Maine Department of Environmental Protection
Guideline for Developing Wet Weather Management Plans and Operation Practices at Publicly Owned Wastewater Treatment Facilities

September, 2002

Document DEP – LW -0531

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Acknowledgments:

This guideline document was prepared by the staff of the Maine Department of Environmental Protection, Bureau of Land and Water Quality, Division of Engineering, Compliance and Technical Assistance. Much of the text and many of the illustrations contained in this guideline were excerpted in whole or in part from training materials developed by and for the New York State Department of Environmental Conservation Facility Operations Assistance Section. We wish to thank the New York DEC FOAS for allowing us to use their material.

Maine Department of Environmental Protection
Guideline for Developing Wet Weather Management Plans
and
Practices for Operation at POTWs during High Flow Events

INTRODUCTION

New Maine Pollutant Discharge Elimination System (MEPDES) permits being issued by the Maine Department of Environmental Protection (MeDEP) will require the managers of virtually all publicly owned treatment works (POTWs) to develop Wet Weather Management Plans. This document provides specific guidance to those managers about how to evaluate the operation of their wastewater treatment facilities and formulate such Wet Weather Management Plans. The implementation of these plans will allow communities to improve wastewater treatment during wet weather events and maintain compliance with the requirements of their MEPDES permits.

Virtually all MEPDES Permits written by the MeDEP will include language equivalent to the following:

> ***WET WEATHER FLOW MANAGEMENT PLAN***
>
> ***On or before ________, 200_****, the permittee shall submit to the Department for review and approval, a new Wet Weather Management Plan which conforms to Department guidelines for such plans. The revised plan shall include operating procedures for a range of intensities, address solids handling procedures (including septic waste and other high strength wastes if applicable) and provide written operating and maintenance procedures during the events.*
>
> [and for systems with combined sewer overflows (CSOs)]
>
> *The Department acknowledges that the existing collection system may deliver flows in excess of the monthly average design capacity of the treatment plant during periods of high infiltration and rainfall. The Department requires the permittee to maximize flows through the treatment plant (with appropriate process adjustments) during these high flow periods, rather than discharging untreated wastewater from any combined sewer overflow (CSO) points. The permittee shall continue to systematically mitigate and eliminate high inflow/infiltration sources and CSO points.*

This manual is divided into three principal sections that will present materials on:

- Characterization of wet weather flows in the sewer system and the treatment facility (Section 1)
- Recommended wet weather flow management techniques. (Section 2)
- Wet weather management plan development guidelines. (Section 3)

There are 6 appendices (Appendix A – Appendix F) that include exercises to demonstrate how to complete some of the steps needed to develop a wet weather management plan and templates useful for writing the actual plan. There is also a diskette with Microsoft Word 97 templates that can be used to write the final plan.

SECTION 1 – CONCEPTS FOR WET WEATHER MANAGEMENT AT WASTEWATER TREATMENT FACILITIES

1.1 CHARACTERIZING HIGH FLOWS

The terms “high flows” and “wet weather flows” are used throughout this document to mean unusually high flow that is caused by any event or combination of events. A warm, sunny day in April may produce “wet weather” flows due to snowmelt even though the “wet weather” occurred far in the past. Normally, high flows are defined as the flows exceeding the design capacity of the facility. However, operational experience may allow the operator to define a high flow threshold that is different than the design flow specified by the designer.

The first, most important step in developing a Wet Weather Management plan is to identify just what “high flow” means for each plant. This definition may vary depending on the type and duration of the event causing the high flows. Continuous high flows from spring snowmelt may have a much different effect on a treatment plant than a strong thunderstorm in August even though the flow through the plant over a period of time is the same.

Storm events and seasonal high water tables can significantly effect the amount and duration of flow and pollutant load received by wastewater treatment facilities. Plants serving combined sewer systems are almost always effected by storm events; but facilities in communities without combined sewer systems can also be plagued with problems at the onset of wet weather.

The adverse wet weather impacts at a treatment plant is determined by a complex combination of factors including:

- Age and condition of the sewer system
- Groundwater elevations in the vicinity of sewers
- Sources of inflow such as footing drains, roof leaders, and manhole covers
- Design of interconnections between the storm and sanitary sewer systems
- Storage capacity in the sewer system
- Operation of Combined Sewer Overflows (CSOs)
- Unlicensed discharge from Sanitary Sewer Overflows (SSOs)
- Capacity of each major unit process at the treatment plant
- Operational strategies employed to deal with wet weather

A wet weather management plan for any wastewater facility must consider these factors. The first step in writing the plan is to gather as much information as possible to provide the basis for wet weather decision making. The necessary information will come from a characterization of the collection system, flow to the treatment plant, performance of major plant processes under wet weather conditions, and wet weather impacts on effluent quality.

A. Characterizing the Collection System

A full understanding of the sewer system is essential when developing a wet weather management plan. Most communities in Maine that have identified combined sewer overflows have developed a good understanding of the sewer systems in their communities. If this work has not been done, the best place to start is to study maps and drawings of the sewer system showing routing, sizes and elevations of the sewer lines. Determine the location and design of control structures including regulators, CSO points, SSO points, and pumping stations. As stated above, SSOs are really a form of discharge incident that should be reported to us and mitigated, but should not occur at all.

Study the operation and control of existing pumping stations. Establish the age and condition of piping and manholes throughout the system. Find the major sources of inflow and infiltration including catch basins, roof leaders, sump pumps, footing drains, submerged manhole covers, and deteriorating pipes and manholes. If previous sewer system evaluation studies or infiltration/inflow studies have been conducted, these can be a valuable source of information. A comprehensive understanding of the collection system will provide the information necessary to identify options for improved wet weather operations.

B. Characterizing Flows and Pollutant Loadings to the Wastewater Treatment Plant

A review of historical plant influent flow data can provide important information for evaluating when the plant’s performance is affected by hydraulic overloads. Most plants normally record the total flow through the facility, daily average flow, and instantaneous minimum and maximum flow for each day. This information provides a good base from which to rate how hydraulic loading affects the performance of each of the plant’s treatment processes. The use of a computer spreadsheet, database software, or commercially available wastewater data management software will allow easy analysis of flow data and determination of trends, if applicable.

The following information will be sufficient to evaluate most plant processes:

- Daily average dry weather flow – the flow that passes through the plant during average day when there is little or no infiltration or inflow adding water to the collection system.
- Maximum 30-day average flow – the average daily flow during a period of 30 consecutive days when the plant receives the highest flows.
- Peak daily flow – the day(s) during the year when the maximum flow is received at the plant in a 24 hour period
- Peak hourly flow – the hour during the year when the plant received the highest flow measured over that hour.

The first three flow values above can be determined directly from information normally recorded on plant monthly report forms. A review of the flow charts recorded during the highest flow periods will allow the operator to establish the peak hourly flow. Average, maximum 30-day average, and peak day values of Biochemical Oxygen Demand (BOD_5) and total suspended solids (TSS) in the plant influent will also be required to assess some unit processes.

The peaking factors for the plant will be computed through an analysis of the flow data. Flow peaking factors are expressed as a multiplier of the daily average flow. If, for example, the average daily flow is 1.0 MGD and the maximum flow in a 30-day period is 1.3 MGD, then the maximum month to daily average peaking factor is 1.3. If the peak hourly flow through the plant is 4.0 MGD, the peaking factor for peak hourly flow as compared to daily average flow is 4.0. The peak hour to daily average peaking factor during dry weather flow will range form a factor of about 4 for plants under 1 MGD to about 3 for a 10 MGD plant. During storm events at plants with combined sewer systems, hourly flows can exceed 10 times the average flow, with additional flows being bypassed at combined sewer overflow (CSO) points.

Operators can develop a correlation between weather events and wastewater flows from records of weather conditions. This can help predict the impacts of upcoming storm events and make preparations for expected weather conditions. The volume of precipitation in a given day (inches of rainfall) is not the only factor which determines the volume of flow received at the plant. Groundwater elevations, stream elevations, ground saturation, and snow melt all contribute to variations in flow received at the plant. With experience, impacts of various combinations of weather conditions and storm events can be predicted and plans developed for the major categories of wet weather events.

C. Characterizing Effects of Wet Weather Flows on Major Unit Processes and Effluent Quality

It is important to understand the impacts of storm events on each major unit process in the plant before a wet weather management plan is developed. For example, a severe summer thunderstorm that dumps 1 inch of rain on the community in 30 minutes will have a much different impact on the treatment plant than the average springtime snow melt. It may be necessary to conduct additional sampling and testing beyond what is required for normal process control and monitoring. Examples of some of the additional data collection required to characterize process impacts are given below.

Flow Measurement – Check the accuracy of the flow measuring device(s) used in your plant. If certain flow levels trigger certain procedures in your wet weather management, it is important that your flow measuring device be accurate up to the maximum flow received at the plant.

Grit Removal – Monitor daily volumes of grit collected. The volume of grit collected can increase greatly with wet weather flows. The largest grit accumulations are likely to occur during a large storm event following an extended period of dry weather. Grit which has collected in the sewer system during low flow will be washed to the plant. Grit volumes can be estimated by determining the volume of the container normally used for grit collection, then estimating the percent full each day (or number of containers filled each day).

Screenings Removal – Monitor daily volumes of screenings collected. While not as highly variable as grit volumes, screenings volumes will also increase with high flows as accumulated screenings are washed out of the sewer system. Screenings volumes can also be estimated on a daily basis by determining the volume of the container normally used for screenings collection, then estimating the percent full each day (or number of containers filled each day).

Primary Clarification – Monitor primary influent and primary effluent BOD_5 and TSS. Many plants regularly monitor plant influent BOD_5 and TSS, but do not sample primary effluent for these parameters. Primary influent and effluent monitoring will determine the percent removal of BOD_5 and TSS under varying flow conditions and allow an assessment of the flow rate at which primary settling is adversely impacted. Primary sludge blanket depths, and volume of primary sludge pumped should also be recorded during high flow periods.

Aeration Tanks – Mixed liquor suspended solids concentrations (MLSS) should be monitored at multiple locations in the aeration tanks to determine the impact on activated sludge system solids inventory. Dissolved oxygen in the aeration tanks should be measured to confirm adequate aeration.

Secondary Clarification – Monitor final settling tank effluent BOD_5 and TSS. Sludge blanket levels in the final settling tanks and sludge volume index (SVI) of the secondary sludge should also be recorded. If ammonia and phosphorus removals are required, these parameters should also be monitored.

Disinfection System – *E. coli* or fecal coliform bacteria levels should be checked on the downstream side of the disinfection system. Chlorine concentrations and feed rates should be checked to ensure that adequate chlorine is available to provide proper disinfection at all flow levels.

The additional sampling and testing suggested above could become a significant time and financial burden on the plant staff and management. The suggested tests need not be performed on a continuous basis. The actual number of samples required will vary depending upon plant size, configuration and weather patterns, but sufficient sampling is required only to show performance variations under various flow conditions. If, for example, previous testing has documented primary clarifier effluent BOD_5 and TSS removals up to a flow rate of 2.5 mgd, it may not be necessary to conduct any more tests at flows of 2.5 mgd or less. Further testing would only be conducted when flows exceed 2.5 mgd in an effort to document the impact of higher flows on clarifier performance.

The type of sample required will also vary depending upon plant size and configuration. When sampling locations such as primary effluent and secondary clarifier effluent for BOD_5 and TSS removal, it is best to use the same sampling procedure that is used for the plant influent and effluent. If, for example, the plant influent sample is a 24-hour flow-weighted composite, it would be best to use a 24-hour flow-weighted composite, collected using an automatic sampler or created from grab samples by proportioning according to flow, for the primary effluent sample. At larger facilities, where more sampling equipment is available this may be practical. If, however, facilities and personnel are not available to perform the ideal sampling, simple grab samples taken during multiple storm events can give adequate information about the performance of the unit processes.

SECTION 2 - OPERATIONS GUIDELINES

2.1 COLLECTION SYSTEM RECOMMENDATIONS

State and federal guidelines for CSO controls require that:

- Properly operate and maintain the collection system
- Maximize storage in the collection system.
- Flow to the POTW is maximized
- Dry weather overflows are eliminated

These four guidelines require implementation of a plan for collection system operation and maintenance. The following sections discuss key elements of combined sewer system O&M

A. Maximizing Sewer System Storage

Trunk, interceptor and other main components of sanitary and combined sewer systems are generally filled to a small fraction of their total capacity during dry weather. During wet weather, this unused capacity begins to fill with stormwater flow. In some systems, combined sewer overflows may begin or treatment capacity at the POTW may be adversely impacted before some of the large capacity sewers in the system are flowing full. This unutilized volume within the sewer piping offers an opportunity to store additional flow, which can reduce volume of overflows and reduce peak flow rates reaching the POTW. Additional storage capacity may be available in manholes, pumping stations, and regulator structures. The system must be carefully assessed to determine the potential for utilizing additional storage.

A good sewer map showing pipe sizes and invert elevations is invaluable for system assessment. Use the following steps to evaluate potential for additional system storage.

- Study sewer map to identify large diameter sewers with potential for storage
- Inspect manholes and regulators during wet weather to determine whether identified pipes are flowing full
- Identify methods to control water levels in the identified pipes
- Confirm that increased water levels will not cause overflows at new locations or sewer system backups into residences or buildings

A simple method to take advantage of unused system storage capacity is to throttle the influent sluice gate at the POTW. Other methods include raising overflow elevations at regulator points, modifying pump station operations (***see Section 3.2***), or constructing removable dams at key locations in the system. When utilizing any of these methods, follow-up inspections during wet weather events are critical to avoid unwanted consequences. Through diligent inspections and recordkeeping, a plan can be developed outlining the steps to take (such as gate throttling or insertion of temporary weir boards) at various flow rates and under various wet weather scenarios.

B. Recommendations for Overflow Points

Sanitary Sewer overflows (SSOs) should not be a regular occurrence in any collection system. However, combined storm and sanitary sewers usually have one or more points in the collection system where combined sewage overflows during storm events. These CSO points employ many different methods of regulating overflows so that normal dry weather flow passes to the wastewater treatment plant and overflows only occur during wet weather. Regular inspections, proper maintenance and in some cases minor modifications to overflow regulators will minimize occurrences of unnecessary overflows. Figures 2.1, 2.2, and 2.3 show CSO regulators and potential minor modifications to increase system storage and decrease overflow volume. Strategies shown include installing flap gates to prevent backflow from receiving streams, raising overflow weir levels, installing extensions to raise overflow outlet pipe elevation, and installation of baffles to maximize capture of floatables.

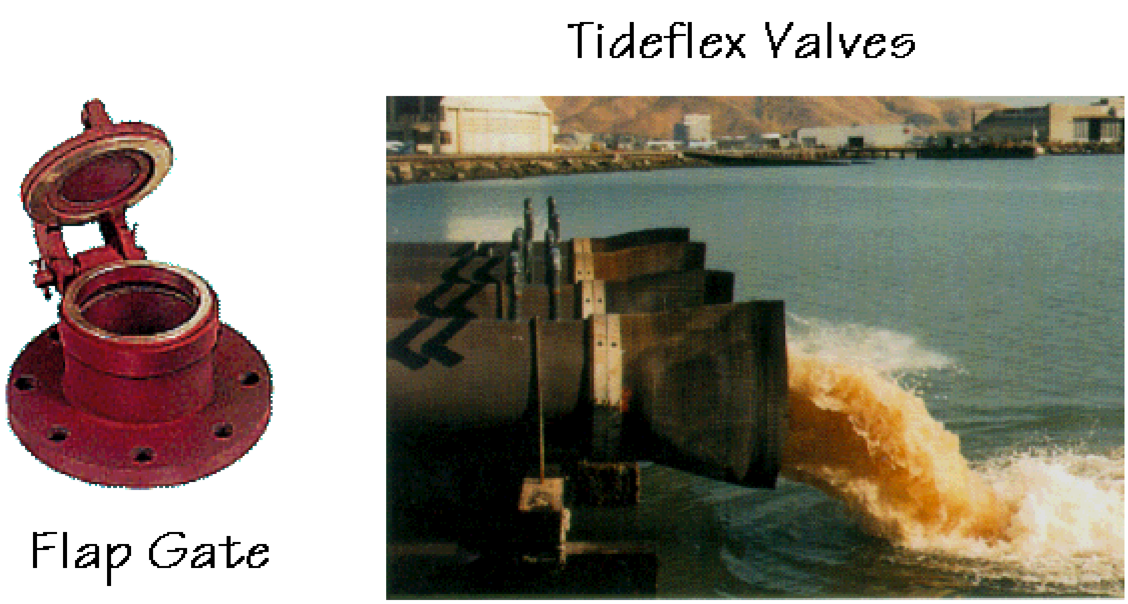


Figure 2.1 Backflow Prevention Devices

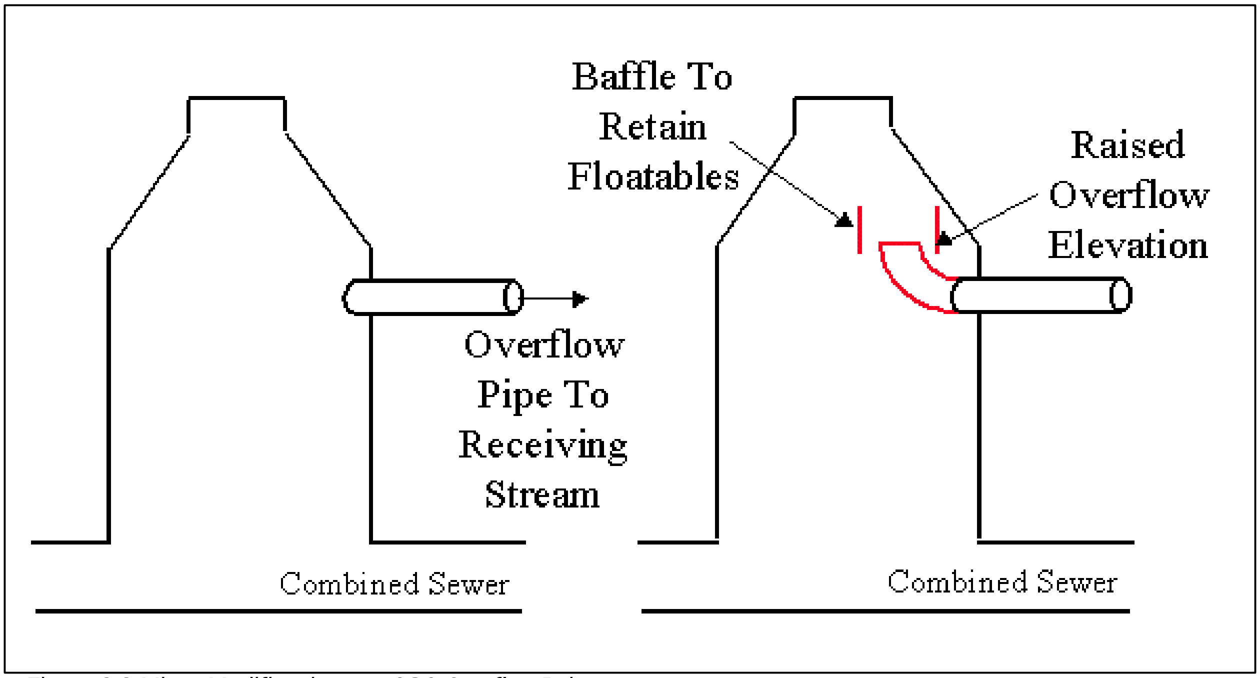


Figure 2.2 Minor Modifications to CSO Overflow Points

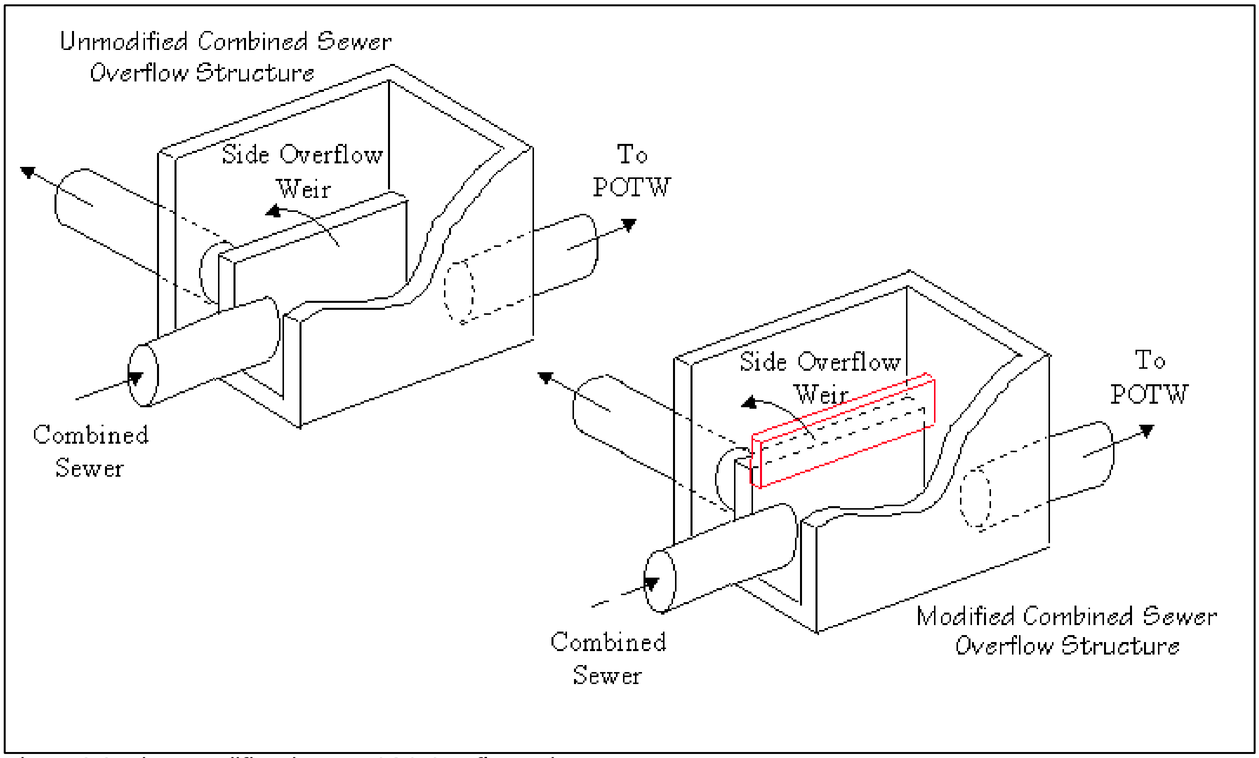


Figure 2.3 Minor Modifications to CSO Overflow Points

Grit and other debris can tend to collect in regulator chambers. This can result in improper operation of the regulator, unnecessary loss of solids to the receiving water, and decreased carrying capacity. Periodic cleaning can minimize these impacts. Determine the frequency of cleaning based on observations made during regular inspections. Flow from the receiving water may enter some overflow locations during times of high receiving water elevation. This can cause large increases in flow to the POTW and rob the system of valuable carrying and storage capacity. Consider adding flap gates or tide gates at the discharge end of the overflow pipe to avoid backflow.

C. Collection System Cleaning and Maintenance

A wet weather management plan should include requirements for collection system cleaning and maintenance. Good collection system operations and maintenance will have the following benefits:

- Maximize sewer flow capacity.
- Maximize sewer storage capacity.
- Avoid excessive buildup of grit and solids that decrease sewer capacity, decrease flow to the POTW and increase overflow volumes.
- Decrease the volume of grit and solids carried to the POTW in the first flush of a storm event.
- Identify minor problems in the system to repair before they become major problems.
- Identify correctable sources of inflow and infiltration.

The storage and transmission capacity of the sewer system depends on sewers that are clean and free from obstructions. Grease buildup, root intrusion, grit deposition, clogging by debris and damaged pipe all reduce capacity. A regular program of inspection, cleaning and repair can minimize all these problems.

TV inspection is an effective method of identifying damaged pipe and sources of infiltration. TV inspection is recommended for sewer systems that have not been inspected in the last 10 years or where pipe damage or significant infiltration is suspected. Prior to TV inspection, the sewer should be thoroughly cleaned, so that all interior portions of the system including pipe, joints and manholes are clearly visible. TV inspections should be recorded on videotape. The tape should include a narration identifying the pipe location and defects observed including cracking, faulty joints and sources of infiltration. By reviewing the videotapes, an assessment can be made of the condition of the sewer and the need for repairs. Required cleaning frequency can vary greatly depending upon the condition of pipes, flow velocities and quantity of grit, grease and debris entering the system. Based upon experience with each sewer system, a regular cleaning schedule should be developed. Special attention should be given to segments of the collection system that are utilized for storage or provide the flow path between CSO points and the POTW.

D. Infiltration/Inflow Reduction Measure

Infiltration of groundwater into a leaky sewer system and inflow through catch basins, storm drains, roof drains and sump pump connections to the sewer systems provide a major source of excess water to those systems. Separation of sanitary and storm sewer systems is an obvious approach to minimizing wet weather flows to POTWs, but for many communities complete separation of the sewer systems is not economically feasible. Significant benefits may be realized, however, by taking steps to reduce infiltration and inflow in portions of the collection system. Identification and removal of infiltration and inflow sources can eliminate some of the wet weather flow entering the system, freeing up capacity for combined sewer flows which cannot be eliminated, and reducing the volume of overflows during wet weather.

Methods of investigation that can be used in an infiltration/inflow study include:

- TV inspection of the sewer system
- Smoke testing
- House-to-house surveys
- Installation of temporary flow monitoring devices in the sewer system

Routine inspections of the system may also identify sources of I/I. Leaking pipe joints and manholes identified through TV or other means of inspection should be considered for replacement or rehabilitation. In areas where storm and sanitary sewers are not combined, property owners should be asked to disconnect sump pumps, roof drains and foundation drains from the sanitary sewer system. In areas where manhole covers become flooded and submerged, sealed manhole covers or cover inserts can eliminate large volumes of inflow. In storm sewers, flow-restricting devices can be installed in catch basins to slow the rate of entry of stormwater into the sewer system.

2.2 PUMPING STATION RECOMMENDATIONS

Operation and maintenance of pumping stations impact both storage and transmission in the collection system. Failure of a pumping station can result in combined sewer overflows, flooding of basements, and property damage. The discharge of untreated wastewater from pump station overflow structures is illegal unless specifically allowed in your MEPDES permit. Required maintenance at pump stations includes regular maintenance of pumps and accessories as well as periodic cleaning of wet wells to remove grit, scum and debris.

If possible, pump stations should be operated to minimize or prevent surges of influent at the treatment facility. Surges can quickly overload treatment units, cause the washout of solids in primary and secondary clarifiers, and cause flooding that can damage electric and electronic equipment and further hamper operations.

It is especially important that the alarm systems at pump stations be checked regularly and exercised periodically. Whenever possible, pump station alarms should signal a central alarm system whenever an alarm condition occurs. For remote pump stations, we recommend a telemetry signal that is "always on" or that is polled periodically. This helps ensure that a power failure at the pump station will be noted and the appropriate response made. If a remote pump station has only a visual and sound alarm, make sure that the residents near the pump station are aware that they should contact the on-call operator if an alarm sounds. Visual and sound alarms at remote pump stations should always have battery back-up and the batteries should be checked frequently to be sure that they are charged and can operate the alarm for the required time period.

MEPDES Permits also require that pump stations have a source of back-up power so that they may be operated properly during electrical system failures. Where emergency generators are permanently located at the pump station, generators should be exercised weekly and properly maintained. Automatic transfer switches for transferring power from emergency generators or backup utility power feeds should be tested and exercised periodically. Portable generators should be exercised under load *at a pump station.* To be sure that all equipment is ready for service when wet weather arrives, provide regular maintenance of all equipment in accordance with the manufacturer's recommendations.

Pump stations and their control systems can be utilized to provide additional sewer system storage during wet weather. If the inlet sewer to the pumping station is not normally submerged and has available storage capacity, pump controls can be adjusted to allow the wet well level to rise above the feed pipe elevation, resulting in storage in the collection system.

2.3 GENERAL PLANT OPERATIONS RECOMMENDATIONS

The general recommendations discussed in this section can apply to many different processes and plant configurations.

A. Use of Unused Equipment and Tankage

Placing unused equipment and tankage in service during wet weather events can provide several benefits including:

- Increasing hydraulic capacity
- Improving treatment capacity
- Preventing mechanical overloads of process equipment
- Providing temporary storage for biological solids to prevent washout
- Storing a storm's "first flush" for later treatment

Often, equipment is not needed during dry weather periods and this equipment cannot easily be placed in service on short notice when high flows arrive. Infrequently used gates may be difficult or impossible to operate. Equipment that is in need of repair may not be usable. Equipment should be maintained in ready condition at all times so that the plant can perform well when wet weather arrives by making full use of available processes.

In some cases tanks may not be used for their intended purpose. An empty tank from any process might be used to store biological solids temporarily or to retain a first flush of incoming wastewater if the necessary piping connections are available.

B. Controlled Bypassing of Process

Once a process has reached its maximum hydraulic capacity, sending additional flow to the unit could result in decreased performance, or even result in damage to facilities. Controlled bypassing of process components once their limits have been reached can improve performance during wet weather events and after the event is over. A bar screen channel may back up during a storm and overflow. Opening a bypass gate to prevent overflowing may prevent damage caused by the high flow and allow the bar screen to continue treating a portion of the flow. Clarifiers and aeration tanks will experience excessive solids loss at some limiting flow rate. If bypassing capabilities exist, a bypass should be considered only when there is a real threat to the integrity of the treatment facilities or process. As a general rule, unless a bypass is allowed in a MEPDES permit, it is a violation to bypass any pert of the treatment process. If bypass is the only way to "save" the treatment process, your inspector should be notified and the bypass eliminated as soon as possible.

The proper flow rates at which bypassing should be started can be determined by conducting the sampling and testing described in Section 1.1(C) and process assessments described in Section 3.

C. Minor Modifications to Increase Flexibility

In some cases minor plant modifications will enhance capability to handle wet weather flows. Gates that require excessive time and effort to exercise throughout the year and to open during a storm event, can be fitted with electric operators. Addition of electric operators on key valves can also make rapid mode changes practical. Tanks that are difficult to clean out after temporary storm use can be sloped with a new layer of grout on the floor, and provided with additional hose connections or a permanently installed flushing system. In some cases minor piping modifications or gate additions may allow activated sludge process mode changes, as discussed in Section 3. When developing a wet weather management plan, minor capital improvements that will benefit wet weather operations should be identified and incorporated in the plan recommendations.

D. Reducing Plant Recycle Flows During Wet Weather

Some plant recycle flows such as digester supernatant, belt press filtrate, filter backwash or gravity thickener overflow can contain high BOD and solids. These flows are generally returned to the head end of the plant or to secondary treatment. During high flows, when treatment capacity may be impaired, recycle flows may not receive sufficient treatment and may impact plant effluent quality. Operators should consider eliminating recycle flows by halting sludge dewatering or other solids handling processes during peak wet weather flows.

2.4 PRELIMINARY TREATMENT RECOMMENDATIONS

A. Screening

Bar screens are normally the first preliminary treatment units at the wastewater treatment plant. Screens may also be located at pumping stations and CSO points. Bar screens remove material that could clog or damage other downstream equipment in the plant. During wet weather, bar screens may be loaded to their hydraulic limits. Excessive screenings quantities can overload the screens causing various problems including:

- Overflowing screen feed channels
- Activation of upstream combined sewer overflows
- Passage of some screenings through the screens due to localized high velocity through the bars
- Activation of bypass channels around screening units
- Overflowing screenings containers

During average flow periods, observed quantities of screenings typically average about 1 cubic foot of screenings per million gallons of flow treated for screens with 2-inch openings, to 3 cubic feet per million gallons treated with 1-inch screens. These quantities can increase dramatically during the first flush of a wet weather event, when material that has collected in the sewers is suddenly washed to the screens. The following paragraphs describe recommendations to minimize the adverse impacts of high flows and large screenings loads during wet weather.

1. **Place All Units in Service.** The velocity of the wastewater approaching a bar screen should normally be in the range of 1 to 3 feet per second. The screen channel will remain cleaner (less grit will settle in the channel) if the velocity is in the range of 2 to 3 feet per second. At plants that have multiple bar screens, it may be necessary to take units in and out of service to maintain the desired approach velocity. For example all units could be placed in service during normal wet weather seasons and when storms are forecast during dry weather seasons.
2. **Set Controls for Continuous Operation During Wet Weather.** The most commonly used control scheme for mechanical bar screens is periodic operation using a programmable time clock. A level sensor in the channel will override the time clock and run the screen continuously when high flows and clogging of the bar screen raise the water elevation in the channel to a pre-set level. When wet weather is anticipated, the controls should be set for continuous operation. This will avoid waiting for a high level alarm condition to initiate continuous operation. It will help avoid washing screenings through the bars due to localized high velocity caused by a clogged screen.

3. **Periodically Clean Out Channels.** Even with proper operation and the proper number of units in service for velocity control, grit and other solids may settle in the bar screen channels. Periodic cleaning of the channel will maintain hydraulic capacity of the channel. It will also avoid sudden washing of the collected solids to the bar screen during wet weather flows, which could adversely impact operation of the screen.

4. **Prepare Screening Containers.** During wet weather, the volume of screenings collected can increase dramatically. Have screenings containers empty before wet weather events. If existing containers overflow during wet weather, increase emptying frequency and consider purchasing larger or additional containers.

B. Grinding and Comminution

Many smaller plants utilize grinders or comminutors in place of mechanical bar screens. As with bar screens, the high volume of large solids carried with the first flush of a storm event can overload a grinder or comminutor with solids. This can result in channel overflows and activation of upstream CSOs. Maximize treatment during wet weather by placing all units in service and periodically cleaning upstream channels. It is also important to keep cutting surfaces sharpened, and perform regular maintenance on the units so that they are available when needed.

C. Grit Removal

High flows in a combined sewer system can inundate a treatment plant with grit. Grit settles and builds up at locations throughout the collection system where velocity is low. When velocity increases during a storm event, collected grit is washed to the plant. The highest volumes of grit will be received at the plant when high flows occur after a long period without wet weather. This excess grit can cause many problems including:

- Overloading and shutting down grit removal facilities
- Excessive grit carrying through grit removal facilities to downstream processes
- Grit blocking channels and pipes at the treatment plant
- Overflowing grit receiving containers

Principal methods of grit removal include:

- Aerated grit chambers
- Detritus chambers
- Velocity controlled grit channels
- Vortex-type chambers
- Cyclone degritting of primary sludge

All of these grit removal processes can be impacted by high wet-weather-induced grit loadings. Quantities of grit received at wastewater treatment plants vary greatly from one community to another. Important factors which influence grit quantities include whether the sewer system is combined or sanitary (with combined sewers sand and grit from roadways will enter the system), whether soils are sandy and can be washed into the sewer system through open pipe joints, and whether garbage grinders are used in local households. Reported volumes of grit collected in aerated grit chambers range from 0.5 to 27 cubic feet of grit per million gallons of wastewater treated, with a typical value of 2. This wide range demonstrates the variability of grit volumes that can be encountered.

Several recommendations for handling wet weather grit loadings are presented below.

1. **Clean Sewers and Catch Basins Regularly.** A program for periodic sewer cleaning should be a part of the wet weather operations plan (See Section 2.1). Catch basins in combined sewer systems are designed to trap grit and stones in their bottom sump. After the sumps are full, additional grit entering the catch basin will wash down the sewer. Periodic sewer and catch basin cleaning can greatly reduce the volume of grit received at the plant during wet weather.

2. **Place All Units in Service.** Most of the grit removal methods mentioned above accomplish grit removal by controlling wastewater velocity. When too much flow enters a grit chamber, the velocity may be too high, causing grit to wash through the chamber. Placing additional units in service will allow the desired velocity to be maintained at a higher flow rate. Additional units will also place a lower grit loading on the grit collection devices which remove grit from the grit chamber. Velocity control and grit removal devices are discussed in greater detail in the following paragraphs.

3. **Control the Velocity.** The method of velocity control varies greatly between grit removal systems. In an aerated grit chamber, air from a coarse bubble diffuser creates a spiraling flow pattern with sufficient velocity to carry organics through the chamber while allowing grit to settle. As flow increases, horizontal velocity through the chamber increases, and it may be necessary to turn down the air volume to minimize grit wash-through. As flow continues to increase, air to the chamber can be turned off entirely. The proper level of airflow can be judged by observing the quantity of organics removed with the grit. If too many organics are removed, airflow can be increased.

   In mechanically controlled vortex type grit chambers (such as a Pista-Grit unit), paddle speed and paddle blade angle can be adjusted to control velocity in the chamber. In both mechanical and non-mechanical vortex units, velocity adjustments can be made through placement of baffles in the chamber. This approach should be discussed with the individual equipment manufacturer before making any baffle adjustments.

   Another type of grit removal common in older facilities is the velocity controlled grit channel. These are simply long rectangular channels with proportional weirs at the outlet end. These weirs are designed to maintain a velocity of approximately 1 ft/sec in the channel at all times. If the channel velocities are too high during wet weather, and if additional channel depth is available, it may be possible to redesign the proportional weir to produce lower velocity by increasing the depth of flow. Detritus-type grit chambers are also used in many older facilities. These grit chambers are shallow square or circular chambers designed to settle grit along with some organic material. The mixture is then sent to a grit washing device to remove the collected organics. Many detritus type units have a set of guide vanes that distribute flow across the inlet end of the chamber. At high flows, flow distribution across the inlet may be uneven. The guide vanes may be adjusted during high flow periods to provide a more even flow distribution.

4. **Remove Grit Continuously.** Whether a plant uses aerated grit chambers, detritus tanks, vortex chambers or various other grit removal processes, grit must be removed from the grit chambers, in some cases washed, and deposited in a container for transport. Some of the methods used to remove grit from the grit chamber include:
   - Chain and flight scrapers
   - Chain and bucket scrapers
   - Collector screws
   - Recessed impeller grit handling pumps
   - Air lift pumps

   These removal devices may discharge to a cyclone degritter or a screw-type classifier which then discharges to the grit collection container. Typical controls for grit removal devices operate the systems on a time clock. As an example, consider a velocity controlled grit channel with a grit screw at the bottom of the chamber which moves grit to a submerged hopper at the influent end of the chamber. A recessed impeller pump removes grit from the hopper through a pipe connecting the hopper to the pump. The pump discharges the collected grit through a cyclone degritter, which then discharges to a screw-type grit washer, which finally discharges to a grit container. This system could be set up to operate the grit chamber bottom screw, the grit pumps and the grit washing screw every four hours for a period of one-half hour. At normal flow this could be adequate to remove all grit received without allowing any excessive grit buildup in the channel. If, however, a sudden storm deposits a first flush of grit into the channel during a period when the grit removal system is off, numerous problems could result. The grit collector screw could be buried under a pile of grit that is too heavy to allow the motor to start the screw, causing it to shut down due to motor overload. The grit hopper could be filled with grit of sufficient depth that the pump suction line is plugged and cannot remove any grit. This scenario could be avoided by placing the entire grit removal system in continuous operation when wet weather is expected. Though there may still be grit loadings high enough that collectors in operation can be overloaded, they have a much greater chance of maintaining operation through the entire wet weather event if they are in operation and the chamber is empty of grit when the first flush arrives. This recommendation applies for all of the grit removal systems described above.

At some plants, grit is not removed before the primary clarifiers. Grit settles out in the primary clarifiers and is removed with the primary sludge. Primary sludge is then pumped to a cyclone degritter where the grit is removed. Usually the degritted primary sludge then flows to a gravity thickener for thickening. With this type of grit removal, continuous operation is also recommended during wet weather. In addition, the primary sludge blanket in the clarifier should be monitored closely and kept low in anticipation of wet weather. Cyclone degritting of primary sludge is most effective when the sludge concentration in the cyclone feed is 1 percent solids or less. If the primary sludge blanket gets too thick, grit removal efficiency at the cyclone will decrease.

5. **Prepare Grit Containers.** During wet weather, the volume of grit collected can increase dramatically. Prepare for wet weather events by having grit containers empty. If existing containers overflow during wet weather, increase emptying frequency and consider purchasing larger or additional containers.

2.5 FLOW SPLITTING RECOMMENDATIONS

An uneven split of the flow to multiple treatment units is a common problem at wastewater treatment plants. Equal distribution of flow to multiple process units allows full use of each unit. When one unit receives more flow than other similar units, process performance will suffer prematurely. At some plants, the split of flows is fairly even at low or normal flow rates. Slight variations in feed rate between two identical units may not be noticed, because performance is satisfactory at average flows. At high flows, however, the difference between flow rates received by adjacent units may become more noticeable. One clarifier may begin producing high effluent TSS before the other if it receives a higher flow.

The best solution to good flow splitting is good design of flow splitting devices. Equal flow splits between identical process units can be achieved through use of identical weirs arranged symmetrically around a center feed pipe in a distribution structure. For existing facilities with poor flow distribution, however, new distribution structures may not be feasible. An evaluation of existing flow distribution and installation of low cost structures to improve flow splitting can improve performance during wet weather periods.

It is first necessary to evaluate the performance of existing flow splitting devices. Visual observation of flows at tank inlet areas and over weirs can provide an indication of unequal flow distribution. Excessive turbulence in one tank, or excessive solids carryover from one tank can also indicate uneven flow splits. Laboratory analysis showing unequal solids distribution between tanks can also indicate uneven flow splits. If any of these observations suggest a flow distribution problem, further checking should be initiated to confirm the extent of the problem. Comparing depths of flow over weirs can show if flows are evenly distributed.

In splitter boxes with multiple weirs, depth of flow should be equal over all weirs. Weirs can be leveled and adjusted to identical elevations to improve distribution. The location and depth of the feed pipe can impact performance of a distribution box. Weirs of equal length and elevation may not create an even split if the feed pipe arrangement caused turbulence or currents that produce unequal liquid depths across the box. The negative effects of asymmetrical feed arrangements in splitter boxes can be moderated by strategic baffle installation.

Primary and secondary clarifiers use long v-notch weirs. In circular clarifiers the weirs are usually placed on the perimeter of a single or double-sided weir trough or launder on or near the tank perimeter walls. In rectangular tanks the v-notch weirs commonly line multiple lateral troughs or serpentine weir troughs near the effluent end of the tank. If these long weirs are not level throughout their entire length, excess flow will pass over the lower portions of the weir. Weirs should be checked and leveled as necessary. It is difficult to use depth over long v-notch weirs to make flow comparisons between multiple tanks. Very small depth variations can represent significant flow differences in these tanks. If depth of flow over clarifier effluent weirs is measurably different, a large difference in flow is indicated, and corrections to the flow split feeding the tanks should be investigated. If there is no measurable difference in depth over the effluent weirs, but unequal flow split is suspected, flow can be estimated through placement of temporary measurement weirs.

Temporary weirs constructed of plywood can be inserted in channels at locations such as those shown in Figures 2.4 and 2.5 below to estimate flow splits between tanks

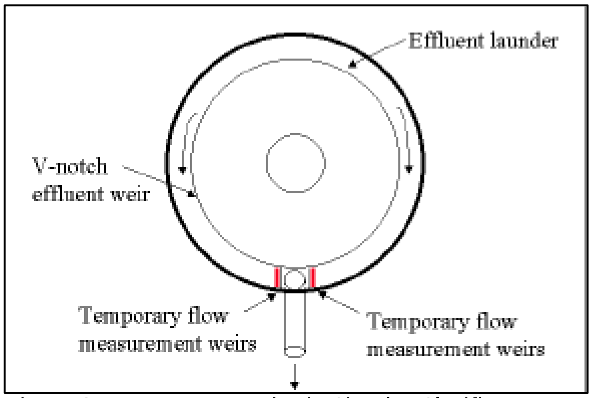


Figure 2.4 Temporary Weirs in Circular Clarifiers

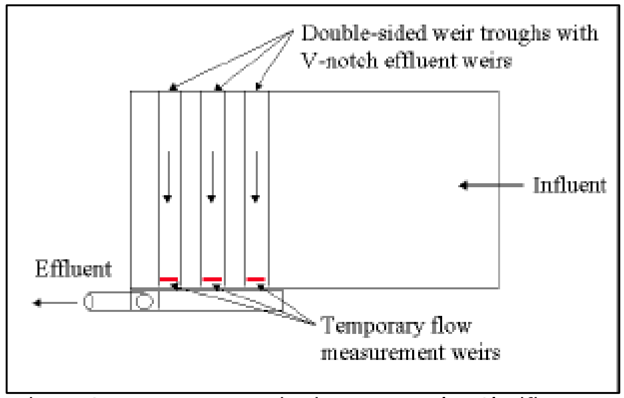


Figure 2.5 Temporary Weirs in Rectangular Clarifiers

If flow rates at the effluent ends of tanks indicate poor distribution, the flow splitting mechanism upstream of the tanks must be investigated. Flow through submerged pipe or port openings covered by gates can be throttled by adjusting the gates. Flow splits in asymmetrical open channels can be adjusted by inserting diverter baffles. These methods will not produce consistent flow splits at all plant flow rates. However, testing at various flow rates can produce a record of gate or baffle settings required for each flow rate.

2.6 PRIMARY TREATMENT RECOMMENDATIONS

Primary clarification separates settleable solids from the influent wastewater. Performance of primary clarifiers is highly dependent on the flow rate through the clarifier. The primary clarification process can be adversely impacted by wet weather flows in the following ways:

- High solids loading in the first flush, causing high sludge blanket levels
- Scouring of solids from the sludge blanket, resulting in excessive solids in the primary effluent
- Reduction in overall removal efficiency of BOD and TSS
- Excess grit and screenings loadings to primary clarifiers due to overloaded preliminary treatment processes
- Flooded scum removal and storage boxes

Standard criteria adopted by many states set the standards shown in Table 2-1 for primary clarifier design:

TABLE 2-1

PRIMARY CLARIFIER DESIGN STANDARDS	
Minimum side water depth	10 feet
Surface overflow rate at design average flow (not receiving waste activated sludge)	1,000 gpd/ft2
Surface overflow rate at design peak hourly flow (not receiving waste activated sludge)	1,500 to 3,000 gpd/ft2
Surface overflow rate, design peak hourly flow (receiving waste activated sludge)	1,200 gpd/ft2

When the overflow rates shown in Table 2-1 are exceeded, removal efficiency will decrease significantly. If sludge blanket depths are high, removals may suffer at even lower overflow rates. Several recommendations for improving primary clarifier performance during wet weather are presented below.

1. **Place All Primary Clarifiers in Service.** If all clarifiers are not needed under normal flow conditions, unused clarifiers can be placed in service during wet weather. The additional clarifier area will reduce the surface overflow rate, which will enhance removal efficiency. If operators are present at the time the first flush arrives at the plant, an empty tank can also be used to catch the excess solids received with the flush. The tank can then be placed in normal operation or isolated if the quantity of solids received would create a washout with continued flow. If the tanks is isolated and removed from service, solids should be removed from the tank as quickly as possible to allow it to be returned to service.

2. **Improve Flow Splitting to the Tank.** Unequal flow distribution to all primary clarifiers can result in some tanks performing well while others operate at reduced efficiency. See the flow splitting recommendations in Section 2.5 for suggested corrective action.

3. **Improve Tanks Hydraulics Through Baffle Addition.** Density currents can form and impact performance of primary clarifiers as well as secondary clarifiers. Though secondary clarifiers are generally the focus for dye testing and baffle additions, baffles can be added to primary clarifiers to improve performance. See the discussion in Sections 2.7 regarding dye testing and baffle installation.

4. **Improve Tanks Hydraulics Through Weir Modifications.** Recommended weir loading rates for primary clarifiers are in the range of 10,000 to 40,000 gallons/ft/day, with a typical weir loading rate of 20,000 gallons/ft/day. If weir loading rates exceed these recommended values, the velocity of currents approaching the weirs may be such that excessive solids are carried over the weir. Weirs can be lengthened by placing additional lateral weir troughs in rectangular primary clarifiers. Weir lengths are normally sufficient with one peripheral effluent weir in circular primary clarifiers. Problems have been observed with solids carryover on the outer weir of double-sided effluent weir troughs in circular primary clarifiers. This often occurs when the v-notch spacing on the outer weir is the same as the v-notch spacing on the inner weir. The approach velocity can be decreased on the outer weir by blocking off alternating v-notches with plywood or other material. Alternately, the outer weir can be blocked off entirely as shown in Figure 2.6.

5. **Discontinue Secondary Sludge Feed to Primary Clarifiers.** The recommended design overflow rates given above indicate that the hydraulic capacity of a primary clarifier is greatly reduced if secondary sludge is fed to the primaries for resettling along with the primary sludge. During periods of high flow caused by wet weather, primary clarifier capacity can be enhanced if secondary sludge is not sent to the primaries. Depending upon the duration of the wet weather event, an alternate method of handling secondary sludge may be required. In fact if the solids inventory in the secondary treatment system is at its maximum, it may be preferable to discontinue sending secondary sludge to the primary clarifiers. If the high flows are of short duration and secondary sludge can be kept within the system by means discussed in Sections 2.8 and 2.9, then temporarily discontinuing secondary sludge wasting should be considered. If high flows continue for extended periods other methods of handling secondary sludge should be considered. If any other empty tanks are available, secondary sludge could be stored temporarily in the spare tank. In some cases, secondary sludge can be sent directly to sludge handling processes without co-settling in the primary clarifiers.

6. **Implement Chemically Enhanced Primary Treatment.** Several plants have shown successful results with chemically enhanced primary settling. Through addition of various chemical coagulants, TSS removals in primary clarifiers have been shown to improve from the normal range of 50 to 70 percent up to 80 to 90 percent removals. BOD removal efficiency has been shown to improve from the normal range of 25 to 40 percent up to 50 to 80 percent. Possible coagulants include ferric chloride, ferric sulfate, alum, polyaluminum chloride, and cationic or anionic polymers. Several plants have had success with a combination of ferric chloride and anionic polymer. At the Point Loma WWTP plant in San Diego, BOD and TSS removals of 60 percent and 85 percent, respectively have been achieved at twice the normal design overflow rates, using a combination of ferric chloride and anionic polymer. Required doses should be determined through jar testing, and full scale trials should be conducted to verify performance. Addition of microsand and polymers to primary clarifiers has been shown to be effective in increasing hydraulic capacity while maintaining excellent solids removal performance.

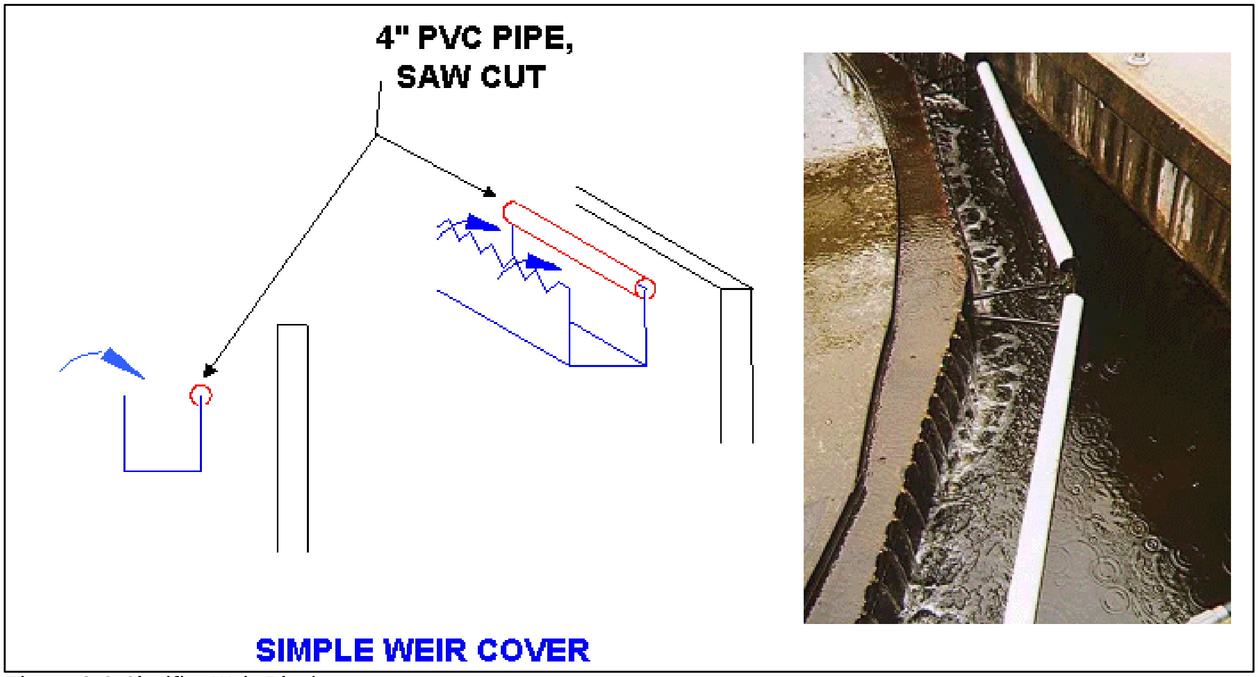


Figure 2.6 Clarifier Weir Block

2.7 DYE TESTING AND BAFFLE INSTALLATION FOR IMPROVED CLARIFIER PERFORMANCE

Numerous studies have demonstrated that density currents in clarifiers can cause marginal or poor clarifier performance. These currents, traveling at higher velocity than the surrounding fluid, can carry solids through the tanks and over the effluent weirs. In center-feed circular clarifiers, density currents tend to travel outward across the top of the sludge blanket, up the outside wall of the tank, and over the effluent weir. In rectangular settling tanks, currents have been shown to travel at various elevations in the tank, producing the same tendency to carry excessive solids in the regions of higher velocity. Dye tests can be used to confirm the presence of density currents. If such currents exist, baffles can be installed to reduce the effects of these currents.

Two dye tests, a slug test and a continuous feed test, are normally performed to assess the need for baffle addition in clarifiers. The slug test is performed by dumping a slug of dye at a point upstream of the clarifier where the dye will be well mixed with the clarifier influent. Samples are taken periodically at the clarifier effluent weir and measured for dye concentration. The time at which the peak dye concentration reaches the clarifier effluent weir is an indication of the travel time through the clarifier. The actual hydraulic detention time in the clarifier is calculated as the area under the curve when effluent dye concentration is plotted versus time.

The continuous feed test is performed by feeding a continuous stream of dye at a constant rate to the influent end of the clarifier at a well-mixed location. Core samples of the clarifier contents are collected and tested periodically for dye concentration. The test results reveal a dye profile that shows the location of density currents in the clarifier. Baffles may be located to interrupt and disperse the density currents based on the observed current locations. Plots of dye concentration after 10 minutes and 35 minutes of continuous dye injection into a typical circular clarifier are shown in Figures 2.7 and 2.8

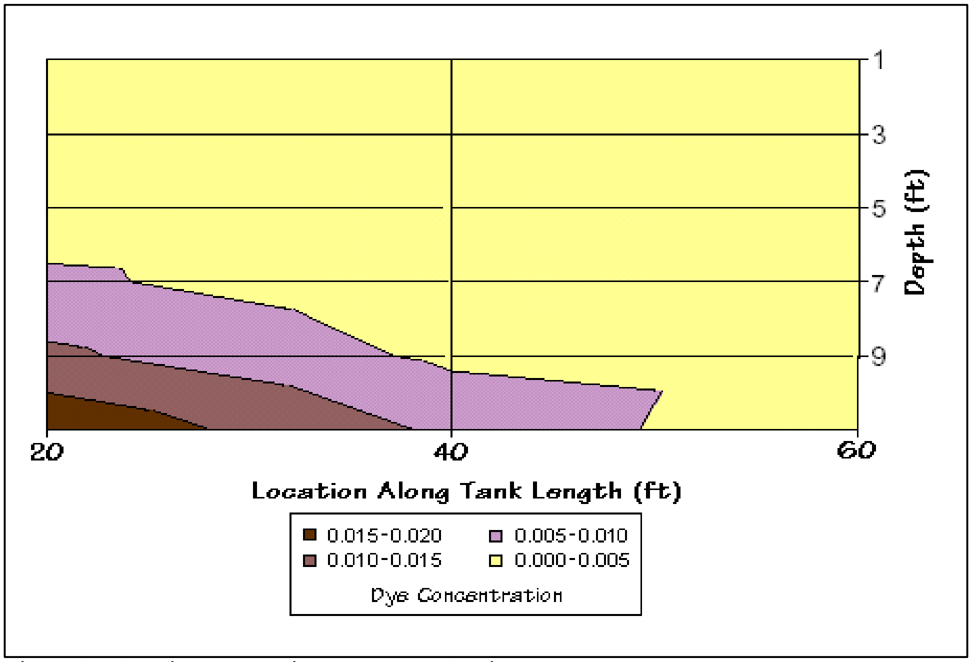


Figure 2.7 Continuous Feed Dye Test at 10 minutes

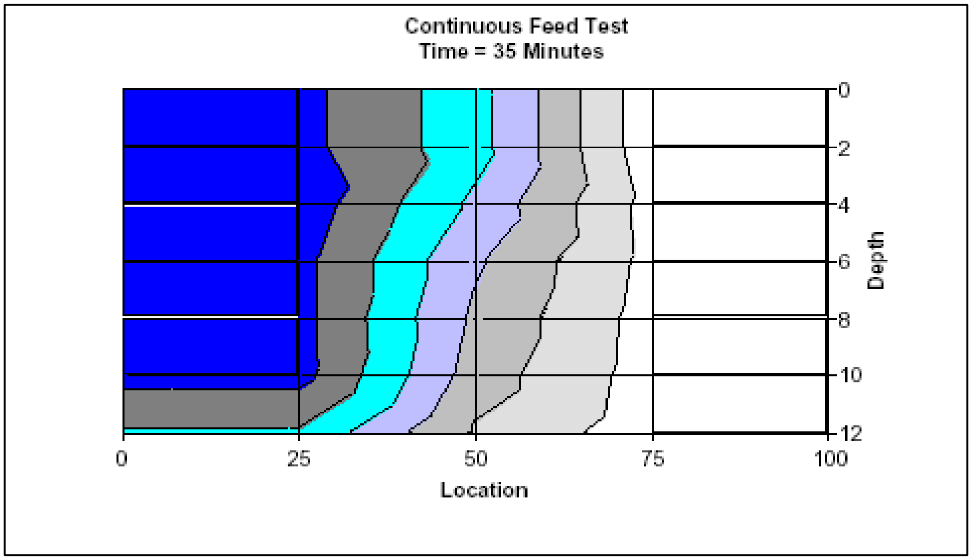


Figure 2.8 Continuous Feed Dye Test at 35 minutes

Peripheral density current baffles, referred to as "Crosby" or "Stamford" baffles, have become standard additions to circular clarifiers. They are typically placed at a 45 to 60 degree angle on the clarifier wall as shown in Figure 2.9. The purpose of these baffles is to deflect solids carrying currents back toward the tank interior, away from the effluent weir. The benefits of this type of baffle have been sufficiently demonstrated that in most cases dye testing is not necessary to determine recommended baffle replacement.

Baffles can also be very beneficial to performance in rectangular clarifiers. Mid-tank baffles will help disperse density currents at various locations as determined through dye testing. Multiple baffles have been found to be more effective than a single baffle. Further discussion of baffle placement, materials and construction can be found in Section 2.9.

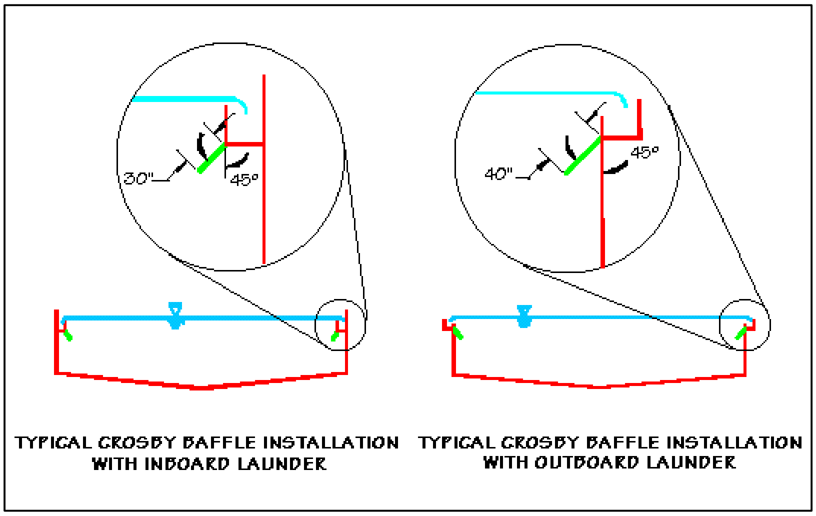


Figure 2.9 Density Current Baffles for Circular Clarifiers

2.8 BIOLOGICAL SECONDARY TREATMENT RECOMMENDATIONS

A. Activated Sludge. Successful treatment with the activated sludge process depends on maintaining a healthy population of organisms in suspension in the aeration tanks. Because it is a suspended growth process, the organisms are very susceptible to washing out of the aeration tanks when high flows occur. As flow to the aeration tanks increases, the rate at which solids are transferred to the secondary clarifiers also increases. Solids are settled out in the secondary clarifiers and returned to the aeration tanks by the return sludge pumps. As long as the hydraulic and solids handling capacities of the secondary clarifiers are not exceeded, the essential organisms can be returned to the aeration tanks and the process can continue to function. When clarifier capacities are exceeded, however, biological solids loss may be difficult to control and process performance may be jeopardized -- not only during the wet weather event, but also for the days or weeks that it may take to recover the lost biomass. Potential impacts of wet weather events on the activated sludge process include:

- Loss of biomass from the aeration tanks and secondary clarifiers
- Overloading of the aeration system resulting from high BOD loadings caused by solids washout from the sewer system and solids washout from the primary clarifiers
- Electrical overload of mechanical surface aerators caused by high water levels
- Decreased BOD removal efficiency due to shortened hydraulic retention time in the aeration tanks

The following recommendations for the activated sludge process are focused on preventing loss of biological solid from the system during wet weather events.

1. **Modify Mode of Operation.** The activated sludge process can be operated in various modes. Three basic modes that will be discussed here are conventional, step feed and contact stabilization. These are illustrated in Figure 2.8. The conventional plug flow mode mixes the full flow of primary effluent with the return activated sludge flow at the head end of the aeration tanks. Step feed mode feeds primary effluent into the aeration tank at multiple points along the length of the tank. Contact stabilization mode mixes primary effluent with return sludge in the last one-half to one-third of the aeration tank volume. One of the most significant problems plaguing activated sludge operations during wet weather events is washout of biomass from the system. This will occur when the solids loading to the secondary clarifier exceeds the clarifier's solids handling capacity.

   We can compare three activated sludge systems: one operated in conventional mode, one in step feed mode, and one in contact stabilization mode. For our comparison each of the three systems has the same total aeration tank volume, the same primary effluent flow rate, and the same total mass of biological solids in the aeration tanks. In this example the conventional activated sludge system would have the highest MLSS concentration leaving the aeration tank, the step feed system would have the second highest concentration leaving the aeration tanks, and the contact stabilization system would have the lowest MLSS concentration leaving the aeration tanks. Since the flow rates are the same for all three systems, the solids loading rates to the secondary clarifiers are significantly lower for the step feed and contact stabilization systems than for the conventional system. This means that the step feed and contact stabilization modes have the potential to handle higher hydraulic loadings than the conventional mode, without suffering a significant solids loss. Although there may be a lower BOD removal efficiency in the step and contact modes than in conventional mode, during extreme wet weather at many plants we are most concerned about keeping solids in the system. The alternatives may be running in contact stabilization mode at lower BOD removal efficiency or losing all of our solids in conventional mode.

For plants that are designed with the flexibility to operate in these various modes, mode changes should be considered if solids loss during high flow periods is a problem.

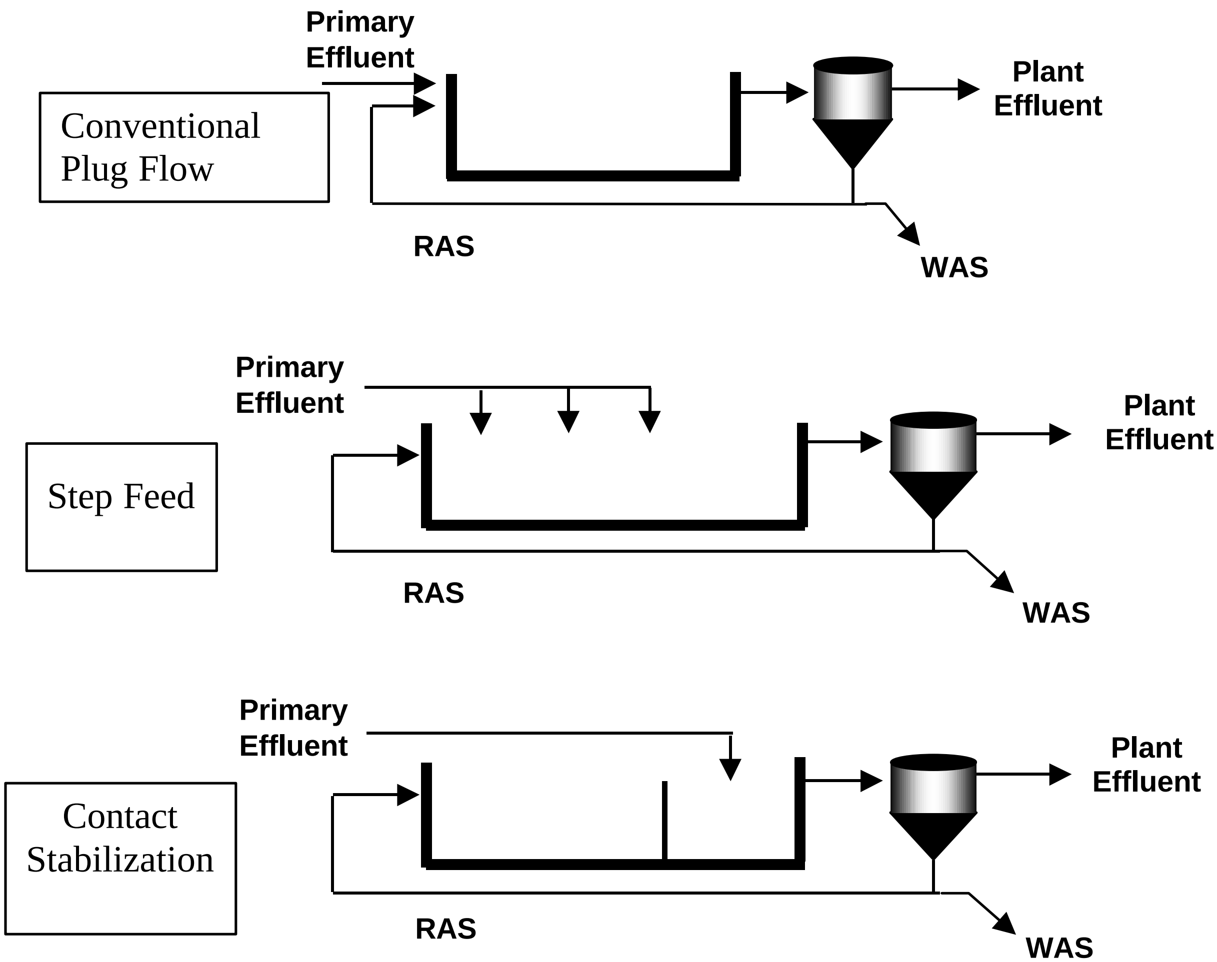


Figure 2.8 Activated Sludge Operating Modes

2. **Adjust Return Sludge Pumping Rate.** The decision whether to turn the return sludge pumping rate up or down can be confusing at times. It is dependent on many factors including sludge settling characteristics, dynamics of the solids inventory that is constantly moving between the clarifiers and aeration tanks, and the rate at which solids are entering the clarifiers.

   In general, the return sludge pumping rate should be increased under any of the following conditions:
   - Low solids in the aeration tanks, high blanket in clarifier
   - Increasing clarifier sludge blanket level, clarifier solids loading rate is below the clarifier's solids handling capacity
   - Solids loss is occurring, and some aeration is shut down for solids storage.

   In general, the return sludge pumping rate may be decreased under any of the following conditions:
   - Low clarifier blanket and additional solids storage is desired in clarifier
   - Low or mid-level clarifier blanket with clarifier solids loading rate approaching its upper limit

3. **Maintain Low MLSS.** Many plants store solids in the activated sludge system, for a variety of reasons. Often this happens due to limitations of the solids handling systems at the plant. Plants that use sludge drying beds for dewatering, for example, may not be able to dewater sludge for a significant length of time during the winter months. This forces the operators to store as much solids in the aeration tanks and clarifiers as possible. This also results in a much higher MLSS concentration than is necessary for proper treatment. If a wet weather event occurs while solids inventory in the activated sludge system is high, a significant quantity of solids can be washed out of the system to the receiving water.

   The activated sludge process should not be used for excess solids storage. This practice not only contributes to potential for solids washout, but also compounds the problem by creating an older, poorer settling sludge that is even more susceptible to washout. If solids handling or other processes are limiting the ability to waste secondary sludge from the system, alternate methods of handling secondary sludge should be investigated. Temporary hauling of thickened sludge to another facility would be a possible alternative.

4. **Maintain Good Settleability and Control Filamentous Growth.** Filamentous growth in activated sludge systems can seriously degrade sludge settleability and increase potential for solids washout during wet weather flows. In order to correct a filamentous growth problem one should attempt to identify the filament and determine the conditions contributing to its growth. Possible conditions that promote filamentous growth include low DO, nutrient imbalance, and long MCRT. Controls include correction of the condition promoting filamentous growth, or if this is not feasible, chlorinating the return sludge flow. Several good references are available on identification and control of filamentous growth.

5. **Conserve Biomass.** If other measures described above have been exhausted and significant loss of solids from the system is at hand, aeration system control can be used to keep solids in the aeration tanks and avoid losing them in the secondary effluent. If aeration can be independently controlled in zones of the aeration tanks, aerators near the effluent end of the tank can be turned off, allowing solids to begin accumulating in that portion of the aeration tank and decreasing the solids loading to the clarifiers. If the condition continues, aerators further upstream in the aeration tanks can be turned off to provide additional solids storage. While this is not a solution that can provide adequate treatment for extended periods of time, it can be the best alternative in some situations. The choice is clear between sacrificing some BOD removal for a period of a few hours or even a whole day, and losing BOD removal efficiency for a few weeks due to severe solids washout. Many plants successfully use controlled aeration shutdown during extreme wet weather flows and maintaining acceptable BOD removals.

B. **Fixed Film.** Fixed film processes including trickling filters and rotating biological contactors have an inherent advantage over suspended growth processes when it comes to wet weather. Their biomass is not as easily washed out of the plant. Nonetheless, fixed film processes are impacted by the occurrence of high flows, and some steps can be taken to improve performance during wet weather. Some of the impacts of wet weather on fixed film processes include:
- Lower hydraulic detention time in the fixed film reactor can decrease BOD removal efficiency
- High hydraulic loading on trickling filters can rotate distributor arms too fast
- High hydraulic loading rates can cause sloughing of biomass in extreme cases
- Uneven flow distribution accentuated by high flows

The following are recommendations to improve fixed film performance during wet weather operations:

1. Reduce or stop trickling filter or RBC recirculation flows. Recirculation around trickling filters is generally practiced to provide adequate wetting of the media. In some RBC installations, recirculation of secondary sludge is practiced to encourage development of some suspended growth. Generally during periods of high wet weather flows recirculation is not necessary and can be discontinued until flows have returned to normal.

2. Adjust trickling filter distributor arm speed. During high wet weather flows, trickling filter arms that are hydraulically motivated may turn at excessive speeds. The distributor arms can be slowed by installing nozzles on the distributor arms that discharge in the opposite direction of the other nozzles. The nozzles can be provided with caps, which can be used to shut them off and return the arms to normal speed when normal flows return.

3. Place trickling filters in parallel operation. At many trickling filter installations, two trickling filters are operated in series. During wet weather flows, design hydraulic loading rates for the filters may be exceeded. If the piping and pumping configuration allows, the filters can be converted to parallel operation during high flows, thereby reducing the hydraulic loading rate by half.

2.9 SECONDARY CLARIFICATION RECOMMENDATIONS

Secondary clarifiers are a critical element affecting the performance of a plant during wet weather. They are the last process unit where solids can be effectively trapped before the effluent leaves the plant. They capture and return sludge that keeps the activated sludge process viable. If high flows cause uncontrolled solids loss from the secondary clarifiers, the discharge permit may be violated and activated sludge process performance may suffer even after the wet weather subsides.

As discussed in Section 2.8A, wet weather can cause solids to wash out of the secondary clarifiers, which can have a long-term negative effect on the activated sludge process. Sludge settling characteristics are a big factor in determining how much flow a secondary clarifier can accept. When poor sludge settling characteristics are observed due to filamentous growth or other problems, operational adjustments should be made to improve settling characteristics.

Standard criteria adopted by many states set the standards shown on Table 2-2 for secondary clarifier design:

TABLE 2-2

SECONDARY CLARIFIER DESIGN STANDARDS	
Minimum side water depth 10 feet (fixed film)	12 feet (suspended growth)
Surface overflow rate at peak hourly flow (conventional activated sludge)	1,200 gpd/ft2
Surface overflow rate at peak hourly flow (single-stage nitrification)	1,000 gpd/ft2
Surface overflow rate at peak hourly flow (with chemical addition for P removal)	900 gpd/ft2
Surface overflow rate at design peak hourly flow (fixed film)	1,200 gpd/ft2
Solids loading rate, peak day (conventional activated sludge)	50 lb/d/ft2
Solids loading rate, peak day (single-stage nitrification)	35 lb/d/ft2

When the above overflow rates, or solids loading rates are exceeded, removal efficiency will decrease significantly. If sludge blanket depths are high, removals may suffer at even lower overflow rates. Several recommendations for improving secondary clarifier performance during wet weather are presented below.

1. **Place All Secondary Clarifiers in Service.** If all clarifiers are not needed under normal flow conditions, unused clarifiers can be placed in service during wet weather. The additional clarifier area will reduce the surface overflow rate and solids loading rate, which will enhance removal efficiency.

2. **Improve Flow Splitting to the Tank.** Unequal flow distribution to secondary clarifiers can result in some tanks performing well while others operate at reduced efficiency. See the flow splitting recommendations in Section 2 for suggestions on corrective action.

3. **Improve Tanks Hydraulics Through Baffle Addition.** Density currents can form and impact performance of secondary clarifiers. Through dye testing and baffle additions, density currents can be deflected to improve clarifier performance. See the discussion in Section 2.7 regarding dye testing and baffle installation.
   In circular secondary clarifiers, peripheral density current baffles known as Crosby baffles have become standard equipment. These baffles are shown in Figure 2.9. These baffles have been sufficiently proven that dye testing is not normally required before baffle installation. Crosby baffles have been constructed of plywood, steel, fiberglass and other materials. Several manufacturers sell standard designs manufactured in fiberglass, but baffles may be constructed of sheets of virtually any rigid water-resistant material. Other improvements to circular clarifiers, including energy dissipating inlet (EDI) baffles and circular, mid-radius baffles may also improve clarifier performance during high flow periods.

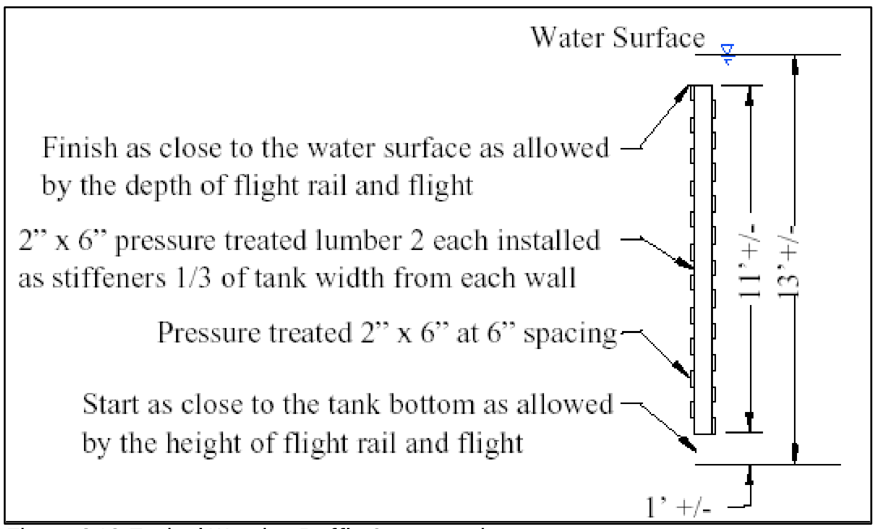


Figure 2.10 Typical Wooden Baffle Construction

In rectangular secondary clarifiers, many plants have installed mid-tank baffles to disrupt density currents. The location of currents in rectangular clarifiers is difficult to predict, therefore dye testing is recommended before placing baffles. More information on dye testing can be obtained from the Maine DEP. Results of continuous feed dye tests as depicted in Figures 2-8 and 2-9 can be used to determine locations of currents and select baffle locations. Baffles for rectangular tanks have been fabricated of many different materials including pressure treated lumber, fiberglass, or even used belt filter press belts cut into strips. Successful baffle placements from previous installations and a wooden baffle design are shown in Figures 2-10 and 2-11.

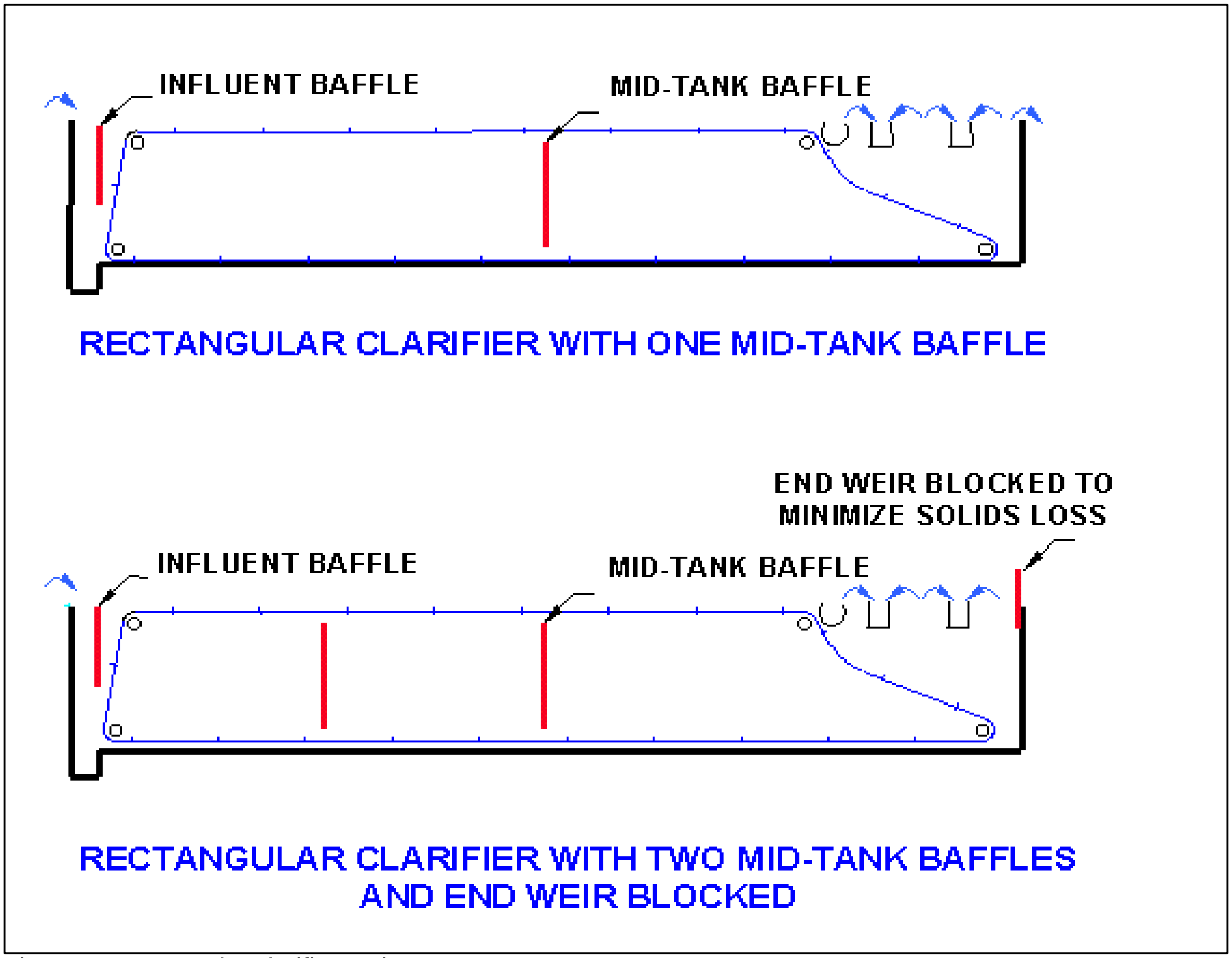


Figure 2.11 Rectangular Clarifier Options

3. **Improve Tanks Hydraulics Through Weir Modifications.** Recommended weir loading rates for secondary clarifiers are in the range of 20,000 to 30,000 gallons/ft/day in large clarifiers, and 10,000 to 20,000 gallons/ft/day in small clarifiers. If weir loading rates exceed these recommended values, the velocity of currents approaching the weirs may be such that excessive solids are carried over the weir. Placing additional lateral weir troughs in rectangular clarifiers can lengthen weirs. Weir lengths are normally sufficient with one peripheral effluent weir in circular clarifiers. Problems have been observed with solids carryover on the outer weir of double-sided effluent weir troughs in circular clarifiers. This often occurs when the v-notch spacing on the outer weir is the same as the v-notch spacing on the inner weir. The approach velocity can be decreased on the outer weir by blocking off alternating v-notches with plywood or other material. Alternately, the outer weir can be blocked off entirely as shown in Figure 2.6.

4. **Add Chemicals to Enhance Settling.** Some plants have improved secondary settling during wet weather through polymer addition. Chemical coagulants used for phosphorus removal including ferric chloride, ferric sulfate, or alum can also be added with polymers, but in some cases chemical doses required for phosphorus removal may cause poorer settling.

2.10 FILTRATION RECOMMENDATIONS

Sand filters are used at plants requiring low effluent suspended solids concentrations or low effluent phosphorus. Potential impacts of wet weather flows on sand tertiary filters include:

- Washing of excessive solids from secondary clarifiers resulting in premature blinding of filter media
- Hydraulic overloading of filters resulting in excessive headloss

Recommendations for maximizing filter performance during wet weather include:

- Place all filters in service
- Backwash before the high flows arrive to be sure that all filters are available at peak capacity
- Reduce backwash time during high flow periods
- Reduce secondary clarifier blankets before high flows to minimize excessive secondary solids carryover

Standard design practice is to provide a filtration rate of 5 gpm/ft2 at peak hourly flow with one filter out of service. Many filters can be operated at higher flow rates, with maximum flow limited principally by headloss through the media. During wet weather, flow through the filters can be maximized up to the point where the limits of available head are reached.

2.11 DISINFECTION RECOMMENDATIONS

Chlorination is commonly used as a means of effluent disinfection. Ultraviolet disinfection is rapidly gaining in popularity. Both disinfection methods rely on required exposure times to adequately disinfect secondary effluent. During periods of extreme wet weather, there may be insufficient exposure time in the chlorine contact tank or the ultraviolet disinfection chamber to adequately disinfect the effluent. In addition, excessive solids in secondary effluent resulting from high flows can hinder either disinfection method. In spite of the potential for reduced effectiveness, it is preferable to convey as much flow through the disinfection units as possible to achieve some degree of disinfection. Recommendations for maximizing chlorine disinfection efficiency during high flows include:

- Experiment with chlorine dosage at high flows. Adequate kills may be achievable at detention times of less than 15 minutes with the proper chlorine dose.
- Optimize chlorine mixing. Poor mixing or diffuser placement can greatly reduce chlorination effectiveness.
- Increase length-to-width ratio of chlorine contact tank. To avoid short-circuiting and effectively utilize chlorine contact tank volume, length-to-width ratios of 10:1 to as high as 40:1 are recommended. Chlorine contact tanks that fall short of this recommendation can sometimes be modified with the addition of longitudinal baffles. This creates a near plug flow regime with less opportunity to short circuit.

Recommendations for maximizing ultraviolet disinfection efficiency during high flows include:

- Place all units in service. Make sure that all ballasts and lamps are operational.
- Clean lamp sleeves before wet weather arrives.

2.12 SOLIDS HANDLING RECOMMENDATIONS

Although solids handling processes do not receive wet weather wastewater flows, they can be impacted by wet weather operations. Solids handling processes can also impact treatment efficiency during wet weather, and modifications to solids processing procedures may be necessary during wet weather. Solids handling impacts of wet weather include:

- Excess solids entering plant with first flush
- Poor treatment efficiency of solids handling recycle streams (such as digester supernatant or belt press filtrate) during wet weather flows
- Inability to achieve adequate drying on drying beds during wet weather

Solids handling recommendations to reduce wet weather impacts include:

- Reduce quantity of solids stored prior to wet weather. Inability to waste solids during wet weather due to insufficient solids storage capacity often results in solids loss from secondary clarifiers. If capacity can be made available in digesters, sludge holding tanks, gravity thickeners, sludge drying beds or other potential solids storage locations, sludge can be wasted from the main process areas as needed during wet weather. Available solids storage will also create potential for reducing solids recycles during wet weather. If digester levels are reduced, production of digester supernatant can be minimized during wet weather.
- Make arrangements for alternate methods of solids disposal. If wet or winter weather prevents solids removal from the facility, resulting in excessive solids in aeration tanks and clarifiers, alternative methods of solids disposal should be investigated. Paying for additional solids hauling costs for a period during the winter can avoid excess solids accumulation when the snow melt and high spring flows arrive at the plant.

SECTION 3 - WET WEATHER MANAGEMENT PLAN DEVELOPMENT GUIDELINES, EXERCISES, AND EXAMPLES

3.1 DEVELOPING A WET WEATHER MANAGEMENT PLAN

A wet weather management plan is intended to provide operators with a guide to minimize the discharge of pollutants during wet weather and to protect their facilities from upset.

A. Key Elements

Every wet weather management plan should contain the following key elements:

- Goals of the Plan. The Goals section will define the overall objectives of the wet weather management plan with respect to protecting water quality and plant performance.
- Critical Components. Critical Components are those components of the collection and treatment system that significantly impact wet weather performance. Specific objectives should be defined for each Critical Component.
- Operating Guidelines. For each Critical Component, the plan will contain step by step guidance for operation, maintenance, and management procedures to be followed before, during and after a wet weather event. The steps to be taken should be triggered by flow levels so that actions can be taken at the plant before treatment efficiency is degraded.
- List of Contacts. The plan should contain a list of important contacts that may be of assistance during wet weather events.

1. Goals of the Plan

The goals of the plan should define the water quality objectives of the collection and treatment system. For most systems with combined sewer overflows, operating decisions made during wet weather events can affect how much flow is treated at the wastewater treatment plant and how much flow is bypassed through CSOs. Difficult decisions must be made rapidly. These decisions may affect water quality in the receiving water at the CSOs, water quality in the receiving water at the plant, and performance of the plant during and after the wet weather event. Well-defined goals for receiving water quality will help guide the development of operating guidelines for the plant and help guide decision making during wet weather events. It may be necessary to obtain advice from the Maine DEP in setting water quality priorities.

2. Critical Components

The critical components are processes in the collection system (such as CSO regulators or pumping stations) or the treatment plant (such as bar screens or aeration tanks) which can significantly have affect treatment of wet weather flow (or can be significantly affected by wet weather flow). The list of critical components is unique to each facility. One plant’s critical components may not be critical at another facility. The wet weather management plan is not intended as a substitute for the plant’s operation and maintenance manual. Components that have no bearing on wet weather operations will not be listed. As an example, a collection system may include multiple wastewater pumping stations, but not all stations may be listed as critical components. Unlisted stations might serve a new portion of the sewer system that has no combined sewers and little I/I. Though regular operation and maintenance procedures are essential at pumping stations, no special procedures may be needed at these stations during wet weather.

The list of critical components should include any major unit process in the collection system or the wastewater treatment plant that is handling wet weather flows. Even if the process does not normally present special problems during wet weather, it should be included on the list if it is handling wet weather flows. In addition, auxiliary processes that are impacted by wet weather flows should be included. If, for example, special provisions for sludge handling must be made during wet weather, sludge thickening, stabilization or dewatering processes might be included on the list of critical components.

3. *Operating Guidelines*

Operating Guidelines should be developed for each critical component identified in the collection system and treatment plant. For each component, tasks should be listed for completion before, during and after a wet weather event. Task descriptions should be <u>brief</u> and <u>specific</u>. The wet weather management plan is intended to serve as a quick reference during a wet weather event. This is not the place for a detailed description of the theory behind a treatment process. The description must be specific enough, however, to describe exactly what needs to be accomplished. For example, “Check water level in influent channel” may not be specific enough. But, “Check water level in influent channel. Open feed gate to second bar screen if water level is above 3-foot mark on staff gauge” provides specific direction based upon a required observation.

The performance of the various unit processes during past wet weather flow events should be carefully reviewed. This can help establish the flow levels at which certain actions must be taken.

4. *List of Contacts*

Develop a list of contacts who can provide advice or assistance during a wet weather event. The list should include supervisors, and other involved public officials, equipment representatives and service organizations, local and state regulatory agencies, utilities, and emergency contacts such as fire department, police department and ambulance.

B. Plan Development.

The members of the operation and maintenance staff who actually run the facility should develop the wet weather management plan. If outside assistance is obtained for plan development, the plant staff members should have a significant role in providing input, guidance, and review of the operating plan. The key steps in plan development are as follows:

- Identify personnel to be involved and form development team
- Break down plant and collection system into physical areas
- Break down areas into unit processes
- List wet weather O&M procedures to be followed before, during, and after each wet weather event for each critical component. Wherever possible, a flow target should be specified for each action.
- Review and refine list of procedures
- Evaluate and continue to revise procedures (continuous process improvement)

At a large facility, the development team may include a large number of people with diverse roles at the plant. At a small plant, the development team may include the entire plant staff. Each of the steps in the development process can be initiated effectively through a brainstorming meeting with ideas contributed by all present. The detailed procedures can then be further developed in smaller work groups.

The Appendices attached to this manual contain exercises and templates that may be useful to the staff of a treatment facility to help structure the process of developing the wet weather plan.

- Appendix A - Plant Data Analysis Exercise – This appendix contains an exercise to help the staff understand what wet weather flows are and how those flows affect the treatment process.
- Appendix B – Impact of Activated Sludge Mode Changes – this appendix includes an exercise designed to help staff members understand how different modes of operation of an activated sludge treatment plant can improve performance during wet weather.
- Appendix C - Troubleshooting Exercise – this appendix is deigned to help staff prepare for an unusual event.
- Appendix D - Wet Weather Operating Strategies for Wastewater Treatment Facilities – this appendix has a series of charts that can used to define steps that can be taken at their facility during a wet weather event.
- Appendix E - Wet Weather Operating Plan Development Worksheets - this appendix includes worksheets that can be duplicated to help develop specific steps that will be taken before, during and after a wet weather event for each major unit process area in the treatment facility.
- Appendix F - Wet Weather Operating Plan Template Sheets - this appendix is a set of forms that can be used for the actual wet weather plan document.

(Note: A diskette including Microsoft Word templates of the forms in Appendix E and Appendix F is included with this manual)

The completed wet weather management plan should not be considered a final document. The plan should be revised if and when operating experience at the plant demonstrates that a different procedure can give better performance during wet weather flows. The plan should be kept in a three-ring notebook that can be easily modified as new revisions are developed. Even after the initial plan is developed, investigate some of the suggestions made in this manual, and other ideas that are developed at your plant. Test and compare various procedures to find new ways to treat more flow more efficiently at your facility. Never stop looking for new ways to make your plant provide better, more efficient performance and further reduce untreated overflows.

Appendix A

Plant Data Analysis Exercise

Analysis of Plant Data

Mo'town WWTF

Attached is a partial set of one month's plant data for the Mo'town wastewater treatment facility. The basic facility data are as follows:

Flow: Design	0.90 MGD	Preliminary:	Barscreen Detriter
Peak Day	2.0 MGD	Primary:	Circular clarifier
Primary Clarifier Volume	0.113 MG	Secondary:	Activated sludge
Secondary Clarifier Volume	0.225 MG		Rectangular clarifiers
		Tertiary: Sand Filters	
		Nutrient Removal: Nitrification Only	

Your task, as a group, is to analyze the attached data sheet and develop some assumptions and basic actions to be taken based upon the data. To guide the discussion within the group, consider the following questions.

1. What days of this month do you consider to be wet weather flow days?

2. What unit processes seem to be under stress during these times?

3. What process adjustments should be considered?

4. During which of these times do you think that the secondary process is stressed?

5. What other data would you like to have collected by the operators?

6. What month do you think this is?

Be prepared to present your groups opinions and answers to the class.

Activity #2 - Mo'town WWTF

				Influent							Bar Screen			Primary Clarifiers				Final Effluent	
Date	AirT	Rainfall	Flow	Temp	SettS	SS	BOD	PH	P	TKN	Op	Screening	Grit	Sludge Depth	Sludge Pumped	ESS	BOD	ESS	BOD
	F	(inch)	MGD	C	ml/l	mg/l	mg/l	mg/l	mg/l	mg/l	Mode	cu.ft.	cu.ft.	feet	gallons	mg/l	mg/l	mg/l	mg/l
1	30	0	0.84	13	11	150	160	6.8	4.3	30	AUTO	<2	0	2.1	1500	72	64	4	2
2	32	0	0.82	13	12	145	165	6.5	4.2	32	AUTO	<2	0	2.2	1520	70	66	3	4
3	40	0	0.85	13	12	135	155	6.7	4.5	29	AUTO	<2	<2	2	1500	65	62	5	3
4	38	0	0.9	12	16	145	165	6.9	4.2	28	alar/con	4	2	2.3	1520	70	65	6	5
5	42	0.1	1.2	12	12	142	162	6.6	4.1	26	alar/con	2	0	2.1	1500	72	80	4	4
6	55	0	0.89	13	13	138	158	6.8	4.3	32	AUTO	<2	0	1.9	1500	66	63	3	3
7	65	0	0.86	14	11	143	163	6.7	4.4	30	AUTO	<2	<2	2	1500	69	65	6	4
8	70	0	0.85	13	11	146	164	6.7	4.3	29	AUTO	<2	0	2	1500	70	66	4	5
9	75	0	0.9	14	14	145	156	6.7	4.1	36	AUTO	<2	0	2.3	1500	66	70	5	4
10	50	0.8	1.76	14	15	80	140	6.4	3.4	24	alar/con	16	20	2.8	1520	95	110	15	25
11	55	0.4	1.45	15	13	85	145	6.8	3.6	26	alar/con	4	4	2.2	1600	45	65	6	12
12	60	0.1	1.2	14	12	120	155	6.9	3.9	28	alar/con	2	<2	1.3	1550	58	65	5	13
13	65	0	0.95	15	10	144	162	6.7	4.3	30	AUTO	<2	0	1.7	1400	69	65	4	10
14	63	0	0.84	15	11	142	163	6.6	4.2	32	AUTO	<2	0	2.2	1500	68	65	6	8
15	58	0	0.81	14	10	138	158	6.9	4.5	33	AUTO	<2	0	1.9	1500	66	63	4	7
16	65	0	0.85	15	11	143	165	6.8	4.3	31	AUTO	<2	<2	2	1500	69	66	5	2
17	66	0	0.88	15	13	145	165	6.6	4.3	29	AUTO	<2	0	2.3	1500	70	72	4	4
18	68	0.1	1.2	16	12	132	150	6.7	4.1	28	alar/con	<2	4	2.2	1520	75	70	5	4
19	70	0.2	0.98	15	13	137	157	6.8	4.2	30	alar/con	<2	2	1.8	1550	70	63	3	3
20	72	0	0.88	16	12	140	163	6.7	4.3	32	AUTO	<2	0	2.1	1480	67	65	6	4
21	75	0	0.85	15	11	137	164	6.9	4.4	29	AUTO	<2	0	1.9	1500	66	66	4	2
22	78	0	0.98	16	22	140	162	6.6	4.1	34	AUTO	<2	<2	2.5	1500	75	60	6	5
23	62	1.8	1.95	17	14	100	140	6.6	2.8	22	alar/con	10	12	2.8	1560	100	120	15	32
24	55	0.2	1.75	18	13	90	105	6.8	3.2	25	alar/con	4	4	2.2	1600	72	62	8	20
25	58	0.1	1.25	18	12	95	110	6.7	3.8	28	alar/con	2	2	1.7	1550	65	60	5	17
26	60	0	0.92	17	14	115	155	6.9	4.1	29	alar/con	<2	0	1.9	1480	60	62	4	12
27	62	0.1	1.2	17	11	130	162	6.7	4	30	alar/con	<2	0	2.2	1500	62	65	5	13
28	65	0	0.88	16	10	140	164	6.8	4.3	30	AUTO	<2	<2	2.1	1500	67	66	4	8
29	63	0	0.87	17	13	140	163	6.7	4.4	31	AUTO	<2	0	1.9	1500	67	65	6	5
30	65	0.1	1.1	17	10	143	158	6.9	4.2	29	AUTO	<2	0	2	1500	69	63	3	3

Appendix B

Impact of Activated Sludge Mode Changes

Impact of Activated Sludge Mode Changes

Three plant configurations are shown in the diagram on the following page. Each plant has a total aeration tank volume of 2 million gallons and a total clarifier surface area of 20,000 ft^2. Mixed liquor suspended solids concentrations, process flow rates, and aeration zone volumes are shown in the attached diagram.

For each of the three configurations, answer the following questions:

1. How many pounds of MLSS are there in the aeration tanks?

Conventional __________

Step Feed __________

Contact Stabilization __________

2. What is the clarifier surface overflow rate?

Conventional __________

Step Feed __________

Contact Stabilization __________

3. What is the clarifier solids loading rate?

Conventional __________

Step Feed __________

Contact Stabilization __________

4. What would the clarifier solids loading rate be if the primary effluent flow increased to 20 mgd?

Conventional __________

Step Feed __________

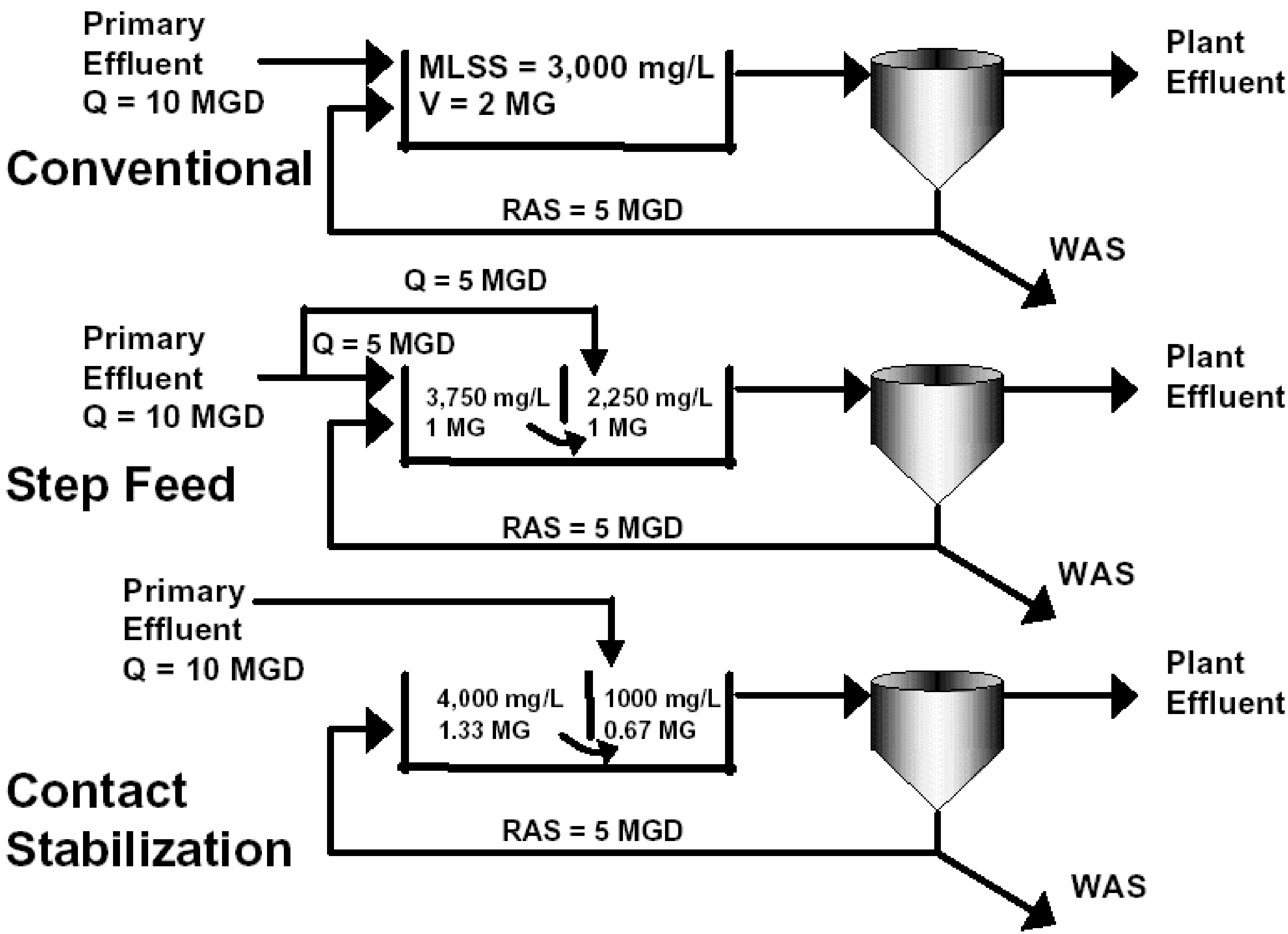
Contact Stabilization __________

5. At the wet weather flow of 20 MGD, using the allowable solids loading rates on the attached chart, what would be the required SVI in each mode?

Conventional __________

Step Feed __________

Contact Stabilization __________


Primary
Effluent
Q = 10 MGD
MLSS = 3,000 mg/L
V = 2 MG
Plant
Effluent
Conventional
RAS = 5 MGD
WAS
Q = 5 MGD
Primary
Effluent
Q = 10 MGD
Q = 5 MGD
3,750 mg/L
1 MG
2,250 mg/L
1 MG
Plant
Effluent
Step Feed
RAS = 5 MGD
WAS
Primary
Effluent
Q = 10 MGD
4,000 mg/L
1.33 MG
1000 mg/L
0.67 MG
Plant
Effluent
Contact
Stabilization
RAS = 5 MGD
WAS

SOLIDS LOADING RATE
RECTANGULAR CLARIFIER

Required Input Data

(1) Clarifier Length (L) ________________ ft

(2) Clarifier Width (W) ________________ ft

(3) Number of Clarifiers (N) ________________

(4) Flow (Q) *Note: does not include RAS flow* ________________ MGD

(5) Mixed Liquor Suspended Solids (MLSS) ________________ mg/l

Surface Area of One Clarifier

(6) $A_s = (L)\times(W)$

(7) $A_s = (\_\_\_\_\_\_\_\_\_\_)\times(\_\_\_\_\_\_\_\_\_\_)$

Enter from Line 1 Enter from Line 2

Total Surface Area

(8) $A_{s(Total)} = (A_s)\times(N)$

(9) $A_{s(Total)} = (\_\_\_\_\_\_\_\_\_\_)\times(\_\_\_\_\_\_\_\_\_\_)$

Enter from Line (3) Enter from Line (7)

Solids Loading

(10) $SL = (Q)\times(MLSS)\times(8.34)$

(11) $SL = (\_\_\_\_\_\_\_\_\_\_)\times(\_\_\_\_\_\_\_\_\_\_)\times(8.34)$

Enter from Line (4) Enter from Line (5)

Solids Loading Rate

(12) $SLR = (SL)/(A_{s(Total)})$

(13) $SLR = (\_\_\_\_\_\_\_\_\_\_)/(\_\_\_\_\_\_\_\_\_\_)$

Enter from Line (11) Enter from Line (9)

SOLIDS LOADING RATE
CIRCULAR CLARIFIER

Required Input Data

(1) Clarifier Diameter (D) ________________ ft

(2) Number of Clarifiers (N) ________________

(3) Flow (Q) *Note: does not include RAS flow* ________________ MGD

(4) Mixed Liquor Suspended Solids (MLSS) ________________ mg/l

Surface Area of One Clarifier

(5) $A_s = (0.785)\times(D^2)$

(6) $A_s = (0.785)\times(\_\_\_\_\_\_\_\_)$

Enter from Line (1)

Total Surface Area

(7) $A_{s(Total)} = (A_s)\times(N)$

(8) $A_{s(Total)} = (\_\_\_\_\_\_\_\_)\times(\_\_\_\_\_\_\_\_)$

Enter from Line (2) Enter from Line (6)

Solids Loading

(9) $SL = (Q)\times(MLSS)\times(8.34)$

(10) $SL = (\_\_\_\_\_\_\_\_)\times(\_\_\_\_\_\_\_\_)\times(8.34)$

Enter from Line (3) Enter from Line (4)

Solids Loading Rate

(11) $SLR = (SL)/(A_{s(Total)})$

(12) $SLR = (\_\_\_\_\_\_\_\_)/(\_\_\_\_\_\_\_\_)$

Enter from Line (10) Enter from Line (8)

SURFACE OVERFLOW RATE
CIRCULAR CLARIFIER

Required Input Data

(1) Clarifier Diameter (D) ________________ ft

(2) Number of Clarifiers (N) ________________

(3) Flow (Q) *Note: does not include RAS flow* ________________ MGD

Surface Area of One Clarifier

(4) $A_s = (0.785)\times(D^2)$

(5) $A_s = (0.785)\times($________$)$

Enter from Line (1)

Total Surface Area

(6) $A_{s(Total)} = (A_s)\times(N)$

(7) $A_{s(Total)} = ($__________$)\times($__________$)$

Enter from Line (2) Enter from Line (5)

Surface Overflow Rate

(8) $SOR = (SL)\times(10^6)/(A_{s(Total)})$

(9) $SOR = ($__________$)\times(10^6)/($__________$)$

Enter from Line (3) Enter from Line (7)

Example Clarifier Solids Loading Guidelines	
SVI mL/g	**Solids Loading Capacity at Average Daily Flow $lbs/d/ft^2$**
75	30
100	25
125	22.5
150	20
175	17.5
200	15

Appendix C

Troubleshooting Exercise

Troubleshooting Exercise

Potope WWTP

General Data

The Potope wastewater treatment facility serves the community of Potope (pop. 7000). The community is residential with only the "normally" associated commercial discharges (gas stations, restaurant, etc.). The plant accepts a limited amount of septage through a separate pretreatment and storage facility. The plant is an oxidation ditch design, with no primary clarifiers preceding secondary treatment. The facility was built in the late 1970's and the solids process was upgraded in the late 1980's. Solids processing consists of aerobic digestion followed by belt filter press dewatering and solids storage for spring land application.

The basic plant design data is:

Design Flow:	0.850 MGD	Preliminary Treatment:	Bar screen & Comminutor
Peak hourly flow:	1.8 MGD	Primary Treatment:	None
Collection system: Combined		Secondary Treatment:	Oxidation ditch
Aeration tank volume: (1 used) 0.750 MG			Circular clarifier
Final clarifier volume: (2 used) 0.250 MG		Tertiary Treatment:	None
		Disinfection:	Cl_2 (no dechlorination)

Operation Mode

The plant is operated as an extended aeration plant. Normal operation is with one of the two oxidation ditches on line (this has been so since start-up). RAS flow rate is manually adjusted to approximately 75% of influent flow rate. Both secondary clarifiers are on line at all times, but RAS is only drawn from one of them. The solids in the other are collected and wasted to the aerobic digester every other day. The clarifiers are alternated every other day so that any solids not sent to the digester are returned to the aeration tank. This procedure assures high solids concentration in the waste line to the digester.

Effluent quality is always below 5 mg/l for both BOD5 and TSS. The discharge permit limit is 30 mg/L for BOD5 and TSS. During high flow events flows increase very rapidly and at 1.5 MGD an alarm is sent to operators and aeration is stopped (the plant essentially maintains primary treatment with the aeration tank and final clarifiers providing treatment). During these times effluent TSS values are maintained near normal and BOD5 rises slightly, but still remains well within permit requirements. Reaeration takes between twelve and 24 hours to resuspend the contents of the aeration tanks.

The Problem

During the last two storms the effluent quality has deteriorated significantly. TSS has nearly exceeded permit values and BOD5 has risen significantly. These two recent storms do not appear to be unlike any other storms and there have been no process changes or plant modifications recently.

Your Task

Your task is to help the award winning operators from Potope maintain their sterling record of permit compliance. It is now Thursday and there are severe thunderstorms forecast for the weekend. The following questions might help guide you through the problem solving exercise.

1. What is the problem? What caused the TSS and BOD_5 to increase during the recent storms?

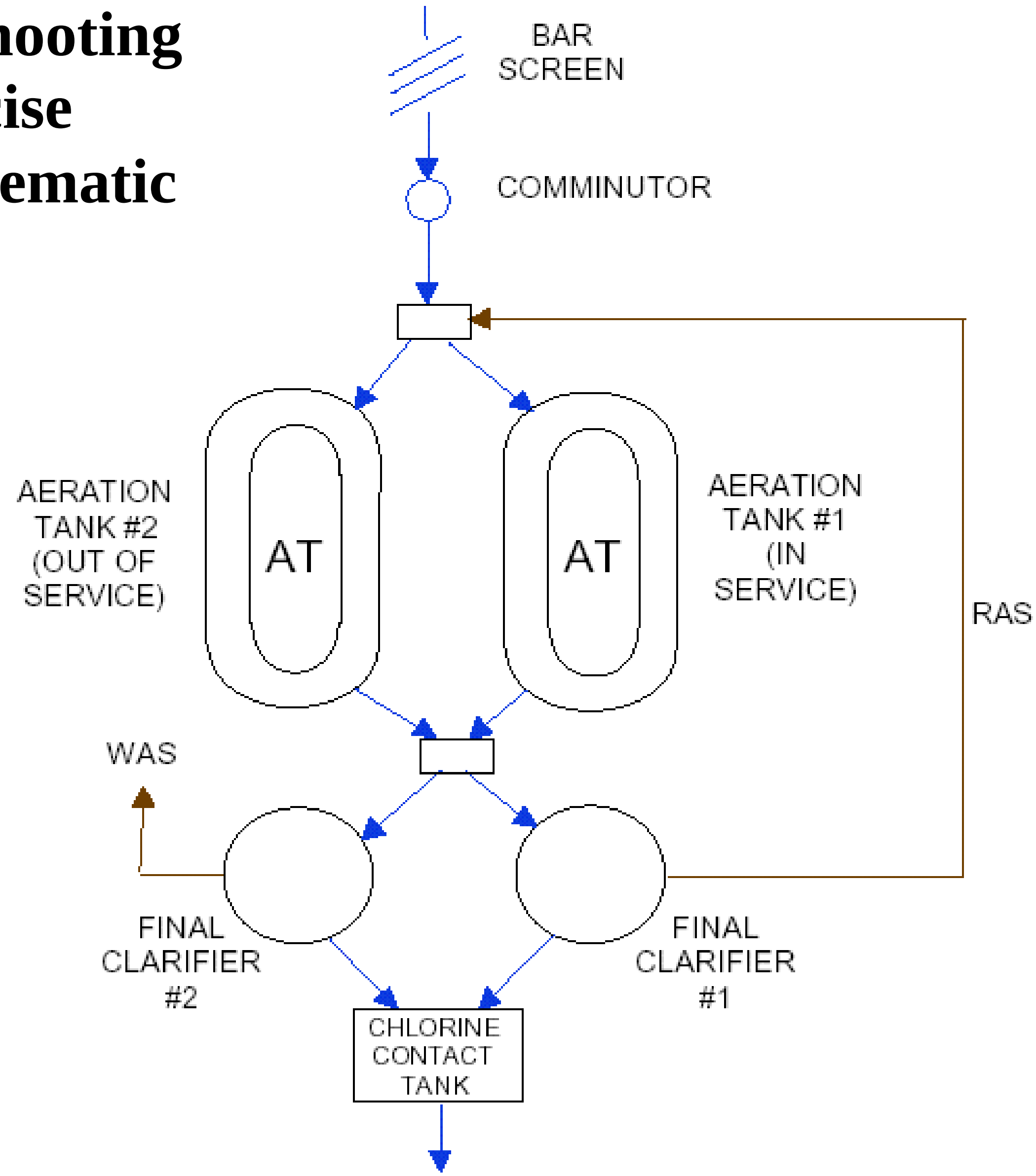
2. What actions could be taken to help reduce the impact this weekend?

3. What are the intermediate solutions to this problem?

4. What additional data needs to be collected?

5. What long-term operational changes do you suggest?

Troubleshooting Exercise Plant Schematic



Appendix D

Wet Weather Operating Strategies For Wastewater Treatment Facilities

WET WEATHER OPERATING STRATEGIES
FOR WASTEWATER TREATMENT FACILITIES

Instructions: **Complete the following chart for your facility. In the "Application to My Plant" column, describe the implications of application of this strategy at your facility. Include the necessary purchases and changes in operating procedures. If a strategy will not work, explain why. Also, try to develop other strategies not listed below that may be applicable to your plant. You may mark Not Applicable (NA) for any processes that you do not have at your facility.**

Process	Strategy	Application at My Plant
General	1. Assure that unused tankage and equipment are available and ready for use when high flows occur. 2. Controlled bypassing of secondary treatment process. 3. Develop sampling and testing regimes to identify the flow rate at which process upsets will occur. 4. Low cost piping additions which increase plant flexibility. 5. Reduce recycle flows (digester supernatant, filtrate, etc.) during wet weather events. 6. 7.	1. 2. 3. 4. 5. 6. 7.

Process	Strategy	Application at My Plant
Collection System	1. Implement regular program for inspecting and cleaning sewers, manholes and catch basins. 2. Adjust weir heights/regulator settings at combined sewer overflow points to maximize system storage. 3. Throttle plant influent gate to increase storage in collection system. 4. Implement regular program to reduce I/I which may include TVing, testing and sealing. 5. Remove unnecessary storm sewer connections. 6. Install simple regulation devices (vortex-type throttling devices, surface retention, manhole cover inserts) to reduce rate of inflow into system. 7. 8.	1. 2. 3. 4. 5. 6. 7. 8.

Process	Strategy	Application at My Plant
Pump Stations	1. Modify pump control system to maximize wet well storage. 2. Modify pump control system to dampen flow surges to treatment processes. 3. Bring stand-by pumps on line. 4. 5.	1. 2. 3. 4. 5.
Screening	1. Place all screening units in service. 2. Increase cleaning frequency (or run mechanical screens continuously) 3. 4.	1. 2. 3. 4.

Process	Strategy	Application at My Plant
Grit Removal	1. Place all grit removal units in service. 2. Shut off or reduce air to aerated grit chambers. 3. Increase grit removal rate or frequency (e.g. run grit collector continuously). 4. Adjust velocity of velocity controlled grit chambers. 5. Use alternate grit removal systems. 6. 7.	1. 2. 3. 4. 5. 6. 7.

Process	Strategy	Application at My Plant
Primary Settling	1. Maintain low sludge blanket levels/increase sludge pumping rate or frequency. 2. Improve flow splitting to settling tanks. 3. Improve tank hydraulics through baffle addition. 4. Improve tank hydraulics through weir modifications. 5. Chemical addition and flocculant aids to maximize solids removal. 6. Increase scum removal rate or frequency. 7. Monitor primary sludge concentration more often, especially during early flow. 8. 9.	1. 2. 3. 4. 5. 6. 7. 8. 9.

Process	Strategy	Application at My Plant
Trickling Filters	1. Adjust Distributor arm 2. Reduce or stop filter recycle or recirculation flows 3. Place trickling filters in paralell operation. 4. 5.	1. 2. 3. 4. 5.
Secondary Settling	1. Maintain low sludge blanket levels 2. Improve flow splitting to settling tanks 3. Improve tank hydraulics through baffle addition. 4. Improve tank hydraulics through weir modifications. 5. Chemical addition and flocculant aids to maximize solids removal. 6. Dye Text Clarifiers 7. 8.	1. 2. 3. 4. 5. 6. 7. 8.

Process	Strategy	Application at My Plant
Sand Filters	1. Place all filter units in service. 2. Adjust backwash mode. 3. Backwash before storm surge hits. 4. 5.	1. 2. 3. 4. 5.
Disinfection	1. Increase chlorination sates to handle increased chlorine demand from solids losses from clarifiers. 2. Clean solids from contact tank. 3. Place all units in service 4. Clean UV Equipment prior to storm surge. 5.	1. 2. 3. 4. 5.

Process	Strategy	Application at My Plant
Solids Processing	1. Assure maximum available solids storage capacity prior to wet weather season 2. Assure all solids processing equipment is in operating condition prior to wet weather conditions. 3. Consider alternative solids disposal during wet weather events 4. Reduce solids volume in digesters prior to wet weather events 5. 6.	1. 2. 3. 4. 5. 6.

Appendix E

Wet Weather Operating Plan Development Worksheets

BEFORE WET WEATHER EVENT

Plant Area: ____ Sheet ID: _____________

Unit Process/Equipment: ___________________________________ Date: ________________

A. We have decided that we need to get ready for a wet weather event.
What do we do before the flow starts to climb?

1. What operating adjustments do we make?

2. What do we look at, what do we observe?

3. What do we measure, what do we record?

4. What maintenance do we perform?

5. Anything else?

DURING WET WEATHER EVENT

Plant Area:____ Sheet ID: _____________

Unit Process/Equipment: ___________________________________ Date: __________

B. The flow has just started to increase at this unit.

What do we do as the flow climbs, reaches it's peak and begins coming back down?

1. What operating adjustments do we make?

2. What do we look at, what do we observe?

3. What do we measure, what do we record?

4. What maintenance do we perform?

5. Anything else?

AFTER WET WEATHER EVENT

Plant Area: ____ Sheet ID: _____________

Unit Process/Equipment: ________________________________ Date: ________________

C. The flow continues to drop and approaches normal.
What do we do to return this to normal service?

1. What operating adjustments do we make?

2. What do we look at, what do we observe?

3. What do we measure, what do we record?

4. What maintenance do we perform?

5. Anything else?

Appendix F

Wet Weather Operating Plan Template Sheets

Using the information developed on the worksheets in Appendix E, develop the wet weather operating plan using the forms in this Appendix.

SECTION ____ - ____________________________

_____ Unit Processes and Equipment

UNIT PROCESS	**EQUIPMENT**

_____ Wet Weather O&M Practices

WHO DOES IT?		**WHAT DO WE DO?**
SUPERVISORY	**IMPLEMENTATION**	
Before the Wet Weather Event		

WHO DOES IT?		WHAT DO WE DO?
SUPERVISORY	IMPLEMENTATION	
During the Wet Weather Event		

WHO DOES IT?		WHAT DO WE DO?
SUPERVISORY	IMPLEMENTATION	
After the Wet Weather Event		

A. WHY DO WE DO THIS?
B. WHAT TRIGGERS THE CHANGE?
C. WHAT CAN GO WRONG?