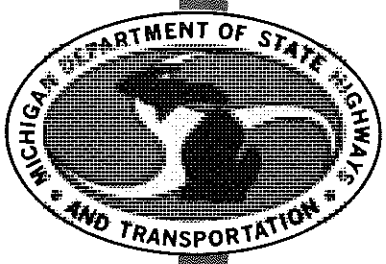
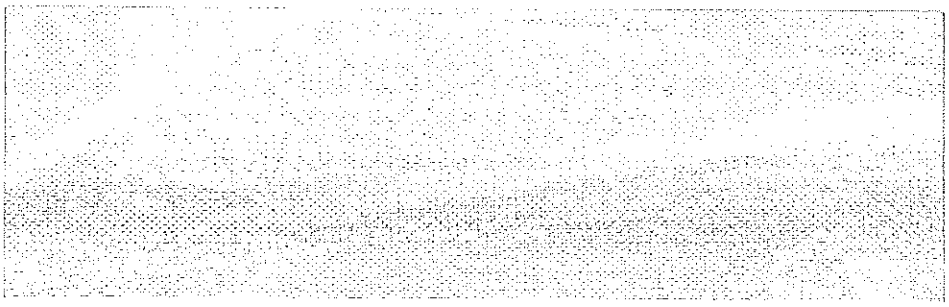
EXPERIMENTAL EVALUATION OF NO-DISCHARGE RECIRCULATING SEWAGE SYSTEM FOR FREEWAY REST AREAS (ON SOUTHBOUND I 275, NORTH OF MONROE)



TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION



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Experimental evaluation of
no-discharge recirculating
sewage system for freeway
rest areas (on southbound

EXPERIMENTAL EVALUATION OF NO-DISCHARGE RECIRCULATING SEWAGE SYSTEM FOR FREEWAY REST AREAS (ON SOUTHBOUND I 275, NORTH OF MONROE)

J. W. Bastian
G. Horton, Jr.
C. A. Zapata

A Category 2 project conducted in cooperation with the Roadside Development Section of the Design Division, the District Maintenance Personnel, the Research Laboratory Section of the Testing and Research Division, the National Sanitation Foundation, and the U. S. Department of Transportation, Federal Highway Administration.

Research Laboratory Section
Testing and Research Division
Research Project 75 G-212
Research Report No. R-1138

Lansing, March 1980

TABLE OF CONTENTS

ABSTRACT

During the past few years, highway agencies have shown increasing interest in experimenting with recirculating sanitary systems for highway rest areas with inadequate water supplies and/or where sewage disposal problems require special sanitary methods. One proprietary method with potential for solving these problems is the no-discharge, non-biological automatic recirculating sewage treatment called 'Aqua-Sans,' developed by the Chrysler Corporation. This proprietary treatment uses an odorless, colorless, non-toxic mineral oil instead of water for a flushing medium. This report discusses the initial performance of the Aqua-Sans Model D, with a treatment capacity equal to 20,000 gal/day of wastewater. The approach taken to attain this evaluation included weekly sampling and testing of the recycled oil system, detailed inspections, data collection, trouble-shooting of system components, and analysis of operating equipment including maintenance costs for the first-year study of the experimental installation. The preliminary results of this investigation indicate that, although the Aqua-Sans sanitary system can be designed and used safely in highway rest areas with low water supply or unsuitable soils, further improvements of the system components are needed to make the experimental unit more efficient and economical to operate. Such further improvements and some operational problems requiring additional evaluation will be discussed in subsequent reports to be written as needed.

The Problem

To install safe and efficient sanitary systems in rest areas with inadequate water supplies and/or soils unsuitable for on-site sewage disposal is a common problem facing highway agencies. In areas where septic tanks, leaching fields, or stabilization lagoons are discouraged or not permitted because of poor soil conditions or insufficient land, the sewage disposal problem becomes especially critical. One proprietary method with potential for solving this problem is the no-discharge, recirculating sanitary system called 'Aqua-Sans,' developed by the Chrysler Corporation.

For a flushing medium, the system uses an odorless, colorless, nontoxic mineral oil instead of water. When the toilet is flushed, the oil - sewage mixture flows into a settling tank where the oil separates from the sanitary waste (urine and accumulated solids). The flush oil (after passing through a series of filters and being chlorinated)[1] is recirculated to the toilets and the waste is discharged into a holding tank for final disposal to a municipal sewage treatment plant. The manufacturer claims that system operation is totally automatic and uses conventional toilets with minor modifications.

A performance evaluation of the Aqua-Sans recirculating sanitary system, 'Model D' is the main purpose of this investigation.

Background

Presently, several recirculating sanitary waste systems are available on the market for use in office buildings, construction sites, parks, recreational areas, and highway rest areas. Some of these systems such as Thiokol, Microphor, and Thetford use a closed-loop recirculating water treatment process. Other sanitary systems such as Interlink, Monogram, Sarmax, and Aqua-Sans use a permanent flush mineral oil rather than water to transport the sanitary waste. After comparing specifications, general characteristics, and cost information related to these sanitary systems, the Chrysler Aqua-Sans unit was chosen by the Michigan Department of Transportation (MDOT) for experimental evaluation. On October 8, 1976, the work plan for this project was approved by the Federal Highway Administration as a Category 2 experimental project. As a result, the Department was authorized to purchase the recommended Aqua-Sans unit, Model D, with a treatment capacity equal to 20,000 gal/day of wastewater, at an estimated cost of $61,000. Also, the Aqua-Sans unit was approved by both the Water Resources Commission of the Department of Natural Resources and the Michigan Department of Public Health, as an experimental installation.

[1] At the present time other means of disinfection are being used.

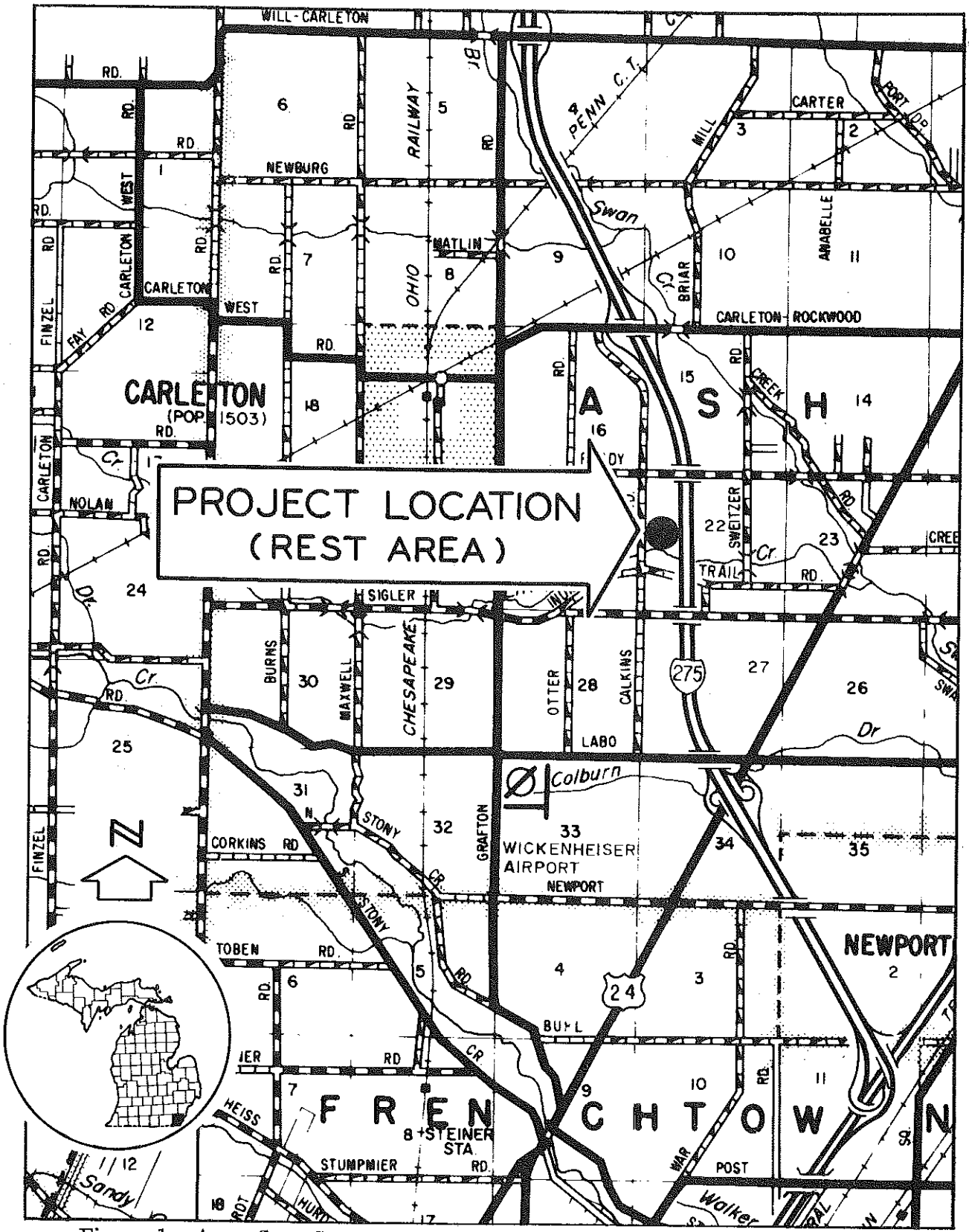


Figure 1. Aqua-Sans Sewage Treatment housed in the Carleton rest area on southbound I 275 in Monroe County.

On November 2, 1977, the National Sanitation Foundation (NSF) of Ann Arbor, Michigan, was contracted by the MDOT to conduct chemical and biological analyses of the recycled oil system at an estimated cost of $15,000.

The contract for the construction of the building housing the Model D Aqua-Sans unit was awarded to the Glenwood Construction Co. of Dearborn, Michigan. On December 26, 1977, the new rest area located on southbound I 275, Monroe County, was opened to the traveling public. On March 28, 1978, the NSF began sampling and testing the experimental installation.

Research Objectives

Specifically, this investigation was designed to:

1) evaluate the recirculating sanitary unit with regard to performance,

2) gain experience with this type of system from a maintenance standpoint,

3) evaluate costs associated with the construction and maintenance of the experimental sanitary unit compared with conventional sanitary systems now used in highway rest areas, and

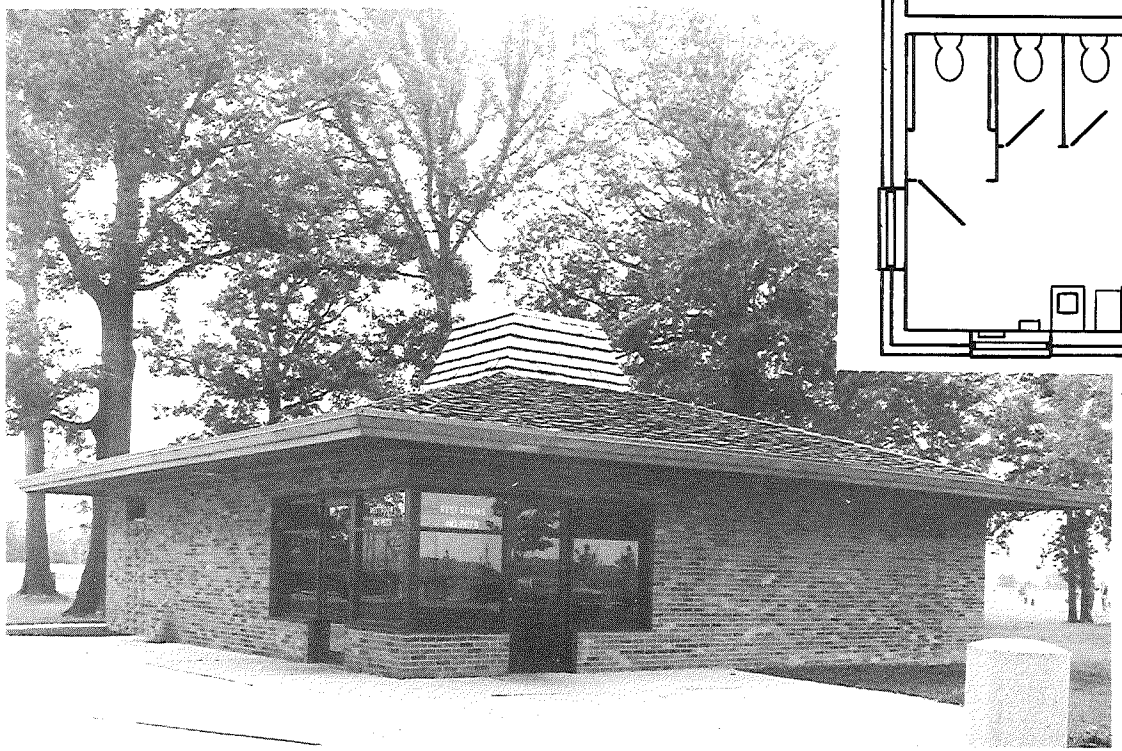
4) assess the potential of this type of sanitary system for future use in areas having problems with inadequate water supply or soils unsuitable for on-site sewage disposal.

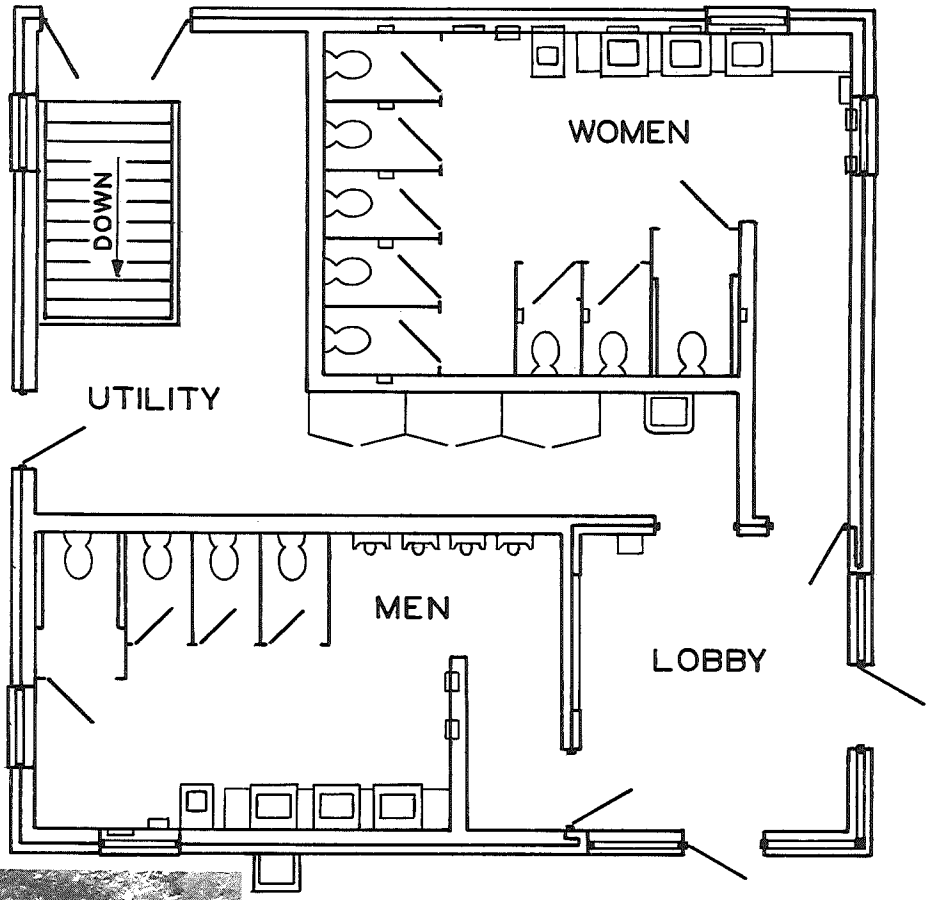
The experimental work was conducted according to Work Plan No. 46 (Research Project 75 G-212) approved by the FHWA as Experimental Highway Construction, Category 2.

Project Location

The rest area is located on southbound I 275 about 1/4 mile north of Indian Trails Rd, Monroe County (Fig. 1). The project site is hampered by a minimal water supply, heavy soils, and very strong local objection to an on-site sanitary lagoon system. The Aqua-Sans sewage disposal system is serving twelve conventional toilets and four urinals within a floor area of 1,300 sq ft. Figures 2 through 4 show the restroom fixtures, basement plan view, and equipment layout. The waste from the holding tank will be periodically hauled away to a sewage treatment plant at the city of Monroe. Drinking water will be supplied by a low capacity groundwater well and wastewater from wash basins will be discharged into a tile disposal field at the project site.

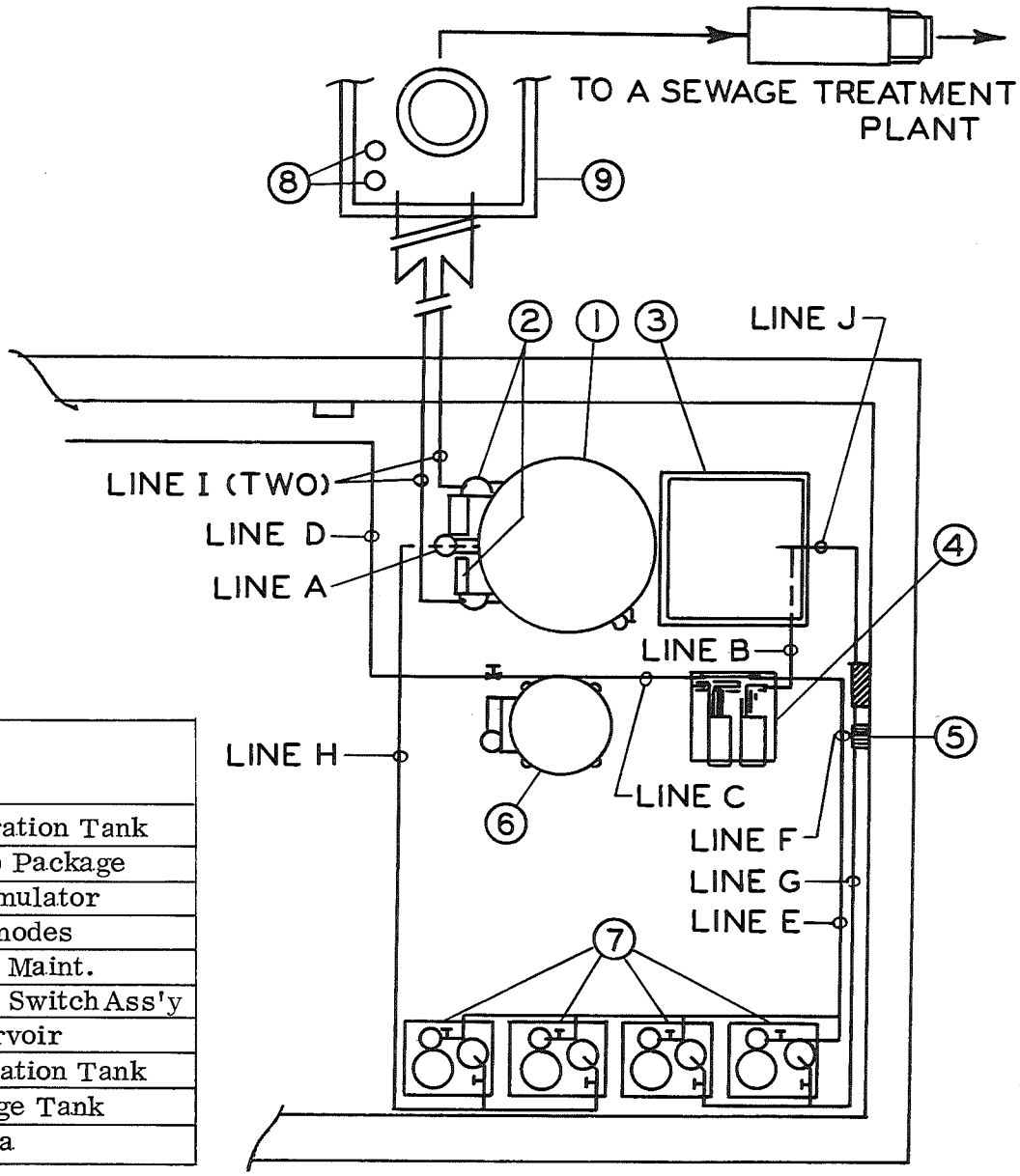
Figure 2. The Carleton rest area, housing the experimental Aqua-Sans sanitary unit, is a modern building equipped to service the traveling public including handicapped people. Besides women and men restrooms, it has a lobby with a drinking fountain.





LEGEND

① CONICAL SEPARATION TANK
② MACERATOR PUMP ASSEMBLY
③ RESERVOIR TANK
④ FLUID PUMP ASSEMBLY
⑤ PRESSURE SWITCH ASSEMBLY
⑥ AIR-PRESSURIZED ACCUMULATOR
⑦ FLUID MAINTENANCE SKID
⑧ LEVEL SENSORS
⑨ STORAGE OR HOLDING TANK



Line No.	Description	From	To
A	Waste Inlet	Commodes	Separation Tank
B	Pump Suction	Reservoir	Pump Package
C	Pump Discharge	Pump Package	Accumulator
D	System Supply	Accumulator	Commodes
E	F. M. Supply	Pump Package	Fluid Maint.
F	Pressure Switch	F. M. Supply	Pres. Switch Ass'y
G	F. M. Return #1	Fluid Maint.	Reservoir
H	F. M. Return #2	Fluid Maint.	Separation Tank
I	Mac. Discharge	Macerator	Storage Tank
J	System Vent	Separation Tank	Cupola

Figure 3. Basement plan view of the Aqua-Sans Model D unit with description of main equipment and flush fluid lines.

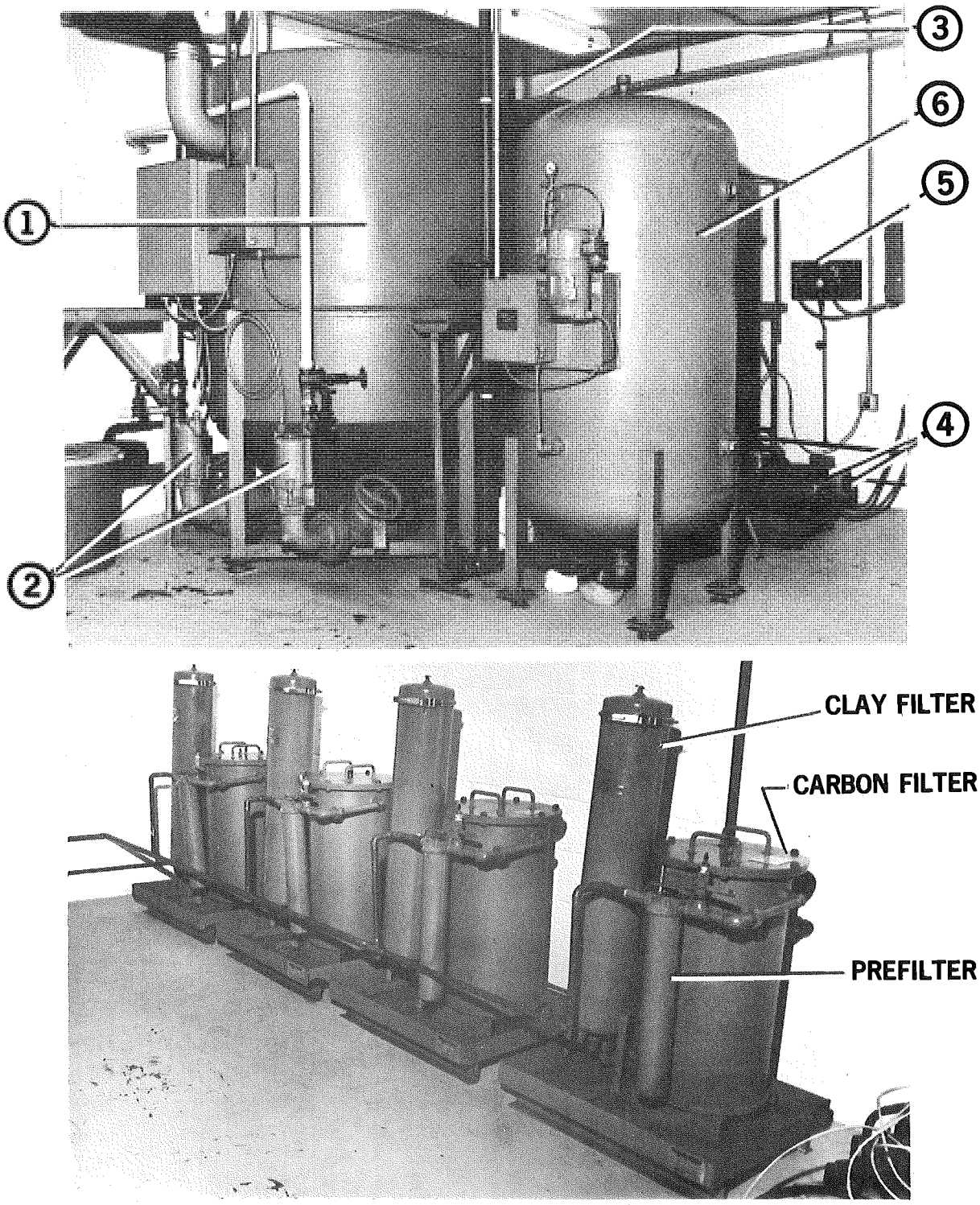


Figure 4. Main components of the Aqua-Sans Sewage Treatment include: 1) a separation tank, 2) two macerator pumps, 3) a reservoir for the separation tank, 4) two fluid pumps, 5) pressure switch assembly, and 6) an air-pressurized accumulator. The lower photo shows four fluid maintenance units, each one with a prefilter, carbon filter, and clay filter.

Research Procedure

The performance evaluation of the Aqua-Sans unit required weekly sampling and testing of the recycled oil system, routine inspections, data collection and analysis of operations, including maintenance costs for the first-year study of the experimental installation.

Process Description

Figure 5 shows a flow diagram of the sewage treatment process. The Aqua-Sans Model D recirculating sanitary system is designed to flush restroom fixtures by using a mineral oil (flush fluid) to transport the waste in the oil flush medium from conventional toilets and urinals to a 770-gal settling tank where the dense water or black water (feces, urine, toilet paper, foreign matter) separates and settles while the light mineral oil rises to the top. As the waste volume and flush fluid increase in the separation tank because of toilet usage, the flush fluid passes through four filters which coalesce and further remove any entrained waste while providing support for chlorine tablets used for disinfecting the flush medium (Fig. 6). The disinfected flush fluid then flows over a weir, through six bag filters into a 915-gal reservoir tank (Fig. 7). The bag filters remove any remaining suspended particles.

Flush fluid is recirculated to the toilets and urinals by a fluid pump-accumulator system operated by a pressure switch. The hydro-pneumatic accumulator prevents pressure surges and provides extra flow during peak demand periods. The quality of the recycled flush fluid is maintained by by-passing each hour about 25 percent of the total flush fluid through a system of prefilters, adsorptive carbon pack filters and clay filters (Fig. 8). They remove fine particles, dissolved contaminants, surface-active agents, color bodies, and odor producing impurities. The filtered flush fluid is then pumped back to the reservoir for reuse. When sufficient waste accumulates in the settling tank, a waste sensor activates a macerator-pump assembly and transports a given amount of waste to a 3,000-gal vault or holding tank. The holding tank at the Carleton rest area was periodically pumped out and the waste disposed of at the Monroe sewage treatment plant.

The Aqua-Sans Model D unit is designed to operate continuously and to perform its task automatically. It has a treatment capacity equal to 20,000 gal/day of wastewater equivalent to 4,200 transient uses per day, according to the manufacturer. However, its automatic operation can be stopped by certain unexpected problems such as build-up of waste in the separation tank, plugging of discharge lines, improper pump cycling time, stuck toilet mechanisms, and power failures. Specifications for Aqua-Sans Model D are given in Appendix A.

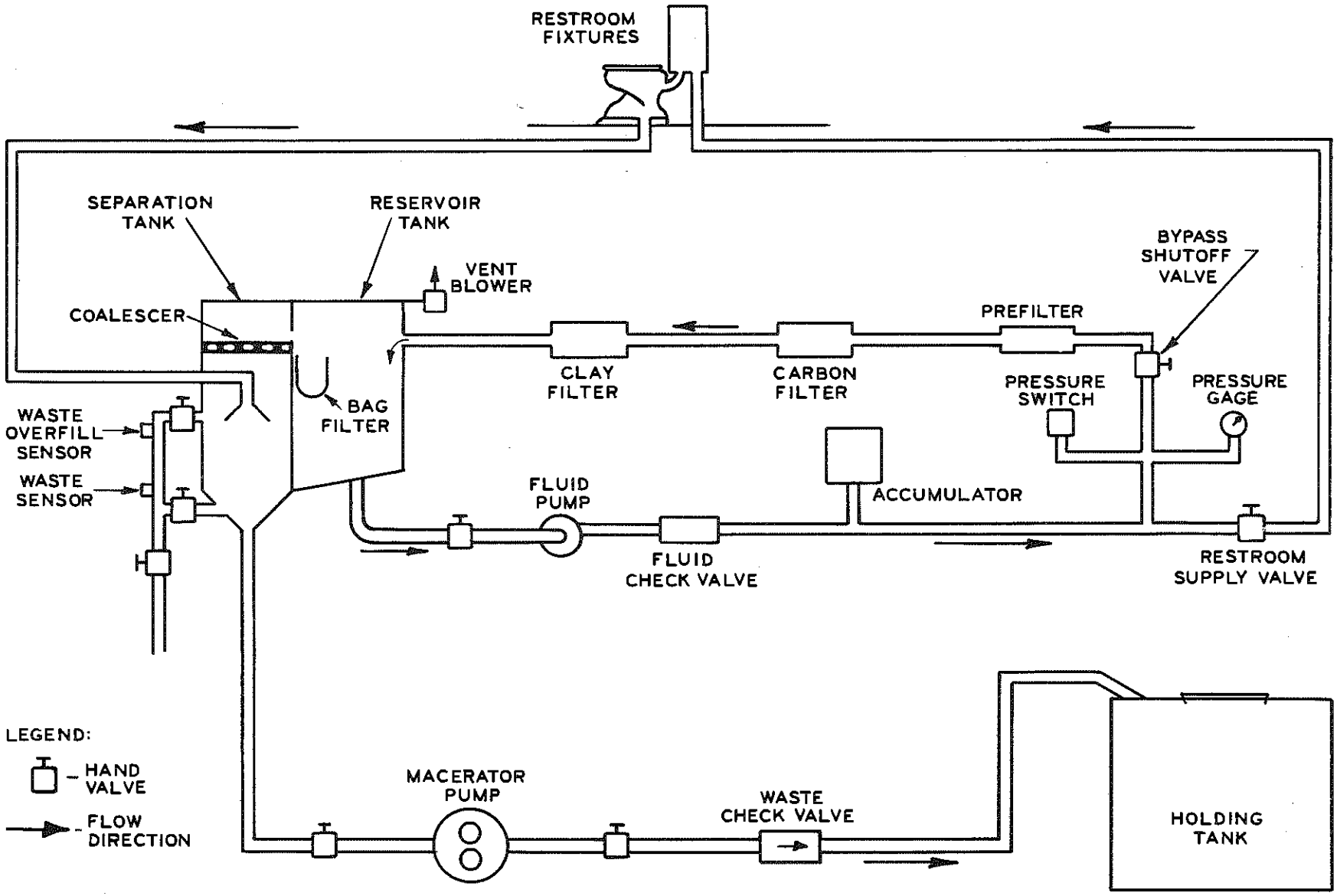


Figure 5. Schematic flow diagram for Aqua-Sans Sewage Treatment Model D.

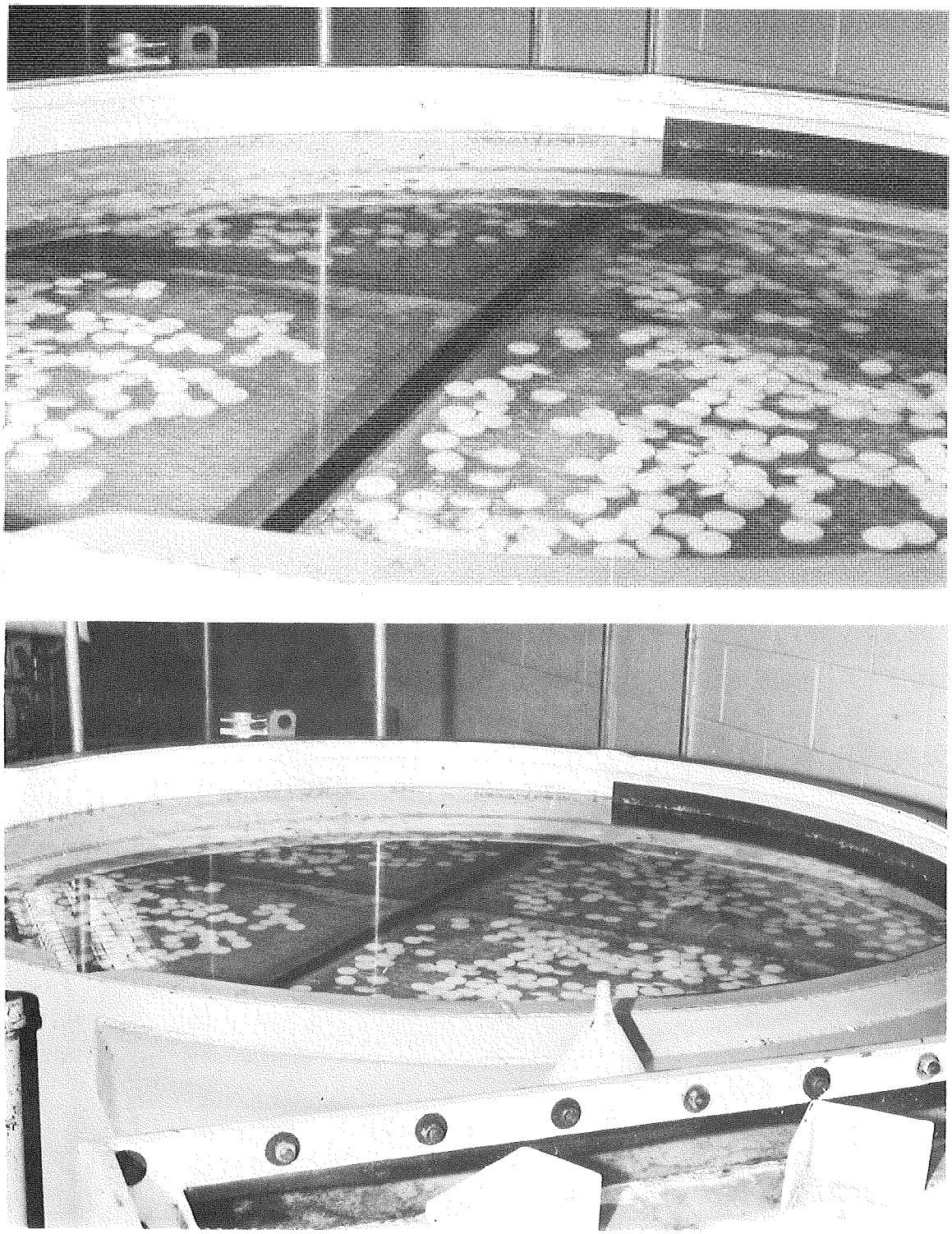


Figure 6. As the flush fluid rises to the top of the separation tank, it passes through fiber-type coalescer filters which remove any entrained waste. Then, the flush oil is treated with chlorine tablets for disinfection and odor control.

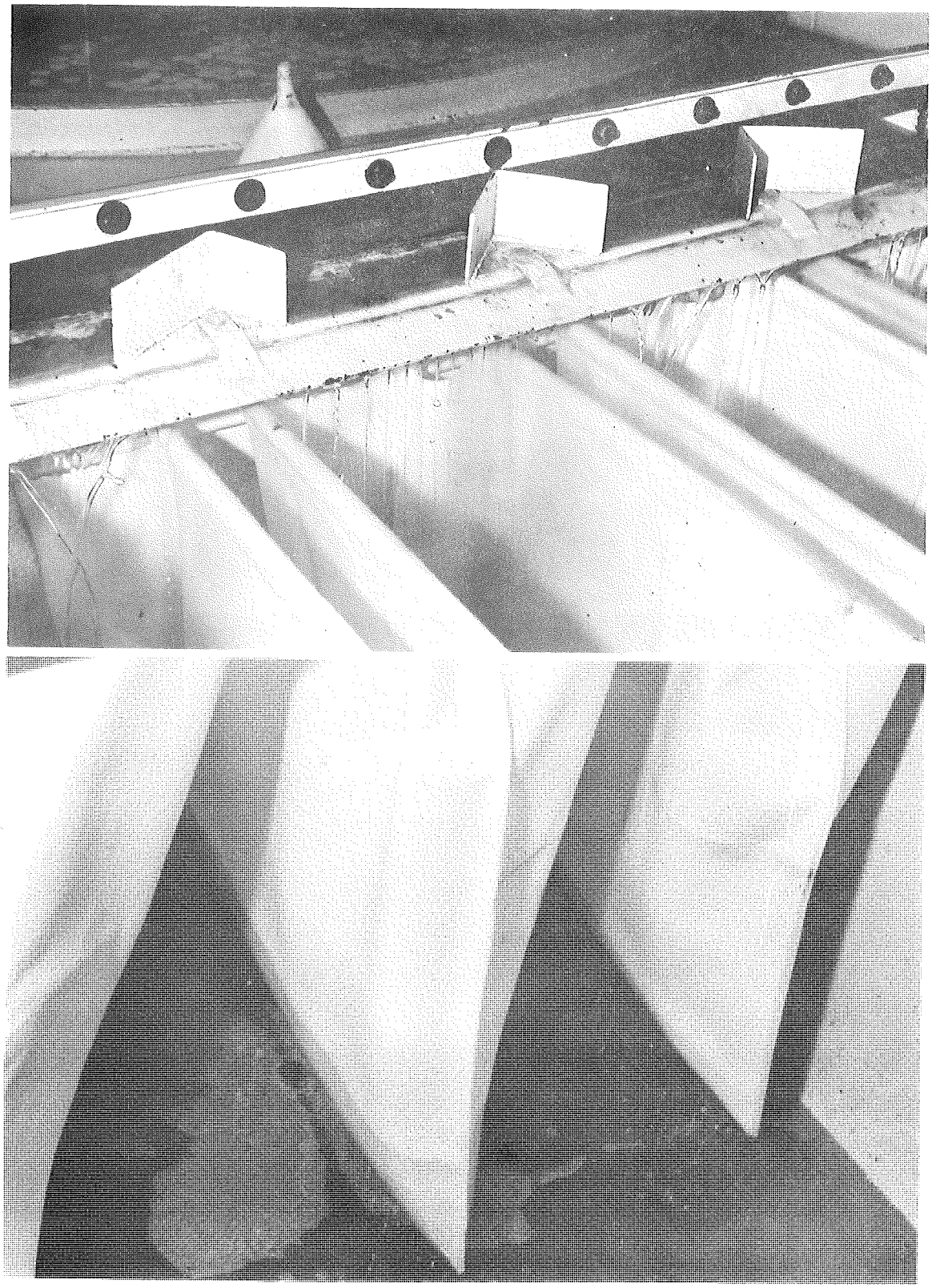
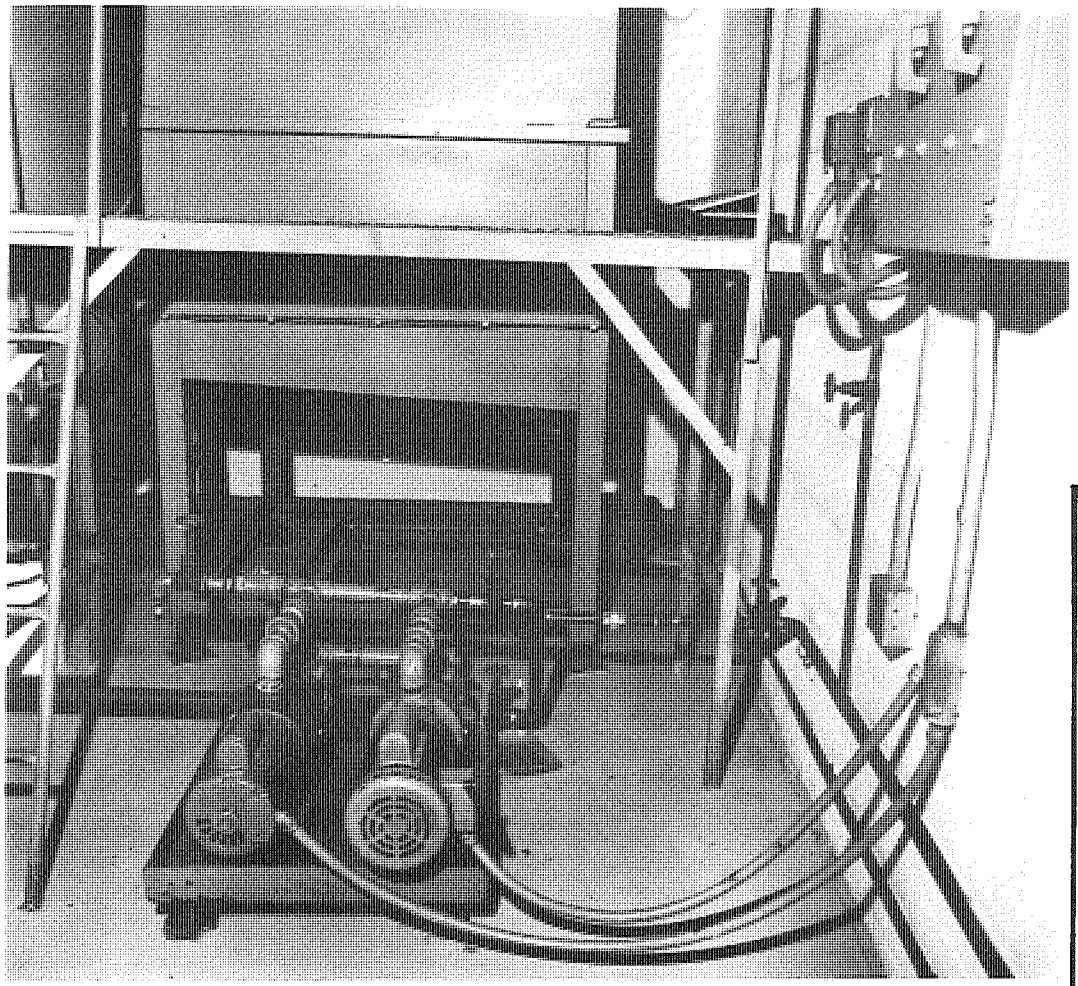


Figure 7. From the separation tank, the disinfected flush oil flows over a weir through bag filters into a 915 gal reservoir tank.



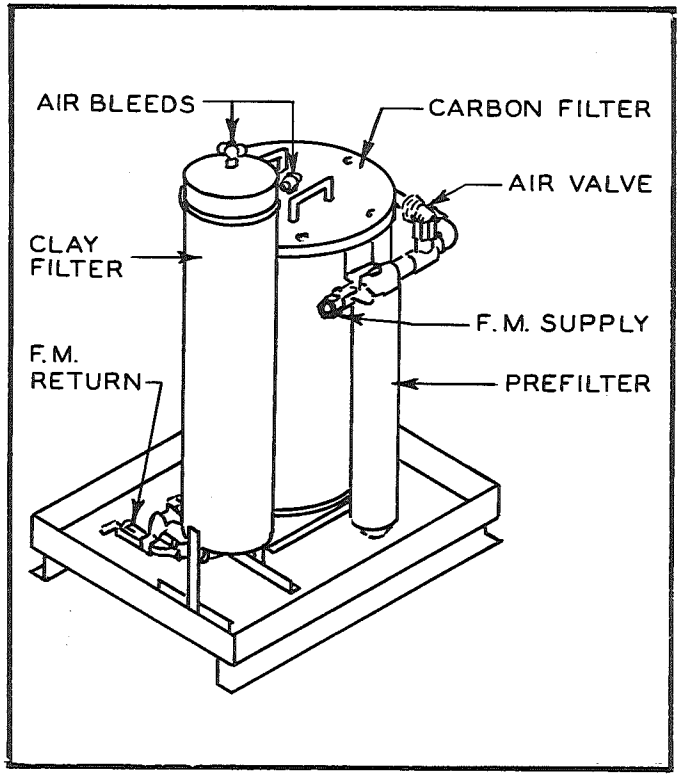


Figure 8. From the reservoir tank, 75 percent of the flush oil is recirculated to toilets and urinals by a fluid pump-accumulator system (above). The remaining 25 percent of the flush oil passes through four maintenance units, each one with a prefilter, carbon filter, and clay filter, before being pumped back to the separation tank and reservoir for reuse (right).

The NSF Evaluation

On March 28, 1978, the National Sanitation Foundation began a weekly sampling schedule of the Aqua-Sans wastewater treatment system. It was completed November 13, 1978. Samples of the flush medium were collected for analysis of turbidity, color, total coliform, and odor. Appendix B summarizes sampling schedule, test procedures, and laboratory results presented in the NSF final report (1). Suspended solids and residual chlorine were not tested because they could not be accurately measured in the oil medium. Visual inspections of the restrooms were conducted during each sampling to determine any adverse aesthetic conditions or hazards such as excessive oil splashing, foaming, or offensive odors from toilets or urinals. None of these were found during each monitoring visit. The final NSF report covering eight months of testing and evaluation, concluded that the Aqua-Sans unit was capable of complying with the requirements of Michigan Department of Public Health by providing a hygienically safe and adequate wastewater treatment at the Carleton rest area.

Operational and Maintenance Problems

During the 17-month test period (December 26, 1977 to May 21, 1979) the Aqua-Sans unit developed four major operational problems which required the rest area to be closed for periods ranging from two hours to two days. These were:

1) leaking spud gaskets and 'O' rings,
2) malfunctioning oil flow meters,
3) burned-out fluid pump motors, and
4) plugged separation tank and lines.

Furthermore, several minor breakdowns which did not require closing the building included:

1) overloaded circuit breakers,
2) plugged macerators,
3) leaks in plumbing lines,
4) fouled sensors.

All repairs were made by either Monroe County Road Commission personnel, the rest area coordinator, or the State mechanical crew.

Routine maintenance required replacing bag filters, coalescer units, and chlorine tablets used for disinfection; changing prefilters, carbon and clay filters every three to four months as recommended by the manufac-

turer or dictated by use. Also, some replenishment of the mineral oil was necessary. Furthermore, the sewage treatment required regular mechanical and electrical inspections for assurance of normal operation (2). Appendix A shows a daily inspection guide for the Aqua-Sans unit. Progress reports dealing with the Aqua-Sans operational problems are included in Appendix C.

Cost Comparison

The cost information in Appendix C (page 37) for the first year of Aqua-Sans operations shows that:

1) Nine days of extra work were required due to breakdown problems for a total of $756.00.

2) About 550 gal of mineral oil at $1.99/gal were used for a total cost of $1,094.50.

3) The disposal service of 14,445 gal of waste at contract cost of $42.00/1,000 gal amounted to $580.00.

4) Annual operating and maintenance costs of the Carleton (I 275) and the Willoughby rest areas (US 127), both areas with comparable traffic, amounted to $44,556 and $33,502, respectively.

Conclusions and Recommendations

1) During the initial eight-month test period by the National Sanitation Foundation, the NSF concluded that the Aqua-Sans system was capable of complying with public health standards by providing a hygienically safe flush fluid with no objectionable odors; no objectionable color; no substantial foaming; low turbidity and chemically and physically stable fluid with minimum bacterial count.

2) Although the Aqua-Sans sewage treatment system was designed to operate automatically and continuously, its operation was stopped by certain major problems such as leaking spud gaskets and 'O' rings in the urinals and toilets, malfunctioning oil flow meters caused by the use of chlorine, burned out fluid pump-motors, and plugged separation tank and fluid lines. These operational problems required that the rest area be closed for periods ranging from two hours to two days requiring a total of nine man-days of extra work.

3) Several minor problems were corrected, without closing the facility, such as circuit breaker overloads, plugged macerators, leaking plumbing lines, and fouled fluid sensors.

4) Operational and maintenance costs of the experimental sanitary unit were higher than that for a conventional sanitary rest area with comparable traffic. Whereas the Aqua-Sans unit with a treatment capacity equivalent to 20,000 gal/day of wastewater required an initial capital outlay of $61,000, the annual operating and maintenance cost for the unit was over $11,000 higher than the Willoughby rest area, a conventional facility with comparable use.

5) Although the Aqua-Sans unit can be designed and used safety in areas with low water supply or unsuitable soils, further improvements of the system components are needed to make the unit more efficient and economical to operate. Such further improvements and some operational problems requiring additional evaluation will be included in subsequent reports.

REFERENCES

1. "Chrysler Aqua-Sans Model "D" Sewage Treatment System," Final Report, National Sanitation Foundation, April 5, 1979.

2. "Aqua-Sans Sewage Treatment System," Operation and Service Manual, Chrysler Corporation, March 1977.

3. American Public Health Association, et al, "Standard Methods for the Examination of Water and Wastewater," 14th Edition, 1975.

4. National Sanitation Foundation, "National Sanitation Foundation Standard No. 41 for Wastewater Recycle/Reuse and Water Conservation Devices," November 1978.

APPENDIX A

SPECIFICATIONS FOR AQUA-SANS, MODEL D
AND
AQUA-SANS DAILY INSPECTION GUIDE

SPECIFICATIONS

AQUA-SANS
SEWAGE TREATMENT SYSTEM
(Model D)

Application - Sewage Treatment

Type of Operation - Separation System - Automatic

Rating
- 44 restroom fixtures
- 600 people nominal
- 4200 uses per day

Capacity
- 240 gallons of raw, undiluted human waste per day
- 1500 gallons of flush fluid and 20,000 GPDE

Temperature - 40° F to 140° F ambient

Power Requirements
- Voltage selected by customer
- 17 KVA service
- 68 KW-Hr. per day consumption

Overall Dimensions (Excluding Working Areas)

	Separation Tank	Fluid Skid	Pump/Acc.	Holding Tank
Drawing No.	D30000	B40300	B45200/D46000	D70000
Width, inches	148	34	72	40
Depth, inches	65	30	45	54
Height, inches	96	48	80	96
Weight, dry	3400	310	245/1000	1170
Weight, wet	11450	555	255/2000	5300

AQUA-SANS
DAILY INSPECTION GUIDE

General Observation	- Observe the system for any evidence of unusual noise, odor, vibration, or leakage. Locate the cause of any such problem. Consult the Trouble-shooting Section for solutions to problems.
Controls	- Verify that all switches and circuit breakers are properly positioned, that no warning or failure lights are illuminated.
Operation	- Determine that system pressure is normal (30 to 50 psig range) and that the primary fluid pump is cycling on and off with normal frequency. Check the interface level in the sensor column. Verify that the by-pass valves are open.
Flush Fluid	- Verify that the flush fluid is clear and odor free and that adequate fluid is available to the reservoir.
Restrooms	- Confirm that the restrooms are in order and that all fixtures are working properly. Correct any malfunctions.

APPENDIX B

NSF WEEKLY SAMPLING SCHEDULE, NSF EVALUATION METHODOLOGY, AND NSF SUMMARY OF DATA

NATIONAL SANITATION FOUNDATION (NSF)
Michigan Highway Study (Carleton Rest Area, Southbound I 75, Monroe County)

Weekly Sampling Schedule

Phase	1					2															3																					
Month	M	APR				MAY					JUNE				JULY					AUG				SEPT				OCT					NOV										
Week Commencing	27	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13							
Sample	X	X	X	X		X		X		X		X		X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							

Phase I - Sampling frequency to be 3 X per week as follows: Sunday, 4 p.m. approximately; Tuesday and Thursday, 11 a.m. approximately.

Phase II - Sampling frequency to be 2 X per month on a Monday at 11 a.m. approximately.

Phase III - Sampling frequency as in Phase I.

NSF EVALUATION METHODOLOGY

The NSF staff collected all samples from the unit at the Carleton Rest Area and performed all analyses at the NSF Laboratory. Samples were collected from a valve placed in the fluid return line between the pump and the reservoir tank. Sample collection and handling techniques were in accordance with procedures in "Standard Methods for the Examination of Water and Wastewater" (3).* Analyses performed on the recycle fluid were turbidity, color, total coliforms, and odor. Odor was evaluated by a trained odor panel at the NSF laboratories. Suspended solids and residual chloride were not measured because they could not be accurately measured in the oil medium.

During each monitoring visit made by NSF for all three phases, a subjective visual observation was made for aesthetic conditions in areas adjacent to the toilet bowls and urinals (in situ). The observations were in terms of 'none, slight, heavy, or offensive' for odor and splashing. Because mineral oil is used as a flush medium, these observations were important to determine whether any hazards such as slippery floors or noxious odors existed that could pose a threat to the user.

During the eight months of operation and evaluation, the Aqua-Sans Sewage Treatment System was capable of reliably producing a reusable flush medium whose applicable physical and aesthetic characteristics, although not evaluated under the provisions of NSF Standard No. 41 (4), were within the limits of the appropriate requirements in the standard. The laboratory results are summarized in Table B-1. Table B-1 also contains corresponding limits established in Standard No. 41.

Turbidity was measured on a Hack Model 2100A turbidimeter, with unused flush medium as a blank. The turbidity of the recycled mineral, expressed in nephelometer turbidity units (NTU) for all samples was less than 2.5 NTU. NSF Standard No. 41 states that for a wastewater recycle/reuse device turbidity must be equal to or less than 90 turbidity units for 90 percent of the samples collected.

Color

Color of the mineral oil was determined with a Hellige Aqua Tester using unused flush medium as a blank. All 68 samples analyzed were measured at less than five units (detector limit of technique). Color occasionally developed that was slightly greater than zero units, but definitely less than five units.

* References follow text of report.

Total Coliforms in the Flush Medium

Total coliform analyses were performed by replicate extractions of 25 milliliters of the flush medium with 11 milliliters of Trypticase Soy Broth (TSB), centrifuging the emulsified mixture at 2,000 rpm for 20 minutes, followed by standard Millipore filter analysis of the TSB for total coliforms. Of the 68 samples analyzed, only one had a positive result. The count for that sample was one total coliform extractable per 100 milliliters. All other samples had a count of <1 extractable per 100 milliliters. NSF Standard No. 41 requires total coliform levels for recycle/reuse flush fluid to be equal to or less than 240 per 100 milliliters.

Tested Odor

Odor from the oil was evaluated to determine the aesthetic acceptability of the flush medium. Organoleptic testing is done routinely at NSF in the plastics and wastewater program. A panel of 10 to 15 people, screened and trained in odor testing, individually entered a room of 10 by 12 ft containing a battery jar which contained 500 milliliters of a flush medium. Panelists were asked to determine whether odor emanating from the oil would be acceptable or unacceptable in their home bathrooms. Of the 68 tests conducted, only one was considered unacceptable (fail). NSF Standard No. 41 requires the recycled fluid odor to be nonoffensive.

Odor In Situ

Odors emanating from the toilet bowls and urinals at the Carleton Rest Area were judged as either none, slight, heavy, or objectionable with the oil standing in the bowl and during the flush cycle. For the 68 inspections made at the Carleton Rest Area, the minimum observations made were 'none' and maximum observations, 'heavy.' Observations of 'heavy' odors corresponded to the ends of routine maintenance cycles; i.e., just prior to change of filters.

Splashing In Situ

Splashing of flush fluid around the toilet bowls and urinals was evaluated at the same time as odor in situ. The range of observations for the evaluation period was a minimum of 'none' to a maximum of 'slight,' with a majority of observations being 'none.' The degree of splashing is partially dependent on the frequency of restroom cleaning. Adequate cleaning will preclude any slipping hazard or unacceptable aesthetic considerations caused by splashing.

Flow

Oil flow as measured by flow meters in the accumulator line is representative of the number of uses of the toilets and urinals. The average

daily flow for the month of September was 5,050 gal, with a minimum of 2,970 gal and a maximum of 6,160 gal. Assuming all flow was the result of toilet flushes and a volume of 4.75 gal/flush, the maximum number of flushes per day was 1,396. This value falls well within the range of the Aqua-Sans System's capacity of 4,200 transcient uses per day.

TABLE B-1
NSF SUMMARY OF DATA

Parameter	Mean	Minimum	Maximum	NSF Standard No. 41[1]
Turbidity in NTU	0.26	<0.10	2.5	≤90
Color Units	All Values Less Than 5			N/A
Total Coliforms Extractable in no./100 ml	<1	<1	1[2]	≤240
Test Odor, pass/fail	Pass	Pass	Fail[2]	Non-offensive
Odor in situ [3]	Slight	None	Heavy	Non-offensive
Splashing in situ[3]	None	None	Slight	N/A
Flow in GPD	5,050	2,970	6,160	N/A

[1] Not to be exceeded in 90 percent of the samples.

[2] Occurred only once.

[3] Measurements are actual observations. Expressed in terms of none, slight, heavy, or offensive.

APPENDIX C

AQUA-SANS MAINTENANCE REPORT NO. 1,
AQUA-SANS MAINTENANCE REPORT NO. 2,
AQUA-SANS MAINTENANCE REPORT NO. 3, AND
AQUA-SANS SUPPLEMENTAL MAINTENANCE REPORT

OFFICE MEMORANDUM

DATE: January 8, 1979

TO: T. R. Wiseman
Engineer of Maintenance

FROM: G. E. Langen
District Maintenance Engineer

SUBJECT: Maintenance - Carleton Rest Area Aqua-Sans Unit (Report No. 1)

On Thursday, January 4, 1979, the Aqua-Sans unit at the Carleton Rest Area was shut down to clean out the separation tank. The work was done by our rest area coordinator and Monroe County personnel. It was a very nasty job.

Several problems were discovered which adversely affect the operation of this system. These are described below with a recommended correction.

Problem #1

Accumulation of solid waste above the sensor level. This caused the sensor to malfunction, making automatic cycling impossible. For the last six weeks pumping of separation tank was done manually. The solids in the tank contain much foreign matter which tend to compact and inhibit the flow to the macerator pumps. Items which are especially bad are undergarments, sanitary napkins, tampon sleeves (plastic), and plastic packages.

Recommendation: A filter trap should be designed to trap out junk items. Human waste and paper are no problem.

Problem #2

Pump cycle of macerators appears to be much too short on automatic cycle. The original timing of the macerators was set at 45 seconds. The actual testing of this automation after complete cleaning of the separation tank resulted in the following:

On automatic, #2 pump ran for 25 seconds; #1 pump then came on and ran 15 seconds with #2 pump. This actually resulted in 55 seconds of total pump operation. In this time, 0.05 ft of waste was pumped into the holding tank. This computes to be approximately 30 gallons. From previous pump out of the separation tank (using water only) it was found it took three minutes and twenty seconds to completely empty the separation tank below the sensor level. This put 0.3' in the holding vault, or approximately 135 gallons of waste. Therefore, the present automated setting is pumping only 25% of the waste capacity each time it cycles. The problem created is that only liquids are pumped off. Solids remain, accumulate, and eventually make the automation malfunction.

Recommendation: Retime the automated cycle. It appears it should be at least two and one-half minutes to make sure solid waste gets pumped along with the liquid.

Problem #3

Discharge lines from the macerators plug and are difficult and messy to clear. When these plug, the macerators do not grind the solids and the solid waste backs up.

Recommendation: To prevent this plugging, elimination of right angle elbows in the discharge line might help. Also, cleanouts where water can be forced into the line would be most useful. This would make necessary a water source other than the present pressure tank drain outlet which is now being used.

If these three problems (waste accumulation, pump cycling time, and line cleanout) can be resolved, the Aqua-Sans should work satisfactorily with only routine maintenance.

Local and district personnel are not equipped to make the recommended corrections. Therefore, I am requesting that Lansing personnel assist us in getting the Aqua-Sans running on an automatic basis. It is now being operated manually.

Attached are copies of pictures made during the recent cleanout operation. Captions detail the work procedures and equipment involved.

/s/ G. E. Langen
District Maintenance Engineer

GEL/GH/ljr
Attachments

cc: J. Burton
C. Horning

MAINTENANCE REPORT (NO. 2)

CARLETON REST AREA AQUA-SANS SYSTEM

Purpose:

This report details the maintenance of the Aqua-Sans sewage treatment system installed at the I-275 Carleton Rest Area in Monroe County. It covers the period from its opening on December 26, 1977, through January 5, 1979.

Summary:

During this twelve month period, the system was monitored daily and maintained by the Monroe County Road Commission.

Four major problems developed in the system in 1978 which required the building to be closed for periods ranging from two hours to two days. These were:

1. Leaking spud gaskets and "0" rings.
2. Malfunctioning oil flow meters.
3. Burned out fluid pumps and motors.
4. Plugged separation tank and lines.

In addition, there were several minor breakdowns which did not require closing the building. These included:

1. Circuit breaker overloads.
2. Plugged mascerators.
3. Leaks in plumbing lines.
4. Fouled sensors.

All repairs to the system were made by either Monroe County personnel, the District 8 coordinator, or the State Mechanical Crew. There was also considerable cooperation between Construction and Design people, as well as the supplier, the Chrysler Corporation.

History of Maintenance Operation:

Carleton Rest Area Aqua-Sans system was placed in operation on November 16, 1977. During the first month of operation the contractor, Glenwood Construction, operated the system while completing work on the rest area.

On December 21, 1977, the final inspection of the building was held and maintenance of the Aqua-Sans system was turned over to the Monroe County Road Commission. The rest area was opened to the public on December 26, 1977.

Maintenance Problems and Solutions:

Problem #1 - The first problem encountered with the Aqua-Sans was leaks. The spud gaskets on the toilets and urinals disintegrated. This was due to the mineral oil eating up the rubber gasket material. These spud gaskets were replaced with neoprene ones obtained through the Sloan Valve Company. When the gaskets were replaced, braces were also installed on the valve tail pieces to strengthen them and make them less susceptible to misuse. Flip-up seats were also installed to help protect the valves and tail pieces.

Problem #2 - Stoppage of oil flow from the fluid pumps to the cartridge filters shut down the system. The cause of the stoppage was a frozen oil flow meter. Meters were installed to measure the quantity of oil used while the National Sanitation Foundation ran their tests of the system. These flow meters were constructed of metal which corroded and froze up. The chlorine used to sanitize the oil was the corrosive agent. When the meters became inoperative, they restricted the oil flow and the pressure system malfunctioned. To correct this, the oil meters were removed from the system and never replaced.

Problem #3 - Shortly after the flow meters were removed, the first fluid pump froze up and the motor burned out. This was replaced with the spare supplied by Chrysler Corporation, the Aqua-Sans supplier. Within a few days, the second motor burned out. This, too, was replaced. No other problems have developed with the fluid pumps. However, occasionally circuit breakers throw out when both the fluid pumps and the accumulator pump start up at the same time. This problem has not been resolved.

Problem #4 - The most severe and frustrating problem was the plugging of the separation tank with solid waste. To correct this, the separation tank was completely cleaned out after removing the coalescer and waste inlet cone. The accumulation of paper, diapers, underclothing, and other debris which had collected above the cone were pumped through the macerators after much stirring and diluting. This buildup was caused by too short of an automatic pump cycle. At the original setting of 45 seconds, only liquid was being removed from the separation tank. The pump cycle was increased to 75 seconds; and, to date, the automatic cycling has worked satisfactorily with no accumulation of solids.

These were the major problems. Others of lesser concern were plugged macerators, oil leaks in plumbing lines, and circuit breaker overloads. These were corrected by either Monroe County forces or our rest area coordinator.

System Improvements:

Some additions and changes were made in the system which improved maintenance and safety. These included construction of a catwalk to service the separation and filter tanks. Also, replumbing of the discharge lines from the macerators with smoother curves and flush out fittings made cleaning the lines much easier.

Waste Storage and Disposal:

The storage of the semi-solid waste pumped from the system has become a routine maintenance activity. When the system was first made operational, the 3,000 gallon holding vault was not watertight. Both surface and subsurface water infiltrated the vault. To correct this, the inspection cover was raised to prevent water from draining into the vault. Also, the exterior of the vault was sealed with waterproofing material to close holes and cracks which allowed water to seep into the tank. These repairs were made in March, and only regular pumping has been required since. A record of these is shown:

Date	Gallons	Remarks
March 13, 1978	2,250	Waste and surface water
March 17, 1978	1,710	Surface water
March 20, 1978	900	Subsurface water
April 20, 1978	1,980	Normal accumulation
June 23, 1978	1,935	Normal accumulation
August 25, 1978	1,935	Normal accumulation
November 21, 1978	1,935	Normal accumulation
January 2, 1979	1,710	Normal accumulation and flush water (300)
January 5, 1979	1,260	Normal accumulation and flush water (600)
Total Gallons	15,615	

The contract cost for pumping in 1978 was $42.00 per thousand gallons. The total cost in 1978 was $655.83.

Conclusions:

Everyone associated with the Aqua-Sans system at Carleton has learned much about the system during its first year of operation. There were some

frustrating times. Much credit must go to Jim Scott and Bill Hicks of Monroe County and Carl Horning, District 8 Rest Area Coordinator, for keeping the system working. Today, the unit seems to be relatively free of problems and should run satisfactorily with routine maintenance and replacement of working parts.

Chrysler Corporation's Mr. R. W. Fullerton recently visited the rest area and furnished the operator with some experimental odor and digesting chemicals to help reduce solids. The effect of these additives will be reported after their worth is evaluated.

/s/ Glen Horton
Glen Horton
District 8 Forester

March 1, 1979

OFFICE MEMORANDUM

DATE: May 21, 1979

TO: Ross M. Wolfe
Roadside Operations Supervisor

FROM: Glen Horton
District Forester

SUBJECT: Aqua-Sans Sewage Treatment System
Maintenance Report (No. 3)

This is a followup to our March 1, 1979, report on the maintenance of the Carleton Rest Area Aqua-Sans system.

During April Jim Scott, our rest area attendant, noticed a buildup of solid materials in the separation tank. This appeared to be similar to the problem we experienced in January, 1979, which required dismantling of the separation tank components.

On May 17, 1979, Jim Scott and Carl Horning pumped approximately 400 gallons of water into the separation tank. This displaced an equal amount of mineral oil which was moved into the filter reservoir. The system was not shut down.

The macerators were used to pump approximately 675 gallons of waste, water, and oil into the storage vault. This completely purged the separator tank of all materials other than mineral oil.

During the pumping out process, both macerators plugged and required manual cleaning. The plugging was caused by articles which do not break up in liquid. Carl reports that fibrous towels come out of the macerator cleanout in their original size, appearing even tougher than before being soaked.

After this cleaning, three barrels of mineral oil were added to the system to bring it back to operating level.

It appears that this type cleaning probably should be a routine activity in the maintenance of the Aqua-Sans system. We are convinced that there are certain objects flushed into the system which do not break down readily. Many of these float and are not pumped out during regular pumpout cycles. These consist of fibrous towels, disposable diapers, sanitary napkins, and other foreign objects.

To minimize the disposal of these items, we considered placing signs requesting only toilet tissue be flushed down the toilets. However, we feel this might only encourage some vandal-prone individuals to see if they could plug up the system.

Therefore, by constant monitoring we will pump out on an "as-needed" basis the separator tank to prevent a solids buildup which could adversely affect the operation of the Aqua-Sans.

This will cost some extra Maintenance dollars. At least one or two barrels of mineral oil are used when completely cleaning out the separator. This amounts to about $200 to $400.

The only other problem we have had is leaking spud gaskets. These are replaced as leaks develop.

/s/ Glen Horton
District Forester

GH/ljr

cc: J. Bastian
B. Hicks
C. Horning

OFFICE MEMORANDUM

DATE: June 27, 1979

TO: Jay Bastian, Asst. Supervisor
Roadside Development

FROM: Glen Horton
District Forester

SUBJECT: Aqua-Sans Supplemental Maintenance Report (No. 4)

The following information is in reply to questions brought up at our June 12, 1979, meeting with Carlos Zapata.

Question #1
How much extra maintenance has the rest area coordinator put into the Aqua-Sans system?

Items and the amount of time required for extra maintenance are shown below:

1.	Replacing leaking spud gaskets	2 days
2.	Bracing Sloan valve tail pieces	1 day
3.	Removing frozen oil flow meters	1 day
4.	Cleaning separator tank	2 days
5.	Changing discharge lines	1 day
6.	Miscellaneous small repairs	2 days
	Total days extra work	9 days

Wages of $84.00 per day, including fringe benefits, results in a total cost of $756.00 for extra maintenance labor as performed by the rest area coordinator.

Question #2
How do costs compare between the Carleton Rest Area and the Willoughby Road Rest Area? These are rest areas with comparable ADTs.

Willoughby Road Rest Area R-10 (Direct Maintenance)	
Routine Maintenance (1978)	$28,799.46
Statewide Crew	851.37
District Crew	3,851.33
	$33,502.16*

* This does not include fringes and supervision (185) charges.

Carleton Rest Area R-26 (County Contract)	
Routine Maintenance (1978)	$26,171.44
Statewide Crew	1,306.21
District Crew	7,038.85
County Overhead	2,526.40
Field Supervision	173.49
Leave & Benefits	7,340.44
	$44,556.83

Question #3
What is the cost of Marcol 52 mineral oil used in the Aqua-Sans system? Who is the supplier?

Supplier: Exxon - C. Barron & Sons, Monroe, MI
Cost: $1.99/GL (for white oil as of June 1, 1979)

Question #4
How much oil was used the first year of operation?

June 21, 1978	110 GL
September 15, 1978	110 GL
December 20, 1978	55 GL
January 5, 1979	110 GL
May 17, 1979	165 GL
Total Oil Used	550 GL

Question #5
How much sewage has been disposed of to date? What was the cost of disposal service?

Contractor pumped as shown below:

June 23, 1978	1,935 GL
August 25, 1978	1,935 GL
November 21, 1978	1,935 GL
January 2, 1979	1,710 GL
January 5, 1979*	1,260 GL
April 2, 1979	1,800 GL
May 2, 1979	1,935 GL
June 22, 1979	1,935 GL
Total	14,445 GL

* Extra pumping for flushing separator.

The total cost of disposing of the 14,445 gallons of waste was $580.00.

Question #6
Are copies of monthly maintenance report available?

Copies are attached.

/s/ Glen Horton
District Forester

GH/ljr
Attachments

cc: R. Wolfe