APPENDIX C

PRETREATMENT ASSESSMENT MEMORANDUM

BLACK & VEATCH

MEMORANDUM

San Luis Obispo
Evaluation of Water Treatment Plant
Evaluation of Plant Data March 30, 2001

To: Bruce Corwin

From: George Budd

A review of relationships that typically affect plant performance is contained in this memorandum. Data for these evaluations were obtained from plant operating records that extend over a period from December 1993 to November 2001.

Discussion of Key Parameters

In reviewing the data for this water treatment plant, several key parameters become a consideration:

- **pH**:

  pH is a parameter that is extremely important to the performance of coagulant chemicals for removal of both turbidity and particles. In the case of alum and other aluminum-based coagulants, the optimum pH for coagulation tends to lie in a pH range between 6 and 7. In many cases, the optimum may fluctuate seasonally within this range, often coming closer to 6 in the summer and 7 in the winter.

  The optimum pH for turbidity and particle removal by ferric coagulants tends to be more site specific and can vary from a low of 4.0 to 4.5 up to 8.0 or greater, depending on water quality conditions. Lower pH optima tend to be observed in low alkalinity waters, while higher alkalinity waters tend to exhibit higher pH optima.

  pH also has an effect on coagulant-based removal of naturally occurring organic matter for achieving disinfection byproduct-related goals. Removal of naturally occurring organic matter tends to increase as pH is reduced for all coagulants. Therefore, capability to achieve goals for disinfection byproducts can be affected by capability to reduce pH during treatment.

  In addition to the direct effect of pH on coagulant performance, higher pH levels tend to correspond to periods of increased algal counts, which can also have an effect on coagulation. Therefore, variations in raw and treated water pH can be associated with several factors that affect plant performance.

- **Temperature**:

  Temperature can have several influences on coagulation-based processes, including formation of weaker floc in colder water and shifts in the optimum pH for coagulation. In addition, temperature can be associated with the presence of algae that can adversely affect coagulation. While algal activity can occur during all times of the year, peak algal activity tends to occur during the warmer period of the year.

- **Alkalinity**:

  Alkalinity determines the extent to which pH will be reduced by the addition of a coagulant chemical. A high alkalinity in the source water will make pH adjustment to optimize coagulation more difficult.

- **Plant Flow**:

  Plant flow dictates the hydraulic loading throughout the plant, can have an effect on plant performance.

Raw Water Characteristics

Raw water turbidity tends to be less than 5 NTU with an occasional excursion to higher levels as shown in Figure 1. From a treatability standpoint, significant features of the raw water are a high alkalinity condition as shown in Figure 2 coupled with a pH that typically is within a range of 7.5 to 8.5, as shown in Figure 3.

Figure 1. Raw Water Turbidity

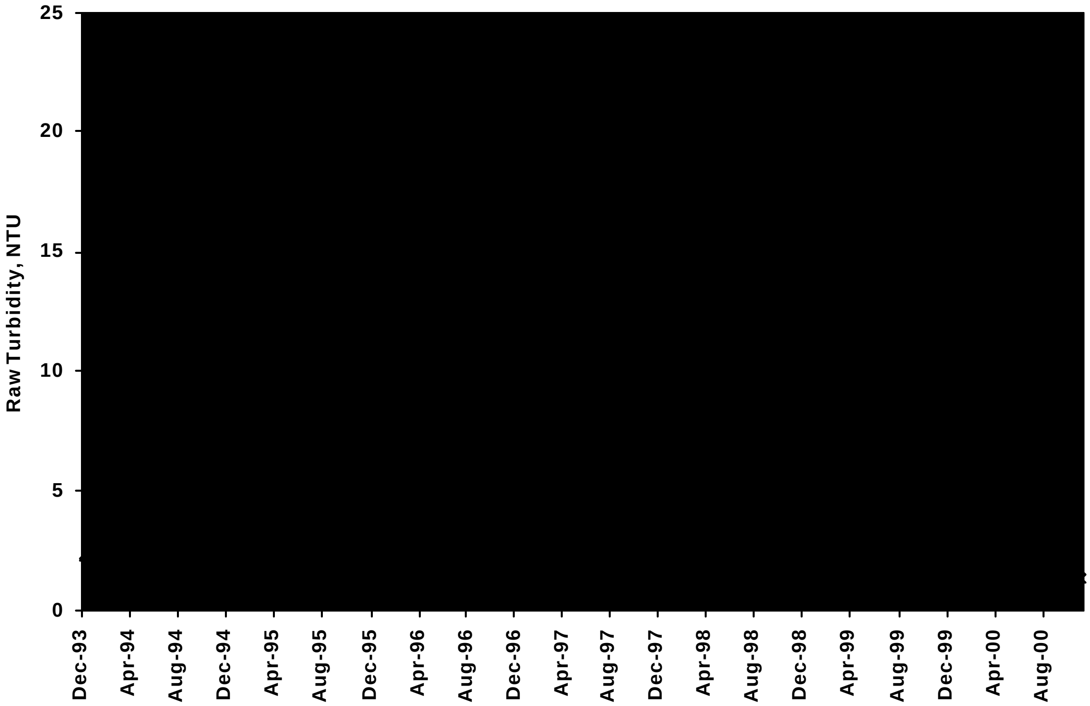


Figure 2. Raw Water Alkalinity

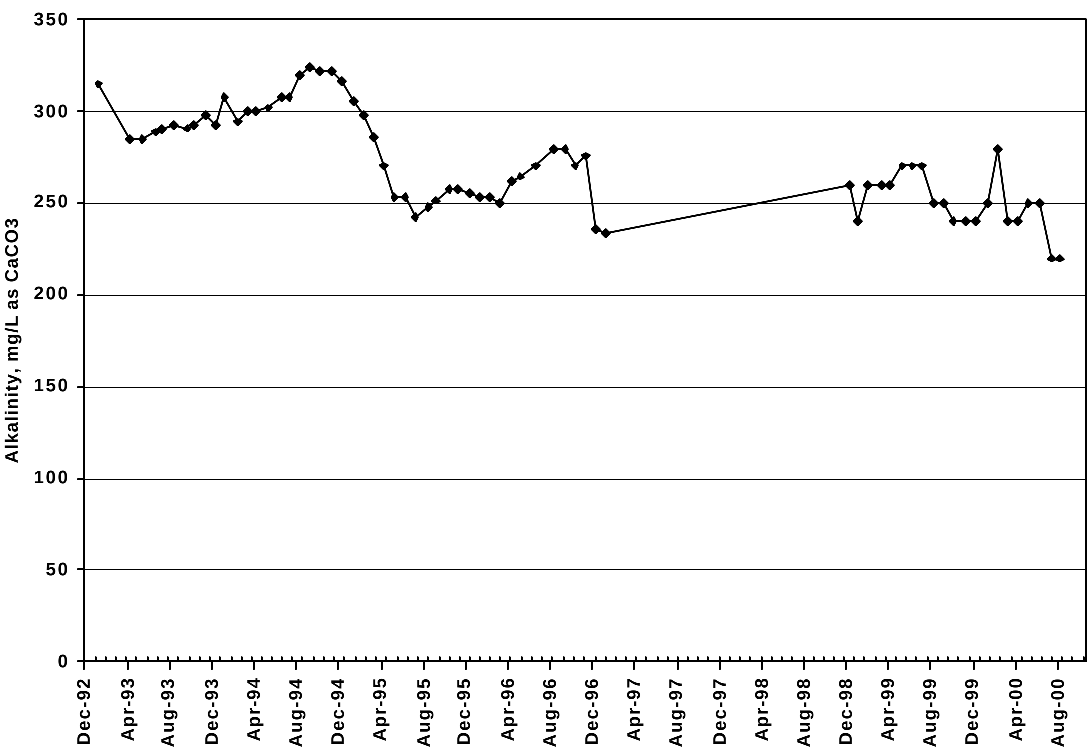
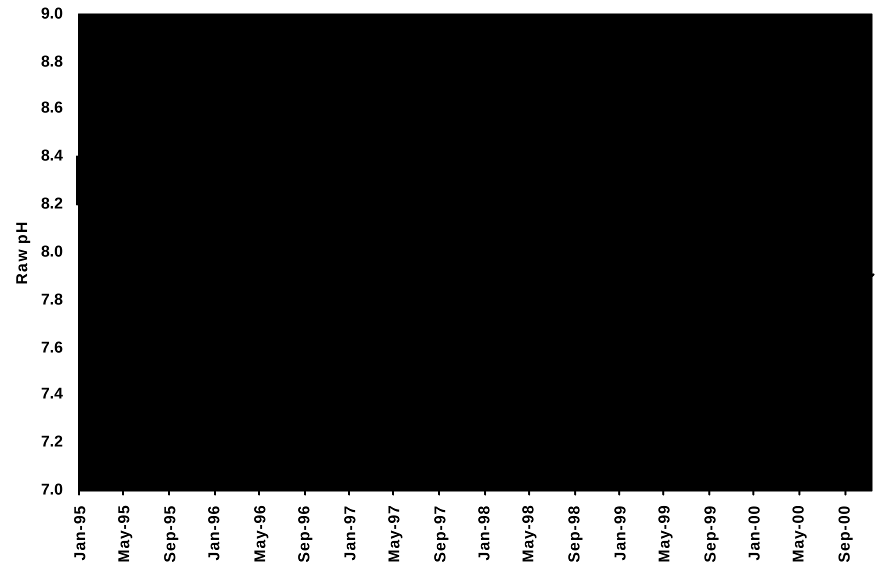
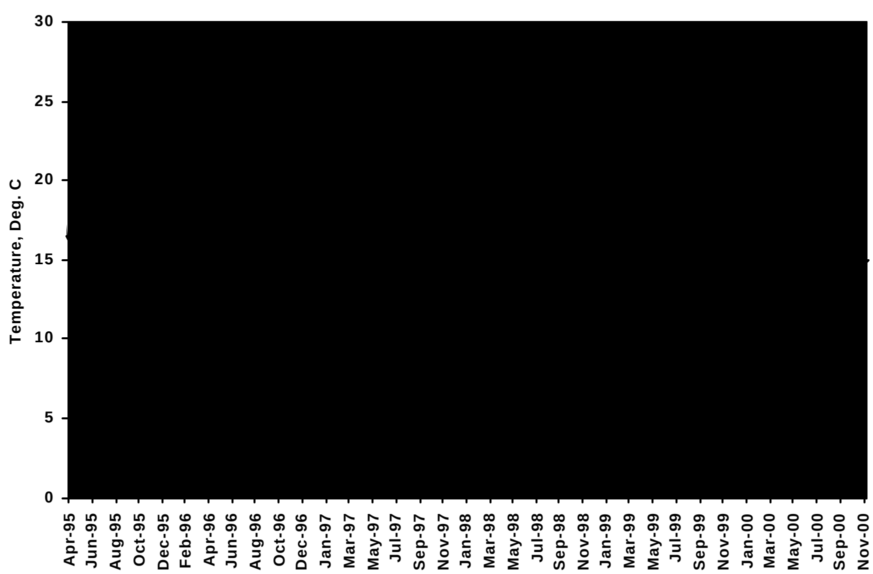


Figure 3. Raw Water pH



Temperature is another critical parameter that affects coagulation processes. It exhibits a seasonal variation, as shown in Figure 4, but extreme cold water conditions under 10 ^oC are not encountered at this plant. While a degree of deterioration in coagulant performance can become apparent at temperatures of 15 ^oC or less, deterioration at temperature levels less than 10 ^oC can be more severe and can have a significant effect on plant performance during the winter.

Figure 4. Raw Water Temperature



Treatment Plant Data

The plant applied alum as a primary coagulant up to September 1998, as shown in Figure 5. Since that time, Sweetwater 9311 and Catfloc T have been applied in varying combinations with alum. One significant effect of the addition of coagulants and other treatment chemicals is a slight reduction in the pH as shown by comparing raw and treated water pH levels in Figure 6. While this drop in pH level is consistent, the high level of alkalinity present in the raw water has limited capability for adjustment down to levels that may be optimal alum and other aluminum based coagulants.

Figure 5. Coagulant Chemical Doses

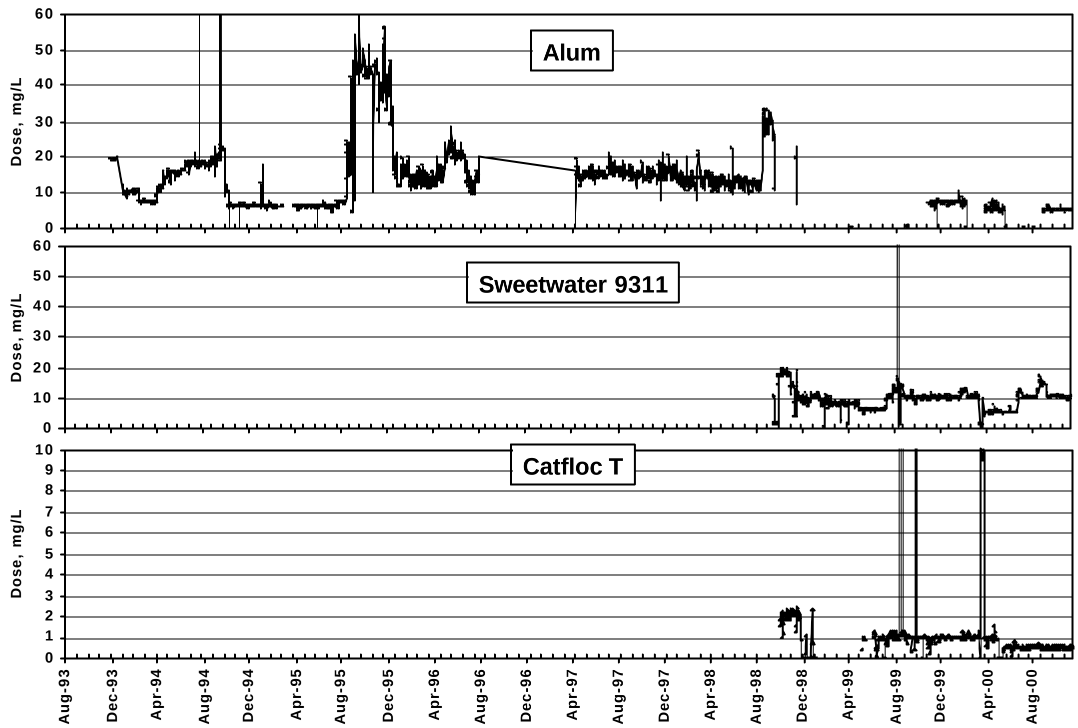
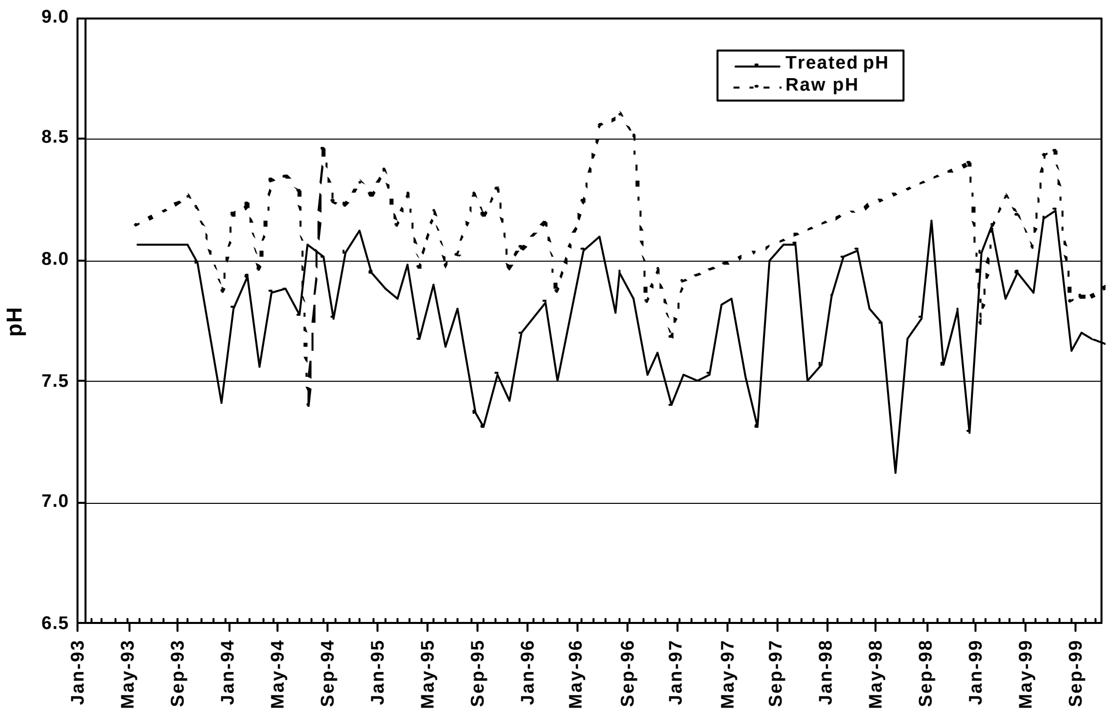


Figure 6. Raw and Treated pH



Filtered water turbidity results are shown in Figure 7 for a period from December 1993 to November 2000. Results prior to September 1998 reflect operating conditions when alum was used as the primary coagulant. Since that time, Sweetwater 9311 and Catfloc T have been used in combination with alum. A degree of improvement appears to have occurred with the change to these new coagulants, with much of the filtered water turbidity data at levels less than 0.1 NTU. However, excursions above 0.1 NTU still occur, particularly during the time period from mid-summer to early fall. While some of this increase in turbidity may be due to increased levels of algal activity that occur during this period of the year, there is also a potential for an effect due to disparity between the optimal pH for aluminum-based coagulants and the actual pH of coagulation.

A statistical evaluation was performed to assess the effect of pH on filtered water turbidity. This evaluation considered the effects of both pH and temperature due to the fact that both parameters can have a significant effect on coagulant performance. Results from this evaluation are shown in the contour mapping of a fit to the pH and temperature data in Figure 7. Raw pH was used in place of treated pH due to the availability of a much larger set of data in the monthly operating report. This provides a general indication of treated pH as can be seen in Figure 6.

Based on these results, it can be seen that the likelihood of achieving a turbidity of less than 0.1 NTU increases as pH is decreased. A similar analysis was performed for data that excluded conditions where the temperature was greater than 15 ^{o}C to limit the possibility that some of the effect was due to an association between elevated levels of pH and the presence of algae in the raw water. These results, shown in Figure 8 also indicate a significant benefit of operating at a lower pH. Similar results are obtained when data are confined to the period since the inclusion of Sweetwater 9311 and Catfloc T as coagulant chemicals.

Figure 7. Filtered Water Turbidity Contour Map of the Effects of Raw Water Temperature and pH

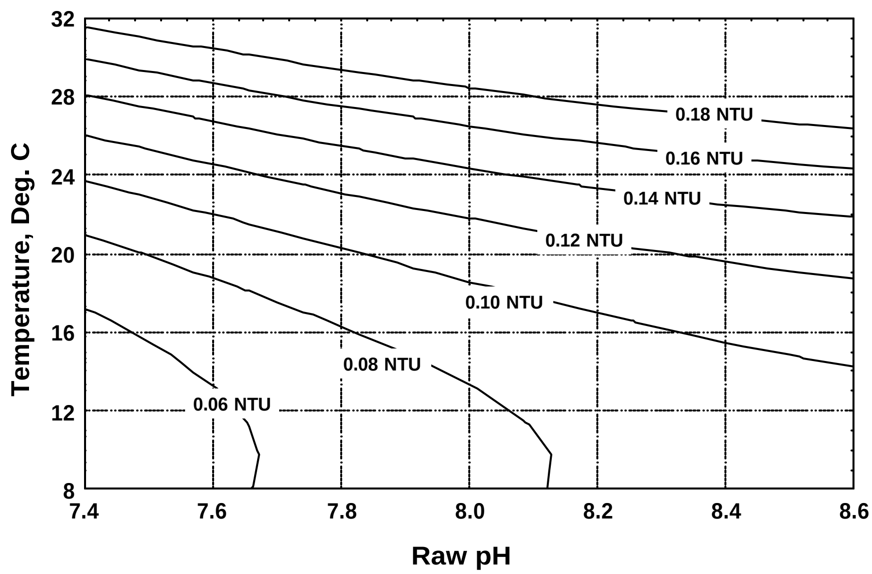
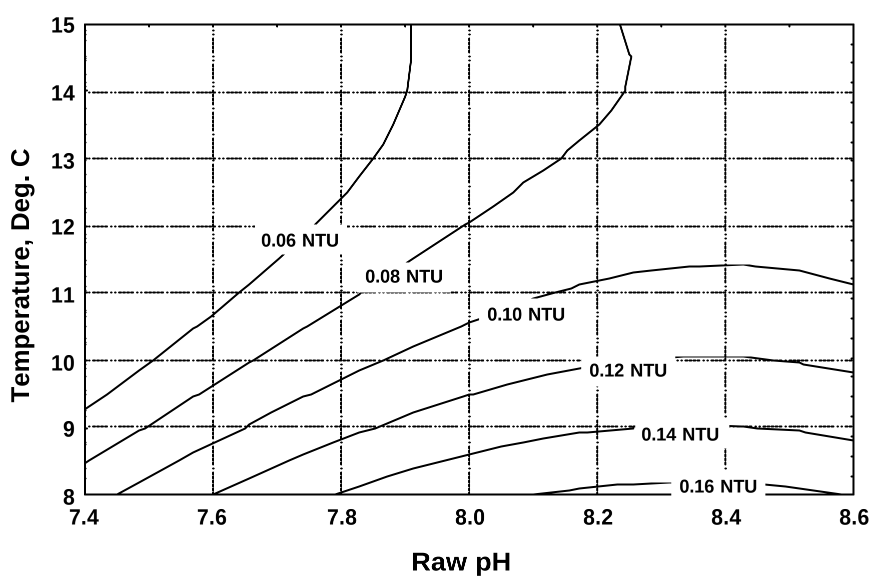


Figure 8. Filtered Water Turbidity Contour Map of the Effects of Raw Water Temperature and pH for Data with Temperature less than 15 ^{o}C



Overall these evaluations indicate raw water quality conditions that may present some challenges in terms of optimization of coagulants for best results, particularly when alum is used. In the absence of a supplemental addition of an acid for pH adjustment, it is difficult to reduce the pH to levels that are typically optimal for alum. A review of the data indicates that some improvement may have resulted from the use of Sweetwater 9311 and Catfloc T.

It is important that optimal coagulant conditions be applied in conjunction with physical improvements to the plant to achieve future goals for turbidity and organic removal. TOC results in the "Water Quality Evaluation" section that we prepared indicate that TOC removal by coagulation is limited. This is as would be expected for the high pH levels that occur in the treated water as compared with other water treatment plants where higher levels of TOC reduction are achieved. More acidic coagulants such as ferric chloride and ferric sulfate could provide some benefit and may also prove to perform better under the pH conditions available at this plant. It is also possible to purchase acidified versions of these chemicals as well as acidified alum. Proprietary aluminum-based coagulants can also exhibit less pH dependency and could also be applicable.