

Consolidated Edison Company of New York

Water Hammer Predictor Model Update

Presented by:

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Agenda

- **Presenter Introductions**
- **Con Edison Steam System Overview**
- **Trap Operations**
- **Monitoring External Water Conditions**
- **Physical Testing**
- **System Modeling**
- **Model Overview**
- **Benefits**

Presenter Introductions

Dowlatram Somrah, ME, PE

- Section Manager – Steam Distribution Engineering
- Education
 - Cooper Union – Undergraduate and Graduate Engineering Programs



Jimmy Tsang, ME

- Senior Engineer – Steam Distribution Engineering
- Education
 - Cooper Union – Undergraduate and Graduate Engineering Programs

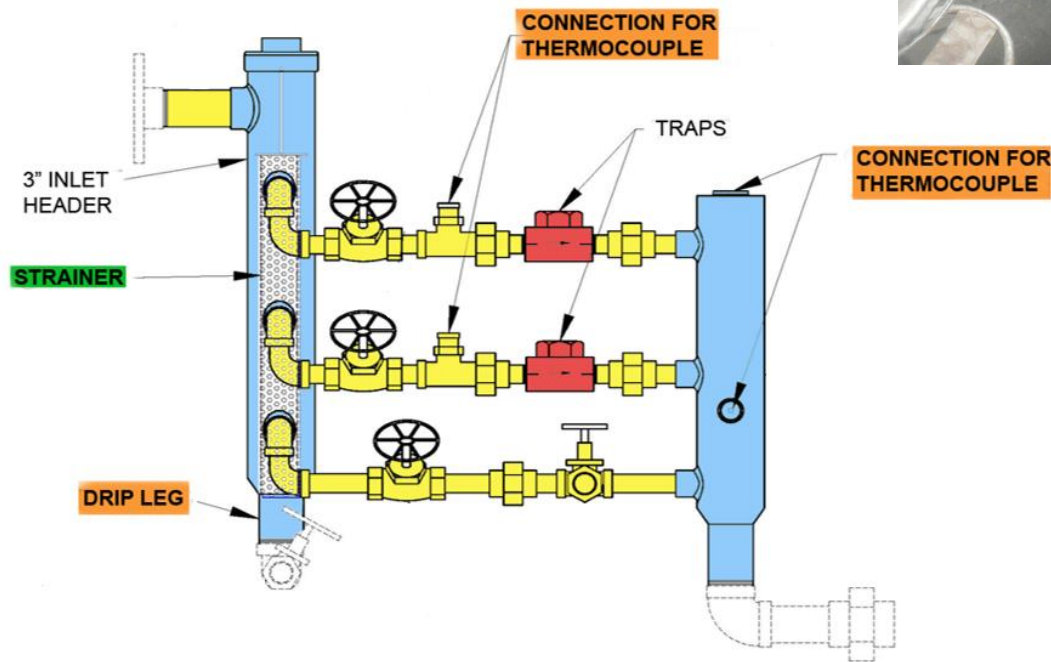
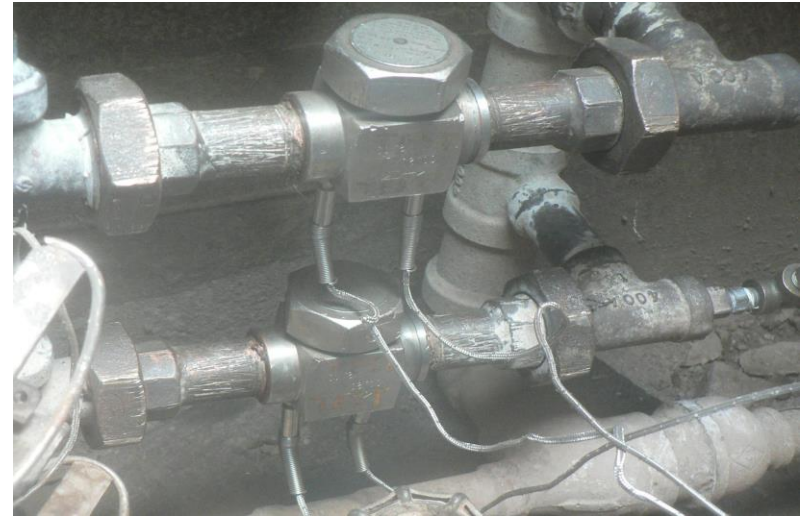


Con Edison Steam System Overview

- 106 miles
- Peak 9,600 Mlb/hr
- 23.5 billion lbs/2016
- Thermal losses

Trap Operations

- 835 trap stations
- Monitor status – cold
- Amount of condensate



Manhole Number: TMH7545

Trap ID: TE20S1

Address: 20th Street w/o fifth Ave

Location:

Trap Temperature

Upper Inlet

Upper Outlet

366.8

222.62

Lower Inlet

Lower Outlet

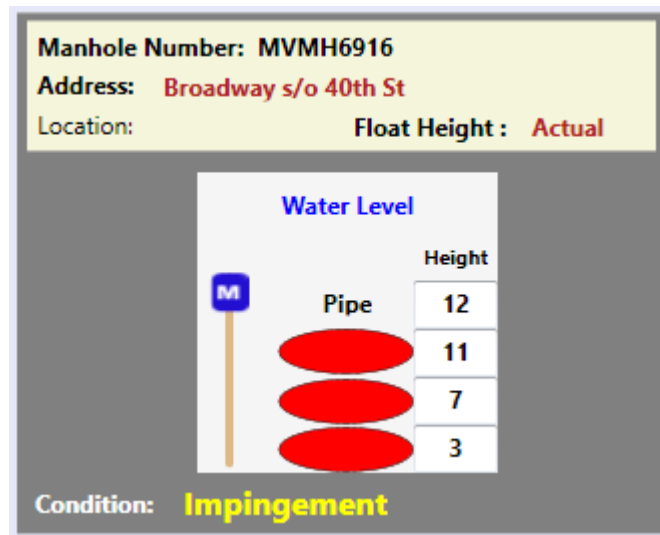
366.44

234.68

Condition: Normal

Monitoring External Water Conditions

- Impingement/submerged mains
- Vapor condition
- Increased condensate generation



Moderate Vapor



Flooded Manhole

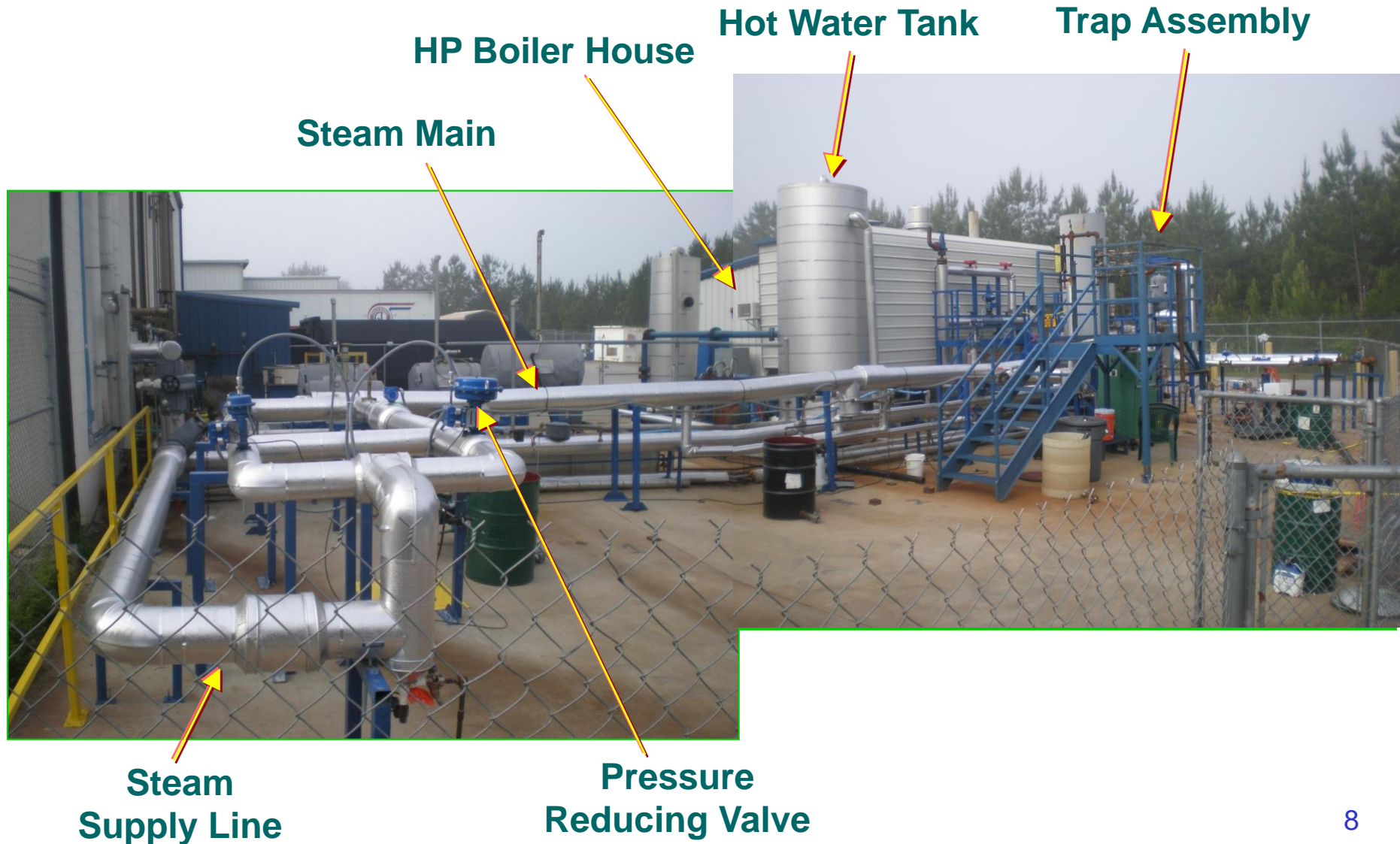


Physical Testing

- Geometrical configurations
 - Straight pipe – slopes from 1° to 5°
 - Pair of $22\frac{1}{2}^\circ$ elbows
 - Pair of 45° elbows
 - Pair of 90° elbows with $h/d = 2$ to 12
 - Bends with shallow to steep angle changes



Physical Steam Testing



System Modeling

- New water hammer model online - 8/17/2016
- 3.7 miles of distribution piping
 - Two send out mains
 - System geometry
 - Real time field measured values input
- Theory – multiphase flows
- Empirical data calibration
- Calculates
 - Steam velocity
 - Condensate build-up

Water Hammer Predictor Model Overview

- Pilot model piping
- Boundary Conditions
- Flow Direction

Water Hammer Predictor Model

Detailed View

- Sub-model area
 - Pipe geometry – plan and profile
- Customer loads
 - Service connections
- Manholes
- Trap stations
- Liquid hold up plot

Benefits of Water Hammer Predictor Model

- Real time calculated values system wide
 - Condensate build up
 - Pressure
 - Temperature
 - Steam velocity
- Supplement field measured values
 - Trap stations
 - Manholes susceptible to flooding



Water Hammer Predictor – Pressure Plot

- Pilot area
- Pressure values
 - Inputs at plants
 - Field measured values at boundaries
 - Calculated values

Model – Pressure and Temperature Profiles

- Sub-model area
 - Pipe geometry – plan
- Pressure profile
 - Calculated values
- Temperature profile
 - Calculated values

Model – Mass Flow Profile

- Sub-model area
 - Pipe geometry – plan
- Mass flow
- Condensate flow

Benefits of Water Hammer Predictor Model

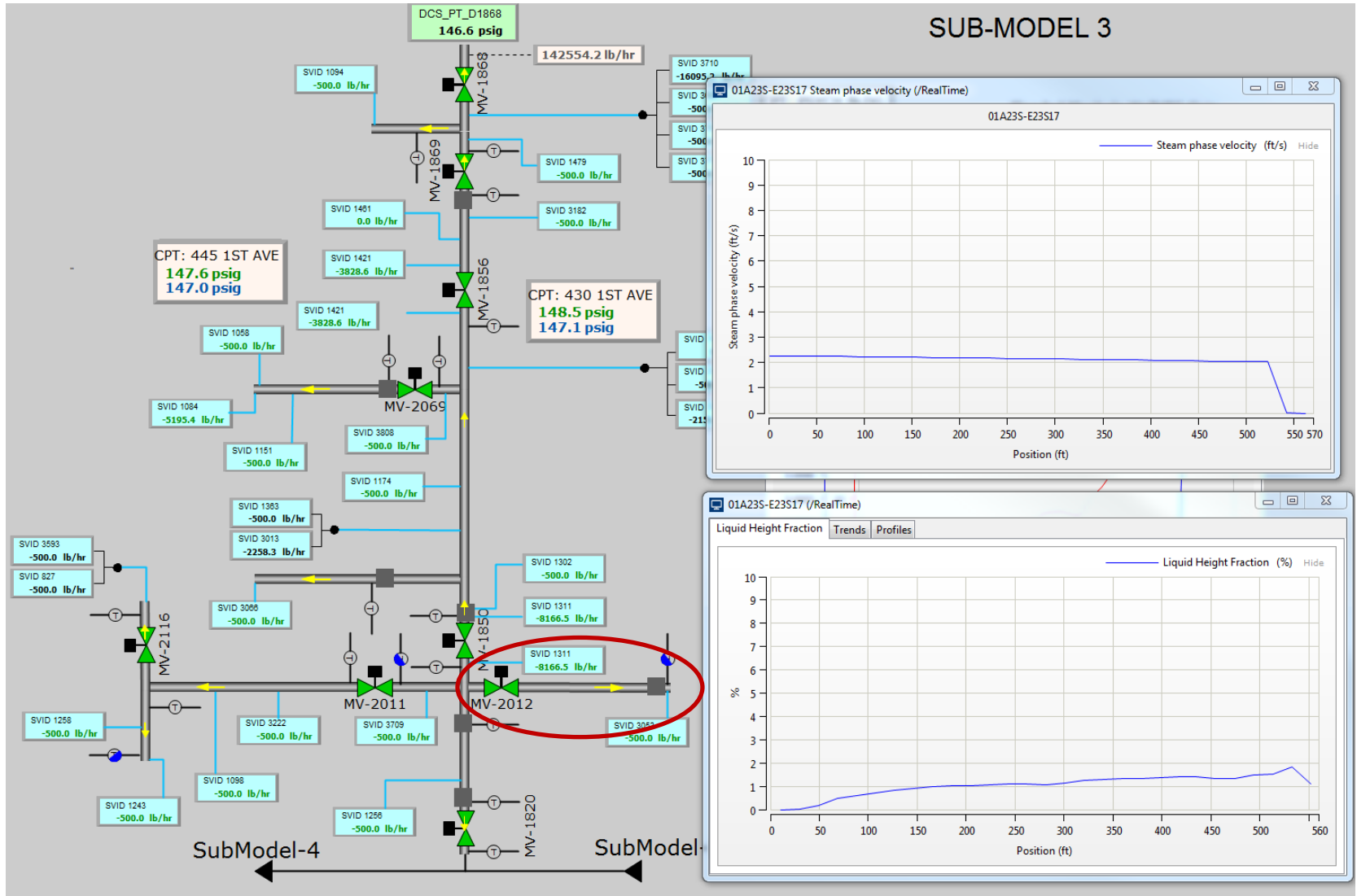
- Potential new alarms
 - Low velocity
 - Condensate build up
- Complement trap monitoring
- Improve confidence in alarms
- Improve response to mitigate high risk conditions



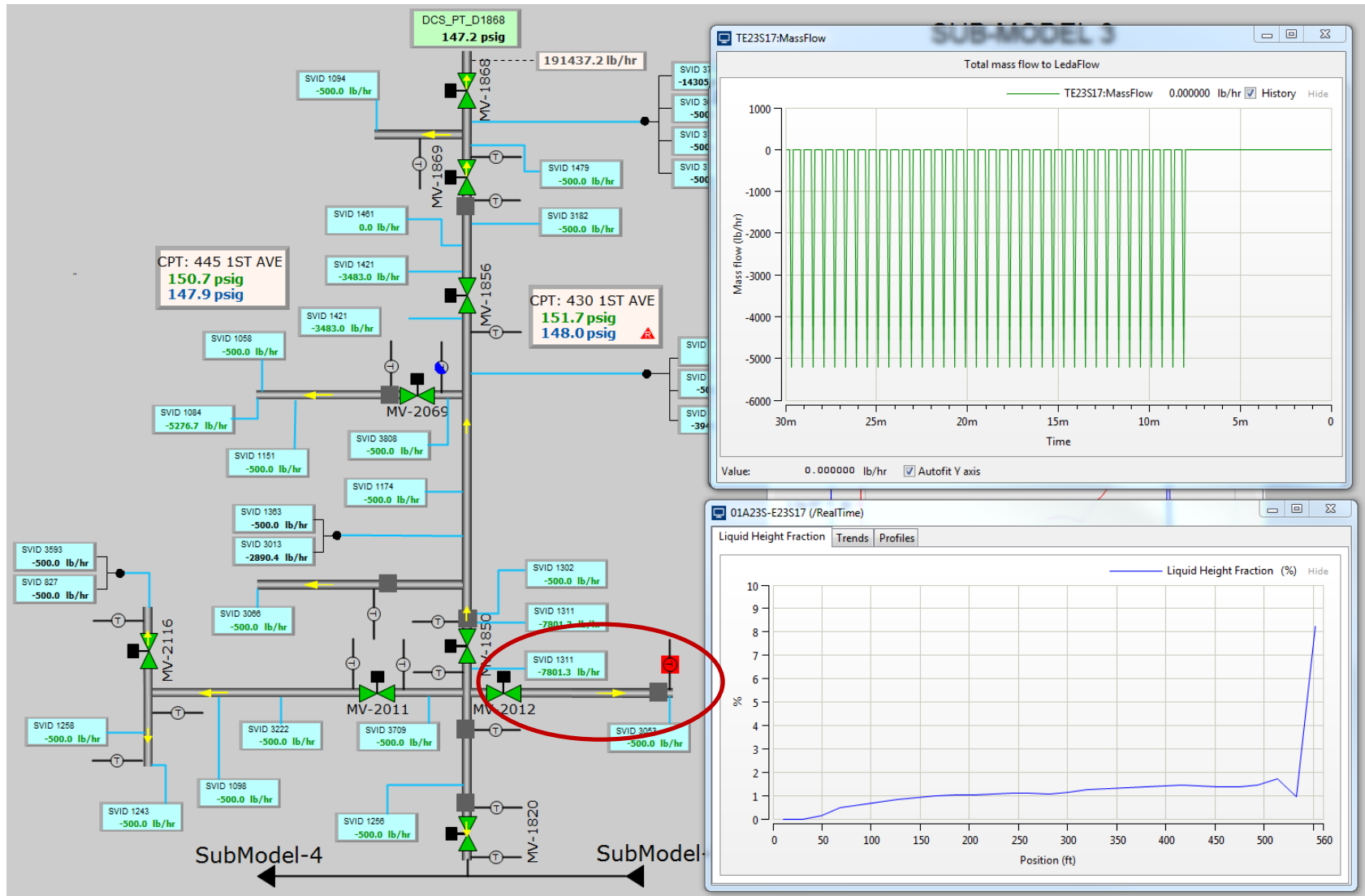
Water Hammer Predictor – Velocity Plot

- Pilot model area
 - Pipe geometry – plan
- Pressures
 - Inlet and boundaries
- Velocity profile
 - Low velocity

Model – Velocity and Liquid Profiles



Model – Simulated Cold Trap



Benefits of Water Hammer Predictor Model

- **Conditional based simulation**
 - Pipes segmented by flood zones
 - External water level monitoring
 - Integrated with remote monitoring
 - Different heat transfer coefficients

System Map
Showing Flood
Zones



The screenshot displays a process simulation interface with a piping network diagram and two associated plots.

Piping Network Diagram:

- The diagram shows a complex piping system with multiple streams, valves (MV), and storage vessels (SVID).
- Key components labeled include:
 - DCS_PT_D1868** (Pressure Transmitter) at the top center, showing a value of **147.8 psig**.
 - CPT: 445 1ST AVE** (Compressor/Turbine) on the left, showing a value of **152.4 psig** and **148.6 psig**.
 - CPT: 430 1ST AVE** (Compressor/Turbine) on the right, showing a value of **153.3 psig** and **148.8 psig**.
 - Valves (MV) such as MV-1868, MV-1869, MV-1856, MV-2069, MV-2116, MV-2011, MV-1850, MV-2012, and MV-1820.
 - Storage Vessels (SVID) with various flow rates, many set to **-500.0 lb/hr**.
- The diagram is divided into sections labeled **SubModel-4** and **SubModel-5**.

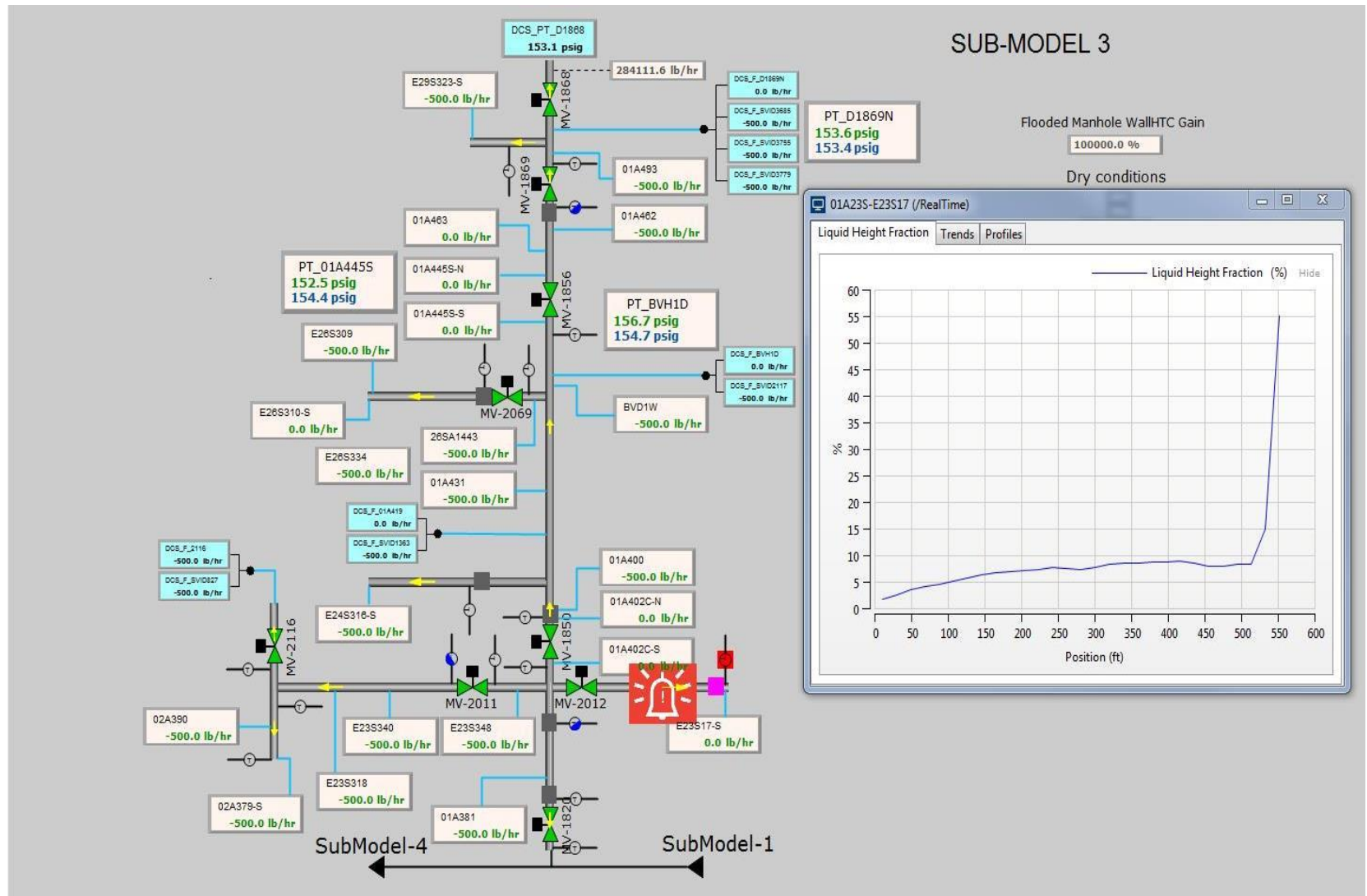
TE23S17:MassFlow Plot:

- Title: **TE23S17:MassFlow**
- Y-axis: **Mass flow (lb/hr)**, ranging from -6000 to 1000.
- X-axis: **Time**, ranging from 30m to 0.
- The plot shows a highly oscillatory signal, indicating rapid fluctuations in mass flow.

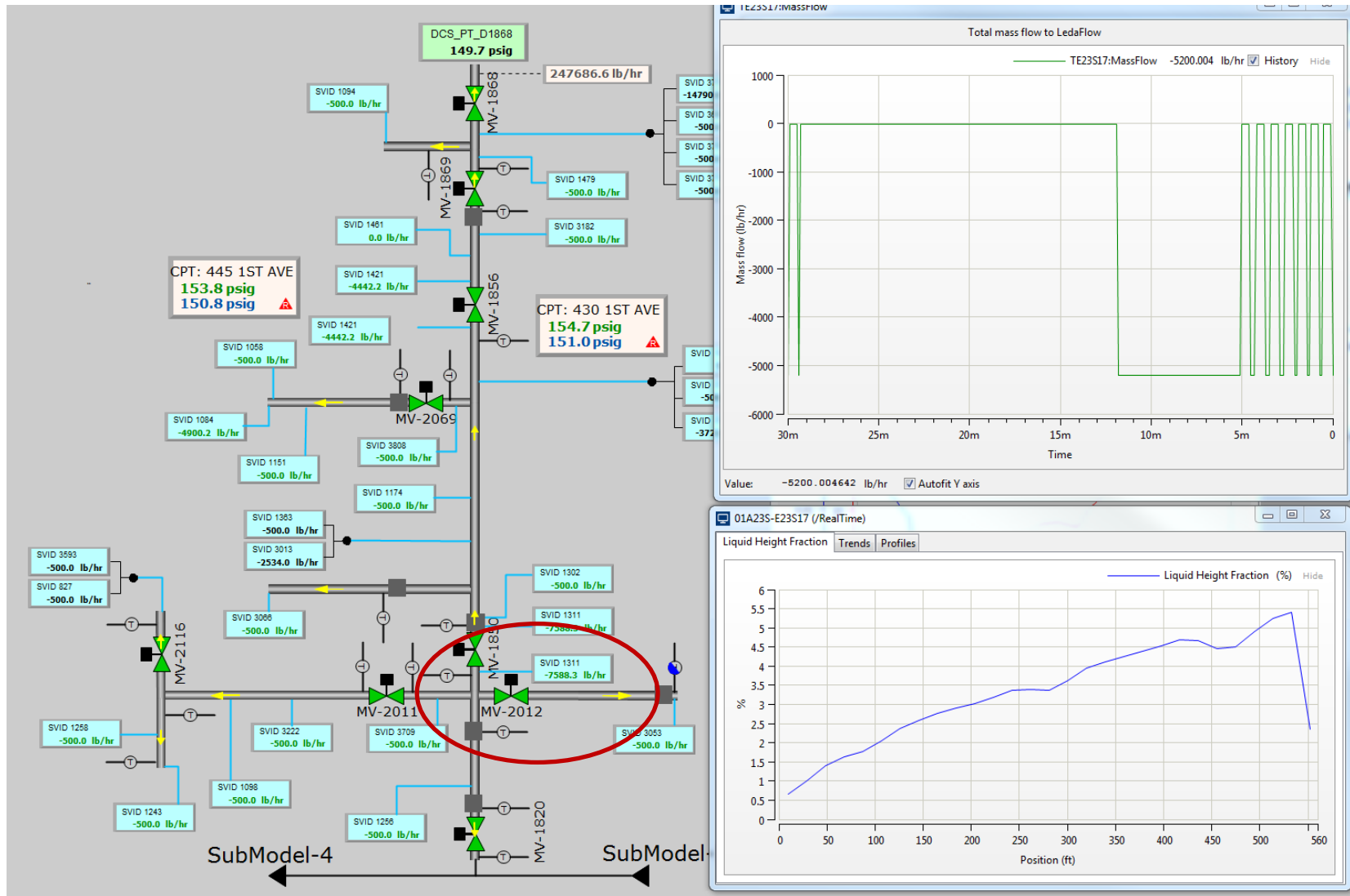
01A23S-E23S17 (/RealTime) Plot:

- Title: **01A23S-E23S17 (/RealTime)**
- Y-axis: **Liquid Height Fraction (%)**, ranging from 0 to 40.
- X-axis: **Position (ft)**, ranging from 0 to 560.
- The plot shows a relatively flat line at approximately 10% liquid height fraction, with a sharp increase to about 38% at the end of the position range (560 ft).

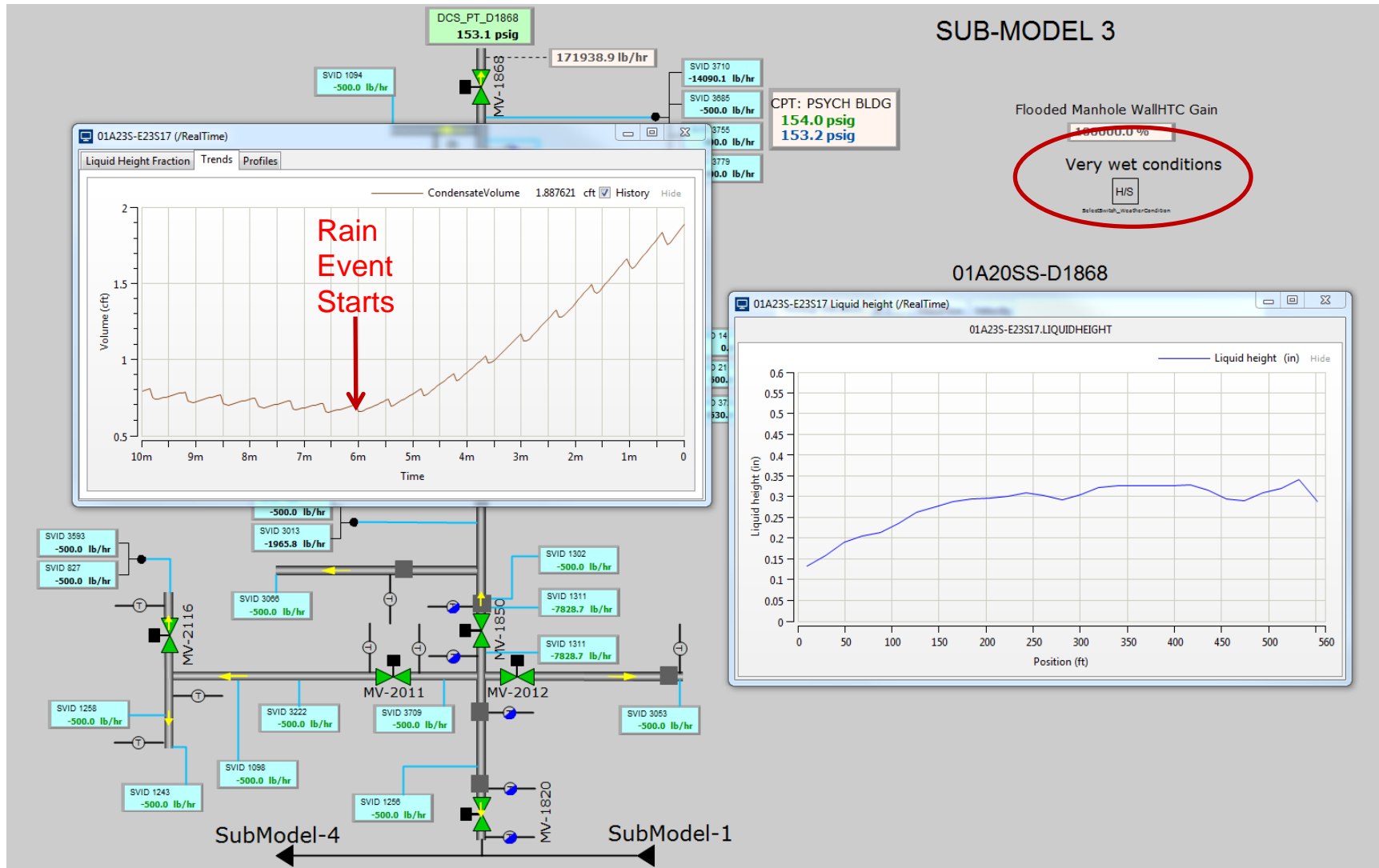
Model – Simulated Water Hammer Alarm



Model – Simulated Restoration From Alarm



Model – Simulated Rain Event



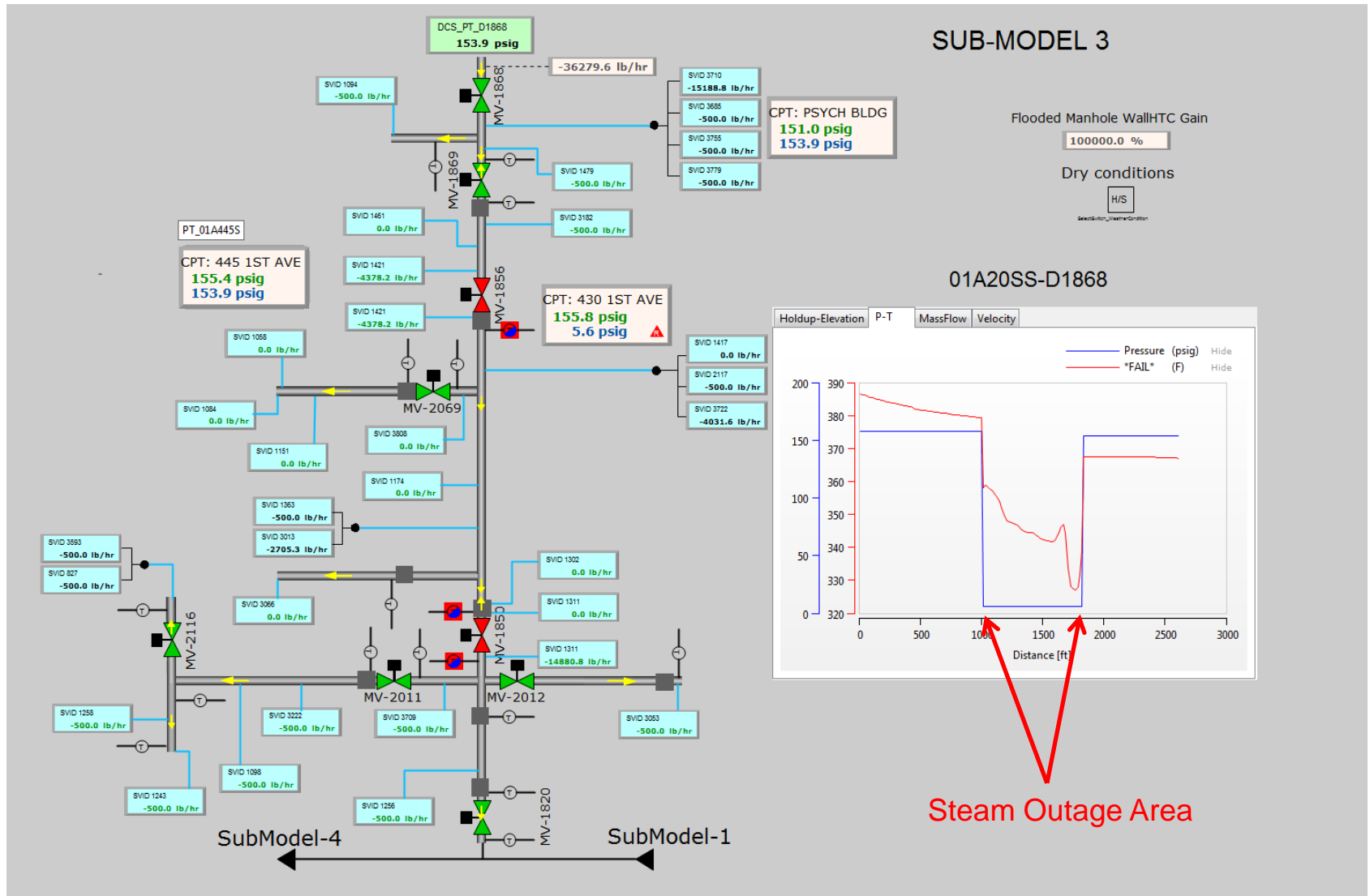
Benefits of Water Hammer Predictor Model

- **Contingency analysis**
 - Plan work outages
 - Improve system dispatch
- **Steam Mimic**
 - Pressure distribution
 - Operate with a packed system
 - 13 psi differential

Model – Simulated Steam Main Outage

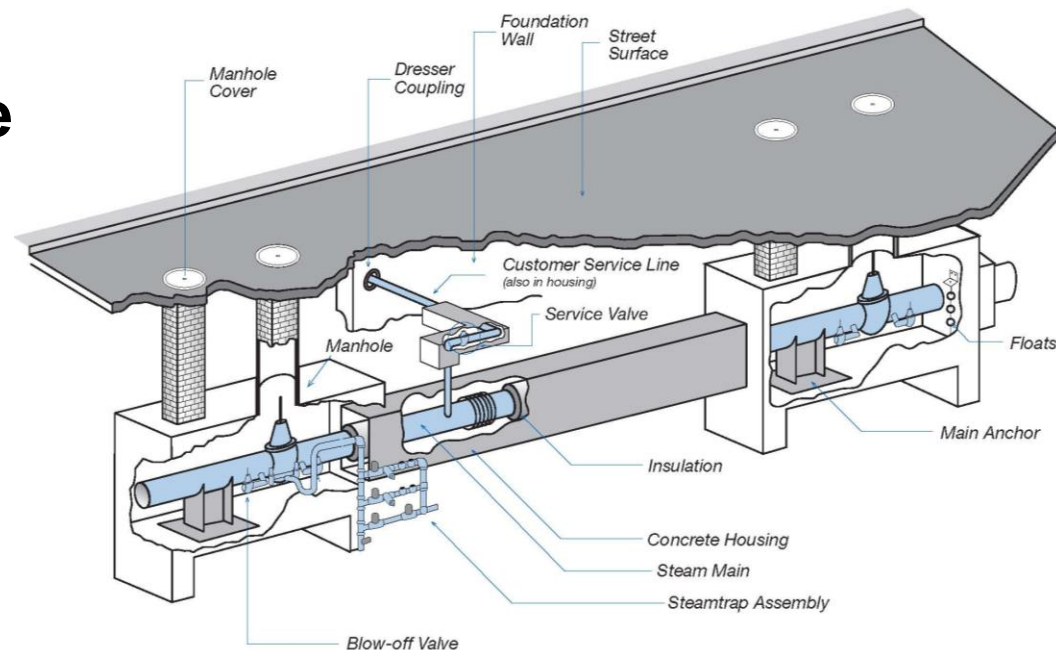
- Pilot model area
- Steam main outage
 - Two main valves closed
- Pressure profile
 - Low pressure in outage area

Model – Simulated Steam Main Outage



Benefits of Water Hammer Predictor Model

- Reduce low velocity in susceptible areas
- Predict high risk conditions
- Improve response time



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