Localized Wastewater Treatment Facilities

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"LOCALIZED WASTEWATER TREATMENT FACILITIES"

BY

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ABSTRACT

The report describes an alternative to the use of septic tanks for individual dwellings. The major problems confronting the larger wastewater treatment plants (0.012 to 10 million gallons per day) in central Florida are also discussed. Solutions in this report are for individual and multi-unit dwelling treatment systems (to 0.06 MGD). These units can provide 90% biochemical oxygen demand (BOD) and suspended solids (SS) removal in accord with new state and county regulations. A comparison of the large versus the small plants reveals that small innovative plants, though more expensive, are more environmentally sound than the poorly operated large facilities. Flexibility of modularized (using multiple small plant equipment) wastewater systems appear to be a major advantage in expanding areas. Finally, proper control of individually owned and operated units is discussed with some practical solutions offered.
ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

GENERAL

The nomadic trend of the people of the United States has become increasingly overwhelming in recent years. Problems of overpopulation, switching employment, and retirement have caused a new real estate market that has the earmarks of continuing for decades to come. To supply the demands and needs of such a population requires research into the philosophies of these middle income groups of which only the most obvious are condensed here. Human trends seek controlled companionship, a high degree of entertainment, a minimum of public controls and laws, and an environment free of pollutants. Such desires dictate homesites remote from urban congestion, but with the luxuries of schools, fire protection, sewer and water facilities, and power facilities.

Developers are not unconscious of these desires if the economics can be kept in line. Grouping, clustering, and combining all the utility concepts have economic benefits attractive to developers to keep the price low. The very essence of efficiency in most industries is to increase quantity, while production changes or evolution is kept at a minimum. The construction of modular homes, mobile homes,
etc., is today an economic necessity and is a balloon industry about to burst (1).

Rural electrification allows power lines to be delivered to remote locations at a reasonable price, environmental engineering technology allows potable water to the country dwellers; but anti-contaminant laws becoming more and more restrictive from 1973 to 1986 may occlude or obliterate the dreams of a remote homesite without the development of further technology. It is for this problem that this paper will present solutions within economic feasibility to extend knowledge to developers and lawmakers about the "mini" rather than the large wastewater treatment plants. The "mini" aerobic plants offer economic advantages over long distance sewer lines and an environmentally safe distribution of treated wastewater for some rural developments. The optimization for such systems is a function of distances to wastewater treatment plants, elevations, soil mechanics, stream contamination of large point discharges, and less important but more elusive characteristics such as public acceptance of high quality irrigation effluent.

"mini" type of treatment facility is that type of wastewater facility employed in an area where conventional wastewater treatment facilities with sewer line connections are not economically feasible or socially acceptable. "mini" plants can be anaerobic and aerobic. The most common anaerobic type is the septic tank. The aerobic types are an innovation to the field of wastewater treatment.
The acceptance of such systems is vitally important to develop a large percentage of unused land to create a balanced prosperity to underdeveloped counties. Typical of this situation is Seminole County which at present has 61% developable land (land that is not swamp or under water) and 21% more land that can be developed with this new technology. Marginal land and unuseable land for development are shown in figure 1.

This paper restricts its study to the Orange/Seminole counties of Florida, but limited source material necessitates using some of the results of the mini-system applications in Michigan, Pennsylvania and Alaska, where the need for break-through technology stimulated the first such systems and their exhaustive testing.

PUBLIC HEALTH NEEDS AND STANDARDS

Since most of Florida is a recreation haven, with swimming, boating, and fishing, wastewater processing has become the focus of attention. Not only is it important to disinfect effluent to prevent such diseases as: cholera, dysentery, typhus, typhoid, and streptococci; but dissolved and suspended solids must be removed to prevent fertilization of unsightly plant life. Malodor and flooding must also be eliminated. Thus, the State and local governments were quick to adopt and augment Federal Standards (2). Basically, adopted standards restrict all wastewater
effluent to greater than or equal to 90% removal of all impurities. Pertinent standards are shown in Appendix B.

Possibly because of Florida's low population density relative to other states which have accepted small aerobic units, i.e. Georgia, Texas, Maryland, Ohio, South Carolina, Mississippi, Pennsylvania, Michigan, New Jersey and Tennessee, the State of Florida Pollution Control officials are reluctant to accept new technology especially for small wastewater treatment units (3). The concept of ever increasing sizes of treatment plants has been over-popularized at the expense of hundreds of miles of large, costly piping with a multitude of giant pumping stations (many of which are equivalent in cost to a medium sized wastewater treatment plant). Parts of the newest large wastewater plant in central Florida are shown in figures 2A and 2B. Note the propeller aerator dispersing filthy aerosols into the wind, and as beautiful as the new equipment is, the land spreading sprinklers are flooding its area, killing all the trees and plant growth—the very absorbing clarifiers needed for treatment. The greatest disadvantages are:

1. The potential dilemma of a breakdown.

2. The shortage of experience, qualified, and licensed personnel to administrate, operate, and maintain facilities.

3. The unprecidented odor from vented tanks holding hugh concentrations of degrading wastes.
THE DILEMMA OF A LARGE PLANT

3.6 Million Gallons per day, Aerobic, with expansion to 5.5 million gallons per day -- Landspread Process -- 30 Acres Present, 80 acres -- TOTAL

PRIMARY AERATION TANK
(NOTE SPLASH AEROSOL DRIFT)

PROPELLOR AERATOR

CHLORINATION

FIGURE 2 A
THE DILEMMA OF A LARGE PLANT (CONTINUED)

LAGOON

LANDSPREAD SPRINKLERS

SLUDGE BED
(Relatively New)

FIGURE 2 B
How much better it would be to treat individual dwelling's wastewater at their sites to a sufficient degree to remove odors, microorganisms, and grit, thereby minimizing pipeline sizes, eliminating pumping problems to a central tertiary plant, and disposing of effluent at the treatment site. The later would abolish all artificial flooding from poorly operated land spreading sprinklers and provide water and fertilizer at proper densities to promote landscape growth (4) (5).

OBJECTIVES

1. Establish alternatives for solving environmental and economic problems associated with large wastewater treatment plants (single to multiple dwelling services).

2. Establish important parameters for consideration in sizing an optimal economic sewer system with high quality effluents.

3. Determine methods, both practical and futuristic for high quality effluent to protect and guard the health and personal comfort of a community.

4. Apply the above alternatives to an existing system in Seminole County, Florida.
CHAPTER 2

WASTEWATER TREATMENT IN CENTRAL FLORIDA

EXISTING PROBLEMS OF LARGE WASTEWATER TREATMENT PLANTS

The typical problems of rapid population increase are evident in central Florida. Perhaps the greatest of these problems is the increased volume of wastewater and subsequent treatment.

In May of 1966, the existing wastewater treatment plants in central Florida were as follows: 27 in Orange County, 10 in Seminole County and 3 in Osceola County, ranging in design capacity from .002 to 8.0 million gallons per day (MGD) (6). Today in Seminole County alone there are 36 treatment plants. A gain of twenty-six plants in only 6 years. Twenty-six of these plants are 0.1 or less MGD design capacities. It would appear that development has occurred more rapidly than proper planning could control. It is unfortunate, but nevertheless not too late, that zoning authorities did not insist on an optimization program utilizing fast, modern, computer techniques (7) to combine many of these little polluters into a centralized plant. North Orlando could have used a piping network in lieu of the clusters of plants that exist presently. The remaining area of Seminole County has the same problems of widely scattered plants (as shown in figure 1).

An example of the other extreme (overcorrection) is a
recently constructed 5.5 MGD plant constructed in north Orange County to serve the town of Altamonte Springs. See figures 2 A and 2 B. The plant is now operating at .9 MGD with expectations of going to 3.6 MGD as sewer lines are tied in. The center picture of figure 2 B shows the flooding already caused by the landsppread sprinkler system. The construction of this plant was encouraged by Federal Matching Funds under the Department of Housing and Urban Development (PFL FLA 128 U.S.) by Glace and Radcliff, Engineering.

This County location was probably chosen primarily because of cheaper land values in this area(1). The most important constraint of a computer optimization program as mentioned by Dr. Wanielista and Mr. Bauer in their report (7) is the selection of a suitable location consistent with natural assimilative capacities. Such violations are common in central Florida since the groundwater table, as illustrated in figure 3 is high in most areas (8).

Of course, landspreading properly controlled with suitable vegetation and drainage is undoubtedly the best tertiary treatment within economic feasibility(4)(5). Useful crops may be grown and foliage areas increased. It is known that water for irrigation needs is about the same as the demand for fertilizer. The value of the dissolved nutrients in reclaimed wastewater is alone worth $0.055 per 1000 gallons to say nothing of the value of the water. The city of Pomona, California receives $0.26 per 100 gallons for
FIGURE 3. BLOCK DIAGRAM TYPICAL OF CENTRAL FLORIDA SHOWING THE MOVEMENT OF WATER.

Reference (8)
reclaimed wastewater (9), therefore a 5 MGD plant would receive an income of $1,300 per day which is normally disposed of in one method or another.

The public attitude toward having their lawns sprayed from their own fertilizer source is an important constraint. A study made in California, shown in figure 4, (10) by interviewing people from two towns showed an average of 86% for and 14% against the use of treated wastewater as irrigation for:

1. Orchard Irrigation
2. Residential Lawn Irrigation.
3. Golf Course Irrigation
4. Irrigation of Recreational Parks and
5. Irrigation of Freeway Greenbelts.

Also many studies have been made to determine the efficiencies of various plants to absorb nitrogen and phosphorous salts. For instance, red pine can assimilate one inch of effluent weekly. Reed canary grass can consume 1.42 milligrams of effluent salts per liter with 2 inches of landspread per week (11).

Discharging effluent after secondary treatment into streams and lakes, sometimes incorporating lagoons or polishing ponds, has been popular in central Florida. Examples of treatment facilities are shown in figures 5 and 6. It is an acceptable method as long as the degree of treatment is kept
### Attitude Assessment Data

<table>
<thead>
<tr>
<th>Activity</th>
<th>Respondents Opposed</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Town 1 No.</td>
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<tr>
<td>1. Drinking Water</td>
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<tr>
<td>2. Cooking and Food Preparation</td>
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</tr>
<tr>
<td>3. Preparation of Canned Vegetables</td>
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<td>4. Bathing in the Home</td>
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<tr>
<td>5. Swimming</td>
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<td>6. Home Laundry</td>
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<tr>
<td>7. Irrigation of Vegetable Crops</td>
<td>8</td>
</tr>
<tr>
<td>8. Manufacture of Facial Tissue</td>
<td>5</td>
</tr>
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<td>9. Irrigation of Dairy Pasture</td>
<td>8</td>
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<tr>
<td>10. Pumped Underground</td>
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</tr>
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</tr>
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<td>13. Seep Underground</td>
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<td>14. Orchard Irrigation</td>
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<td>15. Toilet Flushing</td>
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<td>16. Residential Lawn Irrigation</td>
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<td>17. Irrigation of Recreational Parks</td>
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<td>25. Industrial Air Conditioning</td>
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### Wastewater Use Attitude Assessment

**Figure 4**  
Reference (10)
MODULAR TANK SYSTEM

AERATION TANK SHOWING ROOTS BLOWER

CLORINATION TANK (HYPOCHLORITE SOLUTION HAD BEEN CUT OFF)

TERTIARY LAGOON (HEAVY HYBISCUS WEED AND EFFLUENT WAS A DIRTY BROWN.)

A TYPICAL AEROBIC PLANT LOCATED AT "LEISURE WORLD", ON THE SAINT JOHNS RIVER—35,000 GALLONS PER DAY—OPERATING AT LOW CAPACITY.

FIGURE 5
MODULAR TANKS (NOTE AERATION EQUIPMENT SCREENS TO PREVENT INSECT INFESTATION)

LAGOON OF HIGH POROSITY (EFFLUENT APPEARED CLEAN)

BLUE SPRINGS, AEROBIC, MODULAR DESIGN ***************

25,000 Gallons per day by the Security Company.

FIGURE 6 A
PLANTATION ESTATES, TRICKLING FILTER PLANT

70,000 Gallons per day Operating at full design rate.

SETTLING TANK, FILTER AND CHLORINATION PIT.

POLISHING POND FLOODING AREA, EFFLUENT CLEAN

FIGURE 6 B
high (90) BOD removal) and the volume of water discharged is low enough to maintain the dissolved oxygen content of the receiving waters above 4 parts per million(2). Thus we have two separate practical methods to dispose of our wastewater, both of which pose intensive enigmas to the alteration of larger wastewater treatment plants.

In support of effluent discharging, Dr. Forbes(12) found that the use of rotenone (poison treatments) at Lake Apopka, Florida, over a period of years killed an estimated twenty million pounds of roughfish, decaying to produce phosphates and nitrates greater than the total of the normal effluents from wastewater treatment plants, citrus fertilizing, and drainage from the muck farms during the same period. Also hyacinth control sprays cause rotting of vegetation. This dead vegetation adds to the fish putrification and depicts some of the major causes of Lake Apopka's eutrophication.

The point in issue is that man's sewage is but a small contributor to the overall eutrophication media causing general water contamination existing today. A large sewer plant can affect the natural balance of a small river, and certainly the concentration of groves and cattle around small lakes will concentrate dissolved solids. This is known and controllable (13)(14) with difficulty.
QUALIFIED PERSONNEL FOR OPERATION

Still another riddle for all wastewater treatment systems is that of qualified personnel to operate, maintain and most important, control the production of a safe, sanitary, and high quality effluent. Florida requires the licensing of plant operators. This license requires two years of on-the-job experience and some background knowledge of Microbiology and Sanitary Engineering. Wage scales are necessarily low because revenues per unit of investment in wastewater and water fields are far below other utilities (15). Generally, a plant operator or top personnel are not degreed people. Eighty percent have not gone beyond the two year college level, and yet are licensed to pour millions of gallons of below standard wastewater into our environment. Many writers in the wastewater treatment field feel that a plant operator should have not only an engineering degree, but should have at least one year of specialized graduate study (15).

A major concern, that appears quite justifiable, in a large number of small plants, is that of the frequency of inspection and maintainance. A low manpower situation dictates few if any "visits" to a plant per month. Discussions with local planners, the General Waterworks engineer, and Southern States Utilities management, revealed considerable reluctance to discuss inspection periods. Generally,
it was stated that each of the small plants, usually trickling filter, were inspected once a month.

A below standard situation existed at "Leisure World", a St. John's River development shown in figure 5. Upon an unannounced visit on February 15, 1972, the author discovered that the liquid chlorination system was not functioning. It may have been shut off to save money or it may have run out of solution, but for whatever reason, this incident shows that strict laws and frequent inspections are necessary. Another example of sub-standard maintainance is the Kingswood Manor plant which has contributed to the eutrophication of Lake Weston. Some pictures of the plant are shown in figures 7 A and 7 B. General Waterworks has scheduled public hearings for complaints against the company. These problems exist with the public reaction to the expansion of a present system already causing eutrophication.

To provide better inspection, control and enforcement, Orange County has proposed a "Greater Sewer Authority" as outlined in figure 8 (16). Seminole County has finally recognized the problem and has appointed a full-time one man Sewer Authority (17).

Costs of wastewater treatment systems are illusive. First a great deal of detail study of population densities, projected increases, soil type, costs of land and utility rights-of-way, contours, and finally the economic structure
KINGSWOOD MANOR TRICKLING FILTER PLANT

0.35 Million Gallons per day, Typical Overloaded System with poor Maintenance

ONE OF TWO TRICKLING FILTERS

CHLORINATION LABYRINTH (MUDDY EFFLUENT)

TERTIARY POLISHING POND
(NOTE SOLIDS IN FOREGROUND)

EFFLUENT STREAM TO LAKE WESTON
(APPEARED MUDDY)

FIGURE 7 "A"
KINGSWOOD MANOR TRICKLING FILTER PLANT (CONTINUED)

0.34 MILLION GALLONS PER DAY, TYPICAL
OVERLOADED SYSTEM WITH POOR MAINTAINANCE.

SLUDGE TANK & DRYING BEDS
CLOSEUP OF SLUDGE CAKE
BROKEN DOWN SLUDGE PUMP
WITHIN OFFICE BUILDING

FIGURE 7 "B"
Reference (16)
Total 38 persons

Orange County Commissioner's
Greater sewer authority FIG 8
of the serviced area are necessary to determine economic feasibility. Then, for eleven different areas for example, there are over 1000 different combinations which lend themselves to machine analysis available at certain universities such as Florida Technological University. Generally the wastewater treatment plants of central Florida are sized to 10 MGD or less. Within this range there exists an interesting cost study combining existing systems in several different arrangements to produce an optimum configuration\(^{(17)}\)(\(^{(18)}\))
CHAPTER 3

INDIVIDUAL WASTEWATER DISPOSAL SYSTEMS

AN APPARENT CONFLICT

Septic tanks are historically the answer to all rural wastewater disposal problems. However, the conventional septic tank has some obvious disadvantages which are the results of its design and operation. A typical section of a septic tank is shown in figure 9. Basically, it is an anaerobic system producing methane gas, which is both asphyxiating and explosive, and must be kept covered, making maintenance difficult. Its size must necessarily be large to accommodate a long detention time for the anaerobic process (800 to 1,000 gallons per household) and sludge accumulates to clog drainfields frequently. The effluent requires a very specific type of soil to properly drain and filter the highly contaminated wastes. Virus exists in abundance and can easily filter through many feet of soil. A well, located downstream, may very easily be contaminated by septic effluent through porous soil. The septic tanks however, have one very important advantage over all other systems; they are the cheapest form of wastewater treatment.

Design consideration for septic tanks requires two to five people per acre - which means present restrictions
DIAGRAM OF A TYPICAL SEPTIC TANK FOR 3 - 4 BEDROOM RESIDENCE

INLET

4"

5'

4'

5'

7 1/2'

EFFlUENT

SLUDGE

OUTLET

4"

SOIL PIPE

DRAINFIELD IN FLA. IS 255' LONG

6" CONCRETE

FIGURE 9

Reference (19)
require one dwelling per acre (20). Today in central Florida, a mobile home park contains about 6 mobile homes per acre or about 15 to 18 people per acre. A controlled sewage system is necessary since a septic tank cannot be used. In addition, most of these parks are located at an uneconomical distance for transmitting wastewater to the nearest centralized sewage plant (other than privately installed systems). Therefore there exists the need for small plants, but the small plants are poorly operated and septic tanks cannot be used.

SOIL CONDITIONS AND LAND REQUIRED FOR TREATMENT

The soil structure determines rates of water percolation and is therefore important for landspread opportunities. One fact alone is important - that of landspreading treated water at two inches per week per acre (4)(5). Thus, at 2 inches of water per week, one acre holds $43,560/6 = 7,250$ cu.ft. x 7.48 gallons per cu. ft. = 54,000 gallons per week which can be assimilated by one acre of land. If we choose a 10 MGD size plant, then $10 \times 10^6 / 5.4 \times 10^4 = 185$ acres is the proper requirement of St. Lucie, Blanton Sand for the effluent to properly pass into the aquifer we all drink from. Why then should we deny the privilege of an individual to have his own 90% to 95% treatment plant in his own backyard to landspread his minute effluent to the great aquifer? If 5 is the average number of persons per dwelling
in Seminole County and 105 gallons per capita day is used, then about 525 gallons per dwelling flows out each day.

Therefore, \( \frac{54000}{525} \) GPD \( \times 7 \) days = 14 houses or 70 people per acre is theoretically possible. However, paving access and living quarters require up to 50% impervious coverage and a feasible density would be more like 50% of 70 persons or 35 people per acre providing \( \frac{1}{2} \) of the land is available for landspreading effluent.

NEW TECHNOLOGY FOR INDIVIDUAL WASTEWATER DISPOSAL SYSTEMS

There are available today individual units that can treat wastes from a domestic domicile. These are small tanks obtaining a 90-95% BOD removal by aerobic treatment. This is equivalent to the claims of the large wastewater treatment plants. Equipment such as the "Aquanox Waste Treatment Plants" illustrated in figure 10, currently exists and has proven to be effective for 2 to 20 multi-dwellings. These packaged units range from 500 to 5000 gallons per day in capacity, but the economic useful range is 1500 to 2500 GPD (5 to 7 multi-dwellings served). They are expensive, $5000 to $10,000 per unit (not including installation costs), but they are completely engineered, quickly installed, and require a minimum of space in sites of 4' by 4' by 8' (21).

Then we have the modular tank systems such as the "Bio-Pure" product illustrated in figure 11. This equipment has advantages of easy installation plus proven 85 to 95% BOD
FIGURE 10

Equipment Description

FLOTATION TANK
OXIDATION TANK
SETTLING TANK
CHLORINATOR INJECTION UNIT
EFFLUENT HOLDING TANK
PROCESS PUMP
EFFLUENT PUMP
COMMINUTOR
ELECTRICAL CONTROLS
HYPOCHLORITE TANKS
VENT (TO WEATHER)
INFLUENT COLLECTING TANK
FEED PUMP
BIO-PURE BATCH PROCESS DESCRIPTION

- Sewage is received into and through a basket. No comminutor (grinder) is required.
- Continuous mixing and aeration of normal or excess flows of incoming sewage.
- Automatic reduction of mixing and aeration during low flow.
- Aeration by induced air flow in pump suction, and mixing of air and mixed liquor in pump volute.
removal efficiency. A 1200 gallons per day system costs $3,670 F.O.B. factory. Therefore, the unitized cost would be ($3,670/1200 GPD/105 GPCD)x(.130)(capital recovery factor at 5% for 10 years) = $41.75 per person per year. This design of an influent wire mesh basket coupled with air turbulence appears to effectively break down the solids to a bio-degradable sludge (22). Modular units are particularly attractive because of expansion probabilities. Expansion may or may not occur in any given area for unknown reasons which make some developers millionaires and put others into receivership. By investing in a small but adequate system for the present, with the potential of rapid increase when required, an attractive package for development monies is created.

To depart from centuries of traditional engineering design practice in the areas of water and wastewater disposal is difficult for even the most innovative groups to accept, much less the uninformed politician and average citizen. The first breakthrough, and possibly the best, is a "Cromaglass" product shown in figure 12.

This unit is a small bell shaped, sealed tank made of fiberglass, that is installed in the cellar of a house or buried in the ground in a conventional fashion. The unit comes in two sizes for a single unit dwelling or multiple dwelling of 2 to 4 families. With large apartment or motel complexes with multi-stories these units can be engineered
PROCESS AND FLOW DIAGRAM

A—INFLUENT
B—PRIMARY COMMINUTION CHAMBER
C—AERATION CHAMBER
D—FILTERED EFFLUENT CHAMBER
E—BAFFLE
F—EFFLUENT
G—TANK
H—AIR LINE
I—DIFFUSER
J—COMPRESSOR
K—FILTER
L—MOTOR
M—EFFECTOR AERATOR

CROMAGLASS WASTEWATER TREATMENT SYSTEM
for installation on each level in the utility corridors (elevator shafts, air conditioning ducts spaces, etc.) without adding square footage to the building. A simple compressor supplies air on a timed basis to tank for aerobic treatment. A filter is incorporated as a safety feature. Should the homeowner be indiscriminate enough to shut off the air supply the filter becomes quickly clogged shut that toilets won't flush, etc. The National Sanitation Foundation Standards requires the manufactures to provide a two year service policy which adds to environmental protection (23).

Another similar product shown in figure 13 is available from Nayadic Sciences(24), but the unit does not contain a filter for safeguarding effluent and hence requires a drainfield. Prices are about the same for either unit ranging from $1,000 to $3,000 depending on size and additional equipment, such as a chlorinator and a sprinkler system if irrigation or soaking is unsatisfactory.

The problem of replacing septic tanks was introduced to the Environmental Engineering Section of the Arctic Health Research Center as early as May 1965, by individuals from Anchorage, Alaska. In 1968 this same agency discovered groundwater pollution in a small Alaskan town which triggered vigorous engineering research(25). Alaska has a sheet of ice called permafrost, which even in late summer is seldom more than two feet below the surface of the ground.
FIGURE 13

NAYADIC SCIENCES - TYPICAL SECTION

Reference (24)
This is probably the most difficult situation for wastewater treatment because of no percolation and freezing weather most of the year. An obvious solution was a small aerobic tank located in a heated portion of a home with sufficient effluent flow to prevent freezing. The design illustrated in figure 14 cleverly uses a small air compressor to aerate the water, circulate the sludge, pump the effluent, and backwash the filter plates (25). No comminutor is required here for domestic sewage; because the vigorous aeration breaks up paper and feces to a size small enough for aerobic bacteria to rapidly decompose. The airlift under normal cycling passes the quiescent effluent into a plate settling chamber for further suspended solids (SS) removal and then over a weir to a chlorine contact chamber for final treatment. Published results of tests for this early unit are in the appendix A which shows better than 90% BOD and SS removal. Operation costs are predicted on 4¢ per KWH or $14.80 per month (25). A backwash cycle is incorporated through timed solenoid valves for one hour, once daily to spray off the settling plates to deposit solids back into the settling tank. Aeration is cycled for one half hour duration each hour to allow settling during quiescence.

These units are not as simple as they appear: for instance, sizing and spacing of the plate settling unit involves enough mathematics to create another whole research
INDIVIDUAL DWELLING TREATMENT SYSTEMS

SECTION OF ORIGINAL AQUA-REUSE SYSTEM SHOWING NORMAL OPERATION.

TYPICAL AQUA-REUSE PLANT SHOWING BACKWASH CYCLE.

FIGURE 14

Reference (25)
paper. The shape of the conical diffuser was critically designed to allow maximum air to liquor contact to keep the unit small.

A second generation of devices produced a unit typified here as a "Cromaglass" single home wastewater treatment unit, mentioned earlier (23). This unit is similar to the one just described but simplified into a less than six foot diameter sphere weighing 240 pounds. The unique feature of this single home plant is the incorporation of a plastic bag filter (probably fiberglass cloth) which has enough media depth to become quickly clogged should the system operation become slightly septic*. The capital cost of all equipment for Model CA-610 without the chlorinator is about $1,000. (See specifications and some test results in appendix A).

Some interesting innovations mentioned by Mr. Orval Q. Matteson, "Cromaglass" distributor, in his letters of January and March, 1972, to the author, illustrate the flexibility of these units for on-site treatment (26).

Since the effluent (as measured by BOD and SS) is of equal or higher quality than most large wastewater treatment plants, a sand box 2' deep by 8' by 10' is approved by the State of Pennsylvania as an effluent filter for direct sur-

*System drops below 85% removal (BOD and total solids).
face discharge, Alabama and Colorado require only 33 square feet of sand. Another idea, not in use yet, is to pressure pump the high grade effluent through tiny plastic lines to a tertiary treatment center to create water of equal quality to that of Lake Tahoe, California, which could be used for public swimming pools or drained into any receiving stream without the probable risk of oxygen demand overload. Still a third idea, which is in common use in the Virgin Islands, where water is in short supply, is to utilize the effluent to flush their toilets. In theory, no water is wasted in a complete recycle system (26).

Another similar use of a filter screen to retain solids until the aerobs have the opportunity to breakdown the carbohydrates, proteins, and fats may justify another new product used for tertiary treatment employing the same principal. A California Company (27) advertises a new concept in tertiary polishing, using 500-mesh (30 microns) and a centrifugal aerator. Undigested oils that pass through the screen are skimmed off the surface because of the aeration bubble lift as foam at 3,000 parts per million SS. The disposal of this is not mentioned as greases are the most difficult of the hydrocarbons to dispose of. However, the manufacturer of the unit claims costs of less than one cent per 1,000 gallons of operating, and installation costs which are less than other present mechanical tertiary treatment
systems. An illustration of the unit is shown in figure 15. The representative test data is in appendix A. This is one of many tertiary devices which could easily raise the percent of BOD and SS removal to meet Federal and State standards as a community device sized to accommodate a development area.

Tertiary treatment is not an objective of this paper, for it is an intensely complicated subject, but hundreds perhaps thousands of system combinations are available today when and if such refinement is required. The author prefers landspread as a natural and inexpensive tertiary treatment, but because of population density in desireable areas, the foregoing is an alternative.

An offspring of the "cromaglass" unit offering some competition, necessary for any utility, is the cone-shaped "Naydaic" units shown in figure 13. These units are still under stringent tests and have not to this date proved to meet the standards of NSF #40. The unit incorporated the basic principals of the original Alaska unit with the exception of the fail-safe filter element. The sales claims are out-of-line, and hence will not be mentioned here. The test results were denied to the author for this paper except for verbage of "the tests are going fine and everything is A-Okay", (Per telecons author to secretary 2 May 1972, Laughead Utilities Systems, Inc., Longwood, Florida).
SWECO WASTEWATER CONCENTRATOR  Figure 15

BOD AND SUSPENDED SOLIDS REMOVAL BY AERATION EFFECT OF THE CENTRIFUGAL SCREEN.

SCREEN: 8,325 mesh (50 micron)
RPM: 0-300
Capacities available: 50 to 3500 GPM
Reference: (27)
Possibly this unit will withstand the gruesome tests given in Ann Arbor, Michigan, but the basic design premise of the system shown appears questionable. The price per unit is comparable to the "Cromaglass" units, $1,000 per 3 bedroom dwelling, but there is no protection to a community for an overload or underload condition. The author attempted a discussion of factory warranty, etc. to insure a proper effluent, and this was met by a "perhaps" statement. Nevertheless, it does represent competition, vital to our economic process and still is vastly superior to the septic tank. Should this unit fail to meet National Sanitation Foundation #40 standards, I am sure that additional treatment devices can easily be incorporated to meet the 1973 standards (2). NSF tests are scheduled for completion on these units in September of 1972.

ECONOMIC CONSIDERATIONS

Sewer bills, as with all other charges, have been increasing, and the acceptable average rate in Orange County at this instant is $5.25/month per residence. Connection costs, to date, are $254 x .13 capital recovery factor = $33.00/yr. The charge for treatment is $5.25 x 12 / 2.75 persons/house= $22.90 per capita year plus $34.90 per capita year.

A septic tank installed with drainfield for the present day 3 bdrm, 2 bath home with garbage disposer (900 gal.
tank with 255 feet of drain pipe) will cost $351 (28). Sludge removal, once every two years, is $35 or $17.50 for a one year operation, Seminole County. In Orange County the drain requirements are 330 linear feet running costs from $425 to $650 per unit. At 2.75 persons/dwelling in Seminole County, the per capita cost per year is \((17.50/2.75) + ($351/2.75)(.13 \text{ at } 5\%/\text{yr})\text{or }$22.90\) per person per year. Thus it can be concluded that the costs of septic over sewer treatment is considerably less, but the quality of effluent from septic systems is extremely questionable when related to the 1973 requirements.

Now, the introduction of a new "unit" treatment plant is of importance. These units range in cost from $1,000 to $2,000 basic price plus installation costs with guarantees and proof tests according to NSF, concerning a six months test for a full 90% BOD removal.

The unitized costs of these aerobic systems are as follows:

Operation and Maintenance(50¢/mo)10 yrs...$ 60.00
Original Cost(2 yr guarantee)(1.3)(A/P Factor)1,300.00
TOTAL $1,360.00

(Optional decor such as an installed automatic sprinkler system and the installation could add an additional $300 to $400 and perhaps even more).

\((1,360/2.75 \times 10 = $49.40\) per capita per year which is the highest cost of proper treatment, i.e \((49.40-34.90)\).)
(34.90/100) = 41.6% more than the central sewer system.

This cost difference will undoubtedly be obliterated by the tertiary treatment requirements to all plants in the near future (2)(17).

Some local systems may be able to treat sewage as well or better than a large treatment plant. Of course, such systems cannot compete with the larger plants servicing high rise and condominium densities (15 or more multi-dwellings per acre) where people group together to suffer the inconveniences of noise, parking, and family squabbles to reap the benefits of cheaper services. We have already mentioned the economy of the optimum sized plant or plant combinations for these high density areas (18), but, add to this the costs of 2 to 5 miles of trunk line sewage plus a lift station or two to buy and maintain, and we have surpassed the economic optimum (29).

CHOOSING AN OPTIMUM SYSTEM

The problem of a developer or an individual, who attempts to get the proper permits in central Florida, is one of immense proportions. Before buying a tract of land or a lot, the entrepreneur should first contact the Planning Agency representing his area. These people are knowledgeable of many of the problems existing within their domain and will give advice to guide further actions. A Planner must have two years experience and a Masters
Degree to qualify for this important office.

From the planning office, an engineering firm should be contacted to take soil samples, percolation tests and water samples to establish economic feasibility. This information is available on a general wide area basis free of charge from the U.S. Coast and Geodetic Survey, and water tests are often done by agricultural stations or county sanitation laboratories (30). The individual must be knowledgeable in the field or gain detailed information from these agencies if engineering is not employed at this juncture.

Should a zoning change be made, the county zoning department must be contacted who will advise as to what permits must be obtained. Sometimes a sewer authority will have to agree to connections which must be within biological and hydraulic design loads. If the developer must construct his own facilities, professional engineering should be obtained before the sanitation and/or ecological (anti-pollution) departments can authorize construction permits. Often State departments can dictate the final approval or disapproval.

Thus, one can readily see the immense problems facing any development, large or small. It is to the advantage of a small developer or a rural dweller to have individual wastewater treatment units available and fully approved such that red tape may be by-passed with safety for all.
Much of this administrative and geological background is available through knowledgeable Realtors, who have been in business locally for a number of years. They must, of course, specialize in land selling and preferably belong to a policing institution such as a Board of Realtors. These boards keep records on a Realtor's past performance such that one may select a qualified office to give him thousands of dollars worth of general information. A board's regulatory powers attempt to discriminate against unscrupulous and ignorant salespeople by interpreting and invoking State laws which are not 100% effective but do weed out most of the undesireables. A Realtor should be able to answer such questions as: drainage problems, nearest sewer and water connections, probable quality of well water, city and county zoning regulations, access probabilities, aquifer restrictions, and general environmental hazards. Thus, included in the commission, the real estate salesperson can provide a complete general picture of the problems to be solved by the prospective purchaser.
CHAPTER 4
SUMMARY AND RECOMMENDATIONS

SUMMARY

As the population grows and their exodus from the cities continue (31), individual homes are becoming more and more isolated from central utility systems. The greatest of the many associated problems is the treatment and disposal of wastewater because of costs of right-of-ways, pipelines, and lift stations. A standard clay sewer buried at an average depth of 14 feet costs $79,200 per mile, given the right-of-way (29). Efforts, even with Federal matching funds, to centralize wastewater treatment are becoming economically and physically impractical.

An obvious answer to solve this problem is to turn back to septic tanks, but knowledge of pollution factors negates their use and new regulations attempt to eliminate them in-so-far as possible.

A breakthrough in wastewater treatment was achieved for the larger facilities by using aerobic rather than anaerobic biological breakdown of the organics, and, with the success of the big plants, smaller ones appeared on the market down to the individual household size.

These 6 foot diameter spheres or cones are aerated by small electric compressors automatically timed and claim to
be trouble-free. The quality of effluent from preliminary tests is equal to or better than large, modern installations.

Thus, the substitution of an aerobic household unit for the septic tank affords environmental protection, higher population density, increased land usage, and less development cost.

Central Florida appears ideal for the incorporation of small aerobic units since much land is plagued with poor drainage problems and aquifers are easily polluted.

RECOMMENDATIONS

Based on the research data reported here, the author favors a more extensive use of small package plants for central Florida's wastewater treatment. The landspread techniques, when properly employed, is the best solution for the central Florida environment. The cost of land for landsprea dng on private property obviously adds no expense to the individual homeowner providing he uses a properly approved aerobic system, and sustains a high maintenance. Legislation should encourage the use of such systems and phase out all septic tanks. Once the small package units are in demand, research and new developments will eventually reduce the costs to well within the present charges for the larger plants.
Pollution control may be effectively applied by forcing long term manufacturing warranties and by utilizing fail-safe controls such as fine mesh screens that clog below safe effluent levels, a resistivity instrument to trigger a shut-off valve, chlorinator units with sealed liquid level controls, and a copious use of authoritative seals such as are on electric meter boxes. Enforcement may be affected by official inspection once-a-month.

The author hopes the existence of this report will be helpful in establishing new laws to provide this much needed alternative.
REFERENCES

(1) Orlando/Winter Park Board of Realtors. Multiple Listings. 1972


(6) East Central Florida Regional Planning Council. 1966 Water and Wastewater Treatment Facilities. Appendix Table II, p 2.


(22) Bio-Pure, 1972 Catalog. Sewage and Waste Treatment Equipment, 10510 SW Industrial Drive, Tualatin, Oregon, 97062. Letter from W.A. Turner, Vice President and General Manager.


(30) United States Department of Agriculture, Soil Conservation Service, in cooperation with University of Florida Agriculture Experiment Stations. Soil Survey Seminole County, Florida. Soil Map.

(31) Article, Sentinel Star, Feb. 7, 1972. Where will the next 50 Million Americans Live?
# Specifications for Aquanox, Inc., Units

## Model No. Specifications

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Capacity (gpd)</th>
<th>Dimensions (A* B C)</th>
<th>Electrical (KW Max.)</th>
<th>Dry Weight (lbs.)</th>
<th>Wet Weight (lbs.)</th>
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<td>400</td>
<td>500</td>
<td>6'0&quot; 4'0&quot; 3'0&quot;</td>
<td>2</td>
<td>1300</td>
<td>2000</td>
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<tr>
<td>401</td>
<td>1500</td>
<td>7'0&quot; 5'0&quot; 4'0&quot;</td>
<td>4</td>
<td>1700</td>
<td>3000</td>
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<tr>
<td>402</td>
<td>2500</td>
<td>8'2&quot; 5'0&quot; 4'0&quot;</td>
<td>5</td>
<td>2300</td>
<td>3800</td>
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<tr>
<td>403</td>
<td>5000</td>
<td>10'6&quot; 5'0&quot; 7'0&quot;</td>
<td>7</td>
<td>4600</td>
<td>6500</td>
</tr>
</tbody>
</table>

### Specifications

- **Electrical**: 110V, 220/440V, 50/60 cycle, 3 phase
- **Pump Horsepower**: Variable, according to unit size
- **Tanks and Piping**: Fiberglass or coated steel
- **Disinfection**: Automatic, Chlorine or Ozone
- **Heaters**: None
- **Compressors**: None
- **Special Chemicals**: None

### Performance

- **Process Time (Domestic Wastes)**: 1 Hour
- **Loading Reduction**
  - Suspended Solids — up to 8,000 ppm: 90-95%
  - B.O.D. — ranges up to 1,900 ppm: 90-96%
  - C.O.D. — ranges to peaks of 4,000 ppm: Over 75%
- **Disinfection (Coliform Count)**: to 0/100
## PROTOTYPE - ALASKAN UNIT - TEST RESULTS

### TABLE II. — Results of Operational Tests on Full-Sized Wastewater Treatment Plant, December 1969 - June 1970*

<table>
<thead>
<tr>
<th>Date 1970</th>
<th>BOD</th>
<th>SS</th>
<th>Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effluent (mg/l)</td>
<td>Removal (%)</td>
<td>Effluent (mg/l)</td>
</tr>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
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<td>February</td>
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<tr>
<td>May</td>
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<td>21</td>
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<td>27</td>
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<tr>
<td>June</td>
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<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* BOD and SS efficiency calculated using average of 52 composite influent samples ranging over 1 yr. Average influent BOD = 212 mg/l; average influent SS = 280 mg/l.

Note: Gpd X 0.003785 = cu m/day.

## APPENDIX A

### SWECO TERTIARY POLISHER (28)

## ADVERTISED TEST RESULTS

### TABLE OF REPRESENTATIVE TEST DATA

<table>
<thead>
<tr>
<th>DATE (1971)</th>
<th>SUSPENDED SOLIDS mg/l</th>
<th>BOD mg/l</th>
<th>DO mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>12 8 33</td>
<td>10 5 50</td>
<td>— — —</td>
</tr>
<tr>
<td>13 26 42</td>
<td>13 4 77</td>
<td>4.0 6.8 70</td>
<td></td>
</tr>
<tr>
<td>14 25 36</td>
<td>19 4 79</td>
<td>3.6 6.3 75</td>
<td></td>
</tr>
<tr>
<td>15 24 56</td>
<td>13 6 54</td>
<td>3.9 6.4 64</td>
<td></td>
</tr>
<tr>
<td>21 21 29</td>
<td>12 3 75</td>
<td>4.0 6.4 60</td>
<td></td>
</tr>
<tr>
<td>22 18 55</td>
<td>12 7 42</td>
<td>3.9 6.6 70</td>
<td></td>
</tr>
<tr>
<td>23 12 60</td>
<td>13 6 54</td>
<td>3.8 6.4 68</td>
<td></td>
</tr>
<tr>
<td>26 32 50</td>
<td>21 9 57</td>
<td>3.2 5.9 84</td>
<td></td>
</tr>
<tr>
<td>30 40 27</td>
<td>37 19 49</td>
<td>4.5 7.3 62</td>
<td></td>
</tr>
<tr>
<td>32 40 36</td>
<td>26 7 73</td>
<td>4.0 6.8 70</td>
<td></td>
</tr>
<tr>
<td>34 40 27</td>
<td>37 19 49</td>
<td>4.5 7.3 62</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>7 42 34</td>
<td>26 7 73</td>
<td>4.0 6.8 70</td>
</tr>
<tr>
<td>8 62 40</td>
<td>— — —</td>
<td>4.2 7.2 72</td>
<td></td>
</tr>
<tr>
<td>13 16 12</td>
<td>12 5 57</td>
<td>3.4 6.4 88</td>
<td></td>
</tr>
<tr>
<td>16 22 10</td>
<td>5 4 20</td>
<td>— — —</td>
<td></td>
</tr>
</tbody>
</table>

| AVERAGE    | 39.5% 57.2% 71.1% |         |         |

Note: Gpd X 0.003785 = cu m/day.
SPECIFICATIONS

PROCESS—Aerobic Oxidation and Filtration.

WARNING DEVICE
An Automatic Signal Device that is activated in the event a system fails, indicating need for service.

SURFACE OR STREAM DISCHARGES
In accordance with State and/or Local Health Department Regulations.

MODEL CA-610

TREATMENT CAPACITY (Average Daily Flow)
8 Persons x 75 G.P.D./Person 600 G.P.D.

B.O.D. LOADING
.17 lbs. B.O.D./Person/Day x 8 Persons 1.36 lbs.

AIR RATE
Delivered 3.50 C.F.M.

1750 Cu. Ft./lb. B.O.D. x 1.36 lbs. B.O.D.
—2380 Cu. Ft./Day — 1.65 C.F.M. Required

EFFLUENT QUALITY—600 G.P.D. Flow
Biochemical Oxygen Demand 85 - 95% reduction

COMPRESSOR—Vane Type, 1725 RPM, 3.50 C.F.M. Capacity @ 2 PSIG

MOTOR—NEMA A-48 Open Frame, 1725 RPM, ½ H.P., 115-220v, 60 Cycle

DIFFUSER—2" Dia. x 12" Long Bonded Ceramic Silicone Coated

DIMENSIONS
Tank—70" Dia. x 70" High
Inlet and Outlet—Standard 4" Pipe or as required

WEIGHT
Tank (Net) Complete 240 lbs.
Motor and Blower 40 lbs.
Total 280 lbs.

DISINFECTION—(Chlorination, Etc.) Where Required.

CONSTRUCTION MATERIALS
Tank—Fiberglass Reinforced Plastic
Mixing Cone—Polyethylene
Filter Material—Inert
Piping and Fittings—Schedule No. 40 - PVC - NSF Approved
Metal Fittings—Aluminum

MODEL CA-1510

TREATMENT CAPACITY (24 hrs.) 1500 G.P.D.

B.O.D. LOADING (max. per day)
14.00 x 1440 = 11.52 lbs.

DETENTION TIME
(1500 G.P.D. Flow) — 1275 x 24 = 20.4 Hrs.

1500

COMPRESSOR—Vane Type, 1725 RPM, 14.0 C.F.M. Capacity @ 2.0 PSIG

MOTOR—NEMA A-48 Open Frame, 1725 RPM, 1 H.P., 115-220v, 60 Cycle

AIR DIFFUSERS—3½" O.D. x 12" Long Bonded Ceramic Silicone Coated

DIMENSIONS
Tank—5' 6" I.D. x 10' 6" Long
Inlet and Outlet—Standard 6" Pipe or as required

WEIGHT
Tank (Net) Complete 530 lbs.
Motor and Blower 108 lbs.
Total 638 lbs.

SPECIFICATIONS — TWO CRONAGLASS AEROBIC UNITS

APPENDIX A
### SUMMARY OF TESTS OF CROMAGLASS UNIT TREATMENT PLANTS  

**APPENDIX A**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NO. OF UNITS</th>
<th>DESCRIPTION</th>
<th>BOD%*</th>
<th>SS%*</th>
</tr>
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<tbody>
<tr>
<td>67/'68</td>
<td>-----</td>
<td>Roy F. Weston Laboratory, Pa. (State requirement)</td>
<td>88.8</td>
<td>89.0</td>
</tr>
<tr>
<td>1968</td>
<td>12</td>
<td>Installed, Spot Tests, Pa.</td>
<td>99.2</td>
<td>96.6</td>
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<tr>
<td>'68/69</td>
<td>-----</td>
<td>Delaware</td>
<td>84.7</td>
<td>85.2</td>
</tr>
<tr>
<td>'68-'69</td>
<td>-----</td>
<td>EAWAG (FED. AGENCY) SWITZERLAND</td>
<td>91.7</td>
<td>97.0</td>
</tr>
<tr>
<td>1969</td>
<td>-----</td>
<td>EAWAG</td>
<td>86-95</td>
<td>----</td>
</tr>
<tr>
<td>1969</td>
<td>-----</td>
<td>Swedish Statens Nat. (Fed)</td>
<td>97.0</td>
<td>90.0</td>
</tr>
<tr>
<td>1970</td>
<td>13</td>
<td>Swiss State</td>
<td>93.9</td>
<td>-</td>
</tr>
<tr>
<td>1970</td>
<td>-----</td>
<td>Health Branch, Brit. Col. Canada</td>
<td>94.0</td>
<td>98.0</td>
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<tr>
<td>1970</td>
<td>10</td>
<td>State of Colorado</td>
<td>88.0</td>
<td>-</td>
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<tr>
<td>1971</td>
<td>-----</td>
<td>State of Maine</td>
<td>87</td>
<td>93</td>
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### COMPARISON OF SEPTIC TANKS WITH CROMAGLASS UNITS

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<thead>
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<th>EFFLUENTS</th>
<th>SEPTIC TANKS</th>
<th>AEROBIC UNIT</th>
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<tbody>
<tr>
<td>Clog Tight Soils</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Coliform Bacteria Removal</td>
<td>little</td>
<td>99%</td>
</tr>
<tr>
<td>Biodegradable Detergents Removed</td>
<td>12%</td>
<td>95%</td>
</tr>
<tr>
<td>Total BOD in MG/L</td>
<td>160-200</td>
<td>25-</td>
</tr>
<tr>
<td>Total SS in MG/L</td>
<td>150+</td>
<td>4-6</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Odor</td>
<td>strong</td>
<td>clear</td>
</tr>
<tr>
<td>Color</td>
<td>dark</td>
<td></td>
</tr>
</tbody>
</table>

* Avg. Reduction
## APPENDIX B

<table>
<thead>
<tr>
<th>WASTEWATER</th>
<th>ORGANICS</th>
<th>INORGANICS</th>
<th>DISSOLVED SOLIDS</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>90% removal</td>
<td>90% removal</td>
<td>Chlorides 10% change from</td>
<td>Any change above back-</td>
</tr>
<tr>
<td></td>
<td>4ppm of D.O.</td>
<td>Mercury-0</td>
<td>background</td>
<td>ground +1.0pH</td>
</tr>
<tr>
<td>Class I</td>
<td>1000 per 100ml</td>
<td>Oils 15mg/l</td>
<td>Chlorides 250mg/l total</td>
<td></td>
</tr>
<tr>
<td>(public water supply)</td>
<td>coliform Gp.</td>
<td>no visible</td>
<td>solids 500mg/l Fluorides 1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4ppm D.O.</td>
<td>iridescent</td>
<td>mg/l Detergents 0.5mg/l</td>
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</tr>
<tr>
<td>Class II</td>
<td>Less than con-</td>
<td>Oils - no</td>
<td>Flourides 10mg/l</td>
<td>6.0 - 8.5 pH</td>
</tr>
<tr>
<td>(shellfish harvesting)</td>
<td>centration</td>
<td>visible ir-</td>
<td>Chlorides 10% normal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>causing D.O.</td>
<td>idescence</td>
<td>background</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4ppm coliform</td>
<td>free of toxic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>70 per 100ml</td>
<td>substances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>less than nui-</td>
<td></td>
<td>No color, odor, or other</td>
<td>+1.0 pH from normal</td>
</tr>
<tr>
<td>(recreation, aquatic</td>
<td>sance condi-</td>
<td></td>
<td>nuisance conditions</td>
<td>background</td>
</tr>
<tr>
<td>wildlife)</td>
<td>tions. D.O. 5ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coliform 1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>per 100ml</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class IV</td>
<td>D.O. 4ppm</td>
<td>Suitable for</td>
<td></td>
<td>+ 1.0 pH from normal</td>
</tr>
<tr>
<td>(Agricultural &amp; Industrial</td>
<td>unless back-</td>
<td>livestock and</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>water supply)</td>
<td>ground lower</td>
<td>industrial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>cooling</td>
<td></td>
<td></td>
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</tbody>
</table>

Reference 2