ROMBLON STATE UNIVERSITY
College of Engineering and Technology
Main Campus, Odiongan, Province of Romblon

HANDOUT #5

CE5122 Water Resource Engineering & Irrigation Structures **Tues/Friday – 1:30-3:30/3:30-5:00PM**

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WATER CONSUMPTION FOR VARIOUS PURPOSES

AND

TECHNOLOGIES FOR DRINKING WATER TREATMENT

CONSUMPTION FOR VARIOUS PURPOSES

The water furnished to a city can be classified according to its ultimate use or end. The uses are:

- **Domestic**. This includes water furnished to houses, hotels, etc, for sanitary, culinary, drinking, washing, bathing, and other purposes. It varies according to living conditions of consumers, the range usually considered as 75 to 380 liters(20 to 100 gal) per capita per day, averaging 190 to 340 liters(50 to 90 gal) per capita. These figures include air conditioning of residences and irrigation or sprinkling of privately owned gardens and lawns, a practice that may have a considerable effect upon the total consumption in some parts of the country. The domestic consumption may be expected to be about 50 percent of the total in the average city; but where the total consumption is small , the proportion will be much greater.
- **Commercial and Industrial.** Water so classified is that furnished to industrial commercial plants. Its importance will depend upon local conditions, such as the existence of large industries, and whether or not the industtries patronize the public waterworks. The quantity of water required for commercial and industrial use has been related to the floor area of buildings served. Symons proposes an average of **12.2 m^3/1000 m^2** of floor area per day(**0.3 gal/ft^2 per day**). In cities of over 25,000 population commercial consumption may be expected to amount to about 15 percent of the total consumption.
- **Public Use**. Public buildings, such ass city halls, jails, and schools, as well as public service- flushing streets and fire protection. Such water amounts to 50 to 75 liters per capita. The actual amount of water used for extinguishing fires does not figure greatly in the average consumption, but very large fire will cause the rate of use to be high for short periods.
- **Loss and Waste** . This water is sometimes classified as "unaccounted for", although some of the loss and waste maybe accounted for in the sense that it cause and amount are approximately known. Unaccounted for water is due to meter and pump slippage, unauthorized water connections and leaks in mains. It is apparent that the unaccounted-for water, and also waste by customers can be reduced by careful maintenance of the water system and

by universal or mother metering of all water services. In a system 100 percent metered and moderately well, the unaccounted-for water, exclusive of pump slippage the ideal will be about 10 percent. The losses of MWSS is about 52 percent is very high.

Domestic Per Capita Demand (LPCD)

	1985	1989	1993	1997	2001
General Population	202	206	219	235	254
Urban Development Beneficiaries	115	117	124	133	144
Blighted Population	40	40	40	40	40

For high income population a domestic demand of 400 lpcd may be used.

FACTORS AFFECTING CONSUMPTION

- SIZE OF CITY. The effect of size of the city is probably indirect. It is true that a small per capita water consumption is tobe expected in a small city, but this is usually due to the fact there are only limited uses for water in small towns. On the other hand, the presence of an important water-using industry may result in high consumption. A small city is likely to have a relatively large area that is inadequately served by both water and sewer system than large city.
- CHARACTERISTICS OF THE POPULATION. These are largely dependent upon the economic status the consumers and will differ greatly in various sections of a city. In a high- value residential districts like The Forbes Park in Makati the water consumption is high. In apartment houses, like in Sampaloc, Manila, which may be considered as representing the maximum domestic demand to be expected. The slum districts of Tondo and Quezon City will have low per capita consumption. The lowest figures of all will be found in low-value districts where sewerage is not available and where perhaps a single faucet serves one or several homes.

- INDUSTRIES AND COMMERCE. The presence of industries in a city has a great effect upon total consumption. In estimating present or future water consumption, it is necessary to study the existing industries, their actual use of water and the probability of establishment of more industrial plants in the neighborhood. Zoning of the city will make the prediction of future consumption in various districts far more accurate. Commercial consumption is that of the retail and wholesale mercantile houses and office buildings. Figures are few and widely divergent as to commercial consumption of water; and if the consumption is desired for any district, a special investigation should be made. Use of floor area method has already been mentioned. Another convenient unit for this consumption is the **ground area.** Some investigation indicates that in the highly developed business sections of large cities the water consumption may reach **94,000 m^3/km^2 per day.**
- CLIMATIC CONDITIONS. Where summers are hot and dry, much water will be used for watering. Domestic consumption use will be further increased by more bathing, while publec use will be affected by use in parks and recreations fields for watering grass and for ornamental fountains. On the other hand, in cold weather water may be wasted at the faucet to prevent freezing of pipes, thereby greatly increasing consumption. High temperatures may also lead to high water use for air conditioning.
- METERING . Metering of services consists of placing a recording mete in the line leading from the water main to the building served. Consumers are then billed for the water that they used. Another method is charging by some form of flat rate which has no relation to the actual amount of water used or wasted. If services are unmetered, the careful customers bear some of the burden imposed by careless and wasteful. Lack of service meters has a definite effect upon water consumption. In fact, the installation of meters may so reduce consumption that provision of more water may be indefinitely posponed.
- EFFICIENCY OF THE WATERWORKS ADMINISTRATION. The efficiency of waterworks management will affect consumption by decreasing loss and waste. Leaks in the water mains and services and

illegal use of water can be kept to a minimum by surveys. A water supply that is both safe and attractive in quality will be used to a greater extend than one of poor quality. In this connection it should be recognized that improvement of the quality of water will probably be followed by an increase consumption. Increasing the pressure will have similar effect. Changing rates the rates charged for water has little effect upon consumption, at least in prosperous periods.

PERIODS OF DESIGN AND WATER CONSUMPTION DATA REQUIRED

The economic design period of structure depends upon its life, first cost, ease of expansion, and likelihood of obsolesncence. In connection with design, the water consumption at the end of the period must be estimated. Overdesign is not conservative since it may burden a relatively small community with the cost of extravagant works designed for a far larger population. Different segments of the water treatment and distribution system may be appropriately designed for differing periods of time using different capacity criteria.

1. DEVELOPMENT OF SOURCE. The design period will depend upon the source.

Wells - 5 years

Surface Water impoundments(dam) - 50 years

The design capacity of the source should adequate to provide the maximum daily demand anticipated during design period.

2. PIPELINES

Primary Distribution System, 300 mm and larger - 20 years

Secondary Distribution System, 150 mm- 250 mm pipes - 30 years

Tertiary Distribution System ,75 mm to 100 mm pipes - 25 years

The design capacity of the pipe lines should be based upon average consumption at the end of the period with considerationbeing given to provision of suitable velocities under all anticipited flow conditions.

3. WATER TREATMENT PLANT. The design period is commonly 10 to 15 years since expansion is generally simple if it is considered in the initial design. Most treatment units will be designed for average daily flow at the end of design period since overloads do not result in major losses of efficiency.

4. PUMPING PLANT . The design period is generally 10 years since modification and expansion are expansion are easy if initially considered. Pump selection requires knowledge of maximum flow including fire demand, average flow, and minimum flow during the design period.

5. AMOUNT OF STORAGE. The design period may be influenced by cost factors peculiar to the construction of storage vessels, which dictate a minimum unit cost for a tank of specific size. Design requires knowledge of average consumption, fire demand, maximum hour, maximum week, and maximum month, as well as the capacity of the source and the pipelines from the source.

Technologies for Drinking Water Treatment

Purpose	Technology	Advantages	Disadvantages	Costs
Disinfection	Chlorination	■ Economical. ■ Easy to operate.	■ Chlorine can combine with other compounds to create byproducts harmful to consumers exposed over long periods. ■ Safety problems with gaseous units.	Capital: Low O&M: Medium
	Ultraviolet radiation	■ Easy to operate and maintain. ■ Produces no known toxic byproducts. ■ Safer than chlorine for operations.	■ A secondary disinfectant (chlorine) must be used to prevent bacterial regrowth in the distribution system.	Capital: Medium O&M: Medium
Corrosion control	Limestone contactor	■ Easy operation. ■ Compact. ■ Best for acid waters.	■ Not for very hard, high-iron, high-CO2 waters.	Capital: Medium O&M: Low
	Aeration	■ Easy operation. ■ No chemicals. ■ Also removes other contaminant gases. ■ Best for high CO_2 waters. ■ See aeration systems on next page.	■ Energy costs higher. ■ May have high O&M with hard water. ■ See aeration systems on next page.	Capital: See O&M: aeration systems on next page
	Chemical addition	■ Economical first cost. ■ Very compact. ■ Capable of best lead and copper control.	■ High operation costs—chemicals and equipment/controls requirements.	Capital: Low O&M: Medium
Organics removal: Radon and organic chemicals, including volatile organic chemicals (such as benzene, PCBs, carbon tetrachloride, and gasoline)	Granular activated carbon	■ No gaseous emissions. ■ Low to medium O&M, labor, and power requirements. ■ Relatively low energy needs.	■ Potential waste disposal problems. ■ Very expensive.	Capital: High O&M: High

Technologies for Drinking Water Treatment (continued)

Purpose	Technology	Advantages	Disadvantages	Costs
Organics removal (continued)	Packed column aeration	■ High efficiency for removing volatile contaminants. ■ Low O&M labor requirements.	■ Potential air emissions problems. ■ Might need pretreatment to remove solids and to prevent iron deposits and biological growth.	Capital: High O&M: Medium
	Diffused aeration	■ Simple construction. ■ Low O&M requirements.	■ Potential air emissions. ■ Variable removal effectiveness.	Capital: Medium O&M: Medium
	Multiple tray aeration	■ Simple construction. ■ Low O&M requirements. ■ Low energy needs.	■ Potential air emissions. ■ Variable removal effectiveness. ■ Might need pretreatment to remove iron and manganese and to prevent biological growth. ■ Might be subject to corrosion problems.	Capital: Medium O&M: Low
Inorganics removal: Cadmium, chromium, arsenic, silver, and lead	Coagulation and settling	■ Reliable process. ■ Also removes some organics, bacteria, parasites, suspended solids, and turbidity.	■ High capital and O&M costs. ■ Requires high skill level for operation. ■ Removes only small amounts of nitrogen, nitrites, radium, or barium. ■ Large amounts of sludge generated must be managed.	Capital: High O&M: High
Inorganics removal: All inorganics	Reverse osmosis and similar membrane systems	■ Very high removal efficiency. ■ Simple operation. ■ Insensitive to dissolved solids content. ■ Bacteria and colloidal particles also removed.	■ High capital and operating costs. ■ High level of pretreatment required. ■ Very large volume reject stream disposal problems.	Capital: High O&M: High
Inorganics removal: Barium, radium, cadmium, lead, silver, chromium, nitrites, nitrates, selenium, and radionuclides	Ion exchange	■ Insensitive to flow variations. ■ Usually best choice for removing radionuclides.	■ Spent regenerant waste disposal problems. ■ Might need multiple treatments to remove all contaminants. ■ Pretreatment required to protect resin.	Capital: High O&M: High

Technologies for Drinking Water Treatment (continued)

Purpose	Technology	Advantages	Disadvantages	Costs
Filtration	Slow sand	■ Economical. ■ Easy to operate. ■ No chemicals required. ■ Minimal power needed. ■ High removal of disease-causing organisms.	■ Significant quantities of land needed. ■ Only particular types of sands are suitable. ■ May require more maintenance if high-solids or high-turbidity source is not pretreated.	Capital: High O&M: Low
	Dual or mixed media filters	■ Economical first cost. ■ Only used with pretreatment by coagulation and settling. ■ Land requirements less than for slow sand, but more when coagulation/settling included.	■ Operator training necessary. ■ Pretreatment with chemicals required. ■ May not be suitable for small communities.	Capital: Medium O&M: Medium

Drinking Water Quality: System Options

In some cases, when a contaminant reaches potentially harmful levels in only one part of the service area and/or interferes with only one specialized use, a community might consider **point-of-use** or **point-of-entry devices.** These devices are installed at a homeowner's tap or at the point of entry to a larger area, such as a street or trailer park. Types of treatment available with these devices include reverse osmosis, activated carbon, activated alumina, and ion exchange. The public water supplier must monitor and ensure the quality of water treated with these devices; therefore, the ability to monitor is the controlling step in allowing the use of these devices.

Package plants might offer a low-initial-cost alternative to permanent treatment structures. These are modular units that usually are assembled off site and shipped to the community. The plants contain a number of treatment technologies in one unit and are usually used to treat surface water supplies to remove color, turbidity, and microorganisms. Package plants that remove organic and inorganic substances, however, are also available. Because the operational requirements for package plants are quite significant, except in rare instances a small community should consider using them only if the community can transfer the responsibility to another party (such as the county or a private contractor) or restructure (e.g., combine the local system with other small systems) to improve its ability to operate such sophisticated systems.

Drinking Water Quantity: Conservation

People can do many simple things to use less water, for example, use low-flow shower heads and toilets, place a filled plastic bottle or toilet dam in the toilet tank, or shut off the tap while brushing teeth. Every gallon saved is one less gallon pumped, treated, and delivered to the consumer. A water conservation program can consist of updating building codes, conducting public education, or promoting conservation through financial incentives, such as higher water rates or scaled charging systems. For example, a powerful tool to keep water demand in check is regressive user charges, which charge customers who use more water a higher fee per gallon used. These charges penalize usage beyond basic requirements and encourage people to use less so that they can save money.

Check with your state about water conservation requirements. For example, for more than 10 years, California and other states have required communities planning expansion of water infrastructure to compare structural approaches to expansion (wells, sewers, treatment plants) with nonstructural approaches (leak repair, rate structure modification, and toilet and other water fixture retrofits).

Drinking Water Quantity: Leak Detection

Finding and preventing leaks can save a lot of water. A **water audit** compares the total quantity of water produced with metered water consumption. If the total metered water usage is less than 85 percent of the total metered water production, a systemwide leak detection survey should be conducted. Distribution pipes, treatment facilities, and water pumps all can be sources of large leaks. Finding a leak can be difficult and expensive. Fixing the leak, which often involves excavating covered pipes, can also be expensive. If the leak is severe, however, the expense can be justified.

Drinking Water Quantity: Finding a New Supply

Except for communities with large growth potential or a major new water-consuming user (such as a large subdivision), water conservation, leak correction, reuse options, and regressive user charges may be enough to keep a community from having to seek a new water supply. To justify these programs to members of the community, explain that the programs avoid major capital expenses that go along with developing new water supplies. If a major increase in the demand for drinking water is expected, however, a new water supply might be necessary. This could be an excellent long-term alternative if a relatively pure supply is close and available. Depleting a natural resource, however, always has a price. Keep in mind, too, that increasing the supply will increase the cost of drinking water and will also affect wastewater management costs.

LA MESA WATER TREATMENT PLANT-HOW IT WORKS...

METRO MANILA now has two very large water treatment plants. No longer will Balara Water Treatment Plant be alone in its task of making Metro Manila's water supply safe and pure for drinking.

The new and spanking La Mesa Water Treatment Plant in Novaliches, Quezon City is Asia's largest plant and fourth in the world. This was constructed under *one* single contract at *one* time. It has a design capacity of 1500 million liters per day (ml/d). Now fully operational, the plant initially started operations in March 1982 for only 300 ml/d.

When both plants are working, the total processing capacity of the MWSS will be 3100 ml/d - more than sufficient to keep pace with the growing demand of Manila's expanding population up to the year 1987. The La Mesa Water Treatment Plant will serve the northern half of Metro Manila, while the existing Balara Water Treatment Plant will be confined to taking care of the southern half.

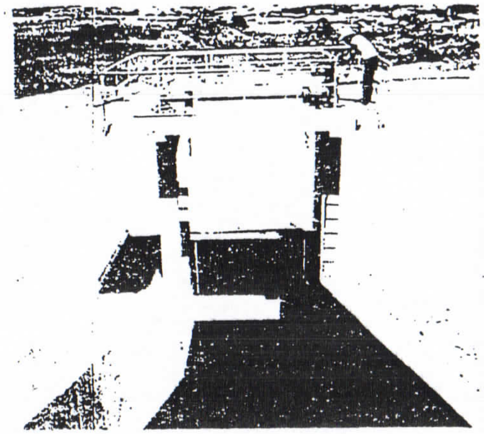
The ₱250-million plant represents the latest state of the art and is a least-cost technological package that features the following innovations:

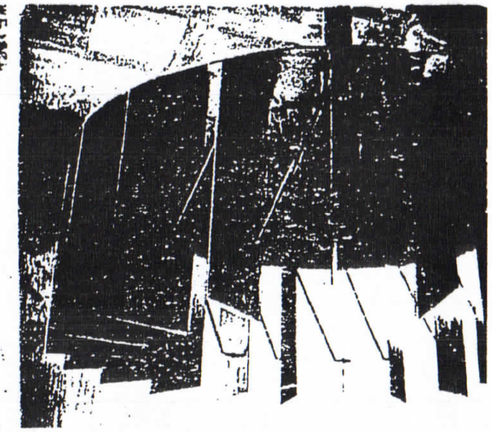
— Energy-efficient design

The plant has very minimal electro-mechanical equipment. It relies mostly on hydraulic properties of water to backwash its filters and gravity to convey raw water from the source, into the plant and out into the distribution system.

— Fluoridation

Concerned with the health of its consumers, the MWSS incorporated fluoridation at both this new plant and the old one in Balara, to help prevent tooth decay. This was done with the blessings of the Ministry of Health and the World Health Organization.



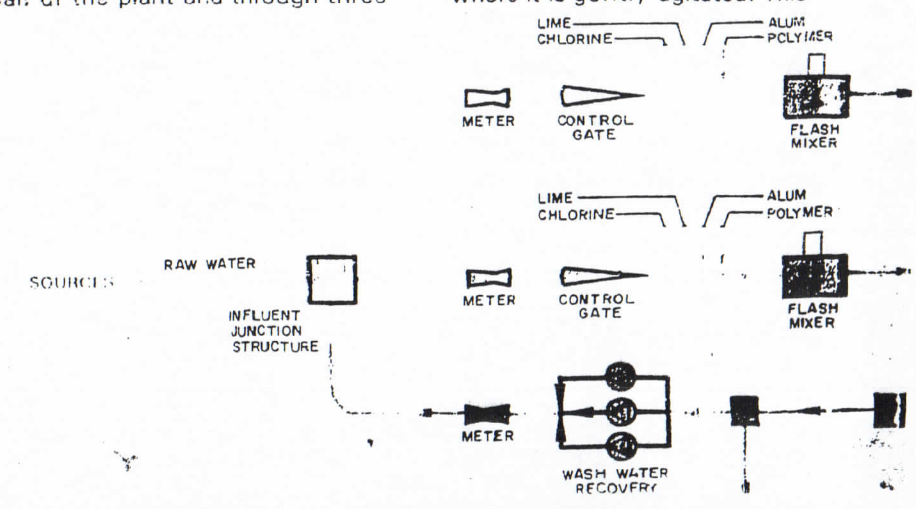


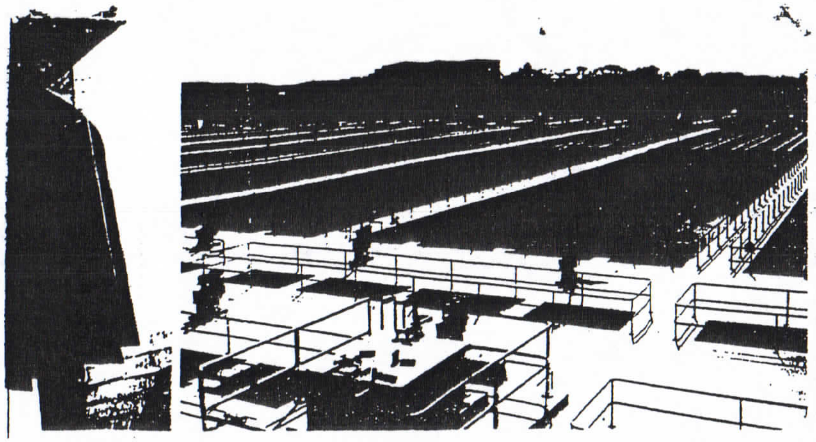
The Process

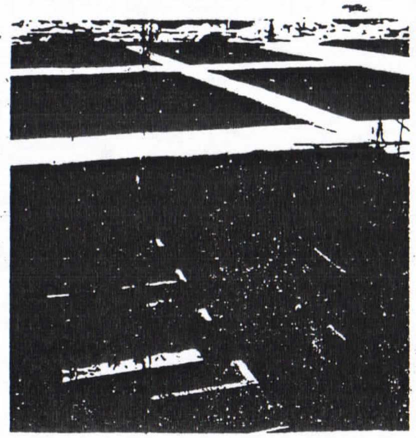
1. **Screening** — Raw water from the Angat-Ipo-Bicti source network travels over 30 kilometers through tunnels and aqueducts before entering the La Mesa Water Treatment Plant. Raw water enters the plant through screens that prevent the entry of foreign objects such as grass, leaves and tree limbs, and other large floatables. The screens thus protect the rapid mixers and flocculators from damage. The water flow is split and distributed through three rapid mixers to the southern half of the plant and through three other rapid mixers to the north basins of the plant.

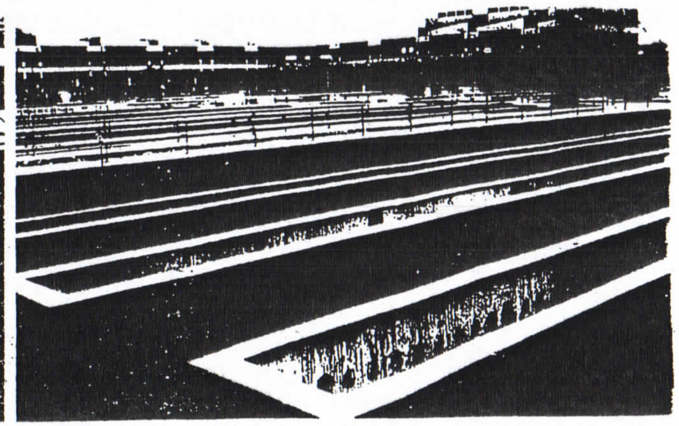
2. **Rapid Mixing** — During this process, rapid mixers uniformly disperse the chemicals (alum and/or polyelectrolytes) throughout the raw water. These chemicals are coagulants which react with undesirable, tiny suspended solids in the raw water, causing the latter to form clusters. Chlorine may also be added for pre-chlorination.

3. **Flocculation** — The water then enters the flocculation basins, 36 flocculators in each half of the plant, where it is gently agitated. This









agitation causes the small clusters of suspended solids to collide with and stick to each other and form into larger particles called "flocs".

4. Sedimentation — The flocculated water then enters the twelve settling basins of the plant, where the floc particles get heavier and settle to the bottom of the basin. Clean water enters the troughs called launders near the top of the basins. The settled floc materials, called sludge, are periodically removed from the basin bottom.

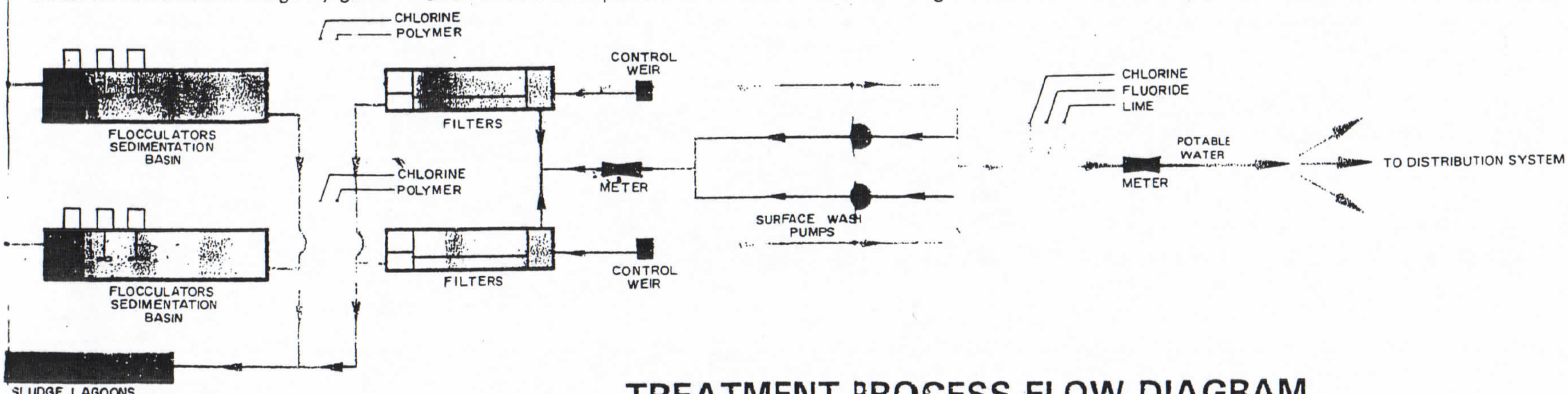
5. Filtration — Purification of the water is done at this stage by gravity. Water flowing from the sedimentation basins is filtered through twenty-four dual-media filters, twelve in the northern half and twelve in the southern half of the plant. Each dual-media filter consists of a layer of anthracite coal on top of a layer of sand. They trap the flocs as water flows down through them.

6. Backwashing — To unclog the filters, each filter chamber is backwashed regularly. This is done by reversing the process of filtration where clean water is put through the filter in reverse direction. Sand and anthracite coal expand and accumulated impurities are flushed into the troughs for diposal. This backwash water and its solids are channeled to settling lagoons to be recovered for another cycle of processing. Using a minimum of equipment, the backwashing process is done by four filters, which perform the backwash operation for an adjoining filter.

7. Surface Wash — The backwash system has built-in surface wash facilities.

8. Post Treatment — Just before the filtered water leaves La Mesa through a 3.2-meter diameter pipe to Bagbag Reservoir, lime, chlorine and fluoride may be added to the water. Chlorine is added to disinfect the water in order to ensure its safeness for the consumer; fluoride, to prevent tooth decay; and lime, to correct the PH or acidity levels of the water, thereby preventing corrosion of the pipes in the distribution system.

9. Storage — A 200-million-liter storage is in Bagbag, Quezon City to maintain a constant head and regulate the flow of water supply to the northern half of the MWSS distribution system.



TREATMENT PROCESS FLOW DIAGRAM