APPENDIX D

1994 CAPACITY ANALYSIS

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1994 TREATMENT PLANT CAPACITY ANALYSIS

The following Existing Treatment Plant Capacity Analysis was included in the 1994 draft of the Redwood SSSD Wastewater Facility.

1. DESIGN CRITERIA EVALUATIONS

The design criteria for the treatment plant, based on information from the Operation and Maintenance Manual, are outlined below.

Influent	
Minimum	0.15 mgd
Average	0.48 mgd
Peak	1.44 mgd
BOD_5	800 lb/day
Suspended Solid	800 lb/day
Final Effluent	
BOD_5	20 mg/ℓ
	80 lb/day
Suspended Solid	20 mg/ℓ
	80 lb/day
Pump Station	
Pumps	2
Capacity	1,000 gpm (each)
Comminutors	
Number	1
Size	12 inch
Capacity	1.5 mgd
Aeration Basin	
Size	45-foot diameter
Volume	24,000 ft^3
Depth	15 feet
Design BOD Loading (@ 2,000 mg/ℓ MLSS)	
F/M	.27/day
Aeration Equipment	
Blowers	2
Size	1,200 SCFM each
Diffusers	Spring leaf - 24 SCFM each

Clarifier	
Number	1
Size	40-foot diameter 11 ft. SWD
Type	Suction withdrawal
Surface Overflow Rate	
@ .48 mgd (Design)	384 gal/ft^2 day
@ 1.44 mgd (Peak)	1,152 gal/ft^2 day
Solids Loading Rate	
@ .48 mgd	.30 lb/ft^2 hr
@ 1.44 mgd	.80 lb/ft^2 hr
Weir Loading Rate	
@ .48 mgd	3,820 gpd/ft
@ 1.44 mgd	11,460 gpd/ft
Chlorine Contact Chamber	
Number	2
Size	5-foot diameter x 70-feet long (1,370 ft^3 ea)
Detention time @ .48 mgd in one chamber	31 min.
Detention time @ 1.44 mgd in one chamber	10.25 min.
Chlorination Facilities	
Chlorinator	
Number	2
Size	100 lb Cl_2/day
Return Sludge Pumps	
Number	2
Type	Self-priming centrifugal
Capacity	350 gpm @ 26 ft. head
Aerobic Digester	
Size	32-foot diameter x 15-feet SWD
Volume	12,000 ft^3
Detention Time	20 days

2. PERFORMANCE REVIEW

Based on the data taken from 1988 to 1993 at the treatment plant, several graphs have been generated to reflect the performance of the treatment plant. The graphs have been divided into winter and summer seasons based on the time period shown in the NPDES permit. These graphs, which are included at end of this Appendix, show the following information:

- Influent BOD Load vs. BOD Removed (Figure 1)

- Flow vs. Percent BOD Removed (Figure 2)
- Flow vs. Effluent BOD Concentration (Figure 3)
- Effluent BOD by Year (Figure 4)
- Percent BOD Removed vs. Influent BOD (Figure 5)
- Flow vs. Influent BOD (Figure 6)
- Influent BOD by Year (Figure 7)
- Flow vs. Effluent BOD Load (Figure 8)
- Effluent BOD Load by Year (Figure 9)
- Flow vs. Percent Solids Removed (Figure 10)
- Flow vs. Effluent Solids Concentration (Figure 11)
- Flow vs. Effluent Solids Load (Figure 12)

The treatment plant performed well in respect to BOD. Figure 1 indicates that there was no major organic loading problems; however, BOD removals do decrease above 800 and 1,100 lbs/day for summer and winter, respectively.

In reviewing the plant's performance relative to BOD limitations, the following observations are made:

- The plant consistently has met the 85 percent removal requirement. Most of the time, the removals have been 95 percent or greater. There does appear to be decreased removals as flow increases. Some of the data for summer does not follow this trend, yet removals are still greater than 90 percent. This data could represent operational difficulties. See Figure 2.

- Effluent BOD is generally very consistent. Figure 3 shows that winter values range between 15 mg/ℓ and just below 5 mg/ℓ. There does appear to be a rising trend in the lowest winter effluent BOD values above .6 mgd.

- The majority of summer effluent BOD values are below 10 mg/ℓ, with a definite relationship proportional to flow. There is recent data that breaks this trend. As shown on Figure 4, effluent BOD for the summer of 1992 always exceeded 10 mg/ℓ. It also appears that 1993 is not as good as previous years.

- One would expect the most diluted wastewater in the winter. Figure 5 demonstrates that summer influent BOD values can be lower than during the winter and the associated higher flows. Winter values show a decreasing removal rate with decreasing influent strength. With recent data, it is difficult to interpret the summer chart.

- Both summer and winter charts in Figure 6 show that influent BOD does decrease with increasing flow. It is interesting that the lowest values do not occur at the maximum flow. This trend is especially true for the winter data.

- As shown on Figure 7, the low values less than 100 mg/ℓ occurred during the summer of 1991. According to available flow records, this summer also had the highest flow of the past six years.

- The monthly limitation for effluent BOD load is 80 and 120 lbs/day for summer and winter, respectively. Figure 8 indicates that during the winter the 120 lb/day limit is being approached by a significant portion of the data. The majority of the summer data indicates an increasing effluent load with flow. Again, a portion of the data does not follow the trend. This data, most of which is above 50 lbs/day, has occurred in the summer of 1992 and 1993. This does raise some concern about lack of consistency and a drop in plant performance. Figure 9 shows yearly plots.

There was a similar trend with suspended solids. As flow increased, especially beyond .6 mgd, the percent suspended solids removed shown in Figure 10 begins to decrease and the treatment level becomes less reliable. Based on the plant's performance, the following observations were made about suspended solids:

- The effluent TSS concentration approached the summer permit limitation of 20 mg/ℓ at flows above .6 mgd. This trend was not duplicated for winter values, which appear to remain below 15 mg/ℓ at all flows. This is shown in Figure 11.

- The summer effluent solids limitation of 80 lb/day was exceeded on a 30-day average above flows of .6 mgd. The winter solids limitation has not been exceeded but is approached at flows greater than .8 mgd (see Figure 12).

The data shows permit violations when flows are greater than .6 mgd. Since the main unit process that controls suspended solids is the secondary clarifier, it is likely that it is being overloaded.

This condition is not, however, a result of an average daily flow of 0.6 mgd. Rather, it is likely the result of the influent pump operation. What is affecting the operating characteristics of the clarifier is the flow rate produced by the influent pumps. On any given day when the volume of wastewater is .6 mgd or greater, most of that flow will occur during an 18-hour period. This corresponds to the influent pumps being on at least 50 percent of the time. During this condition, the secondary clarifier is actually being subjected to peak flow conditions more than half of the time during a day. During these times, the operating conditions in the clarifier are greater than normal design criteria.

3. HYDRAULIC ANALYSIS

The treatment plant has been designed for a maximum flow of 1.44 mgd. This corresponds to the design capacity of each of the influent pumps (1,000 gpm). A hydraulic profile shown in the as-built drawings was used to verify this design capacity.

Based on the verification of the hydraulic profile, there is sufficient hydraulic capacity in the plant for a peak flow of 1.44 mgd. At this flow, there are approximately two feet of freeboard on the major treatment units. The plant was then analyzed for maximum flow. Not including the comminutor, the plant currently could handle flows up to approximately 1.8 to 1.9 mgd peak hydraulic flow.

This hydraulic analysis also assumed normal river flows. Based on current FEMA data, the treatment plant could not discharge by gravity downstream of the influent pumps during a 100-year flood. An analysis to determine what river level would trigger the need for effluent pumping has not been completed. To ensure reliability and safety, an effluent pumping system should be considered.

4. PLANT CAPACITY

Since the performance review revealed a flow limitation of .6 mgd, this section analyzes the impact of that flow to design parameters.

First is an analysis of the aeration basin. In this analysis, both the current permitted capacity and a suggested capacity of .6 mgd are reviewed.

Standard parameters for an activated sludge system include the following:

Θ_c = 5 - 15 days
F/M = .2 - .4 lb BOD_5/lb MLVSS - day
Loading = 18.7 - 37.5 lb/10^3 ft^3 - day
MLSS = 1,500 - 3,000 mg/ℓ
Θ = 4 - 8 hr
Qr/Q = .25 - .5

Θ_c	=	Mean Cell Residence Time
F/M	=	Food to Microorganism Ratio
MLSS	=	Mixed Liquor Suspended Solids
Θ	=	Hydraulic Detention Time
Qr	=	Return Activated Sludge Flow Rate
Q	=	Influent Flow Rate

Checking these parameters with the current and proposed capacity gives the following results:

Θ = 8.9 hour at .48 mgd
= 7.2 hour at .6 mgd

F/M = .27 at .48 mgd
= .33 at .60 mgd

Given MLSS = 2,000 mg/ℓ per operator and influent BOD = 200 mg/ℓ,

Θ_c = 11.6 day at .48 mgd
= 8.5 day at .60 mgd

Given 90 percent removal:

Y = .6
Kd = .06

If percent removed is 95 percent:

Θ_c = 10.6 day at .48 mgd
= 7.8 day at .6 mgd

Qr/Q = 1 at .48 mgd
= .8 at .6 mgd

From the above comparisons, it is evident that operating the aeration basin at .6 mgd is well within acceptable operating parameters.

The next item is the air requirements for the treatment plant. To perform this analysis, the following assumptions were made:

BOD Load = 800 lbs/day at .48 mgd
= 1,000 lbs/day at .6 mgd

O_2 required = 2.3 lbs/lb BOD applied

O_2 = .08 lb/ft^3

Transfer Efficiency = 6%

Percent Oxygen in Air = 23%

Given the above information:

Volume of Air Required = 1,160 cfm at .48 mgd
= 1,450 cfm at .60 mgd

Assuming the aerobic digester requires about 100 cfm, the blower system is currently at capacity at a plant flow of .48 mgd. At plant flows above 0.48 mgd, there is insufficient blower capacity.

The secondary clarifier has the following range of standard design values:

Overflow Rate = Average Flow 400 - 800 gal/ft^2 day
= Peak Flow 1,000 - 1,200 gal/ft^2 day

Solids Loading = Average Flow .6 - 1.2 lb/ft^2 hour
= Peak Flow 1.8 lb/ft^2 hour
= MLSS 2,000 mg/ℓ

At .48 mgd, the overflow rate = 384 gal/ft^2 day and the solids loading = .27 lb/ft^2 hour.

At .6 mgd the overflow rate = 478 gal/ft^2 day and the solids loading = .33 lb/ft^2 hour.

At peak flow, 1.44 mgd the overflow rate = 1,152 gal/ft^2 day and the solids loading = .8 lb/ft^2 hour.

While the design criteria for both .48 and .6 mgd are well within the acceptable ranges, peak flow conditions are nearing the upper limit of the range. Therefore, since the influent pump station has a capacity of 1,000 gpm (1.44 mgd), there could be intermittent overloading of the secondary clarifier.

Finally, the chlorine contact chamber should have detention times greater than 45 minutes at design flow and at least 20 minutes at peak flow for effective disinfection.

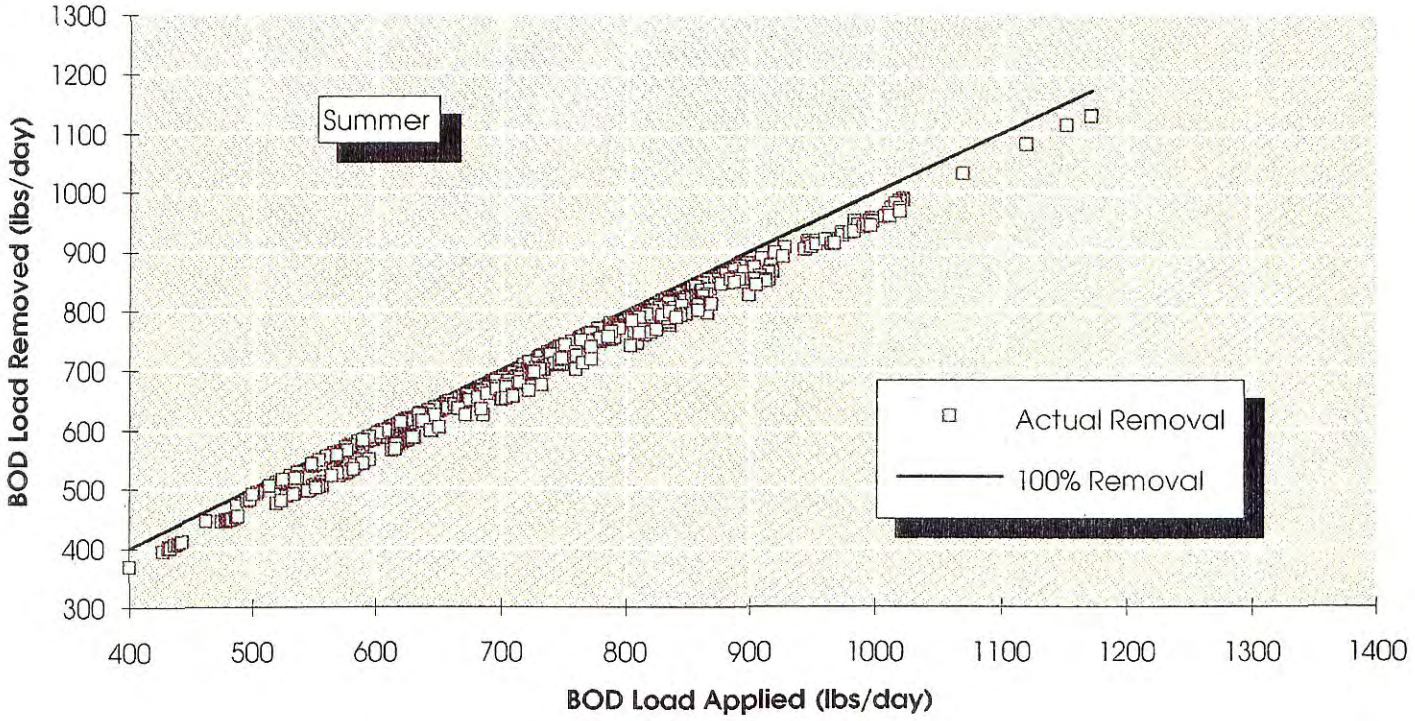
Detention Time	=	31 min. at .48 mgd (1 chamber)
	=	25 min. at .6 mgd (1 chamber)
	=	50 min. at .6 mgd (2 chambers)
	=	10 min. at 1.44 mgd (1 chamber)
	=	20 min. at 1.44 mgd (2 chambers)

The existing contact chamber will provide sufficient contact time at all flows.

Reviewing the sizing of RAS pumps and digester, they are adequate for .6 mgd.

Based on the information contained in this report, the treatment plant has a capacity of approximately .6 mgd, with a peak flow of 1.44 mgd. This is a peaking factor of 2.4, which is adequate given the size of the service area.

Current operation of the treatment plant allows this peak flow to occur every time an influent pump is on. Although this flow is not continuous, it can have an effect on treatment even though the flow may be dampened in the plant. This peak flow can reduce the efficiency of certain units at the plant. This flow has the greatest impact on the secondary clarifier.



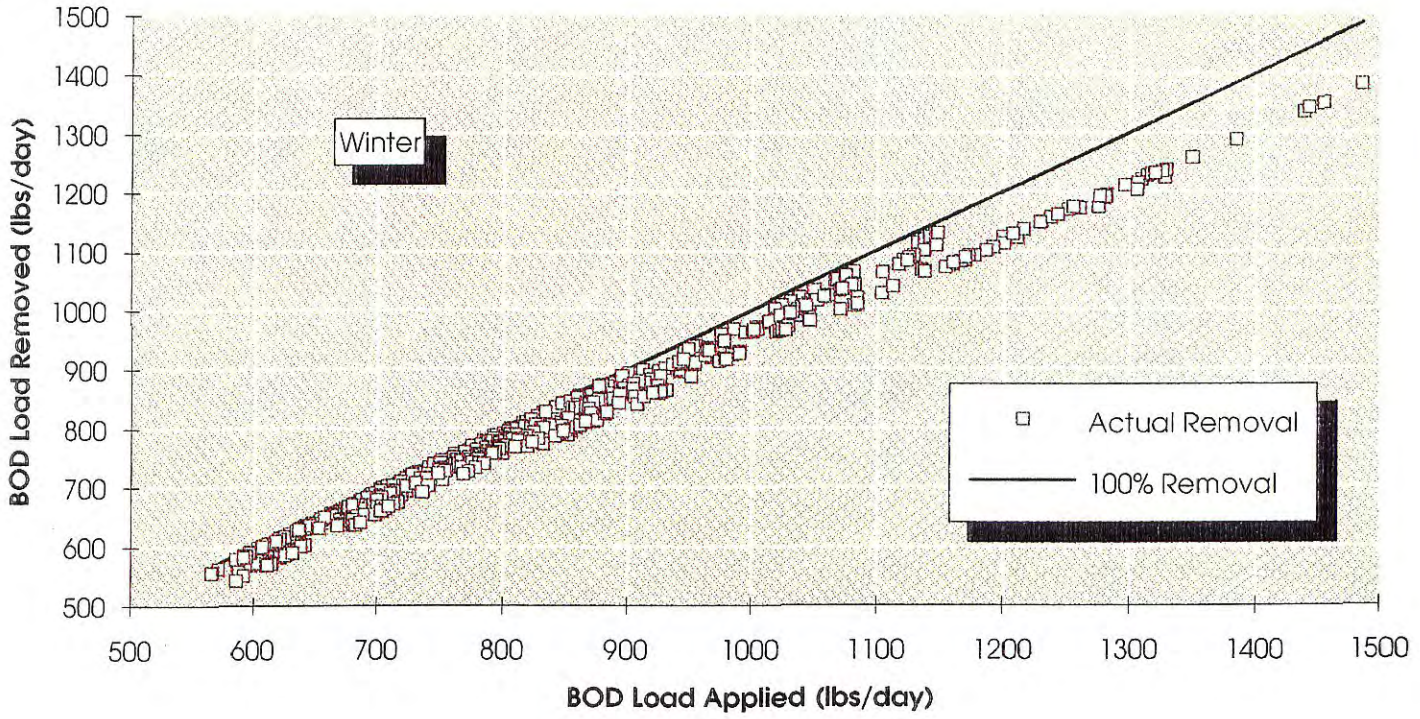
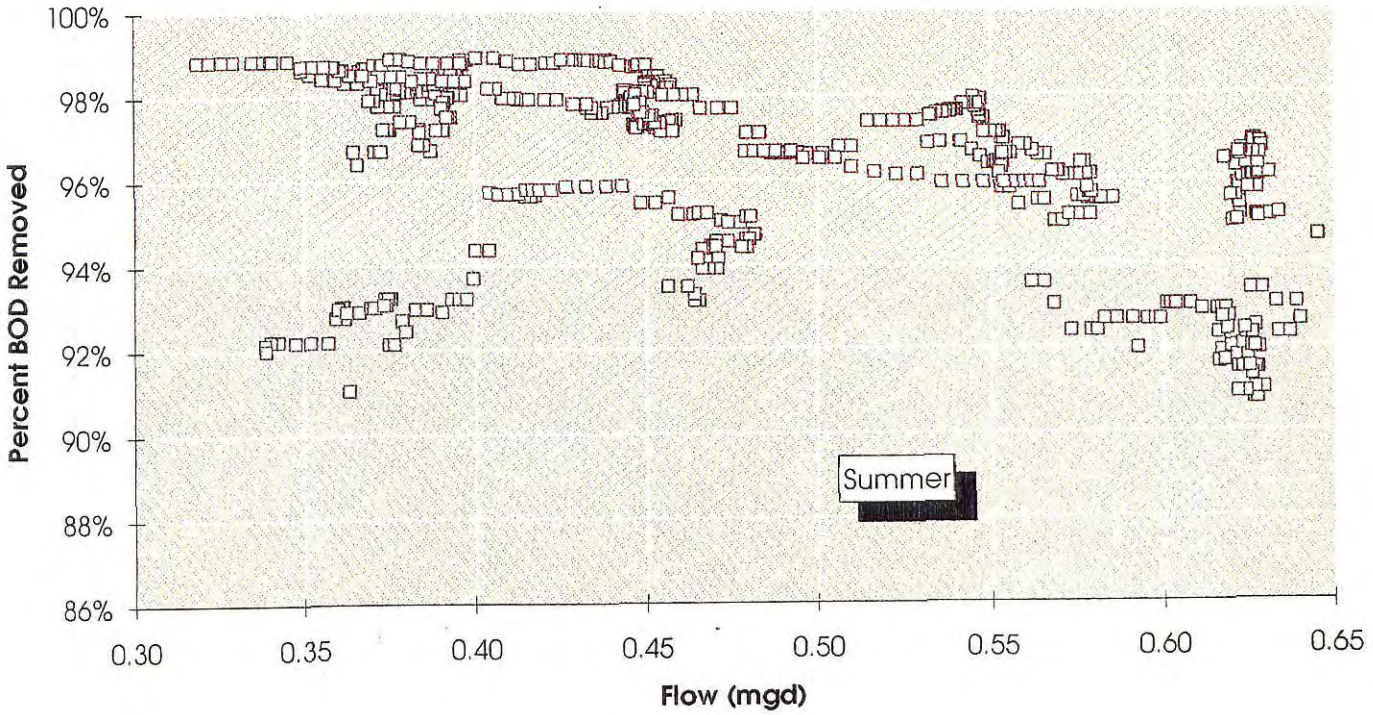


Figure 1
Influent BOD Load vs. BOD Removed
30-Day Running Average



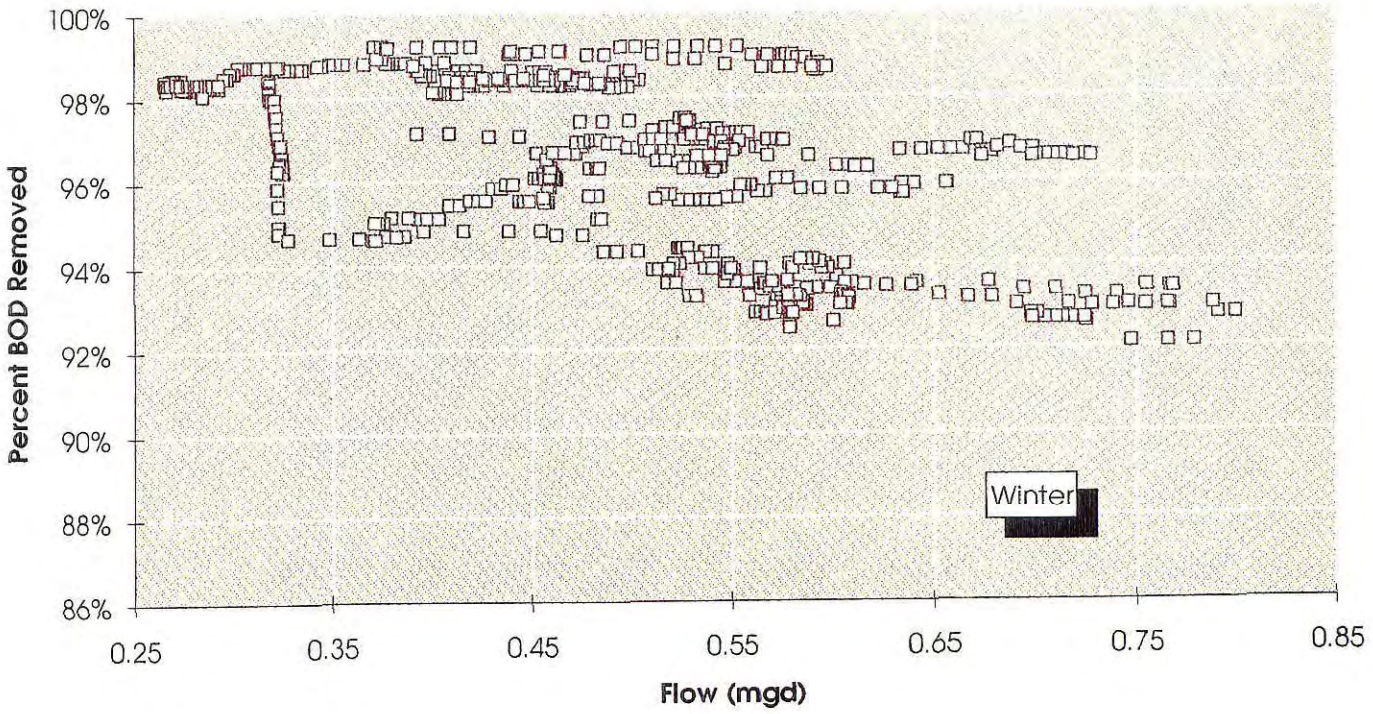
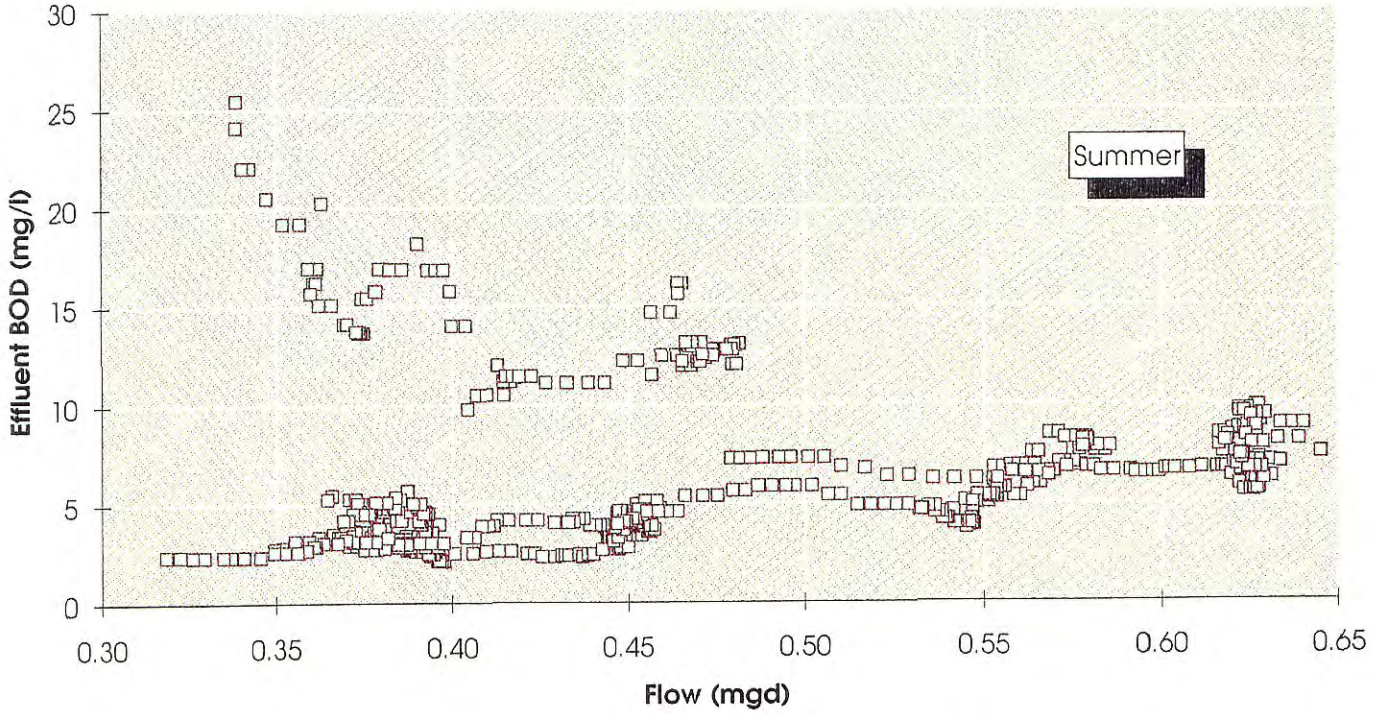


Figure 2
Flow vs. Percent BOD Removed
30-Day Running Average



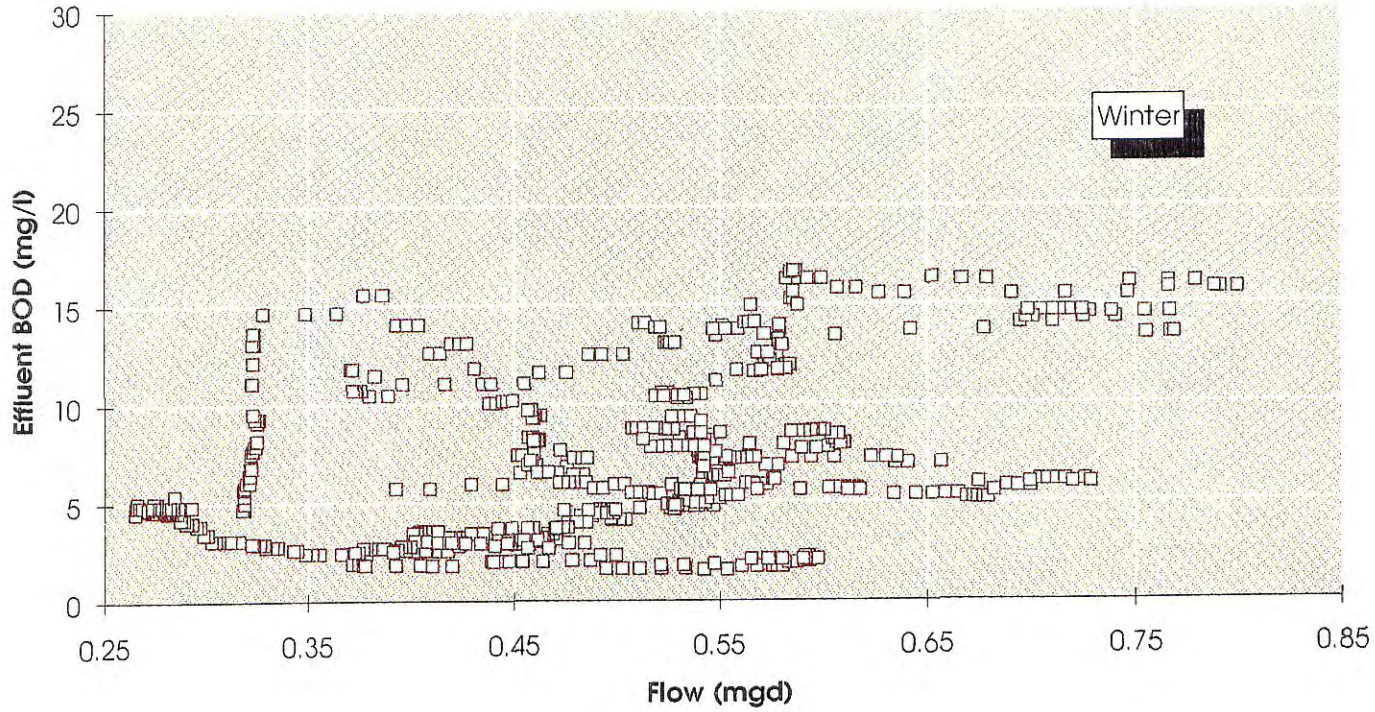
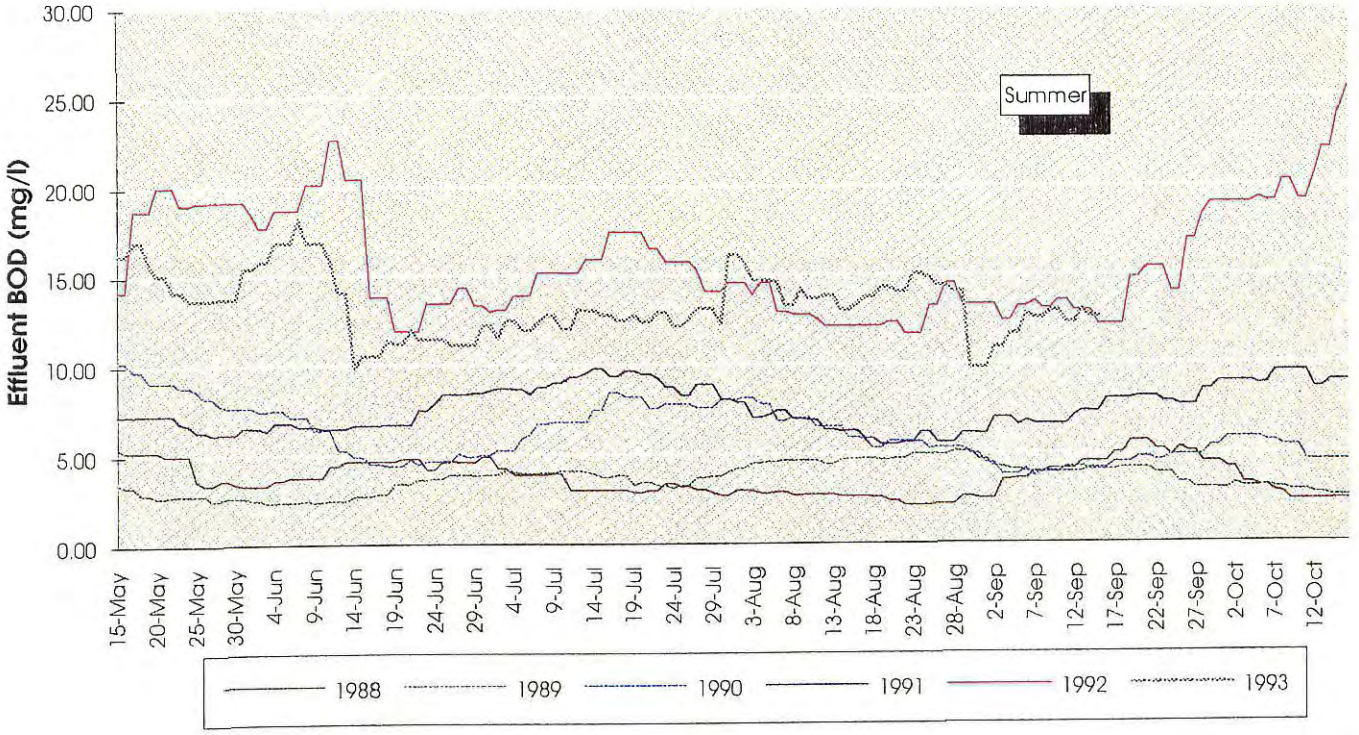


Figure 3
Flow vs. Effluent BOD Concentration
30-Day Running Average



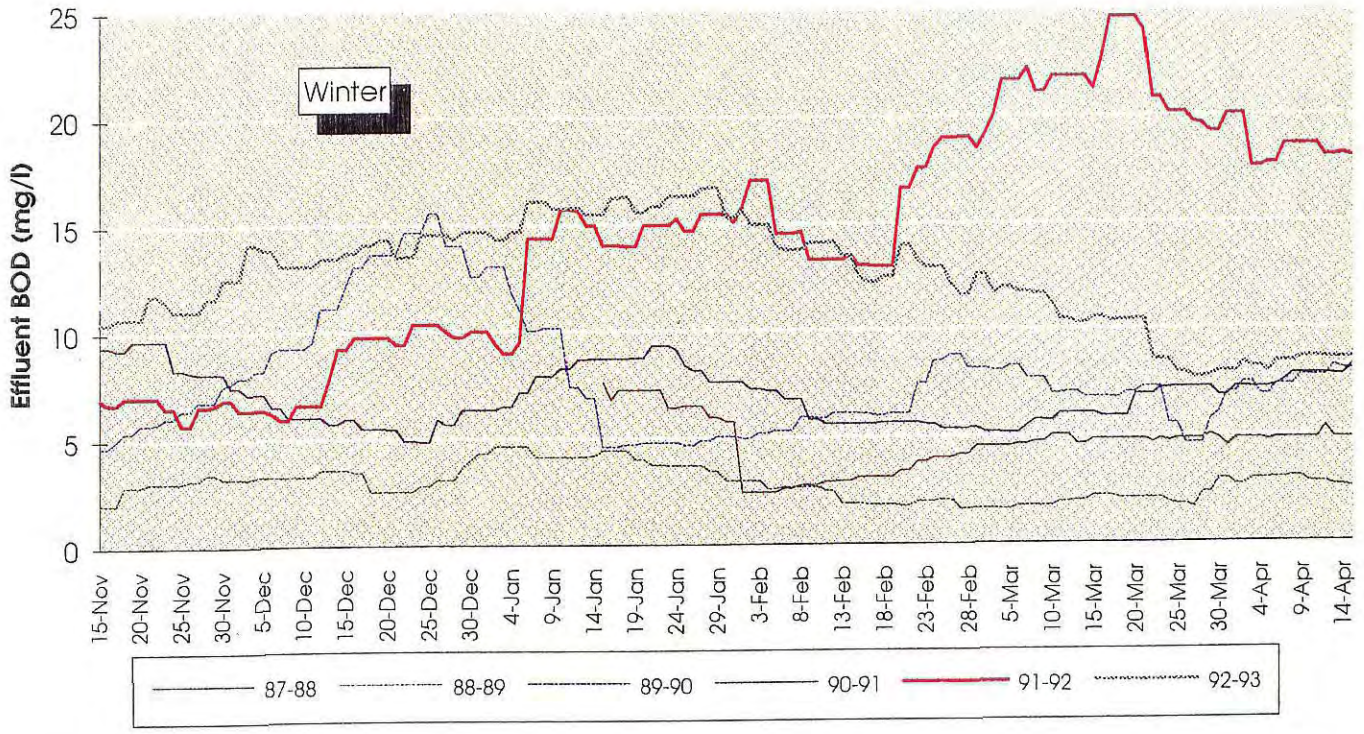
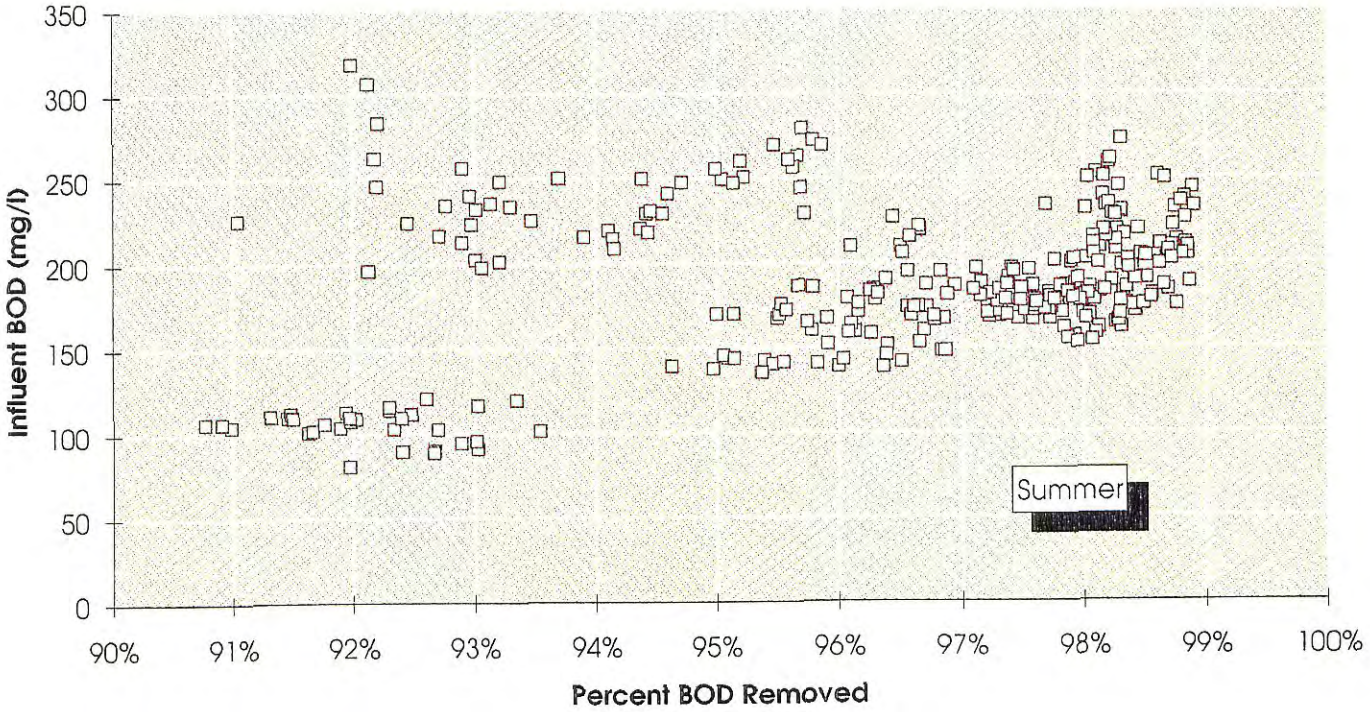


Figure 4
Effluent BOD By Year
30-Day Running Average



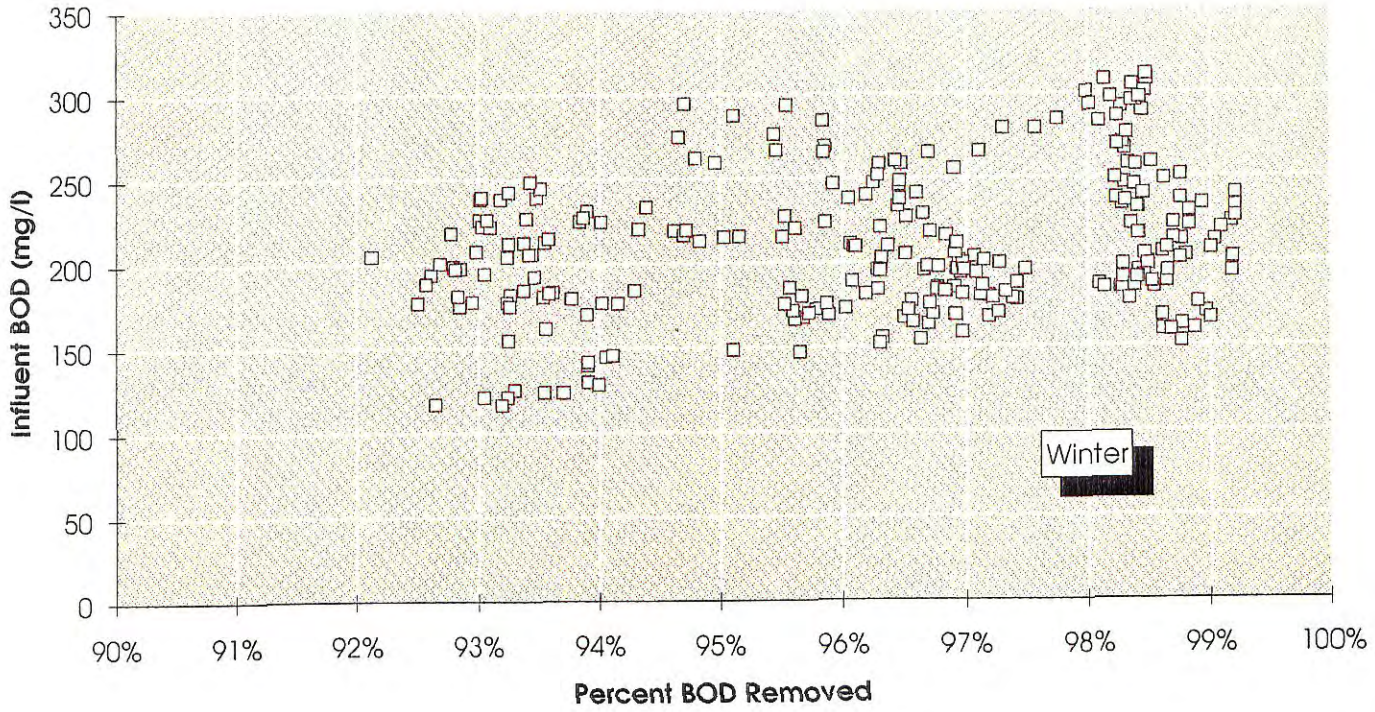
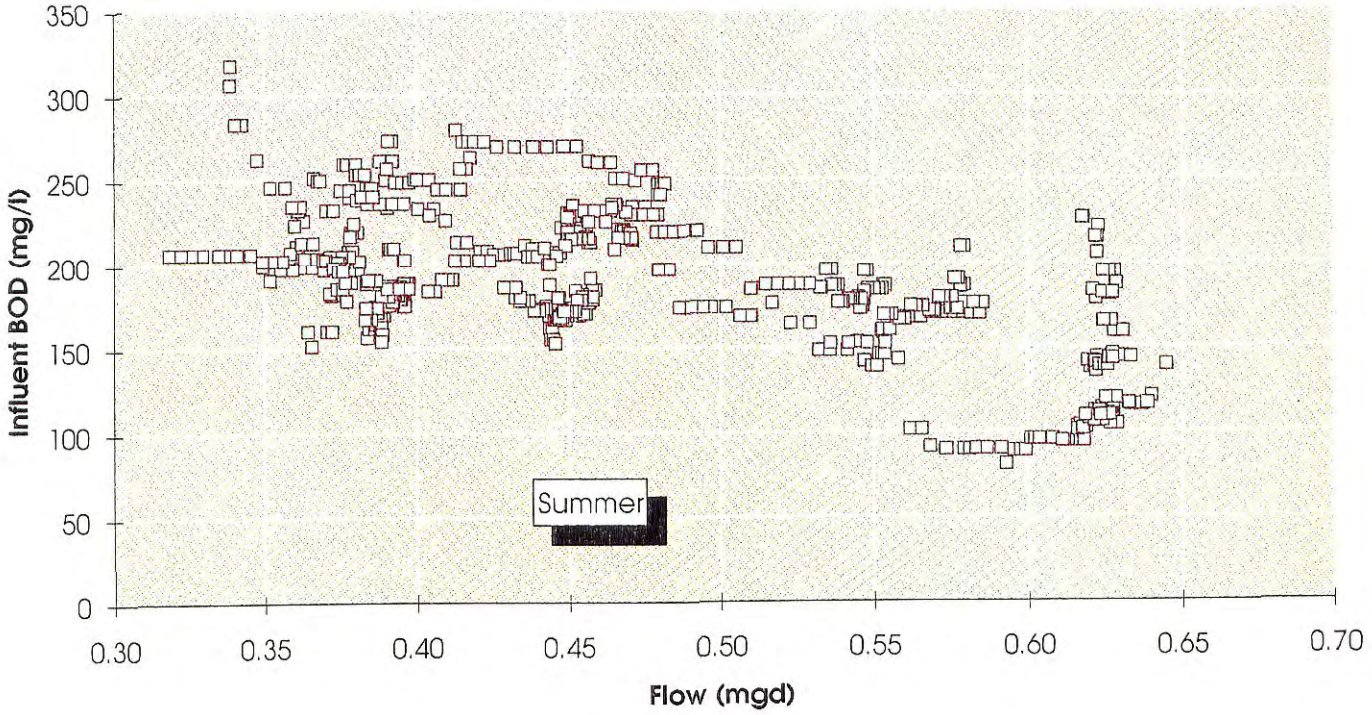


Figure 5
Percent BOD Removed vs. Influent BOD
30-Day Running Average



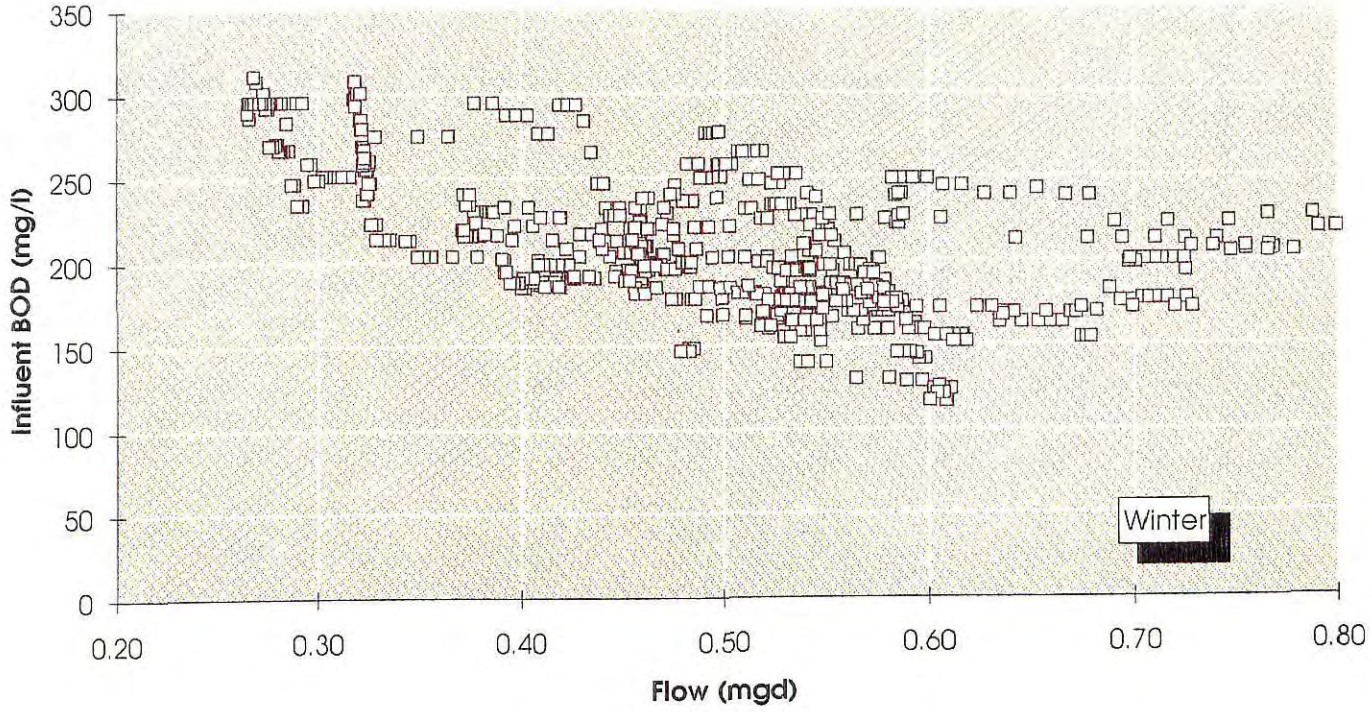
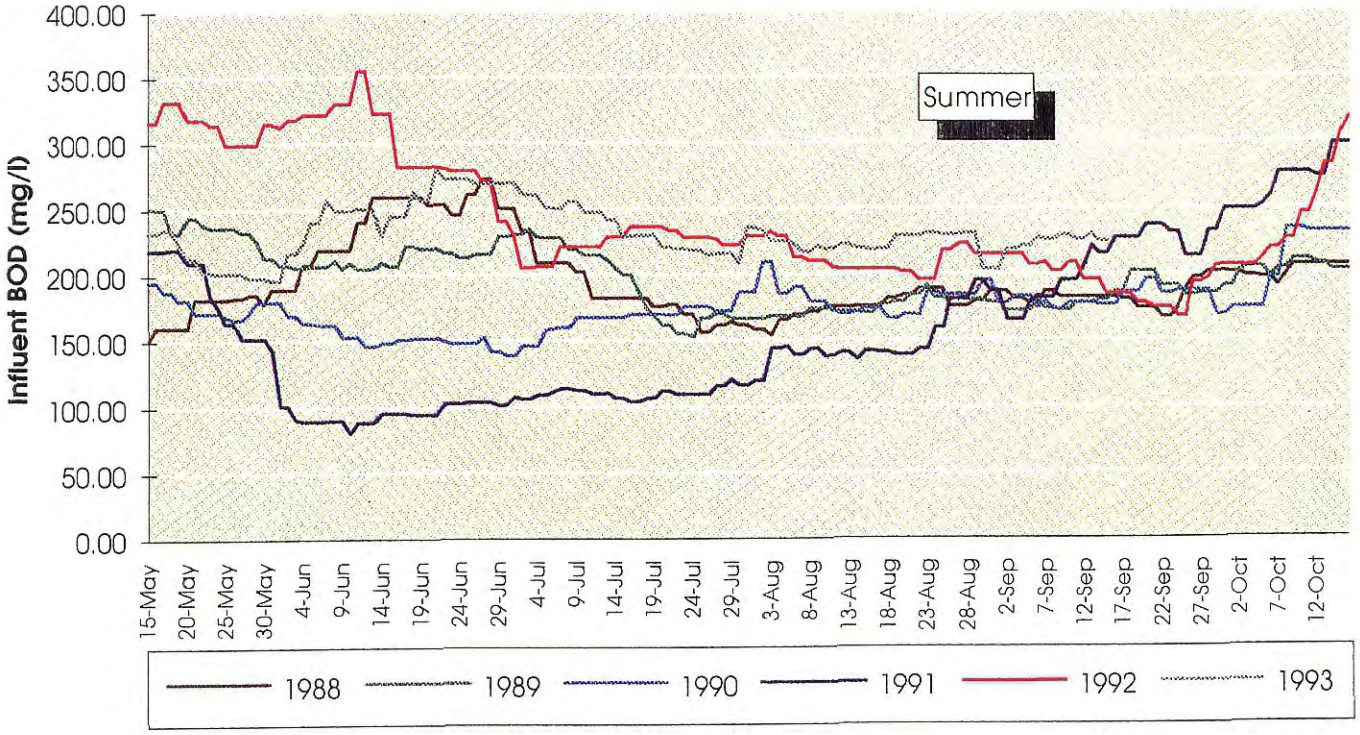


Figure 6
Flow vs. Influent BOD
30-Day Running Average



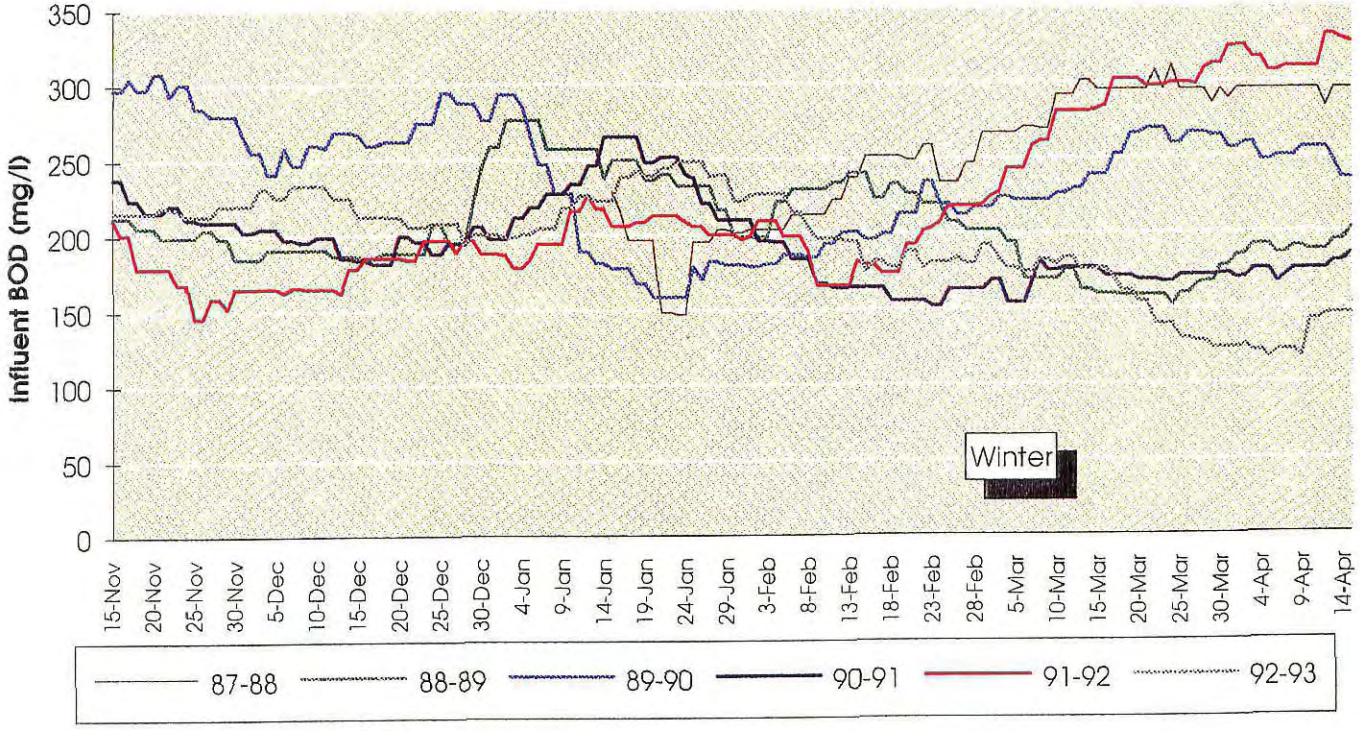
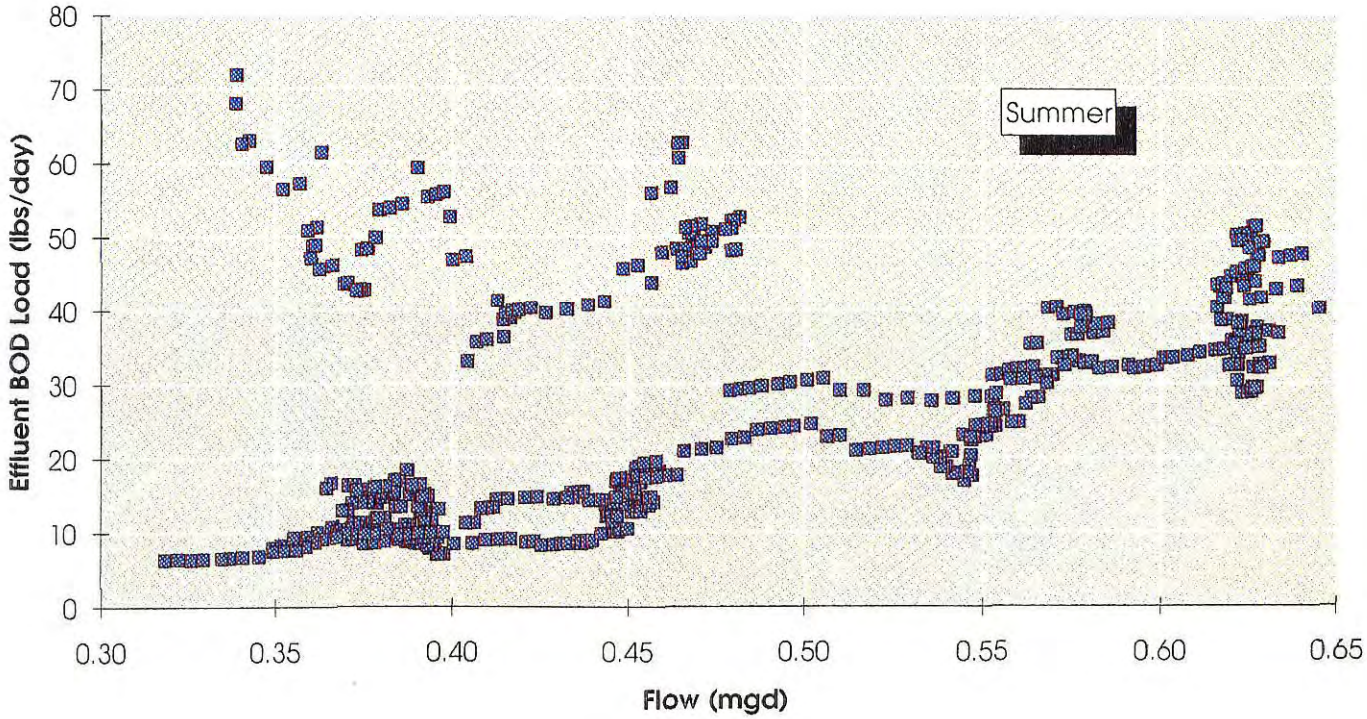


Figure 7
Influent BOD By Year
30-Day Running Average



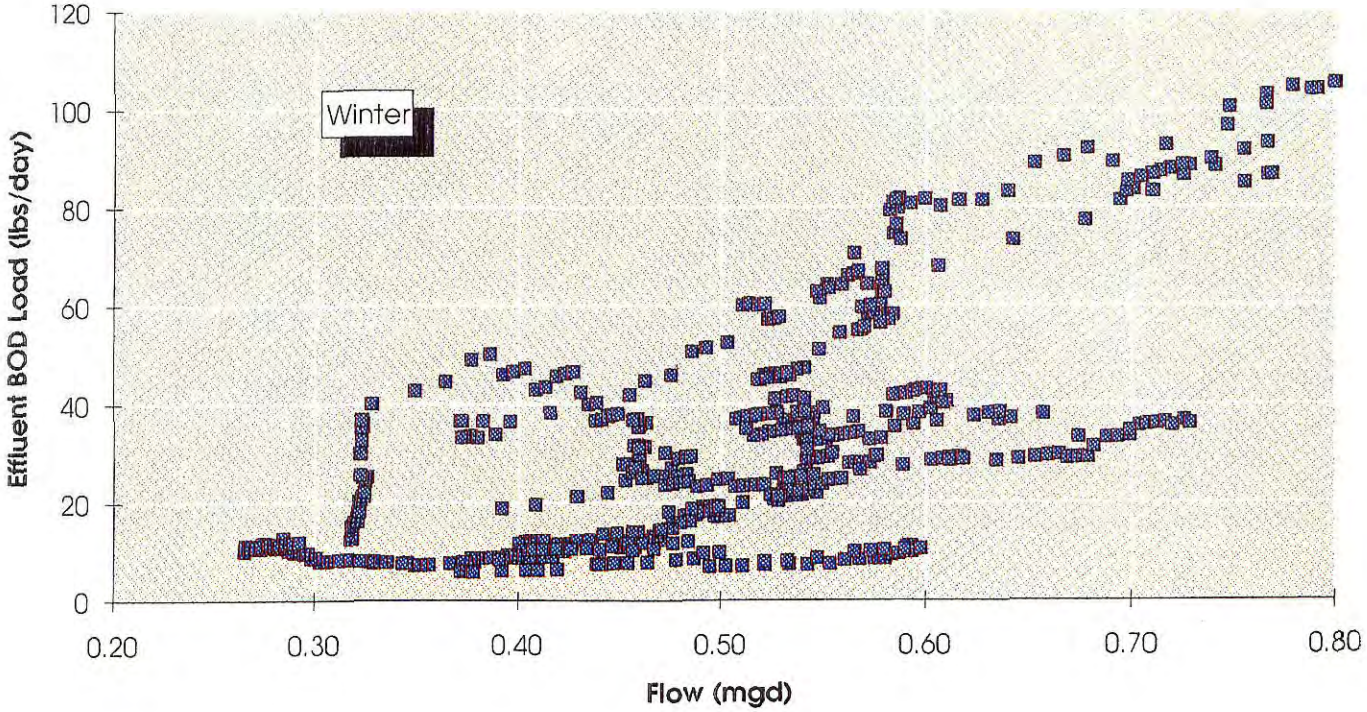
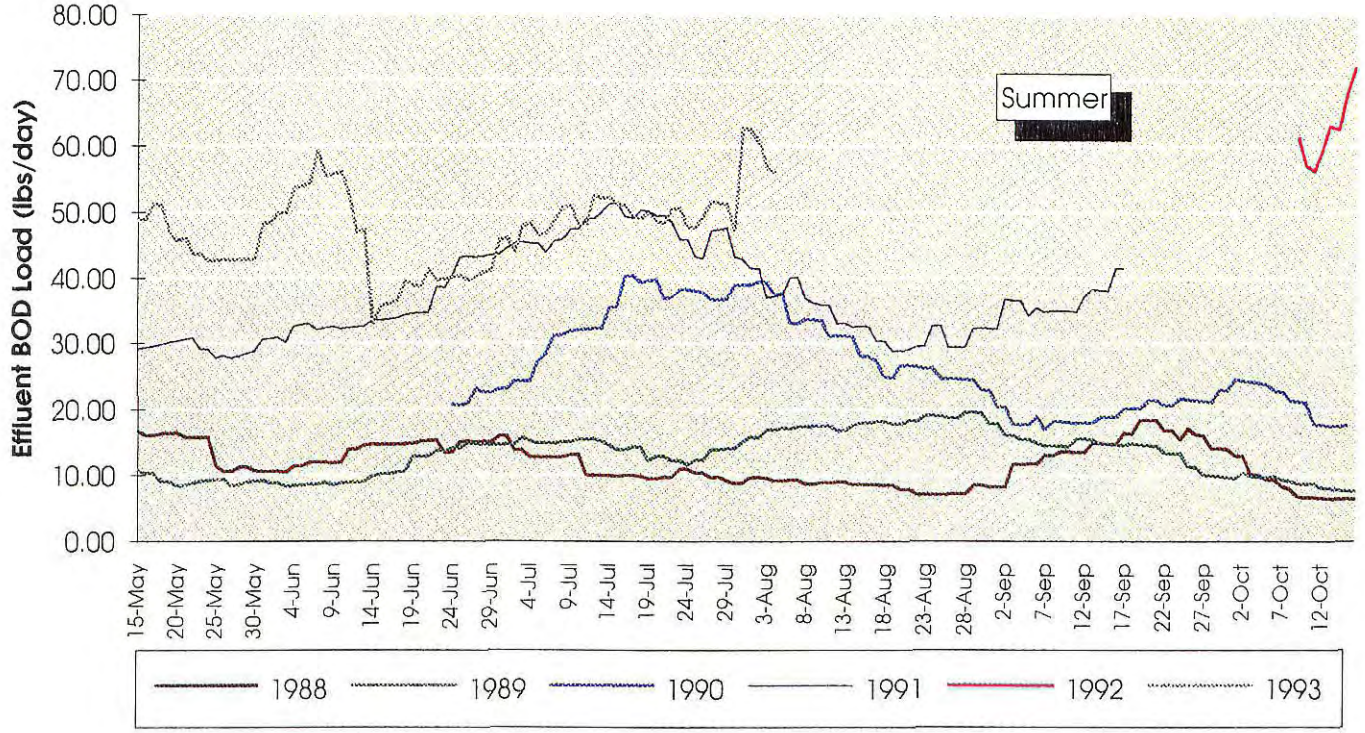


Figure 8
Flow vs. Effluent BOD Load
30-Day Running Average



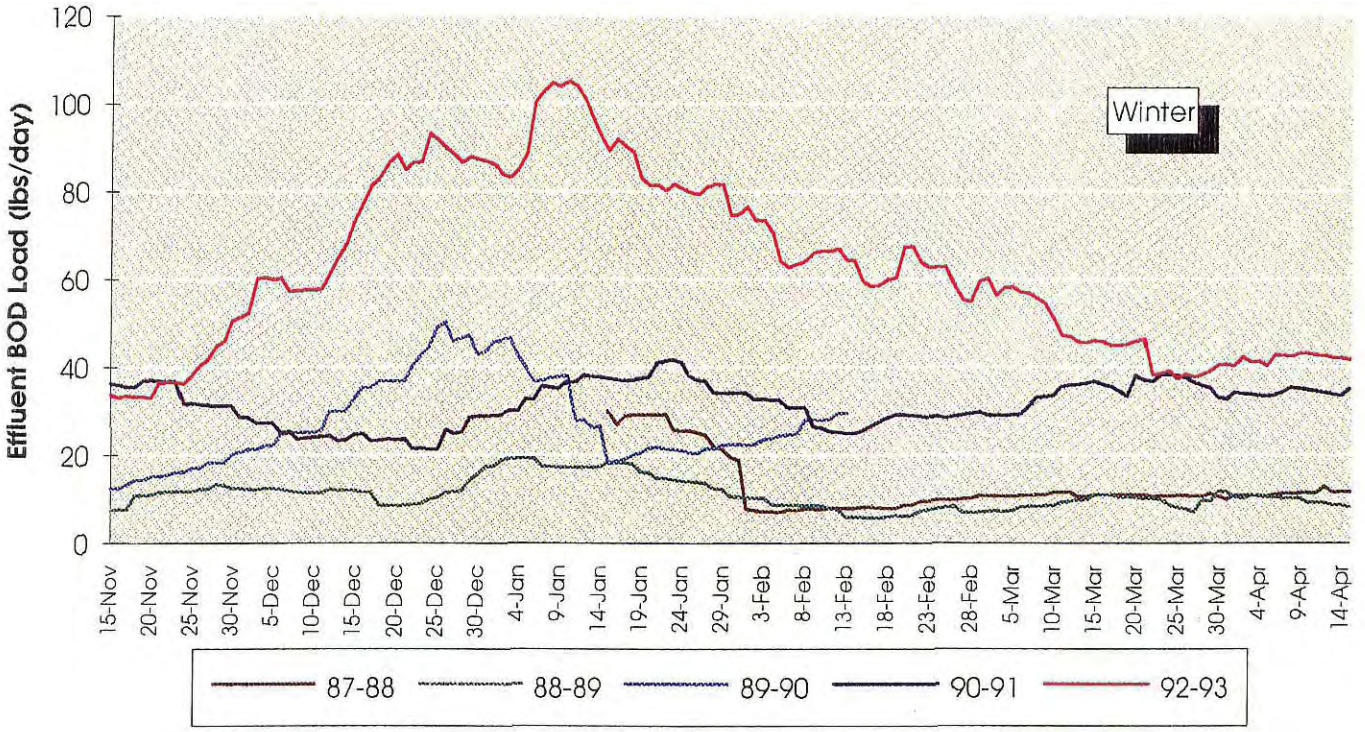
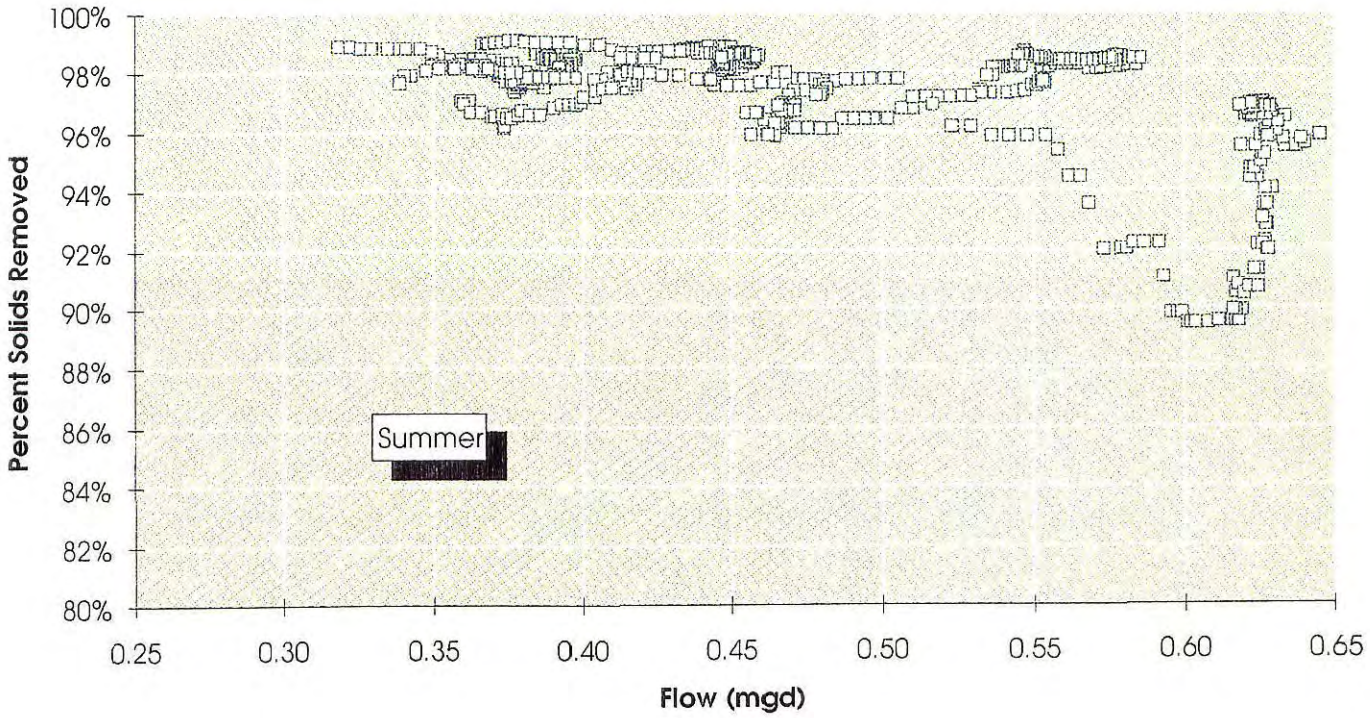


Figure 9
Effluent BOD Load By Year
30-Day Running Average



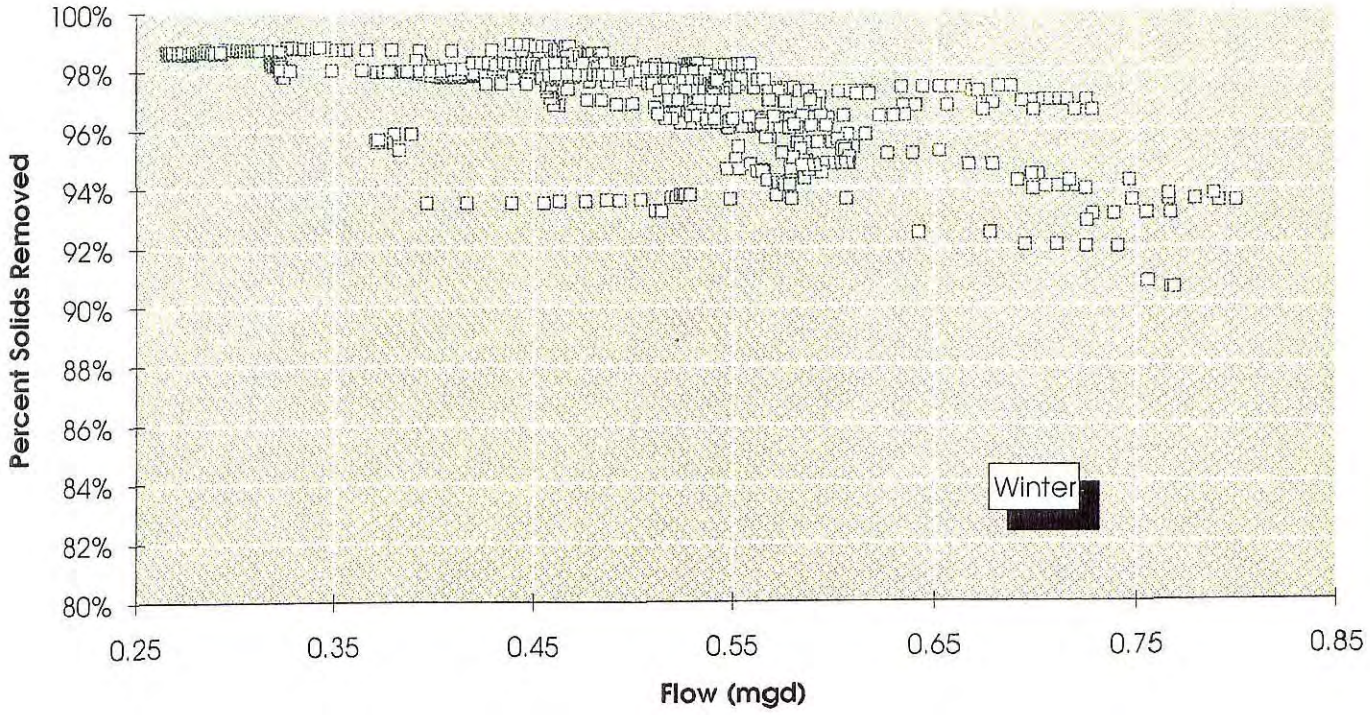
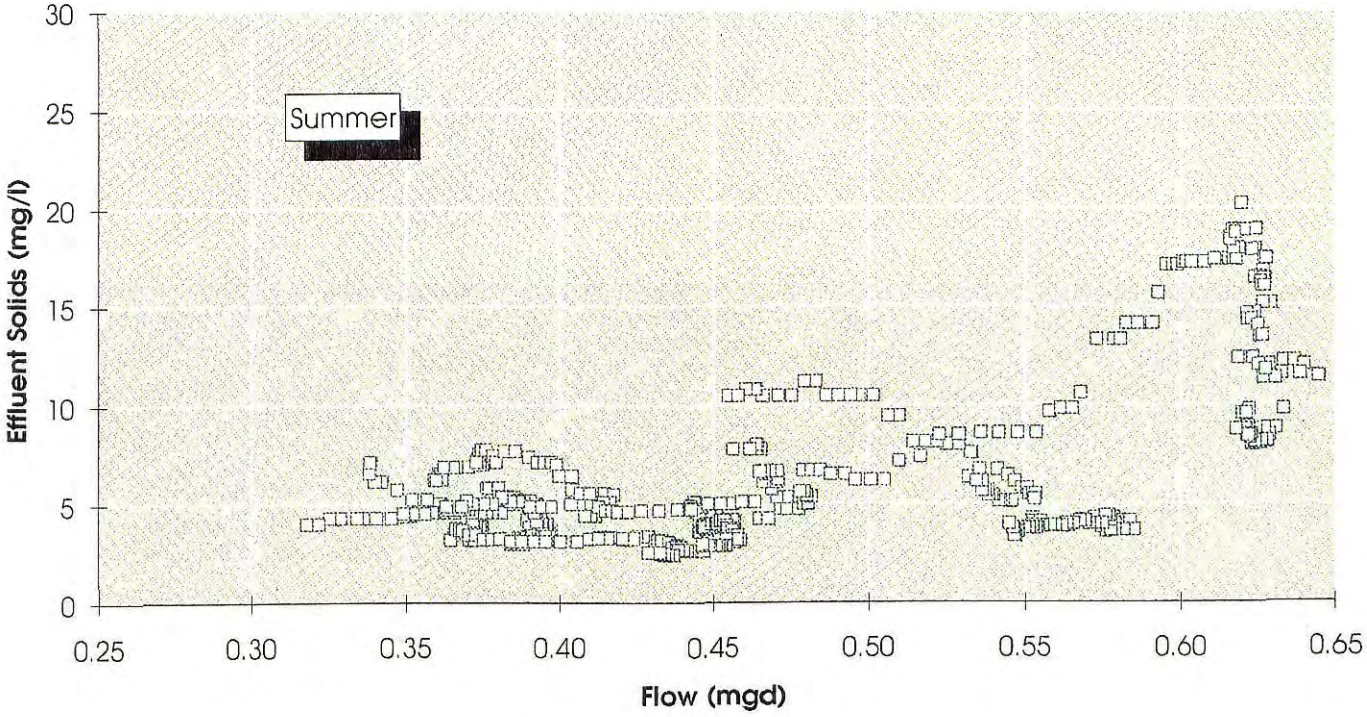


Figure 10
Flow vs. Percent Solids Removed
30-Day Running Average



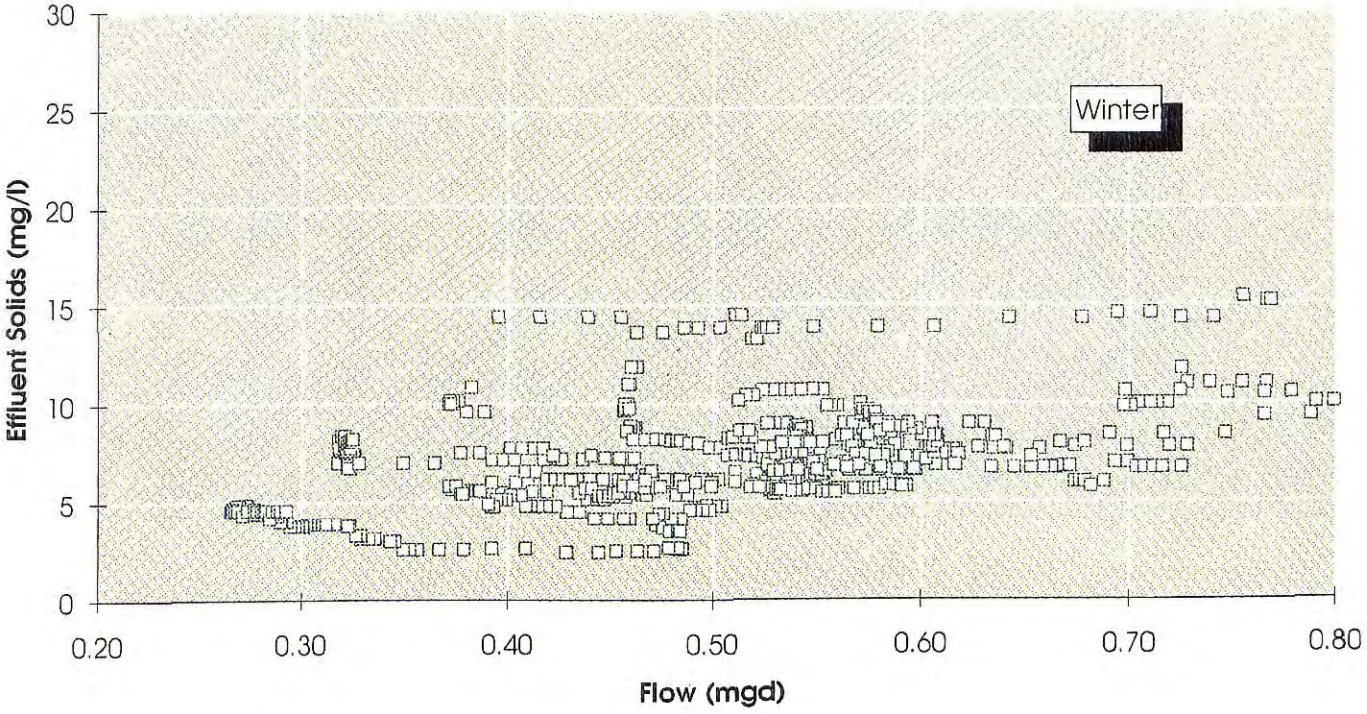
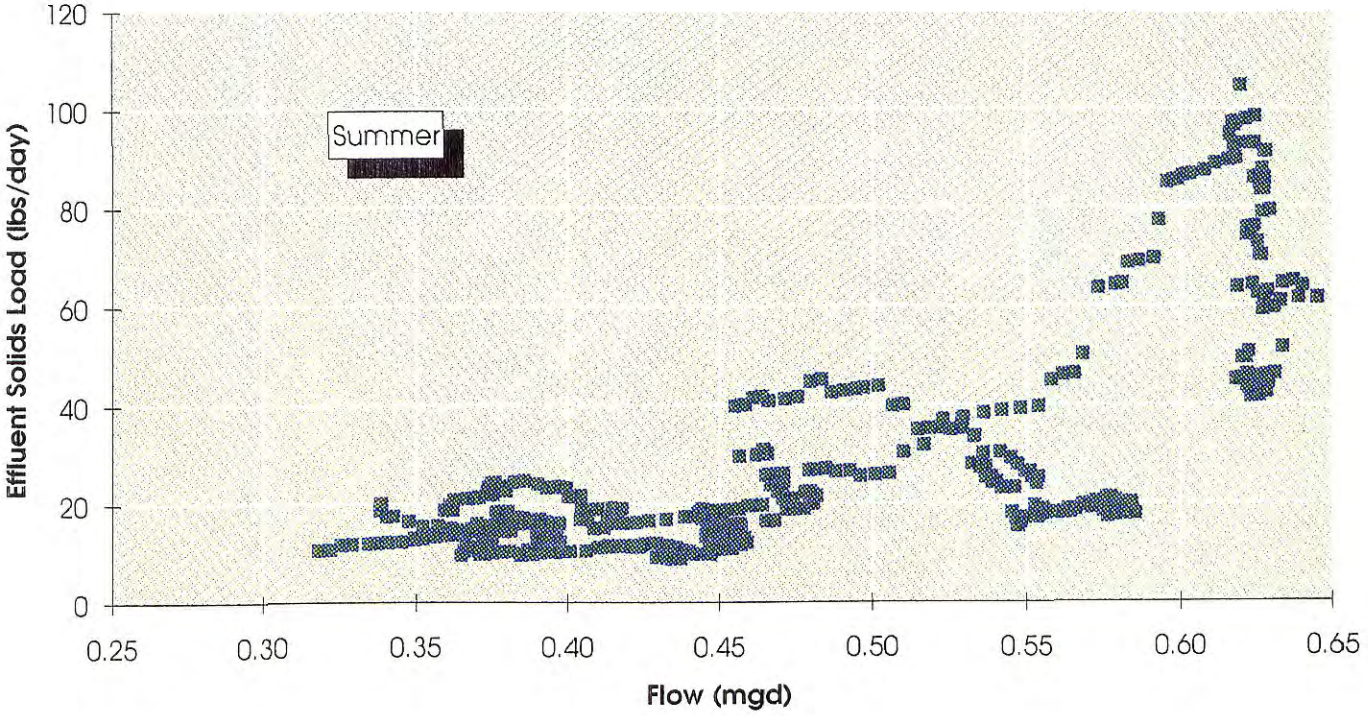


Figure 11
Flow vs. Effluent Solids Concentration
30-Day Running Average



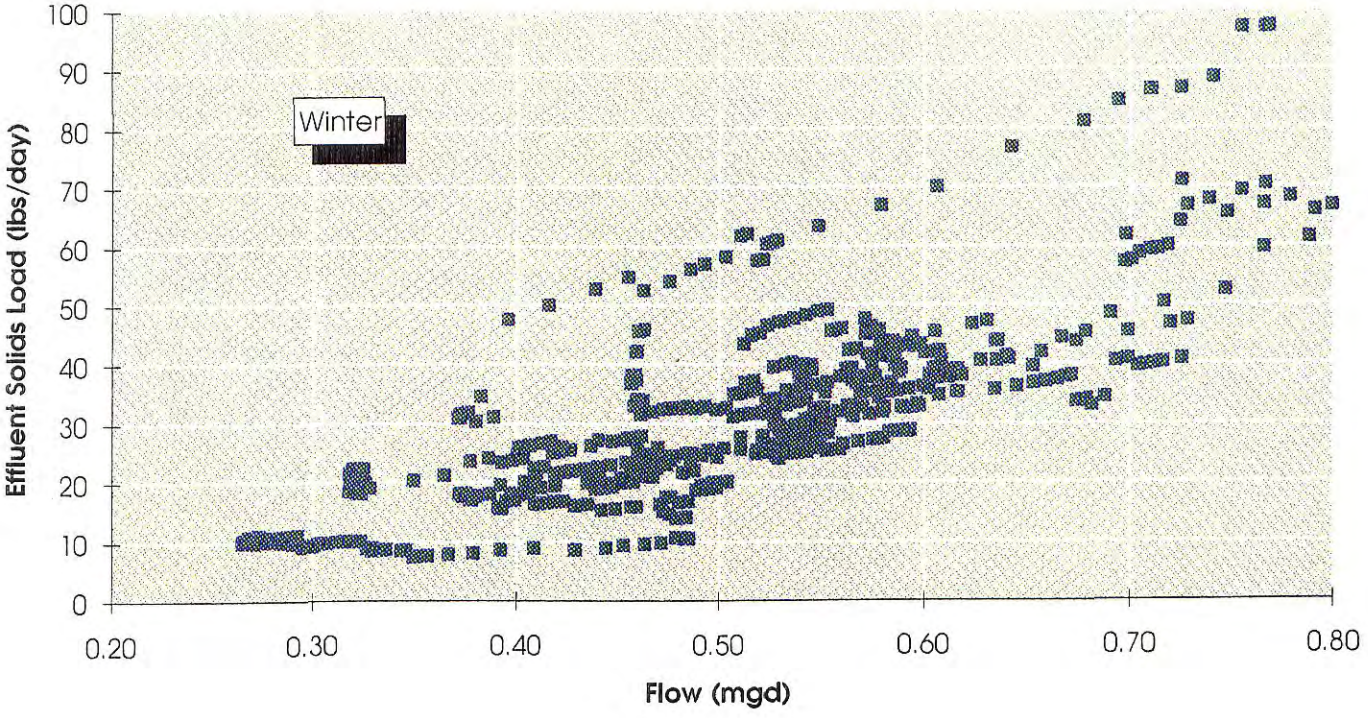


Figure 12
Flow vs. Effluent Solids Load
30-Day Running Average