Drinking Water Distribution - Best Management Practices

Quick Reference Guide

Performance Monitoring

	General Recommendation	Supplemental Information	Budgetary Cost
System Wide Performance Monitoring	Daily, Monthly, Annually	System wide performance monitoring should be performed on an ongoing basis. This job is made easier by SCADA systems using flow data from the treatment plant and pump stations. System-wide performance monitoring will allow you to monitor gradual changes in the efficiency of water delivery.	Minimal - Requires better organization and understanding of existing information.
District Area Metering	Monthly, Annually	District Meter Area (DMA) management involves subdividing the distribution system into districts by manipulating of valves and measuring total water to metered consumption. The subsequent analysis of flow, particularly of the night flow, is used to calculate the level of leakage within the district. DMA flow monitoring is used to determine not only whether work should be undertaken to reduce leakage, but also to compare levels of leakage in the different districts to assess where it is most beneficial to undertake leak location activities.	District meters must be installed. Otherwise this effort requires minimal amount of additional work for analysis. Analysis can be automated using the SCADA and Billing System. Budget 5 to 10 staff hours monthly per district.
Water Audits	Annually	Audit results are more useful when the results are compared over time. The audit program will help producers to identify area in data collection and analysis. The industry is moving toward benchmarks based upon the volume water loss per service connection in densely populated urban situation and volume water loss per pipeline distance in sparsely populated rural systems. **Reference "The Water Audit Handbook for Small Drinking Water Systems - EFCN Smart Management for Small Water System Program"**	Budget 40 to 120 staff hours annually.

Condition Assessments

	General Recommendation	Supplemental Information	Budgetary Cost
Valve Exercising and Maintenance	All valves (such as distribution and transmission valves, air valves, and blow-offs) should be inspected and operated on a regular basis. (I could not locate any specific recommendations)	A valve exercising is a procedure that verifies proper location, operation, and material condition of valves, and initiates replacement as necessary. The physical operation of a valve and the documentation of the actions and procedures necessary to do so are equally important. The useful lifespan of valves at 40 years is less than half that of the pipe to which they are connected. Operational valves are necessary to fix water main breaks which are more likely to occur as the pipeline ages. Plan accordingly.	
Hydrant Testing and Maintenance	Hydrants should be inspected (flushed) twice a year, spring and fall.	The inspection and testing of fire hydrants is critical to determining the readiness of the hydrants to provide water at fire emergencies. The inspections shall verify the location, accessibility, proper mechanical operation, and water flow from the hydrant.	
Pipeline Condition Assessment	One factor used to quantify the occurrences of failing underground pipe is water main break rates. Water main break rates are calculated for all pipe materials used in the transport of water to create a measurement to judge pipe performance and durability.	The Average Age of Failing Water Mains is 47 years old. While pipe life can be estimated at over 100 years, actual life is affected by soil corrosivity and installation practices. Corrosion is a Major Cause of Water Main Breaks. One in four main breaks is caused by corrosion which is ranked the second highest reason for water main pipe failure. When failures rates of Cast Iron, Ductile Iron, PVC, Concrete, Steel, and Asbestos Cement pipes were compared, PVC is shown to have the lowest overall failure rate. "Water Main Break Rates in the USA and Canada: A Comprehensive Study - April 2012"	

Condition Assessments Continued…

Water Source (Wells)	Critical and expensive assets such as these should be monitored rigorously. Wells should be cleaned regularly based upon declines in yield. Pumps and motors should be maintained in accordance with the Operators Manual.	This equipment should be set-up on a predictive monitoring schedule which may includes activities such as Well Drawdown, Amp Readings, Pump Performance Tests, Vibration Analysis, Oil Analysis, Ultrasound and Thermography. Operational data used to pump station performance include: pump run times, start counts, volume pumped, supply voltage, individual phase amp readings, grounding system test, pump breakdown and utility bills. SCADA controls permit remote monitoring which improves labor efficiency.	
Water Source (Reservoirs)	Intake structures and pumping equipment should be maintained rigorously. Reservoir maintenance often involves structures at multiple locations.	Pump and motor maintenance would be similar to the above recommendations for wells. In addition, the dam and spillway should be inspected regularly and repaired as needed. Surface water is must more susceptible to drought and drainage area contaminates. Care should be taked to insure good drainage shed practices upstream of the intake structure.	
Treatment Plants	Water treatment plant equipment should be maintained accordingly to guildlines established in the Owners Manual.	In addition to the routine preventative maintenance outlined in the Owners Manual, this equipment should be set-up on a predictive monitoring schedule which may includes activities such as Amp Readings, Pump Performance Tests, Vibration Analysis, Oil Analysis, Ultrasound and Thermography. The amount of monitoring performed should be weighed against replacement cost of the equipment. Expensive and critical assets without redundancy should be monitored rigorously. SCADA controls permit remote monitoring which improves labor efficiency.	
Inspection of Water Storage Tanks	Sanitary, safety, security and some structural conditions should be inspected every year. Coating system conditions should be inspected every 2 to 5 years. Annual inspections should be preformed by utility department staff. Professional inspection and cleaning should be performed every 5 years. Storage facilities should be cleaned every 2 to 5 years depending on silt build up	Sanitary conditions are those that could allow contamination of the water in storage. Structural and footing conditions are those that can affect the structural integrity of the storage facility. Safety and security conditions are those affecting the equipment that enables or protects inspectors and maintenance workers and prevents access to the tank by unauthorized people. Coating system conditions are those affecting the interior and exterior paint. **"Inspection of Water Storage Facilities - Missouri Department of Natural Resources"**	
Booster Pump Stations	Pumps and motors should be maintained in accordance with the Operators Manual. In general, the larger the pump the greater the consequence of failure.	In addition to the routine preventative maintenance outlined in the Owners Manual, this equipment should be set-up on a predictive monitoring schedule which may includes activities such as Amp Readings, Pump Performance Tests, Vibration Analysis, Oil Analysis, Ultrasound and Thermography. The amount of monitoring performed should be weighed against replacement cost of the equipment. Expensive and critical assets without redundancy should be monitored rigorously. SCADA controls permit remote monitoring which improves labor efficiency. Operational data used to pump station performance include: pump run times, start counts, flow meter records, supply voltage, individual phase amp readings, grounding system test, pump breakdown and utility bills.	
PRV, Attitude and Air Release Valves	Control valves must operate correctly in order to protect other distribution system components and maintain desired flow during periods of peak demand.	Control valves should be check for proper operation at least quarterly. Rust or deposits which could restrict the full range of motion should be removed. Defective control valves should be repaired or replaced at the first sign of operational problems. Excessive pressures will exasperated water loss. Valves which do not open fully could restrict water flow during periods of peak demand. Air release valves must operate to prevent destruction air locks and water hammers.	

Valve Exercising and Maintenance	All valves (such as distribution and transmission valves, air valves, and blow-offs) should be inspected and operated on a regular basis. (I could not locate any specific recommendations)	A valve exercising is a procedure that verifies proper location, operation, and material condition of valves, and initiates replacement as necessary. The physical operation of a valve and the documentation of the actions and procedures necessary to do so are equally important. The useful lifespan of valves at 40 years is less than half that of the pipe to which they are connected. Operational valves are necessary to fix water main breaks which are more likely to occur as the pipeline ages. Plan accordingly.	
Hydrant Testing and Maintenance	Hydrants should be inspected (flushed) twice a year, spring and fall.	The inspection and testing of fire hydrants is critical to determining the readiness of the hydrants to provide water at fire emergencies. The inspections shall verify the location, accessibility, proper mechanical operation, and water flow from the hydrant.	
Backflow Prevention Devices	BPD are a required safety device necessary to protect public health.	Backflow prevention devices must be inspected and certified annually by a professional sensitive locations. While the utility can outsource these inspections it is ultimately their responsibility to insure that the device is operating properly. Therefore a paper trail must be established to show that required inspections were performed and any necessary repairs completed.	
Water Meters	Meters are the cash register for both water and sewer revenues. Operational problems will result in reduced sales.	Bulk sales and commercial meters should be tested and recalibrated regularly. Testing should be prioritized based upon meter size and usage. A small percentage error in meter accuracy could result in significant reduction in revenues. Residential sized meters are normally tested in response to customer complaints and unrealistically low water usage based historical usage patterns. Meter accuracy should be questioned whenever usage fails to fit with known household characteristics.	
Pipeline Condition Assessment	One factor used to quantify the occurrences of failing underground pipe is water main break rates. Water main break rates are calculated for all pipe materials used in the transport of water to create a measurement to judge pipe performance and durability.	The Average Age of Failing Water Mains is 47 years old. While pipe life can be estimated at over 100 years, actual life is affected by soil corrosivity and installation practices. Corrosion is a Major Cause of Water Main Breaks. One in four main breaks is caused by corrosion which is ranked the second highest reason for water main pipe failure. When failures rates of Cast Iron, Ductile Iron, PVC, Concrete, Steel, and Asbestos Cement pipes were compared, PVC is shown to have the lowest overall failure rate. "Water Main Break Rates in the USA and Canada: A Comprehensive Study - April 2012"	

Preventative Maintenance

	General Recommendation	**Supplemental Information**	**Budgetary Cost**
Leak Location and Repair	Ongoing	The frequency at which new bursts and leaks occur depends upon the overall condition of the infrastructure and how well the pressure is managed.	
Flushing Water Mains	Conventional flushing increases chlorine residuals. Dead end lines must be flushed at monthly intervals. Other mains should be flushed as needed.	The amount of water in the main, and therefore the amount that must be flushed out, can be calculated by simple pipe volume formulas. The pressure in the system should never be allowed to drop below 20 psi. Samples of water should be tested for chlorine residual to provide evidence of the effectiveness of the flush. Water quality complaints should be monitored geographically. All municipalities should use some type of data management system to track these water quality complaints to optimize their flushing program.	
	Uni-directional flushing removes accumulated settlements and improves water delivery. All water lines should be cleaned annually.	Unit-directional flushing, which isolates pipe sections or loops in an organized, sequential manner, typically from source to periphery. Flow velocities should reach 1.5 to 2.0 m/s. The goal is to remove as much dirt and settlement as possible by moving water through the pipe at a high velocity. While more costly and time consuming than conventional flushing, unit-directional flushing is more effective and uses less water.	

Predictive Maintenance

	General Recommendation	Supplemental Information	Budgetary Cost
New Metering Technologies	Meters are the cash register of your billing system. Accurate meter readings are critical to revenue generation necessary to pay for overall water system maintenance.	Radio read technology not only reduces the amount of labor required for meter reading it effectively eliminates data transfer errors between the meter and billing system and facilities better data analysis by eliminating much of the time delay which makes water balance calculations so difficult. Coupling AMR with a water accounting tool will give a utility a substantial advantage in its bid to quantify and control apparent water losses.	
Pressure Management	Pressure is an important component to pipe design and material selection. A well-controlled system operated below design limits will lead to extended pipe life. Average supply pressure is 77 psi with pressure fluctuations less than 20 pounds per square inch.	Pressure management can be defined as the "practice of managing distribution system network pressures to the optimum level of service while ensuring sufficient and efficient supply to legitimate users." Water leakage is driven by pressure. Any efforts which result in reduction in water pressure for even part of the day will reduce leakage. In addition, maximum pressure has a considerable influence on the frequency of new leaks. Pressure surges are particularly damaging. Higher new leak frequency have been observed in parts of the distribution system with direct pumping when compared to sections supplied by gravity. Hydraulic modeling is necessary to determine if customer needs can be provided at lower pipeline pressures.	
Corrosion Control		See AWWA Corrosion Control for Buried Water Mains Pocket Field Guide	
Water Main Renovation		See AWWA M28 - Rehabilitation of Water Mains	See Attached CIP Cost sheet

Suggest ordering a copy of AWWA G-200 Standard and Operational Guide for Distribution Systems Operation and Management G200 SET Member Price $91.00

Sewer Collection - Best Management Practices

Quick Reference Guide

Performance Monitoring

	General Recommendation	Supplemental Information	Budgetary Cost
Performance Monitoring	Daily, Monthly, Annually tracking of benchmarks or key-performance indicators (KPI) will indicate trends, changes, and assist to identify planning goal attainment. The KPI's will be established by each system depending upon their specific opportunities.	System wide performance monitoring should occur on an ongoing basis. This job is made easier by SCADA systems using flow data from lift stations and treatment plant. The volume of wastewater treatment should be compared to drinking water sales. System-wide performance monitoring will allow you to monitor gradual changes in the effectiveness of wastewater collection.	Minimual - Requires better orgainzation and understanding of existing information.
Sewershed Flow Monitoring	Perform the monitoring as indicated by an unexplained reduction in collection system performance. The goal is to identify areas and quantify the water, wastewater, and collection system performance relative to precipitation data. (National avg of 33% annually. Often underutilized by small systems which monitor only 2.0% of collection system annually.)	Temporary meters are installed on a roving basis to identify areas with highest wet weather flows. Monitoring results allow you to prioritize problems and provide a basis to determine the effectiveness of completed repairs. Identified problems areas will become the focus of below outlined condition assessment tools.	
Safety Plan	Confined space entry, lock-out/tag-out, traffic controls, and all other safety plans must be in place and executed as applicable during wastewater efforting.		

Condition Assessments

	General Recommendation	Supplemental Information	Budgetary Cost
Manhole Inspections - Assessment vs. Inspection	A comprehensive initial inspection is recommended for new CMOM plans. If necessary, initial inspections can be scheduled over 3 to 5 years. When initial inspection must be phase-in the condition of manholes can be established from a sampling of manholes based upon material and age. Areas with known existing problems should be inspected first. Re-inspect every 3 to 5 years (National avg. is 26% annually) Re-inspections should be scheduled to coincide with sewer line cleaning. End result of pipeline inspection should be a recommended follow-up actions (Repair, Rehabilitation, Replacement or Reinspection)	First line of defense in identification of collection system problems. Look for both structural and operational defects. Information on sewer defects will be used for capital improvement planning. Structural defects must be corrected ASAP. Operational defects should be prioritized for systematic repair and rehabilitation based on the needs and focus of the system. Manhole inspections provide insight into many other problems such as sewer pipeline material and age, storm water inflow, ground water infiltration, sewer FOG, hydrogen sulfide, hydraulic problems, etc. Inspections should be coded to NASSCO standards. Standardization makes it more practical to compare the condition of multiple manholes within the network but also allow for the application of industry benchmarks to gain a better understanding of factors influencing the causes and speed of asset deterioration. See below predictive maintenance for more information.	Budget 20 to 30 minutes per manhole for the initial assessment, 2-3 hours for a thorough inspection (confined space entry). Re-inspections performed with sewer cleaning will have little to no additional budgetary impact.

Gravity Sewer Pipe	Visual inspections, closed-circuit televising, smoke testing, or dye testing will provide clues as to the existing condition of the pipe network.	CCTV inspections should be coded to NASSCO standards. Standardization not only makes it more practical to compare the condition of multiple segments within a pipe network but also allow for the application of industry benchmarks to gain a better understanding of factors influencing the causes and speed of asset deterioration.. See below predictive maintenance for more information. ElectroScan is a new technology used to quantify the amount of leakage. This technology uses electrical current to simulate the flow of water through a hole.	Budget $1 to $2 per lf for CCTV inspections. Sewer pipes in some locations will need to be cleaned prior to inspection.
Pump Station & Force Main	Pumps and motors should be maintained in accordance with the Operators Manual. In general, the larger the pump the greater the consequence of failure	In addition to the routine preventative maintenance outlined in the Owners Manual, this equipment should be set-up on a predictive monitoring schedule which may includes activities such as Amp Readings, Pump Performance Tests, Vibration Analysis, Oil Analysis, Ultrasound and Thermography. The amount of monitoring performed should be weighed against replacement cost of the equipment. Expensive and critical assets without redundancy should be monitored rigorously. SCADA controls permit remote monitoring which improves labor efficiency. Operational data used to pump station performance include: pump run times, start counts, high level alarm occurrences, odor complaints, basement flooding complaints, wet well vortexes, flow meter records, grit accumulation records, grease accumulation records, supply voltage, individual phase amp readings, grounding system test, pump breakdown and utility bills.	
Treatment Plants	Treatment plant equipment should be maintained accordingly to guildlines established in the Owners Manual.	In addition to the routine preventative maintenance outlined in the Owners Manual, this equipment should be set-up on a predictive monitoring schedule which may includes activities such as Amp Readings, Pump Performance Tests, Vibration Analysis, Oil Analysis, Ultrasound and Thermography. The amount of monitoring performed should be weighed against replacement cost of the equipment. Expensive and critical assets without redundancy should be monitored rigorously. SCADA controls permit remote monitoring which improves labor efficiency.	

Preventive Maintenance

Grinder Pump Maintenance	There is no maintenance that can be done on submersible pumps. The best quality ones may be rebuilt should they fail, however, you should take efficiencies into account. The worst enemies to grinder/ejection pumps are women's sanitary napkins, tampons, and condoms, as they can jam up the pump's impeller. Inspect the sewage grinder tank for the following: Accessibility, Venting (to avoid vacuum in the reservior), Evidence of Leaks, Exposed Wires, Unprotected Openings, Evidence of Backups or Overflows, Witness Pump Operation, Container Integrity, Lid Integrity and Fit, Discharge Check Valve.	Septic pump manufacturers provide a pump selection and sizing table that is used to guide the installer in selecting the proper pump. We've seen sewage handling systems where the wrong type or wrong capacity of pump was installed, sometimes as an attempt to "save money."	
Sewer Line Cleaning	3 to 5 years per cleaning cycle is recommended, although difficult to obtain. (The National average is 30% of the system cleaned annually)	Areas with root issues and poor slope will need to be cleaned more frequently. Observe the debris brought back by the cleaning nozzle. Black material is normally sludge and grit which has collected in the pipe. White chunks typically indicate grease deposits, Chunks of pipe and roots have obvious implications. Light brown color could indicate that the jet is excavating fresh dirt from an open joint or missing pipe barrel. When structural defects are suspected the pipeline should be televised at the first opportunity to determine location and extent of the damage.	In small communities this task is best performed by outside contractors. Budget $1.00 per linear foot.

Predictive Maintenance

	General Recommendation	**Supplemental Information**	**Budgetary Cost**
Hydrogen Sulfide Monitoring	Best accomplished through routine manhole inspections. Sewer cleaning to remove deposits typically reduce hydrogen sulfide levels. Hydrogen sulfide problems usually originate in low slope, low flow areas with symptoms exhibited at drop sewers and pump stations.	Sewers with low velocity, long detention times and solid deposition can produce unacceptable levels of hydrogen sulfide. Hydrogen sulfide monitoring should be undertaken in collection systems with significantly reduced effluent flows from successful I&I reduction program.	Inspections performed with manhole inspections and sewer cleaning will have little to no additional budgetary impact.
Smoke Testing	As Needed (National avg. is 8% annually) Inexpensive cost often lead to over use of this condition assessment tool.	Used for trouble shooting when unexplained effluent flows are detected. Inexpensive means of detecting storm water connections such as abandoned sewers, downspouts, yard drains, cellar and footer drains. Typically not performed on a routine basis.	Very inexpensive - Budget 40 to 360 hours of staff time per year.
Dye Testing	Used for trouble shooting I&I problems. Provides evidence that problem exist but does not identify the cause or appropriate corrective action.	Often used to confirm smoke test and private property inspection results. Typically not performed on a routine basis.	Inexpensive - Budget 40 to 360 hours of staff time per year.
Private Property Inspections	Used in areas where flow monitoring and smoke testing indicate the likelihood of illegal connections to the sanitary sewer system. (Nationally avg. is 5%) (Seldom used by small communities) Re-inspection typically required whenever properties are sold.	The only effective way of identifying illegal sump pumps. Education is a key component of private property inspections. Sometimes communities offer rebates or other incentives to encourage property owners to correct I&I defects. (Establishing a Private Property Grant Program)	Normally limited to small areas with suspected problems. Budget 1 to 1.5 hours of staff time per property address.

CCTV Inspections	Inspect every 15 to 20 years. Re-inspection intervals should be based upon condition. (National avg. of 7% annually) End result of pipeline inspection should be a recommended follow-up actions (Repair, Rehabilitation, Replacement or Reinspection)	CCTV is the only practical way of inspecting small diameter sewer pipes. When structural problems are anticipated sewer lines should be televise after cleaning. However if you are reasonably confident that the sewer lines are structurally sound, I&I problems can sometimes be identified by televising sewers during periods of high flow.	Best done by outside contractors. Budget $1.00 lf for cleaning and $2.50 lf for CCTV.
Non-structural repairs	Sealing leaking joints in otherwise structural sound manholes and pipes. The life expectancy of grout and other sealants is approximately 10 years. Regular re-inspection is required.	A sewer rehabilitation program is necessary to defend the collection system against the effects of time. The rehabilitation program should be built upon information obtained from the performance monitoring and , condition assessment program.	See Attached CIP Cost sheet
Structural repairs and renovations	Repair of damaged areas by open excavation and/or trenchless technologies. These repairs provide a relatively long useful life so routine re-inspection is typically not required.	Trenchless technologies include cured in place pipe (CIPP), slip lining, fold and form pipe, spiral wound pipe and shortcrete.	See Attached CIP Cost sheet
Renewal	Assets are replaced using open excavation and/or trenchless teniques. Useful life and maintenance guidelines are the same as new construction.	Renewal options such as open cut replacement and pipe busting offer the best opportunity to correct hydraulic capacity and structural deficiencies. Open cut pipeline replacement which involve street restoration is very expensive.	See Attached CIP Cost sheet
CIP to address Deferred Maintenance	Initial condition assessment often revels the need for catch-up maintenance. These capital improvement projects were made necessary by years of neglect. The cost of mitigating deferred maintenance is one of the largest obstacles to the successful implement of an asset management program.	This money and more would have been spent on ineffective emergency repairs. However the true cost would have been concealed by time.	See Attached CIP Cost sheet