# Performance Limiting Factors

**Plant 1. Administration – Staff Certification and Training**

- **Administrators have not ensured that all personnel responsible for operating the plant have been properly certified and adequately trained.** The operators are responsible for producing safe drinking water that meets minimum regulatory requirements.

  However, the City Council is responsible for ensuring the WTP is properly staffed and that the operators have received the training needed to properly operate the facilities. The mCPE team identified two examples of where the Council has failed to ensure the plant is properly staffed.

- **In the recent past, improperly certified operators have had sole responsibility for operating the treatment plant.** As a result of the Council's failure to replace Mr. Bee in a timely manner, the plant was under the direct supervision of an unlicensed operator for several months. For example, in December 2005 and January 2006, Mr. Cee, who has a "C" Distribution certification, served as the plant operator. In addition, Mr. Dee, the City's operator-in-training, has been allowed to backwash the filters and mix alum in the day tank without the direct, on-site supervision of an operator who holds at least a Class C Surface Water license. Mr. Dee, as a new operator-in-training, has not completed the Basic Water Course, and is not certified at any level.

- **Plant staff have not been provided enough site-specific training to enable them to properly operate the plant facilities.** All licensed surface water operators complete at least forty hours of classroom training that covers basic water treatment concepts and procedures. In addition, licensed surface water operator have at least three years of experience at a surface water treatment plant. However, since treatment plants are not all identical, this experience does not necessarily assure that an individual is familiar with the operational requirements at a specific plant. The mCPE team identified several areas where additional site-specific training is needed. Some of the specific problems include:

  - The operators are unfamiliar with the operational requirements for the Infilco Accelator water treatment plant. The current operator needs to receive additional training on this type of slurry recirculation solids contact technology with very specific guidance for plant startup, plant shutdown, maintenance of the required solids concentration, recommended chemical feed rates at different phases of the startup and operations procedures, process monitoring and testing, and recommended process control parameters.

  - The alum admixture is made by hand, with no assurance that the mixture is prepared in a manner which will assure consistent coagulant concentration.

  - The operators do not know how to adjust the standard jar test procedure to fit the site specific characteristics of the WTP. The plant staff is not aware of how to prepare stock solutions of the coagulant or to adjust the test to model plant performance.

  - The plant staff does not understand the significance of the rate-of-flow indicators for the pressure filters and do not understand the significance of the backwash water flow rate with respect to adequate filter cleaning.

- The plant staff does not know how to adjust the data recording parameters of the SCADA system.

**Plant 2. Administration – Training**

- **The plant staff is not sufficiently familiar with regulatory requirements or the plant's written standard operating procedures.** Each of the operators at the WTP seems genuinely committed to producing safe drinking water. Furthermore, the plant staff seems to have a relatively complete understanding of the essential concepts needed to operate a surface water treatment plant. However, they are not as thoroughly versed with regulatory requirements, the content of the plant's Operations and Maintenance Manual, or the owner's manuals for some of the plant's analytical instruments. The major training needs noted during the mCPE included:
- **The plant staff is not well versed on the monitoring and reporting requirements contained in the SWMOR instruction manual, Regulatory Guidance (RG)-211.** RG-211, *Monthly Testing and Reporting at Surface Water Treatment Plants: Using the New Automated Forms*, contains extensive information and guidance on the routine and special monitoring and reporting requirements at surface water treatment plants. Because the operators are not intimately familiar with the contents of this essential and comprehensive Regulatory Guidance document, they have had some difficulty interpreting information that they have received from TCEQ staff and have been unable to assemble a coherent, representative, and complete compliance record of plant performance. For example, the plant staff have reported inappropriate daily production information, have failed to collect CFE turbidity data at the required frequency, have overestimated the level of pathogen inactivation levels, and have been reporting incomplete information on the disinfection residual entering the distribution system.
- **The operators are not conducting the mandatory Special Studies required when IFE turbidity levels exceed 1.0 NTU.** The operators are required to conduct additional monitoring and submit additional reports when turbidity readings from individual filters exceed 1.0 NTU for extended periods of time. Specifically:
    - Plant operators must complete a Filter Profile Report (FPR) each time the turbidity level at the outlet of an individual filter exceeds 1.0 NTU in two consecutive 15-minute readings. A FPR must be completed within 7 days of each event and must be submitted to the TCEQ with the WTP's SWMOR for that month.
    - If a filter produces water with an elevated turbidity level (above 1.0 NTU for two consecutive 15-minute readings) on three separate occasions during any consecutive three months, the operators must complete a Filter Assessment Report (FAR). This assessment must be completed within 14 days of the third event and submitted to the TCEQ with the SWMOR for that month.
    - The operators must complete and submit a Request for a Comprehensive Performance Evaluation when IFE turbidity levels exceed 2.0 NTU during two consecutive months. The failure to submit this form contributed to the TCEQ's delay in detecting the need to conduct an mCPE.

- **The operators' instrument calibration and instrument verification protocols differ from regulatory requirements.** The plant staff has implemented a rigorous instrument calibration regimen that far exceeds minimum regulatory requirements in most respects. For example, although TCEQ regulations only require a quarterly calibration interval, turbidimeters are being calibrated on a monthly or, in some cases, a weekly or a daily basis. On the other hand, some instrument verification requirements, such as using secondary standards each time a set of turbidity samples is analyzed, are not being implemented.

- **The plant staff is not familiar with the manufacturer's operations manual for the 1720E turbidimeters.** The plant staff is not taking full advantage of the extensive capabilities of the Hach 1720E turbidimeters. For example, the signal from the instrument to the data logger can be temporarily interrupted during instrument calibration. The instruments can also be reprogrammed so that the date and time on the instruments will match the current date and time being recorded by the data logging computer. During the mCPE, the team had to expend considerable time and effort to resolve the time discrepancy between the turbidimeters and data logger. If the plant staff ever had to repeat this evaluation, the process would be significantly simplified if the time stamps of the two data sets were essentially identical.

- **The plant staff does not routinely review the plant's comprehensive Operations Manual.** A few years ago, a consultant created a comprehensive Operations Manual for the WTP. The mCPE team did a cursory review of the document and concluded that it would be a very useful reference document for the plant staff. However, some of the information contained in the document differs slightly from the information contained in the frequently-used, but less-comprehensive, 3-ring binder maintained in the laboratory. The failure to periodically review and edit the Operations Manual not only deprives the operators of a valuable training tool, it can lead to significant discrepancies between the two important documents.

**Plant 3. Administration - Training**

- **The operator has not received adequate site-specific training.** All licensed surface water operators must complete forty hours of classroom training and have at least two years of experience at a surface water treatment plant. However, this classroom training only covers basic water treatment concepts and procedures and it is essential that operators receive site-specific, on-the-job training so that they can gain the skills, knowledge, and experience to operate their treatment plant under adverse operating conditions. As previously noted, the operator in charge of the plant does not have the site-specific training and experience to operate a surface water treatment plant under the circumstances observed at the mCPE.

- **The plant operator does not have adequate training on the operation of a slurry recirculation clarifier.** The Operator does not currently understand the process control tests that must be run to achieve optimum clarifier performance. As an example, he was not aware that the sludge collecting in the bottom of the clarifier must be wasted daily and did not know the proper procedure to waste sludge. Additionally, the Operator was not aware that the condition of the clarifier was adversely affecting the settled water quality.

- **The plant operator has not received adequate training on compliance monitoring and reporting.** The operator's lack of familiarity with the extremely complex regulatory requirements has resulted in a significant number of monitoring and reporting violations. For example, the Operator:

- Was unaware that the on-line instrument being used to monitor the turbidity level of the combined filter effluent, or CFE, does not meet minimum state and federal requirements;
- Has been reporting the highest daily individual filter effluent, or IFE, turbidity value that was recorded at six discrete 4-hour monitoring periods rather than the highest daily turbidity in the 96 discrete 15-minute monitoring periods, and o was unaware that he is required to complete a Filter Profile Report any time that a filter has a confirmed IFE turbidity reading above 1.0 NTU or is required to conduct a complete Filter Assessment if IFE levels exceeded 1.0 NTU on three or more occasions during any three consecutive months.

- **The plant operator has not received site-specific training on the proper use, maintenance, and calibration of some of the laboratory equipment.** As a result, laboratory instruments have not been properly calibrated and their performance has not been verified in accordance with state and federal requirements. For example:
  - The on-line CFE and IFE turbidimeters are not being calibrated with a primary standard at least once every 90 days;
  - The Operator is not validating the performance of the on-line instruments on a weekly basis using an approved method;
  - Although the benchtop turbidimeter is calibrated with primary standards when the CAL light flashes, the operator has not been maintaining a record of the calibration dates or results and has not been using secondary standards to verify instrument performance each time he runs a set of samples; and
  - The Operator is not properly calibrating the benchtop pH meter and is not verifying its accuracy prior to running each set of samples.
- **The plant operator has not been trained on some of the procedures described in the plant Monitoring Plan.** Although the plant had very few written standard operating procedure (SOPs), the mCPE team did find a SOP for backwashing the filters in the plant's Monitoring Plan. However, the operator was unaware that the SOP existed and had not received the training needed to implement this or other activities described in the Monitoring Plan. Furthermore, the mCPE team located a copy of the instrumentation manual for the pH meter near where the monitoring plan was stored. Again, the operator was unaware that this document existed and, as a result, had not been received proper training regarding the operation and maintenance of the pH meter.

**Plant 4. Administrative – Operator Training**

**The individuals responsible for monitoring and operating the plant have not been provided adequate site-specific training.** All licensed surface water operators complete at least forty hours of classroom training and have at least two years of experience at a surface water treatment plant. However, this classroom training only covers basic water treatment concepts and procedures and it is essential that operators continue to receive site-specific, on-the-job training. Historically, process control decisions at the WTP were made primarily by the Plant Superintendent or his assistant. The rest of the staff conducted the tests they were told to conduct but were never provided the training needed to interpret the results or make independent process control decisions. Since neither of these individuals remains employed by the City, the remaining staff members were unable to answer many of the questions about plant monitoring practices, data acquisition and reporting, equipment operation, plant piping layout, etc. In particular, the mCPE team determined that:

- **Operators have not been taught how to properly conduct essential process control tests or trained to interpret and apply the results of those tests.** The mCPE team noted that the plant staff lacked the training needed to properly control the treatment processes at the plant. Although the mCPE team identified many other examples, the inadequacy of the training was demonstrated by the following problems noted during the mCPE:
    - As noted in the Performance Assessment section, the operators are monitoring raw, settled, filtered, and finished water turbidity levels at appropriate sites in the treatment plant. However, until the arrival of the Interim Plant Superintendent, they were not told what constituted acceptable or unacceptable results. In addition, the operators were never shown how to conduct the tests needed to verify the on-going accuracy of the analytical instruments.
    - Although the operators began conducting jar tests a few days before the mCPE team arrived, they had not been fully trained in the jar test procedure. As a result, the staff misinterpreted guidance obtained from one of the classroom training manuals and were only feeding 48% of the coagulant recommended by the jar test. It is significant to note that the plant staff quickly understood and corrected the calculation error as soon as the mCPE team explained the problem.
    - The plant staff has been conducting all of the tests needed to evaluate the chloramination process used at the plant. However, the operators were not taught how to interpret the results of these tests so that they could avoid overfeeding or underfeeding chlorine and liquid ammonium sulfate.
- **Operators have not been taught proper filter operation and maintenance procedures.** Although the operators do understand the basic principles regarding the gravity filter operation and maintenance, they have not received the training needed to maximize filter performance or identify maintenance needs. For example:

- The procedure that the operators are using to “burp” the filters is producing severe turbidity spikes. Although the procedure does temporarily restore filter output, it does so at the expense of water quality. When the filter is “burped”, particles detach from the filter media. However, the loose particles are not flushed from the filter because the filter is not fully backwashed. As a result, the particles reenter the filter bed and, as the filter profile indicates, some of them pass through the filter and enter the filter effluent line. The operators have not been taught that the “burping” procedure increases the risk of waterborne disease if the particles were to include any pathogenic organisms.
- The operators have not removed the mudballs accumulating on the surface of the media bed. Because the formation of mudballs is progressive with the mudballs growing larger and heavier over time, failure to remove them from the surface of the media bed can result in the migration of the mudballs to lower strata and can result in filter clogging.
- The operators have not been taught how to optimize the backwash process to prevent media destratification and media loss or how to modify filter startup procedures to reduce the severity of post-backwash filter spikes.
- The operators have not been trained to conduct the special studies that are required when IFE turbidity levels exceed 1.0 NTU.

- **Operators have not been taught how to properly control the disinfection process.** As previously noted in the report, the operators are rigorously following the verbal monitoring instructions provided by the previous Water Plant Superintendent. However, they have not been provided the information they need to evaluate proposed plant modifications or to make appropriate changes to the treatment process. This lack of training affected the plant performance in the following ways.
  - The operators were unaware that the disinfection protocol implemented at the plant was inconsistent with the CT study approved by the state.
  - The operators were not aware of how to use their disinfectant monitoring test results to control the chloramination process. As a result, they were conducting some unnecessary tests and were unable to use the results of the appropriate tests to precisely adjust the chlorine and liquid ammonium sulfate feed rates so that chemicals are not wasted, taste and odor problems are minimized, and the potential for nitrification in the distribution system is reduced.
  - The operators did not realize that eliminating the ability to feed chlorine at the filtered water transfer well reduced their ability to reduce free ammonia levels in the water entering the distribution system.
- **Operators are not adequately trained on completing the Surface Water Monthly Operations Report (SWMOR).** Until the arrival of the Interim Plant Superintendent, the operators had not been taught what kind of data is needed to complete an SWMOR. Although a significant amount of progress has been made in this area during the two weeks immediately preceding the mCPE, the plant staff needs additional training to ensure that appropriate values are being reported to the TCEQ.

**Plant 1. Operations - Water Treatment Understanding**

**The plant operator's lack of understanding about key water treatment processes results in improper operational decisions.** The plant operator seems genuinely committed to producing safe drinking water. However, he is does not seem to be aware of many essential concepts related to water treatment plant operations and process control procedures and is not fully utilizing some of the information he already knows. For example:

- **Chemical feed rates are not adequately monitored to assure proper chemical dosages.** As noted previously, the chemical feed room is configured in such a way as to make monitoring the feed rate of many of the chemicals very difficult. As a result, the operator has a tendency to make chemical feed adjustments and then wait to see if the adjustment has the desired effect rather than performing calculations to estimate the desired chemical feed rate and the performing drawdown tests to see if the target feed rate is being achieved. Since the operator has so many duties that take him away from the plant, he is often not present to evaluate the effect of the adjustments he makes until the plant is shut off for the day.

  The mCPE team also noted that the operators is not performing essential tests to ensure that the hypochlorite and liquid ammonium sulfate (LAS) feed rates are balanced The chlorine-to-ammonia ratio must be balanced properly to avoid formation of unacceptable levels of disinfection by-products, taste and odor problems, and nitrification problems in the distribution system. A chlorine-to-ammonia ratio of 4:1 is most commonly used for water treatment to ensure formation of monochloramine (which is preferable for disinfection) and to avoid formation of dichloramine and nitrogen trichloride. To maintain the proper chlorine-to-ammonia ratio, process control test for free chlorine, monochloramine, total chlorine, and free ammonia must be run at critical control points in the treatment process. In addition, there were no written procedures for:

  - charting the individual chemical feed pump rates based on stroke, speed and chemical concentration;
  - setting target chemical dose rates based on raw water pH, coagulated water pH, water temperature, alkalinity, turbidity, and, free ammonia present in the raw water;
  - setting chemical feed rates; and
  - confirming that feed rate adjustments resulted in the desired change in performance.

- **Representative samples are not being collected for monitoring Disinfection Zones D2 and D3.** The operator is collecting samples for Disinfection Zone D2 from the filter influent instead of from an IFE sample tap located at the filter effluent. Due to normal biological activity in the filter bed, the chlorine residual decreases as water passes through the filter. Therefore the current sampling location produces results which overestimate the level of disinfection in the filters, i.e., Disinfection Zone D2. In addition, the operator has been collecting the sample for the disinfectant residual in Disinfection Zone D3 from a sample tap located on the side of the northern ground storage tank. Since there is no way to assure that this sample will produce results that represent the actual quality of the water leaving the tanks, the sampling location should be moved to a tap located at the SWTP's high service pump station.

- **The operator is not properly applying jar test results to chemical feed rates.** Jar tests are not being conducted in response to changing raw water conditions. Although jar tests are being conducted periodically, they are not being conducted each time the plant experiences a sudden change in raw water conditions. The operator was not converting units of measurements properly while doing jar tests, which caused a miscalculation of required alum dosage. Written procedures for preparing stock solutions, conducting jar tests, and adjusting and verifying coagulant feed rates are not being followed. As a result, jar tests are not conducted in a manner that will determine appropriate chemical feed rates.
  Well-written procedures will establish:
    - when a jar test should be conducted,
    - how the stock/dosing solutions for the jar test should be prepared,
    - how the mixing speeds and time intervals should be set for each stage of the jar test,
    - how the jar test results will be used to adjust chemical feed rates, and
    - how and when operators will verify that appropriate chemical feed rates have been achieved and maintained for the clarifiers.
- **The operator is unfamiliar with current regulatory requirements for surface water treatment plants.** The operator's lack of familiarity with these extremely complex requirements has resulted in some monitoring and reporting violations. For example, the operator was unaware that he is required to complete a Filter Profile Report any time that the Individual Filter Effluent, or IFE, turbidity level exceeds 1.0 NTU for two consecutive 15-minute readings when the filter is in operation. If the operator had completed a Filter Profile when the filter began malfunctioning, he would have recognized the adverse impact of frequent transfer pump cycles.

**Plant 2. Operations – Understanding and Application of Concepts**

**The operators do not fully understand or do not fully utilize critical process control procedures.** As noted in the discussion of Factor 2, the professional develop approach used by the previous Plant Superintendent did not provide the operators with enough site-specific process control training. In addition, the directive management style of the previous Superintendent significantly reduced the role of the operator in the day-to-day decision-making process at the WTP. As a result, the mCPE team noted the following problems which inevitably resulted from those historical practices.

- **The operators do not fully understand how to utilize the monitoring data being collected.** The lack of adequate training has resulted in an inadequate level of understanding. As a result:
    - The raw, settled, and finished water turbidity data is not collected at least once each shift.
    - Free Chlorine tests are run unnecessarily on chloraminated water.
    - The Total Chlorine, Mono Chlorine, and Free Available Ammonia results are not used to evaluate the chloramination process.
    - CT calculations are not used to evaluate the effectiveness of the disinfection process each time a data set is collected.
    - The results of the corrosivity evaluation are not used to adjust treatment processes.

- Hardness, Alkalinity, and other tests are run at sample sites that are not needed for process control.
- Unconfirmed IFE turbidity readings have been reported on the Surface Water Monthly Operating Report (SWMOR).
- The data being reported on the SWMOR, the data recorded by the SCADA system, and the data recorded on the daily log sheet differed significantly.

- **The operators do not respond to SCADA system alarms in a timely manner.** Prior to the mCPE, the plant staff did not investigate the alarms triggered by the elevated IFE and CFE turbidity readings nor did the Plant Superintendent identify and correct the situation that caused the alarms. The operators have become so desensitized to alarm situations that, during the mCPE, they failed to recognize a SCADA system alarm regarding the water level in the elevated storage tank until the plant received a customer complaint.
    - The operators do not conduct jar tests to evaluate chemical feed rates. (partially corrected)
    - The procedure used to convert jar test results to coagulant feed rates is improper. (corrected)
    - The operators do not routinely verify chemical feed rates. (corrected)

**Plant 3. Operations – Application of Concepts**

- **The plant operators do not fully apply their extensive knowledge of surface water treatment.** As noted previously, the operators seem genuinely committed to producing safe drinking water and seem to be well-aware of many essential concepts related to water treatment plant operations and process control procedures. However, there are some areas where the plant staff is not fully utilizing some of the knowledge and experience. For example:
- **Operators are not adjusting the pH and alkalinity levels in the raw water during the coagulation process.** The pH and alkalinity levels in both the raw water from Reservoir and the recycled water from the lagoons are relatively low. Each of the operators is aware that the coagulation process consumes alkalinity and further lowers pH. However, at the time of the mCPE, the plant staff was not applying this knowledge to make sure that an appropriate balance between coagulant dose and the pH and alkalinity levels was being maintained.

  The operators recently removed an in-line mechanical mixer in the filter gallery, installed a new in-line static mixer near the chemical feed room, and relocated the alum and soda ash feed points to the new static mixer. Although the appearance of the old mechanical mixer suggested that soda ash had been applied in the past, the chemical was not being used at the time of the mCPE. Given the low alkalinity levels and high coagulant doses reported during the mCPE, it is very likely that the new chemical feed strategy does not achieve complete coagulation.
- **The operators are not applying jar test results when adjusting chemical feed rates.** The operators routinely conduct daily jar tests on the raw water produced by the raw water pump station on the Reservoir. However, the jar test results are not routinely applied when adjusting chemical feed rates because neither the operators nor a variety of consultants have been able to emulate the jar test results in the full scale plant. It should be noted that much of the difficulty in emulating plant performance is the result of a failure to provide effective flocculation in the full scale plant.

- **Comprehensive testing is not conducted during periods when the plant is recycling the supernatant from the lagoons.** The plant staff is very aware that the quality of the supernatant water being recycled from the lagoons differs significantly from the quality of the raw water obtained from the Reservoir. They are also aware that these differences in the chemical matrix of the waters can have an impact on plant performance. Due to the large production capacity of the recycle pump, the operators tend to utilize only one of these sources at any given time and, as a result, the impact is magnified as the operators switch between the sources over the course of the day. Although the operators routinely run an extensive array of tests to evaluate the raw water characteristics in the water, they do not routinely run analogous tests on the recycled supernatant. As a result, the plant staff is unable to compare the jar test results on the two sources much less have all of the information they need to optimize treatment during recycling periods.

**Plant 4. Operations – Water Treatment Understanding**

- **The plant operator's lack of understanding about key water treatment processes results in improper operational decisions.** To consistently produce safe drinking water that meets minimum regulatory standards, surface water treatment plant operators must thoroughly understand the basic treatment processes, procedures, and regulatory requirements. The Operator seems genuinely committed to producing safe drinking water. However, as noted previously, he has not been adequately trained and, as a result, does not seem to be aware of many essential concepts related to water treatment plant operations and process control procedures. For example:

- **The plant operator does not understand the importance of some elements of proper backwash procedures.** When the Operator realized that the filters were not backwashing properly, he attempted to compensate by backwashing for much longer periods of time. However, he was unaware that increasing the backwash duration would not result in increased bed expansion and, therefore, would likely produce very little improvement in the effectiveness of the backwash process. Furthermore, he did not seem to fully understand that backwashing for one hour significantly reduced the effective capacity of the plant because it consumed almost as much treated water as the plant produced during a three-hour production run.

- **The operator is unaware of essential process control tests for slurry-recirculation clarifiers.** As noted previously, the Operator had not been taught how the proper techniques for monitoring the solids concentration or settling velocity of the slurry in the clarifier's mixing chamber.

- Additionally, he was unfamiliar with the sludge management procedures that should be used to determine when sludge should be wasted from the clarifier and what volume of solids should be wasted each time.

**Plant 1. Operations – Sampling and Testing**

**Operators are not conducting essential process control tests or using acceptable laboratory practices to assure the accuracy of results.** Laboratory results are only as valid as the sample collection and analysis procedures used by the operators. Poor sample collection and analytical techniques compromise the validity of the data and the operational decisions and compliance calculations that are based on that data. The mCPE team identified a number of areas where the operators were either not collecting appropriate samples or were using inappropriately calibrated instruments to run the tests. Specifically, the team noted that:

- **Laboratory equipment is not properly calibrated.** All laboratory/test equipment used to collect data used to confirm compliance with regulatory treatment requirements must meet the accuracy and precision specifications required by the EPA. Additionally, regulations require the equipment to be calibrated at specified intervals to ensure that the equipment is continuing to operate within these specifications. During the mCPE, the team observed:
    - The Hach 2100P benchtop turbidimeter, used to measure raw water turbidity, is not being properly calibrated. The most recent primary calibration of this turbidimeter was performed 130 days prior to the mCPE. The TCEQ requires that benchtop turbidimeters be calibrated with a primary standard at least once every 90 days and that instrument performance be verified using either a primary or secondary standard each time the operators run a set of samples.
    - The Hach 1720E online turbidimeters used to monitor the IFE turbidity are not being properly calibrated. The most recent primary calibration was performed 130 days prior to the mCPE. The TCEQ requires that on-line turbidimeters be calibrated with a primary standard at least once every 90 days and that instrument operators verify the continued accuracy of the instrument at least once each week using one of the methods approved by the TCEQ.
    - Although the 1720D was calibrated with a primary standard in accordance with regulatory requirements, instrument performance has not been verified on a weekly basis using one of the methods approved by the TCEQ.
    - The Hach 1 pH tester is calibrated daily with the 4.0 and 7.0 pH standards, but the range of pH normally found in the water tested is above 7.0. Calibrations for pH testers are required to be in the range of the sample tested to ensure collection of accurate pH data.
    - The SCADA system is set to limit the recorded maximum turbidities to 5.0 NTU for IFE readings and 1.0 NTU for CFE readings. Although the on-line monitors accurately measure turbidity levels above these respective limits, the SCADA system does not currently record those values. As noted in the Performance Assessment section, historical data suggests that IFE turbidity levels have exceeded 5.0 NTU limit imposed by the SCADA settings and that CFE readings have exceeded the 1.0 NTU setting. By setting the CFE recorder limit at 1.0 NTU, the programmer effectively prevented the operators from ever knowing if a treatment technique violation occurred and prevented the City from notifying its customers about potential public health threats.

- **The sample tap used to monitor the disinfectant residual of the treated water is located at an inappropriate site. Additionally, the filtered water sample line to the laboratory sink is installed at the wrong location.** The sample line for the Hach CL-17 disinfectant residual monitor draws water from the combined filter effluent header, while the WTP's CT study, of February 8, 2005, specifies that the final disinfection zone ends at the effluent line for the Hudson Tank. The sample line for the disinfectant residual monitor must be relocated to provide monitoring at the end of the final disinfection zone. Additionally, the sample line to the laboratory sink, which is used to collect grab samples for CFE turbidity analyses, draws water from a location in the header prior to the conjunction with the filtered water line from Filter 4. This sample line should be relocated so that it will draw water from the commingle water from all filters.

- **Jar tests are not performed with properly prepared stock solutions of coagulant.** Jar tests are conducted to simulate the coagulation, mixing, and clarification processes used at a plant. Since the test is conducted using several small jars, the operators must prepare a dilute alum solution in order to conduct the test properly. During the mCPE, the operators reported that they were performing jar using an undiluted sample of alum from the day tank. This procedure will prevent the jar test from ever mimicking the coagulation and clarification processes at the plant.

- **The operators are not properly monitoring clarifier performance.** The mCPE team is aware that clarifier operation can vary slightly from plant to plant and that proper operation requires a substantial amount of operator skill, artistry, and professional judgement. Nevertheless, the operators at the WTP are not performing some of the essential tests needed to effectively evaluate and control the clarification process. For example:

    - The operators are not monitoring settled water turbidity levels. Settled water turbidity levels are a critical operational parameter. Although the turbidity of the turbidity at the outlet of the clarifier should always remain below 5.0 NTU, the Infilco Accelator clarifier is capable of removing 80 to 90 percent of the turbidity in the influent raw water if it is properly operated. Turbidity ratios of the clarifier influent and effluent showing less removal are an indication that the operators need to adjust the coagulant dose or modify clarifier operating conditions.

    - Operators are not monitoring the solids concentration or settling velocity of the slurry in the clarifier's mixing chamber. These are critical operational parameters for all slurry-recirculation clarifiers and the analysis is conducted using a five-minute settling test. The Accelator owner's manual recommends that this test be conducted at least once each day to help operators determine how often they should waste clarifier sludge and how long the sludge valve should remain open each time they waste.

    - Operators are not properly monitoring the depth of the slurry blanket in the clarifier settling zone. The Accelator owner's manual indicates that the slurry/sludge blanket should not extend above the base of the mixing cone. If the slurry blanket becomes too deep, the water entering the settling zone can disrupt the blanket and cause floc particles to be lifted out of the clarifier, raising the settled water turbidity levels.

- **Operators are not performing essential tests to ensure that the hypochlorite and liquid ammonium sulfate (LAS) feed rates are balanced.** The chlorine-to-ammonia ratio must be balanced properly to avoid formation of unacceptable levels of disinfection by-products, taste and odor problems, and nitrification problems in the distribution system. A chlorine-to-ammonia ratio of 4:1 is most commonly used for water treatment to ensure formation of monochloramine (which is preferable for disinfection) and to avoid formation of dichloramine and nitrogen trichloride. To maintain the proper chlorine-to-ammonia ratio, plant operators need to run free chlorine, monochloramine, total chlorine, and free ammonia tests at critical control points in the treatment process.

**Plant 2. Operations – Process Monitoring**

**Inadequate process monitoring results in improper operational decisions and compliance reporting.** The team identified several SCADA system problems that existed during the 12 months preceding the mCPE. In addition, the team noted several deficiencies the laboratory practices and data recording procedures used by the plant staff. Some of these problems were addressed a few weeks before the mCPE and a couple more were corrected during the mCPE. However, several other problems remain and need to be addressed. Specifically:

- **The SCADA system has not been programmed to accurately record and display essential data.** As noted previously, the City's new contractor has already corrected the programming error that prevented the SCADA system from accurately recording IFE and CFE turbidity readings above 0.5 NTU. However, because the contractor is a computer programmer and not a water treatment plant operator, she does not realize that the system is not yet fully functional. The team identified several problems that need to be addressed before the operators can completely assess plant performance and comply with minimum reporting requirements. For example:
    - The SCADA system's Daily Summary printout did not contain the CFE turbidity values recorded at discrete 4-hour monitoring intervals or indicate the precise time that the data was recorded. Without this capability, the operators must scroll back through historical graphical record that displays on the IFE and CFE screen and manually retrieve the required data each day. While this is possible, it is an unnecessarily burdensome approach.
    - Unconfirmed IFE readings above 1.0 NTU and data collected during periods when the filter is not in service are not automatically excluded from the Daily Summary printout. As a result, the operators must scroll back through historical graphical record that displays on the IFE and CFE screen and manually verify that any 15-minute IFE reading above 1.0 NTU was confirmed by one or more consecutive readings. Again, this is possible but it is an extremely time-consuming approach.
    - Although one of the SCADA system screens displays the current flow rate and head loss through each filter, the system does not appear to maintain, or at least does not display, the historical data trends as it does with the IFE and CFE data. As a result, neither the operators nor the mCPE team could verify the finding that the filtered water flow rate was fluctuating on a harmonic cycle during Special Study No. 1. In addition, without this SCADA record, the operators must precisely record operating times so that they can manually exclude IFE data produced when the filter was off-line from the information submitted on their SWMORs.

- **The performance of benchtop instruments, on-line monitors, and recorders is not verified at the appropriate frequency.** The City does have a contractor calibrate the on-line turbidimeters and disinfectant residual on a quarterly basis as required by TCEQ regulations. In addition, the operators calibrate the benchtop turbidimeter in accordance with TCEQ rules once each day. However, there are other steps needed to ensure the accuracy of the reported data that the plant staff is not taking. Specifically:
    - The operators are not validating and documenting the performance of the on-line instruments and SCADA system on a weekly basis as required. Without these weekly validations, the operators are unable to demonstrate that the system continues to produce accurate data during the three-month period between calibrations. Had these validations been conducted, the plant staff would have realized that IFE and CFE data collected during the period when the SCADA system output was capped (at 0.5 NTU) were erroneous.
    - The operators are not using secondary standards (such as the Gelex standards described in the plant's operations and maintenance manual) to verify and document the continued accuracy of the benchtop turbidimeter each time a sample, or set of samples, are tested. In fact, the plant does not even have a set of secondary standards for the operators to use.
    - Although the staff is calibrating the pH meter once each day, they are not verifying and documenting the continued accuracy of meter each time a sample, or set of samples, are tested.
    - The operators are not using secondary standards to periodically verify the performance of the benchtop colorimeters used at the plant. In fact, the plant does not have a set of SpecCheck secondary standards for the operators to use.
- **The operators collect raw water turbidity, settled water turbidity, and other process data without recording test results on daily log sheets.** Consequently, the additional detail this information would add to the WTP's performance record is lost and operators' ability to refine their process control strategies is compromised. As noted in the Performance Assessment section of the report, the lack of more detailed data may have contributed to the poor correlation that the team observed between raw and settled water turbidity levels.

**Plant 1. Design – Filtration**

**The condition of the filters prevents effective treatment.** Surface water must go through a series of treatment processes before it can be considered safe to drink. Each treatment unit acts as an individual barrier and contributes to the overall effectiveness of the entire treatment plant. When one barrier fails, the quality of the final product is compromised and the risk of waterborne disease increases. During the mCPE, the team determined that the filters at the MSWTP had not been properly maintained and no longer met original design specifications. As a result, their ability to serve as an effective barrier to the passage of pathogen-size particles had been significantly compromised. The following mCPE findings indicate that the filter damage is sufficiently severe to necessitate major repair and complete media replacement.

- **The current condition of the filter media and the depth of the filter media are inadequate to ensure effective particle and pathogen removal.** During the special studies, the mCPE team was able to determine that the dual-media filter contained very little, if any, sand. Additionally, the anthracite layer contained an excessive number of mud balls and the filter grains in this layer were so heavily coated with algae and floc that they had formed a congealed mass rather than a layer of discrete grains.
- **The media support structure (the support gravel and underdrain system) has been damaged and allows the loss of media through the underdrain.** As noted in the Special Studies section of the report, the mCPE team measured a 12-inch variation in the surface elevation of the gravel support layer in the Filter No. 2. Additionally, sand was observed when the IFE turbidimeter sample line was flushed; indicating that sand was being lost through the filter bottom.
- **The media bed has cracks and craters which create channels for unfiltered water to flow while large portions of the media bed have little or no water flow.** Water flows more easily and, therefore receives less particle removal, in areas of the filter that contain less media. Therefore, the presence of large, deep cracks and craters in the media bed prevents the uniform flow and distribution of water during both the filtration cycle and the backwash cycle.
- **The backwash loading rate does not effectively expand and clean the media bed during a backwash.** The filter backwash procedure used by the Operator was ineffective. The team noted that the bed did not expand during the backwash cycle and the cracks and craters present before the backwash were all still present after the backwash cycle was completed. The calculated filter backwash rate did not meet minimum regulatory standards and was less than the reported capacity of the backwash pump. However, the team could not determine whether these problems resulted from the additional resistance imposed by the media cemented together by algae, floc, and mud, or were caused by some other valve or pump problem.

**Plant 2. Design – Disinfection**

**The disinfection protocol is inadequate to ensure effective inactivation of pathogens in Disinfection Zone 3 (D-3) and effective control of disinfection by-products.** A surface water treatment plant must be able to achieve specific inactivation requirements for enteric viruses and *Giardia lamblia* without exposing its customers to unacceptably high levels of disinfection byproducts.

In order to achieve this minimum standard of public health protection, the City must address the following deficiencies noted during the mCPE:

- **The location of the chlorine injection point for D-3 does not guarantee uniform dispersion of the disinfectant throughout the clearwell.** As noted in the Plant Description and Performance Potential Graph sections of the report, chlorine is currently being injected directly into the clearwell rather than into the CFE manifold that feeds the clearwell. When a chemical is applied directly into a large, unbaffled tank, mixing energy is reduced and the facility must rely (at least partially) on the less-efficient diffusion process to help disperse the chemical. Since unbaffled storage tanks exhibit a high degree of hydraulic short-circuiting, the TCEQ requires that chlorine and other disinfectants be applied upstream of unbaffled storage tanks to help ensure that the disinfectant is dispersed by hydraulic mixing prior to entering the tank and a uniform disinfectant residual is achieved throughout the vessel.
- **The failure to chloraminate has resulted in total trihalomethane (THM) levels above 100 micrograms per liter for two consecutive quarterly samples.** When chlorine reacts with naturally-occurring organic matter found in surface water, it forms a variety of disinfection byproducts such as THMs. However, THM formation can be significantly reduced when an ammonia-based material (such as liquid ammonium sulfate, or LAS) is added to the chlorinated water. A few months before the mCPE, the City stopped feeding LAS and THM levels increased significantly. The mCPE team was unable to determine if the decision to cease the LAS feed was conscious or unconscious, but the decision resulted in THM levels that were above 100 micrograms per liter in each of the last two quarterly samples. In order to avoid a regulatory violation, the average THM concentration in four consecutive quarterly samples must not exceed 80 micrograms per liter.

**Plant 1. Operations – O & M Manual**

**The Plant's Operations and Maintenance Manual is not utilized and several sections are outdated.** As noted previously, the City's consulting engineer located the WTP's copy of the *WTP Operations and Maintenance Manual* on a bookshelf in the control room. However, the operators were unaware of its existence and the document has not been routinely used by the plant staff and has not been reviewed, revised, and updated in the eight years since it was created. Although the *Manual* remains a very useful document and training tool, the mCPE team noted the following problems that need to be resolved to maximize its value.

• **The *Manual* does not reference or discuss objectives resulting from State and Federal rules promulgated since 2000.** A number of regulations that affect surface water treatment plants have been promulgated since the *Manual* was created. Since the document has not been updated, it does not address or reference other documents that address:

- The monitoring plan required by TCEQ regulations.
- The monitoring and reporting and treatment technique requirements imposed by Stage 1 of the Long-Term Enhanced Surface Water Treatment Rule
- The treatment technique requirements for Total Organic Carbon and the Maximum Contaminant Levels for Disinfection Byproduct imposed by Stage 1 of the Disinfection/Disinfection Byproduct Rule
- The security requirements imposed by state and federal rules and statutes.

• The ***Manual* does not provide any guidance on the design, operation, or maintenance of the WTP's SCADA system.** The SCADA system is a powerful tool that can help the operators monitor, evaluate, and control the treatment processes at the plant. However, since the system was installed after the *Manual* was written, the document does not provide any information on the SCADA system capabilities or it how it can be utilized to its full potential.

• **The *Manual* has not been updated to reflect current equipment and treatment processes.** The treatment plant has significantly modified its treatment process and chemical feed equipment since the *Operations and Maintenance Manual* was created. Specifically, the manual does not reflect that:

- Fluoride is no longer applied,
- Liquid caustic is no longer applied for pH and alkalinity control, monochloramine is being used as the primary disinfectant in lieu of free chlorine, the liquid chemical feed pumps have been replaced with entirely different models, the treatment plant uses StablCal instead of formazin to calibrate its turbidimeters, the plant uses colorimetric methods to measure disinfectant residual levels rather than the DPD-FAS titrimetric method, and accuracy of the plant's colorimeters must be verified using a method approved by the TCEQ.

- **The *Manual* does not establish acceptable ranges and action levels for critical control points in the treatment process.** As noted previously, the O&M manual does not address all of the testing that the plant staff must conduct. In addition, it does not provide any guidance regarding the performance goals, acceptable ranges, or unacceptable levels for the tests that it does address. For example:

- The *Manual* does not include the performance targets for IFE or CFE turbidity levels or provide any guidance regarding the special studies that have to be conducted if IFE turbidity levels exceed 1.0 NTU or if the plant violates the CFE treatment technique requirements.
- Although the document briefly mentions the settled water turbidity target of 2.0 NTU, it does not define the upper limit that would prompt the operators to evaluate alternative coagulant feed rates.
- The manual discusses a variety of techniques that can be used to evaluate the corrosivity of the water but does not describe the acceptable range for each method.

- **The WTP does not have "as built" plans that clearly reveal design features of some major treatment processes and equipment and the O&M Manual does not provide enough detail to facilitate operation without these plans.** The operators do not have a thorough knowledge of the plant piping layout, the locations of some valves and chemical injection points, or the specifications for some important facilities and equipment. For example:
  - There are no plans for the clearwell actually built. Consequently, the CT study submitted to and approved by the Commission credits the system with more contact time in the clearwell than it actually has.
  - The configuration of some of the plant piping has been changed without updating the plant layout drawings and all information concerning the current layout is anecdotal. Consequently, the operators are not sure about the sizes, locations, and valving for the existing piping.
  - There are no specifications for the solids recirculation pumps. This lack of information compounds the previously noted problems concerning metering of flow control for the solids recirculation stream.
  - A line reported to be from a French drain empties into the backwash water transfer well, but is not shown on plant drawings. The actual collection point should be confirmed to ensure that water entering the recycle stream does not contain biological or chemical contaminants.

**Plant 4. Operations - Operational and Maintenance Procedures**

- **The O & M manual is inadequate.** The operators do not have a complete monitoring plan for the plant, copies of the owner's manuals for the instruments and equipment, or a comprehensive Standard Operating Procedure (SOP) for the facility. As a result, the plant staff lacks much of the information needed to properly calibrate, operate, and maintain the laboratory instruments, chemical feed pumps, treatment units, and other plant facilities. Current plans, specifications, maps, and other pertinent information for the operation and maintenance of the system's facilities and equipment are also not available for the plant's personnel. The mCPE team noted that the following problems had contributed significantly to the poor plant performance and consequently to the mCPE:

- **The written procedures for collecting samples, conducting monitoring tests, and calibrating laboratory equipment are outdated, inaccurate, or nonexistent.** The operator does not have the owner's manuals for any of the on-line turbidimeters. The absence of these manuals, which contain information about appropriate sample tap locations, instrument location, calibration requirements, and other critical information, contributed significantly to the design and operational problems at the plant. Additionally, the procedures for collecting and reporting turbidity and disinfection data were incomplete and, as a result, the Operator has been reporting the highest daily individual filter effluent, or IFE, turbidity value that was recorded at six discrete 4-hour monitoring periods rather than the highest daily turbidity in the 96 discrete 15-minute turbidity monitoring periods mandated by state and federal regulations.

- **A complete procedure for performing jar tests and applying jar test results to adjust coagulant dosages does not exist**. There is no written procedure for performing a jar test that is specifically designed for this water treatment plant. The operator does not have any guidance for making stock solutions, selecting jar test dosages, or for setting jar test conditions so that the results of the jar test emulate how the plant is operated. There is also no guidance for applying the jar test results to operational settings for the plant and for chemical feed equipment.

- **The written procedures for starting and shutting down the plant, backwashing the filters, and blowing off clarifier sludge are outdated, inaccurate, or nonexistent.** Without a current, complete step-by-step SOP to specify the sequence in which switches must be activated, the order in which valves must be opened, and the specific items of equipment that must be checked to make sure that both the mechanical and monitoring equipment are operating properly the likelihood of producing safe water is not assured. In this regard, the operator was not aware that one of the raw water pumps was not working and the switch for one pump actually turned on a different one. A similar procedure for shutting down the plant would ensure that personnel are not injured, none of the equipment is accidentally damaged due to cessation of water flow, chemicals are not wasted, and performance data collected when the treatment plant is idle is not reported on the SWMOR.

  The elements of a good backwash procedure are time-critical and flow critical to ensure that the filter is properly cleaned. A backwash SOP is used to define how the operators are to implement the manufacturer's recommendations, regulatory requirements and operator experience to ensure satisfactory function and to increase the operational life of the filter. The procedure would include information advising the operator of maximum acceptable magnitudes and durations for post-backwash spikes, and include, in step-by-step sequence, all switches to be tripped; all valves to be closed; and all SCADA system and operations record notations that should be made to initiate, perform, and complete the backwash and return the filter to service. Because there is no backwash procedure, the operator has implemented an unsuccessful backwash process without being fully aware that the process was not working.
  Because there is no process control SOP for the clarifier, the operator was not aware of the process control tests which should be performed, did not understand the necessity of managing the solids concentration in the clarifier, did not realize the importance of the solids recirculation motor failure, and did understand the performance parameters which should be used to manage coagulant doses and solids recirculation. Consequently, the operator attempted to manage the clarification process based on visual observations that do not provide the operator enough information to ensure good clarifier performance. Additionally, the mCPE team observed that some of the inadequate clarifier process control procedures have contributed to the serious degradation of the filter performance.

**Plant 1. Maintenance - Preventive Maintenance**

- **The lack of an effective preventative maintenance program causes unnecessary equipment failure that adversely affects the reliability and effectiveness of the treatment processes.** Plant equipment and facilities must be properly maintained in order to prolong equipment life and maintain a consistent, acceptable level of plant performance. The mCPE team noted the following examples of areas where the failure to implement an effective preventive maintenance program contributed to premature facility failures.
- **Routine checks to ensure the function of critical plant equipment are inadequate to ensure continued satisfactory operation.** During the mCPE, the team observed raw water pumps, transfer pumps, flow control valves, and other appurtenances that were not functional, contributing to poor process control at several points in the treatment process. An adequate preventive maintenance program would prevent or resolve these equipment failures in a timely manner.
- **The clarifier is not routinely maintained.** The failure to routinely blow down the sludge from the clarifier has resulted in a high solids level in the clarifier. In addition to routine, daily solids removal, the plant staff has not drained the clarifier and removed the compacted sludge that the sludge rakes cannot remove. As a result, the solids in the bottom of the clarifier have become so dense that the sludge rakes no longer rotate and the rake shaft and motor may have been damaged.
- **The ground storage tank has not been periodically inspected and maintained.** The failure to inspect and maintain the ground storage tank resulted in a catastrophic failure of the tank floor. This coupled with the failure to install a properly designed roof vent resulted in the partial collapse of the ground storage tank. The failure to conduct periodic tank inspections might not have prevented the premature tank failure but it left the City unaware that the tank needed to be repaired or replaced.

**Plant 1. Maintenance – Corrective Maintenance**

**The lack of an effective corrective maintenance program prevents critical facilities and equipment from being placed back in service and adversely affects the reliability and effectiveness of the treatment process.** Equipment failures occasionally occur even at plants with effective preventive maintenance programs. The mCPE team noted the following examples of areas where the complete absence of an effective corrective maintenance program jeopardized the security of the plant facilities and adversely impacted plant performance.

- **A supply of critical spare parts and major pieces of equipment are not maintained.** Water treatment, process control, and process monitoring functions are essential for producing safe water. As previously discussed, several items of equipment at the MSWTP have failed and there were no repair parts and/or replacement equipment to restore critical treatment and process control functions. To ensure continuing production of safe water complying with regulatory requirements, a supply of critical repair parts and major pieces of equipment (certain valves, motors, chemical feed pumps, etc.) must be maintained to repair or replace failing or broken equipment in a timely manner.

- **The sludge rake drive motor has been inoperative for several months.** As noted previously, the failure to prevent excessive sludge accumulations in the clarifier has contributed to the failure of the sludge rake motor. No attempt has been made to evaluate the condition of the motor or to repair or replace the unit, even though it has been inoperative for over five months.
- **The slurry recirculation motor has been inoperative for several months.** The failure to repair the motor in a timely manner has resulted in poor settled water quality, wasted coagulant chemicals, and degraded performance of the downstream treatment components because there is insufficient mixing energy and insufficient particle interaction to form good-settling floc within the clarifier's flocculation zone.
- **The plant is not properly secured.** The mCPE team is aware that the City is in the process of installing two ground storage tanks at a site immediately adjacent to the existing plant. This modification required the removal of a section of the security fencing so that the influent and effluent lines between the plant and the tanks could be installed. However, this installation was not completed in a timely manner and the fence has been allowed to remain un-repaired for several months. Additionally, the lock to the laboratory and chemical feed building is broken, the chlorinators and transfer pump station are not kept locked, and the roof hatch to the clearwell is not secured. As a result, intruders have unfettered access to all of the plant equipment and electrical systems, gas chlorine cylinders, and the treated water storage facilities.
- **The filters require major refurbishment to restore them to design specifications.** At the time of the mCPE, the filters were in such poor condition that they did not function properly in any process mode (filtering to the clearwell, filtering to waste, and/or backwashing). At the time of the mCPE, the filter media was cemented together over more than half of the filter bed, and cracks and craters in the bed provided the direct paths for unfiltered water to pass to the clearwell. In their current condition, the filters cannot consistently achieve acceptable levels of pathogen removal.
- **There are multiple points where water is emerging from broken lines in the plant yard.** In addition to losing treated water, broken lines create cross-connections, create unsanitary and hazardous conditions, and decrease the operators' ability to control plant processes based on a confident knowledge of the flow from one treatment unit to the next. Leaking sample transfer lines can compromise the quality of the sample by the time it reaches the sample tap or the online monitor. Moreover, some of the leaks result in unauthorized discharges into New Lake Mart.
- **The failure to install a tank vent compounded the damage from the catastrophic leak event and resulted in the partial collapse of the tank.** Despite several notifications that the ground storage tank was not equipped with the vent required by TCEQ regulations, the City failed to correct the design deficiency. As a result, a partial vacuum was created within the tank when it developed a severe leak. Since the roof and walls of water storage tanks are not designed to withstand the inward pressures created under such conditions, the absence of a properly designed roof vent resulted in the severe structural damage that ultimately required tank replacement.

- **The sludge lagoons have not been properly maintained.** The sludge lagoons are so overgrown with reeds and weeds that it is impossible to determine their capacity, their freeboard, or the integrity of their walls. The constant flow of water over the side of the walls is sure to have eroded the banks of the lagoon at some locations, though the mCPE team could not confirm this by direct observation was unable to visually verify this fact due to the presence of excessive vegetation. However, the team did note that the water level in the recycle pump sump was well below the level at which the submersible pump was installed, suggesting that erosion or some other condition has produced a significant loss of sludge lagoon capacity.

**Plant 2. Maintenance**

**The plant does not have an effective maintenance program.** The lack of an effective maintenance program compromises the operator's ability to interpret data and prevents critical facilities and equipment from being returned to service and adversely affects the reliability and effectiveness of the treatment process. During the mCPE, the team noted several problems that indicate that the SWTP does not have an effective maintenance program. Specifically, the team noted that:

- **The operator did not verify that the maintenance performed on the turbidity chart recorders corrected erroneous readings being recorded by the instruments.** The City recently had a contractor come and reprogram the IFE and CFE circular chart recorders. However, the operator did not verify that the chart recorders and turbidimeters were reading within 0.1 NTU of each other before the contractor left the plant. During the mCPE, the team was able to determine that none of the three instrument pairs met the 0.1 NTU performance criteria. As a result, the operators remain unable to use the recorders effectively.

- **The City has not developed a plan to rehabilitate the West Sedimentation Basin so that it can be returned to an operational condition.** Although the City has two conventional flocculation/sedimentation units, one of those units cannot be returned to operation until it has been serviced. In addition, the operator has not developed a plan to periodically drain and remove the accumulated sludge from the East Sedimentation Basin. As Figure 12 suggests, a single sedimentation basin can effectively treat no more than 0.63 MGD, or 420 gpm unless both basin are in operation.

- **The maintenance program does not include procedures to confirm the operational status of critical equipment.** During the mCPE, a special study revealed that the LAS pump had stopped working. However, the operator does not verify chemical feed rates on a daily basis and he was, therefore, unaware that corrective maintenance was needed. Daily operations procedures should include steps to ensure that essential equipment continues to perform adequately, and ideally include procedures for cleaning, lubricating, and otherwise maintaining the equipment.

**Plant 3. Maintenance**

- **The plant does not have an effective maintenance program.** The lack of an effective maintenance program compromises the operator's ability to interpret data and adversely affects the reliability and effectiveness of the treatment process. During the mCPE, the team noted several problems that indicate that the SWTP does not have an effective maintenance program. Specifically, the team noted that:

- **There is no documentation indicating that the preventive maintenance program prescribed in the *O & M Manual* has ever been implemented.** For example, the City does not document any of the preventive maintenance performed on pumps, motors, or other equipment.

- **The lack of an effective corrective maintenance program prevents critical facilities and equipment from being placed back in service.** For example:
    - The SCADA system was not properly installed when purchased and was not fully functional.
    - The plant stopped using caustic when the feed pump broke down. This pump was not repaired or replaced, even though the water remained corrosive.
    - The WTP's backwash pump has been broken down for so long that the operators have become accustomed to using the backwash pump by-pass line. This line was installed as an emergency backwash water source. However, the by-pass line cannot be used effectively unless an adequate water level is maintained in the clearwell. Therefore, till the backwash pump is repaired, filters cannot be Backwashed effectively if the water level is low. If the WTP maintains an adequate water level for backwashing, it loses some of the effective capacity of its clearwell.
    - One of the impeller blades in the flash mixing separated from its shaft and got stuck in the transfer line to the East Clarifier. This blade is reported to cause diversion of more water to the West Clarifier when both are in operation while the plant's disinfection and other treatment protocols are based on an equal flow to each clarifier.

**Plant 4. Maintenance – Preventive Maintenance**

**The lack of an effective preventive maintenance program causes unnecessary equipment failure that adversely affects the reliability and effectiveness of the treatment process.** To assure that the plant is continuously capable of producing high quality water, plant staff must properly maintain essential equipment. While the staff reportedly lubricates the pumps on a routine basis, the mCPE team noted that several other preventive maintenance tasks were not being conducted. For example:

- The plant staff does not routinely exercise each valve. Exercising the valves helps to ensure that they open and close properly and extends their economic life.
- The flow meters for Filter 4 and for all backwash lines were not calibrated. Consequently, the operators cannot measure these flow rates or evaluate the condition of the associated pumps.
- Plant staff and City administrators are not properly maintaining the WTP sludge lagoons.
- The basins are overgrown with reeds and the operators reported that sludge accumulations have never been removed from the basins. The failure to properly maintain the lagoons has significantly reduced their effective volume. Loss of sludge basin capacity places additional demands on the operators to dispose of supernatant from the basins, and at present, increases the number of times the City is culpable for unlawful violations of the Texas Water Code.
- Further, if the operators were to use the filter to waste option after a backwash, the sludge lagoons would be certain to overflow, so filtering to waste is not practicable at this time.

**Plant 5. Operations – Operational and Maintenance Procedures**

**Operators are not familiar with critical procedures described in the operations manual for the clarifiers, and comprehensive standard operating procedures (SOPS) have not been developed to assure proper and consistent operational practices.** Equipment manuals, and engineering drawings, and similar materials serve as excellent instructional and reference materials for the operators. Additionally, local anomalies in the raw water, the physical plant, the mechanical equipment, the chemical treatment regime, the monitoring strategy, etc., require a meticulous implementation of site-specific knowledge to consistently produce safe water. This information must be documented in a simple, straightforward SOP so a licensed operator with minimal site-specific experience can perform the tasks with confidence. The system needs to write current SOPs for:

- There is no written startup or shutdown procedure for the WTP. A step-by-step SOP must be developed for starting up the plant. The procedure should specify the sequence in which switches must be activated and the specific items of equipment that must be checked to make sure that both the mechanical and monitoring equipment is operating properly and the likelihood of producing good water is assured. A similar procedure must be developed for shutting down the plant to ensure that none of the equipment is accidentally damaged due to cessation of water flow, chemicals are not wasted, and compliance data are not collected while the plant is not producing water.

- There is no written procedure for conducting process control for the clarifiers. A process control SOP must be developed using the manufacturer's instruction manual as a guideline and the SOP must specify that the process control tests should be performed for both clarifiers at least daily. However, as the operators implement the process control procedures outlined in the instruction manual and record the process control test results, they will develop a body of site-specific information pertaining to successful operation of the WTP. This information will provide insights about the results of specific tests, may indicate a shorter time between the time when tests should be run, and/or may indicate additional tests which might prove useful for process control. As the site-specific information is developed and confirmed over time, it should be incorporated into the SOP.

- There is no written procedure for preparing stock solutions, conducting jar tests, and adjusting and verifying coagulant feed rates. As a result, jar tests are not conducted in a manner that will determine appropriate chemical feed rates. Well-written procedures will establish:

    - When a jar test should be conducted,
    - How the stock/dosing solutions for the jar test should be prepared,
    - How the mixing speeds and time intervals should be set for each stage of the jar test,
    - How the jar test results will be used to adjust chemical feed rates, and
    - How and when operators will verify that appropriate chemical feed rates have been achieved and maintained for the clarifiers.

- Operators at the SWTP have not prepared standard operating procedures for calibrating and adjusting lab equipment, on-line monitors and recorders, and alarms and shutdown equipment. As a result, the staff is not maintaining adequate records to verify the accuracy of instruments and the plant operates while unattended. The lack of a written procedure for selecting and setting the SCADA system recording levels has also contributed to selection of an inappropriate range for recording IFE and CFE turbidity data.

SOPs must be developed for:

- Calibrating the online turbidimeters with primary standards at least every 90 days, and verifying the accuracy of each on-line meter at least weekly with primary or secondary standards or by comparison of identical samples with a calibrated benchtop turbidimeter;
- Calibrating the 2100P benchtop turbidimeter with primary standards at least every 90 days, and verifying the accuracy of the instrument with secondary standards each time one or more samples are tested;
- Calibrating the pH meter at least daily with standards bracketing the results of the samples tested;
- Calibrating the online disinfectant residual monitor with sample solutions of known chlorine concentration at least once every 90 days, and verifying the accuracy of the instrument at least once each month with a chlorine solution of known concentration or by comparing the results from the on-line analyzer with the results of approved benchtop amperometric, spectrophotometric, or titration method;
- Confirming of the accuracy of manual disinfectant residual analyzers at least once every 30 days using chlorine solutions of known concentration;
- Setting and adjusting the alarms and shutdowns based on IFE turbidity, CFE turbidity, and chlorine residual in the water leaving the Hudson tank; and
- Setting and adjusting the recording parameters on the SCADA system to provide an accurate history of the WTP's compliance status with turbidity and chlorine residual standards and to ensure that turbidity data are not collected for any filter or filters that are off-line.
- Each of these SOPs must include a procedure for documenting the results of each calibration and calibration check performed to show that it was conducted by an approved method using appropriate standards, the date and time the calibration or check was performed, and the operator performing the test.

- ***Chemical feed rate adjustment:*** There is no written procedure for preparing coagulant admixtures, balancing the hypochlorite and LAS feed rates, and verifying and adjusting chemical feed rates. As a result, historically, the coagulant feed rate adjustment has been based on a "more-is-better premise" which is seldom accurate, and the issue of balancing the chlorine-to-ammonia ratio has been ignored. SOPs must be written to establish procedures for:
    - Preparing the alum admixture to ensure consistent chemical dosages;
    - Charting the individual chemical feed pump rates based on stroke, speed and chemical concentration;
    - Setting target chemical dose rates based on raw water pH, coagulated water pH, water temperature, alkalinity, turbidity, and, free ammonia present in the raw water;
    - Setting chemical feed rates; and
    - Confirming that feed rate adjustments resulted in the desired change in performance.

- **Wasting of Sludge from the Concentrator and the Bottom Sump:** The SWTP does not have a sludge management SOP, and excessive wasting of solids occurred immediately prior to and during the mCPE. A sludge management SOP must be developed using the manufacturer's instruction manual as a guideline. The SOP should specify the observations and process control tests used to determine when and how much sludge should be wasted from the concentrators and the bottom sump. The SOP should also include guidance to help the operators to subsequently determine whether an adequate volume of sludge was wasted, too much sludge was wasted and what to do in both cases. As the operators' knowledge of the clarifier broadens, the SOP should be updated to incorporate useful site-specific information.
    - The SWTP backwash procedure is incomplete and does not correctly identify how the operator is to determine when a backwash procedure is complete and does not include information pertaining to acceptable/unacceptable backwash spikes in terms of turbidity level and spike duration. A thorough filter backwash SOP must be developed using the manufacturer's instruction manual as a guideline. The SOP must specify the observations, routine monitoring, and process control tests used to determine when a filter should be backwashed and when the backwash is complete. Additionally, the procedure must include, in step-by-step sequence, all switches to be tripped, all valves to be closed, and all SCADA system and operations record notations that should be made to initiate, perform, and complete the backwash and return the filter to service. The procedure must define acceptable and unacceptable backwash spikes in terms of turbidity levels and duration, and offer troubleshooting guidance for those instances when the filter does not appear to be adequately cleaned. The procedure should be modified and updated on a regular basis to incorporate developing operator knowledge and useful site-specific information.
    - The SWTP operators have not prepared an SOP for routine preventive maintenance, and the resulting deterioration of the plant equipment gives the operators fewer options in managing plant processes and hinders their ability to produce safe drinking water.
    - A thorough preventive maintenance SOP must be developed using the manufacturer's instruction manual as a guideline for the larger equipment, and component product literature as a guide for individual items of equipment. The SOP must identify specific daily, weekly, monthly, and annual preventive maintenance tasks which must be performed and specify the observations, routine monitoring, and process control tests that might trigger preventive maintenance on items not normally scheduled for maintenance. If applicable, the procedure should include items of safety equipment, tools, specific lubricants, and cleaning agents necessary to perform the task.

      Additionally, the procedure should include any necessary lockout tag-out procedures to prevent accidental injury to the employee performing the maintenance. If applicable, the procedure should also define acceptable and unacceptable performance parameters to assess the adequacy of the maintenance performed. The procedure should be reviewed and updated on a regular basis as the condition of the equipment changes or as new equipment is installed.

- The SWTP operators have not prepared an SOP for maintaining a record of operations, and the lack of site specific operations data prevents the operators from recognizing and planning for specific events that have previously resulted in equipment failures, operations problems, poor water quality, etc.
- A thorough SOP must be developed to identify specific daily, weekly, and monthly records and reports which will facilitate the assembly of site-specific information which the operators can use in evaluating equipment and operational problems. Records which must be maintained include but are not limited to mandatory reporting data, maintenance records, test equipment calibrations, tests performed and test results, chemical admixture preparation, chemical dose adjustments, maintenance performed, operator on- and off-site schedules, work performed by contractors, and any other process specified in one of the above mentioned procedures. The record keeping protocols should specify record formats that will provide senior operators with a tool for evaluating the task performance of junior operators and should specify formats for records that will provide administrators with a tool for evaluating the management and performance of the entire plant. The procedure should be modified and updated on a regular basis, as necessary, as the condition of the equipment changes or as new equipment is installed.

*These performance limiting factors are taken from actual mandatory Comprehensive Performance Evaluation (mCPE) Reports. Credit goes to Jack Schulze, P.E., Don Tharp, R.S., Noble Johnson, P.E., and Teresa Rogers for writing the reports.*