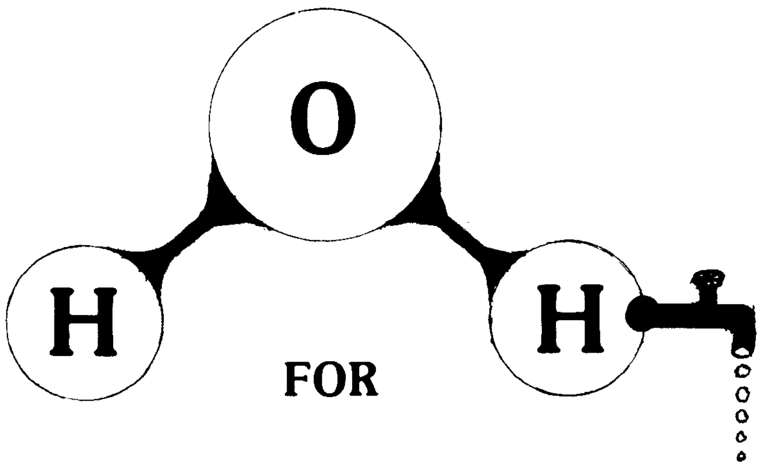
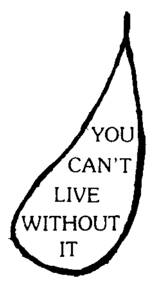
WATER



FOR

SANIBEL-CAPTIVA

CONSERVE
TO
SAVE
IT
BECAUSE

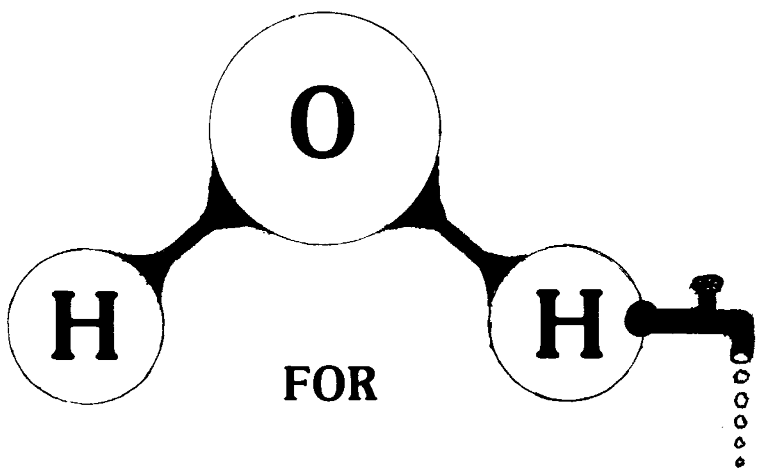


by

Herbert S. Rhinesmith

A Barrier Island Nature Publication
Sanibel-Captiva Conservation Foundation
Sanibel Island, Florida

WATER



FOR

SANIBEL-CAPTIVA

CONSERVE
TO
SAVE
IT
BECAUSE

YOU
CAN'T
LIVE
WITHOUT
IT

by

Herbert S. Rhinesmith

A Barrier Island Nature Publication
Sanibel-Captiva Conservation Foundation
Sanibel Island, Florida

SANIBEL-CAPTIVA WATER SYSTEMS

The Role of Water.

Water has always been a fascinating and truly remarkable substance, even to early alchemists who included it in their four essential elements; fire, earth, water and air. Even today many regard it as the ultimate requirement for life, because of its chemical simplicity, its biological importance, the quantity available and its service to mankind. Seven million tons annually are evaporated from our lakes, rivers, oceans and living organisms, eventually to be condensed and returned to our earth in the form of sleet, snow, ice and rain. In this largest of nature's life-governing cycles, the evaporation of water air-conditions our earth, cools our bodies and purges the atmosphere which we breathe. Our body weight is approximately two-thirds water and each of us requires about one ton per year for maintenance. Every pound of food we grow requires another half ton of water. And finally, within all living systems, millions of miles of arteries, veins, capillaries and cell walls transport, *via water*, the air we breathe, the food we eat and the waste products that result.

Here on Sanibel-Captiva water in general, and potable(drinking) water in particular, is a very special and precious commodity. We need it to support and maintain our unique aquatic life which originated through a rather subtle combination of fresh and saline waters. We also need it to protect the environmental relationships of a delicately balanced ecosystem which many of us are committed to maintain. And finally, we also need water to support the needs, requirements, whims and fancies of some ten thousand people who may one day inhabit these two unique barrier islands.

Water on an Island

Actually the two islands include a total area of 20-square miles, Captiva being about one-twentieth of Sanibel in size. Geologically they exist as a thin crescent-shaped strip of sand, quartz, crushed rock (limestone and dolomite) and shells, held together by intermittent layers of mud and clay. The Gulf of Mexico lies to the south and west of the islands with San Carlos Bay and Pine Island Sound between the islands and the mainland. The question immediately arises as to how and why this tiny bit of land, completely surrounded by salty ocean water and battered by intermittent winds, high tides, storms and hurricanes could have available any useful amount of water? Fortunately for us it does. Much useful water is available, and a look at the historic drainage patterns of the islands will provide a partial explanation for its presence. A more complete explanation will require a bit of water history, a bit of geoolgy and a tiny bit,

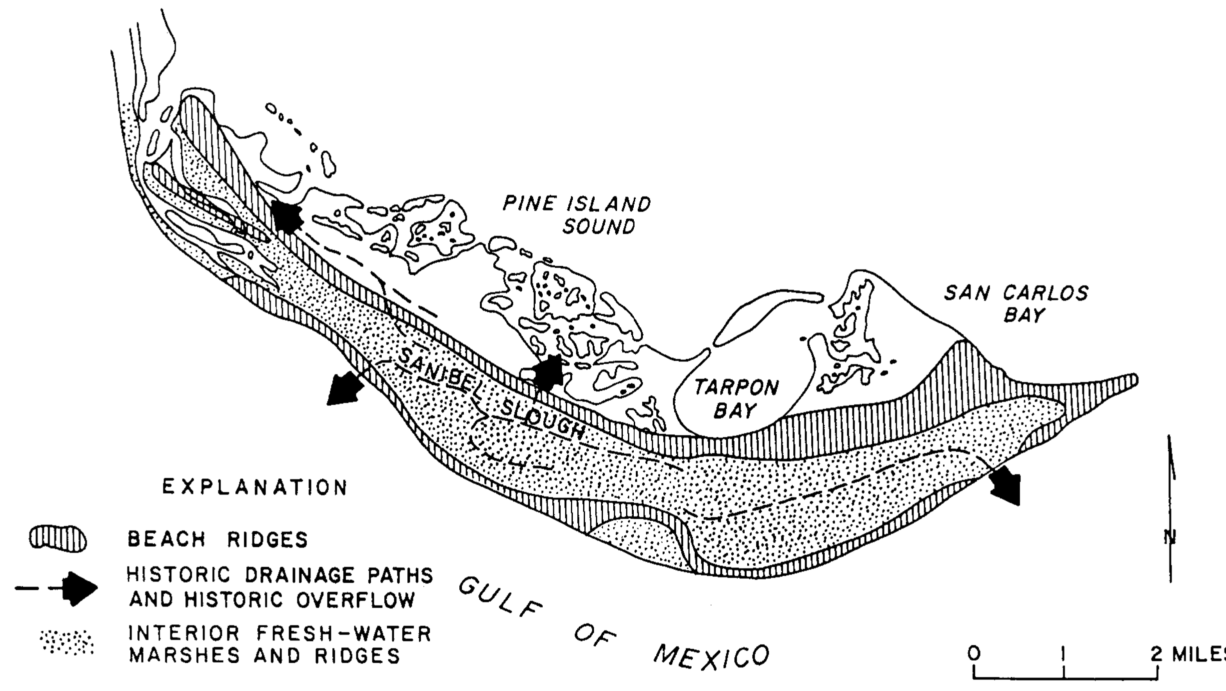


Figure 1

Sanibel Island showing historic drainage patterns (modified from Tabb and others, 1976) indeed, of water chemistry. Finally to resolve the multitude of problems involved in island water production and distribution will require a very hard look at the philosophy of water usage and water conservation.

Historical Drainage Patterns.

The topography of Sanibel Island features two sets of low beach ridges, each roughly four to seven feet above sea level (Fig.1). One of them nearly parallels the crest-shaped Gulf Coast beach on the southern side of the island, while the other follows the northern contours of San-Cap Road (State Road 867) along the tidally inundated salt marshes and mangrove swamps on the northern or Bay side of the island. This is the area which makes up a large part of the J.N. "Ding" Darling National Wildlife Refuge.

Between these two sets of ridges lies the major "wetlands" of the island known as the Sanibel Slough. It too is composed of a parallel system of still lower beach ridges separated in turn by swales or depressions which drain west and northwest along the length of the island. The Slough is seasonally inundated by heavy rainfall at which time the interconnecting swales and several poorly defined water channels combine to form a meandering center drainage system known to local residents as the Sanibel River. This river extends from the vicinity of Tahiti Shores to Beach Road near Shell Harbor, a distance of about eight miles. However, there is *flow* from this river to the Bay only after extended periods of heavy rainfall. The width of the river channel varies from less than ten feet to more than fifty. The river bottom is only slightly below sea level.

The need for fill material to elevate the land for residential construction has led to drastic alterations in the historic drainage patterns by excavating numerous drainage ditches, small ponds, canals and lakes in the interior. In tidal areas similar excavations have occurred for navigational purposes or for mosquito control operations. Road crossings of the river with culvert bottoms several feet above the river bed severely segmented the waterway, and in the dry season actually impounded the water, often causing fresh water from the interior to flow toward the salt water dams or control stations constructed at the low points on Beach Road and Tarpon Bay.

A Bit of Water History: A Few Dates to Remember.

1880: Farming began on the islands about 1880 and in the course of some twenty years Sanibel, Captiva and neighboring Buck Key became flourishing agricultural communities with a very profitable export business in farm products such as peppers, eggplant, tomatoes, grapefruit and watermelons. One farmer reported a profit of nearly

Water management weir for maintaining water levels in the Sanibel River.

$3,000 from 880 crates of peppers and 972 crates of eggplant grown on a couple of acres of land.

1889: The population reached an even 100 which included 40 families and 21 houses. The County School Board offered to provide material for a 16 x 24 x 12 foot schoolhouse, the cost not to exceed $75.00, which island residents would construct. Water for irrigation was essentially brackish from a few shallow artesian wells and rainwater collected in cisterns and small ponds. The bulk of the drinking water was bottled water from the mainland along with some rainwater.

1926: A severe hurricane hit the islands on September 18 and virtually ended commercial farming. This hurricane was not the most destructive of the six which came through the islands in the period from 1888 through 1966, but it was accompanied by 14-foot tides which covered the entire land surface with salt water and salt deposits that took years to leach out through normal rain dilution processes.

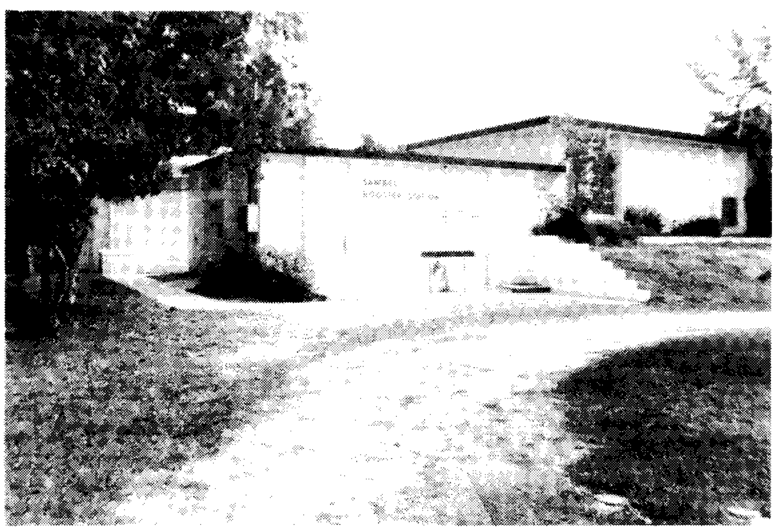
1950: Residential development and tourism began in earnest and soon led to a need for a method of access to the islands other than by boat.

1963: The Fill-and-bridge Causeway was completed and the population began a slow but steady increase. With this increase in population came a parallel demand for clean, safe potable water in quantity.

1965: The need for water and the difficulty of obtaining the satisfactory supply caused the citizens to organize the Island Water Association, a member owned non-profit organization, incorporated under the laws of Florida and franchised by Lee County to be the exclusive supplier of water to Sanibel and Captiva. Officials of the IWA immediately undertook studies to determine the availability of a satisfactory water supply and methods of obtaining this water and distributing it economically to the residents of the two islands.

1966: IWA installed a 9,500-foot underwater pipeline to bring fresh water from Pine Island. The water was purchased from what later became the Greater Pine Island Water Association (GPIWA). The water supplied came from 13 wells of approximately 300 feet located on the mainland east of Pine Island and underwent treatment in a lime softening plant near the well field. The capacity was about 1.4 million gallons per day(MGD). The water distribution system involved three pumping stations located at:

1. Dixie Beach Road, with a 250,000 gallon storage capacity
2. Captiva, with 2 125,000 gallon storage facility
3. Main pumping station, San-Cap Road, with a two million gallon storage capacity



Dixie Beach booster station for maintaining water pressure in eastern portions of the island.

During the following years plans were promulgated for a local source for potable water and IWA directors explored various schemes to accomplish this. IWA finally settled on an electrodialysis desalination plant using water pumped from wells tapping one of the aquifers underlying the island.

1973: Plant acceptance tests for the new electrodialysis facility (ED) which could convert brackish water from deep artesian wells to potable (drinking) water through a process called membrane desalination were completed. The water was obtained from four deep wells, each encased with metal to about 500 feet, followed by open holes to about 600 feet. Other wells in various states of water production were available as supplements, and four additional new wells were planned for the following year. The capacity of the system was 1.4 million gallons per day(MGD) with at least 12 hours per day per well allowed as a recovery period to let new water flow into the pumping area. As the demand for potable water increased the capacity of the electrodialysis facility was built up to 2.4 million gallons per day. Included with the new plant were a fourth and fifth service station located at:

4. Wulfert Road, with a two million gallon storage capacity
5. The Dunes, (County Park), with a two million gallon storage capacity

During this same year the Jamestown-Beachview, Inc. Wastewater System, now known as Sanibel Sewers, was augumented by the addition of a new one million gallon per day (MGD) unit maintaining the original quarter million gallon unit as a reserve. The plant is located at Donax Road and can process a full million gallons of sewerage every twenty four hours including a double chlorination treatment to kill bacteria. This facility serves the eastern one third of the island and collects wastes from more than forty package plants which in turn serve the condominiums, multiple housing units and business complexes. The effluent from the plant is stored in several large settling ponds which, when treatment has been completed, may be used as a source of irrigation water for large areas such as golf courses.

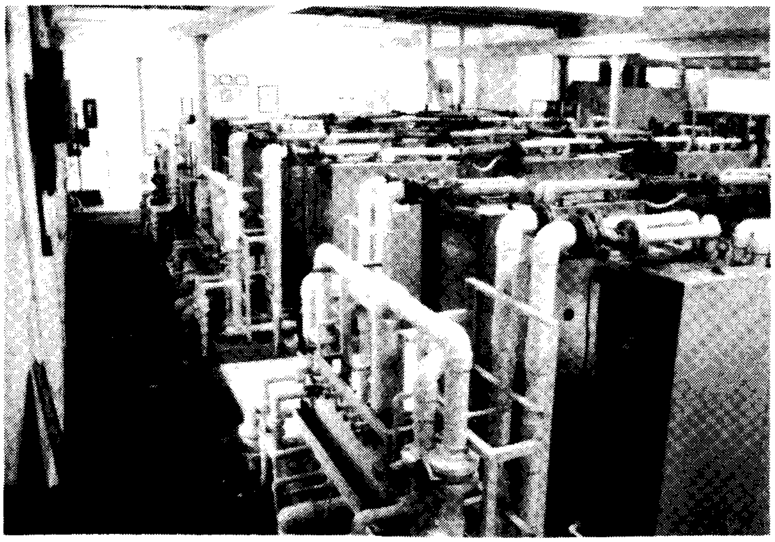
1974: Sanibel Island development and increased water usage brought on land and water-resources problems which resulted in several actions affecting the water supply. First, the United States Geological Survey (USGS) released the Boggess report (2), a two-year study of the freshwater system of Sanibel Island, with special emphasis on the effect of salt water intrusion. At the same time the Sanibel city government issued a general moratorium on all new building permits in order to make decisions on how to govern the accelerated residential growth and the accompanying man-made alterations in the river system. Both of these factors had already accentuated the surface water problems, especially in the interior of the island where the Sanibel Slough was threatened not only with salt water intrusion, but also pollution from run off water and sewer plant discharge. Either of these factors, if not monitored and controlled, could quickly and seriously alter the aquatic environment of the entire island.

Sewage treatment effluent reservoir, or holding pond.

In the meantime the daily water demands on IWA for fresh water were skyrocketing and predictions of a three million gallon per day requirement by 1980 began to seem real. To add to the water problem several of the original wells of the electrodialysis facility were showing signs of deterioration. Pumping fresh water from Pine Island was also becoming increasingly difficult, as well as expensive.

1977: Water management has always been a problem and intrusion of salt water into the interior of a barrier island can do nothing but intensify it, particularly during periods of very high tidal surge. The beach ridges on Sanibel normally offer fairly good protection, but low areas at Tarpon Bay and along the eastern reaches of the Sanibel River have been particularly troublesome. In an attempt to limit tidal surge, a simple board dam or weir was built in 1970 near

Tarpon Bay as a control station. It helped some but was inadequate due to the seepage through the boards and leakage around the concrete construction base. During 1977 a newer and more modern control station was built at Beach Road aided by a partial grant from the Department of Environmental Resources (DER). It was high enough so that tidal surge was prevented up to a level of 3.5 feet. It contained a bottom opening gate which could be opened to let impounded fresh water drain into the salt water canals in neighboring Shell Harbor or closed to keep tidal waters from the lowlands along the Gulf.



Interior view of electrodialysis plant, the earliest IWA system for treating well water.

Also in 1977 a study was completed on the quality of the surface water on Sanibel Island. This study was a geological survey by the United States Department of the Interior with the cooperation of Lee County, the City of Sanibel and the Island Water Association (3). The Investigation was concerned with the slow and often periodic degradation of the surface water not only by high salt concentrations, but by increasing macronutrients and low concentrations of dissolved oxygen.

The salt concentrations (salinity) on the island varied from very low values in a few shallow fresh water wells to the highest concentrations which are found in pure ocean or Gulf water. The highest salinity was found in the Sanibel River near Tarpon Bay and was attributed to leakage from the control system as well as upward movement of salt layers under the island.

Macronutrients are defined as major amounts of elements such as nitrogen, sodium, phosphorus, potassium and sulfur which are essential to both plant and animal life. Dissolved oxygen, which provides the biological oxygen demand (BOD) for aquatic life, varied as expected with the time of day, temperature, water depth and season (dry or wet). It was highest in the moving streams and lowest in the stagnant water in some of the ponds which turned out to be almost anerobic, that is, zero dissolved oxygen. High macronutrients and low oxygen concentrations were attributed in part to urban run off and sewer effluent from direct flow into the surface water. It should be borne in mind that there is no connection between surface water and the IWA well system.

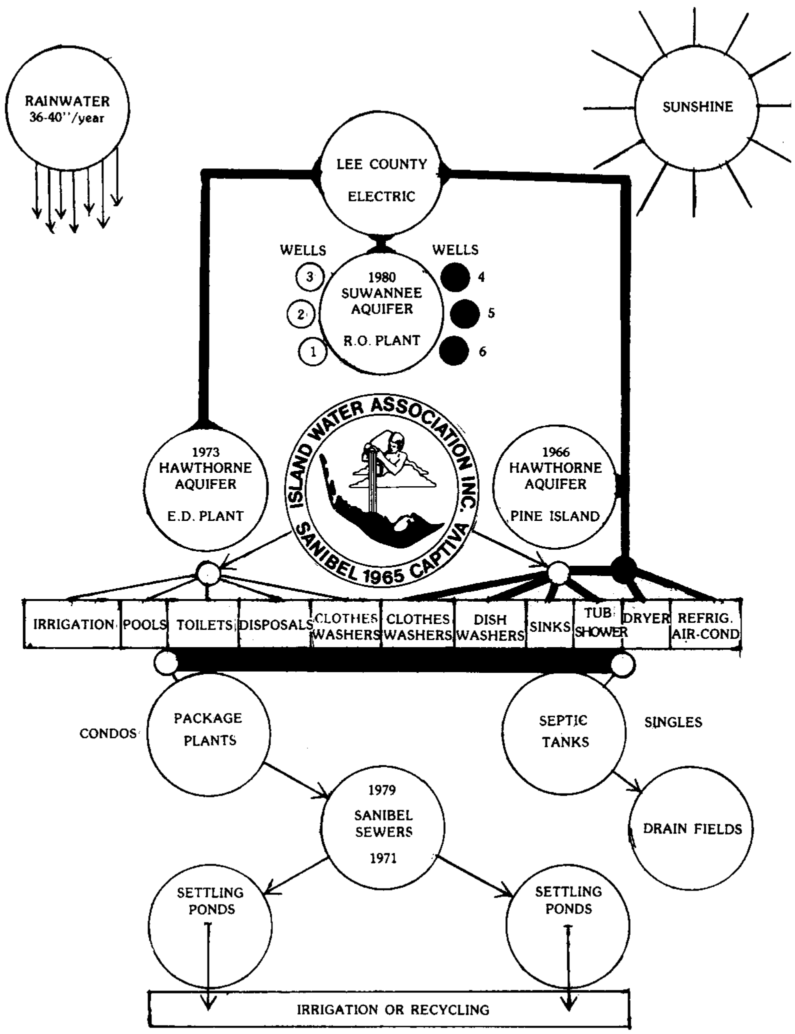
By this time IWA was able to forecast a peak daily demand of about three million gallons per day by the year 1980. After a very careful and thorough study it was proposed that these demands could best be met by a new and very modern osmosis facility. As a part of this study the IWA employed outside consulting firms to prepare a report on the availability of water from deep underground, in what is known as the Hawthorne and Suwannee Aquifers underlying Sanibel Island. Their reports (4) and (5) considered the suitability of utilizing the lowermost part of the Hawthorne Aquifer and uppermost part of the Suwanne Aquifer as a long-term water source for the new reverse osmosis facility.

1980: The reverse osmosis facility was dedicated in May 1980. It was completely computer controlled and operated, and at the dedication the first of six modules was put into operation. Each module has a capacity of 605,000 gallons of water per day which comes from a very deep well, drilled with new techniques, to a depth of 600-900 feet under the island. Future expansion, with all six modules installed, would provide the islands with 3.6 million gallons per day, a supply of good quality water designed to keep well ahead of the 1977 forecasts. Included with the facility were two new storage tanks of 5.0 million gallons each, bringing the total storage capacity on the islands to somewhat over 16.0 million gallons.

But fresh water on a barrier island like Sanibel or Captiva is expensive, more so perhaps than in any other community in the country. Since the primary source of our drinking water is brackish (salty) water from deep in the earth, it must not only be pumped up

Figure 2

THE FLOW OF ENERGY THROUGH THE ISLANDS



but also ''desalted'' by chemical processes, such as electrodialysis or reverse osmosis. From a business point of view our fresh water has to be ''manufactured'' and thus becomes energy intensive, requiring large quantities of electricity as well as large amounts of chemicals in the purification processes. For example, the present cost of electricity (1981) for the reverse osmosis plant is approximately forty cents per thousand gallons of water, and a little less than twice this amount for electrodialysis production. Water from both of these sources is now available to us through a network of pipes and water mains that extend the length and breadth of the islands. After treatment it is excellent fresh water and contains the required amount of chlorine and fluoride to protect our health.

The Flow of Energy Through The Islands.

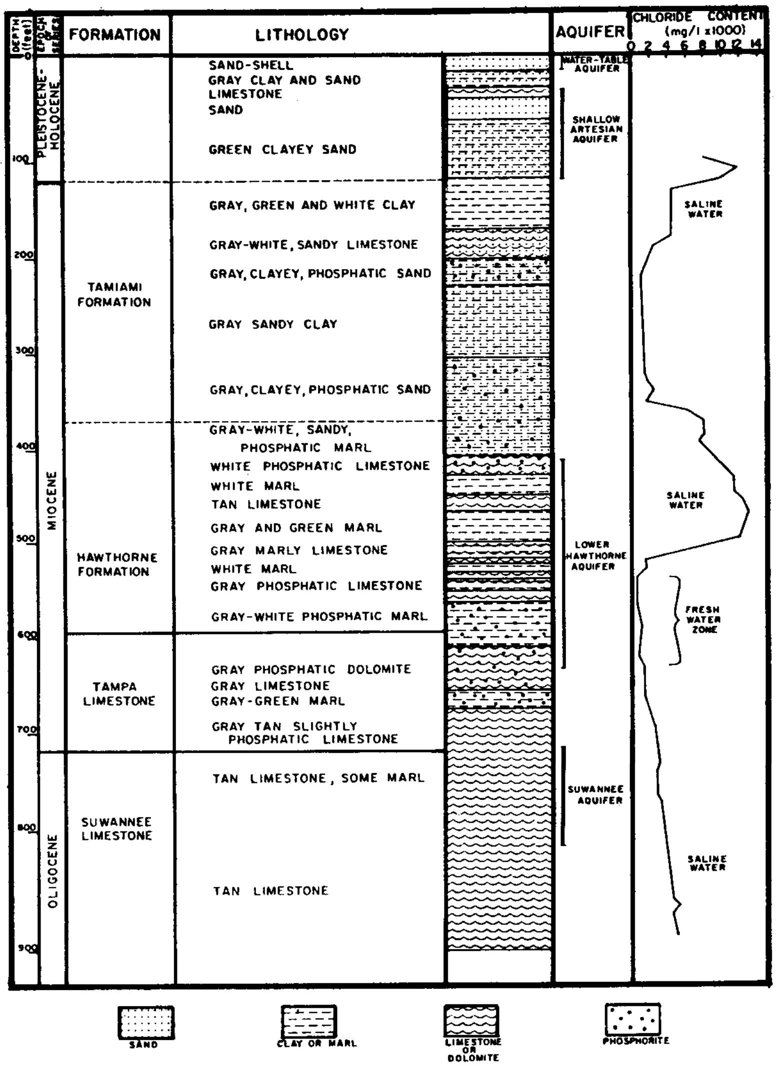
Even a cursory perusal of Figure 2 will make several facts abundantly clear. First, almost every operation on the islands, including all of our water production systems, depends directly on electrical power. Thus the flow of water through the islands is not only energy intensive, but is indeed, electrically intensive and its cost must accordingly reflect the cost of electrical energy. In addition to our water production we heat with electricity during the winter, cool with it during the summer and cook and refrigerate with it every day of the year. We must also recall that one of the primary reasons for required evacuation during a major hurricane is the much publicized warning that if and when a hurricane strikes, electricity will be shut off, and with this closure, water also will be shut off, which means that our homes will be shut off and that we had better not be at home.

Second, both rainfall and solar energy are important adjuncts to our water supply. Our forty inches of annual rainfall is essential for the support of our fresh water aquatic environment. It also dilutes our often brackish or saline surface water, forcing the heavier salt water solutions deeper into our shallow water system. It is hard to believe that somewhere in this world sixteen million tons of rainfall are falling on the earth each second of each day (6). We live in a land of almost eternal sunshine, but the use of solar energy, except for heating swimming pools, is almost negligible. In the immediate future we must look at solar energy for many of our required home operations such as hot water, winter heating and eventually refrigeration. Substitution of solar energy for electrical energy will be reflected in overall water costs.

Third, it should be obvious that our fresh water is ''manufactured'' by the Island Water Association and is distributed to US, the people. Our fresh water has now become ''wastewater'' which contains all the

Figure 3

WELL LOG



contaminants and waste products from the operation of our homes and businesses. There are only two alternatives for the disposition of this wastewater. The lower one third of the island (east of Dixie Beach Road) depends for collection, treatment and disposal on the local sewer system. The remainder of Sanibel as well as Captiva depends for the collection, treatment and disposal of its wastewater on individually owned septic tanks. It should be noted at this point that all wastewater after treatment is returned to the land and becomes part of the surface water system of the islands. Thus the effluent from our sewage system after heavy chlorination and chemical treatment is stored in settling ponds and used for direct irrigation. The effluent from our septic tanks after slow bacteriological and enzymic digestion is stored and settled in the septic tanks themselves, and makes its way back to the surface water system by slow filtration through the drain fields which are a part of each septic tank system.

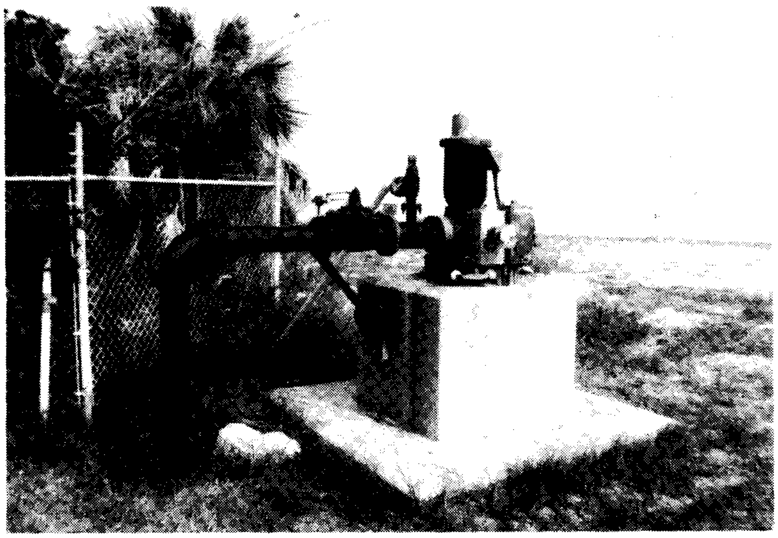
Furthermore, in both systems we have partial degradation of the solid waste materials into sludge and soluble organic materials. Both inorganic and organic nutrients are also formed. Particles known as nitrates, nitrites, phosphates and bicarbonates are released, together with simple molecules like ammonia, sulfur dioxide and hydrogen sulphide, and eventually percolate into the ground area. These nutrients may be removed locally by neighboring trees and vegetation, or, they may continue to percolate laterally though the soil for several hundred feet or more until they connect with some surface water system such as a stream, canal, lake or open ditch, where they become an important source of water pollution. No system is perfect and there will always be places on the islands where individual tests wells show evidence of pollution which is higher than desired. Biannual monitoring and special studies on sources of pollution indicate that both systems on the islands have a reasonably good treatment record.

To understand the geology of our water sources and the chemistry of our water "manufacture" and distribution system it is important to consider both disciplines.

A Little Bit of Geology: The Sources of Our Water Supply.

Located 700 to 900 feet below the surface of the islands is a large volume of water contained in a stratum of earth and porous rock, know technically as an aquifer. This particular one, called the Suwannee Aquifer, is actually very large, extending northward under the State of Florida to the Daytona-Jacksonville area and southward toward the Keys.

When a 1972-74 Geological Survey Study was being conducted on Sanibel more than fifty observation wells or test holes were drilled to collect water samples and to measure water levels. Eighteen of these test holes penetrated the deeper sediments underlying the island. The deepest one on which information was obtained, well L-1533, was drilled to a depth of 895 feet at the IWA facility on San-Cap Road. The well log or geological map of this operation (Fig. 3) gives an excellent picture of the origin of our water supply. It indicates clearly that the Suwannee Aquifer could be a primary source of fresh water. Indeed, brackish water from this deep aquifer is presently being pumped by IWA and processed by reverse osmosis.



Typical IWA wellhead showing motor-driven pump.

Note also in Figure 3 that the second deepest artesian aquifer called the Lower Hawthorne, contains saline water at a depth of 400 to 600 feet and has a rather interesting zone of fresh water associated with it. The lower Hawthorne zone seems fairly well protected from salt water intrusion by rather thick layers of limestone and dolomite rock above it. Sanibel's electrodialysis facility draws most of its water from this source.

The third source of island water is the shallow artesian aquifer which runs 25 to 125 feet below the surface of the island and was initially a source of water for private wells. Thus many of the old homes on Captiva had three faucets in each sink - cold water from a rainwater cistern, brackish water from a shallow well and hot water, which could be either, depending on the source hooked up to the hot water faucet.

Finally, in Figure 3, the water table aquifer which runs just below the surface of the land from about 5 to 35 feet includes the hydraulically connected network of streams, ponds, lakes and canals in the interior of the islands. This aquifer is supplied primarily from rainwater and secondarily from tidal water bodies in the vicinity of the two control stations at Tarpon Bay and Beach Road. Most of the surface water is too salty either to drink or to use as irrigation water.

The Nature and Quality of our water supply:

The brackish or saline water which is pumped from deep aquifers like the Hawthorne or Suwannee is essentially a dilute water solution of simple inorganic compounds previously dissolved from the minerals and rock formations by lake, rain and river water, as it percolates through the outermost crust of our earth. To explain the recovery and purification processes required to convert this brackish water into safe, pure drinking water requires a minimal knowledge of chemistry. The following fundamental definitions are important:

1. An *atom* is the smallest part of an element that can exist and still exhibit the properties of that element. Thus we may have single particles or atoms of such common metals as sodium, magnesium, iron and aluminum.

2. A *molecule* is the smallest part of a compound that can exist and still maintain the properties of the compound. Molecules are composed of multiple numbers of atoms and vary extensively in size. For example, a molecule of oxygen contains two atoms, water three, ammonia four and benzene twelve, but hemoglobin, the red coloring matter in our blood, contains more than ten thousand atoms per molecule.

3. *Protons* and *electrons*. Internally, every atom is composed of equal numbers of positive particles called protons and negative particles called electrons. Since the charges are equal in number but opposite in sign, it follows that all atoms are electrically neutral.

4. An *ion* is simply an atom which has either lost or gained electrons. It is always a charged particle. For example, if a neutral sodium atom transfers one of its electrons to a neutral chlorine atom,

the sodium atom becomes a positively charged sodium ion and the chlorine atom becomes a negatively charged chloride ion. The two ions, being of opposite charge, are attracted to each other, and combine to form a molecule of salt, known as sodium chloride. In water solution the ions always separate and travel about as individual, stable particles.

5. *Impurities* in water. Actually the ''so-called'' impurities which are present in water pumped from our deep aquifers are nothing more than a collection of positive ions like sodium, potassium, calcium and magnesium and an equal number of negative ions such as chloride, bicarbonate, nitrate and sulphate, to mention a few.

6. *Parts per million, ppm*. To evaluate the impurities in water and decide upon the method for removing them, it is important to make it clear that the nature or kind of ions present has little to do with the problem. The only thing we really need to know is the total number of ions or particles present. Analytically, this number is referred to as the total dissolved solids (TDS) and is expressed arithmetically as the number of particles or parts present per million parts of water (ppm). Numerically, this turns out to be identical with the metric unit, milligrams per litter (mg/l).

The following table from the United States Geological Survey (USGS) shows the accepted description of various waters in terms of the impurities present. These impurities are all well known ions and their relative concentrations are expressed in parts per million parts of water. Some interesting information on brine solutions is also included (6).

TABLE I (USGS)

Accepted Water Description	*Impurities in parts per million, ppm or mg/l*	
Distilled water	0 -	
Fresh water (drinking)	0 -	500
Brackish water	500 -	1,000
Slightly saline water	1,000 -	3,000
Moderately saline water	3,000 -	10,000
Very saline water	10,000 -	15,000
Gulf water	35,000 -	Or larger
Brine (from brine wells)	125,000 -	
Brine (from the Dead Sea)	250,000 -	
Brine (from Great Salt Lake, Utah)	266,000 -	

OUR DRINKING WATER, HOW GOOD IS IT?

The chemical composition of our fresh water is checked several times daily. Samples are taken from various stages of the pumping and purification processes and analyzed by trained members of the IWA staff to see that purification is maintained within prescribed limits. At least once each month samples of water are sent to an independent analytical laboratory for more extensive analyses. Small daily and weekly variations in composition can be expected depending on the pumping demands and the recovery time required for individual wells. Larger variations can often be regulated in the desalting processes.

The data presented in Table II are some 1981 values rounded off to whole numbers for convenience. Analytical values for some of the most common ions are presented and the efficiency of the desalting processes can be followed by observing the values for the total dissolved salts (TDS) as the water is pumped and purified.

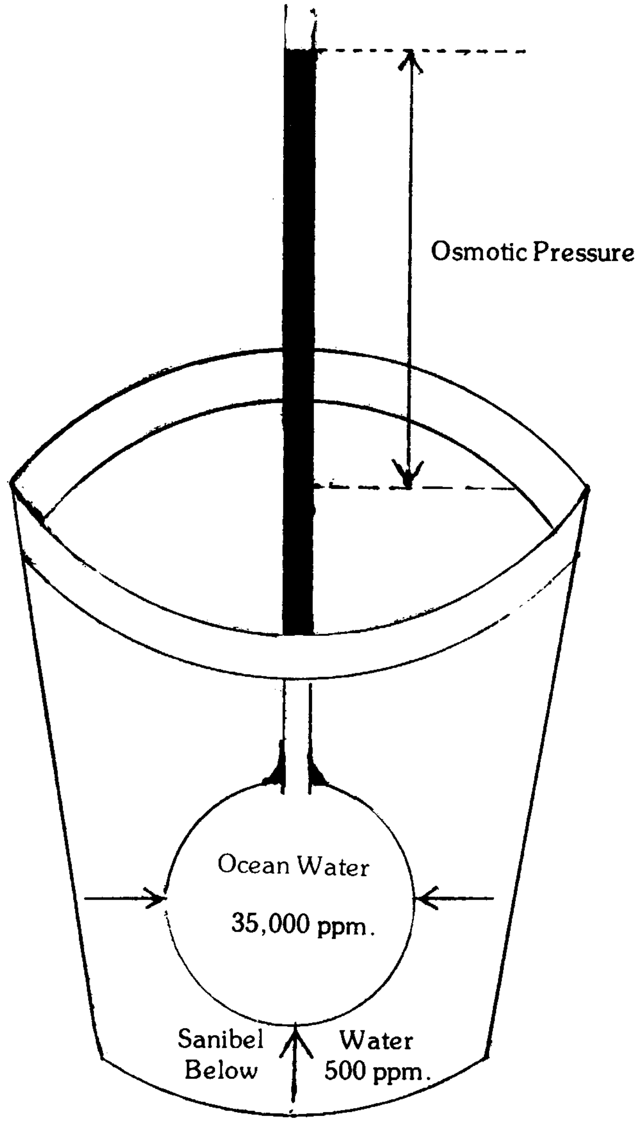
More specifically, columns (A) and (B) compare and contrast the natural impurities in the Suwannee and Hawthorne aquifers, while columns (C) and (D) depict the results of desalination by reverse osmosis and electrodialysis, respectively. The Pine Island water is produced by a combination of both processes. Trace elements, hardness characteristics and other analytical data are not included but are available when needed. When all the information is put together it becomes clear that our water "manufacturing" is producing a product of excellent quality.

TABLE II

Sanibel-Captiva Water Analysis
(Partial List of Ions)

(IONS)	RO Suwannee Aquifer (A)	ED Hawthorne Aquifer (B)	RO Finished Product (C)	ED Finished Product (D)	Pine Island Finished Product (E)
Chloride	1,240	960	60	190	200
Sulfate	350	240	15	100	40
Calcium	135	115	5	20	60
Magnesium	100	85	5	10	80
Sodium	750	350	40	130	90
Bicarbonate	225	220	20	125	120
Total Solids	3,000	2,500	150	700	600

Figure 4 *OSMOSIS*



JUST WHAT IS REVERSE OSMOSIS?

This question is asked many times, especially by visitors to the islands who see the reverse osmosis sign on San-Cap Road a short distance west of Rabbit Road. To answer this question we will illustrate what is meant by direct osmosis and then see if we can reverse this process.

For equipment we need a bucket of water, a length of glass tubing and a fiberglass bag or sac that will hold at least a liter of water. If we fill the sac with ocean water and the bucket with Sanibel drinking water as shown in Figure 4, we will find that water will flow from the bucket into the sac creating a pressure (osmotic) which forces the excess water up the glass tube. Experimentally it has been shown that the amount of pressure caused by the osmosis (water passing through the membrane) is directly proportional to the total dissolved solids (TDS) in the sac.

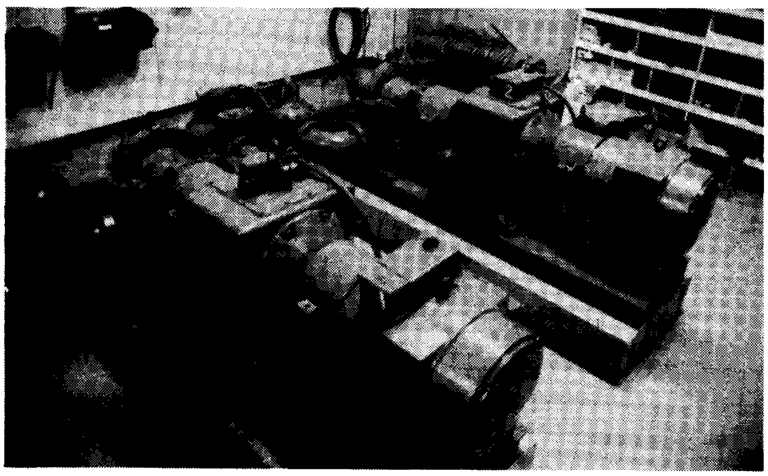
If we now hook up a high pressure pump to the end of the glass tube, we could force the water down the tube, out of the sac and into the bucket. This would, indeed, be reverse osmosis, and is exactly what is done on a large scale in our reverse osmosis facility on San-Cap Road. Here the small fiberglass sac of our experiment is replaced by two standard "hydrablocks" which are large fiberglass reinforced plastic pressure tubes with a capacity of many thousands of gallons. They are filled with saline water pumped from the Suwannee Aquifer and subjected to a pressure of 500 pounds per square inch (psi), or more if necessary, which forces water out of the membranes and into the collecting system. The salts gradually concentrate inside the membranes and are eventually pumped back into the ocean.

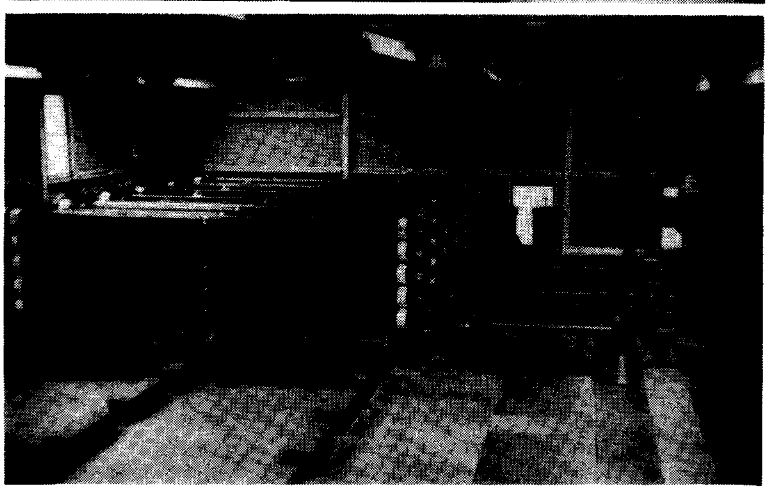
Very simply stated reverse osmosis means that if we collect impure water (brackish, saline or even ocean water) in a suitable membrane we can by pressure alone squeeze or force pure water out through the membrane, leaving the impurities to concentrate on the inside.

AND NOW FOR ELECTRODIALYSIS.

The essential difference between reverse osmosis and electrodialysis is that the latter uses electricity instead of pressure to separate the salt components from the raw water. In the IWA facility for electrodialysis, water pumped from the lower Hawthorne flows through a series of membranes called "Banks" at the rate of about 100 gallons per minute. An electrical potential is applied to the


ISLAND WATER ASSOCIATION INC.
SANIBEL 1965 CAPTIVA
REVERSE
OSMOSIS
FACILITY





outside of these membranes and the positive and negative ions which constitute the salinity pass through opposite walls of the membranes (dialysis) and exit with the waste water (7). Two important items should be noted: First, each ion removed requires an equal amount of electricity which is why the electrical cost is twice that for reverse osmosis. Secondly, when water is pumped from aquifers which are subject to salt intrusion, the total dissolved solids (TDS) may increase to a point where the accompanying electrical costs may make the process uneconomical to operate. It is of concern that lower Hawthorne water is getting saltier and that some of our good wells are showing signs of degrading quality.

AND WHAT ABOUT PINE ISLAND WATER:

It seems important to point out that any water organization whether it be the Greater Pine Island Water Association or the Island Water Association is in the business of selling water and consequently has the duty to meet expenses. If the Pine Island Water Association has excess water and can contract to sell its surplus, that could be called good business. On the other hand, if Sanibel is in the process of improving its electrodialysis facility and expanding its reverse osmosis facility, it could be comforting to purchase a fixed amount of water as a reserve for minor or major breakdowns and/or high seasonal demands. Furthermore, the premium we pay for water that is drilled, purified and pumped to our islands from the mainland, increases the need for the consideration of water conservation.

A LITTLE BIT OF PHILOSOPHY.
IS ALL CONSERVATION GOOD? WHAT DO YOU THINK?

Personally I believe that it is, but I also believe that if we are to discuss conservation intelligently we must agree to deal with the ''extremism'' which a simple discussion of this subject almost always engenders. Take for example, the general topic of conservation in the uses and development of our critical sources of energy. No matter which side of the argument we support, extremism becomes rampant as the battle rages over world supplies of oil, coal vs shale, nuclear vs solar power, electricity vs natural gas, and so down to the top-soil on which we live and the water which we drink, especially if there isn't any.

May I suggest at this point, that we let our minds wander all the way back to the Golden Age of Greece and perhaps look in on

Aristotle, himself, as the creator of the science of correct thinking (logic) argues for support of the Greek concept of "The Golden Mean", a middle of the way guide to excellence. To simplify his arguments Aristotle arranges the qualities of character in simple triads, in each of which the first and last qualities will be extremes or vices, and the middle quality a virtue or excellence. Listen now to some of these triads and consider where your thinking places you.

"So between cowardice and rashness is courage;
between stinginess and extravagance is liberality;
between sloth and greed is ambition;
between humility and pride is modesty;
between quarrelsomeness and flattery, friendship;
between Hamlet's indecisiveness and Quixote's impulsiveness, is self control.

'Right', then, in ethics or conduct, is not different from 'right' in mathematics or engineering; it means correct, fit, what works best to the best result" (8).

And finally, before our quick return to present day thinking and problems, just two notes of caution by our matter-of-fact philosopher. "The golden mean, is not, like the mathmatical mean an exact average of two precisely calculable extremes; it fluctuates with collateral circumstances of each situation, and discovers itself only to mature and flexible reason. .....Also, the golden mean is not all of the secret of happiness. We must have, too, a fair degree of worldly goods: poverty makes one stingy and grasping: while possessions give one that freedom from care and greed which is the source of aristocratic ease and charm. The noblest of these external aids to happiness is friendship (8)." Friendship is the one raw material which is plentiful on our two barrier islands.

To get back to the present discussion of water conservation let us start with a few Sanibel-Captiva water triads and see if the application of the Golden Mean will stimulate our thinking toward a more logical point of view and perhaps a more constructive approach to our water resources problems.

So between conservation and wastefulness is liberality;
between penny-pinchers and spendthrifts, the moderates;
between savers and wasters, the users;
between politicians and radicals, the concerned;
between "natives" and the "snowbirds", the objective thinker who may have an interest somewhere near dead center which may link him with the many who truly care.

TO WASTE OR NOT TO WASTE, IS THAT THE QUESTION?

We may well ask the question: Just what sort of person is the extremist on the lower side of the triads where extravagance and waste often seem to run rampant? The discussion sometimes runs as follows. Turn on the sprinklers, refill the swimming pool, irrigate the golf course, the fruit trees and the lawns. Why not? There is plenty of water, the storage tanks are full and IWA can pump more water if we need it. We pay plenty for our Sanibel vacation and the costs include the water we use.

Of Such Reasoning: On June 17, 1980, our IWA with all pumps working and reserves being rapidly depleted was hard pressed to maintain normal flow, which for that day, at least, reached the three million gallon per day rate for a short time. The cause was probably related to the long dry spell and the need for intensive irrigation.

We should next ask the question: Just what sort of a person is the extremist on the upper side of the triads where intensive saving and dedication to the minutia often seem to be overstressed? Often he is a very thoughtful person, dedicated to the preservation of our natural resources and the intrinsic beauty of our islands. But he may sometimes be a nasty old grouch, irritated with everyone but himself. He will probably do most if not all of the following in a total effort to conserve water.

1. He may remove, disconnect or at least never use his kitchen dishwasher, and garbage disposal, both of which use large volumes of water.
2. He will often collect rainwater or air-conditioning condensate in barrels, small ponds or sub-surface cisterns for future use in irrigation.
3. He will probably beautify his home with native plants and vegetation already conditioned to low requirements.
4. His lawn will probably glisten with crushed rock or better still a mulch of wood chips.
5. If he does operate a pool, it will most likely be covered with solar windows to prevent direct evaporation in the hot weather and to produce heat for the winter.
6. He will not use running water to rinse dishes, to wash his hands and face, to scrub vegetables, to get a cold drink of water or to brush his teeth. Running water is wasted water.
7. He will replace deep tub baths by very quick showers with a reduced pressure head; lathering and shampooing, of course, with the shower turned off.

8. He will wash his car at home with a bucket, a sponge and lots of elbow grease instead of his garden hose.
9. He will apply fertilizer directly to the soil and let rain and not his hose be the dilutent.

THE GOLDEN MEAN FOR THE WATER TRIADS.

Having looked briefly at the extremists on both sides of the water triads, let's place our own IWA in the mathematical center and observe the golden mean theory as it "fluctuates with the collateral circumstances of each of several situations".

Situation 1: The Island Water Association is a business, organized to sell water, and consequently wants its product used and not conserved (false). IWA believes strongly in water conservation; witness its latest publication, "Every Drop Counts", in which many specific water saving ideas are presented. Recently, one of our extreme conservationists, looking to a future of continued population expansion, proposed to an IWA official that a vigorous and intense campaign be initiated which would cut down on water usage by some forty percent. If this were accomplished, replied the official, IWA would go broke within a very short time. As a business profit, it must have water reserves and it must expand its water resources to meet increasing future demands. IWA could well support the slogan, "USE BUT DO NOT ABUSE OUR WATER RESOURCES."

IWA headquarters on Sanibel-Captiva Road.

Situation 2: With sixteen million gallons of water in storage we should be able to meet all demands (false). Actually this amount of water is only a few days supply and should be reserved as a safety factor for "emergency use" only. With a very large pumping distribution system there will always be normal shut downs on a well or break downs in a line. A short while ago IWA technicians spent a number of days helping our Pine Island suppliers maintain their flow and thus, indirectly, ours. Even more recently our own very super computer "refused" to accept a new module. Almost 600,000 gallons a day were held up until a specialist from the home office could be flown in to solve the local problem.

Seasonal demands from the winter tourists now seem almost balanced by lack of rainfall and irrigation demands during the summer months. But sharp, sudden increases in daily demands do and will occur. For these and many other emergencies our reserves are very necessary. We might mention the fire hazard. Even a small or "minor" fire makes heavy demands on both quantity and pressure of our water which we believe our present system can handle. But it should also be noted that we have neither the quantity nor the pressure of water to combat a "Major" fire on the islands.

Situation 3: The "Snowbirds just don't care." They are all water wasters (doubly false). I was a "snowbird" for five years before I bought a permanent home on Sanibel, and I cared very much. Futhermore, the more than forty "snowbirds" from my old home town who enjoyed the islands last year were also people who cared. It would be interesting to know how many of "us" natives were once "snowbirds".

Situation 4: The tourists are all very wealthy and don't care what the water costs as long as it is available to them (false). Listen again to Aristotle's reasoning. "It is poverty that makes one stingy and grasping; while possessions give one freedom from care and greed." It is my personal feeling that people of wealth are instinctively conservative, and they are particularly concerned over the present and future costs of their water.

Situation 5: We want what we want when we want it, and we are willing to pay the price, even when accompanied by a good deal of complaining. This situation I believe, is true to some extent for all of us and the argument merits further consideration. May I begin with my own situation? For a great many years my wife and I washed and dried dishes at home, as well as at a great many church and social functions. I now own and can afford to operate a dishwasher, even though it is the largest water user in my present household. I am willing to conserve water by operating my dishwasher only when full, and at off-peak times to conserve electricity, but very frankly at my age (or any other poor reason), I am tired of washing and drying dishes by hand (a good reason). I intend to use and enjoy my dishwasher.

Some of my good friends on the island maintain beautiful green lawns. As conservationists they water sparsely, they often mix saline canal water with their fresh supply and every once in awhile they have to dig it all up and resod, which can be very expensive. But - they want a lawn, they enjoy a lawn (even the husband who has to mow and fertilize it) and most important of all they can afford this, their pleasure. IWA should provide and sell them the water needed to maintain a lawn in the desert.

My wife and I both love to swim but we can't afford our very own pool. But we do enjoy the ''Aristocratic ease and charm'' of our very friendly neighbors whose lovely pool we do share, especially during the summer months. It is solar heated for the winter, and, of course, IWA provides the water.

Situation 6: A peek into the future. It will take ALL OF US, each making a modest contribution (especially in our kitchen and bathroom facilities) to keep our IWA storage tanks full and slowly to increase both our water production and delivery capacity in the years ahead. We should also remind ourselves that we the people can influence our water destiny just as we have influenced the destiny of our city. We can do this best, perhaps, by a combination of conservation, cooperation and ordinance, or even more readily by rising costs and the accompanying rate increases. And as a final wish for our beloved Sanibel, let us hope that sometime in the not too distant future it can become a ''City State'', an Athens of the south in the true sense of the Golden Mean.

WORLDWIDE WATER CONSERVATION - A PERSONAL POINT OF VIEW.

As a child I spent many summers in northern New Jersey on a large dairy farm, bubbling with cold spring water and traversed by a roaring, splashing trout stream fed by the springs. As a young man I watched the construction of a giant reservoir to impound those sparkling waters for the surrounding cities. Today, as a grandfather, I learned to my horror that the beautiful sparkling reservoir of my childhood was dead, drained to the last drop by the expanding and very thirsty cities.

Later on I lived a few miles from Lake Erie, one of our truly Great Lakes, and watched its slow conversion into a vast eutropic basin by the dumping of industrial and domestic wastes. The famous white fish disappeared, bathing was prohibited, the beaches corroded and the lake almost died. But today there is a happy ending. The fish have returned, the water is sparkling and the lake is alive, due mostly to conservation efforts by a great many people who cared.

In 1955-57 we spent two wonderful years in sunny Pasadena, California. Our rented property required the application of at least one inch of water each week (paid for by the landlord and applied through a complex sprinkler system) in order to make "the desert bloom like the rose". At the same time we watched in unbelief the battle which still rages today between the heavily populated and farmed areas in southern California and the water rich areas in the north, as the state attempted to store and transmit large quantities of water from the north to the south without endangering the environmental beauties and potential of the entire State of California.

About fourteen years ago it was my privilege to co-author a small book which dealt in part with man's attempts to create living substances from inanimate molecular systems and his attempts to find out how nature succeeded in doing just that in the depths of our oceans. The following quotation from the Epilogue seems to summarize well my present point of view on worldwide water conservation.

BACK TO THE OCEANS:

"Frustrated in his attempts to extract the secret of life from nature, man seems determined at times to seek vengeance on nature by destroying the forests; uprooting the crust of the earth, levelling the hills and polluting the atmosphere. Nature counters this madness with its own forces of wind and water. Storms and hurricanes lash the earth in a vain attempt to cleanse the atmosphere; floods swell the rivers and spill them over the earth in a vain attempt to vomit the pollution of man's waste products. In her rage, nature crumbles the mountains, strips off the top soil, leaches out the minerals and returns them all, with some satisfaction I may say, to the depths of the ocean. This battle with nature is a losing game and man is slowly but inexorably being forced back to the ocean for a source of subsistence."

"Already for more than a decade man has been mining the ocean to obtain oil and bromine for his internal combustion engines, to obtain magnesium as a structural metal and iodine as a medicinal. Salt and soda are needed as prime industrial requirements. Man may soon ask nature for the plankton and fish of the seas to supply his protein needs, and as the final insult, he may have to beg for water to drink, through desalination. Nature, however, continues to thicken man's 'dilute soup' which even now has a mineral content higher than the best vichy water. May it please nature to spare us the vichyssoise and jellied bullion cycle!'' (9).

ABOUT THE AUTHOR

HERBERT S. RHINESMITH

Educated at Wesleyan University (A.B.'29, A.M.'30) and Harvard (M.A.'31, PhD, '33) Herbert Rhinesmith has devoted his life to education and chemical research. For 36 years he taught Organic Chemistry at Allegheny College in Meadville, PA., retiring in 1974 as Professor Emeritus. As an educator he was particularly interested in the preparation of students for the health professions such as medicine, dentistry and nursing. As a research investigator he worked in the general field of mental deficiency due primarily to the influence of Linus Pauling with whom he spent two very productive years (1956-57) as a Research Associate at the California Institute of Technology in Pasadena.

His research at Caltech began with the structure of normal, human hemoglobin and soon branched out into related areas of the heart and arteries. His work on the basic causes of mental deficiency was supported for many years by the Pennsylvania Mental Health Association, the Pennsylvania Association for Retarded Children, the American Heart Association and government agencies such as the National Science Foundation and the National Institutes of Health. He is a 50 year member of the American Chemical Society where he served both locally and nationally. He is listed in American Men of Science and Who's Who in America.

Since becoming a Sanibel resident in 1977 he has served as a member of the Research Committee of SCCF where he is especially concerned about the future of Sanibel-Captiva water. He is also active in the Sanibel-Captiva Power Squadron, particularly in its educational programs for safe boating.

REFERENCES CITED

1. Dormer, E.M., 1975, *The Sea Shell Islands, a History of of Sanibel and Captiva,* Vantage Press, New York, 210, p.

2. Boggess, D.H., 1974, *The Shallow Freshwater System of Sanibel Island, Lee County, Florida, with emphasis on the sources and effects of saline water:* Florida Bureau of Geology Report of Investigation, No. 69, 52, p.

3. McPherson, B.F., and O'Donnell, T.H., 1979, *Quality of Surface Water on Sanibel Island, Florida, 1976-77:* United States Department of the Interior Geological Survey, Open-File Report, 79-1478, 50, p.

4. Missimer and Associates, Inc., 1978, *Hydrologic Investigation of the Hawthorne Aquifer System in the Northeast Area, Sanibel, Florida,* prepared for the Island Water Association, 97, p.

5. Missimer and Associates, Inc., 1979, *Hydrolotic Investigation of the Hawthorne and Suwannee Aquifer Systems in the Central Area, Sanibel, Florida,* prepared for the Island Water Association, 102, p.

6. Renn, C.E., 1968, *A Study of Water Quality,* LaMotte Chemical Products Co., Chestertown, MD., 38, p.

7. Vlokert, David and Associates, Inc., 1977, *A Report to the Island Water Association,*
   Volume I, *Summary and Recommendations,* 3, p.
   Volume II, *Evaluation of Future Water Supply and Demand,* 26, p.
   Volume III, *The Distribution System,* 5, p.
   Volume IV, *The Electrodialysis Plant,* 64, p.
   Volume V, *Future Trends and Options,* 77, p.

   1926
8. Durant, W., *The Story of Philosophy,* Simon and Schuster, New York, 412, p.

   1968
9. Rhinesmith, H. S. and Cioffi, L. A., *Macromolecules of Living Systems, Structure and Chemistry, Reinhold Corp., New York, 164, p.*