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OPERATIONAL PERFORMANCE OF THE SLIAMMON SEWAGE TREATMENT PLANT

MARCH 11-16, 1986

By

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TABLE OF CONTENTS

1 INTRODUCTION

An assessment of the operational performance of the Sliammon Sewage Treatment Plant (STP) was carried out from March 11 to 16, 1986, by the Environmental Protection Service (EPS). The Sliammon Indian village is located approximately 6 km northwest of Powell River.

During the last shellfish growing water control survey in 1980 (EPS Report 81-2), the unchlorinated final effluent from an extended aeration activated sludge STP was being discharged through a 490 meter long outfall to a depth of 12 meters in Malaspina Strait. The new rotating biological contactor (RBC) STP installed in 1984 uses the same outfall and the effluent is now chlorinated and dechlorinated before discharge.

For the March 11 to 16, 1986 evaluation, twenty-four hour composite samples of the raw influent, the RBC influent and the secondary clarifiers effluent were taken for 5 consecutive days. Samples were also taken at 3 locations in the RBC. These samples were preserved as outlined in the "Environmental Protection Service Laboratory Manual" until delivery at the EPS' West Vancouver laboratory. Temperature, dissolved oxygen, ammonia nitrogen, free and total chlorine, fecal coliform analyses as well as a chlorine contact chamber dye study were performed on site. A schematic drawing of the STP showing the various sampling stations is shown in Figure 1.

A shellfish survey was also conducted from March 10 to March 21, 1986 to determine the bacteriological quality of the Indian village foreshore waters.

2 TREATMENT DESCRIPTION

The Sliammon STP serves a population of 530. All wastewater is gravity fed to a wet well. It is pumped to the first of two septic tanks installed in series. The septic tanks sludge is pumped out and hauled to the Wildwood Lagoon in the District of Powell River on a regular basis. The effluent from the second tank flows into a wet well and is pumped to the head tank of the RBC.

Four arms equipped with buckets transfer the wastewater to the first of the three RBC (Bio-Surf model) stages. The RBC effluent flows to two parallel secondary clarifiers. The settled sludge is pumped on a timed basis to the first septic tank.

The clarified effluent flows under a baffle and over a weir to a channel which feeds two parallel pipes leading to two parallel chlorination systems. Each is equipped with two vertical plastic type pipes immersed in the treated effluent flow. Calcium hypochlorite pucks stacked in these pipes are dissolved by the effluent and chlorination is provided. Two parallel calibrated V-notch weirs allow direct flow reading. The chlorinated effluent then flows through the chlorine contact chamber. Sodium thiosulphate solution is added at a constant rate to the effluent from the chamber to perform dechlorination. A flume box equipped with a chart recorder measures the flow.

The final effluent is then directed to a pipe which ties in with the existing outfall pipe which was used by the defunct STP. The 200 mm diameter open ended outfall pipe is 490 meters long and discharges the effluent 12 meters below mean low water level in Malaspina Strait.

2.1 Wastewater Flow and Strength

The flow through the plant was practically constant during the 5-day study and averaged approximately 366.5 cu.m/d. This value is very close to the rated maximum capacity of the bucket feed system installed on the RBC shaft (355.8 cu.m/d). This means that the design flow capacity of 311.6 cu.m/d (average daily flow and infiltration) for the 20 year design criteria is already exceeded.

Any daily flows over the bucket feed system maximum capacity of 356 cu·m/d will be recycled in the system and could create an overflow situation at the septic tanks or the RBC. This depends on 1) the overflow pipe position compared to the concrete wall elevation separating the head tank and the first stage and 2) the overflow pipe return outlet configuration.

Two explanations for the large flows are plausible: 1) high water usage (including leaky faucets and running water) and 2) water infiltration in the system. During the survey, the amount of precipitation was minimal which would indicate that direct rainfall is not the problem.

The calculated water usage per person equals 690 l/d·person (152 IMP gpd/person) which represents a large water consumption compared with the typical design value of 450 l/d·person (100 IMP gpd/person).

The weak raw wastewater (see Table 1) supports the theory of high water usage or infiltration.

2.2 Rotating Biological Contactor and Secondary Clarifiers

The Rotating Biological Contactor (RBC) is a three stage Envirex (formerly Autotrol) Bio-Surf. The unit characteristics are listed in Table 2. The hydraulic loading is low for conventional treatment (Table 3) but in the high range to achieve nitrification. The analytical results in Table 1 show that nitrification takes place in the treatment (39% average NH_3 reduction). The low organic loading is mainly caused by a low BOD loading to the plant. The detention time, pH and rotation velocity are within typical design range. The color and thickness of the biomass on the disks looked normal. The dissolved oxygen increased from 1.9 to 6.5 mg/l through the RBC and the temperature stayed constant at 10°C.

The overflow rate and depth of the secondary clarifiers are within the typical design range. One of the two sludge return pumps was clogged at the time of the study. Sludge rising to the surface was observed in clarifier #2. The lack of sludge pumping produced a septic environment in the bottom and two phenomena caused the sludge to rise to the surface: 1) the oxygen associated with the nitrate is removed and remaining nitrogen gas rises to the surface and 2) anaerobic conditions may start the beginning phases of digestion and gas production (foul odor). Both scenarios allow gas to rise to the surface carrying solids with it. The defective sludge pump was repaired on the last day of the survey. Even under the adverse condition of floating sludge, the clarifiers operated well based on the low final effluent non-filterable residue results obtained. This can be explained by the low overflow rate and the presence of an underflow baffle trapping the floating sludge at the surface of the clarifier.

The RBC and secondary clarifiers, based on typical design values, could handle flows up to 700 and 500 cu·m/d respectively.

2.3 Chlorination and Dechlorination

Two parallel Sanuril Model 115 Chlorinators, using chlorine pucks (calcium hypochlorite) stacked in two plastic vertical pipes, chlorinate the effluent from the secondary clarifiers. Theoretically, the pucks are dissolved proportionally to the flow. In practice, as shown in Table 4, the total chlorine concentrations varied from 0.3 to more than 3 mg/l at the exit of the chlorinators. The operator adds 20 chlorine pucks to only one vertical pipe of each chlorinator every 3 to 4 days.

This practice still allows a fecal coliform reduction of more than 99.9% (fecal coliform counts ranging from less than 10 to 60 FC/100 ml) (Tables 4 and 5). The total residual chlorine at the end of the chlorine contact chamber averages 1.1 mg/l. A flow adjustable peristaltic pump injects sodium thiosulfate solution to eliminate the residual chlorine. Not enough sodium thiosulfate solution is added to reduce residual chlorine to undetectable limits; residual total and free chlorine respectively averaged 0.47 and 0.17 mg/l during the study period. As expected, no sulfite was detected after dechlorination because of its entire use to reduce chlorine levels.

2.4 Chlorine Contact Chamber

Table 8 shows the chlorine contact chamber characteristics compared with typical design values. The low length:width ratio indicates that the width is too large compared to the channel length to provide acceptable plug flow. The high depth:width ratio indicates that the channel is too deep compared with the width and creates excessive drag on the side of the channels as well as density currents. A dye study was conducted in order to determine if short-circuiting occurs. The results of the dye concentration at the chamber outlet are presented in Figure 2. The theoretical contact time is almost double the required minimum design contact time of 30 minutes. The low minimum time value indicates that short-circuiting occurs. The high Morrill Index shows a large dispersion contrary to plug flow effect contact chambers are supposed to provide.

Short-circuiting occurs because of the horizontal grooves in the longitudinal galvanized metal baffles separating the channels. The junctions with the contact chamber walls are not tight because of this grooved configuration. The liquid is thus allowed to by-pass a large portion of chlorine contact chamber (see minimum time value in Table 8). The underflow baffles are not efficient because of the large grooves unblocked by the wood baffles allowing the liquid to flow around the baffles. There are no overflow baffles. Floating sludge was observed at the surface.

3 GUIDELINES FOR EFFLUENT QUALITY AND WASTEWATER TREATMENT AT FEDERAL ESTABLISHMENTS

Table 7 shows that federal guidelines were met the majority of the time. The final effluent was of acceptable quality.

4 MARINE BACTERIOLOGICAL WATER QUALITY

Table 6 shows a comparison of fecal coliform levels for 3 years (1975-1980-1986) at the same marine stations. The water quality seems to be improving over the years. It should be noted that the amount of precipitation was minimal in 1986 which might partially account for the low results.

5 CONCLUSIONS

1. The average daily flow to the plant exceeded the design flow for the year 2004 due to high water usage or infiltration.

2. The RBC bucket feed system capacity is being exceeded and overflow could occur at the septic tanks or at the head tank of the RBC.

3. The RBC and the clarifiers are designed to handle flows up to 500 cu·m/d without affecting significantly the final effluent quality.

4. Short-circuiting occurs at the chlorine contact chamber.

5. Chlorination was effective in reducing fecal coliform counts to low levels, but improvement in dechlorination is required to reduce the effluent toxicity to aquatic organisms.

6. Final effluent characteristics complied with the federal guidelines for federal establishments.

7. The effluent discharge had no detectable fecal coliform impact on marine waters offshore Sliammon Village. Marine waters met recreational and molluscan shellfish growing water quality standards.

6 RECOMMENDATIONS

1. A study should be undertaken to determine the source of the large flows (infiltration or high water usage per capita).

2. If the flows cannot be reduced, the bucket feed system capacity should be increased.

3. Junctions of the longitudinal baffles with the chlorine contact chamber walls should be made water tight.

4. The grooves in the longitudinal baffles of the chlorine contact chamber should be blocked to force all the effluent to flow underneath the baffle.

5. Overflow baffles should be installed in the chlorine contact chamber.

6. The water surface and bottom of the chlorine contact chamber should be cleaned periodically.

7. The amount of thiosulphate solution should be increased to maintain a zero total residual chlorine in the effluent discharging through the outfall.

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TABLE 1 ANALYTICAL RESULTS
- all units in mg/l except pH (no units) and flow (cu·m/d)

PARAMETERS	MARCH 11-12, 1986			MARCH 12-13, 1986		
	1	2	10	1	2	10
BOD	47	24	21	58	25	10
NFR	53	24	26	68	9	6
NH_3(N)	9.67	10.9	8.83	12.7	10	7.55
NO_2(N)	.023	.016	.432	.009	.013	.387
NO_3(N)	.077	.284	3.768	.003	< .005	3.813
Total - PO_4(P)	2.57	2.3	2.3	2.62	2.0	1.8
Ortho - PO_4(P)	1.4	1.4	1.9	1.7	1.5	1.6
Oil and Grease	0.74	0.24	0.24	7.34	-	0.65
pH	6.7	6.7	6.8	6.6	6.7	6.6
Flow	-	-	366.5	-	-	392.7

PARAMETERS	MARCH 13-14, 1986			MARCH 14-15, 1986		
	1	2	10	1	2	10
BOD	38	16	5	33	23	14
NFR	46	14	14	46	< 5	< 5
NH_3(N)	9.82	9.72	7.45	11.7	9.17	5.85
NO_2(N)	.1	0.016	.448	.022	.019	.396
NO_3(N)	.048	0.006	4.052	2.178*	.381	4.304
Total - PO_4(P)	2.1	2.0	1.8	2.3	1.8	1.7
Ortho - PO_4(P)	1.2	1.7	1.7	1.4	1.5	1.6
Oil and Grease	0.35	-	< 0.10	0.99	-	< 0.10
pH	6.6	6.9	6.6	6.6	6.7	6.5
Flow	-	-	327.3	-	-	340.4

* error in analysis

CONTINUED...

TABLE 1 (Continued)

PARAMETERS	MARCH 15-16, 1986					
	1	2	3	4	5	10
BOD	55	19	7	13	17	4.8
NFR	47	12	-	-	-	< 5
$NH_3(N)$	12.8	9.22	7.13	6.23	4.1	4.8
$NO_2(N)$	.007	.104	1.1	.382	.338	.338
$NO_3(N)$	.001	.001	2.9	3.218	5.142	4.892
Total $PO_4(P)$	2.8	2.07	1.81	1.86	2.12	1.75
Ortho $PO_4(P)$	1.7	1.5	1.4	1.5	1.4	1.5
Oil and Grease	-	-	-	-	-	-
pH	6.8	6.8	7.2	6.7	6.5	6.6
Flow	-	-	-	-	-	366.5

PARAMETERS	AVERAGE FROM MARCH 11 TO MARCH 16, 1986	
	Influent	Effluent
BOD	46.2	11.0
NFR	52	11.2
$NH_3(N)$	11.3	6.9
$NO_2(N)$	0.032	0.4
$NO_3(N)$	0.032	4.2
Total $PO_4(P)$	2.5	1.9
Ortho $PO_4(P)$	1.5	1.7
Oil and Grease	2.36	0.27
pH	6.7	6.6
Flow	-	358.7

TABLE 2 UNITS CHARACTERISTICS

SEPTIC TANKS		
Number of Units	:	2
Volume of Septic Tank #1	:	78.2 m^3
Volume of Septic Tank #2	:	69.2 m^3
Total Volume Septic Tanks	:	147.4 m^3
Volume Pump Station	:	34.6 m^3
ROTATING BIOLOGICAL CONTACTOR		
Number of Stages	:	3
Length	:	5.5 m
Diameter	:	3.05 m
Medium Area - Stage 1	:	2318.8 m^2
" 2	:	1070.2 m^2
" 3	:	1070.2 m^2
Total Medium Area	:	4459.2 m^2
Bucket Feed Capacity	:	355.8 m^3/d
Rotation Speed	:	1.9 rpm
CLARIFIERS		
Number of Units	:	2
Volume	:	23.5 m^3 each
Surface	:	8.4 m^2 each
CHLORINE CONTACT CHAMBER		
Number of Units	:	1
Number of Chlorinators	:	2
Volume	:	13 m^3
Depth	:	2 m
Number of Channels	:	5
Channels Width	:	.41 m
Channels Length	:	3.18 m
Number of Underflow Baffles	:	5
Number of Overflow Baffles	:	0

TABLE 3 ROTATING BIOLOGICAL CONTACTOR (RBC) AND SECONDARY CLARIFIERS: DESIGN CHARACTERISTICS

	UNITS	TYPICAL DESIGN RANGE	AVERAGE VALUE[2]	REFERENCES
1. RBC				
Hydraulic Loading	$m^3/m^2 \cdot d$	0.08 to 0.16 (0.03 to 0.08)[1]	0.08	2
Organic Loading	kg $BOD_5/d \cdot 100\ m^2$	2.9 to 3.9 (first stage only)	0.7	2
Detention Time	minutes	40 to 250	Approx. 200	7
pH	-	6.5 to 8.5	6.6	3
Velocity	rpm	1 to 2	1.9	3
2. SECONDARY CLARIFIERS				
Overflow Rate	$m^3/m^2 \cdot d$	16 to 33 20 to 33	21.4	2 7
Depth	m	2.1	2.4	2

[1] range to achieve oxidation of ammonia nitrogen
[2] average daily flow = 358.7 cu·m/d

TABLE 4 CHLORINATION/DECHLORINATION VS FECAL COLIFORM COUNT REDUCTIONS

	UNITS	MARCH 12	MARCH 13	MARCH 14	MARCH 15	MARCH 16	MARCH 18	AVERAGE
T. Cl_2 at chlorinators	mg/l	0.60	0.90	1.9	2.1	> 3.0	0.3	1.5
Free Cl_2 at chlorinators	mg/l	-	-	0.2	1.5	2.0	0.25	1.0
T. Cl_2 after Cl_2 chamber	mg/l	0.75	1.45	-	-	-	-	1.1
T. Cl_2 after dechlorination	mg/l	0.25	0.65	0.45	0.6	0.8	0.07	0.47
Free Cl_2 after dechlorination	mg/l	-	-	0.42	0.1	0.15	0.02	0.17
Sulfite NO_2SO_4 after dechlorination	mg/l	-	-	-	-	-	< 1(1)	< 1
Fecal coliform before chlorination	FC/100 ml	7.1×10^4	6.4×10^4	7.2×10^4	1.2×10^4	4.4×10^4	-	5.3×10^4
Fecal coliform after chlorine contact chamber	FC/100 ml	60	40	10	< 10	40	20	30
Percentage fecal coliform reduction	%	99.92	99.94	99.99	99.92	99.91	-	99.94

(1) minimum detection level

TABLE 5 BACTERIOLOGICAL RESULTS (Fecal Coliform/100 ml)

DATE	RAW	BEFORE RBC AT HEAD TANK	AFTER CLARIFICATION	FINAL EFFLUENT AFTER CHLORINATION AND DECHLORINATION
March 12	9×10^5	1.5×10^5	7.1×10^4	60
13	5.8×10^5	1.5×10^5	6.4×10^4	40
14	4.8×10^5	2.3×10^5	7.2×10^4	10
15	5.0×10^5	6.5×10^4	1.2×10^4	< 10
16	1.04×10^6	4.9×10^5	4.1×10^4	40
18	-	-	-	20
Average	7.0×10^5	2.2×10^5	5.2×10^4	30

TABLE 6 COMPARISON 1975-1980-1986: MARINE STATIONS OF SLIAMMON VILLAGE FORESHORE WATERS (Fecal Coliform MPN/100 ml)

1975				1980				1986			
	STATIONS				STATIONS				STATIONS		
Rainfall (mm)	PR4	PR5	PR6	Rainfall (mm)	PR4	PR5	PR6	Rainfall (mm)	PR4	PR5	PR6
26.4	350	17	49	0.0	< 2	-	< 2	3.4	5	5	2
22.1	170	350	130	0.0	2	< 2	< 2	9.0	< 2	2	2
6.4	50	70	90	1.3	8	-	7	Trace	5	17	5
4.82	22	11	17	4.6	*33(13)	*23(23)	*8(33)	0.0	2	2	< 2
29.7	130	110	17	1.3	23	11	13	0.0	2	5	< 2
20.1	13	920	12					7.0	5	5	< 2
								3.2	2	13	13
								0.0	13	5	< 2
								3.8	2	5	4
Median	90	90	16		10.5	17	7.5		2	5	2
90 Percentile	242	578	106		27	23	21		5.8	13.4	5.8

(*) 2 samples on the same day

TABLE 7 GUIDELINES FOR EFFLUENT QUALITY AND WASTEWATER TREATMENT AT FEDERAL ESTABLISHMENTS

	SPECIFIC LIMITS	PERCENTAGE COMPLIANCE
BOD_5	20 mg/l	80 %
NFR	25 mg/l	80 %
Fecal Coliforms (MF method)	400 per 100 ml (after disinfection)	100 %
pH	6 to 9	100 %
Oils and Greases	15 mg/l	100 %

TABLE 8 CHLORINE CONTACT CHAMBER CHARACTERISTICS

	TYPICAL DESIGN VALUES	SLIAMMON	REFERENCES
Length:Width Ratio	> 10	317.5 cm : 41 cm = 7.7	2
Depth:Width Ratio	< 1	203 cm : 41 cm = 5.0	5
Contact Time	minimum 15 to 30 min.	theoretical 13 cu·m ÷ 358.7 cu·m/d = 52 min.	2
DYE STUDY			
Minimim Time	-	6 min.	6
Morrill Index t90/t10	< 1	81 min./27 min. = 3	6
Modal Time (peak concentration)	-	43 min.	6
Median Time	-	46 min.	6
Maximum Time	-	115 min.	6

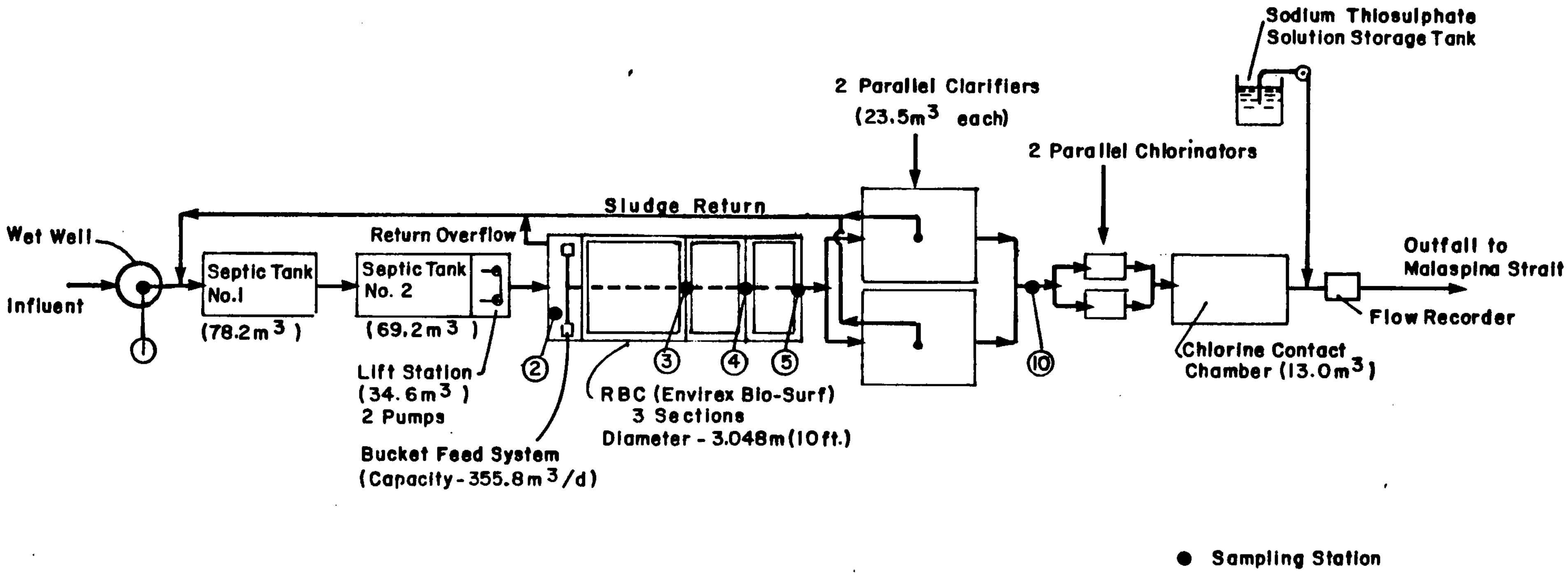

FIGURE 1 SLIAMMON SEWAGE TREATMENT PLANT PROCESS FLOW DIAGRAM

Figure 2 *Dye study for clorine contact chanber at Sliammon.*