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BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

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EXH. HLR-5

HEATHER L. ROSENTRATER

REPRESENTING AVISTA CORPORATION

Avista
Study of Aldyl-A Mainline Pipe Leaks
2018 Update

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Executive Summary

The scope of this study was to review and update the analysis of Aldyl-A pipe conducted in 2013 based upon leaks and replacements through the end of 2017. The original study developed failure distributions that described the likelihood of leaks occurring on the Aldyl-A pipe installed by Avista for natural gas distribution and to evaluate multiple replacement scenarios. Based upon the original study and additional internal analyses, Avista selected the 20-year replacement program.

The original study identified rocky soil as the soil type most likely to have Aldyl-A mainline pipe leaks. Utilizing soil type specific Weibull distributions, and updated pipe information from the end of 2017 the number of leaks predicted when no proactive replacements are conducted over the next 70 years on Aldyl-A mainline pipe is 12,335 and the cumulative replacement costs is $3 billion.

After updating the model with leaks and replacements from 2013-2018 the expected number or leaks for the remaining period (2018-2088) reduced from 26,792 to 12,335 due to the large amount of the worst pipe already replaced. If the 20-year replacement program where all Aldyl-A pipe is removed continues there is a slight reduction in the expected number of leaks, 255 in the original study and 246 in the updated model.

According to the table below the baseline scenario remains more cost effective when compared to the replacement strategies, but it should be considered that current cost forecasts are based on cost of replacement and effects per leak. Safety risks were also incorporated into the study and while no individual segment of pipe exceeded the supplied thresholds in either scenario the cumulative risk was above the stated thresholds. This results in the projected number of catastrophic events drop from 258 to 5 events over the next 70 years by replacing the Aldyl-A pipe.

While Avista's 20-year structured replacement program has proven to reduce the highest risk in the early years of the program, the continuation of this structured replacement program is both necessary and prudent to mitigating the remaining risks within the system, and to achieving Avista's goal of operating and maintaining a safe and reliable natural gas distribution system.

Results of Aldyl-A Mainline Pipe Leak and Replacement Study

Scenario	Leaks from 2018 through 2088	IRR	Levelized Gr. Mar. Requirement*	Lev ROE*	NPV equity*
Baseline with effects – 2013	26792	9.21%	$16,417	$0	$0
20 Year Replacement with effects - 2013	255	6.04%	$23,229	$6,513	$93,490
Baseline with effects – 2018	12,335	18.04%	$10,785	$0	$0
20 Year Replacement with effects - 2018	246	3.87%	$36,147	$12,214	$177,848

*In Thousands

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1 INTRODUCTION

This report has been developed to provide the results of an analysis carried out on the Aldyl-A pipe installed by Avista for natural gas distribution. The scope of the study was to review and update the failure distributions, leak rates and replacement costs originally developed in the original 2013 study.

2 METHOD

During the first phase of this study all available historical data on the Aldyl-A pipe was collected. This included GIS segment, installation year, soil type, leak history, replacement history, location, and length. The various sources of this data were combined in Excel and used to calculate the following:

- The age of the pipe when each of the leaks occurred
- The age of the pipe at capital replacement
- The length of pipe replaced
- The age of the pipe not yet replaced
- The length of the pipe not yet replaced

For the mainline Aldyl-A pipe the data was separated by GIS locations and imported into the Availability Workbench software where Weibull distributions could be developed. Each location had an associated age, soil type, and length. The Weibull distribution was selected, as it is able to provide risk predictions with small samples and can describe infant mortality, chance failure, and wear-out failure behaviors. For two soil types, Control Density Fill (CDF) and Concrete/Grout, a Weibayes distribution had to be used because the numbers of failure events was insufficient for a standard Weibull analysis. For these two soil types the shape factor was set to four to reflect a wear-out failure behavior.

Two models were run for the Mainline Aldyl-A replacement, a baseline scenario with no proactive pipe replacement and a model where all of the Aldyl-A pipe is replaced over a 20-year timeframe.

3 ASSUMPTIONS

The assumptions made during the study were as follows:

1. All models are simulated over a 75 year lifetime
2. A three foot section of pipe is replaced when a leak occurs. This number was included as the location quantity in AWB
3. Only 1.25" OD and greater pipe was considered
4. Soil Types of 0, unknown, or blank was assumed of rocky type
5. All Aldyl-A pipe installed between 1984 and 1987 was manufactured before 1984
6. Pipe of unknown install year was installed in 1970
7. All replacements that were done in 2011 and 2012 were in rocky soil
8. Call out time for corrective replacements includes 1.75 hours of travel time
9. All maintenance costs are included as equipment
10. The PF interval for leak inspections is zero
11. The shape factor, Beta of 4 was used for Concrete/Grout and CDF Soil types
12. Each Exposed Pipe Report for the Davenport and Talent replacement projects reports on an equal length of pipe.
13. Baseline models do not consider any planned capital replacement.
14. Planned replacement of Aldyl-A Mainline pipe costs $357 per three feet in Washington and Idaho and $360 per three feet in Oregon.
15. Unplanned replacement of Aldyl-A Mainline pipe costs $5,071 per three-foot section.
16. Consequences for a Catastrophic Event, Injury with lost time and injury without lost time are applied per Avista standard practice.
17. Safety thresholds were incorporated with the following severity levels
    a. Catastrophic Event: Once per 50 years
    b. Craft Injury, WITH Lost Time/Light Duty: Once per year
    c. Craft Injury, NO Lost Time: Four events per year
18. A different type of pipe is used to replace failed Aldyl-A pipe and as such a second failure of the same length cannot occur in the lifetime.
19. Cost escalations are 2.3% per year.
20. Effects escalation is 10% per year.
21. Revenue Requirement Calculation Assumptions
    a. 75 Year project life
    b. Capital Class 2 (Generation T & D)
    c. Gas: 20% ID, 35% OR, 45% WA

4 MAINLINE ALDYL-A PIPE

4.1 Analysis

As an example, the failure rate curve based on the Weibull distribution developed for Aldyl-A Mainline pipe installed in rocky soil is shown in Figure 1. This curve has the following parameters:

η = 2,548,000 hours or 290 years (63.2% of the installed pipe will generate a leak prior to reaching this age)

β = 3.945 (indicating a predictable end of life)

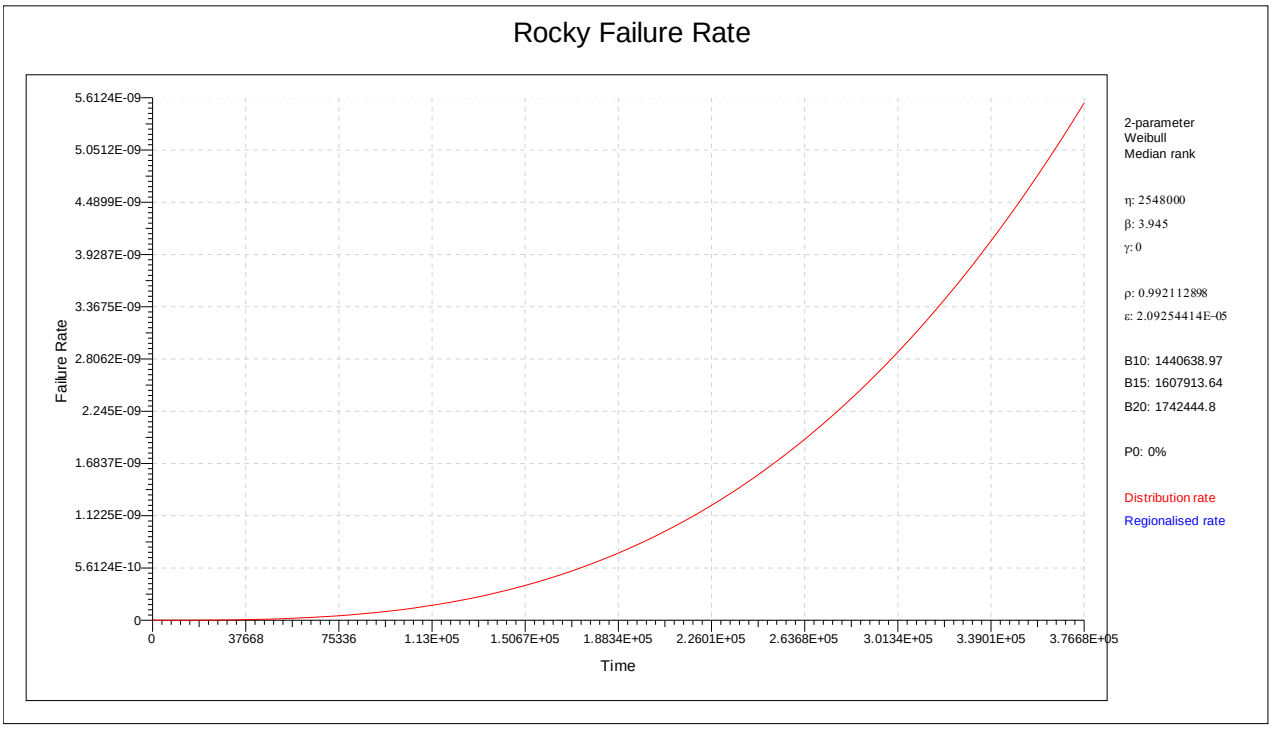

Figure 1: Failure rate curve for Aldyl-A Mainline pipe installed in rocky soil.

Table 1 below shows the change in the failure distributions when the leaks and proactive replacements from 2013 to the end of 2017 were incorporated. While Rocky soil still has the shortest life with an eta value of 290 years, the main change is that the eta values have increased while the beta values have decreased. The result is that on average, the pipe is lasting longer than the original model predicted, but there is less confidence on when it will fail. This is largely due to the large amount of pipe being replaced proactively. The proactive replacement both is

removing the pipe with the worst failure rates and incorporates a large amount of un-failed pipe into the Weibull analysis.

Soil Type	Eta 2013 (Years)	Beta 2013	Eta 2018 (Years)	Beta 2018
Clay/Bentonite	473.52	3.40	627.85	3.18
Concrete/Grout	317.24	4	387.21	4
Control Density Fill (CDF)	308.68	4	347.49	4
Loam	311.53	3.95	425.91	3.55
Other	711.19	2.84	1,386.99	2.44
Rocky	221.92	4.36	290.87	3.95
Sand	274.89	4.32	340.98	4.02

Table 1: Weibull Parameters by Soil Type for 2013 study and 2018 study

Using the distribution shown in Figure 1, along with the distributions generated for the other soil types identified in the study and knowing the length of Aldyl-A pipe installed in each soil type that is yet to be replaced, the expected number of leaks in Aldyl-A if the replacement program is stopped was calculated over a ten-year period. The predicted number of leaks on Aldyl-A pipe for the next 10 years with no proactive replacement program is shown in Figure 2.

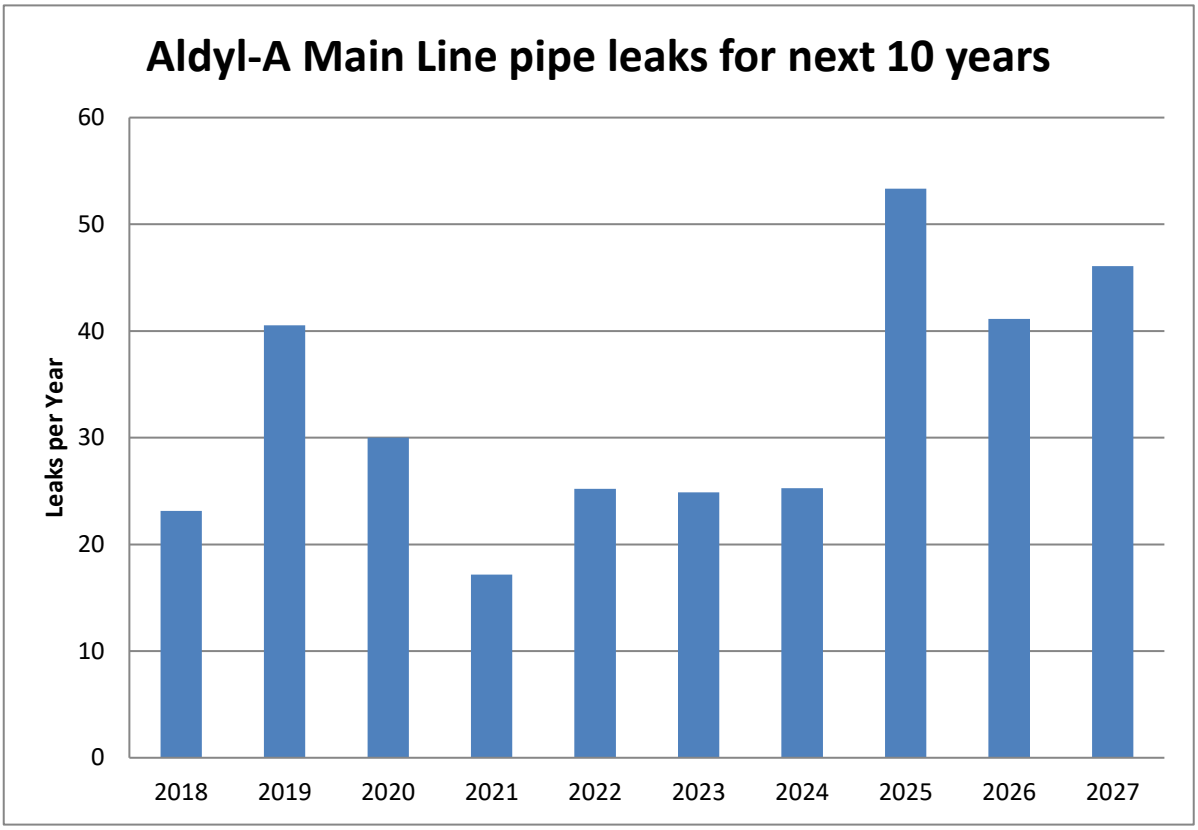

Figure 2: Predicted number of leaks per year in Aldyl-A mainline pipe for next 10 years.

Note: The prediction shown above in Figure 2 and in Figure 3 and Figure 4 assume that repairs are only carried out when a leak occurs. The effect of capital replacement on this profile is not considered as part of the baseline.

If the replacement program were to stop the frequency of leaks for the next 10 years ranges from 17 to 53 and the average number of leaks per year is 32. The uneven increase in leak frequency is most likely due to both pipe of different ages failing, and the actual pipe lengths considered.

It should be noted that the 2013 study predicted an average of 52 leaks per year during the same period. This reduction is caused by the proactive replacement of pipe that has been occurring.

As the pipe continues to age the number of leaks is predicted to continue to increase in the baseline scenario. This can be seen in the 70-year leak prediction for Aldyl-A mainline pipe in Figure 3. The model predicts that the leaks will increase from an average of 36 leaks per year over the next 10 years to an average of 174 leaks per year over a 70-year period.

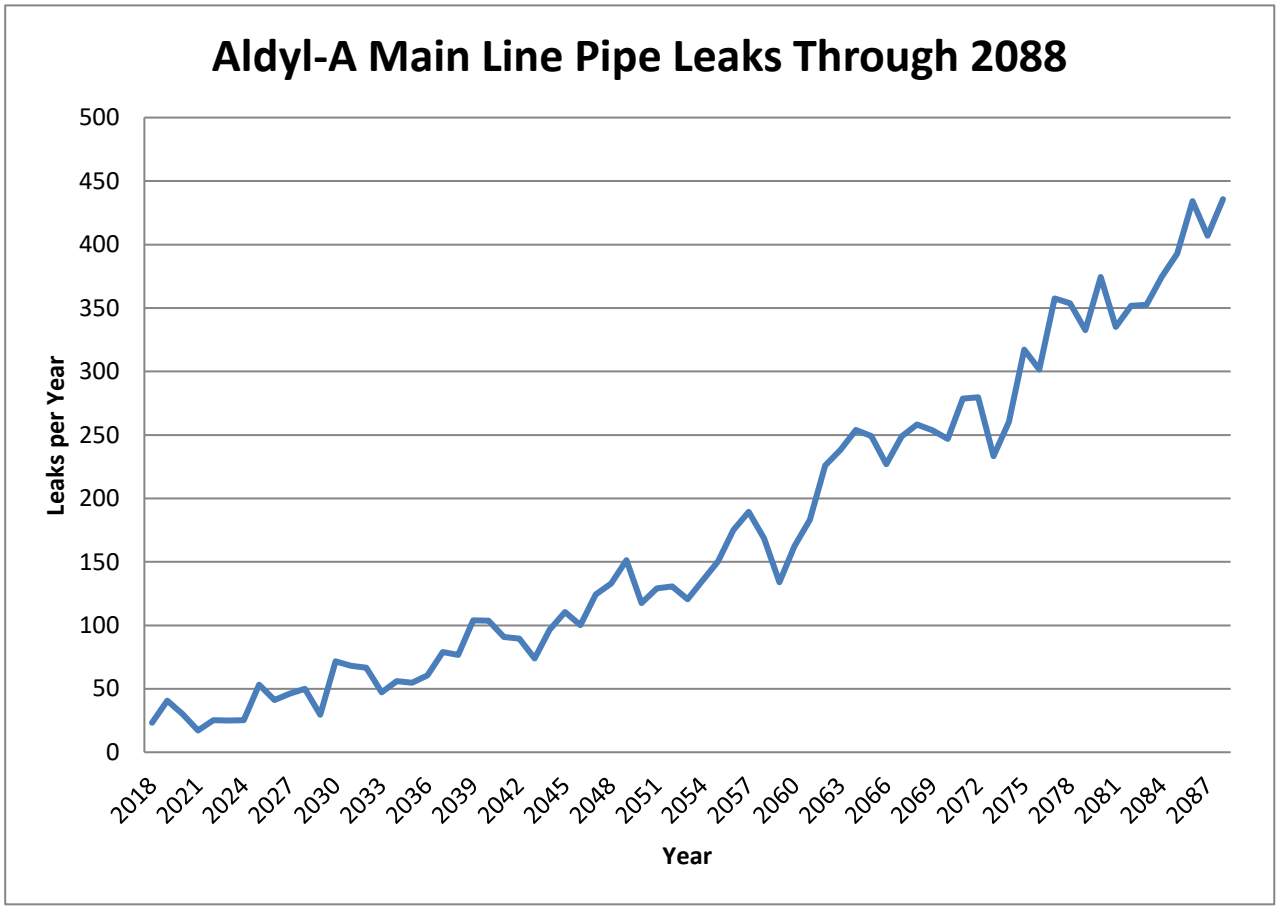

Figure 3: Predicted number of leaks per year in Aldyl-A mainline pipe from 2018 through 2088.

4.2 Maintenance Cost Forecast

By considering all the Aldyl-A mainline pipe installed which has not yet been replaced, a financial forecast can be made based on the number of leaks expected. If an unplanned replacement costs $5,071 is applied to repair each leak, the maintenance budget dedicated to leak repairs can also be determined. The updated baseline maintenance cost forecast is provided in more detail in the following sections of this report.

The total costs, which includes the maintenance costs and effects, is shown in Figure 4 and Appendix A

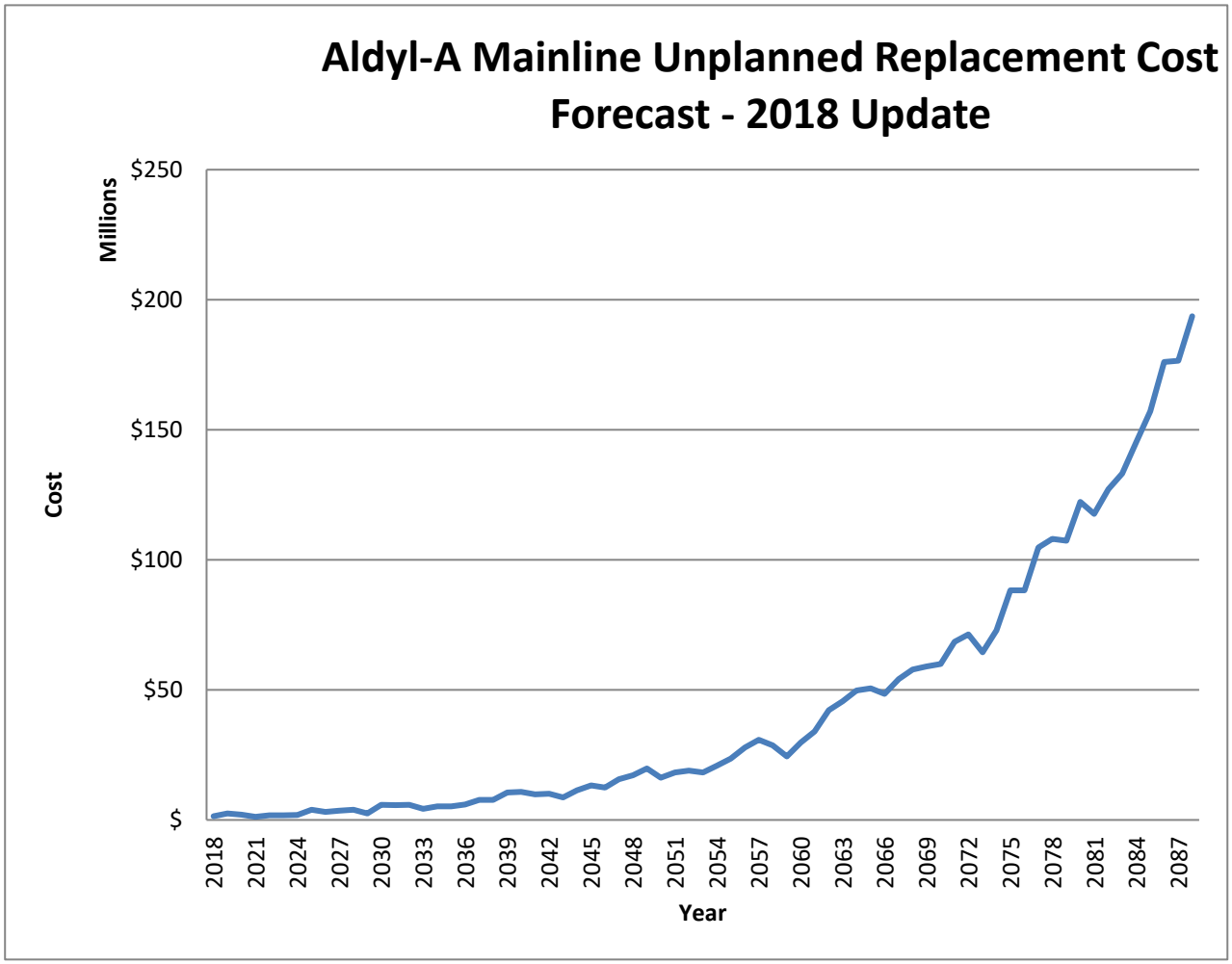

Figure 4: Forecasted unplanned total costs of leaks on Aldyl-A mainline pipe through 2088 per 2018 analysis.

4.3 20 Year Replacement Scenario Update

Avista has previously chosen to replace the Aldy-A mainline pipe over 20 years. To ensure that potential changes in pipe failure rates and costs are taken into account, the results from the 20-year replacement scenario has been updated with pipe replaced from 2013 through then end of 2017 either as part of the replacement program or in response to leaks.

In addition to updated pipe segments, the cost associated with replacement were also updated with current numbers. Capital replacements are assumed to cost $357 per three feet in Washington and Idaho and $360 per three feet in Oregon. These numbers are up from $243.42 in Washington and Idaho and $183.15 in Oregon. Unplanned replacements of leaks are assumed to cost $5,071 per three feet, up from $3,346. The costs were adjusted for inflation and for the additional restoration costs not normally associated with the work (i.e. paving, traffic control, and etc. that get generically billed monthly). Further assumptions are made for the consequence costs, the LCC model and the Revenue Requirement calculator which are standard Avista assumptions and processes and will not be covered in this discussion.

Leaks and capital replacements are not returned to service after repair/replacement to reflect replacing the failed Aldyl-A pipe with a different type of pipe.

Leaks or failures identified through inspection are handled as unplanned replacements with associated costs and consequences. This is reflective of the inspection method which provides no indication of a deteriorating condition, only an indication of a failure or a leak.

The 2018 update of the 20-year replacement program shows a reduction in leaks of 12,079 over from 2018 through 2088 when compared to the updated baseline and an increase of one leak when compared to the original 2013 results. The change in the predictions of the 20-year replacement program is within standard modeling error and could be a result of incorporating the planned replacements that have taken place into the failure rate analysis.

The leak profile comparison can be seen in Figure 5.

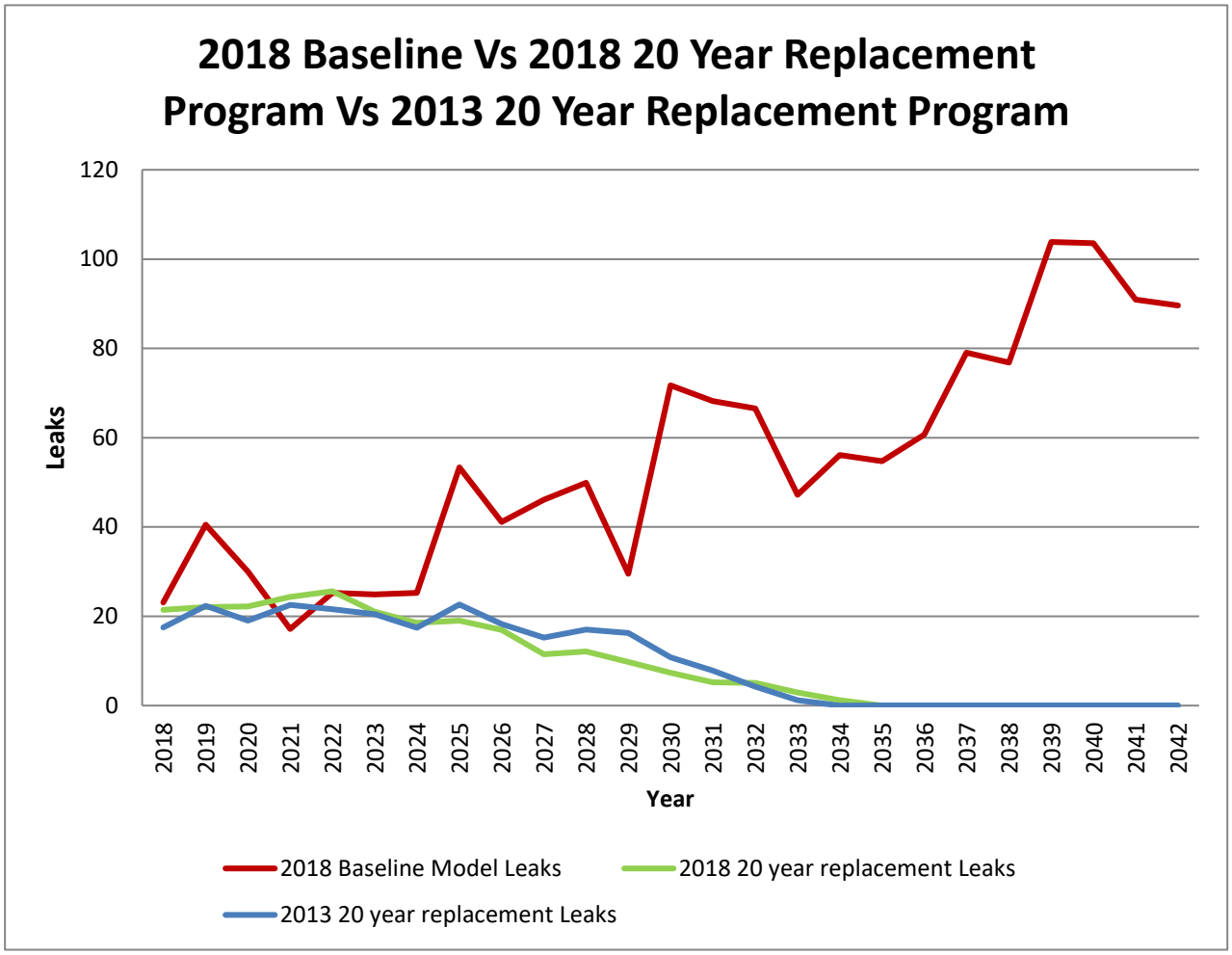

Figure 5: Comparison between Aldyl-A 2018 Baseline, 2018 20 Year Replacement Program and the 2013 20 Year Replacement Program model results.

To show the impact that the replacement program has already had and what can be expected for the remainder of the planned replacements, the total number of leaks over a from 2018 through 2088 are shown below in Table 2. As can be seen, the number of expected leaks if there is no planned replacement program has dropped significantly, while the expected number of leaks with the replacement program has remain basically unchanged.

Study Year	Scenario	Total
2013	Baseline	26,792
	20 Year Replacement Program	255
2018	Baseline	12,335
	20 Year Replacement Program	246

Table 2: Leaks results for Aldyl-A mainline pipe from 2018 through 2088 for 2013 and 2018 studies

To be able to effectively compare the scenarios the results from the RCM and LCC studies were compiled and analyzed in Avista's Replacement Revenue Requirement model. The annual expenditures from this analysis are recorded in Appendix A.

Figure 6 shows the updated cumulative cost comparison of replacing Aldyl-A mainline pipe proactively vs performing replacements as leaks occur. As can be seen, the replacement scenario has significant early life costs when compared to the baseline. After the replacement projects are completed the cost associated with the Aldyl-A pipe is negligible while the baseline maintenance expenditures continue to increase with the increasing number of leaks. Total lifetime expenditures for the baseline surpass the replacement program in 43 years (2061), this is significantly longer than the original study predicted (2049) but that is due to the large amount of pipe that has already been replaced.

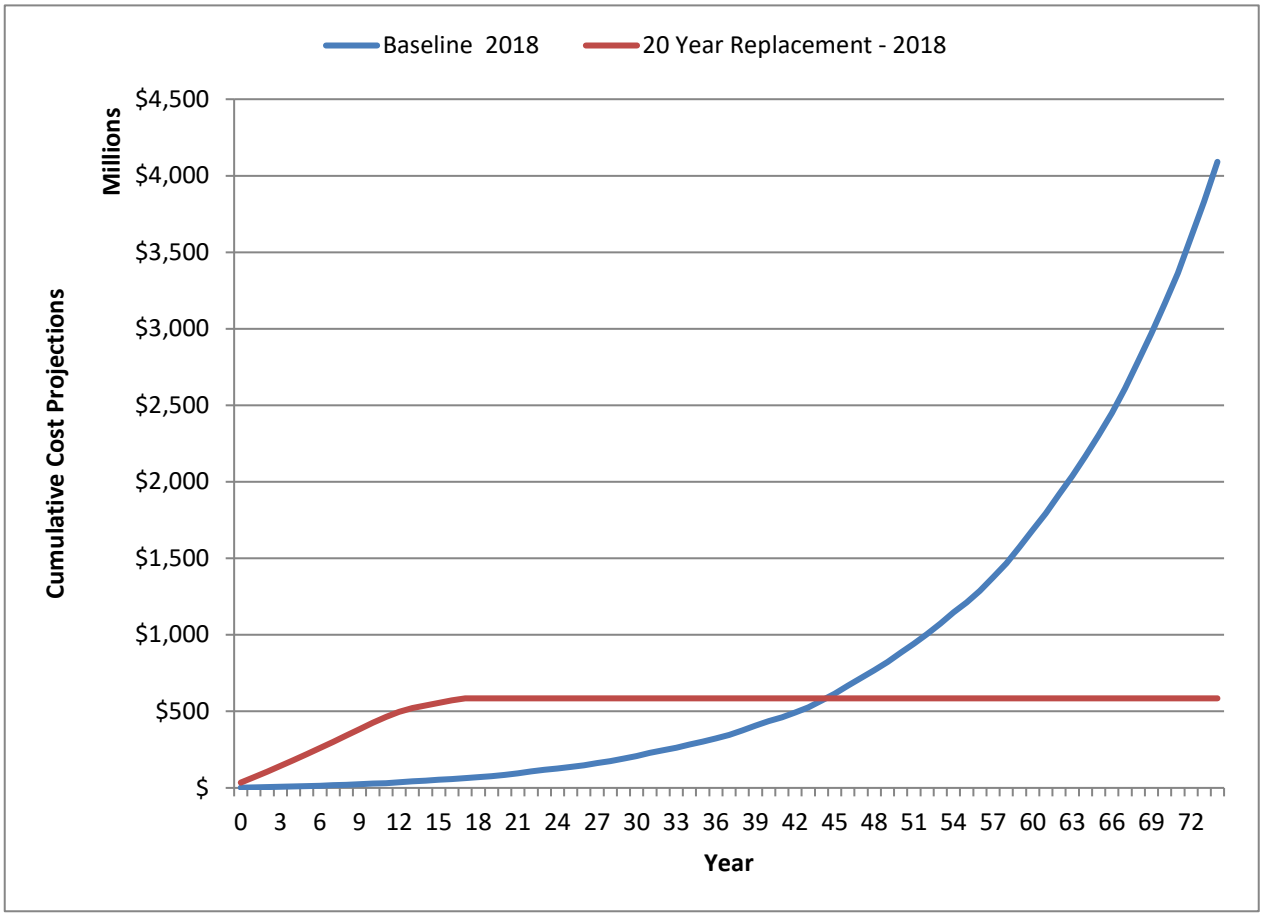

Figure 6: Cumulative Cost Comparison of Aldyl-A mainline Replacement Scenario

Scenario	Leaks from 2018 through 2088	IRR	Levelized Gr. Mar. Requirement*	Lev ROE*	NPV equity*
Baseline with effects - 2013	26,792	9.21%	$16,417	$0	$0
20 Year Replacement with effects - 2013	255	6.04%	$23,229	$6,513	$93,490
Baseline with effects - 2018	12,335	18.04%	$10,785	$0	$0
20 Year Replacement with effects - 2018	246	3.87%	$36,147	$12,214	$177,848

* In thousands

Table 3: Mainline Aldyl-A Replacement Revenue Requirement Analysis Summary

The Aldyl-A Mainline Replacement Revenue Requirement Analysis summary in Table 3 shows that the replacement program is slightly less cost effective than it was in 2013. This is due to the replacement of the worst pipe taking place early in the replacement programs scope. This trend can be expected to continue and should be taken as an indication that the program is meeting its goal of reducing the overall risk of leaks from the Aldyl-A pipe. The option of not replacing the pipe is still more cost effective over though 2088, given the assumptions of the Revenue Requirement model, but it should be noted that as the pipe continues to age the cost and associated risk of leaks increases significantly.

Safety risks and criticality were also considered as part of the study update. It is understood that each failure event (leak) does not always result in an injury and this is incorporated as a percentage of events that result per Avista standard modeling guidelines. The severities used are shown in Table 4 below.

Effect	Severity	% of Failures Where Effect Occurs
Catastrophic event	50 Years	1.82%
Craft injury, WITH Lost Time/Light Duty	1 Year	0.11%
Craft injury, NO Lost Time	3 Months	0.29%

Table 4: Effect Safety Severity and Redundancy Factor

With these assumptions the Safety Criticality was calculated for each segment of pipe in both the baseline and 20-year replacement scenarios. With the pipe that is currently installed, no individual segment exceeded the risk thresholds, but the cumulative risk did exceed the threshold for catastrophic events. The proactive replacement strategy has a significant effect on the overall risk, reducing the expected number of Catastrophic events from 246 to 4 over the next 70 years. It should be noted that slight changes in the percentage of failure events where the effect would occur can have large impacts on the final criticality.

5 CONCLUSION

This study builds upon the 2013 study which showed that soil type was a major contributor to failure rates for Aldy-A pipe. While the basic findings which indicate Rocky soil has the highest likelihood of failure have remained unchanged (see Table 1), the new analysis has shown that the proactive replacements have had a positive effect on failure rates by increasing the characteristic life (eta) of the pipe by an average of 169.7 years. This increase does come with reduced certainty of exactly when failure will happen with the beta value reducing by an average of 0.25 for all soil types.

The 2013 study predicted a total of 26,792 leaks on Aldyl-A mainline pipe from 2018 through 2088 years without any form of a proactive replacement program. Based upon the proactive replacements that have occurred, the number of leaks predicted over the same period has reduced to 12,335 with 246 catastrophic events if the proactive replacement were to not continue.

With the current replacement of all Aldyl-A pipe by 2035, the number of predicted leaks from 2018 to program completion reduces slightly, moving from 255 to 246 leaks of which 4 have the potential to be catastrophic events.

The Avista Revenue Requirement Calculator shows that it is less costly to maintain the current system rather than proactively replacing all Aldyl-A mainline pipe, but it should be considered that current cost forecasts are based on cost of replacement and effects per leak.

While Avista's 20-year structured replacement program has proven to reduce the highest risk in the early years of the program, the continuation of this structured replacement program is both necessary and prudent to mitigating the remaining risks within the system, and to achieving Avista's goal of operating and maintaining a safe and reliable natural gas distribution system.

6 FUTURE DATA COLLECTION

Future data collection focused on better documentation of failures to easily attribute these to Aldyl-A pipe would make it possible to refine the Weibull sets and improve accuracy of model predictions. A better understanding of how soil type affect failures will allow for targeted replacement based upon likelihood of failure. Also, further refinement of per occurrence cost for both planned and unplanned replacements and the associated effects will produce improvement in cost forecasting.

The below Availability Workbench models and excel files have been included in the attachment:

Aldyl-A_Mainline_20YrReplace_2018.awb

Aldyl-A_Mainline_Baseline_2018.awb

2018 Aldyl-A Model Update_Revenue_Requirement.xlsm

For any further information regarding this report please contact:

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APPENDIX A – MAINLINE ALDYL-A PIPE ANNUAL EXPENSES PER YEAR BASED ON AVISTA REVENUE REPLACEMENT CALCULATOR

Year	*Baseline Model - 2013*	*20-Year Replacement – 2013*	*Baseline Model - 2018*	*20-Year Replacement - 2018*
2018	$2,768,005	$17,358,435	$1,496,379	$61,501,245
2019	$1,660,312	$18,218,004	$2,623,336	$62,981,210
2020	$1,730,966	$17,973,699	$2,019,458	$64,442,060
2021	$3,499,201	$18,985,577	$1,234,137	$66,193,994
2022	$4,925,618	$19,501,977	$1,809,645	$67,881,054
2023	$4,880,447	$19,365,478	$1,838,287	$68,810,857
2024	$4,747,529	$19,606,495	$1,916,764	$70,036,504
2025	$5,123,168	$21,534,237	$3,981,535	$71,706,793
2026	$4,519,919	$21,076,111	$3,193,069	$73,034,193
2027	$6,249,062	$20,547,201	$3,650,847	$73,867,356
2028	$5,886,914	$21,629,593	$4,044,537	$75,643,774
2029	$8,341,754	$24,204,686	$2,556,338	$64,905,140
2030	$8,130,556	$21,657,261	$6,015,527	$60,997,106
2031	$7,091,184	$21,951,619	$5,887,637	$44,702,636
2032	$8,308,972	$22,528,242	$5,905,559	$28,442,059
2033	$11,558,254	$23,920,821	$4,407,520	$28,700,776
2034	$8,624,054	$54	$5,313,572	$29,052,089
2035	$14,231,303	$148	$5,343,060	$24,851,075
2036	$9,286,458	$92	$6,046,922	$
2037	$10,436,924	$66	$7,949,943	$
2038	$14,639,935	$127	$7,956,556	$
2039	$14,902,569	$112	$10,841,251	$
2040	$18,513,248	$99	$11,109,812	$
2041	$16,612,017	$109	$10,118,637	$
2042	$24,180,445	$197	$10,270,586	$

2043	$21,360,174	$194	$8,890,772	$
2044	$21,464,664	$186	$11,664,990	$
2045	$28,159,708	$175	$13,566,634	$
2046	$28,103,552	$192	$12,774,871	$
2047	$34,714,096	$253	$16,018,269	$
2048	$32,353,197	$246	$17,532,703	$
2049	$32,105,620	$201	$20,300,245	$
2050	$39,925,133	$289	$16,626,309	$
2051	$40,815,099	$331	$18,643,501	$
2052	$45,896,431	$408	$19,450,184	$
2053	$45,768,912	$326	$18,670,971	$
2054	$50,456,902	$349	$21,387,078	$
2055	$51,042,099	$369	$24,146,643	$
2056	$57,321,609	$340	$28,499,248	$
2057	$62,998,111	$399	$31,547,188	$
2058	$66,025,281	$397	$29,368,841	$
2059	$69,912,764	$369	$24,958,750	$
2060	$72,925,486	$445	$30,384,694	$
2061	$82,840,530	$558	$34,807,376	$
2062	$79,252,603	$425	$43,078,035	$
2063	$97,983,309	$619	$46,629,474	$
2064	$97,760,020	$613	$50,857,240	$
2065	$106,183,812	$613	$51,715,346	$
2066	$109,769,824	$666	$49,439,082	$
2067	$126,136,597	$762	$55,282,848	$
2068	$133,596,627	$802	$59,044,319	$
2069	$133,736,191	$853	$60,283,820	$
2070	$141,958,882	$762	$61,148,120	$

2071	$155,150,583	$976	$69,908,026	$
2072	$133,517,706	$772	$72,768,143	$
2073	$170,774,975	$1,063	$65,650,856	$
2074	$189,628,157	$1,051	$74,271,741	$
2075	$210,917,084	$1,322	$90,000,418	$
2076	$208,313,915	$1,054	$90,030,087	$
2077	$223,209,649	$1,244	$106,772,575	$
2078	$246,975,709	$1,449	$110,098,227	$
2079	$240,213,479	$1,516	$109,421,453	$
2080	$245,517,144	$1,516	$124,549,809	$
2081	$277,541,496	$1,748	$119,758,689	$
2082	$303,475,254	$1,780	$129,447,210	$
2083	$309,803,301	$1,978	$135,555,922	$
2084	$349,869,383	$2,326	$147,872,500	$
2085	$389,165,746	$2,388	$159,836,970	$
2086	$386,439,169	$2,187	$179,133,673	$
2087	$381,916,092	$2,237	$179,508,246	$
2088	$439,216,355	$2,535	$196,880,391	$