AVISTA CORP.
RESPONSE TO REQUEST FOR INFORMATION

JURISDICTION:	WASHINGTON	DATE PREPARED:	06/18/2021
CASE NO.:	UE-200900 & UG-200901	WITNESS:	DiLuciano/La Bolle
REQUESTER:	Public Counsel	RESPONDER:	Larry La Bolle
TYPE:	Data Request	DEPT:	Transm Ops/System Planning
REQUEST NO.:	PC – 360	TELEPHONE:	(509) 495-4710
		EMAIL:	larry.labolle@avistacorp.com

SUBJECT: Availability Workbench Modeling with Public Counsel

REQUEST:

Please refer to the conference call between Public Counsel and Avista on 6-7-21 regarding Avista's Availability Workbench Modeling.

In this call, Avista referred to two types of failures, "failure in service" and "functional failures". Public Counsel understood from this call that "functional failures" included reasons such as (i) age in excess of the economic end-of-life as determined by Avista for the specific equipment type; (ii) failure of a routine test or inspection; (iii) the results of a qualitative assessment by field personnel, among other. Public Counsel also understood from this call that the Availability Workbench tool assumes that qualitative assessments by field personnel are correct 50 percent of the time, as input by Avista personnel.

a) Confirm that these Public Counsel understandings are correct. To the extent that Public Counsel misunderstood, please correct such misunderstandings.
b) Provide additional information regarding the "50% correct" assumption and its use in Availability Workbench software. For example, does the "50% correct" assumption indicate that field personnel determinations replace equipment at a rate 50 percent greater than necessary, or does the "50% correct" assumption indicate that field determinations understate the actual equipment replacements needed by 50 percent?
c) Identify all other assumptions the Avista personnel uses regarding equipment functional failures. Explain these assumptions in detail, and provide all associated values, support, and data used to determine these assumptions.

RESPONSE:

Avista appreciated the opportunity to answer a range of questions from Public Counsel about failure and lifecycle cost analysis and to present our Availability Workbench model, at the request of Public Counsel, for overhead transformers and equipment.[1] Because there were questions about the data used in the Weibull failure analysis, and because there were salient points in the discussion we believed were lost in the running questions and answers, we thought it would be helpful to provide additional clarifying information as a follow-up to our meeting, in addition to responding to this subject request.

a) **Equipment Failures** – The assumptions of Public Counsel are not confirmed. As explained in the section below this response, Avista includes in its failure analysis equipment that fails in service and functional failures, accordingly:

   i. Equipment eligible for replacement at Economic End of Life is not considered a failure or functional failure, and is not included in failure data analysis, as explained below.

   ii. The Functional Failure of equipment as determined by inspection, testing, and condition assessment is included in failure data analysis, as explained below.

[1] Transformer, cutout, lightning arrester, high and low-side clamps, etc.

iii. Equipment is not replaced because of any subjective assessment of poor appearance (and is thus it is not included in any failure analysis), as explained below.

Qualitative Assessment - Functional Failures are not determined by "qualitative assessment."

Failure Detection Rate - The 50% detection rate of failures is discussed below in part (b).

Avista's Weibull Failure Analysis

Foundation is Known Age Historic Failure Data – For our June 7, 2021 online meeting, Avista provided all the life[2] data for overhead transformers and equipment used in developing the Weibull failure curves for the equipment. As we have noted earlier, the foundation of our failure analysis for all assets is actual historic failures of equipment of known age experienced by the Company.[3] This actual historic failure data collected by Avista is the starting place for the identification of failure modes, manufacturer (as applicable), condition and age. As we have also explained, the condition of assets is also evaluated as part of the early failure mode analysis to help determine whether visual or other indicators of asset condition, in addition to age, can be useful in predicting the likelihood of asset failures over time, and the determination of functional failures. This actual failure data continues to be collected and used for a variety of additional purposes including the determination of consequence probabilities associated with each different failure mode, consequence costs associated with each different consequence type, and providing the annual rates of failure for given assets that are used to validate and calibrate the subsequent Weibull failure function.

Failure Data is Based on Failures and Functional Failures – When available, as we discussed for Wood Pole management and overhead transformers and equipment, results of inspections are added to the foundational data of known-aged failures of assets in the life database, which includes assets of known ages that failed in service, assets of known age that were inspected and deemed fit for duty and left in service, and assets that had functionally failed and were repaired or replaced. Avista distinguishes "functional failures" from "potential failures" and does not include the latter classification in its failure analysis, even though for some assets their inclusion is reasonable when properly defined.[4] At a high level, a failure is an unsatisfactory condition, defined by an identifiable deviation from the expected condition, which is determined to be unsatisfactory. Avista has determined, as discussed in our online meeting, that a wood pole that fails strength testing, even though it is still standing and holding the conductor in the air, has reached the point of functional failure. This designation reflects the fact that the pole is no longer capable of meeting the range of service conditions, such as high winds, experienced on our system. As noted below, we have determined the same for transformers that are leaking oil or have been damaged; they no longer meet our service requirements because they are prone to imminent failure. The same is true for broken insulators, insulators and components that are damaged, or where failing polymer material lacks the impedance to meet standards of avoiding flashover, resulting in potential fault or fire.

After our meeting discussion with Public Counsel, we confirmed that transformer "failures" in the database include only complete failures and functional failures. Avista determines a transformer has functionally failed only when it is physically damaged (lid, tank, bushings, etc.) and/or is leaking oil.[5] Other external characteristics, such as generally poor appearance, including substantial rust,

[2] Life data includes assets of known ages from inspections that are still functioning and in service, as well as assets of known ages that have failed in service.

[3] Early on, the failure data is based on units that completely failed in service and were replaced as a result.

[4] Asset failures can include "potential failures," which condition indicates that functional failure is imminent (such as noted in Exh. PADS-19, page 15).

[5] In practice, assets are regularly removed from service and are properly included in failure analysis when designated by inspection to be functional failures.

even over the entire unit, do not constitute any imminent failure, and consequently, those units are left in service. In this program, overhead transformers are only replaced if they are deemed to have functionally failed, by the criteria described above, and if they are confirmed as such by follow-up inspection during design, during installation, and final inspection (as we noted in our online meeting). Avista has provided confirming evidence of this operating practice in the transformer data used for the Weibull analysis, as part of its response to PC-DR-318 and PC-DR-336 Revised/Supplemental, where many hundreds of units over 60 years in age, and ranging up to 97 years in age, were left in service upon inspection because they did not meet the strict requirements of having functionally failed.

Weibull Function is Carefully Fit to the Data – When Weibull failure analysis is applied to this life data the result is much more than a plot of failures with age. The process of selecting parameters that best represent the failure data can result in a single Weibull function or curve, to two or more as needed, to best describe the failure properties of an asset over its entire service life. The Weibull function provided by Avista for overhead transformers is a bi-Weibull curve reflecting the differences in failure rates and patterns over the mid-life and later life of the asset. The Beta 2 value of 1.0 represents a period of random failures, while the Beta 1 value of 6.7 represents a strong tendency toward failure by "wearing out." The same type patterns are evident in the Weibull failure curves presented in the transformer study provided as Exh. PADS-19, on pages 9-12. Once the parameters are initially estimated, the Weibull function is tested by Monte Carlo simulations and is adjusted to remove any bias in the parameters until it reasonably predicts the failure rates in the population over time represented by the actual data.[6]

Weibull Curve is Calibrated to Actual Failures Experienced by Avista – Finally, as we attempted to explain our online meeting, Avista compares the annual number of failures predicted for the asset population from the Weibull analysis with the actual number of asset failures we experience on our system. The comparison of this failure prediction with the results of actual failures allows the Company to calibrate the Weibull function so it is neither underrepresenting actual failures nor overrepresenting them. This calibration process has two components: 1) comparison of the forecast of individual asset failures from the model, with the number of pieces of equipment installed as asset failure replacements from our work and asset management system, and 2) comparison of the forecast of customer outages resulting from equipment failures from the model, with the actual number of such outages we experience on our system. This calibration is central to the discussion we were having about whether or not including functional failures in the Weibull analysis had the potential to underestimate the actual life expectancy of a transformer, as one example. It is also fundamental to the process used to correct for undetected failures in Availability Workbench (the 50% discussed below), which ensures the failure models for our assets are accurately predicting the failures we experience on our system.

Purpose of the Transformer Model Reviewed in Our Meeting

The Question We're Answering with the Transformer Model - Another important point that was difficult to get across in our online meeting was the central question Avista is trying to answer with its Availability Workbench model for overhead transformers: to determine whether or not it is in our customers' best financial interest (lowest lifecycle cost) to replace certain overhead transformers as part of the work we do under the Wood Pole Management Program, 20-year inspection cycle interval, compared with the alternative of replacing transformers later once they completely fail in

[6] For many years Weibull analysis has been the leading method in the world for fitting life data (Abernathy, Robert. The New Weibull Handbook Fifth Edition, Reliability and Statistical Analysis for Predicting Life, Safety, Supportability, Risk, Cost and Warranty Claims. 2006).

service. And, if cost effective, to determine the criteria for replacement, whether based on age or condition of the units.

Condition-Based Transformer Replacements for the Wood Pole Management Program Are Very Cost Effective – As we have shown elsewhere, including the financial models provided in response to PC-DR-336 Revised/Supplemental, replacing overhead transformers (and equipment) based on functional failures, as we have described above, provides our customers a substantial financial benefit (customer internal rates of return ranging from 14.46% to 15.91%), compared with the alternative of allowing them to run to fail (customer internal rates of return ranging from -1.01% to 0.68%). The positive results of these analyses bear out the fundamental fact that the efficiency savings captured in the Company's practices exceed the residual value of the remaining life in an asset that is replaced prior to failure, which practice produces the lowest cost for our customers compared with the run-to-fail alternative.

Replacements Based on Age of Transformers is Also Cost-Effective in a Feeder Rebuild – We have demonstrated that when we replace overhead transformers installed in 1980 or earlier, during a feeder rebuild project, it produces a lower lifecycle cost for our customers compared with reinstalling the transformers and running them to failure. As noted elsewhere and below, in this subject response, the customer internal rate of return for this practice ranges from 10.6% to 12.5%, which returns are superior to the internal rates of return for the run to fail alternative of 1.46% to 2.88%. For the financial analysis used to determine these results please see our response to PC-DR-348, Attachments A, B and C.

b) As noted above in part (a), Avista did not state that functional failures of equipment are based on "qualitative" assessments. Functional failures, as described above, are determined based on condition characteristics identified in failure mode analysis, which is validated in failure data and modeled in Availability Workbench, which process is briefly described in part (c), below.

In Avista's experience in the Wood Pole Management program, the initial inspection <u>systematically underrepresents</u> the actual functional failures in equipment through the inability to detect hidden failures, as determined by both testing and condition assessment. <u>In response to the request of Public Counsel, field inspections (both invasive testing and condition assessments) understate the actual equipment replacements ultimately needed by approximately 50 percent</u>. We have validated this in a couple different ways. First, for poles and equipment which the initial inspection identifies as needing follow-up work, we often detect additional failures during each subsequent inspection of that pole: inspection and design; implementation, and final inspection, which were missed in the initial inspection. We referred to this in our online meeting, noting that after the initial inspection Avista's designers do a field review to confirm equipment determined to have functionally failed and design the follow-up work. The equipment is reviewed again during the follow-up work carried out on the feeder and is reviewed a final time by an Avista inspector. This process helps to find functional failures that may have been missed in the initial inspection, and for eliminating the replacement of equipment that may have been initially determined for replacement, but which was not confirmed by follow-up inspections. These follow-up reviews, however, do not help detect functional failures that were missed in the initial inspection on those poles that were not slated for any follow-up work. To determine functional failures that were missed on these poles (which also applies to poles that were worked on) Avista tracks replacements of equipment that fails in service after the maintenance to determine failures that were likely missed and the time interval between inspection and the failure. These data are used in the Weibull module of Availability Workbench to calculate the detection rate for the initial inspection, based on the P-F curve and P-F interval. Or the detection rate and the P-F interval can by used to predict the P-F curve. Through these processes, we have set the detection rate for functional failures, for the initial inspection, at 0.5. Most importantly, beyond the correction for undetected failures performed in the model, as noted here, Avista calibrates the overall results produced by the failure curve, as described above to ensure the Weibull function is neither underrepresenting actual failures nor overrepresenting them, and thus is accurately is forecasting the physical life expectancy of its feeder assets.

c) Similar to the complexity of the request in PC-DR-358 (a), Avista objects to this request as unreasonably burdensome. A brief description of the objective processes Avista uses to determine functional failures for assets has been provided in numerous data responses, which are briefly discussed here for crossarms. Avista regularly inspects wood crossarms as part of its wood pole management, distribution minor rebuild and grid modernization programs, and has regularly used such inspection, condition and failure mode data for wood crossarms in its Availability Workbench modeling to identify failure curves and perform lifecycle cost analysis, used to identify condition characteristics that constitute functional failure. From these evaluations and analyses, Avista has identified condition characteristics associated with functional failures, which include evidence of damage by breakage, electrical tracking, fire damage, split crossarms that cannot be repaired using split bolts, sunken pins, heavy moss, floating pins, loose corner pins, and sunken washers. Because these visible and identifiable characteristics of condition are based on inspection, analysis of failure modes and failure data analysis, they are a useful indicator of functional failure. Avista has properly identified these characteristics as indicators of end of life for a crossarm attached to a pole being inspected, reinforced, replaced or otherwise worked on as part of a systematic program.