RCAP Asset Management Webinar Series
Completing a Preventative and Predictive Maintenance Plan

Presented by
Wayne Cannon, Sr. Rural Development Specialist
Bud Mason, Sr. Rural Development Specialist
Your Speakers Today

Wayne Cannon

Bud Mason

Today’s Class is sponsored by

Division of Drinking & Ground Waters

Today’s session is being recorded.
Participant Instructions

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- If you wish to receive 1.0 operator contact hour (water or sewer), please email tafishbaugh@wsos.org if you did not include your core operator ID on the registration form.
- To receive credit for a contact hour, you must be logged in the entire time and participate in the polls during the training.
- If you are at a site with multiple people watching on one computer, and one or more attendees wishes to receive a contact hour, please designate one person as the room monitor, and use the sign-in sheet provided with the reminder email this morning.

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RCAP Asset Management Webinar Series

- Sept 8  Completing an Asset Inventory
- Sept 15 Completing a Condition Assessment
- Sept 22 Completing a Capital Improvement Plan
- Sept 27 Completing a Preventative & Predictive Maintenance Plan
- Sept 29 Budgeting for P&P, CIPs & Sustainability

Each webinar is from 10 AM – 11 AM. Please register for the other webinars at www.ohiorcap.org.
Asset Management Webinar Series

Preventive and Predictive Maintenance Plan

Bud Mason – Ohio RCAP Rural Development Specialist
Wayne Cannon – Ohio RCAP Rural Development Specialist
Better management will be needed to achieve our AM Goals.

- **1\textsuperscript{st} Goal** – Maintain assets to achieve their maximum useful life. **IMPROVED MAINTENANCE!**
- **2\textsuperscript{nd} Goal** – Systematically plan for asset replacement. **Escrow Reserve Funds.**

<table>
<thead>
<tr>
<th>Cost of infrastructure replacement</th>
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</thead>
<tbody>
<tr>
<td>Water Distribution $15,000 per customer</td>
<td>$15,000,000</td>
</tr>
<tr>
<td>Source and Treatment</td>
<td>$4,500,000</td>
</tr>
<tr>
<td>Total</td>
<td>$19,500,000</td>
</tr>
</tbody>
</table>

Financed over 30 yrs. at 3.29% interest = $84 customer / month for debt only

**Run-until-failure is not a cost effective management strategy.**
Minimize lifetime ownership cost through improved preventative maintenance and timely predictive maintenance (asset rehabilitation).

History show that scheduled maintenance cost 1/3 less than emergency repairs for the same task.

1st Goal – Maintain assets to achieve their maximum economic life.
The best strategy for O&M varies by asset, criticality, condition and operating history.
Preventive Maintenance

- The base level for preventive maintenance is defined in the owner’s manual.
- Manufacturers recommendations can be supplemented by industry accepted best practices.
- Annual expense item!

Time Based Maintenance
(Date, Hours, Miles)
Preventive Maintenance

- Industry accepted best practices are particularly important for distribution and collection systems because no owner’s manual exist for this infrastructure.
- Condition assessment and performance monitoring are preventative maintenance task.
Preventive Maintenance

- The maintenance budget is often the target of budget cuts because maintenance can be delayed in the short-term with few consequences.
- Deferred maintenance usually results in higher “Life-Cycle Costs”. “Penny wise and dollar foolish”
Predictive Maintenance

- Predictive maintenance activities are scheduled based upon monitoring and inspection report findings.
- Equipment is inspected and monitored for early warning signs of impending failure, such as vibration, leakage or reductions in performance and serviced accordingly.
The renewal and renovation of short-lived components of larger assets is predictable.

Examples include:

- Well Cleaning and Pump Maintenance
- Roof / HVAC Replacement
- Interior / Exterior Coatings on Storage Tanks
- Valves and Hydrants
- Meters

Escrow to savings for anticipated costs which are often 2 to 20 years into the future.
Reactive maintenance activities are scheduled when equipment fails or inspection activities reveal a problem that must be corrected to avoid an emergency situation.

The Vicious Cycle of Reactive Maintenance

"Break it before it breaks you"

This maintenance strategy is often referred to as Run-Until-Failure.
Preventive vs. Emergency (Reactive) Maintenance

- Emergency maintenance cost **1/3 more** than planned maintenance for the same task. **Fix it right the first time!**
- Emergency / reactive maintenance takes resources away from preventive maintenance and predictive monitoring task.
- When reactive maintenance becomes a predominant activity, personal may not be able to perform planned maintenance thus leading to more emergency / reactive maintenance situations.

Based on USEPA’s assessment of Australia’s advanced management practices, 20-30% future life cycle cost savings is achievable for most US water and wastewater utilities.
Measuring the Effectiveness of Preventive Maintenance

- Frequency and cost of emergency repairs relative to schedule maintenance is an indicator of maintenance program effectiveness.
- The CMMS system can be used to track the number and cost of work orders by asset and type.
- CUPSSS Table 5.2 shows the cost and frequency of emergency and reactive maintenance upon work orders entered.

The cost of emergency maintenance should not exceed 20% of total maintenance budget.
# Improved Maintenance Program


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## Drinking Water Distribution - Best Management Practices

### Quick Reference Guide

<table>
<thead>
<tr>
<th>Performance Monitoring</th>
<th>General Recommendation</th>
<th>Supplemental Information</th>
<th>Budgetary Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Wide Performance Monitoring</td>
<td>Daily, Monthly, Annually</td>
<td>System wide performance monitoring should be performed on an ongoing basis. This task 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.</td>
<td>Minimal - Requires better organization and understanding of existing information</td>
</tr>
<tr>
<td>District Area Metering</td>
<td>Monthly, Annually</td>
<td>District Meter Area (DMA) management involves subdividing the distribution system into districts by manipulating 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.</td>
<td>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.</td>
</tr>
<tr>
<td>Water Audits</td>
<td>Annually</td>
<td>Audit results are more useful when the results are compared over time. The audit program will help producers to identify areas in data collection and analysis. The industry is moving toward benchmarks based upon the volume of water lost 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 - EPAN Smart Management for Small Water System Program”</td>
<td>Budget 40 to 120 staff hours annually.</td>
</tr>
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</table>

### Condition Assessments

<table>
<thead>
<tr>
<th>General Recommendations</th>
<th>Supplemental Information</th>
<th>Budgetary Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve Exercising and Maintenance</td>
<td>All valves (such as distribution and transmission valves, air valves, and blow-offs) should be inspected and operated on a regular basis. (It could not locate any specific recommendations).</td>
<td>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 is 40 years or 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.</td>
</tr>
<tr>
<td>Hydrant Testing and Maintenance</td>
<td>Hydrants should be inspected (flushed) twice a year, spring and fall.</td>
<td>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.</td>
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<tr>
<td>Pipeline Condition Assessment</td>
<td>One factor used to quantify the performance of a main line 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.</td>
<td>The average age of failing water mains is 57 years old. While pipe life can be accelerated at over 200 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”</td>
</tr>
</tbody>
</table>
Today we are going to highlight selected best maintenance practices to extend the useful life of your Water System.

You are already familiar with many of these practices from emergency repairs. But how many of you use them in a proactive preventative maintenance program?

Focus on how existing practices can be used for **Performance Monitoring** and **Condition Assessments**.

Think about how to store the information obtained to avoid memory fade and personal changes that render it unavailable.
Poll Question

What Maintenance Planning do you use?

☐ Preventive / Predictable
☐ Postponed / Put Off
Identifying Best Practices
Water Distribution

- Water Audits / Performance Monitoring
- Leak Detection (Active Leak Control)
- Valve Maintenance
- Hydrant (Pressure and Flow Testing)
- Clean pipe (Unidirectional Flushing)
- Maintain Records (GIS Mapping / CMMS Software)

Condition inspection and performance monitoring should become an ongoing maintenance activity. Most utilities will need several years to inspect **ALL** of their assets.

Small communities often struggle with proactive maintenance practices due to limited staffing, equipment and knowledge.
Is 15% water loss a good benchmark? Water is usually lost at the same amount every day no matter how much is pumped or metered.

Nationwide water use is on the decline. If pumpage decreases from 200,000 gpd to 150,000 gpd the lost water percentage goes from 15% loss to 20% loss.

However gallons of unaccounted for water is unchanged!

Perhaps water loss should be based upon a constant such as number of connections or miles of pipe.
"Best Management Practice"

Annual Water Audit

Focus on Real Losses: Mains, Service Lines, Overflows, etc.

- Water Imported
- Own Sources
- Total System Input (allow for known errors)
- Water Exported
- Water Supplied
- Authorized Consumption
- Water Losses
- Real Losses
- Authorized Consumption
- Unbilled Authorized Consumption
- Apparent Losses
- Non-Revenue Water
- Billed Water Exported
- Billed Metered Consumption
- Billed Unmetered Consumption
- Unbilled Metered Consumption
- Unbilled Unmetered Consumption
- Unauthorized Consumption
- Customer Metering Inaccuracies
- Systematic Data Handling Error
- Leakage on Mains
- Leakage on Service Lines
- Leakage & Overflows at Storage
Leak Detection Strategies

- **Passive**
  - Monitor Pumping / Pressures / Metered Usage

- **District Metering**
  - Step Testing

- **Leak Surveys**
  - In-house or consultant
  - Frequency

- **Acoustic Monitors**
  - Fixed or Lift & shift

- **Correlation**

It is **NOT** Lost!
We can find most of it!
Tools of the trade

High quality headphones

Extension Rod used to reach fittings or penetrated soft ground

Shielded ground microphone used on hard even ground surfaces

Tripod foot for uneven surfaces

Base unit – filters and displays noise

Overnight Correlators

Leak Noise Correlator
Active Leakage Control (ALC) is a proactive strategy to reduce water loss by locating and repairing non-visible leaks by technicians with specialized equipment.
ALC focuses on Unreported Leaks and Speed of Repair

Unavoidable

- Background Leakage
  - Unreported and undetectable using traditional acoustic equipment

Detectable

- Unreported Leaks
  - Often does not surface but is detectable using traditional acoustic equipment

Observable

- Reported Breaks
  - Often surfaces and is reported by the public or utility workers

Tools

- Pressure Stabilization
- Pressure Reduction
- Main and service line replacement
- Reduction in the number of joints and fittings

- Proactive leak detection and repair
- Improve speed of repair
Small leaks are important!

Research has shown that the constant flow of low level leaks that cause more water loss than the spectacular water main breaks.

Do the math!

1 gpm for 3 years = 1,576,800 gallons

10 gpm for 45 days = 648,000 gallons.

500 gpm for 4 hours = 120,000 gallons.
Valve Maintenance Equipment
Why Exercise Valves?

- Needed to control flow and address emergencies
  - Main breaks must be isolated
  - Speed of shut-off important in limiting damage
- Will deteriorate over time if not used.
  - Corrosion
  - Sediment deposits
- Valves can be lost!

“A valve that doesn’t work is just a piece of pipe.”
Step 1 – Gather and organize valve information

- Distribution system maps and as-built drawings
- Valve location and depth
- Manufacturer
- Type and size
- Pipe and valve materials
- Operation and maintenance records
- Identify what information is missing that can be obtained in the field.
Step 2 – Develop an action plan

- **Frequency**
  - Exercise critical valves annually
  - 12” or larger every year
  - Smaller valves every three years

- **Identify Critical Valves**
  - Size, Age, Etc.
  - Serve critical facilities (Hospitals)
  - Proximity to main intersection on busy street

- **Schedule by Map Section or Zone**

  *Exercising valves at least once per year ensures they will work when needed*
Step 3 – Field locate and document the valve location

- **Field Verification**
  - May require the use of metal detectors or magnetic locators

- **Note precise location**
  - GPS or Traditional Survey
  - Measure based on two or more permanent objects

- **Take digital picture showing valve and surrounding area**

- **Mark the valve box lid with blue paint**
  - Consider painting valve lids before going to the field.

Don’t lose the valve once you have found it!
Step 4 – Examine and operate the valve

- Clean-up the valve box
  - You can’t inspect what you can’t see.

- Examine the existing state of the valve
  - (open, partially open, closed)

- Operate the valve
  - Use lowest torque setting possible – Don’t force the valve
  - Count the number of turns down and up. They should match.
  - Don’t close the valve completely the first cycle.
  - Open and close slowly to prevent water hammer
  - Listen for changes in flow.
  - Rule of thumb – Number of turns / 3 + 1 or 2 is the valve size
Develop Standard Operating Procedures for Valve Operation

- Remove valve cover
- Visually inspect valve box
- Clean if necessary
- Insert valve key
- Check to see if the valve is open
- Fully close the valve and count the turns
- Exercise up and down 2 to 3 cycles
- Fully open valve
- Close 1 to 2 turns
- Inspect for leaks
- Replace cover
- Collect tools and safety equipment

SOP may vary based upon local conditions and management directives.
“Best Management Practice”

Hydrant Testing

Residual Hydrant
• Static Pressure
• Residual Pressure
• Test evaluates water available at this location

Flow Hydrant
• Pitot Pressure
Why Maintain Hydrants?

- **Improve Water Quality (Flushing)**
  - Reduce water age
  - Expelling sediment and contaminants
  - **Scouring and cleaning of pipes – Unidirectional Flushing**

- **Condition Monitoring Site**
  - Static Pressure
  - Flow – GPM
  - Residual Pressure

- **Fire Protection**
  - Impact on hazard insurance ratings
  - Reduce liability from non-operating hydrants
The WHO and WHEN of hydrant inspection and maintenance

- Who conducts the program?
  - Water Utility – Flushing and Distribution System Maintenance
  - Fire Department – Fire Protection

- Frequency of Inspection
  - Wet barrel - Inspected annually
  - Dry barrel – Inspect twice annually
  - After each use

Fire department and water department view hydrants differently.
NFPA defines Fire Flow as: “The flow rate of water measured at 20 psi residual pressure that is available for firefighting.” The NFPA standard calls for bonnets and caps to be color-coded. **NFPA 291, Chap. 3**

<table>
<thead>
<tr>
<th>Class</th>
<th>Flow Rate</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class C</td>
<td>Less than 500 GPM</td>
<td>Red</td>
</tr>
<tr>
<td>Class B</td>
<td>500-999 GPM</td>
<td>Orange</td>
</tr>
<tr>
<td>Class A</td>
<td>1000-1499 GPM</td>
<td>Green</td>
</tr>
<tr>
<td>Class AA</td>
<td>1500 GPM &amp; above</td>
<td>Light Blue</td>
</tr>
</tbody>
</table>

**Liability Issue:**  
Because it looks like a fire hydrant does not make it a fire hydrant!
How do I inspect and maintain a hydrant?

1. Inspection
2. Operate hydrant
3. Check hydrant valve
4. Schedule Repairs
5. Recordkeeping

More information is available online.
Step 1 - Inspection

- Look for visible signs of damage
- Verify hydrant data
- Digital picture
- Remove caps, inspect gaskets, chains
- Check for water in the hydrant, leakage
- Lubricate
Step 2 - Operation

- Install pressure gauge on one nozzle
- Slowly open hydrant, bleed out air, check pressure
- Shut down hydrant and make sure it drains

Follow SOP established by utility. "If you open it, you own it."
Step 3 - Check hydrant valve

- Locate hydrant valve
- Operate valve
- Ensure that flow stops completely
- Open hydrant valve to flush hydrant line
Step 4 – Repairs

- Inspect then repair or schedule for repair.
- Notify the fire department if out of service
Step 5 - Recordkeeping

- Inspection checklist
- Hydrant data cards
- GIS records
Clean Pipe

**Conventional – Reactive**
- Expulsion of poor quality water.

**Unidirectional – Proactive**
- Maximizes scouring velocities

- Unidirectional flushing maximizes cleaning velocities.
- Unidirectional flushing lowers water use for maintenance.
- Unidirectional flushing requires operational valves.
“Best Management Practice”
Unidirectional Flushing

- Increased friction from sedimentation and/or encrustation can significantly reduce the available pressure and flow. Maximizes scouring velocities. Uses up to 40% less water!
- Can be combined with other maintenance activities (valve exercising, hydrant operation, performance monitoring)
- Provides long-term improvements and performance baseline for future comparison. Hydrants should periodically undergo flow testing to provide data on distribution system performance and fire flow capabilities.
- Record start time, static pressure, sustained rate of flow, length of time of flushing, and discharge pressure.
- Discharge water pressure to must be maintained above the minimum operating pressure of 20 psi.
General guidelines for an effective flushing program.

- Flush all water distribution mains that are less than 12 inches in diameter. Transmission mains typically have enough flow velocity to be cleaned continuously.

- Start at the plant and work outward, larger pipes to smaller pipes (easier to create high velocity). Flush from cleaner pipe to dirty pipe (clean source).

- Identify sequence for opening and closing valves in advance. Size work orders for completion by the flushing crew in 1 day. Limit flush lengths to an average of 1,500 ft.

- Always open the hydrants fully, never leave them open partially. This is a manufacturer’s recommendation to properly lubricate the threads, to fully cleanse the drain holes, and to allow all foreign material to pass properly.
Time and velocity of flush necessary to clean water lines.

- The amount of water in the main, and therefore the amount that must be flushed out, can be calculated by simple pipe volume formulas, such as:

  \[ \text{Length of Pipe} \times [\pi \times (\text{Diameter}^2/4)] = \text{cubic feet}, \text{ so; for} \]
  \[1,000 \text{ linear feet of 6-inch diameter pipe (6”/12 inches per foot = 0.5 feet diameter)}: \]
  \[1,000 \text{ linear feet} \times [3.14 \times (0.5^2/4)] = 196 \text{ cubic feet} \]

  There are 7.48 gallons per cubic foot of volume, therefore:
  \[196 \text{ cubic feet} \times 7.48 \text{ gallons per cubic feet} = 1,469 \text{ gallons}. \]

- The hydrant should remain open long enough to move twice the storage capacity at a minimum flushing velocity of 5 ft. per second.

- Chlorine levels should be tested to document effectiveness of the flush and insure water freshness.
Pipeline Condition Assessment and Performance Monitoring

- Track water main breaks
  - Location
  - Cause of Failure
  - Condition of Pipe (Scale)

- Monitor Pressure and Flow

- Real Water Loss
Benefits of this approach!

- Emphasize sustainable maintenance solutions over unaffordable capital projects.
- Address the **REAL** cause of asset failure.
- Reduce the waste of precious capital resources.

Improve reliability and sustainability of utility systems in small rural communities cutting edge technology.
Questions

Success is the sum of small efforts, repeated day in and day out.

Robert Collier

Questions?

Upcoming Webinars

Friday Sept 29th
Budgeting for Sustainability