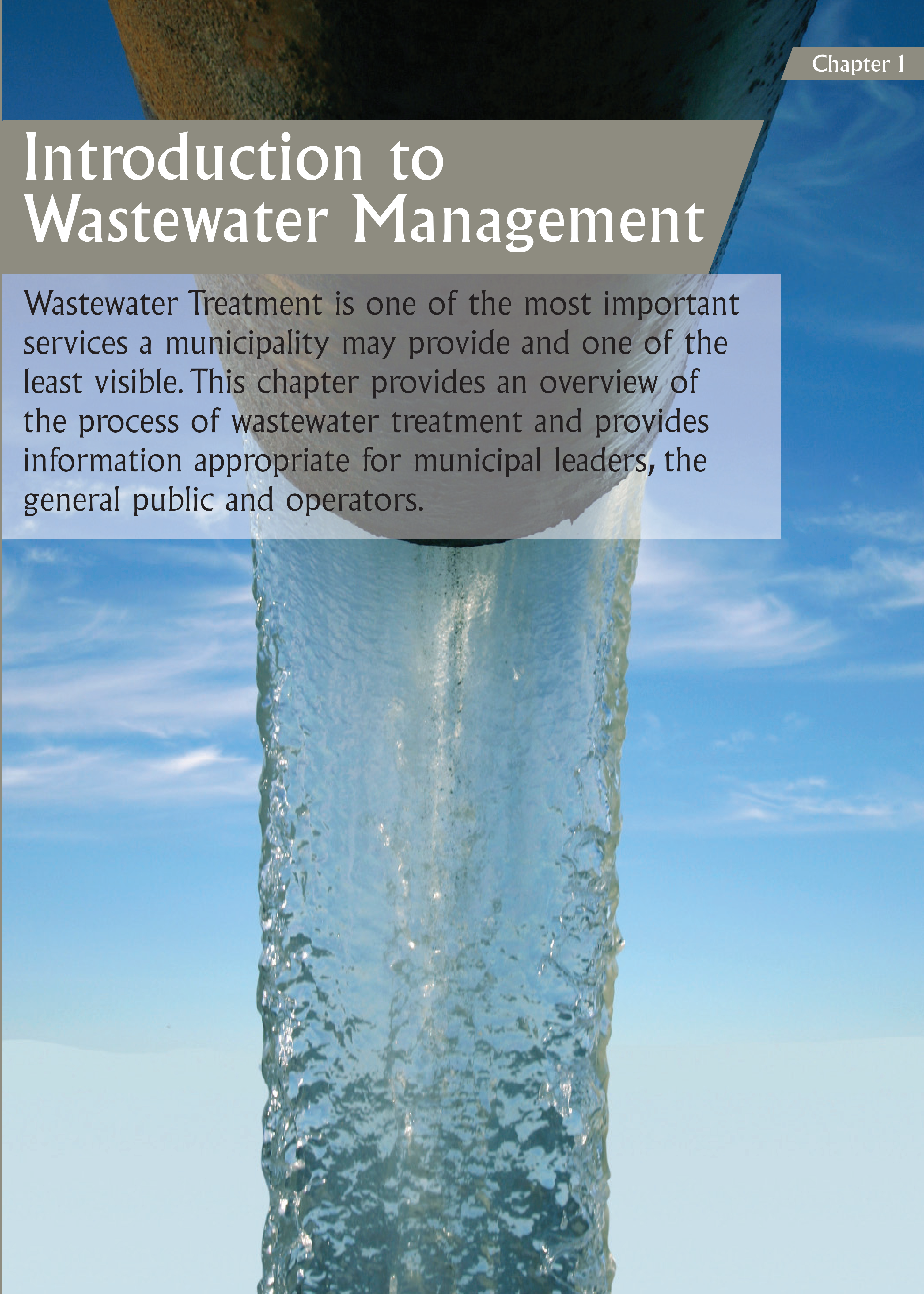
Introduction to Wastewater Management

Wastewater Treatment is one of the most important services a municipality may provide and one of the least visible. This chapter provides an overview of the process of wastewater treatment and provides information appropriate for municipal leaders, the general public and operators.



NYWEA

Environmental Finance Center
Syracuse University

Chapter 1:
Introduction to Wastewater Management

Wastewater 101

Overview

The section provides an overview of wastewater treatment and is intended to provide a brief description of what processes may be at your wastewater plant. Although each plant is designed for particular conditions, there are many similarities in how different processes operate. There may be differences between your plant and a neighboring plant in terms of size, ground area, shape of tanks (circular or rectangular), or the types of treatment processes they use.

What is wastewater?

Wastewater or sewage is the byproduct of many uses of water. There are the household uses such as showering, dishwashing, laundry and, of course, flushing the toilet. Additionally, companies use water for many purposes including processes, products, and cleaning or rinsing of parts. After the water has been used, it enters the wastewater stream, and it flows to the wastewater treatment plant. When people visit a treatment plant for the first time, often it is not what they perceived it would be. These wastewater plants are complex facilities and provide a high quality end product.

"When people visit a treatment plant for the first time, often it is not what they perceived it would be. These wastewater plants are complex facilities and provide a high quality product."

Why treat wastewater?

We need to remove the wastewater pollutants to protect the environment and protect public health. When water is used by our society, the water becomes contaminated with pollutants. If left untreated, these pollutants would negatively affect our water environment. For example, organic matter can cause oxygen depletion in lakes, rivers, and streams. This biological decomposition of organics could result in fish kills and/or foul odors. Waterborne diseases are also eliminated through proper wastewater treatment. Additionally, there are many pollutants that could exhibit toxic effects on aquatic life and the public.

How do we collect the wastewater?

The sewer or collection system is designed so that it flows to a centralized treatment location. The collection system is comprised of smaller sewers with a diameter of about four inches. As more homes and companies are connected along the system, the pipes become larger in diameter. Where gravity systems are not practical, pumping stations are often included to lift the wastewater.

In New York State and in many other states, there are some very old collection systems. Some sewer piping was actually installed in the late 1800s! Materials of construction and methods of construction have changed significantly over the years. Many systems experience problems during wet weather periods with inflow and infiltration. This is commonly referred to as "I&I." Wet weather operating periods typically occur when the snow melts in the spring and/or during heavy rainstorms. Water resulting from snowmelt or storms should flow into a storm water system and not into the sanitary sewer system. Unfortunately, this isn't always the case.

What is Inflow & Infiltration (I&I)?

Inflow is water from a sump pump or a roof leader. This is relatively clean water that should be discharged to a storm water system. In some cases, homeowners in low lying areas connect sump pumps (illegally) to the sewer because it is relatively easy and inexpensive. In many communities, there are "combined sewers" that carry street runoff, as well as wastewater.

Infiltration is water from high groundwater levels. Older sewer pipes may have leaking joints or cracks that allows the water to enter the system. Infiltration usually occurs in the spring when melting snow and rain saturate the ground.

Excessive I&I can lead to Combined Sewer Overflow (CSO) and Sanitary Sewer Overflow (SSO) points in a collection system. If you have CSOs or SSOs, the NYSDEC is probably talking to you about it!

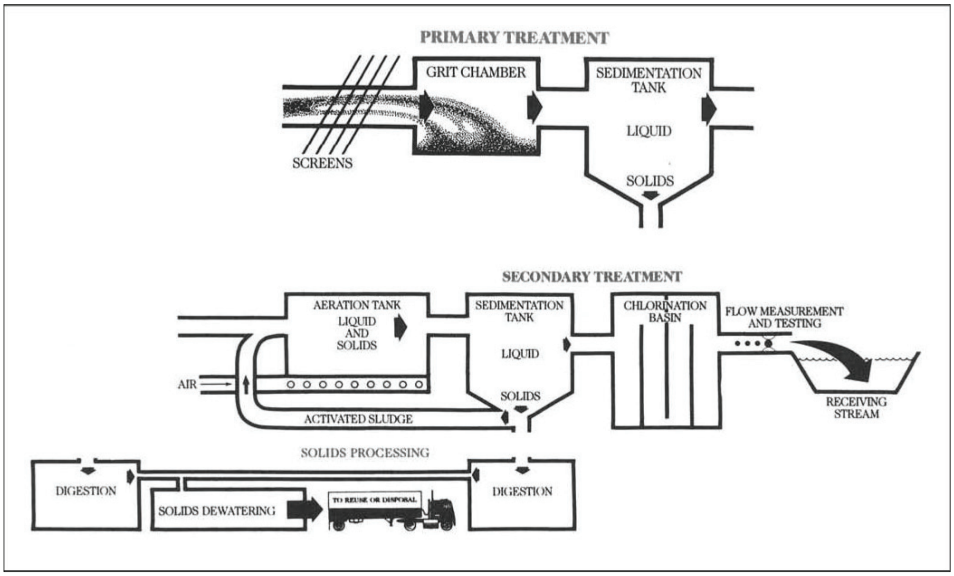


Diagram of Wastewater Treatment Processes from "Clean Water For Today: What is Wastewater Treatment?" Courtesy of Water Environment Federation.

What happens after collection of the wastewater?

The wastewater continues to flow through the collection system and eventually reaches the wastewater treatment plant. Upon reaching the plant, the flow first encounters preliminary treatment. Preliminary treatment is followed by primary treatment, then secondary treatment, and perhaps advanced or tertiary treatment. The solids or "sludge" removed from the wastewater stream also needs to be treated.

What is Preliminary Treatment?

Preliminary treatment processes are the first processes that the wastewater encounters. This typically involves flow measurement so that the operator can quantify how much wastewater is being treated. Flow monitoring is commonly followed by screenings removal. Screenings are string like materials and large foreign objects like sticks or perhaps an errant golf ball. These materials need to be removed because they can damage machinery or clog processes. Screenings can be removed using bar screens and other devices designed for this purpose.

The next process in preliminary treatment is grit removal. Grit is comprised of inorganic material such as sand, gravel, eggshells, etc. It is desirable to remove grit to prevent wear and abrasion on pumps and other mechanical equipment. Grit can also plug lines and pipes. In this influent area, sampling equipment is often used to collect small portions of the wastewater for analysis. Sampling enables the operator to determine the pollutant loadings entering the plant (influent).

Preliminary treatment commonly includes raw sewage pumps. Screening and grit removal are important to the proper operation of the raw sewage pumps. These materials will cause clogging and cause wear on the internal parts. These raw sewage pumps deliver the flow to the next phase of treatment: Primary Treatment.

What is Primary Treatment?

Primary treatment is a physical settling process that removes solids. Wastewater that enters the primary settling tank (or clarifier) is slowed down to enable the heavier solids to settle to the bottom. Lighter materials, such as grease, will float to the top of the tank. Settling tanks are designed with mechanisms to remove both the settled solids, as well as the floating solids. Primary clarifiers are either circular or rectangular. Both types work equally well when properly designed and maintained. Not all plants have primary treatment.

Primary treatment generates primary sludge. The sludge is removed and pumped to the solids treatment process for ultimate removal.

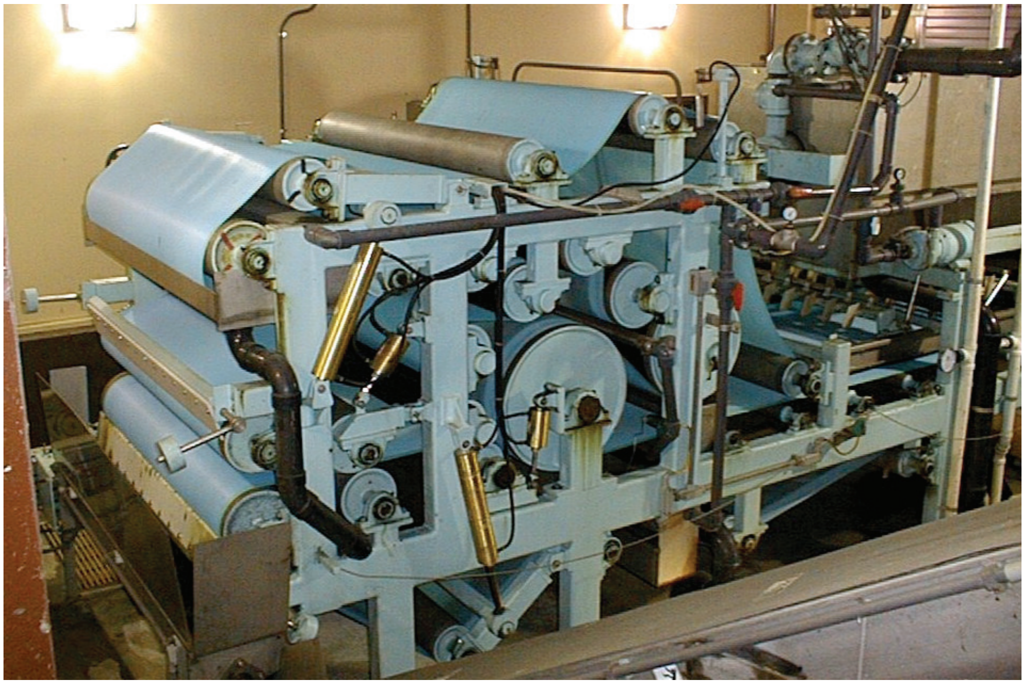
What's left after we remove the pollutants that settle and float? The wastewater still has solids remaining after primary treatment. These solids are either dissolved or suspended. Dissolved solids are very small solids (e.g., dissolving sugar in water). You cannot see the solids but they are there. Suspended solids can be likened to the same ends of a magnet. The solids repel each other. These solids are small, but are visible to the human eye. We remove these dissolved and suspended solids through the next phase of treatment: Secondary Treatment.

What is Secondary Treatment?

Secondary treatment is a biological treatment process used to stabilize the dissolved solids. Microorganisms (e.g., bacteria) feed on the organic solids (food) in the wastewater and convert the organics into a cellular or biological mass that can later be removed. These biological processes are aerobic processes. Oxygen must be provided for these aerobic organisms to work properly and efficiently.

An integral part of secondary treatment processes is another set of settling tanks or clarifiers. These secondary clarifiers (final clarifiers) remove the biological mass that has grown during biological treatment.

There are many different kinds of secondary processes that can be employed. A very common secondary process is known as activated sludge. In activated sludge treatment, the wastewater is mixed with organisms that are returned from the secondary clarifiers. There is a continuous return of organisms from the secondary clarifiers. This is called return sludge or return activated sludge. Oxygen is provided in the aeration tank either by blowers and diffusers or by a mechanical mixing process. A variation of the activated sludge process that is becoming more popular is known as Sequential Batch Reactors (SBR's). This process differs from the more conventional activated sludge systems in that it also uses the aeration tank as a settling tank. This is accomplished by turning off the air to the diffusers or the mixers and allowing the solids to separate from the wastewater. During this settling period, the flow is diverted into a second SBR tank for continuous treatment. Advantages of this SBR process include a relatively small footprint and the capability of removing nutrients (both nitrogen and phosphorus).



A belt press is often used to dewater sludge.

Lagoon systems are also a form of biological or secondary treatment. These lagoons systems are used where there is a lot of land available and/or the wastewater flows (quantities) are low. Lagoons are constructed with lined earthen bottoms and are less expensive to construct than are activated sludge processes that use concrete tanks. Limitations of lagoons may include excessive algae growth (solids violations) and poor performance in the winter.

Another type of secondary treatment is known as fixed film processes. Fixed film processes consist of two types: Trickling Filters or Rotating Biological Contactors (RBC). Trickling filters are sometimes called Bio Towers. Trickling filters are beds with a synthetic material (media). An under-drain system and a rotary distribution system apply the wastewater to the media. The microorganisms grow attached to the rocks or synthetic media as opposed to liquid suspension in the activated sludge. A circular rotary distributor moves over the media bed and the wastewater is trickled onto the media. As the wastewater flows over the media, it comes into contact with the microorganisms and picks up oxygen. When the biological growth becomes too thick, it falls off the media and flows with the wastewater to a secondary settling tank for removal. Many trickling filter plants that originally were designed with rock media have changed to the more efficient plastic media.

The RBC is similar to the trickling filter in that it uses an attached biological growth. An RBC has panels that are circular and mounted to a shaft. The wastewater flows into a basin beneath the media and the media rotates with the shaft. The microorganisms are contacted with the wastewater. Since the RBC's expose the media to the air, oxygen is picked up and transferred into the growth. RBCs have low energy requirements.

Intermittent sand filter (Secondary Treatment).

These systems need to be protected from cold weather by a building.

Intermittent sand filters are employed in some smaller applications. As wastewater passes through the filter bed, solids are removed. Microorganisms grow in the removed solids layer and provide biological treatment of the wastewater as it flows through the sand bed. The sand will need to be replaced at some point in time. Additionally, these sand filter systems generally perform poorly in the winter.

All of the secondary treatment processes produce biosolids. These biosolids are pumped to the solids treatment system for further processing.

What comes after Secondary Treatment?

In many plants, the next process is called disinfection. Disinfection means the inactivation of disease-causing organisms. It is sometimes confused with sterilization which means the killing of all organisms. In disinfection, the wastewater following secondary treatment is usually treated in one of two ways: (1) chlorination or (2) ultra-violet radiation.

Chlorination involves the use of chlorine, either in the form of a gas (less common today), or as a liquid (sodium hypochlorite). The chlorine oxidizes the microorganisms. The effectiveness of this process is monitored by testing the fecal coliform group. This indicator group of microorganisms are easy to grow in a laboratory and are tougher to kill than pathogens. Some chlorination systems also have dechlorination systems to remove any residual chlorine.

Ultraviolet (UV) disinfection systems contact the treated secondary wastewater with UV light bulbs that are encased in clear housings. The UV light kills pathogenic organisms by using a germicidal photochemical wavelength. Unlike chlorination, UV leaves no residual in the wastewater with which to be concerned. Plants that use UV must either have dual UV systems or have chlorination as a backup. Additionally, these UV systems are energy consumptive.

What is Advanced Treatment?

Some treatment plants may be required to remove nutrients (nitrogen and phosphorus) due to the possible negative impacts on the receiving stream (e.g., ammonia toxicity to fish). Advanced treatment processes are used to remove nutrients, additional solids, and/or biochemical oxygen demand. Advance treatment provides a very high level of treatment that goes beyond secondary treatment. In the case of nitrogen removal, the processes are biological. For phosphorus removal, chemical additives are normally required.

Where do all the solids go?

Solids that settle out in the primary and secondary clarifiers are referred to as sludge. Sludge from biological treatment processes (e.g., activated sludge) are referred to as biosolids. Sludge is the byproduct of

Rotating biologial contactors (Secondary Treatment).

treating the liquid wastewater. Proper solids handling is of paramount importance. If sludge is not removed, problems will occur in other areas of the plant. Excess solids can also lead to State Pollution Discharge Elimination System (SPDES) Permit violations and odor problems. There are many different options available for solids handling. Local conditions usually dictate which option is best for your particular facility. General categories of sludge handling include digestion processes, hauling of liquid sludge to a larger treatment plant, thickening, dewatering by mechanical means (belt filter presses, centrifuges), incineration, land filling, and land application.

The Herkimer County Wastewater Plant is designed for 6.1 million gallons per day (mgd). Sludge is pumped to a gravity thickener, treated to reduce odors, and dewatered using a belt filter press. The dewatered solids are treated using dry lime for stabilization and loaded into a roll off container. A contractor takes the container and stores the solids. The sludge is later land applied on crop fields.

The City of Little Falls Wastewater Plant is a 5.0 mgd design and pumps the sludge to a gravity thickener. Solids are dewatered using a belt filter press and then incinerated. The remaining ash is landfilled.

The Village of Clinton Wastewater Plant is a 2.5 mgd design that gravity thickens the sludge before pumping into an anaerobic digester. In the past, solids removed from the digester were pumped to a drying bed and landfilled. The drying beds were troublesome due to weather dependency e.g. rain and winter. Solids from the anaerobic digesters now go to a belt filter press, and then to a landfill.

The Old Forge Wastewater Plant (0.45 mgd) pumps the sludge to an aerobic digester. When the digester approaches capacity, the solids are then treated with polymer and processed through a thickening device. The solids are stored in another aerated tank until it is time to call for a tank truck. A contractor hauls 6,000 gallons to the Watertown Wastewater Plant for further treatment and disposal.

In summary, there are many options available for sludge treatment and handling.

Where does the water go after treatment?

The treated wastewater is referred to as effluent. The effluent is discharged to a water body such as a lake, river, stream, or groundwater. Conditions contained in the SPDES Permit are designed to minimize the

Sand drying beds can be problematic, particularly with rainy conditions.

Fixed film and old trickling filter stone, left, are sometimes replaced with more efficient plastic media, right.

impact that the effluent may have on the receiving stream. Small streams that have a classification of trout spawning or that are used downstream for drinking purposes have more stringent (tighter) permit limits than streams that discharge into a water body with a higher flow and/or sizeable tributaries.

What are common wastewater terms?

In wastewater vernacular, there are acronyms for many processes. Some of the most common terms are listed below with a brief description. A more comprehensive glossary of wastewater terms can be found at the end of the handbook.

Aerobic: A process that requires dissolved oxygen to operate properly. The microorganisms need the oxygen to "eat" the food properly.

Anaerobic: A process that can operate or needs to operate without oxygen being present. A good example is an anaerobic digester used for solids handling.

Biochemical Oxygen Demand (BOD5): A test that measures the organic strength of a sample of wastewater. It provides information on the organic load or how much "food" there will be for organisms. The load can be either to a treatment plant unit or to a receiving water body.

Clarifier or settling tank: Tanks designed for the physical separation of wastewater floatable solids and settleable solids. These two terms are widely used interchangeably.

Disinfection: Killing disease-causing organisms, differing from sterilization, which kills all organisms.

Dissolved Oxygen (DO): A test usually performed by an electronic meter that measures the dissolved oxygen of a sample or process unit. It is important because many of the treatment processes require oxygen (aerobic) to operate properly. Too much oxygen can mean that money is wasted through excess energy consumption to provide the oxygen, which is relatively insoluble in water.

Effluent: Wastewater or other liquid, partially or completely treated, flowing from a reservoir, basin, treatment process, or treatment plant.

Influent: Wastewater or other liquid flowing into a reservoir, basin, or treatment plant.

Parts per million (ppm) or milligrams per liter (mg/L): These terms refer to the results of analyses such as TSS or BOD5. These terms are used interchangeably and mean exactly the same thing.

Total Suspended Solids (TSS): Data from a test that measures by weight how much particulate material is contained in wastewater samples by filtering the sample through a special fiberglass filter. For example, TSS measures the solids that can be seen in a beaker.

Additional Resources

Biosolids Recycling: An Environmentally Sound Way to Put a Valuable Resource to Work for All of Us Nature's Way: How Wastewater Treatment Works For You Clean Water for Today: What is Wastewater Treatment? Be in the Know, Go with the Flow!

All available from:
Water Environment Federation
601 Wythe Street Alexandria, VA 22314-1994
Phone: 703-684-2452
Fax: 703-684-2492
www.wef.org

Personnel Management

Communities should consider personnel management as important as funding for equipment repair and replacement. Local officials must realize that an adequate, well-trained staff is necessary both to provide cost-effective Operations and Maintenance (O&M) of their facilities and to ensure compliance with all regulatory requirements.

This section will provide some guidelines to help local officials determine the necessary steps to develop the best possible staff.

Developing an Adequate Staffing Plan

Generally, staffing is the largest component of an O&M budget for a wastewater facility. For small communities, these costs comprise the main budget component. Local officials should not try to reduce O&M direct labor costs as a way of cutting budgets. For example, it may be that large amounts of overtime pay are being spent on existing staff. Hiring additional personnel may be a more cost-effective approach to spending personnel dollars. Another factor involved in determining staffing cost effectiveness is the use of outside contractors to perform certain O&M functions. A community might consider using contractors for functions such as major maintenance or overhaul.


Aerated lagoons are secondary treatment processes.

Development of a staffing plan will not only ensure cost effectiveness, but will also help local officials meet their responsibility to ensure that wastewater facilities comply with state and federal regulations. Inadequate or poorly trained staff inevitably leads to non-compliance problems and potential fines. In addition to complying with appropriate regulations, local officials also have a responsibility to the citizens of their communities to provide uninterrupted utility service. Protection of the environment is the key consideration in the management of a utility system. An adequate staffing plan is essential to achieving that goal. Here are the steps for preparing a staffing plan:

1. Develop an organizational chart. It is important to have a clear organizational chart to determine how utilities need to be managed. The current trend is to separate water and wastewater utilities from other public works to improve performance, and to enable technical personnel to develop comprehensive expertise in their areas of responsibility. To effectively implement this organizational approach, local officials need adequate information about specific job responsibilities to then determine the number and type of personnel required. The product of this first step in developing a staffing plan is an organizational chart showing all lines of supervision and authority, all filled and unfilled positions, and an approximation of all needed, but as yet unauthorized positions.
2. Conduct a task analysis. A detailed task analysis will help determine how many workers are needed and the level of experience and expertise necessary for each wastewater facility job. Begin by identifying all O&M tasks that must be accomplished to ensure adequate performance by the facility. Include tasks that are currently being accomplished, as well as those that should be done but might not be due to lack of time, talent, or other resources. The task list should reflect all routine O&M tasks required for the entire year. Some tasks may be daily, while others might be performed weekly, monthly, or even yearly. To develop a comprehensive task list that truly reflects the needs of the facility, an experienced supervisor familiar with the facility should be involved at all stages of the task analysis. The product of this second step in developing a staffing plan is a comprehensive task list, organized by unit processes.
3. Determine staffing requirements. The next step is to review the task list and estimate the time each task normally requires. It is necessary to compute the total number of person-hours per task, per technical skill, per year required to provide adequate O&M of the facility. Once that number is determined, it may be divided by the total number of hours that each worker is available per year, taking into account vacations, holidays, etc. In this way it will be

possible to derive a number that approximates the personnel hours needed to provide adequate O&M for the facilities in question. The product of this third step in developing a staffing plan is a break out of required staffing hours, by skill and by task.

4. Create job descriptions. Once the estimated number of staff hours is determined, the organizational chart should be appropriately modified and each staff member's responsibilities redefined. Detailed job descriptions for each position identified on the chart should be prepared or old job descriptions should be modified and updated. Remember to get input from the people actually doing the job. Job descriptions should include areas of responsibility, summaries of required tasks, subordinates supervised, and supervisors to whom reports are made. The product of this fourth step in developing a staffing plan is an updated set of written job descriptions.
5. Implement staffing changes. After approving the staffing changes recommended by steps 3 and 4, the O&M budget must be modified appropriately. In addition to follow-up budget monitoring relating to these staff changes, management should periodically assess them in terms of improved efficiency and performance of the utility's O&M.

The product of this final step in developing a staffing plan is a new written staffing plan and corresponding budget.

Plant Coverage

Plant coverage guidelines call for enough time for the operators to collect, analyze, and record required samples. The plant should be staffed by the Chief Operator or Assistant/Shift Operator a minimum of two (2) hours every day. Additionally, the Chief Operator should be on-site not less than 30 days per calendar quarter. Note that these are the minimum levels of coverage and NYSDEC's Regional Water Engineer may require more coverage depending upon plant size, the receiving water, permit limits, etc.

Certification and Training

The "Grades" of certification are divided into the following levels: 1, 2, 3, and 4. Grade 1 is the lowest level of certification and applies primarily to the smallest plants. Activated sludge plants have an "A" designation. A "Scoring System" is used to determine the required Grade of Chief and Assistant/Shift Operators.

Education requirements vary depending upon Grade. The minimum education required is High School Diploma or High School Equivalency. Classroom training also varies as a function of Grade. For a Grade 2A applicant, the following training is required:

- Basic Operations Course (10 days)
- Activated Sludge Course (5 days)
- Laboratory Proficiency (5 days)

Grade 3/3A operators would also need the Supervision and Technical Operations Course (5 days). Grade 4/4A operators would go on to take the Management Course (4 days).

All applicants must have hands-on operating experience and must have his/her actual operating experience verified. Applications with the necessary documentation are sent to the New York Water Environment Association (NYWEA) and also filed with the NYSDEC Regional Offices and for water operators sent to County Health Department where appropriate.

All certified wastewater operators are required to renew their certificates every five (5) years. Treatment technologies are changing and operators need to keep abreast with the latest operational approaches. Operators are required to attend seminars and obtain between 20 and 80 training contact hours. Failure to renew means that the certificate has expired and that the operator is not certified. If the Chief Operator's certificate has expired, he/she is not certified and the plant may not be under responsible supervision. In a well-run facility, good training will result in a substantial payback. Local officials need to vigorously support continuing education to comply with the regulations. Certified operators generally do a better job. Annual budgets should include line items for certification training (when appropriate) and for renewal training. Work plans and schedules should allow for time to attend training.

Regulations provide for the suspension and/or revocation of operator certificates if the operator was negligent, or practiced fraud or deceit in the performance of his/her duties. The operators are expected to keep up on maintenance and routine sludge removal. Local officials have to financially support these activities. Falsification of data and discharge monitoring reports is very serious and criminal.

All the certification requirements are described in 6NYCRR Part 650 – Qualifications of Operators of Wastewater Treatment Plants and in the Wastewater

Treatment Plant Operator (WWTPO) Manual. For electronic copies of Part 650 and the WWTPO Manual, visit the following website: http://www.dec.state.ny.us/website/dow/bwcp/opcert.html For paper copies, contact NYSDEC's Facility Operations Assistance Section, 625 Broadway, Albany, NY 12233-3506 or call 518-402-8089.

Additional Training Needs

In addition to ensuring compliance with certification regulations, a comprehensive training program for wastewater operators will provide other significant benefits for a local government. A well-trained staff is essential for efficient utility O&M. Good training will result in a substantial payback over the years in terms of well-run facilities. Far-sighted local officials will make sure that O&M budgets provide adequate funds for staff to go to the best training available. This may mean sending staff to off-site training events, paying the cost of course registration as well as travel expenses, or having staff attend training programs during working hours and directing other personnel to fill in during that time.

Another training option is to contract on-site training customized to the individual wastewater facility. Not all training needed is technical in nature. Training programs relating to management, supervision, and other important skills, such as effective report writing and use of the computer, are also important in developing a more efficient and productive staff.

If the staff size is sufficiently large, it may be a good idea to designate a training coordinator. This individual can determine staff training needs and watch for appropriate training opportunities or courses. The training coordinator can schedule employees for off-site training, set up on-site training classes, and monitor the training budget. The coordinator should also evaluate the training programs and determine which ones are most effective in improving staff performance. The individual coordinating training should have some technical experience in water or wastewater treatment.

Training Sources

Many sources of training are available for operators of wastewater treatment facilities. Training will be available through the following organizations:

- State environmental training centers
- State regulatory agencies
- Operator associations
- Professional organizations such as the Water Environmental Federation, the American Water Works Association, and the Rural Water Association In addition, a local government may contract training, including on-site programs, using operations and maintenance consultants, consulting engineers, or manufacturer's representatives.

Quality training opportunities are important for staff development. The best training is not necessarily the cheapest. It is up to local officials to work with their staff to ensure that training being considered develops a staff that can provide effective O&M of the water and wastewater facilities.

Examples of Training Providers

NY Water Environment Association
525 Plum Street, Suite 102
Syracuse, NY 13204
Phone: 315-422-7811
Fax: 315-422-3851
www.nywea.org

NY Rural Water Association
PO Box 487
Claverack, NY 12513
Phone: 518-828-3155
Fax: 518-828-0582
www.nyruralwater.org

New England Interstate Water Pollution Control Commission
116 John Street
Lowell, MA 01852-1124
Phone: 978-323-7929 or 978-323-7930
Fax: 978-323-7919
www.neiwpcc.org

New York State Department of Environmental Conservation (NYSDEC)
Facility Operations Assistance Section
625 Broadway,
Albany, NY 12233-3506
Phone: 518-402-8089
Fax: 518-402-8082
www.dec.state.ny.us/website/dow/bwcp/foas_main.html

Environmental Finance Center
at Syracuse University
727 E Washington St
Syracuse, NY 13210
Phone: 315-443-4445
efc.syracusecoe.org

NYSDOL, Public Employee Safety and Health
State Office Campus, Building 12
Albany, NY 12240
Phone: 518-457-5508
Fax: 518-485-1150
www.labor.state.ny.us./workerprotection/safetyhealth/DOSH_DIRECTORY.shtm

US DOL, Occupational Safety and
Health Administration
201 Varick Street, Room 670
New York, NY 10014
Phone: 212-337-2378
Fax: 212-337-2371
www.osha.gov/oshdir/r02.html

Collection System and Plant Maintenance

Overview

Maintenance is essential to the sustainability of every wastewater system. A preventive maintenance program combined with good operational practices will reduce the need for much of the corrective or emergency maintenance. A good preventive maintenance program will service not only mechanical and electrical equipment, but also the distribution and collection systems, grounds and buildings.

Maintenance includes all functions required to keep a facility operating in accordance with its original design capacities and performance. This includes repairs to broken, damaged, or worn-out equipment (emergency maintenance), and the periodic replacement of equipment and facilities that have reached the end of their design life (corrective or replacement maintenance).

Maintenance Program Elements

A comprehensive preventive maintenance program will have the following components:

- Equipment and component inventory
- Manufacturer's literature
- Preventive maintenance task list
- Records of maintenance performed
- Technical resources
- Tools and equipment
- Spare parts inventory
- Personnel training
- Budgeting
- Scheduling and monitoring
- Recordkeeping

Equipment and Component Inventory

The backbone of any preventive maintenance program is a comprehensive listing or inventory of all system components and equipment. This listing should include a name and code number to every part of the system.

Manufacturer's Literature

For each piece of equipment or component identified in the inventory, the manufacturer's literature should be obtained and compiled. For a new or upgraded facility, it is often the contractor's responsibility to provide manufacturer's information for all installed equipment.

Preventive Maintenance Task List

Once all of the equipment and components have been itemized and the manufacturer's literature has been collected, it is time to develop the comprehensive list of preventive maintenance tasks and to schedule them. Working systematically through each component of the facility, and remembering to address additional areas such as building and grounds maintenance, all preventive maintenance tasks must be identified and a frequency for scheduling should be assigned.

Records of Maintenance Performed

Records must be kept indicating which maintenance tasks have been performed and when. This is helpful for two reasons. First, it is imperative to verify the completion of each maintenance task. Second, to schedule future maintenance activities or to verify the condition of certain equipment, it is always helpful to be able to refer back to the record of past maintenance performed. All tanks should be inspected once per year.

Technical Resources

Manufacturer's maintenance specifications do not always provide complete information on all maintenance tasks. Certain general maintenance tasks are not covered in detail in manufacturer's maintenance manuals, and many general maintenance tasks are not addressed in manufacturer's information at all.

Tools and Equipment

Every wastewater system must have suitable tools and the required specialized equipment available to perform maintenance. These tools and equipment should be of good quality, because they are likely to be used for many years.

Spare Parts Inventory

It is important to maintain an inventory of spare parts required for preventive maintenance, as well as for corrective and emergency maintenance. The initial inventory must be developed based on the requirements of each preventive maintenance task. Procedures also should be implemented to make sure that parts are replaced in the inventory as they are used. Database management of spare parts inventories is usually necessary in larger utilities.

Personnel Training

Even a well-developed maintenance program with a full staff for implementation will not be able to complete the required work unless the staff are trained in both how to carry out the maintenance program and in the precise skills required to perform specific maintenance tasks. If the maintenance program has not been developed internally, the consultant or entity that developed it should be required to provide training in its implementation.

Budgeting for Maintenance

Budgeting for maintenance will require that sufficient funding is available for the following:

- Preventive Maintenance—Operating budget
- Labor (staff time, person hours) Parts and supplies Equipment
- Emergency Maintenance—Operations reserve account
- Labor (overtime) Materials, parts, supplies Replacement equipment Contractors
- Equipment Replacement—Capital reserve account
- Evaluation and design Labor Equipment cost Contractors

Estimating Staff Hours for Various Maintenance Functions (Task Analysis)

Sufficient labor must be available and funded for preventive maintenance functions. A good preventive maintenance program will document the schedule and work plan for each maintenance function. This schedule serves as the basis for estimating the labor requirements for preventive maintenance.

To determine trade and person-hour requirements for each preventive maintenance function, the function should be broken down into tasks. The tasks can then be analyzed further to determine person-hours required for the specific maintenance function and the specific trades needed.

Setting Up a Reserve Account for Emergency Maintenance

Development of an annual budget for maintenance is relatively easy and straightforward, if emergency maintenance is sufficiently funded as annual reserve account contributions.

Emergency maintenance is perhaps the most difficult function to address when trying to anticipate the funding requirements for an emergency repair reserve account. A good preventive maintenance program will cut down on emergency maintenance requirements. Unforeseen conditions, defective equipment and materials, and acts of nature make it certain that some emergency maintenance will always be a fact of life.

Devising Management Systems to Ensure Timely and Cost-Effective Maintenance

Basic preventive maintenance and record keeping systems are typically card systems that can be adapted to the complexity of the facility being served. Simple single card systems use one card for each piece of equipment, with the front detailing the equipment and its maintenance requirements and the back recording maintenance performed (see the Sample Equipment Maintenance Card). Multiple card systems are similar, but use separate cards for equipment information, maintenance requirements, and records of maintenance performed.

Many utilities are moving away from card systems and using one of the many software programs developed specifically for scheduling and tracking preventive maintenance. When used as part of an asset management strategy, these software programs can be very useful for the wastewater facilities.

A very important part of the preventive maintenance program development and improvement is appropriate scheduling of maintenance activities. Preventive maintenance schedules must consider variations in plant and equipment utilization. For example, in wastewater systems, this may involve scheduling to accommodate seasonal wet weather flows or intermittent industrial discharges.

Scheduling should consider weather and its effect on maintenance activities and personnel. Whenever possible, outdoor maintenance activities should be scheduled when favorable seasonal weather conditions can be expected.

Maintenance Reporting and Record Keeping

Once maintenance is performed, it must be properly recorded in a timely fashion, usually on the same day as performed. Preventive maintenance tasks are not complete until their accompanying paperwork is done.

Protecting and Maintaining Wastewater Infrastructure

This section is a compilation of material provided by J. Kirk Rowland, a NYWEA Past President and Division Head – Water & Sewer Maintenance for the Town of Tonawanda and Keneck Skibinski, a NYWEA Past President and Chief Operator for the Town of Orangetown.

Overview

Wastewater infrastructure is a huge capital investment which must be protected and maintained. It is the responsibility of the elected officials and board members to effectively carry out the associated financial and administrative responsibilities for positive, long term stewardship of this capital asset.

Wastewater infrastructure systems are comprised of many components including the collection system pumping stations, treatment plant and personnel. As was emphasized in "Wastewater 101," problems with any one component can have an adverse impact on the rest of the system, often with costly consequences. In many municipalities, wastewater infrastructure is the most significant budget expense next to highway projects.

In addition to the costs incurred to design and build infrastructure systems, both capital and operations expenses are affected by current events. Remember the rise in fuel costs during 2005 that was stimulated by Hurricanes Rita and Katrina? Many communities have also been impacted by changing regulations on Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs). Increasingly stringent regulations and rising fuel and materials costs are significantly impacting your wastewater system's bottom line. To ensure proper long term stewardship, local officials and board members should be familiar with the bottom line.

Budgeting Basics for Wastewater Utilities

In a general sense, the budget can be divided into two basic categories: Operation & Maintenance (O&M) and Capital Expenditures.

The O&M budget provides for the support of routine maintenance, daily operations, and scheduled repairs. Every piece of equipment has a life cycle and will eventually deteriorate to the point of replacement. Without a long term Capital Improvement Plan (CIP) and a funded reserve account to support the CIP, your municipality could find itself without the funds to support needed replacements.

User fees, typically based on metered water consumption, are collected to fund the O&M component. A proper budget ensures that staff, chemicals, and parts are available to keep the system properly operating. A proper budget also helps the municipality to meet their SPDES Permit, which is a legal obligation.

Municipal debt obligations are paid by funds that are typically raised by a tax levy based upon assessed valuation. These funds pay for the debt service on the original bond issued to construct the plant and any other projects that have been undertaken and financed by bonds or bond anticipation notes.

Case Studies

The following case study is intended to illustrate the critical importance of budgeting and project planning to help in maintaining a healthy bottom line.

Village of Weedsport

The Village of Weedsport is a small village in Cayuga County with a total population of approximately 1,800. The Village owns and operates a sanitary sewer system consisting of gravity collector sewers and a wastewater treatment plant (WWTP) with a permitted capacity of 550,000 gallons per day. The sanitary sewage collection and treatment system was originally constructed in 1967 and the WWTP, with an original capacity of

0.35 MGD, was operated for over 35 years without a major upgrade. As of 2009, the plant was operating at its full capacity, and experienced peak wet weather flows up to 10 times its average flow, forcing operators to use emergency bypass pumping to prevent sewer surcharging and basement flooding.

The village's sanitary sewer budget for 2009 was approximately $350,000. The budget can be broken down into the following categories, with percentages of the total budget for each category indicated:

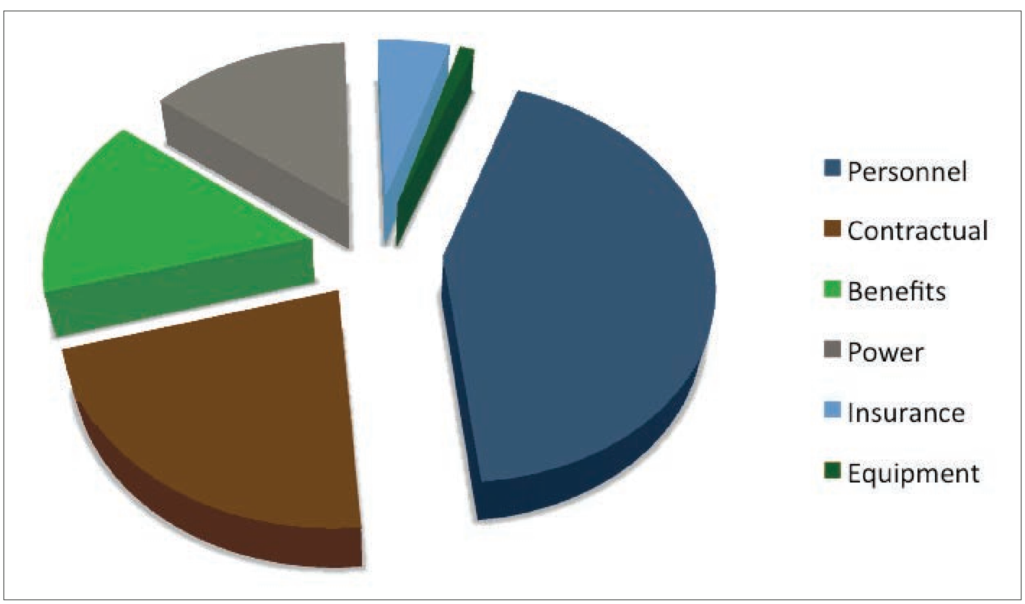
- Personnel 43%
- Contractual 22%
- Benefits 15%
- Power 14%
- Insurance 5%
- Equipment 1%

A portion of the contractual costs, since approximately 2001, has been allocated toward an annual sewer televised inspection and grout sealing program. This is where approximately 15 to 20 percent of the village's gravity sewers undergo internal video inspection followed by pressure testing and grout sealing of leaking pipe joints. Although the program does not appear to have removed I/I (inflow and infiltration) from the system to a significant degree, it was reported that the program was successful in keeping I/I rates from increasing further. It also provided valuable information to the village DPW regarding the condition of the pipelines and identifying defects in the sewer system which could not be repaired by grout injection and required further evaluation.

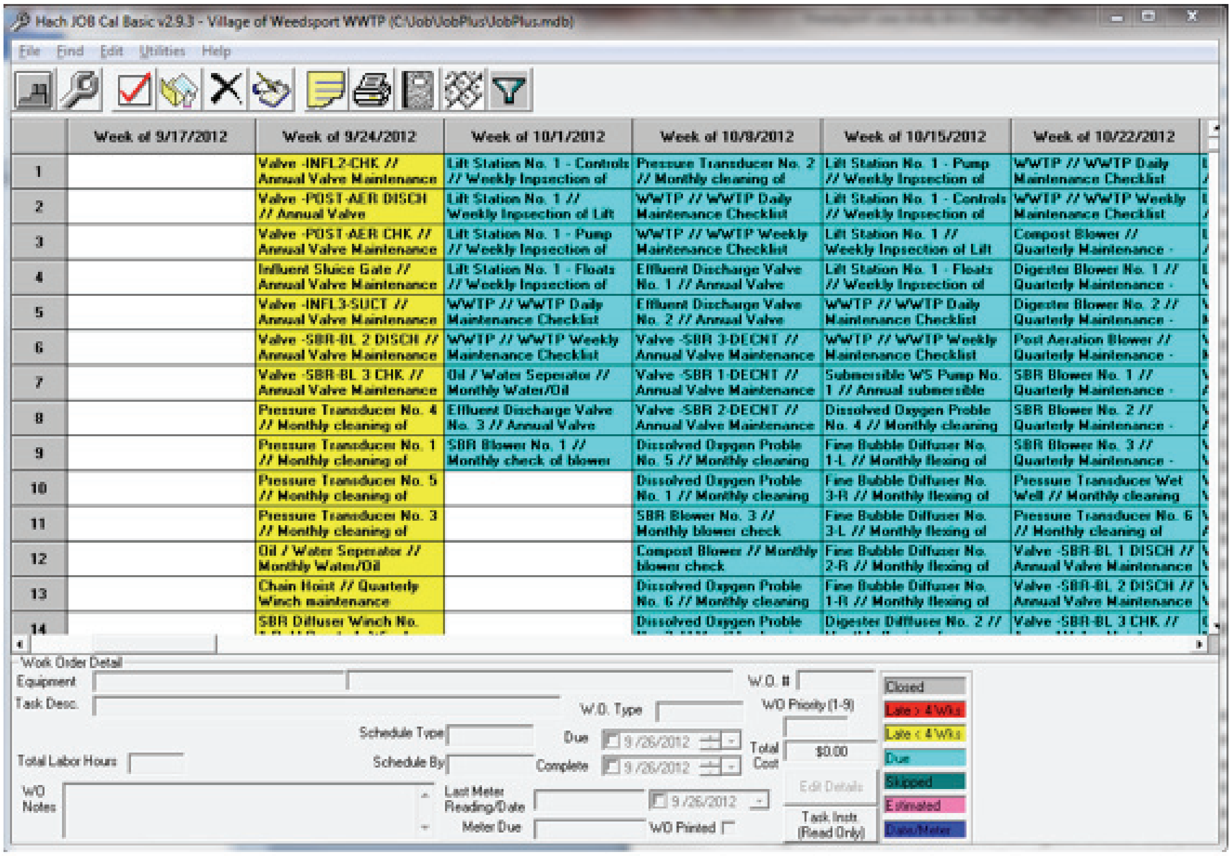
The village has also maintained capital reserve accounts to pay for unexpected repairs, engineering studies, etc., as needed. As of 2009, the village had approximately $74,000 in capital reserves. Capital reserves are replenished annually with sewer fund surplus funds.

The Village Board, recognizing that the WWTP was at the end of its useful life, authorized an engineering study in 2004. It was through the preliminary data collection and analysis phase of the study that the 10 times peaking factor during wet weather was quantified. In accordance with NYSDEC design standards (i.e., "10 State Standards"), any upgrade to the village's WWTP would have to be designed with tanks and equipment sized to handle these peak flows, effectively resulting in oversizing the facilities for the normal flow conditions which otherwise prevail at the plant. On this basis, the village board authorized an I/I evaluation; but because of the information gathered through the televising program initiated years earlier, the areas in the system with severely deteriorated gravity sewers and suspected storm sewer cross connections were identified. The village was able to complete the I/I study for significantly less cost by directing the engineer's study efforts to the worst areas. Through the I/I study, a sanitary sewer rehabilitation project was developed to include lining of severely deteriorated sections of gravity sewer piping, and sealing and redirection of two (2) significant storm sewer cross connections. The total cost of the sanitary sewer rehabilitation project was approximately $570,000, saving an estimated $1 million to $1.2 million in additional costs for oversized WWTP equipment and structures.

The Village of Weedsport completed the engineering study in 2006 which included recommendations for WWTP improvements to increase treatment capacity from 0.35 to 0.55 MGD, combined with I/I



Weedsport's sanitary sewer budget breakdown.



Weedsport's Asset Management Program.

reduction for a total estimated cost of $6.3 million. The project was eligible for loan financing through both the NYSEFC Guarantee Financing Program and USDA Rural Development, with a best case scenario debt service charge of approximately $400 per year per household, on top of an average sewer system operations and maintenance charge of $160 per year per household. The village decided to proceed with design improvements in 2008, and had permits and approvals in place for construction by February 2009. The project was positioned to take advantage of significant funding through the American Recovery and Reinvestment Act (ARRA) of 2009, which included a 50 percent "principal forgiveness" grant as well as an additional grant for "green" energy efficiency measures incorporated into the design (including oxygen level based aeration control, building insulation exceeding state code requirements, and LED light fixtures).

Construction of the sanitary sewer rehabilitation and WWTP improvement projects were completed in 2010, and in spite of increasing the plant's capacity by 57 percent, the Village has seen no noticeable increase in power consumption at the plant. With the ARRA funding for the project, the village debt service charge was reduced to $127 per year per household.

In order to protect its considerable investment in its sewer infrastructure, the village decided to develop an Asset Management Plan (AMP), including a software based maintenance tracking program. Through these efforts, the village is now performing all scheduled maintenance on new equipment, and is keeping records of labor, materials and equipment expended in maintenance on the new plant, so that it can accurately budget for annual maintenance costs. Additionally, the asset management software tracks the remaining useful life of every asset in the sewer system, and includes a capital planning module that allows the village to anticipate future capital expenditures for major equipment repairs and replacement. This will allow the village to establish capital reserves to repair and replace critical pieces of equipment, and anticipate the need for a capital project, if necessary, once large portions of the sanitary sewer system near the end of their useful life.

The Village of Weedsport's experience with the process of upgrading its sanitary sewer infrastructure illustrates several important points:

1. Take a proactive approach to addressing issues with sanitary sewer infrastructure. In Weedsport's case, completing the project planning and design without being forced through a NYSDEC order was essential to take advantage of the ARRA funding received. Project readiness will typically put a project at "the front of the line" for funding, and requires forethought and initiative on the part of municipal officials.
2. Maintain the sewer infrastructure, which serves several purposes:
   a. Get familiar with your infrastructure: Had the village not engaged in annual televising, testing and grout sealing of its collector sewers, it would not have been able to pinpoint some of the large sources of I/I in the system, leading to additional costs and time for study, and potential diminished results from the sewer rehabilitation project.
   b. Extend the useful life of the system. The useful life of WWTP equipment is typically 20 to 30 years maximum. Through diligent maintenance, the village was able to keep the plant operating for over 40 years without a major upgrade. This would not have been possible without investing in equipment maintenance.
   c. Asset management. With the AMP initiated by the village immediately after completing the sewer improvement project, they will be able to protect and sustain the investment made in their sanitary sewer infrastructure through the maintenance scheduling and tracking module in their asset management software. Going forward, the Village will be able to use the asset management software's financial module to set annual budgets for collection system and plant maintenance as well as plan long-term capital reserves to "self-finance" future capital improvements.

This chapter prepared by Keneck Skibinski, Chief Operator for the Herkimer County Sewer District; Phil Smith, former Section Chief at NYSDEC; David Cross, Associate Engineer Monroe County Pure Waters and Brian Skidmore, Managing Engineer, Barton & Loguidice.