ASSESSMENT OF I/A FACILITIES SEEKING 100 PERCENT MODIFICATION/REPLACEMENT FUNDING - CASE HISTORIES

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INTRODUCTION

The 1977 Amendments to the Clean Water Act (P.L. 95-217) provide incentives to municipalities for selecting innovative and/or alternative (I/A) technologies for treating their wastewaters. I/A technologies, by definition, are less expensive to construct or operate than conventional systems, but have a risk associated with their capability to provide the required performance. To offset this risk, Section 202(a)(3) of P.L. 95-217 provides for the U.S. EPA to pay for 100 percent of the cost of modification or replacement of an I/A system which fails to achieve its anticipated performance. Modification or replacement of the I/A system is undertaken to ensure treatment system performance goals will be realized.

The request for a 100 percent modification/replacement (100% M/R) grant must be initiated by the municipality. The guidelines that the municipality must pursue to obtain such a grant are presented in Section 15.2 of the U.S. EPA's Construction Grants guidance document (CG-85).[1] Part of these guidelines requires the U.S. EPA to confirm that the I/A technology has been in operation for at least two years, has not been hydraulically or organically overloaded, and has been adequately operated and maintained. At some point, the agency must also establish that: the I/A portion of the wastewater treatment system has caused the claimed failure or has significantly increased the capital and/or O & M costs of the facility, and the claimed I/A technology failure is not attributable to negligence on the part of any individual.

Once an initial screening of available information has indicated the claimed failure of the I/A technology is probable, CG-85 recommends the preparation of a performance evaluation report which includes:

- A description of the claimed failure.
- A quality assurance review of environmental data utilized to document the claimed failure.
- An assessment of the facility's O & M program.

- An evaluation of the entire wastewater facility design.
- The identification and evaluation of any construction deficiencies contributing to the claimed failure.
- An evaluation of equipment performance and warranties.
- An evaluation of process warranties and performance guarantees.
- A description of any outstanding claims and issues of negligence.

Because the Comprehensive Performance Evaluation (CPE) analyzes all factors contributing to facility non-compliance, the technique was evaluated to determine if it was suitable for meeting some of the CG-85 requirements. The CPE technique is part of the Composite Correction Program (CCP) procedure[2] which was developed by the U.S. EPA to address discharge permit non-compliance at publically owned treatment works (POTWs). A CPE identifies the unique combination of design, operational, maintenance and administrative factors responsible for facility non-compliance, and interprets whether a follow-up CCP could be used as the most expedient and cost-effective alternative for achieving compliance. A CCP is a site specific program which, when implemented, systematically addresses the factors identified in a CPE. Typically CCP activities would not include major modifications or construction.

The CPE portion of the CCP approach (CPE) addresses many of the CG-85 requirements for assessing 100% M/R requests. To formally assess the applicability of the approach, a project was initiated whereby a limited number of facilities that had requested 100% M/R funding would be evaluated using CPE procedures. This paper presents the results of this effort.

APPROACH

Five facilities that had claimed failures of installed I/A systems were evaluated. The evaluations at each facility were typically conducted

during a one week period by a two-person CPE team. Activities during the CPE included:

- A kick-off meeting to inform the City administration and plant staff of the CPE activities and goals as well as what would be required of them during the site visit.

- A detailed tour of the entire wastewater treatment plant conducted by the facility's process control decision-maker(s).

- A review of the O & M Manual, specifications, equipment literature and record drawings to obtain design information on all installed unit processes.

- A review of operational records to allow for development of flow and mass balances associated with each major unit process at the wastewater treatment plant. This step also allowed some verification of laboratory results.

- The development of a unit process potential capacity graph to allow for a comparison of unit process estimated capacity with both current and design loadings.

- The conduct of individual interviews with the treatment plant operations, maintenance and laboratory staff members, City administrators, the facility design engineer, and in certain cases, the manufacturer of the I/A system equipment. Interview questions center on each individual's general role in and understanding of the overall facility design, operation, maintenance and administration. In addition, specific questioning was oriented toward the claimed I/A technology failure.

- The identification and ranking in order of priority by the CPE team members of design, operational, maintenance and administrative factors currently limiting, or potentially limiting in the future, the overall performance of the POTW. This comprehensive identification/ranking was undertaken without regard to interaction with conventional or I/A treatment system components.

- An exit meeting attended by the CPE team members as well as the individuals interviewed by the CPE team. Staff members from the State regulatory agency and from the U.S. EPA regional office were also invited to this meeting. The purpose of the meeting was to verbally present the preliminary findings of the week-long CPE.

- A written report which was subsequently distributed to the municipality and involved regulatory agencies for their use in addressing the claimed failure and the request for a 100% M/R grant.

Limited changes were made in the CPE approach for the evaluation of the facilities requesting 100% M/R funding. Additional effort was made to determine which portion of the facility had been constructed with an I/A grant and additional investigation of the I/A facilities occurred during the personnel interviews.

FIELD ACTIVITIES

The results of the CPEs undertaken at five POTWs that had claimed failures of installed I/A systems are discussed in this section. It is noted that this paper avoids the discussion of specific I/A technologies since the purpose of the evaluations was to assess the use of the CPE procedures. Substantial information is presented on the first case study. This has been done to provide the reader with a better understanding of the methodologies involved in the CPE procedure. Case studies two through five are much more succinct in presentation, highlighting just the findings of the investigative efforts.

Site Visit 1

Facility 1 was a 3,785 m^3/day (1.0 mgd) secondary treatment plant designed for nitrification as well as removal of the more conventional parameters, BOD_5 and TSS. The municipality received I/A funding for a high efficiency aeration system, and for the aeration basin, secondary clarifier and waste secondary sludge holding tank based primarily on their common-wall construction. A schematic of the facility is shown in

Figure 1. Two claims of I/A technology failures were declared by the municipality: 1) the aeration system was inadequate to provide for proper wastewater treatment at greater than the current flow rate of 1,514 m^3/day (0.4 mgd), and 2) the secondary clarifier was subject to freeze-up during periods of cold weather. A 100% M/R request for supplemental aeration equipment and a secondary clarifier cover were being pursued.

In an attempt to provide better definition to the first claimed failure, facility performance data over the past year were reviewed and compared to the limitations stipulated in the facility's NPDES permit. The outcome of this effort is summarized in Table 1.

TABLE 1. Evaluation of Data for Plant 1

PARAMETER	CONDITION	
	CURRENT	PERMIT
Flow		
m^3/day	1,514	3,785
mgd	0.4	1.0
Influent		
BOD_5, mg/L	250	200*
TSS, mg/L	210	200*
NH_3-N, mg/L	26	20*
TKN, mg/L	43	30*
Effluent**		
BOD_5, mg/L	18/17	20/30
TSS, mg/L	30/24	30/30
NH_3-N, mg/L	8.0/-	2.3/-
TKN, mg/L	-/20.6	-/8.0

* - Design values
** - Summer/winter values

It appeared that the claimed failure was probable since the I/A facilities had been operating at loadings significantly less than design capacity and had still failed to consistently meet desired effluent standards. However, further data and information analysis during the CPE field activities indicated a projected loss of about 58,050 kg (128,000 lb) of TSS from the treatment system during the previous one-year period. Probable cause of this TSS loss was inadequate sludge mass

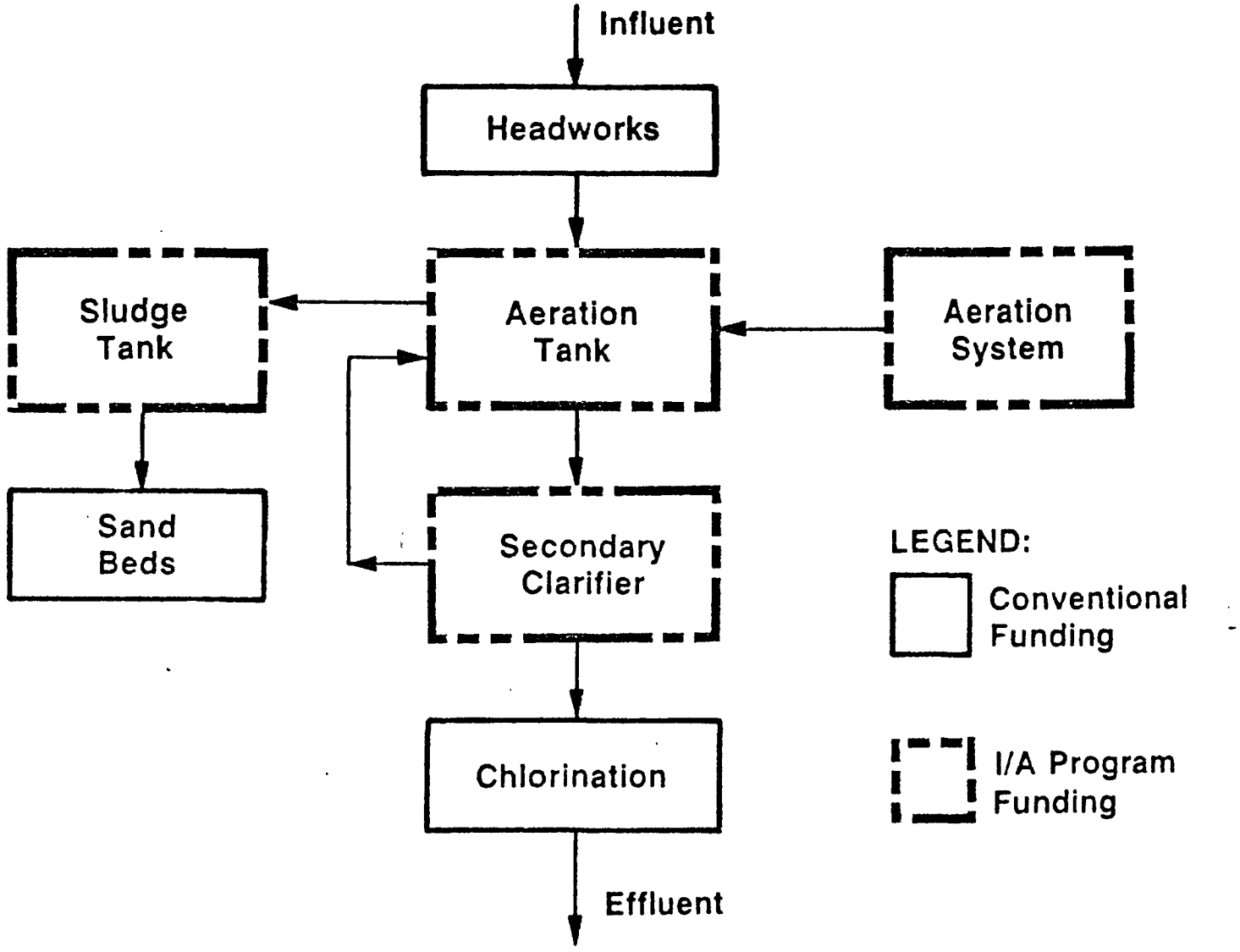

FIGURE 1. Plant schematic for Plant 1.

control in the system coupled with solids washout due to a collection system inflow problem during periods of precipitation. Assuming this mass of TSS was uniformly discharged over the year, effluent quality would more closely approximate that shown in Table 2.

TABLE 2. Comparison of Reported Versus Projected Effluent Quality For Plant 1

PARAMETER	EFFLUENT QUALITY	
	REPORTED	CALCULATED
BOD_5, mg/L	17	71
TSS, mg/L	27	136

Based on the sludge accountability analysis, it appeared that factors other than the I/A facilities needed to be carefully scrutinized.

The unit process potential capacity graph was completed, as shown in Figure 2, as were the individual interviews with the treatment plant staff, the City administrators and the facility design engineer. Supplemental information was obtained from the aeration system manufacturer by telephone. Design, operational, maintenance and administrative factors potentially limiting facility performance were next identified and ranked by the CPE team. "A" factors were felt to have a major impact on performance on a continuous basis, while "B" factors were felt to have either a minor impact on a continuous basis or a major impact on an intermittent basis. The twelve factors identified as potentially limiting facility performance, in descending order of importance, are discussed below.

Factor A-1: Sludge Dewatering-- The conventional sand drying beds were found to have an assessed capacity equivalent to an influent flow rate of 568 m^3/day (0.15 mgd), based on year-round utilization of the beds. Without alternatives or additional facilities to overcome this sludge dewatering limitation, it was projected that the facility could not be expected to meet its NPDES permit requirements, even at current flows.

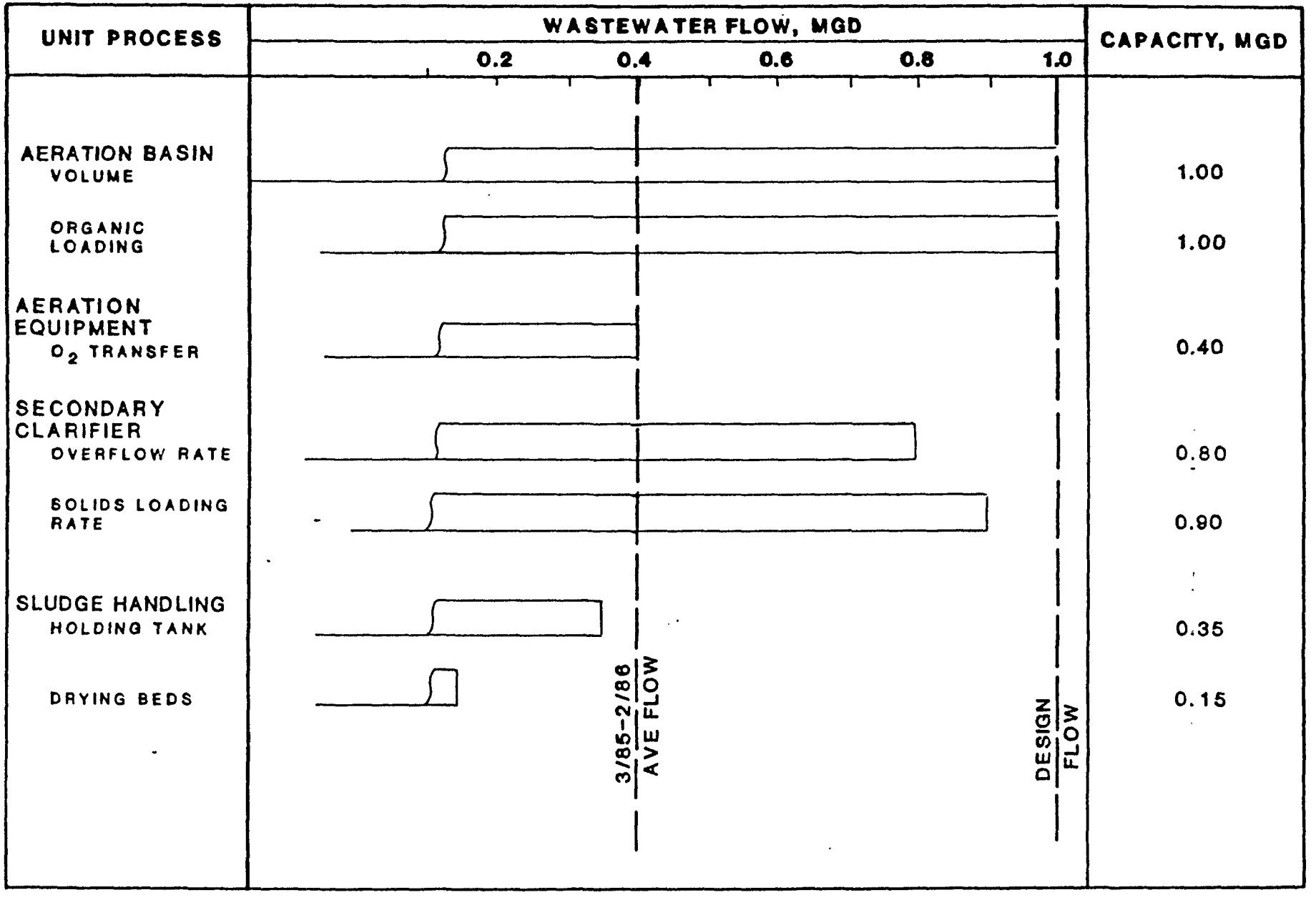

FIGURE 2. Potential capacity of selected unit processes for Plant 1.

Factor A-2: Aeration System-- The I/A-funded aeration system was found to have an estimated capacity equivalent to 2,460 m^3/day (0.65 mgd) at present organic loadings. Supplemental aeration would be required to properly treat the wastewater when the daily influent flow exceeded this value.

Factor A-3: Sludge Wasting Capability-- The I/A-funded 54 m^3 (14,200 gal.) waste sludge holding tank was estimated to have a capacity equivalent to an influent flow rate of about 1,325 m^3/day (0.35 mgd). Capacity of this fill-and-draw system was based on the mass of MLSS that could be concentrated and stored in the tank during an eight-hour work day. Due to system design and operation, the source of waste sludge had to be the MLSS in the aeration tank, and not return sludge from the secondary clarifier. Without adequate removal of excess sludge solids from the treatment plant, it was felt that NPDES permit limits would continue to be violated.

Factor A-4: Bond Indebtedness-- Over 50 percent of the plant's budget was allocated to bond payment. In addition, there was essentially no allocation in the budget for facility capital improvements. A number of the performance limiting factors identified would require substantial capital expenditure to correct, but the capital was not available.

Factor A-5: Performance Monitoring-- Collection of effluent composite samples appeared to have been biased, since it did not include days on which precipitation occurred. Data from days when samples were collected indicated adequate removal of pollutants except for nitrogen components. Since monitoring data was not indicative of plant performance, the plant staff had no incentive to change operating conditions or strategies. A review of operational control parameters indicated that a number of changes were warranted to effect better effluent quality.

Factor A-6: Operator Application of Concepts and Testing to Process Control-- The operators had received formal "classroom" training, but seemed to have a difficult time applying activated sludge process

control parameters to their own facility. This lack of understanding was especially apparent in the area of adequate mass control in the activated sludge portion of the plant.

Factor A-7: Technical Guidance-- The plant staff sought technical guidance from three primary sources: manufacturer's literature, the facility's O & M Manual, and the operator of a neighboring community's trickling filter secondary treatment plant. Information contained in these sources often conflicted and often was not appropriate for the time dependent variables that occur in biological systems. Long term on-site training could be utilized to overcome this factor.

Factor B-1: Administrative Policies-- The plant administrators devoted essentially all of their time and effort to bond indebtedness issues, development of budgets, insuring the prompt connection of users to the collection system, and pursuing corrective actions for claimed treatment plant unit process failures. Although the above were acknowledged as being important, primary focus of the administrators should have been assurance that the treatment plant was in continuous compliance with its NPDES permit.

Factor B-2: Number of Staff-- Current plant staffing was judged to be adequate in all areas except sludge dewatering; where it was estimated to be marginal. If the amount of sludge projected to be produced at current loadings were to be adequately handled it was felt that additional staff would be required to dewater the anticipated sludge quantity.

Factor B-3: Plant Inoperability Due to Weather-- Abnormally cold weather, coupled with low night-time wastewater flow rates, caused the secondary clarifier to freeze up during the initial year of operation. Normal weather patterns, coupled with increased wastewater flow rates as a result of completion of trunk sewage lines, should negate this problem in future years.

Factor B-4: Inflow-- Peak flow to the plant was reported to be 7,949 m^3/day (2.1 mgd) which exceeded the design peak day flow. To minimize system washout because of stormwater inflow, improvements must be made to the collection system.

Factor B-5: Process Controllability-- The secondary clarifier was designed to operate without return sludge pumps. This clarification system worked, but positive control of return sludge rates could not be effected, which was felt to yield less-than-optimum process control.

The results of the CPE as applied to Facility 1 indicated a variety of results. The claimed aeration failure was confirmed while the claim associated with the secondary clarifier was deemed inappropriate. The primary reason for performance problems was determined to be the sludge dewatering capacity (sand drying beds). Integral to this was the limited capacity of the I/A-funded waste sludge holding tank, a failure not claimed by the City.

In summary, twelve factors were identified as potentially limiting the performance of this facility. The comprehensive approach of the CPE efforts was necessary to identify these multiple factors. A clear finding of the failure of the I/A technology was not indicated and a follow-up CCP to systematically address the factors identified was deemed warranted. Findings did indicate that at current loadings and without major modification to the I/A facilities the plant could be expected to be in compliance if an alternative ultimate sludge disposal method could be utilized (i.e., sludge hauling to a land disposal site). However, unless all twelve factors are addressed and corrected, NPDES permit compliance could not be expected as plant flows increased above present levels.

Site Visit 2

Staff at Facility 2 claimed their I/A-funded aeration system was consuming excessive power and were seeking relief from excessive power costs

associated with this equipment. The conduct of a CPE identified the following performance limiting factors and their level of impact.

Factor A-1: Aeration equipment.

Factor B-1: Sludge holding capacity during the winter.

Factor B-2: Operator application of concepts and testing to process control.

The conclusion of the CPE activities was that claimed failure of the I/A technology was justified, as evidenced by the aeration system being noted as the highest ranking factor. The two other factors identified also had a detrimental effect on plant performance and action to correct these factors was recommended.

In Facility 2, the CPE more clearly indicated the failure of the I/A technology. In addition, the comprehensive nature of the evaluation also identified factors that degraded plant performance but were not related to the I/A technology.

Site Visit 3

Facility 3 was designed to treat combined municipal and industrial wastewater. An innovative secondary treatment system was installed in the existing activated sludge facility to allow treatment of wastewater that varied substantially in strength and to allow removal of color from the wastewater being treated. The City claimed that operation of the I/A-funded system caused two failures within the plant. First, the system allowed secondary sludge solids to settle in the aeration basins; second, the system was causing massive scum formation to occur on the final clarifiers. As a consequence, the City was pursuing 100% M/R funding for an aeration system which would provide better aeration basin mixing and for secondary clarifier scum removal equipment.

The CPE efforts identified the following potential performance limiting factors in order of severity.

Factor A-1: The I/A technology.

Factor A-2: Administrative policies.

Factor A-3: Sludge treatment/ultimate disposal.

Factor A-4: Operator application of concepts and testing to process control.

Factor B-1: Process controllability.

Factor B-2: Aeration system.

Factor B-3: Industrial loading.

The I/A-funded technology produced a poorer effluent quality than would result from conventional activated sludge treatment (Factor A-1). An administrative policy of operating the I/A-funded system, even though the operation resulted in NPDES permit violations, was in effect at the facility (Factor A-2). The sludge digestion process yielded a poorly stabilized sludge; the disposal of which was to be limited by more stringent regulations in the near future (Factor A-3). Staff operators were not utilizing daily field measurements and analytical results to optimize a number of the plant's unit processes (Factor A-4). Valving and piping did not allow for equal distribution of loads to parallel treatment trains. In addition, a majority of the flow rate monitoring equipment was either out of calibration or inoperative (Factor B-1). Even with conventional activated sludge operation, the mixing provided by the existing aeration equipment was deemed limiting (Factor B-2). Shock industrial loads were felt to have the potential for plant upsets, even though none had occurred over the recent past (Factor B-3).

With respect to the claimed failures, the CPE team found the aeration system mixing capacity to be limiting. The claim associated with scum formation was not felt to be appropriate; scum formed because of hydraulic conditions between the aeration tanks and the secondary clarifiers, which resulted in massive levels of air entrainment.

The CPE effort identified the I/A technology as the highest ranking factor limiting performance at Facility 3. However, numerous other factors

were identified. It was projected that addressing the other factors during the systematic approach of a CCP would have allowed compliance with NPDES permit criteria to be achieved. It was felt that the clarity provided by the listing of the multiple factors limiting performance provided much needed insight into the complex plant performance problem.

Site Visit 4

Designers of Facility 4, because of changes in the NPDES permit, selected an innovative process for the achievement of wastewater nitrification within the facility's existing aeration basins. The City claimed that operation of the I/A-funded process resulted in two failures. The first was NPDES permit violations for selected inorganics; the second was an excessive rate of corrosion to certain pieces of treatment plant equipment. A 100% M/R grant request was being pursued to rectify these claimed failures.

The CPE yielded the following potential performance limiting factors in order of severity:

Factor A-1: The I/A technology.

Factor A-2: Industrial loading.

Factor B-1: Operator application of concepts and testing to process control.

Factor B-2: Flow proportioning to units.

Factor B-3: Inflow.

The I/A-funded system was ineffective in removing inorganics from the wastewater, a function which it was designed to accomplish (A-1). A review of treatment plant influent characteristics showed abnormally high concentrations of selected inorganics, which indicated the lack of a fully implemented pretreatment program. These high influent concentrations were felt to contribute to effluent quality excursions (A-2). Normal operational parameters were measured by the plant staff, but utilization of the amassed information to optimize the performance of the facility appeared to be lacking in certain areas (B-1). Equal

flow/mass distribution to parallel unit processes was not being achieved at the plant (B-2). Due to stormwater inflow, recorded peak flow rates had exceeded by a factor of four the average daily flow design value. When such high rates occurred, unit processes were bypassed, which resulted in the discharge of partially treated wastewater (B-3).

The CPE results indicated that the I/A-funded system was contributory to the two claimed failures. However, other factors also contributed to limiting system performance. Implementation of a CCP to address the identified factors exclusive of the I/A technology would have led to improved performance. As with Facility 3, the CPE provided much clarity to the complex performance problem at this facility.

Site Visit 5

An I/A-funded process to effect an effluent total phosphorus concentration of 1.0 mg/L was utilized at Facility 5. The City claimed that the process failed to yield an effluent phosphorus of such quality and was pursuing alternatives to meet their NPDES permit limitation for that parameter.

The CPE team identified the following potential performance limiting factors at this facility:

Factor A-1: Application of concepts and testing to process control.

Factor A-2: Industrial loading.

Factor B-1: Process return streams.

Factor B-3: Flow proportioning to units.

Factor B-4: Administrative policies.

A review of operational control parameters utilized for most of the unit processes at the plant indicated operational strategies which were felt to inhibit the achievement of optimum performance (A-1). Influent total phosphorus concentrations ranged from 8 to 27 mg/L on a daily composite

basis. This range was felt to contribute to effluent quality variability (A-2). Return streams from certain ancillary unit processes contributed measurable mass loadings of BOD_5, TSS and total phosphorus to the plant's mainstream major unit processes, which impacted overall system performance (B-1). There was inadequate mixing in the activated sludge aeration tanks to keep all of the MLSS in suspension and, as such, capacity of this system was diminished (B-2). Return secondary sludge solids could not consistently be distributed equally between parallel activated sludge treatment trains (B-3). Shift operators were not involved in establishing operation control parameters set-points; the plant superintendent made all process decisions on his own (B-4).

The CPE results could not be used to confirm the claimed failure of the I/A-funded phosphorus removal system. As such, funding of a 100% M/R grant was not clearly indicated. Other factors were identified as involved in the less-than-optimum performance of this process. A CCP to address the identified factors was recommended to utilize the projected capacity of the existing treatment processes.

DISCUSSION OF RESULTS

Five facilities which had claimed failure of their I/A technologies were evaluated using the CPE portion of the CCP approach. Although the evaluations had many facets, the main objective was the assessment of the CPE for evaluation of poorly performing I/A technologies. Of particular interest was the ability of the CPE to meet the requirements of the CG-85 guidance document for a performance evaluation report prior to approval of a 100% M/R grant. Relative to these requirements, it was demonstrated that the CPE could be used to describe the claimed I/A technology failure; evaluate the facility's current operational, maintenance and administrative programs; assess system treatment capacity relative to current and design loadings; indicate design/ construction deficiencies; and identify design, operational, maintenance and/or administrative factors limiting current system performance.

The major unit process evaluation, as outlined in the EPA Handbook[2], was also modified, since I/A technologies are not included in the published major unit process evaluation forms. The I/A unit processes must be evaluated based on experience gained working with other processes and by analyzing available plant operating data.

Additionally, the CPE did not provide for a quality assurance review of laboratory data, but did allow some assessment of data to occur through use of comparisons of projected versus actual loadings and through the use of system mass balances. The CPE approach did not provide for an analysis of equipment warranties, but did provide for an evaluation of equipment performance, at least as it related to current plant loadings. The CPE evaluations did not include an evaluation of process warranties or performance guarantees, nor did they assess blame for a claimed failure, address issues of negligence, provide specific recommendations to correct identified failures, or ascertain the facility's eligibility for 100% M/R grant funding. These latter activities must be resolved by the municipality, the State regulatory agency, and the U.S. EPA.

The limitations described did not preclude the value of the CPE in assessing facilities with claimed failures of their I/A technologies. The CPE provided a detailed prioritized list of the factors limiting the facilities performance. Performance in this context was the overall performance of the plant as it related to its design objective of meeting certain water quality standards, and not performance solely of the I/A technology. As shown in the case studies, the majority of factors identified were extraneous to the I/A technology, and many had significant impact on facility performance. The findings indicated whether M/R funding was clearly established or whether a comprehensive program to address multiple factors (CCP) was necessary prior to or during activities to ultimately achieve the desired consistent performance and/or capability. It was concluded that the CPE allowed insight into a typically complex situation and provided direction for follow-up action that could not have been accomplished with a less thorough effort. It was concluded that the clarity provided by the approach was the necessary first step to assessment of any 100% M/R request.

SUMMARY

The CPE procedure is a valuable tool for assessing claimed failures of I/A-funded technologies since it allows a comprehensive evaluation of system deficiencies. Utilization of the procedure at the five reported facilities often indicated deficiencies other than the innovative facility design. These findings had a direct effect on priorities for pursuing corrective actions. The CPE did not always result in a clear direction for the implementation of a 100% M/R grant, but the approach was very effective for evaluating the complex set of circumstances surrounding a claimed failure of an I/A technology. Because of these benefits, the CPE evaluation should be considered for inclusion as an integral part of the activities implemented to meet the regulatory requirements for assessing the need for a 100% M/R grant.

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16. ABSTRACT

Before U.S. EPA can pay 100 percent of the costs of modification or replacement (100% M/R) of any I/A process which failed to meet their design performance specifications, a determination must be made that the I/A portion caused the failure or has significantly increased expenditures at the facility and that the failure is not attributable to negligence. The U.S. EPA also developed the composite correcton program (CCP) approach which identifies the unique combination of factors preventing compliance at a particular POTW. As such, the CCP approach was felt to be well suited to meet certain requirements for the determination prior to the awarding a 100% M/R Grant.

Five POTW's that had claimed failure of installed innovative technologies were evaluated using the CCP approach. Multiple factors limiting performance were identified at each POTW. The factors often included deficiencies not related to the M/R grant request. These findings demonstrated that the CCP approach was a viable and necessary first step in implementing solutions for facilities requesting 100% M/R funding.

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