PN-ABG-894
GRENADA

TENNESSEE VALLEY AUTHORITY

Office of Natural Resources and Economic Development
Division of Air and Water Resources

GRENADA, WEST INDIES
INFRASTRUCTURE DEVELOPMENT
WASTEWATER COLLECTION, TREATMENT AND DISPOSAL ALTERNATIVES

Prepared for the Ministry of Health
Government of Grenada

by

Gerald R. Steiner, P.E.
Program Manager, Water and Waste Engineering Program
Water Quality Branch
Tennessee Valley Authority

Chattanooga, Tennessee

December 1985

Funding assistance for this study and report was made available by the United States Agency for International Development.

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EXECUTIVE SUMMARY

As part of the Infrastructure Revitalization Project conducted by the United States Agency for International Development for the Governement of Grenada, West Indies, a study was conducted of the wastewater treatment needs for the St. George's and Grand Anse and Southwest Embayment areas. The author made two trips to Grenada--the first, a fact finding trip on September 30 to October 10, 1985; and the second on November 19 to November 22, 1985, to present the preliminary study report to the Grenadian Ministry of Health and US AID, and obtain additional information needed to complete the final report.

The report contains comprehensive findings of wastewater related matters which are affecting public health, the environment and economic development opportunities. Several wastewater treatment options were evaluated and the report contains detailed discussions of these options. The report recognizes St. George's Town is sewered but raw sewage is discharged at the shoreline into St. George's Bay. It was recommended that this undesirable condition be corrected by an oxidation ditch type sewage treatment plant built in Queen's Park. As a temporary "stop-gap" measure a 600-meter ocean outfall pipe was recommended to carry the raw sewage offshore to a deepwater trough.

The prime tourist development area is the Grand Anse--Southwest Embayment area. Currently, this area does not have a central sewage collection

system. Sewage is now treated by onsite septic tank--soakaway systems which are frequently inefficient, resulting in poorly treated sewage discharging into Grand Anse Bay. It was recommended that a separate treatment system be built for the present and future development in this area, located near Prickly Bay. The recommended sewage treatment process is artificial wetlands, which is an innovative low cost-low maintenance process.

Many other recommendations are identified in the report. The last subsection of recommendations includes a priority listing of administrative and technical needs. Before constructing treatment systems, initial administrative actions which should be taken are the development of a comprehensive sewage treatment plan (including selecting and dedicating treatment plant sites, selecting treatment processes, developing a financing plan, and establishing a schedule), and the establishment of water quality regulations.

INTRODUCTION

The St. George's and Grand Anse and Southwest Embayment areas of Grenada have been identified as areas which will be improved and developed for increased tourism. However, wastewater treatment systems do not exist or have been planned which can handle increased sanitary sewage loads. In fact, present disposal methods are inadequate. Adequately designed sewage treatment systems are needed to protect public health and the island's environment, and enhance economic development opportunities.

At the request of and under contract to the United States Agency for International Development (USAID) as part of its Grenada Infrastructure Revitalization Program, a study was conducted to evaluate the wastewater treatment needs of the referenced areas and recommend appropriate mitigative actions. During the study it was determined that similar studies had been done for the Pan American Health Organization and the World Health Organization (PAHO/WHO) in 1975, and for the Organization of American States in 1984 as part of an overall project to study the erosion of Grand Anse Beach. This current study was conducted to independently determine the problems associated with wastewater discharges and to consider the most current alternatives for low cost-low technology wastewater treatment systems which may be applied in Grenada. The findings and recommendations of the past studies were reviewed and, in many cases, are compatible with those of the current study. The past studies and the current studies strongly agree upon the problems caused by inadequate sewage disposal and the urgent need to implement mitigative actions.

Based upon the findings of the study, this report contains specific recommendations on actions needed by the Government of Grenada to solve problems related to wastewater. Alternative sewage treatment systems were evaluated. Fairly detailed conceptual designs, with materials and costs estimates, are included in the report. Perhaps a more important part of the report is a priority listing of recommendations which could guide short- and long-range planning. After the government decides upon wastewater treatment options, a consulting engineer having significant experience in the selected wastewater treatment options should be contracted to develop detailed engineering designs and specifications and cost estimates before proceeding with construction.

OBJECTIVES

In accordance with the USAID contract requirements, the study was conducted with the following objectives:

1. Survey existing wastewater treatment systems within the St. George's, and Grand Anse areas.
2. Determine acceptable water quality and wastewater treatment standards.
3. Identify existing and potential problems associated with the lack of adequate wastewater treatment.
4. Develop and evaluate practical alternative low cost-low technology wastewater treatment systems for a 10-year development scenario for the St. George's and Grand Anse areas.

5. Survey wastewater treatment sources to the St. John's River and determine measures needed to correct identified problems. (This objective was added at the request of the Grenada Ministry of Health.)

METHODOLOGY

During the period September 30 to October 6, 1985, a field visit to Grenada was conducted by the author to obtain information necessary to accomplish the study objectives. Discussions were held with the following individuals:

Mr. Brathwaite, Laboratory Technician, Grenada Water Commission

Dr. Tillian Cambers, Private Consultant, Physical Oceanographer

Mr. Jan Coester, Project Coordinator, United States AID.

Mr. Selby Dabreo, Senior Environmental Health Officer, Grenada Ministry of Health

Mr. Curtis Edwards, Chief Environmental Officer, Grenada Ministry of Health

Mr. Kyron Edwards, Sewerline Supervisor, St. George's

Dr. Richard Howard, Arnold Arboretum, Howard University

Mr. Edward Hazuroski, Environmental Advisor, Project HOPE

Dr. Dorene Murray, Medical Officer, Grenada Ministry of Health

Dr. J. S. DeVere Pitt, Grenada Science and Technology Counsel

Many of the above individuals either work for or assist the government of Grenada and are knowledgeable with the existing wastewater treatment systems and problems. Some have responsibility for planning and approving new systems. Some are experts on information pertinent to the study.

A survey of the study area was conducted to view existing treatment systems and methods, identify current wastewater treatment problems, and identify potential sites for alternative treatment facilities. Available previous reports related to the study objectives were reviewed. Information obtained from the discussions, field survey and previous reports were evaluated to develop recommendations for wastewater treatment.

During the period November 19 to 22, 1985, a return visit to Grenada was made by the author to present the preliminary report to officials in the Grenada Ministry of Health and U.S. AID, including:

Mr. Danny Williams, The Honorable Minister of Health

Mrs. Grace Duncan, Parliamentary Secretary, Ministry of Health

Mrs. Rahim, Permanent Secretary, Ministry of Health

Dr. F. Alexis, Chief Medical Office, Ministry of Health

Mr. Curtis Edwards, Chief Environmental Officer, Ministry of Health

Mr. Selby Dabreo, Senior Environmental Health Officer, Ministry of Health

Mr. Edward Mazurowski, Environmental Advisor, Project HOPE

Mr. William Erdahl, Director, U.S. AID, Grenada

Mr. Jan Coester, Project Coordinator, U.S. AID, Grenada

Also, during the November visit, discussions were held with Mr. G. V. Nurse, Construction Management Services, St. George's, Grenada, concerning cost estimates for installation of sewage collection system components.

FINDINGS

Several types of sewage treatment processes are currently used in the study area. The central section of St. George's Town has a collection system with no treatment facility. In other areas of St. Georges and the southwest enbayment areas, septic tanks and "soakaways" (absorption fields) are normally used. Some buildings have only septic tanks. In all areas there is often separation of grey water (bath, kitchen, and laundry wastes) which is discharged into drainage ditches without treatment. The only operational conventional treatment plant is one small package plant for the Grand Anse Food Fair. A 3-cell stabilization pond system for the Point Salines Airport with a capacity of 10,000 gallons per day is under construction, and a package plant is planned for the remodeled Grenada Beach Hotel. A more detailed description of the treatment systems and problems identified during the field visit are discussed below. The findings are divided into three areas--St. George's, Grand Anse and Southwest Embayment, and St. John's River and Tempe.

St. George's

A collection system for the central city was completed in 1940. The collection system consists of 4-inch house laterals discharging into 6 and 7-inch collectors. The collectors discharge into 7-inch trunk lines along the Carenage and Esplanade. The trunk lines along the Carenage flow to a wetwell/lift station where the sewage is pumped to a manhole on the west side of a ridge dividing the city. This flow and flow from the Esplanade trunk line combine in another manhole and then discharge to

St. George's Bay at the shoreline near northwest end of Sendall Tunnel. The sewage had discharged by gravity through a 600 foot pipe to a location off Fort George Point until 1955 when the pipe was broken during a hurricane. An inoperable pumping station is located at the present discharge point which was used only to surcharge the Esplanade trunk line when it became plugged.

Identified Problems

1. The collected sewage receives no treatment before it is discharged to St. George's Bay at the shoreline. This is very undesirable. The major immediate problem attributed by the discharge of raw sewage at the present location is probably one of aesthetics and the appearance of a nonprogressive government. It is very commendable that the government of Grenada is now actively seeking short- and long-range solutions to this problem. This is necessary for economic development and environmental protection. Many private businesses and companies which may consider establishing in Grenada may want to avoid an area which is not taking measures to effectively protect public health and its natural resources. Also, sewage could be causing long-term impacts on the coral reefs by smothering the reefs with settleable material, and providing organic matter and nutrients which cause decreased dissolved oxygen levels. The raw sewage contains infectious bacteriological organisms which can be a public health hazard to those coming in contact with the water. During the field investigation, two children were observed to be fishing directly in the raw sewage discharge. Ingestion of poorly cooked

fish could cause a severe health problem. Other recent studies indicate that the raw sewage does not cause unsuitable bacteriological counts along the Grand Anse Beach area, probably due to currents and/or sufficient dilution. Desirable marine life in the discharge area probably have migrated away from the area.

One sewage disposal alternative for St. George's being considered by the Grenada government for correcting the immediate problem of the shoreline discharge is to lay a new 300 to 600 foot offshore discharge pipe. However, to better disperse the discharge so that it would not return to shore, the pipe should be extended to the deep water trough off Fort George's point. From the present outfall location, this requires an outfall pipe about 600 meters (2400 feet) long. This needs to be confirmed by ocean current studies now being conducted around the harbour. The evaluation of the current study has not yet begun. However the qualified professional opinion of the oceanographer responsible for this study is that sewage discharged into the trough would flow southwest with normal currents, away from Grand Anse Beach.

2. No sewer system layout plan exists. Knowledge of pipe locations exists only in the memory of experienced, long-time personnel. A design layout is necessary to repair existing pipe and plan replacement and system expansions.
3. The main collector lines along the Carenage and Esplanade are undersized and probably have a too low slope. This is evidenced by the

frequent plugging of lines with sand and other material and the subsequent overflow from manholes during heavy rains into the Harbour. The plugged lines must be cleaned to remove the sand by a work crew, sometimes several times per week. Accepted engineering design principles require that no gravity sewer conveying raw sewage shall be less than 8 inches (20 cm) in diameter. Also the slope of the pipes should give a mean velocity of at least 2.0 feet per second (0.61 m/s) to keep the sand traveling through the pipes.

4. Inflow/infiltration overloads the collection system. This is evidenced by the reported large increase of sewage flow during storm events. This causes raw sewage to overflow into the Harbour from manholes and the lift station. It is understood that "inspection traps" for individual buildings probably contribute significantly to inflow. It was reported that many are built too low and water washes through the grill cover of the traps into the sewers. (This also contributes to sand entering the collection system, discussed in item 3, above.)

5. No sewage flow records exist which provide hydraulic and organic discharge data for efficient system operation and planning of new collection and treatment systems. (It was reported that flow at the lift station used to be metered by counters but the counters became inoperable about 20 years ago and were not repaired.) Also, no firm sewered population numbers or per capita sewage generation exist with which confident calculations can be made. Previous reports have estimated the hydraulic flow for the existing sewered area to be 0.3 Mg/d to 0.53 Mg/d.

6. The lift station contains two Shone pneumatic ejectors which were installed in 1939. The ejector pumps do not work efficiently due to leaking seals, etc. This causes sewage to overflow to the harbour during higher flow rates. It was understood that an evaluation was underway to determine whether the existing pumps should be reconditioned or replaced. Also, due to electrical power outages, the ejector pumps frequently do not operate. This also causes the lift station wet well to overflow. Although there is a standby generator to operate the compressors for the ejector pumps, it is undersized and cannot pump the total sewage flow. A new adequately sized generator is needed.

7. Sewage from some buildings is discharged directly into the bay instead of into the collection system. Two examples are the Ministry of Health buildings at the north end of the Carenage and the St. Georges Hospital, both discharging sewage near the collection system outfall. The Ministry of Health sewage does flow to a septic tank but the septic tank has not been pumped and is probably full. The hospital discharges its sanitary waste and much of the hospital wastes such as bandage washings, both which could be very infectious. (It was reported that body parts and blood are incinerated.)

8. The discharge of grey water (bath, kitchen, and laundry wastes) is common, probably due to inadequate enforcement of existing regulations and the need to decrease the hydraulic load on poor soakaway system conditions. This adds organic matter, nutrients and colloidal material to the waterways which decreases dissolved oxygen and the clarity of the water.

9. Unsewered housing areas have either septic tank-soakaway systems or only septic tanks which discharge partially treated sewage into the watercourses. Also, raw sewage enters the harbour from the many yachts which are anchored in the Lagoon. As stated above, these sources add organic matter, nutrients, and infections organisms to the water.

10. An adequate septic tank maintenance program does not exist. If septic tanks are cleaned, it was reported that most of the sludge is emptied into the collection system. That is, the settleable solids are removed from the sewage only to be discharged into the waterways in slug quantities. There is a minor amount of land application of the septic tank sludge at the city sanitary landfill. Many tanks are apparently not cleaned which results in raw sewage passing through a septic tank after it is full and is then either discharged raw or to a soakaway which backs up after it is plugged with solids.

Grand Anse and Southwest Embayment Areas

Included in this area from St. George's Town southwest are Paddock, Belmont, Grand Anse Estates, Grand Anse Beach, and Morne Rouge to about Cinnamon Hill. The principal sewage treatment for houses, businesses, schools and hotel/motels are septic tanks or soakaway systems. The Grand Anse Food Fair shopping center is sewered by a small extended aeration plant. Its effluent discharges to a drainage ditch with empties into Grand Anse Bay through the "north sea head" near Grenada Beach Hotel. Another major point source wastewater discharge is from the "south sea head" on Grand Anse Beach near Spice Island Hotel. Other point source

wastewater discharges to the bays are through drainage ditches to the Lagoon, Martin's Bay, and Grand Anse Bay.

Identified Problems

1. Septic tank only systems discharge partially treated sewage. The septic tank-soakaway systems also often have discharges of partially treated sewage, especially during wet periods. These discharges contain organics, nutrients, and biological organisms which can negatively impact marine life and public health. The discharges can have an odor during warm weather which present poor aesthetics and poor impressions upon visitors.
2. Water quality sampling conducted on three dates in September/October, 1984, for an Organization of American States study, indicated high bacteriological concentrations along Grand Anse Beach. The concentrations at some locations exceeded typical United States water quality standards for water contact areas (total coliform concentrations less than 1000 per 100 ml and fecal coliform concentrations less than 200 per 100 ml). Two of these locations were near the north and south sea heads where people were frequently observed in the water during the field study. If these concentrations occurred on a beach in the United States, the areas would be "posted" to warn people not to swim due to a health hazard.
3. Water occasionally backs up in the main drainage ditch along Grand Anse Road fronting St. George's Medical School and Spice Island Hotel. When this occurs it can cause sewage to back up in the soakaway systems and pond in the yards. This drainage ditch discharges through the south sea head where it was observed how

sand washes into the sea head and then settles, forming a dam unless removed. The sand washes through cracks in the sea head and an open top portion during high tides. A crew of five men continually shovel this settled sand out of the drain for 8-hours per day, 5-days per week. The sand is piled and occasionally hauled off for construction use.

4. As in St. George's, many buildings have separate grey water drains which empties into the drainage ditches. The grey water contains organisms and nutrients, and has an odor which can contribute to environmental and aesthetic problems as discussed above.
5. One discharge seen entering the drainage ditch was reported to be waste from the medical school laboratory. The characteristics of this waste is unknown but could contain undesirable chemical, physical, and bacteriological constituents.

St. John's River and Tempe Areas

These residential areas are not currently sewered but could be connected to an expanded central collection and treatment system. Presently, septic tanks and septic tank-soakaway systems are used for sewage disposal. Some sewage is discharged directly to the waterways without any treatment. Numerous light industry and commercial establishments are located in this area, some of which discharge process wastes to the St. John's River and its tributaries. Also, there are agricultural operations in the St. John's River watershed which contribute agricultural nonpoint source pollution to the river and marine systems.

Identified Problems

1. It had rained earlier in the day when the St. John's River area was surveyed. The St. John's River was very turbid and an extensive sediment plume was observed in St. George's Bay extending from the mouth of the river. This incident visibly indicated the effect of one of Grenada's major industries--agriculture. It was reported that most of the sediment is probably erosion from steep-sloped agricultural land which is extensively cleared of ground vegetation to facilitate the production and harvesting of crops such as bananas and nutmeg. Another land management practice contributing to sediment loads in the island's waterways is the clearing of vegetation with a machete to ground level along roadway embankments so that bare soil is exposed. (This practice was observed in all areas of St. George's.) As stated by other investigators, sediment from erosion is possibly the chief cause of coral reef destruction due to the smothering of the reefs by the sediment.

   The use of pesticides, fungicides, and fertilizers in agricultural production contribute organic and inorganic pollutants to the waterways, some of which also can exert a toxic impact on marine organisms. Two chemicals reported to be used are Benlate, a fungicide, and Furadan, a pesticide. The latter, also called Carbofuran contains a highly toxic main ingredient (a 72-hour LC_{50} of 0.16 mg/L to green sunfish). Benlate contains benomyl, thiroam, and other chemicals. It is reported that Benlate can have Captan in its mixture, which is also highly toxic to fish (48-hour LC_{50} of 0.33 µg/L to harlequin fish).

2. The St. Johns River is also polluted with partially treated and untreated sewage, grey water, and industrial wastes. These impact potential uses and cause unmeasured impacts on the marine environment of St. George's Bay. Two water samples collected in September/ October 1985 contained high concentrations of bacteriological organisms and biochemical oxygen demand. Some of the businesses along the river discharge untreated organic and inorganic process wastewaters into the river and/or have land use practices (such as materials storage along the riverbank) which result in pollutants. However, a good inventory of the wastes from each business does not exist. The effect of industrial waste discharges is indicated by the reported large fish kill which occurred in the river about two months prior to the field survey. It was probably caused by the discharge of 3000 gallons of waste caustic solution used for washing bottles at the Cannings Soft Drink Bottling Company.

General Findings and Identified Problems

1. Water Quality and Wastewater Treatment Regulations--There are no regulations for protecting fresh or marine waters for various desired uses. Also, there are no wastewater treatment regulations which define either standards for the design or construction of treatment facilities or limitations for physical, chemical, and bacteriological constituents in the discharges of treatment facilities. The only regulations are those adopted in 1939 and 1940, Statutory Rules and Orders No. 234, 235, and 236, which consist of plumbing codes for building sewers, water closets, and latrines.

2. Financial Support of Sewage Treatment System--The government presently does not have a financial system to support a centralized sewage treatment system--for either retirement of a possible future loan for construction or operation and maintenance costs. A common method used elsewhere for financially supporting municipal sewage treatment systems is to charge a percentage of the cost for potable water usage. However, in Grenada, potable water usage is not commonly metered or recorded. It is understood that only commercial establishments such as large businesses and hotels have water meters. Private households do not have meters and are charged for water on the basis of an annual property assessment.
3. Sewer Maintenance--It was understood that the Ministry of Health is considering establishment of a "sewer maintenance team" to inspect and repair sewer lines on a regular schedule.
4. Sewage and Water Quality Analyses--No physical, chemical, or bacteriological analyses are conducted to measure the current impact of sewage on water quality and the potential impact on public health. The Central Water Commission Laboratory has personnel familiar with laboratory techniques and could be trained to conduct sewage and water quality analyses. The laboratory does not currently have the necessary equipment, but does have space which would be used.
5. Power Generating Station--A drainage ditch along the road adjacent to the power generating station was observed to contain black, probably oil-laden, sediment. This ditch empties into St. George's Bay. Runoff from the power station property discharges into the ditch.

Damaged barrels which appeared to have contained oil were discarded along the ditch. Ground on the power station property appeared to contain oil. During the survey, the ditch was flowing full due to runoff from a recent rain. The water was very turbid and the suspended sediment had the appearance of containing absorbed oil. Two sediment samples were collected from the drainage ditch and analyzed for polychlorinated biphenols (PCBs), a suspected carcenogenic compound and a common constituent of electrical transformer oils. The samples did not contain PCBs, as indicated by a concentration of less than 0.1 micrograms per gram, the minimum detection limit. However, the samples did contain very high levels of sulphur. The oil-laden sediment will affect marine life by smothering benthic organisms and by decreasing dissolved oxygen concentrations due to the chemical oxygen demand of the sulphur. Also, it is very unsightly and presents the appearance of an operation which is not environmentally conscious.

RECOMMENDATIONS

Recommendations for the study are separated into four sections. The first three are general recommendations and recommendations specific to St. George's and the Grand Anse and Southwest Embayment area which are based on the previously discussed findings. Additional information related to the recommendations are found in the referenced appendixes and attachments. The last section of recommendations is a priority listing of the recommendations in the first three sections.

The alternatives considered in this study were: separate treatment systems for the St. George's area and the Grand Anse and Southwest Embayment area; and a single system for the combined areas. Appendix A includes the assumptions for determining the capacities of the treatment systems. Appendices B, C, D, and E contains descriptions, conceptual designs, and cost estimates of the alternative systems which have been considered--a tropical stabilization lagoon, artificial wetlands, an oxidation ditch plant, and a contact stabilization package plant, respectively. Appendix F contains a relative comparison of different construction and operation factors for the alternate treatment processes. Appendix G contains information on the alternative collection systems. Appendix H contains the preliminary cost estimates for construction of the alternative treatment systems.

The findings of this study indicate that two wastewater treatment systems is the least-cost option. Details are discussed in the recommendation sections for St. George's and Grand Anse.

General

1. Adopt and implement a sewage treatment development plan for the St. George's and the Grand Anse Southwest Embayment (henceforth referred to as Grand Anse) areas.
2. Discontinue the practice of separating grey water from the sewage collection system. Enact and enforce government regulations prohibiting this practice. All sanitary sewage should be discharged to the sewage collection systems. New developments should be required

to install water conservation devices. Appendix I is a report on water conservation which includes information on devices and example water conservation ordinances.

3. Enact water quality regulations which will protect inland and marine waters for their desired uses. Appendix J includes regulations for California and Hawaii of the United States and the Virgin Islands, which could be either applied directly or modified to Grenada.

4. For areas not to be sewered, require more efficient designs for onsite disposal systems instead of the current "soakaway" design which often allows discharge of sewage into drains leading to the waterways. Appendix K is a reference which includes basic information on alternative onsite system designs. More detailed information may be obtained from the author.

5. Implement a program of water quality sampling and sewage treatment effluent and process control sampling to ensure that water quality standards and effluent requirements are being met. The water quality analyses should include coliform and fecal coliform as a minimum on a weekly schedule. Sewage treatment analyses should include BOD, suspended solids, settleable solids, and coliform. Appendix L is a reference for simplified laboratory procedures for conducting these analyses. The sampling analyses could be conducted by personnel at the Central Water Commission Laboratory working with the Ministry of Health personnel.

6. Establish a "sewer maintenance team" which would have at least the following two responsibilities:

   a. Inspect and repair sewer lines, pump stations, and manholes on a regular schedule.

b. For areas which are not to be sewered, operate a septic tank maintenance program. On a regular schedule (such as once per five years) accumulated solids would be removed from the tanks and emptied into the central collection system in a manner which would not cause or shock overloading on the treatment plant.

c. Also, establish a sewer use ordinance which regulates the use of sewers and can be used by the sewer maintenance team. Appendix N is a good example of a sewer use ordinance which could be modified for Grenada.

7. Develop and implement a plan for financing the capital and operation costs of the proposed sewage treatment system. Information to consider is included in Appendix M, a reference which has been developed for small communities in the United States.

8. Require that all new construction projects implement best management practices to control soil erosion into the waterways.

9. Conduct a detailed survey of the process wastewaters being discharged from businesses along the St. John's River and its tributaries. Require treatment of all wastes which could cause public health and environmental impacts due to their physical and chemical characteristics.

10. Survey current agricultural land management practices which cause erosion of soil into the watersheds of the St. John's River (and others). Educate crop producers of best land management techniques which would reduce erosion thus saving their valuable topsoil and reducing sediment loads to the waterways. Develop and enforce

regulatory requirements if necessary. Appendix N is a good reference for guidelines of best management practices to control erosion.

11. Survey current pesticide fungicide and fertilizer practices by crop producers which add nutrients and toxic chemicals to the waterways. Educate producers on more cost-effective application practices.

12. Review the practices of clearing roadway bank vegetation which contribute to soil erosion. Implement alternative procedures which would reduce the amount of sediment being added to the waterways from this source.

13. Survey sources, such as the power generating station and the government central garage, having handling, storage, and use practices which result in oil entering drainage ditches. Methods to eliminate the waste sources should be implemented, which may include reclaiming the oil, building containment dikes, or burning waste oil in the power station.

St. George's

1. Construct an oxidation ditch treatment facility to serve the existing sewered area of St. George's Town and have the capacity for expansion of the sewered areas into Tempe, St. John's River, Paddock and Belmont. The hydraulic capacity should be about 0.7 Mg/d and the organic capacity should be about 1920 pounds BOD_5 per day. The treatment plant could be located on the north end of the Queen's Park with a 530 meter (1750 foot) ocean outfall to St. George's Bay. Design details are included in Appendix D.

If future governmental land use decisions do not permit a treatment plant in Queen's Park, a second alternative would be to locate the same plant elsewhere but nearby; however, this would require additional piping and pumping costs. A third alternative would be to select the combined St. George's/Grand Anse alternative having a 1.25 Mg/d oxidation ditch plant located in the Grand Anse area. However, this would be $2.9 million EC more in capital costs than the least cost options and also would require more operating costs due to the increased numbers and sizes of pumping stations.

2. Assuming that a treatment facility will not be operational until 1988-89 due to the time required for planning, financing, and construction, a 600 meter (2000 foot) ocean outfall should be constructed as a "stop-gap" for the existing sewerage system. The 15-inch PVC sewer pipe with proper anchoring should be extended from a sea head near the current discharge point in a southwest direction to the edge of the deepwater trough.
3. Until the new treatment system and outfall for St. George's is built, "post" the current discharge area with a "Danger" sign which warns the public of health hazards from either contacting the water or eating fish caught near the discharge.
4. Reduce inflow/infiltration to the collection system to reduce hydraulic flow and the amount of material such as sand entering the system. All "inspection traps" at service connections should be inspected and brought to grade or covered to prevent surface runoff from entering the sewer system. Appendix O includes a procedure which could be used to inspect sewer lines and correct obvious problems contributing to inflow/infiltration.

5. Replace the two Shone pneumatic ejectors in the St. George's sewer system with a new package lift station. It should be sized to handle current (360 gal/min) and projected (680 gal/min) loads for an expanded system. (The existing pneumatic ejector pump could be used if a feasibility study would indicate that cost-effective repairs could be made providing an acceptable extended service life.)

6. Replace the main collector lines and trunk lines along the Carenage Esplanade with the proper size pipe and install at the correct slope to handle current and future hydraulic flows. The pipe along the Carenage should be 6-inch to 12-inch PVC pipe and the trunk line along the Esplanade should be 15- and 18-inch PVC pipe. Appendix G, table 2, identifies sizing and length for piping and manholes. <u>However, this cannot be done until the location of the treatment plants are selected</u>.

7. Survey and inspect the current sewer system to obtain engineering layout and its maintenance needs to more efficiently maintain the system and plan replacement and system expansions. The estimated cost for the survey is $23,000 EC to $27,000 EC ($8,500 to 10,000 US).

8. Connect all buildings immediately adjacent to the currently sewered St. George's area (such as the hospital) to the sewer system as soon as possible so that this sewage is also treated at the proposed treatment facility.

9. Develop a schedule for sewering the areas of St. John's River, Tempe, and part of Paddock. Pipe sizes and lengths are listed in Appendix G.

10. Construct a sanitary waste dumping station which is connected to the sewer along the Lagoon to develop a regulation requiring ships/boats in the Harbour and Lagoon to hold their sanitary sewage and discharge it at the dumping station.

11. Consider replacing the old sewer lines in the currently sewered St. George's area with new correctly sized PVC pipe which is correctly installed to reduce inflow and infiltration. Pipe sizing is listed in Appendix G.

Grand Anse

1. Construct an artificial wetlands treatment facility to serve the Grand Anse area. Its capacity would be about 0.6 Mg/d. Design details are found in Appendix C. The artificial wetlands would be the "marsh" type, consisting of a manually operated bar screen, grit chamber, aeration cells, a marsh, and a pond, requiring an area of about 22 acres. Adequate area currently exists near the Prickly Bay which was also identified by the 1975 PAHO/WHO study.

   The use of artificial wetlands for sewage treatment is currently more common in Europe. A few systems are being tested or planned in the United States. It is believed that this excellent low-cost process should work even more efficiently in the tropical climate of Grenada. Therefore, a meadow, which normally follows the pond, should be build only if needed. However, land should be reserved for it which is an additional six acres. The effluent from the treatment system should be discharged through irrigation pipe along the mangrove at the head of Prickly Bay so that it can receive additional treatment in this natural wetlands area.

(Note: Recent technical literature reviewed indicates that a "root zone" type artificial wetlands is more efficient than the "marsh" type and would require significantly less land area.)

If future governmental land use decisions do not allow the use of up to 28 acres required for a marsh type artificial wetlands (less area for a root zone type) in the Prickly Bay area, a second option would be to locate the artificial wetland in the reclaimed landfill area near Woburn Bay. However, this would increase capital and operating costs due to piping and pumping. A third option would be to construct an oxidation ditch treatment facility in the Prickly Bay area. This type of treatment facility would require only about three acres. (Design details are in Appendix D.) However, this would cost about $2.6 million EC more than the artificial wetlands system.

2. Until the new treatment system for the Grand Anse area is operational, also "post" the areas immediately around the sea head drains on Grand Anse Beach to protect public health. Zones of noncontact should be determined by bacteriological sampling.
3. Inventory laboratory wastes from the St. George's Medical School to ensure wastes which may be hazardous to public health are not discharged without adequate tratment. These works should be routed to a new treatment system. In the interim, other necessary measures should be considered.
4. Repair the south sea head located near Spice Island Hotel so that sand does not enter and dam the main drainage ditch. The current

labor force which is used to shovel sand from the drain could be trained and used more effectively to do the repair work and similar work in the area.

5. Require that all existing hotels and restaurants hook on to a new collection system, thus eliminating "soakaway" systems. House laterals could be run from the existing septic tanks to the collectors. Require the use of water conservation plumbing devices at all hotels and restaurants (refer to Appendix I).

Recommendations by Priority

The recommendations identified above are either general, applying to the whole study area, or specific to an identified area such as St. George's. The author realizes that all recommendations cannot be implemented immediately due to funding and staffing. Also, some recommendations are more significant to public health and the environment. Therefore, this section identifies the previously discussed recommendations in terms of priority. First administrative recommendations, which require planning, regulation development, and other staff time, are identified by priority. Secondly, major and minor cost (capital and labor) recommendations are listed, each by priority. The priorities are based upon the author's judgment, considering the desires of the Government of Grenada, environmental needs, and costs.

1. Administrative

   a. Priority 1

      (1) Plan sewage treatment systems for St. George's and Grand Anse, including: selecting and dedicating plant sites;

selecting treatment processes; developing finance plan; and determining schedule.

(2) Establish water quality regulations.

(3) "Post" existing St. George's outfall area and areas of sea head drains on Grand Anse beach to warn of health hazard.

(4) Establish sewer use ordinance which also requires use of water conservation plumbing devices on new construction.

a. Priority 2

(1) Establish new guidelines for onsite disposal systems.

(2) Establish soil erosion control requirements on construction and agricultural practices.

b. Priority 3

(1) Eliminate waste oil sources.

(2) Reduce agriculture chemical use through education.

(3) Evaluate need to correct medical school lab wastes.

2. <u>Major Cost</u>

a. Construct sewage outfall pipe for St. George's, 2000 feet.

b. Replace lift station on Carenage and obtain correctly sized diesel generator for emergency power.

c. Survey existing sewerage system for St. George's; can be done in phases.

d. Establish sewer maintenance team to: maintain collection system; install new laterals; inspect system using sewer use ordinance as guide; and advise applicants on requirements.

e. Replace Carenage lift station force main. Relocate along Carenage through Sendall Tunnel instead of to Scott Street. Replace main 7"ϕ collector lines along Carenage with PVC pipe at same time so pipes can be in same trench.

f. Construct Grand Anse artificial wetlands sewage treatment system.

g. Construct St. George's oxidation ditch sewage treatment system.

h. Extend sewers to areas near St. George's such as Paddock, St. John's River, and Tempe.

i. Replace all existing sewer pipe in St. George's with PVC pipe.

3. Lost Cost

a. Priority 1

(1) Repair south sea head drain.

(2) Implement water quality/sewage sampling.

b. Priority 2

(1) Eliminate grey water discharges

(2) Eliminate inflow to existing system

REFERENCES

1. "Studies for Sewerage at Grand Anse-Morne Rouge, Grenada," Pan American Health Organization/World Health Organization, 1975.

2. Archer, A. B. "Grand Anse Beach Erosion Study--The Impact of Wastewater on Coral Reefs," November 1984.

3. Montgomery, James M., Consulting Engineers, Inc. "Short-Term Wastewater System Improvements, Grand Anse and St. George's, Grenada," U.S. Agency for International Development, Project Grenada, Infrastructure Revitalization, Annex III F - Wastewater. August 1984.

4. Archer, A. B. "Review of Pan American Health Organization/WHO Studies for Sewerage at Grand Anse-Morne Rouge, Grenada for the Organization of American States." December 15, 1984.

5. "Grenada: Integrated Physical Development Plan for Tourism, Zone 1," Organization of American States. December 1984.

6. Jackson, Ivor. "Physical Tourism Development Plan, Zone 1, Grenada," Organization of American States, no date (fieldwork for report of September/October, 1983).

7. Mara, D. D. "Proposed Design for Oxidation Ponds in Hot Climates," ASCE, J. Environmental Engineering Division, EEZ:196-300, April 1975.

8. Mara, D. D., et al. "Design Verification for Tropical Oxidation Ponds," ASCE, J. Environmental Engineering Division, EEI:151:155. February 1979.

9. Cambers, T. Personal communication by the author with Dr. Cambers, a physical oceanographer, Barbados, conducting marine current studies in Grenada for the Oceanographer of American States, November 1985.

APPENDIX A

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

ASSUMPTIONS AND CALCULATIONS FOR PROJECTED POPULATION AND HYDRAULIC AND ORGANIC SEWAGE LOADS FOR SEWAGE TREATMENT IN GRENADA, WEST INDIES

Chattanooga, Tennessee

December 1985

ASSUMPTIONS

Assumptions for population and hydraulic and organic sewage loads are based either on statements made by the Ministry of Health, data from previous studies (references 4, 5, and 6), or engineering practice. The source is indicated by each.

1. Population

   a. Resident populations for St. George's Town (4712), Tempe (248), and St. John's River (1503), and the commuter population of St. George's (10,000 per day) was obtained from the Ministry of Health who also said to assume zero growth in these areas.

   b. Commuter populations for Tempe (200) and St. John's River (1000) areas are estimated based upon the number and type of businesses in these areas observed by the author of this report.

   c. The resident population projections for the Paddock, Belmont, Grand Anse Estates, Grand Anse Beach, and Morne Rouge area (henceforth referred to as Grand Anse) is 1050 houses with 4 persons per house (reference 4). Based upon topography, it was assumed that 10 percent and 90 percent would be connected to separate St. George's and Grand Anse treatment systems, respectively.

   d. The hotel room projection for the Grand Anse area is 2300 rooms (reference 4).

   e. A restaurant projection is assumed by the author to be 2000 seats with 400 and 1600 located in the St. George's and Grand Anse areas, respectively.

2. Sewage hydraulic loads

   a. For residential flows, the Ministry of Health said to assume 60 gallons per day per person (gpdc). After reviewing previous studies, a flow of 23,040 gpd per 100 houses is used in this study, or 57.6 gpdc for 4 persons per house (reference 4).

   b. For commuters, a flow of 20 gpdc was used (engineering practice in the United States).

   c. For hotels, a flow of 13,824 gpd/rooms is used (reference 4).

   d. For restaurants, a flow of 35 gpd/seat is used (engineering practice in the United States).

   e. An infiltration flow of 5000 gpd/acre for the currently sewered St. George's system is used (6.5 acres), deleting 25 percent for more watertight PVC sewer lines.

3. Organic loads

   a. For residential, 0.17 pounds BOD_5 per day per person (ppdc) is used (engineering practices).

   b. For commutors, 0.06 ppdc is used (engineering practice).

   c. For hotels, 0.12 ppd per room is used (engineering practice).

   d. For restaurants, 0.2 ppd per seat is used (engineering practice).

ST. GEORGE'S ONLY TREATMENT SYSTEM

1. Hydraulic

		Flow (gpd)
St. George's Town:	Residents - 4,712 x 57.6	271,411
	Commuters - 10,000 x 20	200,000
	Restaurants - 400 x 35	14,000
		485,411
Tempe:	Residents - 248 x 57.6	14,285
	Commuters - 200 x 20	4,000
		18,285
St. John's River:	Residents - 1,503 x 57.6	86,573
	Commuters - 1,000 x 20	20,000
		485,411
Paddock/Belmont:	Residents - 400 x 57.6	23,040
Infiltration:	6.5 x 5000 gpd/acre x 0.75	24,375
	Total	657,684
	Use	658,000 gpd

2. Organic

		BOD_5 (ppd)
St. George's Town:	Residents - 4,712 x 0.17	801
	Commuters - 10,000 x 0.06	600
	Restaurants - 400 x 0.2	80
		1,481
Tempe:	Residents - 248 x 0.17	43
	Commuters - 200 x 0.06	12
		55
St. John's River:	Residents - 1,503 x 0.17	256
	Commuters - 1,000 x 0.06	60
		316
Paddock/Belmont:	Residents - 400 x 0.17	68
	Total	1,920

GRAND ANSE ONLY TREATMENT SYSTEM

1. **Hydraulic**

	Flow (gpd)
Residents - 950 x 23,040	218,800
Commuters - 2,300 x 13,824	317,952
Restaurants - 1,600 x 35	56,000
	592,832
Use	593,000 gpd

2. **Organic**

	BOD_5 (ppd)
Residents - 950 x 4 x 0.17	646
Commuters - 2,300 x 0.12	276
Restaurants - 1,600 x 0.2	320
	1,242

COMBINED ST. GEORGE'S AND GRAND ANSE SYSTEM

1. **Hydraulic**

	Flow (gpd)
St. George's	657,684
Grand Anse	572,833
Restaurants - 1,600 x 35	56,000
	1,250,516
Use	1,251,000 gpd

2. **Organic**

	BOD_5 (ppd)
St. George's	1,920
Grand Anse	1,242
	3,162

APPENDIX B

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

ENGINEERING REPORT AND CONCEPTUAL DESIGN FOR TROPICAL STABILIZATION POND SYSTEMS FOR SEWAGE TREATMENT IN GRENADA, WEST INDIES

Chattanooga, Tennessee
December, 1985

SECTION 1

INTRODUCTION

This report presents the conceptual designs for sewage stabilization pond treatment systems which could be used to treat the domestic wastewater of either St. George's, the Grand Anse area, or the combined flow of St. George's and the Grand Anse area.

The design basis is for a flow-through 5-pond system which has been developed specifically for tropical systems (references 7 and 8). Tropical systems do not have to be designed for cold weather conditions and therefore can be smaller for a given organic load compared to a similar loading in a northern latitude.

Stabilization pond systems are typically less expensive to build and operate than conventional wastewater treatment plants. Also, they do not require as much technical training and experience to operate as conventional systems. They do require a larger amount of land which must be relatively flat.

The tropical pond design requires 5-day retention volumes on each of the ponds in the series. The first cell is designed with about 25 percent greater volume for solids retention.

SECTION 2

BASIC ASSUMPTIONS

Retention Volume - 5 days, each pond

Hydraulic and Organic Loading

	Hydraulic (MGD)	Organic (ppd, BOD5)
St. George's	0.658	1920
Grand Anse	0.593	1242
Combined St. George's/Grand Anse	1.251	3162

References:

(1) Mara, D. D. "Proposed Design for Oxidation Ponds in Hot Climates", ASCE J. Env. Engr. Div. 101 (EE2): 296-300, Apr. 1975.

(2) Mara, D. D., et al. "Design Verification for Tropical Oxidation Ponds", ASCE J. Env. Engr. Div., EE1: 151--155, Feb. 1979.

(3) "Wastewater Treatment Ponds (Lagoons)", Recommended Standards for Sewage Works, Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, 100-1 to 100-10, 1978.

SECTION 3

CONCEPTUAL DESIGN FOR SYSTEM TO SERVE ST. GEORGE'S

Required Volume, each pond = 5 days x 0.658 MGD
= 3.29 MG, or 12,453 m^3

For 1 m depth, required area = 12,453 m^2

The proposed Queen's Park area can not contain a 5-pond system with an effective treatment area of 62,225 m^2. If reduced treatement were accepted and a 4-pond system were used and built square shaped, about 50,000 m^2 of effective area and 68,000 m^2 total area (17 acres) would be required. Attachment B1 shows how this system would be contained in Queen's Pond. Since it uses essentially all the park area, this option is considered unacceptable.

SECTION 4

CONCEPTUAL DESIGN FOR SYSTEM TO SERVE GRAND ANSE AREA

Required Volume, each pond = 5 days x 0.593 MGD
= 2.965 MG, or 11,223 m^3

For 1 meter depth, required area = 11,223 m^3

Use length: width = 2:1, or about 150 m x 75 m.

Use 5 ponds in series, Pond 1 depth = 1.25 m, and Ponds 2,3,4, and 5 depths = 1.0 m.

Pond 1 volume = 14,062 m^3

$$\text{retention} = \frac{14{,}062}{2245\ m^3/\text{day}} = 6.26 \text{ days}$$

Ponds 2-5 volumes = 11,223 m^3
retention = 5 days

Total effective area = 11,223 m^2 x 5 = 56,115 m^2
Total required area = 76,100 m^2, 18.8 acres

Additional areas required for 3:1 slope of dike and a 2.44 m (8 ft.) top of dike width.

The proposed Grand Anse area at the head of Prickly Bay would contain this system. A small stream would have to be channeled around the pond system. The locaton of the system is shown in Attachment B2, and the configuration of the ponds is shown in Attachment B3.

SECTION 5

CONCEPTUAL DESIGN FOR SYSTEM TO SERVE COMBINED ST. GEORGE'S/GRAND ANSE AREAS

For better pond management, use two parallel 5-pond systems to which the flow of 1.251 MGD is split, or 0.625 MGD

Required volume, each pond = 5 x 0.6255 MGD =
= 3.1275 MG, or 11.838

For 1 m depth, required area = 11,838 m^2

Use length to width = 3:1, or about 63 m x 189 m

Total effective area required = 11,907 m^2 x 10 = 119,070 m^2

Total required area = 129,700 m^2, 32 acres

A parallel 5-pond system consisting of 10 ponds could not be contained satisfactorily in the proposed area at the head of Prickly Bay. A parallel 4-pond system consisting of 8 ponds could be contained in the area. However, a lesser degree of treatment will be attained for organics, solids and bacteria. Two additional polishing ponds could be located immediately to the west across a ridge at the head of True Blue Bay. This would require pumping of the total flow. Attachment B4 shows the location of a parallel 4-pond system with two added ponds when desired. Attachment B5 shows the configuration of the parallel 4-pond system.

SECTION 6

ADDITIONAL SPECIFICATIONS

For pond construction details concerning embankments and dikes, pond bottom, influent lines, control structures and interconnected piping, and other miscellaneous items, accepted quidelines such as 10 State Standards should be used. Attachment B6 is a copy of the pertinent pages for 10 State Standards.

SECTION 7

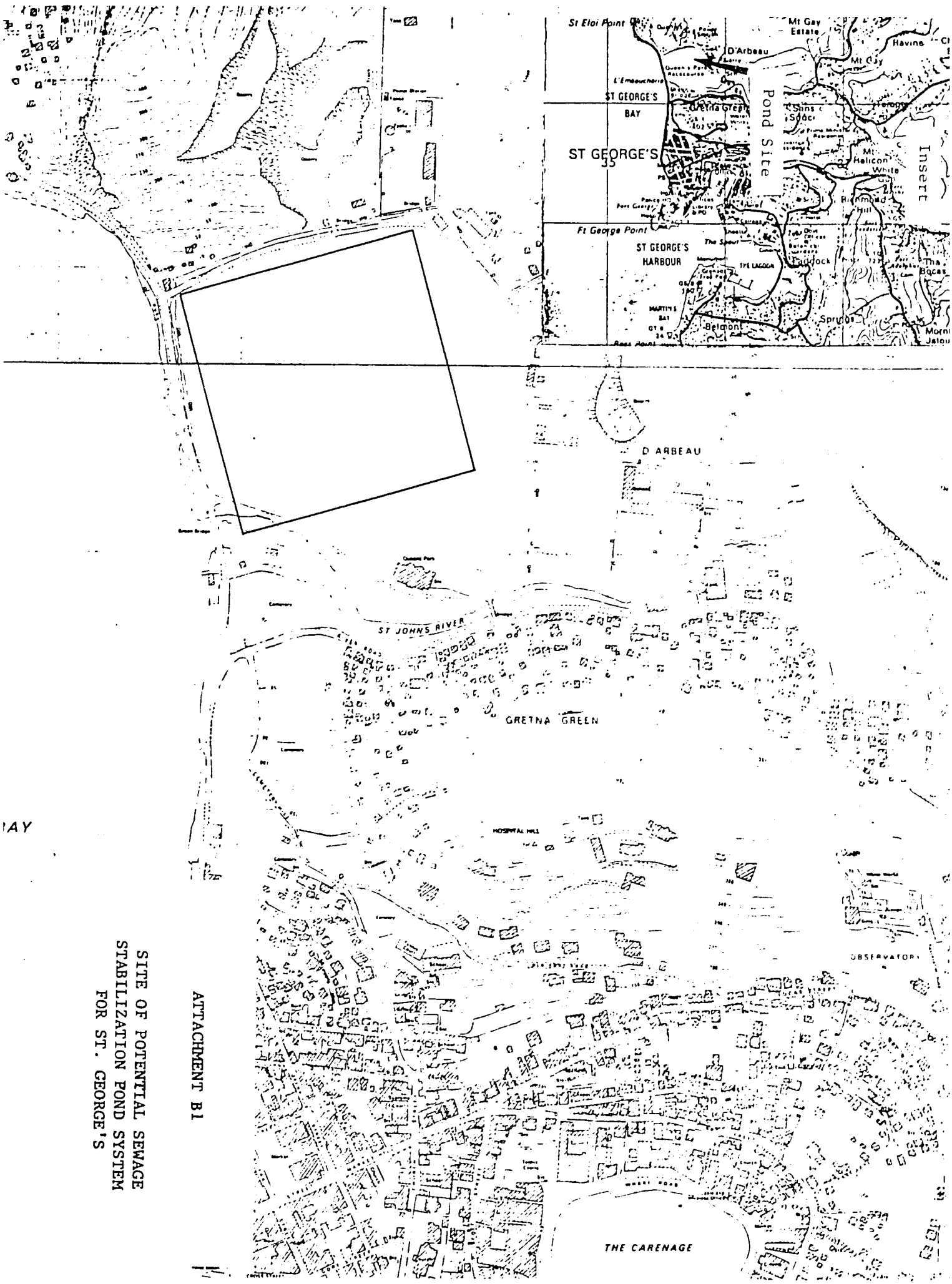
COST ESTIMATES[1]

Estimated construction cost data for tropical sewage stabilization ponds treatment facilities to serve the Grand Anse area and the combined St. George's/Grand Anse flows are listed below.

	Design Flow, MGD	Design Loading 16 BOD_5/day	Cost[2] $EC ($US)
Grand Anse	0.6	1242	$2,860,000 ($1,067,000)
St. George's/Grand Anse	1.25	3162	$4,837,000 ($1,805,000)

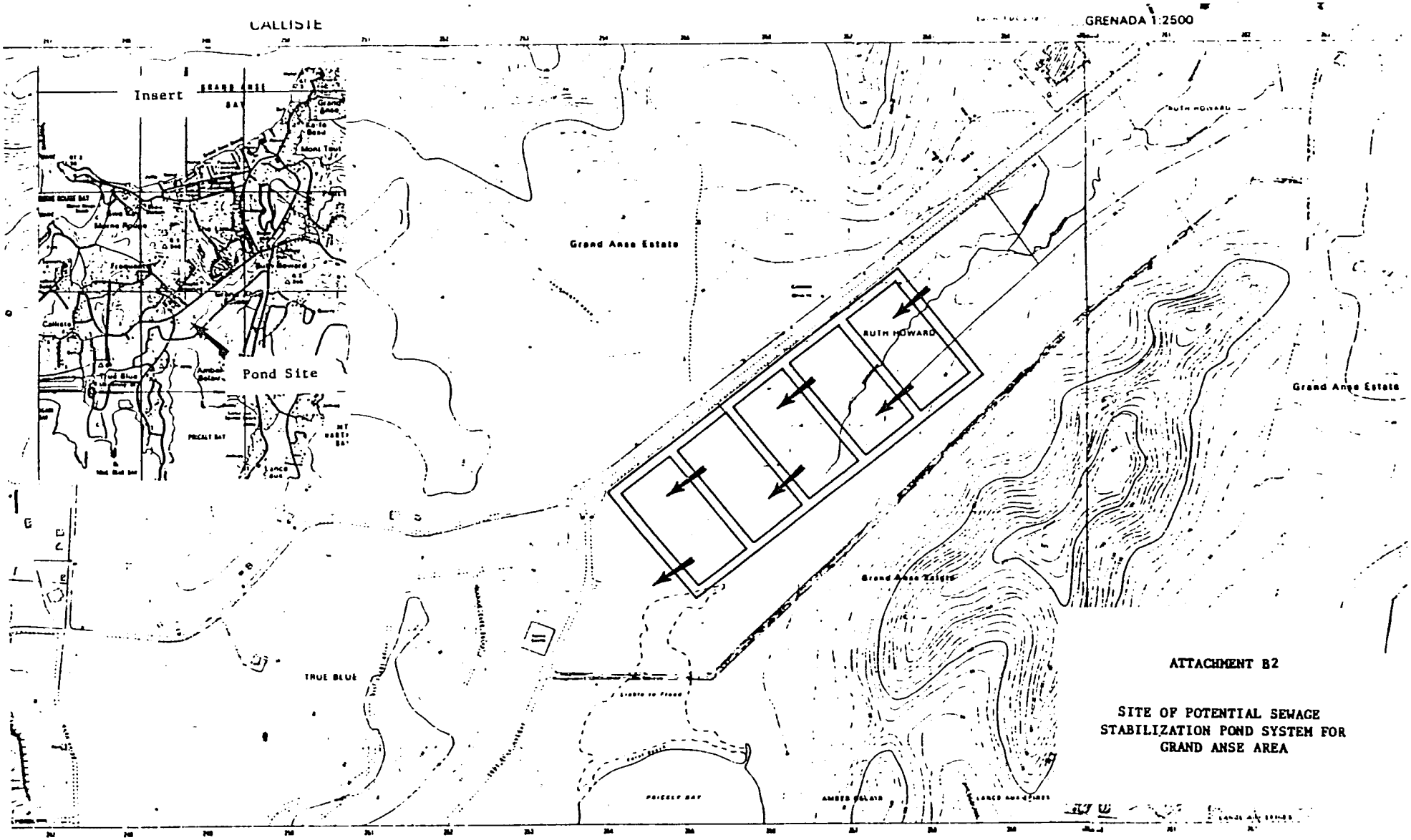
[1]Estimates provided by Howard K. Bell Consulting Engineers, P.O. Box 661, Hopkinsville, KY 42240.

[2]Total costs must include an additional estimated 45% for contingency and engineering services.



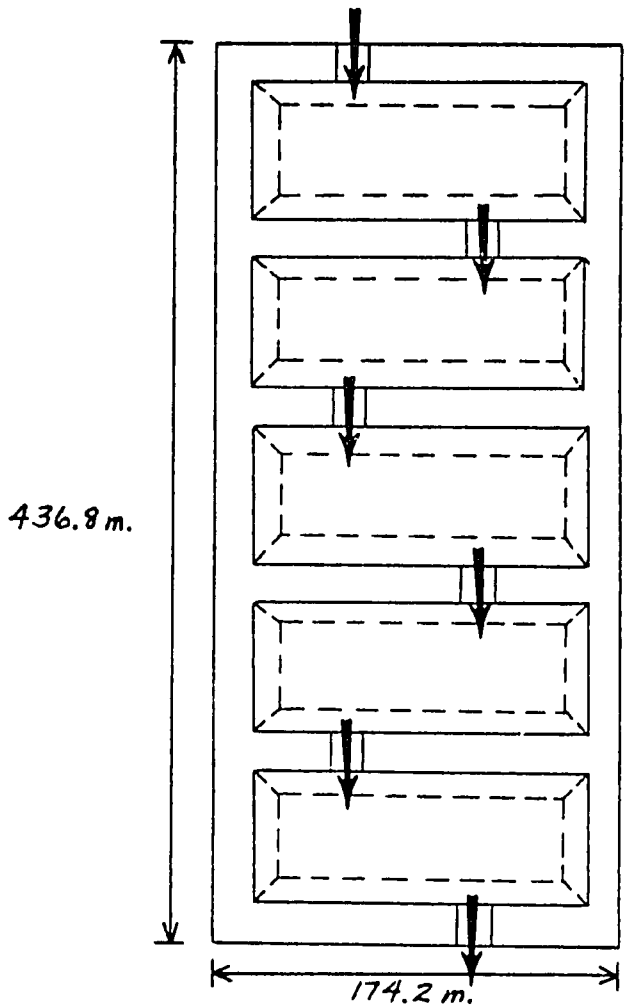
ATTACHMENT B1

SITE OF POTENTIAL SEWAGE
STABILIZATION POND SYSTEM
FOR ST. GEORGE'S



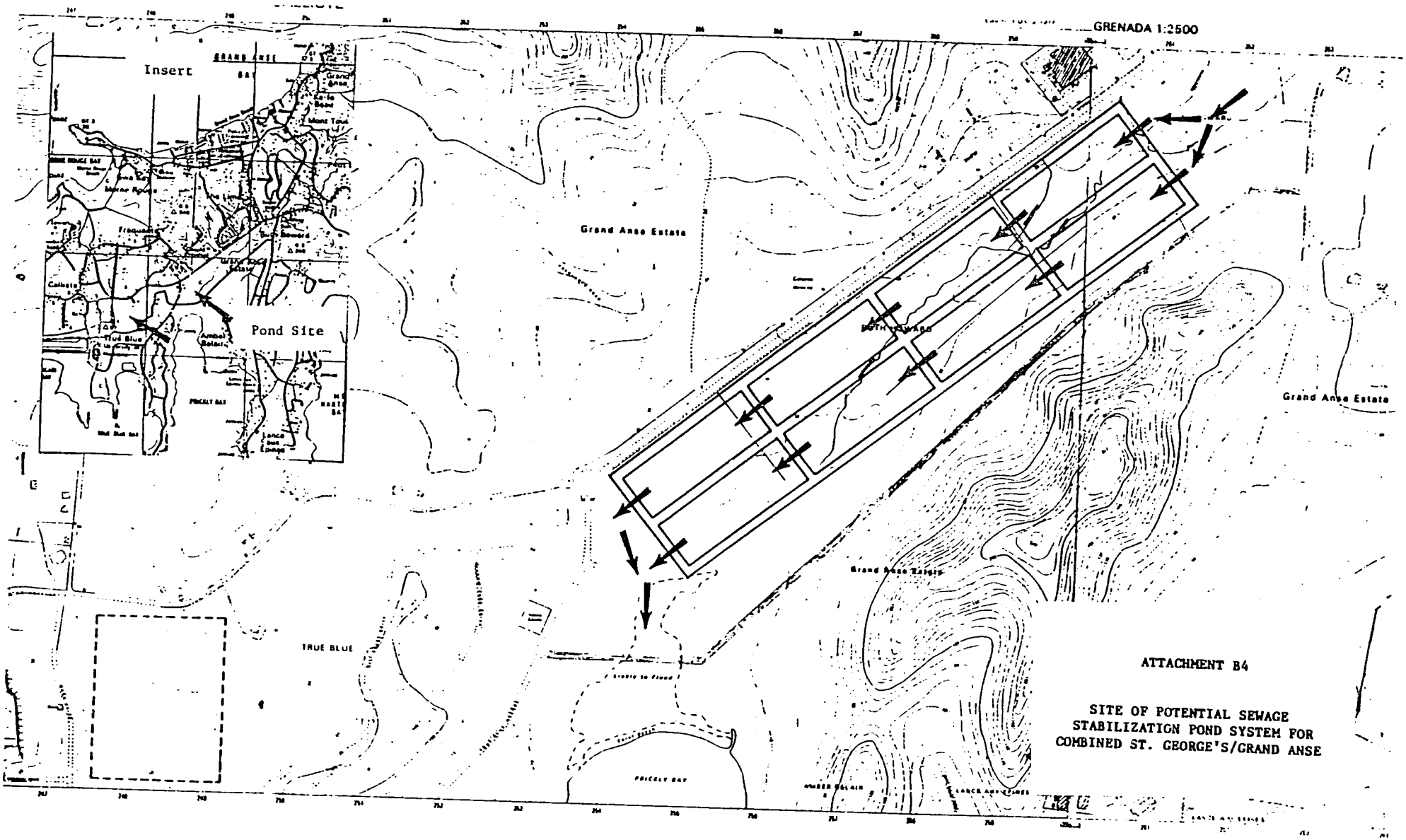
ATTACHMENT B2

SITE OF POTENTIAL SEWAGE STABILIZATION POND SYSTEM FOR GRAND ANSE AREA



ATTACHMENT B3

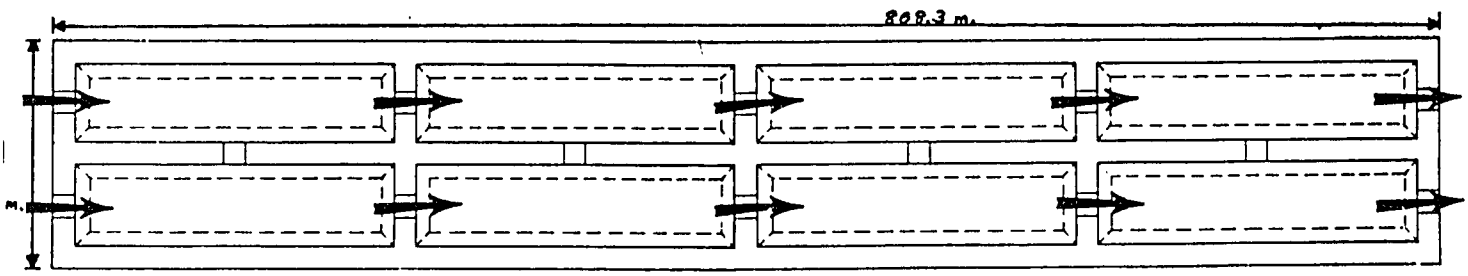
SCHEMATIC OF PROPOSED TROPICAL
STABILIZATION POND SYSTEM
--5-POND SERIES ARRANGEMENT



ATTACHMENT B4

SITE OF POTENTIAL SEWAGE STABILIZATION POND SYSTEM FOR COMBINED ST. GEORGE'S/GRAND ANSE

-45-



ATTACHMENT B5

SCHEMATIC OF PROPOSED
TROPICAL STABILIZATION POND
SYSTEM - PARALLEL 4-POND SERIES
SYSTEM ARRANGEMENT

ATTACHMENT B6

DESIGN GUIDELINES FOR STABILIZATION POND CONSTRUCTION

CHAPTER 100
WASTEWATER TREATMENT PONDS (LAGOONS)

100. GENERAL

This Chapter deals with generally used variations of treatment ponds to achieve secondary treatment including controlled-discharge pond systems, flow-through pond systems and aerated pond systems. Ponds utilized for equalization, percolation, evaporation and sludge storage will not be discussed in this Chapter.

101. SUPPLEMENT TO ENGINEER'S REPORT

The engineer's report shall contain pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required in Chapter 10.

101.1 Supplementary Field Survey Data

101.11 Location of Nearby Facilities

The location and direction of all residences, commercial developments, parks, recreational areas, and water supplies (including a log of each well unless waived by the reviewing authority) within one mile (*1.6 km*) of the proposed pond shall be included in the engineer's report.

101.12 Land Use Zoning

Land use zoning adjacent to the proposed pond site shall be included.

101.13 Site Description

A description, including maps showing elevations and contours of the site and adjacent area shall be provided. Due consideration shall be given to additional treatment units and/or increased waste loadings in determining land requirements. Current U.S. Geological Survey and Soil Conservation Service maps may be considered adequate for preliminary evaluation of the proposed site.

101.14 Location of Field Tile

The location, depth, and discharge point of any field tile in the immediate area of the proposed site shall be identified.

101.15 Soil Borings

Data from soil borings conducted by an independent soil testing laboratory to determine subsurface soil characteristics and groundwater characteristics (including elevation and flow) of the proposed site and their effect on the construction and operation of a pond shall also be provided. At least one boring shall be a minimum of 25 feet (*7.6 m*) in depth or into bedrock, whichever is shallower. If bedrock is encountered, rock type, structure and corresponding geological formation data should be provided. The boring shall be filled and sealed. The permeability characteristics of the pond bottom and pond seal materials shall also be studied. (See Section 104.2)

101.16 Sulfate Content of Water Supply

Sulfate content of the basic water supply shall be determined.

102. LOCATION

102.1 Distance From Habitation

A pond site should be located as far as practicable, with a minimum of 1/4 mile (*0.4 km*), from habitation or any area which may be built up within a reasonable future period. Consideration should be given to site specifics such as topography, prevailing winds, forests, etc.

102.2 Prevailing Winds

If practicable, ponds should be located so that local prevailing winds will be in the direction of uninhabited areas.

102.3 Surface Runoff

Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provision must be made to divert stormwater runoff around the ponds and protect pond embankments from erosion.

102.4 Hydrology

Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of 4 feet (*1.2 m*) between the bottom of the pond and the maximum groundwater elevation should be maintained.

102.5 Geology

Ponds shall not be located in areas which may be subjected to karstification, (i.e., sink holes or underground streams generally occurring in areas underlain by limestone or dolomite).

A minimum separation of 10 feet (*3.0 m*) between the pond bottom and any bedrock formation is recommended.

103. BASIS OF DESIGN

103.1 Area and Loadings for Controlled-Discharge Stabilization Ponds

Pond design for BOD_5 loading may range from 15 to 35 pounds per acre per day (*17-45 kg/ha·d*) at the mean operating depth in the primary cells and at least 180 days detention time between the 2 foot (*0.6 m*) and the maximum operating depth of the entire pond system. The detention time and organic loading rate shall depend on climatic or stream conditions.

103.2 Area and Loadings for Flow-Through Stabilization Ponds

Pond design for BOD loading may vary from 15 to 35 pounds per acre per day (*17-45 kg/ha·d*) for the primary pond(s). The major design considerations for BOD loading must be directly related to the climatic conditions.

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Design variables such as pond depth, multiple units, detention time, and additional treatment units must be considered with respect to applicable standards for BOD_5, total suspended solids (TSS), fecal coliforms, dissolved oxygen (DO), and pH.

A detention time of 90 – 120 days should be provided; however, this must be properly related to other design considerations. It should be noted that the major factor in the design is the duration of the cold weather period (water temperature less than 5°C.).

103.3 Aerated Pond Systems

For the development of final design parameters it is recommended that actual experimental data be developed; however, the aerated pond system design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3K_1 \times (100 - E)}$$

t = detention time, days

E = percent of BOD_5 to be removed in an aerated pond

K_1 = reaction coefficient, aerated lagoon, base 10. For normal domestic sewage, the K_1 value may be assumed to be 0.12/day at 20°C and 0.06/day at 1°C.

The reaction rate coefficient for domestic sewage which includes some industrial wastes, other wastes and partially treated sewage must be determined experimentally for various conditions which might be encountered in the aerated ponds. Conversion of the reaction rate coefficient at other temperatures shall be made based on experimental data.

Raw sewage strength should also consider the effect of any return sludge. Also, additional storage volume should be considered for sludge, and in northern climates, ice cover.

Oxygen requirements generally will depend on the BOD loading, the degree of treatment, and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of 2 mg/l in the ponds at all times. Suitable protection from weather shall be provided for electrical controls.

See Chapter 80 for details on aeration.

103.4 Industrial Wastes

Consideration shall be given to the type and effects of industrial wastes on the treatment process. In some cases it may be necessary to pretreat industrial or other discharges.

Industrial wastes shall not be discharged to ponds without assessment of the effects such substances may have upon the treatment process or discharge requirements in accordance with state and federal laws.

103.5 Multiple Units

At a minimum, a pond system should consist of 3 cells designed to facilitate both series and parallel operations. The maximum size of a pond cell should be 40 acres (*16 ha*). Two-cell systems may be utilized in very small installations.

All systems should be designed with piping flexibility to permit isolation of any cell without affecting the transfer and discharge capabilities of the total system. In addition, the ability to discharge the influent waste load to a minimum of 2 cells and/or all primary cells in the system should be provided.

103.51 Controlled-Discharge Stabilization Ponds

For controlled-discharge systems the area specified as the primary ponds should be equally divided into two cells with the third or secondary cell volume a minimum of 1/3 the total volume of the entire system.

In addition, design should permit for adequate elevation difference between primary and secondary ponds to permit gravity filling of the secondary from the primary. Where this is not feasible, pumping facilities shall be provided.

103.52 Flow-Through Pond Systems

At a minimum, primary cells shall provide adequate detention time to maximize BOD removal. Secondary cells should then be provided for additional detention time with depths to eight feet (*2.4 m*) to facilitate solids reduction. Design should also consider recirculation within the system.

103.53 Aerated Pond Systems

For a total aerated system, a minimum of 3 cells employing a tapered mode of aeration is recommended.

103.6 Pond Shape

The shape of all cells should be such that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at corners to minimize accumulations of floating materials. Common-wall dike construction, wherever possible, is strongly encouraged.

103.7 Additional Treatment

Consideration should be given in the design stage to the utilization of additional treatment units as may be necessary to meet applicable discharge standards. See Section 101.13.

104. POND CONSTRUCTION DETAILS

104.1 Embankments and Dikes

104.11 Material

Dikes shall be constructed of relatively impervious material and compacted to at least 90 percent Standard Proctor Density to form a stable structure. Vegetation and other unsuitable materials shall be removed from the area where the embankment is to be placed.

104.12 Top Width

The minimum dike width shall be 8 feet (*2.4 m*) to permit access of maintenance vehicles.

104.13 Maximum Slopes

Inner and outer dike slopes shall not be steeper than 1 vertical to 3 horizontal (1:3).

104.14 Minimum Slopes

Inner slopes should not be flatter than 1 vertical to 4 horizontal (1:4). Flatter slopes can be specified for larger installations because of wave action but have the disadvantage of added shallow areas being conducive to emergent vegetation. Outer slopes shall be sufficient to prevent surface runoff from entering the ponds.

104.15 Freeboard

Minimum freeboard shall be 3 feet (*1.0 m*). For very small systems, 2 feet (*0.6 m*) may be acceptable.

104.16 Design Depth

The minimum operating depth should be sufficient to prevent growth of aquatic plants and damage to the dikes, bottom, control structures, aeration equipment and other appurtenances. In no case should pond depths be less than 2 feet (*0.6 m*).

104.161 Controlled-Discharge Stabilization Ponds

The maximum water depth shall be 6 feet (*1.8 m*) in primary cells. Greater depths in subsequent cells are permissible although supplemental aeration or mixing may be necessary.

104.162 Flow-Through Stabilization Ponds

Same as 104.161.

104.163 Aerated Pond Systems

The design water depth should be 10 – 15 feet (*3 – 4.5 m*). This depth limitation may be altered depending on the aeration equipment, waste strength and climatic conditions.

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104.17 Erosion Control

A justification and detailed discussion of the method of erosion control which encompasses all relative factors such as pond location and size, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., shall be provided.

104.171 Seeding

The dikes shall have a cover layer of at least 4 inches (*10 cm*), of fertile topsoil to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling (in accordance with 104.24), adequate vegetation shall be established on dikes from the outside toe to 2 feet (*0.6 m*) above the pond bottom on the interior as measured on the slope. Perennial-type, low-growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding on dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water holding efficiency of the dikes.

104.172 Additional Erosion Protection

Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cells the design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope to protect the embankment from erosion due to severe flooding of a watercourse.

104.173 Alternate Erosion Protection

Alternate erosion control on the interior dike slopes may be necessary for ponds which are subject to severe wave action. In these cases riprap or acceptable equal shall be placed from one foot (*0.3 m*) above the high water mark to two feet (*0.6 m*) below the low water mark (measured on the vertical).

104.2 Pond Bottom

104.21 Soil

Soil used in constructing the pond bottom (not including seal) and dike cores shall be relatively incompressible and tight and compacted at or up to 4 percent above the optimum water content to at least 90 percent Standard Proctor Density.

104.22 Seal

Ponds shall be sealed such that seepage loss through the seal is as low as practicably possible. Seals consisting of soils, bentonite, or synthetic liners may be considered provided the permeability, durability, and integrity of the proposed material can be satisfactorily demonstrated for anticipated conditions. Results of a testing program which substantiates the adequacy of the proposed seal must be incorporated into and/or accompany the engineering report. Standard ASTM procedures or acceptable similar methods shall be used for all tests.

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To achieve an adequate seal in systems using soil, bentonite, or other seal materials, the coefficient of permeability (K) in centimeters per second specified for the seal shall not exceed the value derived from the following expression:

$$K = 3.0 \times 10^{-9} \cdot L$$

where L equals the thickness of the seal in centimeters. The "K" obtained by the above expression corresponds to a percolation rate of pond water of less than 500 gallons per day per acre (*4.68 $m^3/ha \cdot d$*) at a water depth of six feet (*2 m*).

For a seal consisting of a synthetic liner, seepage loss through the liner shall not exceed the quantity equivalent to seepage loss through an adequate soil seal.

104.23 Uniformity

The pond bottom shall be as level as possible at all points. Finished elevations shall not be more than 3 inches (*7.5 cm*) from the average elevation of the bottom.

104.24 Prefilling

Prefilling the pond should be considered in order to protect the liner, to prevent weed growth, to reduce odor, and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in Sections 104.171 and 104.172 before the introduction of water.

104.3 Influent Lines

104.31 Material

Generally accepted material for underground sewer construction will be given consideration for the influent line to the pond. Unlined corrugated metal pipe should be avoided, however, due to corrosion problems. In material selection, consideration must be given to the quality of the wastes, exceptionally heavy external loadings, abrasion, soft foundations, and similar problems.

104.32 Manhole

A manhole or vented cleanout wye shall be installed prior to entrance of the influent line into the primary cell and shall be located as close to the dike as topography permits. Its invert shall be at least 6 inches (*15 cm*) above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

104.33 Flow Distribution

Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to primary cells.

104.34 Placement

Influent lines shall be located along the bottom of the pond so that the top of the pipe is just below the average elevation of the pond seal; however, the pipe shall have adequate seal below it.

104.35 Point of Discharge

All primary cells shall have individual influent lines which terminate at approximately the center of the cell so as to minimize short-circuiting. Consideration should be given to multi-influent discharge points for primary cells of 20 acres (*8 ha*) or larger to enhance the distribution of waste load in the cell.

All aerated cells shall have influent lines which distribute the load within the mixing zone of the aeration equipment. Consideration of multiple inlets should be closely evaluated for any diffused aeration system.

104.36 Influent Discharge Apron

The influent line shall discharge horizontally into a shallow, saucer-shaped, depression.

The end of the discharge line shall rest on a suitable concrete apron large enough to prevent the terminal influent velocity at the end of the apron from causing soil erosion. A minimum size apron of 2 feet (*0.6 m*) square shall be provided.

104.4 Control Structures and Interconnecting Piping

104.41 Structure

Where possible, facilities design shall consider the use of multi-purpose control structures to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing, and minimization of the number of construction sites within the dikes.

As a minimum, control structures shall be (a) accessible for maintenance and adjustment of controls; (b) adequately ventilated for safety and to minimize corrosion; (c) locked to discourage vandalism; (d) contain controls to permit water level and flow rate control, complete shutoff, and complete draining; (e) constructed of non-corrodible materials (metal-on-metal contact in controls should be of similar alloys to discourage electro-chemical reactions); and (f) located to minimize short-circuiting within the cell and avoid freezing and ice damage.

Recommended devices to regulate water level are valves, slide tubes or dual slide gates. Regulators should be designed so that they can be preset to stop flows at any pond elevation.

104.42 Piping

All piping shall be of cast iron or other acceptable material. The piping shall not be located within or below the seal. Pipes should be anchored with adequate erosion control.

104.421 Drawdown Structure Piping

a. Submerged Takeoffs

For ponds designed for shallow or variable depth operations, submerged takeoffs are recommended. Intakes shall be located a minimum of 10 feet (*3.0*

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m) from the toe of the dike and 2 feet (*0.6 m*) from the top of the seal, and shall employ vertical withdrawal.

b. Multi-level Takeoffs

For ponds that are designed deep enough to permit stratification of pond content, multiple takeoffs are recommended. There shall be a minimum of 3 withdrawal pipes at different elevations. The bottom pipe shall conform to a submerged takeoff. The others should utilize horizontal entrance. Adequate structural support shall be provided.

c. Surface Takeoffs

For use under constant discharge conditions and/or relatively shallow ponds under warm weather conditions, surface overflow-type withdrawal is recommended. Design should evaluate floating weir box or slide tube entrance with baffles for scum control.

d. Maintenance Drawdown

All ponds shall have a pond drain to allow complete emptying, either by gravity or pumping, for maintenance. These should be incorporated into the above-described structures.

e. Emergency Overflow

To prevent overtopping of dikes, emergency overflow should be provided.

104.422 Hydraulic Capacity

The hydraulic capacity for continuous discharge structures and piping shall allow for a minimum of 250 percent of the design flow of the system.

The hydraulic capacity for controlled-discharge systems shall permit transfer of water at a minimum rate of six inches (*15 cm*) of pond water depth per day at the available head.

105. MISCELLANEOUS

105.1 Fencing

The pond area shall be enclosed with an adequate fence to prevent entering of livestock and discourage trespassing. Fencing should not obstruct vehicle traffic on top of the dike. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

105.2 Access

An all-weather access road shall be provided to the pond site to allow year-round maintenance of the facility.

105.3 Warning Signs

Appropriate permanent signs shall be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one sign shall be provided on each side of the site and one for every 500 feet (*150 m*) of its perimeter.

105.4 Flow Measurement

Flow measurement requirements are presented in Section 46.6. Effective weather protection shall be provided for the recording equipment.

105.5 Groundwater Monitoring

An approved system of wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The need for such monitoring will be determined on a case-by-case basis.

105.6 Laboratory Equipment

For laboratory equipment refer to Chapter 40.

105.7 Pond Level Gauges

Pond level gauges shall be provided.

105.8 Service Building

Consideration in design should be given to a service building for laboratory and maintenance equipment.

APPENDIX C

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

ENGINEERING REPORT AND CONCEPTUAL DESIGN FOR AN 0.6 MGD ARTIFICIAL WETLAND SEWAGE TREATMENT SYSTEM IN THE GRAND ANSE AREA OF GRENADA, WEST INDIES

Chattanooga, Tennessee

December 1985

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References

Attachment C1 Technology Assessment of Artificial Wetlands for Municipal Wastewater Treatment

Attachment C2 Letter, Dr. Richard A. Howard, Wetland Plants for Grenada, West Indies

SECTION 1

INTRODUCTION

This report presents conceptual designs for an artificial wetland wastewater treatment system for the Grand Anse area. The system are based on wetland vegetation (such as cattails) providing the environment for sewage treatment. The contaminant removal mechanisms are complex and a detailed investigation of the technology is presented in the report, Technology assessment of Artificial Wetlands for Municipal Wastewater Treatment (Appendix C1).

The technology is most suitable for small communities with wastewater flows under two million gallons per day (MGD) that have access to reasonably priced, level acreage. The primary advantages of the technology include costs savings and ease of operation. The systems are typically less expensive to build and operate than conventional wastewater treatment plants and they do not require as much technical training and expertise to operate as conventional systems.

In the stand-alone version, the conceptual design will describe a marsh-pond-meadow system intended to provide all treatment necessary to protect the environment for an average daily flow of 0.6 MGD. The design is based on an existing system in the United States and is expected to perform even better in the tropical climate of Grenada.

Figures 1 and 2 show a typical artificial wetlands treatment scheme.

(Recent technical literature reviewed since preparation of this conceptual design indicates that a "root zone" type system is more efficient than the marsh type and requires significantly less land area. Data indicates that capital and operating cost can be about 10 percent of the costs for an activated sludge plant. For comparison, this study indicates that the capital costs for the marsh type artificial wetlands would be about 23 percent of the cost for a contact stabilization (activated sludge) plant. Therefore, a root zone system in Grenada may be one-half the cost of a marsh system.)

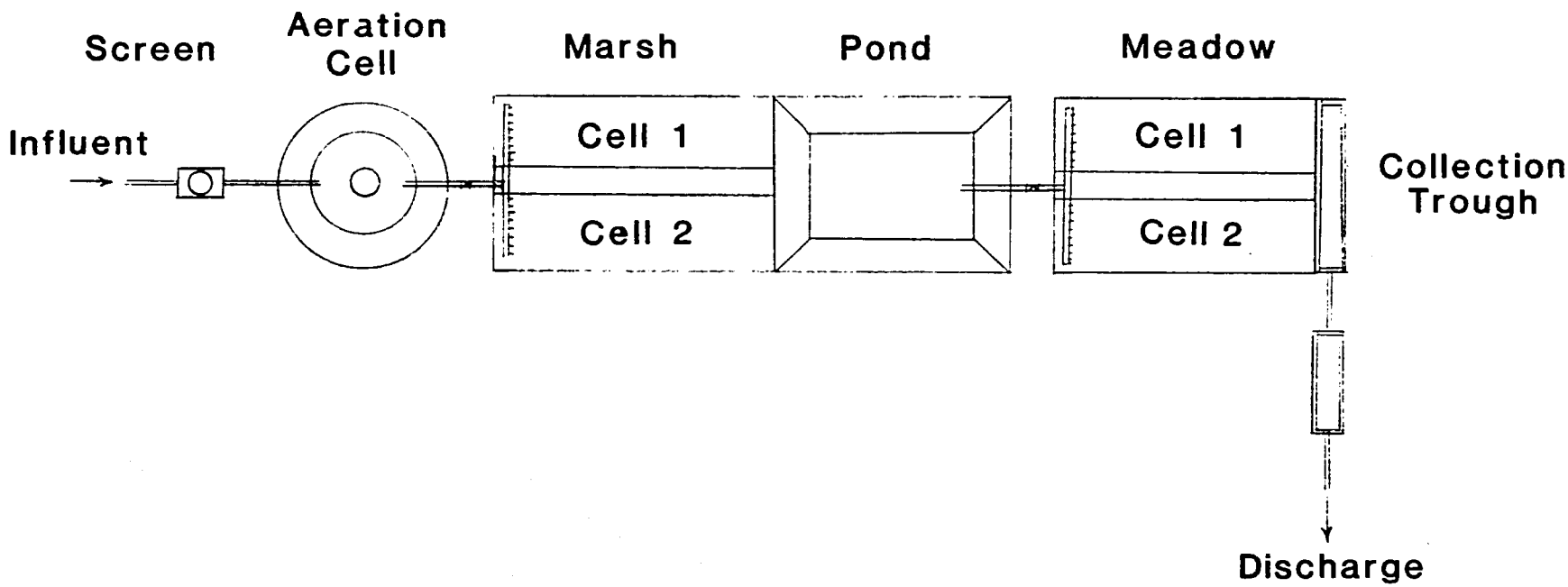


Figure 1. Iselin Artificial Wetland Treatment Scheme

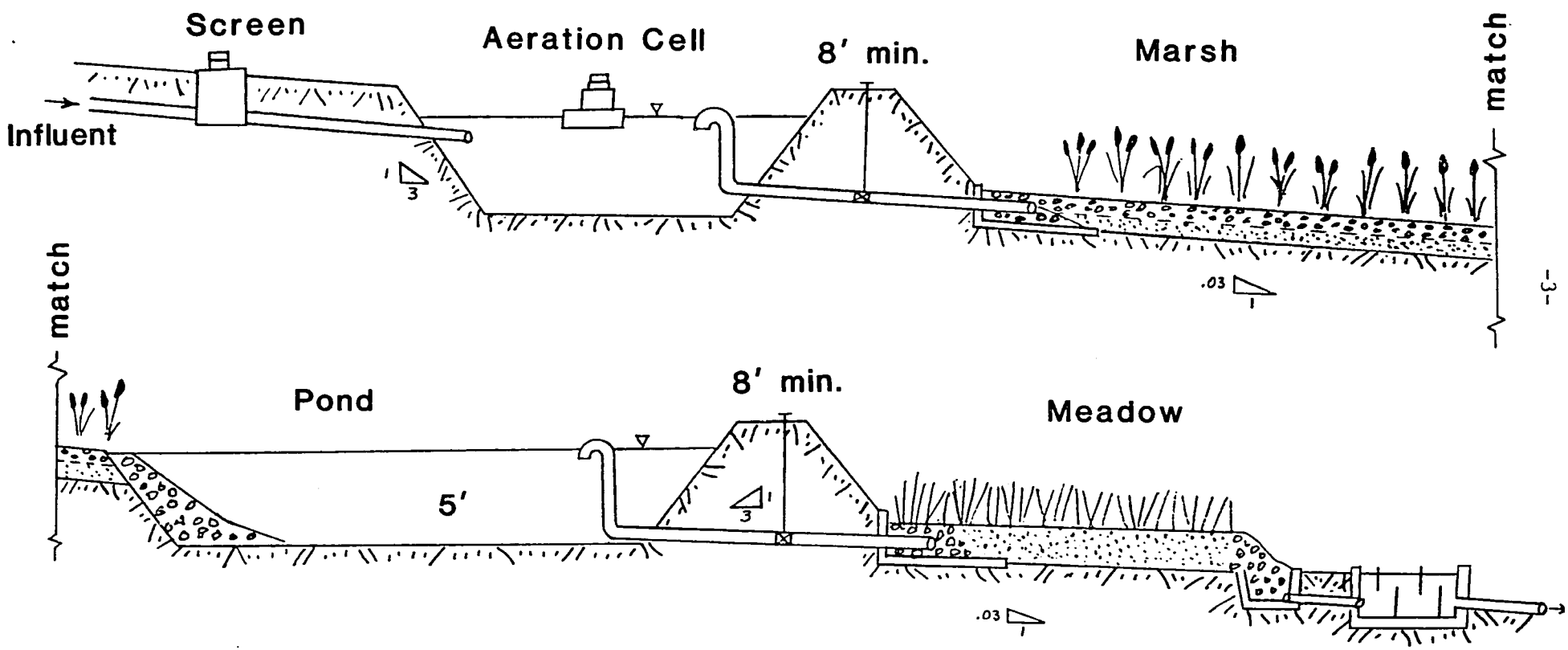


Figure 2. Treatment Scheme Profile

SECTION 2

BASIC ASSUMPTIONS

INFLUENT CONCENTRATIONS

Influent assumptions must necessarily vary according to the two operating scenarios proposed.

Stand-alone system

Ranges of influent parameters are assumed according to Table 1.

Table 1. INFLUENT CONCENTRATIONS FOR THE MARSH/POND/MEADOW SYSTEM.

Parameter	Range* mg/l	Design Value mg/l
Suspended Solids	180-300	250
BOD_5	160-280	200
Nitrogen (Total N)	40-50	45
Organic	15-20	20
Ammonia	25-30	25
Nitrites		
Nitrates		

*Reference: EPA, 1977. Process Design Manual: Wastewater Treatment Facilities for Sewered Small Communities, EPA - 625/1-77-009. USEPA Environmental Research Information Center, Technology Transfer.

EFFLUENT CONCENTRATIONS

Effluent concentrations will be assumed to meet stringent effluent standards which will protect Prickly Bay. These effluent standards are given in Table 3.

Table 3. EFFLUENT STANDARDS

Parameter	Limit
pH	6-9 units
Suspended Solids	30 mg/l
BOD_5	5 mg/l
NH_3 - N (Summer)	1 mg/l
DO	7 mg/l
Fecal Coliform	200 organisms/100 ml

TOPOGRAPHY

The conceptual design assumes level terrain such as flood plain. It is assumed that diking will be necessary to protect the artificial wetlands site from periodic flooding, since the wetlands system is most economically situated near the receiving stream.

POPULATION SERVED

The conceptual design assumes the residential and tourist population of the Grand Anse area.

SECTION 3

CONCEPTUAL DESIGN FOR THE MARSH/POND/MEADOW (STAND-ALONE) SYSTEM

SCREENS

Bypass bar screen, manually cleaned
Bar width: 1/4" to 5/16"
Bar depth: 2"
Spacing: 1"
Slope from vertical: 30-45°
Approach velocity: 1-2 fps
Allowable head loss: 6"
Perforated drainage plate: 1" diameter holes spaced at 2" centerlines

AERATION CELL

given:
Use 2 parallel cells: 0.30 MGD flow to each
BOD_5 influent = 250 mg/l 50% removal
BOD_5 effluent = 125 mg/l
K = 1.0 (@20°C)
Summer wastewater temp. = 81°F (27.2°C)
Winter wastewater temp. = 77°F (25°C)
Cell depth = 5'

a. Calculate required cell volume to maintain 50% BOD_5 removal under summer and winter conditions.

$$S/S_0 = \frac{1}{1 + K(V/Q)} \qquad \text{(equa.12-22,M\&E)}$$

given: S = 125 mg/l
S_0 = 250 mg/l
$K_{summer} = 1.0\ (1.06)^{27.2 - 20} = 1.52$

$K_{winter} = 1.0\ (1.06)^{25 - 20} = 1.34$
V = ?
Q = 0.30 mgd

(1) <u>summer condition</u>: $0.5 = \frac{1}{1 + 1.52\ (V/0.25)} = \frac{1}{1 + 5.07V}$

$V = 0.197$ million gal. $= 197{,}000$ gallons

(2) <u>winter condition</u>: $0.5 = \frac{1}{1 + 1.34\ (V/0.3)} = \frac{1}{1 + 4.47}$

$V = 0.714$ million gal. $= 714{,}000$ gallons or $95{,}500\ ft^3$

Winter condition controls; therefore, each cell volume should be 224,000 gal., or 20,000 ft^3

b. Calculate Retention Time

$$t = V/Q = \frac{0.224 \text{ million gallons}}{0.35 \text{ MGD}} = .75 \text{ days or about 18 hours}$$

c. Estimate oxygen requirements for biochemical oxidation

$R_r = 16.68\ S_0' \cdot Q$ lb O_2/day (eq. 5, p. 415, WPCF MOP 8)

S_0' = influent BOD_5 = 250 mg/l
Q = flow = 0.30 MGD
R_r = 1251 lb O_2/day

d. Estimate power requirement for oxygen addition

(1) Determine correction factor for surface aerator to adjust standard performance data to field conditions

$$\frac{N}{N_0} = \frac{\beta C_{walt} - C_L}{9.17}\ (1.024)^{T - 20}\alpha \quad \text{(eq. 12-15, M\&E)}$$

given: $T = 27.2^oC$ (81^oF) (summer cond.)
N = lb O_2/hp-hr under field cond.
N_0 = lb O_2/hp-hr under standard cond.
$\beta = 1$
$C_{walt} = 8.97 \times 1.0 = 8.97$ mg/l (@ elevation of 0 ft.)
$C_L = 1.5$ mg/l min. operating D.O.
$\alpha = 0.85$

$$\frac{N}{N_0} = \frac{8.97 - 1.50}{9.17}\ (1.024)^{27.2 - 20}\ (0.85)$$
$$= .845\ (1.186)\ (0.85)$$
$$= .852$$

(2) Adjust standard O_2 transfer requirement to a field transfer rate: For aerator units having a standard rate of 3.0 lb O_2/hp-hr:

$N/N_0 = .852$
$N = .852N_0 = 3.0\ (.852)$
2.56 lb O_2/hp-hr

(3) Determine horsepower of aerator units needed if they are rated at 3.0 lb/hp/hr under standard conditions:

$$2.56 \text{ lb } O_2/\text{hp-hr} = 61.4 \text{ lb } O_2/\text{hp day}$$

$$\text{hp. required} = \frac{O_2 \text{ requirement}}{\text{field transfer rate}}$$

$$= \frac{1251 \text{ lb } O_2/\text{day}}{61.4 \text{ lb } O_2/\text{hp/day}}$$

$$= 20.37 \text{ hp}$$

e. Determine power requirement for complete mixing:

rules of thumb: 30 hp/10^6 gal. (EPA 625/1-77-009 p. 10-48)

.5 hp/1000 ft^3 (M & E,p. 519)

hp required = 30 hp/10^6 gal. x 0.224 million gal.
= 6.72 hp

hp required = .5 hp/1000 ft^3 x 30.0 1000 ft^3
= 15 hp
say 20 hp/cell

f. Determine demension of circular cell

Given: depth (h) = 5 ft
volume (v) = 30,000 ft^3
v/h sidewall slope = 1/3

$$r^2 = \frac{V}{3.14h}$$

$$r^2 = \frac{30{,}000 \text{ ft.}^3}{3.14 \text{ (5 ft.)}} = 1909.9 \text{ ft}^2$$

r = 43.7 ft. at 2.5 ft. depth, say 44.0 ft.

Diameter = 88 ft. at 2.5 ft. depth

Determine diameter at max. depth

D = 88 ft. + 2(7.5 ft.)
D = 103 ft.

Determine diameter at bottom

D = 88 ft. - 2(7.5 ft.)
D = 73 ft.

Determine diameter at top, assuming a 3 ft. freeboard

D = 103 ft. + 2(9 ft.)
D = 121 ft.

MARSH

Given: application rate - 50,000 gal/acre/day
(typical rate is 43,000 gal/acre/day or 23 acre/mgd: see table 16 in the report, Technology Assessment of Artificial Wetlands for Municipal Wastewater Treatment)
slope of marsh bottom - 0%
number of cells - 4
vegetation - indigenous such as cattails
liner - none unless groundwater supply could be affected
freeboard - 0.5 ft
sidewater depth - 1.0 ft.
design to vary sidewater depth between 0.5 and 2.0 ft.

a. Determine area required:

$$A = \frac{Q}{\text{rate}} = \frac{600{,}000 \text{ gal/day}}{50{,}000 \text{ gal/acre/day}}$$

$$= 12 \text{ acres}$$

4 cells @ 3.0 acres or 130,680 ft^2

b. Determine dimensions of each cell:

Given: 4 cells with 8' dikes separating each cell

Assume cell width = $\frac{100' - 3(8')}{4}$ = 92.5'

Cell length = $\frac{130{,}680 \text{ ft}^2}{100 \text{ ft.}}$ = 1307'

Say 100' x 1310' Good since gives at least 10 to 1 length to width ratio

POND

a. Design based on conventional facultative design

Given: depth = 6 ft.
flow = 600,000 gpd
BOD_5 infl. = 62 mg/l about 50% removal
BOD_5 effl. = 30 mg/l
K_{20} = 0.25

(1) Determine value of kt from figure 12-6 in M & E for 50% removal, d = 1

kt = d

(2) Determine detention time

(a) Summer condition

$$K_{27.2} = 0.25\ (1.06)^{27.2\ -\ 20} = 0.380$$
$$0.380\ t = 1$$
$$t = 2.7 \text{ days}$$

(b) Winter condition

$$K_{25} = 0.25\ (1.06)^{25-20} = 0.088$$
$$0.335t = 1$$
$$t = 3.0 \text{ days}$$
say 3 days

Detention time should be 13 days.

(3) Calculate surface area required

Volume of Pond = Qt
Q = 600,000 gpd
t = 3 day

$$V = 600{,}000\ (3)$$
$$= 1{,}800{,}000 \text{ gallons or } 240{,}642 \text{ ft}^3$$

$$\text{Area} = \frac{240{,}642 \text{ ft}^3}{6 \text{ ft}} = 40{,}107 \text{ ft}^2 \text{ or } .92 \text{ acres}$$

b. Design based on literature

Given: application rate - 10 acre/MGD (Table 16, Appendix A)
flow - 600,000 gpd

Area required = 0.6 MGD x 10 acre/MGD = 6.0 acres or 261,360 ft^2

Use 3.0 acres, or 130,680 ft^2

c. Determine dimensions of pond:

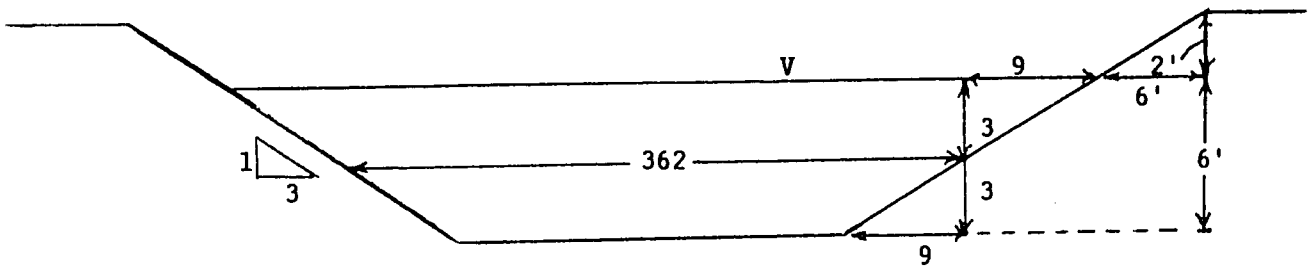
Given: depth = 6 ft.
V/H sidewall slope = 1/3
assume square pond
freeboard = 2 ft.

x^2 = 130,680 ft^2
x = 362' width/length

Use 362' x 362' @ 3' Depth

Final Dimensions

	Water Level	Bottom	Berm
Width/Length	362 + 18 = 380	362 - 18 = 344	380 + 12 = 392



MEADOW

Given: Application rate = 100,000 gal/acre/day
(Iselin loading rate)
Slope = 0%
number of cells = 4
vegetation - indigenous grass grass
liner - none
Freeboard - 0.5 ft.
Sidewater depth - 1.5 ft.

a. Determine area required:

$$A = \frac{Q}{\text{rate}} = \frac{600{,}000 \text{ gal/day}}{100{,}000 \text{ gal/acre/day}}$$

$$= 6 \text{ acres}$$

Use 4 cells @ 1.50 acres or 65,340 ft^2

b. Determine dimensions of each cell:

Given: 4 cells with 8 ft. dikes between cells

Assume cell width = $\frac{80.0'}{4}$

Cell length = $\frac{65{,}340 \text{ ft.}^2}{80.0 \text{ ft.}}$ = 817 ft.

Say 80' x 820' Good since gives at least length to width ration of 10 to 1.

CHLORINATION

None initially required. Data indicates that adequate fecal coliform die-off will occur.

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SECTION 4

ADDITIONAL DESIGN INFORMATION

INTRODUCTION

Recommended design criteria for meeting the previously stated effluent limitations are also provided. These recommendations are probably more conservative than needed for most communities because the stringent effluent limitations have been chosen as the design basis.

VEGETATION

Vegetation varies from a single species such as cattails to a wide variety including cattails, bulrushes, seeds, and other emergents. Local varities should always be used as opposed to non-native species. Aquatic plants, such as grasses, with extensive root development in the water column appear to have a greater effect on solids removal than those plants which present a uniform surface in the water column such as cattails (Gearheart, et. al., 1984). Plant coverage should be at least 75 percent.

Recommendation - - Use a wide variety of native species. Cattails should be placed in the first portion of the cells since they have a higher loading tolerance and produce toxins which inhibit other vegetation.

HYDRAULIC LOADINGS

Reported loading rates for polishing systems using secondary effluent vary tremendously, ranging from 4 acres/MGD (a high rate) to thousands of acres. (a low rate) Recent projects have used higher loading rates in the range of 4 to 55 acres/MGD with good results. Suspended solids removals are generally good at the higher rates while high BOD, fecal coliform, and nitrogen removals require lower loading rates.

FLOW DEPTH

Flow depths typically vary between 0.5 ft. to 2 ft. Consideration should be given to the root length of floating plants and depth of submergent plants to afford maximum contact and involvement with plants surface area and associated microbial and periphtic communities (Gearheart, et. al. 1984). The root zone of floating plants should reach the bottom to prevent short circuiting of flow along the bottom of the cell.

Recommendation - -Flow depth should be approximately 1 foot, but the system design should incorporate flexibility to vary the depth from 0 to 2 feet. The system can then be operated to maintain adequate detention times and for special conditions such as high storm flows, mosquitoe control, and maintenance.

RECIRCULATION

Intermittent recirculation of a portion of the marsh effluent may increase the overall removal of BOD, ammonia, and other parameters. The objective of recirculation is basically to maintain an optimum retention time in the system for peak performance. The calculated design retention time is fixed based on the design hydraulic loading and flow depth; however, the actual retention time is an important process control variable. It is affected by the actulal flow rate, the volume of vegetation, evapotranspiration rates, seepage rates, operating depth, and the extent of short circuiting. The Listowel, Ontario, system (Black, et.al., 1981) obtained best treatment results with retention times between 7 and 10 days. Lower detention times decreased treatment efficiency due to insufficient contact, and longer detention times (≈18 days) lead to stagnation and anoxic conditions with concomitant reductions in treatment efficiency.

Recommendation - -Provide for recirculation of the effluent to the head of the marsh to maintain an actual retention time between 7 and 10 days whenever practicable.

LENGTH TO WIDTH RATIO

Length to width ratios vary from 3:1 to 10:1 or greater (EPA, 1983; Gearheart, et.al, 1984; and Reed, et.al, 1984). The larger ratios help achieve plug flow reactor conditions. The majority of suspended solids, BOD, and fecal coliforms are removed in the front half of the cell. The large length to width ratio allows for conpartmentalization of the removal processes such as sedimentation, flocculation, filtration, nitrification/denitrification, etc. (Gearheart, et.al. 1984). If the vegetation is to be harvested, the width needs to be small enough to accommodate the method of harvesting.

Recommendation - -Use a marsh length to width ratio of at least 10:1. For an area of 12 acres, use multiple cells (4) with a single cell length of 1310 ft. and a width of 100 ft. Multiple cell design is recommended over a single cell to provide greater operation and maintenance flexibility. Multiple cells, both in parallel and series, may also allow the available land to be used more cost effectively.

SLOPE

Marsh slopes typically vary from 0 to 2%. Flat slopes (<1%) appear to be generally preferred (Chan, et. al., 1982).

Recommendation - -Use a slope of 0.5% to overcome friction losses and aid in drainage of the cells if needed.

FLOW DISTRIBUTION

Flows should be evenly distributed across the cell width to minimize channelling and short circuiting in the upper end of the cell. The two primary methods for achieving even flow distribution are multi-port and spray distribution. Spray distribution requires adequate head, either by gravity or pump.

Recommendation - -Select the most cost effective method based on site conditions.

SOILS AND BALLAST

Substrates used in artificial wetlands for growth and ballast of vegetation range from native soils to sand and gravel. Sand or gravel provide additional benefits in that the net surface area available for growth of bacteria and other microorganisms that feed on the organic matter in the wastewater is increased. Sand and gravel also filter suspended solids, increasing the overall effectiveness of the system. Data do not appear to be available to allow evaluation of the relative effectiveness of systems using native soils and those using sand and gravel.

Recommendation - -Since use of sand or gravel would substantially increase system costs, use of native soil is recommended. Addition of gravel should be considered as an upgrade alternative if needed.

LINERS

Liners have been used in many artificial wetland systems to control seepage and protect groundwater quality. The type of liners vary from compacted clay to artificial membranes.

Recommendation - -The need to control seepage is a site specific variable. Where groundwater protection is important or the native soils are so permeable that water levels cannot be satisfactorily controlled in the marsh, liners are essential. However, most applications of the marsh system is expected to be on the floodplains of creeks and rivers where seepage would tend to recharge the receiving stream and not adversely impact groundwater supplies unless wells were located adjacent to the marsh. Also, native soils in the areas investigated to date have been relatively impermeable containing high percentages of clay and silt. Artificial liners should not generally be needed in these situations.

HARVESTING

Harvesting vegetation increased the net removal of parameters such as nitrogen, phosphorus, and metals (Hammer and Kadlec, 1983.) However, the cost effectiveness of harvesting is generally considered very low unless a viable market for the vegetation can be developed (EPA, 1985).

Recommendation - -Harvest only if a market can be developed to make the method economical.

DISINFECTION

In general, the bacterial quality of marsh effluents appear to be comparable to the quality of disinfected secondary effluent except during winter months and occasional unexplained spikes. Data are not generally available on specific pathogenic bacteria or viruses. Disinfection is not considered to be necessary but data should be collected and disinfection added if required.

ADDITIONAL SPECIFICATIONS

Basin construction: side slopes, 1:3
freeboard, 2 ft. minimum
dike width, 8 ft. minimum

Flood protection: physical damage protection should be provided for the 100 year flood. The system should be fully operational and accessible during the 25 year flood.

Discharge structure: design to maintain variable marsh water levels(0 to 2 ft.)

The discharge should be dispersed with irrigation pipe along the head of a mangrove swamp or other natural wetlands areas to provide additional treatment.

LAND AREA REQUIREMENT

To contain a bar screen, aeration cells, marsh, pond and meadow an area of about 2800 ft. by 500 ft., or 32 acres is needed. However, due to the tropical climate in Grenada, the meadow is not recommended for the initial system, but should be added if operating datas indicates its need.

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ATTACHMENT C1

TECHNOLOGY ASSESSMENT
OF
ARTIFICIAL WETLANDS FOR MUNICIPAL WASTEWATER TREATMENT

Chattanooga, Tennessee
October, 1985

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

TECHNOLOGY ASSESSMENT
OF
ARTIFICIAL WETLANDS FOR MUNICIPAL WASTEWATER TREATMENT

Chattanooga, Tennessee
October, 1985

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ATTACHMENT C2

WETLANDS PLANTS FOR GRENADA, WEST INDIES

THE ARNOLD ARBORETUM of HARVARD UNIVERSITY
22 DIVINITY AVENUE · CAMBRIDGE · MASSACHUSETTS 02138 · U.S.A.

October 29, 1985

Mr. Gerald R. Steiner
Water Quality Branch
248-401 Building
Tennessee Valley Authority
Chattanooga, TN 37401

Dear Mr. Steiner:

Here is an initial reply to your inquiry regarding plants that could be transplanted into and grow densely in artificial freshwater systems and grow in brackish water. The list is based on my own collections of the vegetation growing in the Grand Etang on Grenada as well as those in the wet landlands to the north of the Lake. Those listed as not in Grenada at the present time could be acquired as propagating material and would be expected to grow. I have not listed any in this category which might escape or become troublesome.

Floating plants
Ceratopteris thalictroides - not currently in Grenada, a floating fern
Nymphaea alba - water lily
Pistia stratioides - water lettuce
Potamegeton nodosus - water weed, mostly submerged

Shallow water or rooting at edge - as in Grand Etang
Acrostichum aureum - a large fern of mangrove or fresh water
Asplundia insignis - relative of panama hat plant, free standing
Cladium jamaicensis - saw grass
Cyclanthus bipartitus - not reported from Grenada, panam hat plant, on Martinique
Fuirena umbellata - a sedge
Eleocharis species such as interstincta, maculosa, mutata not in Grand Etang
Ischnosiphon arouma - Carib basket plant, now in Grand Etang
Montrichardia arborescens - now in Grand Etang
Typha domingensis - not in Grenada, the cat-tail

On land extending into water, fresh or brakish
Anona glabra - pond apple
Chrysobalanus Icaco - Icaco or beach plum
Coccoloba uvifera - sea grape
Conocarpus erectus - button mangrove
Dalbergia ecastophyllum - beach bean, penny
Haematoxylon campechianum - logwood
Machaerium lunatum - ear ring (may be briar)
Laguncularia racemosa - white mangrove
Avicennia germinans - black mangrove
Rhizophora mangle - red mangrove
Pterocarpus officinalis - no common name, good river bank plant elsewhere

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I can elaborate on this list if you wish.

John Criswick, P.O. Box 21, St. George's is the nurseryman I mentioned who should know these plants or be able to obtain them or propagate them. Elsewhere Iris Bannochie owner of the Andromeda Gardens on Barbados is an excellent plantswoman.

Hope this is of some help to you.

Sincerely,

Richard A. Howard

Richard A. Howard
Professor of Dendrology

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APPENDIX D

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

DESIGN INFORMATION FOR 0.6, 0.7, AND 1.25 MGD OXIDATION DITCH SEWAGE TREATMENT PLANTS FOR THE ST. GEORGE'S AND GRAND ANSE AREAS OF GRENADA, WEST INDIES

Chattanooga, Tennessee

December 1985

INTRODUCTION

Another modification of the activated sludge process for treating wastewater is the oxidation ditch process. Oxidation ditches were originally developed for use by small communities. The sewage usually enters the plant through a bar screen and is continuously circulated around a closed aeration channel. No primary settling tank is used. Aeration is provided by rotors revolving on a horizontal shaft which provides intense surface agitation. A mixture of the treated sewage and microorganisms flows from the ditch to a final clarifier for solids separation. The settled sludge is returned to the ditch. Periodically excess sludge is removed from the process directly to sludge drying beds.

The advantages of the oxidation ditch process to other activated sludge processes are lower capital costs, minimal mechanical equipment, low operation cost, and ease of maintenance. Attachment D1 is a manufacturers' example literature which further describes the treatment process and design information.

The oxidation ditch process was considered as an alternative for individual systgems at St. George's and the Grand Anse area, and for a combined system located in the Grand Anse area. Estimated cost data for oxidation ditch with bar screen, chlorination, and sludge drying beds are listed below.

EQUIPMENT DESIGN

Preliminary design for oxidation ditches and clarifiers provided by Lakeside Equipment Corporation, 1022 E. Devon Avenue, P.O. Box 8448, Bartlett, Illinois 60203, USA.

St. George's

Design flow - 0.7 MGD; design loading - 1920 lb. BOD_5/day.

Oxidation Ditch

Size - 278 feet by 49 feet overall; oval.

Depth - 10 feet liquid, 1 1/2 feet freeboard.

Rotors - Two 23-foot Magna, each with 40-hp drive.

Overflow Weir - 17 feet.

Clarifier - Two 32-foot diam., w/10 foot liquid depth.

Sludge Wasting

1. Use sand drying beds--12,000 ft^2 total for 1.0 ft^2/P.E.; Provide three 100 foot by 40 foot sand beds with underdrains returned to influent.
2. As an option, drain excess sludge to tank truck and land applicate.

Required Land

With sand drying beds, an area about 600 foot by 200 foot, or 2.8 acres is required.

Grand Anse Area

Design Flow - 0.6 MGD; design loading - 1242 lb. BOD_5/day.

Oxidation Ditch

Size - 265 feet by 33 feet overall; oval.

Depth - 10 feet liquid, 1-1/2 feet freeboard.

Rotors - Two 15 foot Magna, each with 25 hp drive

Overflow Weir - 15 feet

Clarifier - Two 30 foot diam. w/10 foot liquid depth.

Sludge Wasting

1. Use sand drying beds - 7500 ft^2 for 1.0 ft^2/P.E.; Provide three 85 foot by 30 foot sand beds with underdrains returned to influent.
2. As an option, drain excess sludge to tank truck and land applicate

Required Land

With sand drying beds, an area about 600 feet by 300 feet, or 2.8 acres, is required.

Combined St. George's/Grand Anse

Design Flow - 1.25 MGD; design loading - 3162 lb. BOD_5/day.

Oxidation Ditch

Size - 349 feet by 53 feet overall; oval.

Depth - 12 feet liquid, 1-1/2 feet freeboard.

Rotors - Three 25 foot Magna, each with 40 hp drive

Overflow Weir - 22 feet

Clarifier - Two 42 foot diam. w/10 foot liquid depth.

Sludge Wasting

1. Use sand drying beds 19,000 ft^2 for 1.0 ft^2/P.E.; Provide four 105 foot by 45 foot sand beds with underdrains returned to influent.
2. As an option, drain excess sludge to tank truck and land applicate

Required Land

With sand drying beds, an area about 700 feet by 200 feet, or 3.2 acres, is required.

COST ESTIMATES[1]

	Design Flow MGD	Design Loading lb. BOD_5/day	Cost Range $EC ($US)
St. George's	0.7	1920	2,814,000-4,690,000 (1,050,000-1,750,000)
Grand Anse	0.6	1242	2,413,000-4,020,000 (900,000-1,500,000)
St. George's/Grand Anse	1.25	3162	5,025,000-8,040,000 (1,875,000-3,000,000)

1. Estimates provided by Lakeside Equipment Corporation, 1022 E. Devon Avenue, P.O. Box 8448, Bartlett, Illinois 60103, USA. Estimates do not include shipment of prefabricated equipment port to Grenada.

WATER PURIFICATION EQUIPMENT SINCE 1928

LAKESIDE EQUIPMENT CORPORATION

1022 E. DEVON AVE. ■ P.O. BOX 8448 ■ BARTLETT, IL 60103 ■ 312/837-5640

November 14, 1985

FEDERAL EXPRESS

Mr. Gerald R. Steiner
Tennessee Valley Authority
Water Quality Branch
248 - 401 Building
Chattanooga, Tennessee 37401

Subject: St. Georges, Granada
Oxidation Ditch Design

Dear Mr. Steiner:

Enclosed please find the additional information we promised you regarding the design of three (3) Oxidation Ditch alternates for St. Georges and Grand Anse Beach, Granada.

Rather than describing each alternate in detail, we would recommend that you refer to the enclosed drawings and design summaries (RAD-393) which will provide you information regarding ditch layouts, equipment sizing, and equipment pricing. The equipment prices represent budget figures and include shipping to the job site. However, no additional ocean freight has been included, so the stated equipment costs would only include freight to the nearest U.S. port.

We trust that this information will satisfy your current needs as you prepare your preliminary recommendations. Should you require any further information, please do not hesitate to call.

Very truly yours,

Wayne Langeland

Wayne Langeland
WL/cl

enclosures

cc: Roy Smith, J. T. Guthrie & Son

OXIDATION DITCH SPECIFICATIONS

PROJECT: Gunnison - Alternate 2 (St George's) DATE: 11/13/85

ENGINEER: Tennessee Valley Authority

TOTAL PROJECT LOADING (MGD) 0.7

REFERENCE DRAWING(S): _____

I. EQUIPMENT SUMMARY:

Number of Oxidation Ditches Required	1
Number of Rotors Required	2
Number of Liquid Level Controllers Required	1
Number of Clarifiers Required	2

II. OXIDATION DITCH DETAILS

Design Criteria:

Population Equivalent (each Ditch)	—
Hydraulic Flow (Design - GPD)	700,000
(Design - GPM)	486
Volumetric Loading (#BOD/1000 ft^3)	15.0
Organic Loading (#BOD/day)	1920
Oxygen Required (#O_2/DAY) — SOR	4512
Aeration Detention Time (hrs.)	32.8

Characteristics:

Length Overall (Ft.)	278
Width Overall (Ft.)	49
Water Depth (Ft.)	10
Sidewall Slope (Degrees)	Straight
Median Strip Width (Ft.)	1
Volume (Cu.ft.)	128,000
Bottom Width (Ft.)	24
Width @ Water Surface	24
Cross Sectional Area (Sq. ft.)	240

PROJECT: GRANADA - ALTERNATE 2

III. ROTOR DETAILS (Each Rotor)

Type		MAGNA
Diameter (in.)		42
Length (Ft.)		23
RPM		61
Immersion (in.)	Design	10.7
Oxygenation (#O_2/Hr./ft.)	Design	4.10
Power Required (bhp/ft.)	Design	1.229
Mixing (Gal/ft.rotor)	Design	21,000
Drive Required (HP)		40
Brake Horsepower per drive		28.3

IV. LIQUID LEVEL CONTROLLER DETAILS

Length (ft.)	17
Head over weir at 3 times design flow (in.)	1 3/4

V. FINAL CLARIFIER

Diameter (ft.)	32
Side Liquid Depth (ft.)	10
Surface Loading - Design (GPD/ft^2)	450
Detention time (hrs.)	4.1
Weir Overflow (GPD/ft)	3084

Mechanized YES ~~Non-Mechanized~~ _____

VI. EQUIPMENT PRICES

2-23FT MAGNA Rotor(s), (each) with 40 HP drive, including motor motor, motor support base, shaft bearings, helical gear reducer, drive belts, sheaves with guard, but no electrical controls.

Unit Price: $ 24,400 Approximate shipping weight

Total Price: $ 48,800 (each unit): 5725 #

.91

PROJECT: GRANADA - ALTERNATE 2

Spiraflo Final Tank: 2 - 32 ft. diameter x 10 FT total liquid depth (non) mechanized equipment complete with ALL mechanical equipment within the concrete tank.

Unit Price: $ 28,600 Approximate shipping weight

Total Price: $ 57,200 (Each unit): 11,500 #

Effluent Weir: 1 - 17 ft. long adjustable effluent weir with all necessary mechanical equipment.

Unit Price: $ 5550 Approximate shipping weight

Total Price: $ 5550 (Each unit): 2030 #

These prices include shop painting, service and are freight allowed.

IX. For a complete plant, the following must be added to the above items:

(a) Raw sewage lift station (if required)
(b) Yard piping
(c) Electrical equipment
(d) Ditch excavation and liner
(e) Fence
(f) Bar screen
(g) Final clarifier tank structure
(h) Sludge beds or holding tank
(i) Combination storage-laboratory building
(j) Chlorinator
(k) Sludge Recycle Pumps
(l) Bridge

2 - 23 FT ROTOR BAFFLES

UNIT PRICE: $3000

TOTAL PRICE: $ 6000

LAKESIDE EQUIPMENT CORPORATION

MS/jp4577

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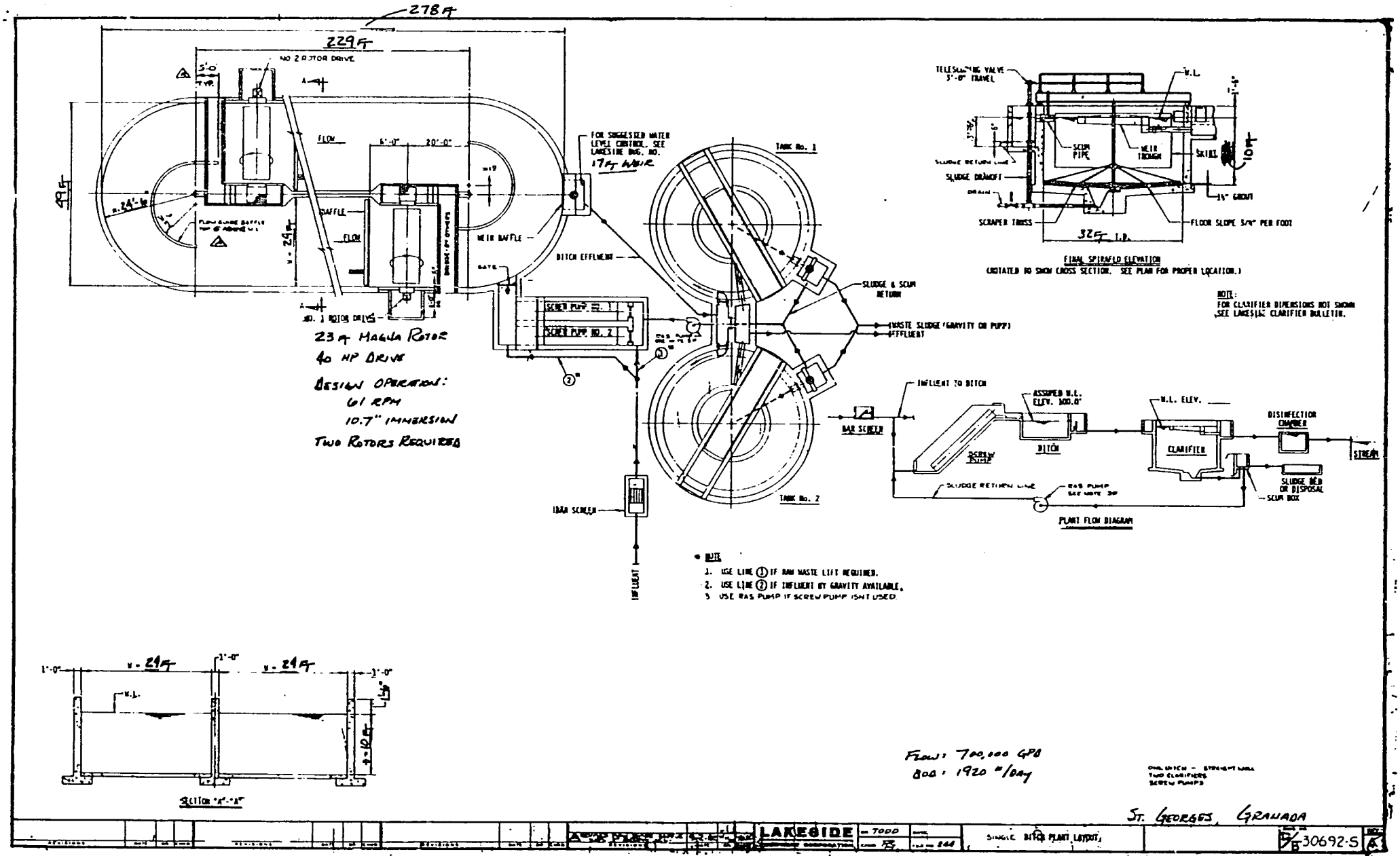
278 ft
229 ft
NO 2 ROTOR DRIVE
FLOW
BAFFLE
NO. 1 ROTOR DRIVE
23 ft MAGNA ROTOR
40 HP DRIVE
DESIGN OPERATION:
61 RPM
10.7" IMMERSION
TWO ROTORS REQUIRED
FOR SUGGESTED WATER LEVEL CONTROL, SEE LAKESIDE DWG. NO.
17 ft WEIR
WEIR BAFFLE
DITCH EFFLUENT
GATE
SCREW PUMP NO. 1
SCREW PUMP NO. 2
TANK No. 1
TANK No. 2
SLUDGE & SCUM RETURN
WASTE SLUDGE (GRAVITY OR PUMP)
EFFLUENT
BAR SCREEN
INFLUENT
INFLUENT TO DITCH
ASSUMED W.L. ELEV. 100.0'
SCREW PUMP
DITCH
W.L. ELEV.
CLARIFIER
DISINFECTION CHAMBER
STREAM
SLUDGE RETURN LINE
RAS PUMP
SLUDGE BED OR DISPOSAL
SCUM BOX
PLANT FLOW DIAGRAM
TELESCOPING VALVE 3'-0" TRAVEL
W.L.
SCUM PIPE
WEIR TROUGH
SKIRT
SLUDGE RETURN LINE
SLUDGE DRAWOFF
DRAIN
SCRAPER TRUSS
FLOOR SLOPE 3/4" PER FOOT
1/2" GROUT
32 ft I.D.
FINAL SPIRAFLO ELEVATION
(ROTATED TO SHOW CROSS SECTION. SEE PLAN FOR PROPER LOCATION.)
NOTE:
FOR CLARIFIER DIMENSIONS NOT SHOWN SEE LAKESIDE CLARIFIER BULLETIN.
NOTE
1. USE LINE 1 IF RAW WASTE LIFT REQUIRED.
2. USE LINE 2 IF INFLUENT BY GRAVITY AVAILABLE.
3. USE RAS PUMP IF SCREW PUMP ISN'T USED.
W = 24 ft
49 ft
SECTION "A"-"A"
W.L.
FLOW: 700,000 GPD
BOD: 1920 #/DAY
ONE DITCH - STRAIGHT LOOP
TWO CLARIFIERS
SCREW PUMPS
LAKESIDE
TODD
SINGLE DITCH PLANT LAYOUT
30692-S
ST. GEORGES, GRANADA
ALTERNATE 2
11/13/85

93.

G. Sieker

RAD-393

OXIDATION DITCH SPECIFICATIONS

PROJECT: GRANADA - ALTERNATE 1 (Grand Anse) DATE: 11/13/85

ENGINEER: TENNESSEE VALLEY AUTHORITY

TOTAL PROJECT LOADING (MGD) 0.6

REFERENCE DRAWING(S): _____

I. EQUIPMENT SUMMARY:

Number of Oxidation Ditches Required	1
Number of Rotors Required	2
Number of Liquid Level Controllers Required	1
Number of Clarifiers Required	2

II. OXIDATION DITCH DETAILS

Design Criteria:

Population Equivalent (each Ditch)	—
Hydraulic Flow (Design - GPD)	600,000
(Design - GPM)	417
Volumetric Loading (#BOD/1000 ft^3)	15.0
Organic Loading (#BOD/day/~~[illegible]~~)	1242
Oxygen Required (#O_2/Day) - See	2914
Aeration Detention Time (hrs.)	24.8

Characteristics:

Length Overall (Ft.)	265
Width Overall (Ft.)	33
Water Depth (Ft.)	10
Sidewall Slope (Degrees)	STRAIGHT
Median Strip Width (Ft.)	1
Volume (Cu.ft.)	82,800
Bottom Width (Ft.)	16
Width @ Water Surface	16
Cross Sectional Area (Sq. ft.)	160

PROJECT: GRANADA - ALTERNATE 1

III. ROTOR DETAILS (Each Rotor)

Type		MAGNA
Diameter (in.)		42
Length (Ft.)		15
RPM		60
Immersion (in.)	Design	11.0
Oxygenation (#O_2/Hr./ft.)	Design	4.07
Power Required (bhp/ft.)	Design	1.234
Mixing (Gal/ft.rotor)	Design	21,000
Drive Required (HP)		25
Brake Horsepower per drive		18.5

IV. LIQUID LEVEL CONTROLLER DETAILS

Length (ft.)	15
Head over weir at 3 times design flow (in.)	1 3/4

V. FINAL CLARIFIER

Diameter (ft.)	30
Side Liquid Depth (ft.)	10
Surface Loading - Design (GPD/ft^2)	450
Detention time (hrs.)	4.23
Weir Overflow (GPD/ft)	3948

Mechanized YES ~~Non-Mechanized~~ _____

VI. EQUIPMENT PRICES

2-15 FT MAGNA Rotor(s), (each) with 25 HP drive, including motor motor, motor support base, shaft bearings, helical gear reducer, drive belts, sheaves with guard, but no electrical controls.

Unit Price: $ 17,000 Approximate shipping weight

Total Price: $ 34,000 (each unit): 4285 #

PROJECT: GRANADA - ALTERNATE 1

Spiraflo Final Tank: 2-30 ft. diameter x 10 ft total liquid depth ~~area~~) mechanized equipment complete with ALL mechanical equipment within the concrete tank.

Unit Price: $ 25,800 Approximate shipping weight

Total Price: $ 51,600 (Each unit): 8150 #

Effluent Weir: 1-15 ft. long adjustable effluent weir with all necessary mechanical equipment.

Unit Price: $ 5450 Approximate shipping weight

Total Price: $ 5450 (Each unit): 1850 #

These prices include shop painting, service and are freight allowed.

IX. For a complete plant, the following must be added to the above items:

(a) Raw sewage lift station (if required)
(b) Yard piping
(c) Electrical equipment
(d) Ditch excavation and liner
(e) Fence
(f) Bar screen
(g) Final clarifier tank structure
(h) Sludge beds or holding tank
(i) Combination storage-laboratory building
(j) Chlorinator
(k) Sludge Recycle Pumps
(l) Bridge

2-15 ft ROTOR BAFFLES

UNIT PRICE: $2000 EACH

TOTAL PRICE: $4000

LAKESIDE EQUIPMENT CORPORATION

MS/jp4577

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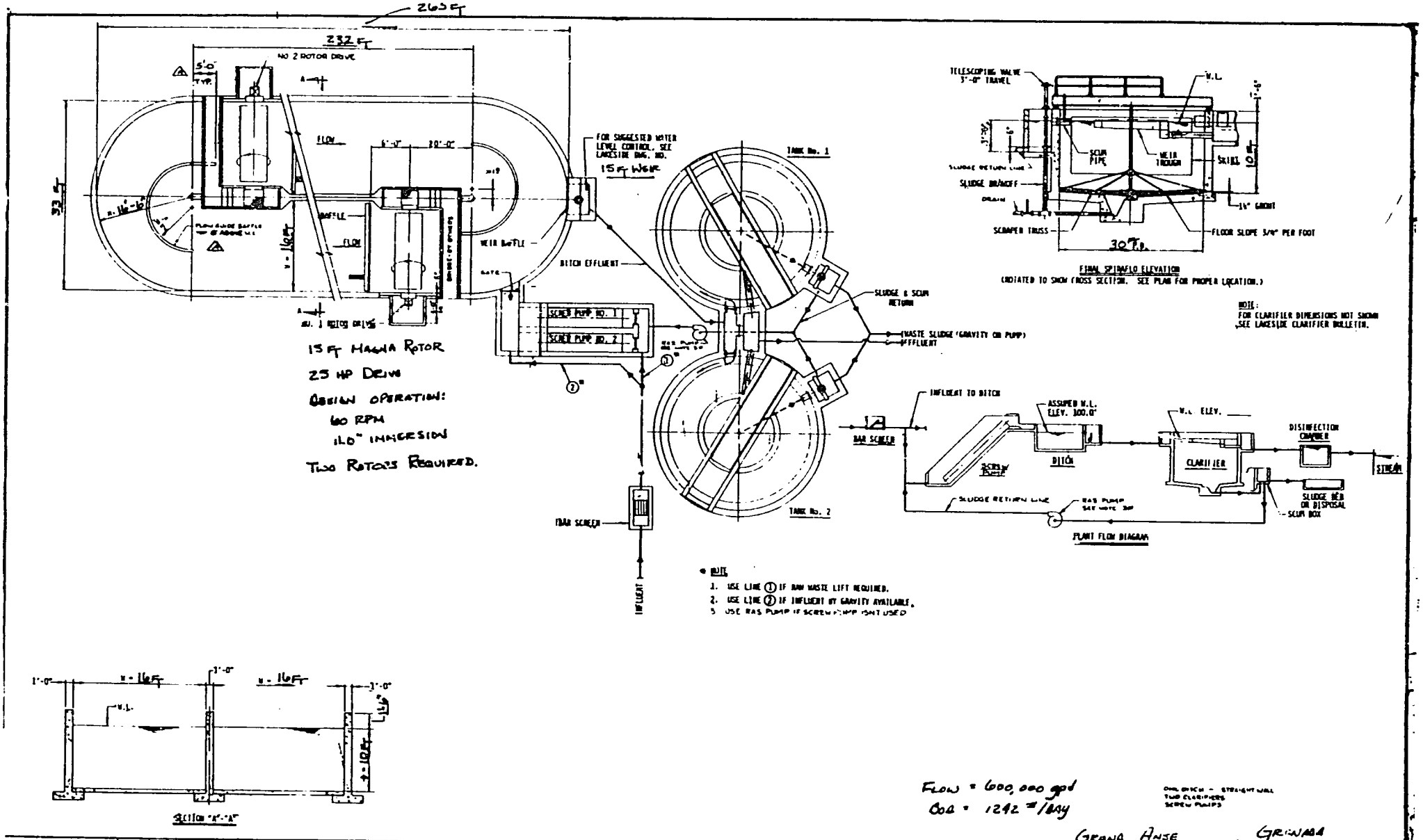
265 FT
232 FT
NO 2 ROTOR DRIVE
FLOW
BAFFLE
WEIR BAFFLE
NO. 1 ROTOR DRIVE
FOR SUGGESTED WATER LEVEL CONTROL, SEE LAKESIDE DWG. NO.
15 FT WEIR
DITCH EFFLUENT
TANK No. 1
TANK No. 2
SLUDGE & SCUM RETURN
WASTE SLUDGE (GRAVITY OR PUMP)
EFFLUENT
SCREW PUMP NO. 1
SCREW PUMP NO. 2
BAR SCREEN
INFLUENT
15 FT HAGNA ROTOR
25 HP DRIVE
DESIGN OPERATION:
60 RPM
1'-0" IMMERSION
TWO ROTORS REQUIRED.
TELESCOPING VALVE 3'-0" TRAVEL
W.L.
SCUM PIPE
WEIR TROUGH
SKIRT
SLUDGE RETURN LINE
SLUDGE BRANOFF
DRAIN
SCRAPER TRUSS
FLOOR SLOPE 3/4" PER FOOT
1/4" GROUT
30 FT.
FINAL SPIRAFLO ELEVATION
(ROTATED TO SHOW CROSS SECTION. SEE PLAN FOR PROPER LOCATION.)
NOTE:
FOR CLARIFIER DIMENSIONS NOT SHOWN SEE LAKESIDE CLARIFIER BULLETIN.
INFLUENT TO DITCH
ASSUMED W.L. ELEV. 100.0'
W.L. ELEV.
DISINFECTION CHAMBER
STREAM
DITCH
CLARIFIER
SCREW PUMP
SLUDGE RETURN LINE
RAS PUMP
SLUDGE BED OR DISPOSAL
SCUM BOX
PLANT FLOW DIAGRAM
NOTE
1. USE LINE 1 IF RAW WASTE LIFT REQUIRED.
2. USE LINE 2 IF INFLUENT BY GRAVITY AVAILABLE.
3. USE RAS PUMP IF SCREW PUMP ISN'T USED
W = 16 FT
1'-0"
W = 10 FT
W.L.
SECTION "A"-"A"
FLOW = 600,000 gpd
BOD = 1242 #/DAY
GRAND ANSE . GRENADA
LAKESIDE
SINGLE DITCH PLANT LAYOUT
ALTERNATE 1
30692-S
11/13/85

OXIDATION DITCH SPECIFICATIONS

(Combined St. George's/Grand Anse)

PROJECT: GRENADA - ALTERNATE 3 DATE: 11/13/85

ENGINEER: TENNESSEE VALLEY AUTHORITY

TOTAL PROJECT LOADING (~~P.E.~~ MGD) 1.25

REFERENCE DRAWING(S): _____

I. EQUIPMENT SUMMARY:

Number of Oxidation Ditches Required	1
Number of Rotors Required	3
Number of Liquid Level Controllers Required	1
Number of Clarifiers Required	2

II. OXIDATION DITCH DETAILS

Design Criteria:

Population Equivalent (each Ditch)	—
Hydraulic Flow (Design - GPD)	1,250,000
(Design - GPM)	868
Volumetric Loading (#BOD/1000 ft^3)	15.0
Organic Loading (#BOD/day/~~P.E.~~)	3162
Oxygen Required (#O_2/~~#BOD~~ day)	7431
Aeration Detention Time (hrs.)	30.3

Characteristics:

Length Overall (Ft.)	349
Width Overall (Ft.)	53
Water Depth (Ft.)	12
Sidewall Slope (Degrees)	STRAIGHT
Median Strip Width (Ft.)	1
Volume (Cu.ft.)	210,800
Bottom Width (Ft.)	26
Width @ Water Surface	26
Cross Sectional Area (Sq. ft.)	312

PROJECT: GRANADA, — ALTERNATE #3

III. ROTOR DETAILS (Each Rotor)

Type		MAGNA
Diameter (in.)		42
Length (Ft.)		25
RPM		60
Immersion (in.)	Design	9.4
Oxygenation (#O_2/Hr./ft.)	Design	4.14
Power Required (bhp/ft.)	Design	1.189
Mixing (Gal/ft.rotor)	Design	21,000
Drive Required (HP)		40
Brake Horsepower per drive		29.7

IV. LIQUID LEVEL CONTROLLER DETAILS

Length (ft.)	22
Head over weir at 3 times design flow (in.)	2 1/4

V. FINAL CLARIFIER

Diameter (ft.)	42
Side Liquid Depth (ft.)	10
Surface Loading - Design (GPD/ft^2)	450
Detention time (hrs.)	3.98
Weir Overflow (GPD/ft)	5123

Mechanized YES ~~Non-Mechanized~~ _____

VI. EQUIPMENT PRICES

3-25 FT MAGNA Rotor(s), (each) with 40 HP drive, including motor motor, motor support base, shaft bearings, helical gear reducer, drive belts, sheaves with guard, but no electrical controls.

Unit Price: $ 25,000 Approximate shipping weight

Total Price: $ 75,000 (each unit): 5975 #

PROJECT: GRANADA - ALTERNATE 3

Spiraflo Final Tank: 2 - 42 ft. diameter x 10 FT total liquid depth ~~(non)~~ mechanized equipment complete with ALL mechanical equipment within the concrete tank.

Unit Price: $ 36,500 Approximate shipping weight

Total Price: $ 73,000 (Each unit): 15,500 #

Effluent Weir: 1 - 22 ft. long adjustable effluent weir with all necessary mechanical equipment.

Unit Price: $ 5800 Approximate shipping weight

Total Price: $ 5800 (Each unit): 2480 #

These prices include shop painting, service and are freight allowed.

IX. For a complete plant, the following must be added to the above items:

(a) Raw sewage lift station (if required)
(b) Yard piping
(c) Electrical equipment
(d) Ditch excavation and liner
(e) Fence
(f) Bar screen
(g) Final clarifier tank structure
(h) Sludge beds or holding tank
(i) Combination storage-laboratory building
(j) Chlorinator
(k) Sludge Recycle Pumps
(l) Bridge

3 - 25 FT ROTOR BAFFLES
UNIT PRICE: $3000
TOTAL PRICE: $ 9000

LAKESIDE EQUIPMENT CORPORATION

MS/jp4577

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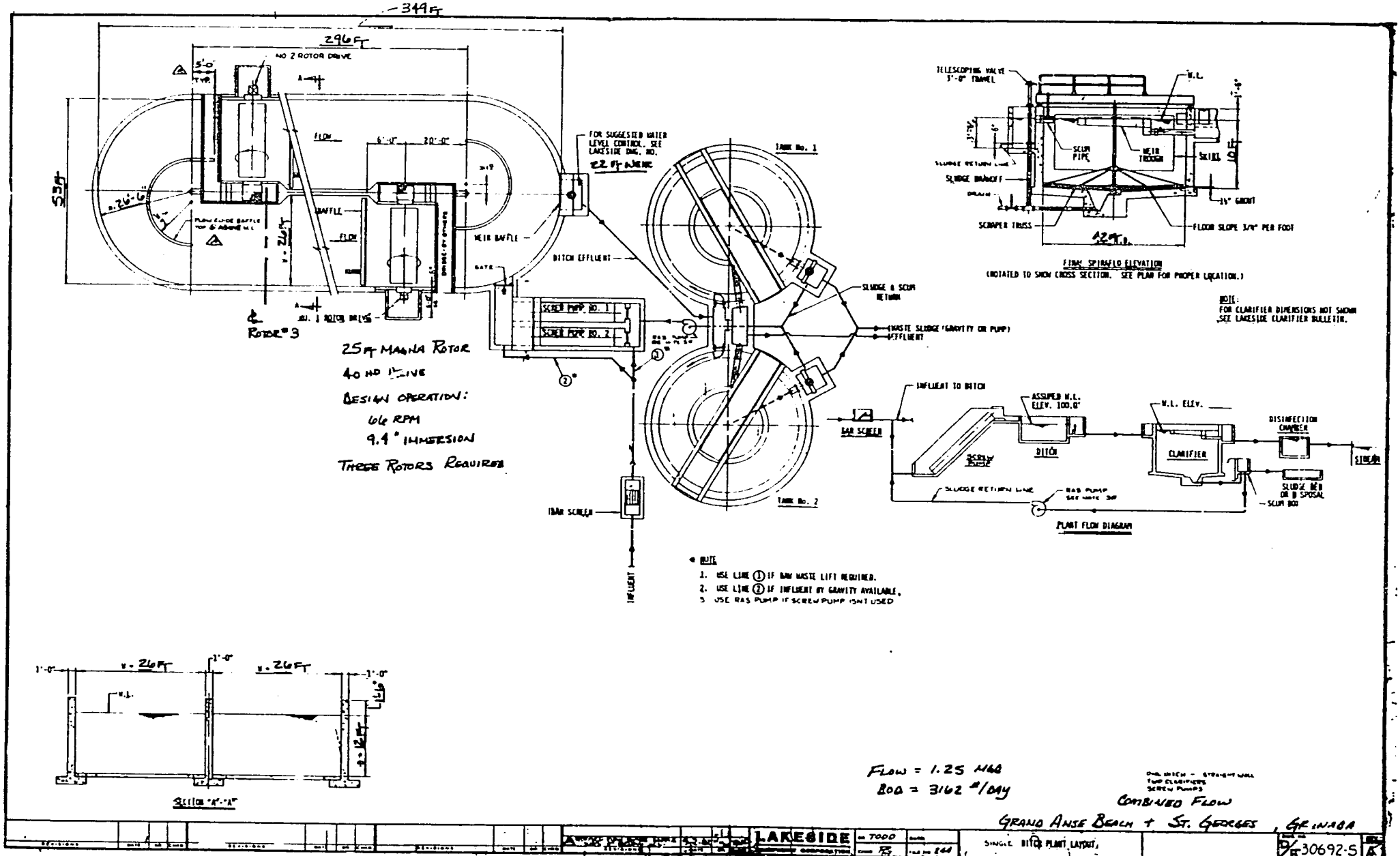

349 FT
296 FT
NO 2 ROTOR DRIVE
FLOW
BAFFLE
WEIR BAFFLE
GATE
DITCH EFFLUENT
FOR SUGGESTED WATER LEVEL CONTROL, SEE LAKESIDE DWG. NO.
22 FT WEIR
TANK No. 1
TANK No. 2
SLUDGE & SCUM RETURN
WASTE SLUDGE (GRAVITY OR PUMP)
EFFLUENT
SCREW PUMP NO. 1
SCREW PUMP NO. 2
BAR SCREW
INFLUENT
NO. 1 ROTOR DRIVE
℄ ROTOR #3
25 FT MAGNA ROTOR
40 HP 1½" LINE
DESIGN OPERATION:
66 RPM
9.4" IMMERSION
THREE ROTORS REQUIRED
TELESCOPING VALVE 3'-0" TRAVEL
W.L.
SCUM PIPE
WEIR TROUGH
SKIRT
SLUDGE RETURN LINE
SLUDGE RUNOFF
DRAIN
SCRAPER TRUSS
FLOOR SLOPE 3/8" PER FOOT
FINAL SPIRAFLO ELEVATION
(ROTATED TO SHOW CROSS SECTION. SEE PLAN FOR PROPER LOCATION.)
NOTE:
FOR CLARIFIER DIMENSIONS NOT SHOWN SEE LAKESIDE CLARIFIER BULLETIN.
INFLUENT TO DITCH
ASSUMED W.L. ELEV. 100.0'
DITCH
SCREW PUMP
W.L. ELEV.
CLARIFIER
DISINFECTION CHAMBER
STREAM
SLUDGE BED OR DISPOSAL
SCUM BOX
SLUDGE RETURN LINE
RAS PUMP
PLANT FLOW DIAGRAM
NOTE
1. USE LINE 1 IF RAW WASTE LIFT REQUIRED.
2. USE LINE 2 IF INFLUENT BY GRAVITY AVAILABLE.
3. USE RAS PUMP IF SCREW PUMP ISN'T USED
SECTION "A"-"A"
W.L.
FLOW = 1.25 MGD
BOD = 3162 #/DAY
COMBINED FLOW
GRAND ANSE BEACH + ST. GEORGES, GRENADA
LAKESIDE
SINGLE DITCH PLANT LAYOUT
30692-S
ALTERNATE 3
11/13/85

101.

ATTACHMENT D1

EXAMPLE MANUFACTURER'S INFORMATION
FOR OXIDATION DITCH PROCESS

WATER PURIFICATION EQUIPMENT SINCE 1928

LAKESIDE EQUIPMENT CORPORATION 1022 E. DEVON AVE. ■ P.O. BOX 8448 ■ BARTLETT, IL 60103 ■ 312/837-5640

November 8, 1985

Gerald R. Steiner
Tennessee Valley Authority
Water Quality Division
248 - 401 Building
Chattanooga, Tennessee 37401

Subject: St. Georges, Granada
Oxidation Ditch Information

Dear Mr. Steiner:

In response to your phone call, we are attaching a booklet containing various information on the Oxidation Ditch process. Also, we are enclosing six (6) copies of bulletin 143 for use in your visit to Granada week after next.

We will work up calculations on the three size plants which you mentioned, but will not be able to get this to you before the end of next week. Hopefully, the enclosed information and this letter will be sufficient for your preliminary discussions regarding the Oxidation Ditch.

The three (3) alternates you mentioned were for flows of 0.6 mgd, .07 mgd, and 1.25 mgd. The cost of construction will vary and we have no idea what it might be in Granada. In the United States, we would estimate the overall cost at $1.50 to $2.50 per gallon. In other words, the 0.6 mgd plant might run in the range of $900,000 up to as much as $1,500.000. The 1.25 mgd plant would probably vary from $1,875,000 up to as much as $3,000,000. There are a number of factors involved which cause the cost to vary. Not only construction costs in various areas, but also the preference of the consulting engineer and what he puts into the plant. Obviously, the needs of a particular locale also have an affect on the overall cost. However, the above numbers should give you at least a range.

With regard to the Oxidation Ditch process, we would like to emphasize that this is the simplest and, with the exception of a lagoon, the least costly approach to designing a sewage treatment plant. A small plant does not require highly skilled personnel to operate it. Lakeside has supplied equipment for Oxidation Ditches for the past 20 years and presently have about 1500 installations in the United States. Many of these are very small plants and are often operated by the Mayor of the local town or one of his assistants. We would be very happy to supply you with documentation in that regard.

At the same time, the Oxidation Ditch process is capable of achieving a very high quality effluent. In Florida, for example, which is a warm weather climate, we have installations where they are getting effluents with BOD and Suspended Solids of less than 10 mg/l. Also, these plants get virtually complete nitrification as ammonia nitrogen of less than 2 mg/l and, in some cases, even denitrification where the total nitrogen is less than 5 mg/l. We will be happy to send you a few slides to show the people in Granada if that will be helpful. This will take a couple of weeks, since we have to have duplicates made.

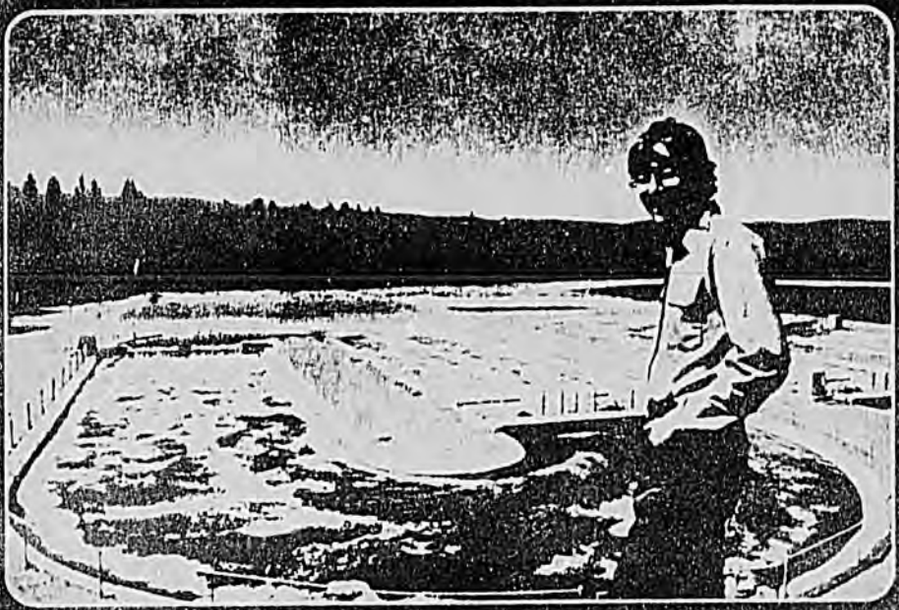
We trust the above and attached information is satisfactory and will forward the calculations and recommendations on the alternates which you requested. As stated above, this probably will not go out until the end of next week. In the meantime, we hope this if helpful.

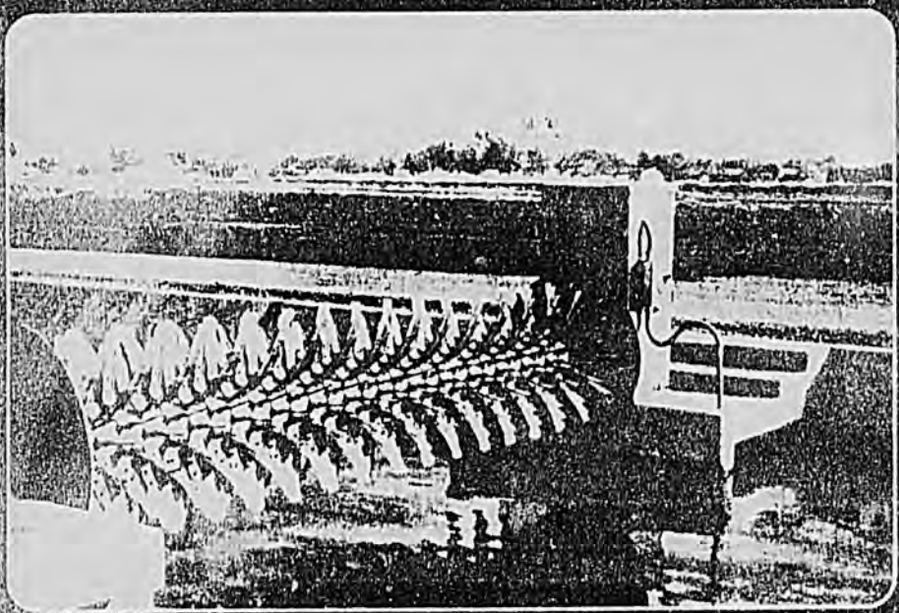
Very truly yours,

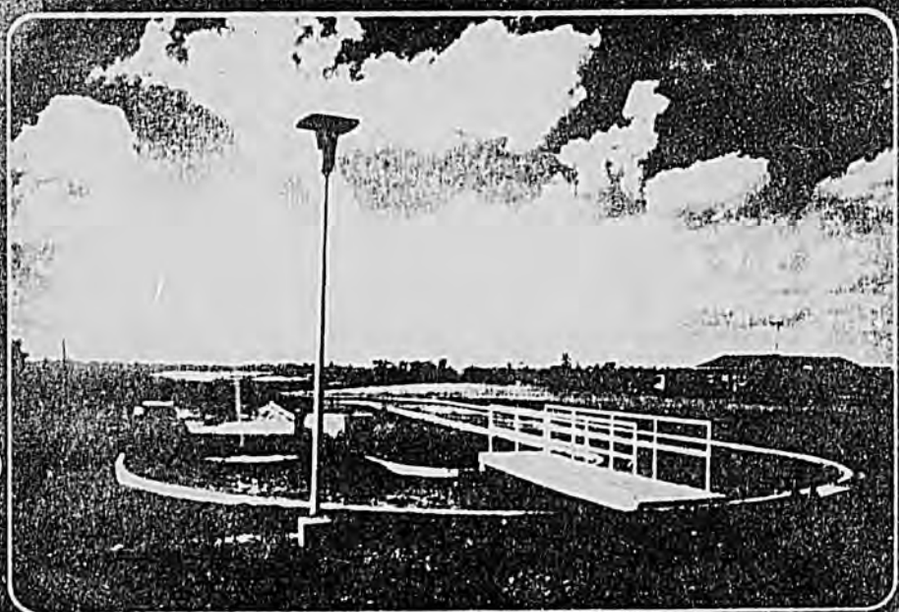
Melvin Salkeld

Melvin Salkeld
MS/cl

cc: Roy Smith, J. T. Guthrie & Son







Bulletin 143

ROTOR AERATION IN THE OXIDATION DITCH

Lakeside Equipment Corporation has developed quality equipment and processes for the water and wastewater treatment industry since 1928.

The Lakeside Oxidation Ditch wastewater treatment process described in this bulletin is simple and reliable.

It can be designed for low construction and operation costs.

There is no secondary wastewater treatment process that produces a higher level of effluent quality.

The Lakeside Oxidation Ditch has clearly demonstrated these characteristics in years of successful operation.

LAKESIDE
LAKESIDE EQUIPMENT CORPORATION
1022 E. Devon Ave. • Bartlett, IL 60103 • (312) 837-5540

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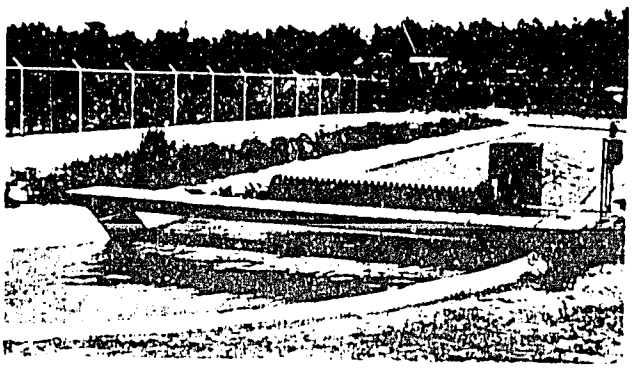
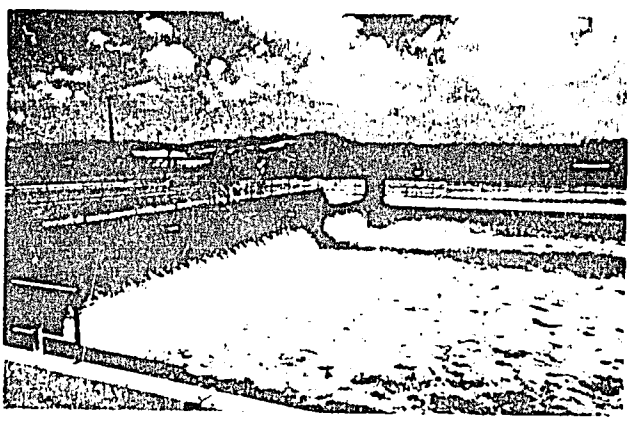
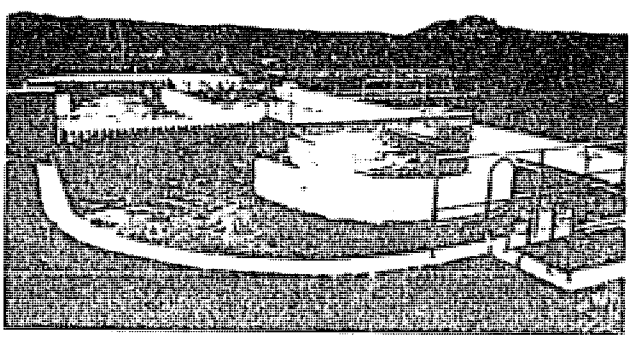


Simple low cost construction to fit tight budgets.



High capacity flexible aeration for efficient large plant application.



Deep channel construction for special soil, land and hydraulic concerns.

High quality effluent in extreme climates.

Process Application

Any wastewater that can be treated biologically can be treated in an Oxidation Ditch. The large mass of microorganisms normally contained in the Oxidation Ditch make it especially suited for treatment of wastes where shock loads are common, where cold temperatures are anticipated and where skilled operation is not expected.

For municipal wastes, the Oxidation Ditch provides unexcelled secondary treatment. BOD_5 and suspended solids are reduced by 90 to 98%, depending on plant design. Nitrification of ammonia and organic nitrogen is virtually complete. Close operator control can provide substantial levels of denitrification. Phosphorus removal can be achieved by chemical addition to the Oxidation Ditch.

For industrial wastes the Oxidation Ditch with its low cost design and highly efficient Rotor Aeration system will provide excellent treatment simply and economically. Industries with experience using the Oxidation Ditch include:

- Milk processing
- Meat and Poultry packing
- Soft drinks and breweries
- Paperboard
- Food Processing
- Pharmaceutical
- Petrochemical

Treatment Category

The Oxidation Ditch is a wastewater treatment process which uses naturally occurring bacteria to remove organic wastes from sewage or industrial discharges. It is an activated sludge process with a non-conventional continuous channel hydraulic design and highly efficient rotor aeration equipment. It provides unparalleled complete mix conditions and higher allowable concentration of microorganisms than conventional activated sludge systems. The Oxidation Ditch is an advanced modification of the complete mix extended aeration activated sludge process.

Design flexibility to fit special site requirements.

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Principal Characteristic:

Simplicity

The Oxidation Ditch process is designed for simple, reliable operation. A high mixed liquor suspended solids concentration, usually between 3000 to 8000 mg/l, is carried in the Ditch. This high solids concentration allows the process to handle shock loads generally without special operator attention and without upsetting plant operation. There is no foam problem in the Oxidation Ditch after initial solids buildup. Cold weather operation has less effect on plant efficiency than other biological processes because of the large population of microorganisms contained in the Oxidation Ditch. These features and the simplicity of the structure and equipment reduce the necessity for highly technical operation supervision.

Design

BOD removal, nitrification, denitrification and sludge digestion occur simultaneously in the aeration channel. The design of separate unit processes for these stages of treatment is eliminated. No primary clarifier, no sludge digester.

Operation Control

The process is stable so that even with organic and hydraulic shock loads close process control is unnecessary. A turn of a telescoping valve handwheel adjusts return sludge rate. A settleable solids test tells when to waste sludge. A dissolved oxygen probe tells if you have too much oxygen. A turn of an adjustable weir handwheel in most plants is all that is needed to control aeration. No foaming, no odors.

Maintenance

All but the blades of the Rotor Aerator sit above the sewage. Rotor bearings are greased weekly, its gear reducer oil changed three times a year. There is no primary treatment equipment or sludge digestion equipment to service or maintain. There is no constant cleaning of diffusers or spargers to maintain aeration efficiency.

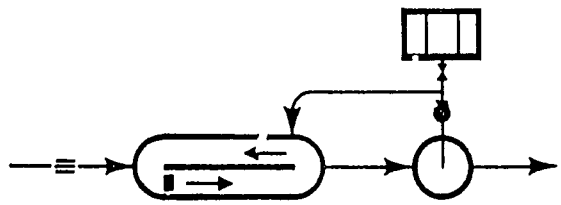

Figure 1. Simplicity of design

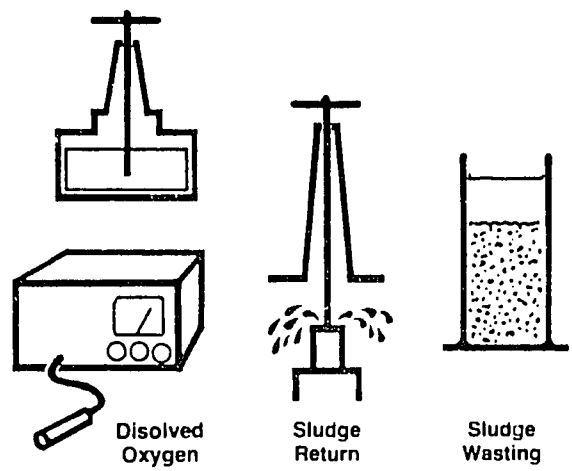

Figure 2. Simplicity of Control

Principal Characteristic:

Economy

Economy in construction and operation is a characteristic of the Oxidation Ditch that has led to its wide acceptance and use.

Two types of channel construction are available. The shallow channel Oxidation Ditch, usually 4 to 7 feet in liquid depth, uses simple excavations with a lightly reinforced concrete liner rather than reinforced concrete to cut construction costs. The deep channel construction with vertical or sloping walls to 12 foot liquid depth saves land and also can be used when site hydraulics or flooding considerations dictate above grade construction.

Capital Costs

Eliminates primary treatment, sludge digestion, and nitrification equipment, piping and tankage. Normally eliminates surge holding basin requirements. Saves excavation and concrete costs with shallow ditches and thin channel liners. Saves land and pumping costs with deep channel construction.

Operating Costs

Efficient, flexible aeration. 5.0 bhp/1000 PE including nitrification power requirements. Operating at 50% design capacity? You need only 50% design power for aeration and mixing. Simple process operation means savings in operator training and reduced supervision and maintenance.

Under normal conditions, the construction cost of this type plant is 20 to 33% below that expected for other secondary treatment plants. Significantly greater savings when compared to other processes providing nitrification and denitrification.

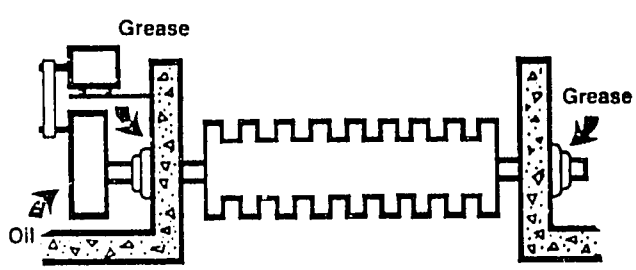

Figure 3. Simplicity of Maintenance

Process Components

The principal components of the Lakeside Oxidation Ditch are the bar screen, aeration channel, rotor aerator, final clarifier, return sludge pump and excess sludge handling facility. (See Figure 1.)

There is no primary clarifier or sludge digester used for this process. There is no requirement for comminution or grit handling equipment (in the absence of special wastewater characteristics or governmental requirements).

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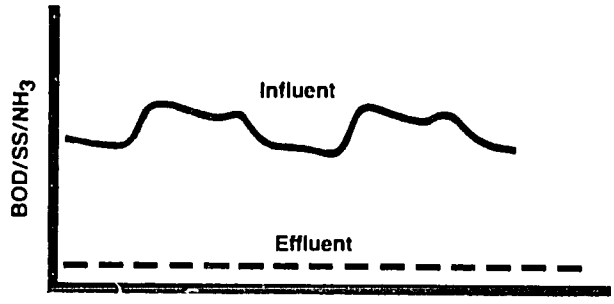

Figure 4. Constant, reliable effluent in all climates

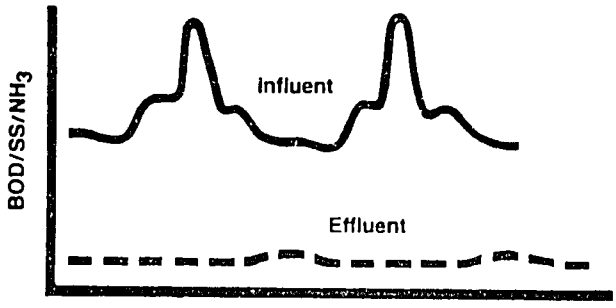

Figure 5. Reliable effluent in face of organic shock loading

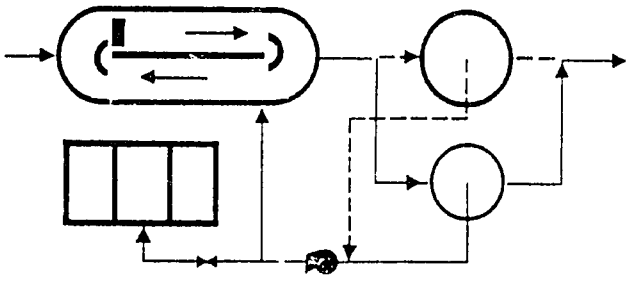

Figure 6. Hydraulic shock loading; a simple design revision

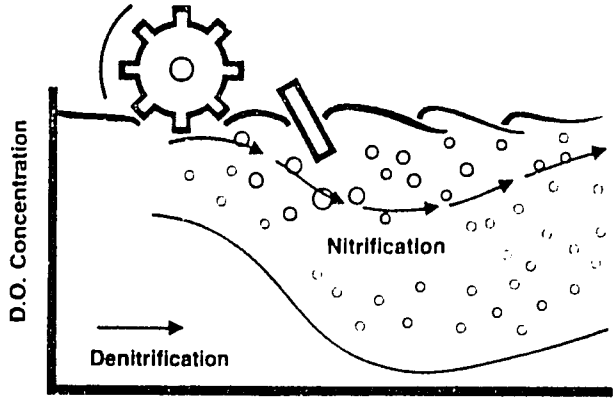

Figure 7. Complete mix conditions and controlled aeration

Process Advantages: Performance

Effluent BOD/SS

Long detention times and complete mix conditions, readily controllable oxygenation capacity and high MLSS concentrations with controlled sludge wasting will provide 90-98% removals (depending on design) consistently and reliably. This means positive compliance with secondary treatment discharge permits and a high quality influent to any tertiary treatment facility.

Cold Weather Operation

The ability of the Oxidation Ditch to continue the high degree of treatment demonstrated in warm weather operation during the coldest winters is again due to the very low f:m ratio used in this process. While biological activity is slowed substantially in cold temperatures, the large colony of microorganisms found in the Oxidation Ditch, including nitrifying organisms, compensate for the reduced activity of each organism. These factors contribute once again to the high quality of the Oxidation Ditch effluent in cold weather operation.

Hydraulic Shock Loadings

f:m ratios govern the rate of BOD removal. The Oxidation Ditch's low f:m with long detention times (over 10 times the contact time of a contact aeration zone in a Contact Stabilization plant) and high microorganism population will properly treat hydraulic shock loadings due to wet weather infiltration and inflow when the Oxidation Ditch is designed with appropriate final clarifier and return sludge pumping facilities.

Organic Shock Loading

The large population of microorganisms in the aeration channel provides one of the lowest food to microorganism ratios (f:m) of any biological waste treatment process. Low f:m and true complete mix conditions give the Oxidation Ditch the ability to **treat** organic shock loadings, and not just let them pass through.

Nitrification

High sludge ages with long detention time and high MLVSS, plus efficient aeration and mixing provide complete nitrification even in winter operation.

Denitrification

Close operator attention and low dissolved oxygen concentrations in the aeration channel will allow denitrification to occur while nitrification is carried out in other parts of the channel. The reuse of nitrifying oxygen yields power savings in addition to reducing total nitrogen in the effluent.

Complete Mix

The "moving belt" circulation of the Oxidation Ditch aeration channel produces the "complete mix" conditions found in this process. This moving belt mixing provides the most efficient use of oxygen and aeration volume.

Simply stated, the "moving belt" of the mixed liquor in the aeration channel receives a small amount of raw sewage continuously over its entire length as the mixed liquor moves past the influent pipe hundreds of times each day. A conventional complete mix plant introduces raw sewage only at specific points along the aeration basin. The "moving belt" of the Oxidation Ditch provides better distribution and therefore better complete mix conditions.

For vertical mixing in deep tanks, horizontal baffles assure mixing from top to bottom with an equal distribution of oxygen, food and organisms.

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Process Flow Sheet

Raw wastewater passes directly through the bar screen into the aeration channel. Here the wastewater is mixed with previously formed naturally occurring microorganisms. The Rotor Aerator in the aeration channel entrains the necessary oxygen into the liquid for microbial life and keeps the contents of the Ditch mixed and moving to insure ready contact of all microorganisms with the sewage.

Following treatment in the channel, the mixture of treated sewage and microorganisms (known as mixed liquor) flows over a weir out of the Oxidation Ditch channel and into the final clarifier. In the clarifier the microorganisms are settled out of the mixed liquor and pumped back to the Oxidation Ditch. The remaining liquid, now clear, passes over the clarifier effluent weir. From there it may be discharged or sent for further treatment such as disinfection or tertiary filtration.

Excess sludge formed in the process is stable and requires no further digestion. When sludge is wasted, direct application to drying beds, lagoons or mechanical dewatering equipment and landfill are normal handling procedures for this nuisance free material.

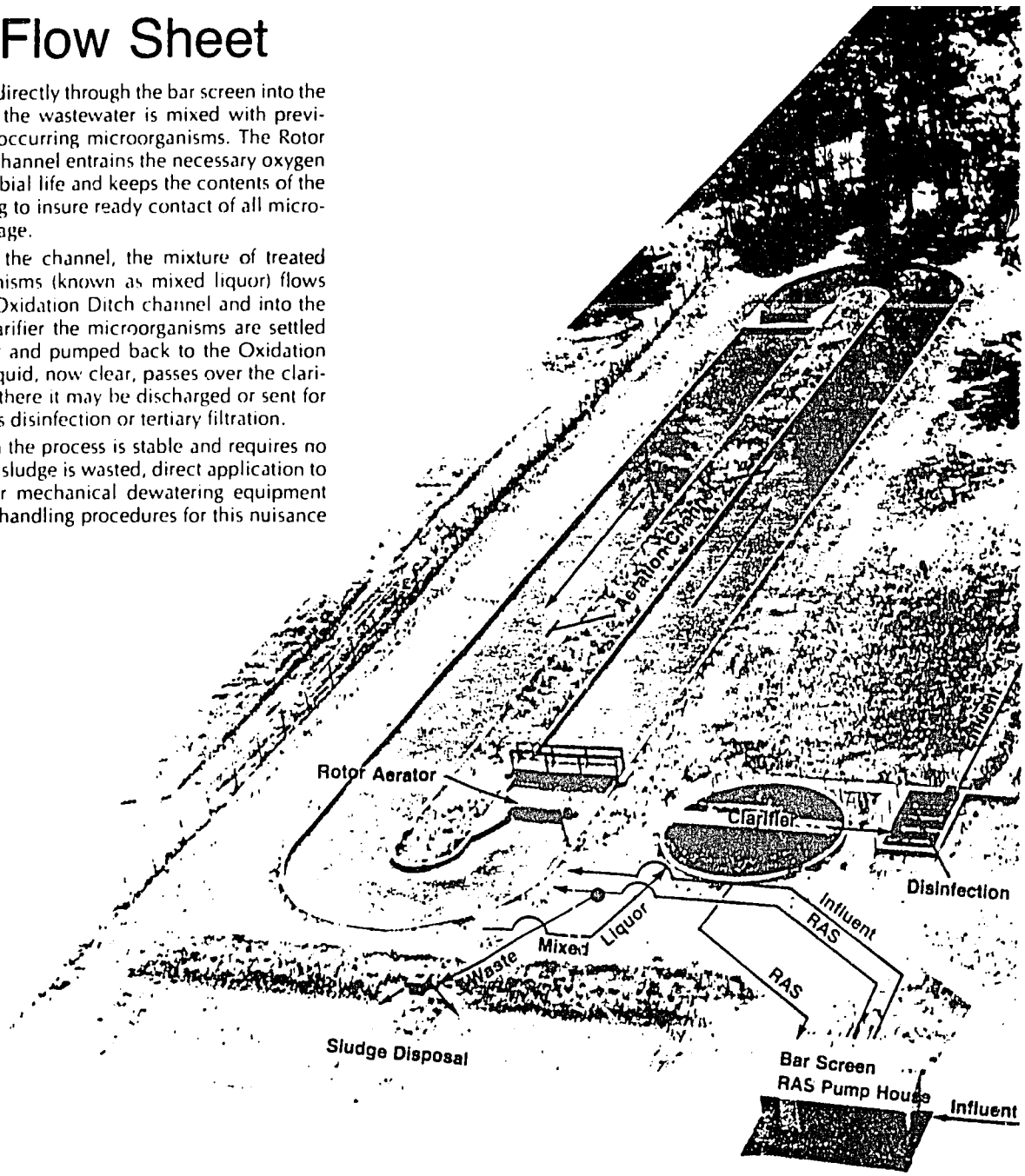

Figure 8.

History

In the 1950's the Research Institute for Public Health Engineering of the Netherlands (T.N.O.) undertook a study to develop a simpler and more economical waste treatment process for small municipalities and industries. The research effort resulted in the development of the horizontal Rotor Aerator and the race track channel hydraulics characteristic of the Oxidation Ditch process. The first full-sized Oxidation Ditch plant was installed in Holland in 1954.

In 1963 Lakeside Equipment Corporation (then Lakeside Engineering Corp.) introduced the Oxidation Ditch to North America. Beaverton, Oregon became the first U.S. plant to treat domestic wastewater with the Oxidation Ditch process. Shortly thereafter its use began to spread throughout the continent from Mexico to Alaska.

While it was first developed for small municipal and industrial plants, engineers began evaluating its use in the mid-1960's for treatment of larger wastewater flows. In 1969, the city of Greenville, Ohio installed a 3.3 mgd Oxidation Ditch for treatment of their municipal wastewaters. The John Morrell Company in Ottumwa, Iowa installed an Oxidation Ditch for treatment of its 129,500 PE meat packing wastewater discharge in that same year.

In the late 1960's the continued push to build larger Oxidation Ditches by engineers led to the development of the high capacity Magna Rotor and the first use of deep channel construction. Deep Oxidation Ditch aeration channels now require land area of only one quarter acre per million gallons capacity and installations are being constructed to treat design flows exceeding 7 mgd.

Over 500 plants using the Oxidation Ditch process were installed in the United States and Canada in the first 12 years following Beaverton, Oregon. The excellent reputation and broad acceptance of this process for both small and large treatment facilities guarantee its use in future wastewater treatment projects.

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In the course of building over 10,000 feet of Rotor Aerators in its first 15 years of Oxidation Ditch development, Lakeside has continually worked to improve aerator design. The following section describes the different rotors available from Lakeside, their designs, characteristics and some of the features that reflect, in part, Lakeside's design experience and continued attention in Rotor development.

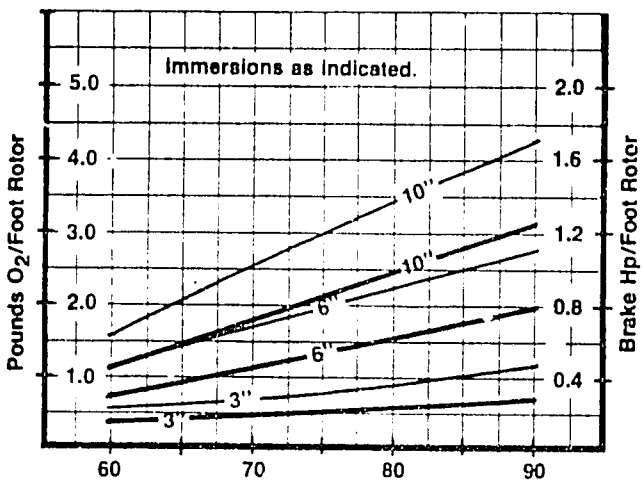

Table 1. Cage & Mini-Magna Rotor: oxygen entrainment (standard conditions) & power consumption

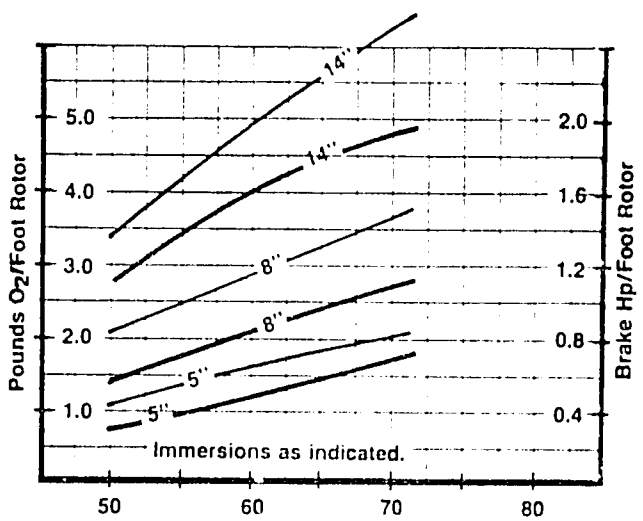

Table 2. Magna Rotor: oxygen entrainment (standard conditions) & power consumption

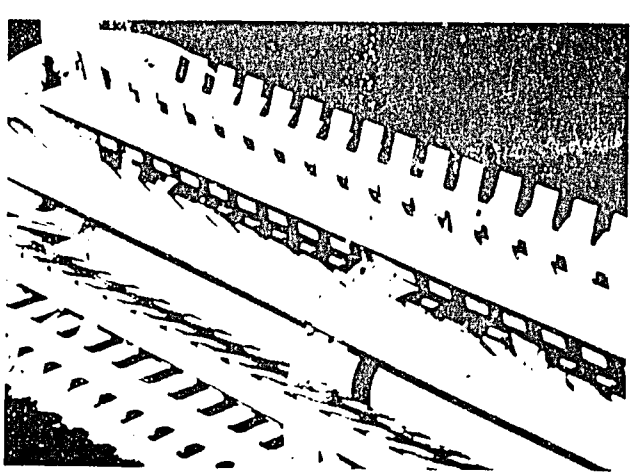

Figure 9. Rugged dependable Cage Rotor

Advantages of the Rotor Aerator

Rotor Aerators are stable aerators, and among the most adaptable mechanical aerators available in the industry. A very wide range of oxygen transfer is available from a given aerator length. For example, a 20 foot Magna Rotor can entrain from 22 pounds of O_2 per hour at 54 rpm and 5" immersion to 132 pounds at 15" immersion and 72 rpm, either of which output with proper aeration channel design will provide complete mix conditions in the aeration basin.

High oxygen transfer efficiency is also a characteristic of the Lakeside Rotor Aerator, equal to or exceeding the best conventional mechanical aerators in oxygen entrainment. The wide range of efficient oxygenation and exceptional mixing characteristics let the operator match O_2 output and power usage to meet the O_2 requirements of his waste. This saves power and is especially valuable when plants go on line at 50% design load or less.

And the Lakeside Rotor Aerator is reliable. Over 15 years of rotor development has gone into the design of this rugged, clog-free, low maintenance device that works equally well in cold northern winters and hot, humid southern summers.

Cage Rotor Aerators

The Lakeside 27½" diameter Cage Rotor Aerator is the result of over 15 years of development by Lakeside. This aerator, which rotates in a plane horizontal to the liquid surface, consists of 12 horizontal blades each with 2" wide teeth designed for tough winter operation. These blades are supported by cast end plates with the entire rotor assembly in turn supported by field replaceable stub shafts.

The Cage Rotor is used in aeration channels to 6' liquid depth. It is available in lengths from 3 to 12 feet and will provide complete mix conditions when sized to provide one foot of rotor for every 16,000 gallons aeration channel volume.

The oxygen transfer from the "Cage" is a function of the rotor speed and immersion. Table 1 shows the oxygen transfer characteristics through the typical operating range of the Cage.

Mini-Magna Rotor

The 28" diameter "Mini" Magna Rotor is Lakeside's answer to the need for a small diameter rotor with oxygenation and power consumption characteristics similar to the traditional Cage Rotor, with longer available lengths. The development of the "Mini" by Lakeside has provided that capability, a rotor with all the advantages of the "Cage" in spans up to 16'.

The same rugged blade construction, field replaceable stub shafts and support stand options that have provided high reliability for the Cage Rotor are found on the Lakeside Mini-Magna.

Magna Rotor Aerator

The 42" diameter Magna is Lakeside's high capacity Rotor Aerator used in both shallow and deep aeration channel configurations. The rotor blades for the Magna have been developed to withstand impact from floating debris such as ice floes which are expected in severe winter operation. These blades are secured to the 14" diameter support torque tube with end splash shields and field replaceable stub shafts.

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The Magna Rotor is capable of providing complete mix conditions in the Oxidation Ditch aeration channel when sized to provide one foot of rotor for every 21,000 gallons of aeration channel volume.

Like the Cage and Mini-Magna Rotors, the Magna Rotor oxygen output and power draw is a function of both speed and immersion. Table 2 shows the oxygen transfer characteristics through the typical operating range of the Magna.

Rotor Drive Assembly

Lakeside Rotor Aerators designed for normal wastewater aeration applications incorporate a low maintenance, high reliability shaft mounted helical gear reducer driven by belts from standard constant speed squirrel cage induction motors. The motor, reducer and drive belt assembly are enclosed in a steel housing for protection from the elements. Construction emphasizes simplicity of lubrication, maintenance and repair.

Rotor Mounting Options

A variety of Rotor mounting options have been developed for Oxidation Ditch applications. While special designs are always available from Lakeside, the following designs should meet the needs of almost all applications.

Sidewall Mounted Rotor

The sidewall mount has been developed by Lakeside to provide the ultimate operator convenience in Rotor maintenance. The sidewall mount supports the Rotor on vertical concrete sidewalls which protect the Rotor bearings and drive from the splashing of mixed liquor and provides the operator with an easily accessed clean dry well from which to service the unit.

The sidewall mount is the recommended mount for Rotors in Oxidation Ditches in northern climates where freezing conditions are commonplace. The drives and outboard bearings are protected from freezing Rotor spray for ease of lubrication and service. (Figure 11.)

Base Mounted Rotor

The base mounted Rotor Aerator is a Lakeside standard design for low cost construction. The Rotor drive housing doubles as a Rotor support stand, mounted on a horizontal concrete platform. The outboard bearing is also mounted on a similar platform, protected from mixed liquor spray by grease loaded end caps and dual neoprene seals. (Figure 10.)

Modified Sidewall Mount

The modified sidewall mount combines the drywell Rotor drive servicing feature of the sidewall mount with the low cost horizontal platform support for the outboard bearing.

Overhead Bridge Mount

For package-type Oxidation Ditch plants such as Lakeside's E.A. Aerotor plant, the bridge mounted Rotor design is available. This unit provides a combination walkway and Rotor support structure for mounting Cage, Mini, or Magna Rotors.

Floating Magna Rotor Mounts

When special engineering studies show variable volume aeration basins are best suited to plant designs, or where variable depth lagoon aeration is required, Lakeside offers the floating Magna Rotor. This unit features all aluminum float construction with immersion adjustments by ballast addition to the foam filled flotation pods. Floating Rotors are not recommended where heavy icing conditions can be expected. (Figure 12.)

Special Rotor Mounts

In the case where conditions require special Rotor mounts, Lakeside engineers stand ready to advise and assist in the design of these units.

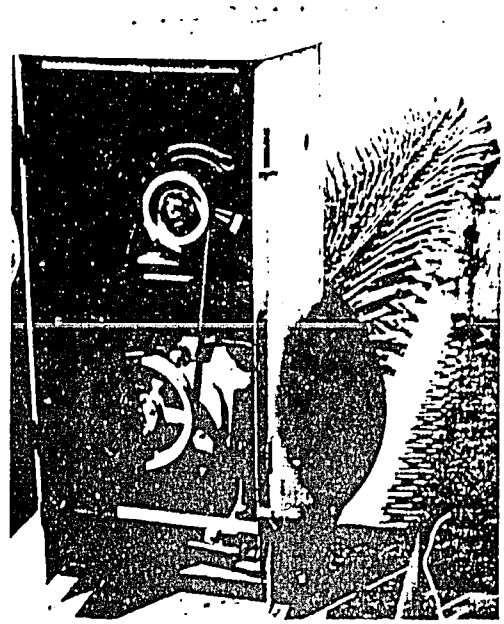

Figure 10. Base Mount Magna Rotor

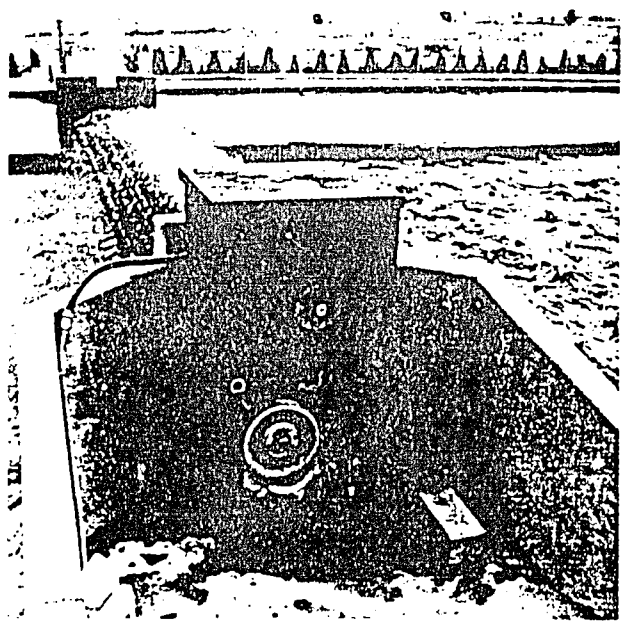

Figure 11. Sidewall Mount Magna Rotor

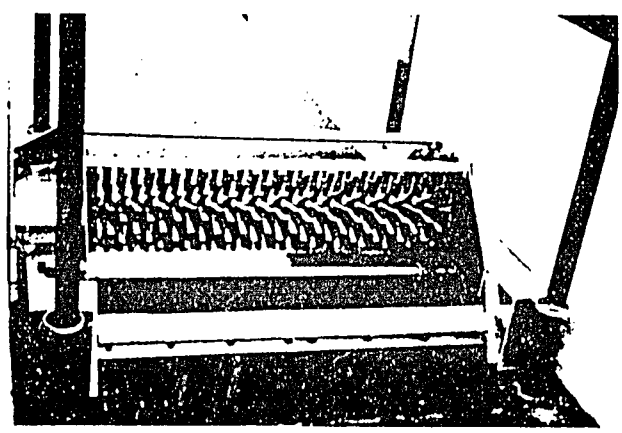

Figure 12. Floating Magna Rotor

Oxidation Ditch Design Procedure

While the Oxidation Ditch is a simple and inexpensive process to design, construct and operate, there are many aspects of design that can be improved by careful engineering. For the engineer desiring to evaluate an optimized Oxidation Ditch process, Lakeside is ready to help. Here are questions which will help Lakeside determine design alternatives that best suit your application:

Are there special site limitations or conditions that will make deep tank or shallow tank construction more desirable? Shallow bedrock or relatively low bearing capacity soils may make shallow Oxidation Ditches desirable. In some areas available land, flooding potential or plant hydraulics may make deep above-grade Oxidation Ditches the proper choice.

What is the hydraulic load to be treated in the Oxidation Ditch plant? Since the final clarifier and its design is such a critical component of the Oxidation Ditch process, knowledge of peak flows will help to determine proper clarifier and return sludge pumping design.

For industrial applications, where waste load allocations govern plant design, is it more desirable to discharge secondary effluent to the sewers alone with separate sludge disposal? Or is it more economical to design the aeration process and hydraulics so that excess sludge can be metered into a high quality clarifier effluent to meet municipal sewer discharge requirements yet simultaneously eliminate excess sludge handling from the process?

With answers to these questions, Lakeside will be able to provide improved initial Oxidation Ditch design approaches for your wastewater treatment project, designs reflecting the latest in Oxidation Ditch process technology.

The following design procedure is for 90% removal of BOD_5 from normal domestic sewage and industrial wastes with similar treatability characteristics. Under most conditions, this design will also provide for complete nitrification of organic nitrogen and ammonia. This procedure outlines the basic design considerations that are used in the development of Oxidation Ditch designs. The intention is to give the engineer a feeling for important design considerations, not to provide an exhaustive set of rules with which he can optimize his own Oxidation Ditch design. The Oxidation Ditch process can also be used for treatment of industrial wastewater that is amenable to biological degradation. The design procedure for industrial wastes will depend upon the particular wastewater to be treated. Unusual applications should be referred to Lakeside.

Aeration Channel Design

Volume

The volume of the standard municipal Oxidation Ditch aeration channel is based on the organic loading of 13.5 lbs. BOD_5 per day per 1000 ft^3. Most designs fall within the range of 9.0 to 15 lbs. BOD/1000 ft^3.

Geometry

The aeration channel is sized with a liquid depth from 4' to over 12'. The shape of the channel is normally an elongated oval like a racetrack, but it can be other shapes so long as a continuous circuit is maintained. The median strip width in the aeration basin should be wide enough so the curvature at the ends is not too sharp. For narrow median strips or center dividing walls, flow guide baffles are used to improve channel hydraulics. Generally speaking, for population equivalents less than 6000, a center island 16' wide is found to be the economical choice. For larger plants, center dividing walls with flow guide baffles become increasingly attractive.

Aeration Velocity

The length of Rotor used for a given aeration channel should be the larger of the two lengths computed to satisfy the oxygenation capacity and the channel velocity criteria. First calculate the Rotor length required to satisfy the velocity criteria. The channel velocity is a function of the propulsion capability of the Rotor and the frictional resistance of the wetted perimeter of the channel. Sufficient propulsion must be provided to produce a velocity so that all solids are maintained in suspension.

For plant designs with a population equivalent in excess of 600, the channel volume should not exceed 16,000 gallons per foot of Cage Rotor or Mini-Magna Rotor or 21,000 gal/ft. of Magna Rotor. For plant designs less than 600 population this figure should not exceed 13,000 gallons per foot of Rotor. These criteria are based on actual experience accumulated from operating plants.

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Rotor Oxygenation

To determine the speed and immersion for the given design requirements refer to tables 1 and 2. These curves represent the oxygenation capacity of the rotor in tap water at standard test conditions of 20° C, 760 mm pressure and zero dissolved oxygen. Since oxygen transfer rates are not the same for test conditions and wastewaters, the numbers shown on the graphs must be adjusted with an appropriate conversion factor.

For the Oxidation Ditch the conversion factor of 2.35 is normally used to calculate the required oxygenation capacity of the Rotors from the BOD_5 applied daily to the process. This conversion factor is based upon providing 1.5 $\#O_2/BOD_5$ while the Rotor is operating in mixed liquor with a dissolved oxygen concentration of 2.0 mg/l, temperature of 20° C at elevations less than 2000 ft. The alpha and beta factors are considered to be 0.8 and 1.0, respectively.

To calculate the amount of oxygen required from the Rotor Aerators, multiply the pounds of influent BOD_5 by 2.35 and divide by 24 hours. For typical domestic wastes and organic loadings to the aeration channel, the Rotor length calculated for channel velocity may be used for calculating Rotor length needed for oxygenation requirements. Divide the oxygen output required by the length of Rotor needed for mixing to determine the pounds of oxygen required per foot of rotor per hour. With a selected design rotor immersion (4"-9", normal 6" for Cage and Mini-Magna Rotors, 6"-10", normal 8" for Magna Rotors), the table can be entered for the appropriate rotor speed.

With the length, speed and immersion of the Rotor known, the brake horsepower per foot of Rotor is selected from Tables 1 and 2 to calculate horsepower required for each Rotor. If it is anticipated that the Rotor will operate at immersions greater than the selected design immersion due to variations in waste loads or fluctuating water levels in the aeration channel, then the deeper immersion should be used in calculating the required motor horsepower for the Rotor assembly.

Aeration Channel Lining

It is recommended that the aeration channel be furnished with some type of lining for erosion protection. Several types of economical channel liners are available, the choice dependent upon plant location and site considerations.

While there are other possibilities, 4" concrete with 6 x 6 wire mesh reinforcement for channel bottoms and sloping sidewalls has shown in most cases to be superior. For vertical walls, formed, reinforced concrete is frequently used.

Final Clarifier

The Oxidation Ditch process is designed to withstand wide flow and organic load fluctuations and to operate with high mixed liquor suspended solids concentrations in the aeration channel. To accomplish this end, efficient settling must be provided. It is strongly recommended that peripheral feed clarifiers, such as the highly efficient Spiraflo Clarifier, be used to insure the most effective plant operation. Rectangular clarifiers are not recommended for Oxidation Ditch use.

The final clarifier is normally sized with surface overflow rates of 400 to 600 gallons per day per square foot based upon average daily flows and minimum liquid depth of 8'. When high peak flows are expected at a plant due to infiltration or inflow, consideration should be given to sizing the final clarifier on the 2-hour peak flow at 1000 g/sfd for centerfeed clarifiers or 1200 gpd/ft^2 for peripheral feed units. This alternate sizing is especially desirable when solids sensitive processes such as filtration receive the clarifier effluent or when nitrification is required in cold weather applications.

Return Sludge

Several excellent ways are available for regulation of return sludge. Operating experience has shown continuous removal of sludge from the final clarifier is preferred over intermittant sludge removal. Continuous sludge withdrawal can be controlled by a telescoping valve in the return sludge line. Return sludge flow from the T-valve is collected in the return sludge wet well for pumping to the aeration channel by screws or float switch operated constant speed centrifugal pumps. Other acceptable means of controlled continuous sludge return include variable speed pumps and, for small plants, air lift pumps.

Excess Sludge

The need for wasting sludge from the Oxidation Ditch process depends on plant loading and the quality of final effluent required. With design requirements for BOD and SS reductions of 90% and greater, it is necessary to waste excess sludge.

The surplus sludge from the Oxidation Ditch is fully nitrified and highly stable. It does not have offensive odor and is discharged without further treatment for drying to sludge drying beds. The excess sludge can also be diverted to a sludge storage tank for accumulation and decant thickening or to sludge lagoons for storage. The final disposal of the sludge is normally to landfill or farmland application

Approximately 0.15 pounds of waste solids are generated per pound of BOD, in addition to the biologically inert suspended solids received by the plant. The waste sludge from the Oxidation Ditch has a sludge age in excess of 25 days. The sludge has been sufficiently broken down so that the water binding properties present in the sludges of some other processes are not present

For open sludge drying beds, an area of 1.0 sq.ft. per capita is used in most climates. For northern climates, consideration should be given to increasing this capacity to 1.5 sq.ft. per capita. A minimum of two beds are required so one may be in use while the second dries. The volume of the sludge produced after thickening is approximately 4.5 ft^3 per 100 PE per day.

The Oxidation Ditch can also be operated as a balanced system with no control of the mixed liquor suspended solids concentration. This type of operation will not continually produce a highly polished effluent. Excess sludge (mostly ash) is continually wasted over the effluent weir of the final clarifier with resulting discharge of some BOD and suspended solids.

Additional Information

For a more detailed discussion of Oxidation Ditch design, operation and performance or for specific project design information, consult your Lakeside representative or contact us at our main office in Bartlett, Illinois.

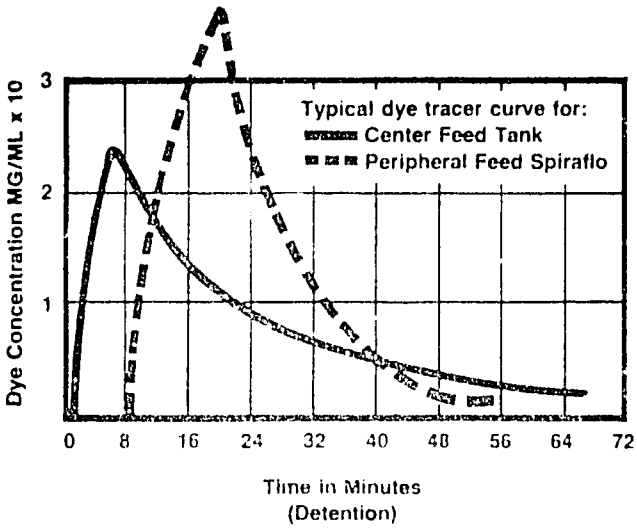


Figure 13. Dye tracer studies by Iowa State University confirm the high efficiency of the Spiraflo.

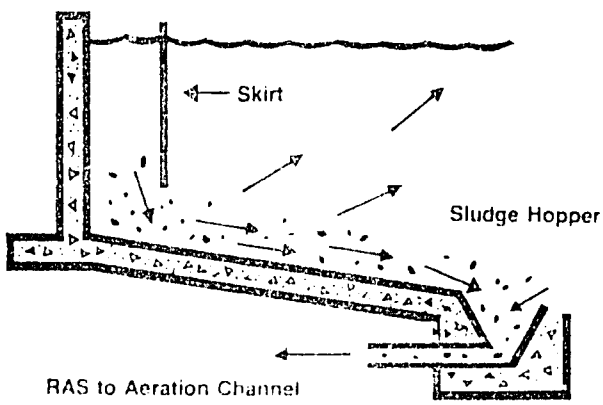


Figure 14. Only in the Spiraflo design does the hydraulic flow help move the solids to the sludge drawoff hopper. This means low sludge detention time and high solids concentration sludge for return to aeration.

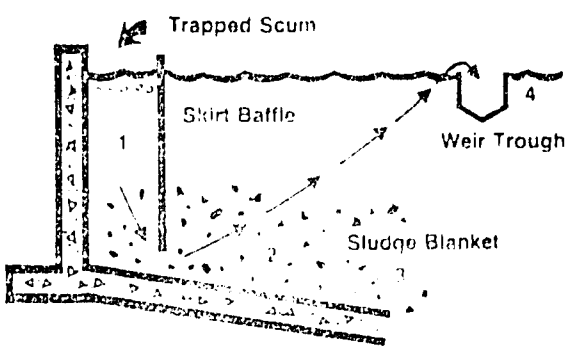


Figure 15. The deep skirt baffle provides for scum capture, sludge blanket filtration and eliminates short circuiting.

1. With the Spiraflo [illegible] flow down under the skirt [illegible] trapped [illegible].
2. At the skirt bottom, the flow passes through the sludge blanket as it moves upward towards the effluent weir trough.
3. Settled solids move toward the center takeoff for recirculation to the aeration channel.
4. Clear liquid is discharged over the effluent weir.

A Word About Clarifiers

The heart of any activated sludge process is the final clarifier. No matter how well designed the aeration process is, no matter what care was taken in the plant hydraulics or concrete design, the plant will not achieve the highest effluent quality if the design of the final clarifier is inadequate.

The Lakeside Spiraflo peripheral feed clarifier is ideally suited to getting the most from the Oxidation Ditch process. Here are reasons why Lakeside recommends Spiraflos on all Oxidation Ditch plants:

Peripheral feed hydraulics have shown in studies to be more stable than conventional centerfeed hydraulics when subjected to high peak or widely varying flows. This means the Spiraflo will maintain effluent quality during wet weather flow periods when other clarifiers begin to wash out.

Raceway flocculation of solids and sludge blanket filtration of activated sludge solids occur in the Spiraflo, improving capture of fine suspended solids and giving the well run Oxidation Ditch effluent sparkling clarity. In the Spiraflo, this is achieved by the use of the deep baffle skirt which forces influent solids to the bottom of the tank and up through the filtering sludge blanket prior to discharge over the clarifier effluent weir.

The co-current sludge removal in the Spiraflo provides a much greater uniformity of sludge detention and less chance for old solids to denitrify. In the Spiraflo, solids are introduced along the clarifier periphery and moved hydraulically and scraped mechanically towards the center of the tank where they are removed.

In conventional clarifiers counter-current sludge movement occurs, allowing centerwell influent solids to directly short circuit to the return sludge drawoff. Solids reaching the outside of the tank must be scraped mechanically towards the center, against the flow of the influent. This results in longer solids detention in the centerfeed type clarifier and a greater possibility for denitrification.

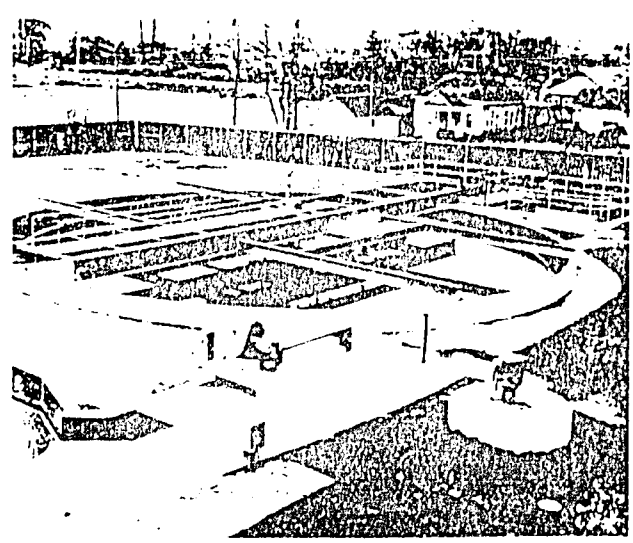


Figure 16. Spiraflo Clarifier

Associated Equipment

Lakeside Adjustable Weirs
Lakeside manufactures handwheel and motor actuated weirs for control of Oxidation Ditch liquid level and Rotor Aerator output. Designed for strength and rigidity, the complete line of weirs models available from Lakeside will handle any Oxidation Ditch flow requirement from 0.02 mgd to 20 mgd.

Lakeside Telescoping Valves
For the best in final clarifier performance, all sources of turbulence should be minimized. Control of return sludge by the use of telescoping valves by Lakeside will minimize sludge bed disruption due to on/off cycles of constant speed return sludge pumps. Telescoping sludge valves also are very well suited to controlling sludge flow to screw pumps, influent wells and sludge drying beds.

Lakeside Screw Pumps
Variable capacity, constant speed, low shear, clog free and highly efficient screw pumps are ideally suited to pumping raw sewage, mixed liquor and return sludge to the Oxidation Ditch or final clarifier. Simple controls and very low power usage cause this pump to be highly recommended for this service.

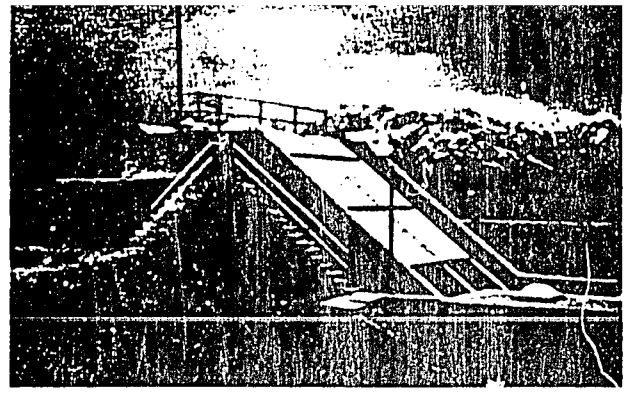
Lakeside Flocculating Clarifiers
For use as a tertiary clarifier for residual suspended solid and phosphorus removal, the Spirafloc Clarifier exhibits all of the same hydraulic and upflow solids filtration advantages of the Spiraflo clarifier. Flocculation of solids in the influent raceway is achieved with the addition of flocculation equipment and chemical solids recycle pumping.

Lakeside Thickeners
Lakeside Spirathickeners have applications on larger projects where thicker waste sludge can improve the economics of sludge handling.

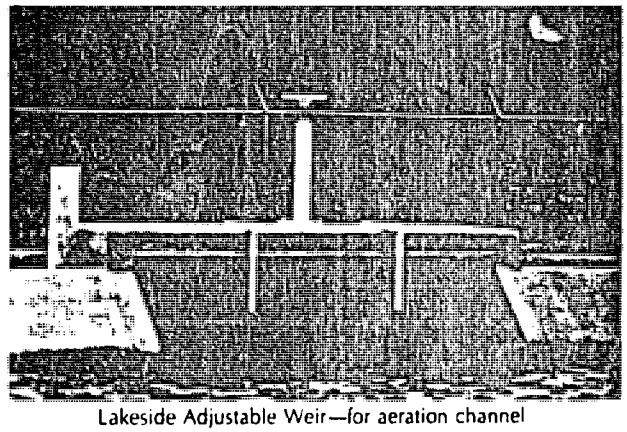
Excellent results can be obtained in this application of peripheral feed hydraulics in the Spirathickener because the waste solids are forced to the bottom of the periphery of the tank from where they travel to the thickened sludge takeoff only after being kneeded thoroughly for water release by the picket fence equipped rake arm.

Lakeside Wastewater Samplers
The better and more reliable wastewater sampling programs required by regulatory agencies can be obtained with the Trebler Sampler. The Trebler is unique in the industry for its ability to obtain flow proportioned composite samples from a complete vertical cross section of wastewater flows. The Trebler with its simple but rugged construction is designed for the most accurate of sampling needs.

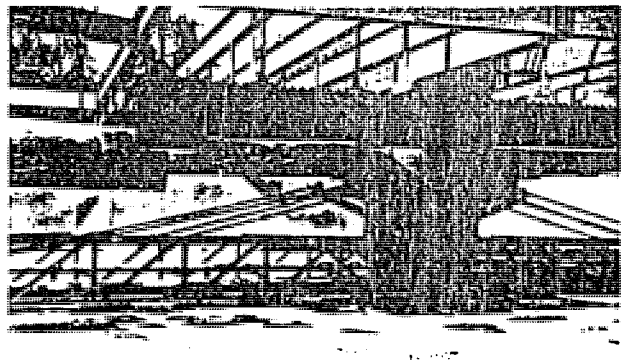
Lakeside EA Aerator Plants
Where small volumes of wastewaters are to be treated by the Oxidation Ditch process, Lakeside provides the package type EA Aerotor plant. This compact design provides all of the same advantages of the conventional Oxidation Ditch plus significant savings in yard piping and common wall construction.



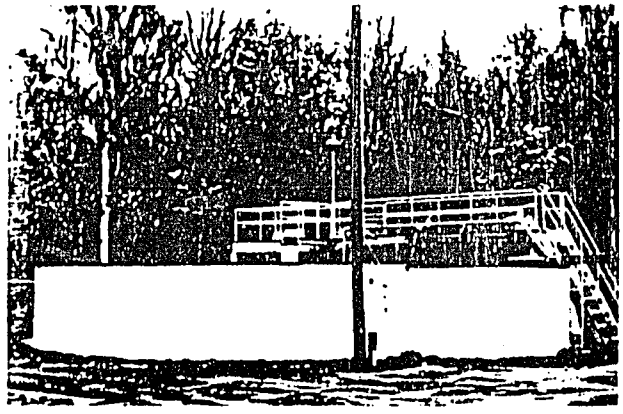
Lakeside Screw Pumps—for raw sewage and return sludge pumping



Lakeside Adjustable Weir—for aeration channel disolved oxygen control



Lakeside Spiravac Clarifiers—for oxidation ditches over 4. MGD



Lakeside EA Aerotors—for oxidation ditch package plants

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THE "CONTACT STABILIZATION" MODIFICATION OF THE ACTIVATED SLUDGE PROCESS

The "Contact Stabilization" variation of the Activated Sludge Process is rapidly gaining in popularity and is being applied to the full range of daily sewage flows. It has not proven too successful in the treatment of industrial wastes since certain of its advantages are nullified due to the character of these wastes.

The gain in popularity has, to a great extent, been due to a compact "package" design offered by several of our competitors. These designs are good and offer an engineer a completely pre-designed unit requiring no ingenuity or engineering judgment and certainly, no time spent on a drafting board. It is felt, however, that this package concept is being carried too far with respect to small daily sewage flows. In many cases an extended aeration plant would be a far better choice due to the simplicity of its operation.

It is true that the package design with diffused air aeration has advantages over the surface aeration design, especially in the low daily flow category. Air diffusion lends itself to small, irregularly shaped tanks and therefore, makes good use of the circular, compartmented design. But it is also true that the design has its limitations. It is not expandable, thus, in order to increase plant capacity it is necessary to add an additional package or packages, whereas, with the mechanical aeration design, it is only necessary to add aeration and clarification units, as required, and take full advantage of common wall construction.

The mechanical aeration design has limitations too, generally associated with minimum tank sizes that will accommodate the surface aerators. With these thoughts in mind, consideration can now be given to the process itself.

The contact stabilization concept was used many years ago with varying degrees of success. It was an outgrowth of the sludge reaeration principle which had been employed in conjunction with the conventional activated sludge process. It was not overly successful and was laid aside in favor of the high rate trickling filter and later, the extended aeration process. Since that time, continued research and experimental installations have shown it to be a valuable addition to the repertoire of aeration processes.

Basically, the process takes advantage of the fact that the BOD in sewage is very rapidly adsorbed by the biological floc after initial contact. Removals obtained by the physical adsorption are comparable to those of the conventional process. The BOD is *removed* but not *reduced* and thus by settling out the floc with the adsorbed BOD, the clarified liquid can readily be discharged without further treatment other than chlorination. Physical adsorption of the BOD requires very little time, perhaps 30-60 minutes, but little or no stabilization takes place during this period, and therefore, after separation of the biological floc from the water carrier the concentrated sludge must be subjected to further treatment for stabilization or *reduction* of the BOD. The application of this concept results in a substantial reduction in plant volume over that required by the conventional and the extended aeration processes.

Simply stated, in the conventional and extended aeration processes, the adsorption and stabilization functions proceed simultaneously in the aeration tank and consequently a substantial aeration volume is required. The contact stabilization process separates these functions and provides an aeration unit for each, resulting in aeration volume saving. High solids concentrations are carried in the stabilizers, thereby keeping the sludge return rates within reasonable limits.

The general practice is to use a short contact aeration period, usually 1 to 1½ hours based on the average flow plus an assumed 100% sludge return rate and a mixed liquor concentration of about 2000 ppm. However, in surface aeration designs, it is advantageous to make all tanks the same size, which often results in a somewhat longer contact time. Stabilizers usually provide an aeration period of 4 to 6 hours based on the average flow, and the clarifier should provide a surface settling rate not in excess of 600 gal./SF/day.

(Cont'd.)

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The stabilizer volume to contact volume ratio is usually 2:1 or 3:1 and recent experimental work has indicoted that the 2:1 ratio is most efficient and is best suited to the design. Aerobic sludge digester volume is usually based on 2 cu. ft. per capita, but can be adjusted somewhat for convenience of the physical plant arrangement.

Again it should be noted that the loading is the governing factor in this process design just as it is in the process designs previously discussed. In the contact stabilization design, two loading categories are considered. First, and most popular, is the extended aeration loading, and second, the conventional activated sludge loading. The advantage of the contact stabilization process will became apparent as the design procedure progresses. This procedure can be quite technical and involved, but it is the purpose of this section to outline o simplified method that sacrifices none of the accuracy required.

A typical flow sheet of the contact stabilization process is given in Figure No. 4.

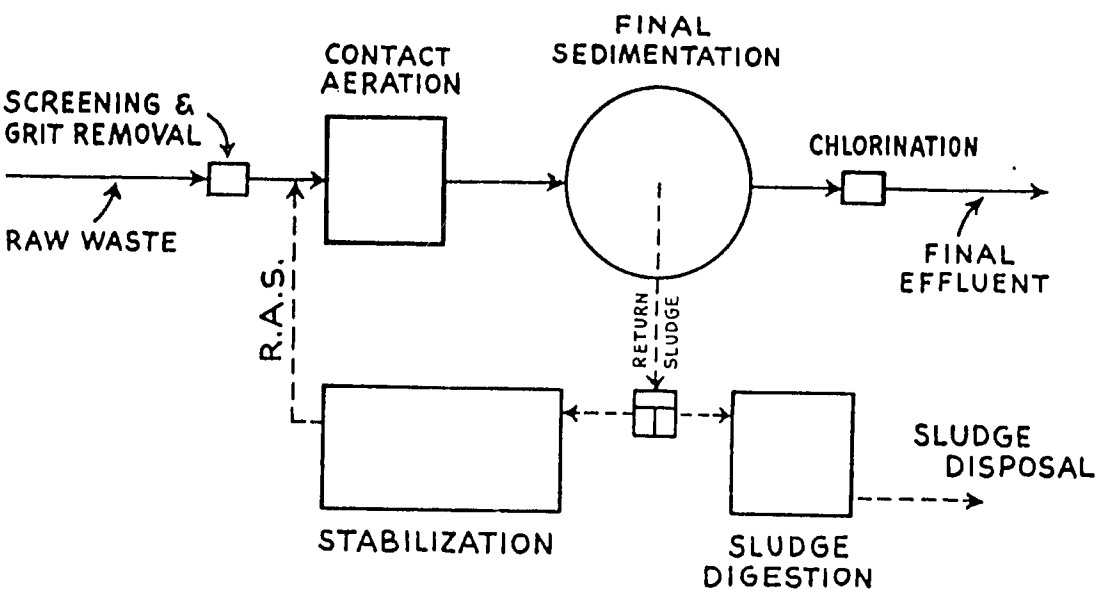

FIG. NO. 4

GENERAL

For the purpose of this section, extended aeration loading shall be considered as 10 lbs. BOD/day/100 lbs. MLSS and 12.5 lbs. BOD/day/1000 cu. ft. aeration capacity, bearing in mind that some flexibility in loading is permissible in actual designs. Conventional activated sludge loadings shall be considered as 35 lbs. BOD/day/100 lbs. MLSS and 44 lbs. BOD/day/1000 cu. ft. aeration capacity.

AERATION CAPACITY

The following paragraphs will be related only to the extended aeration loading category and the activated sludge loading category will be discussed in later paragraphs.

Since it is the object of the contact stabilization process to produce in 8 hours results comparable to those produced in 24 hours by the extended aeration process, it follows that the volumetric loading becomes three times that of the extended aeration plant. Thus, the total aeration capacity required (exclusive of digestion) becomes:

$$\text{Cu. ft. aeration capacity} = \frac{\text{Lbs. Raw BOD/day}}{\text{Vol. Loading}} \times 1000 \quad \ldots\ldots\ldots\ldots (6)$$

(Cont'd.)

If the stabilization to contact ratio of 2:1 is maintained, the contact tank capacity is 1/3 of that found by equation (6) and the stabilization capacity is the remaining 2/3.

The average concentration of solids under aeration ($MLSS_{av.}$) becomes:

$$MLSS_{av.} = \frac{\text{Vol. Loading} \times 1600}{\text{Solids Loading}} \quad \ldots\ldots (7)$$

and if a value is assigned to the contact mixed liquor (for example, 2000 ppm), the stabilizer mixed liquor ($MLSS_{stab.}$) becomes:

$$MLSS_{stab.} = \frac{MLSS_{av.} - MLSS_{cont.}}{\text{Stab. to Cont. Ratio}} + MLSS_{av.} \quad \ldots\ldots (8)$$

Since the stabilizer solids concentration has been established by equation (8), and since the sludge return to the contact tank is taken from the stabilizer, the quantity of return sludge necessary to maintain the contact MLSS can be determined from:

$$\% R = \frac{MLSS_{cont.}}{MLSS_{stab.} - MLSS_{cont.}} \times 100 \quad \ldots\ldots (9)$$

These four equations are all that is required to establish the required mixed liquor aeration volume and its proportioning between contact and stabilization, as well as the mixed liquor concentrations. The next step is the determination of the required oxygenation capacity and aerator selection.

OXYGENATION CAPACITY

The foregoing is based upon extended aeration loading and therefore the oxygenation capacity must be on the same basis. Oxygen requirement can be determined from the basic equation:

$$\text{Lbs. } O_2/\text{Lbs. } BOD_{rem.} = 0.5 + \frac{10}{(S)}$$

or, more simply, the oxygenation capacity in Lbs./hour can be determined from the extended aeration equation:

$$\text{Lbs. O.C./Hr.} = \frac{\text{Lbs. BOD/day} \times 2.4}{24}$$

or still more simply:

$$\text{Lbs. O.C./Hr.} = \text{Lbs. Raw BOD/day} \times 0.10$$

The hourly capacity thus determined is then equally divided between three units, one for the contact and two for the stabilizer, and the aerator selection is made from the oxygenation capacity tables.

CLARIFIER

Clarifier design has been covered previously, and will not be discussed here other than to stress the importance of an acceptable surface settling rate.

AEROBIC DIGESTER

To complete the design, provision must be made for aerobic digestion of the surplus sludge. Experience indicates that the provision of 2 cu. ft. of digester volume per capita population equivalent is sufficient for a well digested sludge. However, the digester volume can be adjusted to equal that of the contact tank, thus permitting a compact and convenient design with all tanks the same size, but by so doing, the volume per capita is reduced to approximately 1.5 cu. ft. per capita.

(Cont'd.)

Oxygenation capacity requirements are based on the provision of 0.8 lbs. O.C./lbs. raw BOD/day.

DESIGN EXAMPLE

Since application of the foregoing can best be demonstrated by an example, assume a design to satisfy the following basic data:

Daily Sewage Flow – 0.8 MGD
Sewage Strength – 250 ppm BOD_5

Daily Raw BOD = 0.8 x 8.34 x 250 = 1670 lbs./day
Volumetric Loading = 37.5 lbs. BOD/day/1000 ft.^{3} aeration capacity

Aeration Capacity = $\frac{1670}{37.5} \times 1000 = 44{,}500$ ft.^{3} (From equation No. 6)

Aeration Period H = $\frac{1.5 \times 250}{37.5} = 10$ hours

Contact Tank Capacity = $\frac{44{,}500}{3} = 14{,}850$ ft.^{3}

Stabilizer Capacity = 44,500 – 14,850 = 29,700 ft.^{3}

Assuming a liquid depth of 12'-0" the contact tank size becomes – $\frac{14850}{12} = 1235$ ft.^{2} or a tank 35'-0" square, and to provide for 3'-0" fillets another foot should be added to the liquid depth. Thus, the tank sizes as determined from equation No. 6 are:

Contact – 35'-0" x 35'-0" x 13'-0" L.D.
Stabilizer – 35'-0" x 70'-0" x 13'-0" L.D.

From equation No. 7, the average mixed liquor solids concentration becomes:

$$MLSS_{av.} = \frac{37.5 \times 1600}{10} = 6000 \text{ ppm and,}$$

assuming a contact mixed liquor solids concentration of 2000 ppm, the stabilizer mixed liquor solids concentration becomes:

$$MLSS_{stab.} = \frac{6000 - 2000}{2} + 6000 = 8000 \text{ ppm (From equation No. 8)}$$

The return sludge rate in terms of % of the average daily flow as determined by equation No. 9 becomes:

$$\% R = \frac{2000}{8000 - 2000} \times 100 = 33\%$$

Oxygen requirements of the system can be determined from the basic equation, thus:

$$\text{Lbs. } O_2 \text{ lbs. } BOD_{rem.} = 0.5 + \frac{10}{10} = 1.5 \text{ lbs.}$$

and, correcting this figure for a residual D.O. concentration of 2.0 ppm and alpha equal to 0.8, the required oxygenation capacity becomes:

$$N_o = \frac{0.9 \times 1670 \times 1.5}{0.78 \times 0.8 \times 24} = 150.5 \text{ lbs. O.C./hr. and,}$$

dividing this amount equally between three aerators, each unit must have an O.C. of 50.0 lbs./hr.

From the capacity tables it can be seen that a 15 hp aerator operating at 42 rpm will be the proper aerator selection.

(Cont'd.)

Sludge digestion capacity is based upon the population equivalent and in this case, using 2.0 ft.^{3}/cap. P.E., the required tank volume becomes:

$$\frac{1670}{0.17} \times 2.0 = 19{,}600 \text{ ft.}^3$$

This volume is obviously greater than that provided in the contact tank, and therefore we have the choice of three options:

a. Make the tank the same depth as the contact tank and increase its plan dimension to 40'-0" square.

b. Make the tank the same plan dimension as the contact tank and increase its depth by 4'-0".

c. Make the tank the same as the contact tank, thus providing 1.5 ft.^{3}/cap. P.E.

The use of option "c" would be suggested.

The required oxygenation capacity would be: $\frac{1670 \times 0.8}{24} = 55.0$ lbs. O.C./hr.

Again from the capacity tables it can be seen that a 20 hp aerator operating at 45 rpm will satisfy the condition.

CONVENTIONAL ACTIVATED SLUDGE LOADING BASIS

It is, no doubt, apparent that the activated sludge loading basis has been somewhat neglected. This is true, but the reasons for the apparent neglect should be considered carefully, and this approach should be used only with full agreement of the reviewing authority.

Since this method proposes to accomplish in four hours the results anticipated in the previous design in eight hours, the volumetric loading, obviously, becomes twice that of the extended aeration loading basis. There is strong reason to doubt that approval will be granted on a volumetric loading of 75 lbs. BOD/day/1000 ft.^{3} aeration capacity. Also, at the heavier loading, the contact tank and the stabilizer are reduced in size and the digestion tank size is increased, thereby presenting problems in the physical arrangement of the plant.

However, this method should not be ignored and should be used where higher daily sewage flows provide justification. Also, there is a so-called, grey area which in terms of loading could be considered a compromise between conventional and extended aeration. For example, a volumetric loading of 50-55 lbs. BOD/day/1000^3 aeration capacity.

The design approach is essentially the same as that demonstrated in the previous example, and therefore, only the points of difference will be indicated here. They are:

(a) Solids loading = 30-35 lbs. BOD/day/100 lbs. MLSS
(b) Volumetric loading = 45-75 lbs. BOD/day/1000 ft.^{3} aeration capacity
(c) O.C./lbs. raw BOD/day = 1.6 lbs.
(d) Sludge digester volume = 3-4 ft.^{3}/capita equivalent
(e) Digester O.C. = 1.0 lbs./lbs. raw BOD/day

Aerator selection tables are given on Page 13,314.

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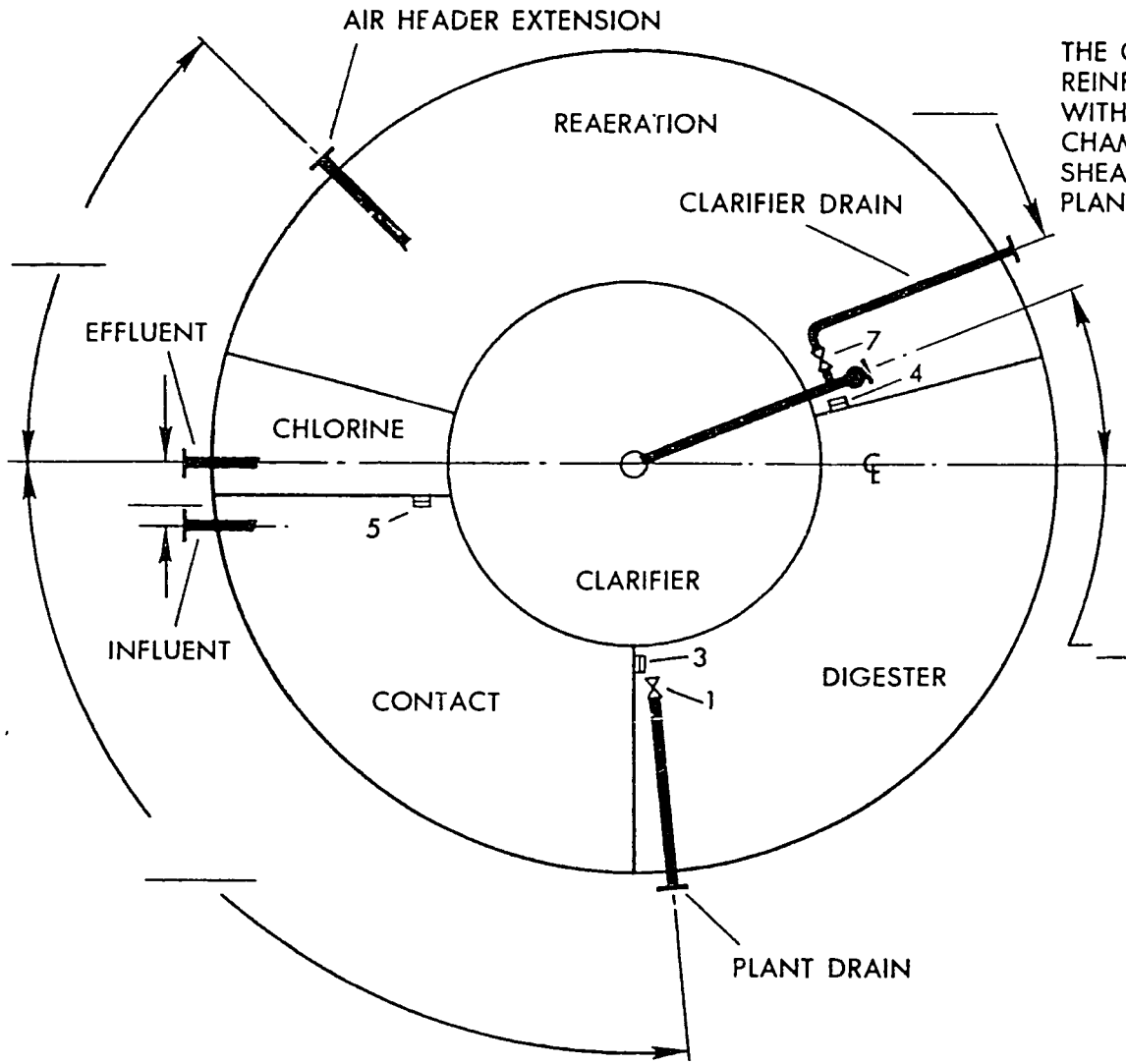

THE CLARIFIER CHAMBER WALL OF THIS SYSTEM IS REINFORCED TO ALLOW DEWATERING OF THE CLARIFIER WITHOUT DRAINING THE ENTIRE PLANT. REMAINING CHAMBERS MAY BE DEWATERED BY FIRST OPENING ALL SHEAR GATE VALVES BETWEEN CHAMBERS THEN OPENING PLANT DRAIN GATE VALVE INDICATED ON DIAGRAM.

DRAIN VALVES ARE LABELED AS FOLLOWS:

1) DIGESTER GATE VALVE
*2) AERATED SLUDGE HOLDING GATE VALVE
3) CONTACT SHEAR GATE VALVE
4) REAERATION SHEAR GATE VALVE
5) CHLORINE SHEAR GATE VALVE
*6) AERATION SHEAR GATE VALVE
7) CLARIFIER GATE VALVE

*VALVES NOT APPLICABLE IN THIS SYSTEM.

CLOW

WASTE TREATMENT DIVISION
CLOW CORPORATION
FLORENCE, KENTUCKY

PIPING LOCATION AND CLARIFIER CHAMBER DEWATERING SYSTEM
CONTACT STABILIZATION WITH CHLORINE

DWG. NO. AE-557061

TECHNICAL SPECIFICATIONS

Factory Fabricated – Field Erected

Contact Stabilization Treatment Plant

SCOPE

The work covered in these specifications consists of furnishing all labor, materials, equipment and tools and performing all work required to manufacture and erect a factory fabricated sewage treatment plant complete; including all treatment components, piping, equipment, electrical work and appurtenances as shown on the drawings and/or as specified herein to provide a satisfactorily operating sewage treatment plant utilizing the "Contact Stabilization Process."

GENERAL DESCRIPTION

The plant shall be fabricated complete with all treatment components, equipment and appurtenances that may be required to accomplish: screening, aeration and mixing, clarification, sludge activation, activated sludge recirculation and aerobic sludge digestion – all in a single steel structure having separate compartments. The unit shall be a Clow Model _____ or approved equal.

The composite structure shall consist of two concentric circular steel tanks forming an inner chamber and an outer annulus. The inner chamber shall serve as a clarifier or settling basin. The outer annulus shall be divided into compartments or chambers to form a mixing chamber, a sludge activation chamber and an aerobic digester. The structure shall be fabricated and erected as herein after specified and as shown on the drawings.

The plant shall be (above) (below) grade as shown on the drawings. All necessary reinforcement to resist external compressive pressures shall be provided by the Manufacturer.

The principle items of equipment to be supplied are as follows: A bar screen, complete aeration assemblies and facilities, complete clarification equipment and appurtenances, sludge airlifts, air blowers and accessories and all other items of equipment and accessories required to provide a complete installation as specified herein.

SHOP DRAWINGS

Complete and detailed design information shall be submitted to the Engineer and shall be approved prior to fabrication and erection.

OPERATING CONDITIONS

The plant shall be designed for an average daily flow of _____ gallons with a total BOD_5 loading of _____ pounds per day. Peak hydraulic flow capacity shall be 3.0 times the design average daily flow.

DESIGN CRITERIA

Efficiency:

BOD_5 removal 90% plus, when properly operated at design flow.

Mixing Chamber (Contact Zone):

1.5 hours at design average daily flow with a return sludge rate equal to 100% design average daily flow.

Settling Chamber (Clarifier)

Surface rise rate less than _____ gallons per square foot per day at design average daily flow.
Weir overflow rate less than _____ gallons per lineal foot per day at design average daily flow.

CLOW CORPORATION • WASTE TREATMENT DIVISION
FLORENCE, KENTUCKY AER-O-FLO • YEOMANS PRODUCTS

Sludge Activation Chamber (Reaeration Zone):

_____ hour detention time at design average daily flow.

Aerobic Digestion:

3 cubic feet per 100 gallons of design average daily flow.

Aeration Requirement:

1800 cubic feet of air per pound of BOD_5 per day.

Maximum Sidewater Depth:

15.25 feet with a minimum free board of 1.25 feet.

FOUNDATION

The plant shall be anchored to a reinforced concrete foundation slab as shown on the drawings. The poured foundation slab and vertical base channel supports shall be provided and installed by the General Contractor. Structural design of the concrete foundation shall be the responsibility of the Engineer. Base channels for anchoring the annular walls and partition walls shall be provided by the sewage treatment plant manufacturer. The General Contractor shall bolt the base channel sections together, weld the joints and locate the base channels within the tolerances given by the Manufacturer. Installation of the base channels in the concrete foundation and grouting the web area as per the drawings provided by the sewage treatment plant manufacturer shall be performed by the General Contractor.

STEEL

The outer and inner vertical tank walls and all partition walls shall be low carbon steel plate not less than one-fourth inch thick. All steel plates or shapes in contact with water shall have one-fourth inch minimum thickness at the thinnest section.

All interior partitions shall be designed to withstand a two foot liquid level differential between adjacent compartments. The clarifier wall shall be reinforced to allow a two foot liquid level differential between the clarifier and any outer chamber.

A 45^{0} steel access stairway designed to support a live load of 500 pounds at any one point shall be provided to permit access to the top of the plant.

A steel bridge shall be provided. This bridge shall span the full diameter of the clarifier and shall extend to the outer tank wall on one side meeting the access stairway. The bridge shall be designed to safely support all normal operating loads plus a 500 pound live load on any two square foot area of the walkway. The walkway surface shall be checkered steel plate.

A service walkway shall be provided around the top of the clarifier wall to allow access to the air diffusers for servicing and maintenance. The service walkway shall be designed to support a concentrated load of 500 pounds at any one point along its longitudinal axis. The service walkway shall be checkered steel plate.

FABRICATION

All welding shall conform to the most recent standards and practices of the American Welding Society.

All joints in the outer and inner tank walls and partitions including the junctions of the partitions and inner and outer tank walls shall be made watertight by continuous welds on both sides.

Provisions shall be made to assure watertight joints at the junctions of all tank walls and all partition walls to the base channels embedded in the concrete foundation.

Painting shall be as hereinafter specified.

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FIELD ERECTION

Field erection shall be performed by the (Manufacturer) (General Contractor). Unloading at the jobsite of all components to be erected by the (Manufacturer) (General Contractor) shall be their responsibility.

EXTERNAL PIPE CONNECTIONS

Influent, effluent, sludge draw-off, plant drain and air piping connections shall be flanged at the outer tank wall. The dimensions and locations of these connections shall be as shown on the drawings.

BAR SCREEN

A hand cleaned bar screen shall be provided at the plant influent. The bar screen shall be fabricated of one-half inch diameter steel bars on one inch centers. The bar screen shall be sloped 45° with the horizontal.

AERATION SYSTEM

There shall be provided a combination bridge beam air header to which are connected sufficient individual air distribution assemblies to permit introduction of the maximum quantity of air required without excessive pressure loss. The header shall be securely supported on the main tank structure and shall, in turn, support drop pipes to which are attached the air diffusion devices. Each drop pipe shall include an air control valve near the air header to provide regulation of the air supply. In addition, a union shall be provided on each drop pipe to permit convenient removal of the diffuser assembly. This union shall be adjacent to the service walkway for accessability. The air diffusion devices installed on the air drop pipe assemblies shall be designed to minimize clogging as well as to insure proper air distribution over the entire length of the aeration tank. The diffusers shall be of corrosion resistant construction. The diffuser assemblies shall be easily removable, without the use of mechanical hoists, for inspection and servicing. The air diffusion efficiency and the number of diffusers shall be such that an adequate oxygen supply can be maintained in the aeration zones to meet the treatment requirements of the sewage load for which the plant is designed. All aeration piping three inches in diameter and smaller shall be galvanized steel. The aeration piping shall be sized to suit the conditions of operation and withstand the stresses, strains and corrosive conditions of use. Total air requirement shall exceed 1800 cubic feet of air per pound of BOD_5 per day, in order to provide sufficient air for airlift operation.

RETURN SLUDGE AIRLIFT

There shall be provided a return sludge airlift to transfer sludge from the clarifier to the sludge activation chamber. This airlift shall be properly sized for a capacity equal to a minimum of 100 per cent of the average daily design flow of the plant. A manually operated needle valve shall be furnished for regulation of the air supply to the return sludge airlift.

WASTE SLUDGE AIRLIFT

There shall be supplied one waste sludge airlift to transfer waste sludge from the clarifier to the aerobic digester as required. The waste sludge airlift shall be attached directly to the return sludge airlift to insure the maximum concentration of waste sludge. The waste sludge airlift shall have a capacity of not less than 50 GPM and shall be equipped with a manually operated needle valve.

CLARIFIER

There shall be supplied a final clarifier which shall include a center influent well, a sludge collector mechanism with two collector flight arms and adjustable scraper blades, a skimmer assembly with scum box, a peripheral effluent trough with adjustable V-notch weir and a drive assembly with torque overload protection.

The collector mechanism shall consist of two fabricated structural steel arms, rigidly braced to the torque tube or center shaft, designed to transmit the full torque of the drive unit. Each collector arm shall be complete with removable and adjustable collector blade plates. A guide pin shall be provided at the bottom center of the clarifier to stabilize the rotation of the lower end of the torque tube.

The surface skimmer assembly shall consist of an adjustable neoprene wiper supported from an outrigger arm attached to the influent well. The arm shall be designed to continually skim the surface scum into the scum box.

An airlift pump shall be provided in the scum box to pump the clarifier skimmings from the scum box to the aerobic digester. This airlift shall be automatically operated by a limit switch tripped by the drive shaft. Activation of the limit switch shall open a solenoid valve on the air line to the skimmer airlift. An adjustable cam shall also be provided to regulate the length of time the solenoid valve remains open. For further control, a manually operated air control valve shall be provided in the air supply line.

The collector-skimmer assembly shall be driven by a totally enclosed electric motor of not less than _____ horsepower and 1750 RPM for use with three phase, 60 cycle, _____ volt service. The drive shall be a triple reduction motor driven worm gear speed reducer. The drive assembly shall be provided with an overload protection device which will automatically disconnect electric current to the motor and the drive mechanism when rated torque capacity is exceeded. In addition, an electric alarm system shall be provided which will be energized when the applied torque exceeds 75% of the rated torque capacity. The speed reducer shall be capable of supporting all operating loads.

The clarifier bottom shall be formed of concrete and finish grout placed inside the steel tank wall on a 1:12 slope. The General Contractor shall place the concrete and grout the clarifier after erection of the steel tanks has been completed.

SUPERNATANT RETURN

An adjustable decanting airlift shall be provided to return aerobic digester supernatant liquor to the reaeration chamber. Discharge of the aerobic digester supernatant directly to the contact chamber shall not be permitted, to avoid carryover of soluble organics to the clarifier. The airlift shall be capable of transferring not less than 35 GPM. The intake of this airlift shall be vertically adjustable not less than 24 inches to allow supernatant removal from six inches to thirty inches below the design water level in the digester.

HANDRAIL

There shall be supplied handrails for both sides of the access stairway and main bridge and the outer side of the service walkway. Handrails shall have double horizontal rails with vertical posts spaced not more than eight feet on centers and shall be fabricated from one and one-half square tubing.

AIR BLOWERS AND ACCESSORIES

(Two) (Three) (rotary positive displacement) (centrifugal) blowers shall be supplied by the Manufacturer for installation by the General Contractor (in a separate building) (on a concrete pad adjacent to the plant). Blowers and motors shall be mounted on common base plates. Each blower shall have a capacity of _____ CFM at _____ psi. _____ blower(s) shall be capable of supplying the air requirements of the treatment plant. The additional blower(s) shall serve as stand-by. Blower model number and accessories shall be as described in the attached section on "Blower Specifications."

BLOWER MOTORS

There shall be provided for each blower a _____ horsepower (minimum) three phase, 60 cycle, _____ volt (horizontal open drip-proof) (TEFC) motor with grease lubricated ball bearings. Motors shall not be loaded beyond the nameplate rating at any design condition of the installation.

ELECTRICAL CONTROLS

A prewired electrical control panel for mounting within a control building shall be provided. The equipment to be provided within the control panel shall include the necessary magnetic starters and switches to control the blower motors and all electric motors on the plant. The blower and sludge drive mechanism motors in addition to the motors on any optional accessories shall be controlled by hand-off-auto selector switches in conjunction with magnetic starters. All electrical equipment on the plant shall be equipped with safety disconnect switches on the plant bridge.

All electrical equipment and circuitry shall be protected by properly sized circuit breakers. Any duplex or stand-by equipment shall be wired so that they may be alternated automatically by controls located within the control panel.

The enclosure shall be NEMA 12 and shall be installed within a control building by the General Contractor. Power shall be supplied to the control panel and to the junction box on the plant bridge by the General Contractor.

TESTING

Upon completion of the structure, and before it is painted, the structure shall be examined for leaks by filling the plant with water up to its maximum working level. Water for this test shall be furnished by the Owner. Any leaks disclosed in this test shall be repaired by welding missed welds or by chipping or melting out any defective welds and then rewelding. No repair work shall be performed unless the water level is at least two feet below the point being repaired.

PAINTING

Painting to be completed in the field shall be performed at such time that the Engineer and General Contractor may agree neat and dust-free work may be accomplished. All painting, both in the shop and in the field, shall be conducted in strict accordance with the paint manufacturer's instructions. Final cleaning, brushing and field painting after field erection has been completed shall be the responsibility of the General Contractor.

SURFACE PREPARATION

All surfaces to be painted shall be prepared in a workman-like manner with the objective of obtaining a clean, dry surface. All surface preparation guidlines presented by the paint manufacturer shall be followed.

CLEANING, SANDBLASTING AND APPLICATION OF SHOP PRIMER

All ferrous metal to be factory primed shall have all rust, mill scale, and weld slag removed by SSPC #6 commercial sandblasting. Within four hours following sandblasting, the metal shall be coated with one coat of a high solids epoxy primer with a coverage of 1.0 to 1.5 mil dry film thickness.

APPLICATION OF FINAL PAINT

All surfaces to be final painted in the field shall receive spot priming as required with the specified primer. A final coat, compatible with the primer shall be applied to all surfaces which will be submerged or below grade during normal plant operation. All surfaces which shall be exposed to the atmosphere during normal plant operation shall receive sufficient coats of paint compatible with the specified primer to provide the paint manufacturer's minimum recommended dry film thickness. Deficiencies in film thickness shall be corrected by the application of additional coats of paint. Additional coats of paint shall not be applied, nor shall the plant be placed in operation until the paint is thoroughly dry.

SERVICE

The equipment manufacturer shall furnish two copies of an operation and maintenance manual. These manuals shall describe the step-by-step operation and maintenance of the component parts and equipment provided with treatment plant. The equipment manufacturer shall furnish the services of a factory representative for two days to inspect the finished installation and provide detailed instruction to the owner's representative in the actual operation and maintenance of the equipment.

GUARANTEE

For a period of fifteen months from date of shipment or twelve months from start-up, whichever occurs first, the equipment manufacturer shall warrant that the equipment and structure covered by these specifications shall be free from defects in material and workmanship under normal use and service. The Manufacturer shall agree to repair or replace, F.O.B. point of shipment, such equipment or structure, or any part thereof, previously furnished by them and as actually found by the manufacturer after inspection to be defective provided: (a) said equipment or structure has been operated and maintained by the Buyer in accordance with the Manufacturer's recommendations and specifications and (b) the Buyer notifies the Manufacturer in writing as soon as any such defect becomes apparent.

EXCLUDED ITEMS

The following items of equipment and work are not included in the equipment manufacturer's area of responsibility and shall be accomplished or provided by the General Contractor.

1. All concrete work in the base, grouting the clarifier bottom, and grouting under the lips of all base channels.
2. Unloading and installation of the base channels shipped by the manufacturer.
3. Vertical base channel supports.
4. All air piping between the blower discharge port and the external flange on the bridge beam air header.
5. Installation of the blower assemblies.
6. All electrical work from the control panel to the power source and from the control panel to the equipment provided by the equipment manufacturer, including installation of the control panel.
7. Site improvements or access roads.
8. Temporary electricity for construction.
9. Water for plant testing including disposing of test water.
10. All site work including excavation, backfilling and landscaping.
11. All piping outside the flange connections on the outer wall of the sewage treatment plant.
12. All final cleaning and spot priming after field erection. All field painting including the paint.
13. Field erection – unless otherwise specified herein.

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Data Sheet

CONTACT STABILIZATION

CIRCULAR – STEEL – FIELD ERECTED

MODEL	DESIGN LOADING #/BOD/D	MINIMUM C.F.M.	CLARIFIER HYDRAULICS		PLANT PIPING					
			SURFACE SETTLING RATE (GPD/FT.^{2})	WEIR OVERFLOW RATE (GPD/FT.)	INFLUENT AND EFFLUENT	DRAIN	SLUDGE RETURN AIRLIFT	TRANSFER LINES	AIR HEADER EXTENSION	DECANTING & WASTE SLUDGE AIRLIFTS
CS-100	170	234	430	1,800	6"	4"	4"	8"	6"	3"
CS-125	213	293	530	2,300	6"	4"	4"	8"	6"	3"
CS-150	255	351	500	2,400	6"	4"	4"	8"	6"	3"
CS-175	298	410	470	2,500	8"	4"	6"	10"	6"	3"
CS-200	340	468	540	2,900	8"	4"	6"	10"	6"	3"
CS-225	383	527	500	3,000	8"	4"	6"	10"	6"	3"
CS-250	425	584	550	3,300	8"	4"	6"	10"	6"	3"
CS-275	468	644	510	3,300	8"	4"	6"	10"	6"	3"
CS-300	510	702	550	3,600	8"	4"	6"	10"	8"	3"
CS-350	595	819	550	3,900	10"	4"	8"	12"	8"	3"
CS-400	680	937	540	4,100	10"	4"	8"	12"	8"	3"
CS-500	850	1,169	580	4,800	10"	4"	8"	12"	8"	3"
CS-600	1,020	1,403	540	5,100	10"	6"	8"	12"	10"	4"
CS-750	1,275	1,753	540	5,700	12"	6"	10"	14"	10"	4"
* CS-1000	1,700	2,338	590	6,900	12"	6"	10"	14"	10"	4"
* CS-1250	2,125	2,922	560	7,500	12"	6"	10"	14"	12"	4"
* CS-1500	2,550	3,506	580	8,300	14"	6"	12"	16"	12"	4"

Design Criteria:

1) Flow calculated at 100 GPD/cap. with 17# BOD/cap./D.
2) Minimum C.F.M. to provide 1800 CF/#BOD plus 10% for airlifts.
3) Exact Clarifier rates are less than above.

* Refer to factory if there is to be internal reinforcing.

Form 231303 – Feb., 1974
Supersedes Form 364

CLOW CORPORATION
WASTE TREATMENT DIVISION

Data Sheet

CONTACT STABILIZATION

CIRCULAR – STEEL – FIELD ERECTED

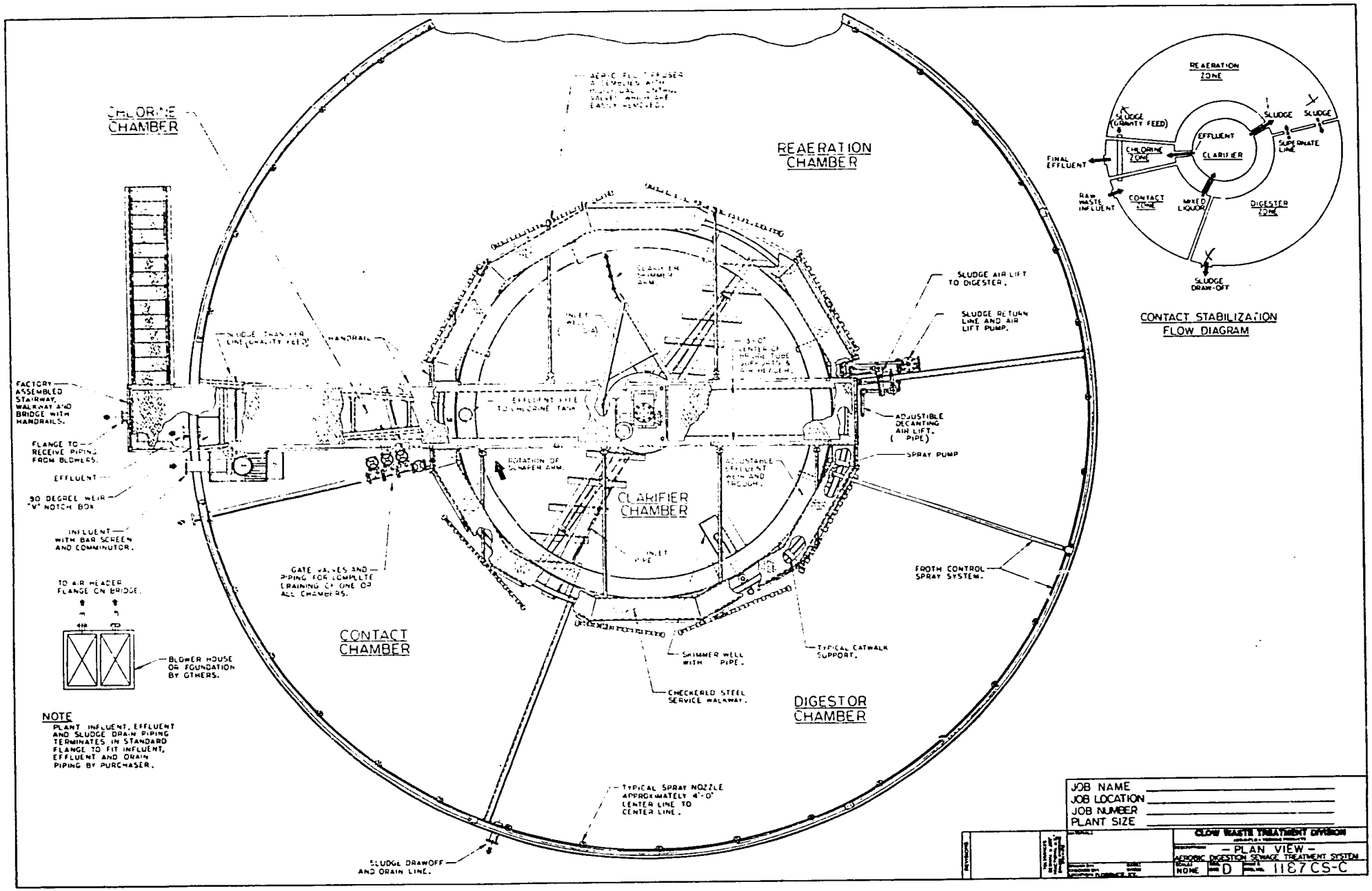
MODEL	DESIGN FLOW (GPD)	DIMENSIONS					CL_2 TANK H_2O DEPTH	EFFLUENT INVERT	
			CLARIFIER						
		MAIN TANK DIAMETER	NUMBER OF SIDES	INSCRIBED DIAMETER	INLET WELL DIAMETER	SIDEWATER DEPTH		WITHOUT CL_2 CHAMBER	WITH CL_2 CHAMBER
CS-100	100,000	32'-8"	8	16'-11"	4'	13'-7"	13'-6"	3'-7"	4'-0"
CS-125	125,000	35'-5"	8	16'-11"	4'	13'-7"	13'-6"	3'-7"	4'-0"
CS-150	150,000	39'-2"	9	19'-3"	4'	13'-5"	13'-6"	3'-7"	4'-0"
CS-175	175,000	42'-7"	10	21'-7"	4'	13'-1"	13'-6"	3'-7"	4'-0"
CS-200	200,000	44'-10"	10	21'-7"	4'	13'-1"	13'-6"	3'-7"	4'-0"
CS-225	225,000	48'-0"	11	23'-10"	4'	12'-11"	13'-6"	3'-7"	4'-0"
CS-250	250,000	49'-11"	11	23'-10"	4'	12'-11"	13'-6"	3'-7"	4'-0"
CS-275	275,000	52'-11"	12	26'-1"	4'	12'-10"	13'-6"	3'-7"	4'-0"
CS-300	300,000	54'-8"	12	26'-1"	4'	12'-10"	13'-6"	3'-7"	4'-0"
CS-350	350,000	59'-1"	13	28'-5"	5'	12'-9"	13'-6"	3'-7"	4'-0"
CS-400	400,000	63'-4"	14	30'-8"	5'	12'-8"	13'-6"	3'-7"	4'-0"
CS-500	500,000	70'-1"	15	32'-11"	6'	12'-7"	13'-6"	3'-7"	4'-0"
CS-600	600,000	77'-5"	17	37'-5"	6'	12'-5"	13'-6"	3'-7"	4'-0"
CS-750	750,000	86'-7"	19	41'-11"	7'	12'-1"	13'-6"	3'-7"	4'-0"
* CS-1000	1,000,000	99'-2"	21	46'-5"	7'	11'-10"	13'-0"	4'-1"	4'-6"
* CS-1250	1,250,000	111'-5"	24	53'-2"	7'	11'-7"	13'-0"	4'-1"	4'-6"
* CS-1500	1,500,000	121'-8"	26	57'-8"	8'	11'-4"	13'-0"	4'-1"	4'-8"

Design Criteria:

1) Less than 30# BOD/D/1000 $ft.^3$ aeration volume (total of contact and reaeration without CL_2 chamber).
2) Less than 600 GPD/$ft.^2$ surface settling rate in clarifier.
3) A digester volume equal to 3 $ft.^3$/100 GPD design flow.
4) A 1.5 hr. detention in contact zone (with 100% of design flow raw sewage return).
5) An 8 hr. detention time in reaeration chamber without CL_2 chamber/7.4 hr. with 30 min. CL_2 chamber.

* Refer to factory if there is to be internal reinforcing.

CLOW CORPORATION
WASTE TREATMENT DIVISION



Form 239-B

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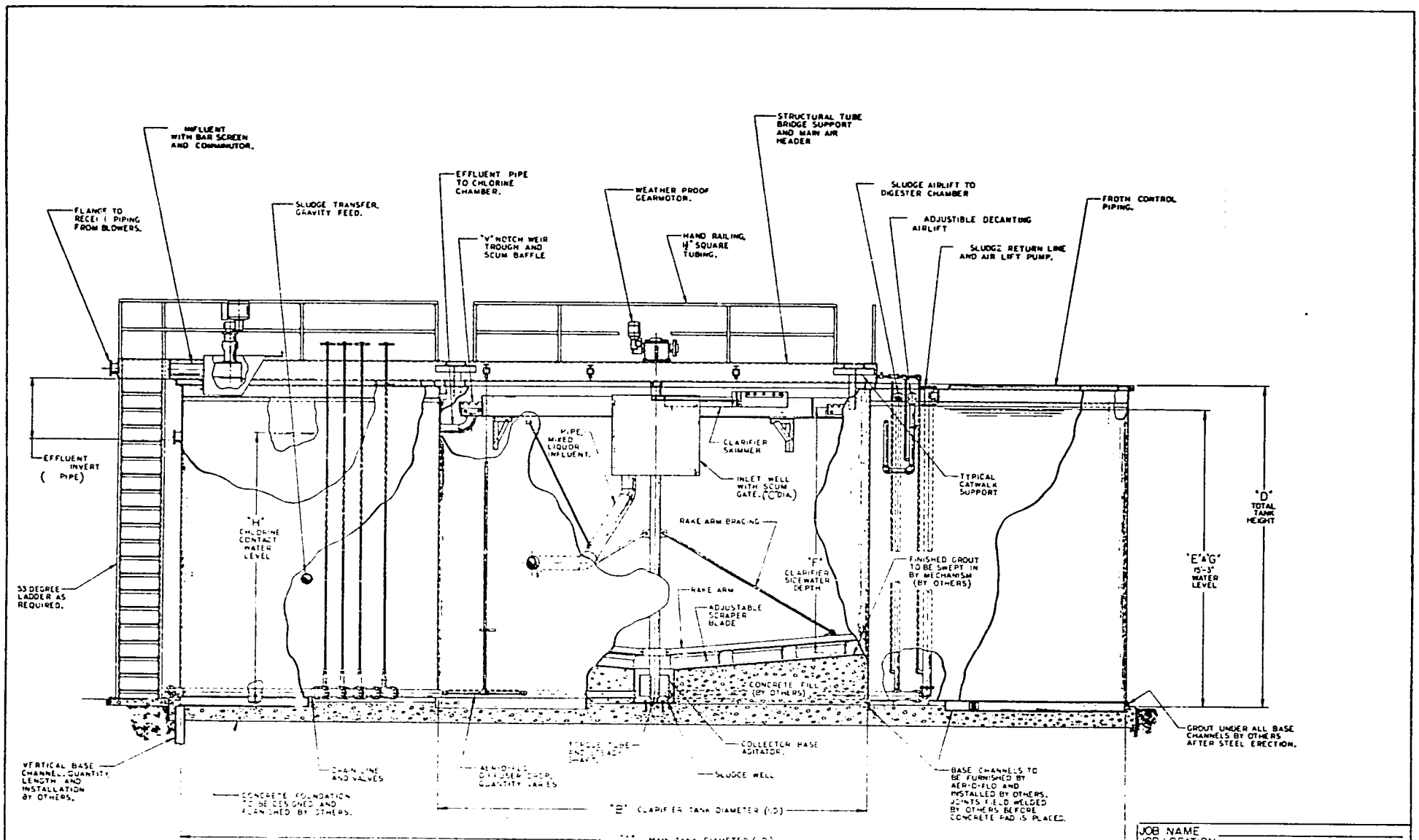

DESIGN FLOW	MODEL NUMBER	CLARIFIER CHAMBER		CONTACT CHAMBER		DIGESTER CHAMBER		REAERATION CHAMBER		TOTAL AERATION CHAMBER		CHLORINE CHAMBER	
U.S. GAL. PER DAY		VOLUME GALLONS	SURFACE AREA SQ. FEET	VOLUME GALLONS	DETENTION TIME	VOLUME GALLONS	CU. FT. DATA	VOLUME GALLONS	DETENTION TIME	VOLUME GALLONS	DETENTION TIME	VOLUME GALLONS	DETENTION TIME

JOB NAME
JOB LOCATION
JOB NUMBER
PLANT SIZE

FLOW WASTE TREATMENT DIVISION

-ELEVATION VIEW-
AEROBIC DIGESTION SEWAGE TREATMENT SYSTEM

SCALE NONE | SHEET D | DWG. 1186 CS-C

Form 238-1

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APPENDIX F

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

RELATIVE CHARACTERISTICS OF ALTERNATIVE TREATMENT PROCESSES

Chattanooga, Tennessee

December 1985

Relative Characteristics of Alternative Treatment Processes

Item	Tropical Pond	Artificial Wetlands	Oxidation Ditch	Contact Stabilization
Treatment Reliability	Good	Good	Good	Fair
Load Variation Flexibility	Good	Good	Good	Fair
Operational Complexity	Simple	Simple	Some	Complex
East of O&M	Good	Good	Good	Fair
Power Requirements	Low	Some	Moderate	Moderate
Sludge Handling	Low	Low	Some	Moderate
Land Area Needs	Large	Large	Low	Low
Capital Cost	Low	Low	Moderate	High
O&M Cost	Low	Low	Moderate	High

APPENDIX G

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

COLLECTION SYSTEM DATA FOR ALTERNATIVE TREATMENT PLANT SITES

Chattanooga, Tennessee

December 1985

New and/or improved sewage collection systems are needed for the alternative sewage treatment systems (i.e., a separate system for the St. George's area, a separate system for Grand Anse area, and a combined St. George's -Grand Anse system). The collection systems can be constructed in phases depending on the alternatives chosen and the availability of funds.

Initially, an ocean outfall for St. George's should be installed so that raw sewage is not discharged at the shore, and the 45 year old Carenage lift station should be replaced. The outfall would utilize the existing collection system and extend from a manhole near the present discharge point to the edge of a deepwater trough off Fort George Point (about 600 meters, or 2000 feet). This would be a temporary outfall until the treatment plant is constructed. The Carenage lift station would be sized for the existing flow plus additional capacity for future expansion to currently unsewered areas adjacent to St. George's Town. The recommended capacity of the lift station assumes that separate treatment systems, not a combined system, would be built for St. George's and Grand Anse. The existing force main would be used but its receiving manhole may need enlarging.

The next two phases of improvements to the St. George's system are: first, replace the main collection pipe along the Carenage and relocate and install a new force main from the lift station along the Carenage through Sendall Tunnel (place in same trench to reduce installation costs); and secondly, in conjunction with the construction of a treatment

plant in Queen's Park, replace the main collector/trunk line on the Esplanade, and install a new 1750 foot ocean outfall from the treatment plant into St. George's Bay.

Further improvements to a St. George's collection system would be to expand the system to currently unsewered adjacent areas and eventually replace the old clay pipe with new PVC pipe. The main collector pipes previously installed along the Carenage and Esplanade were sized to carry these added flows.

For a sewage treatment system serving the Grand Anse area, a collection system must be completely installed. If the St. George's system is connected with the Grand Anse system so that one treatment facility treats the combined flows, interconnecting piping and lift stations would be required and larger main collector/trunk line pipes would be needed to carry the combined flow.

These alternatives and phases for new and/or improved collection systems are summarized in table 1. Table 2 identifies the materials and estimated costs of materials and installation for each alternative or phase. Material costs do not include shipping from a United States port to Grenada. Installation costs were estimated by a technician experienced in construction work in Grenada. The installation costs are based upon many assumptions and include many provisional costs. Therefore, the installation costs could be high or low and should be used only for comparative purposes. Good cost estimates would be obtained using detailed engineering drawings and site work.

Table 1

Description of Collection
System Alternatives/Phases

Alternative	Description
A.	St. George's system--new Carenage lift station; outfall pipe.
B.	St. George's system--new collector pipe on Carenage; new force main from Carenage lift station, along Carenage and through Sendall tunnel.
C.	St. George's system--in conjunction with new treatment facility at Queen's Park, new collector/trunk line pipe along Esplanade and new outfall pipe.
D.	Expanded St. George's system--sewer currently unsewered areas of St. John's River, Tempe, Belmont, Paddock, Hyde Park, and St. George's.
E.	St. George's system--all new pipes to replace existing pipes in St. George's.
F.	Grand Anse system--new system
G.	Combined St. George's/Grand Anse system--new pipes on Carenage and Esplanade; existing St. George's system connected to Grand Anse with treatment facility in Grand Anse area.

Table 2

Materials for Various Alternatives and Phases of Collection System, and Estimated Costs for Materials and Installation

PVC Pipe[a] Nominal Size, in.	Feet of Pipe for Various Collection System Alternatives						
	A	B	C	D	E	F	G
4	-	1,115	-	36,830	16,555	13,145	13,145
4 (force)	-	-	-	600	-	400	365
6	-	285	-	1,475	2,235	4,850	4,850
6 (force)	-	1,770	-	400	-	-	675
8	-	1,250	-	3,010	-	4,100	1,880
8 (force)	-	-	-	-	-	-	-
10	-	365	-	-	-	1,990	690
10 (force)	-	-	-	-	-	1,430	1,425
12	-	525	-	-	-	2,755	1,120
12 (force)	-	-	-	-	-	-	1,430
15	2,000	-	1,119	-	-	4,030	1,610
18	-	-	4,700	-	-	-	6,025
21	-	-	-	-	-	-	4,185
24	-	-	-	-	-	-	4,055
Cost, $US	14,000	11,000	53,000	30,000	12,000	77,000	218,000

Table 2

(Continued)

Fiberglass Manholes[b] with Metal Frames and Covers[c]	A	B	C	D	E	F	G
Number	None	18	17	124	45	84	131
Cost, $US	-	6,000	6,000	40,000	15,000	27,000	43,000

Lift Stations[d]

	Capacity of Pumps Required, gpm						
	A	B	C	D	E	F	G
	360*	None	None	4	None	250	260
	-	-	-	20	-	1,235	490
	-	-	-	290	-	-	1,370
	-	-	-	-	-	-	1,480
	-	-	-	-	-	-	2,712
Total Cost, $US	25,000	-	-	43,000	-	54,000	197,000
Materials Cost, Total, $US	39,000	17,000	59,000	113,000	27,000	158,000	458,000

*Sized to pump 680 gal/min with impeller change.

Table 2

(Continued)

	A	B	C	D	E	F	G
Installation Cost[e]							
Pipe	1,200,000[f]	251,000	375,000	2,250,000	796,000	1,580,000	2,280,000
Manholes	-	25,000	24,000	174,000	63,000	118,000	183,000
Lift Stations	15,000	-	-	123,000	-	82,000	205,000
Total, $EC	1,215,000	276,000	399,000	2,547,000	859,000	1,780,000	2,668,000
Total Cost, $EC	1,320,000	322,000	557,000	2,850,000	931,000	2,203,000	3,895,000
($US)	(492,000)	(120,000)	(208,000)	(1,063,000)	(348,000)	(822,000)	(1,454,000)

Note: At currency exchange rate of $1.00 U.S. to $2.68 EC is used.

---

a. Hunter Plastics
Lincoln, Alabama
Mr. Ken Bell
205/763-7741

b. Brem Interprize
Iota, Louisiana
Mr. Ed Swain
318/779-3694

c. Hajoca
Chattanooga, Tennessee
Mr. Steve Rapp
615/756-1157

d. Smith and Loveless
Lenexa, Kansas
Mr. John Mowen
913/888-5201

e. Installation costs based on estimates prepared by Mr. G. V. Nurse, Construction Management Services, P.O. Box 230, St. George's Granada, phone: 5300/2771.

f. This estimated cost appears to be extremely high. A firm experienced in laying ocean outfall pipe should be consulted.

APPENDIX H

Tennessee Valley Authority
Office of Natural Resources and Economic Development
Division of Air and Water Resources
Water Quality Branch

COST ESTIMATES FOR CONSTRUCTION OF ALTERNATIVE TREATMENT SYSTEMS

Chattanooga, Tennessee

December 1985

Cost estimates for construction of alternative treatment systems includes the cost of the treatment facility and the cost of the collection system. The facility costs for the four alternative processes at three sites are given in Attachment H1.

Attachment H2 identifies the total project costs, including treatment plant from Attachment H1 and collection system from Appendix G. For a St. George's system, the collection system increment of the total cost includes new collector and trunk lines along the Carenage and Esplanade, a new force main, and a new 1750 foot outfall pipe. Although the plant is sized to handle added flows for expansion into nearby areas such as Paddock, St. John's River, and Tempe, the collection system costs for these areas have not been added. If it is desired to include sewering of these areas in the initial project, these incremental costs must be added from Appendix G.

For a Grand Anse system, the total costs in Attachment H2 include treatment facility costs from Attachment H1 and collection system costs from Appendix G.

For the combined St. George's/Grand Anse system alternative, the total costs include the costs of the treatment plant from Attachment H1, new collector lines along the Carenage and Esplanade, lift stations, forces mains to carry the flow from St. George's to the Grand Anse collector lines and from the Esplanade to the Carenage, and the Grand Anse collection system. Sewering new areas near St. George's, Tempe, or along the St. John's River, or replacing existing pipe with new pipe would be incremental costs which are found in Appendix G.

ATTACHMENT H1

Estimated Costs for Alternative Treatment Facilities

Alternative System	Total Cost, $million EC ($million US)[a]		
	St. George's	Grand Anse	St. George's/Grand Anse
Tropical Stabilization Pond[b]	-	4.2 (1.6)	7.0 (2.6)
Artificial Wetlands[c]	-	1.4 (0.5)	-
Oxidation Ditch[d]	4.8 (1.8)	4.0 (1.5)	8.3 (3.1)
Contact Stabilization[e]	7.0 (2.6)	5.9 (2.2)	11.8 (4.4)

a. Total cost includes equipment costs FOB to U.S. port, construction costs, and engineering costs. A currency exchange rate of $1.00 US to $2.68 EC is used.

b. Total cost includes 45 percent engineering costs for contingency (10 percent) and project development and implementation (35 percent). The Grand Anse alternative is the desired 5-pond system; whereas, the combined St. George's/Grand Anse alternative is only a 4-pond system. For a 5-pond St. George's/Grand Anse system, the costs would be increased by about 30 percent.

c. Principle costs are for construction which are based upon estimates provided by Mr. G. V. Nurse, Construction Management Services, St. George's, Grenada. Total cost includes 28 percent for engineering costs.

d. Average cost range supplied by one principal equipment company. Total cost includes 28 percent engineering costs for contingency (10 percent) and project development and implementation (18 percent).

e. Includes equipment price average of four manufacturers. Assumes equipment is 35 percent of construction cost. Total cost includes 28 percent engineering costs for contingency (10 percent) and project development and implementation (18 percent).

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ATTACHMENT H2

Estimated Total Project Costs for Alternative Sewage Treatment Systems

Alternative System	Total Cost, $million EC ($million US)		
	St. George's	Grand Anse	St. George's/Grand Anse
Tropical Stabilization Pond	-	6.5 (2.4)	10.9 (4.1)
Artificial Wetlands	-	3.6 (1.3)	-
Oxidation Ditch	5.7 (2.1)	6.2 (2.3)	12.2 (4.6)
Contact Stabilization	7.8 (2.9)	8.1 (3.0)	15.7 (5.9)

NOTE: Total cost includes treatment facility and collection system. Amounts were calculated in EC dollars, converted to US dollars using a currency exchange rate of $1.00 US to $2.68 EC, and then rounded to the nearest tenth of a million dollars.

Costs for alternatives treatment facilities are included in Attachment H1. Costs for the collection system are found in Appendix G. For comparative purposes, the following collection system alternatives/phases were used: St. George's--B+C; Grand Anse--F; and St. George's/Grand Anse--G. Expansion or improvement to the collection systems included in D and E can be added to either alternative site.

APPENDIX I

WATER CONSERVATION

TENNESSEE VALLEY AUTHORITY

HOUSEHOLD WATER CONSERVATION
STATE-OF-THE-ART

This Report Contains Preliminary Information
Subject to Change or Revision and Is
Intended for Use Within TVA Only

DIVISION OF WATER RESOURCES

- 147 -

TENNESSEE VALLEY AUTHORITY

Division of Water Resources

Water Quality and Ecology Branch

HOUSEHOLD WATER CONSERVATION STATE-OF-THE-ART

Prepared by

Alice L. Cannella
Special Projects and Research Program

Chattanooga, Tennessee

May, 1979

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›/202/A&B

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APPENDIX J

EXAMPLE WATER QUALITY REGULATIONS

tunity to present oral or written statements, arguments or data, Provided, however, that the Department shall have the discretion to fix reasonable time limits on the presentation of oral statements and when time and scheduling considerations necessitate, may require the submission of statements in writing.

(b) The hearing shall be conducted by a hearing officer [who] shall cause a record of the hearing to be made, which shall include any public comments or statements received, and shall render a report to the Commissioner setting forth the appearances and relevant facts and arguments presented at the hearing. The hearing officer is empowered to:

(1) Provide for the taking of written and oral statements, testimony under oath, and documentary evidence; and

(2) Regulate the course of the hearing, fix the time for the filing of written statements and data, provide for the scheduling and preservation of oral statements, testimony under oath and documentary evidence, and set the time and place for continued hearings.

(c) Any materials, including records and documents, in the possession of the Department of which it desires to avail itself, may be offered by the Department and made part of the record. Such materials may be relied upon by the Commissioner in making a final decision or other disposition.

(d) Cross-examination of witnesses shall be permitted and the strict procedural rules of evidence may be modified at the discretion of the hearing officer. The determination of the hearing officer shall be founded upon the record of the hearing and upon competent relevant material evidence which is substantial in view of the entire record.

DIVISION 10. CONFLICTS OF INTEREST

SECTIONS

184-91. Conflicts of interest

§ 184-91. Conflicts of interest

Pursuant to 12 V.I.C. § 196, the Commissioner or his designee responsible for issuance of TPDES permits, is prohibited from receiving, or from having received during the previous two years, a significant portion of his income directly or indirectly from permit holders or applicants for a permit. For the purposes of this section (a) "significant portion of his income" shall mean 10 percent of gross personal income for a calendar year, except that it shall mean

Sections 186-1 — 186-11

50 percent of gross personal income for a calendar year if the recipient is over 60 years of age and is receiving such portion pursuant to retirement, pension, or similar arrangement; (b) "income" includes retirement benefits, consultant fees, and stock dividends, and (c) income is not received "directly or indirectly from permit holders or applicants for a permit" where it is derived from mutual-fund payments, or from other diversified investments over which the recipient does not know the identity of the primary sources of income.

Subchapter 186. Water Quality Standards for Coastal Waters of the Virgin Islands

SECTIONS

186-1. General water quality criteria
186-2. Class A
186-3. Class B
186-4. Class C
186-5. Thermal policy
186-6. Mixing zones
186-7. Antidegradation
186-8. Analytical procedures
186-9. Applicability of standards
186-10. Natural waters
186-11. Legal limits
186-12. Reissuance of this chapter

§ 186-1. General water quality criteria

All surface waters shall meet generally accepted aesthetic qualifications and shall be capable of supporting diversified aquatic life. These waters shall be free of substances attributable to municipal, industrial, or other discharges or wastes as follows:

(a) Materials that will settle to form objectionable deposits.

(b) Floating debris, oil, scum, and other matter.

(c) Substances producing objectionable color, odor, taste, or turbidity.

(d) Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in human, fish and other animal life, and plants.

(e) Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.

Source. Sections 186-1 to 186-11: Rules and Regulations Relative to Water Quality Standards for Coastal Waters of the Virgin Islands were revised and issued by Commissioner

of Health, dated July 20, 1973, and approved by Governor. Filed with Lieutenant Governor July 26, 1973; File No. 750.

Authority. 12 V.I.C. § 186(a).

Prior regulations—1968. Similar regulations of the Commissioner of Health, dated Oct. 4, 1968, and approved by the Governor were filed with Government Secretary Jan. 16, 1969; File No. 570.

§ 186–2. Class A

(a) Best usage of waters: Preservation of natural phenomena requiring special conditions, such as the Natural Barrier Reef at Buck Island, St. Croix and the Under Water Trail at Trunk Bay St. John.

(b) Quality criteria: Existing natural conditions shall not be changed.

§ 186–3. Class B

(a) Best usage of waters: For propagation of desirable species of marine life and for primary contact recreation (swimming, water skiing, etc.).

(b) Quality criteria:

(1) Dissolved oxygen: Not less than 5.5 mg/l from other than natural conditions.

(2) pH: Normal range of pH must not be extended at any location by more than ± 0.1 pH unit. At no time shall the pH be less than 7.0 or greater than 8.3.

(3) Temperature: Not to exceed 90° F. at any time, nor as a result of waste discharge to be greater than 1.5° F. above natural. Thermal policy section 186–5 shall also apply.

(4) Bacteria: Shall not exceed a geometric (log) mean of 70 fecal coliforms per 100 ml. by MF or MPN count.

(5) Dissolved gas: Total dissolved gas pressure shall not exceed 110 percent of existing atmospheric pressure.

(6) Phosphorus: Phosphorus as total P shall not exceed 50 ug/l in any coastal waters.

(7) Suspended, colloidal, or settleable solids: None from waste water sources which will cause disposition or be deleterious for the designated uses.

(8) Oil and floating substances: No residue attributable to waste water nor visible oil film nor globules of grease.

(9) Radioactivity:

(A) Gross beta: 1000 picocuries per liter, in the absence of Sr 90 and alpha emitters.

(B) Radium-226: 3 picocuries per liter.

(C) Strontium-90: 10 picocuries per liter.

(10) Taste and odor producing substances: None in amounts that will interfere with the use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life.

(11) Color and turbidity: A Secchi disc shall be visible at a minimum depth of one meter.

§ 186–4. Class C

(a) Best usage of waters: For the propagation of desirable species of marine life and secondary contact recreation (boating, fishing, wading, etc.).

(b) Quality criteria:

(1) Dissolved oxygen: Not less than 5.0 mg/l from other than natural conditions.

(2) pH: Normal range of pH must not be extended at any location by more than ± 0.1 pH unit. At no time shall the pH be less than 6.7 or greater than 8.5.

(3) Bacteria: Shall not exceed a geometric (log) mean of 1,000 fecal coliforms per 100 ml. by MF or MPN count.

(4) Taste and odor producing substances: None in amounts that will interfere with the use for potable water supply or will render any undesirable taste or odor to edible aquatic life.

(5) Other provisions for Class B waters shall apply.

§ 186–5. Thermal policy

(a) Fish and other aquatic life shall be protected from thermal blocks by providing for a minimum 75 percent stream or estuarine cross-section and/or volumetric passageway, including a minimum of one half of the surface as measured from water edge to water edge at any stage of tide.

(b) In non-passageway the surface water temperature shall not exceed 93° F.

(c) No heat may be added except in designated mixing zones which would cause temperatures to exceed 90° F., or which would cause the monthly mean of the maximum daily tempera-

ture at any site, prior to the addition of any heat, to be exceeded by more than 1.5° F.

(d) No discharge or combination of discharges shall be injurious to fish or shellfish or the culture or propagation of a balanced indigenous population thereof.

(e) Rate of temperature change outside the mixing zone shall not be more than 1° F. per hour nor to exceed 5° F. in any 24-hour period except when natural phenomena cause these limits to be exceeded.

(f) Unless specific conditions, such as spawning ground, migratory routes, or other sections of conditions from these regulations are applicable, the mixing zone should be defined by a sphere with a specified point as the center (not necessarily the outfall but limited to one point for each installation) and a radius equal to the square root of the volume of discharge (A) expressed as millions of gallons per day, times 200 feet; and in no case exceed ⅜ mile. The formula is:

$$\frac{2}{\sqrt{A}} \qquad 200 = \text{radius of mixing zone.}$$

—Amended Sept. 1, 1978, File No. 1053, §§ 1.2, 1.3.

Amendments—1978. Section 186-5(b) and (f) was amended by the Department of Conservation and Cultural Affairs August 31, 1978, and approved Sept. 1, 1978 by the Governor. Filed with Lieutenant Governor Sept. 1, 1978; File No. 1053. Amendment became effective without prior publication by gubernatorial certification dated Sept. 1, 1978.

§ 186-6. Mixing zones

The need, location, size and depth of the mixing zones in surface waters and estuaries shall be established according to the following mixing zone criteria and boundaries.

(a) Mixing zone criteria:

(1) Mixing zones shall be provided solely for mixing. Mixing must be accomplished as quickly as possible through the use of devices which insure that the waste is mixed with the allocated dilution water in the smallest practicable area.

(2) For the protection of aquatic life resources, the mixing zones must not be used for, or be considered as, a substitute for waste treatment facilities.

(3) At the boundary of the mixing zone the water should comply with all the water quality standards set forth for its

classification. If, after complete mixing with the available dilution water, these requirements are not met, the effluent must be adequately pretreated until the standards are met.

(4) No conditions shall be permitted to exist within the mixing zone. (A) that are rapidly lethal (i.e. exceed the 96-hour median tolerance limit) to locally important and desirable indigenous aquatic life, (B) that prohibit planktonic organisms from being carried through the mixing zone. These organisms will be exposed to its conditions only for the period of time required to drift through the mixing zone and will survive without undue damage or stress while they are passing through.

(5) Maximum vertical dispersion of waste water discharge flow shall be provided for in the mixing zone.

(6) Mixing zones shall not intersect spawning or nursery areas, migratory routes, water intake nor mouths of rivers.

(7) Suspended solids in waste waters being discharged shall not settle in measurable amounts in the mixing zones.

(b) Mixing zone boundaries:

(1) The mixing zone must be located in such manner as to allow at all times, passageways for the movement on drift of the biota (pelagic or invertebrate organisms). The width of the mixing zone and the volume of flow in it shall depend on and will be determined by the nature of the water current and/or the estuary. The area, depth, and volume of the flow must be sufficient to provide a usable and desirable passageway for fish and other aquatic organisms.

(2) The passageway must contain at least 75 percent of the cross sectional area and/or volume of flow of the estuary, and should extend to at least 50% of the width.

(3) A mixing zone shall not overlap with an adjacent mixing zone.

§ 186-7. Antidegradation

Waters whose existing quality is better than the established standards as of the date on which such standards become effective l be maintained at their existing high quality. These and other ters of the Virgin Islands will not be lowered in quality unless l until it has been affirmatively demonstrated to the Territory's ter pollution control agency and the Environmental Protection ency that such change is justifiable as a result of necessary nomic or social development and will not interfere with or be-

come injurious to any assigned uses made of, or presently possible in such waters. Any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required, as part of the initial project design, to provide the highest and best practicable degree of waste treatment available under existing technology, and since these are also Federal standards, these waste treatment requirements will be developed cooperatively.

§ 186–8. Analytical procedures

The analytical procedures used as methods of analysis to determine the chemical, bacteriological, biological, and radiological quality of waters sampled shall be in accordance with the latest edition of "Standard Methods for the Examination of Water and Waste Water" or other methods approved by the Virgin Islands Department of Conservation and Cultural Affairs and the Environmental Protection Agency.—Amended Sept. 1, 1978, File No. 1053, § 1.4.

§ 186–9. Applicability of standards

The proceeding criteria will be applicable to all Virgin Islands Coastal Waters at all places and at all times.

§ 186–10. Natural waters

Natural waters may, on occasion, have characteristics outside of the limits prescribed by these criteria. The criteria contained herein do not relate to violation of standards resulting from natural forces.

§ 186–11. Legal limits

(a) Class "A" (natural phenomena).

(1) Within 0.5 miles of the boundaries of Buck Island's Natural Barrier Reef, St. Croix.

(2) Trunk Bay, St. John.

(b) Class "B" (marine life and primary contact recreation).

(1) All other coastal waters not classified Class "A" or Class "C".

(c) Class "C" (marine life and secondary contact recreation).

(1) St. Thomas:

(A) St. Thomas Harbor beginning at Rupert Rock and extending to Haulover Cut.

(B) Crown Bay enclosed by a line from Hassel Island at Haulover Cut to Regis Point at West Gregerie Channel.

(C) Krum Bay.

(2) St. Croix:

(A) Christiansted Harbor from Fort Louise Augusta to Golden Rock.

(B) Frederiksted Harbor from La Grange to Fisher Street.

(C) Hess Oil Virgin Islands Harbor.

(D) Martin-Marietta Alumina Harbor.

§ 186–12. Reissuance of this chapter

Title 12, chapter 7, sections 186–1 through 186–11, Virgin Islands Rules and Regulations, as previously issued by the Commissioner of Health, are hereby reissued by the Commissioner of Conservation and Cultural Affairs.

Source. Section 186–12: Regulations to reissue this chapter issued by the Commissioner of Conservation and Cultural Affairs Aug. 31, 1978, and approved Sept. 1, 1978 by the Governor. Filed with Lieutenant Governor Sept. 1, 1978; File No. 1053.

Effective date. The regulation, File No. 1053, contained a gubernatorial certificate dated Sept. 1, 1978, which provided such regulation shall take effect without the usual prior publication.

HAWAII WATER QUALITY STANDARDS

(Hawaii Code of Rules and Regulations, Title 11 — Department of Health Chapter 54 — Water Quality Standards; Approved January 26, 1968; Amended November 1, 1969; June 14, 1971; February 25, 1974; September 6, 1979, Effective December 7, 1979; November 12, 1982)

§11-54-01 Definitions. As used in this chapter:

"Ambient conditions" means the existing conditions in surrounding waters not influenced by man.

"Best degree of treatment or control" means that treatment or control which is required by applicable statutes and regulations of the State of Hawaii and the Federal Water Pollution Control Act, as amended, or which is otherwise specified by the Director considering technology or management practices currently available in relation to the public interest.

"Brackish waters" means waters with dissolved inorganic ions (salinity) greater than 500 ppm (parts per million), but less than 30,000 ppm.

"Director" means the director of health, state of Hawaii, or his duly authorized agent.

"Fresh waters" means all waters with dissolved inorganic ions of less than 500 ppm.

"Saline waters" means water with dissolved inorganic ions greater than 30,000 ppm.

"State waters" means all waters, fresh, brackish, or salt, around and within the State of Hawaii which includes all the islands of the Hawaiian Archipelago together with their appurtenant reefs and waters except the Midway Islands.

§11-54-02 - Classification of State Waters

(a) The provisions of this Chapter shall apply to all state waters excluding the following: groundwater, and ditches, flumes, ponds, and reservoirs required as part of a pollution control system or which are used solely for irrigation water. State waters covered by this chapter are classified as either inland waters or marine waters.

(b) **Inland Waters**

(1) All inland waters are either fresh waters, brackish waters, or saline waters.

(2) All inland fresh waters are classified as follows, based on their physical characteristics, ecological systems, and other natural criteria:

(A) Streams (perennial or intermittent);

(B) Springs and seeps, natural lakes, and reservoirs;

(C) Elevated wetlands;

(D) Low wetlands;

(3) All inland waters which are brackish waters or saline waters are classified as follows, based on their physical characteristics, ecological systems, and other natural criteria:

(A) Coastal wetlands;

(B) Estuaries;

(C) Anchialine pools.

(c) **Marine Waters**

(A) All marine waters are either embayments, open coastal, or oceanic waters.

(2) All marine waters which are embayments or open coastal waters are also classified according to the following bottom subtypes:

(A) Sand beaches;

(B) Lava rock shorelines and solution benches;

(C) Marine pools and protected covers;

(D) Artificial basins;

(E) Reef flats and reef communities;

(F) Soft bottom communities.

§11-54-03 Classification of Water Uses

(a) The following use categories classify inland and marine waters for purposes of applying the standards set forth in this Chapter and for the selection or definition of appropriate quality parameters and uses to be protected in these waters.

(b) **Inland Waters**

(1) CLASS 1

(A) General—It is the objective of this class that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character to such areas shall be protected. Waste discharge into these waters is prohibited.

(B) CLASS 1.a—The uses to be protected in this class of waters are scientific and educational purposes, protection of breeding stock and baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other non-degrading uses which are compatible with the protection of the ecosystems associated with waters of this class.

(C) CLASS 1.b—The uses to be protected in this class of waters are for domestic water supplies, food processing, the support and propagation of aquatic life, compatible recreation, and aesthetic enjoyment. Public access to waters in this class may be restricted to protect water quality.

(2) CLASS 2—It is the objective of this class of waters that their use for recreational purposes, propagation of fish and other aquatic life, and agricultural and industrial water supply be protected.

The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in

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WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

1983

State Water Resources Control Board

157

APPENDIX K

ALTERNATIVE DESIGNS FOR ONSITE SEWAGE DISPOSAL SYSTEMS

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30365

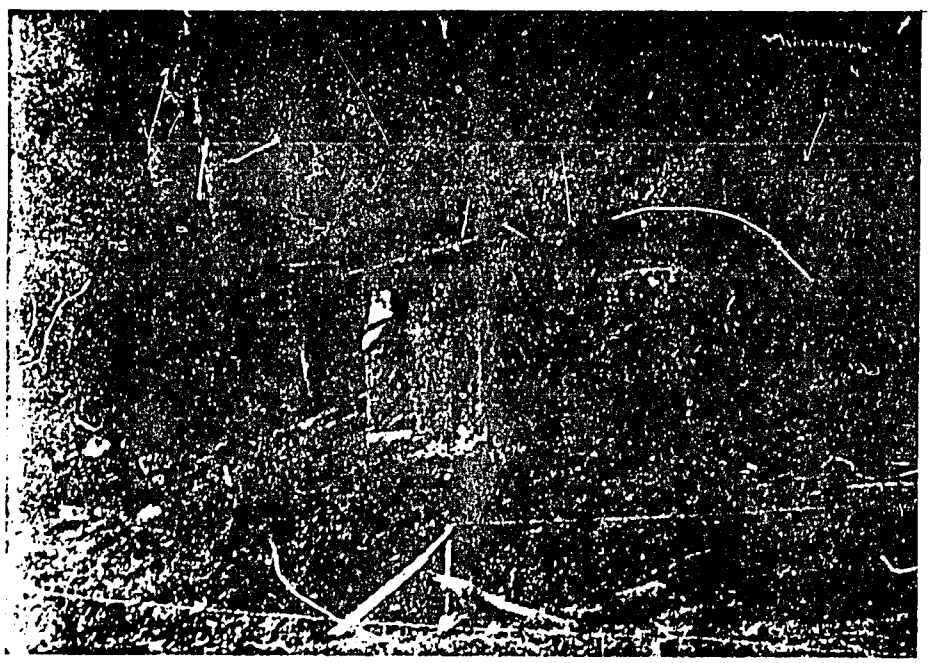
EPA 904/10-84 125
November 1984

EPA

Environmental Assessment

Mountain Communities Wastewater Management Alternatives Report

Volume II - Technical Engineering Alternatives



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APPENDIX L

SIMPLIFIED LABORATORY PROCEDURES FOR SEWAGE EXAMINATION

WPCF Publication No. 18

Simplified Laboratory Procedures for Wastewater Examination

Prepared

by

LABORATORY MANUAL FOR OPERATORS

COMMITTEE

1969

(First printing 1968)

WATER POLLUTION CONTROL FEDERATION

3900 Wisconsin Avenue, Washington, D. C. 20016 U.S.A.

APPENDIX M

FINANCIAL TECHNIQUES FOR SUPPORTING A WASTEWATER TREATMENT SYSTEM

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30365

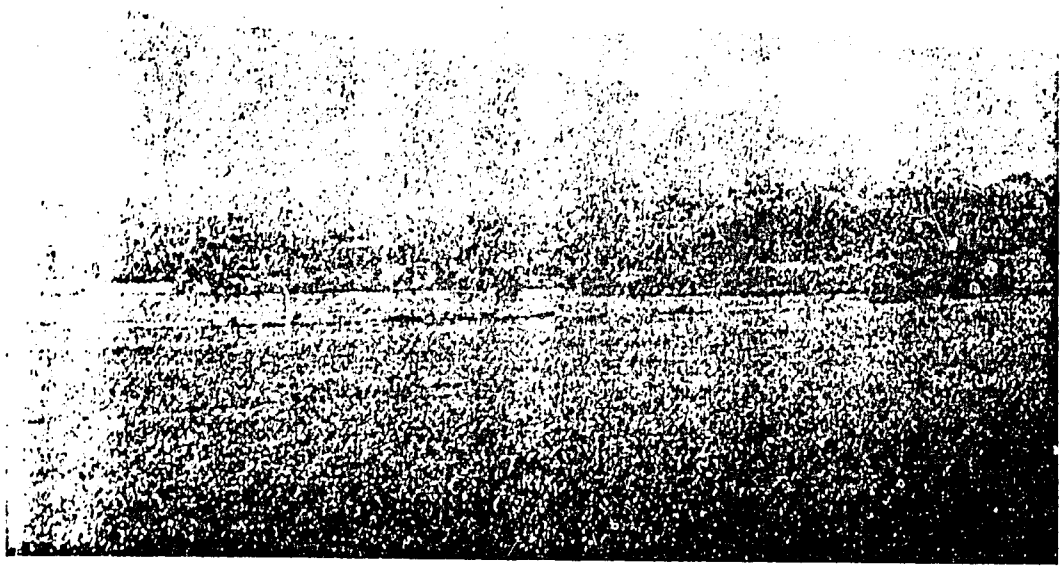
EPA 904/10-84 127
November 1984

EPA

Environmental Assessment

Mountain Communities Wastewater Management Alternatives Report

Volume IV - Financial Alternatives



APPENDIX N

GUIDELINES FOR EROSION AND SEDIMENT CONTROL

EPA-R2-72-015
August 1972

Environmental Protection Technology Series

Guidelines for Erosion and Sediment Control Planning and Implementation

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

APPENDIX O

EXAMPLE SEWER USE ORDINANCE

ORDINANCE OF THE CITY OF TRENTON, GEORGIA

ARTICLE 1

SEWER USE ORDINANCE

An ordinance regulating the use of public and private sewers and drains, private wastewater disposal, the installation and connection building sewers, and the discharge of waters and waste into the publi sewer system and providing penalties for violations thereof in the Ci of Trenton, State of Georgia.

Be it ordained and enacted by the City of Trenton as follows:

ARTICLE 2

DEFINITIONS

Unless the context specifically indicates otherwise, the meaning of terms used in this ordinance shall be as follows:

2.1 "Biochemical oxygen demand (BOD)" shall mean the quantity of oxygen utilized in the biochemical oxidation of organic matter under EPA approval laboratory procedure in five (5) days at 20° C, expressed in milligrams per liter.

2.2 "Building drain" shall mean that part of the lowest horizontal piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of buildings and conveys it to the building sewer, beginning five (5) feet outside the inner face of the building wall.

2.3 "Building sewer" shall mean the extension from the building drain to the public sewer or other place of disposal, also called house connection or service connection.

2.4 "Combined sewer" shall mean a sewer receiving both surface runoff and sewage.

2.5 "Customer" shall mean every person who is responsible for contracting (expressly or implicitly) with the City of Trenton in obtaining, having, or using sewer connections with, or sewer tap to, the sewer system of the City of Trenton and in obtaining, having, or using water and other related services furnished by the City of Trenton for the purpose of disposing of wastewater and sewage through said system. Said terms shall include the occupants of each unit of a multiple-family dwelling unit building as a separate and distinct customer.

2.6 "Easement" shall mean an acquired legal right for the specific use of land owned by others.

2.7 "Floatable Oil" is oil, fat, or grease in a physical state such that it will separate by gravity from wastewater by treatment in an approved pretreatment facility. A wastewater shall be considered free of floatable oil if it is properly pretreated and the wastewater does not interfere with the collection system.

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2.8 "Flush toilet" shall mean the common sanitary flush commode in general use for the disposal of human excrement.

2.9 "Garbage" shall mean the animal and vegetable waste resulting from the handling, preparation, cooking, and serving of foods.

2.10 "Health Officer" shall mean the director of the Coundy Board of Health or other person designated by the director and their duly appointed assistants.

2.11 "Industrial wastes" shall mean the wastewater from industrial processes as distinct from domestic or sanitary wastes.

2.12 "Infiltration/Inflow" shall mean groundwater and surface water which leaks into the sewers through cracked pipes, joints, manholes, or other openings.

2.13 "Natural outlet" shall mean any outlet, including storm sewers and combined sewer overflows, into a watercourse, pond, ditch, lake, or other body or surface of groundwater.

2.14 "May" is permissive (see "shall," Section 2.27).

2.15 "Municipality" shall mean the governmental body having jurisdiction over the maintenance and operations of the sanitary sewer system within the City.

2.16 "Normal wastewater" shall mean wastewater discharged into the sanitary sewers in which the average concentration of total suspended solids is not more than 350 milligrams per liter (mg/l), BOD_5 is not more than 300 mg/l, total phosphorous is not more than 15 mg/l, total Kjeldahl nitrogen is not more than 20 mg/l, and the total flow is not more than 25,000 gallons per day.

2.17 "Person" shall mean any individual, firm, company, association, society, corporation, or group.

2.18 "pH" shall mean the logarithm of the reciprocal of the hydrogen ion concentration.

2.19 "Pit privy" shall mean shored, vertical pit in the earth completely covered with a flytight slab on which is securely located a flytight riser covered with hinged flytight seat and lid.

2.20 "Properly shredded garbage" shall mean the wastes from the preparation, cooking, and dispensing of food that have been shredded to such a degree that all particles will be carried freely under the flow conditions normally prevailing in public sewers, with no particle greater than one-half inch in any dimension.

2.21 "Public sewer" shall mean a common sewer controlled by a governmental agency or public utility.

2.22 "Sanitary sewer" shall mean a sewer that carries liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not intentionally admitted.

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2.23 "Septic tank" shall mean a subsurface impervious tank designed to temporarily retain sewage or similar waterborne wastes together with:

a. A sewer line constructed with solid pipe, with the joints sealed, connecting the impervious tank with a plumbing stub out; and

b. A subsurface system of trenches, piping, and other materials constructed to drain the clarified discharge from the tank and distribute it underground to be absorbed or filtered.

2.24 "Sewage" is the spent water of a community. The equivalent term is "wastewater" (See Section 2.33).

2.25 "Sewer" shall mean a pipe or conduit that carries wastewater.

2.26 "Sewage works" (sewerage) shall mean all facilities for collecting, pumping, treating, and disposing of sewage.

2.27 "Shall" is mandatory (See "may," Section 2.15).

2.28 "Slug" shall mean any discharge of water or wastewater which in concentration of any given constituent or in quantity of flow exceeds for any period of duration longer than fifteen (15) minutes more than five (5) times the average twenty-four (24) hour concentration of flows during normal operation and shall adversely affect the collection system and/or performance of the wastewater facilities.

2.29 "Storm drain" (sometimes termed "storm sewer") shall mean a drain or sewer for conveying water, groundwater, subsurface water, or unpolluted water from any source and excluding sewage and industrial wastes other than unpolluted cooling water.

2.30 "Superintendent" shall mean the utilities commissioner or his authorized deputy, agent or representative.

2.31 "Suspended solids" shall mean total suspended matter that either floats on the surface of, or is in suspension in, water, wastewater, or other liquids, and that is removable by laboratory filtration as approved by EPA and referred to as nonfilterable residue.

2.32 "Unpolluted water" is water of quality equal to or better than the effluent criteria in effect or water that would not cause violation of receiving water quality standards and would not be benefited by discharge to the sanitary sewers and wastewater treatment facilities provided.

2.33 "Wastewater" shall mean the spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial building, industrial plants, and institutions together with any groundwater, surface water, and stormwater that may be present.

2.34 "Wastewater facilities" shall mean the structures, equipment, and processes required to collect, carry away, and treat domestic and industrial wastes and dispose of the effluent.

2.35 "Watercourse" shall mean a natural or artificial channel for the passage of water either continuously or intermittently.

ARTICLE 3

USE OF PUBLIC SEWERS REQUIRED

3.1 All premises shall be provided, by the owner thereof, with at least one (1) toilet. All toilets shall be kept clean and in a sanitary working condition.

3.2 No person shall dispose of human excrement except in a toilet.

3.3 It shall be unlawful to discharge to any natural outlet within the City of Trenton, or in any area under the jurisdiction of the City of Trenton, any wastewater of other polluted waters, including septic tank effluent or cesspool overflow to any open drain or well-penetrating, water-bearing formation, except where suitable treatment has been provided in accordance with subsequent provisions of this ordinance.

3.4 Except as hereinafter provided, it shall be unlawful to construct or maintain any privy, privy vault, septic tank, cesspool, or other facility intended or used for the disposal of wastewater.

3.5 The owner(s) of all houses, buildings, or properties used for human occupancy, employment, recreation, or other purposes situated within the City of Trenton jurisdiction and abutting on any street, alley, or right-of-way in which there is now located or may in the future be located a public sanitary sewer of the City of Trenton is hereby required at the owner(s) expense to install suitable toilet facilities herein, and to connect such facilities directly with the proper public sewer in accordance with the provisions of this ordinance, within thirty (30) days after date of official notice to do so, provided that said public sewer is within 100 feet of the property line.

3.6 All sinks, dishwashing machines, lavatories, basins, shower baths, bathtubs, laundry tubs, washing machines, and similar plumbing fixtures or appliances shall be connected to the public sewer; provided, that where no sewer is available, septic tanks or other private subsurface disposal facilities approved by the health officer may be used.

ARTICLE 4

PRIVATE WASTEWATER DISPOSAL

4.1 Where a public sanitary sewer is not available under the provisions of Article 3, the building sewer shall be connected to a private wastewater disposal system complying with the provisions of the City of Trenton and the Georgia Department of Human Resources.

4.2 Septic tanks shall be constructed, repaired, altered, enlarged and maintained in accordance with plans and specifications approved by the health officer. Septic tanks shall be maintained in sanitary working order.

4.3 No person shall construct, repair, alter, or enlarge any septic tank unless he shall hold a valid permit for such work issued by the health officer. The health officer may withhold the issuance of such a permit pending the inspection and approval by the health officer of the site and location of the proposed work. Before any septic tank or any part thereof

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may be covered after it has been constructed, repaired, altered, or enlarged, it shall be inspected and approved by the health officer.

4.4 The type, capacities, location, and layout of a private wastewater disposal system shall comply with all recommendations of the Department of Human Resources of the State of Georgia. No permit shall be issued for any private wastewater disposal system employing subsurface soil absorption facilities where the area of the lot is less than 20,000 square feet. No septic tank or cesspool shall be permitted to discharge to any natural outlet.

4.5 No septic tank or other subsurface disposal facility shall be installed where a public sewer is accessible to the premises involved, nor in any place where the health officer deems the use of same to be a menace to human health or well being.

4.6 At such time as a public sewer becomes available to a property served by a private wastewater disposal system, a direct connection shall be made to the public sewer within thirty (30) days after notice. Any septic tanks, cesspools, and similar private wastewater disposal facilities shall then be cleaned of sludge and filled with suitable material.

4.7 The owner(s) shall operate and maintain the private wastewater disposal facilities in a sanitary manner at all times, at no expense to the City of Trenton.

4.8 No subsurface disposal facilities shall be installed in any place where the health officer deems the use of such facilities to be a menace to human health or well being.

4.9 Every flush toilet shall be connected to a public sewer where available or to a septic tank. Flush toilets shall be provided at all times with sufficient running water under pressure to flush the toilet clean after each use.

4.10 No pit privy shall be installed in the following locations:

a. Where a public sewer is accesible to the premises involved; or,

b. In areas where the health officer deems the use of pit privies to constitute a nuisance or menace to the public health; or,

c. Where a pit privy may pollute any water supply; or,

d. Where the use of pit privies is not in keeping with the standard of sanitation in adjacent areas.

4.11 Discharge of septic tanks in sewer system.

a. Restricted. It shall be unlawful to empty, dump, throw or otherwise discharge, into any manhole, catch basin or other opening, into the City of Trenton sewer system, or any system connected with and discharging into the sewer system, the contents of any septic tank, sludge, sewage, or other similar matter or material, except as provided in Subsection "b" hereof.

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b. Permits. The Superintendent is hereby authorized to grant permits to discharge the contents of septic tanks at locations specified by the Superintendent and under his supervision. Such permits may be revoked at any time if, in the opinion of the Superintendent, continued dumping of such matter into the sewers will be injurious to the sewer system or treatment processes.

c. Charges. A charge shall be made for the privilege of dumping the contents of septic tanks, as provided in separate rules. A record shall be kept of such dumpings and statements rendered at the first of each month, the amount of such statements shall be payable within ten (10) days after rendition. Failure to pay the amounts due within such 10 day period shall be cause for revoking the permit.

4.12 Any premise that has a septic tank, privy, or any other sewage, industrial waste, or liquid waste disposal system, located thereon that does not function in a sanitary manner shall be corrected within thirty (30) days from the receipt of written notification from the health officer and said system is not functioning in a sanitary manner, and order that said system be corrected.

4.13 Premises with private water systems shall not be connected with the public sewerage system.

4.14 No statement contained in this article shall be construed to interfere with any additional requirements that may be imposed by the health officer.

ARTICLE 5

BUILDING SEWERS AND CONNECTIONS

5.1 No unauthorized person shall uncover, make any connections with or opening into, use, alter, or disturb any public sewer or appurtenance thereof without first obtaining a written permit from the City of Trenton.

5.2 The owner or his agent shall make application on a special form furnished by the City of Trenton. The permit application shall be supplemented by any plans, specifications, or other information considered pertinent in the judgement of the Superintendent. A permit and inspection fee as specified elsewhere shall be paid at the time the application is filed.

5.3 All costs and expenses incidental to the installation and connection of the building sewer shall be borne by the owner. The owner shall indemnify the City of Trenton from any loss or damage that may directly or indirectly by occasioned by the installation of the building sewer.

5.4 A separate and independent building sewer shall be provided for every building: except [illegible] building stands at the rear of another on an interior lot and no private sewer is available or can be constructed to the rear building through a adjoining alley, court, yard, or driveway, the front building may be extended to the rear building and the whole considered as one building sewer, but the City of Trenton does not and will not assume any obligation or responsibility for damage caused by or resulting from any such single connection aforementioned.

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5.5 Old building sewers may be used in connection with new buildings only when they are found, on examination and test by the Superintendent, to meet all requirements of this ordinance.

5.6 The size, slope, alignment, materials of construction of a building sewer, and the methods to be used in construction shall all conform to the requirements of the building and plumbing code or other applicable rules and regulations of the county. In the absence of code provisions or in amplification thereof, the materials and procedures set forth in appropriate specifications of the American Society for Testing and Materials (ASTM) and Water Pollution Control Federation (WPCF) Manual of Practice No. 9 shall apply.

Additionally, the following materials and methods shall apply to building sewers within City of Trenton supervision:

a. The building sewer shall be cast iron soil pipe, ASTM Specification A74, latest revision, or equal; ductile iron pipe, American National Standards Institute (ANSI) Specification A21.51, latest revision, or equal; or polyvinyl chloride (PVC) sewer pipe, ASTM Specification D3034, latest revision. All joints shall be tight and waterproof.

   Any part of the building sewer that is located within ten (10) feet of a water service pipe shall be constructed of cast iron soil pipe or ductile iron pipe with bolted mechanical joints may be required by the Superintendent where the sewer is exposed to damage by tree roots. If installed in filled or unstable ground, the building sewer shall be of cast iron soil pipe, except that plastic pipe may be acceptable if laid on a suitable concrete bed or cradle as approved by the Superintendent.

b. The size and slope of the building sewer shall be subject to the approval of the Superintendent, but in no event shall the diameter be less than four (4) inches. The slope of such four (4) inch pipe shall not be less than one-eighth (1/8) inch per foot. Furthermore, the appropriate requirements of the Occupational Health and Safety Act (OSHA) shall be followed.

c. The depth shall be sufficient to afford protection from frost, and the building sewer shall be laid at uniform grade and with straight alignment insofar as possible. Changes in direction shall be made only with properly curved pipe and fittings. Building sewers shall not be placed in the same trench with water service lines.

d. An excavation required for the installation of a building sewer shall be open trench work unless otherwise approved by the Superintendent. Pipe laying and backfill shall be performed in accordance with ASTM Specification C12, latest revision, except that no backfill shall be placed until the work has been inspected and approved.

e. All joints and connections shall be made gastight and watertight.

   Push-on joints for cast iron soil pipe shall have neoprene gaskets in accordance with the requirements of ASTM C-564.

   Push-on joints for ductile iron pipe shall also have neoprene gaskets and be installed according to the manufacturer's recommendations.

PVC pipe joint material shall be of the bell and spigot type, sealed with a rubber "O"-ring gasket, having a composition and texture which is resistant to the common ingredients of sewage, industrial wastes (including oils), and groundwater, and which will endure permanently under the conditions likely to be imposed by this use. Installation of gasket shall be done in accordance with the pipe manufacturer's instructions using all the necessary materials, lubricants, and equipment recommended by the manufacturer.

Other jointing materials may be used only when approved by the Superintendent.

f. The connection of the building sewer into the public sewer shall be made at the "Y" branch, if such a branch is available at a suitable location. If the public sewer is twelve (12) inches in diameter or less, and no properly located "Y" branch is available, the City of Trenton shall, at the owner's expense, cut a neat hole into the public sewer, with entry in the downstream direction at an angle of about forty-five (45) degrees, and install a forty-five (45) degree elbow with the spigot end cut so as not to extend past the inner surface of the public sewer. The invert of the building sewer at the point of connection shall be at an elevation of at least one-tenth (0.1) foot above the invert of the public sewer. A neat smooth joint shall be made, and the connection made secure and watertight by encasement in concrete. Special fittings may be used for the connection only when approved by the Superintendent.

5.7 Whenever possible, the building sewer shall be brought to the building at an elevation below the basement floor. No building sewer shall be laid parallel to or within three (3) feet of any bearing wall which might thereby be weakened. In all buildings in which any building drain is too low to permit gravity flow to the public sewer, sanitary sewage carried by such building drain shall be lifted by an approved means and discharged to the building sewer.

5.8 No person shall make connection of roof downspouts, foundation drains, areaway drains, or other sources of surface runoff or groundwater to a building sewer or building drain which in turn is connected directly or indirectly to a public sanitary sewer unless such connection is approved for purposes of disposal of polluted surface drainage.

5.9 The applicant for the building sewer permit shall notify the Superintendent when the building sewer is ready for inspection and connection to the public sewer. The connection and testing shall be made under the supervision of the Superintendent or his representative.

5.10 All excavations for building sewer installation shall be adequately guarded with barricades and lights so as to protect the public from hazard. Streets, sidewalks, parkways, and other public property disturbed in the course of the work shall be restored in a manner satisfactory to the City of Trenton.

5.11 The City of Trenton will define the availability of sewers and any costs associated with sewer permits or construction.

5.12 The connection of the building sewer into the public sewer shall conform to the requirements of the building and plumbing code or other applicable rules and regulations of the City of Trenton or the procedures set forth in

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appropriate specifications of the ASTM and the WPCF Manual of Practice No. 9. All such connections shall be made gastight and watertight and verified by proper testing. Any deviation from the prescribed procedures and materials must be approved by the Superintendent before installation.

5.13 If any house sewer permits the entrance of infiltration or inflow, the City of Trenton may:

a. Require the owner to repair the house sewer.

b. Charge the owner a sewer rate that reflects the costs of the additional expense of sewage treatment from the owner's property.

c. Require the owner to disconnect his sewer from the Trenton sewer system.

ARTICLE 6

RESTRICTED USE OF THE PUBLIC SEWERS

6.1 No person shall discharge or cause to be discharged any unpolluted waters such as stormwater, groundwater, roof runoff, subsurface drainage, cooling water, or unpolluted industrial process waters to any sanitary sewer.

6.2 No person shall discharge or cause to be discharged any sanitary wastewater into a storm sewer system.

6.3 No person shall discharge or cause to be discharged any of the following described water or wastes to any public sewers:

a. Any gasoline, benzene, naptha, fuel oil, or other flammable or explosive liquid, solid, or gas.

b. Any waters containing toxic or poisonous solids, liquids, or gases in sufficient quantity, either singly or by interaction with other wastes, to injure or interfere with any waste treatment process, constitute a hazard to humans or animals, create a public nuisance, or create any hazard in the receiving waters of the wastewater treatment plant.

c. Any waters or wastes having a pH lower than 5.5 or greater than 9.0, or having any other corrosive property capable of causing damage or hazard to structures, equipment, and personnel of the wastewater works.

d. Solid or viscous substances in quantities or of such size capable of causing obstruction to the flow in sewers, or other interference with the proper operation of the wastewater facilities such as, but not limited to, ashes, bones, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, unground garbage, whole blood, paunch manure, hair and fleshings, entrails and paper dishes, cups, milk containers, etc., either whole or ground by garbage grinders.

6.4 The following described substances, materials, waters, or waste shall be limited in discharges to municipal systems to concentrations or quantities

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which will not harm either the sewers, wastewater treatment process or equipment, will not have an adverse effect on the receiving stream, or will not otherwise endanger lives, limb, public property, or constitute a nuisance. The limitations or restrictions on materials or characteristics of waste or wastewater discharged to the sanitary sewer which shall not be violated without approval of the City of Trenton are as follows:

a. Wastewater having a temperature higher than 150°F (65°C) or wastewater which will elevate the temperature of the influent to the publicly owned treatment works (POTW) to 104°F (40°C) or higher.

b. Wastewater containing more than 25 milligrams per liter of petroleum oil, nonbiodegradable cutting oils, or product of mineral oil origin.

c. Wastewater containing more than 100 milligrams per liter of oils, fat, grease, or wax, whether emulsified or not, or containing substances which may solidify or become viscous at temperatures between 32°F (0°C) and 150°F (65°C).

d. Any garbage that has not been properly shredded. Garbage grinders may be connected to sanitary sewers from homes, hotels, institutions, restaurants, hospitals, catering establishments, or similar places where garbage originates from the preparation of food in kitchens for the purpose of consumption on the premises or when served by caterers.

e. All industrial discharges to the Trenton sewer system must comply with the Federal Industrial Pretreatment Standards (40 CFT Part 403) and those Industrial Pretreatment Standards developed by the Georgia Environmental Protection Division.

f. Any waters or wastes containing taste-or odor-producing substances exceeding limits which may be established by the City of Trenton.

g. Any radioactive wastes or isotopes of such half-life or concentrations as may exceed limits established in compliance with applicable state or federal regulations.

h. Quantities of flow, concentrations, or both which constitute a "slug" as defined in Section 2.28.

i. Waters or wastes containing substances which are not amenable to treatment or reduction by the wastewater treatment processes employed, or are amenable to treatment only to such degree that the wastewater treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.

j. Any water or wastes which, by interaction with other water or wastes in the public sewer system, release obnoxious gases, for solids which interfere with the collection system, or create a condition deleterious to structures and treatment processes.

k. Materials which exert or cause:

(1) Any unusual concentrations of inert suspended solids (such as, but not limited to, Fuller's earth, lime slurries, and lime residues) or of dissolved solids (such as, but not limited to, sodium chloride and sodium sulfate).

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(2) Excessive discoloration (such as, but not limited to, dye wastes and vegetable tanning solutions).

(3) Unusual BOD (above 300 mg/l), chemical oxygen demand, or chlorine demand in such quantities as to constitute a significant load on the sewage treatment plant.

6.5 If any waters or wastes are discharged or are proposed to be discharged to the public sewers, which waters contain the substances or possess the characteristics enumerated above and which in the judgement of the (Municipality), may have a deleterious effect upon the wastewater facilities, processes, equipment, or receiving waters, or which otherwise create a hazard to life or constitute a public nuisance, the City of Trenton may:

a. Reject the wastes,

b. Require pretreatment to an acceptable condition for discharge to the public sewers,

c. Require control over the quantities and rates of discharge, and/or

d. Require surcharge payment to cover added cost of handling and treating the wastes.

6.6 Grease, oil, and sand interceptors shall be provided when, in the opinion of the City of Trenton, they are necessary for the proper handling of liquid wastes containing floatable grease in excessive amounts, sand, or other harmful ingredients; except that such interceptors shall not be required for private living quarters or dwelling units. All interceptors shall be of a type and capacity approved by the Superintendent and shall be located as to be readily and easily accessible for cleaning and inspection. In the maintenance of these interceptors, the owner shall be responsible for the proper removal and disposal by appropriate means of the captured material and shall maintain records of the dates and means of disposal which are subject to review by the Superintendent. Any removal and hauling of the collected materials not performed by owner's personnel must be performed by currently licensed waste disposal firms.

6.7 When required by the City of Trenton the owner of any property serviced by a building sewer carrying industrial wastes shall install a suitable structure together with such necessary meters and other appurtenances in the building sewer to facilitate observation, sampling, and measurement of the wastes. Such structure, when required, shall be accessibly and safely located and shall be constructed in accordance with approved plans. The structure shall be installed by the owner at his expense and shall be maintained by him so as to be safe and accessible at all times. This requirement will be on a case-by-case basis.

6.8 The industrial users may be required to provide information needed to determine compliance with this ordinance. These requirements may include:

a. Wastewater discharge peak rate and volume over a specified time period;

b. Chemical analyses of wastewaters;

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c. Information on raw materials, processes, and products affecting wastewater volume and quality;

d. Quantity and disposition of specific liquid, sludge, oil, solvent, or other materials important to sewer use control;

e. A plot plan of sewers of the user's property showing sewer and pretreatment facility location;

f. Details of wastewater pretreatment facilities; and

g. Details of systems to prevent and control the losses of materials through spills to the public sewer.

6.9 No statement contained in this article shall be construed as preventing any special agreement or arrangement between the City of Trenton and any industrial concern whereby an industrial waste of unusual strength or character may be accepted by the City of Trenton for treatment.

6.10 All measurements, tests, and analyses of the characteristics of waters and wastes to which reference is made in this ordinance shall be determined in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater," published by the American Public Health Association. Sampling methods, location times, durations, and frequencies are to be determined on an individual basis, subject to approval by the City of Trenton.

6.11 Pretreatment of Wastes
Persons discharging industrial wastes into the sewerage system may be required to pretreat such wastes. Plans for all pretreatment facilities shall be approved by the Superintendent or the Georgia Environmental Protection Division prior to construction. At the time written plans are submitted for approval, written maintenance plans shall also be submitted and approved by the Superintendent. The facilities shall be allowed to operate only as long as they are maintained in accordance with the approved maintenance plans. Pretreatment requirements shall be determined on a case-by-case basis and shall include the following facilities as a minimum:

a. Neutralization - If plans are submitted for the neutralization of strong acid or alkaline wastes, the plans shall include the necessary instrumentation and controls to assure compliance with the above regulations at all times.

b. Equalization - Holding tanks or equalization basins shall be required ahead of the receiving manhole of the Trenton sewerage system when deemed necessary by the Superintendent to prevent peak flows that exceed the capacity of the system or that result in operational problems.

c. All pretreatment facilities shall be operated and maintained continuously in satisfactory and effective operation by the owner at his expense.

6.12 Waiver of Requirements - There shall be no provision for the granting of variances for discharge of incompatible wastes. If a user begins to violate any of the provision of Article 6, it shall be his responsibility to apply

to the Superintendent who can issue a temporary permit along with a compliance schedule for planning and construction of necessary treatment or pretreatment works. Each case will be carefully evaluated with respect to its effect on the wastewater treatment system and the environment prior to issuance of a temporary permit and compliance schedule.

Any dilution of the wastewater by the user for the purpose of decreasing the concentrations of toxic materials shall be considered as a violation of this ordinance.

6.13 Discontinuance of Service for Failure to Comply - Failure to comply with the provisions of Article II shall be cause for the discontinuance of sewer or water service to the offending person. The procedure shall be as follows: A written notice, signed by the Superintendent, shall be delivered personally to the person then responsible for the offending use, outlining the conditions of the wastes which violate the City of Trenton ordinances. In the event that the person in charge will not accept the notice, it shall be conveyed by registered mail to the responsible person. The person notified shall have twenty-four (24) hours from the time of receipt of the notice, either personally delivered or received by registered mail, to correct the offending conditions. If correction is not made or a request for extension is not received by the City of Trenton within twenty-four hours, it shall be mandatory that water or sewer service shall be discontinued to the offending person without further notice. If a request for an extension of time is received by the City of Trenton within twenty-four (24) hours of the above notice and if circumstances are such that, in the opinion of the Superintendent, the best interest of the City of Trenton would be served by extending the time for correction of the offending condition, then he may grant an extension of time up to a maximum limit of thirty (30) days.

6.14 Responsibilities of the Person Discharging Waste - It shall be the responsibility of the person discharging industrial waste into the Trenton sewerage system to:

a. Build a control structure in the discharge line from his premises, immediately prior to the entrance of the discharge line into the Trenton sewerage system, suitable for the sampling and measuring of wastes. Plans for this structure must be approved by the City of Trenton. This requirement may be waived if deemed unnecessary by the City of Trenton.

   In the event that no special manhole is required, the control manhole shall be considered to be the nearest downstream manhole in the public sewer to the point at which the building sewer is connected.

b. Contact the Superintendent prior to operation changes which will materially alter the characteristics of the waste from the last prior sampling.

c. Make timely, periodic payments to the City of Trenton of surcharges for excessive loadings.

ARTICLE 7

MALICIOUS DAMAGE

7.1 No person shall maliciously, willfully, or negligently break, damage, destroy, uncover, deface, or tamper with any structure, appurtenance, or equipment which is a part of the wastewater facilities. Any person violating this provision shall be subject to immediate arrest under charge of disorderly conduct.

ARTICLE 8

POWERS AND AUTHORITY OF INSPECTORS

8.1 Duly authorized employees or agents of the City of Trenton bearing proper credentials and identification shall be permitted to enter all properties for the purposes of inspection, observation, measurement, sampling, and testing pertinent to discharge to the public sewerage system in accordance with the provisions of this ordinance.

8.2 While performing the necessary work on private properties referred to herein, the authorized employees or agents of the City of Trenton shall observe all safety rules applicable to the premises established by the company, and the company shall be held harmless for injury or death to the employees, and the City of Trenton shall indemnify the company against loss or damage to its property by said employees or agents and against liability claims and demands for personal injury or property damage asserted against the company, except as such may be caused by negligence or failure of the company to maintain safe conditions as required by this ordinance.

8.3 Duly authorized employees or agents of the City of Trenton bearing proper credentials and identification shall be permitted to enter all private properties through which the City of Trenton holds an easement for the purposes of, but not limited to, inspection, observation, measurement, sampling, repair, and maintenance of any portion of the wastewater facilities lying within said easement. All entry and subsequent work, if any, on said easement, shall be done in full accordance with the terms of the duly negotiated easement pertaining to the private property involved.

ARTICLE 9

COMPLIANCE WITH REGULATORY REQUIREMENTS

9.1 The provisions of this ordinance shall not be deemed as alleviating compliance with applicable state and federal regulations. Specific user charge and industrial cost recovery requirements, promulgated pursuant to Public Law 92-500, shall be considered as a part of this ordinance upon official adoption. All non-residential users will be required to comply with pretreatment standards as outlined in Title 40 of the Code of Federal Regulations, Part 403.

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ARTICLE 10

VIOLATIONS

10.1 Violations of this ordinance shall be a misdemeanor punishable under the laws of the State of Georgia. Each day of continuing violation shall be considered a separate offense. Any person violating any of the provisions of this ordinance shall become liable to the City of Trenton for any expense, loss, or damage occasioned the City of Trenton by reason of violation.

10.2 In the event of violation of this ordinance, the health officer or authorized employees may verbally instruct the owner as to the necessary corrective action. If the owner fails to carry out verbal instructions in a timely manner or if a serious violation or hazard to public health exists, the health officer or City of Trenton may issue to the owner a written order stating the nature of the violation, the corrective action, and the time limit for completing the corrective action. The record of the mailing of said notice or order shall be prima facie evidence thereof and failure of said owner or owners to receive same shall in no way affect the validity of any proceedings conducted pursuant to this ordinance.

10.3 Failure to comply with any written order duly issued by the health officer or City of Trenton pursuant to this ordinance will constitute a separate misdemeanor and upon conviction thereof shall be punishable as provided by the laws of the state. Provided further, that compliance with this ordinance is required notwithstanding the fact that a written order might not have been issued.

10.4 The violation of any provisions of this ordinance, as now existing or as may be hereafter amended, may be enjoined by instituting appropriate proceedings for injunction in the courts of competent jurisdiction in this state. Any public nuisance which is injurious to the public health, safety, or comfort may be abated by instituting appropriate proceedings for injunction in the court of competent jurisdiction in this state. Such actions may be maintained notwithstanding the fact that such violation also constitutes a crime, and notwithstanding that other adequate remedies at law exist. Such actions may be instituted in the name of the City of Trenton.

10.5 Upon the receipt of a notice of a violation of this ordinance and/or an order of the City of Trenton requiring an act or thing to be done or to cease, the owner or owners of any premises then in question may, in writing, demand a hearing before the City of Trenton to present the evidence challenging the validity of the City of Trenton's order. The owner may appear in person, by agent, or by attorney. Said demand must be filed with the Clerk of the City of Trenton and be made within five (5) days from the receipt of the order being challenged. Upon receipt of a demand for a hearing, the City of Trenton will set a date, time, and place for said hearing to be not less than twenty-one (21) days from the date of filing of said demand.

The hearing as provided herein shall apply to any customer's complaint, dispute, or challenge of the City of Trenton's rules, regulations, resolutions, ordinances, or policies. Upon customer's written complaint

filed with the clerk, the Municipality shall set a hearing as provided herein or at a time agreed upon by the parties.

10.6 Evidence before the City of Trenton of any hearing conducted pursuant to Section 9.5 herein shall be admitted in accordance with the rules of evidence of the superior courts of the state; provided, however, the City of Trenton may take official notice of any order, rule, regulation, or any other document, record, or entry contained in its official record or minutes for evidentiary purposes.

10.7 For the purposes of this ordinance, the decisions of the City of Trenton will prevail in any instance in which there is a conflict between it and the health officer on any issue of sanitation, or the lack of it, and its effect on human health or well being.

ARTICLE II

SERVICE CHARGES

11.1 It is hereby determined necessary to fix and collect sewer service charges from customers. Such charges shall be published separate from this ordinance and the revenue received shall be used for operation, maintenance, debt retirement, and other authorized expenses.

ARTICLE 12

AUTHORITY TO DISCONNECT SERVICE

12.1 The City of Trenton reserves the right to terminate water and wastewater disposal services and disconnect a customer from the system when:

a. Acids or chemicals damaging to sewer lines or treatment process are released into the public sewer causing rapid deterioration of these structures or interferring with proper conveyance and treatment of wastewater; or

b. A governmental agency informs the City of Trenton that the effluent from the wastewater treatment plant is no longer of a quality permitted for discharge into a watercourse, and it is found that the customer is discharging wastewater into the public sewer that cannot be sufficiently treated or requires treatment that is not provided by the City of Trenton as normal domestic treatment; or

c. The customer:

(1) Discharges industrial waste or wastewater that is in violation of the permit issued by the approving authority; or

(2) Discharges wastewater at an uncontrolled, variable rate in sufficient quantity to cause an imbalance in the wastewater treatment process; or

(3) Fails to pay monthly bills for sanitary sewer service when due; or

(4) Repeats a discharge of prohibited wastes into public sewers.

12.2 Notification processes for discontinuance of service are presented in Paragraph 6.13 of Article 6.

ARTICLE 13

CONFLICT WITH OTHER ORDINANCES

13.1 All ordinances or parts of ordinances in conflict herewith are hereby repealed.

13.2 The invalidity of any section, clause, sentence, or provision of this ordinance shall not affect the validity of any other part of this ordinance which can be given effect without such invalid part or parts.

13.3 In the event a wastewater discharge is made to a publicly owned treatment works (POTW) under the jurisdiction of an approved sewer use ordinance for another governing authority, the more restrictive requirement shall prevail.

ARTICLE 14

ORDINANCE IN FORCE

This ordinance shall be in full force and effect from and after its passage, approval, recording, the public welfare requiring it.

Passed and adopted by the Trenton City Council, Dade County, Georgia on the 9th day of July, 1984.

ATTEST:

A. T. Lawson
A. T. LAWSON, MAYOR CITY OF TRENTON

Louise E. Wright
RECORDER

John L. Warren
JOHN L. WARREN, COUNCILMAN

John Newsome
JOHN NEWSOME, COUNCILMAN

Joey Fisher
JOEY FISHER, COUNCILMAN

Robert McClure
ROBERT McCLURE, COUNCILMAN

APPENDIX P

SEWERLINE VISUAL INSPECTION PROCEDURE

Sewerline Visual Inspection Procedure

Identification

Identify and number each manhole on a map of the sewer system so that problems observed during the inspection can be located on the map. Also, any discrepancies between the map and actual sewerline construction should be corrected on the map at this time.

Safety

Manhole or sewerline inspection is hazardous work and extreme safety precautions should be observed at all times. Some of the hazards are toxic gases, physical injury, infections, chemicals, and drowning.

Manhole

Visual inspection of manholes involves both surface and internal inspection. Things to look for are surface drainage, holes in cover, leaks around cover or frame, condition of manhole walls and floor, leaks through walls or around pipes, and increased flows.

Sewerlines

Walk the collection system to locate sources of inflow. Particular attention should be given to sunken areas over the sewerline, areas with ponding water, and condition of sewerline at stream crossings.

Flow and Temperature

Flows can be measured or estimated and water temperature measured in each manhole to locate I/I areas. A sudden unexplained change could indicate surface or groundwater entering the system. This information can be used later to determine sections for conducting smoke testing.

Smoke Testing

Conduct smoke tests in the areas suspected of having I/I problems. However, smoke will not pass through pipes that have sags or water traps. Examples of I/I that can be identified with smoke testing are storm drain connection; holes in sewerlines; and roof, cellar, yard, and foundation drains.

Repairs

All sources of I/I identified in the inspection should be repaired. Material suppliers should be contacted for information concerning the methods and materials for the repairs.

General

For detailed information for correcting I/I problems, the following manual should be purchased at a cost of $18.00: Existing Sewer Evaluation and Rehabilitation, WPCF Manual of Practices No. FD-6.