DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC AND YUKON REGION

FILE REPORT

IMPACT OF DUNCAN-NORTH COWICHAN SEWAGE DISCHARGE ON THE COWICHAN RIVER DURING 1985 LOW FLOW PERIOD

By

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1 INTRODUCTION

The affect of the Duncan-North Cowichan sewage discharge on the water quality and benthic community of the Cowichan River was first documented in 1980 (Derksen et al 1981, Munro 1985). River nutrient levels (nitrogen, phosphorous) were significantly elevated and a large algal bloom developed within one week of the discharge starting. The abundance of benthic invertebrates greatly increased for Oligochaeta ($\bar{x}$ of 19,000 m^2 upstream to a maximum $\bar{x}$ of 165,000 m^2 downstream) as well as Tardigrada and Cladocera. A moderate increase was recorded for Diptera (Chironomidae) ($\bar{x}$ of 22,600 m^2 upstream to a maximum $\bar{x}$ of 65,500 m^2 downstream).

Subsequent evaluations of the options to control the impact of the discharge indicated that phosphorous removal alone would not likely be sufficient to prevent algal blooms. Due to the limited capacity of the lagoon system, effluent storage over the total summer river low-flow period was not considered feasible. However, if the time period for storage was reduced from an original consideration of 14 weeks over June to September to 6 weeks over August to September, some control might be achievable.

In 1985, Duncan-North Cowichan undertook a trial effluent drawdown and storage program to evaluate it as an effluent control option. This report presents effluent, water quality and algal standing crop data collected by EPS over the trial period.

2 STUDY AREA AND DRAW DOWN/STORAGE SCHEDULE

The location of the sewage lagoons relative to the Cowichan River is shown on Figure 1.

In order to stop the effluent discharge for as long as possible in August, the storage capacity of the lagoon system had to be increased. To increase the storage capacity, the City of Duncan sandbagged the outlet of cell #4 and decreased the levels in cells #1, #2 and #3 to the extent possible by pumping at a high rate from cell #4 directly to cell #5. The drawdown occurred over July 23 to August 5 and provided 14 days of capacity so that no discharge to the river was made from August 6 to August 19 (Figure 2).

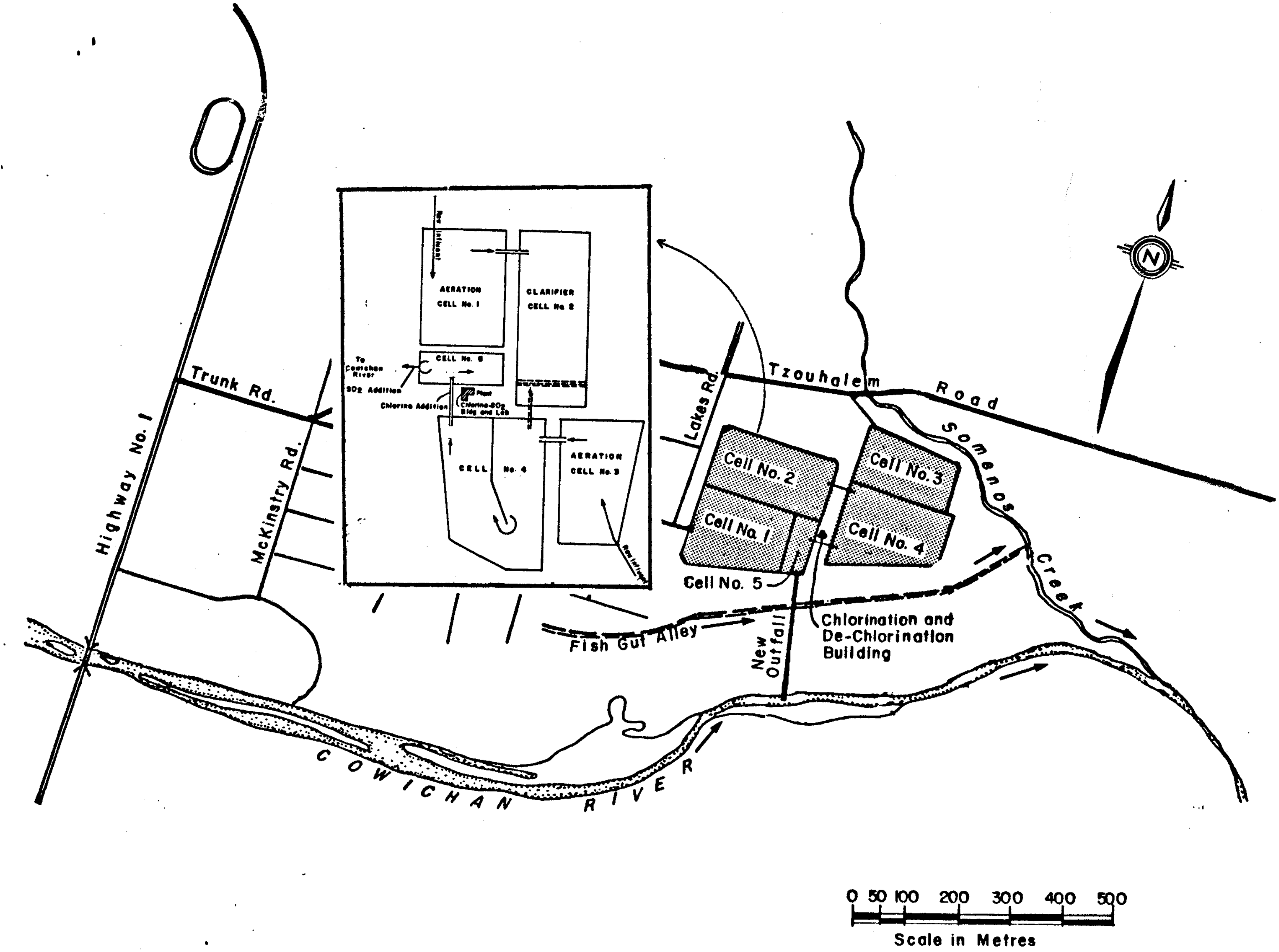


FIGURE 1 LOCATION MAP OF SEWAGE LAGOONS

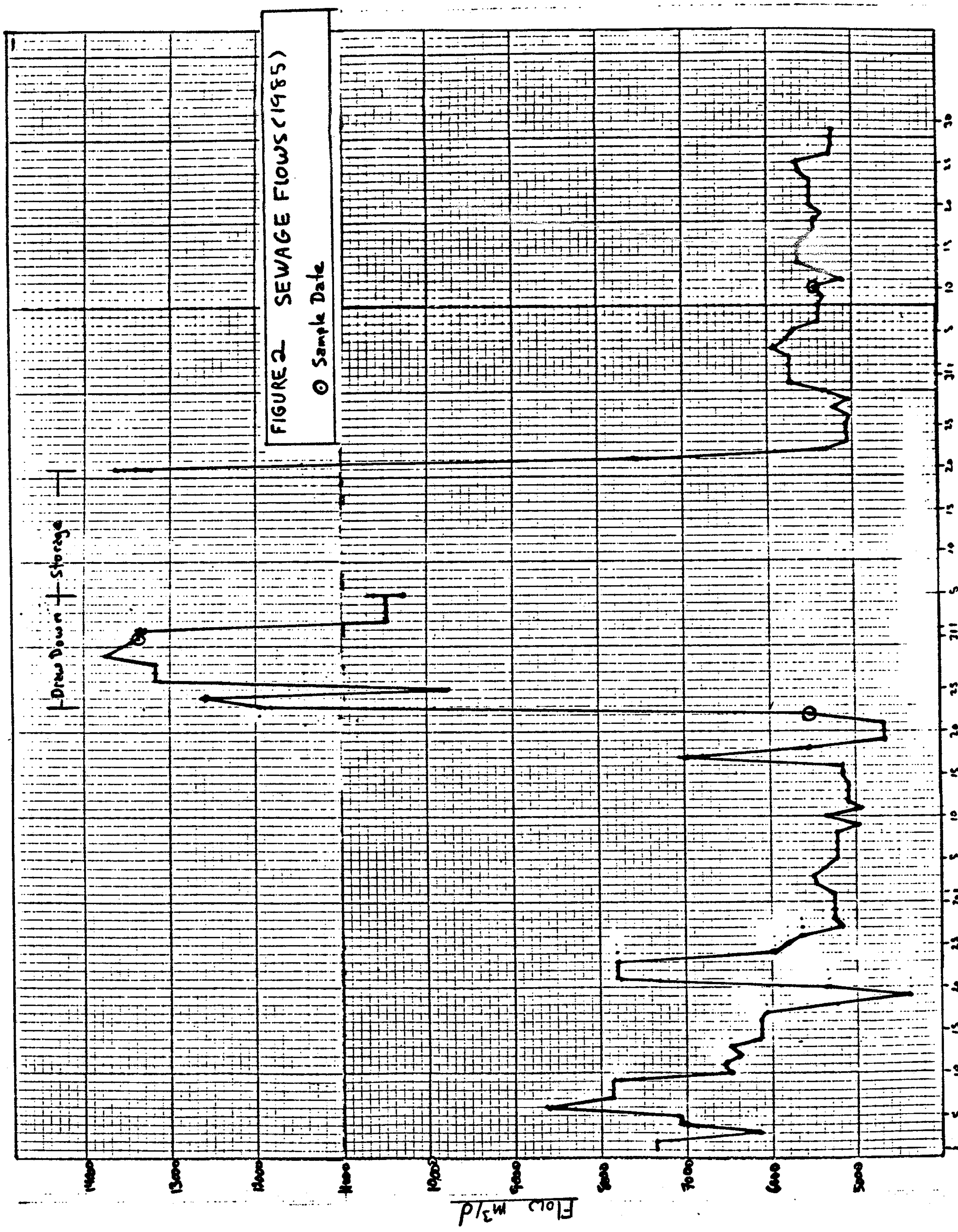


FIGURE 2 SEWAGE FLOWS (1985)

3 METHODS

3.1 Water and Effluent Samples

Sewage samples were collected on three occasions, twice during normal operation (July 22 and September 10) and once during the drawdown (July 31). The Ministry of Environment operates a salmonid hatchery with an effluent discharge located approximately 600 meters upstream of the sewage outfall. Samples were collected from the hatchery discharge on the same frequency and analyzed for the same parameters. River water samples were collected on four occasions (July 22, July 31, August 19 and September 10).

The samples were analyzed for: NH_3, NO_2, NO_3, TP, TDP (field filtered, 0.45 u), total and fecal coliform, pH and dissolved oxygen (Winkler method and/or Hydrolab). Samples were kept cool until analyzed at the EPS/DFO laboratory in West Vancouver (Anon 1979).

3.2 Algal Standing Crop

Samples of attached algae were collected from midstream and/or nearshore areas of the river to monitor the response of the river to increased nutrients. Samples were collected from 3 rocks at each site. The rocks were somewhat standard in that they had to be sufficiently large and flat to be sampled adequately with the sampling device used. The sampler (50 cm^2 sample area) was placed over a rock removed from the river. It was then partially filled with distilled water and if the seal was secure (no loss of water) the rock area inside the sampler was scrubbed with a toothbrush. The toothbrush was then rinsed into the sample bottle and the contents of the sampler pipetted into the sample bottle. Three samples were collected to make one composite.

Samples were collected from the same area of the river on each occasion (July 22, July 31, August 19 and September 10). The composite sample was kept cool and dark until filtered on a GFC filter paper and analyzed for chlorophyll-a and phaeopigments (Anon, 1979).

4 RESULTS AND DISCUSSION

The hydrograph for the Cowichan River from June to September 1980 and 1985 is shown on Figure 3. Flows in 1985 were very low for the whole summer period and in fact, were often below the Water Survey of Canada discharge curve minimum of 3.7 m^3/s. Thus, the drawdown and storage trial occurred during a worst case (dilution) scenario.

4.1 Water and Effluent Samples

As expected, nutrient levels (NH_3, TP, TDP) increased greatly downstream of the sewage discharge (Figures 4, 5 and 6). The September 10 results show a gradient of highest concentrations on the nearshore side (STP discharge side) to lower concentrations on the farside. Undissociated ammonia levels 250 meters downstream of the sewage discharge were less than the 10 ug/l maximum recommended for hatchery water supplies by Sigma 1983 but higher than the 2 ug/l suggested by Haywood 1983 (Figure 4). The hatchery discharge did not appear to affect NH_3 or TP concentrations but on July 31, August 19 and September 10 the TDP levels were slightly higher downstream.

For both July 22 and July 31, background ammonia levels were detectable (12 and 24 ug/l respectively). These background levels are higher than for July 1979 ($\bar{x}$ = 3-5.5 ug/l) and July 1980 ($\bar{x}$ = < 2 ug/l) (Derksen et al 1981). In August and September, NH_3 levels were below or near the detection limit (< 5 to 6 ug/l).The mean background level of NH_3 in September 1979 was 2.5 ug/l and in September 1980 it was 6.4 ug/l. Background TDP levels were at or below detectable levels ($\leq$ 2 ug/l) in July and September and detectable (4 ug/l) in August. The mean background level of TDP was 2.9-4.6 ug/l in July 1979 and 5.4 ug/l in July 1980. The mean background level of TDP was 3.8 ug/l in September 1979 and 4.8 ug/l in September 1980 (Derksen et al 1981).

Nitrite were generally below detection levels (5 ug/l) but was detectable on July 22 at all stations (Figure 7). Background nitrate levels were at or below the detection limit (5 ug/l) for all months (Figure 8). There appeared to be some influence on NO_3 due to the hatchery on July 31 and August 19 and due to the sewage discharge on September 10.

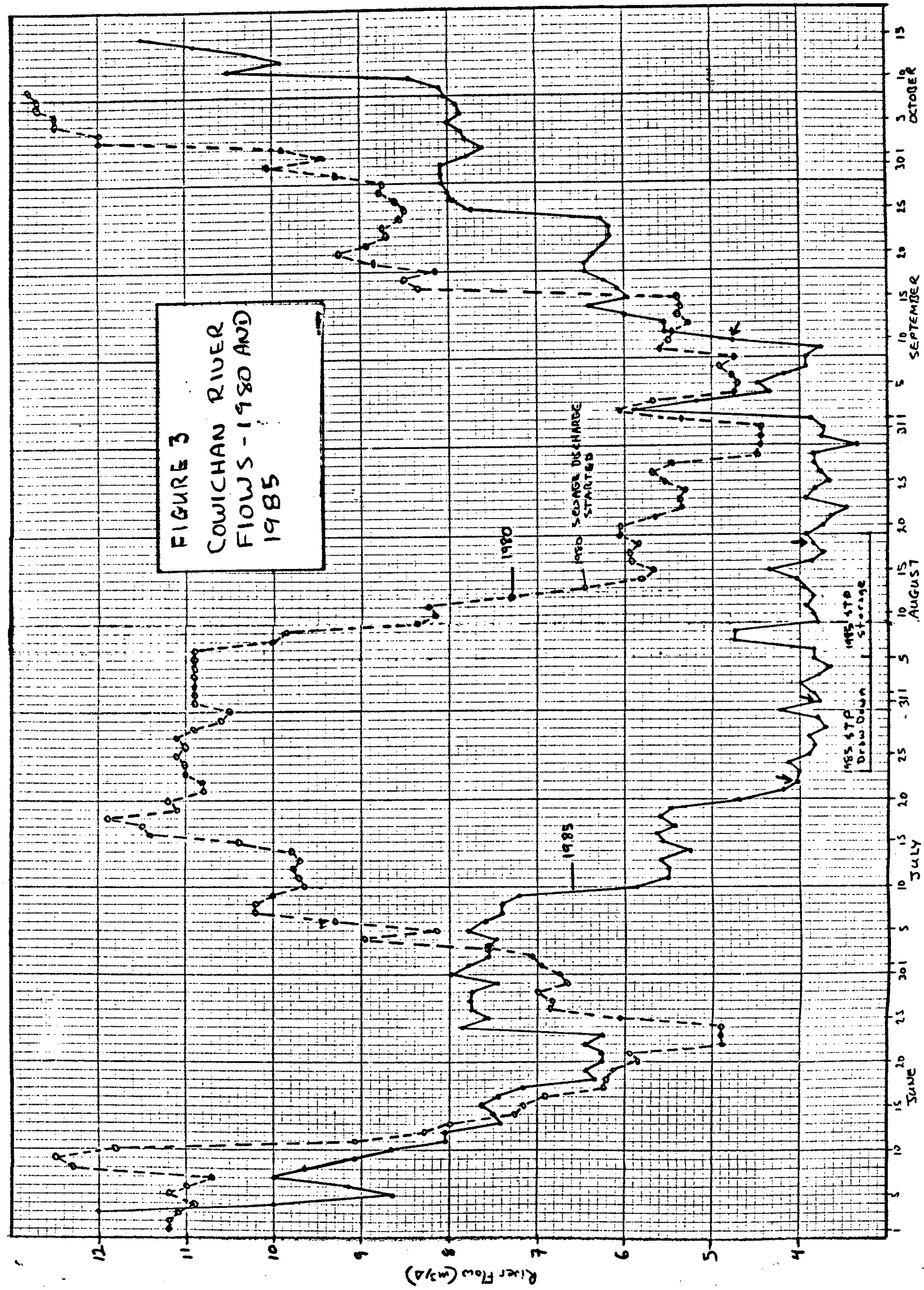
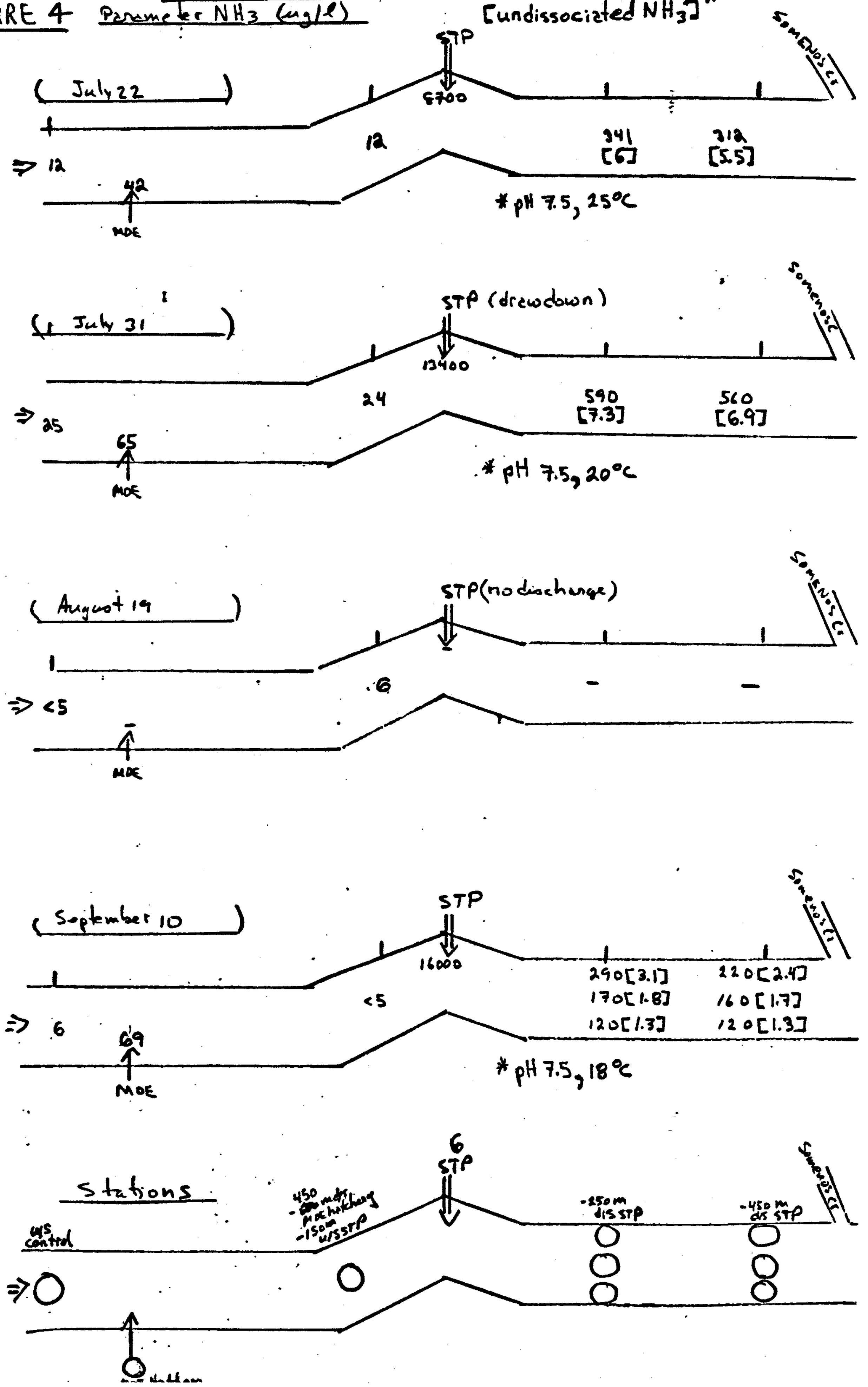


FIGURE 3
COWICHAN RIVER FLOWS - 1980 AND 1985

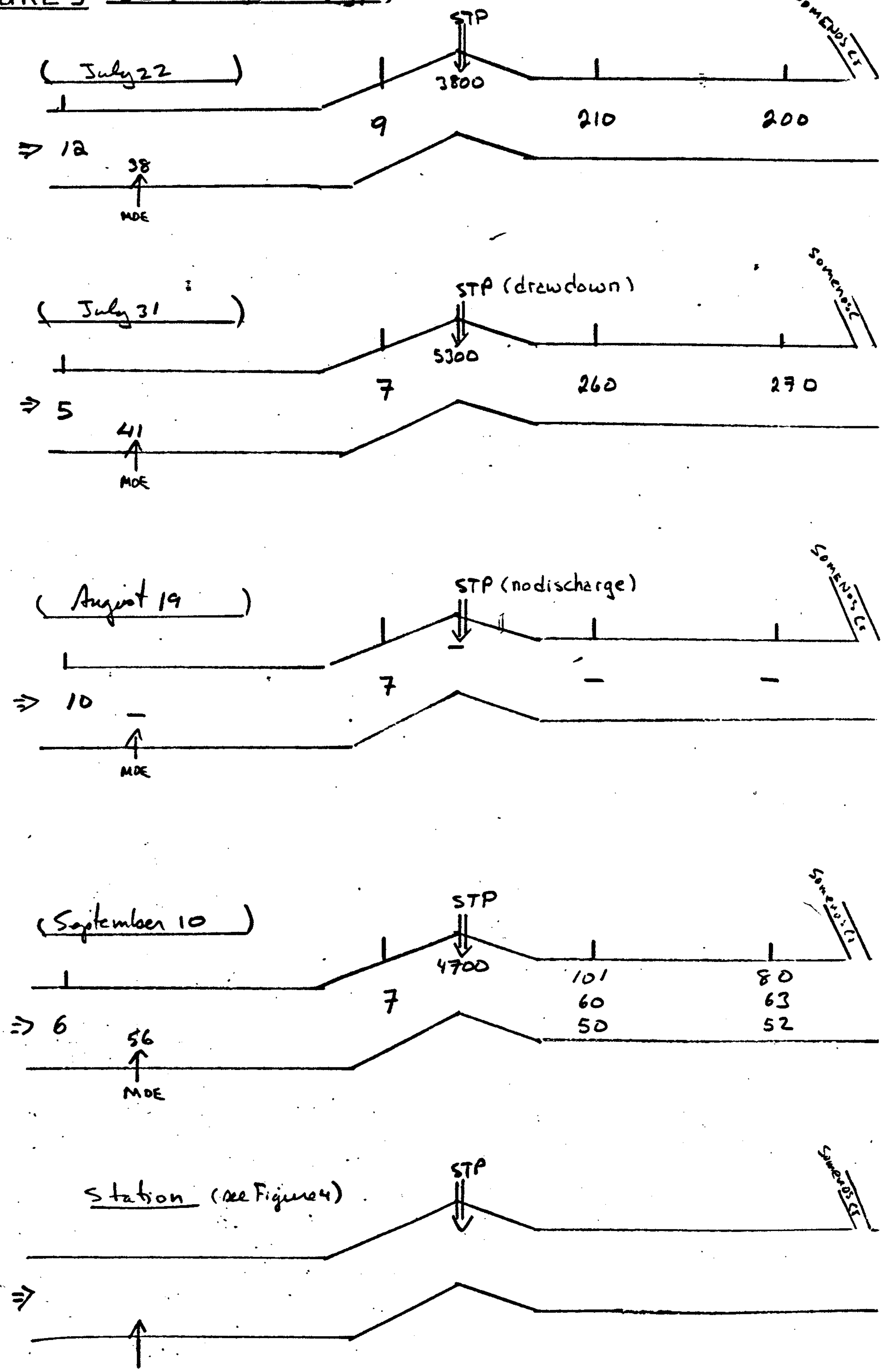
COWICHAN RIVER - 1985 LOWFLOW

FIGURE 4 Parameter NH_3 (ug/l) [undissociated NH_3]*



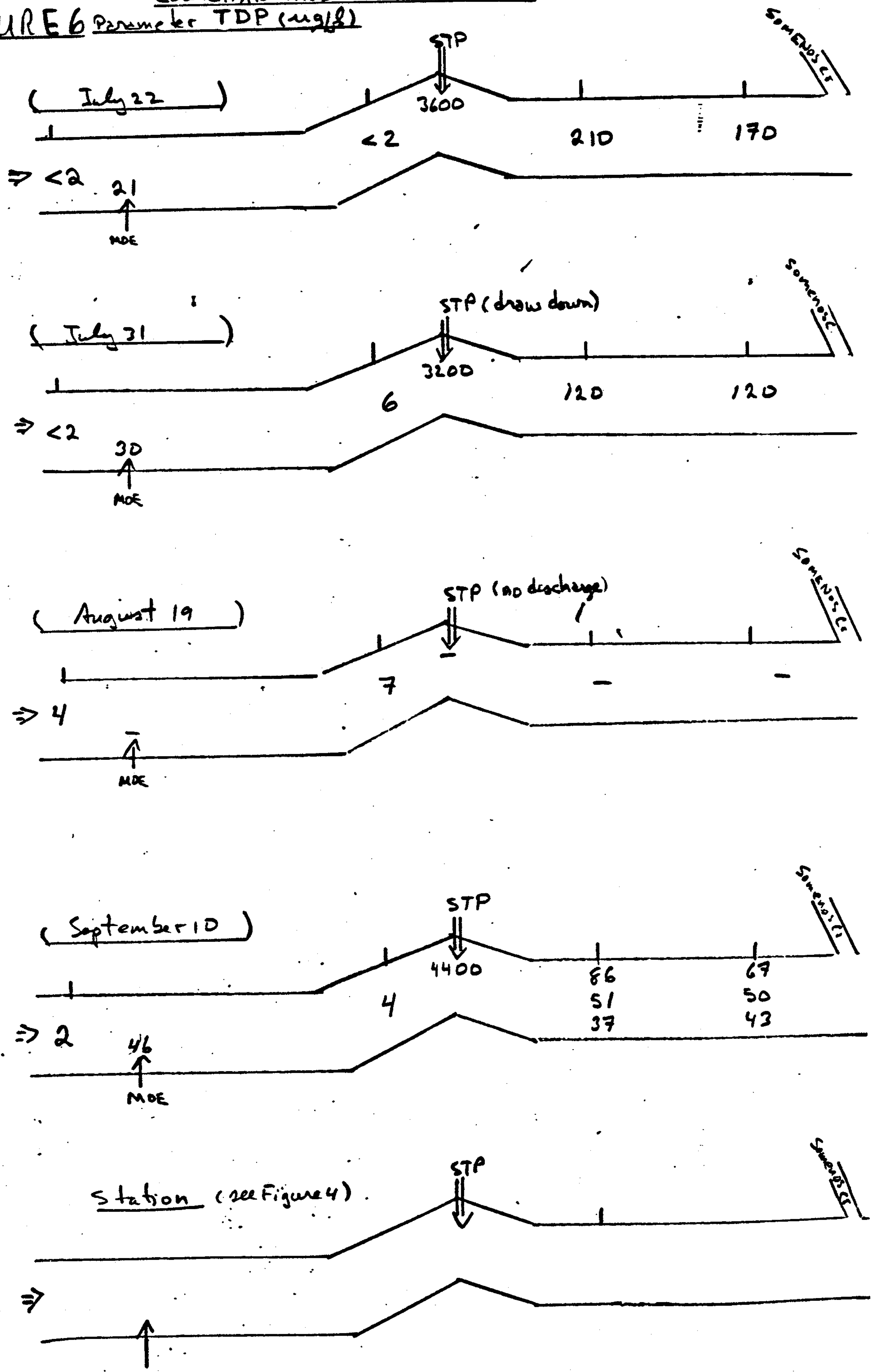
COWICHAN RIVER - 1985 LOWFLOW

FIGURE 5 Parameter TP (ug/l)



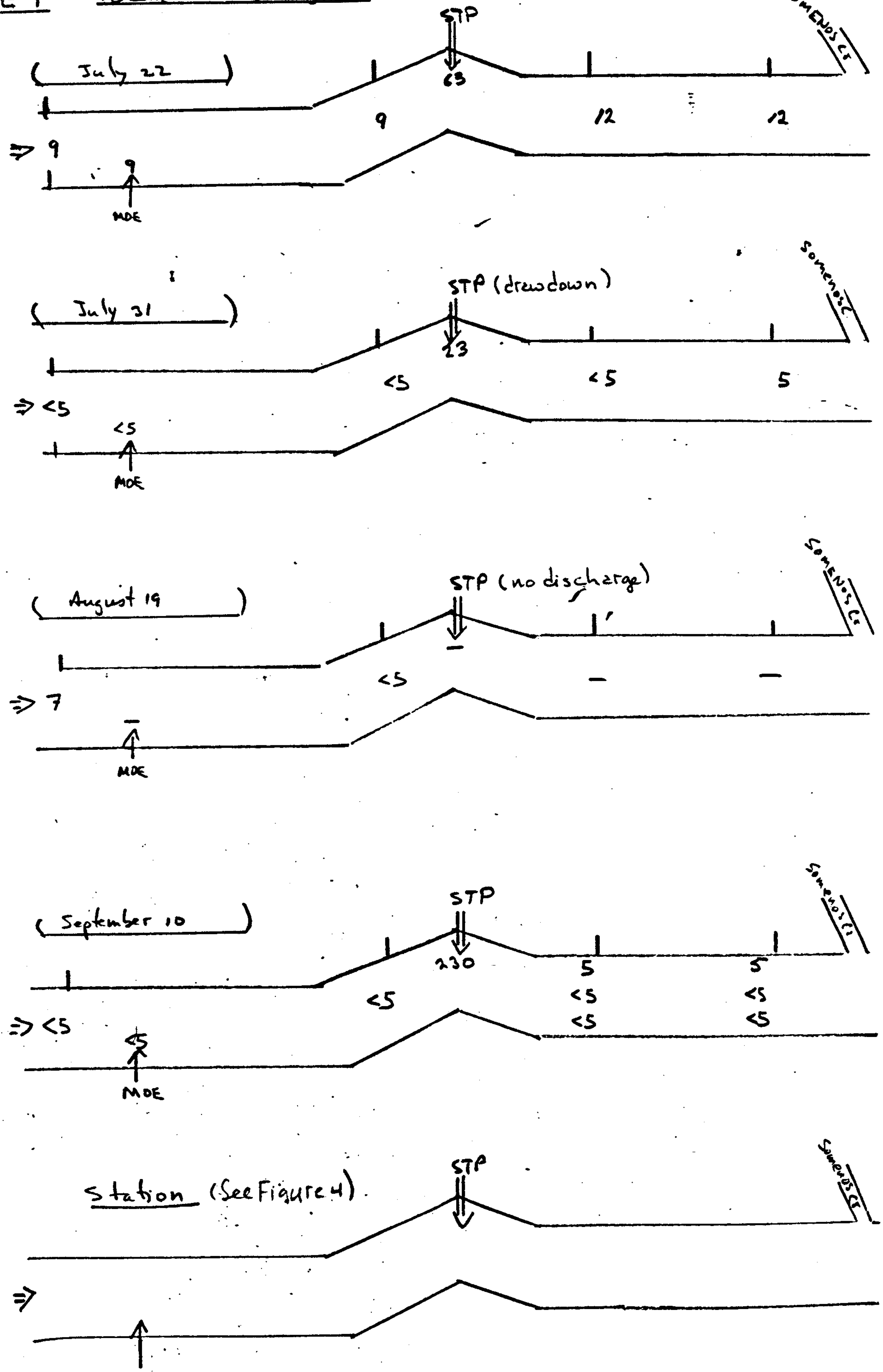
COWICHAN RIVER - 1985 LOW FLOW

FIGURE 6 Parameter TDP (ug/l)



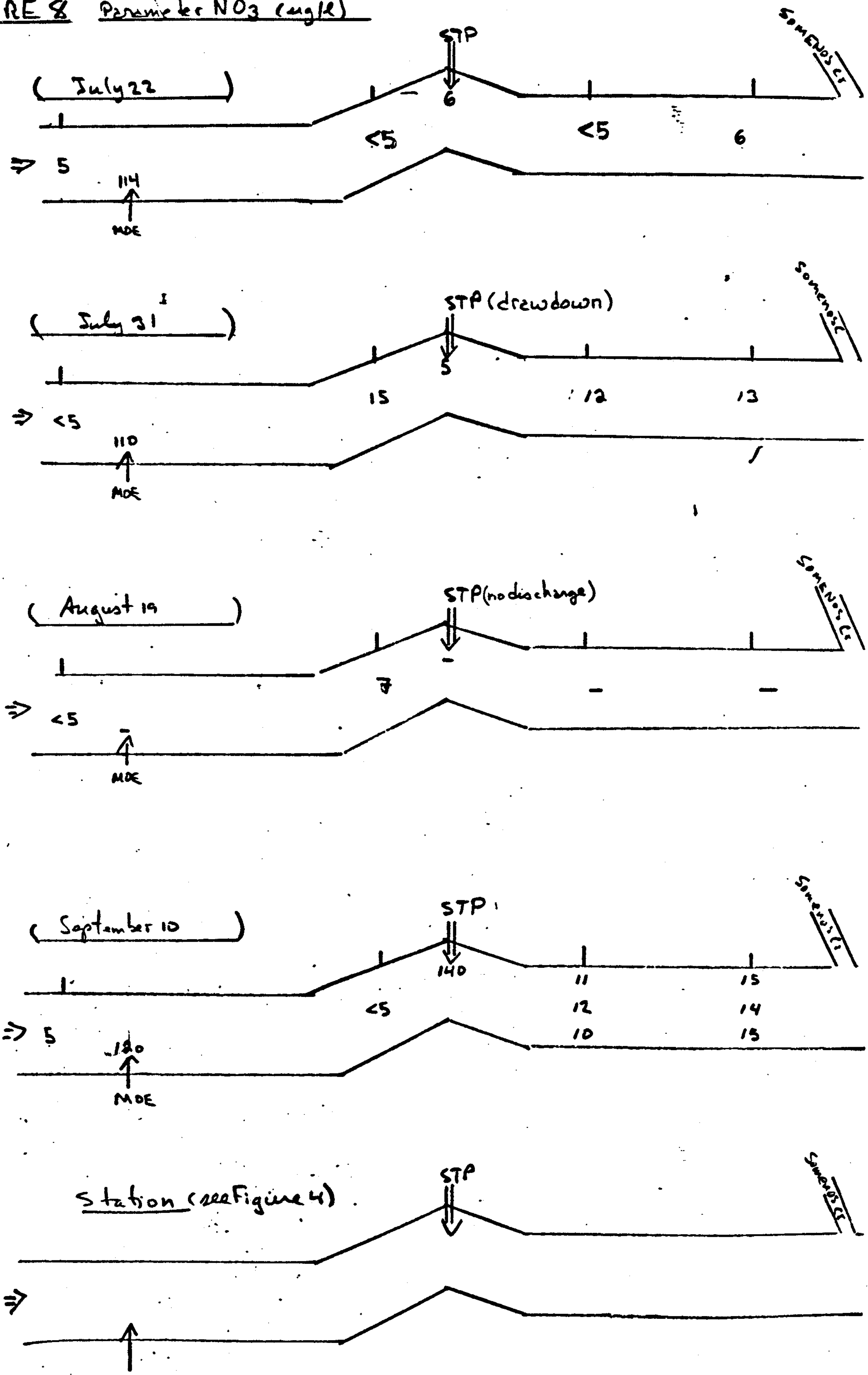
COWICHAN RIVER - 1985 LOWFLOW

FIGURE 7 Parameter NO_2 (ug/l)



COWICHAN RIVER - 1985 LOWFLOW

FIGURE 8 Parameter NO_3 (ug/l)



4.2 Dissolved Oxygen and pH

A back eddy had concentrated effluent in the large pool upstream of the diffuser. While levels were depressed in the area immediately adjacent to the diffuser, levels quickly returned to near background downstream. On July 22 during the normal discharge, dissolved oxygen levels were greater than 7.6 mg/l (94% saturation) whereas during the drawdown (July 31) a lower level of 6.0 mg/l (70% saturation) was measured (Figures 9 and 10). Davis, 1975 suggested that few members of a fish population will likely exhibit effects of low oxygen at 7.75 mg/l. At 6 mg/l the average member may start to exhibit oxygen stress and some risk exists at exposures greater than a few hours.

The sewage discharge did not appear to have any influence on pH levels which ranged between 7.4 to 8.4 (Figure 11).

4.3 Total and Fecal Coliform

Total and fecal coliform levels are reported on Figures 12 and 13 respectively. Fecal coliform levels were not affected by the discharge on July 22 (MPN < 10 per 100 ml). On July 31 during the drawdown, the 250 metre downstream station had a fecal coliform level of 75 compared to background levels of 33-47 per 100 ml.

4.4 Algal Standing Crop

Chlorophyll-a and phaeopigment were used to measure algal standing crop (Figure 14). In addition, photographs were taken to compare visual changes that occurred over the study period (Appendix I).

When sewage was first discharged into the main channel of the Cowichan River on August 13, 1980, an extensive algal bloom was observed within one week. A review of the hydrograph for 1980 (Figure 3) indicates the mean river flow for the preceeding week was 5.97 m^3/s. In August 1980, nutrient levels downstream (d/s) were 83-216 ug/l NH_3 and 51-130 ug/l TDP. The first observation of the river in 1985 was July 22. The mean river flows for the two weeks preceeding this was approximately 4.93 m^3/s. Downstream nutrient levels were 312-341 ug/l NH_3 and 170-210 ug/l TDP. It was anticipated the river would be in a bloom condition in July.

FIGURE 9 Dissolved Oxygen and Temperature Near Diffuser and Backwater u/s of Diffuser

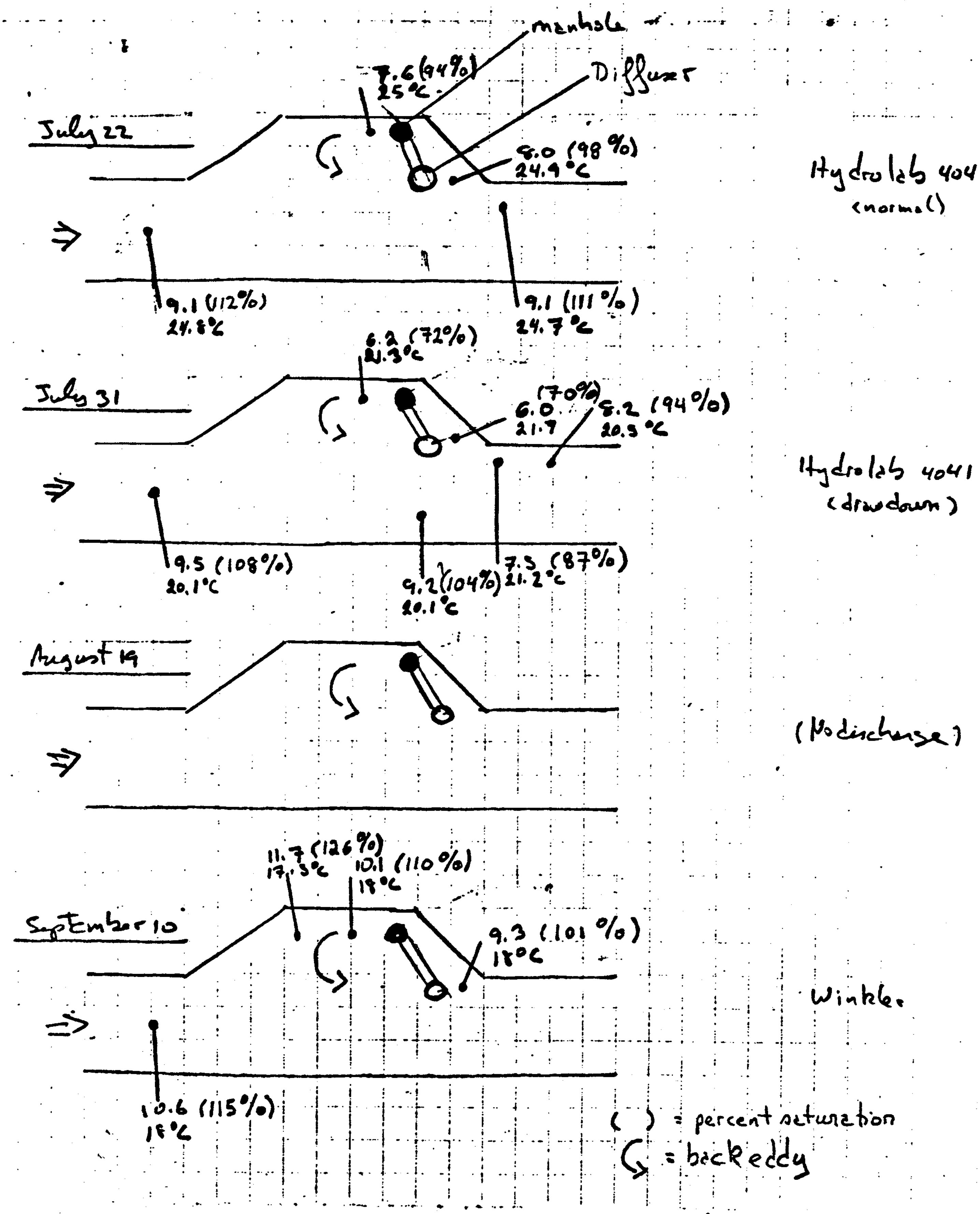


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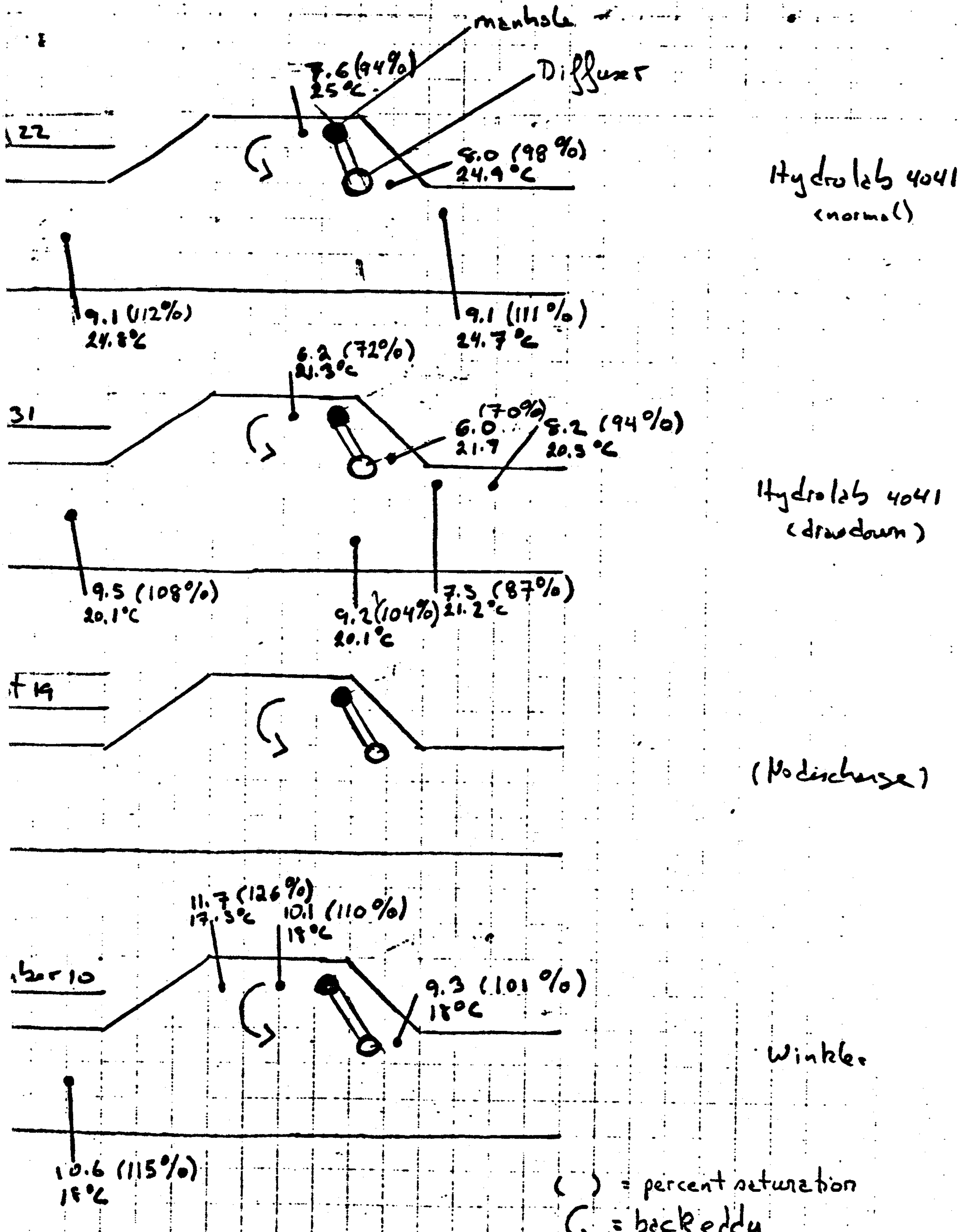
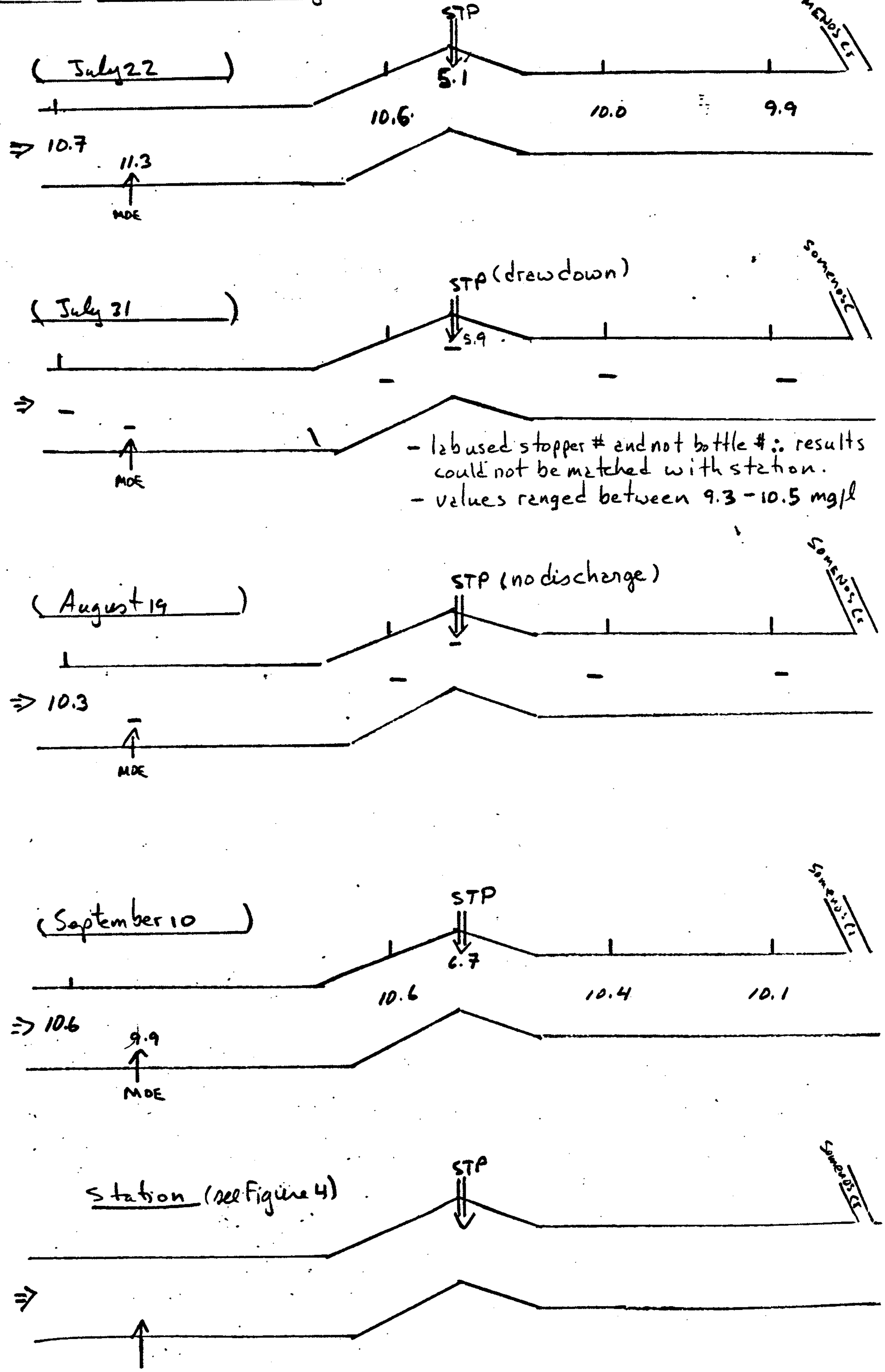
FIGURE 9 Dissolved Oxygen and Temperature Near Diffuser and Backwater u/s of Diffuser



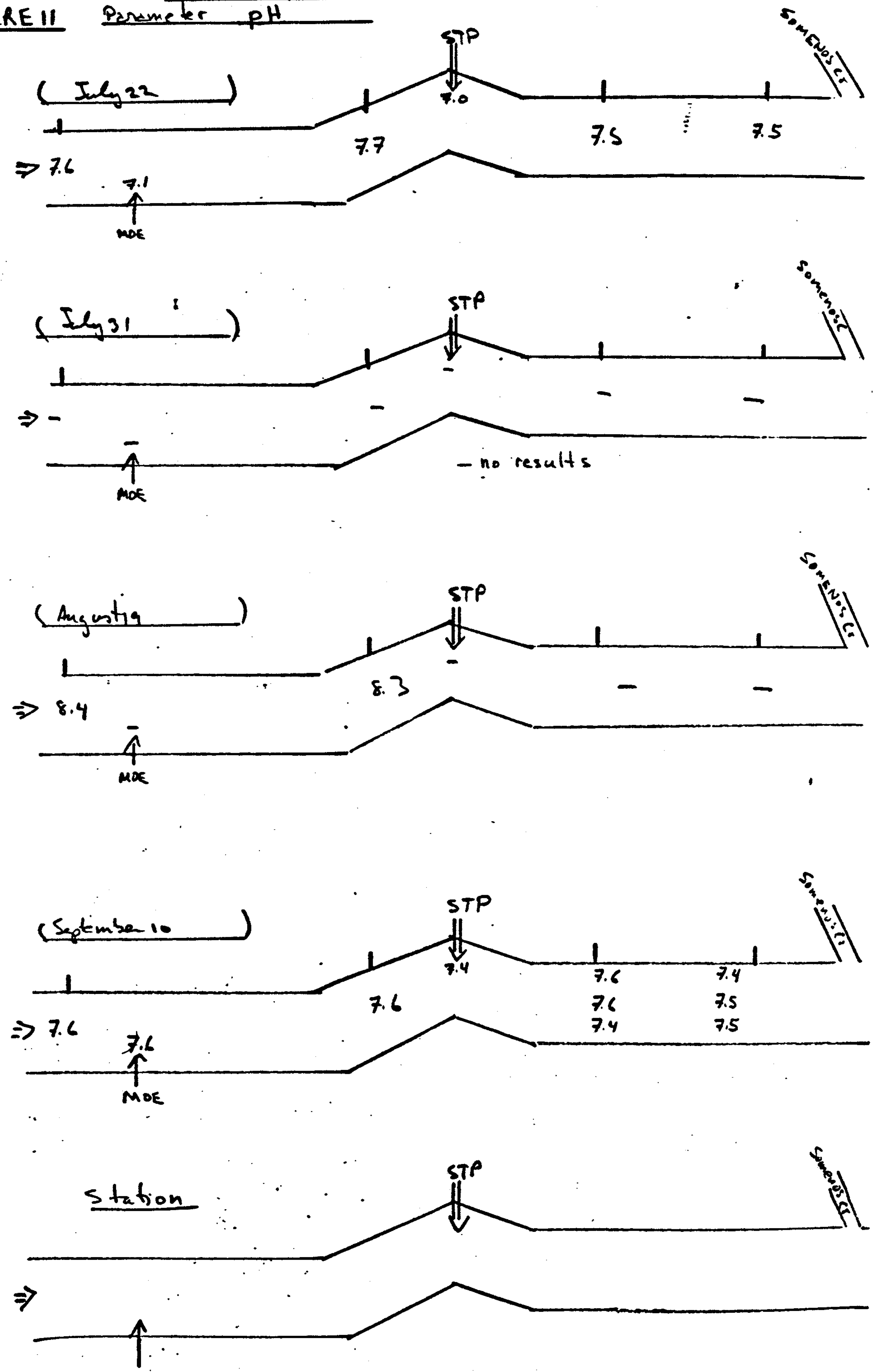
COWICHAN RIVER - 1985 LOWFLOW

FIGURE 10 Parameter D.O. (mg/l) (Winkler)



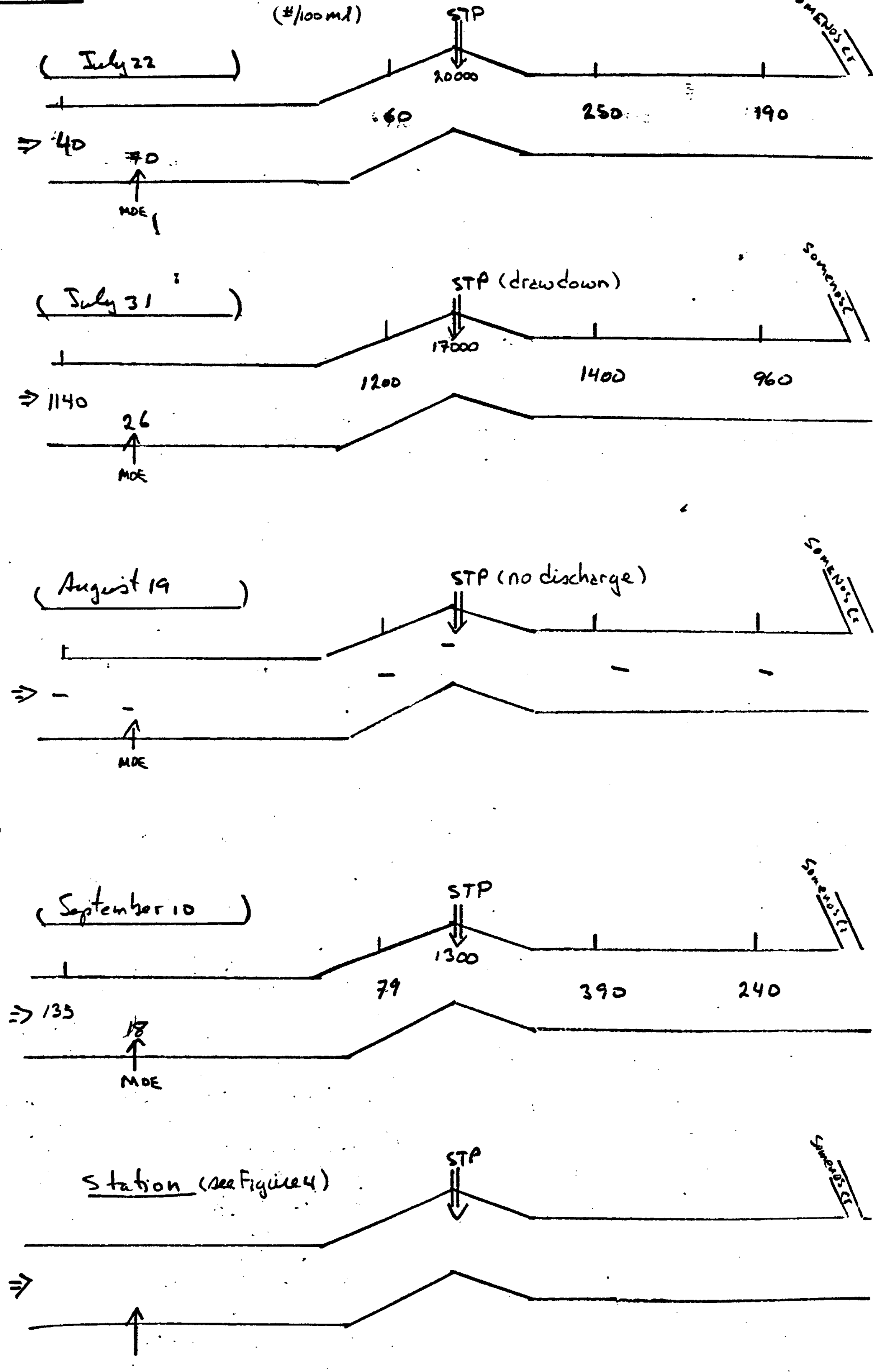
COWICHAN RIVER - 1985 LOW FLOW

FIGURE 11 Parameter pH



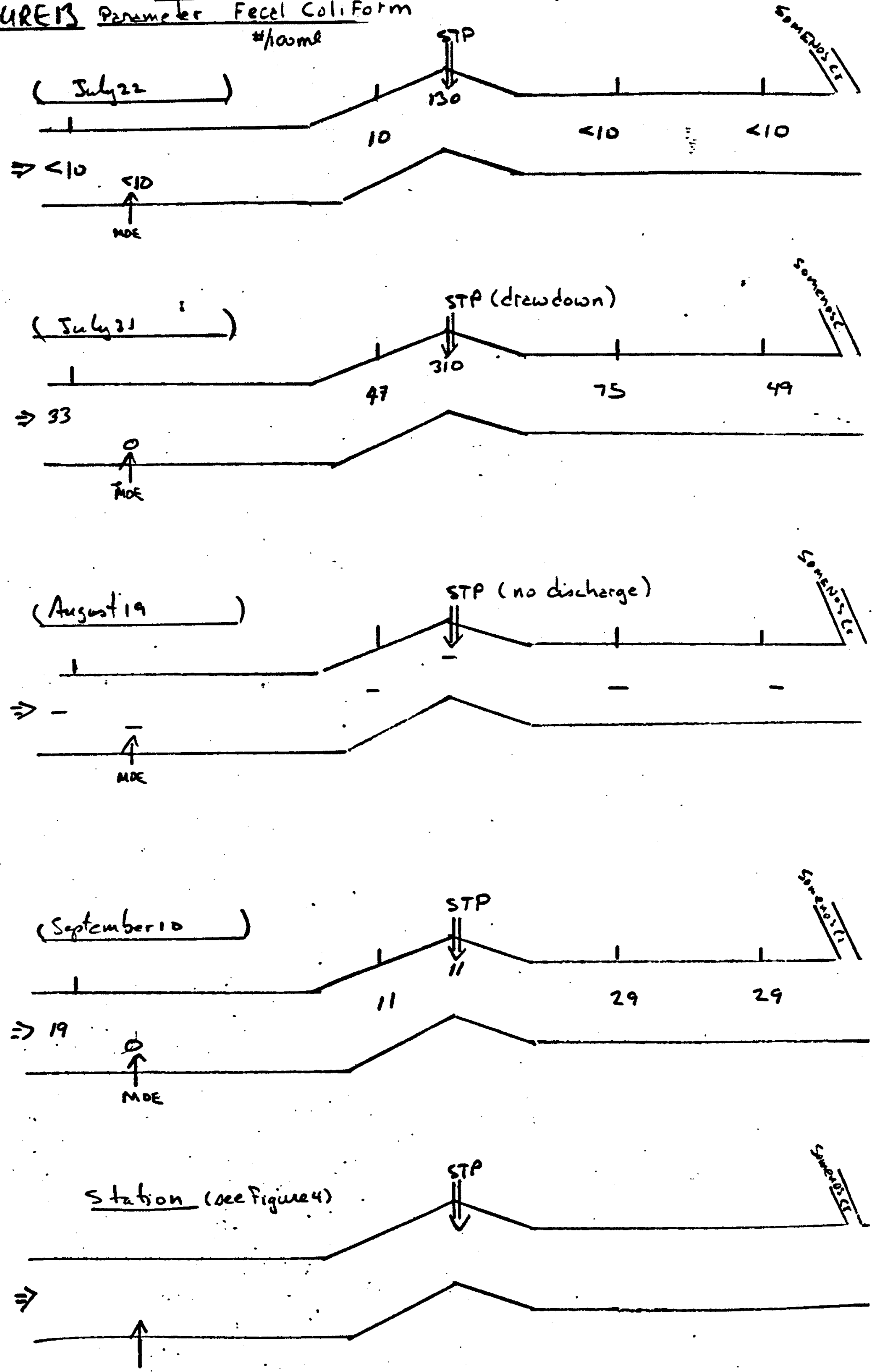
COWICHAN RIVER - 1975 LOWFLOW

FIGURE 12 Parameter Total Coliform
(#/100 ml)



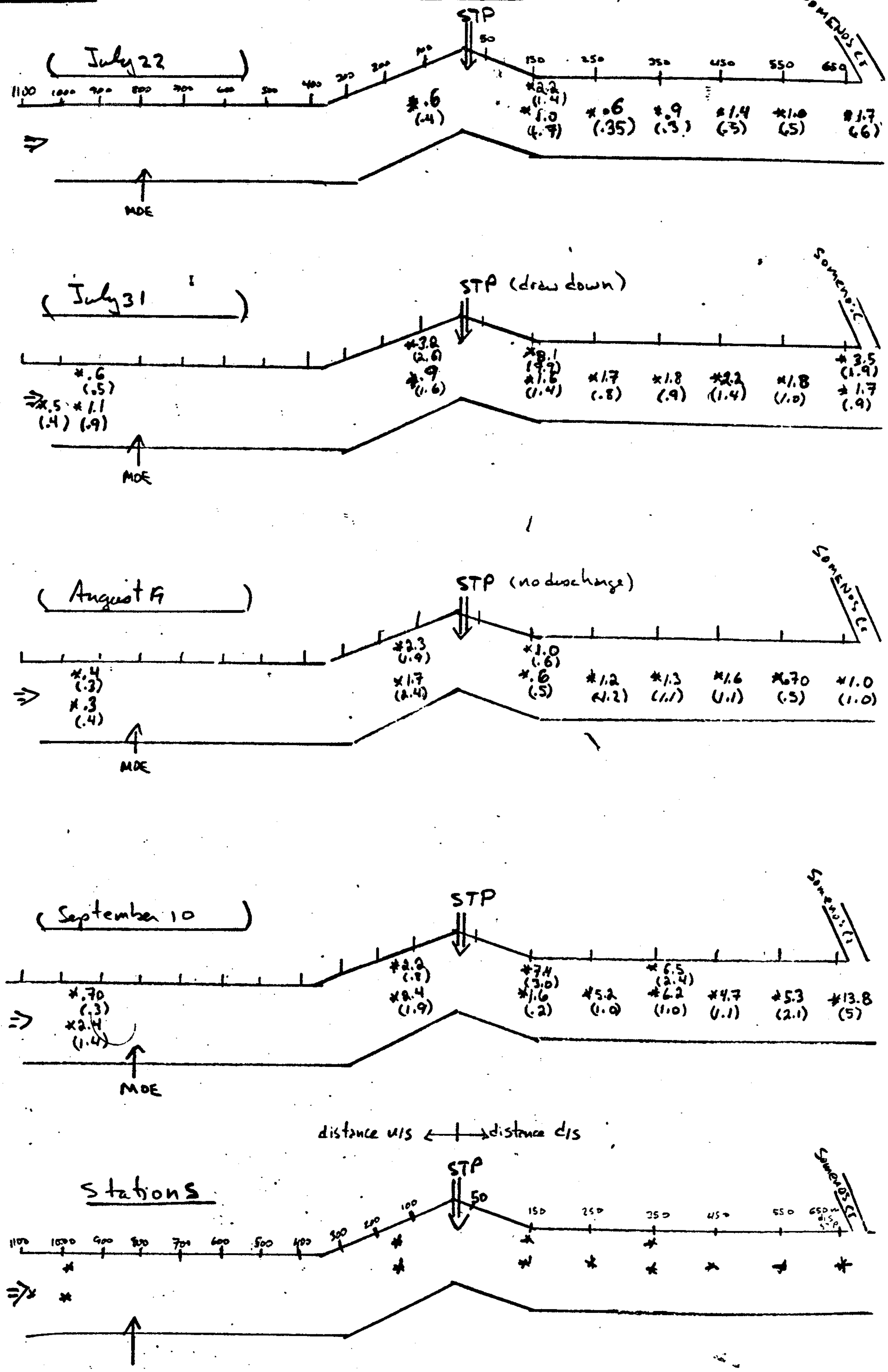
COWICHAN RIVER - 1985 LOW FLOW

FIGURE 13 Parameter Fecal Coliform #/100ml



COWICHAN RIVER - 1975 LOWFLOW

FIGURE 14 Parameter Chlorophyll-a (phaeopigment) ug/cm²



Observations indicated that extensive algal growth was restricted to a 3-4 meter band on the nearshore (STP side) and extended for approximately 150 meters downstream (Appendix I(a), Plate 1). Areas downstream of this had visible but not extensive periphyton cover (Appendix I(b), Plate 5; Appendix I(c), Plate 9). There was extensive nearshore growth 650 m downstream and to a much lesser degree, in a few areas upstream of the sewage discharge (Appendix I(d), Plate 13; Appendix I(e); Plate 17; Appendix I(g), Plate 25). The chlorophyll-a results reflect a generally higher midstream level of standing crop downstream (.6-1.7 ug/cm^2, $\bar{x}$ = 1.1 ug/cm^2) than upstream (.6 ug/cm^2) on July 22 (Figure 14).

The river was next inspected on July 31, 10 days into the drawdown. Observations indicated that the nearshore bloom extended to approximately 180 m downstream. Further downstream nearshore and midstream conditions were not unlike those on July 22 (Appendix Ia, photo 2; Appendix Ib, photo 6; Appendix Ic, photo 10; Appendix Id, photo 14). Midstream chlorophyll-a values ranged from .5-1.1 ug/cm^2 ($\bar{x}$ = .8 ug/cm^2) upstream to 1.6-2.2 ug/cm^2 ($\bar{x}$ = 1.8 ug/cm^2) downstream. River flows were very low (Figure 3). The drawdown ceased on August 5.

The river was inspected on August 19, 13 days into the 14 day storage period. The condition of the river was similar to the July 31 period. Midstream chlorophyll-a values ranged from .3-1.7 ug/cm^2 ($\bar{x}$ = 1.0 ug/cm^2) upstream to .6-1.6 ug/cm^2 ($\bar{x}$ = 1.1 ug/cm^2) downstream (Figure 14) (Appendix I(a), Plate 3; Appendix I(b), Plate 7; Appendix I(c), Plate 11; Appendix I(d), Plate 15; Appendix I(e), Plate 19).

The sewage discharge recommenced on August 21. The river was inspected on September 10 and an algal bloom was well established downstream of the sewage discharge (Appendix I(c), Plate 12; Appendix I(f), Plate 24). Midstream chlorophyll-a values were 2.4 ug/cm^2 upstream while downstream values were 1.6 to 13.8 ug/cm^2 ($\bar{x}$ = 6.1 ug/cm^2). The growth was heavier on the margins in the area 250-400 m downstream. The 250-400 m downstream stretch of the river was channelized and currents were much faster. The area 500-650 meters downstream was similar to the condition in September 1980.

4.5 Cell #5 Quality

The effluent quality of cell #5 was checked on August 19 prior to resumption of the discharge. Dissolved oxygen levels had dropped to < .05 mg/l and ammonia levels were 24 mg/l (undissociated NH_3 = 48 ug/l at pH 6.7 and 20°C). City of Duncan staff placed an aerator in the cell to aerate it prior to and during resumption of the discharge.

4.6 Cowichan River Flows

Water Survey of Canada flows for the Cowichan River from 1970 to 1985 are reported in Table 1. The summer low flow period has been arbitrarily defined as the period when flows consistently remain less than 10 m^3/s. The onset of summer low flows generally occurs in July but frequently begins in June. River flows generally begin to rise again by mid to late September. However, the low flow period can continue into October.

TABLE 1 COWICHAN RIVER MEAN FLOW-SUMMARY 1970 TO 1985 (WSC Data)

DATE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985*
May 1-5	22.1	69.6	47.6	9.60	56.6	46.2	69.2	40.4	20.9	26.4	41.9	71.9	41.5	17.3	49.4	49.1
6-10	20.4	72.4	48.0	9.98	53.6	55.8	69.1	36.9	15.5	29.6	28.7	64.2	40.5	17.6	37.2	46.9
11-15	20.3	73.8	47.0	15.5	50.1	61.9	68.3	15.5	14.5	24.6	21.6	46.2	39.8	18.2	50.1	38.2
16-20	15.9	67.6	51.6	20.4	42.6	61.2	59.9	11.5	18.5	20.6	14.9	30.5	38.0	15.3	58.2	30.1
21-25	12.8	58.8	46.3	24.0	38.7	53.2	50.9	9.92	18.6	16.9	13.9	22.2	31.9	11.7	65.8	28.8
26-31	12.8	55.5	25.1	38.1	64.2	37.1	53.6	10.3	20.7	13.1	11.7	17.8	30.1	6.80	70.3	24.8
Jun. 1-5	9.85	48.7	19.1	16.5	60.0	36.0	53.2	11.6	17.8	12.0	11.1	10.8	25.8	6.53	53.2	12.9
6-10	8.58	36.9	20.9	14.6	57.8	34.9	43.3	20.1	13.6	10.4	11.7	9.18	18.3	6.40	39.4	9.31
11-15	7.20	25.3	20.8	20.1	51.6	21.2	23.7	20.6	11.7	5.84	7.96	11.4	14.0	6.35	25.4	7.73
16-20	6.37	15.3	14.1	33.3	47.9	14.8	24.1	12.6	10.4	4.05	6.27	17.4	14.4	6.42	10.4	6.73
21-25	6.19	28.3	10.8	20.7	35.8	9.62	34.6	7.38	7.94	3.94	5.34	29.2	14.6	7.99	8.89	6.89
26-30	5.73	50.1	12.0	15.5	19.3	7.76	17.8	6.15	6.67	4.03	6.81	38.6	13.0	10.5	10.9	7.75
Jul. 1-5	5.66	32.3	11.4	10.5	17.0	13.6	10.7	6.33	6.65	4.17	7.74	29.1	15.2	15.2	14.3	7.64
6-10	5.46	18.3	10.2	7.92	19.8	17.6	17.7	6.03	6.51	3.99	9.87	16.1	14.8	15.4	17.1	7.10
11-15	5.32	22.1	25.9	9.34	26.2	12.1	29.3	6.34	6.90	5.79	9.87	12.9	11.3	26.9	12.5	5.48
16-20	5.09	15.9	38.2	7.71	27.0	7.88	10.6	5.93	6.80	4.93	11.4	12.5	9.11	39.5	6.34	5.36
21-25	4.60	14.1	23.8	6.44	35.3	7.07	10.1	5.83	7.06	4.71	10.9	9.29	6.77	27.0	5.20	4.05
26-31	5.32	10.3	7.81	6.18	21.4	7.10	11.5	5.98	5.08	4.58	10.8	8.42	5.91	19.2	5.54	3.87
Aug. 1-5	5.19	8.39	6.78	5.93	9.63	7.11	8.12	5.48	5.10	4.49	10.9	7.83	5.38	13.6	5.47	3.83
6-10	5.32	6.98	6.47	6.36	9.34	7.21	5.25	5.34	5.27	4.66	9.47	7.07	5.49	6.03	5.40	4.20
11-15	4.99	6.76	6.56	6.04	7.48	7.07	6.15	4.84	5.62	4.65	6.70	7.04	5.51	5.90	5.43	4.03
16-20	4.70	6.82	6.83	6.07	7.34	7.28	9.43	5.62	4.95	4.80	5.97	6.83	5.46	5.83	5.28	3.83
21-25	5.00	8.77	6.51	5.71	7.27	8.43	11.9	6.16	5.68	4.89	5.44	5.98	5.51	6.12	5.10	3.71
26-31	5.17	12.4	6.63	4.94	6.80	15.5	11.5	6.50	5.99	4.88	4.82	5.52	6.01	6.27	5.07	3.72
Sep. 1-5	5.24	8.37	6.37	5.24	7.49	26.0	10.9	7.34	7.95	6.79	5.32	5.03	6.34	8.65	5.78	4.76
6-10	5.29	9.98	6.43	4.66	7.52	22.1	13.3	6.87	10.6	16.4	5.10	4.94	6.21	10.0	5.57	4.11
11-15	5.24	16.5	6.21	4.68	7.11	18.5	16.4	5.83	23.1	27.9	5.38	5.38	5.70	13.8	7.93	5.89
16-20	6.09	15.1	6.35	4.81	7.41	15.7	13.4	6.28	32.1	27.3	8.62	7.07	5.78	14.3	12.1	6.32
21-25	9.67	12.9	17.8	5.41	7.39	11.9	11.6	8.65	36.4	22.3	8.69	9.70	6.06	12.2	16.0	6.53
26-30	11.4	12.0	16.6	4.90	6.88	10.5	9.77	13.7	35.9	20.6	9.19	16.0	6.61	9.88	11.7	8.03
Oct. 1-5	10.4	12.6	14.1	4.56	7.97	14.1	9.66	13.9	32.6	18.8	11.2	29.7	7.58	9.04	9.64	7.82
6-10	8.42	15.0	11.2	5.00	7.14	26.7	8.31	13.0	28.0	16.1	12.8	49.3	10.7	8.35	37.4	8.08
11-15	7.27	14.5	8.97	6.06	8.06	34.3	9.86	11.9	23.1	13.7	14.7	48.1	11.2	7.25	85.8	10.6
16-20	6.78	15.6	7.89	8.37	6.90	112	9.57	11.3	19.3	12.9	14.5	39.2	11.0	6.86	85.9	19.3
21-25	18.8	29.1	6.98	14.7	5.54	113	8.55	16.7	17.0	18.1	13.4	31.4	32.4	11.8	67.2	49.6
26-31	25.7	40.6	6.23	27.7	3.98	143	12.5	48.6	15.2	64.9	13.6	62.4	93.4	15.3	49.6	69.6

*1985 - preliminary data

5 SUMMARY

The Duncan-North Cowichan trial sewage drawdown and storage did not prevent algal bloom conditions from developing in September 1985. Observations of the river over July to September 1985 did indicate some interesting results. Although river flows in July 1985 were lower than flows in August 1980, when algal bloom conditions were first observed, mid stream sections of the river did not develop bloom conditions. A dense algal mat did exist along the nearshore margin (STP side) for approximately 150-180 meters downstream. Considerable nearshore growth was observed at 650 m downstream. To a much less degree, nearshore growths existed upstream as well. The section of river 250-400 m downstream was channelized compared to conditions in 1980 and velocities in this section were high.

The area of river 500-650 meters downstream was unchanged from 1980 and appeared to be the best indicator of overall growth potential. While nutrient levels were high entering this area in July (NH_3 > 300 ug/l, TDP > 200 ug/l) and river flows were extremely low, the extensive bloom conditions of August 1980 did not develop. During the drawdown, the nearshore bloom area increased to approximately 180 m downstream but midstream sections did not respond. With removal of the effluent for two weeks, the condition of the river remained unchanged. Observations on September 10, three weeks after the discharge resumed, indicated the area 500-650 meters downstream was in a bloom condition comparable to August and September 1980. The area 250-400 m downstream had extensive nearshore growth, but faster midstream velocities could have been a physical limitation.

The diffuser was located at the downstream end of a large pool and a back eddy condition existed. Extensive algal growth was observed in this area. That area and the nearshore area for 150-180 m downstream was largely affected by the effluent. Dissolved oxygen levels were lower in the immediate area of the diffuser (6 mg/l, 70% saturation during drawdown) but were not critically low and recovered quickly downstream.

6 CONCLUSIONS

Based on observations of the Cowichan River during July 1985, it would appear that for that period, the response of attached algae to high nutrient levels (during extremely low flows) is marginal. The nearshore area to 150-180 meters downstream was highly influenced and due to a back eddy, so was the pool upstream of the diffuser. However, beyond 180 meters downstream, nearshore and midstream areas were only marginally affected with increased periphyton.

Flows during the 1985 low flow period were unusually low and presented a worst case scenario for the trial drawdown and storage.

The 1985 results indicate that the river in July appears to be marginally sensitive to nutrient increases (except for nearshore affect). Observations in August 1980 and September 1980 and September 1985 indicate that during these months the river is sensitive to nutrient inputs. The reason(s) for this seasonal difference is not obvious but may have something to do with the seasonal reproductive requirements of the bloom species involved.

A review of flow data for 1970 to 1985 indicates that river flows generally drop over June and July. August generally has the lowest flows and flows generally begin to increase again by mid to late September.

Based on the river response in July 1985 and the fact river flows generally increase by mid to late September, it would seem reasonable to focus effluent control measures for a 6 to 8 week period over August and September. This period appears to be the critical with respect to algal growth due to increased nutrients.

The 1985 drawdown experience indicates that a 2 week storage capacity is the maximum practically achievable with the present lagoon configuration. Additional storage would have to be provided and/or an alternate means of effluent disposal would have to be found, to prevent the discharge of sewage to the Cowichan River during August and September.

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APPENDIX I

PLATES

APPENDIX I(a)

PLATE 1 150 M DOWNSTREAM - NEARSHORE
July 22, 1985

PLATE 2 180 M DOWNSTREAM - NEARSHORE
July 31, 1985

APPENDIX I(a)

PLATE 3 180 M DOWNSTREAM - NEARSHORE
August 19, 1985

PLATE 4 150 M DOWNSTREAM - NEARSHORE
September 10, 1985

APPENDIX I(b)

PLATE 5 250 M DOWNSTREAM - MIDSTREAM
July 22, 1985

PLATE 6 250 M DOWNSTREAM - MIDSTREAM
July 31, 1985

APPENDIX I(b)

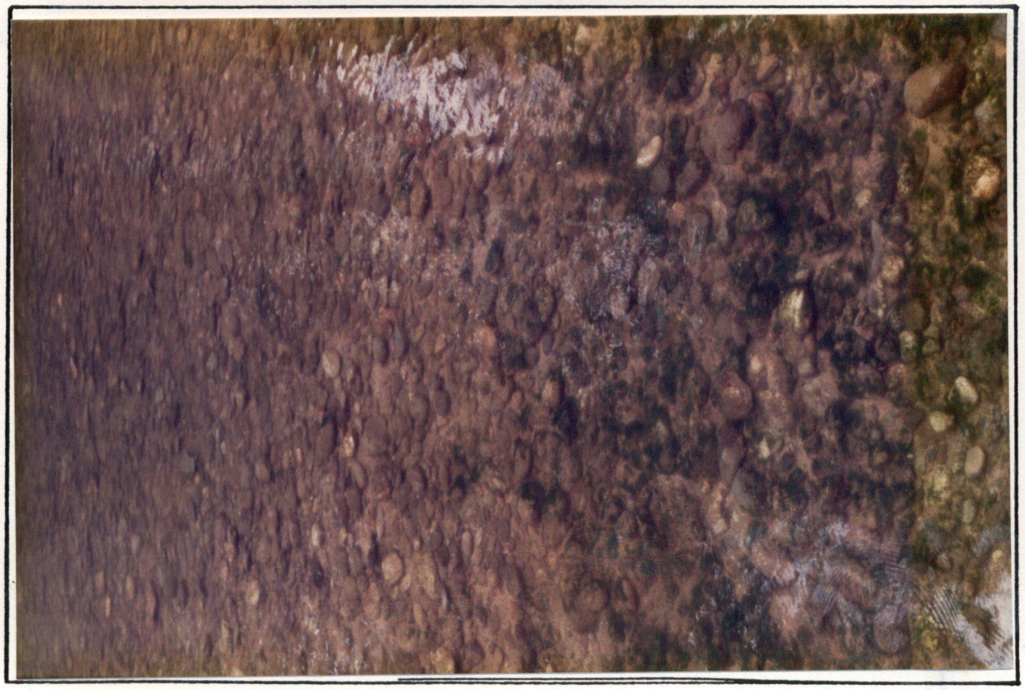
PLATE 7 250 M DOWNSTREAM - MIDSTREAM
August 19, 1985

PLATE 8 250 M DOWNSTREAM - MIDSTREAM
September 10, 1985

APPENDIX I(c)

PLATE 9 650 M DOWNSTREAM - MIDSTREAM
July 22, 1985

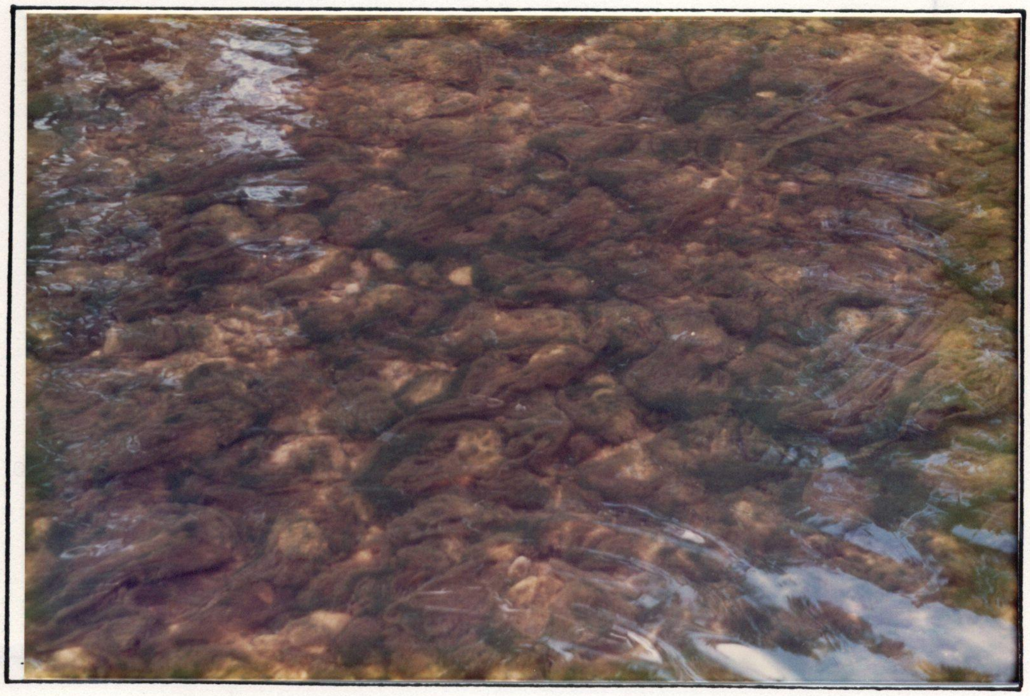
PLATE 10 650 M DOWNSTREAM - NEAR/MIDSTREAM
July 31, 1985



APPENDIX I(c)

PLATE 11 650 M DOWNSTREAM - MIDSTREAM
August 19, 1985

PLATE 12 650 M DOWNSTREAM - MIDSTREAM
September 10, 1985



APPENDIX I(d)

PLATE 13 650 M DOWNSTREAM - NEARSHORE
July 22, 1985

PLATE 14 650 M DOWNSTREAM - NEARSHORE
July 31, 1985

APPENDIX I(d)

PLATE 15 650 M DOWNSTREAM - NEARSHORE
August 19, 1985

PLATE 16 650 M DOWNSTREAM - NEARSHORE
September 10, 1985

APPENDIX I(e)

PLATE 17 200 M UPSTREAM STP
July 22, 1985

PLATE 18 50 M UPSTREAM STP
July 31, 1985

APPENDIX I(e)

PLATE 19   40 M UPSTREAM
August 19, 1985

PLATE 20   50 M UPSTREAM
September 10, 1985

APPENDIX I(f)

PLATE 21 400 M DOWNSTREAM - MIDSTREAM
July 22, 1985

PLATE 22 400 M DOWNSTREAM - MIDSTREAM
July 31, 1985

APPENDIX I(f)

PLATE 23 400 M DOWNSTREAM - MIDSTREAM
August 19, 1985

PLATE 24 400 M DOWNSTREAM - MIDSTREAM
September 10, 1985

APPENDIX I(g)

PLATE 25 150 M UPSTREAM STP - MIDSTREAM
July 22, 1985

PLATE 26 150 M UPSTREAM STP - MIDSTREAM
July 31, 1985

APPENDIX I(g)

PLATE 27 140 M UPSTREAM STP - MIDSTREAM
August 19, 1985

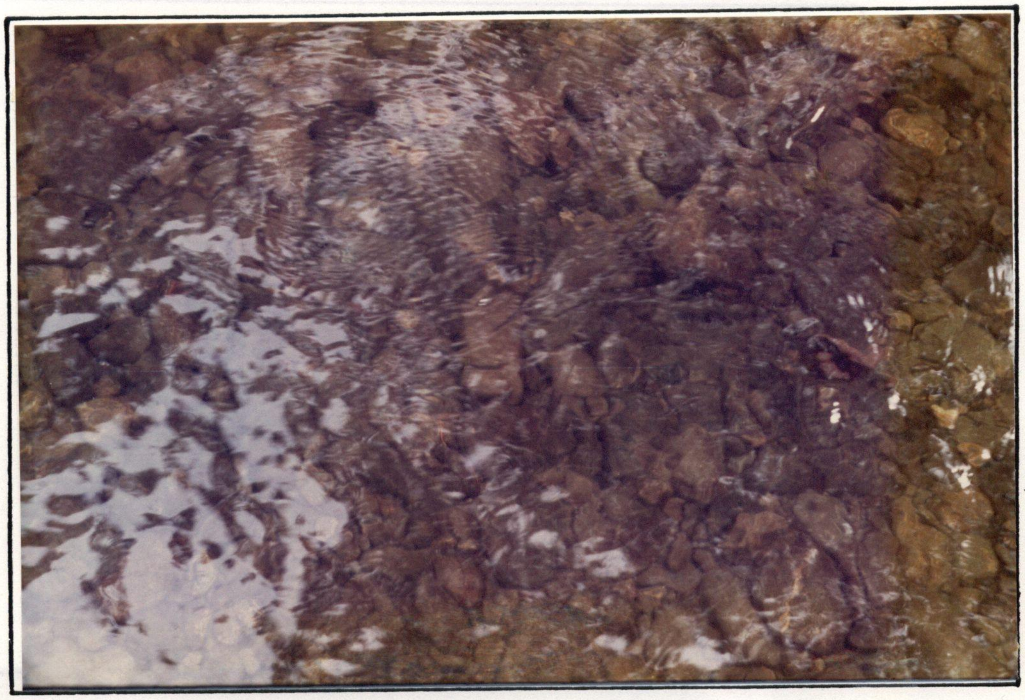


PLATE 28 150 M UPSTREAM STP - MIDSTREAM
September 10, 1985

APPENDIX I(h)

PLATE 29 POOL UPSTREAM OF DIFFUSER - NEARSHORE
August 19, 1985

PLATE 30 POOL UPSTREAM OF DIFFUSER - NEARSHORE
September 10, 1985