BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

Docket No. LC 71

In the Matter of NW Natural's 2018 Integrated Resource Plan	Final Comments

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Introduction

The Public Utility Commission of Oregon Staff (Staff) files these Final Comments on Northwest Natural Gas Company's (NW Natural, NWN, or Company) 2018 Integrated Resource Plan (IRP or Plan), filed on August 24, 2018. These Final Comments include a summary of Staff's Initial Comments and the Initial Comments submitted by the Citizens' Utility Board of Oregon (CUB), and also address NW Natural's Reply Comments. A final order is expected to follow the Commission Public Meeting on February 26, 2019.

Staff finds that NW Natural's 2018 IRP generally adheres to the Guidelines and relevant orders related to least-cost, integrated resource planning. Staff identified specific areas of interest that warranted further analysis and review in its Initial Comments. NW Natural has responded to discovery requests and held workshops and phone conferences with Staff to provide further detail on the Action Items and other aspects of the IRP.

Summary of Staff's Initial Comments

In Opening Comments, Staff had questions about NW Natural's load forecast and changes made to the planning standard in the 2018 IRP. Specifically, Staff questioned the specification of the econometric load forecast and the number of years of data that should be used in calculating a capacity planning standard.

Staff identified questions about the Company's DSM analysis and avoided cost methodology for further investigation.

Regarding supply side resources, Staff requested more detail on the anticipated costs at the Portland Gasco LNG Plant and Miller Station, and requested that NW Natural include any significant expenses related to studying or investing in these facilities in an amended 2018 Action Plan.

In analyzing the distribution system action items, Staff wrote that additional justification was needed before Staff could recommend acknowledgement of the distribution reinforcement Action Items in the 2018 IRP. Staff requested data showing the system issues that resulted in the need for new investment, and proof that other options have been thoroughly assessed.

Finally, Staff expressed a need to more thoroughly understand the Renewable Natural Gas (RNG) Evaluation Methodology Action Item and requested an additional RNG workshop with NW Natural.

Summary of CUB's Initial Comments

CUB was encouraged by the Company's consideration of actions to reduce carbon output and supportive of the proposal to evaluate RNG against conventional gas based on all-in costs which include costs of carbon regulation and avoided capacity costs. CUB also mentioned the opportunity to develop on-system RNG through a pilot program and cautioned that delaying an RNG Pilot could endanger the Company's carbon emissions reduction goals.

CUB also expressed concerns that the Company did not adequately discuss the amount of fuel switching away from natural gas that could take place in response to concerns about carbon emissions. CUB recommended investigating whether fuel switching could begin to reduce demand for distribution system reinforcements, and recommended not acknowledging the North

Eugene Reinforcement because the Company needs to do additional analysis regarding the City's climate plan and fuel switching incentives, noting that the City has a goal of reducing fossil fuel use by 50 percent.

CUB also recommended the Company adopt a forecast of fuel switching in future IRPs and begin looking at a trended weather forecast.

Summary of AWEC's Initial Comments

AWEC provided comments on the Enbridge pipeline rupture of October 9, 2018. AWEC noted that service to many industrial customers was interrupted, and urged NW Natural to provide special analysis of how the system performed following the rupture and loss of service from Sumas, including analysis of how curtailment of industrial load allowed NW Natural to avoid interrupting core customers. AWEC also requested analysis of a scenario where this type of event happened in winter.

The Action Plan

NW Natural's Action Plan includes the RNG Evaluation Methodology described in Appendix H, recalling Mist storage capacity, several Distribution Reinforcement Projects, and the acquisition of energy savings through collaboration with the Energy Trust of Oregon (Energy Trust):

5.1. JOINT MULTIYEAR ACTION PLAN

Supply Resource Investments

1) Recall 10,000 Dth/day of Mist storage capacity for the 2020-21 gas year. Recall 35,000 Dth/day of Mist storage capacity for the 2021-22 gas year.

2) Use the methodology detailed in Appendix H to evaluate renewable natural gas resources against conventional sources based on all-in costs, where all-in costs are defined as:

   All-in costs = Net Present Value ([cost for delivered gas] + [net GHG emissions intensity*Cost of GHG Emissions Compliance] – [avoided supply capacity costs] – [avoided distribution capacity costs])

5.2. OREGON-ONLY ACTION PLAN

Distribution System Planning Projects

3) Proceed with the Hood River Reinforcement project to be in service for the 2019 heating season and at a preliminary estimated cost ranging from $3.5 million to $7 million.

4) Proceed with the Happy Valley Reinforcement project to be in service for the 2019 heating season and at a preliminary estimated cost ranging from $3 million to $5 million.

5) Proceed with the Sandy Feeder Reinforcement project to be in service for the 2020 heating season and at a preliminary estimated cost ranging from $15 million to $21 million.

6) Proceed with the North Eugene Reinforcement project to be in service for the 2020 heating season and at a preliminary estimated cost ranging from $5 million to $11 million.

7) Proceed with the South Oregon City Reinforcement project to be in service for the 2020 heating season and at a preliminary estimated cost ranging from $4 million to $6 million.

8) Proceed with the Kuebler Road Reinforcement project to be in service for either the 2020 or 2021 heating season and at a preliminary estimated cost ranging from $14 million to $20 million. Demand-side Resources.

9) Working through Energy Trust, NW Natural will acquire therm savings of 5.2 million therms in 2019 and 5.4 million therms in 2020, or the amount identified and approved by the Energy Trust board.

Load Forecast

Demand Forecasts
In opening comments on Demand Forecasts, Staff identified a number of topics for further investigation:

- The methodology of blending the econometric forecast and the subject matter expert (SME panel) forecast of the number of customers in NW Natural's system,
- The projected higher future commercial customer usage as compared to the 2016 IRP,
- Interaction effects utilized in the daily system load model,
- Considerable methodological updates to the Capacity Planning Standards,
- Annual to monthly transformation of customer forecasts to facilitate the peak forecasts, and
- The econometric modeling equations used by NW Natural.

Expert Forecasts
In the 2016 IRP, NW Natural used the forecast of a Subject Matter Expert (SME) panel for the first two years of the forecast, a blend of the SME panel and an econometric forecast in the third year, and a full transition to the econometric forecast in the fourth year of the forecast out to 2038. In the 2018 IRP, NW Natural follows the same methodology, except the SME panel and econometric model are blended in the fourth year. Staff evaluated the Company's responses to information requests on this topic and determined that the current blending timing may provide a marginal improvement in modeling accuracy over the methodology used in the 2016 IRP.

Staff Recommendations

- In addition to the statistical analysis, Staff requests that the Company's next IRP contain a narrative to explain the near term factors that the subject matter expert (SME panel) forecast is capturing that led the Company to favor the choice of the blending and transitioning years from the SME panel forecast to the econometric forecast.

- Staff recommends the establishment of a consistent standard relating to the year in which the Company blends and fully transitions from the SME panel to the econometric forecast. The standard should stay the same from one IRP to the next unless the Company has reason to believe it has found a substantial improvement over the current method.

Commercial load growth forecast

Staff is not satisfied with NW Natural's response to information requests relating to the projected higher future commercial customer usage in the 2018 IRP. The Company lists three factors as possible explanations for the increase:

1) Changes in statistical modeling,
2) Changes in building characteristics (square footage, building shell, building age, etc.), and
3) Changes in proportions of commercial market segments being added.

Staff Recommendation

- Focusing on the third point, a common tool used within load forecasting to track the usage of market segments is tracking customers with the NAICS or SICS database. Staff recommends that NW Natural pursue the creation of such a tool for the 2020 IRP.

Interaction effects utilized in the daily system load model

Staff appreciates the Company's approach of incorporating interaction effects towards the goal of including a wider range of temperatures in modeling. Staff would also agree that technically there are enough degrees of freedom necessary to perform the forecasts. However, as an industry standard, the principle of parsimony, which suggests using models and procedures that contain all information necessary but nothing more, still applies.

Staff Recommendation

- For the 2020 IRP, Staff recommends the Company use an automated stepwise regression process for variable selection to compare against a model similar to the 2018 IRP in the use of interaction variables. Cross validation, or more specifically k-fold validation[1], would then help to assess how the results of each predictive model will generalize to an independent data set.

Capacity Planning Standard

Staff and the Company have spent a considerable amount of time discussing the changes to the Capacity Planning Standard. Again, Staff supports the Company's goal of reducing large shifts

[1] Bergmeir, C., Hyndman R.J., 2018, A Note on the validity of cross-validation for evaluating autoregressive time series prediction. Computational Statistics and Data Analysis *120, 70-83.*

in capacity planning standards from one IRP to the next and believes that the new methodology shows promise towards that end. However, prior to the 2020 IRP, Staff recommends NW Natural coordinate a series of workshops to address concerns regarding the Company's method of implementing probabilistic methodology when determining planning standards. The US EPA has set up some very helpful guidelines to frame the purpose and scope of Monte Carlo analyses in risk assessment activities. Key highlights provided are below[2]:

- An understanding of the key sources of variability and key sources of uncertainty and their impacts on the analysis.

- Numerical experiments should be conducted to determine the sensitivity of the output to different assumptions with respect to the distributional forms of the input parameters. Identifying important pathways and parameters where assumptions about distributional form contribute significantly to overall uncertainty may aid in focusing data gathering efforts.

- The presence or absence of moderate to strong correlations or dependencies between the input variables is to be discussed and accounted for in the analysis, along with the effects these have on the output distribution. Covariance among the input variables can significantly affect the analysis output. It is important to consider covariance among the model's most sensitive variables. It is particularly important to consider covariance when the focus of the analysis is on the high end (i.e., upper end) of the distribution.

- The numerical stability of the central tendency and the higher end (i.e., tail) of the output distributions are to be presented and discussed.

- Calculations of risks using deterministic (e.g., point estimate) methods are to be reported if possible. Providing these values will allow comparisons between the probabilistic analysis and past or screening level risk assessments. Further, deterministic estimates may be used to answer scenario specific questions and to facilitate risk communication. When comparisons are made, it is important to explain the similarities and differences in the underlying data, assumptions, and models.

Staff Recommendation

- Prior to the 2020 IRP, Staff recommends NW Natural coordinate a series of workshops to address concerns regarding the Company's method of implementing probabilistic methodology.

Allocation of annual customer forecasts to monthly values to facilitate peak load forecasting
NW Natural has provided Staff with sufficient information on this topic and Staff has determined that the Company's methodology is appropriate for the purpose of the forecast.

[2] Firestone, M., Fenner-Crisp, P. et al., 1997. Guiding Principles for Monte Carlo Analysis. EPA/630/R-97/001.

Econometric modeling approach
After reviewing the data and models provided Staff finds that, besides potentially including unnecessary independent variables, the econometric modeling approach appears sound.

Avoided Costs

In Opening Comments Staff sought more information on how avoided costs are applied to resources other than energy efficiency. NWN provided Staff with further information on their proposed methodology for applying "avoided costs" to non-energy efficiency resources. This methodology is about framing the relative costs and benefits of different supply- and demand-side resources. Staff appreciates NWN's attempts to provide context to the relative benefits of new supply-side options such as on- and off-system RNG.

Staff appreciates NWN on its ongoing work to refine estimates for different aspects of avoided cost, including working with Energy Trust to look at peak day and peak hour impacts, and the creation of new end-use load profiles to model savings and costs over time. Since the 2016 IRP, the Commission has opened conversations about avoided cost methodology for energy efficiency in UM 1893. While much of the development of new techniques and estimates for avoided cost calculations was conducted prior to the opening of this docket, UM 1893 is now the place where these ongoing conversations will be pursued. Staff intends to review NWN's proposed updates in UM 1893 during 2019, particularly the proposed new load profiles, including applications to infrastructure and process loads. Staff looks forward to ongoing discussions with NWN and sharing these contributions with the wider community.

Staff Recommendation

- NWN work with staff to review proposed end use load profiles as part of UM 1893. Review may potentially involve a third party evaluator and additional supporting research.

Demand Side Resources

Staff appreciates NWN's cooperation in explaining to Staff details related to the modeling of demand side resources over the course of multiple meetings.

Since the 2016 IRP, NWN began working with Energy Trust to develop a targeted DSM pilot. After experiencing some delays, NWN held a workshop on December 3 where they, along with Energy Trust, presented the proposed pilot design to stakeholders. Staff and other stakeholders expressed concerns about the proposed design. NWN and Energy Trust will be meeting with Staff in January to discuss potential adjustments to the design and will revise the plan before bringing it back to the larger stakeholder group.

In the 2018 IRP, NWN proposes six pipeline reinforcement projects in Oregon totaling at least $45 million dollars as well as proposing a methodology to evaluate RNG options. These activities suggest a significant need for geographically targeted resources. Given this need, it is unfortunate that the rollout of the targeted DSM pilot is behind schedule. Staff does not believe that NWN has sufficiently explored geographically targeted energy efficiency and demand response options as alternatives to these costly reinforcement projects, nor should these options be bypassed in favor of RNG.

Staff Recommendations

- Acknowledgement of NWN's Action Item number 9: Working through Energy Trust, NW Natural will acquire therm savings of 5.2 million therms in 2019 and 5.4 million therms in 2020, or the amount identified and approved by the Energy Trust board.

- NWN launch the targeted DSM pilot in 2019. This is an Action Item from the 2016 IRP. The pilot study is behind schedule and the results could have informed many aspects of NWN's 2018 IRP. Staff does not believe NWN has sufficiently evaluated targeted DSM as alternatives to proposals in this 2018 IRP to pursue pipeline reinforcements and RNG.

- NWN hire a third party to perform a Demand Response Potential Study in its service territory. Staff does not believe NWN has sufficiently evaluated demand response programs as alternatives to proposals in this 2018 IRP to pursue pipeline reinforcements and RNG. This analysis should include their interruptible rates as a DR option.

Supply Side Resources

There are minimal supply-side resource investments for which NWN is seeking acknowledgement in the Action Plan. However, upon further investigation, Staff found near-term investments that potentially warranted inclusion in the Action Plan. In initial comments, Staff requested that if NW Natural anticipates incurring significant expenses at the Portland Gasco LNG Plant in the next four years, the Company should file an updated Action Plan detailing the expenses that NW Natural sees as likely or as likely contingent on the results of third-party analysis. Staff also requested that NW Natural re-file its Action Plan with the Miller Station study included as an action item.

At this time, NW Natural has not refiled an updated IRP or altered its Action Plan in any way.

RNG Pilot Project

In initial comments, CUB recommends that the Company should consider an RNG pilot program that would identify sources, technologies, and best practices that might be required to bring RNG onto the system. NW Natural's Reply Comments note that a pilot project can serve as a test ground for acquiring RNG from sources that would not be considered in the ordinary course of business, such as smaller dairies. Staff is supportive of an RNG pilot project which could serve as an opportunity for NW Natural to begin integrating RNG into its system while sharing any learnings with stakeholders.

Staff Recommendation

- NW Natural develop more detailed discussion around potential future supply-side resource investments in future IRPs in order to provide sufficient information and more transparent analysis for resource planning purposes. The Company should include Action Items for any significant investments, including those associated with anticipated studies expected within the first four years of the IRP.

Portfolio Selection

In Opening Comments, Staff requested a workshop on Monte Carlo analysis and SENDOUT modeling in the 2018 IRP. NW Natural provided an informative workshop and answered questions that increased Staff's level of comfort with the modeling used in the 2018 IRP. Staff is generally comfortable with the inputs to the portfolio modeling for the purposes of modeling long-term future resource acquisition, including the limitation of 3,000 Dth/Day assumed for on-system dairy RNG. However, Staff notes that there is significant uncertainty about greenhouse gas (GHG or Carbon) pricing in Oregon, Washington, and at the national level over the planning horizon. Failing to include a price path that considers the possibility of no carbon policy is an oversight that could result in the selection of portfolios that are not least-cost or least-risk. Staff proposes that introducing a carbon price path in the stochastic IRP analysis that is equal to or close to zero, similar to the zero-carbon-price path included in the 2016 IRP[3], will help to provide a more realistic distribution of potential future carbon price outcomes. Allowing each carbon price path to begin as late as 2030 will also help account for uncertainty in carbon pricing.

Staff Recommendation

- For any state that continues not to have a carbon policy by the next IRP, include an additional carbon price path in the stochastic analysis that is near to or equal to zero, and allow a carbon price to begin as late as 2030.

Distribution System Planning

Summary of Staff comments:

In Opening Comments, Staff's overall view was that additional justification was needed for Staff to feel comfortable recommending acknowledgment of the distribution Action Items, which are repeated below: [4]

Project	Schedule	Estimated Cost (Millions of $2017)	Estimated PVRR (Millions of $2017)
Hood River Reinforcement	2019	$3.5–$7.1	$3.6–$7.2
Happy Valley Reinforcement	2019	$2.9–$4.7	$3.0–$4.8
Sandy Feeder Reinforcement	2020	$15.2–$21.1	$14.3–$19.7
North Eugene Reinforcement	2020	$5.3–$10.6	$5.0–$9.9
South Oregon City Reinforcement	2020	$4.1–$6.2	$3.9–$5.8
Kuebler Road Reinforcement	2020–2021	$14.1– $19.7	$13.2–$18.4
Total		$45.1–$69.4	$43.0–$65.8

Staff's initial concerns about these projects included a lack of sufficient information to justify potentially $65 million in investments. While Staff is not opposed to necessary distribution system upgrades, the Company had not sufficiently clarified why these upgrades are the best

[3] NW Natural. 2016 Integrated Resource Plan. Page 4.13.
[4] NW Natural 2018 Integrated Resource Plan at Page 8.14.

options for customers. Staff has submitted several rounds of additional discovery requests in an attempt to obtain sufficient information.

Summary of CUB Comments:
Other than Staff, only CUB submitted comments on NW Natural's distribution system Action Items. CUB believes that NW Natural has shown enough evidence as to the need for Action Items 3, 4, 5, 7, and 8. However, CUB does not recommend acknowledgment for Action Item 6, which is the North Eugene Reinforcement project. CUB states that NW Natural should do additional analysis regarding the impact of Eugene's climate plan and the Eugene Water and Energy Board's (EWEB) fuel switching incentives. CUB explains that the City of Eugene has a goal of reducing fossil fuel use by 50 percent, and, as a result, is offering fuel switching incentives. CUB believes it is possible that the City's efforts to promote fuel switching could offset load growth in NW Natural's Eugene service territory. Because the IRP does not contain analysis regarding the fuel switching, CUB believes it is possible that the North Eugene Action Item is not necessary.[5]

Summary of NW Natural comments:
In its Reply Comments, NW Natural provided some additional detail regarding the justification of need for its projects. NW Natural clarified that each of the project areas were modeled in Synergi using demand and pressure data obtained during recent cold weather events. NW Natural uses the Synergi model to verify system conditions. For each of the projects, the Company explains that Synergi identified low pressure conditions. The Company has maintained that the conditions modeled by Synergi and observed in the field in some (not all) cases indicate a need for system reinforcement. The more substantive responses to Staff, however, occurred primarily through discovery, which Staff discusses below.

Analysis
In addition to providing responses to Staff data requests, the Company reached out to Staff and hosted another workshop on December 10 to provide additional clarification on the justification of need for the projects. The PUC Safety Division was consulted and provided additional clarification. It was through this workshop, conversations with PUC Safety Staff, and additional discovery,[6] that Staff was able to come to a conclusion regarding recommendations for acknowledgment. Staff reiterates that it greatly appreciates the Company's willingness to reach out to Staff and provide clarification of its methodology.

Several issues arise in considering acknowledgment for the projects. The first is that data collection points are limited throughout NW Natural's system. The Company clarified this in the workshop on December 10 and Staff confirmed this through discovery. For example, NW Natural did not possess historical pressure data for several of the projects in the Action Plan. The Kuebler, Oregon City, and Happy Valley projects were specifically identified as lacking a

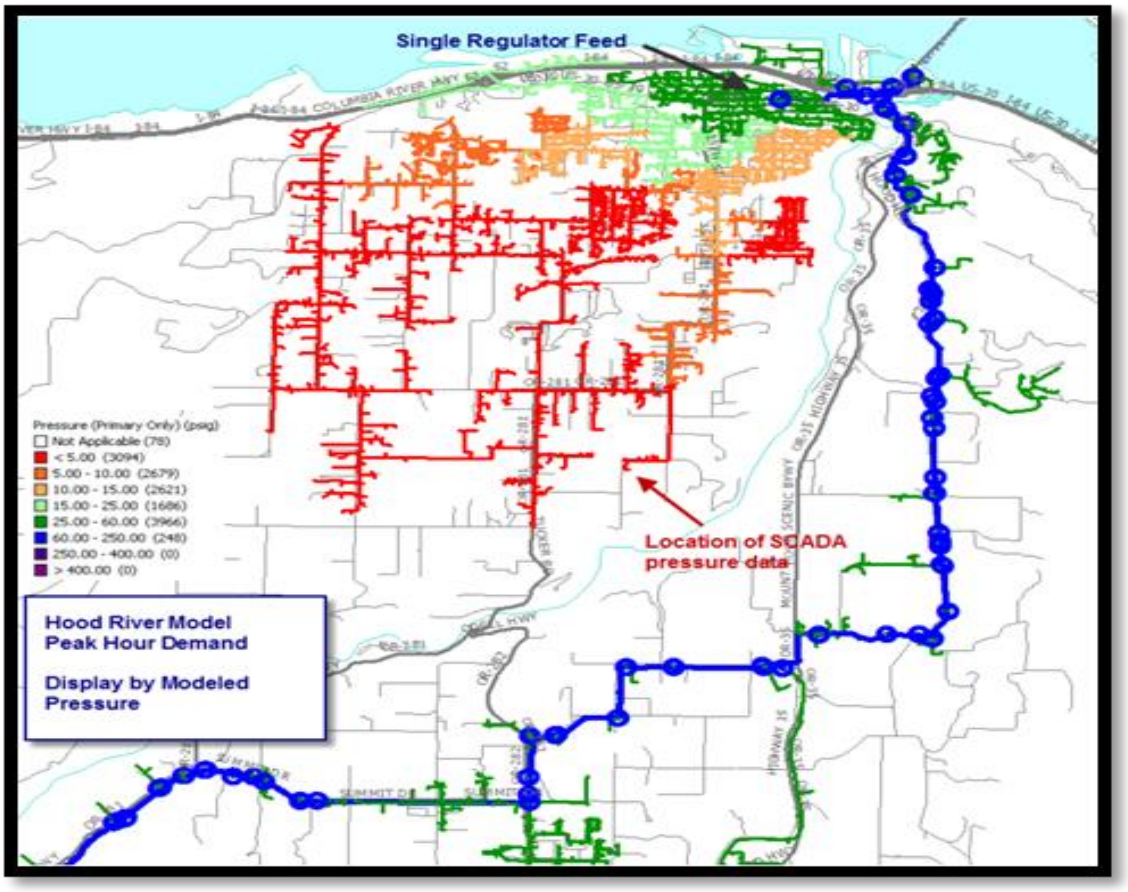
[5] LC 71. CUB Opening Comments. Pages 4, 5. Accessible at https://edocs.puc.state.or.us/efdocs/HAC/lc71hac164926.pdf.
[6] See Staff Attachments 1-4.

Supervisory Control and Data Acquisition (SCADA) site to monitor and store historical data.[7] Thus, Staff was unable to verify claims of historical low pressure conditions.

Staff would like to clarify that, although the language of the IRP and discovery responses seemed to indicate that NW Natural was using a forecasted peak hour distribution planning standard to test the system in modeling,[8] the Company clarified in the workshop on December 10, 2018, that NW Natural did not use a peak hour standard in Synergi. Instead, the Company clarified that it used actual demand and pressure data from a cold weather event that occurred in January 2017. It was under these observed conditions that Synergi modeling showed pressure drops and low pressures.

The matter of limited data was a point of confusion for Staff throughout the discovery process. The Company clarified in the workshop on December 10, 2018 that NW Natural does not have the infrastructure in place to substantially monitor pressure readings. Rather, the Company uses the limited pressure data it has available, which may be collected manually during actual cold weather events,[9,10] to simulate recent cold weather events in Synergi. The Company used fixed inputs from cold weather events—such as pipeline diameter and load—and input the information into Synergi to "validate" how a cold weather event would likely impact gas pressures throughout its system. NW Natural clarified at the workshop and through discovery that necessary infrastructure is not in place to measure granular pressure readings. As Staff understands it, the Company's pressure reading points primarily occur along the backbone of the system,[11] with limited additional granular readings scattered throughout the system. As an example, see the map below for the Hood River project:

[7] Se Staff Attachments 1-4.
[8] NW Natural's reply to Staff DR 52 uses the term, 'peak hour' to describe modeling inputs.
[9] See Staff Attachments 1-4. NW Natural took manual pressure readings during cold weather events for the Kuebler and Oregon City projects.
[10] In the case of this IRP, the weather event occurred in January 2017.
[11] I.e., gate stations.



The location of the single SCADA point in this area is demonstrated above on the middle right; as the map demonstrates, there is only one SCADA point in this area.

In its initial comments, Staff stated that it was uncomfortable recommending acknowledgment for all six distribution projects in the Action Plan due to the lack of available data. The Company reached out to Staff several times to provide Staff with additional clarification and to provide answers to Staff's questions. The Company submitted a substantive report on project need, submitted as Attachment 1 in these comments.[12] Staff has been greatly appreciative of the Company's willingness to meet with Staff. The additional workshops were very useful for Staff and helped clarify several concerns. However, though Staff believes the Company has provided sufficient information to justify some of the projects, Staff remains uncomfortable with the lack of data for others and cannot, with confidence, recommend acknowledgment for all six projects.

As it currently stands, the Company is relying on modeling software (Synergi) as a mechanism for demonstrating need. There are limited data points throughout the Company's system. As a matter of best practices, the Company must work to ensure that all modeling software be validated by data. In the case of the North Eugene Enforcement project, the company provided no evidence of actual pressure readings to verify that low pressure conditions exist. Staff

[12] See Staff Attachment 1 (Response to Staff DR 52).

recognizes that system infrastructure challenges may exist, but this should not preclude the Company from collecting or verifying additional evidence to demonstrate a system need.

At the December 10, 2018 workshop, Staff inquired as to why alternatives to permanently installed SCADA systems weren't being utilized to verify Synergi's simulations at problematic locations. The Company indicated that it is moving away from more old-fashioned paper charts and employing the use of more sophisticated reading technology. Staff can understand that it may be difficult to install fully automated and integrated measurement equipment at key locations. However, the Company indicated that there were work-arounds under consideration, such as the use of cellular technology, and indicated that it was also interested in gathering additional data.

The issue remains that Staff still has concerns about the lack of data verifying system need. Staff can appreciate that weak areas of the system may not be visible until a cold weather event occurs, however it is Staff's understanding that federal regulations guide each operator to give consideration to installing temporary recording gauges at locations in the distribution system at suspected or anticipated low-pressure points.[13] In the case of this IRP, suspected points would include the six areas where project need was determined. In the case where there are no outages or direct data confirming low pressure events, it is Staff's opinion that the Company should postpone reinforcement until it has gathered enough data to confirm that reinforcement is required. This would give additional time to install temporary recording gauges, confirm low-pressure events, and allow rate impacts to be spread over a longer period of time.

According to the Company's data responses,[14] the Company obtained SCADA data for the Hood River project and reported not only low pressure violations, but outages as well. Based on all the evidence presented to Staff, we recommend acknowledgement of the Hood River project.

According to the Company's data responses,[15] South Oregon City does not have a SCADA site to monitor and store historical pressure data. However, customers reported outages, and NW Natural service technicians took pressure readings to confirm that gas system pressures were substandard and were affecting customer equipment.[16] Based on all the evidence presented to Staff, we recommend acknowledgment of the South Oregon City project.

According to the Company's data responses,[17] the Company stated that SCADA data is not available in the area of Happy Valley in need of reinforcement. The Company used a nearby SCADA site to validate the accuracy of the modeled pressures and indicated that though the pressure reads by themselves do not violate any standards, they indicate a weak pipeline backbone that will not meet customer demand properly. Staff can understand the concerns around Happy Valley pressures, however, Staff would be more comfortable recommending acknowledgment after additional data from the locations where there are weaknesses is provided.

[13] See 49 CFR 192.741, OAR 860-024-0020(2).
[14] See Staff Attachment 1 (Response to Staff DR 52).
[15] See Attachments 1 and 3 (Response to Staff DRs 52 and 91).
[16] See Attachments 1 and 3 (Response to Staff DRs 52 and 91).
[17] See Attachments 1 and 4 (Response to Staff DRs 52 and 93).

According to the Company's data responses,[18] the area around the Kuebler reinforcement project does not have SCADA monitoring, so historical pressure data was not available. However, the Company was aware that this area was problematic during cold weather events and added it to a list of areas to monitor. As a result, field personnel was available to record low pressure readings during the cold weather event in January 2017 and reported a 60 percent pressure drop. The Company's reinforcement pressure drop criteria is 40 percent. Staff appreciates these preventive steps—the Company was aware of a problem and sent field personnel to monitor a system. However, due to the lack of actual pressure measurements, Staff would be more comfortable recommending acknowledgment after additional data has been collected demonstrating weaknesses in the system.

According to the Company's data responses,[19] the area around the Sandy Feeder reinforcement project does not have SCADA monitoring, so historical pressure data was not available. However, Company field personnel recorded pressure drops of 80 percent. The Company indicated that district regulators[20] require that the inlet pressure be at least 20 pounds per square inch gauge (psig) higher than the outlet pressure for proper operation. This means that there must be a difference of at least 20 psig between inlet and outlet valves for proper functioning of the regulator. The Company recorded a difference between inlet and outlet pressure of exactly 20 psig, which indicates that the Company has approached the minimum standard. Notably, there were no low pressure recordings or outages recorded in Sandy, but the Company maintains that the regulators feeding the town of Sandy were very close to being starved by low inlet pressures, indicated by the 20 psig difference. Staff appreciates these preventive steps—the Company was aware of a problem and sent field personnel to monitor a system. However, due to the lack of additional actual pressure measurements, Staff would be more comfortable recommending acknowledgment after additional data has been collected demonstrating weaknesses in the system.
According to the Company's data responses, the Company did not collect any actual pressure measurements to confirm low pressures for the Eugene project. The Company's justification for the project was that modeling demonstrated that system reinforcement standards are violated by modeled low system pressures.[21] Staff is not satisfied that this warrants sufficient evidence for acknowledgment. In the case of the Eugene project, the Company is relying entirely on modeling to justify reinforcement. In the rest of the cases, there were nearby (though not exact) SCADA locations or field personnel during cold weather events to validate low pressures. Of all the Action Items, Staff is the least comfortable recommending acknowledgment for the North Eugene reinforcement project.

Staff's primary conclusion is that additional evidence of need is required to recommend substantive system reinforcement. Staff is comfortable recommending acknowledgment of the Hood River and South Oregon City projects, but Staff believes that additional steps can be taken to verify low pressures in the other areas. Staff recognizes that the Company's data collection techniques are evolving, and we hope to work with the Company, going forward, in its efforts to collect the required information to support acknowledgment. Staff proposes that as

[18] See Attachments 1 and 2 (Response to Staff DRs 52 and 90).
[19] See Attachment 1 (Response to Staff DR 52).
[20] District regulators regulate pressures. They are essentially switching stations that take high pressure gas and lower pressure to deliver onto the distribution system.
[21] See Attachment 1 (Response to Staff DR 52).

the Company continues to collect data, it should file any additional data relevant to these projects in an IRP update. If data points continue to validate the Synergi modeling, Staff would be more comfortable recommending acknowledgement of these projects.

Staff Recommendations

- Based on available evidence, acknowledge the following distribution projects:
  - The Hood River project;
  - The South Oregon City project.
- Collect more data, as recommended by Staff in Final Comments, and resubmit acknowledgement requests in an IRP update or in the next IRP for the following distribution projects:
  - Happy Valley project;
  - Kuebler reinforcement project;
  - Sandy Feeder reinforcement project;
  - North Eugene reinforcement project.

Renewable Gas Supply Resource Evaluation Methodology

In its initial application, NW Natural requested acknowledgment of an Action Item to use the Renewable Gas Supply Resource Evaluation Methodology (RNG Evaluation Methodology) detailed in Appendix H to evaluate Renewable Natural Gas resources against conventional sources based on all-in costs.

The methodology in Appendix H proposes using avoided cost values to establish whether a specific RNG contract or project is cost effective compared to the procurement of conventional gas. On-system RNG has the potential to provide value to customers by allowing NW Natural to delay or forego distribution and capacity investments. Additionally, both on-system and off-system RNG may provide cost savings from avoided greenhouse gas compliance costs. NW Natural proposes to use an avoided cost methodology to evaluate RNG resources outside of the IRP process.

In Staff's Opening Comments, Staff expressed concerns regarding whether or not the application of the RNG Evaluation Methodology outside of the IRP is the appropriate way in which to evaluate RNG.

In its Opening Comments, CUB supported the evaluation of RNG as an alternative to conventional sources on an all-in cost basis.

Staff has continued to evaluate the methodology and participated in several workshops and phone conferences with NW Natural regarding RNG Evaluation Methodology implementation.

The potential of bringing cost-effective RNG to NW Natural customers is an intriguing possibility, and Staff commends NW Natural for considering this resource option in the 2018 IRP. However, because the evaluation methodology is a new and complex process with many uncertainties in key assumptions, Staff has several concerns about broadly acknowledging the RNG Evaluation Methodology as an Action Item at this time.

Staff's concerns with the methodology described in Appendix H are as follows:

1. Greenhouse gas policy outcomes are difficult to accurately predict. The avoided costs for greenhouse gas policy compliance at this time are hypothetical forecasts of future policy. They are based on NW Natural's best estimate of what future carbon pricing policy may look like in Oregon and Washington. For an RNG evaluation methodology to reflect the most reasonable expectations about carbon pricing, NW Natural should:
    a. Use the most up to date estimate of GHG policy expectations. The current forecast from the 2018 IRP is already out of date, as it expects a carbon price in Washington to already have begun.
    b. Include a zero- or low-price carbon price path in the stochastic analysis as well as allowing the carbon price paths to begin in any year from 2019 to 2030 instead of using a price that must begin by 2026.[22] This will account for the risk to customers of procuring a long-term contract for RNG in a world where a carbon price turns out to be lower or later than expected. Because a carbon price is the most difficult variable to predict in the stochastic analysis, including a wider range of potential policies reasonably acknowledges this uncertainty and the risk it may pose to customers.

2. The 2018 IRP inputs and assumptions are already out of date.
    a. NW Natural should update any inputs, assumptions, or forecasts to the RNG Evaluation Methodology at the time that the Company is evaluating a potential RNG project.

3. As written in Appendix H, the methodology lacks a detailed description. The equations provided are descriptive only, and the actual modelling process and assumptions used in SENDOUT are not clearly defined in Appendix H. Staff understands that the assumptions are anticipated to be project-specific, but the process of modeling the resources in SENDOUT is also not described fully in Appendix H. The Company should update Appendix H with a description of the modeling process in SENDOUT.

Staff agrees with NW Natural that it is worthwhile to evaluate whether any RNG contracts may be cost-effective in the near term. Staff also finds that the RNG methodology suggested by NW Natural in Appendix H has the potential to become a reasonable methodology. However, the proposed RNG Evaluation Methodology in Appendix H still needs to be better defined by the Company and assumptions need to be adjusted to manage risk to customers.

Staff also has some questions and concerns about the implications of acknowledging a methodology, in general. For example, there is currently no indication of the quantity or dollar value of RNG that NW Natural might acquire over the next two years, or the duration for which NW Natural could be locked into RNG contracts as a result. Acknowledgement of the RNG Evaluation Methodology would seem to result in acknowledgement an unknown quantity of RNG at any time. Without some insight into the quantity of RNG that might be procured between now and the next IRP, the implications of the action item are difficult to assess.

Staff and stakeholders do not have the same familiarity with RNG contracts as with conventional gas or energy efficiency. Although the Company has engaged comprehensively and amicably with Staff regarding the RNG evaluation methodology, NW Natural has not provided real-world examples of their methodology in use. Whereas energy efficiency (EE) potential is evaluated

[22] NW Natural. 2018 Integrated Resource Plan. Page 7-19.

using technologies and measures that are familiar and available to Energy Trust and NW Natural today, the RNG methodology has been presented in the context of hypothetical, future RNG contracts with unknown details and duration. It is also unclear to what extent the avoided costs for EE apply to RNG. Staff is especially interested in the potential for an avoided cost value that reflects the centralized geography of a RNG project compared to EE investments.

NW Natural's IRP notes that the RNG Evaluation Methodology uses most of the same avoided cost values that are used to evaluate energy efficiency:[23]

Costs Avoided		Calculation Characteristics		Resource Option Application					
				Demand-Side Resources			Supply-Side Resources		
					Demand Response		Low-Carbon Gas Supply		
		Varies by Load or Supply Shape?	Methodology Change from 2016 IRP?	Energy Efficiency	Interruptible Schedules	Other DR	On-System Resources	Off-System Resources	Recall Agreements
Commodity Related Avoided Costs	Natural Gas Purchase and Transport Costs	Yes	No	✓			✓	✓	
	Greenhouse Gas Compliance Costs	No	No	✓			✓	✓	
	Commodity Price Risk Reduction Value	No	No	✓			✓	✓	
Infrastructure Related Avoided Costs	Supply Capacity Costs	Yes	No	✓	✓	✓	✓		✓
	Distribution System Costs	Yes	Yes	✓	✓	✓	✓		
Unquantified Conservation Costs	10% Northwest Power & Conservation Council Credit	Yes	No	✓			?	?	

However, while the EE Action Item is for investment in a known quantity of EE over two years, the RNG Action Item includes no specific limits on cost or duration. Staff feels comfortable recommending acknowledgement of the EE Action Item using NW Natural's current avoided cost methodology. The implementation of the RNG methodology, however, is presently untested and the potential quantity of RNG is unbounded.

Staff is concerned about the risks to ratepayers in acknowledgement of an evaluation methodology surrounded by so many unknowns. Staff feels strongly that an Action Item should include an estimated range in terms of cost or quantity. Staff is not aware of any information NW Natural has provided on how much RNG NW Natural may acquire in the next two to four years.

Investigation into RNG Avoided Cost Evaluation

RNG may present an important opportunity to bring a least-cost, least-risk resource to customers. However, RNG evaluation is a new methodology that deserves more discussion and evaluation. For this reason, Staff proposes a process for evaluating and acquiring cost-effective RNG that emphasizes collaboration and learning.

Staff proposes a limited-duration process for NW Natural to assess and procure up to a limited quantity of cost effective RNG using the avoided cost RNG Evaluation Methodology in Appendix H. The suggested process would be as follows:

1. **NWN files a revised Appendix H.** The Company re-files Appendix H with the changes suggested above.

[23] NW Natural. 2018 Integrated Resource Plan. Page 1.10.

2. **Limited RNG acquisition over the next two years.** Staff does not recommend acknowledgement of the RNG Evaluation Methodology itself. Staff proposes that NW Natural file a revised RNG action item to acquire up to a limited number of cost-effective therms of RNG over the next two years using the avoided cost RNG Evaluation Methodology in the revised Appendix H. Staff suggests three and a half million therms as a reasonable limit that is approximately one third the amount of energy efficiency the Company plans to acquire over the next two years.

3. **RNG Evaluation Investigation.** Staff will conduct an investigation into the use of avoided costs by NW Natural to evaluate RNG acquisition.
4. NW Natural will file the evaluation workpapers, modeling inputs and outputs, and results of the RNG Evaluation Methodology in the investigation docket at least 30 days prior to committing to any RNG resource.
5. **Prudence Review.** Any RNG contracts or projects will be subject to prudence review before cost recovery.
6. **Establish an RNG Evaluation Methodology review process**. At the successful conclusion of the evaluation investigation, a process would be established for stakeholders to review the avoided costs and methodology annually or biennially.

An investigation will provide stakeholders the opportunity to observe the methodology in practice, allowing for a collaborative, ongoing discussion to take place around the new prospect of cost-effective acquisition of RNG. Stakeholders would have the opportunity to weigh in on important issues, and could gain familiarity with the RNG Evaluation Methodology as applied to an actual project. Important discussion could take place around avoided costs, forecasted GHG prices, and how to bring RNG onto the system safely and reliably. The collaborative process would unfold while potentially moving forward with limited RNG acquisition. As a limited testing ground, Staff's proposal is a low-risk way to investigate a potentially cost-effective new resource option that could bring additional diversity to NW Natural's resource portfolio.

Staff Recommendations

- Staff recommends that NW Natural Re-file Appendix H to address the concerns identified by Staff in Final Comments.

- Staff recommends that NW Natural file a revised RNG Action Item. Staff proposes an RNG Action Item for assessing and procuring up to a limited amount of cost-effective RNG over the next two years using the methodology in Appendix H, and participating with stakeholders in an investigation into the use of NW Natural's proposed avoided cost methodology to evaluate RNG.

Conclusion

In Summary, with regard to NW Natural's 2018 IRP, Staff recommends the following:

Demand Forecasting

1. In addition to the statistical analysis, Staff requests that the Company's next IRP contain a narrative to explain the near term factors that the subject matter expert (SME panel)

forecast is capturing that led the Company to favor the choice of the blending and transitioning years from the SME panel forecast to the econometric forecast.

2. Staff recommends the establishment of a consistent standard relating to the year in which the Company blends and fully transitions from the SME panel to the econometric forecast. The standard should stay the same from one IRP to the next unless the Company has reason to believe it has found a substantial improvement over the current method.

3. A common tool used within load forecasting to track the usage of market segments is tracking customers with the NAICS or SICS database. Staff recommends that NW Natural pursue the creation of such a tool for the 2020 IRP.

4. For the 2020 IRP, Staff would recommend the Company use an automated stepwise regression process for variable selection to compare against a model similar to the 2018 IRP in the use of interaction variables. Cross validation, or more specifically k-fold validation[24], would then help to assess how the results of each predictive model will generalize to an independent data set.

5. Prior to the 2020 IRP, Staff recommends NW Natural coordinate a series of workshops to address concerns regarding the Company's method of implementing probabilistic methodology.

Avoided Costs and Demand Side Resources

6. Work with staff to review proposed end use load profiles as part of UM 1893. Review may potentially involve a third party evaluator and additional supporting research.

7. Staff recommends acknowledgement of NWN's Action Item number 9: Working through Energy Trust, NW Natural will acquire therm savings of 5.2 million therms in 2019 and 5.4 million therms in 2020, or the amount identified and approved by the Energy Trust board.

8. Staff recommends NWN launch the targeted DSM pilot in 2019. This is an Action Item from the 2016 IRP. The pilot study is behind schedule and the results could have informed many aspects of NWN's 2018 IRP. Staff does not believe NWN has sufficiently evaluated targeted DSM as alternatives to proposals in this 2018 IRP to pursue pipeline reinforcements and RNG.

9. Staff recommends NWN hire a third party to perform a Demand Response Potential Study in its service territory. Staff does not believe NWN has sufficiently evaluated demand response programs as alternatives to proposals in this 2018 IRP to pursue pipeline reinforcements and RNG. This analysis should include their interruptible rates as a DR option.

Supply Side Resources

[24] Bergmeir, C., Hyndman R.J., 2018, A Note on the validity of cross-validation for evaluating autoregressive time series prediction. Computational Statistics and Data Analysis *120, 70-83.*

10. Staff recommends NW Natural develop more detailed discussion around potential future supply-side resource investments in future IRPs in order to provide sufficient information and more transparent analysis for resource planning purposes. The Company should include Action Items for any significant investments, including those associated with anticipated studies expected within the first four years of the IRP.

Portfolio Selection

11. For any state that continues not to have a carbon policy by the next IRP, include an additional carbon price path in the stochastic analysis that is near to or equal to zero, and allow a carbon price to begin as late as 2030.

Distribution System Planning:

12. Based on available evidence, Staff recommends acknowledgement of the following distribution projects:
    - The Hood River project;
    - The South Oregon City project.

13. NW Natural should collect more data, as recommended by Staff in Final Comments, and resubmit acknowledgement requests in an IRP update or in the next IRP for the following distribution projects:
    - Happy Valley project;
    - Kuebler reinforcement project;
    - Sandy Feeder reinforcement project;
    - North Eugene reinforcement project.

RNG Evaluation Methodology

14. Staff recommends that NW Natural Re-file Appendix H to address the concerns identified by Staff in Final Comments.

15. Staff recommends that NW Natural file a revised RNG Action Item. Staff proposes an RNG Action Item for assessing and procuring up to a limited amount of cost-effective RNG over the next two years using the methodology in Appendix H, and participating with stakeholders in an investigation into the use of NW Natural's proposed avoided cost methodology to evaluate RNG.

This concludes Staff's Final Comments.

Dated at Salem, Oregon, this 31st day of December, 2018.

Rose Anderson
Senior Utility Analyst
Energy Resources and Planning Division

Project Name: Hood River Reinforcement

System Background and Description: The Hood River Distribution System serves the town of Hood River, Oregon and its surrounding area. This system of approximately 2,500 customers is supplied solely by the NWPL Hood River Gate Station. The majority of customers in Hood River and the surrounding countryside are fed by one district regulator station. This configuration makes the system more vulnerable to choke points in the pipelines as customer demand increases.

Recent Events Supporting Reinforcement Project: Cold Weather, January 5-6, 2017

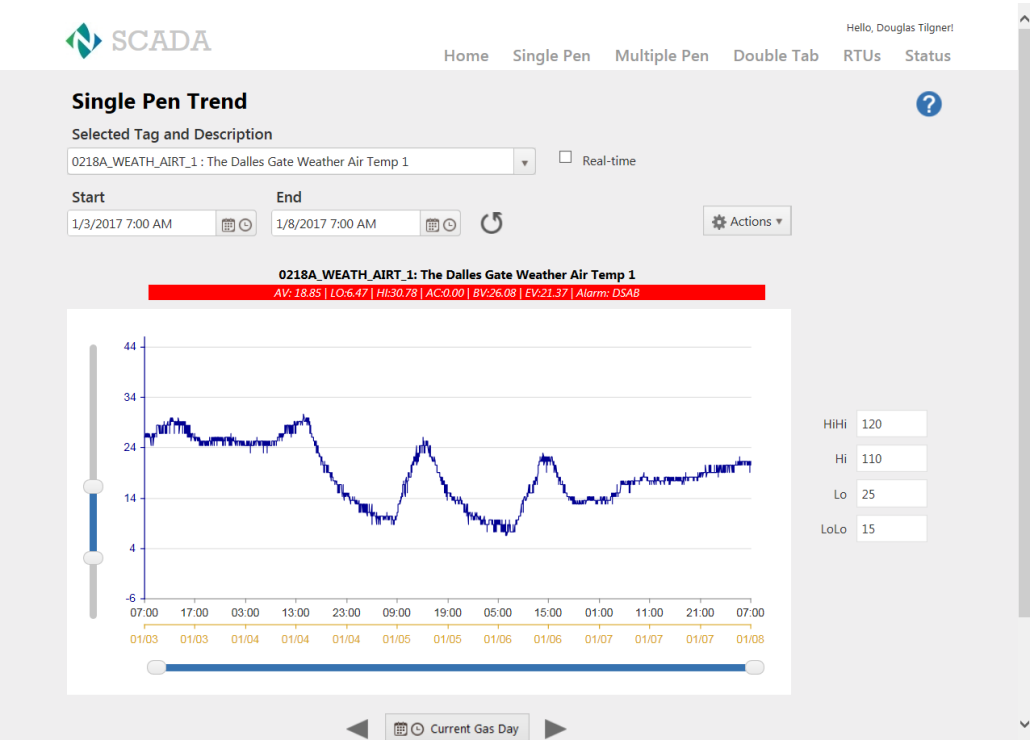
Summary:

- Non Peak cold weather events in January 2017 resulted in widespread low pressures resulting in reported outages of 62 customers in Hood River.[1] No system abnormalities were experienced to produce low pressure conditions[2]
- System reinforcement standards were violated by low system pressures less than 10 psig
- Weather events colder than January 2017 have occurred 8 times since the start of our hourly weather history in 1985[3]
- Modeling validates low pressures under experienced conditions
- The Hood River system remains a safety and reliability concern until reinforcement occurs

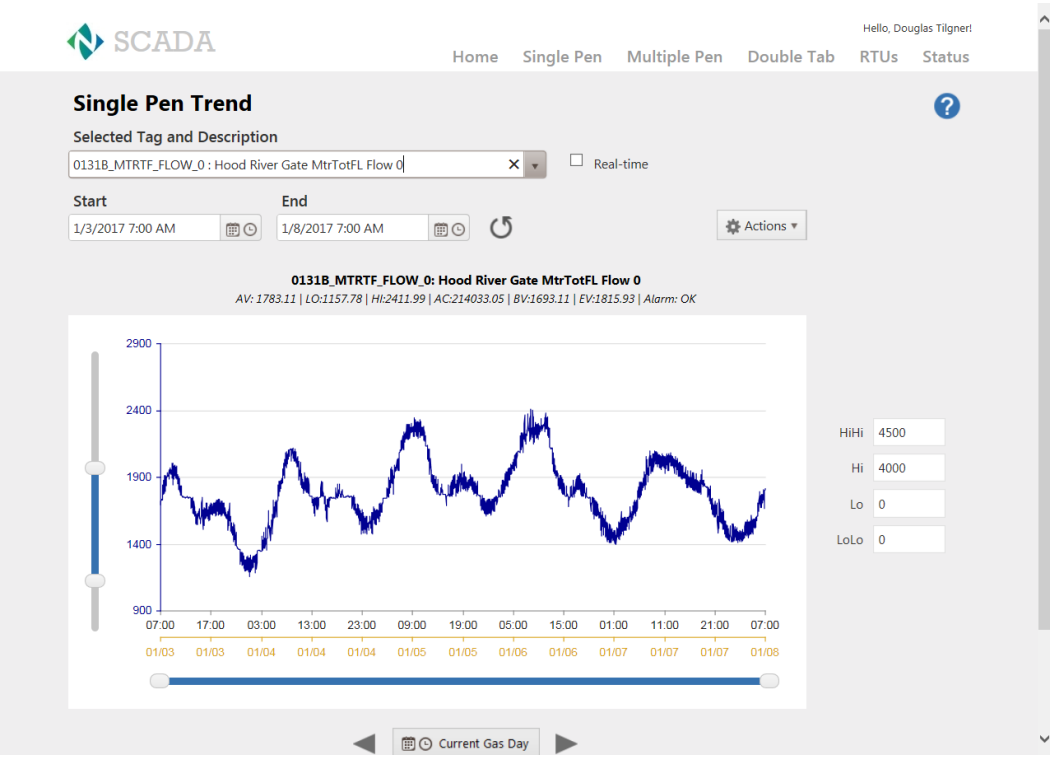
Weather: The following graphs were generated from data collected by the Gas Control SCADA system which monitors near real time data from the field. The period of all graphs is a five day period from 7 AM January 3, 2017 to 7AM January 7, 2017. This period was chosen to show the days before and after the cold event.

The first graph below shows air temperature in The Dalles, Oregon, about 40 miles east of Hood River. Hood River does not have an air temperature SCADA data tag. Spot checks of other air temperature sources indicate that Hood River experienced approximately the same weather as The Dalles during this event. The low temperature on the morning of January 5 was 8 DegF and the low on January 6 was 6 DegF. Colder temperatures were experienced at this location in 1990, 1996, 1989, 1985, 2013, 2004, and 1998 (see attached spreadsheet containing cold weather event data). January 2017 was not an anomalous weather event in Hood River, nor was it a design “Peak” day.

[1] See Attachment 1 to this response
[2] I.e., unexpected equipment malfunctions unrelated to cold weather
[3] See Attachment 2 to this response



System Conditions: The next graph shows the demand in therm/hr from Hood River Gate Station (NWPL). The Hood River system is fed by this single gate station so it accurately reflects the entire customer demand in Hood River. High flows of approximately 2,300 therm/hour were experienced on the two coldest mornings. The morning prior, January 4, saw a high flow rate of approximately 2,100 therm/hour. The colder mornings on January 5 & 6 resulted in approximately 10% (200 therm/hr) more demand than the previous day.



The following SCADA graph shows the system pressure near the Hood River Airport as indicated on system map below. This location is near the south end of the distribution system and should be representative of the lowest pressures in the system. January 5 saw pressures down to 3 psig at this location and it reached less than 1 psig on January 6. Pressures this low in a gas system will always result in at least a few outages, if not widespread outages. Notice that the morning of January 4 showed a downward spike in pressure but did not dip much below 30 psig. System pressures were more than adequate on the previous day. This is a very good example of how fast a heavily loaded gas system can fail under slight increases in customer demand.

The large system pressure drops experienced on the mornings of January 5 & 6 were created by just an additional 10% customer demand over the January 4 demand. On two consecutive mornings the system was unable to reliably deliver gas to customers. System pressures approached zero psig and 62 customers reported equipment issues (outages) due to low pressure. See attached spreadsheet containing customer pressure issues. A significant number of the approximately 2,500 customers in Hood River experienced pressures less than 10 psig. We would expect a design peak demand to exceed these experienced demand volumes and generate significantly more customer outages.

Normal winter operations activities were performed during this event. Field personnel validated that the regulator feeding the system was performing properly. This regulator was bypassed during morning hours to maximize pressures. There were no closed valves or damages in the system that would have contributed to low system pressures. Interruptible customers were curtailed as soon as the magnitude of the event was recognized. Significant low pressures and outages were still experienced after all winter troubleshooting was completed.

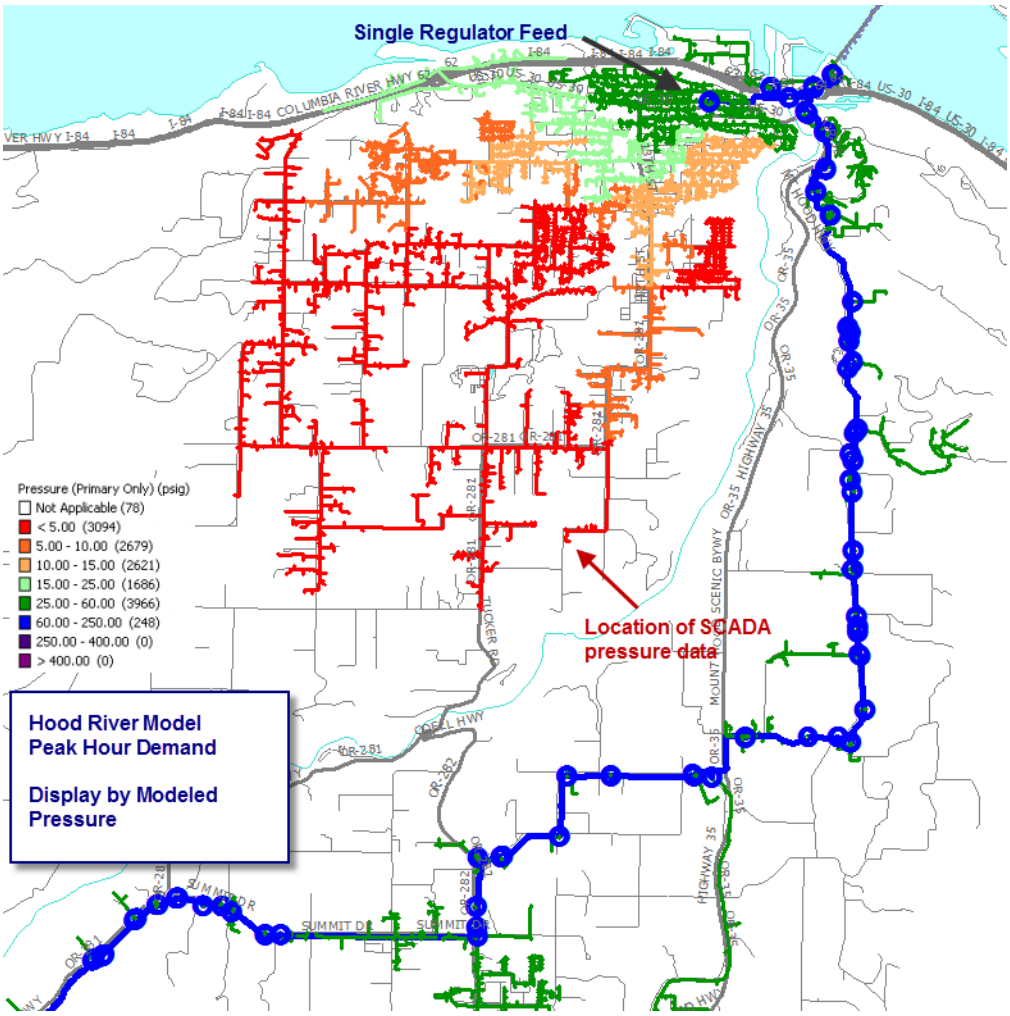
When low pressures are experienced during cold weather events, NW Natural investigates the District Regulator Station(s) that feed the distribution system to ensure they are functioning properly and that they are adequately sized. These stations are maintained in the field once per calendar year, and the regulator and relief sizing report is also verified annually. If a regulator station is not properly meeting demands then a relatively low cost/scope construction project can be planned to improve regulator performance.

If the District Regulator Station(s) are fully functional and adequately sized, then we would investigate the high pressure (greater than 60 MAOP) pipeline system that feeds these stations. These stations require a minimum inlet pressure (specific for each station) for the regulator to function properly. NW Natural system reinforcement criteria for lower pressure systems identifies 10 psig as our lowest operating pressure threshold due to the proper operation of Excess Flow Valves, a safety device. As large numbers of customers experienced less than 10 psig, the current capability of the Hood River system is a reliability issue and a safety concern.

During this cold weather event, neither the district regulator sizing nor the high pressure pipeline feed contributed to the low pressures experienced in the system, and the pressures experienced in the distribution system violated the reinforcement criteria.

Current System Analysis:

The Synergi model for the existing Hood River system (current piping configuration and customers) under peak hour customer demand is shown below. The model indicates that we would experience widespread low pressures (red areas = 5 psig or less) and resulting customer outages under peak hour conditions. The modeled results closely correlate with the system conditions experienced in January 2017. The experienced pressures significantly violates our system reinforcement criteria for lower pressure systems which specifies that 10 psig is the lowest acceptable pressure in a distribution system. System reinforcement actions must be taken to assure safe and reliable service to firm customers in Hood River.



System Reinforcement Selection:

The Hood River system was carefully examined to determine if there were choke points where pipelines could be replaced to ease cold weather impacts on system pressures. It was determined that significant portions of the system would have to be replaced for substantial gains in performance to be made. The less difficult system ties and replacements for size (choke points) had already been done in this system.

Pressure uprates of gas systems are always considered viable alternatives as they are usually much less expensive than pipeline construction. The Hood River system is already operating at 60 MAOP and cannot be uprated to increase system capacity.

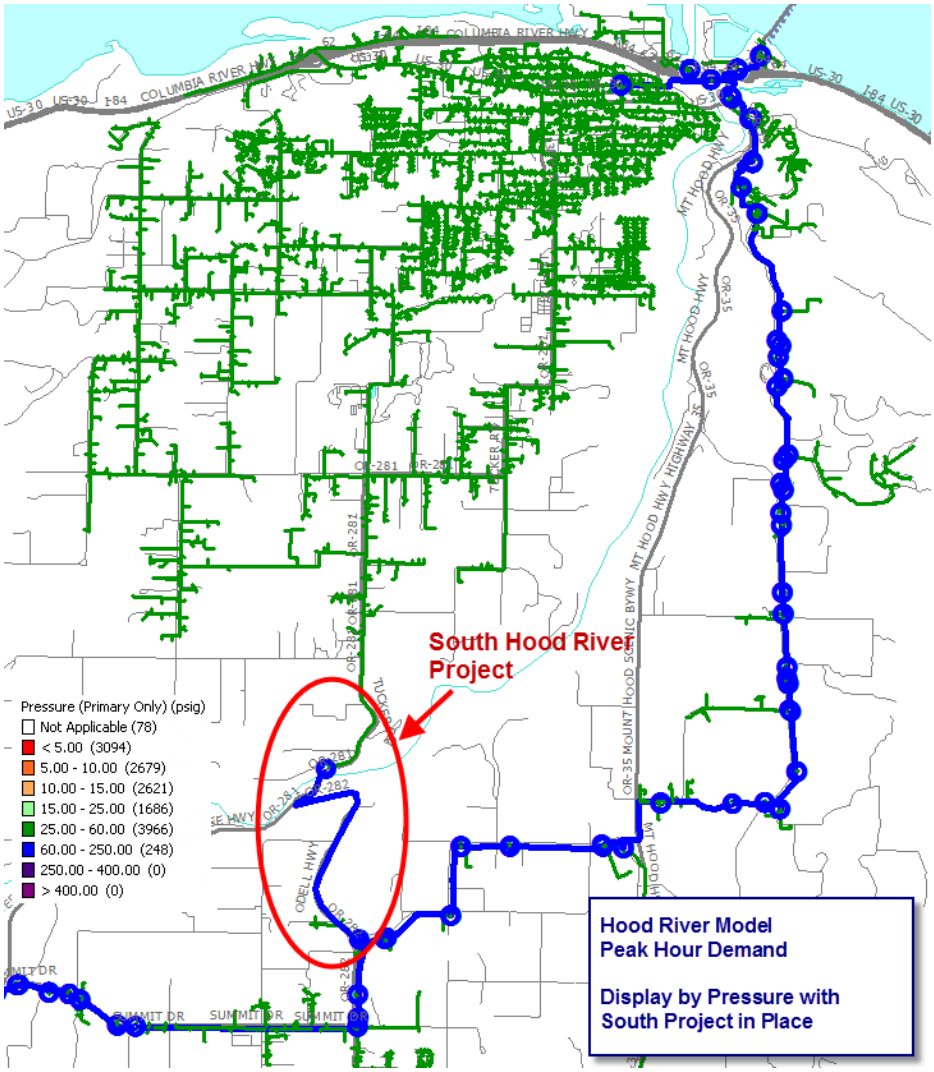
Analysis shifted to new pipeline design. As stated above, the Hood River system is fed by a single district regulator. A very desirable attribute in a new pipeline would be a second feed into the system, both to alleviate cold weather pressures and to work as a redundant supply in the system. The high pressure system in Hood river runs from north to south along the east side of town and then across the south end. Any project to bolster this system has to involve high pressure gas. The east side high pressure is isolated from the core of Hood River by a large canyon containing a river and a tall

rock plateau. These are significant obstacles and focus was turned to the high pressure systems in the north and south.

Pipeline design processes iteratively weigh cost versus performance by many variables including pipe size, pipe length, pipe route, operating pressure, customer demand, soil conditions, restoration costs, terrain, and many more. It should also be noted that pipeline attributes can change between preliminary design and final design, ready for construction. Field validation is an important part of final design.

A southern pipeline design was determined to offer the best solution for addressing the pressure issues in Hood River because:

- Pressure issues are remediated
- Expected costs are lowest
- Traffic, public, and customer impacts are minimal.



The southern project was selected as the preliminary pipeline design for the Hood River Reinforcement Project.

Additional Alternative Analysis:

The benefit volume from this pipeline project (modeled therms delivered to customers on peak from this project) is compared to other alternatives. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design had a higher estimated cost than the proposed pipeline project.

The alternative analysis also examines the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the Hood River system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The pipeline project was selected as the initial design for the Hood River Reinforcement Project and was determined to be our best alternative for 2018 IRP action item submittal.

Project Name: Sandy Feeder Reinforcement

System Background and Description: The Sandy Feeder pipeline serves the town of Sandy, Oregon and its surrounding area. This system of approximately 2,000 customers is supplied by the NWPL Sandy Gate Station. The Sandy Feeder pipeline is a 3 ½" wrapped steel pipeline that was installed in 1965 and operates at 400 MAOP.

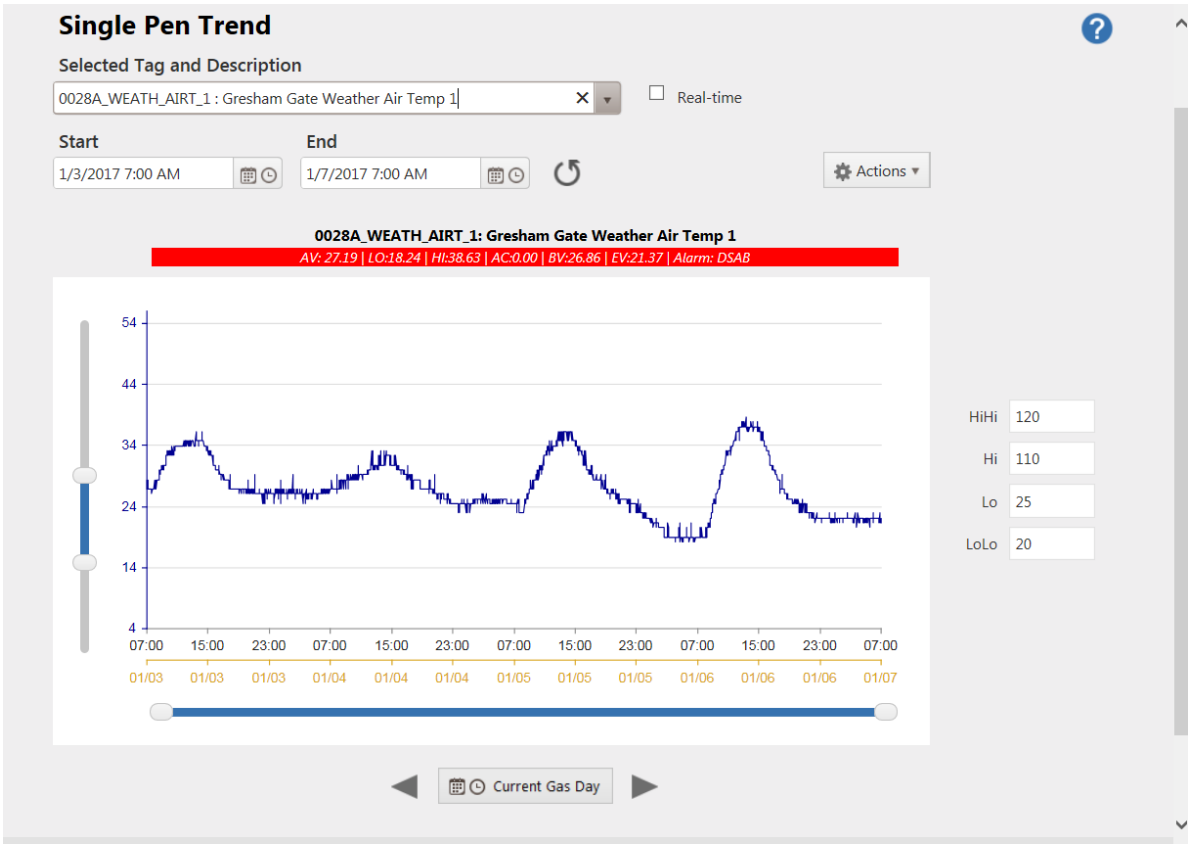
Recent Events Supporting Reinforcement Project: Cold Weather, January 5-6, 2017

Summary:

- Non Peak cold weather events in January 2017 resulted in very significant pressure drops on the Sandy Feeder pipeline. No system abnormalities were experienced to produce these pressure drops[1]
- No customers outages were reported
- Modeling validates the experienced pressure drop conditions
- System reinforcement standards were violated by pressure drops exceeding 40% on this high pressure pipeline
- Marginally higher demands than were experienced in January 2017 would result in downstream regulator malfunction and subsequent low pressures and customer outages
- The Sandy system remains a safety and reliability concern until reinforcement occurs

Weather: Sandy also experienced the cold weather and increased customer demand that other areas faced in January 5-6, 2017. The following graph was generated from data collected by the Gas Control SCADA system which monitors near real time data from the field. The period of the graph is a five day period from 7 AM January 3, 2017 to 7AM January 7, 2017. This period was chosen to show the days before and after the cold event. There is no SCADA temperature location in Sandy but we do have a SCADA air temperature at our Gresham Gate Station, about 12 miles northwest. This SCADA site indicates a low air temp of about 18 DegF on the morning of January 6, 2017.

[1] I.e., unexpected equipment malfunctions unrelated to cold weather



Historical air temperature data (see attached coldest events by location spreadsheet) shows that we have experienced numerous colder days in recent history including 1989, 1996, 1990, 2004, 2008, 1998, and 2014. The January 2017 event was not an anomalous weather event in Sandy nor was it a design “Peak” day.

System Conditions: Normal winter operations activities were performed during this event. Field personnel validated that the regulators feeding the system were performing properly. The regulator at the end of the Sandy Feeder was bypassed during morning hours to maximize pressures. There were no closed valves or damages to the upstream feeder or in the system. There are no interruptible customers in the Sandy system which could have been curtailed to remove demand from the feeder.

The lower pressure system (less than 60 psig) in the town of Sandy is currently configured well and no customer outages or significantly low pressures were experienced by Sandy customers.

The performance of the lower pressure system is wholly dependent upon the ability of the high pressure pipeline to deliver adequate gas pressure to the regulator inlet. The high pressure pipeline that feeds Sandy is the current bottleneck in this system. Regulator inlet pressure is the telling statistic that identifies the capacity issues of the Sandy Feeder Pipeline. The pressure being delivered to the Gate Station end of the Sandy Feeder is approximately 390 psig.

The following regulator inlet and outlet pressures were measured by field personnel at the end of the Sandy Feeder at Rueben Rd. and Hwy 26:

January 6, 2017, approximately 5am to 10am

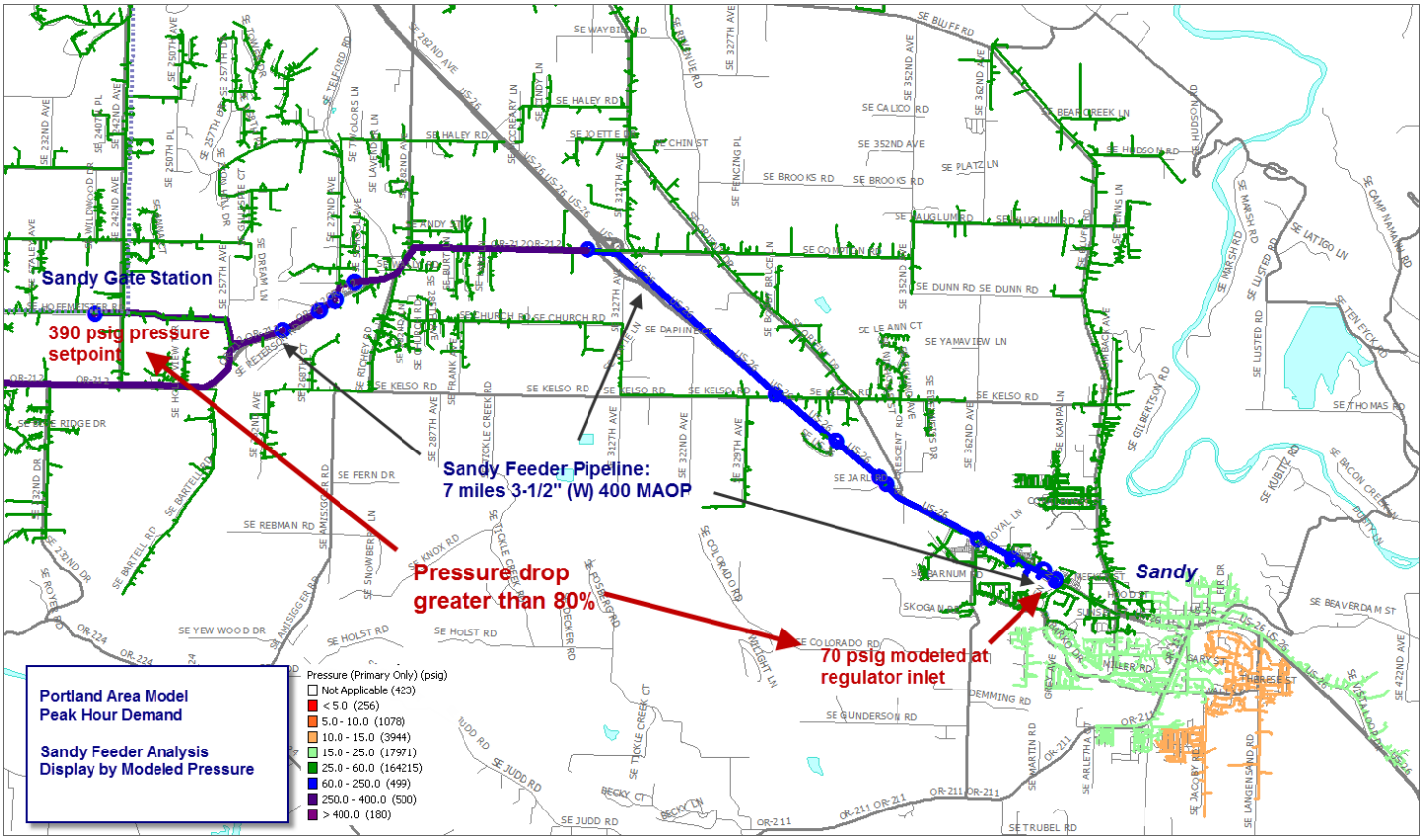
Inlet Press	Outlet Press	Air Temp	
175	50		
140	52	18	
120	52	17	
87	52	17	
72	**52**	**17**	**inlet pressure at 20 psig above outlet pressure**
72	**52**	**18.5**	**inlet pressure at 20 psig above outlet pressure**
97	52	25	
130	52	28	

District Regulators require that the inlet pressure be at least 20 psig higher than the outlet pressure for proper operation. The regulators feeding the town of Sandy were very close to being starved by low inlet pressure. This was not an isolated incident, very low inlet pressures were also reported (but not documented) on days prior to and after January 6, 2017.

The measured pressure drop on the Sandy Feeder on January 6. 2017 was 313 psig (390 - 72) or just over 80%. This closely correlates to the peak hour Synergi model which predicts 70 psig on peak. This result greatly exceeds our 40% pressure drop criteria for high pressure pipelines and indicates that this pipeline requires reinforcement.

Current System Analysis:

The Synergi model for the existing Sandy system (current piping configuration and customers) under peak hour customer demand is shown below. The model indicates that the distribution system within the town of Sandy is adequate but weak (orange) in the east under peak hour conditions. The primary concern for this system is the capacity of the Sandy Feeder pipeline. Modeling indicates very large pressure drops (greater than 80%) on this high pressure pipeline that greatly exceed system reinforcement standards (40%) on a peak hour. The existing pipeline configuration significantly violates our system reinforcement criteria for high pressure systems which specifies that 40% is the largest acceptable pressure drop. System reinforcement actions must be taken to assure reliable service to firm customers.

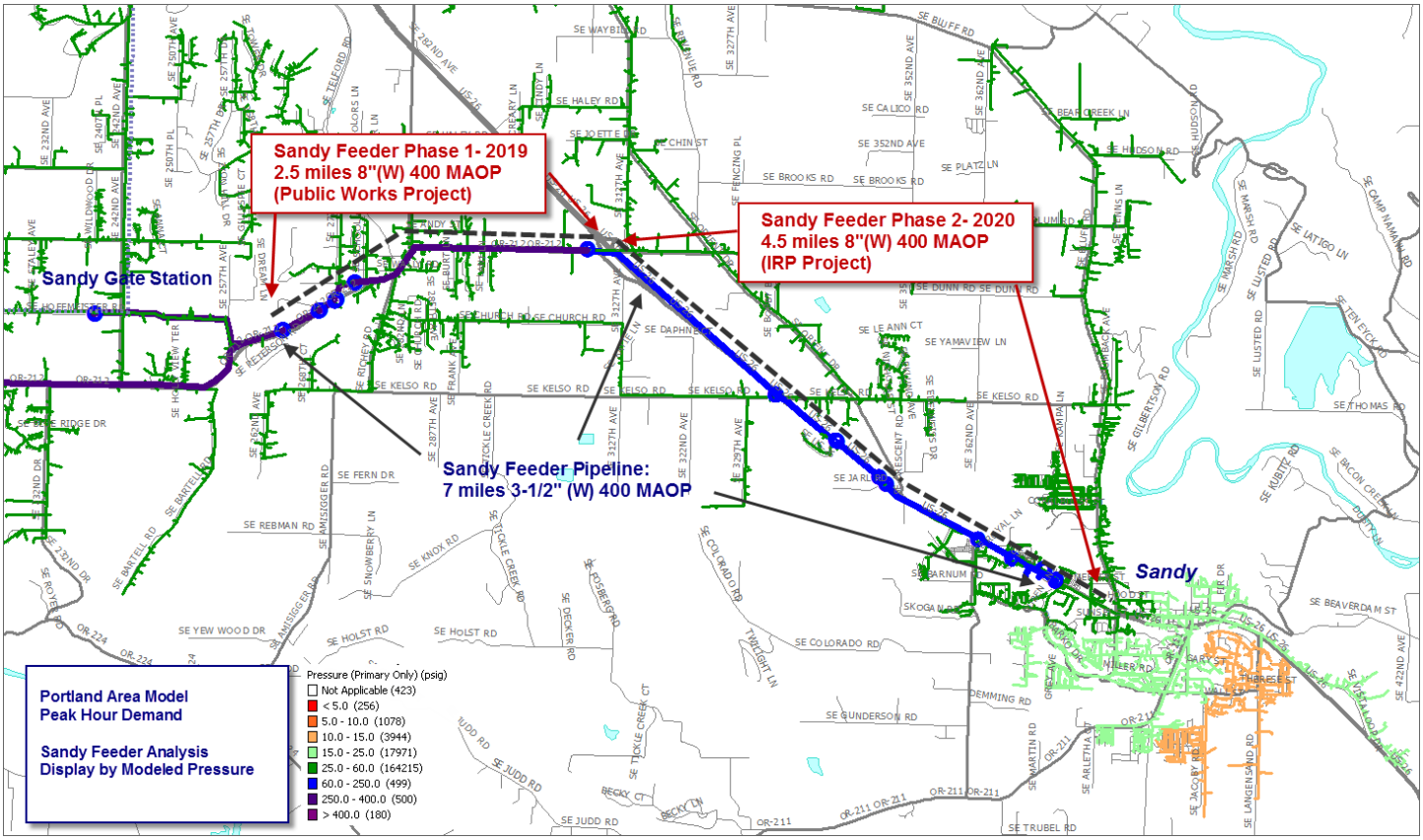


System Reinforcement Selection:

The Sandy Feeder pipeline was installed in 1965 and was sized to support the town of Sandy with some margin for growth. Today, this pipeline's capacity is being stressed by over 50 years of additional demand from customer growth in the town and surrounding area. This pipeline has no choke points which could be replaced to increase capacity. The appropriate choice for pipeline design in this case is replacement for the Sandy Feeder.

Pressure uprates of gas pipelines are always considered viable alternatives as they can be relatively inexpensive procedures. The Sandy Feeder pipeline is already operating at 400 MAOP and cannot be uprated to increase pipeline capacity.

The preliminary design for this pipeline consisted of approximately 7 miles of 8" wrapped steel operating at 400 MAOP. This was a direct replacement of the 3 ½" pipeline with an 8" pipeline. About 2.5 miles of this pipe runs along Hwy 212. ODOT is working on a project to widen and regrade Hwy 212 which requires us to move our existing pipeline. Public works activities such as this impact NW Natural regularly. The overall project design changed to split this replacement project into two phases. Phase 1 in 2019 is a replacement of the first 2.5 miles of the existing feeder and will be a Public Works activity. The remaining 4.5 miles of replacement was submitted in the 2018 IRP as Phase 2 to be installed in 2020. The drawing below shows the preliminary project layout:



Additional Alternative Analysis:

Once a pipeline project is selected, the benefit volume from this pipeline project is compared to other alternatives. For this project the benefit volume is calculated as the net therms required to restore pressure drop on the existing pipeline to 30% pressure drop. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design for Sandy had a higher estimated cost than the proposed pipeline project.

The final alternative analysis is to examine the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the Sandy system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The Sandy Feeder Reinforcement Project as defined above was selected as the best alternative for 2018 IRP action item submittal.

Project Name: South Oregon City Reinforcement

System Background and Description: The Oregon City Distribution System serves the town of Oregon City, Oregon and its surrounding area. This system of approximately 4,000 customers is supplied mainly by the NWPL Oregon City Gate Station. A district regulator under the old Oregon City Bridge also brings gas into Oregon City from the Portland high pressure system (400 MAOP). Generally speaking, the customers in downtown Oregon City are fed by this regulator and its gas from Portland. The customers on top of the hill and to the west, east and south are served from Oregon City Gate Station.

Recent Events Supporting Analysis: Cold Weather, January 5-6, 2017

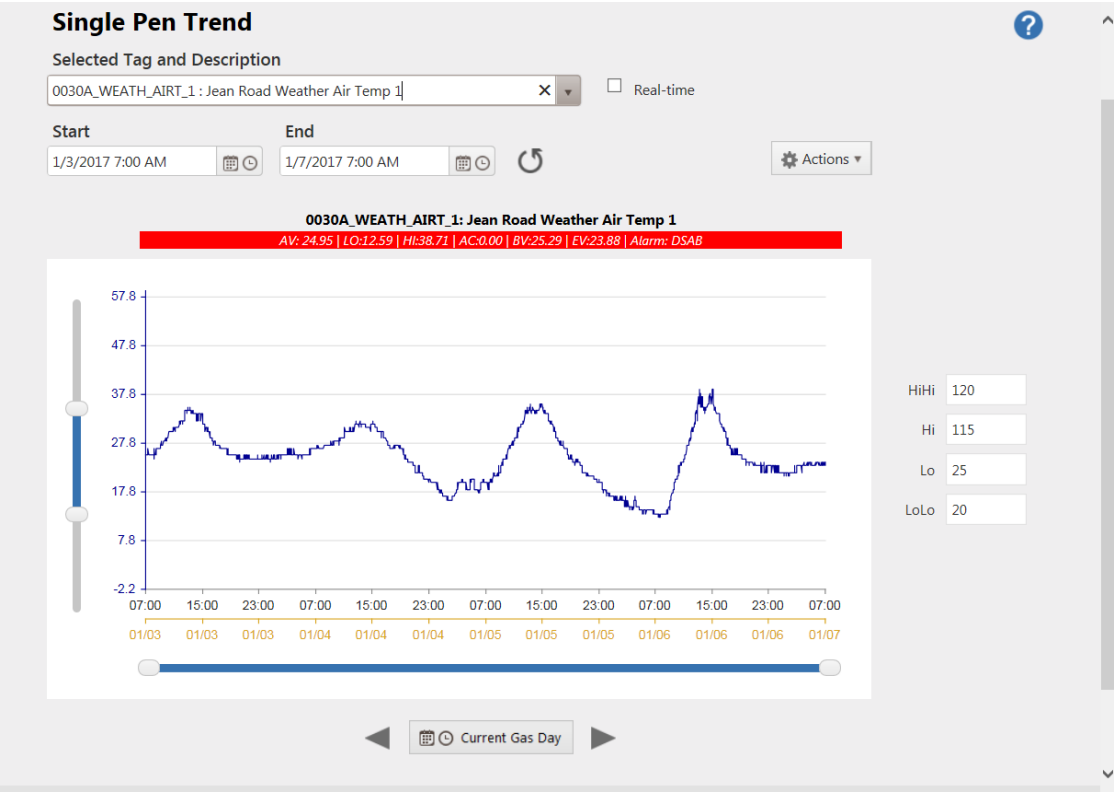
Summary:

- Non Peak cold weather events in January 2017 resulted in widespread low pressures and reported outages of 87 customers in South Oregon City[1]
- No system abnormalities were experienced to produce low pressure conditions[2]
- Modeling validates low pressures under experienced conditions
- System reinforcement standards were violated by low system pressures less than 10 psig
- The South Oregon City system remains a safety and reliability concern until reinforcement occurs

Weather: The following graph was generated from data collected by the Gas Control SCADA system which monitors near real time data from the field. The period of the graphs is a five day period from 7 AM January 3, 2017 to 7AM January 7, 2017. This period was chosen to show the days before and after the cold event for reference.

The graph shows air temperature at Jean Rd. Station in Tualatin, Oregon, about 7 miles west of Oregon City. Oregon City does not have an air temperature SCADA data tag. The low temperature on the morning of January 5 was 15 DegF and the low on January 6 was 13 DegF. Colder temperatures were experienced in this area in 1989, 1990, 1985, 2014, 2013, and 2009 amongst others (see attached spreadsheet containing cold weather event data by area). January 2017 was not an anomalous weather event in Oregon City nor was it a design “Peak” day.

[1] See Attachment 1 to this response
[2] I.e., unexpected equipment malfunctions unrelated to cold weather



System Conditions: NW Natural began receiving no heat calls from customers in the Oregon City area on the morning of January 5, 2017. The outage of 71 customers located in a clustered area in southwest Oregon City indicates a system problem versus individual customer issues. Crews were dispatched and cold weather troubleshooting occurred. Normal winter operations activities were performed during this event. Field personnel validated that the regulators feeding the system were performing properly. One regulator was bypassed during morning hours to maximize system pressures. There were no closed valves or damages in the system. No interruptible customers were curtailed as there were no large interruptibles in this area. All customers were relit the same day. Customer outage spreadsheet is attached.

The following morning, January 6, 2017 was slightly colder. Field personnel were on site to bypass regulators to begin the day. This maximizes system pressures during the peak demand hours. Low pressures persisted in some locations and 16 customers called in to report outages. All customers were relit the same day. Customer outage spreadsheet is attached.

When low pressures are experienced during cold weather events, NW Natural investigates the District Regulator Station(s) that feed the distribution system to ensure they are functioning properly and that they are adequately sized. These stations are maintained in the field once per calendar year, and the regulator and relief sizing report is also verified annually. If a regulator station is not properly meeting demands then a relatively low cost/scope construction project can be planned to improve regulator performance.

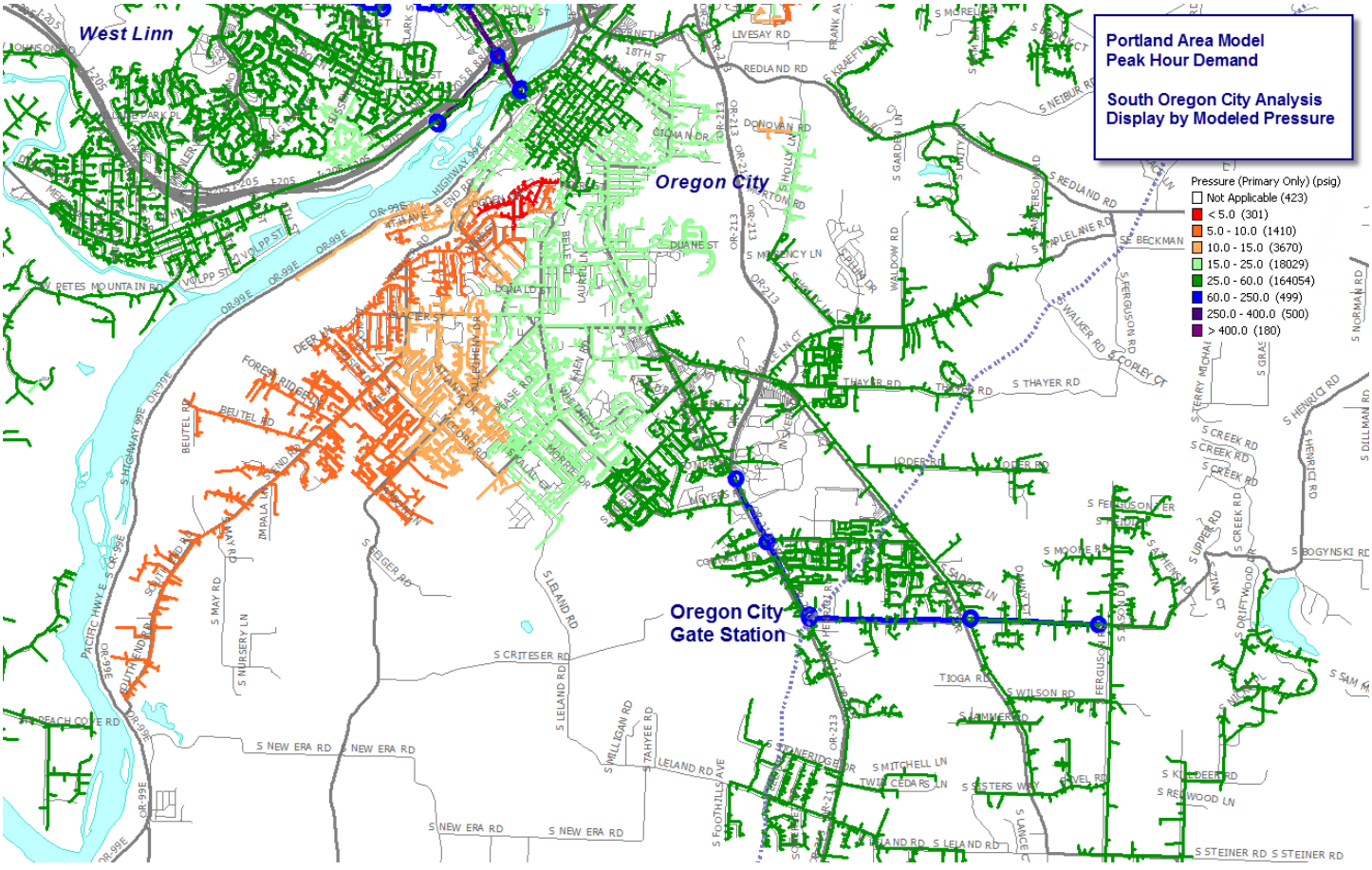
If the District Regulator Station(s) are fully functional and adequately sized, then we would investigate the high pressure (greater than 60 MAOP) pipeline system that feeds these stations. These stations require a minimum inlet pressure (specific for each station) for the regulator to function properly.

Customer outages confirm that we experienced widespread low pressure issues well below our 10 psig system reinforcement standard. Our system reinforcement standard for lower pressure systems identifies 10 psig as our lowest operating pressure threshold due to the proper operation of Excess Flow Valves, a safety device.

During this cold weather event, neither the district regulator sizing nor the high pressure pipeline feed contributed to the low pressures experienced in the system.

Current System Analysis:

The Synergi model for the existing Oregon City system (current piping configuration and customers) under peak hour customer demand is shown below. The model indicates that we would experience widespread low pressures (orange = 5-10 psig, red = 5 psig or less) and resulting customer outages under peak hour conditions. This significantly violates our system reinforcement criteria for lower pressure systems which specifies that 10 psig is the lowest acceptable pressure in a distribution system. The 10 psig threshold is driven by Excess Flow Valves which according to manufacturer specifications, are not designed to operate properly below that pressure. System reinforcement actions must be taken to assure safe and reliable service to firm customers in South Oregon City.



System Reinforcement Selection:

The Oregon City system was carefully examined to determine if there were choke points where pipelines could be replaced to ease cold weather impacts on system pressures. It was determined that significant portions of the system would have to be replaced for substantial gains in performance to be made. The less difficult system ties and replacements for size (choke points) had already been done in this system. Significant feeder pipelines must be built to improve cold weather system performance.

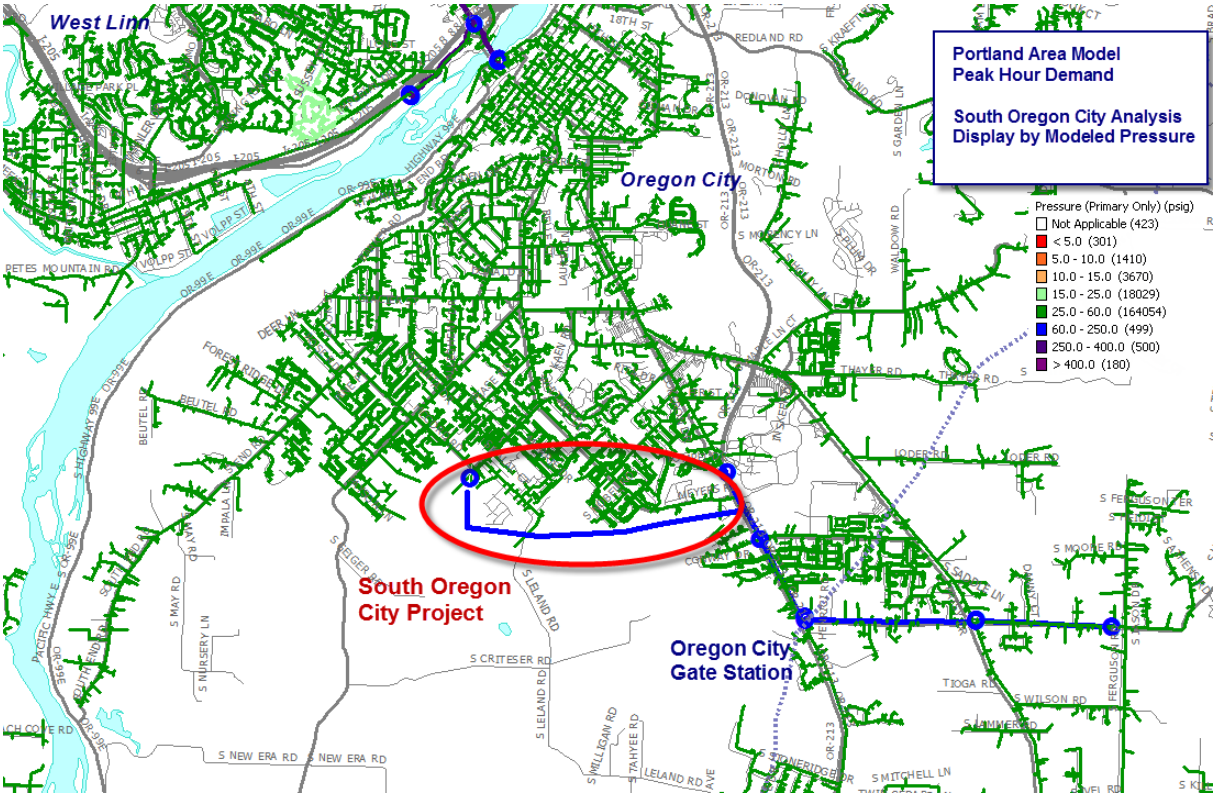
Pressure uprates of gas systems are always considered viable alternatives as they are usually much less expensive than pipeline construction. The Oregon City system is already operating at 60 MAOP and cannot be uprated to increase system capacity.

Analysis shifted to new pipeline design and how to get more gas into the weak areas. Any project to bolster this system has to involve high pressure gas. The only two sources of high pressure gas in the Oregon City area are from the Gate Station and from the regulator in downtown Oregon City. The downtown regulator is isolated from the weak systems to the south. Oregon City is very much a town divided by topography due to the 100 foot tall basalt cliffs that surround the downtown area. The least cost solution is a pipeline from the Oregon City gate station in the south to the area of low pressure.

Pipeline design processes iteratively weigh cost versus performance by many variables including pipe size, pipe length, pipe route, operating pressure, customer demand, soil conditions, restoration costs, terrain, and many more. It should also be noted that pipeline design can change between preliminary design and final design, ready for construction. Field validation is an important part of final design.

A 1.5 mile high pressure pipeline design in south Oregon City was determined to offer the best solution for addressing the pressure issues because:

- Pressure issues are remediated
- Expected costs are lowest
- Follows BPA right of way so that traffic, public, and customer impacts are minimal
- Future extension of the pipeline is possible



This route was selected as the preliminary pipeline design for the South Oregon City Reinforcement Project.

Additional Alternative Analysis:

Once a pipeline project is selected, the benefit volume from this pipeline project (modeled therms delivered to customers on peak from this project) is compared to other alternatives. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design had a higher estimated cost than the proposed pipeline project.

The final alternative analysis is to examine the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the Oregon City system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The pipeline project was selected as the initial design for the South Oregon City Reinforcement Project and was determined to be our best alternative for 2018 IRP action item submittal.

Project Name: Happy Valley Reinforcement

System Background and Description: The distribution system in the area of Happy Valley, OR is an interconnected part of the much larger East Portland system. The Happy Valley system serves approximately 2,500 customers is supplied mainly by gas from the NWPL Southeast and Johnson Creek Gate Stations. The Happy Valley/Sunnyside area has experienced significant growth for many years. Many main extensions and small system reinforcement projects have occurred over time to meet the growing customer demand. This area has been a cold weather concern for many years.

Recent Events Supporting Analysis: Cold Weather, January 5-6, 2017

Summary:

- A SCADA pressure location near the area of weakness validates model results which predict widespread low pressures below 10 psig. No system abnormalities were experienced to produce low pressure conditions[1]
- Modelling confirmed that system reinforcement standards were violated by low system pressures less than 10 psig
- The Happy Valley system remains a safety and reliability concern until reinforcement occurs

Weather: The following graphs was generated from data collected by the Gas Control SCADA system which monitors near real time data from the field. The period of the graphs is a five day period from 7 AM January 3, 2017 to 7AM January 7, 2017. This period was chosen to show the days before and after the cold event for reference.

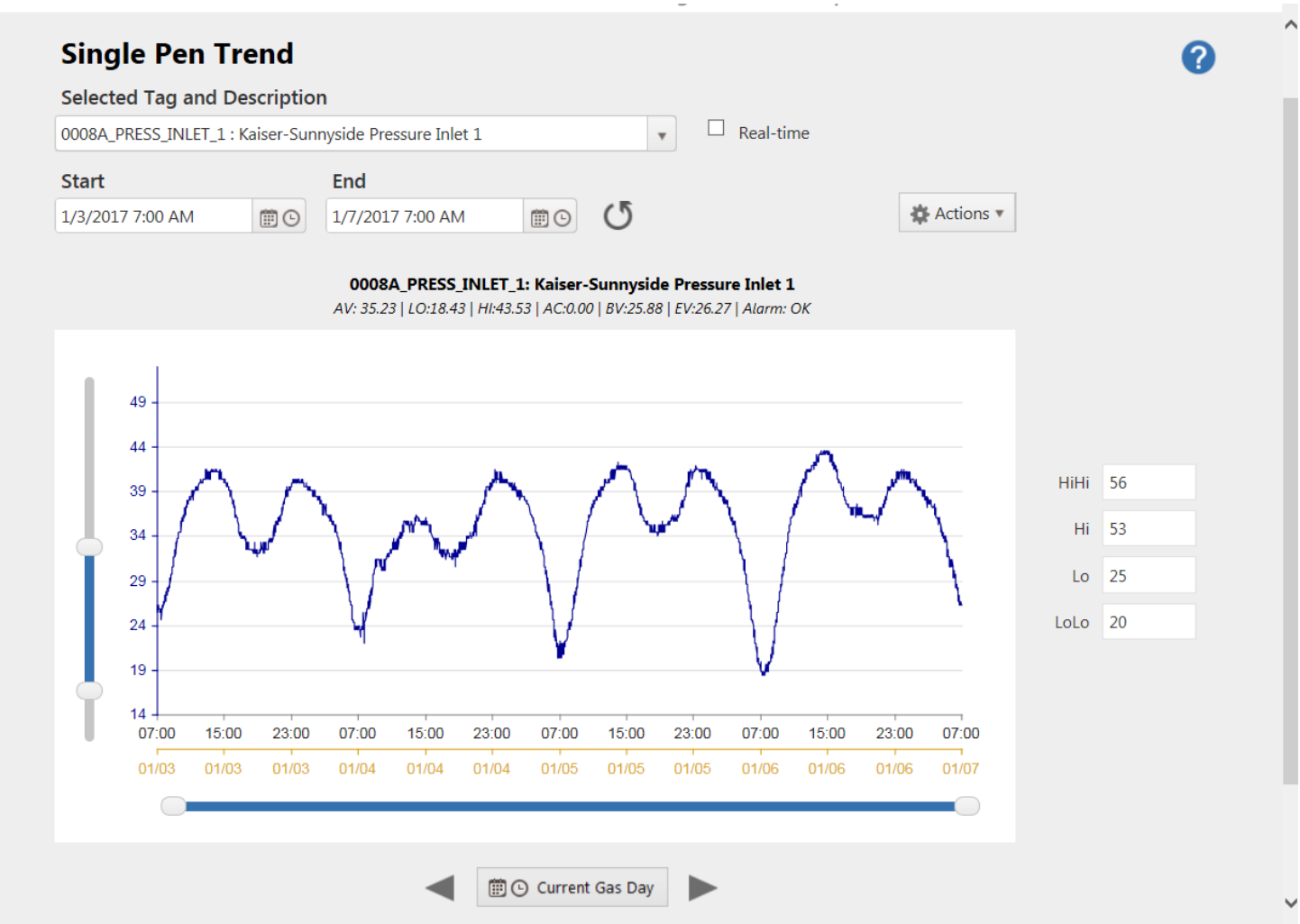
The graph shows air temperature at Gresham Gate Station in Gresham, Oregon, about 5 miles northeast of Happy Valley. Happy Valley does not have an air temperature SCADA location. This SCADA site indicates a low air temp of about 18 DegF on the morning of January 6, 2017. Colder temperatures were experienced in this area in 1989, 1990, 1985, 2014, 2013, and 2009 amongst others (see attached spreadsheet containing cold weather event data by area). January 2017 was not an anomalous weather event in Happy Valley nor was it a design “Peak” day.

[1] I.e., unexpected equipment malfunctions unrelated to cold weather

System Conditions: NW Natural did not experience customer outages in Happy Valley during the January 2017 cold weather event. Normal winter operations activities were performed during this event. Field personnel validated that the regulators feeding the system were performing properly. There were no abnormalities experienced in this system. No interruptible customers were curtailed as there were no large interruptibles in this area.

There is no current SCADA data feed that indicates system pressures in the weakest areas of Happy Valley. A SCADA pressure location does exist at the Kaiser-Sunnyside Medical Center immediately to the southwest of Happy Valley along Sunnyside Rd. The 6" 57 MAOP pipeline that parallels Sunnyside Rd from west of Interstate 205 to SE 172nd is a critical backbone in this area. The pressures seen on this pipeline are directly related to lower pressures that would be witnessed on top of the hill in Happy Valley. The pressure at Kaiser-Sunnyside is a key indicator of the health of this feeder and validates model results that show very low pressures in Happy Valley.

The following SCADA graph from the Kaiser-Sunnyside location indicates that system pressures on the 6" Sunnyside Rd pipeline sagged heavily on the mornings of January 5-6, 2017. The nearby regulators feeding this pipeline were set to feed at 50 psig. These regulators all functioned properly. Heavy demand on this pipeline under cold conditions causes significant pressure drops as customer demand ramps up in cold mornings.

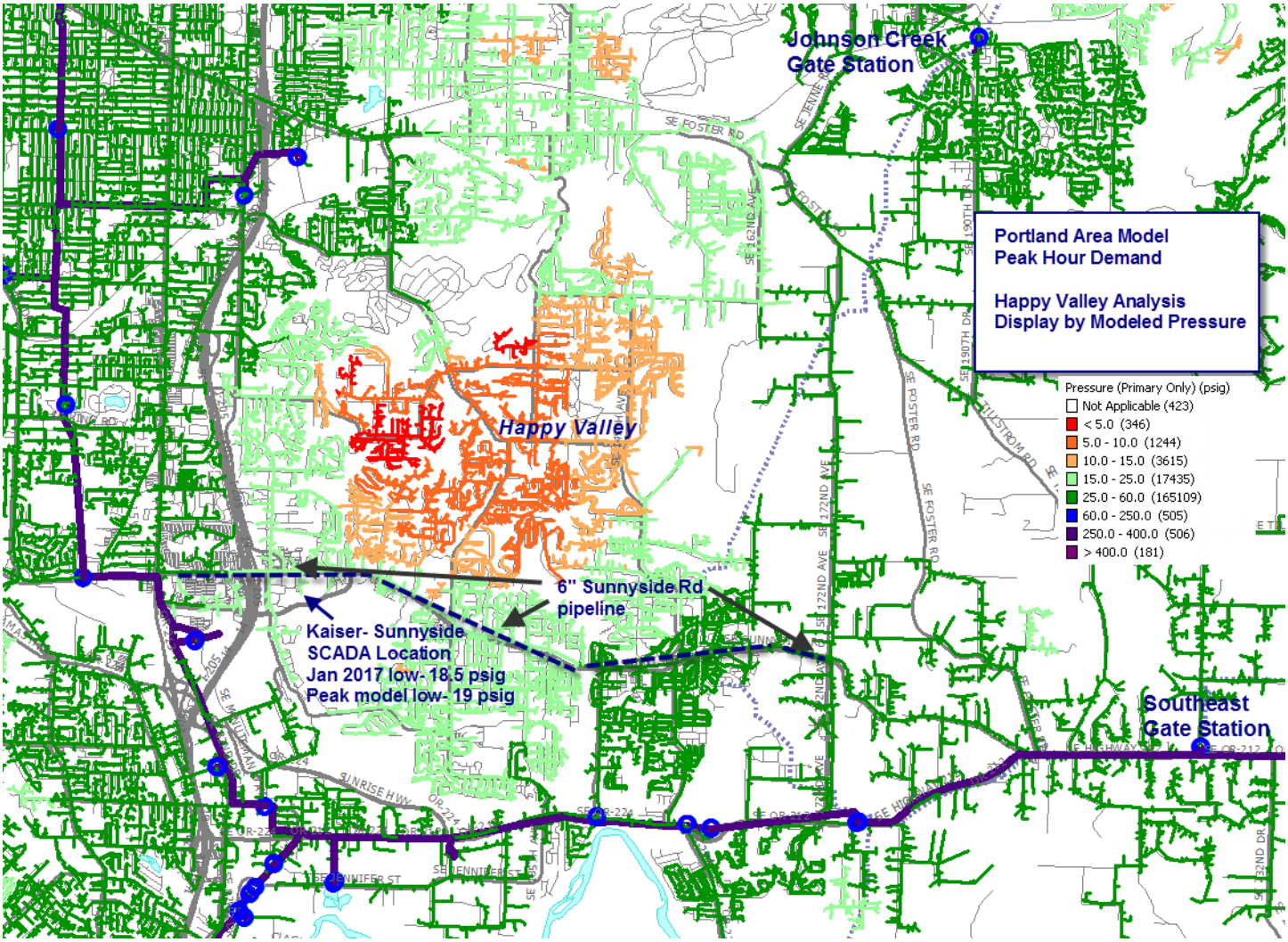


The mornings of January 5 & 6, 2017 saw low pressures of 20 psig and 18.5 psig respectively at the Kaiser location. These pressure reads by themselves do not violate any standards but indicate a very weak pipeline backbone that cannot properly support customer demands under peak conditions.

Current System Analysis:

The Synergi model for the existing Happy Valley area (current piping configuration and customers) under peak hour customer demand is shown below. The model indicates that we would experience widespread low pressures (orange = 5-10 psig, red = 5 psig or less) and resulting customer outages under peak hour conditions.

The modeled pressure at Kaiser-Sunnyside under peak demand closely correlates with the SCADA pressures experienced in January 2017. Although no outages were experienced, a significant number of customer pressures in the Happy Valley system violated the 10 psig minimum standard under less than peak demand.



Modeled low pressures violates our system reinforcement criteria for lower pressure systems which specifies that 10 psig is the lowest acceptable pressure experienced or modeled in a distribution system. The10 psig threshold is driven by Excess Flow Valves which according to manufacturer specifications, are not designed to operate properly below that pressure. System reinforcement actions must be taken to assure safe and reliable service to firm customers in Happy Valley.

System Reinforcement Selection:

The Happy Valley system was carefully examined to determine if there were choke points where pipelines could be replaced to ease cold weather impacts on system pressures. It was determined that significant portions of the system would have to be replaced for substantial gains in performance to be made. The less difficult system ties and replacements for size (choke points) had already been done in this system. Significant feeder pipelines must be built to improve cold weather system performance.

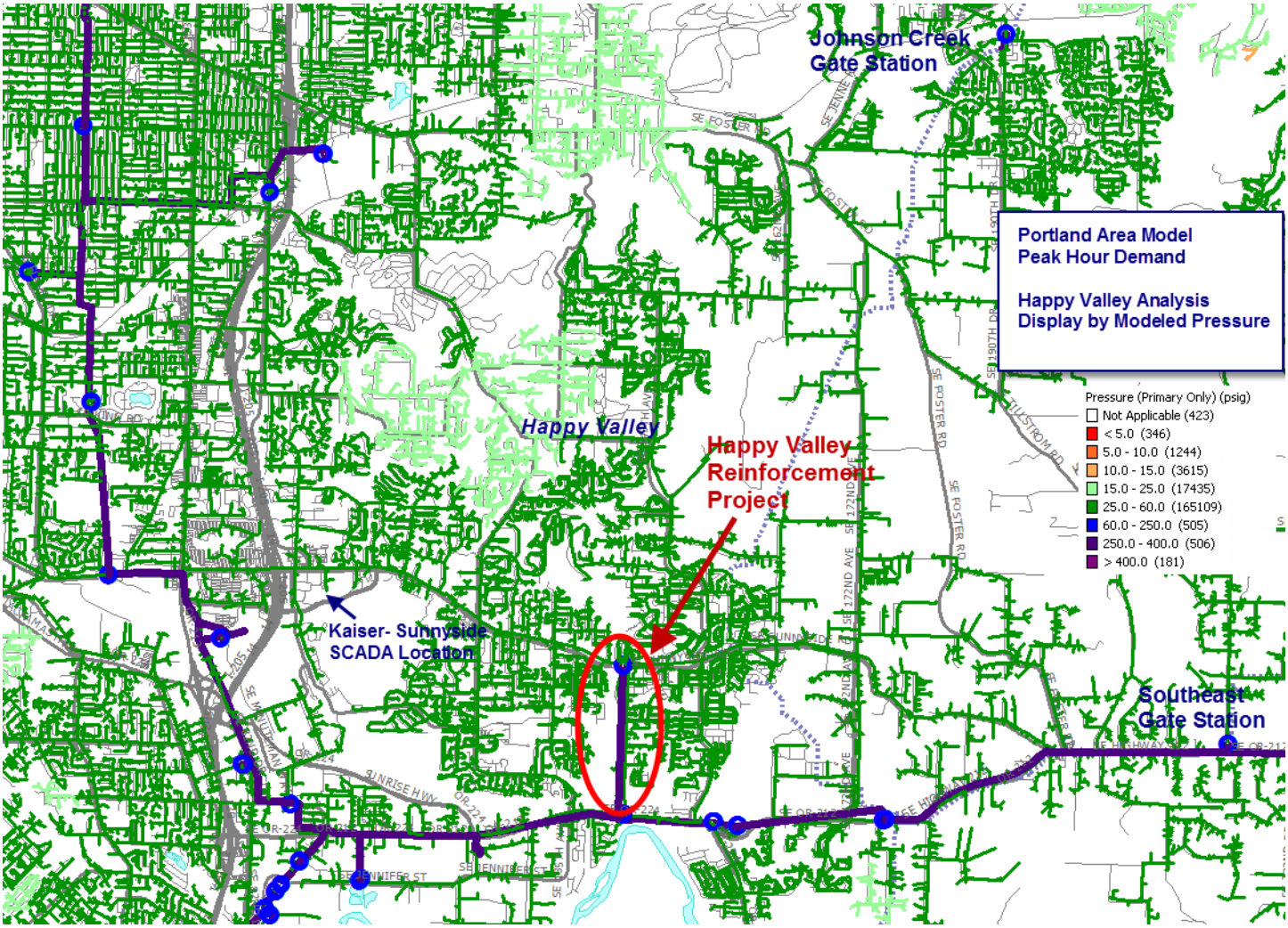
Pressure uprates of gas systems are always considered viable alternatives as they are usually much less expensive than pipeline construction. The Happy Valley system is already operating at 57 MAOP and cannot be uprated to increase system capacity.

Analysis shifted to new pipeline design and how to get more gas into the weak areas. A backbone pipeline like the 6" on Sunnyside Rd. should not be experiencing such large pressure drops. This is an indication that the 6" is undersized for the customer demand it is experiencing. This pipeline needs an additional source of support, likely from a high pressure source.

Pipeline design processes iteratively weigh cost versus performance by many variables including pipe size, pipe length, pipe route, operating pressure, customer demand, soil conditions, restoration costs, terrain, and many more. It should also be noted that pipeline design can change between preliminary design and final design, ready for construction. Field validation is an important part of final design.

A 1.2 mile high pressure pipeline design in Happy Valley was determined to offer the best solution for addressing the pressure issues because:

- Pressure issues are remediated
- Expected costs are lowest
- Least impacts on public, traffic, and customers
- Future extension of the pipeline is possible



This route was selected as the preliminary pipeline design for the Happy Valley Reinforcement Project.

Additional Alternative Analysis:

Once a pipeline project is selected, the benefit volume from this pipeline project (modeled therms delivered to customers on peak from this project) is compared to other alternatives. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design had a higher estimated cost than the proposed pipeline project.

The final alternative analysis is to examine the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the Happy Valley system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The pipeline project was selected as the preliminary design for the Happy Valley Reinforcement Project and was determined to be our best alternative for 2018 IRP action item submittal.

Project Name: North Eugene Reinforcement

System Background and Description: The distribution system in North Eugene in the area of River Rd. has experienced significant residential growth for a number of years. Subdivisions continue to be developed and new homes are being built. Like many gas systems it continues to grow organically, one main extension at a time to serve new customers.

This system consists of a 4" backbone pipeline on River Rd. with 2" and 1" mains extending into neighborhoods. There are approximately 1,500 customers in this localized area. Gas supplies come from high pressure pipelines to the south and west. Many main extensions and small system reinforcement projects have occurred over time to meet the growing customer demand.

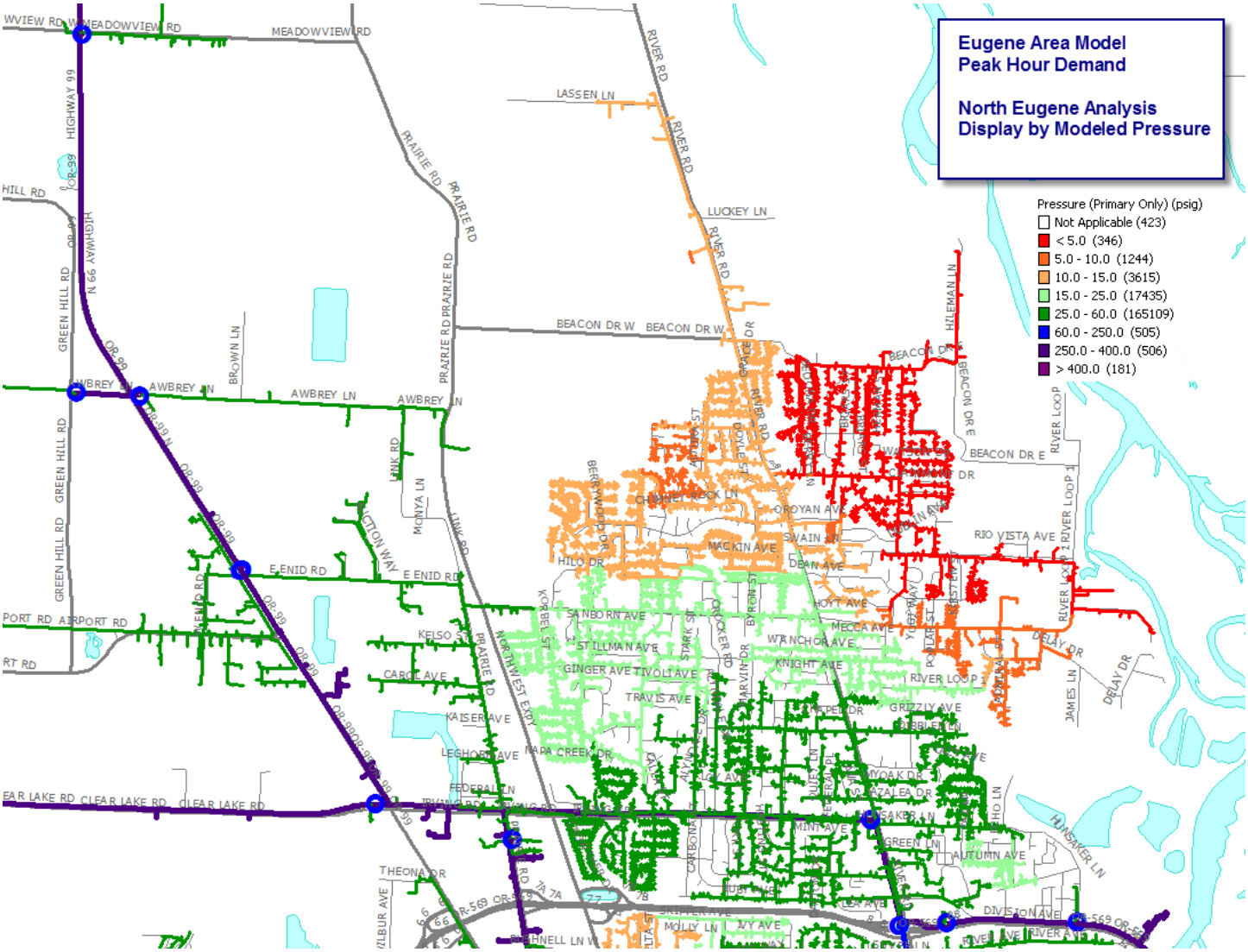
Summary:

- System reinforcement standards are violated by modeled low system pressures less than 10 psig
- No system abnormalities were experienced to produce low pressure conditions[1]
- The North Eugene system remains a safety and reliability concern until reinforcement occurs

Current System Analysis:

The Synergi model for the existing North Eugene area (current piping configuration and customers) under peak hour customer demand is shown below. The model indicates that we would experience widespread low pressures (orange = 5-10 psig, red = 5 psig or less) and resulting customer outages under peak hour conditions.

[1] I.e., unexpected equipment malfunctions unrelated to cold weather



Modeled low pressures violate our system reinforcement criteria for lower pressure systems which specifies that 10 psig is the lowest acceptable pressure experienced or modeled in a distribution system. The10 psig threshold is determined by Excess Flow Valves which according to manufacturer specifications, are not designed to operate properly below that pressure. System reinforcement actions must be taken to assure safe and reliable service to firm customers in North Eugene.

System Reinforcement Selection:

The North Eugene system was carefully examined to determine if there were choke points where pipelines could be replaced to ease cold weather impacts on system pressures. It was determined that significant portions of the system would have to be replaced for substantial gains in performance to be made. The less difficult system ties and replacements for size (choke points) had already been done in this system. Significant feeder pipelines must be built to improve cold weather system performance.

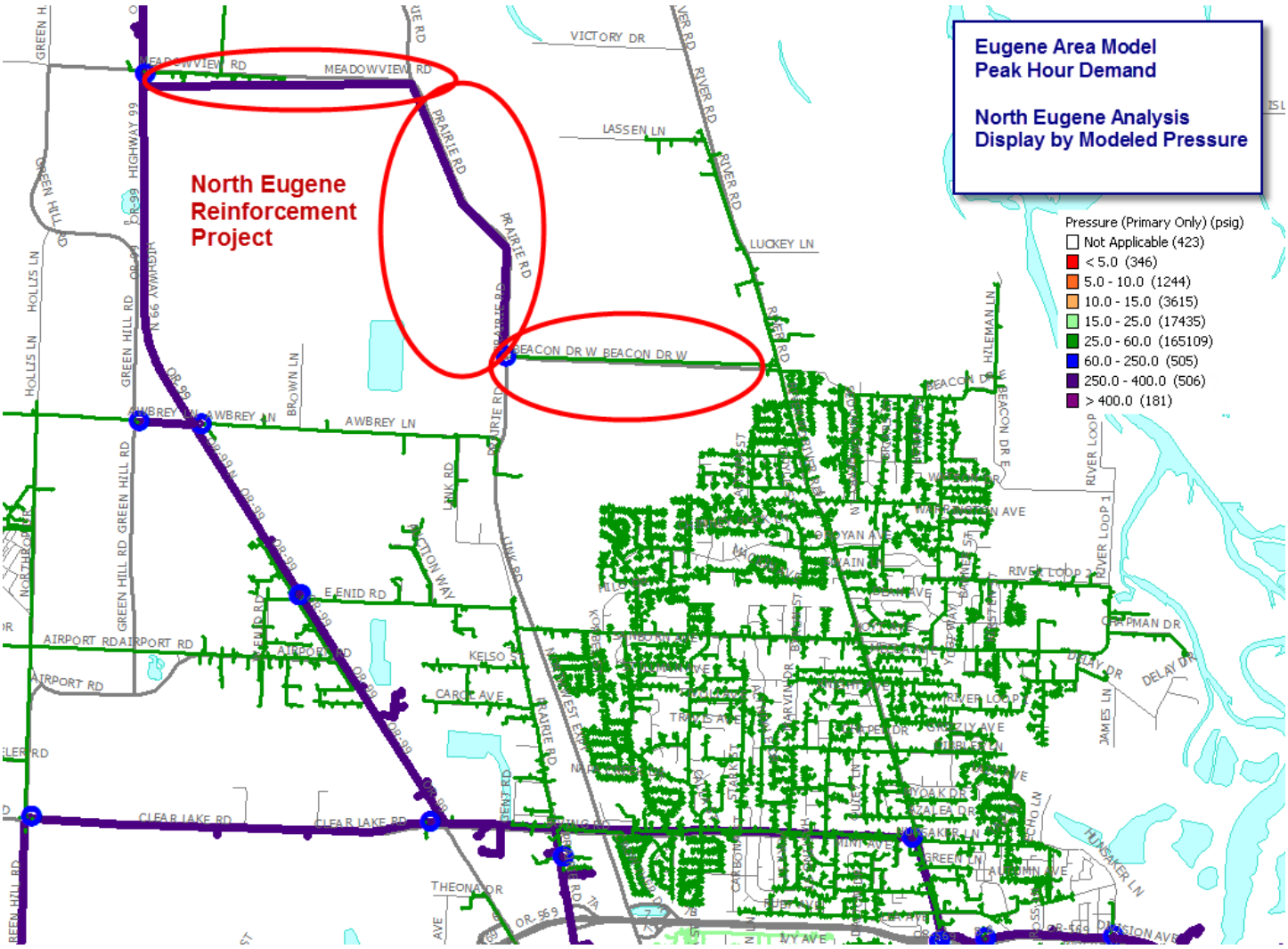
Pressure uprates of gas systems are always considered viable alternatives as they are usually much less expensive than pipeline construction. The North Eugene system is operating at 45 MAOP. An uprate of this system is technically possible, but pressures below 10 psig (violating system reinforcement criteria) would remain in this area even after an uprate.

Analysis shifted to new pipeline design and how to get more gas into the weak areas. A high pressure pipeline parallel to OR Hwy 99 is approximately 2.5 miles west of this area. A high pressure spur to the east towards River Rd, would provide an optimal mix of meeting today's demand and providing capacity to address growth.

Pipeline design processes iteratively weigh cost versus performance by many variables including pipe size, pipe length, pipe route, operating pressure, customer demand, soil conditions, restoration costs, terrain, and many more. It should also be noted that pipeline design can change between preliminary design and final design, ready for construction. Field validation is an important part of final design.

A pipeline design of 2 miles of high pressure and one mile of lower pressure pipeline in North Eugene was determined to offer the best solution for addressing the pressure issues because:

- Pressure issues are remediated
- Expected costs are lowest
- Least impacts on public, traffic, and customers
- Future extension of the pipeline is possible



This route was selected as the preliminary pipeline design for the North Eugene Reinforcement Project.

Additional Alternative Analysis:

Once a pipeline project is selected, the benefit volume from this pipeline project (modeled therms delivered to customers on peak from this project) is compared to other alternatives. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design had a higher estimated cost than the proposed pipeline project.

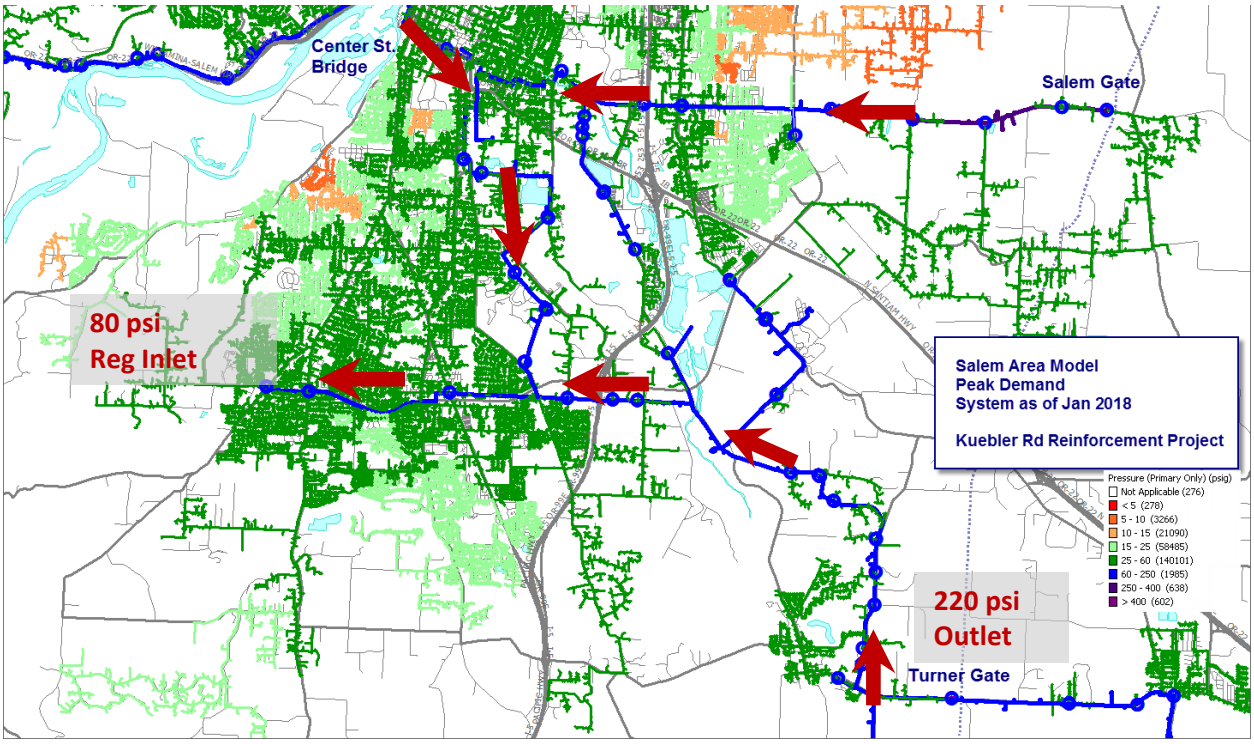
The final alternative analysis is to examine the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the North Eugene system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The pipeline project was selected as the preliminary design for the North Eugene Reinforcement Project and was determined to be our best alternative for 2018 IRP action item submittal.

Project Name: Kuebler Road Reinforcement

System Background and Description:

The 225 MAOP high pressure system in Salem is fed by three different sources: Turner Gate in the south and Salem Gate and Center Street Bridge regulators in the north. The north and south portions of this system are connected by a single 6-inch pipe which does not have adequate capacity under cold weather conditions. Growth to the south and west has increased demand on the Turner Gate and the high pressure distribution system to the point where pressure drop criteria are exceeded and regulator inlet pressures are in jeopardy.



Recent Events Supporting Reinforcement Project: Cold Weather, January 5-6, 2017

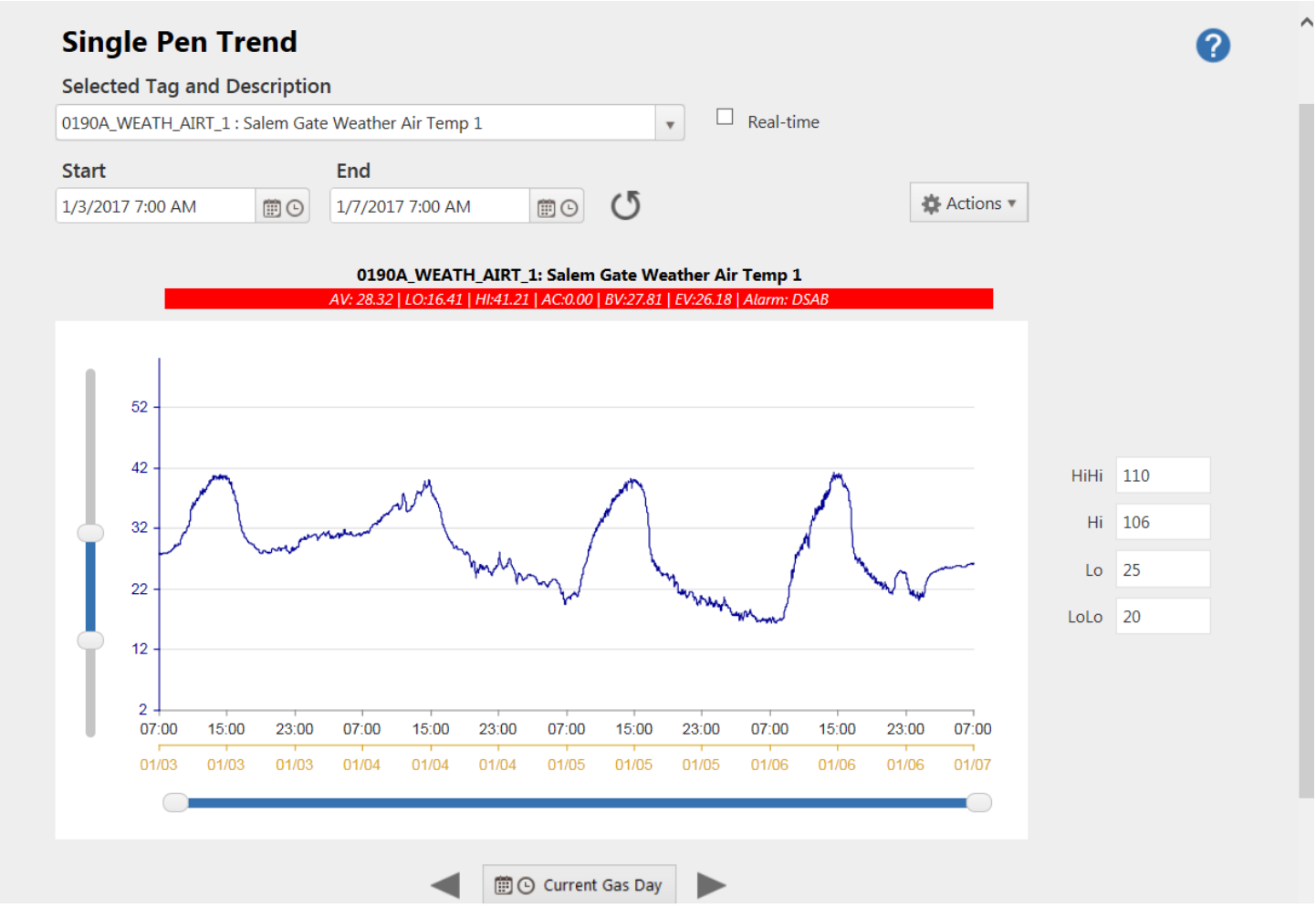
Summary:

- Non Peak cold weather events in January 2017 resulted in significant pressure drops on the Salem high pressure system (225 MAOP). No system abnormalities were experienced to produce pressure drops[1]
- No customers outages were reported
- Modeling validates the experienced pressure drop conditions
- System reinforcement standards were violated by pressure drops exceeding 40% on this high pressure pipeline

[1] I.e., unexpected equipment malfunctions unrelated to cold weather

- Marginally higher demands than were experienced in January 2017 would result in downstream regulator malfunction and subsequent low pressures and customer outages
- The South Salem system remains a safety and reliability concern until reinforcement occurs

Weather: Salem experienced the cold weather and increased customer demand that other areas faced in January 5-6, 2017. The following graph was generated from data collected by the Gas Control SCADA system which monitors near real time data from the field. The period of the graph is a five day period from 7 AM January 3, 2017 to 7AM January 7, 2017. This period was chosen to show the days before and after the cold event. The graph below depicts the air temperature at the Salem Gate Station. This SCADA site indicates a low air temp of about 16 DegF on the morning of January 6, 2017.



Historical air temperature data (see attached coldest events by location spreadsheet) shows that Salem has experienced numerous colder days in recent history including 1989, 1990, 2013, 1985, 2009, and 2004 amongst others. The January 2017 event was not an anomalous weather event in Salem nor was it a design “Peak” day.

System Conditions: Normal winter operations activities were performed during this event. Field personnel validated that the regulators feeding the system were performing properly. The regulator at the southwest end of the Salem high pressure system (Kuebler Blvd & Skyline Rd) was bypassed

during morning hours to maximize pressures. The regulator inlet pressure at this location reached a low pressure of 80 psig on the morning of January 6, 2017. There were no closed valves or damages to the upstream feeder or in the system. There are no interruptible customers downstream of this regulator which could have removed demand from this regulator and its upstream system.

The performance of the lower pressure system is wholly dependent upon the ability of the high pressure pipeline to deliver adequate gas pressure to the regulator inlets. The high pressure system in Salem is the current bottleneck in this system and is in danger of starving district regulators.

District Regulators require that the inlet pressure be at least 20 psig higher than the outlet pressure for proper operation. The regulators feeding Southwest Salem which are set to feed at 40 psig (45 MAOP system) were very close to being starved by low inlet pressure. This was not an isolated incident, low inlet pressures at the Southwest Salem regulator have also reported (but not documented) on days prior to and after January 6, 2017 and during previous events.

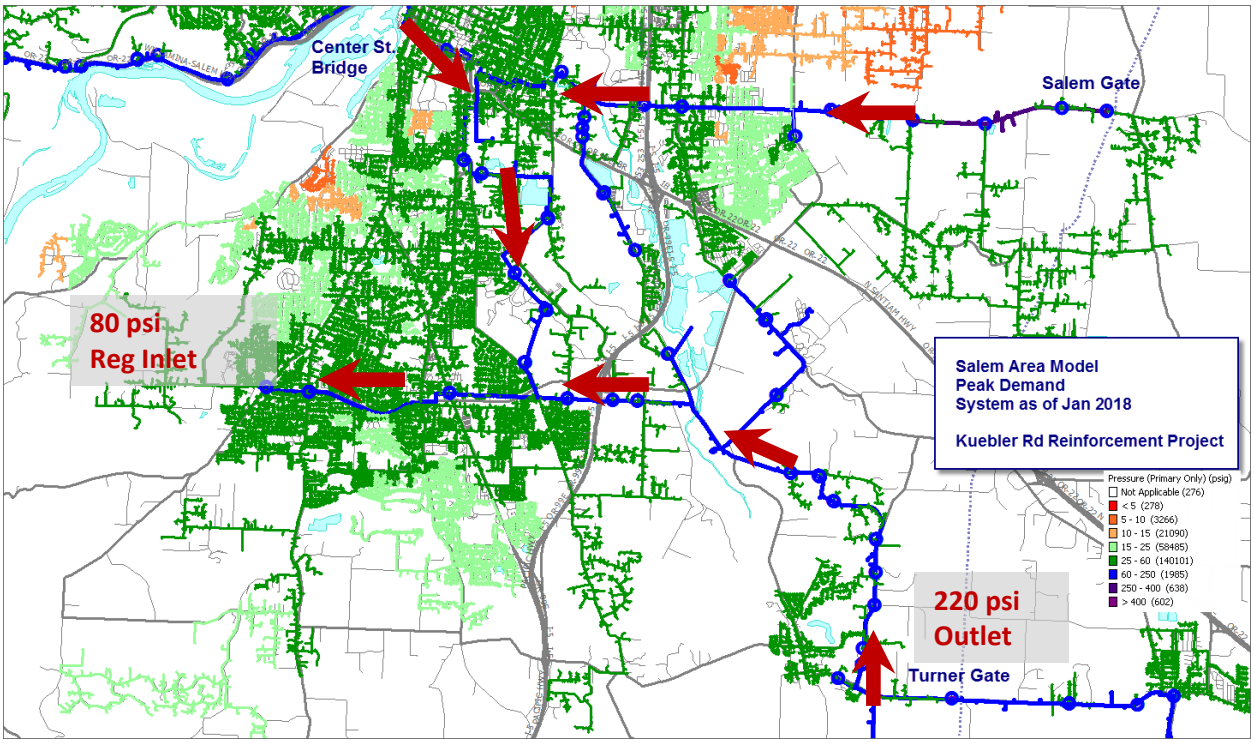
The measured pressure drop on the South Salem system from Turner gate to the Kuebler Regulator on January 6. 2017 was 140 psig (220 - 80) or just over 60%. This result exceeds our 40% system reinforcement pressure drop criteria for high pressure pipelines and indicates that this pipeline requires reinforcement.

Current System Analysis:

The Synergi model for the existing South Salem system (current piping configuration and customers) under peak hour customer demand is shown below. Arrows are added to this model to indicated flow directions on the high pressure system to better understand how the three gas sources support each other.

The model indicates that the distribution system within the town of Salem is adequate but weak (orange) in some under peak hour conditions. These weaknesses are being addressed over time with small system ties.

The primary concern for this system is the capacity of the high pressure system (225 MAOP) west of Turner Gate. Modeling indicates very large pressure drops (greater than 60%) on this high pressure pipeline that greatly exceed system reinforcement standards (40%) on a peak hour. The existing pipeline configuration significantly violates our system reinforcement criteria for high pressure systems which specifies that 40% is the largest acceptable pressure drop. System reinforcement actions must be taken to assure reliable service to firm customers.



System Reinforcement Selection:

The Kuebler Road Reinforcement project is needed to support high pressure distribution system pressures for firm service customers in the South Salem area.

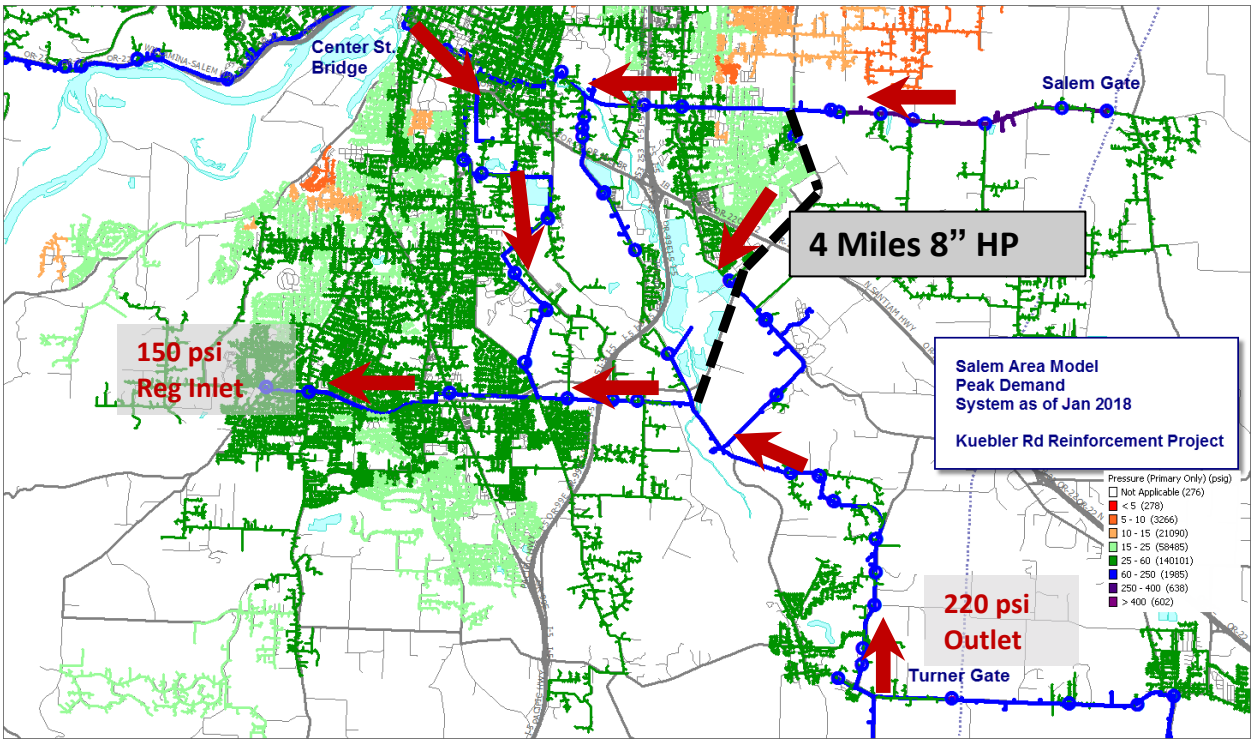
Pressure uprates of gas pipelines are always considered viable alternatives as they can be relatively inexpensive procedures. The Salem high pressure system operates at 225 MAOP. Pipeline records indicate that there are many sections of the Salem high pressure system that were installed in the late 1950's and early 1960's that were not designed or pressure tested to allow for service above 225 psig. It is not a NW Natural practice to retest and recertify pipes from this vintage.

Pipeline design processes iteratively weigh cost versus performance by many variables including pipe size, pipe length, pipe route, operating pressure, customer demand, soil conditions, restoration costs, terrain, and many more. It should also be noted that pipeline design can change between preliminary design and final design, ready for construction. Field validation is an important part of final design.

The Kuebler Road Project installs approximately four miles of high pressure pipeline to create a high pressure loop in the Salem 225 MAOP system. This pipeline allows Salem Gate and the Center Street Bridge regulators to contribute significantly more supply to the southern end of the system and reduce demand from Turner Gate. The project restores pressures at the southwest end of the Salem high pressure system to reasonable conditions on Peak. This project also has the benefit of eliminating required capacity improvements at Turner Gate, which were estimated to cost $2 million.

A 4 mile high pressure pipeline design along Kuebler Road in South Salem was determined to offer the best solution for addressing the pressure issues because:

- High Pressure system issues are remediated
- Provides a high pressure loop in the Salem System which enhances performance and reliability
- Expected costs are lowest
- Eliminates required improvement costs at Turner Gate, $2 million
- Pipeline route through relatively undeveloped area reduces road traffic, public and customer impacts



The Kuebler Road pipeline route was chosen as the preliminary pipeline design for the Kuebler Road Reinforcement Project.

Additional Alternative Analysis:

Once a pipeline project is selected, the benefit volume from this pipeline project is compared to other alternatives. For this project the benefit volume is calculated as the net therms required to restore pressure drop on the existing pipeline to 30% pressure drop. A high level design for a satellite LNG facility for peak shaving is created which is sized to match the pipeline project benefit. The resulting satellite LNG facility design for Southwest Salem had a higher estimated cost than the proposed pipeline project.

The final alternative analysis is to examine the possibility of acquiring interruptible customer contracts that will match or exceed the project benefit therms and defer pipeline construction. An analysis of existing firm customers within the Southwest Salem system was performed to identify if sufficient volumes could be recovered from firm customers by contracting with them to become interruptible. There was not sufficient firm demand available on peak to replace the pipeline project benefit volume.

The Kuebler Road Reinforcement Project as defined above was selected as the best alternative for 2018 IRP action item submittal.

NW Natural®

Rates & Regulatory Affairs
LC 71
Integrated Resource Planning
Data Request Response

Request No.: LC 71 OPUC DR 90

90. See page 32 of NW Natural's response to Staff DR 52 regarding the Keubler Reinforcement Project, which states, "The regulator inlet pressure at this location reached a low pressure of 80 psig on the morning of January 6, 2017." Please provide any pressure readings from the regulator for January 4 through January 8, 2017.

Response:

The regulator at the intersection of Kuebler Blvd and Skyline Rd in Salem, OR is located at the southwest end of the Salem 225 MAOP high pressure system. The location does not have SCADA monitoring so historical pressure data is not available. Based on previous cold weather events, this is a known area for experiencing low pressures under cold weather conditions. As such, it was added to a list of sites to be monitored during cold weather events. The pressure read of 80 psig on the morning of January 6, 2017 that was cited in Staff DR 52 was manually taken by field personnel. System Operations personnel were on site at this regulator on the mornings of January 5 & 6, 2017 and were actively notifying Gas Control of inlet and outlet pressure readings approximately every 15 minutes. The lowest reported inlet pressure at this location was 80 psig.

Rates & Regulatory Affairs
LC 71
Integrated Resource Planning
Data Request Response

Request No.: LC 71 OPUC DR 91
91. See page 13 of NW Natural's response to Staff DR 52, regarding the South Oregon City Reinforcement, stating "System reinforcement standards were violated by low system pressures less than 10 psig." Does NW Natural have pressure readings showing the pressure of lower than 10 psig? If so, please provide pressure readings for several days surrounding and including the low pressure event. If not, please explain how NW Natural knows that system pressures were less than 10 psig.

Response:

The South Oregon City area which experienced low pressures and outages in January, 2017 does not have a SCADA site to monitor and store historical pressure data. Customers reported equipment failures (outages) which were confirmed by NW Natural service technicians. Service technicians took pressure readings to confirm that gas system pressures were substandard and were affecting customer equipment. Eighty-seven customers reported outages for pressure on two consecutive mornings in January 2017. Although NW Natural's standards for system reinforcements are designed to avoid any customer outages, weak areas of the system may not be visible until cold weather events. Extremely low pressure on the system (0-1 psig) can result in simultaneous outages in localized areas. We can infer that system pressures were well below 10 psig and were more likely 0-1 psig in this location that experience simultaneous outages.

NW Natural®

Rates & Regulatory Affairs
LC 71
Integrated Resource Planning
Data Request Response

Request No.: LC 71 OPUC DR 93
93. Regarding page 20 of NW Natural's response to Staff DR 52, which states, "Although no outages were experienced, a significant number of customer pressures in the Happy Valley system violated the 10 psig minimum standard under less than peak demand." Were these low pressures recorded by SCADA equipment? If so please provide the pressure readings. If not, please explain how NW Natural knows that customers actually experienced low pressures below 10 psig under less than peak demand.

Response:

As discussed on page 19 of response to Staff DR 52, there is no SCADA data available in this area of Happy Valley. There is however a nearby SCADA site which can be used to validate the accuracy of the modeled pressures. The Kaiser-Sunnyside location in the model is calibrated to the Kaiser-Sunnyside SCADA recorded pressures and as such, this location is an accurate indication for pressure readings in Happy Valley. This validates that the model is properly calibrated and that the large areas of Happy Valley shown in orange (less than 10 psig) and red (less than 5 psig) in the model on page 21 of response to Staff DR 52 are accurate. The model shows a significant area of Happy Valley with substandard pressures (less than 10 psig) under peak conditions.