CHAPTER 3-2

# Alternative Water Resources and Recycle Program as Effort to Strengthen Ground Water Management in Metropolitan Bandung

## 1. Background to the Study Area

Groundwater differs from other water sources in that it takes a long time for groundwater to gather and fill its aquifers. As this is often overlooked, it makes groundwater vulnerable to over-exploitation. This unconscious imbalance between the natural recharge rate of groundwater and its abstraction has a broad impact. The question which often arises as to why groundwater is used so much more than other water resources. Approached in economic terms, this is a natural resource, available and ready to use without processing or high cost. The quality is relatively stable and usually meets health standards or process production standards more than surface water resources which fluctuate greatly depending on weather and other factors. In economic development terms, groundwater can be used to support human activities, including social, developmental and economic. All these conditions exist in the Metropolitan Bandung area. Groundwater use has become a primary source for supplying various activities in the Bandung area. Along with the population growth rate in Metropolitan Bandung, which has reached 2.7% (based on analysis of Statistical Data 1986 –2000), the demand for water for domestic needs is continually increasing. Increasing use of groundwater by industry puts pressure on water resource quantity, particularly groundwater. At present, nearly 70% of domestic water and approximately 60% of industrial water needs are satisfied by the use of groundwater, though groundwater accounts for only 10–15% of the available water supply. Meanwhile, increasing water pollution from both industrial and domestic wastewater puts pressure on the quality of surface water.

Research reveals that in deep aquifers almost 43% (113 million $m^3$/year) of the flow rate of groundwater which is exploited showed an imbalance between recharge rate and the abstraction rate of groundwater. In contrast, middle and shallow aquifers are relatively safe. Of 329 million $m^3$/year of domestic water needs in Metropolitan Bandung, approximately 150 million $m^3$/year is provided by shallow groundwater from residents' wells, while 76 million $m^3$/year is provided by the Water Supply Enterprise (WSE), including 12 million $m^3$/year taken from several wells which are still producing. Groundwater used by industry, however, shows an increasing trend. Data of groundwater use from this sector (Environmental Geology and Mining Agency, 2005) noted that more or less 51.4 million $m^3$ of groundwater, especially deep aquifer sources, is utilized in this sector. Dependence of industry on groundwater is still high; data in 1993-2000 showed that nearly 60% of industry used groundwater to fulfil its needs. This is because the WSE supply for industry of is still very low, supplying 2.9% of total industry needs. Meanwhile, dependence on surface water sources, i.e. rivers, still faces obstacle in terms of both quantity and quality. In the wet season, minimum discharge of the main river, the River Citarum and its tributaries, tends to decrease, while in the rainy season, entering run-off can be uncontrolled. The decline of groundwater quality also occurred, particularly at the Citarum River. The impact of these factors in Metropolitan Bandung is water table depletion in several places caused by extreme exploitation, as well as land subsidence as a further impact of that water table depletion (Abidin, et All. 2002). From the preliminary survey conducted by the West Java Environmental Protection Agency, it is estimated that the radius of the affected area could reach at least $2km^2$.

To avoid further possible negative impacts, there must be a prioritized policy. According to the research and water resources development plan, maximizing surface water resources and gradually stopping groundwater use is the most appropriate policy for Metropolitan Bandung. Additionally, an increase of water recycling programs for industry can help to recover groundwater sustainability.

### 1.1 Location of Study Area of Metropolitan Bandung

The Bandung Basin, a plateau encircled by mountains that forms a basin, is located between 7°19' and 6°24' south latitude and 106°51' to 107°51' east longitude. That is one of Java's largest watersheds. It is located in the province of West Java and encompasses an area of 234,088 ha; the basin includes four administrative areas: two regencies (part of Bandung and Sumedang) and two cities (Bandung and Cimahi). It provides water for drinking, agriculture, and fisheries, as well as being the main water supply for three reservoirs, which have a total volume of 6,147 million $m^3$ (Wangsaatmaja, 2004). These reservoirs supply water for 300,000 ha of rice fields, and their hydroelectric dams are important energy suppliers for the islands of Java and Bali. In 2003, the population in Metropolitan Bandung was approximately 5,854,340, and is predicted to reach 9,706,363 in 2025. The average density is 340 persons/$km^2$. Figure 1 depicts the administrative boundaries of the Bandung Basin.


**Figure 1. Map of the Administrative Boundary Defining the Bandung Basin**
*Source: Wangsaatmaja 2004*

# 2. State of Water Resources

## 2.1 Surface Water

Ten main rivers which flow are classified as Citarum River tributaries. Its main river flows from east to the west and ends in the Saguling Reservoir. This basin is used mainly for water power plant and agriculture needs in its lower course and is not only used for the surrounding area, but also for supporting other activities. Of the tributary rivers that flow to Citarum River, it has been identified that some have more potential to be developed. Further explanation will be given about potential of the tributary rivers in the Citarum River Area. According to existing data (Regional Office of Public Works, 1996), surface water resources supply potential is quite abundant. According to calculations by the Regional Office of Public Works, surface water resources used account for 899.86 million $m^3$, or 53% of total of existing surface water supply, while the flood unit which almost happens every year has not yet been considered. More details can be viewed in surface water resources in table 1.

**Table 1. Surface Water Resources**

| No | Sub River Basin | Water Supplying | | Water Used | | |
|---|---|---|---|---|---|---|
| | | Normal | Minimum | Irrigation | Raw Water | Total Used |
| | | (million $m^3$/year) | | | | |
| 1 | Cimahi | 75.06 | 10.41 | 37.29 | 5.05 | 42.31 |
| 2 | Cibeureum | 71.72 | 10.40 | 27.05 | 0.95 | 28.00 |
| 3 | Cikapundung | 152.32 | 21.13 | 29.25 | 25.86 | 55.11 |
| 4 | Cipamokolan | 153.9 | 21.13 | 0.00 | 0.00 | 0.00 |
| 5 | Cikeruh | 131.51 | 18.29 | 86.44 | 0.00 | 86.44 |
| 6 | Citarik | 209.08 | 29.33 | 181.4 | 1.89* | 181.40 |
| 7 | Citarum Hulu | 251.97 | 35.00 | 103.92 | 0.00 | 176.05 |
| 8 | Cisarea | 0.00 | 0.00 | 72.13 | 0.00 | 0.00 |
| 9 | Cisangkuy | 379.69 | 52.98 | 153.52 | 42.26 | 195.78 |
| 10 | Ciwidey | 278.78 | 38.79 | 134.78 | 0.79** | 134.78 |
| | **TOTAL** | **1704.00** | **237.46** | **825.78** | **76.80** | **899.87** |

*Source: Regional Office of Public Works, 1996*

* *It has been utilized for sumedang area*

** *Some water from Saguling lake has been operated and water industrial supply from surface water is relative low*

## 2.2 Saguling Reservoir

Saguling reservoir is the first reservoir of three in succession located alongside the Citarum River. This reservoir is an outlet from Bandung Metropolitan Area and has been in operation since July, 1986. Based on data from the Electricity Power Plant Institution in 2004, the average flow of the Citarum River into this reservoir is about 71 $m^3$/s. This reservoir is located in Bandung Regency. According to the operation procedure, "curve's guidelines" show that theoretical volume in Saguling Reservoir in 1996 for High Water Level condition is about 835.45 billion $m^3$ including surface area of 49.9 $km^2$, whereas in Lower Water Level condition created surface area is about 16.56 $km^2$. The report from the Electricity Power Plant Institution in 2003 shows that the theoretical volume in high surface water is about 806.5 million $m^3$ with a total surface area of about 48.6 $km^2$ and in lower surface water, the theoretical reservoir reached about 215 million $m^3$ with total surface area of about 16.3 $km^2$. The volume capacity changes because of sedimentation. In 1998, the data showed that capacity is decreasing by almost 30 million $m^3$. The draft for surface water operation is at the 623 m level and 643 m above sea level with a flood water draft of 645 m.

## 2.3 Spring Water Resource

Spring water resources are generally found in the upper area, which is a conservation area. Discharge of spring water registered is less than 2.768 $m^3$/s total and fluctuates depending on the season. These water resources are used significantly in rural areas (Gunawan, 1997)

## 2.4 Groundwater Resource

Based on groundwater quantity and quality (Warsono 1985 in Harnandi and Iskandar 1998) the area of study is classified into two areas of groundwater potential, namely (i) Areas with Moderate Potential of Groundwater in Shallow and Deep Aquifers and (ii) Areas with Moderate Potential of Groundwater in Shallow Aquifers and Low Potential in Deep Aquifers. Meanwhile, the Decree of the Minister Energy and Mineral Resources No. 716.K/40/MEM/2003 acknowledged that groundwater potency in Bandung Basin is divided into three groundwater basins: Lembang, Batujajar dan Bandung-Soreang, with classification of groundwater as confined or unconfined.

Table 2. Groundwater Availability and Potential in Upper Citarum River Basin

| Groundwater Basin | | | Rank of Investigate | Amount of Groundwater (million $m^3$/year) | |
|---|---|---|---|---|---|
| No | Name | Area ($km^2$) | | Unconfined | Confined |
| 1 | Lembang | 169 | Known | 164 | 16 |
| 2 | Batujajar | 89 | Known | 66 | 1 |
| 3 | Bandung-Soreang | 2 | Inception | 795 | 117 |

*Source: Decree of Ministry of Energy and Mineral Resources No. 716.K/40/MEM/2003*

## 2.5 Rainfall Pattern in Metropolitan Bandung

Mean annual rainfall in Bandung Basin varies from 1,000 mm/year in middle shares to South-East of Bandung City up to more than 3,500 mm/year in North and less than 3,000mm/year in the South. The wet season is from November to April and the rest of the year is the dry season. Data analysis shows that yearly rainfall intensity ranges between 1,700-3,500 mm/year with mean value of 2,195 mm/year, average temperature is 22.6°C, and value of evaporate-transpiration 1,060 mm/year.

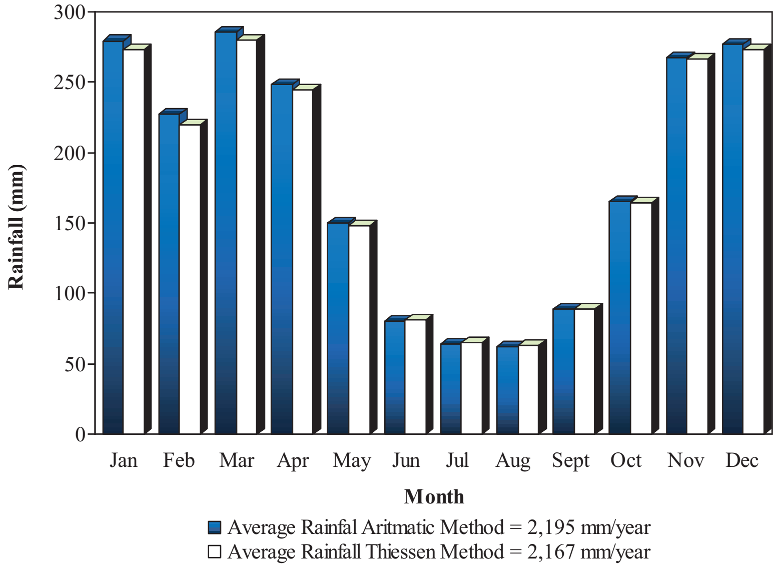



**Figure 2. Comparison Rainfall Monthly Average in Bandung Basin 1950 -1999**
*Source: Raw Data coming from Metrological and Geophysics Bureau, 1950-2003*

## 2.6 Water Supply Infrastructure

**(1) Bandung City**

The installed capacity on Water Supply Enterprises which has been reported is 3.5 $m^3$/s with 2.3 $m^3$/s derived from surface water. Mostly, the water resources are derived from Cisangkuy River and Cikapundung River, located in Bandung Regency Area. In 2000, the service scope is 40.40 %, of which 29.4 % is by direct connection. The domestic consumption in 2000 is 137 l/capita and the number has increased about 6 l/capita from 1996 (the domestic consumption in 1996 is 131 l/capita). On the other hand, the needs of non domestic units have decreased 10% in the last 5 years and in 2000, consumption reached 1.44$m^3$/connection/day. In 2000, the number of connections is 142,000, of which 90% consists of domestic connections (including public hydrants). The domestic service rate (including public hydrants which assume 100 people/hydrant) is 40% with 29% connected to housing. The condition of leaks in production before water goes into the distribution system has varied greatly in the last 5 years. The maximum leak rate was more than 5.9% in 1996 and was at its minimum of 2.4% in 1998. The leaks which were reported in 2000 were ± 4.6 % where 66% of standard water was derived from river. The leak maximum should be 4% whereas the leaks in distribution system has varied greatly between 45% and 47% (West Java Land Use Planning and Settlement, 2006). In most cases, leaks which happened were caused by physical problems.

**(2) Bandung Regency and Cimahi City**

Water Supply Enterprises of Bandung Regency and Cimahi City consists of the 18 systems with operation systems which include: (i) Main system, gravitation and pumps, especially in Cimahi with 184 l/s, (ii) Four system (Lembang-gravitation and pump, Batujajar and Pangalengan-both of them using gravitation system, and Soreang/ Banjaran-pump) with their capacity of 30-40 l/s, (iii) Four system (Cisarua dan Majalaya- both using gravitation systems, and Padalarang and Rancaekek, both using pump systems) with their capacity being 20-25 l/s and. The total usage capacity in 2000 was 450 l/s. The number of customer connections in 1998 was 3,600, where 40% were located in the Cimahi system area (with 96% domestic connections). Furthermore, domestic service scope (with public taps) is 8.2% of the total population in cities (with 6.5% private connections). Average domestic consumption is 105 l/capita/day, with an average of five people per household, so the community which does not have any fixed customer connections still has a possibility of using the clean water supply. In the existing report of 2000, 8.6% of the produced vanishes or leaks before getting into the distribution system. This is compared with 3% last year (West Java Land Use Planning and Settlement, 2006).

**(3) Kabupaten Sumedang**

The water supply in Sumedang block includes pipes systems and non-pipes systems. Pipes systems in Tanjungsari and Jatinangor district are maintained by Water Supply Enterprises of Sumedang Regency, and for Cileunyi District are maintained by Water Supply Enterprises of Bandung Regency. Water resources are derived from Walet Cave (Jatinangor River) which was built in 1992 with a design capacity of 135 l/s. Water supply systems using WSE pipes service 48% of the people in the Jatinangor sub district, and 83% of the people in the Tanjungsari sub district. The service rate in Tanjungsari and Jatinangor sub district is 66% of the number of people in Sumedang Block (Tanjungsari and Jatinangor). Water supply systems by using non-pipes are maintained by communities and households who mostly used shallow wells and pump wells (West Java Land Use Planning and Settlement, 2006).

## 2.7 Wastewater Infrastructure

**(1) Bandung City**

Wastewater disposal services for both liquids and solids in Bandung City (including middle area in Bandung City) which gravitationally flows to wastewater treatment installation in Imhoff Tank currently have not functioned optimally as a consequence of the excessive load. Thus, through Bandung Urban Development Projects I and II project, the centred system (off-site) has begun to extend to east and west areas clustering an old system which still uses the open system. The existing centre system has created two centred sub-system (West Java Land Use Planning and Settlement, 2006):

i. Eastern Area in which domestic waste water treatment plant has been installed in Bojongsoang.
ii. Some of the west area still has no wastewater treatment, so the river remains a disposal site, like the Citepus River in Karasak – South Bandung Area. The central sub-system consists of pipe networks and covered strips extending 318km$^2$, pump stations in the east area and 1 wastewater installation in Bojongsoang.

Nowadays, service area and catchments area are limited in the south area in the middle of Bandung which has developed to the east and west. The cost of new construction of central sewerage system for all areas is quite expensive, because the sewerage area is still limited. As a consequence, that service area is still very limited, and only includes 2,817 ha (17 % from total area in city). The existing service serves 1,500,000 people, or 65% of the population of which the centred wastewater treatment installation service scope is currently achieved ± 20 % as a consequence of tertiary and secondary wastewater treatment pipes, which still are limited.

**(2) Local Sub-system Service Area (On Site System)**

Local sub-system service areas currently include almost all of Bandung City Area except in the Middle and East of Bandung. The service area scope is 13,675 ha or 81% from a total area of a city which consists of 94 sub district. Most of the local system service is through individual septic tanks which serve 13,665 ha (80% of the Bandung City Area) with 202,000 units of septic tanks. Subsidence flows from septic tanks are distributed to infiltrate fields, but unfortunately the infiltrate field construction generally is still not supported, so that the septic tank finally distributes to drainage, and mixes with liquid wastewater from households. The disposal system using communal septic tanks can be found in several locations in Bandung City with a 10 ha-total area service, including Sarijadi Estate, Sadang Serang, Melong Asih and DPMB-Turangga Estate (West Java Land Use Planning and Settlement, 2006). The communal septic tank is generally made from ribbed steel and completed with infiltrate field with final disposal in nearest drainage system. However, because the sludge intake system from the communal septic tanks and infiltrate fields still does not function, the wastewater from septic tanks distributes to drainage which in turn pollutes rivers and other rivers downstream.

**(3) Bandung Regency**

Not every area in Bandung Regency is already served by wastewater and drainage service system. The cluster area which is served by wastewater and drainage service systems can be represented by the cities which are mentioned below (West Java Land Use Planning and Settlement, 2006).

***a. Padalarang Sub District***

Sewerage systems have not been made in every street; thus, the water from wastewater from households and rainfall cannot be distributed with wells. The current conditions show that some of the existing sewerage systems, especially those associated with human activities, have been pressed and choked so that they cannot accommodate water flows. Troughs for water disposal are generally available, although the quality is still not good. The sewerage systems with steel/concrete construction is available only in downtown whereas for another area the disposal site still generally consists of ground pipes, and they very often become plugged by grass. This causes some of the area in Padalarang sub district to become flooded, especially after the rain. Furthermore, the sewage system in Padalarang sub-district is very simple and limited. The existing communal sanitation facility is different in other city. Generally, the communal sanitation facility consists of septic tank system and direct communal sanitation facilities near or beside the river.

***b. Soreang Sub District***

The infrastructure of domestic wastewater disposal in Soreang sub-district consists of individual infrastructure and communal which uses both on-site and off-site systems. The on-site individual infrastructure consists of family toilet with or without septic tank, whereas on-site communal infrastructures have communal sanitation facilities and communal toilets. Furthermore, off-site infrastructure includes piping systems with Small Bore Sewer (SBS). Thus, the sludge from on-site system is drained with vacuum truck and disposed to communal fecal sludge treatment unit with wastewater which was collected through pipes on SBS. The domestic wastewater service scope is 78.8 %. Generally, drainage follows the street pattern with a flow course from west to east, which follows the topography in the area. The rivers which function as natural drainage are the Ciwidey and Cikambuy Rivers. Beside that, drainage has another function as final disposal from drainage in city, like the Leuwi Kuray Drainage which is located in north of the Soreang sub district. The drainage service area scope currently with sufficient quantity is still limited. Most existing drainage is still made from ground construction whereas the gutters of covered steel/concrete construction are still limited to the center of the city, especially at stations and shopping centers or traditional centers, and on main streets that formed as covered troughs which are completed by street inlet. In some of the street internodes, drainage tends to less maintained and much rubbish piles in the surrounding stripes. Thus, this condition causes gutters to become narrowed and it will disrupt the function of strips especially in the rainy season.

***c. Majalaya Sub District.***

Generally, waste in the Majalaya sub district comes from industry and household activity. This is because most people in the Majalaya sub district still do not have septic tanks, so domestic waste is disposed directly into the nearest river without going through a septic tank. Majalaya sub district has three types of drainage: primary, secondary and tertiary. Primary drainage is existing rivers in surrounding city with average condition. Thus, secondary and tertiary drainage is gutters along the street. The condition of secondary and tertiary drainage has generally damaged which caused by rubbish piled or sludge. There are four rivers that are used as primary drainage: Citarum, Cipadaulun, Cipeujeuh, and Cibotor Rivers. In addition, waterways of irrigation are used for drainage system in this area. Majalaya sub district until 2001 has five irrigation check dams which are located in Citarum River (three irrigation check dams) and Cisunggalah River (two irrigation check dams).

***d. Rancaekek Sub District***

Domestic wastewater disposal infrastructure in Rancaekek sub district consists of individual and communal infrastructure with on-site and off-site systems. Individual on-site system consists of family toilet with or without septic tank, whereas communal on-site is communal sanitation facility and communal toilet. The off-site infrastructure is pipe system made of SBS. Sludge from on-site systems is drained with vacuum truck and disposed to communal fecal sludge treatment units together with wastewater which was collected and disposed to Majalaya Fecal Sludge Treatment Installation in Cibeet. The domestic wastewater service scope is 88 %. The existing drainage system in Rancaekek sub district generally is still made predominantly of ground pipes. The rivers which function as primary drainage are Citarik and Cikeruh Rivers. Thus, existing drainage system in Rancaekek sub district can be clustered into a macro drainage system which consists of receiver pipes like the Cikeruh River that serves a wider area, and micro drainage which consists of some artificial pipes with local service scale. The current condition showed that existing drainage is in poor condition, and mentioned that drainage is no longer able to load water in normal capacity as consequence of insufficient carrying capacity drainage rate caused by shallow sludge and rubbish in the drain area. Based on data of Water Management Agency, Rancaekek sub district is including as flood area and ± 7.3% is flood area. Average depth of flooding is 0.3 – 0.5 m with average flooded duration is between 1 – 2 hour.

**(4) Cimahi City**

The wastewater flow pattern in Cimahi City currently uses the Cimahi River Flow and its tributaries as primary drain and some of water drains, whereas existing water drain (secondary drainage) currently is of an unpatterned condition. The existing condition of wastewater drain in Cimahi City is beginning to become damaged and because of sludge and rubbish which caused the carrying capacity from drain to become reduced. In some places, the existing drainage has changed its function and use for land use.

**(5) Sumedang Regency**

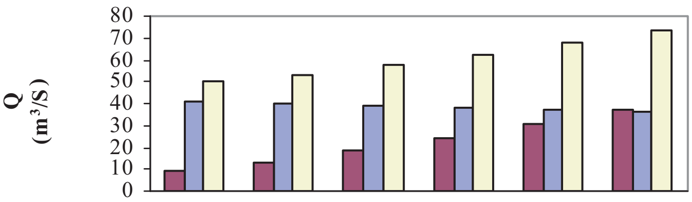
Sumedang Regency, especially districts which includes in Bandung Metropolitan like Jatinangor, Tanjungsari and Cimanggung, their drainage infrastructure availability is still limited. Only Tanjungsari and Jatinagor District have drainage, whereas Cimanggung District has no drainage system. The final destinations of sewage drainage of Tanjungsari City are Cisamangka and Cipeles River. Drainage infrastructure in Jatinangor City is maintained by Public Works of Sumedang Regency, a branch of Public Works of Tanjungsari.

## 2.8 Water Demand

In the Water Resources Development Plan of Metropolitan Bandung has indentified how much demand of water which have to be supplied in 2005 to 2025. It estimates that there are two possible scenarios, namely:

i. Rapid water demand growth based on tendency and implicit assumption that the economic condition would enhance and the government could optimize economic potency that in turn would hasten the economic growth pace.
ii. Lower water demand scenario because of slow economic growth.

Various issues have been considered in the development plan. To mention a few, there are the issues of ineffective wastewater treatment both for industry and for domestic, over-exploitation of groundwater that results in groundwater depletion, especially in areas with clustered industries. Estimation for water scarcity in the future requires special attention on conservation and water demand management, including minimization of water leakage, public awareness campaigns, and improvement of tariff/tax system that can support conservation efforts. One point of the Water Resources Development Plan for Citarum River Basin is that the water demand for domestic, urban, and industry is not described in detail, which makes it difficult to estimate water allotment for each sector. However, the appendix mentioned that water demand estimation for each sector was determined based on a target of number of population served with a tap water system. The interpretation below is based on current conditions and several assumptions of what might happen between 2005 and 2025. Estimates for agricultural water demand decreasing is at around 1-2 % /year due to population pressure and land use change, while the increase in water demand for the industrial sector is estimated to be around 0.5-1 % /year.
The figures above presents water demand scenarios for various sectors, i.e. domestic, urban (flushing, public hydrant),



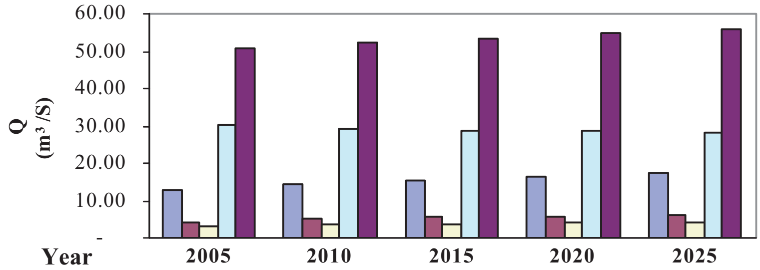

| Year | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|
| Demand for Domestic, Urban and Industry | 9.323 | 13.085 | 19.041 | 24.604 | 31.027 | 37.083 |
| Demand for Agriculture | 40.868 | 39.969 | 39.07 | 38.171 | 37.221 | 36.372 |
| Total | 50.191 | 53.054 | 58.111 | 62.775 | 68.248 | 73.455 |

**Figure 3. Water Demand Projection**

*Source: Water Resources Development Plan for Citarum River Basin, 2002*

industry, and total requirement for agriculture. Total demand for the three main sectors, domestic, industry, and urban use, have similar increasing tendencies due to economic growth in the area. In the early years of planning (2000) it was estimated that total demand for the three sectors will achieve 9.32 $m^3$/s. In the second period of planning, total demand for the three sectors was estimated to be 13.1 $m^3$/s. Similar trends will continue to apply in planning period of 2010, 2015, 2020 and 2025. From the projections, water demand for the three sectors is estimated to be around 37.1 $m^3$/s.

Meanwhile, water demand estimation for agricultural sector will have a different tendency from the previous three sectors. One of the causes is assumption of land use change. Generally, there will be 0.18 $m^3$/s decrease in water demand for the agriculture sector during 25 years of planning period. In the year 2000, water demand from agricultural sector is estimated to be 40.87 $m^3$/s and decreasing, so that by the end of the planning period the number will become 37.22 - 36.37 $m^3$/s. From figure 1 we can see that by the end of the planning period (2025) the water demand from the agricultural sector will be equal to total water demand from the other three sectors. Scenario of total water demand in the early planning period (2000-2005) will range from 50 – 53 $m^3$/s. Generally, water demand increase will achieve total of 46,35 $m^3$/s or equal to 46.35% from early planning scenario in year 2000. By the end of planning period (2025), total water demand in the river basin will achieve almost 73.5 $m^3$/s. As mentioned previously, absence of detailed information about water demand for each sector makes it difficult to measure target achievement. Another analysis was conducted to calculate portion of water demand for each sector. To calculate water demand for the domestic sector, statistical approach using latest data of population growth from Board of Statistics was applied. Figure 4 shows that the water demand for domestic sector in year 2005 was 13.03 $m^3$/s. In 2010 the number is estimated to be 14.13 $m^3$/s, and by the end of planning period the number will increase to 17.41 $m^3$/s.




| Year | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| Domestic Use | 13.03 | 14.13 | 15.22 | 16.32 | 17.41 |
| Industry Use | 4.25 | 5.22 | 5.49 | 5.76 | 6.05 |
| Others Use | 3.26 | 3.53 | 3.81 | 4.08 | 4.35 |
| Agiculture Use | 30.30 | 29.34 | 28.90 | 28.46 | 28.03 |
| Total | 50.85 | 52.22 | 53.41 | 54.62 | 55.85 |

**Figure 4. Re-analysis Water Need 2005-2025**

On the other hand, water demand to supply 10 industrial clusters (Padalarang, Cimahi, Batujajar, Cimahi Selatan, Ujung Berung, Rancaekek, Majalaya, Dayeuhkolot, Banjaran) in year 2005 was 4.23 $m^3$/s. Based on estimation of industrial growth by 1% /year, for the planning period of 2020-2025 total water demand for the industrial sector will achieve 5.76 – 6.05 $m^3$/s. By the year 2025, water demand from urban sector (flushing, public hydrant) will increase to 4.35 $m^3$/s. From a re-analysis, total water demand for the three sectors by 2025 is almost 30 $m^3$/s. Water demand from the agricultural sector based on re-analysis will fall in the range of 30.30 $m^3$/s in year 2005, becomes 29.34 $m^3$/s in 2010, and continually decreasing to 28.03 $m^3$/s by the end of the planning period. Total water demand from all sectors in Bandung Metropolitan area is estimated to reach 55.85 $m^3$/s by the year 2025.

## *3. Issues and Discussion on Groundwater Management*

Groundwater extraction has been well recorded by the Direktorat Geology Tata Lingkungan dan Kawasan Pertambangan (the Directorate of Environmental and Geology) since 1900. Groundwater extraction from 1900 to 1990's showed an increasing trend and achieved its peak in 1997. It was strongly expected due to economical crisis which hit this area. Groundwater use by industry went down significantly in 1997. After recovery, the trend of groundwater abstraction tended to increase back toward the level or previous usage. The abstraction trend of groundwater usage can be seen in this following figure 5.

Nearly 50% of textile processing plants include immersion process which requires great amounts of water. Many of them are located in areas that have no water supply infrastructure. Thus, groundwater becomes a cheap and effective solution for operating the factory. In 1993, groundwater use for the industrial sector reached almost 59.55 % of total water requirement, increasing to 66.34 % in 1995 and decreasing a bit in 1996, almost 59.60 % from the total amount of water required. The economic crisis took place in Indonesia in 1997, including West Java Province, had a significant impact on groundwater abstraction, as shown in following figure 6. In 1999, groundwater usage for industry decreased to 57.20 %, and went up into approximately 57.84 % in 2000. The prediction is that until 2004, groundwater usage will continue to increase, reaching almost 70 % of the contribution of total water required by the industrial sector in the Bandung Basin, as until now the water works system covered less that 2% of total water needs.

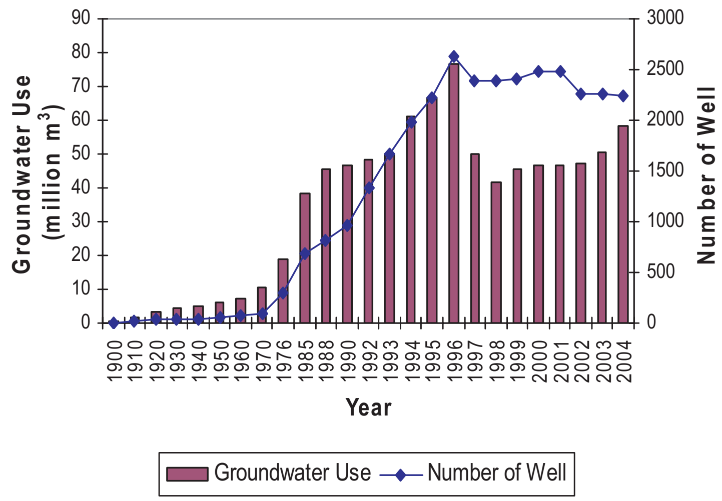
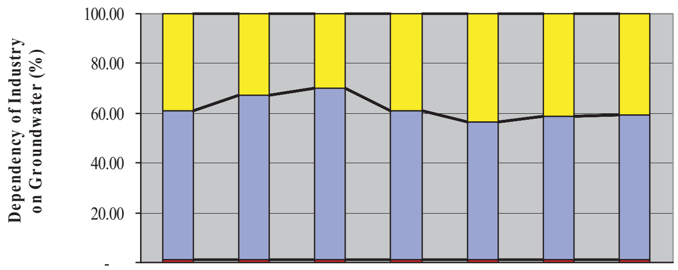



**Figure 5. Numbers of Boreholes vs. Abstraction Period 1900 – 2004**

*Source: Based on Monitoring Data from the Directorate of Environmental Geology 1990 – 2001 and West Java of Mining Agency (2001-2004)*




| Year | 1993 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|
| Surface Water | 39.21 | 32.64 | 29.72 | 39.16 | 43.51 | 41.48 | 40.87 |
| Rainfall | - | - | - | - | - | - | - |
| Spring Water | - | - | - | - | - | - | - |
| Ground Water | 59.55 | 66.33 | 69.34 | 59.60 | 55.11 | 57.20 | 57.84 |
| Water Work System | 1.24 | 1.03 | 0.94 | 1.24 | 1.38 | 1.31 | 1.29 |

**Figure 6. Percentage Dependency Groundwater Use at Industry Activities**

This following table describes the amount of groundwater extraction from 1993 to 2000. Recorded Data in 1993 groundwater use for domestic purpose was 104,218,377 $m^3$ and tending to increase, though during the period of 1997 -1998 it rather slowed down. In 1995, domestic groundwater use reached 107,239,387 $m^3$ and went down to become 95,088,048 $m^3$ in 1998. It was estimated that there would be a decrease in water consumption caused by economical crisis, and that many residents would decrease their consumption. But for the next year the groundwater domestic use increased back over 134,634,849 $m^3$ in 2000.

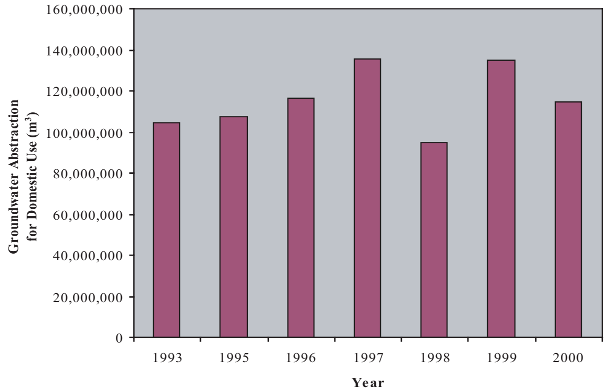



**Figure 7. Groundwater Abstraction for Domestic Use 1993 – 2000**

## 3.1 Associated Groundwater Problems

**(1) Water Table Depletion**

According to data from monitoring wells in some periods of years, the static groundwater table in Bandung basin has changed significantly, from a positive artesian (flowing) to a negative artesian (pumping). For example, positive arthesis distinguished in Dayeuhkolot-Bojongsoang area was +4.0 m above ground level in 1920, but in 1960 the water table depleting to +3.9 m above ground level. In mid 1970's, groundwater table has changed to -2 m below ground level and decreasing to 40 – 80 m below ground level 1990. The same phenomenon occurs in one of area in Cimahi City area, in a well that has been monitored since 1920, which initially had positive arthesis with pressure +19 m. In the mid 1950's, the pressure decreased and in the early 1980's the pressure reduced and went into a pumping phase with pressure -3 m under ground level. In 1985, the groundwater table has reached -10 m under ground level, and in 1995, the groundwater table perceived penetrating into - 40 m under ground level (Harnadi and Iskandar 1993, 1998; Suyono 1990; Priowijanto and Gatot 1995; Agus and Iskandar 2000).

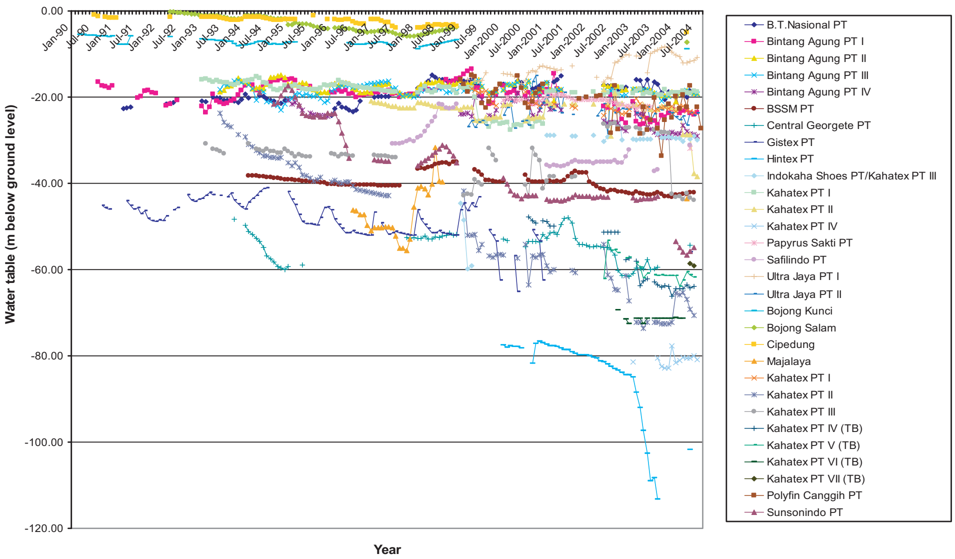



**Figure 8. Water Table Depletion in Several Monitoring Well**
*Source: Satrio, Directorate of Environmental Geology 1990-2004*

The groundwater level was also monitored by Automatic Water Table Recorder (AWLR) at 30 monitoring wells in the study area. The Directorate of Environmental and Geology (Satrio, DEG 2004) identified the change of groundwater table until July 2004. Areas with deepest depletion of static groundwater level forming cone of depression are Cijerah with over

20 m depletion during 1997-2004 period, Cimanggung with more than 60 m depletion over the past decade (1994-2004).

In Rancaekek, measured at PT. Kahatex deep well, the groundwater has depleted more than 60 m throughout the past decade, and in Leuwigajah Industrial Estate, the depletion reaches 40 m during 1994-2004. Moreover, groundwater depletion also affects WSE deep wells. There were 32 deep wells along the rail and it was effecting the decreasing of WSE water extraction, from 550 l/s in 1982-1983 to 115 l/s in 2004.

From the empirical data above, groundwater table in middle aquifer ranges from 0.92-84.24 meter and deep aquifer ranges from 62,83 – 85,76 m below ground level. Excessive groundwater consumption, especially in dense industrial clusters, manifestly has the negative effect of significant groundwater depletion. Meanwhile the result of the monitoring period from July 2004 until July 1995 concluded that the rate of groundwater depletion in middle aquifer is about 0.12 - 8.76 m/year and in deep aquifer is about 1.44-12.48 m/year.

**(2) Land Subsidence Symptom**

Although many factors causing of land subsidence in Metropolitan Bandung, yet excessive groundwater extraction for industry, trading, and domestic uses are the main factors. Land subsidence very significantly happened, particularly with deep aquifer. The source of groundwater coming from recharge area which is located quite far away and the flowing into discharge area need may take years time to replenish. Land subsidence of shallow aquifer was not as terrible as with deep aquifer. That could be because groundwater is more replaced by surrounding surface water, particularly in the wet season. Drastic land subsidence happened since 1980's in line with the increase of industrial and settlement activities. Therefore, the significant problem of land subsidence happened in industrial area such as Leuwigajah, Batujajar, around Mohamad Toha Street, Dayeuhkolot, Rancaekek-Cicalengka, Ujungberung, Cicaheum, and Kiaracondong. At settlements and housing, decreasing happened at shallow groundwater level, seen by the difficulty residents encountered in attempting to get groundwater from their dug well.

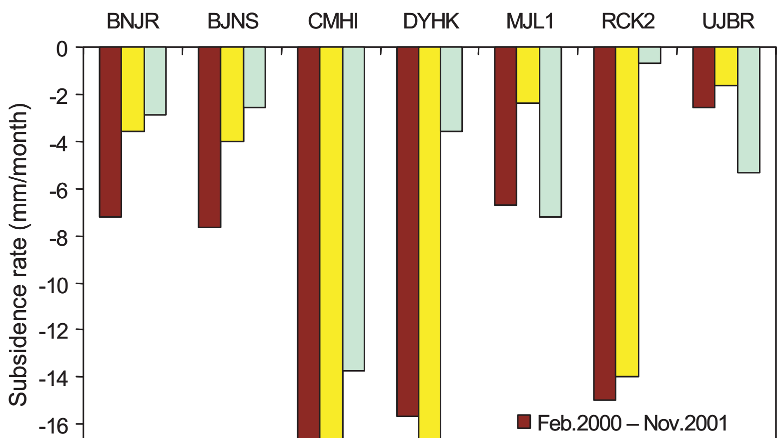



**Figure 9. Various of Land Subsidence Average Temporary in Several Area**

*Source: Abidin et. all, 2003*

*Note: BNJR, BJNS, CMHI, DYHK, MJL 1, RCK, UJBR, mean Banjaran, Bojong soang, Cimahi, Dayeuhkolot, Majalaya 1, Rancaekek 2, Ujung berung, respectively.*

Measurement of land subsidence periodically conducted using Global Positioning System (GPS) reveals that land subsidence for several location can achieve 20 mm/month or equivalent 24 cm/year particularly at several area which are entering a critical zone, including Cimahi, Rancaekek and Dayeuhkolot (Abidin et. all, 2003).

One of the main causes of groundwater depletion is change of land cover, which may lead to changes in the hydrological cycle, especially when the conversion occurs in the recharge area. The Directorate of Environmental and Geology (DTLGKP and BPDPJB 1996) categorized 21 sites of recharge areas in the Bandung Basin as follows: 60,881.31 ha

(26%) as "main recharge areas," 67,911.89 ha (29%) as "inconsequential water recharges areas" and 56,069.66 ha (24%) as "additional recharge area." The "discharge area" covers 38,970.4 ha (16.6%), as shown in following figure. General recharge mechanism of shallow aquifer in Bandung basin is a direct process whether it comes naturally or is caused by human, and it takes place at once or lately in weekly range. Meanwhile, recharge process to middle aquifer and deep aquifer happened directly or indirectly. Direct process happens in the main recharge area and indirect process happens in almost every watershed area. This condition happens because isometric height from deep groundwater in position under shallow groundwater phreatic height. It means that recharging process takes place firstly to shallow aquifers and continues to middle and deep aquifer through the leak.

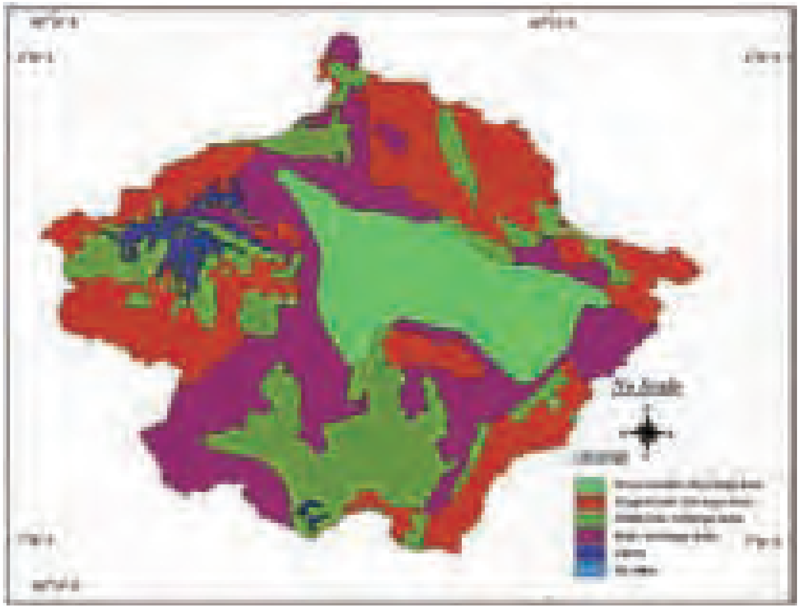


**Figure 10. Categories of Water Recharge Areas in The Bandung Basin**
*Source: DTLGKP and BPDPJB 1996.*

An overlay of land-cover patterns in 1983, 1993, and 2002 in the Upper Citarum Watershed is shown in the table, in which the following two main patterns in land-use change can be observed: (1) a dramatic increase of open area, bushes, and urban and suburban area, and (2) a decreasing trend of rice fields, forest, and grass/open fields. Based on these results, it is obvious that the main change in land-cover pattern is an overall decrease in vegetated land to non-vegetated/built areas and open areas.

**Table 3. Types of Land Cover in the Upper Citarum River Basin, 1983, 1993, and 2002**

| Land-use type | 1983 | | 1993 | | 2002 | |
|---|---|---|---|---|---|---|
| | (ha) | (%) | (ha) | (%) | (ha) | (%) |
| Lake | 253,44 | 0.11 | 4,223.52 | 1.80 | 3,202.56 | 1.37 |
| Open space | 15,806.88 | 6.75 | 23,997.60 | 10.25 | 29,325.60 | 12.53 |
| Meadow | 6,474.24 | 2.77 | 3,620.16 | 1.55 | 2,105.28 | 0.90 |
| Grassland | 30,510.72 | 13.03 | 16,852.32 | 7.20 | 7,866.72 | 3.36 |
| Rice field | 52,702.56 | 22.51 | 44,575.20 | 19.04 | 23,510.88 | 10.05 |
| Forest | 85,138.56 | 36.36 | 69,454.08 | 29.66 | 39,150.72 | 16.73 |
| Bush | 33,363.36 | 14.25 | 48,470.40 | 20.70 | 93,638.88 | 40.01 |
| Plantation | 1,810.08 | 0.77 | 2,731.68 | 1.17 | 3,306.24 | 1.41 |
| Urban | 5,117.76 | 2.19 | 10,499.04 | 4.48 | 17,038.08 | 7.28 |
| Suburban | 2,473.92 | 1.06 | 5,156.64 | 2.20 | 6,304.32 | 2.69 |
| Public facility | 136.80 | 0.06 | 982.08 | 0.42 | 1,869.12 | 0.80 |
| Industry | 355.68 | 0.15 | 2,553.12 | 1.09 | 3,444.48 | 1.47 |
| Cloud | 2.88 | 0.001 | 1,022.40 | 0.44 | 3,278.88 | 1.40 |
| **Total** | **234,146.88** | **100.00** | **234,138.24** | **100.00** | **234,041.76** | **100.00** |

*Source: Wangsaatmaja 2004.*

### (3) Groundwater Quality Deterioration

The result of groundwater quality monitoring conducted in 2004 shows that total coliform levels of 76 % of all samples (19 of 25 samples) exceed the standard of 1000 MPN/100ml. Fecal coliform of 25 sample's location is indicated that 18 among (72 %) are over standard stated for class 1, namely 100 MPN/100 ml. This shows that treatment of water for drinking purpose, in particular at those locations above need to be done before that water will be consumed domestically. If considering based on sampling locations, locations with high number of coliform bacteria which exceed water standard are high-dense residential area, such as settlement area. Also, some of them represent industrial area in Bandung Basin at the present time. The result of laboratory to 50 tested samples taken at locations in the Bandung Basin in 2005 show that 78 % of those samples did not comply with standards, and 70 % exceeded fecal coliform standard. Only one of the sampling point did not show presence of coliform bacteria. It was because the well was quite deep. In fact, almost 90 % of all samples are relatively close between dug well and septic tank. According to our standards, the distance between a well and septic tank should be over 10 m. It can be predicted that all dug wells have been contaminated by domestic waste water, such as human faces. Another reason why the number of coliform is above the standard in those areas is that the sanitation facility around the sampling points were unclean and not maintained.

## 3.2 Policy Responses

### (1) Centralized period (1945–1998)

The following section presents the major policies related to groundwater management instituted during Indonesia's centralized period.

The National Act of the Indonesian Republic, 1945 (UUD 1945), 2nd Amendment, 2000, stated very clearly that natural resources, including water resources, are considered a public good that must be managed fairly and used for the benefit of the Indonesian people.

Act Number 11, 1974, Watering, article 2, stated that water, which includes groundwater (articles 3, 4, and 5), is a public good that has a social function and must be optimally used for the well being of people. Yet, in contrast to surface water, other institutions were put in charge of managing groundwater. As stated in article 5, the authority for water management was divided between two bodies, i.e., all water except groundwater was the responsibility of Menteri Pengairan (the Minister of Watering), while groundwater became the task of the Mining Department/Minister of Mining, as further detailed by the central government through the Government Law on Water Arrangement. According to article 5, Act Number 11/1974, the Minister of Watering was responsible for coordination of all efforts in planning, technical planning, monitoring, usage, maintenance, and protection of water and/or water resources, taking into consideration the interests of related departments and institutions. Section (2) of the article states that administration arrangement of groundwater and hot springs as mineral and power sources was outside the authority of the Minister of Watering. In 2004, Act 11/1974 was revised under Water Resource Act, Number 7, 2004 (discussed further in the next section on the decentralized period).

In an effort to conserve groundwater in the Bandung Basin, the governor of West Java in 1982 issued Governor Decree Number 181.1/SK.1624-Bapp/82, a land-use policy arrangement for the core of the Bandung metropolitan area, which included an administrative boundary arrangement, land-use policy, and efforts and guidance for land development. Simultaneous to these efforts, the central government, through Direktorat Geologi Tata Lingkungan (DGTLKP) (the Directorate of Environmental and Geology), conducted research on groundwater and began monitoring the static groundwater level in their monitored wells. In the mid-1990s, the directorate issued the Groundwater Zoning Recommendation to reduce the rate of groundwater depletion. It became the official guide for related parties in terms of groundwater usage, including industries that mostly use groundwater as their water source for production processes. Formal operational and implementation plans were set out in the Minister of Mining and Energy Rule Number 02P/101/M.PE/1994, Minister of Mining and Energy Decree Number 1945.K/102/M.PE/1995 on Guidance for Groundwater Management in the Second State Government, and DJG Decree Number 005.K/10/DDJG/1995 on the Technical Guidance for Groundwater Management. Referring to recommendations by the Directorate of Geology and Environmental, the West Java provincial government issued West Java Provincial Rule, Number 9, 1995, on Groundwater and Surface Water Monitoring, which basically included the following items:

i. Groundwater abstraction must be conducted by an operational body that possesses a groundwater abstraction license or by a government institution with devices accredited by the general director of Geology and Mineral Resources, the national institution which is under the Ministry of Mining and Energy.
ii. Construction of a groundwater abstraction installation must be based on technical guidance from the Public Works Agency or a technical institution of water management in a related river watershed. It states implicitly that the groundwater abstraction mechanism requires the active involvement of the Direktorat Geologi Tata Lingkungan Kawasan Pertambangan (DGTLKP) (the Directorat of Environmental and Geology) and Dinas Pertambangan Provinsi Jawa Barat (DPPJB) (the Mining Agency of West Java Province).

Simultaneous to issuance of the provincial government's rule, the local government issued Bandung Regency Government Rule Number 43/1995 on Groundwater Control License, which contained similar content.

With the establishment of Act Number 18/1997 on Local Tax and Retribution, the tax on surface water and groundwater usage was classified as a second[3] state government tax. In 1998, the city of Bandung issued Bandung City Government Rule Number 3, 1998, on Groundwater and Surface Water Usage Tax. The calculation of tax was described in chapter III, articles 5 and 6, of the rule. Article 5 stated the following: (1) tax is based on water provision value; (2) water provision value is calculated by multiplying the water volume by the basic water price; (3) the basic water price is calculated by considering the type of water source, its location, groundwater abstraction, water quality, area of water usage, season of water abstraction, and environmental degradation due to water abstraction; (4) the basic water price is determined periodically by the mayor with approval from the Bandung City Legislation Board; and (5) the water provision value is also determined by the mayor. Article 6 of the act determined that the tax charged would be a maximum rate of 20%.

**(2) Decentralized Period (1998–)**
The interesting point in the decentralized period began in Indonesia in 1999 when Act Number 22/1999 on Local Government was issued (it was revised by Act Number 32/2004). This act handed governing authority (including natural resources management) from the central government to local governments, and it was to be accompanied by funding, infrastructure, and human resources. Facts show, however, that not all of these elements have been entrusted by the central government to local governments. The consequence of local governments being forced to generate their own revenues was a massive exploitation and poor management of resources, especially trans-boundary assets.

Act Number 34, 2000, of Amendment of Indonesian Republic Act, Number 18, 1997, changed several taxation mechanisms. It stated that local governments are given the authority for taxing groundwater abstraction, while, according to Act 34/2000, article 2, that kind of taxation authority is part of provincial government revenues. To implement the act, the Provincial Government Rule of Regional Tax was issued. The Tax on Surface Water and Groundwater Usage and Abstraction can be found in chapter 5, articles 33, 34, 35, and 36, which set the tax for groundwater abstraction at 20%.

In 2000 the Minister of Energy and Mineral Resources issued Decree Number 1451 K/10/MEM/2000, appendix 1, Technical Guidance For Groundwater Potency Evaluation, and appendix 2, Technical Guidance for Groundwater Planning and Usage, as reference material and a source of information on groundwater potential, with the specific aim of integrating groundwater management among different local governments. According to Minister of Energy and Mineral Resource Decree Number 716.K/40/MEM 2003 on Groundwater Basin in Java and Madura Island, the groundwater basin in Bandung Basin is divided into three basic aquifers, namely, the Lembang, Batujajar, and Bandung-Soreang basins.

In 2001, the West Java provincial government issued Provincial Regulation Number 16/2001 on Groundwater Management. Chapter 2 of the regulation, Planning for Groundwater Usage, stated that planning activities must be conducted as a basic condition for proper groundwater management in any given groundwater basin. In article 5, sections 1 and 2, it is stated that groundwater is prioritized for domestic use, and that other uses are allowed under certain conditions. In chapter 6, Licensing Facilitation, article 6, it states that groundwater abstraction activities can

3. The second tax is taken by provincial or district level. The ground water and surface water tax is among them

be conducted only with a license from the relevant mayor or regent. Meanwhile, groundwater abstraction in trans-boundary areas has to follow several technical conditions set by the related agency, the Mining Agency of West Java, except for those abstracting less than 100 cubic meters per month ($m^3$/month). Article 12 mentions that monitoring and enforcement activities are done by the Mining Agency in cooperation with related institutions at the city or regency government level, which includes the following: (a) the location of the groundwater abstraction point, (b) a technical construction and pumping test, (c) limitation of groundwater discharge abstraction, (d) technical arrangements and installing a monitoring device, (e) data collection of groundwater abstraction, (f) taping water technical, and (g) hydrology analysis.

To support Provincial Regulation Number 16, 2000, the West Java Governor Decree Number 23/2002 on Implementation Guidance for Provincial Legislation Law Number 16/2000 was issued in 2002. It is clearly stated in article 2 of the decree that the governor has the authority and responsibility for groundwater management in trans-boundary areas. Article 8, sections 1 and 2, lists the following technical information required from applicants for a groundwater abstraction license: (a) location of the abstraction point, (b) distance between the planned point and the nearest point, (c) the number of points the applicant possesses, (d) name of the registered abstraction contractor, (e) depth of the aquifer, (f) the maximum discharge, (g) pump depth and capacity, and (h) details of bore hole construction. Included under the last item are the following: (i) depth of the well, (ii) diameter and length of the main pipe, (iii) diameter and length of the strainer pipe, (iv) diameter and length of the head pipe, (v) diameter and length of the piezometer pipe (for measuring the elevation of the water table), (vi) location of the gravel mantel, (vii) location of the cement layer, and (viii) location of the piezometer pipe. Article 9 of this regulation states that applicants must provide a 1:10,000 layout map showing the abstraction point and a 1:25,000 map for well coordination. Hydrological analysis is compulsory to gain information for zoning the groundwater abstraction point as being in a critical, vulnerable, or safe zone.

Bandung City Regulation Number 8/2002 issued by the city of Bandung is similar to the provincial regulation. In article 6, groundwater abstraction for domestic use below a withdrawal of 100 $m^3$/month with depth ranges from 40–60 m do not need a license for abstraction, a recharge well, or a monitoring well.

West Java Governor Decree Number 29/2003 was issued as the basis for calculating the groundwater usage tax, which considers three main components: natural resources, conservation, and raw water price.

### 3.3 Overview Effectiveness and Deficiencies of the Policies

Basically there have been several regulations trying to improve and protect groundwater management in Metropolitan Bandung since 1980's. But in fact, deficiencies are still happening and rather difficult to implement issued regulation both by provincial and local government. For instance, the idea of limiting excessive groundwater abstraction through stopping a new license and zoning for critical area is also difficult to implement. The following table explains the effectiveness and deficiencies of existing measures.

Table 4. List Measure and Effectiveness Policy in Metropolitan Bandung

| Measures | Date Implemented | Effectiveness | Deficiencies |
|---|---|---|---|
| Using of License | 1974 | N/A | Unregistered well particularly by industry use still exists |
| Zoning Area (1) Critical Area, (2) Vulnerable Area, (3) Safe Area | 1994 | N/A | Water table depletion in critical areas is still happening |
| Groundwater Use Charge | 1974 | N/A | No charge for domestic use due to that this subject is public goods |
| Abandonment of Groundwater Wells by WSE | 1990 | N/A | Groundwater source is still used by WSE for certain area |
| Plan of Industry Relocation | 1990 | | High Cost |
| Groundwater License Requirement Based on Technical Aspect: (1) Deep and Length of Strainer, (2) Discharge of Pipe Diameter, (3) Power of Pumping Equipment, (4) Deep of Well, (5) Piezometer Pipe Diameter, (6) Deep of Aquifer Extracted | 1995 | Effective | |
| Limiting Groundwater Abstraction | 1995 | | Water table depletion is continuing |
| Groundwater Charge | 1995 | Effective for industry use but not effective for domestic use | No charge for domestic use |
| Metering | 1995 | 80 % | Not all wells are metered |
| Decentralization (Hand Over Groundwater Management Authority from Centre to Provincial and Local Government) | 1999 | | |
| Stopping a New License for Certain Area | 2000 | | Water table depletion is continuing |
| Land Use Regulation | 2000 | | Uncoordinated land use planning between Provincial and Local Level |
| Groundwater Tax Based on Natural, Conservation and Raw Water Price | 2001 | Effective for industry use but not effective for domestic use | No charge for domestic use |
| Establish Monitoring Well | | | Water table depletion is continuing |
| Introduce Recycle and Reuse Technology | 2000 | Not effective | No incentive for industry which has done |
| Reporting of Groundwater Extraction | | Effective for knowing how much groundwater amount extracted by industry use | |
| Introduce Recharge Well for Both Domestic and Industry Use Particularly in Conservation Area | 1995 | N/A | Only 5 % domestic residing in the conservation area complied with this regulation |
| Groundwater Data and Information System | 2002 | | Not up-dated |
| Closing Unregistered Well | | Effective | |

*Source: Stakeholders Meeting' Bandung Case in January 2006 under SWMP*

# 4. Issues and Discussion on Alternative Water Resources and Water Recycle Program

## 4.1 Maximizing of Surface Water Resources

Figure 11 below depicts more clearly water balance condition in Metropolitan Bandung. In normal condition all tributary and the main rivers (Citarum River) have water availability around 806.71 million $m^3$/year. The water surface potency in minimum condition is able only to provide 237.46 million $m^3$/year, meanwhile in maximum condition the water potency will be 1,750 million $m^3$/year. Those things in dry season have caused in several areas to undergo deficit of water in terms of fulfilling the needs. Phenomenon of water scarcity is a common situation and tends to increase recently. Based on total necessity which has to be provide for agriculture (825 million $m^3$/year), raw water for Water Supply Enterprise

(WSE) (76.8 million m³/year) and industry need (135 million m³/year) at least are needed 1,036 million m³/year to fulfil those activities.

From the identification result of Water Resources Development of Public Works in 1996 it is known that at least 25 reservoir locations have the potential to be further developed and many locations have been investigated. Annual volume of those reservoirs are calculated based on how much water availability and capacity by analyzing input – output of flow rate in monthly basis.

Efforts to fulfil water demand in Bandung Metropolitan area is emphasized on maximizing surface water resources potency. This scheme shows that at least eight small dams will be constructed to supply raw water for household, industrial and urban sector demand. Raw water from Saguling Dam is another alterative to be used in the year 2015. In the meanwhile, groundwater usage will be allocated for areas with difficult access to piping system in Bandung Metropolitan. The following table shows us that surface water development plant through building several reservoir in upper area can significantly increase the amount of water in that area. At least, around 331.96 million m³/year can be provided by those reservoirs. This grand design to maximize surface water resources have not been constructed yet so far because of burden on the budget. The resulting amount of surface water resources added by development with engineering can be viewed in table 4 below.

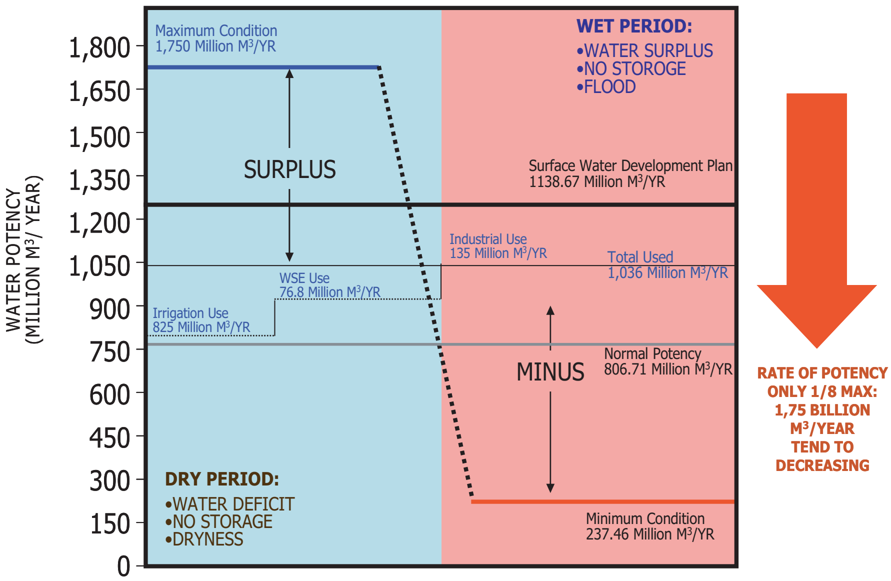



**Figure 11. Surface Water Condition in Metropolitan Bandung**

### Table 5. Surface Water Resources Development With Enginering

| Sub River Stream Area | Water Available | Potency (million $m^3$) | | Treatment Capacity (million $m^3$/year) | Potency With Engineering | Location of Reservoir |
|---|---|---|---|---|---|---|
| | | Without Engineering* | Engineering** | | | |
| Cimahi | 32.75 | 10.41 | 22.34 | 10.00 | 20.41 | Paneungteung |
| Cibeureum | 43.27 | 10.4 | 32.87 | 0.00 | 10.4 | |
| Cikapundung | 97.21 | 21.13 | 76.08 | 3.70 | 24.83 | Cikawari |
| Cipamokolan | 153.9 | 21.13 | 132.77 | 0.00 | 21.13 | |
| Cikeruh | 45.07 | 18.29 | 26.78 | 3.20 | 21.49 | Cikuda |
| Citarik | 27.68 | 27.68 | 0.00 | 0.00 | 27.68 | |
| Citarum Hulu | 75.92 | 35.00 | 40.92 | 1.40 | 36.4 | Cipariuk |
| Cisarea | 0.00 | 0.00 | 0.00 | 3.35 | 3.35 | Peuris Hilir |
| Cisangkuy | 183.91 | 52.98 | 130.93 | 9.50 | 62.48 | Talun |
| Ciwidey | 144.00 | 38.79 | 105.21 | 8.00 | 46.79 | Ciwideuy |
| Daerah Banjir | | | | 50.00 | 50.00 | Tegalluar |
| **Total** | **806.71** | **239.81** | **572.90** | **95.15** | **331.9*** ** | |

*Source: Regional Office of Public Works, 1996*

* *Water which has no been optimized*

** *Water potency could be optimized by engineering approach*

*** *The total water which has no been optimized by engineering approach (construct reservoir/small lake)*

## 4.2 Water Recycle Program

As has been explained in the previous facts, it has been discovered that the biggest groundwater user is the industrial sector. Almost all (57.84 %) the water requirements in this sector are supplied from groundwater sources and only 2 % are fulfilled by the water piping network. This process has occurred continuously, and the result is a continuing worsening in groundwater level depletion. In the Metropolitan Bandung water development plan it mentioned that two structural approaches shall be conducted focusing on perpetual groundwater management. In the bottom line, those two approaches could be divided into groundwater usage limitation on 2.4 $m^3$/s since 2003 and providing alternative water sources to the industrial sector that shall be started in 2005.

Structural effort on groundwater usage limitation is strengthened by best case scenario that would be implemented as studied in groundwater utilization plan (Mining Agency, 2002). This scenario is intended to alter several critical zones, and is expected to improve the situation and turn vulnerable sectors into safe zones. To achieve it, reducing groundwater abstraction is conducted in difficult and critical zones and increased groundwater abstraction to a certain limit in safe zones.

Simulation results show that in 2013, critical zones would become extremely problematic areas by 100% or decreased for 222 $km^2$ total areas than the current condition. Discharge abstraction zone shall be implemented to achieve maximum target from this determined scenario. Discharge zone for only 300-400 $m^3/km^2$/day is implemented to critical zones and no new groundwater abstraction permit would be issued for industrial zone. Therefore this effort would reach the target in 2013. Whereas 1400-2000 $m^3/km^2$/day discharge zone would be implemented in safe zone or central urban activities areas and focused in groundwater utilization for domestic necessity.

An important question emerging is how the industrial sector activity could develop its production processes, including participation in actively reducing of dependence on groundwater utilization. The water resources development plan states that one effort that should be conducted by industry is to introduce cleaner technology concepts including implementing and utilizing water recycling processes within the industrial sites.

It is uncertain when the water recycling concept was started in Metropolitan Bandung. From a preliminary survey conducted by direct interview method, however, resulted in that at least from several recent years industrial sector has initiated this recycling program. Their main motivation is concerning their difficulties to fulfil the water requirements either from groundwater or surface water. Allowing no new abstraction permits has become an obstacle when the production capacity is intended to be increased. Purchasing of water from individual supplier is more expensive. Another motivation is that water recycling is indirectly economical, and more profit could be obtained than by purchasing water from individual suppliers.

One of the recycling efforts in industry originated from wastewater produced by production process. Total of wastewater produced by 194 textile industries (spread out) is noted at least 2.6 $m^3/s$ (Wangsaatmaja, 2004). If it could be exploited maximally, the target is to decide how much recycled wastewater rate that would be approved in the next water recycling meeting, at least it could be a potency of raw water supply for production process in industries. As an illustration, if this effort succeeds and reaches the target, 50% of wastewater will be recycled, hence raw water necessary for industries that is around 1.3 $m^3/s$ can be supplied from this scheme.

There are two options which could be considered in application of recycling program in industrial sector. The first option is to conduct recycling of water off-site or else integrated into the industrial area. This option guarantees that wastewater recycling program is conducted consistently and constantly, and runs in a wide scale. The weakness of this option is the requirement of higher investment, considering that its implementation has preconditions that must be fulfilled.

The main precondition to apply this option is having a prepared integrated wastewater management system and operated in industrial area scale with relatively wide area necessary. The only integrated wastewater management that has been built since 1985 is located in Cisirung, Kabupaten Bandung, with an operation capacity of 0.175 $m^3/s$. This infrastructure is built from the Central Government fund and the second stage of development is from Central Government. At this moment, the plant is able to treat wastewater coming from 27 industries (26 textile industries and 1 food industry). Whereas, an option of on-site industrial wastewater recycling system is relatively easier and could be applied immediately in industries, however, the option of on-site water recycling also has weakness because it only depends on the willingness of the industrial parties themselves and is voluntary. Economic calculation is mostly considered whether option to conduct water recycle could give economic benefit to the company.

From all industries in Metropolitan Bandung, it has not been listed exactly how many industries already conduct a recycling program. For temporary example, from around 400 industries located and spread out in Cimahi City, only about 10 industries identified applying water recycling program in their production process. Result of preliminary survey conducted in several industrial locations located in Cimahi cluster shows an interesting fact related to recycling implementation. Part of it already mentioned in the previous chapter, is that economic motivation is the main reason for implementation of this program

Arising from the difficulty of several industrial parties in water demand fulfilment for production process, especially in dry season, they initiated finding alternative substitute for groundwater by buying from a third party that provides this service. On the other hand, the proposed price from this individual water provider is 20,000.00 -25,000.00 IDR/$m^3$, while maximum groundwater tax that is burdened for usage above 5000$m^3$ is around 3,318 IDR/$m^3$, while WSE tariff is around 4,725.00-9,600.00 IDR/$m^3$. If consideration of water source is based on price viability, so that option of using water for production process by buying from individual water provider is the most expensive option and inevitable, considering until this moment WSE service has not reached to this area. To know the perception of industry concerning the water recycling program in detail, in the table below is summarized the result of a questionnaire which was taken from 33 industries.

### Table 6. Result of Water Recycle Program for Industry

| Item Questioner | Result |
|---|---|
| Water demand | Clean Water is the main need for the industry to conduct their activities, more so in the textile industries. From the collecting data, we can conclude that most of the industries (41.2 %) need about 10,000 -< 30,000 $m^3$/month of clean water, and (29.4 %) need 30.000 – 50.000 $m^3$/month, while the others (17.6 %) need clean water up to 50,000$m^3$/month, and the remaining 4 industries (11.8 %) did not answer the question. |
| Industrial Water Use | The water demand are including all the industrial demands, which are production process, domestic activities in the industrial site, i.e. shower (bath), washes and rinses. Some industries need to supply clean water to the residential areas near the industrial site, for the geothermal electricity generator, etc., while (64.7 %) stated the main needs are for the production process, domestic industry activities, and other activities and (23.5 %) stated that the needs are for the production process and domestic only. The others (5.9 %) stated that the needs are for the production process only. The table of the Water Usage in the industry is shown in table below. |
| Water Resources | There is none of the industries that use the water from the Water Supply Enterprises (WSE). 47.1 % industries that use the groundwater with the surface water, or the groundwater with the rainfall, stated that the most used resources is the groundwater, so it can conclude that the groundwater is the most used water resources in Metropolitan Bandung |
| WSE service area | The reason that none of the industries use the water from the Water Supply Enterprises (WSE) is because of the low coverage of WSE service area (the supply does not reach the industry). From the 33 industries, there is only one industry that is reached by WSE. The rest of all (88.2 %) stated that they were not covered by the WSE service area, and 5 % did not answer the question. |
| Water Problem in Industry | Although the industries have the licenses to use several types of water resources, but the water resources availability does not optimally fulfil industrial activities demand. Some industries have problems from the water resources that they used. The main problems are the minimum capacity of the water resources (quantity), especially in the dry seasons (47.1 %), minimum number of the water sources (11.8 %), and two industry (5.9 %) is in quality (one of them are bottling drink water industry). The others did not answer or stated that they don't have any problems with their water resources. |
| Restriction of the groundwater usage for industries | Some of the industries that using groundwater agree if government established the regulation about the restriction of groundwater usage for industry. Percentage of industry which did not agreed with the proposed policy (46 %). Agreed as long as government can provide or search for other water resources (20 %). Agreed because they have got access to surface water or other water resources (20 %). Not response (1 %) |
| Water Resources Alternative for the Ground Water Usage Restriction for Industries | From the respondents that agree with the restriction of the groundwater usage for industries, 25 % of them agree if only the government facilitated the other water resources from the Water Supply Enterprises (WSE), another 25 % choose the alternative water resources from the Reuse/Recycle Water, and the other 37.5 % (most of the industries) not giving any alternative water resources answers if the restriction regulation has established. |
| Licenses and Capacity | Another information about the Industrial Water Resources Data is the licence of the water resources usage and its capacity. Having license (94.1 %), not answer (5.9 %) and no license (0 %). Out of that survey, 94,1 % of the respondents stated that they have the licenses, 52.9 %; the rest of them stated that the allowed capacity of the water resources usage has fulfilled their water demand. The others (35.5 %) did not answer, and (11.8 %) stated that the allowed capacity isn't fulfil the water demand. |
| Water Resources Quality and the Minimum Requirements for Production Process. | 64.7 % of respondents stated that the quality of their water resources (surface and groundwater) do not fulfil the requirement quality as the process water, while the other 35.3 % stated that the quality of their water resources have fulfil the requirement for the production process water. |
| Water Tariff | Minimum tariff for the Surface Water Resources is 2,100,000 IDR/month, and 6,500,000 IDR/month for maximum. While the minimum tariff for the Ground Water Resources is 800,000 IDR/month, and 37,000,000 IDR/month for maximum. |
| Wastewater Discharge Volume | The minimum flow rates that can be generated by the industrial respondent is 10.000$m^3$/month, while maximum flow rates generated by those industries is 160.000$m^3$/month. <10.000$m^3$/month (0 %). 10,000 - <20,000 $m^3$/month (41.2 %) 20,000 - <30,000$m^3$/month (29.4 %). |
| Knowledge about the 'water recycle' term | 94.1 % know the term of 'water recycling', while the 5.9 % did not answer the question. |
| Recycle Water Implementation in Industry | 64.7 % of respondents stated that they have implemented the reuse/recycling water or rain water harvesting, while another 29.4 % stated that they had not implemented the Recycle water principal yet, and the other 5.9 % did not answer the question. |
| The motivation of the Industry to implemented the water reuse/recycling | - Economic factor<br>- Water scarcity |
| Proposed Policy | - Improving the surface water quality (41.2 %)<br>- Socialization of the Water Recycling Program (35.3 %)<br>- Upgrade the water supply pipeline network (23.5 %) |

*Source: Data Questioner under SWMP, 2007*

Basically there are some regulations which endorse to be implemented this water recycle program Regulation like Governor of West Java' Decree No 39 of 2000 about Standard for Raw Water, Governor of West Java' Decree No 9/1999 about Wastewater Standard for Industry Activities and Local Law about License for Wastewater Discharge are some of them. Those regulations state clearly that industry must obey and meet the required standards from both physical and biological aspects, but there are many obstacles that can be barriers for applying this program, namely (i) image of industry that water reuse and recycling is an "expensive effort" (ii) lack or insufficient disincentive and incentive mechanism, (iii) lack of national law to regulate incentive-mechanism, (iv) Insufficient law enforcement, (v) lack of support of management of industry, (vi) insufficient public awareness, (vii) less willingness to obey this proposed program from industry side because they have to spend some of their budget.

Here is a list of possible solutions and barriers of promotion of water recycling which were raised from industries in Bandung Water Recycle Meeting done in January 2007 under the SWMP research,.

**Table 7. Proposed Solutions to Strengthen Water Recycle Program**

| Solutions | Stakeholders in charge of implementation |
|---|---|
| Support of management is one of the most important thing | Industry |
| It needs a recycling team to deliver or promote this program | Government |
| Incentive-Disincentive Mechanism | Government |
| It requires big invest to construct integrated industrial waste water plant | Government |
| Modifying of process production to decrease leakage of water in industrial process | Industry |
| Implement this program gradually | Industry and Government |
| Speed up the development of water infrastructure | Government |
| It is suggested to use biological treatment (technical solutions) | Industry |
| Develop public awareness on environment | Government and Community |
| Environmental credit/loan with low interest rate | Government |

*Source: Water Recycle Meeting under SWMP, 2007*

# 5. Conclusion

High dependency of industrial sector on groundwater supply is one of the constraints of groundwater management in Bandung. The high dependency is closely linked with lack of infrastructure which is able to be provided by WSE. Currently, capacity of WSE for supplying clean water to industrial sector only reaches about 3.5 million $m^3$ in the year 2003. Calculation of actual volume of water supply of WSE compared to the requirement volume of industry sector concludes that water reaches less than 1 % of total industry requirement. The fact shows that almost all or most requirement of water of industrial sector is supposed to be fulfilled by groundwater supply. Another factor that influences scarcity of groundwater that should be addressed is decrease of groundwater recharge area. Groundwater recharge can interpreted as an additional process of groundwater from external area to saturated water column artificially. Generally, groundwater recharge can come from rainfall, river, and human treatment by such as recharge wells.

Besides that, the main issue of managing groundwater in the Bandung Basin is not just the problem of groundwater itself, but also involves complex problems concerning water scarcity in general, particularly in terms of industrial use. Land-use changes have negatively affected water resources, and the fact that there is no waterworks infrastructure for industry has made using groundwater the only option for carrying out industrial activities. Looking at groundwater control mechanisms in the Bandung Basin, licensing is still considered the main tool for controlling groundwater abstraction. But licensing does not work properly when there is only a minimum of awareness among stakeholders about the importance of groundwater conservation, combined with weak law enforcement and monitoring. This is shown by the fact that many unregistered deep wells have been found in the basin.

Water recycling is promising option to reduce the dependency on groundwater by the industrial sector. However, there is no incentive mechanism to promote water recycling, such as tax compensation to industry that promote water recycling effort, and therefore many industries are not interested in water saving efforts, which makes it extremely difficult to control groundwater extraction in Bandung Basin. Water Supply Enterprise inability to supply raw water and to extend its coverage area is also becoming a trigger to accelerate groundwater problems. Covering percentage by Water Supply Enterprise is approximately 37.75% (50 % for Bandung City, 23 % for Bandung Regency, 7 % for Sumedang Regency and 20 % for Cimahi City). The raw water for Water Enterprise mostly comes from surface water with biggest service to domestic use. Industry still depends on groundwater, and since the management is performed by the industry themselves, groundwater control becomes difficult.

The future challenge about groundwater management is adjusting the water provision mechanism that applies for the time being. The tax based on calculation of water value provision is divided in three components. The mechanism has been seen to give cheaper prices than price of water which is supplied by WSE. From calculation simulation with costliest component, the price which must be paid by using water provision value mechanism is much cheaper than tariff released by WSE. To 1-500m$^3$ relate to this mechanism will reside in price 1,038 IDR/m$^3$, to 500-1,500 is 1668 IDR/m$^3$, to 1,500 to 3,000 will reside in at spanning 2,298 IDR/m$^3$ and to 3,000 to 5,000 m$^3$ will be imposed around 3,138 IDR/m$^3$.whilst tariff of WSE is 1,750 to 9,600 IDR/m$^3$ for the usage of the industrial sector.

From the perspective of groundwater usage and management, it is urgent that a review of the situation be conducted for maintaining or recovering groundwater in Metropolitan Bandung. Efforts of maximizing surface water use and proposed water recycle program need supporting. There are 6 categories of measures that have to be developed, namely:

i. Institutional Measures: maximization of roles of related existing institutions through effective coordination with each other. Besides, establishment or development of a specific institution that handles the needs of water for industry in Metropolitan Bandung is necessary. The other important thing to conduct this program is composing a national strategy for water reuse and recycling as guidance for local or provincial level in term implementing it.
ii. Legal Aspect Measures: From the policy aspect, issuance of Law Number 22/1999 and the Revision Number 32/2004 on Local Government (Decentralization) has an implication to groundwater management. The law has given the authority for groundwater management to local government from the Directorate of Geology and Environmental in the centralized period. The decentralization could be another trigger in poor management of groundwater which is considered as a trans-boundary natural resource. Besides, it is necessary to amend groundwater regulations, particularly on how to enter critical points such as critical areas agreed on, or groundwater tax calculation of both technical and economical measures into the substance of that regulation. To promote voluntary commitment of industry for reuse and recycle program, groundwater and surface water shall be integrated and incentive and disincentive mechanism shall be incorporated into official regulations. Consistency in applying the existing or rearranging policy which will be issued such as giving penalty and license withdrawal to industries that exceed groundwater abstraction limits and applying Pollution Prevention and Polluter Pay Principle properly as agreed strategy in water resources development plan.
iii. Economic Measures: There are several recommended policies which were proposed in the stakeholders meeting conducted under the SWMP research. Such recommended policy includes establishment of incentive and disincentive mechanisms for use of groundwater, like reducing interest bank for constructing waste water treatment and water recycling facilities, and increasing groundwater charge or tax for industry use to the price higher than the water charge of WSE. In addition, if there are no incentive mechanisms in place such as tax compensation for industries that conduct water recycling, not many in industry are interested in water-conservation efforts, making it extremely difficult to control groundwater extraction in the basin.
iv. Technical Measures: In perspective of groundwater utilization and management, a review needs to be done with the aim of maintaining and recovering groundwater level and thus the carrying capacity of aquifers can be sustained. A policy alternative that needs to be conducted is to alter the water source from groundwater to surface water, particularly for industrial use. Another alternative is to relocate industrial cluster to other areas being designed as industrial estate, although relocation of industry to another location where surface water is abundant will also require development of new infrastructure. This option has a significant weakness in feasibility because of high investment, political and social cost that the national and provincial government has to bear. Introduction of appropriate and available technology for recycling is another alternative that can be implemented by industry in order to fulfil its water demand. Support of management in industry and consistency from government in the implementation is a key to achieve success of water recycling program.

v. Informative Measures: Through public awareness and education, like water saving awareness, the related stakeholders at each level should promote how to save water and disseminate both groundwater and surface water problem.
vi. Supporting Measures: Several recommendations were also proposed to cope with groundwater problems. The recommendations include establishment of groundwater proper monitoring system dealing with quantity and quality, land acquisition for conservation area in term of enhancing recharging aquifer both naturally and artificially, and trans-boundary integrated planning.

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