.6	91.4
Year	2012	2012	2012	2012	2012	2012	2001	2011	2010	2003	2012	2012	2012

I Diagram 2-1 I Budget Savings from Increase in RWR (1989~2013)



<Increase in Management Efficiency>
- ▶Reduction of leaks: 7.5 billion tons
- ▶Budget savings: 4.2 trillion won
- ▶Energy savings: 1.260,000 CO_2 tons
- ▶Reduction of purification plants:
  10 plants in 1999 (z,300,000 tons/day)
  ⇒ 6 plants (4,350,000 tons/day) as of now

I Diagram 2-2 I Impacts of Less Leaks on Budget Reduction (1989~2013)



Leak reduction rate: 82.5%

No. of reduced leaks: 725,998

Budget saved: KRW 1.8 trillion

Applicability of the Policy

Small and mid-sized municipalities in Korea and developing countries with low RWR can benchmark the method to improve their RWR. This method can be particularly effective on hilly areas.

Q & A

How do you calculate RWR?

The ratio of billed water to net water produced at purification plants

→ RWR(%) = Amount of revenue water / Total amount of supplied water x 100

※ Revenue water: Billed water

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Water Distribution 03

Water Supply Geographic Information System (GIS)

Building a smart water supply facility management system by providing high-quality spatial information of the facilities

The **"Water Supply Geographic Information System (GIS)"** utilizes GIS technology to create a digital database of design and properties information of water pipes, supporting components, and other urban facilities in general. It is an information system consisting of hardware, software, and application allowing input, output, and analysis of digital data.
In 2001, the Seoul Metropolitan Government's Office of Waterworks created a team dedicated to the efficient design and management of the **"Water Supply GIS."** At the same time, we are also implementing projects to upgrade the water supply GIS and improve the accuracy of the GIS database.

Before the Policy Implementation	After the Policy Implementation
• The location and design of facilities were hand-marked on maps. • The lack of underground facility management system caused safety incidents. • The planning, analysis, and projection of water supply system including supply network, leak, interruption, and tap water quality became critical.	• A web-based water supply GIS is established. • A water supply GIS DB with improved accuracy is created using the standard coordinates of the World Geodetic System. • The cost of repairing leaking pipes is reduced thanks to the enhanced accuracy of pipe location information.

Overview of the Policy

《 Creating Water Supply GIS

《 Setting up a division responsible for operating and managing the GIS

《 Implementing projects to upgrade the GIS functions and making the database more accurate.

Background

The lack of underground facility management system caused various safety incidents

The previous underground facility management scheme using hand-marked 1:3000, 1:5000 scale maps with lot numbers or 1:1200 scale planimetric maps was rather disorganized. Its poor quality led to a gas explosion in Ahyeon-dong, Seoul in 1995, leaving 12 people dead, 101 injured, and 145 buildings damaged. Numerous accidents broke out every year including the 1995 gas explosion at a subway construction site in Daegu, a fire in 2000 caused by an overheated power line in Yeouido, Seoul, and many other damages caused by nearby facility excavations. Such incidents called for a systematic, integrated underground facility management system.

The Korean government's national GIS initiative laid the foundation for the establishment of new geographic information system infrastructure

In 1995, the Korean government initiated the first National GIS Master Plan (1995 - 2000) with the aim of gathering digital geographic information of the entire country. It also began subsidizing local municipalities' GIS projects starting with Seoul's in order to spur the nationwide promotion of digital geographic information collection.

New demands from users arose with the advancement of GIS technology

Tap water quality has been improved due to the recent development of water supply technology. Consequently, facility management and planning, analysis, and projection of water supply system including the supply network, leak, interruption, and water quality have become even more important. The location information of water pipes managed by non-specialized public servants was extremely inaccurate; the properties information of the facilities turned out to be at least 30% different from the actual specifications on average. Not only that – the offset survey method using relative measurements made it difficult for the water supply system to be integrated into other underground facility (e.g., sewage, electricity, gas, communication, heating, and oil supply) management systems.

The permissible range of error was largely different for each of the systems.

Process of Policy Implementation

- 1998 Seoul's water supply GIS project plan was created.
- 1999 Seoul's water supply GIS project was initiated.
- 2000 Program development and location & structure information editing were completed.
- 2001 The water supply GIS project was completed.
- 2002~2004 The water supply GIS DB was created, and system maintenance efforts began.
- 2005~2014 Projects to upgrade the water supply GIS & improve DB accuracy are implemented.

I Table 3-1 I Progress of Water Supply GIS DB Establishment

Year	Progress	Means		Remarks
		Personnel	Measurement	
1998~2001	Creation of Water Supply GIS DB (initial version) - 9,844km of pipes were explored and measured. - Facility information was entered into the system. - New tools and application system were developed and introduced.	Public laborers	Offset Survey (using landmarks)	Provision of new jobs during the IMF bail-out period ※ Project size: 18.2 billion KRW (government subsidy of 10.7 billion KRW)
2002~'04	Improvement & adjustment of information	Day workers	Offset Survey (using landmarks)	

| Table 3-1-1 |

Year	Progress	Means		Remarks
		Personnel	Measurement	
2005~'07	Survey on new pipes laid out each year - 804km of new pipes were explored and measured. - Facility info was entered into the system.	Specialized personnel	Absolute measurement (coordinates)	
2008~'09	Survey on new and large pipes with diameter of 500mm or more & pipes near Han River - 1,102km of new/existing pipes were explored and measured. - Facility info was entered into the system.	Specialized personnel	Absolute measurement (coordinates)	
2010	Survey on new pipes by surface per block - 748km of new/existing pipes were explored and measured. - Facility info was entered into the system.	Specialized personnel	Absolute measurement (coordinates)	Focus on new pipes & sections ⇒ existing pipes & small-sized blocks
2011~'13	Survey on new and large pipes with diameter of 300mm or above - 1,925km of new/existing pipes were explored and measured. - Facility info was entered into the system.	Specialized personnel	Absolute measurement (coordinates)	

Details of the Policy

Creating the GIS to be applied to Seoul's Water Supply System

Between 1998 and 2001, the Seoul Metropolitan Government conducted a survey on the water supply system across the city (513km) with the aim of managing the system more effectively. Based on a 1:1000 scale map, Seoul created a digital database of water supply facilities' location and properties information, which was further improved with additional programs and maintenance. Based on the Korean government's "Basic Plan for National Spatial Data Policy," we drafted the "Basic Plan for the Seoul Geographic Information System," initiated 9 new GIS services in 2002, and implemented several Gl-related policies and projects. We continue to lay the groundwork for the development of Gl-related technologies and extended use of the collected information.

Creating a division fully dedicated to GIS operation and management

We created the Geographic Information Division consisting of 1 director overseeing the entire project (Director of GI Division), 3 officials in charge of the water supply GIS DB (facility manager) and responsible for water supply GIS maintenance (computer systems manager), and 2 for data management and administrative support (facility manager). Moreover, we assigned a GI specialist (facility manager) and a DB editor (civil servant) at each of the eight district waterworks offices in Seoul.

Implementing projects to upgrade the water supply GIS & improve DB accuracy

We now live in an era in which advanced information technology such as the digital database and the Internet can be converged with geographic information. To manage the water supply facilities more scientifically and efficiently as well as to satisfy the multi-faceted demand by users for reasonable decision making on pipe design, network plan, and leak projections, a more sophisticated GIS is required. Therefore, we are implementing projects to enhance the accuracy of the water supply GIS DB and to upgrade the system.

I Diagram 3-2 I Annual Cost of Establishing and Maintaining the Water Supply GIS

Category (Project)	GIS establishment	GIS upgrade	GIS maintenance	Transfer to web	Functional improvement
Cost (Million KRW)	18,200	1,518	790	1,837	222
Duration (Year)	1998~2001	2007~'11	2008~'12	2010~'12	2014~'15

I Diagram 3-3 I Annual Cost of Improving the Water Supply GIS DB Accuracy

Category (Year)	2005~'09	2010	2011	2012	2013	2014
Cost (Million KRW)	11,118	4,203	2011	3,980	4,800	4,731
Length (km)	1,906	748	716	629	580	540

In the future, we plan to improve our water supply management capability by developing new programs such as “Pipe Depreciation Assessment/Management Program,” “Water Supply Asset (Completion) Management Program,” and “Land-use Permission Management Program” and by creating a more user-oriented supply system. In addition, we plan to survey, explore, and measure 5,889km of water pipes and supporting facilities by 2020 through the “Water Supply GIS DB Upgrade Project” and use its outcome as the basis for making science-based decisions on city management and planning.

Know-how & Insights

Introducing the web-based water supply GIS

Replacing the previous C/S-based system with a web-based one, we made it easier for the workers at the site to send reports on their progress using PC or other devices and respond to various situations in a timely manner. Furthermore, maintenance work has become much more efficient since all works are now on a single web browser. The system‘s user interface (UI) was redesigned to fit the workflow (process) better, allowing users to respond more intuitively.

Surveying more water supply facilities

There are sections of underground water supply facilities that cannot be explored due to technical difficulties caused by other nearby facilities, depth of the facility, or other ground barriers. The more sections become unexplorable, the less accurate the water supply facility location information becomes. Consequently, systematic facility management becomes more challenging. Not only that -- inaccurate and unclear information provided to the users may hinder them from making a reasonable decision. Thus, we made workers who identify an unexplorable section keep a record of it for future management purposes and re-explored the site two to three times with different equipment and personnel. Additionally, we had multiple entities conduct a cross-examination of the site to stimulate mutual exchange of technology and virtuous competition among them, which would ultimately lead to the efficient fulfillment of our goal.

Creating a network of experts

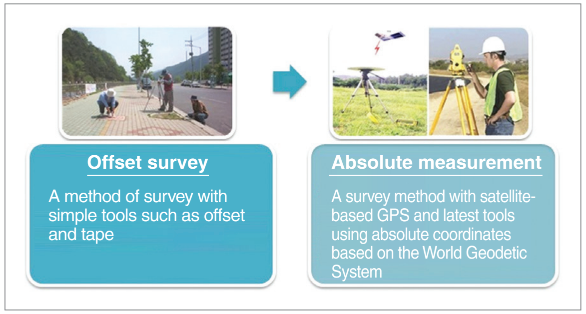
When external experts are required (for consulting and evaluation), we use the spatial information expert pool of Seoul Metropolitan Government‘s Information Planning Office to form an advisory committee, a proposal evaluation committee, or the like, so that experts’ opinion and assessment are reflected on projects. Moreover, annual meetings and workshops with all district waterworks office GI managers are held to listen to the ideas and suggestions of the working-level officials.

Providing GIS user training and user support

We created a user manual of the water supply GIS and distributed it to all users. When the system is upgraded, or new functions are added, the person in charge from the GI Division and system developers visit each district waterworks office and provide training on how to use the new system. In addition, a bulletin board is created within the system to respond quickly to any and all user grievances. Moreover, real-time, remote-controlled support via online network is provided upon request.

Switching to an absolute measurement system that utilizes the World Geodetic System ensures accuracy of information

The switch from offset survey scheme using nearby geographic features to the absolute measurement method following the World Geodetic System -- which utilizes concepts such as public reference points (survey monuments) and city reference points -- has contributed to increasing the accuracy of the underground facilities’ spatial information. Newly installed pipes must now be measured before the ground is filled above them (Provisions on Public Survey). Existing pipes are surveyed using appropriate equipment depending on the depth of the facility and the material it is made of.



Offset Survey & Absolute Measurement

Providing rigorous guidance and monitoring to prevent safety accidents

On July 22, 2011, a worker died of asphyxia while surveying an underground water pipe in Namyeong-dong, Seoul, and two of his co-workers developed serious medical conditions. After the incident, which was caused by poor safety management, regulations on working in a closed, underground area were added to the Provisions on Public Survey. We now provide safety education to all personnel working at the site and guide and monitor them in abiding by the safety standards.

Policy Experience & Outcome

Water supply management capability is improved with higher-quality geographic information system

By switching from GIS and from a C/S-based model to a web-based one, we have laid the groundwork for the mobile operation of the system. As such, we strive to respond rapidly to the latest technological developments as we implement the GIS project. We also made the system more useful by adding new functions such as GIS editing program, thematic map management system that allows users to search the GI under different themes, and drawing management system for the integrated management of as-built drawings. Moreover, errors in the existing water supply facility information are constantly being corrected using city reference points (survey monuments) and GPS, contributing to improving the quality of our administrative service.

Strict adherence to the Provisions on Public Survey and public survey evaluations led to stronger public confidence in the information

Water supply facility is one of the seven most critical underground facilities of the city. The survey and measurement of water supply facilities are categorized as “public survey (underground measurement)” in the <Act on Measurement, Hydrographic Survey, and Land Registration Record>. Public survey must be conducted in accordance with the Provisions on Public Survey stipulated by the National Geographic Information Institute in the <Enforcement Rule of the Act on Measurement, Hydrographic Survey, and Land Registration Record> and certified through the Korea Association of Surveying & Mapping‘s public survey evaluation. Thus, in 2005, we started the “Water Supply GIS DB Accuracy Improvement Project” and went through the evaluation to gain public confidence for our GI.

Implementation of the World Geodetic System and data standardization provided a basis for conversion and integration with other management systems

The World Geodetic System is the worldwide standard coordinate system that we adopted to make our location information more accurate. The introduction of a standard coordinate system enabled dual or cross-analysis with maps in other systems, since all the maps use the same coordinates. Data structure, analysis method, and design were also standardized so that they can be transferred among different systems. All in all, systems with overlapping functions and themes can now be integrated with each other. Ultimately, such conversion and integration of systems can lead to value creation.

Leak incidents caused by pipe users were reduced

The water supply GIS provides the exact location of water pipes to nearby road, subway, or other construction sites to ensure that they do not hit the pipes. Such led to the reduction of leak incidents caused by pipe users.

Consequently, problems such as water interruption and rusty water were greatly reduced, and more citizens can now enjoy Seoul's healthy and tasty tap water, Arisu.

In case of leak, the exact leak spot can be excavated using location and properties information collected through the "Water Supply GIS DB Accuracy Improvement Project." This system has reduced the number of excavated sites and the maintenance cost. Not only that – since accurate location information enabled rapid excavation after the leak, the duration of water interruption was minimized, and public confidence in the city's waterworks was restored.

I Table 3-4 I Water leaks caused by pipe users

Classification (Year)	Total	2008	2009	2010	2011	2012
Pipe Users	340	92	77	61	58	52
No. of leak incidents	78,277	16,394	16,491	16,633	15,652	13,107

I Table 3-5 I Excavations performed for maintenance after leak
(for leaks of metal pipe with diameter of 80mm or above)

Classification (Year)	Total	2008	2009	2010	2011	2012
No. Leak Incidents (①)	10,598	2,068	2,135	2,075	2,367	1,953
No. of Road Excavations (②)	14,490	2,850	2,924	2,892	3,228	2,596
Ratio (②–①/①)	36.70%	37.80%	37.00%	39.40%	36.80%	32.90%

Policy Evaluation

The factors contributing to the successful adoption of water supply GIS as an efficient management tool can be summarized into the following:

First, the national and city governments' strong interest and effort in spatial information policies

The central Korean and Seoul Metropolitan governments created the "Basic Plan for National Spatial Data Policy" and "Basic Plan for the Seoul Geographic Information System," respectively, to lay the groundwork for the scientific and systematic management of urban infrastructure using GIS. They also devised steps of policies to allow the utilization of spatial information for diverse purposes. As a result, standard spatial information collection and processing procedures were created. Moreover, the two governments' generous financial support in the initial stage contributed to the stable introduction of the system.

Second, the expertise of the responsible division

The Office of Waterworks' GI division is a highly specialized branch consisting of a total of seven personnel -- spatial information specialists (with the relevant master's degree or technical expertise), seasoned civil servants with over 10 years' experience at district waterworks offices, and working-level officials for system establishment. We also store and manage all documents created as a result of the project in an organized manner. By keeping a guideline and a manual on the division's responsibilities, we ensure that there is no vacuum even in case of any personnel change.

Third, the active participation of system users

Users of the water supply GIS include working-level officials of district waterworks offices or facility managers at the Waterworks Office headquarters. They participate in user training so that they can fully understand and utilize the system. Moreover, they continue to express interest and provide suggestions about the system via online bulletin board, phone, e-mail, or user meetings.

Applicability of the Policies

Starting with the major metropolitan governments, many large municipalities have implemented water supply GIS projects since 1995 when the first National GIS (NGIS) initiative kicked off. As of now, most municipalities, regardless of size, have their own water supply GIS up and running.

Among them, Seoul's GIS project is relatively larger in size and has been carried out gradually over several years, allowing the city to build unique experience in the process. As a result, various organizations including the Gwangju Metropolitan Government are seeking Seoul's advice on the water supply GIS establishment process and maintenance know-how.

The system can also be passed on to developing regions of the world such as Southeast Asia and Latin America as an exemplary case.

:Q & A

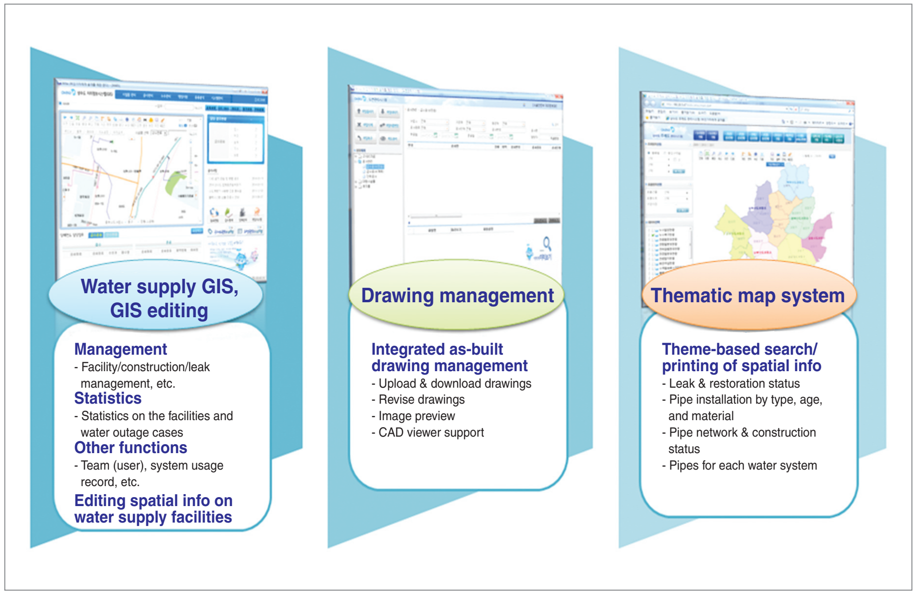
What are the main functions of the water supply GIS?

The water supply GIS consists of four main parts: water supply GIS, GIS editing program, drawing management system, and thematic map system. Detailed functions of the four parts can be found below.

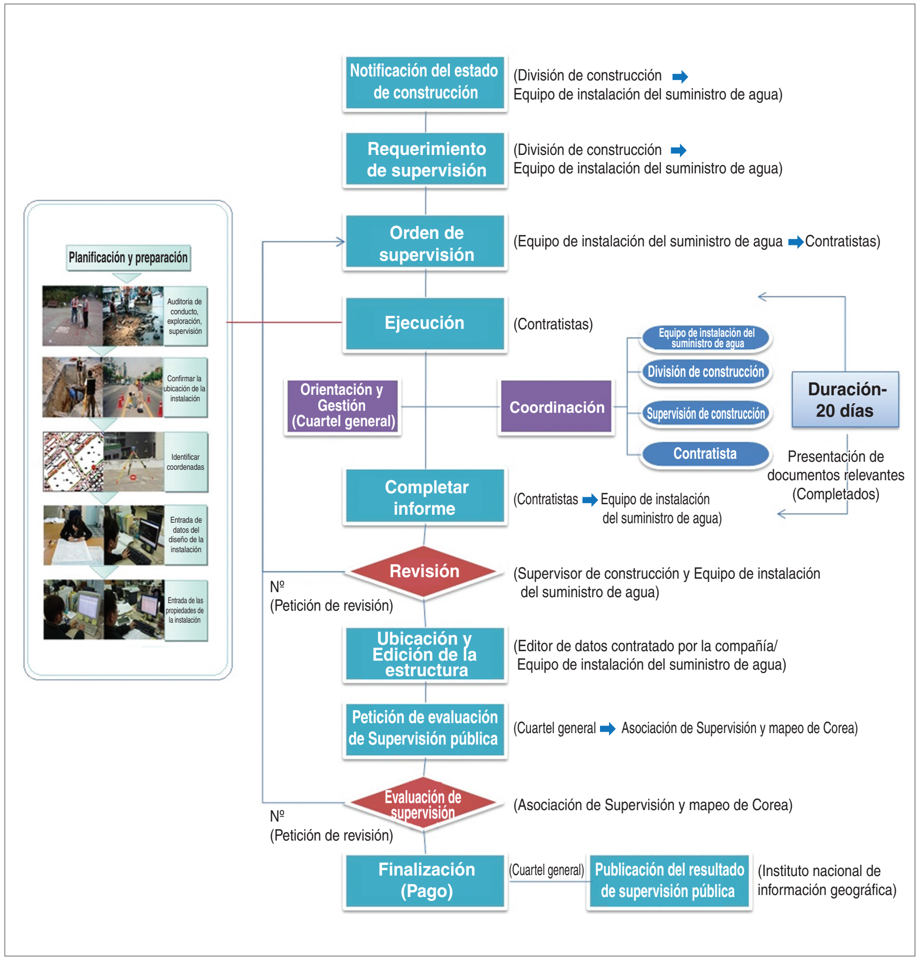
How is a water supply facility database created?

Creating a water supply facility DB starts with a survey request and order to initiate the project. It is then followed by planning and preparation, due diligence/exploration/survey, data input, data editing, public survey evaluation, and announcement of survey results. The procedure is illustrated in detail in the diagram below:

[Major functions of the water supply GIS]



[Creating a Water Supply Facility DB]



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Water Distribution 04

Old Pipe Network Maintenance Project

Systemic Maintenance based on the "Comprehensive Old Pipe Maintenance Plan"

The "**Old Pipe Maintenance Plan**" was adopted in 1984 to supply clean tap water to household consumers, minimize leak, and build a stable inter-region supply system. Based on the plan, of the 13,728km that run throughout Seoul, 96.1 % of the old water pipes, or 13,192km, were replaced by the end of 2013.
By 2018, all other remaining old water pipes will be replaced with corrosion-resistant cast iron pipe and stainless pipe. The total budget for the replacement was set at 3.5 trillion won, 2.9 trillion won of which was invested from 1984 to 2013; another 622 billion won will be injected by 2018.
After 2018 when all the pipes will have been replaced completely, healthy and tasty tap water produced in water purification plants will be distributed to Seoul citizens through the new and clean water pipe network.

Before the Policy Implementation	After the Policy Implementation
The lack of systemic management of old water pipes such as galvanized steel pipe and grey cast iron pipe led to rust leak and lower water quality, which eventually led to a decrease in revenue water ratio.	Adopting the "Basic Plan for Waterworks Improvement" and replacing old water pipes led to the stable supply of clean and safe tap water and a drop in leaks, both of which contributed to an increase in the revenue water ratio.

: Overview of the Policy

I Table 4-1 I Replacing outdated, corrosion-prone pipes with corrosion-resistant water pipes

Classification	Corrosion-prone pipes	Corrosion-resistant water pipes
Water supply pipe	Galvanized steel pipe	Stainless pipe
Transmission and drainpipe	Grey cast iron pipe and steel pipe	Ductile cast iron pipe

I Table 4-2 I Achievements and Future Plans by Year

2010 (1984-1993)	2020 (1994~2003)	2030 (2004~'13)	2035 (2014~'18)
5,518 km (40.2%)	5,668 km (41.30%)	2,006 km (14.60%)	536 km (3.90%)

Background

It is crucial to supply healthy and safe tap water produced in purification plants to household consumers without any contamination in the distribution process. No matter how healthy and safe the water produced in the purification stage is, outdated, rusty water pipes will pollute the water, damage citizens' health, and incur massive financial loss due to water leak.

Recognizing the paramount importance of water pipes, the Office of Waterworks of the Seoul Metropolitan Government began maintenance works for old pipes to minimize leaks and ensure the health of our citizens.

Process of Policy Implementation

Need for Pipes Repair and Japanese Colonial Era

In general, the life span of transmission and drainpipes is considered to be 30 years, whereas supply pipes last 20 years. It was in 1908 when the water system was first introduced in Seoul, so the initial transmission and drainpipes would have already come to the end of their life by 1943. Since Imperial Japan was engaged in war around the time, however, it was probably too under-resourced to replacement the old pipes -- an assumption confirmed by the book titled History of Japanese Civil Engineering, which records the state of Seoul's water system until 1940. The book made no mention of any maintenance or repair work of water pipes.

Construction of intake pipes in 1906

Post-WWII and Economic Development

After Korea's independence from Japan, records were found on the construction of drainpipes and supply pipes, but no reference can be claimed for the replacement of old pipes. Records on replacing the old pipes of Seoul's water system first appeared in the Overview of City Management issued in 1962. According to the document, the "5-Year Plan to Prevent Leak" was set with 1962 as the base year to reduce leak rate of 57 % in 1961 to 35 % in 1966. A total of 265.46 million won was allocated to the project to replace 113 km of drainpipes.

Mayor Kim Hyunok directing the construction of water system in 1966

The second plan was implemented for 10 years from 1965 to 1974, with the project costing 1.65512 billion won. The project replaced a total of 418 km, which consisted of 151 km of drainpipes and 267 km of supply pipes, or 62 km longer than the originally planned 356 km.

As of the end of 1971, old transmission and drainpipes accounted for 126 km or around 9.4% of a total of 1,341 km; old supply pipes were 939 km long or about 17.9% of a total of 5,239 km. The third replacement plan was carried out from 1972 to 1981 with 6.179 billion won. A total of 1,262 km were replaced including 324 km of drainpipes and 938 km of supply pipes, accounting for only 39.7 % of the planned 3,179 km.

Stable Growth and Quality Improvement

Replacing old pipes proved to be a very challenging task since the number of old pipes remained sizable despite the consistent replacement. Old drain and supply pipes accumulated annually to reach a total of 1,370 km by the end of 1980, with 186 km of drainpipes over 35 years old and 1,184 km of supply pipes over 20 years old.

Until 1990, no tangible outcomes were seen; only 150-700 km of pipes was replaced annually. It was from 1991 to 1993 when the old pipes were replaced in large numbers.

Launch of the Office of Waterworks in 1989

A total of 4,200 km were replaced for three years -- 1,200 km in 1991 and 1,500 km each in 1992 and 1993, marking a record-high replacement in a short period of time; 500-600 km have been replaced every year since 2000.

From year 2000 onwards, we have been thoroughly inspecting rusty pipes and washing outdated pipes to ensure the quality of pipe networks. In particular, we focused on establishing both net and line for conduit so that tap water can be supplied without water interruptions. In addition, we set up a support team dedicated to improving old indoor water pipes; the team evaluates the state of old pipes and gives financial support to households to facilitate replacement.

Modernizing Water Pipes and Management

Modernizing management became possible thanks to our Geographic Information System (GIS), a system that creates a digital database of design and properties information of water pipes, supporting components, valves, fire hydrant, and water meter, including turning attributes and current data into figures and maps. In addition to GIS, we have conducted aerial surveys, checked underground facilities, streamlined different data, and created a database since the mid-2000s. Through such multi-layered efforts, we are getting closer to establishing a comprehensive management program that combines GIS and Management Information System (MIS).

We pursue systemic, scientific water-related data management, rational decision-making process on facility investment, scientific facility maintenance, preventive management system for stable water supply, higher efficiency in processing tasks in water facilities, and highest-quality public service.

Introduction of the Policy on Old Pipe

Maintenance Plan

As part of the "Old Pipe Maintenance Plan," 36.6 billion won was injected for 22 years from 1962 to 1983 to replace 1,821km of old pipes. Note, however, that the highest priority during this period was resolving water interruptions, not ensuring the cleanliness of water.

Today, water interruption is no longer a major problem; even if there are some issues, they are caused by rust leak, old domestic pipes, and narrow gauge. Therefore, to address this issue effectively, we started subsidizing constructions of old interior pipes in the latter half of 2007.

From 1984 when maintenance works on drain and supply pipes began in full swing, we established a comprehensive maintenance plan and invested 2.8777 trillion won to replace 96.5% or 13,192km of the 13,668km old pipes until 2013. The remaining 476km old pipes will be fully replaced by 2018.

| Table 4-3 | Types of Corrosion-resistant Pipes and Initial Years of Use

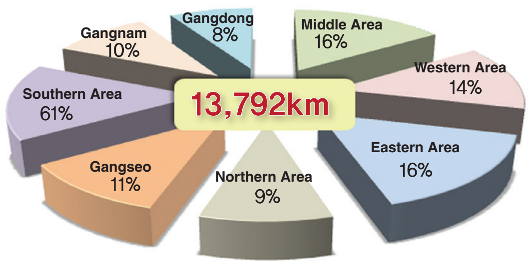
Classification	Initial Year of Use	Reference
• Steel pipes painted inside and outside	1978	Galvanized steel pipes went out of use (Apr 1, 1994) - Clause 350, Article 1993 by the Ministry of Construction
• Cement-mortar-lined ductile cast iron pipe	1984	
• Stainless steel pipe, copper pipe (below 50mm)	1987	
• PE pipe (13~200mm)	1989	

A total of 13,791km conduit was extended as of the end of 2013. The length of transmission pipes from purification plants to reservoir is 552km; drainpipes from reservoir or drainage pump to water supply facilities span 9,811km, and supply pipes from reservoir to household consumers, 3,335km. As shown in the table below, the number of extended transmission pipes increased thanks to the construction of new pipes followed by pipe network maintenance, whereas supply pipes decreased in number as a result of continuous maintenance of unused pipes. There were almost no changes in the extension of drainpipes, but old pipes were mostly replaced thanks to the maintenance works on drain and supply pipes.

Steel pipes were mostly used for transmission pipes, whereas pressure- and corrosion-resistant ductile cast iron pipes and PE pipes were utilized for drainpipes with gauge of over 80km. For supply pipes with gauge under 50km, galvanized steel pipes were used before 1987, but stainless steel pipes and copper pipes were utilized from late 1987; stainless steel pipes have been commonly used since 1993. The current status of water pipelines is as follows:

I Table 4-4 I Current Status of Water Pipes: 13,791km

Classification	Total	Conducting Pipe	Transmission Pipe	Drainpipe	Drainpipe	Industrial water pipe
Total	13,792	86	552	9,811	3,335	8
13㎜~50㎜	4,166	–	–	949	3,217	–
80㎜~350㎜	7,941	–	49	7,772	118	2
400㎜ and more	1,684	86	503	1,090	–	6



Maintenance of drain and supply pipes of Seoul first began in 1984 when the "Old Pipe Maintenance Plan" was formulated; since then, maintenance efforts continued. The efforts have expanded to include new maintenance targets such as pipes in renewed and rebuilt establishments and coal tar enamel-coated steel pipes among transmission and drainpipes. The project is set to be completed by 2018, and results per stage and future plans are listed in the table below.

I Table 4-5 I Drainpipe Maintenance Results and Yearly Plans

Classification			Target	Project Result (1984 ~2013)	Yearly Plan					
					Total	2014	2015	2016	2017	2018
Initial Plan	Total	Extension (ta)	13,668	13,192	433	47	83	96	102	105
		Expense (bil. won)	31,998	28,777	3,221	433	599	693	737	759
	Drain/Supply Pipes (under 350m)	Extension (ta)	13,108	12,640	425	39	83	96	102	105
		Expense (bil. won)	23,898	20,828	3,070	282	599	693	737	759
	Transmission/ Drain Pipes	Extension (ta)	560	552	8	8	–	–	–	–
		Expense (bil. won)	8,100	7,949	151	151	–	–	–	–
Modi- fied Plan	Total	Extension (ta)	13,728	13,192	536	63	100	120	125	128
		Expense (bil. won)	34,997	28,777	6,220	733	1,130	1,416	1,458	1,483
	Drain/Supply Pipes (under 350m)	Extension (ta)	13,042	12,640	402	39	80	90	95	98
		Expense (bil. won)	24,297	20,828	3,469	282	705	791	833	858
	Transmission/ Drain Pipes	Extension (ta)	686	552	134	24	20	30	30	30
		Expense (bil. won)	10,700	7,949	2,751	451	425	625	625	625

I Table 4-6 I Maintenance Results from 1984 to 2013 & Operating Expenses

Classification		Total	Project Result by Year									
			(1984 ~'89)	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total	Extension (ta)	13,192	871	447	1,200	1,500	1,500	516	479	632	636	543
	Expense (bil. won)	28,777	2,419	227	729	1,070	1,230	504	533	961	1,223	1,143
Drain/Supply Pipes (under 350m)	Extension (ta)	12,640	871	447	1,200	1,500	1,500	516	479	595	607	506
	Expense (bil. won)	20,828	2,419	227	729	1,070	1,230	504	533	661	973	773
Transmission/ Drain Pipes (over 400m)	Extension (ta)	552								37	29	37
	Expense (bil. won)	7,949								300	250	370

| Table 4-6-1 |

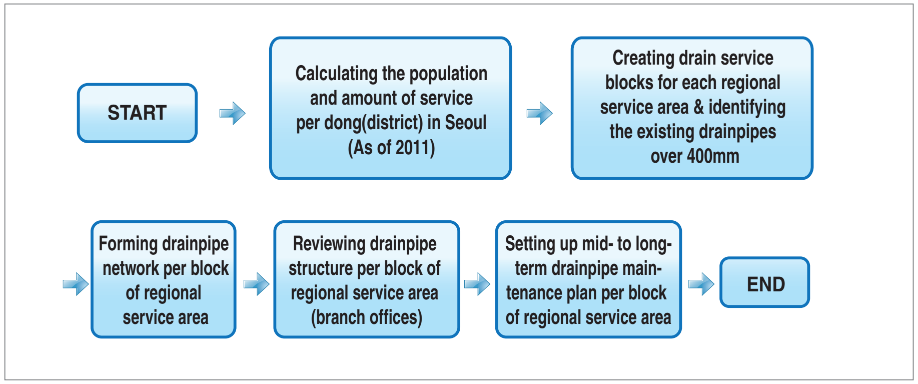
Classification		Project Result by Year														
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	Extension (ta)	483	468	605	665	641	637	469	107	144	184	125	123	59	88	70
	Expense (bil. won)	1,068	1,058	1,351	1,878	1,634	1,794	1,768	910	911	1,407	1,408	880	687	1,068	916
Drain and Supply Pipes (under 350mm)	Extension (ta)	453	439	570	630	625	620	449	70	120	149	80	95	39	48	32
	Expense (bil. won)	778	758	951	1,478	1,422	1,564	1,468	309	511	751	468	384	283	368	216
Transmission and Drain Pipes (over 400 mm)	Extension (ta)	30	29	35	35	16	17	20	37	24	35	45	28	20	40	38
	Expense (bil. won)	290	300	400	400	212	230	300	601	400	656	940	496	404	700	700

:Policy Experience & Knowhow

Establishment of the "Drainpipe Network Maintenance Plan"

We first launched a task force team tasked with forming a long-term plan for drainpipe network maintenance. In line with this, we divided Seoul into 39 blocks; in each service area, block programs developed in the US such as KYPIPE Ⅲ and CYBERNET 3.1 were used to perform pipe scan. We carried out comprehensive and close probing of all existing drainpipes, drew maps, and planned a proper drainpipe network for each regional water reservoir.

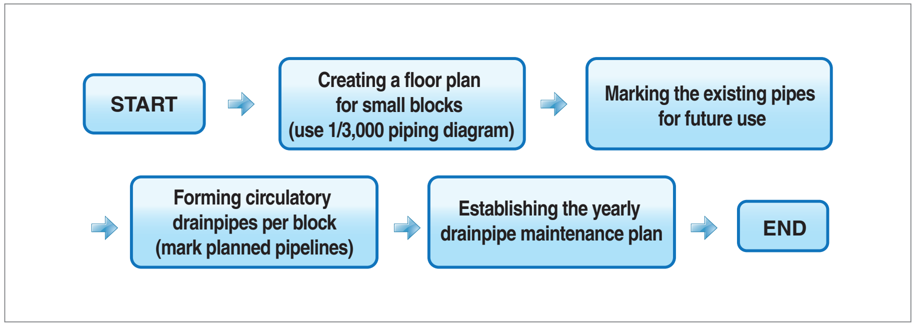
Phase of Drainpipe Maintenance



Small Block Planning

The entire city of Seoul was divided into 39 blocks of regional reservoirs, which were again categorized into 1st, 2nd, and 3rd reservoirs composed of 2,037 small blocks. Block planning enabled more efficient drainpipe management, facilitating regional maintenance and adjustment of demand for water supply.

Procedure for Small Block Maintenance Planning



Old Pipe Maintenance Plan Aligned with Basic Plans on the Water System

The "Old Pipe Maintenance Plan," which was implemented in line with the "Basic Plan for Waterworks Improvement," divided Seoul into 2,037 small blocks. We tried to use the longitudinal excavation method whenever possible in fixing unused pipes. Moreover, when building new drainpipes, we made sure the size is at least 150mm-wide gauge so that, if necessary, we can turn this area into direct water supply. The 150mm width is also suitable for monitoring by Seoul's maintenance and management system. (At the same time, blocks were clearly separated so that the minimum flow rate could be measured per block.)

Moreover, we required the identity of all builders to be disclosed when they engage in pipe works so that we can ensure responsibility and quality. To this end, we developed an online program called "Real Name System" in which the names of constructors are listed and attached to the connection of the pipeline structure. The system helped us better manage the workers, both electronically and at the site; this in turn contributed to enhancing the responsibility of the workers and the quality of the work they do.

Meanwhile, a central management system for construction materials was introduced to minimize inconvenience. In the past, different materials used for drainpipe construction were purchased per construction site and placed on the road, causing inconvenience to pedestrians. Currently, however, the Material Management Office makes integrated purchase and management to improve the drawbacks.

Policy Outcome & Evaluation

Thanks to efforts to repair and replace old water pipes, we can now ensure the stable supply of clean and safe tap water. Not only that -- we were able to increase the revenue water ratio by cutting leak. In addition, we introduced GIS in the maintenance and management system of the water pipe network. Since GIS creates a systematic database and turns into figures and maps the design and properties information of water pipes, supporting components, valves, fire hydrant, and water meter as well as their attributes and current data, we can efficiently manage all data on the water pipe network in Seoul.

Meanwhile, we strengthened the capacity of our civil servants who have accumulated expertise and experience in the process, and they have become an important asset not just for Seoul but also the entire country.

Tangible Outcomes of the Old Water Pipe Maintenance Project

- Reduced Leak (DOWN by 82.5%): In 1989, before replacing old pipes, 59,438 cases of leak were observed. In 2013, after replacing old pipes, the number went down to 10,421.
- Increase in revenue water ratio (UP by 171%): In 1989, before replacing old pipes, Seoul's revenue water ratio was 55.2 %; it surged to 94.4% in 2013, however.

Applicability of the Policies

Seoul's experiences in establishing the "Basic Plan for Waterworks Improvement," introducing the operation of GIS & integrated control station for water supply, and increasing the revenue water ratio are some of the good practices that can be benchmarked by other municipalities in Korea as well as Southeast Asian countries.

Applicable Areas

- Establishing a water supply system in line with the old water pipe maintenance and stable water supply infrastructure
- Presenting the mid- to long-term path of water system maintenance
- Building small- and medium-sized blocs in line with the old water pipe maintenance
- Measuring the nighttime minimum flow rate, enhancing the revenue water ratio, and performing post-construction impact analysis on old pipe maintenance

Q & A

Seoul is about to complete the old water pipe replacement project. Soon, however, some water corrosion-resistant pipes that replaced the old pipes will see their life span expire. Does Seoul have plans to replace those as well?

- Replacing old pipes with new ones began in 1984. By the end of 2013, 2.8 trillion won was spent on the replacement of 13,192km out of 13,668km old pipes with new ones, for a maintenance rate of 96.5 %. In 2014, we expanded our scope even further to include coal tar enamel-coated steel pipes, and a total of 13,728km will be replaced by 2018.
- From 2014, we will begin evaluating the deterioration of pipes over 30 years old or ductile cast iron pipes, steel pipes, and stainless pipes that will soon exceed their life span. We will use the assessment factors listed in the guidelines set forth by the Ministry

of Environment titled "Water Pipe Network Optimum Control System and Standard Maintenance Guidelines." Through the evaluation project, we will ensure that our water pipe network is maintained at its highest quality.

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Water Distribution 05

Shifting to the Direct Water Supply System

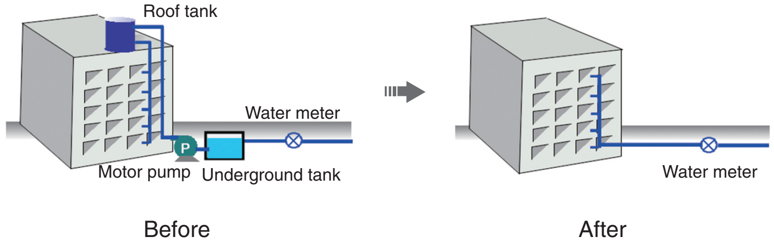
Ensuring the highest water quality by removing rooftop water tanks and applying the direct water supply system for buildings up to 5 stories high

In 1997, with the goal of removing rooftop water tanks of small buildings – which served as a loophole in water quality management – and installing a direct water supply system, the **"Direct Water Supply System Establishment Plan"** was developed as part of the Basic Plan for Waterworks Improvement. In September 1999, Seoul amended Article 35 of Seoul's ordinance on Water Supply and Waterworks Installation in order to establish the **"Enforcement Guidelines for Affairs Pertaining to Direct Water Supply."** Based on this groundwork, we began pushing through with the direct water supply system in earnest. In addition, we have been running active PR campaigns in an effort to remove completely small water tanks for households by 2014, at the same time mandating the cleaning of small water tanks to manage sanitation as strictly as that of large tanks. At present, small buildings are required to clean the tanks at least semiannually.

Before the Policy Implementation	After the Policy Implementation
• Water stored for a long time led to the deterioration of water quality. • Additional pressure using motor pump wasted energy. • Water tanks and other facilities led to high installation and maintenance cost.	• Water quality improved • Energy saved as motor pumps are not needed • The cost required for facility installation and maintenance was cut. • Aesthetics and space efficiency are improved.

Overview of the Policy

- Removing small rooftop water tanks & switching to the direct water supply system
- Mandating the cleaning of small water tanks
- Expanding the use of the direct supply system & prohibiting roof tank installation



Background

As of 2014, Seoul operates the world's best water supply system with water supply rate of 100% and revenue water ratio of 94.4%. Optimized for the citizens, the system ensures steady supply of tap water using reservoirs with retention time of over 17 hours, water pressure of 2.5kg/cm2 across the city, and pipelines arranged into blocks to ensure uninterrupted water flow during maintenance works. As conditions for waterworks improved, rooftop water tanks lost their advantages as an important facility that supplied water to small buildings. Instead, roof tanks became a loophole in water quality management, posing a number of problems.

The water quality for general water supply facilities is strictly managed by Seoul because the city as the water service provider owns and maintains such facilities. Nonetheless, there was no mandate regarding the maintenance of roof tanks of small buildings; in some cases, owners or managers of such buildings took sanitary measures only perfunctorily. All these factors contributed to the public distrust in tap water.

In general, large buildings such as apartments, multi-family houses, high-rise buildings, and schools opted for a water supply system that involved tanks. After water is produced at the purification plants, the system first stores it in an underground tank, and then pumps the water all the way up to a roof tank, from which water is supplied to each floor. Note, however, that the system presented several problems. Because tap water sits in tanks for more than 2-3 days, residual chlorine stays at a low level, giving rise to concerns of bacteria and low turbidity caused by foreign particles.

Roof tanks also pose the risk of deteriorating water quality particularly due to its location. Placed outdoors on building rooftops, water tanks become vulnerable to foreign particles that undermine water quality as well as to penetrating sunlight that creates a breeding ground for algae. Even with these problems, issues related to water quality management persisted. Managers/Owners would either perform cleaning works as a mere formality or forego doing them at all since sanitation and maintenance were left to the managers/owners' discretion, not required.

On the other hand, the direct water supply system supplies healthy and tasty water straight from the purification plants to household consumers without going through tanks. Thus, this system was urgently needed to address public distrust in tap water.

Process of Policy Implementation

Introduction of the direct water supply system

- 1985 "Direct Water Supply System" employed for the newly built apartment complex in Mokdong as a pilot project
- 1996 Study on the introduction of the "Direct Water Supply System" initiated by the Seoul Institute
- 1997 "Direct Water Supply System Establishment Plan" included in the Basic Plan for Waterworks Improvement of Seoul
- 2001 Set of standards for the "Direct Water Supply System" provided by the Basic Plan for Waterworks Improvement of Seoul

Modifications to the relevant laws and regulations

- July 31, 1999 Article 12 (Installation of Direct Water Supply Systems) of the Ordinance on Water Supply and Waterworks Installation newly added
- October 5, 1999 Provision on the "Direct Water Supply System" inserted into the Enforcement Rule of the Ordinance on Water Supply and Waterworks Installation, defining the administrative procedures and buildings that fall under exceptions

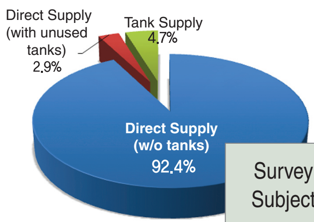
• September 29, 1999 Article 35 of the Ordinance on Water Supply and Waterworks Installation amended

Installation of the direct water supply system

As of 2000, 2,990 buildings employed the direct water supply system following our promotion efforts and test run on 33 general buildings. In 2001, we provided training and education on the direct water supply system, method, effect, and facility details to 1,441 water supply and pipeline companies located in Seoul and distributed newsletters and leaflets to buildings where installation was available. Our strong commitment produced positive results: a total of 35,712 buildings switched to the direct water supply system by 2007.

Complete enumeration survey on the water supply status of small buildings

In 2009, we hired job seekers to conduct a “complete enumeration survey on the water supply status of small buildings.” The survey results revealed that 488,238 small buildings (95.3%) supplied water through the direct system, and that a mere 23,817 (4.7%) small buildings used water tanks.



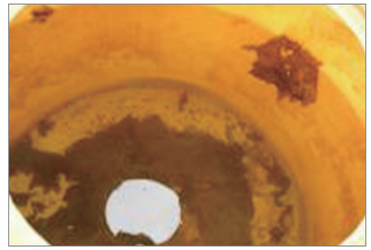
Survey Subject	Buildings with Direct Water Supply System			Buildings Using Water Tanks
	Total	Without Tanks	With Unused Tanks	
512,055	488,238	473,118	15,120	23,817

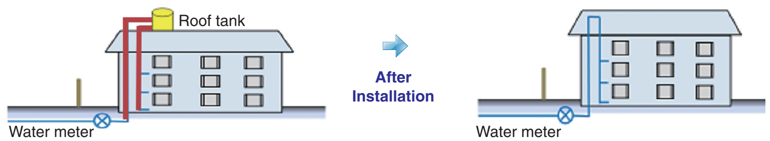
Details of the Policy

Removal of (small) rooftop water tanks & shift to the direct water supply system

Replacing (small) rooftop water tanks with the direct water supply system does not mean new pipes need to be installed in the building. Rather, the tank pipes, after tank removal, are directly connected to the pipeline of the building.


Small Rooftop Water Tank


Roof tank



Between 2010 and 2011, 9,722 buildings voluntarily removed their roof tanks after we informed the building owners and managers of our project to employ the direct water supply system. When the project yielded weak results, the Seoul Metropolitan Government stepped up and allocated its own budget to remove all the small water tanks of low-rise houses. We plan to complete the project for most general buildings by 2014, with the exception of those where the direct supply system is not applicable. For such buildings, routine maintenance is encouraged through PR activities.

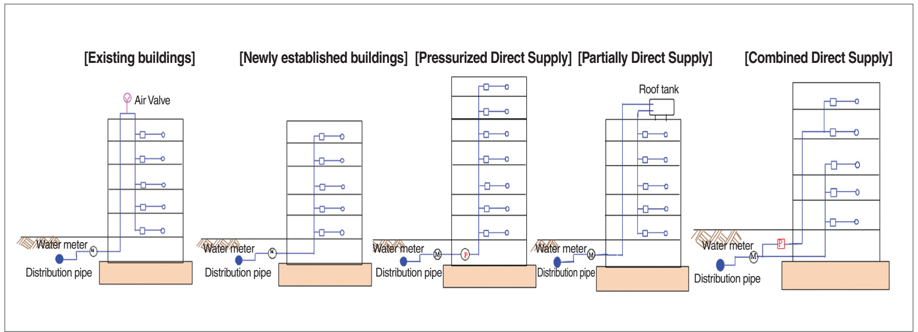
Current status of the removal of (small) rooftop water tanks & shift to the direct water supply system

Category	Buildings	2012	2013	2014 (Plan)
Removal and change to direct supply system	9,240	3,545	3,626	2,069
Removal of unused tanks	18,061	6,094	11,967	–
Budget requirements (Million)	4,700	1,500	2,000	1,200

After promoting the direct supply system, 9,722 buildings voluntarily removed their roof tanks

Types of direct water supply system

The direct water supply system has a number of different types, including pure direct system, pressurized direct system, partially direct system, and combined direct system. If pipes provide enough pressure to send water to the rooftop, the pure direct system is installed. High-rise buildings with insufficient pipe pressure choose pressurized or combined direct systems.



Procedures for the installation of the direct water supply system

① Application

- Those who wish to install direct or pressurized direct water supply system for buildings at least 4 stories high shall submit an application through the online customer center at the website of the Office of Waterworks of the Seoul Metropolitan Government, to customer support divisions at the waterworks offices in the district, or to civil affairs centers at Gu offices.
- Upon receiving the application, officials shall compare the submitted building information with a building management ledger and a building permit, issue a receipt to the requester, and forward the request to the division in charge.

② Designation of official in charge and site survey

- The head of the division shall assign an official as appropriate to take charge of the request and conduct an on-site survey.
- The official in charge shall thoroughly inspect the building in question including the number of floors, distribution pipeline, inlet pipes, diameter of water meters, and water pressure at pipeline intersection points. Subsequently, the official shall write an inspection report and attach a pipeline network map.

③ Decision to install the direct water supply system

- Within 3 days of the date of receipt, the official shall write a direct supply system report certificate and a direct supply system notice of return of report and record the result on a logbook. The office shall keep the relevant documents after sending them to the requester.

Mandatory cleaning of small water tanks

As for buildings that choose to maintain small water tanks without changing the mode to the direct water supply system, the "law obliges them to clean the tanks" at least semiannually to ensure strict sanitation management.

[Amendment to the Ordinance on the Mandatory Cleaning of Small Buildings]

○ Relevant Ordinance: Seoul Metropolitan Government Ordinance on Water Supply and Waterworks Installation

○ Amendment: Article 40-2 (Sanitary Measures such as Cleaning of Small Buildings) newly inserted

Where tap water is supplied to a building or a facility not falling under Article 50 of the Enforcement Decree of the Water Supply and Waterworks Installation Act through a water tank pursuant to Article 33(5) of the aforesaid Act, the owner or manager of the relevant building or facility shall clean the water tank at least semiannually; where the water tank has been newly built or has not been used for at least one month, he/she shall clean it before using it.

○ Implementation date: "Mandatory cleaning of small water tanks" enforced on July 1, 2014

Following the aforesaid amendment to the ordinance, the law mandates all buildings to clean the water tanks at least semiannually regardless of the tank's size. Thus, sanitation for small water tanks is expected to be strengthened to the same level as that of large water tanks.

The table below illustrates the sanitation measures adopted for large and small water tanks.

Cleaning small tanks at least semiannually may seem insufficient compared to the sanitation measures for large tanks. Still, the fact that the measure is institutionalized by Seoul based on the "obligation to clean small water tanks" is significant in itself. We will decide whether to expand the scope of application further based on an analysis of the progress and a long-term review.

We will promote "the obligation to clean small water tanks" - the first of its kind to be implemented in Korea by the Seoul Metropolitan Government - through various media such as 25 Gu office newsletters, town hall meeting newsletters, bills, and electronic signboards. Supervision and monitoring of the implementation will follow suit.

Category		Large Water Tanks	Small Water Tanks
Reference Law (Act on Water Supply and Waterworks Installation)		Article 33 of the Act, Article 50 of the Enforcement Decree, Article 22-3 of the Enforcement Rule	Clause 5, Article 33 of the Act, Article 40-2 of the Seoul Metropolitan Government Ordinance on Water Supply and Waterworks Installation
Sanitary Measures	Cleaning	At least semiannually	At least semiannually
	Quality Inspection	At least once a year	×
	Sanitation Maintenance	At least once a month	×
Training for Water Supply Facility Managers		At least once (Art 36 of the Act)	×
Penal Provisions in Cases of Violation		Imprisonment for not more than two years or fine not exceeding ten million won (Item 6, Art 83 of the Act)	Suspension of water supply (Item 9, Clause 1, Article 43 of the Ordinance)

[Promotion of Mandatory Cleaning of Small Tanks]

Promotion of Seoul's New Policies in 2014

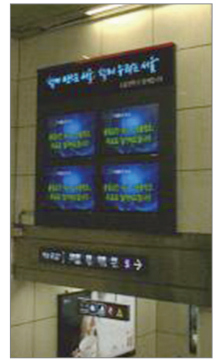
Gu Office/ Town Hall Meeting Newsletters

[Promotion of Mandatory Cleaning of Small Tanks]

Notice

Notification on Bills

Press Release



Signboard Display

Prohibition on rooftop water tanks

Water tanks became unnecessary for low-rise buildings with 5 stories or less after the establishment of distribution reservoirs and block system. High-rise buildings such as apartments still maintain water tanks, but the technological development allowed them to employ a booster pump system that places the water tank underground instead of on the rooftop.

In case of new buildings, the water supply agreement for building permits requires houses with up to 4 stories and general buildings up to 5 stories high to install the direct water supply system. We inserted a new clause for apartments and general buildings where the direct system cannot be installed to ban rooftop tanks and mandate the use of the booster pump system.

Know-how & Insights

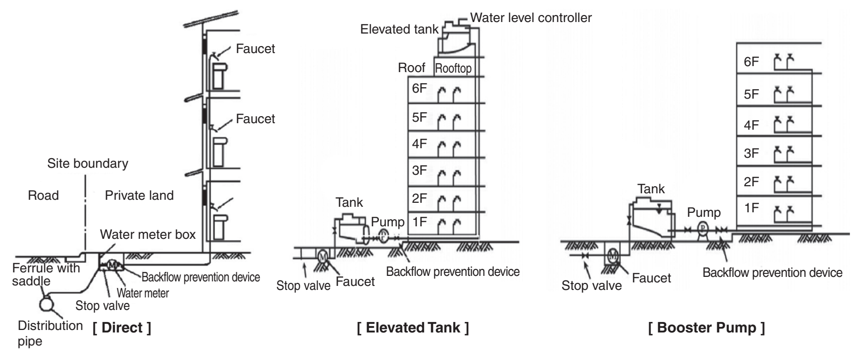
Overcoming the opposition to the direct water supply system

The reasons for opposing the introduction of the direct system varied: overwhelming costs of performing preliminary water supply works for the building (pipe replacement, diameter expansion); lack of will among building owners who experienced no difficulties in using tap water; tank water being used for emergencies or toilets, and; difficulty in obtaining consent from all the residents in case of multi-family houses.

[Major Water Supply System for Ordinary Household Consumers]

· Direct system: Water supply·distribution pipes ⇒ Household tap
· Elevated tank system: Water supply·distribution pipes ⇒ pump ⇒ Roof tank ⇒ Household tap
· Booster pump system: Water supply·distribution pipes ⇒ Pump ⇒ Household tap

<Water Supply System>



※ Source: Standards for Water Supply Facilities

In the end, we overcame the challenges by utilizing the city budget and support and actively persuading those who were against the project.

Robust promotion of the direct water supply system

Through Gu offices, cable TV, and local newspaper companies, we promoted the advantages of the direct water supply system -- which included improved water quality, reduced cleaning expenses and electricity bills, better building appearance, and space saving -- as well as the newly imposed obligation to clean small water tanks at least semiannually starting July 1, 2014. We hired water supply system companies based in Seoul to perform PR activities while making on-site visits to hand out notices and persuaded people.

Policy Outcome & Evaluation

The direct water supply system prevents water pollution because tap water does not stay in tanks for a long time, supplying healthy and tasty water with secured residual chlorine. Furthermore, the space previously taken up by underground tanks, roof tanks, or water supply pumps can be used for other purposes. Maintenance also became cheaper including reduced electricity bills for operating pumps.

[Example of the Booster Pump Water Supply System]

○ Location: XX Apt., XX-dong, Seodaemun-gu, Seoul
○ Size: 213 households, 15 floors
○ Tap water consumption: 3,700irf
○ Reduced electricity usage: Saved 33% after switching to the booster pump system (KRW 1,300 saved per month for each household)

Category		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
Electricity Usage (kwh)	Before	1,985	2,190	2,060	1,888	1,981	2,080	2,115	2,154	2,057
	After	1,288	1,353	1,346	1,162	1,336	1,488	1,424	1,579	1,372
Saved Amount(kwh)		697	837	714	726	645	592	691	575	685
		-35	-38	-35	-38	-33	-28	-33	-27	-33

※ Saved amount of electricity per year
: KRW 210 mil. = KRW 1,300/month per household x 13,408 household/year x 12 months/year

○ Changes in water quality

Category	Turbidity	pH	Residual Chlorine	Iron	Copper	Remarks
	(0.5NTU or less)	(5.8~8.5)	4.0mg/ lor less	1.0mg/ lor less	0.3gg/ lor less	
Apts with new system	0.2	7.2	0.18	0	0.03	Same water source
Nearby apts w/o the system	0.15	7.1	0.02	0.01	0.01	

Applicability of the Policy

- By sharing our know-how with local governments where roof tanks are common, such as the Busan Metropolitan City, we can expect a shift to the "direct water supply system" in such districts.
- We can widely promote the system as a successful policy of Seoul through the Ministry of Environment and the Korea Water and Wastewater Works Association and export it to other countries with high-rise buildings such as Taiwan, Singapore, and Hong Kong.

Contact Information	
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Water Distribution 06

Frost Protection for Water Meters

Minimizing water supply interruptions by introducing measures to protect water meters from freezing and bursting

Due to the widespread impacts of global warming, Korea has been suffering from water supply interruptions during winter time. As a countermeasure, Seoul Metropolitan City has implemented policies to protect water meters from freezing and bursting in order to minimize water supply interruptions and inconvenience to citizens. Furthermore, our efforts have been focused on improving citizens' standard of living by promoting technological innovation and implementing various other preventive measures.

Before the Policy Implementation	After the Policy Implementation
• Up to thousands of water meter bursts occurred in a day. • Water meter freezing and bursting caused serious inconvenience to citizens. • Water meter bursts incurred huge economic loss.	• There has been a huge drop in the number of water meter bursting cases. • Citizens have shown higher level of satisfaction with Seoul's water supply. • Less meter damage meant easing the economic burdens of citizens.

Overview of the Policy

- Upgrading and deploying water meters designed to withstand cold weather
- Upgrading and deploying insulated meter covers for apartment (multi-family) establishments
- Installing heat-insulating materials for meter boxes at single-family houses
- Introducing protection measures against water meter freezing at small construction sites
- Waging a water meter frost prevention campaign

Background

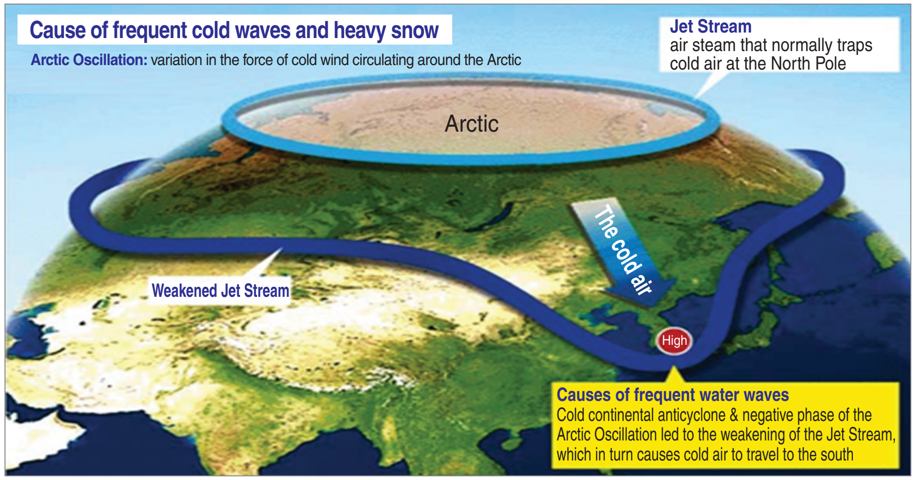
Water plays a vital role in day-to-day human life. If a water meter bursts in winter, it becomes difficult to use the heating boiler, toilet, and cooking facilities. In addition, melting frozen water pipes can be very costly, imposing sizable financial burdens on citizens.

Water meter damaged from frost

To minimize the potential inconvenience of citizens, we have been pushing through with various water meter insulation and protection policies.

Until the mid-2000s, citizens themselves protected water pipes during winter by placing insulating materials around water meters and pipes. Note, however, that such measure was found to be ineffective against the unexpectedly cold temperatures due to global warming effects as witnessed after El Niño.

[Recurrent winter weather conditions in Korea]

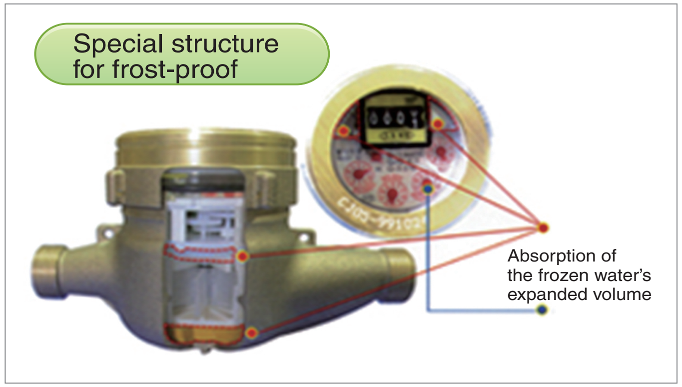


Process of Policy Implementation

After the multi-layered analysis of the water meter bursting issue, we realized that the priority should be the development of water meters that are more resilient to freezing and bursting. Even if we built strong meters, however, we realized that other parts of the water supply facilities could burst if water freezes and its volume expands, leading to even bigger problems.

To tackle such problems, we established the "Technical Standard for Manufacturing Frost-Resistant Water Meters in Seoul," a technical standard used to test and certify water meters that meet the technical requirements to be considered frost-proof.

After the introduction of the Standard, many manufacturing companies started to develop water meters that are more resistant to freezing weather. In 2006, the first certified water meters were developed and introduced to communities that were more susceptible to winter frost, thereby greatly reducing the number of water pipes damaged by frost.



Current design of the frost-resistant water meter

Moreover, we have applied various other measures, such as introducing the standard for water meter boxes and improving the insulation of water meter covers to reduce the incidence of water meter bursts effectively.

Freezing and bursting of water meters depend largely on the pipes and the environment where the meters are located, such as housing types (apartment, town house, shopping area, or construction site). To prepare a suitable protection measure for each type of environment, we have been conducting complete enumeration surveys of the water supply systems since the beginning of 2000. The surveys allowed us to count the number of water supply systems by housing type and pipe.

Upgrading frost-resistant water meters

Regular water meters are susceptible to damage from cold weather because the water volume expands when it freezes inside. Note, however, that the frost-resistant water meter can better withstand subzero temperatures because it includes a special component that can absorb the expanded volume. The airbags found inside these water meters can absorb 8-13% increases in water volumes, effectively minimizing the troubles and costs incurred by water meter freezes.

In an experiment performed by the Ministry of Security and Public Administration in December 2012, under minus 15 degrees, a regular water meter froze and burst in five hours, but the frost-resistant water meter did not. In fact, the Korean government is carrying out various support mechanisms -- including financial support -- to deploy frost-resistant water meters more widely across the nation.

Upgrading and deploying insulated meter covers for apartment buildings

For water meter boxes located outside buildings like corridor-type apartments, we have been distributing insulated meter covers together with posters like the images below. Corridor-type apartments experience the highest incidence of water meter bursts, which sometimes escalate into bigger problems. Therefore, Seoul has long been committed to resolving the bursting issue in these types of buildings. In particular, since 2013, we have been pushing to improve the insulation of meters by developing the double-lid meter cover instead of the single-lid one since the upgraded version shows improved insulation by creating an air layer between the two lids.

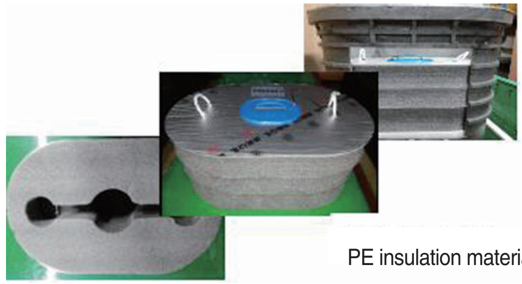
Installing heat-insulating materials inside meter boxes for single-family houses

During the first half of 2013, we conducted a complete enumeration survey of all meter boxes in order to repair those that have been deformed or those with damaged heat-insulating materials.

The survey found that 110,000 units of meters were in need of repair works, and we are currently replacing them with PE insulation materials in order to minimize the risk of freezing.

Insulated water meter covers in 2012
(low-density polyethylene 0.1mm x 1layer)

Upgraded version of water meter cover design and structure
(low-density polyethylene 0.05mm x 2 layers)



PE insulation materials

[Annual Plan for Replacement]

Classification	Total	2013	2014	2015	2016	2017
Estimated amount of funding (won)	3.7 billion	500 million	900 million	900 million	900 million	500 million
Number of water meters subject to repair	111,918	17,537	30,800	29,386	25,532	8,663
15mm	62,147	17,201	27,017	17,929	-	-
20mm	23,249	242	3,783	11,457	7,767	-
25mm	14,344	79	-	-	14,265	-
30mm	5,396	11	-	-	3,500	1,885
40mm	5,220	2	-	-	-	5,218
50mm	1,562	2	-	-	-	1,560

Water meter insulation for small construction sites

According to research conducted over the past years, water pipe freezing and bursting are most likely to occur on pipes located outside, during holidays, and at night when water stops running, all of which are basic conditions of small construction sites.

Therefore, we plan to require small construction sites to install frost-resistant water meters when they apply for temporary water supply, and we will issue permits only when all the measures are in place. Moreover, we will enhance the level of inspection for construction sites that are more susceptible to water pipe freezes and run a campaign for protecting water meters from frost.

Promotion of campaign for winterizing water meters

We are cooperating with local district governments and media to run a campaign to educate citizens on how to winterize water meters. For example, we have utilized various communication channels such as the Korea Meteorological Administration and media to inform citizens on how to winterize the meters. We also distributed communication materials and posters with precautionary warnings to communities that are especially vulnerable to water meter freezes, made announcements to apartment residents, requested cooperation from local authorities, campaigned through various media channels, and used large electronic billboards and websites to communicate campaign messages.

: Know-how & Insights

Seoul has faced many obstacles in implementing new measures to tackle water meter freezing and bursting; below are some lessons learned from our experiences.

Selecting a standard water meter for the city

Selecting the most suitable water meters for Seoul from so many meters produced by a myriad of manufacturers was not an easy task, made even more difficult when all the manufacturers present evidence of meters being scientifically proven and quality-tested.

Moreover, we only had a very limited time to make such a difficult decision since the bursting problem was recurring every winter. In addition, we felt that selecting the best-quality water meter for our citizens was our duty.

After numerous discussions and consultations with manufacturers, meter installers, and staff members, we were able to set up successfully the “Standard Test for Frost-Resistant Water Meters,” which manufacturers had to pass in order to supply their meters to the public.

Once the Standard was in place, we made the information widely available to all manufacturers so that they are clear on what our objectives and methods are. In other words, we encouraged them to follow the standard as closely as they can to be selected as our partners. We equipped the Waterworks Research Institute and Waterworks Material Management Center with the tools needed to conduct the test for manufacturers.

Upgrading and deploying insulated water meter covers for multi-family houses

In many apartment buildings, water meter boxes are placed in the corridor outside the house. As water meter boxes outdoors become exposed to cold air in winter, many meters freeze or burst. Some citizens voluntarily used insulated water meter covers to protect the water meters from frost. Still, such method proved ineffective in protecting water meters when temperature dropped to below minus 10 degrees. We recognized the urgent need to seek ways to improve the insulating capabilities of the water meter lids.

At first, we used insulating materials called "Atiron" or aircap to cover the water meter lids. Note, however, that this measure proved to be ineffective because the materials got easily detached due to their heavy weight. After many trial and errors, we decided to adopt the double-lid meter cover, which shows improved insulation by creating an air layer between two lids. So far, it has been found to be the most effective insulation method. Though we are quite satisfied, we will continue to push ourselves even further so that we can deliver the best services to our citizens.

Installing heat-insulating materials for meter boxes at single-family houses

Water meter manhole covers can be easily damaged from the weight of pedestrians or heavy cars parked over the covers. Previously, there were disputes as to who should be responsible for the cost of replacing the water meter boxes — the city government or the users themselves. In the end, Seoul decided to pay for the cost to reduce the inconvenience to its citizens. Currently, a new investment plan has been set up to fund the cost of replacing the damaged water meter manhole covers.

Policy Outcome & Evaluation

The change in temperature is the most critical cause of water meter damage from frost. The table below shows that, at similar temperature, the number of water meter damage cases dropped to 1/9 in 2013 or after the policy was implemented; thus proving the effectiveness of our policy. (Compare the data of 2009 and 2011, 2010 and 2012, and 2008 and 2013.)

Classification	2013	2012	2011	2010	2009	2008	2007	2006
Average temperature	-2.99℃	-7.70℃	-5.46℃	-6.14℃	-4.78℃	-2.98℃	-3.74℃	-1.64℃
# of Water meters damaged from frost	585	12,335	8,276	24,519	13,869	5,570	2,146	2,174

This is an encouraging result since fewer meter bursts mean not only less financial burden on the citizens but also less stress and higher quality of life for our citizens.

Applicability of the Policy

The Korean government and many other local governments in Korea are exerting various efforts to deal with water meter freezing and bursting, and some have approached the Seoul Metropolitan Government for advice on this issue.

We believe that maximizing the benefits of such policy requires public support and engagement, which in turn necessitates rapid and accurate communication among the government and citizens.

For one, we can take advantage of the strong infrastructure of the Korea Meteorological Administration (KMA), which delivers more accurate weather information than ever before. For example, when we get weather forecast from KMA that the temperature tomorrow is going to be below minus 10 degrees, we can send a warning message to our citizen’s smartphones the night before. The message will prompt the citizens to leave their faucets at home open to let the water run very slowly through the night, which will prevent bursting.

Besides KMA, we can also work with the media and newspaper to give the same information to citizens to raise their awareness of the need to take precautionary measures and to be more engaged in the city‘s initiative.

Q&A

How effective have the frost-resistant water meters and the insulated water meter cover been?

• Effectiveness of frost-resistant water meters

Compared to regular water meters, frost-resistant water meters are 7-9% less likely to freeze and burst from the cold temperature.

• Effectiveness of insulated water meter covers

According to an experiment conducted by the Waterworks Research Institute, installing water meter covers raises the temperature to up to 1.5 degrees. In addition, when water meter boxes were filled with enough insulating materials and protected by the insulated covers, such caused the temperature to rise by up to 7 degrees.

What are the differences between frost-resistant water meters and regular water meters?

• Characteristics of frost-resistant water meters

Frost-proof water meters can withstand frosts without getting damaged because they contain airbags that absorb 8-13% increases in water volumes. Such water meters can be used again when they thaw, thereby greatly reducing the costs and inconvenience related to water meter damage.

In an experiment performed by the Ministry of Security and Public Administration in December 2012, under minus 15 degrees, a regular water meter froze and burst in five hours, whereas the frost-resistant water meter did not. This shows the outstanding performance of frost-proof water meters compared to regular meters.

Regular water meter

Frost-proof water meter [contains airbags at the top and the bottom]

What are the criteria, standard, and method for the water meter frost resistance test?

① Internal pressure test - it has to be able to withstand pressure of 20kg/cnf for more than 1 minute

② Primary test for frost resistance

Water Flow Test	→	Frost Resistance Test • Temperature: -20C • Pressure: 5.0kg/oif • Time: 48 hours	→	Rapid Thawing • Using warm water at 80 degrees	→	Water Flow Test	→	Repeat twice

③ Secondary test for frost resistance

Decrease temperature • Room temperature ⇨ -20°C • Pressure: 5.0kg/cm² • Duration: 4 hours	→	Maintain low temperature • Temperature:-20°C • Pressure: 5.0kg/cm² • Duration: 10 hours	→	Increase temperature • -20°C ⇨ 30°C • Pressure: 5.0kg/cm² • Duration: 4 hours	→	Raise temperature: 30°C • Pressure: 5.0kg/cm² • Time: 6 hours	→	Repeat 14 times

※ Conduct a flow test after repeating the process above for 7 out of 14 times.

④ Final flow test: The measurement error has to be within the user's tolerance (±4%).

⑤ Dismantling inspection: There should be neither deformation nor damage of the internal parts.

Contact Information

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Operation & Management

Operation & Management 01

"Arisu INFO System"

Systematic billing management with new system and institution

The outdated billing management program for water and sewer service is upgraded to a web-based, up-to-date application to enhance work efficiency and provide the best service to the citizens.

Before the Policy Implementation	After the Policy Implementation
• The overly complex menu hindered efficient work. • The C/S environment had low compatibility with other newly developed systems and caused many errors. • The electronic bill took too long to reach homes (5 days). • The PDA meter reading result was reflected the next day, not in real time. • Social security number was required on the Cyber Customer Support Center, increasing the risk of personal information leak.	• Rapid billing calculation allows better service. • Various information systems are integrated, enhancing work efficiency. • Happy e-eum (Ministry of Health and Welfare: information management system for welfare benefits receivers). • Seoul's GIS: system conducive to site visits. • Electronic bill can be sent in just 1 day. • PDA meter reading is reflected on bills in real time. • I-pin, Certificate of Authentication can be used in place of the social security number, thereby reducing the risk of personal information leak.

Overview of the Policy

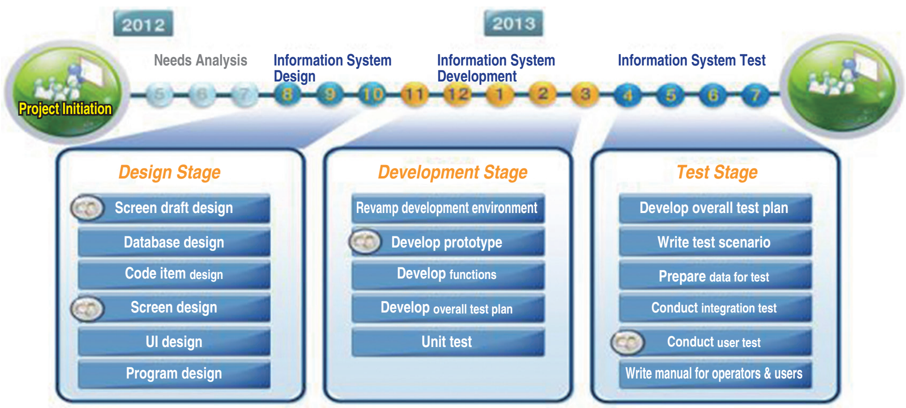
The "Arisu INFO System" is a web-based system designed to provide online & offline billing services and to enhance service quality. Fully equipped with various features such as real-time PDA metering and data retrieving as well as public disclosure of information, the "Arisu INFO System" effectively improves efficiency and transparency.

- Redeveloping the web-based "Arisu INFO System" for billing management
- Adopting web-based infrastructure and application software to facilitate the conversion of billing database and other revenue management
- Upgrading the PDA meter reading system, PDA replacement
- Overhauling the cyber customer support center

Background

Seoul's utility bill management system was first developed in 1998 in the C/S environment. Since the development tool is no longer in use, however, maintenance and compatibility issues arose. On the other hand, the weak security of the database rendered the system's capability to protect information highly vulnerable. This gave rise to the need to upgrade the overall IT system of water bill management. In addition, customers increasingly found the system inaccessible and inconvenient since they could not easily voice their complaints. Evidently, an advanced system based on high technology was needed to provide customer-centered, convenient, and tailored service.

Process of Policy Implementation



The project was started in May 2012 and completed in October 2013, with a total of 4.169 billion won spent on system building.

Analyzing existing business practices and identifying needs: May ~ October 2012

- Collect the feedback/needs of users in the Office of Waterworks HQ & branch offices and analyze them (343 cases).
- Design screen tailored to the task and have managers review the screen (20 times).

Developing program and performing user test: November 2012 ~ May 2013

- Develop the program (1,228) and perform unit test.

Converting the billing database and verifying them: May ~ September 2013

- Analyze the current billing database and convert and verify it (5 times).

User integration test: June ~ July 2013

Upgrading the PDA meter reading system and replacing PDAs: June ~ October 2013

Reestablishing the Cyber customer support center: June ~ October 2013

Performing user training: August ~ October 2013

- Group training for billing officials (2 times for each branch office): 1200 people in all

Operating the "Arisu INFO System" in parallel with the previous system (billing, PDA metering, cyber customer support): September ~ October 2013

- Applied to all steps from metering to billing in all branch offices

Official launch of the "Arisu INFO System" (billing, PDA metering, cyber customer support): October 21 ~ present

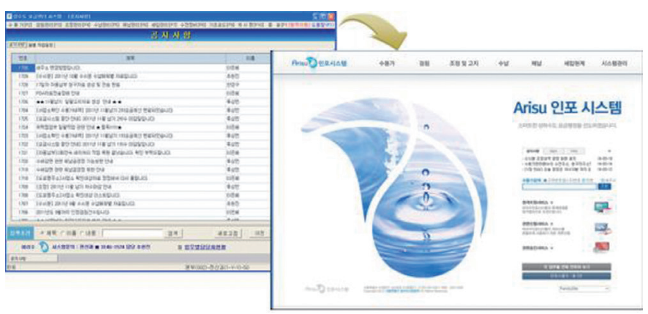
Details of the Policy

The existing billing system for Seoul's water supply at the time was becoming obsolete, and the information environment was rapidly changing. Against this backdrop, the billing service and the relevant policies had to adjust to the changing needs of users and to provide mobile and web-based services to citizens. The new system provides an answer to this by enabling advanced billing management.

EFFICIENCY: The newly developed web-based program enhances administration efficiency

The "Arisu INFO System" was created with 1,930 million won re-development cost and 1,091 million won for database conversion and revenue management. The new program is a full-featured, easy-to-use, user-friendly water/sewer billing software package with streamlined payment and metering reading entry, providing an efficient solution for managing, billing, and collecting all water/sewer receivables and making it easy for users to navigate through.

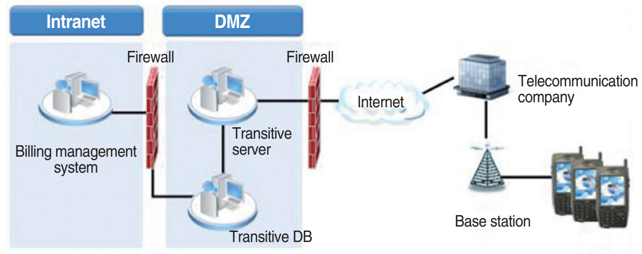
Moreover, various information systems have been integrated into this system, thereby enhancing business efficiency (22 systems). In addition, database conversion -- also known as data migration -- allows a range of analysis and calculation with accuracy and speed. Today, search has been made quicker thanks to successful data migration.



TRANSPARENCY: Real-time PDA meter reading and disclosure of information

Developing a PDA meter reading system and replacing 380 units of PDA devices cost a total of 8.63 million won.

This new application integrates directly with the central billing system and allows handheld PDA devices to upload/transfer its routes, work orders, and meter results automatically. As the PDA meter is read, the information collected will be automatically forwarded to the new system, and customers can check bills when the meter reading or a bill is delivered to their homes.



Lessons in System Deployment

To minimize the risks of implementation of a new system and to increase the probability of project success, we divided the process into several phases: system development → data migration and equipment preparation → system advancement. This broken-down process can deliver software that meets expectations and deal with various and complicated information of 2 million faucets in Seoul.

The system also allows speedy service delivery to end customers, which is important in responding fast to civil complaints and other social issues. Equipped with verified, most updated IT solutions, the new system ensures safety and security. Role-based access control provides various access privileges that suit each role and need of users, enabling all the required functionality and authentication for a security system while reducing the risk of information leak. The added function of personal data encryption further strengthens privacy protection.

Experiences in Policy Implementation

To ensure better analysis and design of the system, the Office of Waterworks HQ and branch offices had more than 50 meetings; we also held 2 meetings for the advisory committee. Along with such occasional discussions, we surveyed users' responses and preferences to draft system design reflecting users' feedback on the process and tested the system for each unit. For smooth transition, we operated both old and new systems in line with each other for some time until we completely fixed all the possible issues with the new system.

Furthermore, we provided various forms of training sessions for users to understand the system better and familiarize themselves with the usage.

: Policy Outcome & Evaluation

The new system provides an optimized support tool; it is also flexible enough to reflect the changes of rates or relevant policies in the future. It is a web-based program equipped with PDA real-time meter reading and checking system, and the information is provided to the public via website on a real-time basis as well.

Such efforts have contributed to enhancing administration efficiency, transparency, and service quality.

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Operation & Management 02

"Arisu Integrated Information System"

Cutting-edge Smart Water Management System for safe Arisu

The "**Arisu Integrated Information Center**" monitors and analyzes all the necessary information from water intake, purification, storage, distribution, and faucet quality management, contributing to producing and delivering stable, clean water to Seoulites. Established as one of the major mid- to long-term projects of Seoul's "**Ordinance on Water Supply and Waterworks Installation 2020,**" the center integrates science into current water production and supply management, thereby enhancing the operation efficiency of facilities. To make the most of the Center, we have applied cutting-edge ICT to our current water.

Before the Policy Implementation	After the Policy Implementation
• Information was collected separately from purification stations and branch offices. • Pump operation decision was made based on personal, subjective experiences. • Production process control was separate by purification station and reservoirs, making integrated and speedy response impossible.	• Information on water production and supply of different source waters is collected automatically. • Decision is made based on scientifically predicted demand, thereby reducing electricity cost. • The entire production process including alternative supply and change of source water is now centrally controlled.

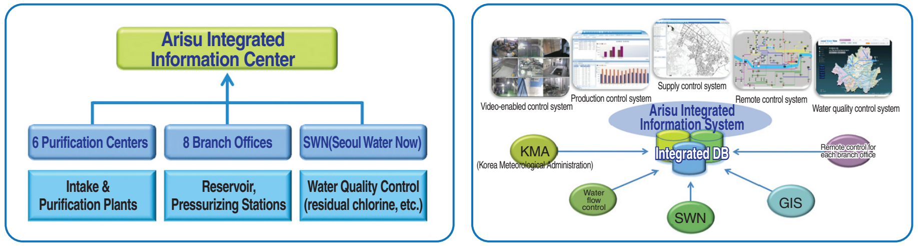
Overview of the Policy

Production control, supply control, remote control, video-enabled control, and quality control all at once

- Production control system: The scientific demand-forecasting model enables planned production and efficient pump use, cutting down energy consumption.
- Supply control system: Block management and online pipe analysis detect leaks and analyze the revenue water ratio.
- Remote control system: capable of collecting and analyzing the operational information of the entire water supply system on a real-time basis (6 purification stations and 8 reservoirs)

- Video-enabled control system: double control system for both purification centers and branch offices
- Water quality control system: The quality of water throughout the water supply process is monitored and made public.

[Process Diagram for the Arisu Integrated Information Center]



Background

Enhancing work efficiency required an integrated water supply management system

Previously, the management of each facility (purification stations, reservoir, pressurizing stations, etc.) was done separately by unit. Such fragmented system hampered efficiency in water supply management, a problem that called for a new system that would integrate all units. Furthermore, instead of relying solely on experience or intuition in making decisions, a formulaic algorithm needed to be the basis of any decision making.

The answer lay in using an ICT-enabled automated system in the entire water supply process to integrate all management-related tasks and analyze the collected data in a scientific, logical way.

An integrated control system needed to be in place to prepare for any sudden change

Internally, our Office has seen frequent organizational changes and gradual reduction of workforce. Therefore, to prepare for any personnel change, an automatic system that can analyze and manage all the data regarding water production and supply was of paramount importance. Externally, climate change and subsequent abnormal weather patterns have emerged as serious issues. Against this backdrop, there was a need for an integrated monitoring system (CP) that can see, monitor, and check all information including water flow, hydraulic pressure, etc.

Process of Policy Implementation

Setting up a plan to create the Arisu Integrated Information Center

Seoul's "Ordinance on Water Supply and Waterworks Installation 2020" lays the blueprint for establishing the basic functions and the required system for the "Arisu Integrated Information Center," whose details were included in the working drawings. In particular, during this stage, extensive research and information collection were done on hardware, software, and existing system, to be used as the basis for more concrete implementation plans.

Developing the Arisu Integrated Information System

It took about 2 years and 6 months (from June 2009 to December 2011) to create the system. At an early stage, project managers visited other well-known, similar sites (Japan, K-Water, Busan City, etc.) to benchmark best practices so as to minimize trial and error and reduce the time required for system creation.

Launching a task force and constructing the Center

In September 2011, which is before the completion of the center, a task force team that took charge of the 3-month pilot run of the system was launched. After the pilot run, we added an important feature, which is the automatic report printing module.

We also ran a consistency test for the video-enabled control system and remote control system. Through the pilot run, on December 18, 2011, the Center was finally completed, and the system was up and running. Running the Center and the System together helped us achieve our stated goal of controlling and reproducing the information needed to operate the water supply system in the most stable, efficient way.

The System also integrated the automatic water quality control system that was previously taken care of by the Water Supply Research Institute, linking the water quality data with the production/supply/remote control systems.

Details of the Policy

Production Control System

This system is equipped with a scientific demand-forecasting model that enables finding out how much water should be produced at the purification centers and when to operate the pump. Previously, such decisions were made only on the basis of water level at the purification stations & reservoirs along with the experience of staff; with the new System, however, we have a more scientific approach that utilizes water distribution patterns by time period, previous operation data analysis, seasonal information, and meteorological information, among others. Based on these data, each purification center forms its production plan every 24, 48, and 72 hours and operates pumps accordingly. Such new practice leads to an optimal level of production, saves energy, and cuts down the tap water production cost.

Supply Control & Management System

This system monitors major data (water volume, hydraulic pressure, water quality, etc.) to prevent any accident and to allow evidence-based, fast decision making for recovery in case of emergencies or accidents (leak, water contamination). For this system, we developed a mathematical pipe analysis program that accurately calculates pressure and water flow in each water pipe throughout Seoul.

This pipe analysis program uses real-time water volume and pipe size, length, height, and pump features. It has proven to be effective in analyzing the revenue water ratio and in addressing water interruptions.

Remote Control System

This system is capable of collecting and analyzing the operational information of the entire water supply system on a real-time basis (6 purification stations and 8 branch offices), all of which used to be managed separately.

With the remote control system, any information related to operation in 82,500 facilities (including all production, supply, and distribution facilities in Seoul) such as water quality, water level, pressure, pump operation, and electricity use are all transferred to this system and collected in its integrated database. The database enables performing comparative analysis on such extensive information, which could not be done when they were handled separately by each purification center. The system has improved our decision-making process, leading to higher efficiency.

To assist better in the monitoring practices on a real-time basis, a 67-inch DLP Cube (with 18 screens) is installed along with sound alarm in case of emergency within the facility.

Video-enabled Control System

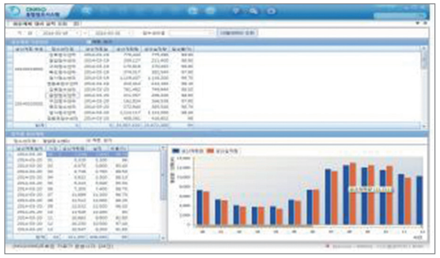
For purification centers and branch offices, a dual control system that can check the situation of all facilities is in place with 690 surveillance screens. Conference call system is available in case any urgent meeting needs to be held prior to decision making.

Water Quality Control System (Seoul Water Now = SWN)

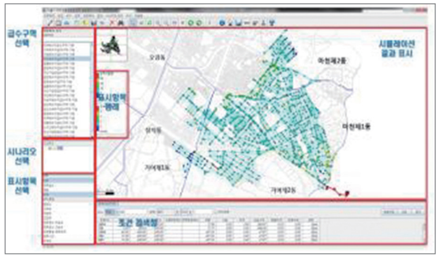
This system analyzes water-related data (pH, turbidity, residual chlorine, etc.) coming from automatic readers installed throughout the water production and supply system. The system issues alert or warning depending on how far the current situation exceeds or falls short of the permissible level. It also sends text messages to the staff in charge so that immediate response measures can be taken.

Besides the analysis and alert functions of the system, it also stores all the information in the form of database that can readily be analyzed scientifically. Most importantly, the system lets citizens access up-to-date information on the quality of water. Thus, it won the 2009 UN Public Service Awards for upholding citizens' right to know.

※ Required Budget for the System: 18.3 billion won (7.3 billion won for the Arisu Integrated Information Center & System; 11 billion won for the Automatic Water Quality Control System)



Production Control System



Supply Control System

Remote & Video-enabled Control System

Water Quality Control System

Know-how & Insights

Production Control System

One problem we faced was the ±10% margin of error in our demand prediction due to the inaccuracy in some of the data (previous water volume, meteorological data, etc.) To address the margin of error, we corrected the water volume data for the past 5 years, inspected the sites ourselves to compare the accuracy, and specified the weather information of KMA into 12 types. Such efforts eventually paid off, and the margin of error was reduced to ±3%.

Supply Control System

Mathematical, real-time water pipe monitoring and analysis require highly accurate data on pipe size, length, height, valve properties, and other data from GIS. Note, however, that accuracy is compromised during pipe repair and maintenance works; this in turn affects the supply control system's ability to make precise analysis. To resolve this issue, we developed another program that automatically reflects the changes in GIS on the supply control system.

Remote Control System

The best way to deal with various tag values for the remote control system is to standardize them all together. Since this measure requires significant time and budget, however, we decided to add a set prefix before every tag value so that we can achieve a level of standardization without having to change everything that has been in use before.

Video-enabled Control System

Given the big size of video data, we needed proper bandwidth for the data to be transmitted. We resolved this issue by setting 10G, NIS-certified exclusive line for this system and renting some line from telecommunications companies.

Water Quality Control System

Real-time water quality monitoring and public disclosure of the information require accurate measuring devices, efficient operation of the devices, and stable transmission of the data. To ensure accuracy, we had companies specializing in manufacturing such devices provide technical support including maintenance of devices on a regular basis. We also monitored the data transmission status regularly and took countermeasures immediately should any issue arise.

In addition, we provided high-level training programs for system operators and held workshops to share best practices and know-how on system and device management.

Policy Outcome

Thanks to the "Arisu Integrated Information System," the operation budget for water production and supply was cut; thus improving the management efficiency to a great extent. In particular, the production control system, which makes a close prediction of water demand and pump usage, helped cut down electricity cost by 2 billion in 2013 alone. This is equivalent to 270 tons of greenhouse gas emission cutting effect.

The supply control system enables mathematical pipe analysis that allows the early detection of potential leaks and reduction of repair time, which in turn improves the revenue water ratio. The water quality control system helped prevent water-related accidents, thereby achieving our goal of "zero accident" in Seoul.

Instead of relying solely on the experience of our staff, decision making is now complemented by the scientific analysis of data and automatic analysis. This helped streamline the work process in the most innovative way.

Previously, a call had to be placed to report an accident, which will then be handled. Today, the Arisu Integrated Information System centrally controls and responds to any issue automatically. The same is true for water quality management; instead of each branch office doing its own monitoring and site inspection, the central system performs control and analysis, and all facilities are linked by the integrated system.

Policy Evaluation

The success of the Arisu Integrated Information Center can be attributed to the following three factors:

First, success was enabled by thorough and exhaustive research on the existing operating system as well as case studies of information systems in Korea and abroad. The Office of Waterworks performed complete enumeration survey and exhaustive research on the existing systems. We went a step further and analyzed the strengths & weaknesses of other water information centers in K-Water,

Busan Metropolitan City Government, Tokyo, Fukuoka, and Paris; such information was used to identify the best hardware and software for Seoul.

Second, the Center became more competitive thanks to the software and algorithm that were newly developed for the Center. The integration was not limited to the physical integration of systems that were previously operated separately; it also included the new development of software to link data organically among all the systems. In particular, this system links various sets of data such as meteorological data, water consumption patterns of citizens, pipes properties, etc. This is one of the most distinguishing aspects of Seoul's Arisu Integrated Information Center.

Third, continuous efforts for the maintenance and upgrade of the system played a big part in the overall success. A task force team, which was launched before system development was completed, identified the areas of improvements and took measures accordingly. In 2011, we assigned a group of staff tasked with upgrading the accuracy of the system continuously by comparing the result value taken from the system with the value taken on the spot.

Applicability of the Policy

This next-generation, cutting-edge, IT-based water supply management system can be applied to Southeast Asian nations, Latin American countries, and other developing nations to upgrade their own water supply management system.

From 2011 to 2013, 353 people from 37 domestic organizations and 184 people from 16 different countries have visited the "Arisu Integrated Information Center" for learning and benchmarking.

Q & A

What does the future of the "Arisu Integrated Information Center" look like?

From the beginning, we set 3 stages for the Center.

In the first stage, the goal is to create the basic and most necessary system to manage production & supply operation and which integrates data and video. This particular goal was achieved in 2011.

In the second stage, the goal is to add the newly developed advanced purification process to the system and to build the block management system in order to ensure overall precision of the system. This stage is set to be completed by 2016.

In the third stage, the goal is creating a system wherein decision making can be remotely controlled and made. The entire process of water supply in Seoul is integrated into the system and can be perfectly managed by the least manpower necessary. This system is also linked to the Data Warehouse in Seoul so that the information can be served to the public when necessary.

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Operation & Management 03

Arisu Small Hydropower (SHP) Plant

Small Hydropower Plant in Noryangjin Reservoir

Hydroelectric power is a type of renewable energy that uses head and flow of moving water to produce energy; small hydropower (SHP) in particular is the result of the development of hydroelectric power on a scale serving a small community or with capacity of up to 10,000kW in general. SHP eliminates pollutants and allows the constant supply of electricity. Note, however, that it has not been widely adopted in Korea due to difficulties involving high initial investment cost and plant site selection.

Our Arisu small hydropower plant takes advantage of the kinetic energy of non-pressurized water or head (difference between upstream and downstream water levels) of 24 meters, which is produced in the Amsa purification center and Noryangjin reservoir. This is the first time waterwheel is installed in the drinking water supply network to produce hydropower. Currently, the 103MWh per month generated through this system is being purchased by KEPCO (Korea Electric Power Corporation) for 1.6 million won every month.

In line with Seoul's **"One Less Nuclear Power Plant"** project, the Arisu SHP is expected to play a pivotal role in solving the electricity shortage in the country and reducing CO2 emissions; thus contributing to the country's wider environment preservation initiative.

Before the Policy Implementation	After the Policy Implementation
• Water flowed from the Amsa purification center to the Noryangjin reservoir.	• The kinetic energy freed by falling water in the Amsa purification center (non-pressurized water) is now used to generate energy.

Overview of the Policy

Installing small hydropower plants: generation capacity of 300 kW (100 kWx3 ea.)

- Using water flowing from the Amsa purification center to the Noryangjin reservoir, we built the country's 1st small hydropower plant where waterwheel is installed in the drinking water supply network.
- The Seoul Metropolitan Government is selling electricity from SHP's monthly generation capacity of 103 MWh, earning income of 1.6 million won every month.

Background

Electricity production capacity could not meet the rapid increase in electricity demand.

The ratio of aggregate electricity consumption to GDP in Korea is 0.44 kWh/$, which is far higher than the OECD average of 0.2 kWh/$. On top of such high energy consumption pattern, Korea's reserve electricity has been falling short in the midst of occasional surges in demand caused by abnormal weather patterns such as heat wave, cold wave, etc.

Nuclear power plants can no longer be the answer to address the shortage issue due to strong opposition to this type of energy generation. The opposing voice has gained steam especially after the Fukushima accident in March 2011 and after a scandal that involved fake certificates for some parts in the nuclear reactors in Korea.

Seoul is moving forward in line with the government's renewable energy policies.

In Korea, 91.9% of power is generated by thermal and nuclear energy, whereas other advanced nations are expanding the portion of renewable energy for their stable supply of electricity. Following suit, the Korean Ministry of Trade, Industry, and Energy (MOTIE) has been implementing various policies and making investments such as Green Home, Green Building, and Green Community. The Arisu hydropower project is part of such government initiative to support municipalities in adopting more renewable energy projects.

Environmental preservation has become a social issue.

As citizens have become more aware of the direct and indirect impacts of global warming, rise in sea level, endocrine-disrupting chemicals, and other environmental issues, they recognize the need to preserve the environment and ask the government to do its part and to engage more in the cause.

Trends in SHP

Global Trend

Having recognized the economic and social benefits of SHP, many advanced countries around the world have already acquired hydrologic statistics and technology in this field. These countries regard SHP not only as a source of energy but also as an important energy industry, and they have already established an assessment method as to the feasibility of SHP as well as optimal design for plants, streamlined, standardized waterwheels system, and automatic control system, all of which have contributed to the wider adoption of SHP globally.

• China: 38,500MW, Japan: 1,700MW, Germany: 1,600MW, France: 1,956MW, Italy: 2,233MW

Other countries have developed low-head waterwheels since low-head units are much smaller in capacity than the conventional large hydro turbines but just as economically viable.

• Higher capacity means more economical options. Korea (around 1,400kW), Other countries (around 1,000kW)

Policies and Institutions of Other Countries

Governments around the world have adopted various systems considering their own situations in terms of demand, supply, generation capacity, and production level.

I Table 3-1 I Support Schemes of Countries around the World

Country	Support Mechanism	Remarks
Germany Spain Denmark	Introduction of FIT ※ FIT (Feed In Tariff): a policy tool designed to encourage the deployment of renewable electricity technologies by providing a fee (a "tariff") or a certain amount of money to those who generate their own electricity through renewable energy technologies above the retail rate of electricity	
US/Canada India	Introduction of RPS ※ RPS (Renewable Portfolio Standard): a regulation that requires power producers of a certain size to supply a certain amount of the total power generated using renewable energy	

Country	Support Mechanism	Remarks
China	Legal and institutional mechanisms are in place to encourage hydropower, especially SHP, anywhere possible.	
Japan	Micro-hydropower (output is less than 100kW) and pico-hydropower (less than 5kW) are in operation.	

I Table 3-2 I SHP generation by countries

Country	Capacity (Mw)	Country	Capacity (Mw)	Country	Capacity (Mw)
Argentina	400	Italy	2,233	Belgium	60
Austria	843	Japan	1,700	Luxemburg	40
Brazil	859	**Korea**	**65**	Portugal	317
Canada	1,056	Norway	806	Britain	68
China	38,500	Pakistan	107	Greece	60
Czech	201	Peru	215	Ireland	37
Finland	309	Rumania	311	Malaysia	107
France	1,956	Spain	1,700	Bolivia	104
Germany	1,600	Sweden	935	Vietnam	70
India	1,694	Turkey	83	Congo	65
Indonesia	58	United States	3,420	Sri Lanka	35

Data : Renewable Energy R&D Strategy 2030(2007)

Domestic Trend

In Korea, as of the end of 2010, SHP generation capacity was 95,220kW at 68 plants, and annual SHP generation, 3.39 million kWh.

I Table 3-3 I SHP in Korea

Classification	Generation Capacity (kW)	Share (%)
68 plants	95,220	100
KEPCO and other public power generation companies (13 plants)	33,573	35.2
Independent power producer (IPP) (18 plants)	30,559	32.1
K-Water (19 plants)	18,054	19
Korea Rural Community Corporation (11 plants)	10,659	11.2
Municipalities (7 plants)	2,375	2.5

SHP plants constructed before 2000 were mostly run by IPPs, but the trend reversed after 2001 when the government began various projects including Feed-in-Tariff. Since then, most of the SHP plants have been controlled by municipalities or other public corporations.

Currently, SHP is not utilized to the full extent compared to its high potential. In fact, SHP can be adopted in agricultural reservoirs and sewage treatment plants; hence the huge room for adoption. With RPS now adopted in Korea, SHP is becoming an even more economical option in which many are interested in investing.

Process of Policy Implementation

- 2012.02.25: Report on measures to implement the lessons learned from the Mayor‘s visit to Japan (pilot project for 1 SHP, 1 PV)
- 2012.03.13: Report on how to adopt SHP
- 2012.10.10: Secured budget for investment in SHP (1.231 billion won appropriated by the Korean Ministry of Knowledge Economy)
- 2013.04.04: Working design
- 2013.07.02: Service performance
- 2013.10.16: Permit as utility enterprise (generation 300kW)
- 2013.08~2014.01: SHP plant construction
- 2014.01.29: Construction completed

Details of the Policy

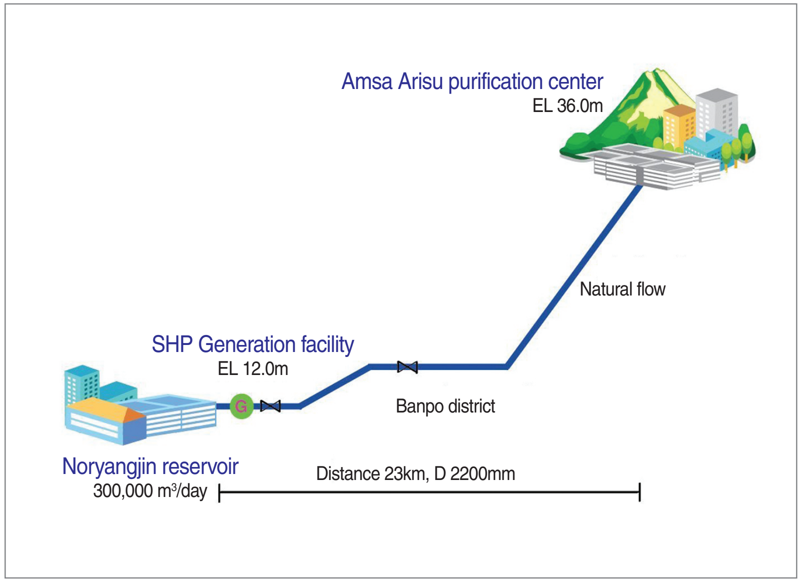
Arisu SHP plant

- Project Overview
  - Location: Noryangjin Reservoir in Seoul
  - Transmission Pipe: 23.2 km (diameter: 2,200 mm) of water pipes from the Amsa purification plant to the Noryangjin reservoir

– Water Level: head of purification plant (upstream): 37.79m, head of reservoir (downstream): 12m
– Waterwheels (3 units): pump-turbine type, rated capacity of 94kW, maximum output of 107kW
– Generators: three-phase induction generator (capacity: 100kW x 3EA)
– Operation: Automatic, remote control from the central control center at the Noryangjin reservoir

• Budget: 2,341 billion won (central government: 50%, city government: 50%)
• Characteristics
– A natural effective head of 10m is guaranteed.
– A large amount of water (daily average of 300,000m3) flows to the reservoir.
– No additional establishments or structures are required.
– There is no impact (noise, vibration, other environmental impact) on the surrounding areas; therefore, there is little concern of civil complaints.

[Arisu SHP Distribution Diagram]



Know-how & Insights

Concerns of potential threat to water quality

There were concerns of oil leaks from waterwheels, which could affect 800,000 households. After thorough inspections including numerous discussion sessions with expert advisory groups, more than 20 times of site inspection, and analysis of overseas cases studies, we selected non-corrosive, pump-type waterwheels that can ensure lubricant-free operations, eliminating any possibility of oil leaks.

Other concerns existed as well. Sudden changes in pressure to the pipeline could cause slime formation that pollutes water. Moreover, mid-valve operation to increase water flow -- a necessary step to compensate for the pressure loss when SHP is in operation -- could drastically change the water velocity, which could also damage the water quality. To prevent these problems, we implemented measures such as generator pilot operation, monitoring of parameters of water quality in real time, and adjustment of mid-valve.


Countermeasure meetings in case of compromised water quality


Countermeasure meetings for emergency valve operation

Technical issues regarding construction

To ensure that our construction works do not affect the households in Seoul, we made sure we took advantage of a special piping technology that eliminates the possibility of water interruptions during the construction in 4 sites. We also used pipe sleeves to prevent pipes from being pushed under pressure and strengthened the support fixtures to be used for water pressure simulation.

To compensate for the limited space in workstation, we had 2 workers in 1 group when carrying materials to pump stations and contracted a company specializing in such operations. Most importantly, all safety measures and accident prevention measures were in place with our inspectors, who stayed at the sites throughout the construction period.

Perforating works for pipes connected to the ground

Valve connected to the ground

Policy Outcome & Evaluation

Contributing to the energy reduction initiative of the Government and the Seoul Metropolitan City

Our SHP generation helped realize C02 reduction of 1,032 tons/year and energy saving of 482 TOE/year.

※ TOE(Ton of Oil Equivalent): 1 toe = 107kcal

In addition, 2,286 MWh of power generated by SHP were sold for 0.5 billion won/year to KEPCO, creating revenue for Seoul.

Raising awareness and educating on renewable energy

Our SHP project has been documented in the form of video materials, which are being used for middle and high school students in Korea to teach them various sources of energy and the importance of energy. We also promoted our SHP project via broadcasting and newspaper outlets to raise public awareness of renewable energy.

Applicability of the Policy

Seoul's SHP plant using water supply pipelines can be applied to other municipalities in Korea as well as other developing countries in Southeast Asia and South America.

Q & A

Where would more SHY plants be installed in the future?

We are looking into sites with lower head (over 2m) such as Yeongdeungpo Purification Station (200kW) and Samsung Reservoir (30kW).

Contact Information

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Arisu Small Hydropower plant takes advantage of the kinetic energy of non-pressurized water produced in the Amsa purification center and Noryangjin reservoir. For the first time in Korea, Arisu SHP uses waterwheel installed in the drinking water supply network to produce hydropower.

Operation & Management 04

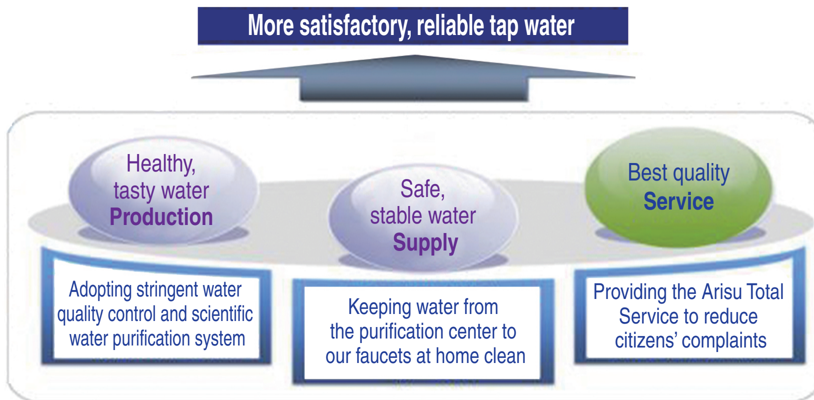
Arisu Total Service

Proactive, comprehensive approach to complaint handling to enhance citizens' satisfaction with tap water service

The **"Arisu Total Service"** is a platform by which the Office of Waterworks analyzes data related to tap water usage to use them in predicting what citizens are concerned about and what kind of complaints they may lodge. With such innovative service, we are responding more proactively to civil complaints and providing comprehensive, integrated service to all citizens. The Arisu Total Service was first initiated to resolve widespread mistrust in tap water among many citizens. Despite the advancement in quality of Arisu both in terms of production and supply, the public continued to voice their dissatisfaction and lodge complaints every year. Therefore, we launched this system so that we can provide tailored service to each and every citizen and even reach out to citizens with the solution before they lodge complaints.

During the planning stage of this innovative system, we listened to all stakeholders through various forums and reflected their valuable input on designing the Service to prevent any and all conflicts in the future. Our focus was on the training of staff, the most important element in the service level. Therefore, we utilized various resources including extensive training sessions to minimize trial and error. As a result of such efforts, the total number of water-related complaints dropped by 19.6% compared to the year before, and complaints related to the Arisu Total Service decreased by 35.9% during the same period.

Before the Policy Implementation	After the Policy Implementation
• Government-led, passive approach to complaint handling • Long waiting time • Fragmented system by each office	• Citizen-led, proactive approach to complaint handling • Shorter waiting time & rapid response to complaints • Comprehensive, integrated, one-stop service



Overview of the Policy

- Taking preventive actions against civil complaints by adopting various data analyzing techniques
- Taking a comprehensive approach to complaint handling; instead of simply responding to complaints, we reach out to take care of other possible inconveniences
- Providing additional services such as cleaning of sink and hygiene check on chopping boards to create a good impression and truly move the hearts of our citizens
- Having high-level officials make a "happy call" personally to check how the complaint is handled and to give feedback to complaint managers

Background

Despite the advancement in water supply infrastructure, citizens continue to complain about tap water.

Great strides have been made in Seoul's tap water. For example, the quantity of water production grew in the 1980s, and production level stabilized in the 1980~1990s; In the 2000s, with quality rather than quantity as the new focus, Seoul raised the revenue water ratio to a whopping 94.4%. The growth did not end there. Since 2010, many facility infrastructures also saw great advancements, especially with the "Advanced Purification Facility" and "Chlorine Re-dispersion System." As such, Seoul has endlessly worked to reach world-class quality in terms of health and taste. Note, however, that the number of civil complaints on water was as high as 473 cases in 2013 alone, and public satisfaction level continued to drop over time.

A completely new, innovative, customer-centered complaint handling system was necessary.

We realized that, to resolve civil complaints on tap water and eventually improve the satisfaction of customers, the focus has to shift from water production/supply to excellent service provision. It became clear that the answer lies in greater administrative capacity and completely new, innovative approach to civil service.

To this end, in 2014, Seoul committed to providing reliable, clean, and tasty water anytime, anywhere to anyone (3 As) and to providing the best service to citizens. Against this backdrop, the "Arisu Total Service," which is known for its comprehensive, proactive nature, was adopted in Seoul before any other city in Korea.

Process of Policy Implementation

We used various communication channels to ensure the success of policy implementation.

- Feb. 5, 2014: meeting with staff and labor union representatives
  - Discussed the current status of civil complaints and sought ways to resolve conflicts caused by the heavy workload of staff
- Feb. 5 ~ 10, 2014: collected extensive opinions of all employees and staff regarding the future plan
- Feb. 12, 2014: advisory council meeting held with civil groups, citizens, CS instructors, etc.
  - Agreed on the need to train staff and nurture specialist
  - Agreed on the need to expand the scope of the service to touch the hearts of our citizens
- Feb. 6 ~ 16, 2014: invited the public to propose ideas
- Feb. 13, 2014: workshop for public officials (over Grade 5)
  - Discussed the future direction, goal, and action plan for the Arisu Total Service
- Feb. 20, 2014: Action plan presentation for each branch office

Presentation by each branch office → Identify best practices to be benchmarked, areas of improvement → Form the plan for the Arisu Total Service based on what is realistic and feasible

- Feb. 24 ~ 28, 2014: training on communication capabilities, an important element in providing the best service and enhancing the service satisfaction level

Previous efforts to enhance civil service improvement

Since it was given the water supply task, which was previously handled by the district government, in 1989, the Office of Waterworks has implemented various measures to resolve civil complaints.

▽ 1990 – Call Center (#121)

This is a complaint handling system wherein anyone can call when a water-related accident takes place. This measure was established as part of the leak-free water supply project. When a citizen places a call to 121, an operator at the Office of Waterworks HQ will receive the issue first, and then escalate it to the department or branch office in charge of the matter, who will then take immediate action.

▽ 1993 – Water supply patrol team

It was launched to reduce water-related inconveniences such as water shortage and interruption. What was unique about this team was that, instead of driving cars, the agents rode motorcycles, which would give them better mobility when navigating through the small alleys of the city.

▽ 1998 – Water bill management system

Developed within the city government itself, the system computerizes operations related to billing. The system is equipped with 465 screens and around 700 programs, sending bills to about 1 million households every month.

▽ 2000 – Water supply customer

Service Charter: To realize higher customer satisfaction, the following elements are necessary: scientific and safe water quality management system, highest-quality administration, best customer service, and civil engagement. To this end, we adopted the Charter by which we promise to deliver the best possible service to citizens.

▽ 2000 - Happy Call System

A "happy call" is placed within an hour to the person who lodged a complaint to check the person's satisfaction with the service received. If dissatisfied, the person receives another visit the next day to resolve any persisting issue.

▽ 2005 – Customer Support System

First introduced to the general public in June 2006 after thorough analysis of the previous system, the new system lets citizens view the process of complaint handling from application to completion online. The system has enhanced transparency in the administration process. In addition, each branch office opened a customer support department that handles complaints; the staff were trained to be service-oriented instead of being authoritative and inflexible. With this, we separated works between the civil complaint handling department and billing department, which enabled both to be more specialized and stabilized.

▽ 2008 - 120 Seoul Dasan Call Center and 121 Tap Water Call Center

From 1990 to 2007, the 120 Seoul Dasan Call Center took care of every issue related to water supply. Today, the 121 Tap Water Call Center took over this work so that it can provide comprehensive, speedy, one-stop customer service.

: Details of the Policy

The "Arisu Total Service" is a completely new approach introduced to Seoul before any other city in the country. The service covers all steps of complaint handling; it proactively responds to complaints by anticipating them, handles complaints comprehensively, and provides additional services even after handling complaints.

Minimizing inconveniences by proactively handling complaints

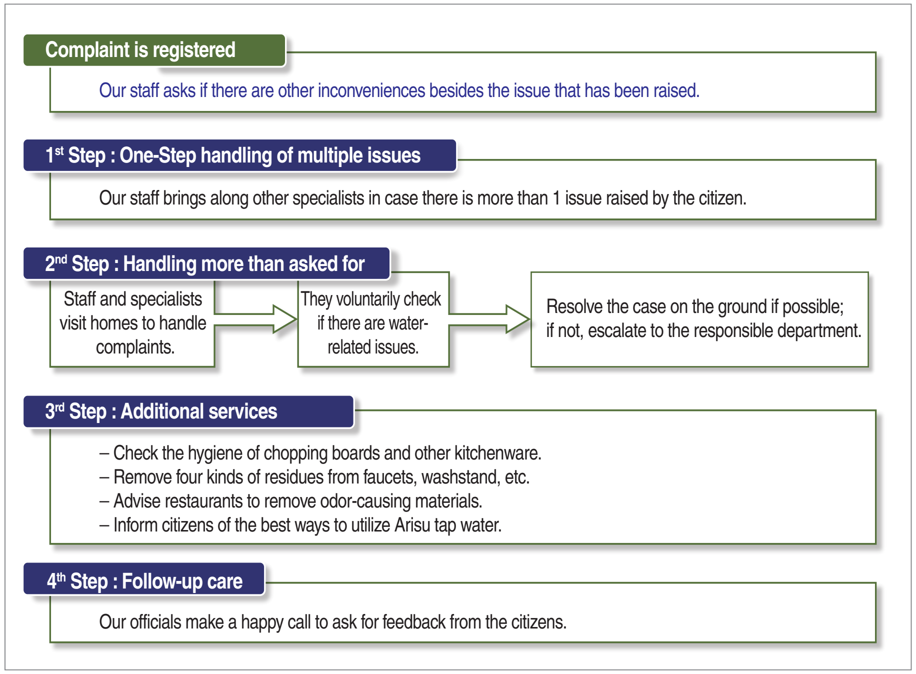
If the meter reading of a household has dramatically surged outside its previous consumption pattern, then we first check if there was any high water-consuming event such as addition of family member and special family rituals requiring high water consumption. In the absence of such, then we dispatch our agents to check leaks before the household in question lodges a complaint.

Integrated civil complaint handling service

With the comprehensive, integrated service packages, our staff not only responds to the issue in question but also asks the caller to check if there are other issues that may cause inconvenience. When visiting the caller's home after taking note of the complaint, our staff (sometimes accompanied by a specialist) handles all issues at the same time. During the visit, our staff once again checks for any and all additional issues they can help resolve; anything that has been identified is handled by our staff on the ground or directed to the government agencies concerned.

Providing additional services to touch the hearts of our citizens

Our service is not limited to simply resolving complaints regarding tap water. We also deliver services beyond expectations. For instance, our services includes hygiene check of chopping board and other kitchenware, endoscope inspection of pipes, cleansing service for faucets and washstand, etc.



• High-level officials personally make a "happy call" to check the result of complaint handling and give feedback to complaint managers.

Analysis of water supply-related complaints

In 2013, 8,910,000 cases were lodged through the 120 Call Center in Seoul; of those, 687,000 or 7.7% were related to tap water. As the tables suggest, 653,000 of the water-related complaints were simple enough to be handled by the Call Center themselves, and 34,000 or 5% were forwarded to 8 relevant branch offices under the Office of Waterworks.

I Table 4-1 I Complaints placed with Seoul # 120 Dasan Call Center (in 2013)

Total # of Calls	Water/Sewer	Transportation	General Administration	Etc.	District Issue
8,910,118	687,314	1,710,644	1,429,802	869,851	4,212,507
100%	7.70%	19.20%	16.00%	9.80%	47.30%

I Table 4-2 I How water supply complaint is handling through Seoul # 120 Dasan Call Center (in 2013)

Classification	Water/Sewer	Resolved by 120	Forwarded to other agencies/departments
# of case	687,314	652,859	34,455
Percentage	100%	95.00%	5.00%

The number of complaints handled by the Office of Waterworks HQ-run Customer Support System stood at 473,000 in 2013; this is about the same as the number handled by the 120 Dasan Call Center. These also largely constitute simple complaints that can be resolved by the call itself, but some are complicated issues.

I Table 4-3 I Types of complaints related to tap water use (in 2013)

Total # of cases	Complaints related to tap water use						
	Leak	Water interruption	Construction	Meter	Water Quality Check	Indoor pipe	Etc.
131,745	49,123	16,539	13,141	17,318	2,072	33,141	411

I Table 4-4 I Types of complaints related to tap water use (in 2013)

Total # of cases	Complaints related to water bills						Request for proof/ certificate, etc. (7,598 0.53%)
	Change of user name	Automatic payment request	Request for reduction of charges	Request to separate billings in multiple-family houses	Termi-nation of use	Etc.	
340,964	115,180	131,901	51,197	6,035	7,720	27,041	1,890

Complaint Filing Methods

From 2011 to 2013, 87% of complaints were lodged by phone call, 9%, by physical visits, and 2%, by fax; another 2% were referred by different agencies.

Water interruption impacts everyday life and work immediately and directly. For example, just a few minutes of water interruption means no cooking, toilet, heater, and laundry, which is why many people are prone to filing a complaint via phone call, visit, or fax, through which they can expect to get quick response as opposed to email or other written means, which relatively takes longer.

I Table 4-5 I Complaint Filing Methods by Type of Complaint

Classification	Total (100%)	Phone call (86.80%)	Visit (9.08%)	Fax (2.24%)	Mail (0.02%)	Etc. (1.86%)
Total	1,427,791(case)	1,239,304	129,650	31,941	289	26,607
2013	472,709(case)	420,581	14,910	25,815	146	11,257
2012	454,638(case)	384,772	59,873	2,941	64	6,988
2011	500,444(case)	433,951	54,867	3,185	79	8,362

The nature of complaints can be categorized into administrative (85%) and direct impact (15%). The administrative nature of complaints includes (temporary) water construction, change of name, and request for automatic payment (direct debit/automatic withdrawal), whereas the direct impact nature includes leak check, meter replacement, water quality check, and other issues that actually cause inconvenience to users. Seoul plans to reduce the latter by 50% by 2018 with our "Arisu Total Service."

I Table 4-6 I Nature of complaints (in 2013)

Administrative	Direct Impact
Water construction, change of name, request for automatic payment, termination of water service, etc. (in 2013: 401,409 cases - 85%)	Water leak at home, water interruption, malfunctioning meter, water quality check (in 2013: 71,300 cases - 15%)

Know-how & Insights

Diverse ideas from different stakeholders were gathered to reduce trial and error.

From the very beginning and at the planning stage, we listened to complaint handling staff and labor union, including getting opinions from Seoul's civil groups, housewives, and many others who would be using the "Arisu Total System." By doing so, we could prevent any and all conflicts among stakeholders and listen to users as to what issues bother them the most, etc.

We also held a workshop participated in by 130 high-level officials of our Office to find the best ways to solve complaints with little trial and error.

In addition, the "Arisu Total Service Action Plan Presentation" participated in by those on the front line and who handle complaints themselves was held to share best practices, compare services among 8 branch offices, and learn insights from experienced complaint handlers and their creative ways of dealing with complaints.

Presentation on Action Plans from Branch Offices

Training our staff to be service-oriented on the spot

Recognizing that the change of staff's mindset is the most important factor in enhancing customer service and better complaint handling, we had extensive training sessions for all our staff on how to deliver excellent customer service as well as the procedures for complaint handling.

The Waterworks Research Institute set up a curriculum focusing more on the theory, and the Guui purification station complemented this effort by establishing programs that focus more on practice on the field to train professional practitioners. In addition, highly experienced members of each branch office were chosen as instructors who would then hold training sessions for water-related complaint handling exercises. As such, much innovation and various efforts have been made to resolve complaints.

Utilizing the most experienced talents

For the "Arisu Total Service" to have the greatest impact, staff with 10 ~ 20 years' experience is required. Most of the time, however, these highly experienced staff have either retired or have gotten transferred to different departments. We have solved such issue of shortage of professional and qualified manpower by employing experienced ones on fixed-term contracts. This was tested by a pilot run in 2014 and will be expanded in the coming years.

Providing a forum for honest communication to resolve internal conflicts

To minimize any and all possible conflicts or disagreements about the "Arisu Total Service" among the stakeholders, we provided numerous opportunities wherein all staff involved and labor union members can frankly voice their opinions, both in the planning stage and after implementation. Such open communication and constant efforts to respond to staff's concerns with regard to the Service have been conducive in building trust among all the stakeholders.

Upgrading the Customer Information System to raise efficiency

• Caller's previous history

The system allows our staff to view the entire history of the caller from the same address so that, when a staff is dispatched, he/she can double-check if previous cases were handled properly. Such personalized, thorough care can win the hearts of our customers.

• Rapid response through smart phones

We have dramatically reduced the waiting time and handling time by equipping our staff with smart phones to which a complaint is transferred immediately once submitted.

• Precise statistical analysis system

When building a database from the call center, complaints submitted by citizens themselves are categorized differently from cases proactively handled by our staff. Such precise categorization in database has helped with the statistical analysis and feedback.

Policy Outcome & Evaluation

The number of complaints submitted from March 12 to May 30, 2014 dropped by 19.4% compared to the same period in the previous year. The number of complaints regarding the "Arisu Total Service" dropped by 35.6%, suggesting the remarkable success of the service even in such a short period of time.

Mystery Shopper

There are two ways to evaluate the "Arisu Total Service." First, officials at branch offices make "Happy Calls" to get feedback from citizens. Second, the mystery shopping tool is used, in which case a civil monitoring group composed of 5 representatives from 423 dong (districts) in Seoul and members of civic groups measure using a mystery shopping program. The mystery shopping method is effective in objectively evaluating many aspects of the service. Mystery shoppers also recommend the best staff for recognition.

Using feedback to improve service quality

When citizens evaluate the "Arisu Total Service," they are also asked to provide feedback such as areas of improvement. The valuable feedback, combined with our multi-modal analysis, has been used to improve any and all weaknesses.

Applicability of the Policy

In Korea, a similar level of distrust in tap water found in Seoul has been identified in almost all municipalities. The main reasons for such mistrust are the fact that the tap water service is mostly a government-led initiative, focus on water production and supply, spillage of phenol into Nakdong River, and green algal bloom, among others.

The answer lies in the shift of administrative focus from water production/supply to citizen-focused service delivery. Along with this shift, we expect our "Arisu Total Service," the first system to be implemented in any municipality, to solve the root causes of the water supply system and to be adopted gradually by other municipalities.

Developing countries that will inevitably go through problems similar to those of Korea can also benchmark our system.

Q & A

What are the main features of the "Arisu Total Service"?

The main feature is that the service is a citizen-centered, comprehensive, integrated complaint handling system. First of all, the system allows us to predict potential complaints so that we can proactively respond to them even before actual complaints are lodged. For example, if the meter reading of a household has dramatically surged outside its previous consumption pattern, then we first check if there were high water-consuming events such as addition of family member; in the absence of such, then we dispatch our agents to check leaks before the household in question lodges a complaint. Second, with the comprehensive, integrated service packages, our staff not only responds to the issue in question but also asks the caller to check if there are other issues that may cause inconvenience. When visiting the caller's home after taking note of the complaint, our staff (sometimes accompanied by a specialist) handles all issues at the same time.

On the visit, our staff once again checks for any and all additional issues they can help resolve; anything that has been identified is handled by our staff on the ground or directed to the government agencies concerned.

[Complaint Handling Process in Arisu Total Service]

A citizen lodges a complaint, or our staff proactively handles a potential complaint (# 120 Call Center, Branch Office)	→	Staff are dispatched (Check for other issues and provide additional service)	→	Make a Happy Call to get feedback	→	Increase the satisfaction and happiness of our citizens!

What does the additional service include?

Our service is not limited to simply resolving complaints regarding tap water; instead, we are committed to delivering services beyond our citizens' expectations. For instance, our services include hygiene check of chopping board and other kitchenware, endoscope inspection of pipes, and cleansing service for faucets and washstand. As such, our staff are devoted to providing services to our citizens in the most genuine, sincerest, and most effective way possible.

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Operation & Management 05

Overseas Support

Supporting developing nations with our advanced waterworks technology

The Korean government began promoting and supporting the water industry and its overseas expansion since 2010. In line with the government's initiative, the Office of Waterworks implemented support mechanisms designed to utilize its operational experiences and excellent technology in helping private companies tap into foreign markets. The Office of Waterworks has also been expanding its global network and exchange in response to the high demands from foreign cities to learn our know-how and experiences in the operation and technology of the water supply system.

Before the Policy Implementation	After the Policy Implementation
• Private companies had difficulties tapping into foreign markets due to the lack of operational experience. • When domestic waterworks infrastructure projects ended, there was no growth engine for our companies. • Despite our high technology, Korea only took up 2.1% of the global water market.	• Private companies receive support to make inroads into foreign markets. • Foreign expansion has led to job creation and financial expansion. • Seoul is sharing its know-how and best policies with other countries and strengthening its competitive edge.

Overview of the Policy

- Cooperating with the private sector to participate in the foreign water supply tender
- Using Seoul's own EDCF (Economic Development Cooperation Fund) in improving the water supply system in developing countries
- Participating in the feasibility study of foreign waterworks projects with funding from the relevant agencies
- Establishing cooperative networks for overseas expansion in waterworks

Winning the contract for the infrastructure development consulting project for PMB Island, Brunei

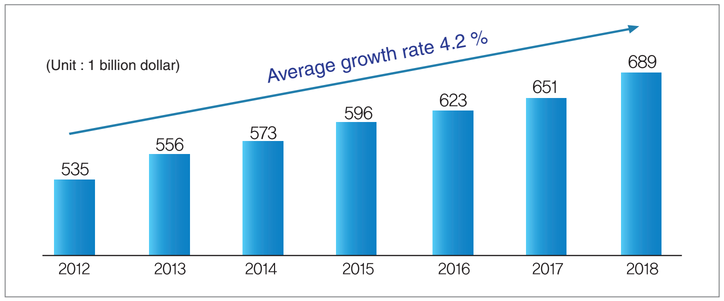
Completion of the 1st-stage waterworks improvement project in Chanchamayo Province, Peru

: Background

The global water market is emerging as a blue-gold industry, growing at 6.5% annually

Dubbed as a "blue-gold" industry, the water industry is an essential part of the lives of all human beings. Since the 21st century, the global water industry has been growing at 6.5% annually, and its market size is expected to reach a whopping 689 billion dollars by 2018. As a result, there is fierce global competition in the industry.

I Graph I Global Water Industry Forecast



Traditionally, the water industry was largely considered public good or SOC. Today, however, water has become a commodity, and the industry looks promising in the 21st century. Despite the paradigm shift, Korea's water industry only takes up 2.1% of the global water market; even companies with advanced technology are having difficulties expanding to overseas markets due to hostile conditions such as barriers and lack of support.

Against this backdrop, public-private partnership can be the answer to tackling the situation wherein the industry is currently controlled by very few global companies.

The Korean government is adopting strategies to promote the water industry in keeping with the rapid changes in the market

Having already recognized the water industry as their growth engine, many advanced countries have strengthened their support mechanisms and formulated promotion strategies. At the same time, private companies specializing in the water market have expanded their business in operation and management as a way of enhancing operational efficiency and securing investment funds.

In Korea, too, the Ministry of Environment has come up with a plan to make the country a water industry powerhouse. More specifically, the plan targets the following: domestic water industry valued at 2.6 billion won; 38,000 new jobs; 10 Korean water-related companies competing on the global stage, and; 8-billion-dollar export in the water market (taking up 1% of the global market share).

[Ministry of Environment's Water Industry Promotion Strategy]

Core Strategies	Major Policies
Strengthening competitiveness by developing source technology	• Developing source technology in the water market • Promoting the commercialization of new technology: Give companies an opportunity to test the technology.
Nurturing water specialist companies	• Integrate regional water supply & sewage. • Nurture water specialist companies through private engagement.
Promoting industries related to water (bottled water, water recycling, etc.)	• Implement the water recycling project and pass the relevant act. • Promote bottled water domestically as well as an export item.
Supporting foreign expansion	• Formulate policy tailored for each region. • Form public-private partnership as well as the basis of foreign expansion.

More foreign countries and cities are reaching out to Seoul to learn our water policies and experiences in operation and management and to receive support

As the country's largest water utility provider that takes up 20% of the domestic water market, the Seoul Metropolitan Government has been on the move to expand to the overseas water market through partnership with the private sector since 2012.

Many developing countries or their cities have shown interest in learning Seoul's water policies and technology and asked for support in this industry. To meet this growing demand, we have used various channels to share our best practices and policies as well as the city's EDCF (Economic Development Cooperation Fund) to help them upgrade their outdated water supply system.

Foreign expansion has created jobs and served as a growth engine

Most of the water infrastructure projects are completed in Korea, which means not much room for our companies to grow within the country. Given such lack of demand in Korea, foreign expansion provides the answer to job creation and generation of profits for otherwise struggling companies. When Korean companies participate in a tender for water projects, most of the time, they are required to partner with public entities such as the Seoul Metropolitan Government, which has several years' operational experience in the water supply system.

Process of Policy Implementation

Since 2012, we have made various efforts to prepare for foreign expansion in the global water market. First of all, we laid a solid foundation for public-private cooperation. For example, we signed MOUs with the relevant organizations and held the Arisu Globalization forum and briefing sessions. Second, we worked to lay a solid foundation for overseas support projects such as training sessions for foreign officials in the water sector and consulting service by dispatching our specialist staff. At the same time, we also formed a consortium with private companies to enter a tender for foreign water projects and used Seoul's EDCF to help developing countries upgrade their water supply system.

In July 2012, the Seoul Metropolitan Government, in a form of consortium with private companies, became the first local government in Korea to win a waterworks project from the Brunei government. Seoul plans to participate in similar projects in partnership with the private sector for Indonesia's Bandar Lampung.

Since 2013, Seoul has been using its EDCF to help improve the waterworks of Chanchamayo City in Peru. This is the first case in which a municipality used its own waterworks technology and Korean-made materials in waterworks improvement projects in developing countries.

Seoul formed a consortium with private companies in 2014, and it has been conducting feasibility studies for the purification facilities improvement project in Port Moresby, Papua New Guinea and 8 purification centers in Central Java, Indonesia.

Details of the Policy

In 2012, a consortium made up of the Seoul Metropolitan Government and the private sector won the tender for "Brunei PMB Island Infrastructure Development Consulting Project," for which Seoul will provide consulting services without committing financial investment.

Seoul is currently moving forward with the water facilities improvement project in Chanchamayo City, Peru using the city's EDCF.

In addition, the city government is currently conducting feasibility studies for foreign waterworks projects in private-public consortium form.

Cooperating with the private sector to participate in foreign water supply tenders

- Brunei PMB Island infrastructure development consulting project

In July 2012, Seoul signed an agreement with the Brunei government to perform auditing and operational works of the consulting service, and it has been working on this project since then.

I Table 5-1 I Overview of the Brunei PMB Island infrastructure development consulting project

Name of the project	Brunei PMB Island infrastructure development consulting project
Overview	• Overview – Scope: Construction of bridges, roads, waterworks, communications, and electricity on PMB Island 2.8 km bridge and 5.0km road connecting to the bridge, 400m³/day of drinking water, 2,000m³/day of industrial water (for oil refining, gas, petrochemical) – Order placed by: Department of Economics and Development, Brunei – Order amount: 13.5 billion won (500 million won for Seoul in accordance with its 3.6% share) – Duration of project: 6 years – Form of participation: Consortium with the private sector
Partners	• Domestic companies: Pyung-Hwa ENG (PM), Korea Expressway Corporation (O&M), Sam-An Ltd. (water and sewage) • Local companies: OMC (design of construction, machinery, electricity)
Roles of the Seoul Metropolitan Government	• Main R&R: Supervision and operation work from the construction period with Sam-An Ltd. – Full-time (resident) staff to be dispatched for 2 years to cover supervision with the designer of the construction - 1 supervising manager and 1 staff to be dispatched for 4 months as part-time workers

Project involving the production, installation of water meter and construction of remote control network for Trinidad and Tobago

Production, installation of water meter and construction of remote control network project for Trinidad and Tobago

I Table 5-2 I Overview of the project involving the production, installation of water meter and construction of remote control network for Trinidad and Tobago

Name of the project	Production, installation of water meter and construction of remote control network for Trinidad and Tobago
Overview	• Overview – Scope: Production, installation of water meter and construction of remote control network for Trinidad and Tobago Production, installation, and test run of 15,000 units of water meters – Order placed by: Government-run water and sewage corporation in Trinidad and Tobago – Order amount: 9 billion won estimated (no financial investment from the Seoul Metropolitan Government) – Duration of project: about 11 months – Form of participation: Consortium with private sector
Partners	• Domestic companies: HITEC
Roles of the Seoul Metropolitan Government	• Main R&R: Supervision and management of construction (the Seoul Metropolitan Government has no stake) – Personnel dispatch: under discussion

Using Seoul's own EDCF (Economic Development Cooperation Fund) in improving the water supply system in developing countries

This project first began in May 2012 when the Mayor of Chanchamayo, Heung-won JUNG, the first ethnic Korean to be elected as mayor in Peru, visited the mayor of Seoul. The two discussed Seoul's support for the Peruvian city's water facility improvement project. Seoul put the words into action by sending technicians to Peru in July 2012 to do preliminary research. The support project kicked off in May last year, and Korean technology and materials are being transported to Peru for their waterworks construction.

Upgrading the water pipe network

Repairing water intake facilities

| Table 5-3 | Waterworks Improvement Project for Chanchamayo, Peru

Name of the project	Waterworks Improvement Project for Chanchamayo, Peru (ODA)
Overview	• Overview – Scope: Waterworks Improvement Project for Chanchamayo, Peru (ODA) 1st Stage (2013~2015): Water facility improvement in the San Ramon region • Repair water intake facilities in San Ramon (3,530m^3day), Repair water pipe networks (HDPE 3,091m) • Construct the San Ramon purification center (3,000m^3day) 2nd Stage (2015-2017): Water facility improvement in La Merced 3rd Stage (2018):Water facility improvement in Pichanaki – Amount : Approx. 2.7 billion won
Partners	• Main R&R : Overall project management – Select a PMC (Project Management Consultant)

Type of Work	1st Stage			2nd & 3rd Stages (2015~2018)
	Total	2013	2014	
Total	648	318	330	Approx. 2,052
1. Water intake facility	11	11		
2. Water pipe network	140	140		
3. Purification facility	330	-	330	
4. Transmission pipe	-	-	-	
5. Reservoir	-	-	-	
6. Distribution pipe	-	-	-	
7. Design	9	9	-	
8. Supervision	102	102	-	
9. Etc.	56	56	-	

Participating in feasibility studies for foreign waterworks projects with funding from the relevant agencies

- Feasibility studies for the purification center improvement project and RWR (revenue water ratio) improvement project in Central Java, Indonesia
  – Scope/Expenses: upgrading 8 purification centers and water pipe network/120 billion won
  – Order placed by: Central Java Government in Indonesia
  – Amount: 76 million won (funding from the Foreign Construction Association: 68 million, private companies: 8 million)
  – Duration of study: May ~ Dec. 2014 (8 months)
  – Executing organizations: Consortium (Roswell Watertech Glocal and other private companies, Seoul Metropolitan Government)
  – Role of the Seoul Metropolitan Government: Increasing RWR, technical consultation on the efficient operation and facility improvement of purification centers

- Feasibility study for the water facility improvement project in Port Moresby, Papua New Guinea
  – Scope/Expenses: upgrading/expanding & operating/managing the Eriama purification center (Q=184,000rf/day),16 billion won
  – Amount: 140 million won (funding from the Environment & Industry Technology Institute: 70 million, private companies: 70)
  – Duration of study: June 2014 ~ March 2015 (10 months)
  – Executing organization: Consortium with private companies (Dohwa Engineering, Daewoo Construction)
  – Role of the Seoul Metropolitan Government: Reviewing and analyzing the site inspection result for upgrading/expanding & operating/managing purification facilities

Signing MOUs with foreign cities and inviting foreign officials in waterworks for training opportunities

We signed MOUs with 6 different water-related institutions around the world, including one with the Water Authority of Bangkok, Thailand in 2012.

The MOUs help form cooperative networks that will serve as the basis for our future attempts to tap into foreign markets. We also signed MOUs with domestic institutions such as Korea Environment Corporation as part of our future attempts to expand to foreign water markets together.

Meanwhile, we invited water-related officials from Latin America, including the Mayor of Chanchamayo, Peru, in 2012 to Seoul where they can learn about our technology and policies as well as take a look around our water facilities.

In 2013, we also invited 30 policymakers in the water sector from 18 cities (12 countries) for 2 different training sessions, through which we established close networks.

Training for policymakers in the water sector from southeastern countries

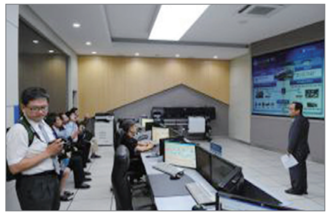
Details of the Policy

Setting up a task force for the foreign expansion of water projects

In 2012, we formed a task force for Arisu's foreign expansion and formulated a master plan that includes manuals for selecting target cities and support works. The following year, we set up a department dedicated for this purpose, which devoted all resources to making a database of professional manpower and reviewing the relevant acts and regulations, among others.

Sharing Seoul's best policies and technology with foreign water-related officials

Countries around the world are looking into and asking Seoul to share its own experience and know-how in tap water production and management. In fact, more than 300 foreign guests from 30 countries including Azerbaijan have visited the Office of Waterworks to learn and benchmark our excellent examples such as "Advanced Purification Facility" and "Arisu Integrated Information Center."



Visiting the Arisu Integrated Information Center (by the Water Authority in Taipei, Taiwan)

Visiting the Office of Waterworks HQ (by Water and Sewage Corporation in Papua New Guinea)

Forming a network for public-private partnership

Since 2013, we have led various meetings and discussions to share our thoughts regarding the trends in the water industry at home and abroad, water supply situation in Seoul, and technology with the private sector to encourage them to participate in public-private partnership. On top of this, we launched the "Arisu Globalization Forum" in November 2012 as the advisory body in the water business. Consisting of 25 members from the academe, government, private sector, and other agencies, the forum has provided valuable research and advisory input for our common objective.

Presentation for the Private Sector

Arisu Globalization Forum

Policy Outcome & Future Challenges

We have been supporting private companies in the water sector and which are interested in tapping into foreign markets by offering them our own experience and technology in operation. We ourselves are also making efforts to make inroads into overseas markets to strengthen our competitive edge at the same time.

In addition, we have been offering our own funds (EDCF) to help developing countries upgrade their obsolete water facilities; thus contributing to making the world a better place to live for all.

Thanks to such efforts, the Seoul Metropolitan Government became the first city in Korea to win a contract for the "Brunei PMB Island Infrastructure development consulting project," which is an opportunity for Seoul not only to support the private sector but also to export to other countries its own operational know-how and prowess in waterworks. Furthermore, with Seoul’s EDCF, we are implementing an ODA project in Chanchamayo, Peru with their water facility improvement project. By lending a helping hand to places suffering from water shortage, Seoul is enhancing its overall image on the global stage and helping citizens all over the world live in a cleaner place with enough tap water to go around.

Despite the considerable progress, however, there are still many challenges that need to be overcome.

First, there is a general lack of law and regulation or system needed to implement foreign projects, which has delayed the authorization process for personnel dispatch or business trip. The lack of such system and inflexible response have delayed or hindered some projects from moving forward.

Second, financing and participation to projects are limited. For the development project in general, financial investment is required from the feasibility study stage; under our current system, however, any development project without specific plans cannot get its budget appropriated, thereby making it difficult to participate in the project. Even if we form a consortium with private companies to win a tender, our role is limited to operation due to lack of financing.

Third are the lack of information and vulnerability in risk management. Since we cannot open an overseas office or dispatch expats, our understanding of the business practices and water environment in the target country is extremely limited. Such lack of professional manpower and information on the local situation also makes us vulnerable to risks.

Under the current legal system, local government officials are not allowed to be dispatched to private for-profit corporation in a foreign country. To deliver the Brunei PMB Island project that we won earlier, however, we are required to dispatch our officials in 2015 for 2 years to a for-profit corporation established in Brunei. To address this issue, we are currently working with the Ministry of Safety and Administration to amend the relevant law but have yet to reach an agreement.

Applicability of the Policy

Under the current legal system of Korea, only municipalities and K-Water are authorized to operate and manage water supply. Due to such limitation, private water companies in Korea had considerable difficulties winning contracts in foreign countries that are looking for operational experience. To compensate for their lack of eligibility, we have cooperated on several occasions with the private sector to help them tap into foreign water markets. Other municipalities in Korea can also do the same by providing their operational experiences to private companies that are otherwise qualified to win tenders placed by foreign countries.

In Japan where foreign expansion was pursued earlier than Korea, many cities including Tokyo, Nagoya, Yokohama, and Kitakyushyu had already begun ODA projects. After having built trust in the recipient countries, they have since turned their businesses into profit-making ones and have earned sizable profits. To facilitate foreign expansion, some big municipalities in Japan have established subsidiaries under the Waterworks Bureau, formed a cooperative mechanism with the private sector, and signed MOUs with investment fund companies for financing.

Q & A

How could Seoul's Waterworks Office help other countries with its experience and technology in water supply?

The Office of Waterworks has invited various officials from different countries to participate in training opportunities on Seoul's policies and advanced technology as well as form a friendly network with us.

We have also signed MOUs with developing nations whose water facilities are obsolete and have dispatched our professionals to teach them specialized technology on site selection, design and construction of purification facilities, and purification process and management, among many others.

In addition, we are opening our doors to officials from various countries who visit our office to learn and benchmark Seoul's system, including our advanced purification system, purification facilities, direct water supply system, integrated information center, remote metering, etc.

Furthermore, we are actively forming consortia with private companies to win water project tenders as well as providing support to developing nations with obsolete water facilities.

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Operation & Management 06

Developing New Water Supply-related Technologies

Leading the advancement of water supply technologies through research and development

With the aim of producing world-class, healthy, and tasty Arisu, Seoul's Waterworks Research Institute strives to develop innovative new technologies for delivering clean tap water from purification centers to homes through a safe supply and distribution system. The Institute focuses on developing sustainable technologies that will help it prepare for the changing domestic and international environment including climate change and water scarcity and create new value and opportunities. Such strong commitment has enabled the institute to acquire 2 international patents and 11 domestic patents, making it a leading organization in the development of Korea's water supply-related technology. Equipped with approximately 40 distinguished researchers who are MA or PhD holders and 678 state-of-the-art analysis devices, the institute examines the raw and purified water of Seoul as well as that of other municipalities, playing the role of an internationally accredited examination body under the Korea Laboratory Accreditation Scheme (KOLAS).

Overview of the Policy

Introducing major new technologies studied and developed by the Seoul Waterworks Research Institute

- Development of a new water supply network analysis and simulation technology
- Study of measures to reduce water distribution/supply pipe corrosion and improve tap water quality
- Research and development of an integrated telemetry system
- Development of a new method to examine the damage in membrane modules that can be used in various fields

Background

Our ultimate goal is to ensure rigorous quality management in all steps, from raw water to every household faucet, and to realize stable water supply that meets the demands of Seoul residents for clean, tasty water.

Many domestic and global changes -- political, social, and economic -- surrounding water supply have suggested the importance of developing key technologies to achieve such goal. Thus, Seoul is making aggressive efforts to develop new technologies that can lead the future water supply system covering the water source all the way to household faucets and help deliver clean tap water.

Among such technologies, the most critical ones for restoring consumer confidence in tap water and providing high-quality service to the citizens include: membrane filtering system for the complete removal of particles generated from diverse industrial developments; optimal management of water pipes; supply system quality management; prevention of pipe corrosion to block any and all potential complaints about rusty water, and; integrated remote metering system, which is an ideal model of IT conversion for the improvement of metering efficiency.

Process of Policy Implementation

- 1980 ~ '90s : With the establishment of the institute in 1989, efforts to lay the foundation for water quality management and technological development began in earnest. Stable management of water quality and supply was the highest priority, leading to the hiring of the relevant personnel and initiation of research.
- 2000 ~ : Water quality management was the primary focus until 2000. As a result, our analysis technique and capability grew to become the best in Korea. We were able to bring in state-of-the-art analysis equipment thanks to aggressive investments and focus on technological development to improve the quality of Arisu further.
- 2007 ~ : Our analysis technique has advanced greatly, and it has been recognized to be world-class by various analysis institutions of advanced countries. We began to see some fruits of joint technological developments as well. Furthermore, the development efforts were extended to the sewage system as the need for R&D in the area increased.
- 2012 ~ : The need to develop leading technologies was highlighted to ensure continued growth of the institute and to secure a future growth engine. To that end, we created an exclusive body for future strategies in charge of early collection of global technological trends and information and suggestion of future direction.
- 2014 ~ : We set an ambitious goal of becoming a world-class comprehensive water studies center with new transformation initiatives. Various meaningful changes are underway such as hiring of new researchers and organizational restructuring for more effective technological development.

※ Waterworks Research Institute's Achievements

Nov. 1989	Appointed as a potable water quality examination body
Apr. 2003	Appointed as the national institution for virus examination
Sept. 2004	Accredited as the national institution for protozoa examination
Jan. 2005	Appointed as the internationally accredited examination body under KOLAS
May 2006	Appointed as an agent for environmental monitoring device accuracy inspection
Jun. 2009	Appointed as the national institution for Norovirus examination
	Appointed as the national institution for membrane module capability certification test

: Introduction of Studies on Major New Technologies

1. Water Supply Network Analysis & Water Quality Simulation

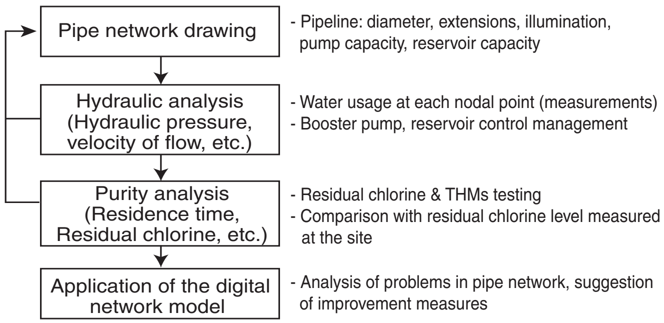
| Background |

Growing need for...

- Better maintenance and management of water distribution and supply system
- Enhanced crisis response ability in accordance with the changes in the city environment
- Application of computer technology to water distribution and supply network management
- Water quality management technology to meet the citizens' demand

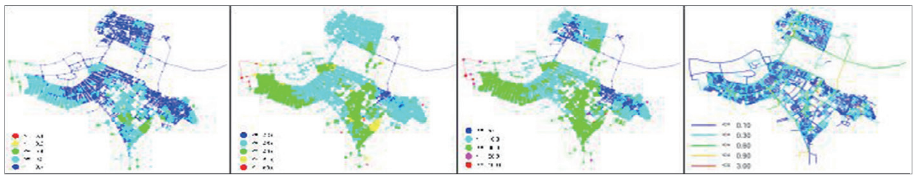
| Research Overview |

- Distribution and supply network model created



- Purity fluctuation modeling

  Computer simulation and analysis of residual chlorine, disinfection byproducts, residence time, and flow velocity



Residual chlorine | Disinfection byproducts | Residence time (time of concentration) | Flow velocity

| Applied Technologies and Their Impact |

- Set the seasonal standard residual chlorine level at each purification plant.

  The standard residual chlorine level in transmitted water can be set in a systematic manner using the pipe network model. This method can help lower the chlorine level at purification plants, thereby getting rid of unpleasant taste or smell in water supply as well as cutting the cost of purchasing chlorine.
- Conduct hydraulic analysis, water purity assessment, and evaluation by small block.

  Examination criteria are categorized into two: water purity concerning safety and hydraulic pressure concerning stability. The evaluated items under water purity include residual chlorine and THMs, which are disinfection byproducts. Items under hydraulic pressure include minimum hydrodynamic pressure, average pressure by block, and pressure fluctuations. Such items help us identify problems in each category and resolve them.
- Prepare contingency plans.

  In case accidents occur in the water supply system and cause damage in large pipes or inflow of contaminants, pipe network analysis can be used to forecast the impact of damage in transmission pipelines and power interruption at pressurizing stations, expected recovery time, and impact of contaminant inflow to be applied in disaster or accident response plans.
- Enhance pipe network maintenance and management capabilities.

  The digital pipe network model can be used for hydraulic pressure and residual chlorine management and to contribute to the improvement of the overall water supply management capability.

Researcher in charge: Jaechan AN, Distribution & Supply Studies Division, Waterworks Studies Department, Waterworks Research Institute, 02-3146-1823, anjchan@seoul.go.kr

2. Measures to Reduce Pipe Corrosion and Improve Tap Water Purity

| Background |

- To curb the corrosion of water pipes, the United States and European countries have water purity specialists manage the pH level at purification centers or use corrosion inhibitors. In particular, the US has been using phosphate-based corrosion inhibitors at purification plants since the 1930s; with the enactment of the <Lead and Copper Rules> in 1991, the number of purification facilities using corrosion inhibitors increased significantly.
- Korea does not yet have anti-corrosion measures put in place at the purification center level to prevent rusty water. For the more effective prevention of rusty water, Korea should also make water suppliers manage anti-corrosion methods as is the case in the US, Europe, and Japan. It also needs to develop new technologies for monitoring and reducing tap water pipe corrosion at the purification plants.

| Research Overview |

- Langelier Saturation Index (LI) assessment of the Han River system
  US and Germany maintain their LI level at 0, whereas Japan keeps its LI level at -1.0 to 0. The Korean government does monitor LI but is still studying what the ideal range of LI should be. Purified water has greater potential to cause corrosion due to the chlorine and coagulants injected into the purification process, which cause the pH level to drop. If an alkaline chemical is added toward the end of the purification process, corrosivity of water drops since the chemical neutralizes the water.
- Suggestion of LI monitoring
  We suggested that the Ministry of Environment include tap water LI in the list of water quality assessment categories to manage better ductile cast iron pipes with cement lining, prevent old water pipes at homes from causing rusty water, and reinforce the safety of corrosion inhibitors currently managed in small units such as apartment complexes.
- Development of corrosivity index and corrosion prevention technology
  To prepare for the introduction of LI management standards, Seoul installed the first ever pilot plant for corrosivity management in 2007. The city obtained three new patents for techniques such as the "Method of Corrosion Inhibition of Water Pipe (18 January 2008)," "Method for Corrosion Prevention of Water Distribution Systems by Lime Slurry (14 November 2008)," and "Method for Supplying Water with Controlled Corrosive Characteristics (25 August 2010)." Such techniques are the first case in the world to use carbon dioxide to dissolve limewater in tap water completely. They can be differentiated from the techniques used in the US or Japan since they ease the burden of workers at plants using hydrated lime powder; they can also turn 99.9% hydrated lime into calcium.



Anti-corrosion process	(CO2+hydrated lime)	(CO2+ hydrated lime+ phosphate)	(Phosphate)
Iron (mg/L)	0.13	0.07	0.59
Reduction of rusty water (%)	97.6	98.7	89.1

- Total cost of the project: 400 million KRW (cost of constructing the corrosion management plant)

| Implementation Experience and Know-how |

- At the initial stage of the project, lime water did not dissolve at all when 0.13% was supposed to theoretically. Nonetheless, innovative technological development led to the increase of Ca solubility level to up to 40ppm.
- We suggested that the Ministry of Environment add new LI monitoring categories (1 September 2005). Such suggestion laid the foundation for potential corrosivity management in the future, since it led to the enactment of the relevant act on 22 December 2011 and its enforcement on 1 July 2012.

| Research Outcome |

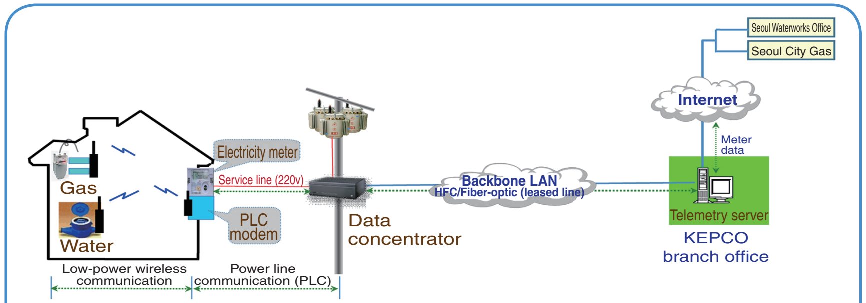
- After assessing the LI of all pipes in the Han River system, we have asked the Ministry of Environment to add LI in its purity assessment criteria to extend the life span of water pipes and prevent the sending of rusty water to faucets at home. Consequently, LI was added to the ministry's monitoring list on 1 July 2012. The ministry and the institute are working on a joint research project to develop a new index corrosivity management that suits the Korean water conditions better.

Researcher in charge: Yeongbok PARK, Water Distribution and Supply Studies Division, Waterworks Studies Department, Waterworks Research Institute, 02-3146-1824, ybpark0510@seoul.go.kr

3. Integrated Telemetry System

| Research Overview |

- Integrated telemetry is a process of sending and receiving the usage data for water, electricity, gas, and other utility bills altogether at remote points. This project used power line communication to combine telemetry systems for water, electricity, and gas at the lowest cost. Using power lines to communicate requires data to be sent from water meters to digital electricity meters. Thus, the data was sent through low-power wireless communication. The integrated telemetry system structure is illustrated below.



※ Low-power wireless communication: a type of wireless communication that does not require prior approval of a local radio station
※ HFC: Hybrid fiber-coaxial

At least 100 houses in Yangcheon-gu, Mok-dong had new meters installed. The new system was connected to 86 15mm faucets and 16 20mm faucets. We monitored the measurements from each faucet, identified the reasons for any and all abnormalities through on-site surveys, provided solutions to the problems, and analyzed the outcome of the pilot operation. To guarantee the compatibility of the integrated telemetry system, we teamed up with the Korea Electric Power Research Institute (KEPRI) to study and design the digital water meter protocol and wireless communication protocol. The protocols developed through the joint study were applied to the integrated telemetry simulator for 43 days to check whether data moves from digital water meters to the main server without any issue.

| Research Outcome |

- During the pilot period, the monthly average success rate of communication varied between 85.4% at the lowest and 95.9% at the highest. The average success rate was 91.9% throughout the period. Between January and June 2009, the average success rate of participating companies was 99.3% at the highest and 86.3% at the lowest. The rate of successful connection in water supply telemetry rose to a reliable level thanks to the development of a new telemetry device technology.
- After the pilot operation, we found that the direst challenge was ensuring the interoperability of digital water meters, mobile metering devices, and digital electricity meters. Thus, we designed a protocol for digital water meters and one for wireless communication jointly with KEPRI. We tested the feasibility of the protocols by applying them to the water telemetry simulator in our lab. After 43 days of pilot operation, we confirmed that the initial registration data were sent from metering devices to the server without any problem. We also found no issue in data linkage between the two protocols as well as in the measured data and connectivity.
- An integrated telemetry system using power line communication is unprecedented. This project confirmed that the integrated metering system has technical strength

compared to the independent water supply metering system. Certain sections of the network use cable communication since the underground water meters do not provide a favorable environment for wireless communication. This reduces the range of wireless communication and renders repeaters for improving wireless connectivity unnecessary; hence the less installation and maintenance efforts.

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4. Membrane Module Damage Assessment Technology for Broad-range Application

| Background |

In current water treatment centers, raw water passes through a flocculation tank and a sedimentation basin. Sand filters are commonly used to remove contaminant particles in the water during the process. Note, however, that sand filters cannot remove organic particles, viruses, protozoan cysts, or other particles smaller than 1um since they are meant for the removal of those larger than 10um. For such reasons, membrane integrity tests are conducted to check if the membrane can remove pathogenic microorganisms or whether it has any damage. A damaged membrane cannot remove particles effectively but adversely affects the purity of water. Therefore, the damage should be detected in the early stage for repair or replacement in serious cases. Note, however, that damages are invisible to the naked eye, making it extremely difficult for them to be detected earlier.

To resolve such issue, we have developed a new integrity testing method of reducing the surface tension of liquid solution, which allows more accurate testing results at lower pressure.

In this method, citric acid for cleaning the membranes is used to adjust the surface tension. It increases the resolution of the direct integrity test and enables detecting small-size rupture or damage using lower pressure. Pressure-drop testing is a convenient method that can be easily applied to actual purification plants.

| Research Outcome |

- In a direct integrity test for validating high removal credits of a membrane module, a method using the reduced surface tension of liquid can be applied in the following steps:

  – Create a solution by mixing water and a chemical reducing the surface tension of water.
  – Inject into the filtration membrane module the solution for lowering surface tension.
  – Close the raw water supply valve and filtered water supply valve of the membrane module while keeping the air pressure supply and discharge valves open.
  – Close the air pressure supply valve: Measure changes in air pressure after a certain duration of time.
  – Compare the measured air pressure with a preset standard value to detect possible damage in the membrane. The pressure-drop method enhances the resolution of the membrane integrity test.

| Application and Impact |

This method can be applied to integrity tests in any field utilizing a membrane module. It lets the users conduct a direct integrity test of the membrane filter during its chemical cleaning or maintenance cleaning process; thus, it can be adopted at any site that uses membrane filters.

| Impact of the applied technology |

Pressure-drop testing is a practical method with enhanced resolution, which enables conducting direct integrity test and chemical cleaning of membrane filters at the same time. Using the method, damage on the membrane surface can be easily identified and fixed during its chemical cleaning process so that the damage does not lead to the degradation of water purity.

Researcher in charge: Kwangje LEE, Water Treatment Studies Division, Waterworks Research Institute, 02-3146-1821, lkjnara@seoul.go.kr

Policy Outcome & Evaluation

- The pipe network model developed by the Waterworks Research Institute can help set the standard residual chlorine level in transmitted water more systematically, thereby removing any unpleasant taste or smell in the water distribution and supply network and cutting down the cost of purchasing chlorine. It also contributes to more rapid and precise management/maintenance of the pipe network.
- Pipe network analysis enables building rapid response measures against unexpected accidents or disasters that cause the destruction of large pipes or inflow of contaminants.
- We are the first in the world to have developed a technology to make limewater soluble. The new technology eases the burden of field workers using hydrated lime powder, and it can also transform 99.9% hydrated lime into calcium. Moreover, we have laid the legal foundation for the management of Langelier Saturation Index at purification plants.
- An integrated telemetry system using power line communication has never been attempted before. We have confirmed that the integrated telemetry system has technical strength compared to the independent water metering system. Thanks to the development of the integrated telemetry protocol, we can check water usage anytime, anywhere, which would ultimately enhance the quality of public service.
- Direct integrity test can be conducted to detect damage of membrane modules in any field that uses filtration membranes. As the benefit of the new testing method, it allows the direct integrity test and chemical cleaning or maintenance cleaning of the membranes to take place simultaneously; thus reducing the maintenance cost and enhancing membrane module efficiency.

Patented New Technologies

- Patent : 16 items (13 obtained, 3 in progress)

No.	Division	Type	Certification No.	Registration Date	Owner-ship	Title of the Invention	Remarks
1	Water Treatment	Patent	10- 0720140	2007.05.14	Joint	Operation Selection Device using the Water Code of Membrane Filtration Device and Method Thereof	
2	Water Treatment	Patent	10- 0720139	2007.05.14	Joint	Operation Control System using the Water Analysis of Membrane Filtration Device and Method Thereof	
3	Water Treatment	Patent	10- 0791896	2007.12.28	Joint	Membrane Filtering Water Treatment Apparatus Having Pretreatment Selectively Controlled by the Quality of Raw Water and Method Using the Same	
4	Water Distribution & Supply	Patent	10- 0797847	2008.01.18	Seoul	Method of Corrosion Inhibition of Water Pipe	
5	Water Treatment	Patent	10- 0843656	2008.06.27	Joint	Advanced Water Treatment Equipment using Two-layer SMF	
6	Water Distribution & Supply	Patent	10- 0853382	2008.08.18	Joint	Method for the Corrosion Prevention of Water Distribution Systems by Lime Slurry	Not trans-ferred
7	Advanced Water Treatment	Patent	10- 0890246	2009.03.17	Seoul	Upflow Ozone Contractor for Suppressing Residual Ozone	
8	Water Distribution & Supply	Patent	10- 0979250	2010.08.25	Seoul	Method for Supplying Water with Controlled Corrosive Characteristics	
9	Water Treatment	Patent	10- 1164600	2012.07.04	Seoul	Membrane Integrity Test through the Lowering of Surface Tension	
10	Water Treatment	Patent	10- 1179008	2012.08.27	Seoul	Baffle for Preventing the Congestion of Water at Purification Plants or Reservoirs	
11	Water Distribution & Supply	Patent	10- 1309980	2013.09.11	Joint	Post-welding Treatments to improve the corrosion resistance level of Duplex Stainless Steel for Water Supply Facilities	
12	Advanced Water Treatment	Chinese Patent	ZL200980122 574.3	2013.09.11	Seoul	Upflow Ozone Contractor for Suppressing Residual Ozone	
13	Advanced Water Treatment	Japanese Patent	Patent No. 5356512	2013.09.06	Seoul	Upflow Ozone Contractor for Suppressing Residual Ozone	
14	Advanced Water Treatment	US patent	Application submitted (US)	2009.05.28	Seoul	Upflow Ozone Contractor for Suppressing Residual Ozone	Application submitted
15	Wastewater Treatment	Patent	Application submitted	2013.10.22. (10-2013-0125686)	Seoul	Reject Water Recovery and Total Phosphorous Control Device	Application submitted
16	Wastewater Planning	Patent	Application submitted	2013.10.17 (10-2013-0124104)	Seoul	Water discharge delaying device	Application submitted

• New Excellent Technology (NET) certification: 3 items (completed)

No.	Division	Type	Certification No.	Registration Date	Ownership	Name of the Technology
1	Water Treatment	NET	NET certification NO.198	2007. 03.19	Seoul Metropolitan Government, Daewoo E&C	Pressurized MF with Auto-controlled Pretreatment and Purification Technique using SMF for the Recovery of Discharge Water
2	Water Treatment	NET	NET certification NO. 235	2007. 11.23	Seoul Metropolitan Government, Taeyoung Corp., Greenex, Korea Institute of Civil Engineering and Building Technology (KICT)	Membrane Separation-Type Advanced Water Treatment System using Auto-coagulant Control and Selection of Pretreatment by Code of Raw Water Quality
3	Water Treatment	NET	NET certification NO. 270	2008. 12.24	Seoul Metropolitan Government, Hanwha E&C, Taeyoung E&C, KICT	Advanced Drinking Water Treatment Technology using the Korean Submerged MF with an Intermittent Air Scouring Filtration System

: Q & A

How has the Waterworks Research Institute supported other local water supply quality examinations?

• The Waterworks Research Institute has shared water quality analysis methods with local water suppliers including membrane module test, protozoan, advanced water treatment, sample analysis, potable water quality standards, virus (purified water) and water treatment solution testing, etc.

• In 2013, 117 organizations including Wonju, Gangwon-do received support from the institute, generating 79.414 million KRW in profit. As of June 2014, 68 organizations including Hanam and Gyeonggi Province received the institute's support, with 43.495 million KRW worth of profit generated.

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History of Best Policies for
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