Using the Comprehensive Performance Evaluation Approach to Optimize Industrial Waste Treatment Facilities

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ABSTRACT

The Comprehensive Performance Evaluation (CPE) process presented by Hegg, DeMers and Barber (1) has been successfully used for over a decade in the municipal wastewater treatment sector to establish the actual hydraulic and organic treatment capacity of a facility and identify the factors that lead to poor performance. Once the poor performance factors have been identified, a Composite Correction Program (CCP) can be developed to improve the performance of the treatment facility. The CPE defines the CCP and determines whether the facility improvement will require operational changes, minor facility modification, major facility modification or a combination of these.

RTW has modified this approach and applied it to industrial wastewater treatment facilities. While there are thousands of municipal waste treatment plants and the characteristics of municipal wastewater and biological treatment processes are relatively well understood, significantly less is known about the myriad of different industrial wastes and their associated treatment processes. However, the same biological, physical and chemical laws apply to both municipal and industrial waste treatment. Even though we may not understand each industrial waste or process to the degree that we understand municipal waste treatment, we can still apply the CPE approach to minimize the factors leading to poor performance and can optimize treatment at existing industrial wastewater treatment facilities.

This paper presents an example of the use of this approach. At the invitation of the wastewater treatment staff, the consultant and operations staff formed a team to improve performance at a chemical wastewater treatment plant treating formaldehyde and related compounds at a location in the central United States. The results of that team effort are shown in data from January 1995 through December 2001. With the project starting in February 1997, 26 pre-project months of data were evaluated and compared with 58 months of data following project initiation. Pre-project effluent BOD and TSS values were 39 mg/L and 100 mg/L respectively, and within permitted limitations. However, after the project was initiated, effluent BOD and TSS averaged 11 mg/L BOD and 33 mg/L TSS for the 58 months of data. Dramatic savings, average over 66%, in cost of polymer required for sludge settleability has also been maintained during that time period. These results were attained with modified process control and utilization of existing treatment units, and with an extensive effort to minimize the organic shock loadings to the plant. This paper discusses the approach, effluent quality improvement, chemical savings, load reductions and the minimal costs related to the project.

KEYWORDS

Comprehensive performance evaluation, CPE, industrial waste, formaldehyde, methanol, polymer, sludge settleability.

INTRODUCTION

The Hercules plant staff and Rothberg, Tamburini & Winsor (RTW) teamed to perform a comprehensive performance evaluation (CPE). Hegg, DeMers and Barber (1) developed the CPE approach to quickly evaluate municipal treatment facilities including design, operation, maintenance and administration. The CPE objective is to quickly evaluate the capabilities of the plant and identify "performance limiting factors" that may lead to such things as poor effluent quality or high costs. Once these factors are identified, a Composite Correction Program (CCP) can be defined to address the range of factors. Some factors may be addressed quickly with little or no cost while others may have to be addressed on a long-term basis and at high cost such as through construction.

The Missouri Chemical Works (MCW) wastewater treatment plant had met discharge standards most of the time for years, but large amounts of polymer were used to accomplish the task. Periodically, poor-quality effluent had to be returned to the PE Lake for reprocessing. MCW staff felt that proper treatment could be accomplished with less polymer usage and requested the assistance of RTW to accomplish that. RTW had extensive experience with the CPE/CCP process and felt that with modifications the CPE/CCP process could be used as well at industrial facilities as at municipal facilities. Therefore, the RTW-MCW team set out to reduce polymer usage while maintaining good effluent quality by:

1. Becoming familiar with the existing facilities.
2. Defining present plant loadings
3. Defining present plant operating conditions
4. Suggesting process control modifications
5. Suggesting simple process modifications
6. Identifying longer-term, construction oriented projects

The first step in accomplishing the tasks was to implement good communications. RTW and MCW BOD Plant staffs worked side-by-side for four days in the lab, operations room and at the aeration tanks and clarifiers. RTW has found it useful to listen in detail to the operating staff as their experiences have taught them certain things about the plant that cannot be ascertained without that experience. Those operating experiences are then analyzed and compared to accepted standards of practice to verify their validity or to suggest alternate findings that would explain why the past experience did not relate to the situation at hand. Findings were discussed with MCW staff and issues resolved. The MCW staff welcomed this approach, felt comfortable with it and made this a true team effort.

Facility Description

The Missouri Chemical Works at Louisiana, Missouri, manufactures several commercial chemicals produced at several production plants around the MCW site. Sanitary and production wastes are collected in separate systems and treated in separate wastewater treatment plants. The "BOD plant" treats the industrial wastewater, only, and is shown schematically in Figure 1.

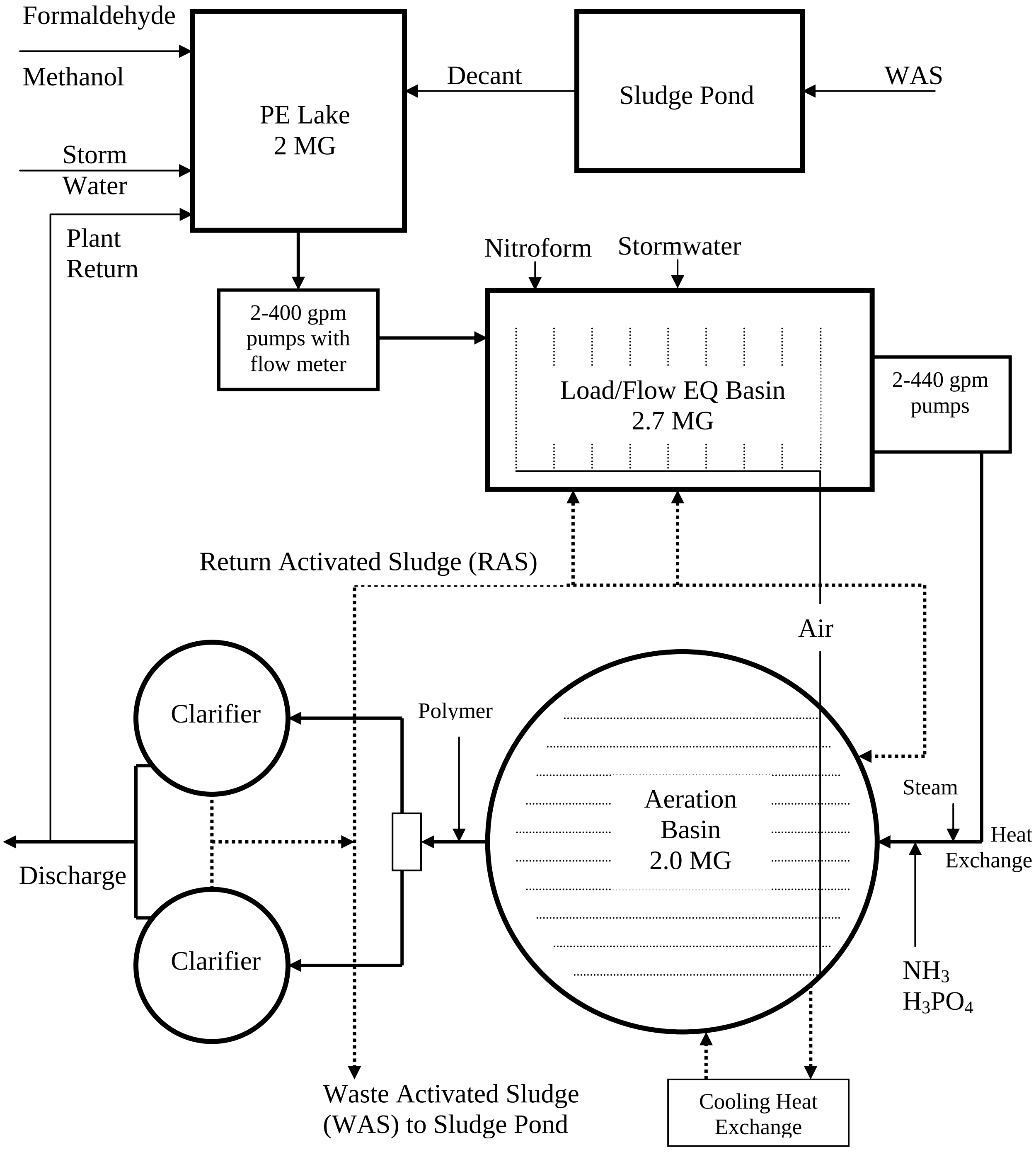
The BOD Plant includes an initial pond, PE Lake, which collects wastes from a number of manufacturing areas along with decant from the waste activated sludge lagoon. The influent stream contains formaldehyde, methanol and various derivatives of those chemicals. The variable depth pond also receives storm flow from the processing areas, and serves to store flows above the rated capacity of the plant. It can also receive the return partially treated wastewater that may not meet standards for discharge. The mixture of wastes from PE Lake is pumped through Lift Station #1 (2-400 gpm pumps) to an aerated load/flow equalization basin (EQ) ahead of the aeration tank. Air is supplied to the basin from the BOD Plant's blower system that feeds Parkson Biolac floating aeration-chains located along the basin. The volume of the basin is 2.7 MG and typically operates at a 10-10.5 foot depth. Thus, it provides more load equalization than flow equalization since the flow equalization is provided in PE Lake. Two additional waste streams enter the EQ basin, stormwater and a process blowdown from another process unit.

Equalized flow is discharged to the aeration tank by 2-440 gpm pumps. The flow is heated in the winter to maintain an aeration tank inlet temperature of about 97°F. Past laboratory work suggested that this temperature range was optimum for development and maintenance of microorganisms suited for the metabolism of formaldehyde and its derivitives. Ammonia and phosphate can be added to supply nutrients as required for process stability. The circular, 2.0 MG aeration tank is 20 feet deep and is aerated with 16 Parkson aeration headers with 1404 diffusers. In the summer, the organisms can grow fast enough to increase the temperature to the upper limit of the mesophylic range and can inhibit themselves when operating much above 100°F. Therefore, a heat exchanger is used to cool the mixed liquor and maintain a temperature that does not stress the microorganisms.

Oxygen is provided with 3-600 hp blowers. At the time of the initial plant evaluation, only two blowers were functional and, if used together, had to be throttled to 65-70% capacity because of diffuser limitations.

Mixed liquor from the aeration tank was discharged to two secondary clarifiers that are 45 feet in diameter and 12 feet deep. Because of the type of growth developed in the aeration tank, the biomass will not settle without the aid of polymer(s) that are added between the aeration tank and clarifiers. The clarifier overflow is discharged to outfall #006 and the settled biomass is returned

Figure 1 – BOD Plant Flow Schematic



to the aeration tank. If at any time the effluent is not satisfactory, the discharge may be directed to the PE pond for processing.

Return activated sludge (RAS) is pumped with 2-450 gpm pumps using butterfly valves to manually control the return sludge flow rate. The total RAS flow is metered, but there is no way to measure or control the RAS from each clarifier. RAS can also return to the EQ basin or may be wasted to the sludge lagoon.

Initial Conditions

Permit limits for Outfall #006 included 153 lb BOD/day and 225 lb TSS/day average. There were also TSS, ammonia, nitrate and organic nitrogen limits at a subsequent outfall, #001, to the Mississippi River. Therefore, excess nitrogenous nutrients could not be added.

One year of data was used in the initial process analysis to determine what could be done quickly under current conditions. Longer-term data analysis would be useful for design purposes, but for immediate reduction in polymer usage, much less data had to be analyzed. The plant loadings and effluent quality for the year 1996 were analyzed and are presented in Table 1. Average, minimum, maximum and standard deviation were calculated for each parameter, but only the average and peak month values are reported here.

Table 1 – Plant Loadings and Effluent Quality in 1996

Parameter	Average	Peak Month
Flow		
Lift Station #1, MGD	0.32	0.462
COD		
Lift Station #1, mg/L	9,157	11,136
Lift Station #1, lbs/day	23,915	29,403
Influent to Aeration Basin, mg/L	6,846	8,955
Plant effluent, mg/L	1,271	1,653
BOD		
Lift Station #1, mg/L	4,349	8,315
Lift Station #1, lb/day	11,190	17,005
Clarifier effluent, lb/day (006)	77	146
TSS		
Clarifier effluent, mg/L	50	71

Table 2 summarizes the plant process data for the same period.

Table 2 - Process Data for 1996

Parameter	Units	Yearly Average	Peak Month Average
Aeration Basin MLSS	mg/L	6,305	7,004
Aeration Basin MLVSS	mg/L	5,376	6102
RAS, Flow (RSF)	gpm	350	451
RAS, Flow (RSF)	MGD	0.504	0.649
RASW, Flow	% of Influent	160	312
WAS	lb/day	1,460	2,456
MCRT	Days	73	128

In an effort to determine if cause-effect relationships existed within the data set, correlations were calculated. For instance, one might suspect that effluent COD might be affected by or related to mixed liquor suspended solids (MLSS) values. If such a relationship exists it should be possible to develop an equation that reliably expresses the relationship. If such an equation can be developed, the data set can be reviewed to determine the reliability (correlation coefficient) of the equation. If the correlation coefficient is sufficiently high (greater than 95%) a relationship is said to exist. No relationship appeared with any reasonable level of correlation for any parameters evaluated in this project. This situation was true even in areas where one would suspect a correlation to occur, such as a relationship between polymer doses and effluent suspended solids.

Since no relationships could be established that could be used to institute operational set points, it was concluded that many of the operating parameters, which operation staff believed must be maintained to ensure proper operations, did not truly affect plant performance. For example, we could find no relationship between plant flow and effluent suspended solids or effluent COD level. This led us to believe that plant flow can be varied in the range of 100-400 gpm without negatively impacting plant performance. The fact that we could not see a relationship between polymer dose and effluent suspended solids led us to believe that the method of determining and controlling polymer dose was not directly related to suspended solids. Further, close review of the summary data suggested fairly minimal variability in product produced at the MCW site. We concluded from this that the majority of the upset conditions observed at the BOD Plant were a result of unusual releases rather than changes in production.

PROCESS EVALUATION

Upstream Processes

Typically, production personnel expect the wastewater that discharges from their plant will be treated at the wastewater treatment plant regardless of the volume, frequency, character and source. This thought pattern is best addressed if production personnel better understand the operation of the wastewater treatment plant, so that they consider how actions taken as part of production can adversely affect the treatment system capability. Production personnel in general understand the chemistry associated with their production units. For example, they know that when they add certain quantities of chemical A and chemical B, under specified conditions of temperature and pressure, they will produce a known quantity of chemical C and by-products. Unfortunately, a biological treatment system does not follow this level of predictability, particularly when several production units contribute different products on an intermittent basis. This situation would be similar to asking a production manager to reliably produce chemical C with no control over when and how much of chemicals A or B are added. Therefore, it is necessary to work with production units to educate them about the complexities of the biological treatment process. However, this takes a significant amount of time and positive results are most often realized over the long term.

Many of the chemicals and by-products produced at MCW can exert toxic effects on a biological treatment system. Toxicity can be affected by both the concentration of various constituents, and potentially, by combinations of the various constituents. Respirometer tests can often be used to determine this toxicity, however, that was not available during the project. Therefore, MCW had to depend on the flow and load leveling capabilities of the PE Lake to minimize any toxic or high organic-load conditions. To accomplish this, the pond system must be properly mixed and not short-circuit. Because of daily variations in PE Lake characteristics, it did not appear to be completely mixed and allowed “shock” loads to affect the biological system. This problem was made worse by one of the process waste streams discharging directly to the EQ basin.

Aeration

The function of the aeration tank is to provide an environment where microorganisms can use BOD, converting it to microorganism mass and liberating carbon dioxide and other waste products. The mass of microorganisms is then settled and returned from the clarifier to the aeration tank. To function properly, the microorganisms must have a satisfactory food supply, an oxygen source, proper levels of nutrients, and an environment conducive to growth and reproduction. The MCW waste contains materials that are not necessarily considered “satisfactory” according to industry standards. For instance, formaldehyde is usually toxic or inhibitory to microorganisms. However, microorganisms have the ability to adapt. Given enough time and providing low concentrations of the material such that it is not toxic, the microorganisms can often develop the capability to degrade such materials. Through the “fed oxygen uptake rate” test, it was shown that the MCW microorganisms had adapted to degrade the wastes supplied. However, it was not known what concentrations of wastes were toxic.

Compressed air is diffused into the mixed liquor to supply oxygen for the microorganisms. However, a side effect of aeration is the formation of foam. The waste at MCW tends to foam, and it can be severe at times to the point of foaming the biomass over the walls of the aeration tank, removing the biomass from the tank. Antifoam has to be added to compensate, however, the foam can appear so fast that it is difficult to react with the proper amount of antifoam. Thus, foaming can be a large problem, because wasting biomass from the system as foam greatly alters the growth characteristics and settling characteristics of the biomass.

The MCW waste contains a large amount of carbonaceous BOD, but very few nutrients. Therefore, aqua ammonia and phosphoric acid are added as needed to maintain optimum growth characteristics. Typically, a target value of 2-3 mg/L of ammonia and phosphorus was desirable in the effluent to minimize the production of excess biological slime, compound that inhibit sludge settleability in the clarifier.

If everything is functioning properly, the system should develop a biomass that removes almost all the soluble and particulate BOD from the waste. That sludge should also settle well, removing almost all of the suspended solids from the effluent and leaving a clear effluent. However, MCW had not been able to maintain such a biomass. Often the biomass did not settle well and left a turbid effluent. It still met discharge standards, or was diverted to PE Lake for retreatment to assure that permit limits were not violated.

The normal treatment approach at MCW was to introduce the waste from PE Lake through lift station #1 to the EQ basin where minimal aeration was provided. The objective was to mix the wastes to eliminate spike conditions that would be detrimental to the microorganisms. Typical detention time in the EQ basin, based on average flow for 1996, was about 7.9 days. There was no biomass return to the EQ basin from the aeration tank-clarifier system. Thus, the influent was mixed together for almost eight days to provide “average” conditions. Even without addition of biomass about 25% of the COD added from lift station #1 was removed either through volatilization or biological conversion.

At the 1996 average flow rate, the two million gallon aeration tank provided approximately 2.4 days of treatment time when 350 gpm (0.5 MGD) of return sludge was added. This is a relatively short detention time when trying to stabilize the difficult-to-degrade wastes that may exert toxic effects. For treatment to be effective, the operators had to maintain a very high (6,000 mg/L) concentration of biomass in the mixed liquor to assure that treatment was completed. For 1996 the average BOD discharged to the aeration tank was approximately 8,500 lb BOD/day and the peak month BOD was about 13,900 lb/day. These loads provided space or volumetric loadings of 32 to 52 lb BOD/1000 ft^3 of aeration tank volume. A typical value for completely mixed activated sludge plants is about 40 lb BOD/1000 ft^3. To compensate for these high organic loadings the plant was operated with a reduced ratio of food (BOD) for the microorganisms in the system. To maintain a realistic F/M ratio of approximately 0.1, an MLSS value of approximately 6,000 mg/L was required. However, high mixed-liquor-suspended-solids concentrations, especially above about 5,000 mg/L, make it difficult to maintain dissolved oxygen concentrations and it requires higher concentrations of polymer to effect proper settling.

Secondary Clarifiers

Aerated mixed liquor enters a splitter box for distribution to two circular clarifiers, each 45 feet in diameter and 12 feet deep. Return activated sludge is returned through two pumps rated at 450 gpm each. The return rate is controlled by butterfly valves on each pump. The 1996 flow rate loaded the clarifiers hydraulically at an average 101 gal/ft^2/day and a peak month average of 145 gal/ft^2/day. The resulting solids loading ranged from a yearly average of 13.6 lb MLSS/ft^2/day and a peak month average of 18.36 lb MLSS/ft^2/day. Clarifier hydraulic and solids loadings were well below typical standards of 600 gal/ft^2/day and 25-30 lb/ft^2/day respectively. However, the return activated sludge flow rate ranged from a monthly average of 160% of influent flow rate to a peak month of 312%. A ratio below 100% was expected and much lower values would have been useful.

One reason that the return rates were kept high was the accumulation of a “black” layer at the bottom of the sludge blanket. Operations staff felt that this black layer was indicative of significant anaerobic conditions, and they did not want to cause process upsets by having the return sludge in septic conditions. Typical sludge-blanket thickness was 1-2 feet at the most.

The high return rate required more polymer since more polymer was required to maintain the appropriate dose. At MCW the polymer requirements were highly variable over time ranging from 73-400 lbs/day in 1990. During 1991, polymer doses were significantly lower, and with few exceptions ranged from 70-200 lbs/day until 1994. In 1995 polymer doses increased significantly and remained high until the project was initiated.

Observation of the clarifier flow splitter suggested uneven split. This caused more flow and higher loading to one clarifier than the other.

PROCESS AND CONTROL MODIFICATIONS IMPLEMENTED

During the project it was concluded that some changes in plant operation and configuration may enhance plant performance, reduce variability of effluent quality and reduce costs through chemical and power reductions. Other modifications would require a longer time period.

Aeration

The first recommendation, made and implemented on a test basis, was to convert the EQ basin into additional aeration basin volume. Because the EQ basin was efficiently aerated and piping was in place to return sludge to the basin, the conversion was both simple and economical. The primary rational for the change was to obtain additional aeration basin volume to reduce the space loading in the activated sludge system. Both the literature and experience has shown that activated sludge systems with space loadings exceeding 35-40 lb BOD/1000 ft^3 of basin volume experience problems with sludge settling and effluent variability. By adding another 2.7 million gallons of basin volume, the space loading was cut by almost 60%. The second factor in this recommendation was based on increasing the inventory of active microorganisms in the system while simultaneously reducing the MLSS concentration. The benefit of increasing the active biomass is several fold. First, more active mass allows for more efficient and faster stabilization of slowly biodegradable materials. Additional inventory should be less impacted by toxic events. A lower concentration of MLSS should also improve oxygen transfer efficiency, and may potentially reduce polymer requirements. By placing the EQ basin in service as an aeration basin, the microorganism inventory could be increased 50% while reducing the MLSS concentration from 6,000 mg/L to 3,750 mg/L.

One concern associated with this plant change was the ability of the aeration system to provide sufficient oxygen for the EQ basin. Plant staff had reported that odors had occurred in the EQ basin during the summer. There was no question that sufficient blower capacity existed to satisfy all oxygen demands. However, when first considered, staff felt that there would not be enough air for the EQ basin since only one blower could be used at a time, because one would trip-out when both were started. However, analysis indicated that both blowers could be used if the second blower was brought on-line slowly. Two blowers at 65% capacity could provide significantly more air than one blower at 100% capacity.

A further complication was that the existing diffusers were limited to a maximum air-flow of five scfm per diffuser. Based on the diffuser limitation, two blowers could operate at about 70% capacity each. If the airflow was not enough to control odors, a simple piping change could have been made to initiate some step-feed. Step-feed would spread the influent around the tank so that the BOD concentration was not high at any point in the tank. However, the airflow proved acceptable and no additional aeration modifications were required to begin utilizing the EQ basin for the purpose of treatment rather than just equalization.

Secondary Clarifiers

Based on the low hydraulic and solids loadings to the clarifiers, it was recommended that one clarifier be removed from service. This would accomplish a number of things. First, it would eliminate the immediate flow split problem. Second, it would reduce the amount of time that return sludge would have to stay in the clarifier. And, third, it would allow reduced return flow rate back to the aeration tank. The reduced flow rate would in turn reduce the amount of polymer required to settle the biomass. The removal of one clarifier from service was even more important in light of the potential reduction in MLSS concentration and solids loading due to the reduction in MLSS from use of the EQ tank for treatment.

One nontechnical impediment to removing a clarifier from service became apparent. The operations staff was reluctant to remove a clarifier from service since they had never functioned that way before and it just did not ”feel right” to take a clarifier down when they had had years of sludge-settling problems. After much thought the staff went along with the idea and a clarifier was removed from service, but only after agreement had been reached that sludge blanket depths would be monitored each half hour to assure that they did not rise significantly.

Stabilization of Organic Loading

As mentioned previously, it was apparent that the variability of wastewater treatment plant organic loading was more a function of unusual releases rather than production changes. The MCW staff began working with production supervisors to educate them regarding three different aspects of wastewater treatment. First, they addressed the problems caused by variable quantities of wastewater being discharged, specifically unusual releases. Second, the toxic affects of certain discharges were considered. Third, the wastewater treatment plant was not designed to handle excess waste. Wastewater treatment is significantly different from the production situation where there are options for unsatisfactory material such as rework, discount pricing, etc. The wastewater treatment plant must ultimately treat the wastewater.

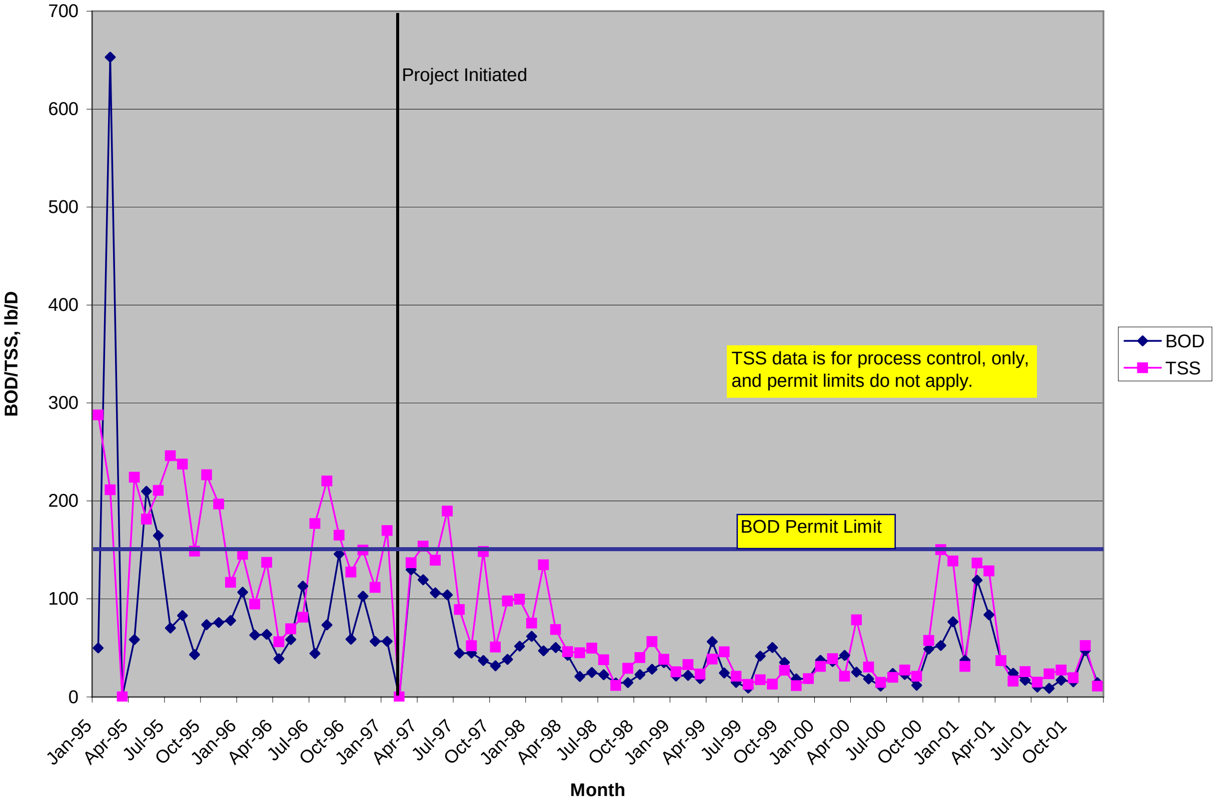
RESULTS

Effluent Quality

Once the EQ basin was initiated as an aeration tank, the MLSS reduced dramatically. Wasting was reduced to allow the MLSS to increase in the two tanks to about 3,700 mg/L. If one aerator at full capacity was not enough, two blowers were used, each at less than 70% of capacity, to maintain the necessary dissolved oxygen and to control odors. One clarifier was taken off-line and the return rate was reduced as much as possible using the unreliable butterfly valves.

Figure 2 shows the effluent results from the pre-project date of January 1995 through December 2001. The effluent was of good quality except for a few instances that occurred in early 1995, which were addressed and reported to the regulatory authority as required by the NPDES permit. After the project, effluent BOD and TSS values began to reduce and by April 1998 had stabilized to 50 lb/day or less. The effluent remained at these low values until October 2000 when the effluent TSS began to increase and spiked at 150 lb/day in November, but was still well within permit limitations. Except for January 2001, the TSS stayed high until April 2001 when it stabilized again. BOD values were also higher, but not as high as TSS. Evaluation of process conditions suggested that the only variation from now-normal conditions was a high BOD load of over 10,000 lb/day in October 2000 (Figure 3) compared to a now-normal loading at or less than 8,000 lb/day. The condition of the mixed liquor deteriorated in October 2000 and remained in poor condition through the cold winter, allowing discharge of fine pin-floc particles that could not be removed with polymer. Finally, in April the system recovered and has remained in good condition since.

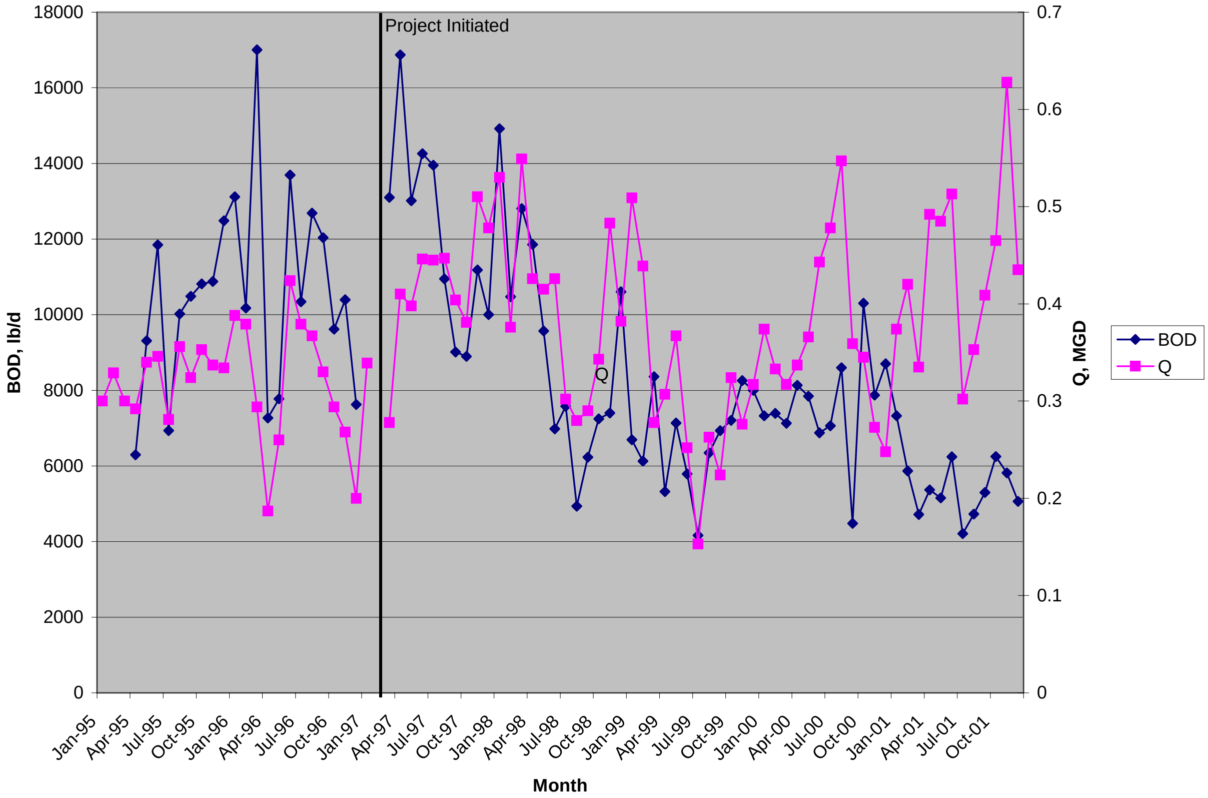
Figure 2 – Effluent BOD and TSS Values



Long-Term Organic Loading Stabilization

From mid 1998 through 2001 production rates were reduced during the same period that MCW operating staff was working with production personnel. Figure 3 shows the combined results of reduced production and BOD Plant staff's efforts to minimize organic load variations through education of production staff. By June 1998 the monthly average BOD loading to the plant was reduced to near or below 8,000 lb BOD/day except for the months of December 1998 and October 2000 (Figure 2). Both of the months spiked to over 10,000 lb BOD/day. The influent flow remained quite variable and showed no relationship to the BOD load. Therefore, the reduction in BOD load appears due in large part to improved control of the influent load by minimizing unusual releases. The December 1998 incident had little or no effect on the effluent BOD or suspended solids, however, the October 2000 loading upset the plant and it took until April 2001 to regain control to the degree seen from April 1998 until the October 2000 problem. Production levels have again reached full capacity and the effluent remains very good.

Figure 3 – Influent BOD Loading and Flow Rate

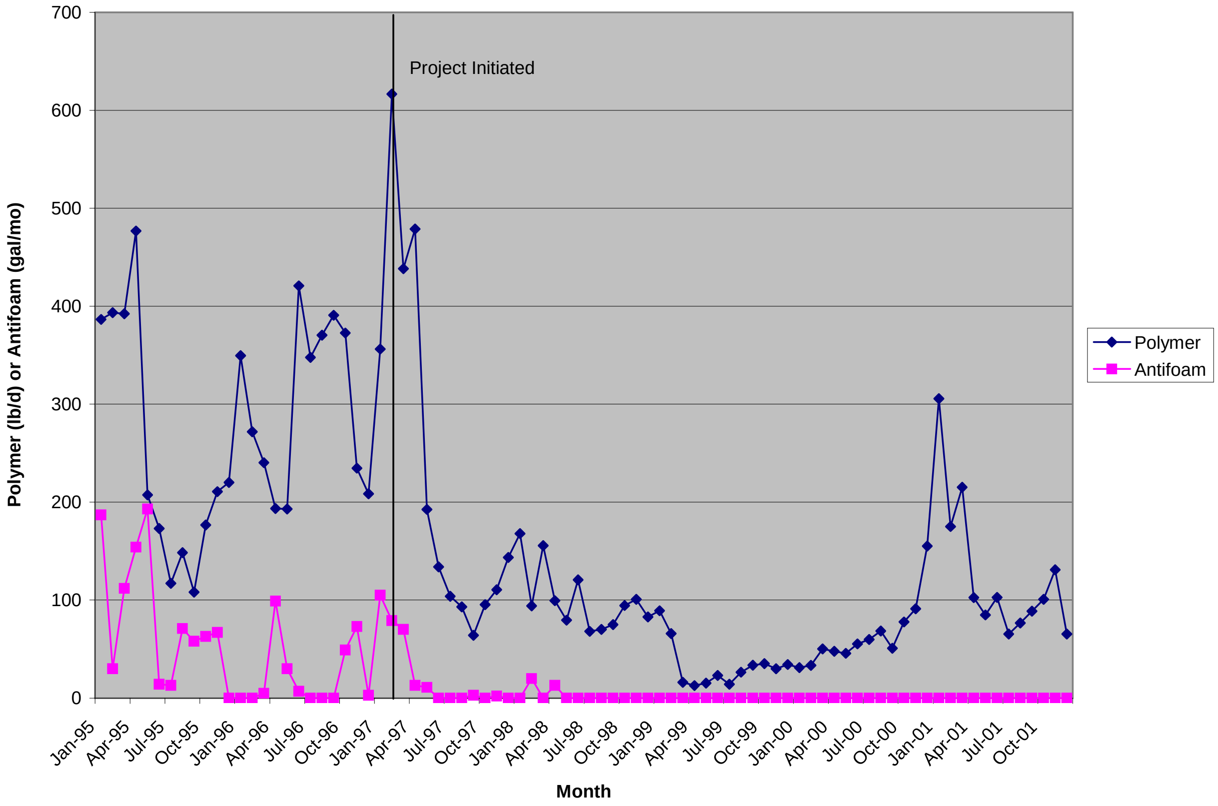


At this time it is fair to say that while the production personnel still do not understand the technical aspects of wastewater treatment operation, they have started to take necessary action to allow the BOD Plant to perform better. They understand that their process decisions can negatively impact the BOD Plant. Environmental control is in transition from a "command control" led by the environmental staff to a team approach with production personnel as full partners.

Chemical Savings

The primary reason for initiating the project was to optimize the system and reduce the cost of polymer addition required for proper settling of the activated sludge. Figure 4 shows that, within days of initiating the on-site process changes, the polymer requirements reduced dramatically. From a pre-project use of about 283 lb/day, the polymer use dropped to 99 lb/day since the project was initiated and has been as low as 13 lb/day. The polymer dosage rate averaged 224 mg/L for February 1997 and had dropped to19 mg/L by September 1997. Based on initial project conditions the month of minimum polymer-use realized about a 94% reduction while the entire post-project period has averaged a reduction of 66%. As discussed previously, not only did the polymer demand reduce drastically, but the effluent quality also improved significantly.

Figure 4 – Polymer and Antifoam Use



An unanticipated benefit of the project related to the use of antifoam to control aeration tank foaming. The pre-project average use was 54 gal/month, with a peak month use of 193 gallons. After the project was initiated the use averaged 2 gal/month, and no antifoam has been used to control aeration tank foaming since April 1998, 14 months after project initiation.

Secondary Clarifier Conditions

When the MLSS was reduced to the recommended levels, the sludge blanket levels in the clarifier dropped. Upon removal of one clarifier from service, the immediate effect was a slight increase in blanket level for about the first half-hour. After that the blanket level remained about 1-2 feet in depth and the two clarifiers have not been used together since the project was initiated.

CONCLUSIONS

The CPE process was effectively used to evaluate the wastewater treatment process at MCW. Good communications between RTW and MCW staff lead to a true team approach. Based on the evaluation, simple process modifications were made that resulted in dramatic reductions in polymer and antifoam usage. Even though initial effluent quality was good in most instances, it improved significantly within the few months after the project was initiated. The MCW staff has been able to maintain the reduced polymer and antifoam requirements and good effluent quality for the five and a half years since the project was initiated. Over that time the MCW staff has also begun to reduce the organic loading to the plant by educating the production staff MCW in the necessity of minimizing unusual discharges that can adversely affect a biological wastewater treatment system.

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