

SCADA System Fundamentals & Architecture

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SCADA Systems for Water & Wastewater

A comprehensive technical guide to system architecture, field instrumentation, and operational best practices — designed for engineers and technical managers in the water/wastewater industry.

1 HR 15 MIN TECHNICAL SESSION



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What We'll Cover Today

01

SCADA Fundamentals & Architecture

System layers, components, and how they interconnect — from field device to operator screen.

03

Alarm Management

Designing effective alarms, rationalization, and after-hours notification.

05

Remote Access & Cloud SCADA

Cloud vs. on-premise architecture, secure remote access, and future trends.

02

Field Instrumentation

Level, flow, and pressure sensors — selection, calibration, and failure modes.

04

System Integration

Connecting SCADA to CMMS, lab systems, GIS, and enterprise platforms.

CHAPTER 1

SCADA System Fundamentals & Architecture

Understanding how SCADA systems are structured is foundational to operating, troubleshooting, and expanding any water or wastewater facility.



What Is a SCADA System?

Supervisory Control and Data Acquisition

SCADA is the backbone of modern water and wastewater operations — a distributed system that collects real-time data from the field, processes it, and enables operators to monitor and control processes from a central location.

Why It Matters in Water/Wastewater

Water systems span miles of geography with hundreds of remote assets. SCADA enables a small operations team to monitor pump stations, storage tanks, chemical dosing, and distribution pressure — all from a single interface — 24 hours a day.

The Four Layers of a SCADA System

1

Field Layer

Sensors, transmitters, pumps, valves, motors

2

Control Layer

PLCs, RTUs, control logic execution

3

Communication Layer

Cellular, radio, fiber/Ethernet networks

4

Supervisory Layer

SCADA servers, historian databases, HMI

Each layer has a distinct role. A failure or misconfiguration at any layer cascades upward — understanding this hierarchy is essential for effective troubleshooting and system design.

LAYER 1

The Field Layer

This is where physical reality meets digital data. Every piece of information in your SCADA system originates here.



Field Layer Components



Sensors & Transmitters

Measure physical process variables — level, flow, pressure, turbidity, chlorine residual — and convert them into electrical signals (typically 4–20 mA or digital protocols) that can be read by controllers.



Pumps, Valves & Motors

The actuators of the field layer. SCADA sends commands — start, stop, open, close, speed setpoint — and these devices carry out the physical work of moving water through the system.



Local Control Panels

House terminal blocks, circuit breakers, relay logic, and local HOA (Hand-Off-Auto) switches. They provide a physical interface at the equipment and allow manual override when remote communication is lost.



LAYER 2

The Control Layer

PLCs and RTUs form the intelligent core of field-level automation — executing logic, making real-time decisions, and serving as the bridge between field devices and the communication network.

- Example in practice: High Tide Technologies' GEN-2 RTU is designed for water and wastewater systems — with no user programming required, dual SIM cellular failover, 2-minute data polling, and remote firmware updates.

PLCs vs. RTUs: Know the Difference

Programmable Logic Controller (PLC)

Designed for fast, scan-cycle-based logic execution in environments with consistent power and network infrastructure. Ideal for pump stations, treatment plants, and any process requiring fast I/O response times.

- High-speed I/O processing
- Rich instruction sets for complex logic
- Typically used in local panel environments

Remote Terminal Unit (RTU)

Built for harsh, remote environments where power may be limited and communication is intermittent. RTUs are ruggedized for outdoor installation, support battery/solar power, and store data locally until a connection is available.

- Low power consumption
- Store-and-forward data capability
- Ideal for remote lift stations, wells, tanks

Control Logic: The Brain of the Operation

Ladder Logic

The most common PLC programming language in water/wastewater. Visual, relay-logic-style programming that is intuitive for electricians and control engineers. Ideal for discrete I/O and sequential control tasks.

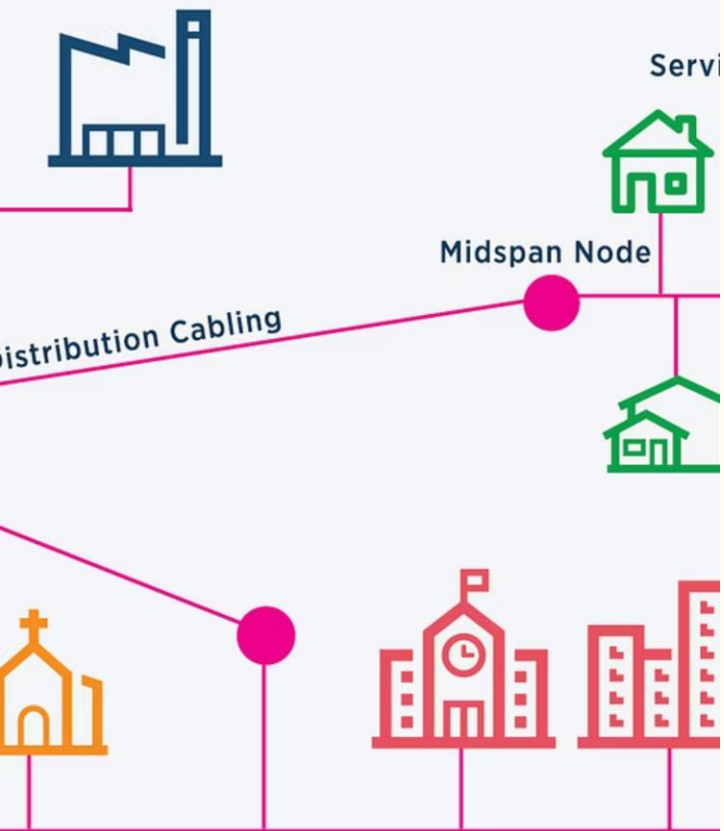
Function Block Diagrams

Graphical blocks representing control functions — PID loops, timers, counters. Preferred for analog control applications such as valve positioning and chemical dosing.

Structured Text

High-level, Pascal-like language used for complex mathematical operations and data manipulation. Increasingly used in modern, advanced control applications.

Fiber to the Premis



LAYER 3

The Communication Layer

How data moves from the field to the control room — reliably, securely, and without interruption — is one of the most critical design decisions in any SCADA deployment.

SCADA Communication Technologies



Cellular (4G/LTE, 5G)

Low infrastructure cost, rapid deployment. Ideal for remote lift stations and wells. Dependent on carrier coverage and subject to outages during storms. Use VPNs to secure data in transit.



Licensed & Unlicensed Radio

Utility-owned infrastructure with no recurring carrier costs. Licensed radio (900 MHz, UHF) offers reliable, interference-protected links. Unlicensed (900 MHz spread spectrum) works well in rural areas with line-of-sight.



Fiber / Ethernet

Highest bandwidth and lowest latency. Best for plant floor networks and campus environments. Single-mode fiber supports long-distance runs. Immune to electrical interference — the gold standard for critical links.

 Most modern systems use a hybrid approach — fiber at the plant, radio or cellular to reach remote assets. Design for redundancy at every link.

 Cloud-Based SCADA: Modern cloud-hosted platforms like the High Tide Web App take cellular connectivity further — eliminating on-premise servers entirely. Data from RTUs is transmitted over cellular to a cloud SCADA platform accessible from any device, 24/7/365, with no local IT infrastructure required.

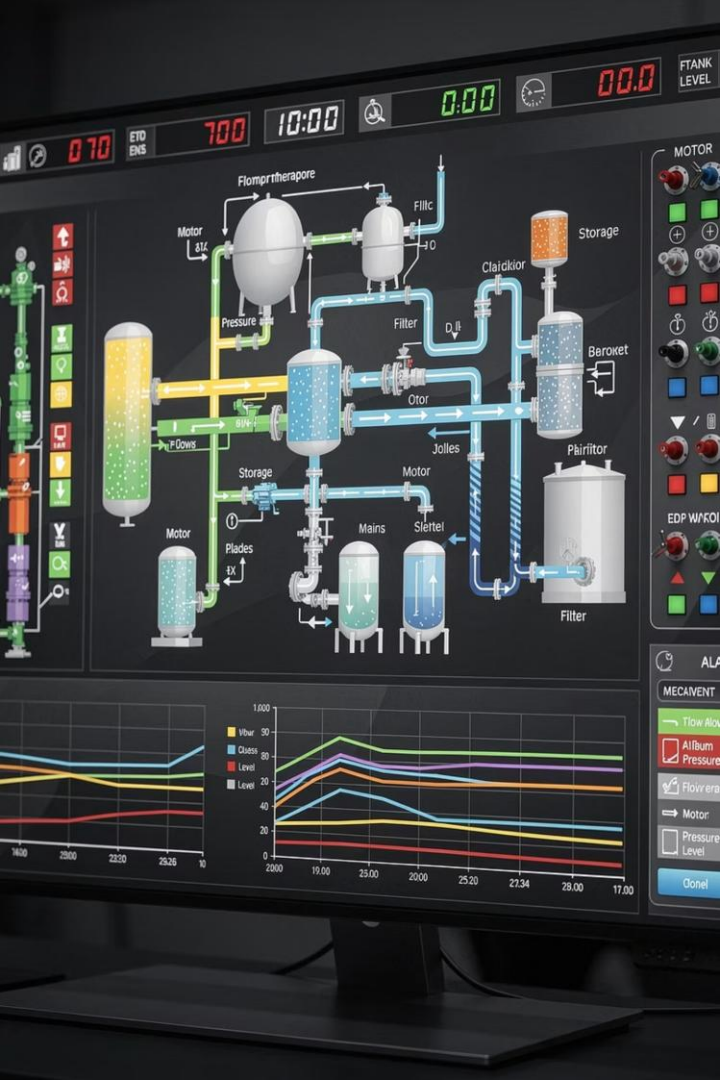
Communication Protocols in Water/Wastewater

Legacy Protocols

- **Modbus RTU/TCP** — Simple, widely supported, still common in older RTUs and instruments
- **DNP3** — Purpose-built for SCADA, supports time-stamping and data integrity checks
- **Profibus** — Common in European-supplied equipment and older plant floors

Modern & Emerging Protocols

- **OPC-UA** — Secure, platform-independent data exchange between systems
- **MQTT** — Lightweight publish/subscribe protocol gaining traction in IIoT deployments
- **EtherNet/IP** — High-speed industrial Ethernet for modern PLCs and plant-floor integration



LAYER 4

The Supervisory Layer

This is where raw field data becomes actionable operational intelligence — where operators see, control, and record the behavior of the entire water system.

Supervisory Layer Components



SCADA Servers

The central processing hub. SCADA servers poll field devices, execute alarm logic, enforce setpoints, and serve real-time data to operator workstations. Modern systems use redundant server pairs to ensure continuous availability.



Historian Databases

Store time-series process data — tag values, alarm states, operator actions — at high resolution. Essential for regulatory compliance reporting, process optimization, and post-incident investigation. Common platforms include OSIsoft PI, Ignition Historian, and Wonderware.



Human-Machine Interface (HMI)

The operator's window into the process. A well-designed HMI provides clear situational awareness through process graphics, trending, alarm management, and control access — without overwhelming the operator with noise.

What Makes a Good HMI?

High-Performance HMI Design Principles

The water industry has adopted ISA-101 and the High Performance HMI Handbook as design standards. Key principles include:

- Gray-scale base graphics with color used only for alarms and critical states
- Abnormal conditions immediately visible without hunting
- Consistent navigation and element placement across all screens
- Trend displays embedded at point of use
- Alarm rationalization — only actionable alarms displayed



Poor HMI design is a leading contributor to operator error during abnormal events. Cluttered, color-saturated screens mask critical alarms and slow response time.



Utilities that have adopted High Performance HMI principles report significant reductions in alarm response time and operator fatigue.

SCADA in Practice: The High Tide Web App

The High Tide Technologies Web App is a cloud-based SCADA platform for water and wastewater utilities, accessible from any device without on-premise server infrastructure.

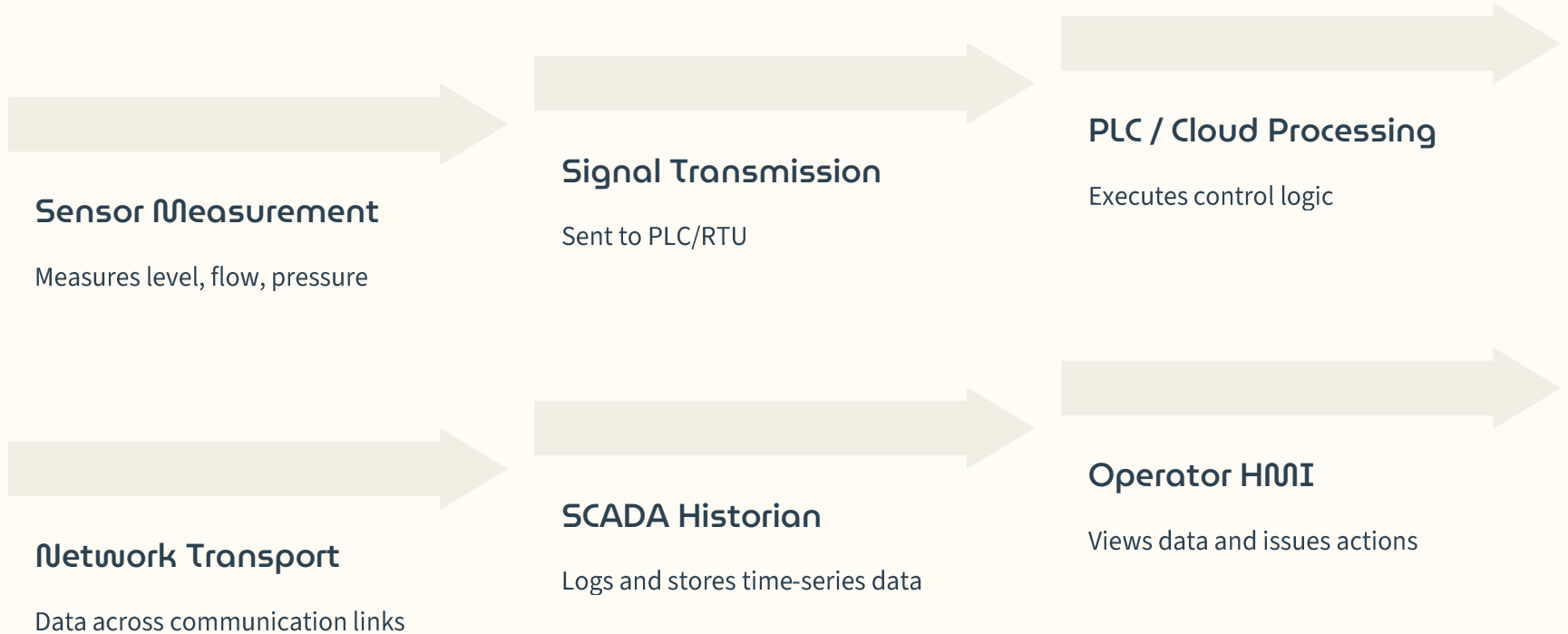


Key Features

- Real-time monitoring of pumps, wet wells, tanks, and flow meters
- Alarm management with text, phone, and email notifications
- Historical data trending for preventative maintenance
- Interactive sites map with live status updates
- Accessible from desktop, tablet, or mobile — 24/7/365

Included with High Tide RTU hardware. Learn more at htt.io

How Data Moves Through the System



Step 1: Sensor Measures Process Variable

At the Instrument

A pressure transducer, level sensor, or flow meter responds to a physical change in the process. The instrument converts the measured variable into a standardized electrical signal — most commonly a 4–20 mA analog signal or a digital value over a fieldbus protocol.

Signal Scaling

The 4–20 mA signal represents 0–100% of the instrument's calibrated range. For example, a level transmitter with a 0–20 ft range outputs 4 mA at empty and 20 mA at full. The PLC/RTU scales this raw count to engineering units for display and control logic.

Steps 2 & 3: PLC/RTU Receives and Processes

1

Signal Received

Analog or digital input is read on each PLC scan cycle. The raw value is converted to engineering units and checked for out-of-range conditions.

2

Logic Executed

Control logic compares the value to setpoints. The PLC decides: start a pump, close a valve, generate an alarm, or hold current state.

3

Output Commanded

The PLC sends a discrete or analog output to the controlled device — a motor starter, valve actuator, or VFD speed reference.

Steps 4–6: Network to SCADA to Operator

Network Transmission

PLC/RTU packages data and transmits via cellular, radio, or fiber to the SCADA server using configured polling intervals or exception reporting.

1

2

3

Operator Display

HMI client displays updated values, highlights alarms, and logs any operator control actions with a timestamp and user ID for auditability.

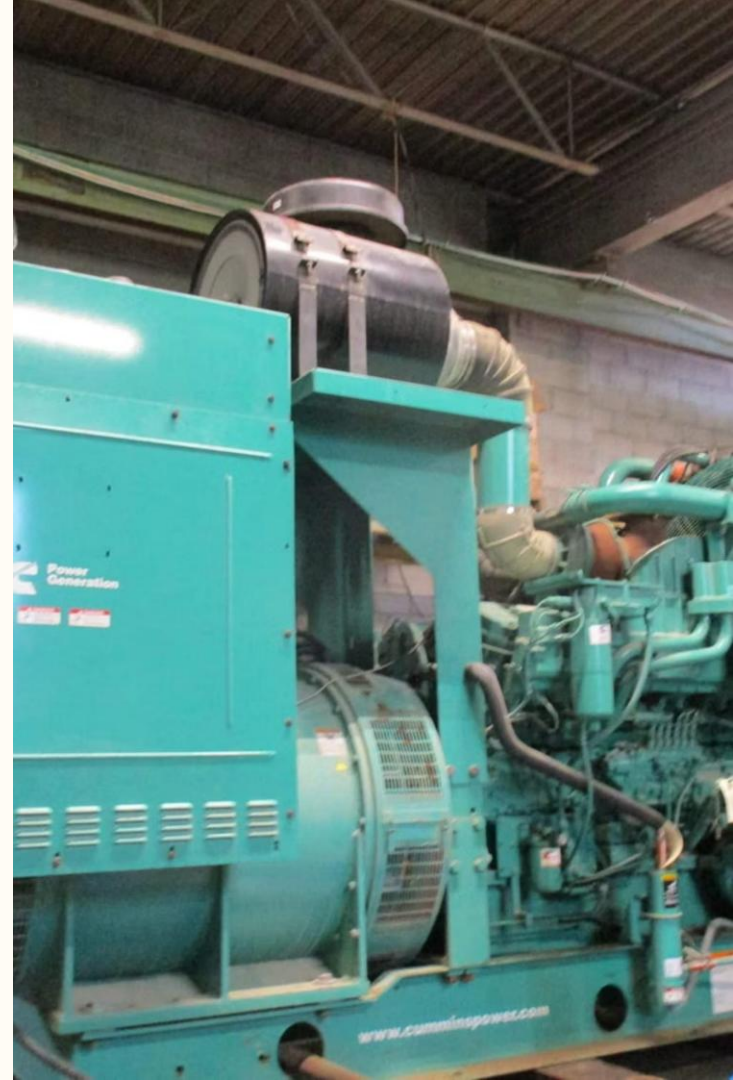
Server Processing

SCADA server receives data, updates the real-time database, evaluates alarm conditions, and writes time-stamped values to the historian.

RELIABILITY

System Reliability & Redundancy

A SCADA failure at a water or wastewater facility is not just an operational inconvenience — it can have public health and regulatory consequences. Reliability must be designed in from the start.



Redundancy Strategies

Redundant SCADA Servers

Primary and standby servers run in parallel. If the primary fails, the standby assumes control with no data loss. Hot-standby configurations switch over in seconds — transparent to operators.

Communication Redundancy

Dual communication paths — e.g., primary fiber with cellular backup — ensure data continues to flow if one link fails. Modern RTUs support automatic path failover.

Backup Power

UPS systems provide bridge power during brief outages. Generators provide sustained backup for critical facilities. Battery backup on RTUs keeps remote sites operational during extended outages.

Fail-Safe Control Strategies

Control logic must define safe default states for all outputs. If communications are lost, should a valve stay open or close? Should a pump run or stop? The answer depends on the process — document and test every scenario.

Fail-Safe Design: Getting It Right

Define "Safe State" for Every Output

For each controlled device, the design team must explicitly define the safe state on communication loss or controller failure. This decision must consider both public safety and process continuity:

- **Pump stations** — typically fail to last commanded state or stop
- **Chlorine dosing** — typically fail closed to prevent overdose
- **Pressure relief valves** — typically fail open

Watchdog Timers

A watchdog timer in the PLC detects loss of communication with the SCADA server and triggers the pre-defined fail-safe output state after a configurable timeout period. This is a fundamental safety feature — verify it is configured and tested on every system.



Always test fail-safe behavior during commissioning and after any major system change.

SCADA Availability: Setting the Right Expectations

99.9%

Target Availability

Industry standard for critical water/wastewater SCADA systems — equates to less than 9 hours of downtime per year.

4–20

mA Signal Range

Standard analog signal range used by the majority of field instruments in water/wastewater applications.

2x

Communication Paths

Minimum recommended for any critical remote site — primary plus one independent backup path.

CHAPTER 2

Field Instrumentation for Water & Wastewater

The quality of your SCADA data is only as good as the instruments generating it. Understanding sensor technology, limitations, and failure modes is essential for every control systems engineer.



The Three Critical Measurement Categories

Level Measurement

Monitoring storage tanks, wet wells, clearwells, and open channels to manage inventory and control pump cycles.



Flow Measurement

Quantifying water movement through mains, treatment processes, and discharge points for operations and regulatory reporting.

Pressure Monitoring

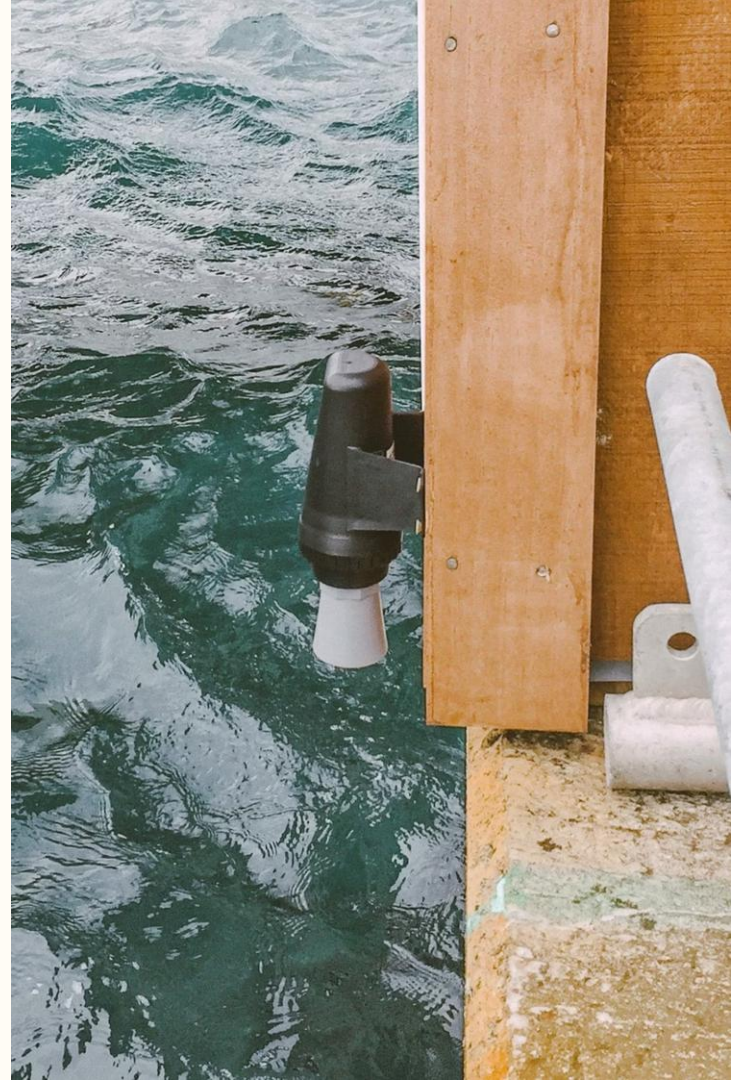
Maintaining safe distribution system pressures, protecting pumps, and detecting leaks or main breaks in real time.



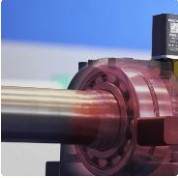
LEVEL MEASUREMENT

Level Measurement Technologies

Level is one of the most frequently measured variables in water and wastewater operations — from raw water reservoirs to finished water storage and wet wells.



Level Sensors: Technology Comparison



Ultrasonic

Emits sound pulses and measures return time. Non-contact, no moving parts. Excellent for wet wells and tanks. Can struggle with foam, turbulence, or very close targets (blanking distance).



Pressure Transducer

Submersible or side-mounted. Measures hydrostatic pressure to calculate level. Simple, reliable, and cost-effective. Requires compensation for variations in specific gravity and temperature.



Radar (Guided Wave & Non-Contact)

Highest accuracy and immunity to foam, vapor, and temperature changes. Non-contact radar ideal for potable water tanks. Guided wave radar suited for narrow vessels and challenging applications.



Float Switches

Simple, discrete (on/off) level detection. Used as high/low alarms or pump alternator inputs. Highly reliable for backup protection but provide no continuous measurement.

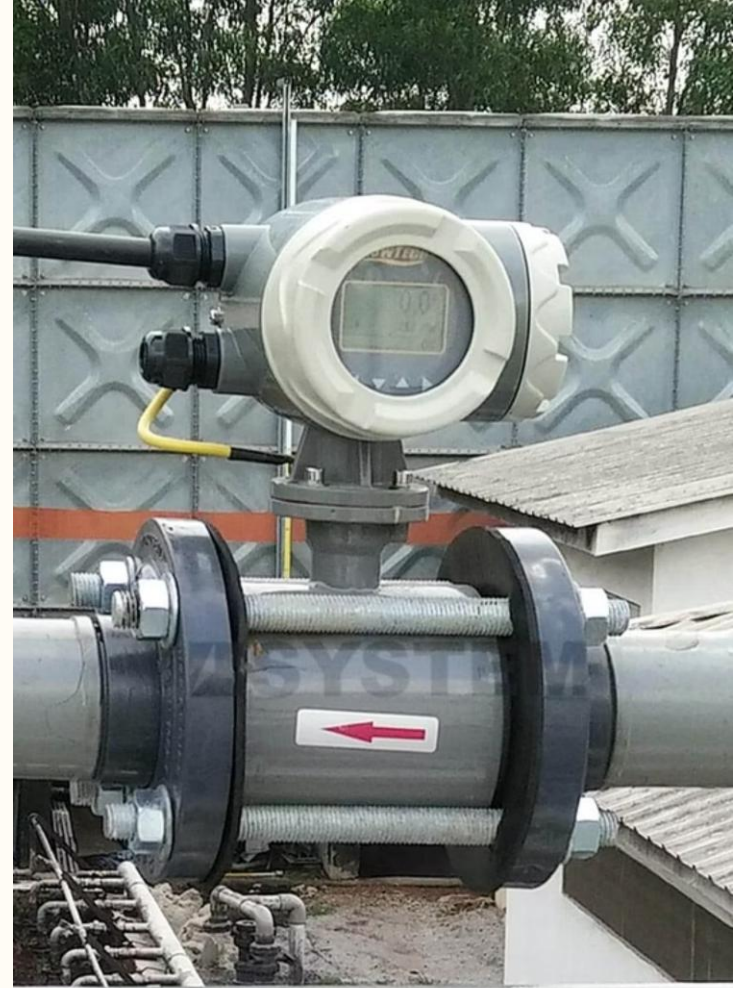
Selecting the Right Level Technology

Technology	Contact?	Accuracy	Best Application	Watch Out For
Ultrasonic	Non-contact	$\pm 0.25\%$	Wet wells, open tanks	Foam, turbulence, condensation
Pressure Transducer	Contact (submersible)	$\pm 0.1\%$	Wet wells, tanks, rivers	Plugging, SG variation
Radar (Non-contact)	Non-contact	$\pm 0.1\%$	Clearwells, potable tanks	Nozzle height, obstructions
Float Switch	Contact	Discrete only	Alarm/backup, pump control	Debris, binding, wear

FLOW MEASUREMENT

Flow Measurement Technologies

Accurate flow measurement is foundational to water loss accounting, regulatory compliance, and process optimization — yet it remains one of the most common sources of data quality issues.



Magnetic Flow Meters

How They Work

Magnetic flow meters (mag meters) apply Faraday's law of electromagnetic induction. A magnetic field is generated across the pipe; as conductive liquid flows through it, a voltage proportional to flow velocity is induced and measured. There are no moving parts and no flow obstruction.

Ideal Applications

- Raw water and treated water mains
- Plant influent and effluent metering
- Chemical dosing verification
- Any full-pipe, conductive liquid application

Key Specifications

- Accuracy: ± 0.2 – 0.5% of reading
- Minimum conductivity: $\sim 5 \mu\text{S}/\text{cm}$
- No moving parts — low maintenance
- Bi-directional measurement capable
- Liner must be compatible with fluid



Mag meters require a full pipe. Partially filled pipes will produce erratic or zero readings.

Ultrasonic & Open Channel Flow

Clamp-On Ultrasonic Flow Meters

Transducers clamp onto the outside of an existing pipe — no pipe cutting, no process shutdown. Ideal for retrofits and temporary measurement. Transit-time technology measures velocity; accuracy depends heavily on installation geometry and pipe condition. Typical accuracy: $\pm 1\text{--}3\%$.

Inline Ultrasonic Flow Meters

Wetted transducers installed inline provide higher accuracy than clamp-on. Common in custody transfer and regulatory metering applications. Multi-path designs reduce sensitivity to velocity profile distortions.

Open Channel Flow (Flumes & Weirs)

Used at plant discharge, stormwater, and collection system monitoring points. A level sensor (ultrasonic or radar) measures depth; flow is calculated using the appropriate flume or weir equation (Manning's, Parshall, etc.). Accuracy depends heavily on approach conditions and sensor placement.

PRESSURE MONITORING

Pressure Monitoring in Water Systems

Distribution system pressure monitoring is a critical early-warning tool — for main breaks, pump failures, pressure zone exceedances, and water quality events triggered by pressure transients.



Pressure Monitoring Applications



Distribution System

Remote pressure monitors throughout the distribution network detect main breaks, zone pressure deviations, and night-time pressure spikes. Typical range: 0–200 psi. Target: 40–80 psi at all service connections per AWWA guidelines.



Pump Discharge

Monitors pump performance and detects closed valve conditions. Used in pump run/no-run logic and protection against dead-head operation, which can damage pump seals and impellers within minutes.



Process Pressure

Differential pressure across filters indicates head loss and drives backwash initiation. Inline pressure monitoring in treatment processes ensures membranes and vessels operate within rated limits.

Instrumentation Considerations

Calibration

All instruments drift over time. Establish a formal calibration program with documented intervals, procedures, and as-found/as-left records. Critical meters such as effluent flow and chemical dosing should be calibrated at minimum annually — more frequently if process changes occur.

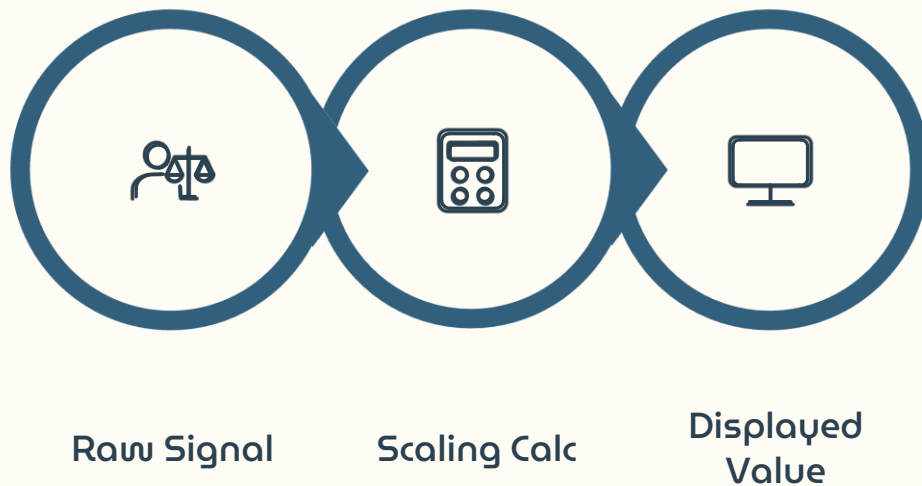
- Use NIST-traceable reference standards
- Document as-found deviation before adjustment
- Track drift trends to predict future failures

Environmental Factors

Water and wastewater environments are harsh. When selecting and installing instrumentation, account for:

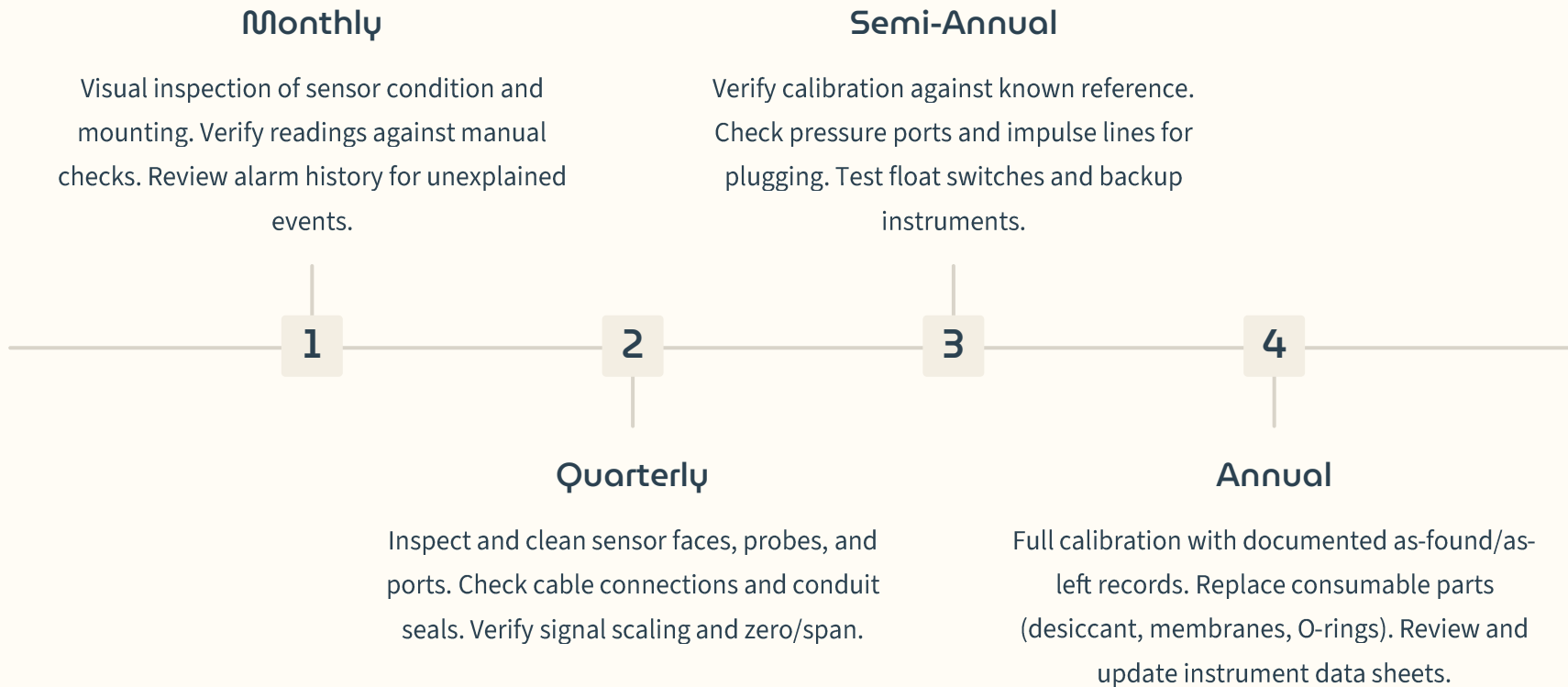
- **Temperature extremes** — freezing in northern climates, heat in exposed locations
- **Humidity & condensation** — can corrode terminals and affect electronics
- **Chemical exposure** — chlorine, hydrogen sulfide, and acids attack sensor materials
- **Vibration** — pump stations generate vibration that loosens connections over time

Signal Scaling: From Raw Count to Engineering Units



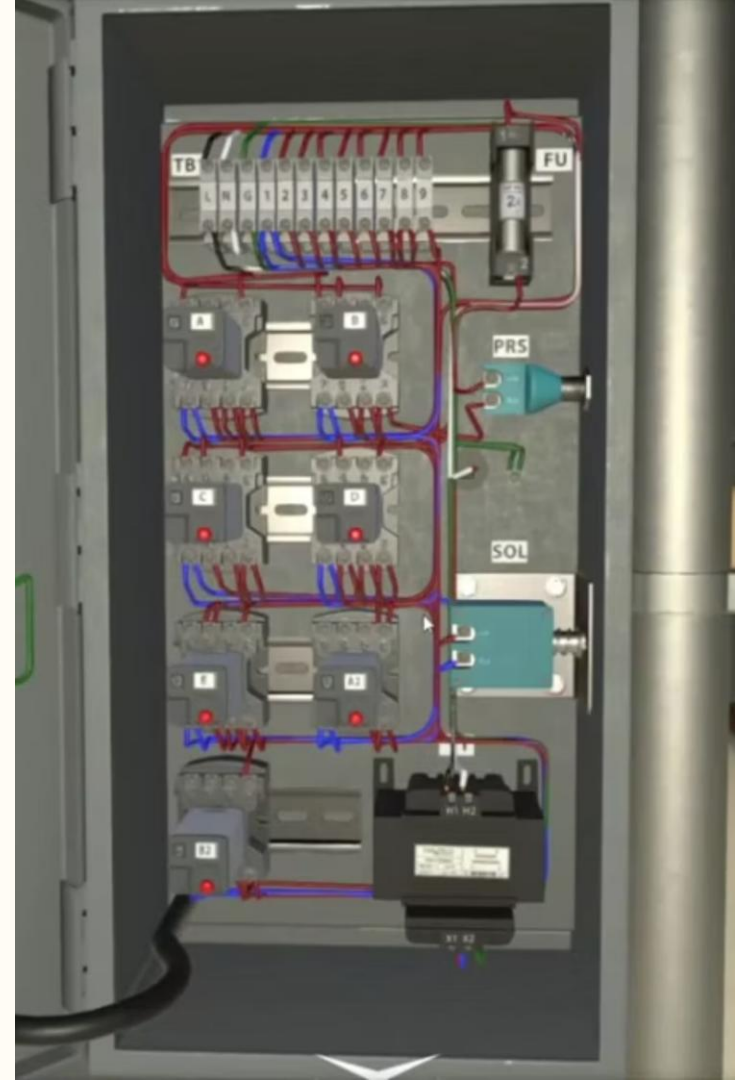
Signal scaling errors are a common source of instrumentation problems. Always verify the PLC scaling block matches the instrument's calibrated range — a mismatch here will produce inaccurate readings that look plausible and are easy to miss.

Maintenance Intervals: Don't Wait for Failure



Common Instrumentation Failures

Understanding failure modes — and their signatures in the SCADA data — is one of the most practical skills an operations engineer can develop. Most failures follow recognizable patterns.



The Four Failure Signatures



Flatline Reading

The tag value stops changing and holds a constant — often the last valid value or a rail value (0% or 100%). Indicates complete loss of signal, failed transmitter power, broken wire, or failed analog input card. Confirm: does the physical process actually hold steady?



Sudden Unrealistic Spikes

Value instantaneously jumps to an extreme high or low, then may recover. Indicates electrical noise, loose wiring, grounding issues, or a failing transmitter. A single spike could be noise; recurring spikes point to an installation or hardware problem.



Inconsistent vs. Field Conditions

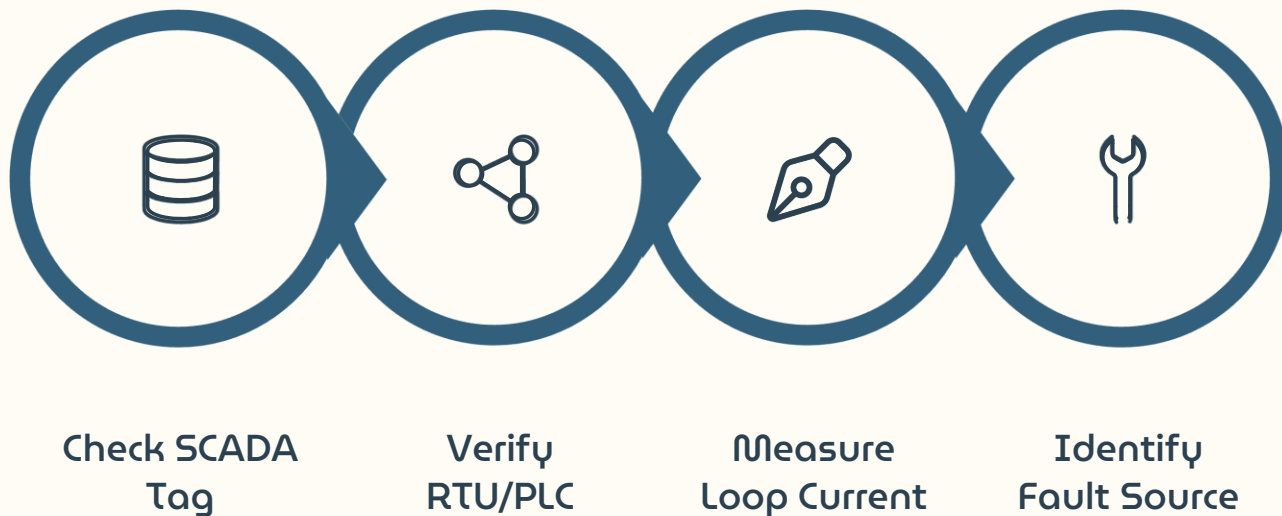
The instrument reads a value that contradicts observable field conditions — for example, a level sensor reading 8 ft when the tank is clearly near empty. Points to calibration drift, scaling error, or sensor fouling.



Loss of Signal

The SCADA tag shows "Bad Quality" or a communication fault rather than a process value. Indicates a communication failure between the RTU/PLC and the SCADA server — or between the field instrument and the controller. Distinguish from a hardware failure before dispatching field crews.

Diagnosing a Flatline Reading



A systematic approach prevents wasted field trips. Always start at the SCADA server and work outward toward the field — you can eliminate the most common causes (communication loss, PLC I/O failure) before rolling a truck.

Diagnosing Inconsistent Readings

Most Likely Causes

- **Calibration drift** — instrument has shifted from its original calibration. Compare against a manual reference measurement.
- **Signal scaling mismatch** — PLC range does not match the instrument's configured output range.
- **Sensor fouling** — debris, scale, or biological growth on sensor face (common in ultrasonic level, mag meters).
- **Changed process conditions** — e.g., water density changes affecting submersible pressure transducers.

Verification Steps

1. Obtain a manual reference measurement (tape measure, visual inspection)
2. Compare to SCADA-displayed value
3. Check instrument zero and span in transmitter configuration
4. Verify PLC scaling parameters match instrument range
5. Inspect and clean sensor if fouling is suspected
6. Recalibrate and document as-found/as-left

Electrical Noise & Grounding Issues

What Causes Electrical Noise?

Variable frequency drives (VFDs), motor starters, and high-current switching equipment generate electromagnetic interference (EMI) that can corrupt 4–20 mA signals. The result is erratic readings or unexplained spikes in the SCADA historian.

Best Practices to Prevent It

Route instrumentation cables in separate conduit from power cables. Use shielded twisted-pair cable for all analog signals. Terminate shield drain wires at one end only (typically the panel). Maintain separation of at least 12 inches between instrument and power conduit where they must run parallel.

Grounding: The Silent Killer

Improper grounding creates ground loops that inject 60 Hz noise into analog circuits. All panels and instrument enclosures should have a dedicated instrument ground bus connected to the facility ground system. Never rely on conduit as the only ground path for instrument circuits.

Building a Troubleshooting Culture

Document Everything

Every instrumentation anomaly, calibration event, and field investigation should be documented in a maintenance management system (CMMS). Over time, this creates a failure history that reveals patterns — recurring failures at specific sites, seasonal issues, or equipment families with reliability problems.

The 5-Minute SCADA Check

Train operations staff to review SCADA trends before field visits. A 5-minute review of historian trends for a suspect instrument can tell you when the problem started, whether it's intermittent or steady, and whether it correlates with external events (storms, power outages, maintenance activities). This information is invaluable — and it costs nothing.

Instrumentation Failure: Real-World Impact

“

Wet Well Overflow — A fouled ultrasonic level sensor in a lift station reads 3 ft low due to foam on the surface. The SCADA system never triggers the high-level alarm. The wet well overflows before the on-call operator receives any notification.

”

“

False Billing Data — A mag meter with an incorrect scaling parameter in the PLC over-reports flow by 12% for six months before a customer billing discrepancy triggers an investigation. The as-found calibration is within spec — the error was entirely in the scaling configuration.

”

“

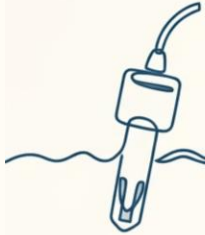
Pump Cavitation Damage — A plugged suction pressure port provides a falsely high reading. The SCADA system does not alarm for low suction pressure; the pump operates in cavitation for several hours before operators notice unusual vibration during a routine site visit.

”

These scenarios are not hypothetical — they reflect real events that occur at water and wastewater utilities every year. The common thread: a small instrumentation problem that went undetected until it caused a larger operational consequence.

Instrumentation Best Practices Summary

1. SELECT CORRECT SENSORS



based on environment.

Choose sensors based on environment.

2. INSTALL PROPERLY

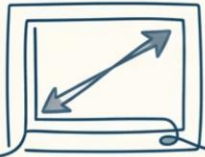


Follow manufacturer mounting rules.

3. CALIBRATE SCHEDULE

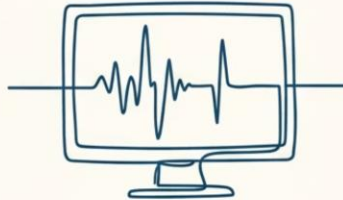


Keep a documented calibration plan.



4. VERIFY SIGNAL SCALING

Check PLC range vs instrument range.



5. MONITOR FOR FAILURES

Watch for spikes and loss of signal.



6. DOCUMENT EVERYTHING

Build key institutional knowledge.

Alarm Management in SCADA Systems

Alarm overload can overwhelm operators, hide real process issues, and increase safety and environmental risk. This chapter covers practical ways to keep alarms clear, actionable, and under control.



The Alarm Management Problem

1 / 10 min

EEMUA 191 Target

Industry guideline for maximum average alarm rate.

10-20x

Typical Actual Rates

Many facilities exceed recommended alarm rates during upsets.

Alarm floods can overwhelm operators and hide genuine process upsets, making standards like **EEMUA 191** and **ISA-18.2** essential.

Alarm Design Principles

Actionable Alarms

Each alarm must require a clear operator response.

Prioritization

Group alarms into Critical, High, Medium, and Low tiers.

Eliminate Chattering

Use deadbands and delays to prevent rapid alarm cycling.

Shelving & Suppression

Temporarily shelf or suppress alarms based on operating conditions.

Documentation & Change

Document setpoints and control changes through formal management.

Alarm Rationalization: A Practical Process

01

Audit Existing Alarms

Export the full SCADA alarm list to establish a baseline.

02

Classify by Consequence

Identify each alarm's consequence and required operator response.

03

Assign Priority Tiers

Assign each alarm to Critical, High, Medium, or Low.

04

Optimize Setpoints & Delays

Set limits, deadbands, and delays to reduce nuisance alarms.

05

Document in AMDB

Record each alarm's rationale, priority, setpoints, and action.

06

Monitor KPIs & Review

Track alarm KPIs and review performance regularly.

After-Hours & On-Call Alarm Notification

Multi-Channel Notifications

Critical alarms reach on-call personnel by SMS, email, or push notifications.

Automated Escalation Chains

Unacknowledged alarms escalate automatically until someone responds.

On-Call Scheduling Integration

Notifications route to the correct personnel based on active schedules.

Nuisance Alarm Filtering

Filtering removes false positives before alerts are sent.

Acknowledgment & Tracking

Acknowledgments and responses are logged for audit and review.

Cloud-Based Platforms

Cloud platforms simplify after-hours notifications without on-site server complexity.

CHAPTER 4

System Integration: SCADA Beyond the Control Room

SCADA becomes far more powerful when connected to the rest of the enterprise. Integrated with systems like CMMS, LIMS, billing, reporting, and GIS, it turns operational data into actionable intelligence.



SCADA + CMMS Integration

Seamless Operational Alignment

- Work orders from runtime, alarms, or faults.
- Update CMMS assets with live health data.
- Shift from reactive to predictive maintenance.

Real-World Applications

- Pump runtime triggers bearing inspection.
- Motor vibration creates emergency repair orders.
- Valve cycles schedule preventive actuator service.

Common CMMS platforms include **IBM Maximo**, **Cityworks**, and **UpKeep**.

SCADA + Lab & Regulatory Reporting



LIMS Integration

SCADA process data automatically populates LIMS with compliance context.



Automated Reporting

Historian data generates accurate DMRs and regulatory submissions.



Data Integrity

Audit trails and time-stamps protect the integrity of reported data.



Eliminate Manual Errors

Digital integration removes transcription errors and compliance risk.

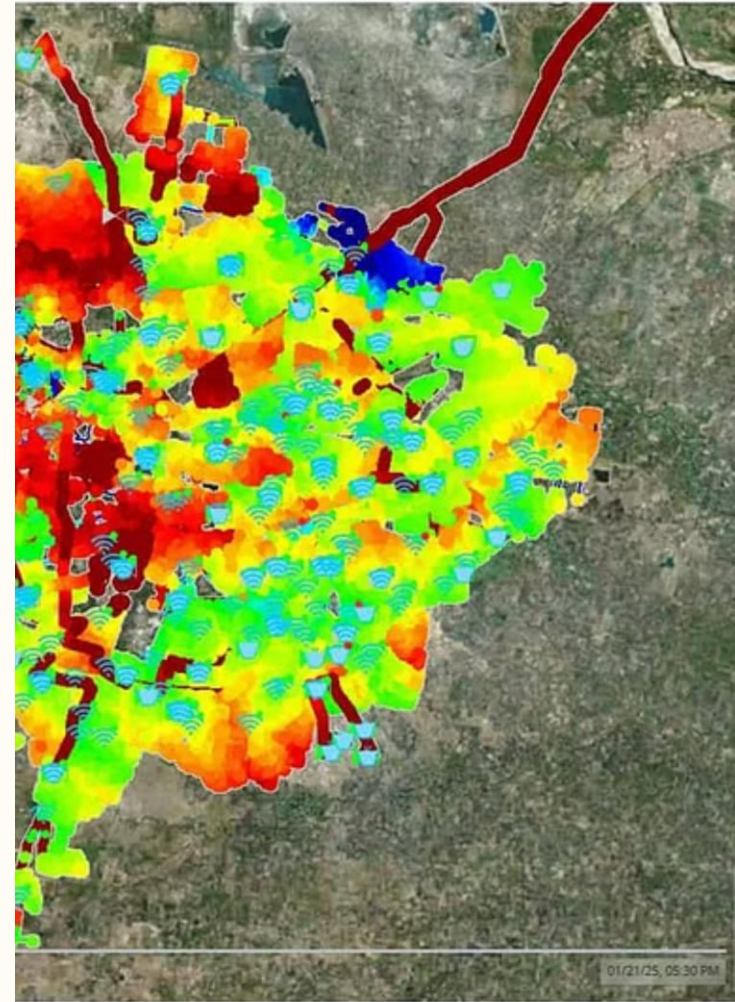
SCADA + QIS & Asset Management

Spatial Context & Visualization

View sensor readings and pressure zones directly on maps. Match SCADA alarms to exact asset locations for faster response.

Asset Lifecycle Management

Feed SCADA data into asset systems for lifecycle tracking. Monitor condition and plan maintenance or replacement proactively.



Integration Architecture: How Systems Connect



OPC-UA: The Modern Standard

Ensures secure, real-time exchange between SCADA and enterprise systems.



REST APIs: Cloud-Based Integrations

Connects cloud platforms for scalable data transfer and analytics.



Database-Level Integration

Links historians to databases for archiving, analysis, and reporting.



Middleware & Integration Platforms

Bridges OT and IT with streamlined ingestion, processing, and routing.



Key Integration Considerations

Focus on latency, security boundaries, and accurate data mapping.



CHAPTER 5

Remote Access & Cloud SCADA: The Modern Shift

Utilities are moving from on-premise SCADA servers to cloud-hosted and hybrid architectures. The shift is driven by lean staffing, 24/7 visibility, and more mature cloud security.

Traditional vs. Cloud SCADA Architecture

Traditional On-Premise

- Dedicated SCADA server hardware onsite
- Remote access usually requires VPN
- High IT maintenance overhead
- Large upfront CapEx investment
- Scalability limited by physical infrastructure

Cloud-Native SCADA

- Operational data hosted in cloud
- Anywhere access via browser or app
- Vendor-managed infrastructure reduces IT burden
- Subscription-based OpEx for predictable costs
- Scales on-demand with system growth

Benefits of Cloud SCADA for Small & Mid-Size Utilities

No Dedicated IT Staff

Cloud providers handle maintenance, security, and infrastructure.

Lower Total Cost of Ownership

Shift from CapEx to predictable subscription-based OpEx.

Built-in Redundancy & DR

Cloud infrastructure provides backup, redundancy, and disaster recovery.

Automatic Software Updates

Get the latest features and security patches automatically.

Mobile Access for Operators

Operators can monitor and control systems from anywhere.

Easier Compliance & Reporting

Data logging and report generation become simpler.

Remote Access: Doing It Safely

The Oldsmar Incident: A Real-World Threat

In 2021, an attacker remotely accessed Oldsmar's water plant and altered chemical levels.

Multi-Factor Authentication (MFA)

Require MFA for every remote access point to block unauthorized logins.

Role-Based Access Control (RBAC)

Limit users to only the SCADA functions and data their role requires.

Secure Network Access (VPN/ZTNA)

Use VPNs or ZTNA to encrypt and authenticate remote connections.

Comprehensive Logging & Audit Trails

Log remote sessions and actions to support investigations and detect anomalies.

Limit Remote Control & Prioritize Read-Only

Keep most remote access read-only and restrict control to essential staff.

The Future of SCADA: Trends to Watch



Edge Computing

Processes data at the RTU/PLC level for faster local decisions.



Digital Twins

Enable simulation, predictive maintenance, and safer scenario planning.



AI/ML for Anomaly Detection

Detects subtle failure patterns before traditional alarms trigger.



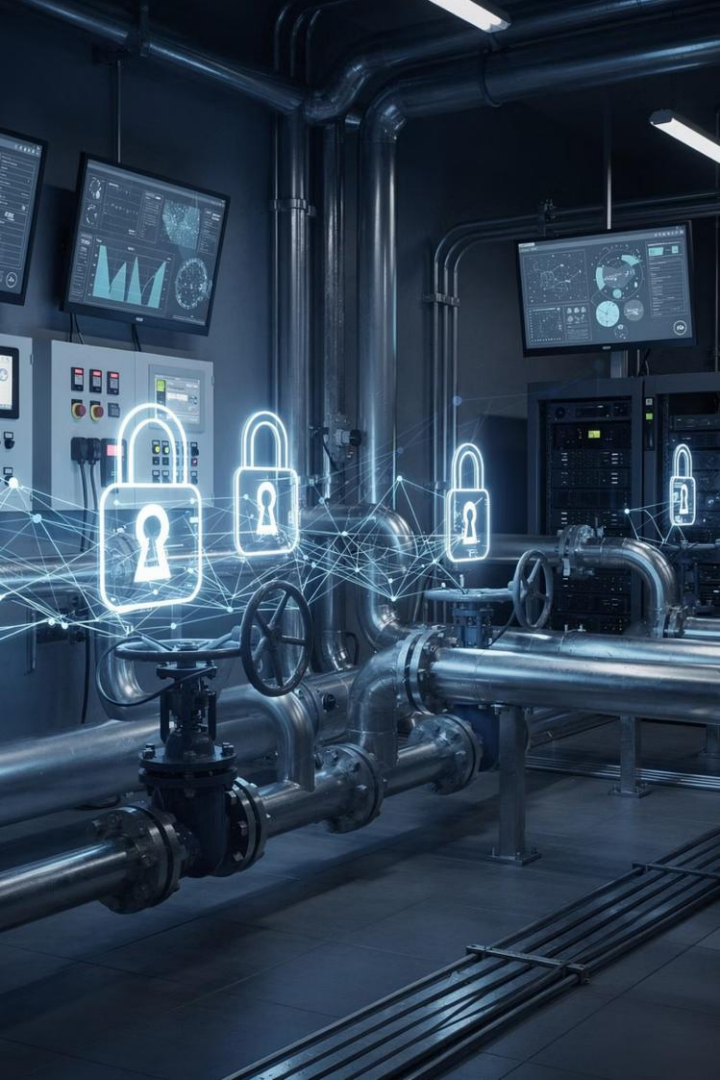
5G Connectivity

Provides high-bandwidth, low-latency connectivity for remote utility sites.



SCADA Consolidation

Centralizes operations across utilities to improve efficiency and reduce cost.



CHAPTER 6

SCADA Cybersecurity: A Growing Priority

Water and wastewater SCADA systems are increasingly targeted by cyber threats. Understanding basic security principles is now a required competency for every engineer working on these systems.

Cybersecurity Fundamentals for SCADA

1

Network Segmentation

Isolate the OT (operational technology) network from corporate IT and the internet. Use a DMZ architecture with firewalls to control all data flows between zones.

2

Access Control

Enforce role-based access. Every user should have the minimum privileges needed for their job. Eliminate shared accounts. Log all access events — who did what, and when.

3

Patch Management

Keep SCADA servers, HMI workstations, and network equipment current on security patches. Test patches in a non-production environment before deploying to live systems.

 The EPA's Cybersecurity Guidance for Water Utilities and CISA's ICS-CERT advisories are the primary resources for water sector cybersecurity requirements and threat intelligence.

 Vendor Compliance: When evaluating SCADA vendors, ask about their security certifications. High Tide Technologies, for example, maintains SOC-2 Type 2 compliance — an independent audit framework that verifies controls around data security, availability, and confidentiality. This is increasingly expected by utilities and regulators.

Key Takeaways

1 SCADA is a Layered System

Field → Control → Communication → Supervisory.

Understand each layer's role and failure modes. A problem at any layer affects everything above it.

3 Design Reliability In — Don't Add It Later

Server redundancy, communication failover, backup power, and fail-safe logic must be designed from the start.

Retrofitting reliability is expensive and incomplete.

2 Data Quality Starts in the Field

The best SCADA software cannot compensate for a poorly calibrated, improperly installed, or failing instrument. Invest in your instrumentation program.

4 Know Your Failure Signatures

Flatlines, spikes, inconsistencies, and loss of signal each point to different root causes. A systematic, data-driven approach to troubleshooting saves time and prevents escalation.

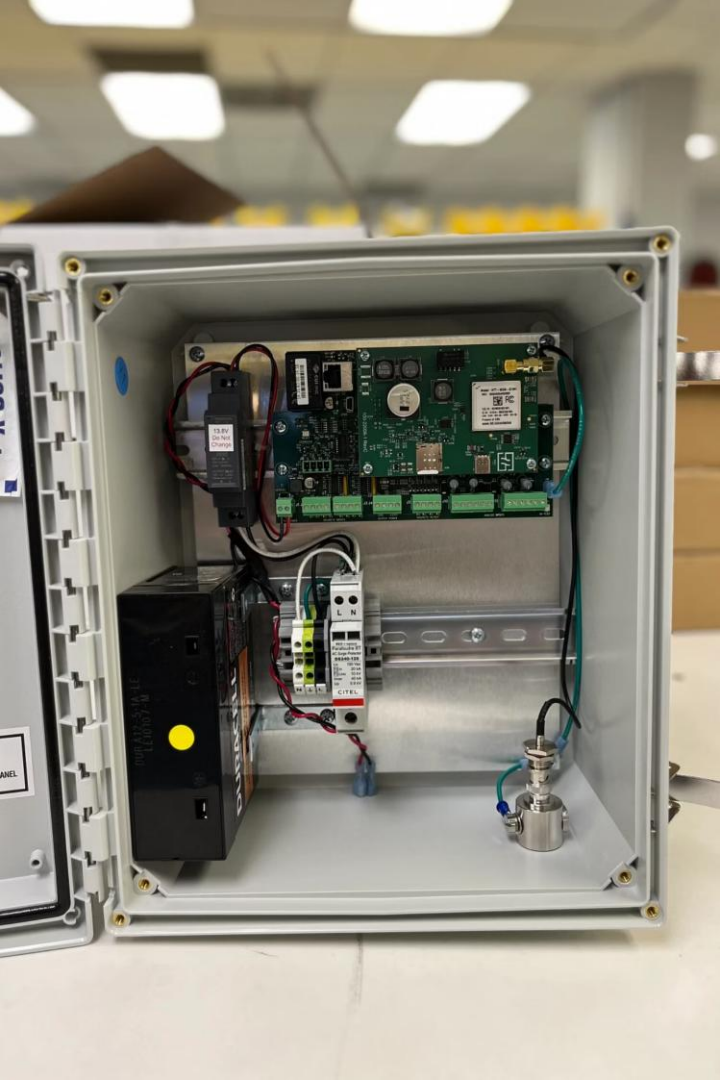
Questions & Discussion

Topics Covered Today

- SCADA system architecture and the four layers
- PLCs vs. RTUs and when to use each
- Communication technologies: cellular, radio, fiber
- End-to-end data flow from sensor to operator
- Redundancy and fail-safe design
- Level, flow, and pressure instrumentation
- Calibration, scaling, and maintenance
- Common failure modes and diagnostics

Resources for Further Learning

- **AWWA** — Water Sector Cybersecurity Guidance and SCADA Security Guidance
- **ISA-95 / ISA-101** — Standards for industrial automation and HMI design
- **WaterISAC** — Threat intelligence sharing for water utilities
- **CISA ICS-CERT** — Advisories for industrial control system vulnerabilities
- **EPA Water Security** — Risk and resilience assessments, cybersecurity tools



Thank You

Presented by High Tide Technologies — cloud-based SCADA for water & wastewater utilities.

About HTT

- Turnkey cloud-based SCADA — no programming required
- GEN-2, GEN-2 Lite & NANO RTU hardware
- SOC-2 Type 2 certified | 24/7/365 support

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