PURE WATER FOR HONOLULU

HONOLULU. BOARD OF WATER SUPPLY

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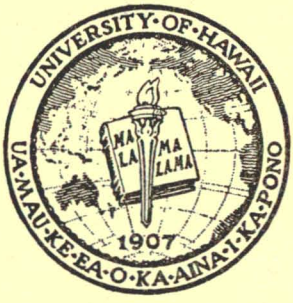

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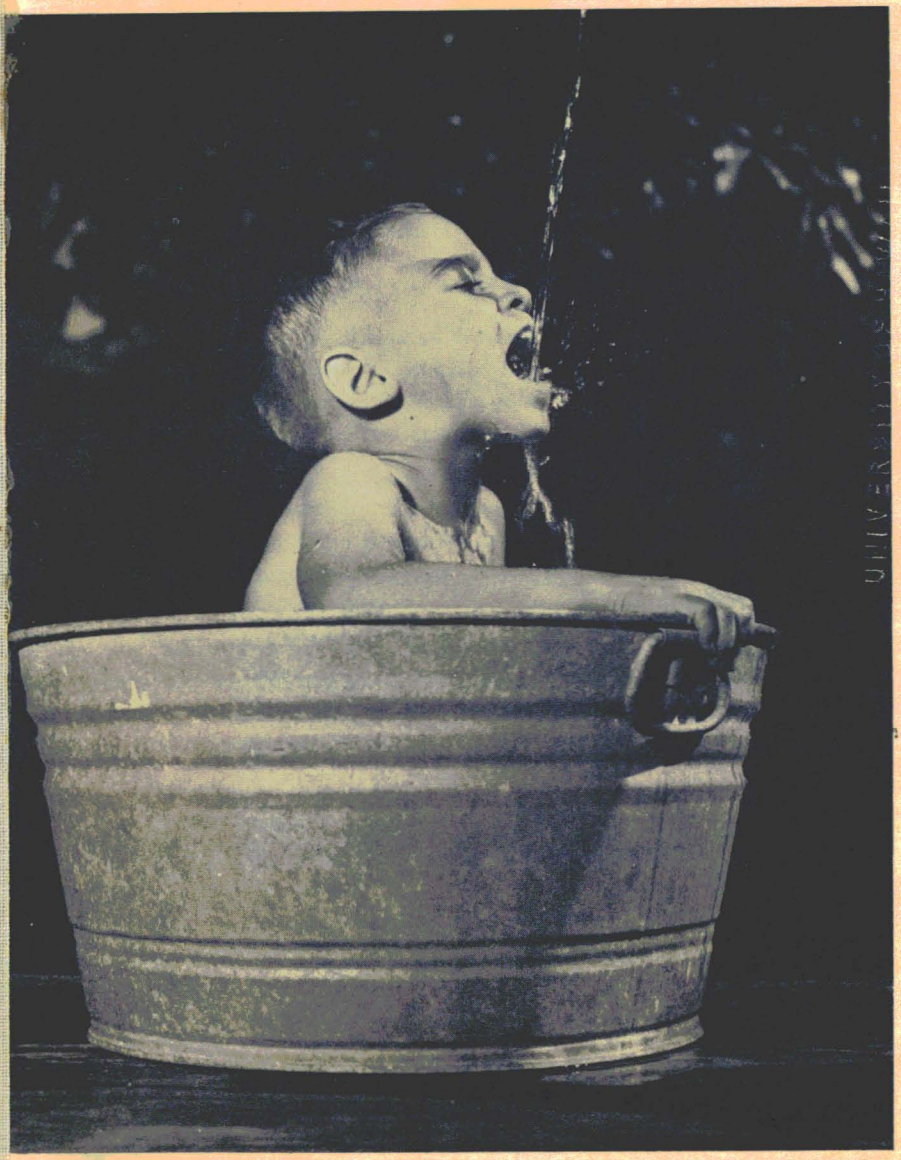

Honolulu

BOARD OF WATER SUPPLY,
Honolulu, Hawaii

FOREWORD

Water supply has been fundamental in the growth of Honolulu. Perhaps no other factor has played such an important part in the agricultural, industrial, and community development of Oahu.

The first ships to visit Honolulu obtained their fresh water by sending small boats with casks up Nuuanu Stream above the salt water tidal area. The first governmentally owned and operated water system was in service on March 31, 1848. Many New England whaling ships made Honolulu Harbor their winter headquarters and took water from a tank near the wharves.

The existence of a large reservoir of artesian water underlying the coastal caprock was established in July, 1879. Mr. James Campbell, the owner of large tracts of land in the Ewa district, engaged James Ashley, an experienced well borer from California, to drill the first artesian well on Oahu at Honouliuli near Pearl Harbor. Encouraged by the success of Mr. Campbell, other islanders carried on and drilled many successful artesian wells.

The first well in the city of Honolulu was completed on the Dr. Augustus Marques property on Wilder Avenue near Punahou School on April 28, 1880. The water rose to an elevation of 42 feet above sea level, establishing the artesian head for the Honolulu district at that time.

The Board of Water Supply of the City and County of Honolulu was created by the 1929 legislature of the Territory of Hawaii to manage, control, and operate the water system in the city. The Board is still the agency responsible for furnishing the people of Honolulu with an adequate supply of pure water.

The Board consists of seven members, of whom five are appointed by the Mayor with the approval of the Board of Supervisors and two are ex officio members. These two are the Superintendent of Public Works, Territory of Hawaii, and the Chief Engineer, City and County of Honolulu. The Manager and Chief Engineer is appointed by the Board.

This publication is the result of many inquiries for information concerning Honolulu's water system.

EDWARD J. MORGAN
Manager and Chief Engineer

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PURE WATER
FOR HONOLULU

By MARY LOU LLOYD

Honolulans take it for granted that their water will be pure, safe to drink, cool and delicious to taste, and unending in supply. Few take more notice of the problem than the mere turning on of a faucet.

Beyond this happy situation, however, is a vastly important piece of work done by well-trained, conscientious workers. The Board of Water Supply of Honolulu is responsible for providing all the water the city needs, clear and safe enough so that citizens need have no fear of drinking it or washing in it.

WHO FORMS THE BOARD OF WATER SUPPLY?

There are nine divisions in the Board of Water Supply. The divisions are: Water Resources, Mechanical Engineering, Water Distribution, Engineering, Executive Engineer, Water Sales, Hydraulic Design and Planning, Land and Contracts, and General Accounting.

Many varied skills are required to operate the system. Included are ground keepers and beginning clerks, as well as highly trained engineers and administrators. Among the different workers are: posting machine operators, oilers, steam firemen, meter mechanics, collectors, chemists, bacteriologists, electrical, civil, mechanical and sanitary engineers, accountants, administrative officers, meter readers, typists, stenographers, pipefitters, janitors, masons, and auto mechanics.

Some of the simpler jobs require only an eighth grade education and a year of experience. Others, more complex, require graduation from an accredited college or university and years of professional experience. There are many different combinations of education and experience between these extremes.

WHO USES WATER?

Everyone in the city uses water. In the District of Honolulu, reaching from the sea to the summit of the Koolaus and from Makapuu Point to Red Hill, there are tens of thousands of households with water piped to them. In addition there are dozens of kinds of businesses that need it for their daily work.

The Board provides many services. First in Honolulu's daily activities comes an adequate supply of potable and safe water, and also the important matter of water in hydrants for fire fighting.

Its major engineering includes the designing of reservoirs, booster pumping stations, water main installations and other additions to the system. Other services to

the public include advice on lawn sprinkler systems, property piping, and water systems for new subdivisions. Its investigation services include two main divisions. First, technicians check for leakages, noises in pipes, water quality and many other factors concerning the supply of water to the city. Second, if a system of property piping was installed many years ago and plans for it have been lost, staff members are trained to use detectional devices in tracing the system for repair or relocating.

WHERE DOES THE WATER COME FROM?

The Hawaiian Legend — The ancient Hawaiians told of Kane and Kanaloa, two of the four gods who came from the sea to Hawaii long ago. In those days the islands were dry except in forested uplands and water was often hard to find.

Like executives and government officials of today these two friendly gods traveled through the islands, making sure that all was well with their people. Growing thirsty, they liked to stop now and then for a drink of awa, a liquid crushed from a root found throughout the islands.

The awa, however, was bitter and strong, and tasted better when diluted. Kanaloa would say at intervals, "Kane, our awa is exceedingly good, but there is no water in this place. Where can we find some?"

And Kane answered, each time, "There is indeed water here," striking the ground with his long, stout spear. Deep went the point of the spear into the rock, splintering it and opening a hole out of which clear water gushed. Two famous pools on Oahu, said by the Hawaiians to have been formed in this way, are Ka-Puka-O-Kalihi (the Water Door of Kalihi), and Ka-Wai-a-ke Akua (the Water Provided by a God) at the head of Manoa Valley.

Modern Geology — Scientists today have a less poetic explanation of water sources. It reaches back into the distant past, when the islands were being formed.

Millions of years ago, the infant island of Oahu poked its steaming head out of the Pacific. Year by year and century by century the youngster grew. From a long crack in its back new lava flows built up more land.

This land began as magma, the molten lava found deep in the earth, exactly the same kind of lava that makes today's flows on the island of Hawaii. Hotter than the most savage fires found at the surface, magma contains gas dissolved in the liquid rock, much as carbon dioxide gas is dissolved in a bottle of ginger ale before the cap is lifted off. The tremendous pressure far below the surface holds the gas in solution.

As the lava approaches the surface, the pressure grows less and bubbles of gas begin to form, like the bubbles in the same bottle of ginger ale when it is uncapped. When the flow emerges from cracks at the surface it takes on a frothy characteristic. The surface hardens slick and smooth and the gas is kept from escaping. The young rock hardens around each small bubble, forming what is called "pahoehoe".

When the flow has cooled a bit on its way down the mountain, it may gradually be transformed into "aa". Like the same bottle of ginger ale when it has gone flat, the gas has been able to escape. On the surface of a cooled aa flow are rough clinkers;

below is a mass of hard, blue rock, of a kind now quarried for road gravel. Below again is another layer of clinker with many jagged bits where air and water can get through. However, this sandwich layer of blue rock cracked as it cooled, and in it are networks of vertical breaks through which water can filter down.

To return to the young island of Oahu, it stretched and cracked as it grew. New flows forced themselves up to the surface from the reservoir of magma under the sea. These channels up through the lava mass became filled with new molten rock under great pressure. Upon cooling, the intruded lava became an unusually dense dike rock, so dense that it was used by the ancient Hawaiians for adzes and other tools. The older rock between the dikes was divided into walled, watertight compartments reaching down through the mountain mass.

Meanwhile, the island of Oahu acquired a few wrinkles on its young face. Valleys were cut by water streaming down its sides. The bits of rock and soil carved from the slopes by wind and rain were washed down into these valleys, forming a hard-packed valley fill and a caprock along the leeward coastline. Eventually the Koolau and Waianae ranges took their present shape. They now have backbones of lava rock, filled with tiny bubbles, honeycombed by hard, cracked dikes, and overlaid with hardened fill in the valleys and along the shore.

Now, the water gathers. The pahoehoe lava, being frothy and full of cooling cracks, has plenty of space through which rain water can trickle. The aa lava also welcomes water. The blanket of rough clinker on the surface has countless holes and cracks for its passage, and the blue rock in the center has many cooling cracks to carry water down. Through this the dikes, reaching up through the mass of older rock, form a network of watertight shafts approximately along the crests of the two mountain ranges down into the center of the island.

The tropic rains drop tons of water each year on the forested mountains. A mat of last year's leaves, ferns, spongy soil, and roots acts as an absorbent blanket to retain the moisture. Drop by countless drop the water filters down through the rock into the heart of the island. A single raindrop may take months to reach sea level. This is why Oahu's forests are of such great importance. Without this spongy surface to hold water, rains would flash off the hills, run off the island in streams, and return to the ocean, lost to man.

Down to the level of the ocean goes the pure rain water. If there were no rain, the island rock would be dry above sea level and soaked with sea water below. (See the diagram on page 7.)

The fresh water, however, makes its way down and fills the spaces in the rock. Because sea water is slightly heavier, the fresh rain water tends to float on its surface. Scientists call this floating pool a Ghyben-Herzberg lens, after the two Europeans who discovered the principle.

The upper surface of this lens-shaped zone of water stands somewhat higher than the surrounding sea level. Its lower surface reaches deep below the level of the ocean. Scientists say that because of the heavier weight of the sea water, the lower edge of the lens-shaped pool stands 40 times deeper below sea level than the height of the upper edge above sea level.

The caprock on Oahu's coastline makes the lens even deeper. It reaches far below the surface of the ocean. Underlying it is more of the porous water-holding rock. This caprock keeps the sea water out. (See the third diagram on page 7.)

HOW IS THE POOL OF WATER USED?

In the early days of the Islands the Hawaiians used only water from surface streams or springs. Later, shallow wells were dug to sea level and the lens of fresh water below the surface was discovered.

Eventually, someone realized the size of the great pool of water lying under Honolulu. People found that they could drill wells down into it, and that the pressure of the water under the caprock would send streams of pure ground water gushing to the surface. This kind of well is called an artesian well, and works on a well-known principle of physics, that water seeks its own level. Fill a U-shaped piece of hose with water, and you'll find that the level will be exactly the same in both sides of the hose.

The first well of this type was dug at Ewa in 1879. So successful was it that between 1879 and 1910 about 430 wells were drilled on Oahu for city water and plantation irrigation.

In a few years some of the wells nearest the sea began to turn salty. It became clear that all of these unregulated wells were draining water from the underground reservoir faster than the rain could replace it, and the ocean began to rise under the fresh water. Some people, forgetting that this source would not last forever, were even using it as a source of power to turn water wheels.

In 1880 the top of the Ghyben-Herzberg lens stood at 42 feet above sea level; by 1926 it had dropped to 23 feet. It was time to conserve this crucially important resource.

WHAT DOES THE BOARD OF WATER SUPPLY DO?

In 1929 a central water-management agency, the Board of Water Supply, was authorized. One of its early programs was the sealing of faulty and leaking artesian wells, and the wasteful draining of the resource decreased. Another early step was metering of all water distributed.

Twenty-five wells of the artesian type are now maintained by the Board and supply water to three steam pumping stations in Kalihi, on Beretania Street and in Kapahulu. They are drilled from about 300 to 600 feet deep, and are set only a mile from the sea. Huge pumps (see the photo on page 10) produce up to about 10 million gallons a day for each station, and the saltiness of the water is watched carefully. The actual pumpage is regulated to prevent the water from becoming too salty for use.

Still more water was needed. About 1900, sugar plantations had developed a new method of digging wells by sinking shafts down to the surface of the water pool and pumping up the water. So expensive was this equipment to install that the Honolulu board did not use it to any great extent until just before and during World War II.

Need for more water has led the Board to install three of this special type of underground station. The Board has pioneered many design improvements and its installation in Halawa Valley is considered one of the best examples now operating.

By this system, a sloping shaft is sunk deep into a hillside, reaching down into the Ghyben-Herzberg pool. A skimming tunnel is driven horizontally into the water-bearing rock and the flow is collected in a sump and pumped into mains on the surface. Some of these skimming tunnels are 1,000 to 1,200 feet long.

Since the tunnels are below the top level of the lens, water flows into them continuously. (See the photos on page 12.) In fact, one of the problems of building a tunnel of this type is keeping it clear of water long enough to finish the digging. These tunnels produce from 15 to 30 million gallons of water a day. The artesian wells and the skimming tunnels together produce about 90 per cent of the water supply of Honolulu.

The dikes confine small but valuable amounts of water also. Since many dikes are watertight, water does not leak from the dike-walled compartments into the mass of bedded lava. In some spots these vertical tanks are tapped to supply homes at higher elevations. Moreover, in a few spots pockets hold water perched high in the mountains, in watertight basins in lava flows, watertight masses of weathered lava, or on dense beds of ash. These too can be tapped for more water.

WHAT MAKES THE WATER PURE?

Keeping the water pure and healthful is one of the Board's most important jobs. No amount of water would help Honolulu much if it were dirty, full of bacteria, or otherwise polluted.

The ancient Hawaiians were wise enough to make rules about water pollution. They forbade anyone to bathe or wash in streams except far down at the mouth, to keep the flowing supply pure for those living along the stream.

Carrying this principle one step further the modern water system uses no surface water whatever. The problems of keeping such water pure are too great to make its use economical now.

Water users in Honolulu are protected from water-borne disease or contamination from the time rain falls on the forest reserve watershed until it comes from the faucets at home. Painstaking work and constant checking by the Board's staff members keeps the water pure every step of the way.

Forest Reserve — An area of 34 square miles makes up the Honolulu watershed forest reserve in the Koolau mountains back of the city. Entry to this area is carefully restricted so that the water does not become polluted before it leaves the surface. Anyone driving over the Pali has seen roadside signs forbidding casual passersby from entering the watershed area, and the Board has good reason for making this rule.

Those given permission to go into the watershed area — water works employees and others who enter it regularly — must be checked every six months to make sure they meet certain health standards.

Intake Areas — Sanitary surveys are made of all intake areas. Before a major pumping station is built its location and design are studied to make sure there is no drainage

or seepage of contaminated surface water. Once the water is in the underground pool it is fairly safe from contamination until it is pumped up for use; however, it could become polluted on its way down.

Samples regularly collected from sources of supply, suction and discharge pump lines, reservoirs and tanks are examined in Board laboratories so that any contamination may be detected promptly and remedial action taken.

The pumps and pipes themselves must be disinfected when they are installed and whenever their repair and maintenance might cause contamination. For instance, bacteria might find a delightful breeding ground in the leather packing of pumping equipment and care must be taken to keep them completely out of the system.

Distribution Points — Over 200 bacteriological samples are collected from various points in our distribution system each month. These points are selected by the Board of Water Supply and approved by the Territorial Board of Health. Sampling points may include faucets in private homes, service stations, schools, restaurants and fire stations and thus water, as it reaches the consumer, is regularly checked. (See photo, page 11.)

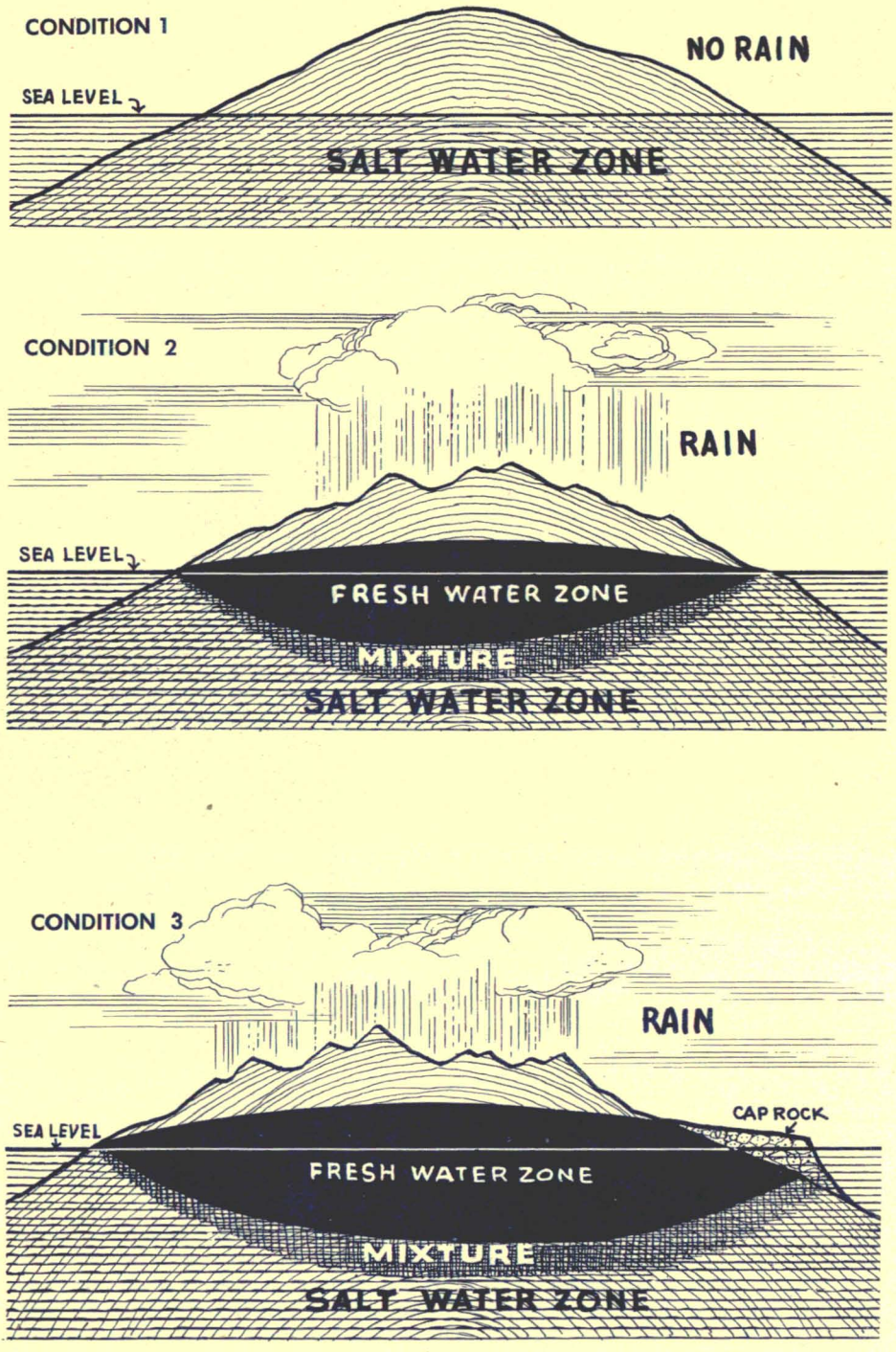
Water Mains — While all water mains are disinfected before they are used to carry water to Honolulu users, the work does not end there. Sometimes the system is damaged and must be made clean before it is used again.

For instance, when a fire hydrant is broken by a careless motorist the water pressure must be cut off for repairs. If contamination is suspected, piping in the whole area must be flushed and disinfected before water service is restored. Follow-up bacteriological samples are taken from this area to determine complete disinfection.

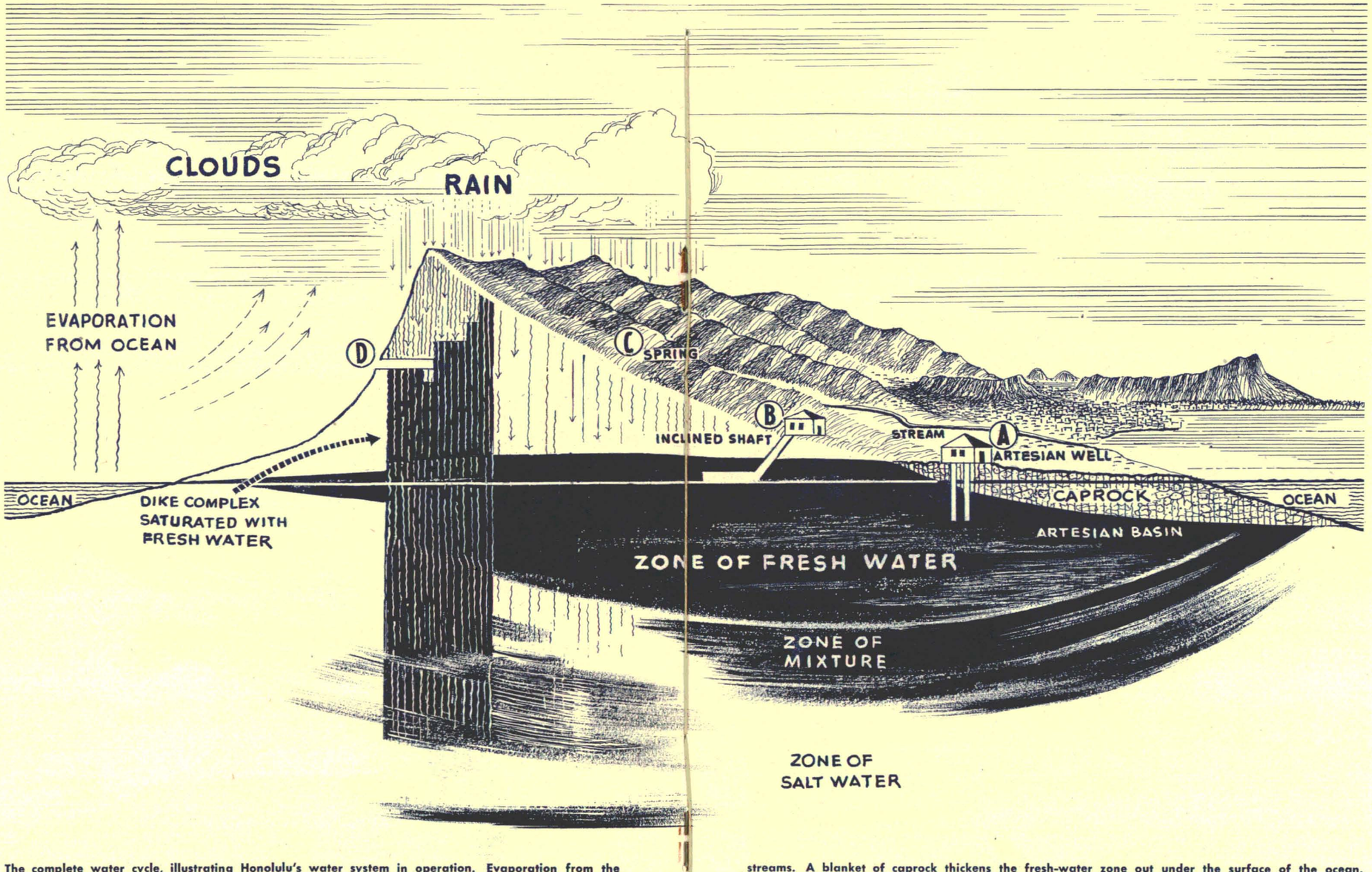
Other Sources — Among other possible sources of contamination are cross connections causing backflow. When pipes from other sources of supply, such as privately owned wells, are connected with the city system there is a chance that contaminated private water may find its way into the general distribution system. If the private source is pure, well and good; if not, it may be a constant hazard to thousands of consumers. The Board is busy finding and cutting out all such cross connections.

Equally serious backflow occurs when nondrinkable water, wastes, and industrial pollution are sucked back into the city system. For example, a hose with its free end in a wash tub or a chemical tank, and the other end attached to a water outlet, may draw soapsuds, chemicals, or other impure water back into the system. This may happen if the pressure in the city system drops through a break in the mains or if there is a heavy demand for fire fighting. The problem here is one of educating water users to be sure there is no way that this can happen.

Testing the Water — All samples collected by the Board of Water Supply are examined by its bacteriological staff in its own laboratories. Monthly results are forwarded to the Territorial Department of Health. The Department of Health in turn submits an annual summary of bacteriological reports to the United States Public Health Service. The United States Public Health Service has given the Board of Water Supply an annual rating of certification of approval.

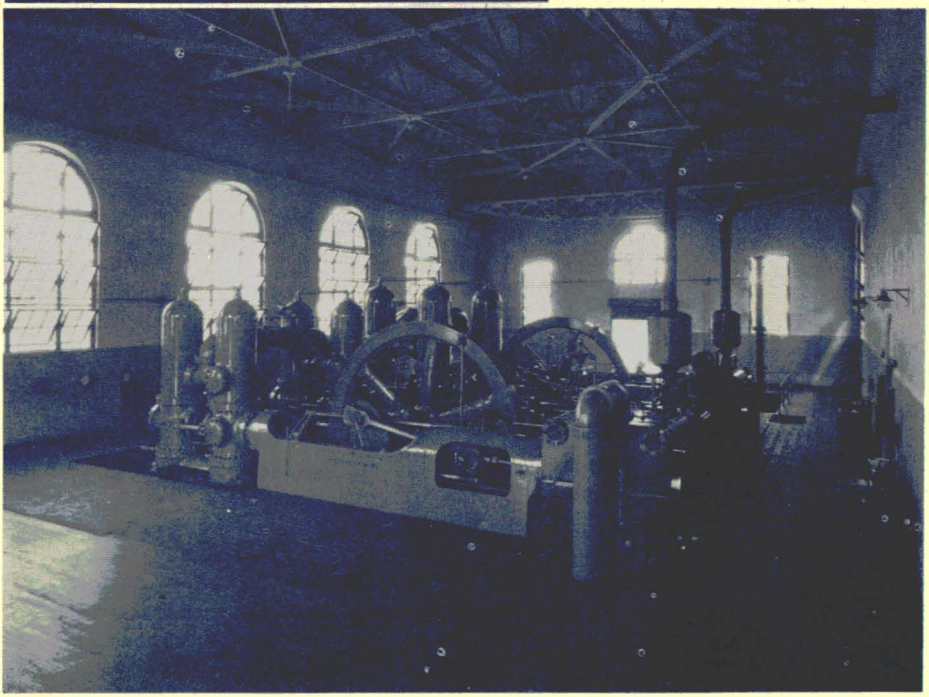


The formation of a Ghyben-Herzberg lens. Condition 3 prevails on Oahu today.

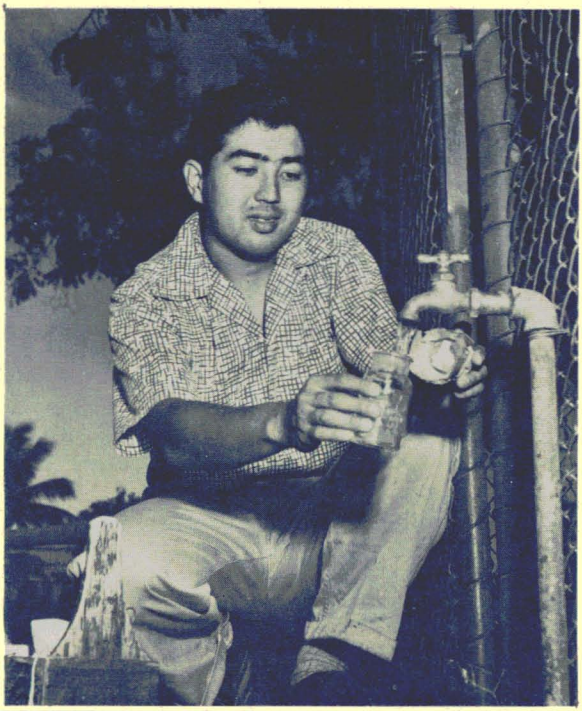


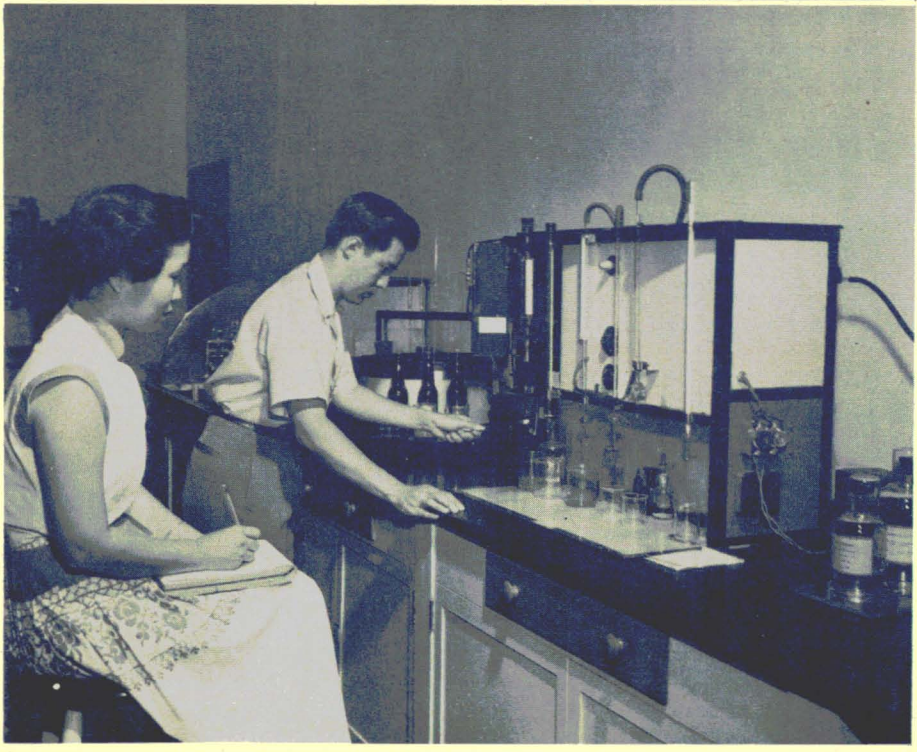
The complete water cycle, illustrating Honolulu's water system in operation. Evaporation from the ocean off windward Oahu forms clouds, at left. As they rise over the Koolaus and cool, condensation occurs and rain pours on the uplands. Some of the water filters down through the water-tight dike complex; much of the rest trickles through the mass of rock into the zone of fresh water underlying the island. Below this zone is salt water. A small amount goes into springs at C, and into surface streams. A blanket of caprock thickens the fresh-water zone out under the surface of the ocean. Some of this pure, fresh water is drawn off by means of artesian wells drilled through the caprock at A. More is taken from well shafts and skimming tunnels at B. Small but important amounts of water are tapped from the dike complex at D. The water is brought to the surface, used, returned to the sea through sewer mains and other disposal methods, and the cycle begins again.

It all began with volcanoes. The photo of the 1935 eruption of Mauna Loa, left, illustrates the process of island formation. Huge pumps, below, bring water up from the depths at the Board's three artesian pumping stations in Honolulu.

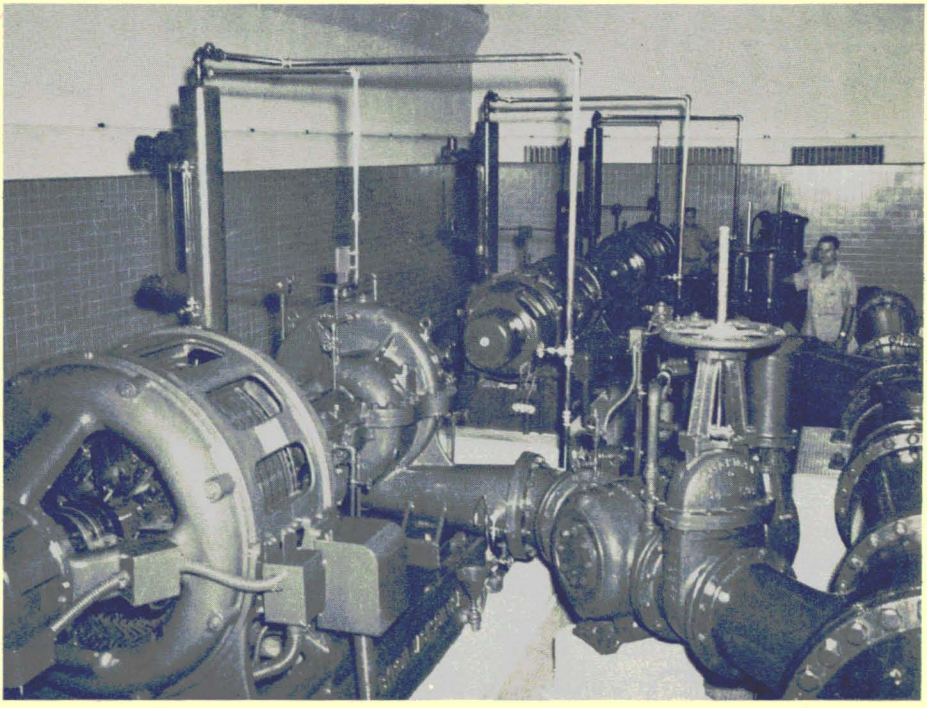


The Board's testing program keeps Honolulu's water pure. Right, a bacteriologist takes a sample from a faucet for testing. Below, an assistant staff chemist runs a titration test for salt content in a water sample.

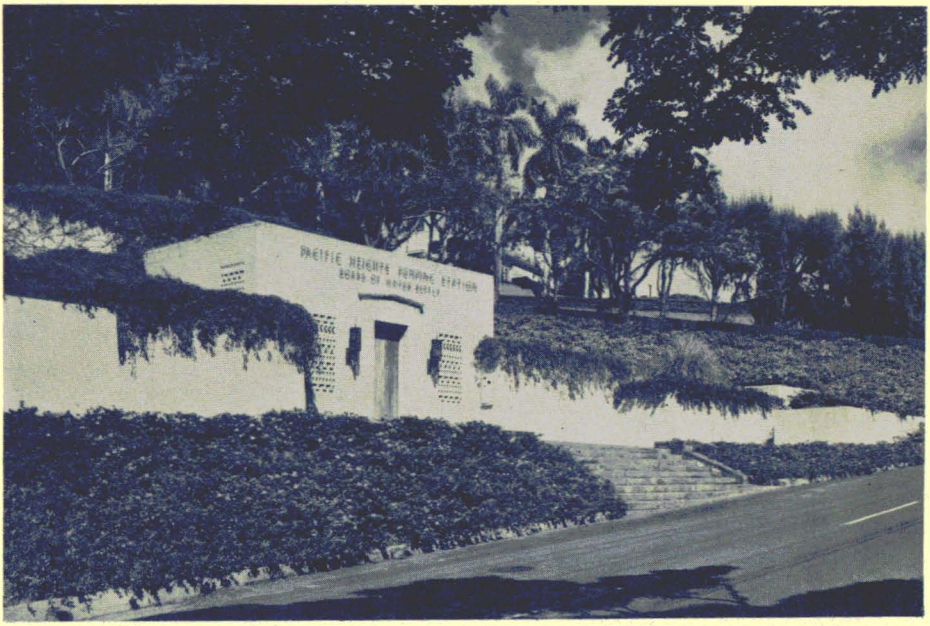




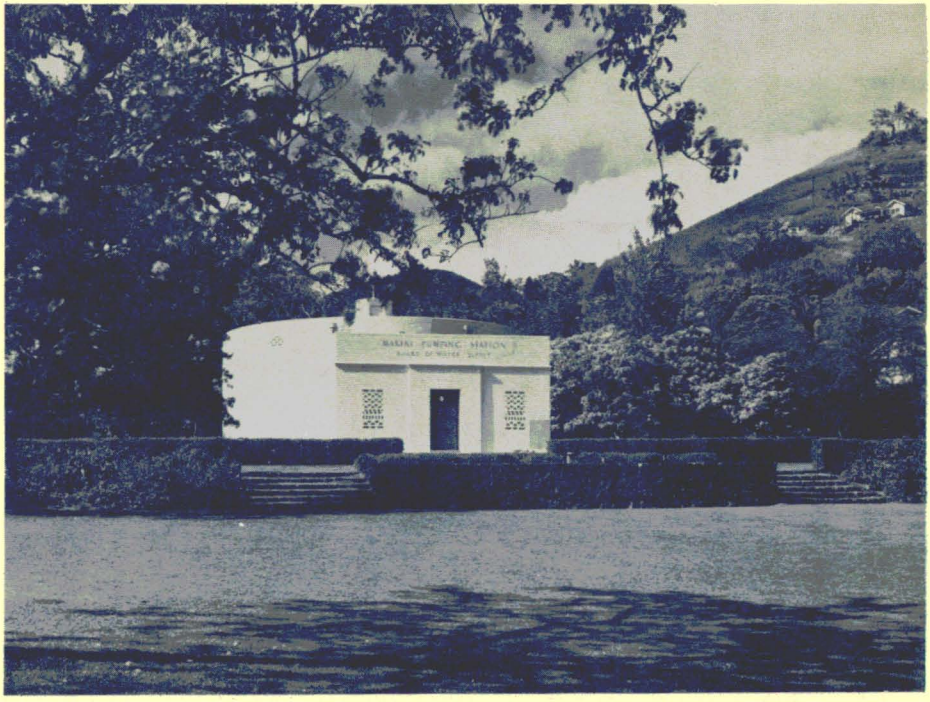
One of the newest types of water installations in Honolulu is the skimming tunnel. Above, water surges into the Halawa tunnel from the water-bearing rock below the surface of the fresh-water pool. Below, powerful pumps bring it to the surface.

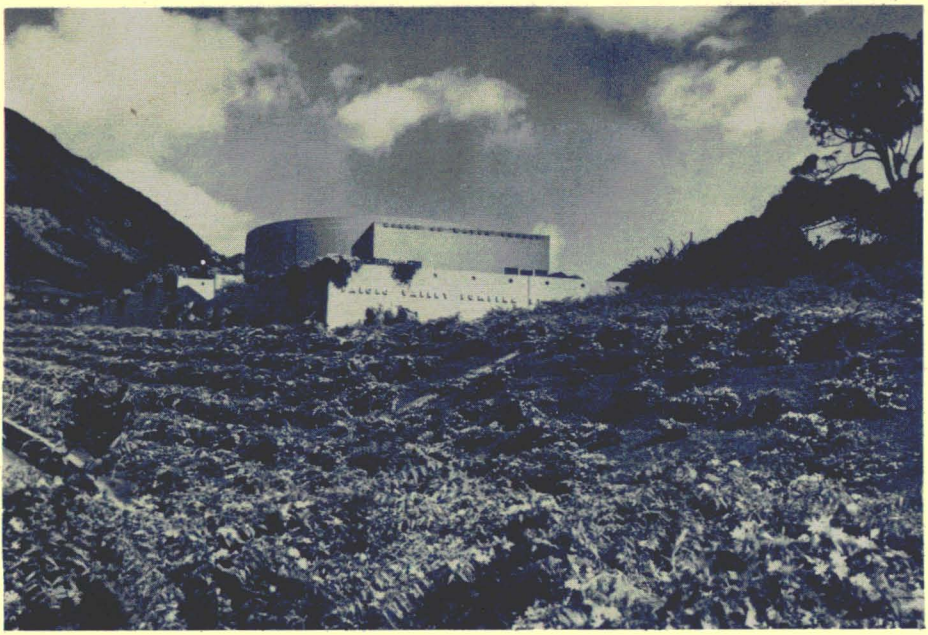


Two of the three steam pumping stations maintained by the Board of Water Supply. Above, the Beretania-Alapai Streets station, adjacent to the central administrative offices of the Board. Below, the Kalihi station. The third station is at Kapahulu and Harding Avenues. These three pump water from artesian wells into the water mains of the city.

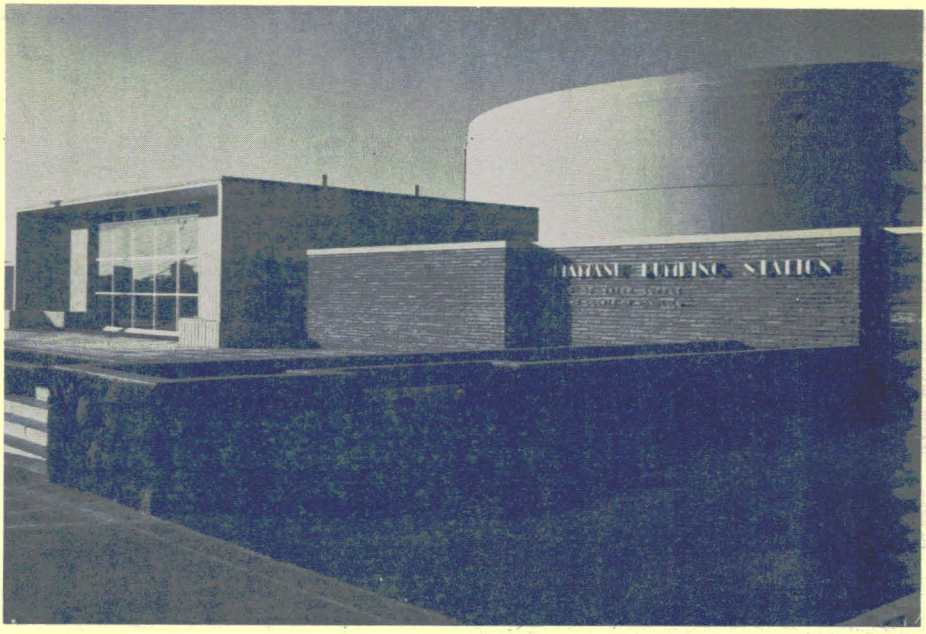


Twin booster stations, examples of the handsome architecture in the water system. Above, the Pacific Heights station; below, the Makiki station. These are beautifully landscaped in the Board's tradition of providing beauty spots for the city.





Pumping stations in the system are both large and small. Above, the imposing Palolo Valley station; below, the Kalihi-Uka station, less impressive but no less attractive. Again, they are designed with attractive landscaping.



Two more impressive Board of Water Supply installations. Above, the Aliamanu pumping station, a youngster among the Board's installations. Below, the lush and beautiful upper Nuuanu aerator, on the Pali road.

BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU

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EDWARD J. MORGAN
Manager and Chief Engineer

Honolulu, Hawaii — 1955

THERE IS PLENTY OF WATER TO USE
THERE IS NONE TO WASTE

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