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A plan for the adjustment of water distribution in the Korean waterworks system

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ABSTRACT

The primary objective of this plan is to consolidate the current water supply system of Korea organized in the unit of city and county into wide area in order to supply the deficient region by fully utilizing the superfluous water volume of neighboring city and county. Furthermore, it also aims to prepare for the penetration of large foreign water supplier into domestic market by securing competitiveness through consolidation of domestic medium and small water suppliers in consideration of the forthcoming market opening. We determined the regions for which supplying system needs to be adjusted by analyze regions with deficient and superfluous water through the forecast of water supply and demand for established life areas. Further, we established a plan to utilize the superfluous water volume as an adjusted multi-regional water supply system such as a water supply plan in populated areas.

Keywords: Water distribution system; Local water and multi-regional system; Purification plants

1. Introduction

In Korea, domestic waterworks are separated into local water supply systems which are facilities designed to provide water to one local government system under the authority of the Ministry of Environment (MOE) and the multi-regional water supply system, which is a facility designed to provide water to more than two local governments under the authority of the Ministry of Construction and Transportation (MOCT), respectively. According to Korea waterworks statistical data [1], the total production capacity is 30,663,000 m^3/d. The local water supply system and multi-regional water supply system has a capacity of 23,028,000 and 7,635,000 m^3/d, respectively. However, the operating rate of local water supply system and multi-regional water supply system is 57.2 and 45.8%, as shown in Fig. 1, respectively, responsible for the duplicate costing of $4 billion.

In response to this circumstance, the MOE has started to the plan on the adjustment of water distribution systems including a local water supply system and a multi-regional water supply system for minimizing economical loss and increasing the operating rate of the purification plants. The primary objective of this plan is to unify the current water supply system of Korea organized in the unit of city and county into wide area in order to

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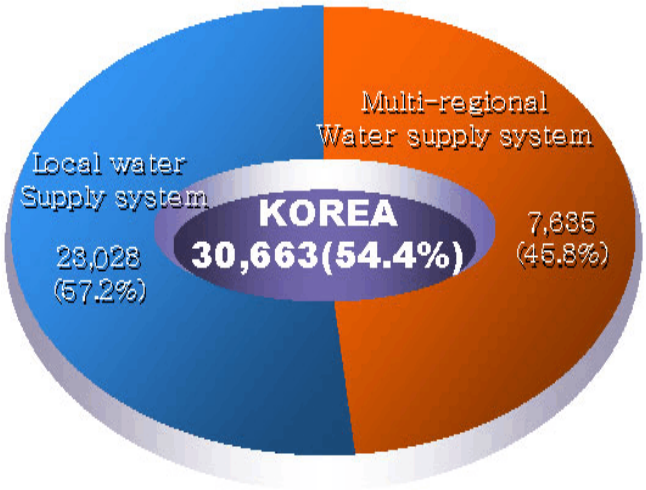

Fig. 1. Water supply condition of Korea in 2005 [unit; thousand m^3/d].

supply the deficient region by fully utilizing the superfluous water volume of the neighboring city and county. Furthermore, it also aims to prepare for the penetration of large foreign water suppliers into the domestic market by securing competitiveness through consolidation of small domestic water suppliers in consideration of the forthcoming market opening.

2. The plan

2.1. Subject

The subject of this plan is the 167 local water supply and multi-regional water supply systems of Korea. Thus, generally surveying and analyzing the population served, water demand volume, available water supply volume, present situation of water resource and management situation of all water suppliers in Korea, this research established the feasibility test and basic plan to set up populated areas. Moreover, the water supply plan was reviewed to solve excess and deficiency in the area by grasping water demand volume, available water supply volume, etc., in the area and fully utilizing superfluous volume. Then, the water will be supplied by preferentially utilizing the superfluous quantity of existing facilities through the adjustment of water distribution systems after fiscal year 2010.

2.2. Details

2.2.1. Estimation of water demand index

The direction of the detailed planning index is shown in Table 1.

Estimation of the water demand index mostly followed the existing water demand estimation method, while the detailed index estimation could become the nationwide demand estimation protocol under the following conditions.

1. Estimation of future value was made using time series analysis and regression curve.
2. Estimation of average daily water supply volume was based on accounted-for water.
3. Forecasting of water demand was made by the down-up approach by analyzing from administrative districts to the national level.
4. When the future value cannot be estimated using a time series analysis, the method to estimate the value was suggested considering social and economic values.

For the scheduled population in the future, the estimated population of cities and provinces announced by the National Statistical Office was adopted and the previous statistical data were analyzed to be applied to the population of city, county, town and sub-county [1]. Industrial waterworks provided as purified water were mostly included in an original consumption basic unit, it was estimated as the original basic unit according to accounted-for water without additional calculation. Industrial waterworks were excluded from this plan. Other waterworks not included in domestic and industrial waterworks were principally estimated up to each basic unit. When a development plan was made for a nation or local government, which had a large population influx, the water demand was estimated for a development plan for waterworks considering the area conditions. The estimated results according to the above planned index are shown in Table 2.

It was expected that the population in 2004, 49,052,988, would grow to 49,959,093 in fiscal year 2020 with an increase of 906,105. The rate of service pervasion, 90.1% in 2004, is estimated to be 97.1% in fiscal year 2020. Surveying statistical data (water supply statistics, data for each city, town and sub-county) for 10 years (1994–2004), the LPCD was analyzed and calculated as total accounted-for water without an analysis by use (domestic, business, office, bath and industrial waterworks, etc). Then, it was anticipated that 365 LPCD in fiscal year 2004 would be 357 LPCD in the fiscal year 2020.

2.2.2. Estimation of water supply index

The planned local water supply capacity and multi-regional water supply was surveyed and used as an index for waterworks supply index estimation. Local water supply system (based on purification) supply index and future local water supply expansion and development plans until 2010 year were evaluated about facilities under

Table 1
Direction of detailed planning index

	Determination of detailed planning index	
Water supply area	• The reflection of local government plan • Established and planning water supply areas (local and multi-regional water supply system)	
Domestic waterworks	Planned population	• Multi-city: estimated population of cities and provinces announced by the National Statistics Office [1] • Local city: previously statistical data were applied to the population of city, county, town and sub-county
	LPCD	• Surveying statistical data for 21 years • Individual forecasting in case of under 0.1 million • Forecasting of standard city analysis of population size
	Rate of service pervasion	• Reflection of local government plan
	Accounted-for water rate	• Goal value of water demand plan [2,3] • 82% in 2010, 85% in 2015, 88% in 2020
	Peaking factor	• Over 1 million population : 1.20 • 0.5–1 million population : 1.35 • 0.5–0.1 million population : 1.30 • Under 0.1 million population : 1.25
Industrial waterworks	• Because industrial waterworks provided as purified water were mostly included in consumption basic unit, it was estimated as the original unit according to accounted-for water without additional calculation.	
Other waterworks	• Basic unit estimation for each city was made in principle.	
Development waterworks	• When development plan was made for a national or local government which had a large population influx, separate water demand was estimated for development plan waterworks taking into consideration the area conditions.	

Table 2
Direction of detailed planning index

	Year 2004	Year 2010	Year 2015	Year 2020
Population projection	49,052,988	49,219,537	49,802,615	49,956,093
Rate of water supply, %	90.1	95.9	97.0	97.1
Accounted-for water rate, %	78.4	81.2	84.3	86.5
LPCD	365	368	363	357

registration and construction referring the existing data under design or planned facilities were excluded from supply capacity estimation.

After the year 2010, superfluous waterworks will be used up to the limit through this adjustment of the water distribution system. Moreover, during performing the basic and detailed design by each area (future project), if there is a place hard to supply water during high water demand periods such as summer due to a lack in water resources and water pollution among local government system facilities, it will be able to solve problems by reevaluating the water source, water quality, and water quantity. The multi-regional water supply system was evaluated by considering the currently operating systems or constructing new ones.

2.3. Outlook of water demand and supply

2.3.1. Water demand and supply volume

The estimated water demand and supply volume according to above planned index are shown in Tables 3 and 4, respectively. It was expected that water demand volume would increase by fiscal year 2015, after which it would decrease slightly. It was estimated that the

Table 3
Water demand volume estimation

	Year 2010	Year 2015	Year 2020
Average daily water supply (thousand m^3/d)	18,163	18,492	18,257
Maximum daily water supply (thousand m^3/d)	23,166	23,613	23,316

Table 4
Water supply capacity estimation (in thousand m^3/d)

	Year 2004	After year 2010
Local	23,155	23,211
Multi-regional	5,814	7,332
Total	28,970	30,543

Table 5
Water demand and supply estimation (in thousand m^3/d)

	Year 2004				Year 2020			
	Demand	Supply	Superfluous	Deficiency	Demand	Supply	Superfluous	Deficiency
Local	10,663	14,040	3,377	−883	13,737	16,416	2,679	−1,257
Multi-regional	9,794	14,930	5,136	—	9,579	14,128	4,549	—
Total	20,457	28,970	8,513	−883	23,316	30,544	7,227	−1,257

maximum daily water supply volume would increase from 16,144,000 m^3/d in 2004 to 23,316,000 m^3/d in 2020. The total water supply capacity was estimated to increase from 28,970,000 m^3/d in 2004 to 30,543,000 m^3/d in 2020.

2.3.2. Estimation of water demand and supply volume

It is expected that water demand and supply are 23,316,000 and 30,544,000 m^3/d, respectively, in fiscal year 2020. According to the estimation of water demand and supply, it is expected that 7,227,000 m^3/d would be totally superfluous in fiscal year 2020. However, it was anticipated that water in the quantity of 1,257,000 m^3/d, as shown in Table 5, would be deficient in 40 cities on account of the imbalance of supply and demand between regions.

2.4. Establishment of populated areas

2.4.1. Direction and standard of establishment

On the basis of this estimation of basic water demand and supply, we established the following plan to utilize the water supply system. We determined the regions for which supply system needs to be adjusted by analyzing regions with deficient and superfluous water through the forecast of water supply and demand for established populated areas.

The establishment of a populated area is based on water source relationship, geographic accessibility, relation to the waterworks supply system, relation to the administration and management, and area relationship. Basic establishment direction according to the establishment standard, divided into large, medium and small areas and their concepts, are:

1. Large area installation: Area including river basin management concept and management and administration service concept and established by considering future water supply and sewerage river basin management system.
2. Medium area installation: Area introducing management and total management concept. Area was considered emotional and geographical uniformity due to the future consolidation of water suppliers and administration and management of a water supplier.
3. Small area installation: Area evaluating the possibility of networking in engineering, economics, and geography based on the actual network management basic concept.

2.4.2. Establishment content

We set up nine large, 26 medium (for effective administration and management), and 42 small areas according to the populated areas established direction and standard, excluding Jejudo. The established large areas were Hangang, Bukhangang, Namhangang, Youngdong, northern Geumgang, southern Geumgang, Youngsangang and northern Nakdonggang. The populated area conceptual diagram is shown in Fig. 2, and detailed information is given in Table 6.

2.4.3. Evaluation standard in network administration

The plan of water distribution system was evaluated on the following standard to evaluate the possibility for

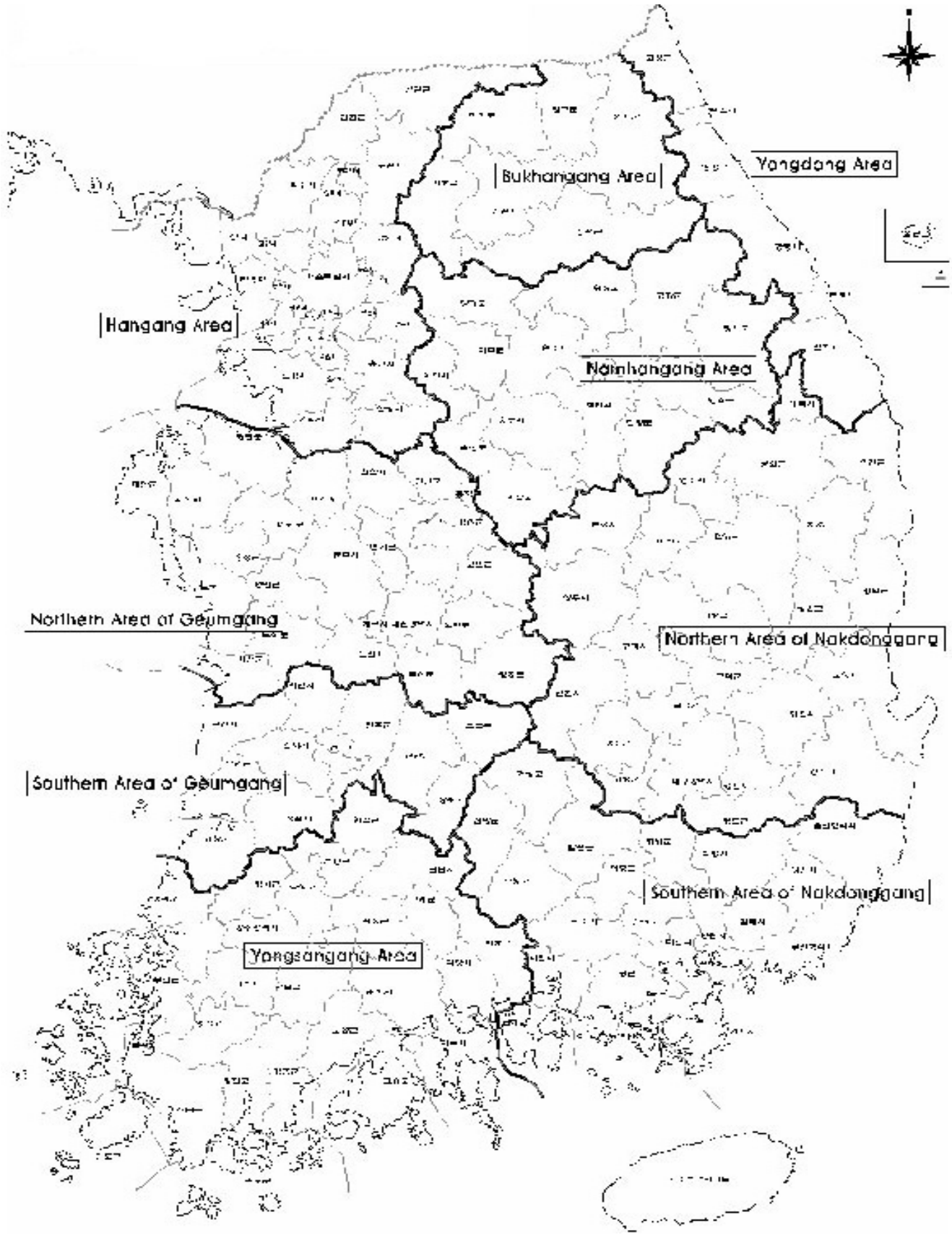

Fig. 2. Map of water supply basin area.

Table 6
Detailed information about the populated areas in the supply basin

Hangang	• Total population: 23,139.1 thousand (47.7%) • Population served: 22,318.9 thousand (rate of service pervasion : 96.5%) • Total production capacity: 10,651.4 thousand m^3/d (55 places)
Bukhangang	• Total population: 4619 thousand (1.0%) • Population served: 364.2 thousand (rate of service pervasion : 78.8%) • Total production capacity: 246.6 thousand m^3/d (26 places)
Namhangang	• Total population: 1,358.4 thousand (2.8%) • Population served: 920.6thousand (rate of service pervasion : 67.8%) • Total production capacity: 447.5 thousand m^3/d (60 places)
Youngdong	• Total population: 554.2 thousand (1.1%) • Population served: 494.8 thousand (rate of service pervasion : 89.3%) • Total production capacity: 329.2 thousand m^3/d (28 places)
Northern Geumgang	• Total population: 4,412.9 thousand (9.1%) • Population served: 3,444.4 thousand (rate of service pervasion : 78.1%) • Total production capacity: 1,477.7 thousand m^3/d (61 places)
Southern Geumgang	• Total population: 1,754.0 thousand (3.6%) • Population served: 1,468.6 thousand (rate of service pervasion: 83.7%) • Total production capacity: 276.7 thousand m^3/d (23 places)
Youngsangang	• Total population: 3,617.6 thousand (7.5%) • Population served: 2,766.7 thousand (rate of service pervasion: 76.5%) • Total production capacity: 1,635.0 thousand m^3/d (109 places)
Northern Nakdonggang	• Total population: 5,311.7 thousand (11.0%) • Population served: 4,646.3 thousand (rate of service pervasion: 87.5%) • Total production capacity: 3,137.0 thousand m^3/d (122 places)
Southern Nakdonggang	• Total population: 7,885.9 thousand (16.3%) • Population served: 7,204.8 thousand (rate of service pervasion: 91.4%) • Total production capacity: 4,492.4 thousand m^3/d (70 places)

water supply and demand between waterworks deficit cities and superfluous cities according to the above life area network plan.

1. Cities with not more than 10,000 m^3/d waterworks were excluded in the evaluation to steady water supply to those cities.

2. Supply possibility among local government systems and between local government system and multi-area water supply system was evaluated.

3. A new water supply facility installation evaluation list in the established local government basic water management plan, multi-area water supply system, adjustment of water distribution system plan, and new multi-area water supply system development plan were evaluated.

4. Mutual economic values were evaluated between local government system, between multi-area water supply system, and the new local government system according to the facility installation.

2.5. Integration controlling center

An integration controlling center was constructed and administered in the Ministry of Environment for effective water supply management. The local government system will have main centers in 16 cities and each area. A multi-area water supply system will have an established main center for each area and each watershed area built and each sub-center will have a sub-division. The multi-city, including the city of Seoul, will develop and administer the main center, which can administer and manage unit facilities. Other provinces are planned to have a main center to develop a sub-center in each city as a sub-division.

2.6. Effect analysis of this plan

We established a plan to utilize the superfluous water volume as an adjusted multi-regional water supply

system and local water supply system such as a water supply plan in populated areas, and a water supply plan between the life areas. The indirect effect of adjustment of water distribution system will resolve the service imbalance in water quantity and quality due to the differences in administration quality, duplicated investment between local government system and multi-area water supply systems. A direct effect will be to restrict the new or expansion of water supply facilities, while water supply is expanded with a higher rate of service pervasion. The purification facility unification will reduce cost and it is expected to effectively use and distribute the water resources, which are unevenly distributed according to geographical factors.

Moreover, it is expected that limited water resources would be efficiently utilized and the imbalance of supply and demand would be eliminated by advancing and improving the operation of all water supply facilities in Korea. Moreover, it is possible to stabilize a water supply system and to improve the efficiency of operation and management by adjustment of water distribution systems—both individually operated local water supply systems and multi-regional water supply systems in Korea.

Finally, it is expected that the competitiveness of Korea's water suppliers could be secured by rationalizing operation organization and improving management efficiency through consolidation of water suppliers to cope with the penetration of large foreign water suppliers into the domestic market.

3. Conclusions

We have established a plan for the adjustment of the water distribution system, including local water and multi-regional water supply systems to minimize economical losses and to increase the operating rate of the purification plants. The main results obtained are:

1. It was expected that the population would rise in 2004 from 49,052,988 to 49,959,093 in fiscal year 2020, an increase of 906,105. The rate of service pervasion, 90.1% in 2004, is estimated to be 97.1% in fiscal year 2020.

2. It is expected that water demand and supply are 23,316,000 and 30,544,000 m^3/d, respectively, in fiscal year 2020.

3. We set up nine large, 26 medium (for effective administration and management), and 42 small areas according to the populated area established direction and standard, excluding Jejudo. The established large areas were Hangang, Bukhangang, Namhangang, Youngdong, Northern Geumgang, Southern Geumgang, Youngsangang and Northern Nakdonggang.

4. According to the estimation of water demand and supply, it is expected that a total of 7,227,000 m^3/d would be superfluous in fiscal year 2020. The plan of water distribution system was evaluated to the possibility for water supply and demand between waterworks deficit cities and superfluous cities.

5. It is possible to stabilize the water supply system and to improve efficiency of operation and management by adjustment of the water distribution system individually operated local water supply system and multi-regional water supply system in Korea.

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