
# *Modeling and Simulation Transient Analysis Case Study of a Liquids Gathering System*

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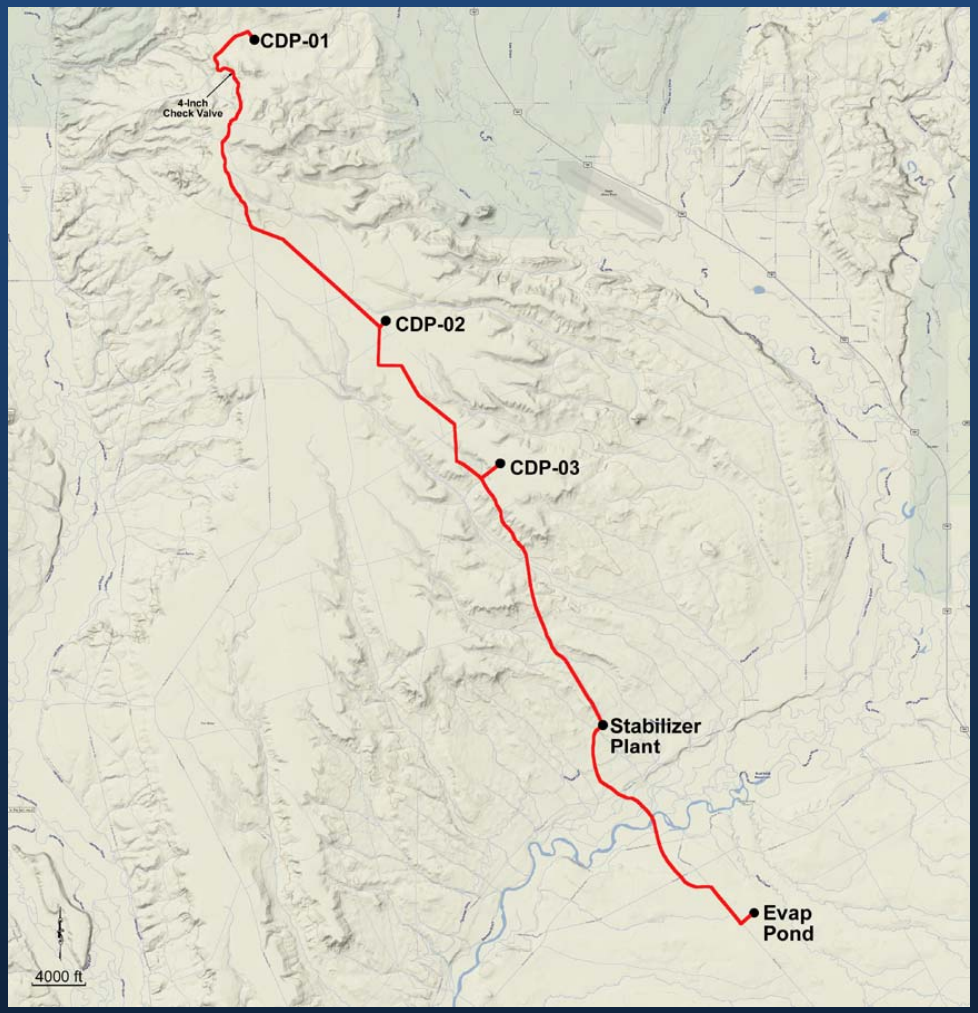
# Description & Outline

- Numerous failures of a flexible composite pipeline
- Liquids gathering system
- Transient hydraulic model to evaluate a 4-inch flexible composite pipeline and an 8-inch steel pipeline

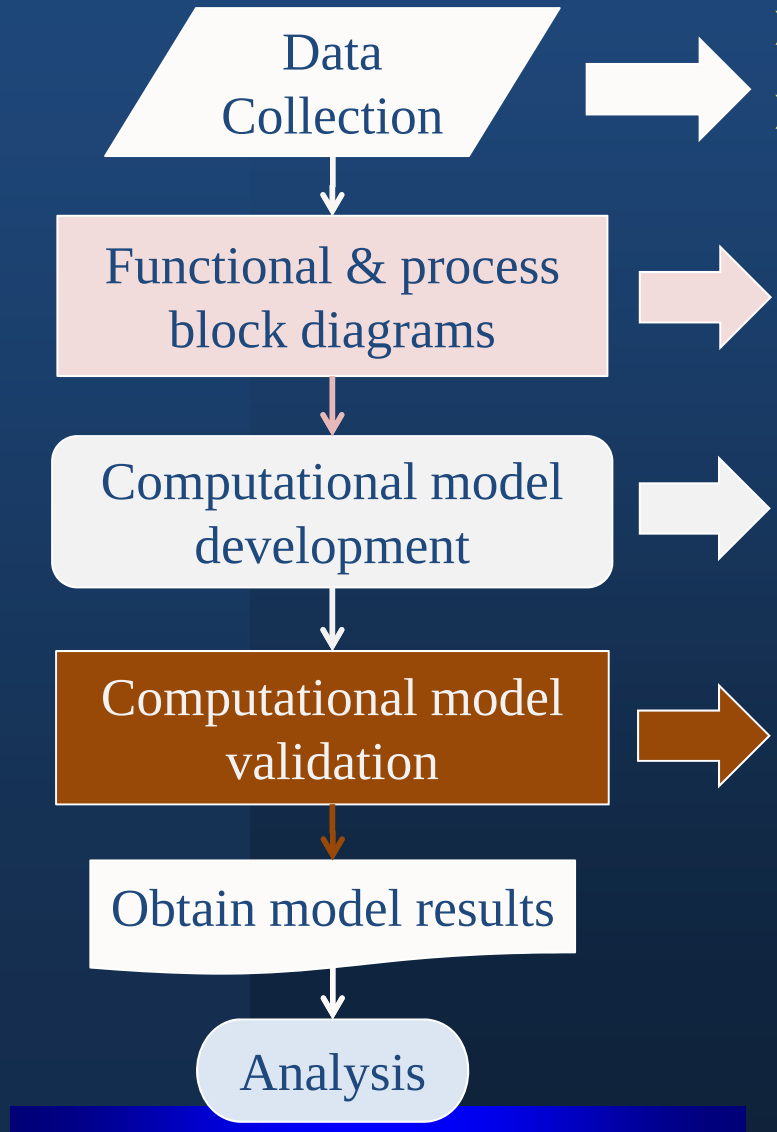
- Introduction
- Data Collection
- Computational Modeling
- Results
- Analysis
- Summary & Conclusions/Questions

# Gathering System Map

- CDP-01, -02, -03, and Stabilizer plant
- CDPs identical in configuration with 2 triplex pumps (PDP)
- ~12.5 Miles from CDP-01 to stabilizer plant
- Stabilizer plant PCV holds 500 psig back pressure
- Check valve half way up hill
- ~500 ft from CDP-01 to top of hill

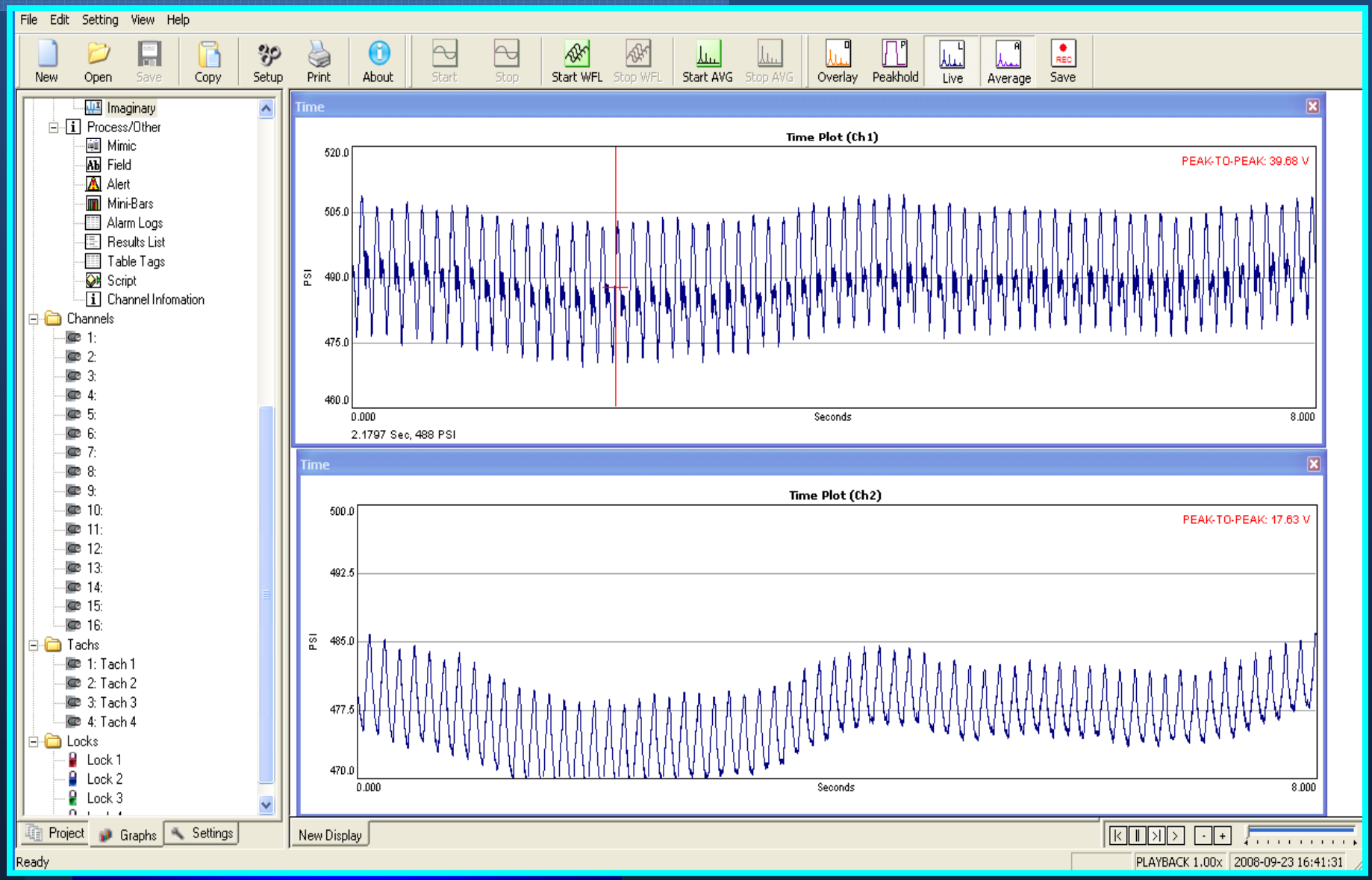


# Modeling Process




- Verify data is consistent
- Collect additional data and make corrections as needed
- Document assumptions
- Verify data is consistent and appropriate for modeling software
- Ensure predictive measures are consistent and appropriate for intended analysis
- Check that the units are correct
- Use known operating parameters from data collection phase if possible
- Ensure results are consistent with known operating conditions

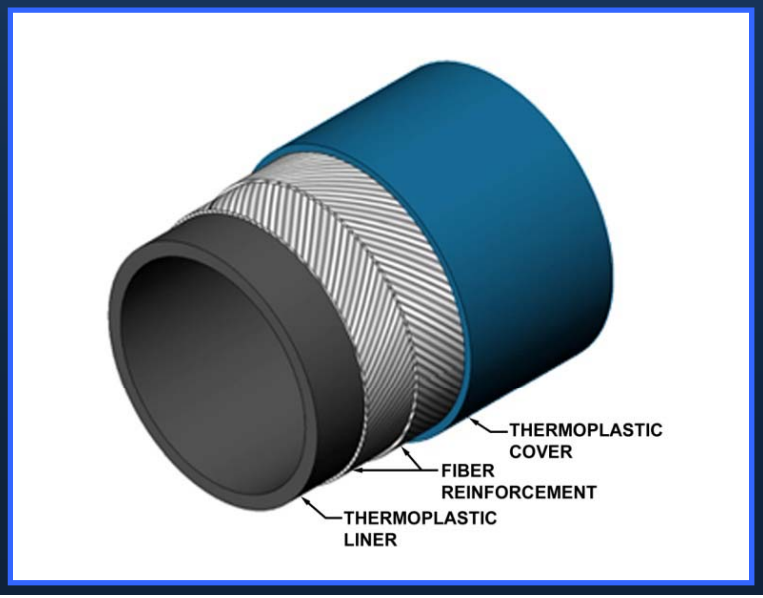
# Data Collection



# Documentation

- P&IDs and isometric diagrams
- Datasheets
- Operational philosophy
- Reports
- Anecdotal data
  - Failures appeared to increase after check valve installed

Flexible Pipe Structural Components

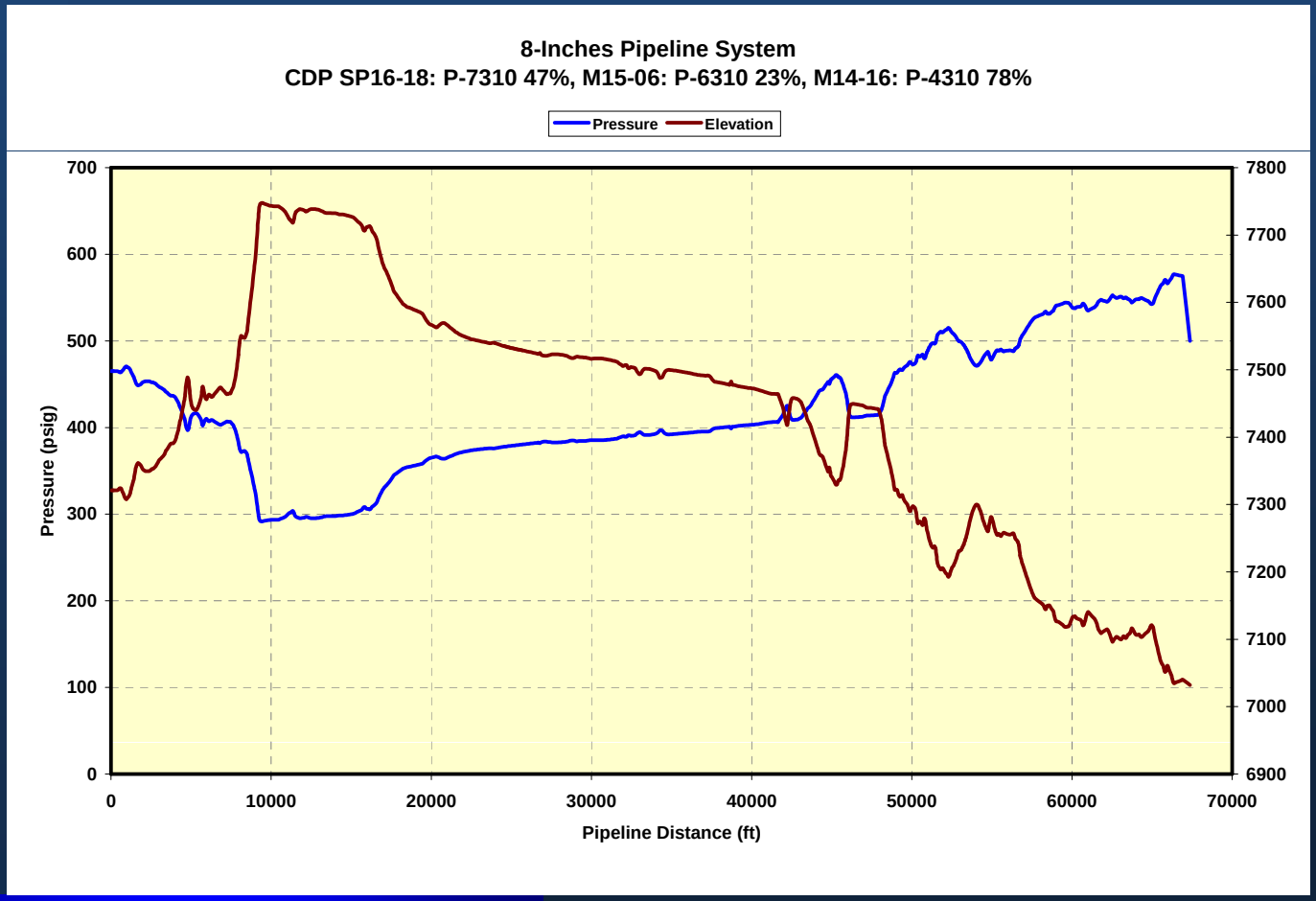


# Field Survey

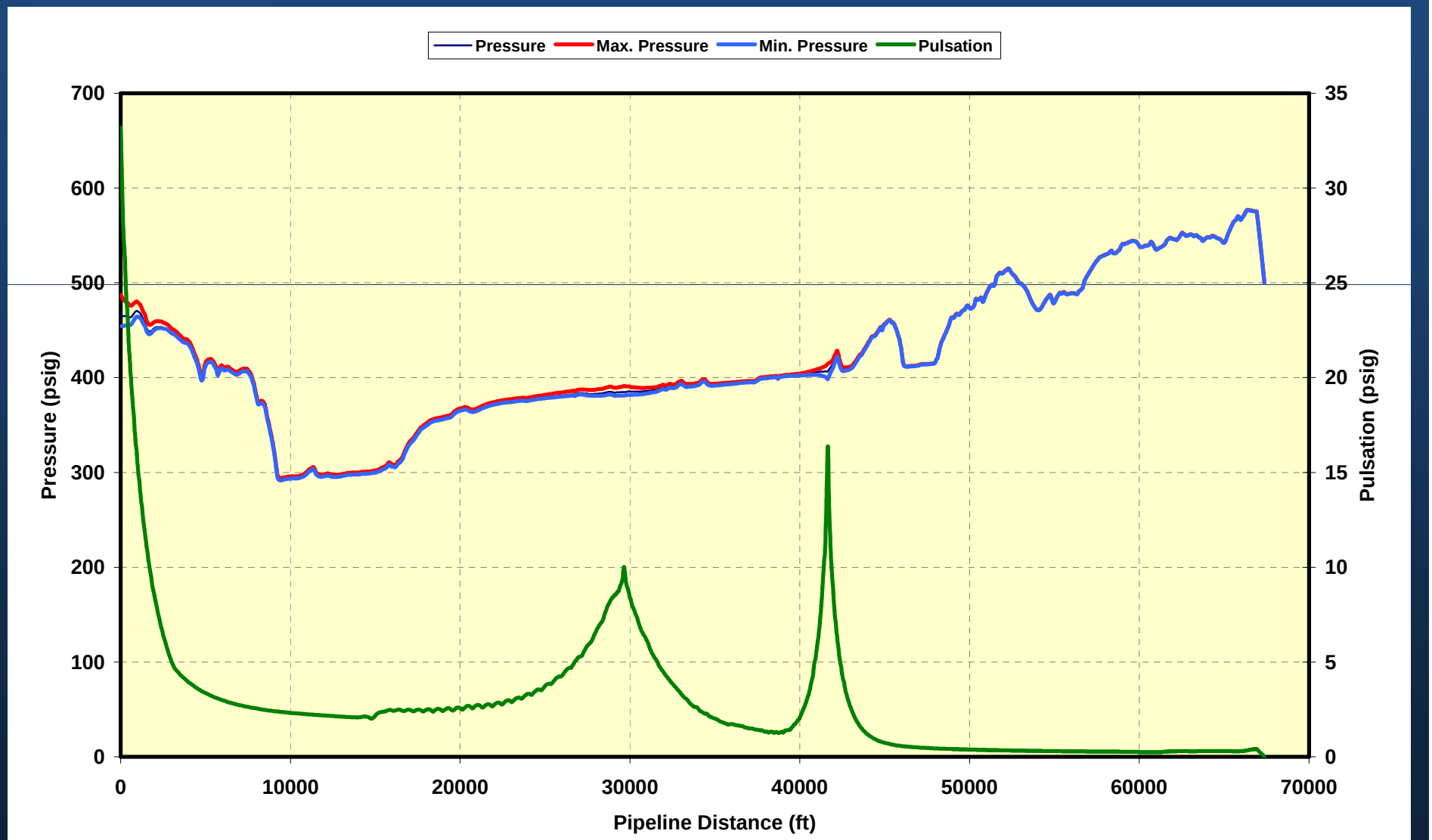
- Verified documentation and collected additional information
- Instrumented all three CDPs
- Did not go to stabilizer plant

# Transient Hydraulic Modeling

- Utilized the Stoner Pipeline Simulator (SPS)
- Slightly compressible liquids EOS



# 8-Inch Pipeline System Pressure with Pulsation



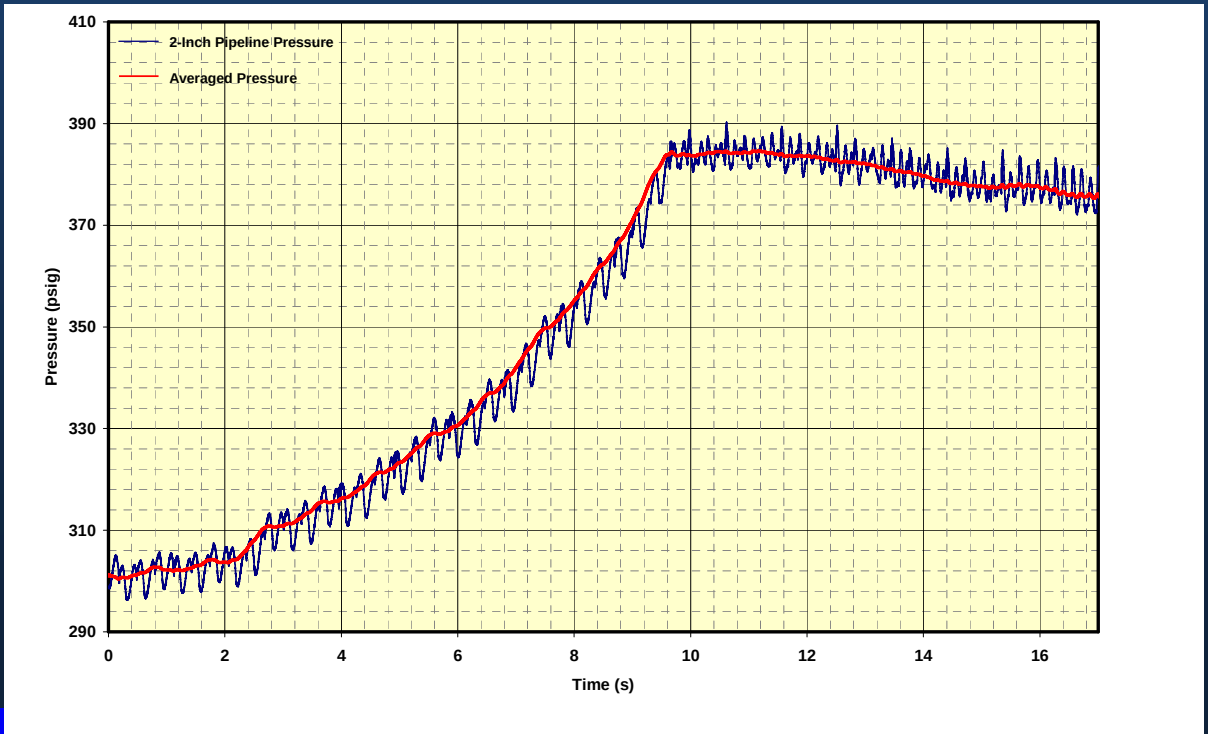
# Summary Results

- The results did not reveal a problem related to water-hammer in either the pre-existing or existing pipelines
- The pulsations were a little high in the pre-existing pipeline, but were not considered excessive
- Transients during pump start and stops were significant but were well within the limits of the pipeline
- An investigation of failed composite pipeline sections revealed the failure occurred from the inside outward
- There was no creep, and adjacent sections were burst tested to greater than 2 times the MAOP

# Water Hammer Analysis

- Water hammer not a problem
  - Flow velocities are low and therefore the momentum change is low
  - No mechanism found for causing any significant water hammer issues

2-in pipe Ramp-up from 20%-100%

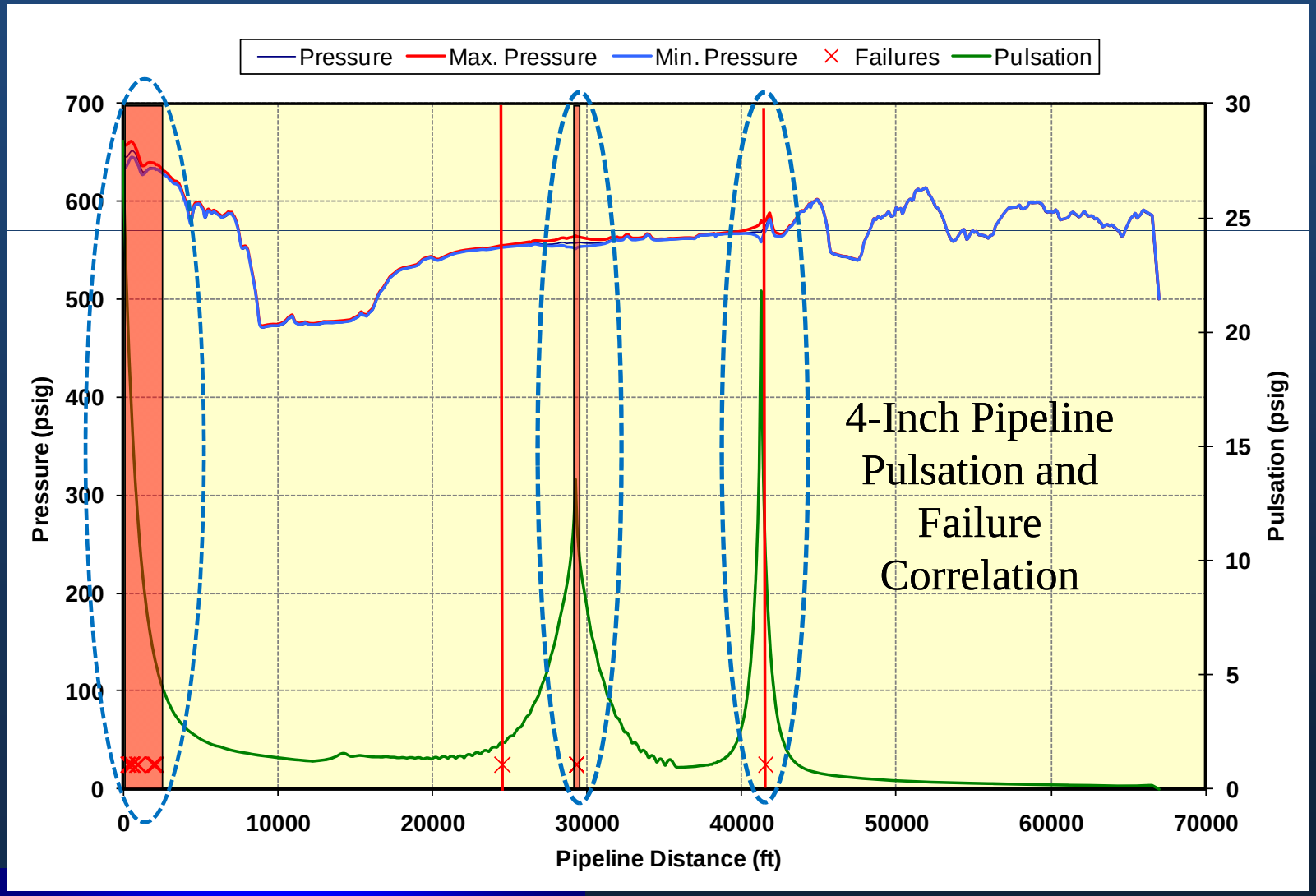


# Transient Response Analysis

- Startup & shutdown transients not a problem
  - Several test cases were run which resulted in significant transient responses but were not enough to lead to a pipeline failure
  - There was no significant response related to the addition of the check valve half way up the hill
- Pulsation while small may play a significant part in the flexible composite pipeline failure

# Pulsation Analysis

- Pulsations are strongly correlated failure sites



# Failure Analysis

- Analysis of failed segments revealed failure from inside outward
- Inner-liner erupted through outer liner with little evidence of water between layers
- Hydro-testing of adjacent segments met or exceeded specifications
- Glass fibers near the inner liner tended to have jagged breaks where as fibers near the outside tended to be clean breaks

# Failure Assessment

- There appears to be no obvious failure mechanism
- Failures occur somewhat randomly and as soon as a failure is fixed another one appears
- However, the failures appear to correlate very well to the areas with the highest pulsation
- The pipe vendor warns that the pipe is not designed for use in cyclic application above 20% of rated pressure (Cyclic is defined as approximately once per day)

# Failure Assessment, continued

- We theorize the following:
  - Damage is incurred to the inner fibers due to the small pulsations, potentially from bending stress in the glass
  - This generates a weakness in the pipe which causes increasing stress in that area
  - Individual fibers continue to break further staining the remaining fibers
  - The failure of the outer fibers occur suddenly when the tensile strength of the fiber is exceeded leaving a clean break
  - As the glass layer is weakened the inner liner bulges outward before erupting through the outer liner

# Failure Assessment, continued

- From and O&M standpoint, this would appear to be somewhat like operating a metal pipe above the endurance limit with pulsation
- Even a small pulsation can eventually lead to pipeline failure
- Once an failed area is repaired the stresses build up elsewhere

# Summary & Conclusions

- Failures likely due to small cyclic stresses in the glass fibers
- Lesson learned, verify that your assumptions are correct and review all data in the field when provided the opportunity
- No evidence to support water hammer as an issue for either the 4-inch or 8-inch pipeline
- The revised operating philosophy is a substantial improvement over that of the pre-existing system
- Pulsations are not a significant threat to the integrity of the 8-inch steel pipeline, but may be a significant factor in the failure of the 4-inch pipeline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Thank you for your Attention