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Supplemental Eastside Solutions Study Report

Transmission System

King County

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Puget Sound Energy

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Executive Summary

This document is an update to the Eastside Transmission Solutions Report dated February 2014 (herein referred to as “2014 Solutions Report”). It incorporates the latest technical information of the transmission system model. Updates to the 2014 Solutions Report include an updated PSE load forecast, as well as changes in system topology, facility ratings, changes affecting the Northern Intertie as the monitored flowgate for the Puget Sound area transmission capacity issues, and changes to the Seattle City Light (SCL) system. This Supplemental Eastside Solutions Study Report (herein referred to as “2015 Solutions Study”), verified the findings of the 2014 Solutions Report that a wires option to construct a new 230/115 kV transformer and 230 kV line with associated ancillary facilities is the preferred solution to solve the transmission deficiencies identified in the 2013 and 2015 Needs Assessment Reports.

As in the 2014 Solutions Report, many types of alternatives and combination of types were reviewed and studied. The solution types include conservation, generation, energy storage, transmission substations expansion, transmission line upgrades and new transmission lines. The discussion of the solution types and combination of types are discussed in the body of this report.

The 2015 Solutions Study identified one solution that fully satisfies and four solutions that marginally satisfy the needs identified in the 2015 Needs Assessment and the solution longevity and constructability requirements established by PSE as discussed in the body of this report. The four marginal solutions were classified as marginal because of transformer loadings being very close to meeting the criteria listed in Section 2.5.1.

Table 1-1 lists both the 2015 and 2014 solutions and shows there is only one different solution between the 2014 and 2015 solutions studies. The new solution added in the 2015 Solutions Study was 7d, which was to build a new Talbot Hill-Lakeside 230 kV line on new right of way (ROW), rebuild Lakeside-Sammamish 115 kV lines and loop through the Lakeside substation.

Table 1-1: Alternatives which Passed the Power Flow Screening 2015 as Compared to 2014

2015 Case #	Alternative Description	Viable Solution: 2015	Viable Solution: 2014
6d	**Transmission Line:** Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV line to 230 kV and loop through Lakeside substation **Transformer:** Add 230-115 kV transformer at Lakeside	Yes	Yes
6e	**Transmission Line:** Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV line to 230 kV and loop through Westminster substation **Transformer:** Add 230-115 kV transformer at Westminster	Yes Marginal	Yes
7d	**Transmission Line:** Build new Talbot Hill-Lakeside 230 kV line on new ROW, rebuild one Lakeside-Sammamish 115 kV line to 230 kV **Transformer:** Add 230-115 kV transformer at Lakeside	Yes Marginal	Yes - as sensitivity
7e	**Transmission Line:** Build new Talbot Hill-Westminster 230 kV line on new ROW, rebuild one Westminster-Sammamish 115 kV line to 230 kV **Transformer:** Add 230-115 kV transformer at Westminster	No	Yes
10d	**Transmission Line:** Build a new Talbot Hill - Sammamish Line 230 kV on a new ROW and loop this line through Lakeside substation **Transformer:** Add 230-115 kV transformer at Lakeside	Yes Marginal	Yes
10g	**Transmission Line:** Build a new Talbot Hill - Sammamish Line 230 kV on a new ROW and loop this line through Vernell substation **Transformer:** Add 230-115 kV transformer at Vernell	Yes Marginal	Yes

The longevity results of the five solutions identified in the 2015 Solutions Study, indicated that all five solutions will be viable until sometime past 2028, when other improvements will be required in the electrical network. The other improvements include Talbot Hill to Paccar 115 kV line, Talbot Hill to Mercer Island 115 kV line, South King County upgrades, and a second 230/115 kV transformer and 230 kV line to the new Eastside substation. The major findings of the longevity testing are:

1. All solutions are sufficient to meet the transmission capacity needs until 2028;
2. The addition of a second transformer in the Eastside area will reduce the loadings on Sammamish and Talbot Hill transformers. The addition of the second 230 kV line into the Eastside area reduces the loading for a much longer period of time;
3. South King County improvements will reduce the loading on the Talbot Hill transformers and marginally reduce the loading on Sammamish transformers.

Based on the results of the screening and longevity testing, the best electrical solution is case 6d, which is to build one new 230 kV line from Sammamish to Lakeside to Talbot Hill and a second line from Sammamish to Lakeside to Talbot Hill built at 230 kV but operated at 115 kV until needed. This will provide the option to add a second transformer in the Eastside area when needed and will provide the necessary transmission capacity for now and many years into the future.

1.0 Introduction

This document summarizes the results of the 2015 analysis efforts performed to update the Eastside Transmission Solutions Report dated February 2014. This updated study is referred to as the 2015 Supplemental Eastside Solutions Study Report (herein referred to as "2015 Solutions Study"). This 2015 Solutions Study report documents the results of the analysis that factored in -

- recent updates to the PSE load forecast,
- recent updates to the system topology,
- changes to facility ratings,
- changes affecting the use of the Northern Intertie as the monitored flowgate for Puget Sound Area Northern Intertie (PSANI) issues, and
- changes to the SCL system.

These changes and their impacts on system need were documented in the 2015 Needs Assessment Report dated April 2015. The 2015 Needs Assessment reinforced that the project date of need will remain the same at the 2017-18 winter due to these key factors:

- The 2017-18 winter power flow cases still require the use of Corrective Action Plans (CAPs) to mitigate transmission transformer overloads with load at risk beginning between 2017-18 to 2019-20.
- The number of contingencies requiring the use of CAPs steadily increases as load grows.
- The forecast uses a 1-in-2 year weather forecast. Colder weather will result in higher load levels.
- 100% conservation may not be achieved which would result in a higher load level. Even if 100% conservation is achieved, it may not be in the appropriate locations and magnitudes assumed for this assessment.
- There is only 20 MW difference on the Eastside between the winters of 2017-18 and 2019-20, and in the winter of 2019-20, over 60,000 customers are at risk.
- By the summer of 2018, the 2015 Needs Assessment showed that 68,800 customers will be at risk of outages and 10,900 customers at risk of load shedding using CAPs to mitigate transmission transformer overloads.
- Load shedding will become an increasingly necessary action as load grows if no other steps are taken to address the transmission capacity needs.

The method and criteria are the same as utilized in the February 2014 Eastside Transmission Solutions Report with the exception of those items discussed below.

2.0 Differences Between the 2014 and 2015 Solution Reports

2.1 Changes to the Power Flow Cases which have Minimal Impact

There are three changes described below that had minimal impact on the results of the 2015 Solution Study. The three changes are also included in the power flow cases utilized in the 2015 Needs Assessment.

2.1.1 WECC Base Case Differences

For the updated solutions study analysis, PSE utilized the same WECC base cases as utilized in the 2015 Needs Assessment. PSE used WECC approved Heavy Winter base cases for the years 2019-20 and 2023-24 and developed a 2017-18 case from the 2019-20 case. PSE used WECC approved Heavy Summer base cases for the years 2020 and 2024 and developed a 2018 case from the 2020 case. The 2014 Solutions Report was based on WECC 2012 cases and the 2015 Solutions Study is based on 2014 WECC cases. A comparison of the cases utilized is shown in Table 2-1.

Table 2-1: Comparison of cases utilized in the Eastside Transmission Solutions Study

Case	Forecast 2012	Forecast 2014
2017-18 HW SN 100% Cons	✓	✓
2017-18 HW NS 100% Cons	✓	--
2017-18 HW SN 75% Cons	✓	--
2017-18 HW SN Extreme 75% Cons	✓	--
2021-22 HW SN 100% Cons	✓	--
2021-22 HW SN 75% Cons	✓	--
2021-22 HW SN Extreme 100% Cons	✓	--
2023-24 HW SN 100% Cons	--	✓
2023-24 HW SN 75% Cons	--	✓
2023-24 HW SN Extreme 100% Cons	--	✓
2018 HS NS 100% Cons	✓	✓
2018 HS NS 75% Cons	--	✓
2018 HS SN 100% Cons	✓	--
2024 HS NS 100% Cons	--	✓
2024 HS NS 75% Cons	--	✓
2024 HS NS 4100 MW	--	✓
2023-24 HW SN 5500 MW	--	✓

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2.1.2 Topology Changes in the Base Case

The 2015 Solutions Study included all projects included in the 2014 Solutions Report, which are listed in Appendix B Table B-1 and Table B-2 of the 2014 Eastside Solutions Report. Changes in topology between the previous set of study cases and the current study cases are included in Appendix C below. Based on power flow analysis, no topology changes listed in Appendix C significantly impacted the study results. The only change was the Talbot 230/115 kV transformer #1 replacement, which increased the operational and emergency limits from 383 MW and 464 MW to 398 MW and 484 MW respectively.

2.1.3 Northern Intertie vs. North of Echo Lake and South of Custer Flowgates

Prior to 2013, BPA used the West-Side Northern Intertie as the monitored flowgate for PSANI capacity transfers. This flowgate was managed through the use of nomograms which would dictate the amount of capacity available on the Northern Intertie based on varying Puget Sound area generation levels, expected load levels, ambient temperature and the next worst contingency. Nomograms were published on this Path for flows in both the north-south direction and the south-north direction. The amount of power that could be transferred between the Northwest and BC Hydro's system on the West-Side Northern Intertie was somewhat dependent on generation in the Puget Sound area. Transmission across the Northern Intertie would be curtailed if it was found that conditions would not support transfers, both in real time and in the operations planning timeframe. In February of 2013, BPA moved away from using the Northern Intertie as the basis for determining available transfer capability through the Puget Sound area and instead developed two new flowgates. These flowgates are the South of Custer (SOC) flowgate, used for determining acceptable north – south transfer levels through the Puget Sound area and the North of Echo Lake (NOEL) flowgate, used for determining acceptable south – north transfer levels. One-line diagrams of these updated flowgates are included in Appendix D. These changes are used operationally to monitor flows which do not impact the study results but helps determine and prevent adverse reliability impacts when power is flowing between the Northwest and BC Hydro's system.

Table 2-2: Definitions of PSANI Flowgates

North of Echo Lake (NOEL) Flowgate Definition:	South of Custer (SOC) Flowgate Definition:
Echo Lake – SnoKing Tap 500 kV	Monroe – Custer #1 & #2 500 kV
Echo Lake – Maple Valley 500 kV	Murray – Custer 230 kV
Covington – Maple Valley 230 kV	Bellingham – Custer 230 kV

2.2 Changes to the Power Flow Cases which had Substantial Impact

There are three changes to the models and underlying assumptions that do have a substantial impact on the results of the Eastside Solutions Study (February 2014). These are also the same as those modeled in the 2015 Needs Assessment. See the 2015 Needs Assessment for details on the following changes:

- PSE has updated the Facility Ratings for all transmission lines in the system

- Seattle City Light load levels decreased in the WECC model
- Differences in load forecast levels utilized in the February 2014 Eastside Solutions Study and Supplemental Eastside Solutions Study as a result of the 2014 PSE load forecast

The 2014 Solutions Report is based on the 2012 load forecast and the 2015 Solutions Study is based on the 2014 load forecast, plus transmission transportation load as shown in Table 2-3, Table 2-4, and in Figure 1 and Figure 1. The corporate load forecast together with the interconnected transmission customer load, or transmission transportation load, was used to determine future loads for the power flow studies. The Transmission Customer load typically runs between 250 MW and 300 MW. For purposes of this study, 270 MW was used for a typical value. For example, using the 17-18 HW case in Table 2-4 the total load is 5,162 MW, which is 4,892 MW corporate load forecast plus 270 MW transmission transportation load.

Table 2-3: Eastside and King County load levels using 2012 load forecast

Case	King County (excluding Eastside)	Eastside	Remainder of system	Total
17-18HW	1924	699	2585	5208
18HS	1258	550	1744	3552
21-22HW	1828	748	2617	5193

Table 2-4: Eastside and King County Load levels using 2014 load forecast

Case	King County (excluding Eastside)	Eastside	Remainder of system	Total
17-18HW	1881	688	2592	5162
17-18EHW	2091	728	2828	5647
18HS	1379	538	1707	3625
23-24HW	1817	764	2577	5158
23-24EHW	2053	804	2833	5691
23-24HW 75% Cons	1853	791	2647	5291
2023-24 HW 5500 MW	1984	777	2739	5500
24HS	1399	618	1800	3817
24HS 75% Cons	1445	637	1856	3938
2024 HS 4100 MW	1504	664	1935	4103

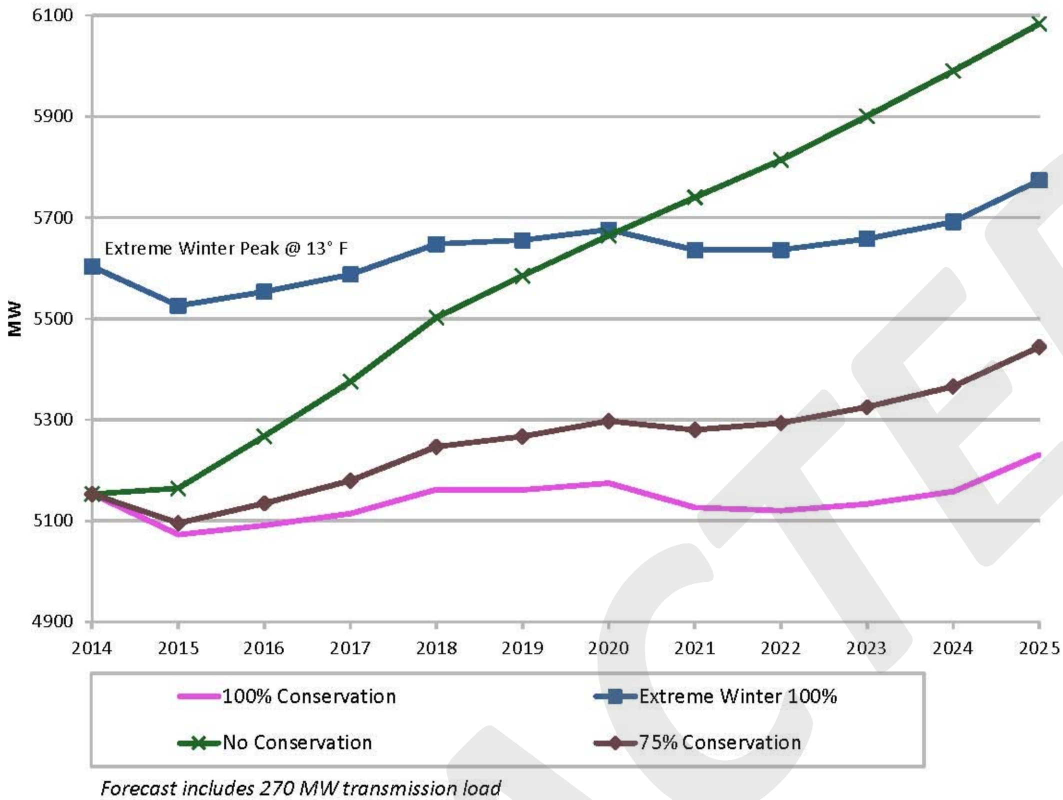

Figure 1: PSE 2014 Load Forecast for Normal and Extreme Winter Weather with PSE Transmission Transportation Load

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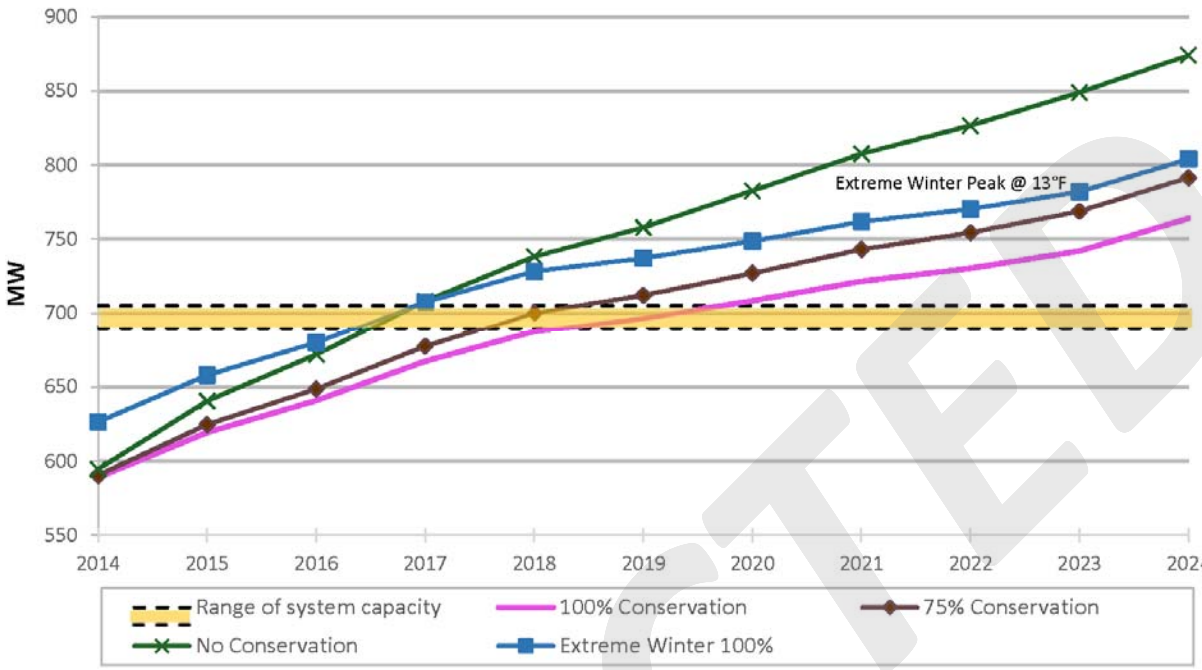

Figure 2: PSE 2014 Eastside Load Forecast for Normal and Extreme Weather with PSE Transmission Transportation Load

2.3 Base Cases Used for Solution Study Analyses

The same base cases used in the 2015 Needs Assessment were used in the 2015 Solutions Study analyses. The WECC base cases are updated annually. The cases available for this update were the 2019-20 and 2023-24 Heavy Winter cases and the 2020 and 2024 Heavy Summer cases. All other cases were derived from those WECC cases, including ten-year proxy cases to represent anticipated load levels in 2028. The Table 2-5 below lists the cases utilized in the 2015 Solutions Study.

Table 2-5: Cases utilized in the 2015 Solutions Study

Case	MW
2017-18 HW SN 100% Cons	5,162
2023-24 HW SN 100% Cons	5,158
2023-24 HW SN 75% Cons	5,291
2023-24 HW SN 5500 MW*	5,500
2023-24 EHW SN 100% Cons	5,691
2018 HS NS 100% Cons	3,625
2024 HS NS 100% Cons	3,817
2024 HS NS 75% Cons	3,938
2024 HS NS 4100 MW*	4,103
**Representing anticipated load levels in 2028.*	

2.4 Contingencies Used for Solutions Study Analyses

The alternatives in this study were evaluated using a group of contingencies that cause impacts to King County facilities. These contingencies included 230 kV and 500 kV lines terminating in King, Pierce, and Snohomish Counties as well as PSE's 115 kV lines in King and Pierce Counties. Outages of the proposed facilities were added to the existing facility outages. The contingencies fell into three groups:

- Category B (N-1): Loss of one transmission line or transformer (over 300 contingencies).
- Category C (N-2): Loss of two transmission lines on the same tower or loss of a bus section or two bus sections due to bus or circuit breaker fault (over 400 contingencies).
- Category C (N-1-1): Loss of one transmission line or transformer followed by a system adjustment and then loss of another transmission line or transformer (over 31,000 contingencies).

2.5 Points of Clarification from the 2014 Solutions Study

2.5.1 Criteria which Defines a Valid Solution

In the 2014 Solutions Report, PSE considered a proposed project to be a viable solution if it solved the power flow issues identified in the Needs Assessment Report, satisfied the longevity criteria, was deemed to be constructible, and was judged to be environmentally acceptable (pending subsequent environmental review).

For the 2015 Solutions Study, PSE further defined and expanded these criteria: to be a valid solution for the Eastside study area, the project must meet or adhere to the following electrical and non-electrical criteria:

Electrical Criteria:

a. Must meet all performance criteria:
   - Applicable transmission planning standards and guidelines including mandatory NERC and WECC standards (e.g. NERC TPL-001-4 and WECC TPL-001-WECC-CRT-2)
   - Within study period (2015-24)
   - ≤95% of emergency limit for lines
   - ≤90% of emergency limit for transformers
   - Normal Winter load forecast with 100% and 75% conservation
   - Normal Summer load forecast with 100% conservation
   - Adjust regional flows and generation to stress cases similar to annual TPL assessment
   - Take into account future transmission system improvement projects that are expected to be in service within the study period
   - Minimal or no re-dispatching of generation
   - No load shedding
   - No new Remedial Action Schemes (RAS)
   - No Corrective Action Plans (CAPs)

b. Must address all relevant PSE equipment violations

c. Must not cause any adverse impacts to the reliability or operating characteristics of PSE's or surrounding systems.

d. Must meet performance criteria listed above for 10 or more years after construction with up to 100% of the emergency limit for lines and transformers

<u>Non-Electrical Criteria</u>:

a. Environmentally acceptable to PSE and communities it serves
b. Constructible by winter of 2017-18
c. Utilize proven technology which can be controlled and operated at a system level
d. Reasonable project cost

The above electrical criteria are addressed in this report. The non-electrical criteria will be addressed during the environmental review and/or PSE's project development process.

2.5.2 Use of Corrective Action Plans (CAPs)

PSE does not advocate the use of CAPs as a solution to an identified need. PSE uses operating procedures such as CAPs as a temporary measure to prevent any loss of firm load, either intentionally or due to a credible outage condition. CAPs are generally considered temporary in nature with the understanding that permanent solutions are forthcoming. NERC Standard TPL-001-4 allows CAPs to be used to meet the performance requirements for most N-1-1 and N-2 contingencies while specifying how long they will be needed as part of the CAPs.

As stated in the 2014 Solutions Report, the focus of the operational flexibility assessment is to determine if a proposed alternative will allow for the elimination or reduce the need for CAPs. CAPs are used to prevent thermal overloads of transmission lines and transformers. For example, there is an existing CAP in place to prevent overloads in the winter on either of the Talbot Hill transformer banks. This CAP requires the manual opening of 115 kV breakers at Talbot Hill Substation, which removes the two 115 kV lines between the Talbot

Hill and Lakeside substations. Taking this step switches the load to radial (non-network) connections, which reduces the inherent reliability of the network since the transmission system cannot handle as many contingencies without overloads, voltage issues, or loss of customers' power.

The performance testing referenced in Section 6.0 is the same testing used to determine the need for CAPs. Based on the power flow results, the CAPs above will not be needed in the study period after one of the five alternatives has been placed into service.

2.5.3 Use of Load Shedding

PSE does not utilize load shedding as a solution to meet mandatory performance requirements. While NERC and WECC allow dropping load for certain contingencies, intentionally dropping firm load for an N-1-1 or N-2 contingencies to meet its federal planning requirements is not a practice that PSE endorses. All load modeled in the Needs Assessment studies was firm load and PSE doesn't consider any of its firm requirements to be "non-consequential[1]."

2.5.4 Substation Design Criteria for Bulk Transformers

PSE has guidelines for standardizing specific types and sizes of substation equipment, which provides many benefits and allows for consistency throughout the electric system. The benefits are in terms of safety, reliability, operations, maintenance, physical and cyber security, purchasing, training, and inventory; ultimately the cost to the customer.

PSE's practice is to plan for a maximum of two 230 kV – 115 kV transformers at any one substation. This practice has been implemented for many years and is codified in PSE's Transmission Planning Guidelines. With the terrorist attack on Pacific Gas & Electric's Metcalf transmission substation on April 16, 2013, much attention is being focused on physical and cybersecurity and more utilities are considering similar criteria to minimize reliability risks from a physical or cyber-attack.

It should be noted that PSE already has two 230 kV – 115 kV transformers at the Talbot Hill and Sammamish substations. Adding a third 230 kV – 115 kV transformer at either of these substations would adversely impact the area reliability and security and would not be consistent with PSE's Transmission Planning Guidelines.

[1] Non-Consequential Load is defined as Non-Interruptible Load loss that does not include: (1) Consequential Load Loss, (2) the response of voltage sensitive Load, or (3) Load that is disconnected from the System by end-user equipment. Consequential Load is defined as all Load that is no longer served by the Transmission system as a result of Transmission Facilities being removed from service by a Protection System operation designed to isolate the fault

3.0 Methodology and Key Assumptions

The methodology and key assumptions have not changed from the February 2014 Solutions Report. The specifics can be found in Section 3 of the 2014 Eastside Transmission Solutions Report.

4.0 Solution Types Reviewed and Technical Analysis

The solution types reviewed in the 2015 Solutions Study are the same as the 2014 Solutions Report with some enhancements. The solution types include conservation, generation, energy storage, transmission substations expansion, transmission line upgrades, and new transmission lines. The solution types are discussed below.

4.1 Conservation within the Eastside Area

As stated in the 2014 Eastside Transmission Solutions Report, PSE currently employs conservation as a strategic measure to manage energy requirements and provide customer benefits. Conservation programs have been funded for over 20 years and are projected to continue to receive strong funding in PSE's budgets through the next 20 years. Utilizing the updated load forecast, PSE considered whether additional demand side options Energy Efficiency (EE), Demand Response (DR), and Distributed Generation (DG) within the King County area would reduce the load adequately to eliminate or delay any needed transmission.

Based on power flow results, the amount of incremental conservation needed in the King County area to delay, not avoid, upgrades to the transmission system is similar to the results of the 2014 Solutions Report. The amount of conservation required to avoid transmission upgrades ranges from a low of 138 MW to a high of 244 MW[2]. The minimal conservation level of 138 MW within the Eastside area is in addition to being able to achieve 100% (424 MW from the 2014 Load Forecast) of the projected conservation for the entire PSE system, and the 244 MW is in addition to achieving 75% (318 MW from the 2014 Load Forecast) of the projected conservation for the entire PSE system. As discussed in the 2014 Solutions Report, a range of conservation is used because of the uncertainties in load growth, long-term prediction of conservation programs in the IRP vs. implementation programs, with customers willing to participate, customer operating characteristics, incentives of the offerings, expected savings measurements, and timing of the conservation. As noted in the 2014 Solutions Report, conservation program potentials do not account for program interactions.

Also, the assessment performed by Energy and Environmental Economics, Inc. (E3) of available conservation was discussed in the 2014 Solutions Report. Before the report was published, E3 was hired to determine how much incremental economic and achievable conservation was possible and whether there was enough achievable incremental conservation to avoid or defer the need of the transmission upgrade options. The additional conservation evaluated by E3 was in addition to the proposed conservation included in the 2012 load forecast. E3's analysis indicated that the cost-effective non-wires potential in the area, including energy efficiency, demand response, and distributed generation measures, did not represent a permanent alternative to avoid the need for the transmission upgrade options. The assessment also indicated that the non-wires potential was not sufficiently cost-effective to defer the need date of transmission upgrades while maintaining

[2] A 70 MW to 140 MW range was identified in the 2014 Solution Study. This level was sufficient to drop below 100% of the Talbot Hill transformer rating in winter of 2017-18. However, a valid solution requires a transformer loading of no more than 90%. Therefore the 2015 Solution Study identified a higher level of conservation which was sufficient to drop the loading level on the Talbot Hill transformers down to 90% under the worst contingency.

equivalent reliability levels.[3] For the 2015 Solutions Study, nothing has changed in the PSE conservation programs or in recent technology developments that would reverse this conclusion.

4.2 Generation within the Eastside Area

As in the 2014 Solutions Report, conventional generation and distributed generation (DG) were also reviewed in the 2015 Solutions Study. Conventional generation includes combustion turbines, combined cycle facilities, coal plants, and nuclear units. DG includes small scale, behind the meter generation that is installed by PSE customers. As in the 2014 Solutions Report, to be effective, the team determined that the total amount of generation would need to be at least 300 MW located in the Eastside area. The results are the same as in the 2014 Solutions Report. Locating conventional generation of this size on the Eastside has major siting and environmental concerns.

DG includes solar panels, combined heat-power units, micro-turbines, thermal generators, and small wind turbines. As in the 2014 Solutions Report, in order for DG to meaningfully impact the needs identified within the Eastside area, DG must be installed in the right locations, available when needed, and be of significant magnitude. Locating 300 MW or more of renewable generation within the eastside area by the winter of 2017-18 is not practical and also has its challenges.

4.3 Energy Storage

Energy storage was again reviewed as a possible solution based on the changes discussed in Section 2.0. The results are the same as discussed in the 2014 Solutions Report. An energy storage system with power and energy storage ratings comparable to PSE's identified need has not yet been installed anywhere in the world. Projects of lesser size have been contracted by other utilities; however, it is unlikely that even this magnitude of system could be contracted, permitted, sited, interconnected, procured, and commissioned by the winter 2017-2018.

In the energy storage field, battery storage technology is rapidly advancing, but the only system of significant size is a 100 MW/400 MWh lithium-ion Energy Storage System recently procured by Southern California Edison ("SCE"), which is not expected to be operational until 2021. Per PSE's understanding, the largest currently deployed and commissioned battery storage project (by power rating) in the United States is SCE's Tehachapi Wind Energy Storage ESS, an 8 MW/32 MWh lithium ion battery. Even though battery storage of significant size is not practical at this time, PSE studied an option that included a 20 MW battery resource in the Eastside area. Further discussion on that option is included in Section 5 and is referred to in this report as battery storage.

4.4 Transmission Line Reinforcements and Transformer Additions to Support the Eastside Area

PSE studied several alternatives in order to determine which possible designs could serve as solutions to the Eastside transmission deficiencies described in the 2015 Needs Assessment. The successful solutions from the

[3] Jack Moore, Lakshmi Alagappan, & Katie Pickrell, Eastside System Non-Wires Alternatives Screening Study, February 2014

earlier 2014 Solutions Report were re-studied using new load forecasts and system updates. These solutions included a new substation transformer plus new 230 kV transmission line, with some additional 115 kV lines as necessary. Even though PSE's practice is to not add a third 230/115 kV transformer at a substation, this option was still studied as suggested to see if it was a viable electrical solution.

4.4.1 Alternatives Considered for Transmission Line Reinforcements and Transformer Additions

Based on the knowledge gained from the 2014 Solutions Report, there were 22 transmission line and transformer alternatives reviewed as listed in Table 4-1. Of the 22 reviewed, 19 alternatives were studied. The alternatives not studied are listed in Table 4-7 with a line through each. Graphically, the alternatives are shown in

Figure 3. To understand the reliability impacts and help eliminate those alternatives that were electrically infeasible, power flow simulations were performed on the 20 potential alternatives, utilizing cases from the Needs Assessment and a set of select contingencies described in Section 2.4 to determine the reliability impacts of each alternative. These 20 alternatives are described in more detail in the following sub-sections.

Table 4-1: Identified Potential Combinations of Line Sources with Transformer Sites

Source ID No.	230 kV Transmission Sources	Site ID	Transformer Sites	Combinations of Sources & Sites
1	New transformer without 115 kV upgrades	a	Sammamish	1ab, 1ac, 1bc, 1abc
2	New transformer with 115 kV upgrades	b	Talbot Hill	2ab, 2ac, 2bc
3	New transformer with 500 kV system reinforcement and 115 kV upgrades	c	Lake Tradition	3a, 3b
4	Sammamish – Lakeside 230 kV (double circuit) (plus rebuild Maple Valley – SnoKing)	d	Lakeside	4d
5	Talbot Hill – Lakeside 230 kV (double circuit) (plus rebuild Maple Valley – SnoKing)	e	Westminster	5d
6	Loop thru one Talbot Hill - Lakeside - Sammamish 115 kV line rebuilt to 230 kV (PSE Corridor)	f	Woodridge	6d, 6e
7	Talbot Hill - Lakeside 230 kV line on new ROW, rebuild one Lakeside - Sammamish 115 kV line to 230 kV (PSE Corridor)	g	Vernell	7d, 7e
8	Rebuild and loop thru of SCL lines			~~8d~~, ~~8e~~, 8f, ~~8g~~
9	*This non-transmission line and transformer alternative is discussed in section 4.5.*			
10	New 230 kV line between Talbot Hill and Sammamish on new ROW. Loop thru sub			10d, 10f, 10g

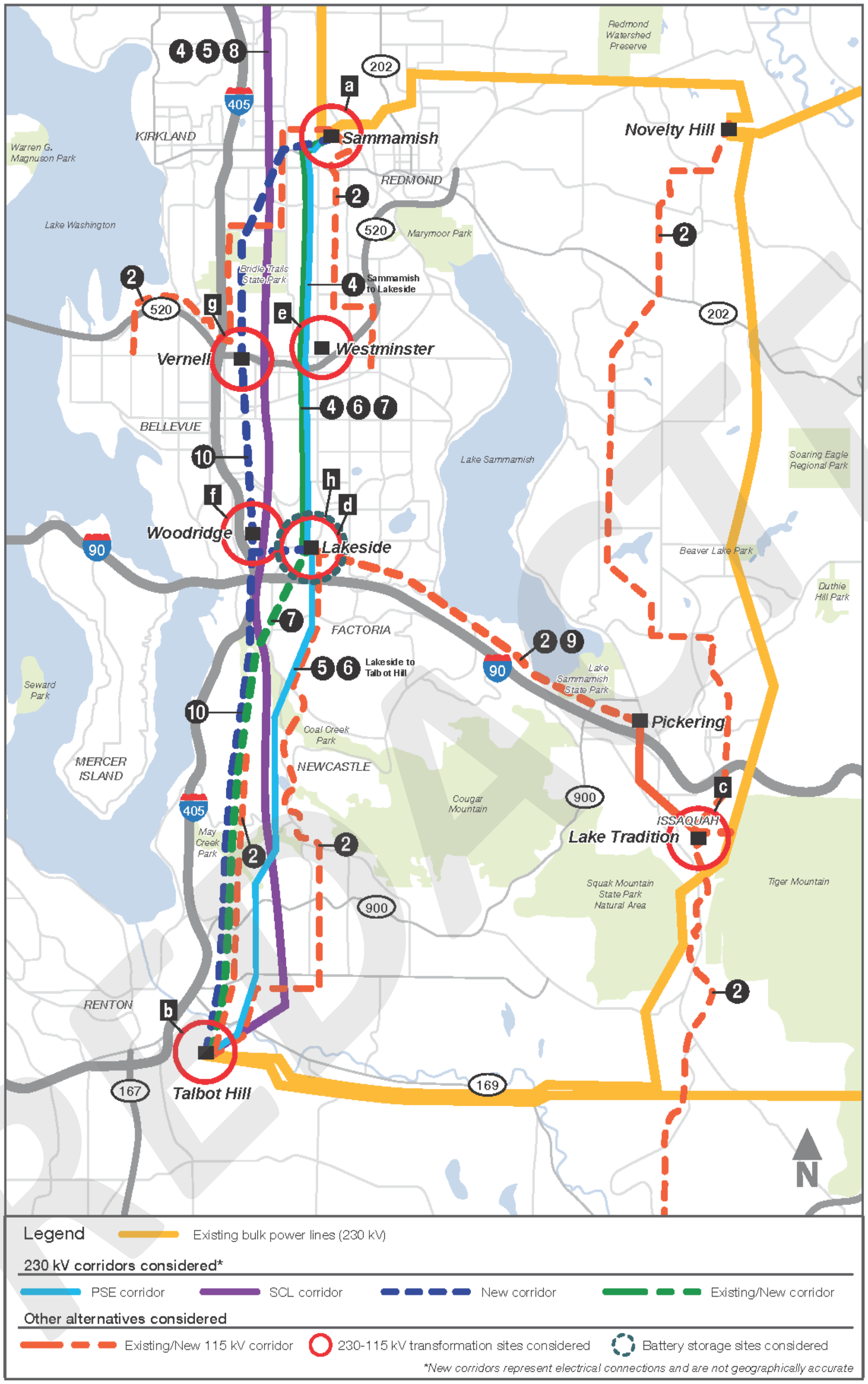

Figure 3: Graphic Showing all 10 Alternatives with Options

The alternatives considered for this report are described in Table 4-2:

Table 4-2: Identified Potential Combinations of Line Sources with Transformers

Alt	230 kV Wires Alternative	Generation/Energy Storage or Substation Alternative	East-West Distance between 230 kV line and substation	Comments
1ab	Add transformers at Sammamish & Talbot Hill (no additional 115 kV infrastructure)	Sammamish & Talbot Hill	Not Applicable	Not a generally accepted practice to put more than 2 bulk transformers at a substation
1ac	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Sammamish (no additional 115 kV infrastructure)	Sammamish & Lake Tradition	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation
1bc	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Talbot Hill (no additional 115 kV infrastructure)	Talbot Hill & Lake Tradition	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation
1abc	Add transformers at Sammamish, Lake Tradition and Talbot Hill (no additional 115 kV infrastructure)	Sammamish, Talbot Hill & Lake Tradition	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation
2ab	Add transformers at Sammamish & Talbot Hill (with additional 115 kV infrastructure)	Sammamish & Talbot Hill	Not Applicable	Not a generally accepted practice to put more than 2 bulk transformers at a substation
2ac	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Sammamish (with additional 115 kV infrastructure)	Sammamish & Lake Tradition	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation
2bc	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Talbot Hill (with additional 115 kV infrastructure)	Talbot Hill & Lake Tradition	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation
3a	New Monroe – Echo Lake – Raver 500 kV line plus transformer at Sammamish	Sammamish	Not Applicable	New 500 kV line parameters based on existing Monroe – Echo Lake – SnoKing 500 kV line

Alt	230 kV Wires Alternative	Generation/Energy Storage or Substation Alternative	East-West Distance between 230 kV line and substation	Comments
3b	New Monroe – Echo Lake – Raver 500 kV line plus transformer at Talbot Hill	Talbot Hill	Not Applicable	New 500 kV line parameters based on existing Monroe – Echo Lake – SnoKing 500 kV line
4d	Rebuild both Sammamish-Lakeside 115 kV lines to 230 kV and add transformer at Lakeside plus rebuild Maple Valley – SnoKing	Lakeside	Adjacent	Convert Rose Hill to 230 kV and loop in Sammamish – Lakeside #1
5d	Rebuild both Talbot Hill-Lakeside 115 kV lines to 230 kV and add transformer at Lakeside plus rebuild Maple Valley – SnoKing	Lakeside	Adjacent	
6d	Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV Line to 230 kV and loop through new substation	Lakeside	Adjacent	
6e	Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV Line to 230 kV and loop through new substation	Westminster	Adjacent	
7d	Build new Talbot Hill-Lakeside 230 kV line on new right of way, rebuild one Lakeside-Sammamish 115 kV line to 230 kV	Lakeside	Adjacent	
7e	Build new Talbot Hill-Westminster 230 kV line on new right of way, rebuild one Westminster-Sammamish 115 kV line to 230 kV	Westminster	Adjacent	
8d	Rebuild SCL Maple Valley-SnoKing lines and loop into new substation	Lakeside	Adjacent	Was not studied…8f is better option based on 2014 Solutions Study
8e	Rebuild SCL Maple Valley-SnoKing lines and loop into new substation	Westminster	2 miles	Was not studied…8f is better option based on 2014 Solutions Study
8f	Rebuild SCL Maple Valley-SnoKing lines and loop into new substation	Woodridge	Adjacent	
8g	Rebuild SCL Maple Valley-SnoKing lines and loop into new substation	Vernell	1 mile	Was not studied…8f is better option based on 2014

Alt	230 kV Wires Alternative	Generation/Energy Storage or Substation Alternative	East-West Distance between 230 kV line and substation	Comments
				Solutions Study
9bch	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Talbot Hill (with one additional 115 kV line), energy storage/generation at Lakeside	Transformers at Talbot Hill & Lake Tradition Energy Storage / Generation at Lakeside	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation Energy storage at this size has no proven track record.
10d	Build new Talbot Hill- Sammamish 230 kV line on new right of way and loop thru new substation	Lakeside	Up to 2 miles	
10f	Build new Talbot Hill - Sammamish 230 kV line on new right of way and loop thru new Substation	Woodridge	Up to 1 mile	
10g	Build new Talbot Hill - Sammamish 230 kV line on new right of way	Vernell	Up to 1 mile	

Several alternatives include a new 230-115 kV transformer at or near Lakeside Substation. Lakeside presently has a 115 kV main and auxiliary bus with 11 115 kV transmission lines connected. Additional equipment modeled include 230 kV bus and breakers, a 325 MVA 230-115 kV transformer, a 115 kV circuit breaker, and a 42 MVAr 115 kV capacitor bank. The 230 kV bus would need a minimum of two 230 kV transmission line feeds for adequate reliability. The study evaluated different means of providing the two 230 kV transmission lines including a double line from Sammamish to Lakeside or from Talbot Hill to Lakeside, or a line from Sammamish to Lakeside to Talbot Hill. This latter line could be built on PSE's corridor that presently contains two 115 kV H-frame transmission lines, or it could follow a new route. The new route could be off PSE's corridor the entire distance or for just the segment between Talbot Hill and Lakeside.

Another alternative would be to build the new 230-115 kV substation at a site on NE 24th Street called "Westminster." In addition to the equipment required for the Lakeside site, there would be initial site development work, control house and 115 kV bus and breakers required. Additional 115 kV line work would be required to bring at least four transmission lines to the site to connect to the existing network. The 230 kV line routes would be similar to those used for the Lakeside site.

Another alternative would be to build the new 230-115 kV substation on property owned by PSE at 116th Avenue NE and approximately NE 22nd Street in Bellevue called "Vernell." The Sammamish-North Bellevue 115 kV line passes by the site on 116th Avenue NE. Additional 115 kV work would be required to loop in two 115 kV lines and build a third 115 kV line. In addition significant bus and breaker work will be required. The 230 kV line routes would be similar to Lakeside.

Another alternative would be to build the new 230-115 kV substation at a site near I-90 and I-405 called "Woodridge." The substation equipment required at Woodridge would be similar to that required for Westminster. Additional 115 kV line work would be required to bring at least two 115 kV lines to the site to connect to the existing network. The 230 kV line connection would be to one of the Seattle City Light (SCL) Maple Valley-SnoKing 230 kV lines that pass by the site.

The study evaluated whether these modeled solutions would be adequate to solve overloads relevant to the Eastside area. If additional system improvements would make a solution viable, those are identified.

4.5 Combination of Types of Solutions

PSE also identified an alternative using a combination of transformers, Demand Side Resources (DSR), and battery storage. The PowerWorld software Transmission Loading Relief (TLR) tool and the Line Loading Replicator were used to determine the best location for battery storage to relieve loading on the overloaded transformers. The TLR sensitivity tool determines the sensitivity of flows on a specified element to changes in real power at each individual bus in the system. The Line Loading Replicator will set the loading on a transmission line or transformer to a desired real power flow amount and will determine how much loads and generators in the system need to be adjusted to achieve the specified flow. Note: As an alternative to battery storage, a small scale generator could also be utilized as the impact of the small scale generator would be the same as battery storage of the same capacity.

Example TLR calculations are included in Table 4-3 and Table 4-4 below.

Table 4-3 lists the buses with the greatest impacts on Talbot Hill bank loading in a winter case and Table 4-4 lists buses with the greatest impacts on Sammamish bank loading in a summer case. A positive value indicates that the bus is downstream or on the low side of the transformer. A negative value indicates that the bus is upstream or on the high side of the transformer. From this analysis, the most effective location for battery storage to reduce loading on any of the transformers is on the high side of the transformer (greater P Sensitivity number). If batteries are placed on the low side, the 115 kV bus being fed by the transformer in question is the best option, and P sensitivity decreases as battery storage is placed farther from the substation.

Table 4-3: Buses with the greatest impact on Talbot Hill Transformer #1 and #2

Talbot Hill #1		Talbot Hill #2	
Bus Name	P Sensitivity	Name	P Sensitivity
TALBOT HILL S 115kV	0.095	TALBOT HILL N 115kV	0.102
TALBOT HILL 115kV	0.093	TALBOT HILL 115kV	0.100
TALBOT HILL N 115kV	0.092	TALBOT HILL S 115kV	0.099
GRADY	0.082	GRADY	0.091
ROLLHLS	0.068	ROLLHLS	0.080
PACCAR	0.066	MPLEWOOD	0.072
MPLEWOOD	0.063	PACCAR	0.069
CLAY CRK	-0.067	BERYDALE	-0.095
GREENWTR	-0.067	CHRISTOP	-0.099
OBRIEN	-0.084	TALBOT HILL S 230kV	-0.100
CHRISTOP	-0.101	OBRIEN	-0.103
TALBOT HILL N 230 kV	-0.103	TALBOT HILL N 230kV	-0.158
BERYDALE	-0.126		
TALBOT HILL S 230kV	-0.171		

Table 4-4: Buses with the greatest impact on Sammamish Transformer #1 and #2

Sammamish #1		Sammamish #2	
Bus Name	P Sensitivity	Name	P Sensitivity
SAMMSH E	0.121	SAMMSH W	0.127
SAMMAMSH	0.12	SAMMAMSH	0.125
SAMMSH W	0.119	SAMMSH E	0.123
NORKIRK	0.113	TOTEM	0.12
TOTEM	0.113	RHILL TP	0.118
ROSEHILL	0.113	NORKIRK	0.118
RHILL TP	0.111	NOVELTY	-0.124
NOVELTY	-0.122	KLAHANIE	-0.129
KLAHANIE	-0.128	SAMMSH E	-0.188
SAMMSH W	-0.185	SAMMSH W	-0.191
SAMMSH E	-0.189		

The Line Loading Replicator was run to determine how much Eastside loads would need to change in order to reduce transformer loading by a specified amount. For example, a Line Loading Replicator study was run to determine the amount that Eastside loads would need to decrease to reduce loading on Talbot Hill bank 2 by 50 MW. This tool indicates that the greatest impact on Talbot Hill bank 2 would be placing batteries on the Talbot Hill south 115 kV bus and 236MW would be needed to achieve a 50MW reduction on the bank. A limitation of this tool is that it will only calculate sensitivity to loads or generation modeled in the case, so loads were added at Talbot Hill and Lakeside in order to include them in the analysis. Buses without loads or generation are excluded.

Results of this analysis indicate that the best location for energy storage to mitigate transformer issues at Talbot Hill in the winter would be in the vicinity of Talbot Hill substation. The best location for battery storage in the summer to mitigate transformer issues at Sammamish would be in the vicinity of Sammamish substation. Due to the changing need based on season and direction of flows through the system, it was determined that placing energy storage in between Talbot Hill and Sammamish would provide the greatest benefit to both stations. Based on the results of the TLR and Line Loading Replicator analysis, PSE ran the following scenarios on two different topologies (Case 9a - additional transformer at Sammamish and Talbot Hill and Case 9b - additional transformer at Lake Tradition and Talbot Hill). Table 4-5 lists the various combinations.

Table 4-5: Alternative scenarios reviewed for cases 9a and 9b

Scenario 1	Additional transformers + 20 MW batteries at Lakeside
Scenario 2	Additional transformers + 40 MW batteries at Lakeside
Scenario 3	Additional transformers + 60 MW batteries at Lakeside
Scenario 4	Additional transformers + 20 MW batteries at each of Lakeside, Sammamish and Talbot Hill
Scenario 5	Additional transformers + 20 MW batteries at each of Lakeside and Berrydale
Scenario 6	Additional transformers + 40 MW batteries at each of Lakeside and Berrydale
Scenario 7	Additional transformers + 40 MW batteries at each of Sammamish and Berrydale

To perform this screen, PSE ran a limited set of contingencies that were relevant and causing issues for the case 1 scenarios. The entire sets of contingencies were run on the case that is shown to have the best performance. In power flow simulations, case 9b performed better than case 9a. An additional 115 kV line between Lake Tradition and Lakeside was added to eliminate 115 kV line overloads. Results showed that Lakeside is the best location for batteries to relieve overloads, and the larger the battery, the lower transformer loading becomes. Spreading batteries out between various locations provided little to no benefit. PSE chose to place 20 MW of batteries at Lakeside for studying this scenario.

In summary, PSE chose to run case 9bch with 20 MW of storage at Lakeside and one additional 115 kV line out of Lake Tradition. Table 4-6 describes that alternative.

Table 4-6: Identified Potential Combinations of line, transformer, and Energy Storage

	230 kV Wires Alternative	Generation/Energy Storage or Substation Alternative	East-West Distance between 230 kV line and substation	Comments
9bch	Add transformer at Lake Tradition (Loop Maple Valley - Sammamish) and Talbot Hill (with one additional 115 kV line), energy storage/generation at Lakeside	Transformers at Talbot Hill & Lake Tradition Energy Storage / Generation at Lakeside	1/2 mile	Not a generally accepted practice to put more than 2 bulk transformers at a substation Energy storage at this size is an immature technology with no proven track record.

4.6 Summary of all alternatives considered

The 20 alternatives considered are summarized in Table 5-1 below.

Table 4-7: 20 Potential Alternatives Analyzed

Source ID No.	230 kV Transmission Sources	Site ID	Transformer and Generation / Battery Storage Sites	Combinations of Sources & Sites
1	New transformer without 115 kV upgrades	a	Sammamish	1ab, 1ac, 1bc, 1abc
2	New transformer with 115 kV upgrades	b	Talbot Hill	2ab, 2ac, 2bc
3	New transformer with 500 kV system reinforcement and 115 kV upgrades	c	Lake Tradition	3a, 3b
4	Sammamish – Lakeside 230 kV (double circuit) (plus rebuild Maple Valley – SnoKing)	d	Lakeside	4d
5	Talbot Hill – Lakeside 230 kV (double circuit) (plus rebuild Maple Valley – SnoKing)	e	Westminster	5d
6	Loop thru one Talbot Hill - Lakeside - Sammamish 115 kV line rebuilt to 230 kV (PSE Corridor)	f	Woodridge	6d, 6e
7	Talbot Hill - Lakeside 230 kV line on new ROW, rebuild one Lakeside - Sammamish 115 kV line to 230 kV (PSE Corridor)	g	Vernell	7d, 7e
8	Rebuild and loop thru of SCL lines	h	Battery Storage	~~8d~~, ~~8e~~, 8f, ~~8g~~

Source ID No.	230 kV Transmission Sources	Site ID	Transformer and Generation / Battery Storage Sites	Combinations of Sources & Sites
9	Combination of Battery storage, Transformers, Transmission Lines			~~9a~~, 9bch
10	New 230 kV line between Talbot Hill and Sammamish on new ROW. Loop thru sub			10d, 10f, 10g

5.0 Performance and Longevity

5.1 Steady State Performance Results

Initial screening evaluated the proposed system improvements using power flow cases for years 2018 and 2024, both winter and summer with all of PSE's planned conservation.

Similar to the 2015 Supplemental Needs Assessment, there were several overloads in the study results that did not require PSE to address. A significant number of overloads show up in the results of power flow studies due to outages of high voltage lines owned by other utilities that interconnect to PSE. Most of these are outages in BPA's 230 kV or 500 kV network. BPA and the other interconnected utilities have operating procedures in place to prevent overloads of area facilities, including PSE lines and equipment. For example, the most frequent external contingency that causes PSE overloads is an outage of the BPA Monroe-Echo Lake-SnoKing 500 kV line. BPA operates the flowgates so that this 500 kV line outage does not cause overloads. Therefore, while PSE did not attempt to solve overloads caused by the BPA 500 kV lines, overloads resulting from this 500 kV BPA line were reviewed to be sure the proposed solution did not make the overloads worse.

A number of PSE and neighboring utilities' facilities overload for a number of studied contingencies in or near King County. These have identified solutions that will address the majority of overloads. Therefore, overloads related to these elements were not included in the results. Examples include:

- Monroe-Novelty 230 kV line: BPA has plans for a thermal uprate.
- Maple Valley-Sammamish 230 kV line: BPA has recently raised the ratings.
- Moorlands Area of Northwest King County: PSE has new and upgraded lines planned.
- Krain Corner Area of Southeast King and Pierce Counties: PSE has new and upgraded lines planned.
- Snoqualmie 115 kV bus: An upgrade is planned.
- Beverly-Cottage Brook 115 kV line: Overloads occurring due to new Snohomish PUD transformer. A local solution will be developed.

PSE's system load level in 2023-24, Heavy Winter with 100% conservation (5,158 MW), is less than 2017-18 (5,162 MW) and 2019-20 (5,175 MW). In order to make sure a solution work for the study period, the 2023-24 Heavy Winter with 75% conservation (5,174 MW) case was used as the screening case in addition to the 2023-24 Heavy Winter with 100% Conservation. The results of the screening are presented below.

5.1.1 Alternatives 1ab, 1bc, 1ac, & 1abc

Alternative 1 looked at adding an additional 230/115kV transformer at either Sammamish & Talbot Hill, or Talbot Hill & Lake Tradition, or Sammamish & Lake Tradition, or at Sammamish & Talbot Hill & Lake Tradition Substations. In this alternative, no additional 115kV transmission lines were added. Adding an additional transformer at either Sammamish or Talbot Hill would increase the total number of transformers to three at each substation. Having three 230/115 kV transformers at any substation is not a practice that PSE endorses because of reliability and security concerns.

For these combinations of two new 230-115 kV transformers:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of N-1-1 violations and those are summarized in Table 5-1.

Table 5-1: Alternative 1ab, 1ac, 1bc, & 1abc results

Alternative	Winter 2023-24	Summer 2024	Results
1ab – Add transformers at Sammamish and Talbot Hill with no additional 115 kV infrastructure	Talbot – Lakeside 115 kV lines are overloading for multiple N-1[redacted] Re-dispatching is not enough, additional lines are required. TAL-LAK 1 115 kV (up to 116%) for 9 contingencies over 105%. Similar for TAL-LAK 2 114%. TAL-PCR: [redacted]	No Issues	Alternative 1ab is not a viable solution for the following reason: Multiple 115 kV lines are overloading for N-1-1 contingencies

Alternative	Winter 2023-24	Summer 2024	Results
1ac - Add transformers at Sammamish and Lake Tradition with no additional 115 kV infrastructure	Talbot Hill transformer #2 at 97% for outage of [redacted] TAL-LAK #1 at 111% for double line outages. Tal-LAK #2 at 105% for double outages	No issues.	Alternative 1ac is not a viable solution for the following reasons: Multiple 115 kV lines are overloading for N-1-1 contingencies Talbot Hill #2 getting close to the emergency limit for loss of 2 transformers
1bc - Add transformers at Talbot Hill and Lake Tradition with no additional 115 kV infrastructure	Tal-Lak #1 & #2 115 kV overload for multiple double line contingencies.	Overload on Sammamish #2 (100%) for N-1-1: [redacted] Sammamish 230/115 kV transformer #1 is stressed (95%).	Alternative 1bc is not a viable solution for the following reasons: Multiple 115 kV lines are overloading for N-1-1 contingencies Sammamish #2 is 100% for loss of 2 transformers; Sammamish #1 is 95% for loss of 2 transformers
1abc - Add transformers at Sammamish, Talbot Hill, and Lake Tradition with no additional 115 kV infrastructure	Tal-Lak #1 & #2 115 kV overload for multiple double line contingencies. TAL-LAK #1 at 114% for double line outages. Tal-Lak #2 at 111%	No issues.	Alternative 1abc is not a viable solution for the following reason: Multiple 115 kV lines are overloading for N-1-1 contingencies

See Appendix A for detail results.

5.1.2 Alternatives 2ab, 2bc, & 2ac

Alternative 2 looked at adding an additional 230/115 kV transformers at either Sammamish & Talbot Hill, or Talbot Hill & Lake Tradition, or Sammamish & Lake Tradition substations, but with the addition of two additional 115kV transmission lines for each additional transformer added to support load in the Eastside area. As with Alternative 1, adding an additional transformer at either Sammamish or Talbot Hill would increase the total number of transformers to three at each substation. Having three 230/115 kV transformers at any substation is not a practice that PSE endorses because of reliability and security concerns.

For these combinations of two new 230-115 kV transformers with two additional 115 kV lines at each substation:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of N-1-1 violations and those are summarized in Table 5-2.

Table 5-2: Alternative 2ab, 2ac, & 2bcresults

Alternative	Winter 2023-24	Summer 2024	Results
2ab – Add transformers at Sammamish and Talbot Hill with 2 additional 115 kV lines at Sammamish and Talbot Hill	Talbot Hill #2 is 95% for loss of 2 transformers; [redacted] Talbot Hill #3 is 93% for loss of 2 transformers; [redacted] Talbot Hill #1 is 91% for loss of 2 transformers; [redacted]	No issues.	Alternative 2ab is not a viable solution for the following reasons: Talbot Hill #2 is approaching the emergency limit
2ac - Add transformers at Sammamish and Lake Tradition with two additional 115 kV line at Sammamish and Lake Tradition	Talbot Hill #2 is 98% for N-1-1 loss of a transformer and a line Talbot Hill #2 is 96% for N-1-1 loss of 2 transformers [redacted] Talbot Hill #1 is 93% for N-1-1 loss of 2 transformers [redacted]	No Issues.	Alternative 2ac is not a viable solution for the following reasons: Talbot Hill #2 is approaching the emergency limit for a number of N-1-1 contingencies

Alternative	Winter 2023-24	Summer 2024	Results
2bc - Add transformers at Talbot Hill and Lake Tradition with two additional 115 kV lines at Talbot Hill and Lake Tradition	No Issues	Sammamish #2 is 96% for N-1-1 loss [redacted]	Alternative 2bc is not a viable solution for the following reasons: Sammamish #2 is approaching the emergency limit for the loss of two transformers

See Appendix A for detail results.

5.1.3 Alternatives 3a & 3b

Alternative 3 looked at reinforcing the 500kV regional transmission system by adding a new Monroe – Echo Lake – Raver 500 kV line plus a 230/115kV transformer at either Sammamish or Talbot Hill. As with Alternatives 1 and 2, adding an additional transformer at either Sammamish or Talbot Hill would increase the total number of transformers to three at each substation. Having three 230/115 kV transformers at any substation is not a practice that PSE endorses because of reliability and security concerns.

For these combinations of a new 500 kV line plus a new 230-115 kV transformer:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of N-1-1 violations and those are summarized in Table 5-3.

Table 5-3: Alternatives 3a and 3b Results

Alternative	Winter 2023-24	Summer 2024	Results
3a – addition of New Monroe – Echo Lake – Raver 500 kV line plus transformer at Sammamish	Talbot Hill #2 overloads to 101% [redacted] Talbot Hill #2 is 99%, 96%, for the loss of 2 transformers [redacted] Talbot Hill #1 is 96%, 92%, for the loss of 2 transformers [redacted]	No Issues.	Alternative 3a is not a viable solution for the following reasons: Talbot Hill #2 is overloading and approaching its emergency limit for multiple N-1-1 contingencies
3b - addition of New Monroe – Echo Lake – Raver 500 kV line plus transformer at Talbot Hill	TAL-LAK #1 is 107% for 2 lines; TAL-LAK #2 is 105% for loss of 2 lines; re-dispatch will not fix; Sammamish #2 is 93% for loss of two transformers. [redacted]	Sammamish #2 is 103% for loss of two transformers [redacted] Sammamish #1 is 97% for loss of two banks. [redacted]	Alternative 3b is not a viable solution for the following reasons: Sammamish #2 is overloading and Sammamish #1 is approaching its emergency limit for the loss of 2 transformers

See 7.0Appendix A for detail results.

5.1.4 Alternative 4d

Alternative 4 looked at rebuilding both Sammamish-Lakeside lines to 230 kV and adding a 230/115kV transformer at Lakeside. Alternative 4 also included rebuilding the Maple Valley – SnoKing 230 kV line to increase its thermal capacity.

For these combinations of a new 230 kV line looping to the new Lakeside substation from Sammamish plus a new 230-115 kV transformer at Lakeside:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of N-1-1 violations and those are summarized in Table 5-4.

Table 5-4: Alternative 4d Results

Alternative	Winter 2023-24	Summer 2024	Results
4d – Rebuild both Sammamish-Lakeside 115 kV lines to 230 kV and add transformer at Lakeside plus rebuild Maple Valley – SnoKing 230 kV line	Talbot Hill #2 overloads to 101% [redacted] Talbot Hill #2 is 97% or 95% for loss of two transformers. [redacted] Talbot Hill #1 is 96%, 93%, or 92% for loss of two transformers [redacted]	No Issues	Alternative 4d is not a viable solution for the following reasons: Talbot Hill #2 is overloading and approaching its emergency limit for a number of N-1-1 contingencies Talbot Hill #1 is approaching its emergency limit for a number of N-1-1 contingencies

See Appendix A for detail results.

5.1.5 Alternative 5d

Alternative 5 looked at rebuilding both Talbot Hill-Lakeside lines to 230 kV and adding a 230/115kV transformer at Lakeside. Alternative 5 also included rebuilding the Maple Valley – SnoKing 230 kV line to increase its thermal capacity.

For this alternative of rebuilding the Talbot Hill-Lakeside lines to 230 kV to loop in to the new 230-115 kV substation at Lakeside:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are a number of N-2 violations and those are summarized in Table 5-5.

There are a number of N-1-1 violations and those are summarized in Table 5-5.

Table 5-5: Alternative 5d Results

Alternative	Winter 2023-24	Summer 2024	Results
5d – Rebuild both Talbot Hill-Lakeside 115 kV lines to 230 kV and add transformer at Lakeside plus rebuild Maple Valley – SnoKing 230 kV line	Multiple N-2 overloads at the new Lakeside transformer [redacted] Lakeside #1 overloads for many N-1-1 contingencies for 2 transformers (13) - Max is 110% [redacted] , and 107% for loss of 2 230 kV lines feeding Sam.	Sam #2 is 103% for loss of 2 transformers [redacted] Sam #1 is 98% for the loss of 2 transformers [redacted]	Alternative 5d is not a viable solution for the following reasons: Multiple overloads of Lakeside #1 transformer for the loss of 2 transformers, Loss of 2 230 kV lines feeding Sammamish, and buss and breaker faults. Sammamish #2 is overloaded and Sammamish #1 is close to overloading

See Appendix A for detail results.

5.1.6 Alternatives 6d & 6e

Alternative 6 looked at rebuilding one of the Talbot Hill-Lakeside-Sammamish 115 kV lines to 230 kV and looping this line through a substation to support an additional 230/115kV transformer near the Eastside. Alternative 6 evaluated two locations for the transformer: Lakeside and Westminster.

For these combinations of a new 230-115 kV transformer from a new Talbot Hill-Sammamish 230 kV line:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of instances where N-1-1 loading indicates future stress and those are summarized in Table 5-6.

Table 5-6 Error! Reference source not found.**: Alternatives 6d and 6e Results**

Alternative	Winter 2023-24	Summer 2024	Results
6d – Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV Line to 230 kV and loop through Lakeside substation	No Issue	Sammamish #2 is 90% for N-1-1 [redacted]	Alternative 6d is a viable solution for the following reason: Meets the performance requirements
6e - Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV Line to 230 kV and loop through Westminster substation	Talbot Hill #2 is 91% for N-1-1 loss of two transformers. [redacted]	No issues.	Alternative 6e is a viable but marginal solution for the following reason: Meets the performance requirements but Talbot Hill #2 is marginal at 91% for the loss of 2 transformers

See Appendix A for detail results.

5.1.7 Alternatives 7d & 7e

Alternative 7 looked at building a new Talbot Hill-Lakeside 230 kV line on new right of way, rebuilding one of the Lakeside-Sammamish lines to 230kV and looping this line through a substation to support an additional 230/115kV transformer near the Eastside. Alternative 7 evaluated two locations for the transformer: Lakeside and Westminster.

For these combinations of a new 230-115 kV transformer looped on a new 230 kV line:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of instances where N-1-1 loading approaches the emergency limit and those are summarized in Table 5-7.

Table 5-7: Alternatives 7d and 7e Results

Alternative	Winter	Summer	Results
7d – Build new Talbot Hill-Lakeside 230 kV line on new right of way, rebuild one Lakeside-Sammamish 115 kV line to 230 kV and loop through Lakeside substation	Talbot Hill #2 is 93% or 92% for N-1-1 loss of two transformers. [redacted]	No issues.	Alternative 7d is a viable but marginal solution for the following reason: Meets all performance requirements but Talbot Hill #2 is marginal at 93% or 92% for the loss of 2 transformers
7e - Build new Talbot Hill-Westminster 230 kV line on new right of way, rebuild one Westminster-Sammamish 115 kV line to 230 kV and loop through Westminster substation	Talbot Hill #2 is 95%, 94% or 91% for N-1-1 loss of two transformers. [redacted]	No issues.	Alternative 7e is not a viable solution for the following reason: Talbot Hill #2 is 95% or 94% for N-1-1 loss of two transformers.

See Appendix A for detail results.

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5.1.8 Alternatives 8d, 8e, 8f, & 8g

Alternative 8 looked at rebuilding the Seattle City Light owned Maple Valley-SnoKing lines to increase capacity and looping this rebuilt line into a substation to support an additional 230/115kV transformer near the Eastside. Since the 2014 Solutions Study showed that the most promising alternative was the location of 230 kV/115 kV transformer was Woodridge, the other three locations, Lakeside, Westminster, and Vernell were not studied.

For the Woodridge transformer looped on the rebuilt Seattle City Light Maple Valley-SnoKing 230 kV lines:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of instances where N-1-1 loading approaches the emergency limit and those are summarized in Table 5-8.

Table 5-8: Alternative 8f Results

Alternative	Winter 2023-24	Summer 2024	Results
8f - Rebuild SCL Maple Valley-SnoKing lines and loop into new Woodridge substation	3 115 kV lines overload for N-1-1 [redacted] Talbot Hill #2 is 92% or 90% for the loss of 2 transformers [redacted]	Sammamish #2 is 94% for loss of 2 transformers [redacted]	Alternative 8f is not a viable solution for the following reasons: 3 115 kV lines connected to Woodridge overload Sammamish #2 is approaching its emergency limit

See Appendix A for detail results.

5.1.9 Alternative 9bch

Alternative 9bch looked at adding 20 MW of batteries at Lakeside along with additional 230kV/115kV transformers at Talbot Hill and Lake Tradition, and an additional 115 kV transmission line from Lake Tradition to Lakeside. As with Alternative 1 and 2, adding an additional transformer at Talbot Hill increases the total number of transformers to three. Having three 230/115 kV transformers at any substation is not a practice that PSE endorses because of reliability and security concerns.

For these combinations of large scale batteries, and new 230-115 kV transformers:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of instances where N-1-1 loading approaches the emergency limit and those are summarized in Table 5-9.

Table 5-9: Alternative 9bch Results

Alternative	Winter 2023-24	Summer 2024	Results
9bch – 20 MW of batteries at Lakeside, plus additional transformers at Talbot Hill and Lake Tradition, plus additional 115 kV line from Lake Tradition	No Issue	Sammamish #2 is 96% for N-1-1 [redacted] Sammamish #1 is 90% for N-1-1 [redacted]	Alternative 9bch is not a viable solution for the following reason: Sammamish #2 is approaching its emergency limit

See Appendix A for detail results.

5.1.10 Alternatives 10d, 10f, & 10g

Alternative 10 looked at a new Talbot Hill - Sammamish 230 kV line on a new ROW and looping this line through a substation to support an additional 230/115kV transformer near the Eastside area. Alternative 10 evaluated three locations for the transformer: Lakeside, Woodridge, and Vernell.

For these combinations of a new 230-115 kV transformer looped on a new 230kV line:

There are no N-0 issues for the winter or summer peaks.

There are no N-1 issues for the winter or summer peaks.

There are no N-2 issues for the winter or summer peaks.

There are a number of instances where N-1-1 loading indicates future stress and those are summarized in Table 5-10.

Table 5-10: Alternative 10d, 10f, & 10g Results

Alternative	Winter	Summer	Results
10d– Add a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Lakeside substation	Talbot Hill #2 is 93% or 92% for the loss of 2 transformers [redacted]		Alternative 10d is a viable but marginal solution for the following reasons: Meets performance requirements but Talbot Hill #2 is marginal at 93% for the loss of 2 transformers
10f– Add a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Woodridge substation	Talbot Hill #2 is 92%, 91% for the loss of 2 transformers [redacted]		Alternative 10f is a viable but marginal solution for the following reasons: Meets performance requirements but Talbot Hill #2 is marginal at 92% for the loss of 2 transformers
10g – Add a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Vernell substation	Talbot Hill #2 is 93% or 92% for the loss of 2 transformers [redacted]		Alternative 10g is a viable bt marginal solution for the following reasons Meets performance requirements but Talbot Hill #2 is marginal at 93% for the loss of 2 transformers

See Appendix A for detail results.

5.1.11 Summary Results – Comparison of 2015 to 2014 Power Flow Screening Results

The 2015 power flow screening criteria, which defines a valid solution, section 2.5.1, was used to reduce the alternatives from twenty (20) to six (6). Alternatives 1ab, 1ac, 1bc and 1abc, which were the addition of a transformer at two different substations, were not valid solutions primarily due to multiple 115 kV line overloads. Alternatives 2ab, 2bc, and 2ac, which were the addition of a transformer at two different substations plus two additional 115 kV lines at each of those substations, were not valid solutions primarily because they did not meet the transformer screening criteria. Alternatives 3a and 3b, which were the addition of a new Monroe – Echo Lake – Raver 500 kV line plus a 230/115kV transformer at either Sammamish or Talbot Hill were not viable primarily because they also did not meet the transformer screening criteria. Alternatives 4d and 5d, which were the rebuilding of SCL's Maple Valley – SnoKing 230 kV lines and rebuild either Sammamish – Lakeside 115 kV lines to 230 kV or Talbot Hill – Lakeside 115 kV to 230 kV, plus add a transformer at Lakeside, were not valid solutions primarily because they did not meet the transformer screening criteria. Alternative 8f, which was the rebuild of SCL's Maple Valley – SnoKing 230 kV lines and loop through a new Woodridge substation and add a transformer at Woodridge, was not a viable solution primarily because three 115 kV lines overload and not meeting the transformer screening criteria. Alternative 9bch, which was the addition of batteries, additional transformers at Talbot Hill and Lake Tradition, and an additional 115 kV transmission line from Lake Tradition to Lakeside, was not a viable solution primarily because it did not meet the transformer screening criteria.

The 2015 power flow screening resulted in six viable alternatives. Also based on the non-electrical factors described above, the six viable alternatives were reduced to five. The viable alternatives of the 2015 Solutions Study include alternatives 6d, 6e, 7d, 10d, and 10g. Of these five alternatives one, 6d, fully meets all screening criteria and other four, 6e, 7d, 10d, and 10g, marginally meets the screening criteria. For example, solution 6e marginally passed because Talbot Hill # 2 transformer had a loading of 91% for the winter screening and the criteria for passing is less than or equal to 90%. If the transformer loadings are within 3% of the criteria, then the solution is listed as marginal. Marginal also is an indication of needing the next increment of facilities. These five alternatives moved on to the longevity testing to determine if the alternatives would last 10 years without exceeding 100% of the emergency limit. Alternative 10f was screened out due to the non-electrical alternatives and also because two other similar alternatives were found to be viable.

In the 2014 Solutions Study, there are three potential 230 kV sources and four potential substation sites which meet the performance requirements, combining to make twelve electrically viable solutions. The twelve final solutions from the 2014 Solutions Report are listed in Table 5-12. Note the Source and ID numbers represent the 2014 case numbers. Based on the non-electrical factors the 12 solutions reduced to 5. The non-electrical factors include:

- Seattle City Light future need for the 230 kV lines from Maple Valley to SnoKing substations, resulting in PSE not being able to use the SCL lines to feed a PSE substation.
- Added cost to develop a new substation site versus the use of an existing site for the new 230 – 115 kV transformer.

Table 5-11: 2014 Results of Step Three Detailed Analysis - 12 Combinations of Sources and Substation Sites

2014 Study Source ID No.	2014 Study 230 kV Sources	2014 Study Site ID.	2014 Study Substation Sites
2	TAL-LAK-SAM	*b*	Westminster
4	New ROW	*c*	Vernell
6	Rebuild SCL 230 kV lines	*d*	Woodridge
		e	Lakeside

Table 5-12 lists both the 2015 and 2014 solutions and shows there is only one difference between 2014 and 2015 solutions studies. The new alternative added in the 2015 Solutions Study was 7d, which was to build new Talbot Hill-Lakeside 230 kV line on new right of way, rebuild Lakeside-Sammamish 115 kV lines and loop through Lakeside substation.

Table 5-12: Alternatives which Passed the Power Flow Screening 2015 as Compared to 2014

2015 Case #	Alternative Description	Viable Solution: 2015	Viable Solution: 2014
6d	**Transmission Line:** Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV line to 230 kV and loop through Lakeside substation **Transformer:** Add 230-115 kV transformer at Lakeside	Yes	Yes
6e	**Transmission Line:** Rebuild one Talbot Hill-Lakeside-Sammamish 115 kV line to 230 kV and loop through Westminster substation **Transformer:** Add 230-115 kV transformer at Westminster	Yes Marginal	Yes
7d	**Transmission Line:** Build new Talbot Hill-Lakeside 230 kV line on new right of way, rebuild one Lakeside-Sammamish 115 kV line to 230 kV **Transformer:** Add 230-115 kV transformer at Lakeside	Yes Marginal	Yes - as sensitivity
7e	**Transmission Line:** Build new Talbot Hill-Westminster 230 kV line on new right of way, rebuild one Westminster-Sammamish 115 kV line to 230 kV **Transformer:** Add 230-115 kV transformer at Westminster	No	Yes
10d	**Transmission Line:** Build a new Talbot Hill - Sammamish Line 230 kV on a new ROW and loop this line through Lakeside substation **Transformer:** Add 230-115 kV transformer at Lakeside	Yes Marginal	Yes
10g	**Transmission Line:** Build a new Talbot Hill - Sammamish Line 230 kV on a new ROW and loop this line through Vernell substation **Transformer:** Add 230-115 kV transformer at Vernell	Yes Marginal	Yes

5.2 Longevity

As in the 2014 Solutions Report, longevity tests were performed on the alternatives that were viable based on the power flow screening process discussed in Section 6.1.

To represent approximately 10 or more years after 2018, PSE reviewed the following cases: Heavy Winter 2023-24 at 75% conservation (5,174 MW); 2023-24 Extreme Winter at 100% conservation (5,691 MW); Heavy Summer 2024 at 75% conservation (3,817 MW), Heavy Winter at 5500 MW representing 2028 winter loading, and Heavy Summer at 4100 MW representing 2028 summer loading. As discussed below, the PSE electrical study team identified potential limitations in reliability associated with the proposed alternatives. Proxy projects to solve the identified issues were included in the analysis and are more fully described in 6.4. The proxy projects included:

- Rebuild of the Talbot Hill-Boeing Renton-Shuffleton 115 kV line between Talbot Hill and Paccar for greater capacity (identified in the 2014 study).

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- Rebuild of the remaining Talbot Hill-Lakeside 115 kV line if any portion of a Talbot Hill-Lakeside 115 kV line is used for rebuild to 230 kV (identified in the 2014 study).
- Build a new four mile 115 kV transmission line between Talbot Hill and the Mercer Island Tap and rebuild seven miles of the existing 115 kV lines across Mercer Island, including the two submarine cable crossings to Mercer Island (identified in the 2014 study).
- Install a new 230-115 kV transformer in South King County (identified in the 2014 study).
- Install a second 325 MVA 230-115 kV transformer at the new Eastside site. Construct at least one more 230 kV line and 115 kV lines adequate to distribute power from the substation (identified in the 2014 study).

These proxy projects will need to be addressed on a case by case basis. The timing for each project may vary depending on which solution is selected from this report. The future projects and their likely year of need are shown in Table 5-13.

For those alternatives where the existing PSE Talbot Hill-Sammamish 115 kV corridor is rebuilt to 230 kV, the Talbot Hill – Paccar 115 kV line rebuild and Talbot Hill-Lakeside 115 kV line rebuild are the only additions needed within the study period.

All other additional projects (Talbot Hill – Mercer Island 115 kV line, South King Area Projects, and a second Eastside 230 kV Line & Transformer) are not needed until 2028-2030 or later. The second Eastside transformer should be planned at the time of the original construction of the Eastside substation. Similarly, any measures that could be taken to prepare for the second 230 kV line to augment the 230 kV supply to the second 230-115 kV transformer should be taken under advisement.

The major findings of the longevity testing are:

1. All solutions are sufficient to meet the transmission capacity needs until 2028;
2. The addition of a second transformer in the Eastside area will reduce the loadings on Sammamish and Talbot Hill 230–115 kV transformers.
    a. Building a second 230 kV line between Sammamish and the new Eastside substation will provide needed reliability while avoiding transformer and transmission line overloads past 2028.
    b. Building a second 230 kV line between Talbot Hill and the new Eastside substation will generally be driven by future growth. If driven by local growth, it will probably be required within five years after installation of the second 230-115 kV transformer.
3. PSE's South King County improvements will reduce the loading on the Talbot Hill 230–115 kV transformers and marginally reduce the loading on Sammamish 230–115 kV transformers.

Table 5-13: Longevity Testing Results

Longevity Testing Results														
230 kV Line Source	**Site**	Approx Miles of 230 kV corridor (Total/New)	Miles of new 115 kV lines	Miles of rebuilt 115 kV lines	Need for Additional Projects *									
					Talbot Hill-Paccar 115 kV line rebuild		Talbot Hill 230 kV Bus Improvements		Talbot Hill - Mercer Island 115 kV line;		South King Area Projects		2nd Eastside Line & Transformer	
					Year	System Load	Year	System Load	Year	System Load	Year	System Load	Year	System Load
PSE Corridor Rebuild PSE corridor to two 230 kV lines from Talbot Hill to E230 site to Sammamish	**Lakeside**	16/0	0	19	2018	Concurrent with E230 project	2020	5160	2029	5570	2030+	5710	2030	5650
	Westminster	16/0	1	19	2018	Concurrent with E230 project	2020	5160	2029	5570	2029	5570	2028	5500
New Right of Way New single-circuit 230 kV line on new ROW from Talbot Hill to E230 site, and new 230 kV line on PSE ROW from new E230 site to Sammamish	**Lakeside**	18/18	0	0	2018	Concurrent with E230 project	2018	5160	2029	5570	2030+	5710	2032	5780
	Westminster	18/18	1	0	2018	Concurrent with E230 project	2020	5160	2029	5570	2029	5570	2028	5500
New Right of Way New single-circuit 230 kV line on new ROW from Talbot Hill to E230 site to Sammamish	**Lakeside**	18/18	0	0	2030+	5710	2018	5160	2030	5650	2030+	5710	2031	5710
	Vernell	18/18	2	1	2030+	5710	2020	5160	2030	5650	2029	5570	2027	5420

* "Need for Additional Projects" year and system load estimates based on linear extrapolation between 2023-24 Heavy Winter with 75% conservation (assumed to be year 2024 5,174 MW and 5,500 MW assumed to represent 2028) and 2023-24 Extreme Winter (assumed to be year 2030 with 100% conservation 5,610 MW based on linear extrapolation of Eastside area forecast)

6.0 Detailed Descriptions of the Five Solutions

Section 6.1 provides detailed electrical descriptions of the five solutions presented in Section 5.1.11 to provide a clearer electrical understanding and the associated requirements of each solution. The descriptions include points of interconnection, whether additional property is required, distribution impacts, substation requirements, and ultimate build outs. The descriptions are separated by source and then by site.

6.1 PSE Corridor

The alternatives which rebuild one of the Talbot Hill-Lakeside-Sammamish lines on the PSE Corridor to 230 kV were also studied to determine whether it was necessary to rebuild the remaining 115 kV line on the same corridor in the 2014 Solutions Study. It was found that the 115 kV line south of the new substation needed to be rebuilt to avoid overloads, while the 115 kV line north of the new substation did not require rebuilding to avoid overloads. However, looking to the future for the second 230-115 kV transformer installation, a new 230 kV line will be required to provide adequate reliability for the second transformer. Rather than return at that time to rebuild the same corridor between the new substation and Sammamish substation, it may be more efficient to rebuild both lines with this project and operate the second line at 115 kV until needed for future 230 kV operation.

6.1.1 Solution 6d - 230 kV Source on PSE Corridor – Lakeside

This solution includes a rebuild of two 115 kV transmission lines to 230 kV, thereby connecting the new Lakeside transmission substation to Talbot Hill and the Sammamish Substation. See the one-line diagram in Figure 4.

The 230 kV source to the new Lakeside substation would come from the PSE corridor, where both 115 kV transmission lines would be rebuilt (16 miles) with 230 kV Falcon conductor rated at 200°C. One line will loop into the 230 kV bus in the new portion of the Lakeside substation, while the other line will be operated at 115 kV until a second 230 kV line is needed. The 115 kV line will loop into the 115 kV bus at the existing Lakeside 115 kV switching station. The new 230 kV portion of the Lakeside substation would connect to the existing switching station with a bundled 115 kV Bittern line at 100° C.

The new transmission substation would be built on undeveloped PSE owned property located south of the existing Lakeside Switching Station at SE 30th Street and approximately 136th Avenue NE in Bellevue. The property is on PSE's transmission corridor where the two parallel Talbot Hill-Lakeside 115 kV lines are built.

If the existing 115 kV switching station had not previously been configured for breaker and a half, then a double bus section breaker would be installed to replace the existing oil-filled bus section breaker. The Lakeside-Phantom Lake and Lakeside-Lochleven lines would be swapped on the north bus to improve reliability.

The substation will be built for future second transformer layout. The second transformer will require a second 230 kV looped line and eight or more 115 kV lines to distribute the load. The 230 kV lines will be available by cutting over the rebuilt 115 kV line on the PSE corridor from 115 kV to 230 kV operation and doing some rebuild work at Rose Hill Substation. The required 115 kV lines are already located at the Lakeside 115 kV switching station.

The following requirements are noted for this project:

230 kV lines

- Remove Talbot Hill – Lakeside #1 & #2 and Sammamish – Lakeside #1 & #2 115 kV lines
- Two new lines built on PSE Corridor, 1590 Falcon conductor @ 200°C, one energized at 230 kV connecting Talbot Hill to Lakeside to Sammamish, the other energized at 115 kV connecting Talbot Hill to Lakeside to Rose Hill to Sammamish

115 kV lines

- Rebuild the three mile line section between Talbot Hill and Paccar on the Talbot Hill – Boeing Renton #2 line to 1272 Bittern conductor @ 100° C

230 kV substation

- Three bays, double-bus double-breaker
  - Two overhead lines
  - One 230-115 kV transformer

115 kV substation

- Re-use two bays vacated by Talbot Hill – Lakeside #1 and Sammamish – Lakeside #1
  - One 230-115 kV transformer
  - One capacitor installation, 2-21 MVAr banks each with a circuit switcher

Additional work required if 115 kV substation has not already been rebuilt to breaker and a half:

- A double bus section breaker would be installed to replace the existing oil filled bus section breaker
- The oil-filled breakers used for the transformer and capacitor connections would be replaced with SF6 breakers appropriately sized
- The Lakeside – Phantom Lake and Lakeside – Lochleven lines would be swapped on the north bus to improve reliability, including constructing new transmission poles outside the substation

Ultimate build-out

- 230 kV double bus double breaker with six bays
  - Two 230 kV lines initially
  - Future 2 additional 230 kV lines
  - One 325 MVA 230-115 kV transformer initially
  - Future 325 MVA 230-115 kV transformer
- No distribution transformers

Rose Hill Substation

Loop thru rebuilt Sammamish – Lakeside #2 115 kV line, rebuild any portions of loop thru limiting the 517 MVA line rating

REDACTED

Figure 4: PSE Corridor - Lakeside One Line Diagram

6.1.2 Solution 6e - 230 kV Source on PSE Corridor – Westminster

This solution includes a rebuild of two 115 kV transmission lines to 230 kV between Talbot Hill and Sammamish substations (PSE Corridor), as well as connecting to a new transmission substation called Westminster as shown on the one-line diagram Figure 5Figure 5.

The 230 kV source to the new Westminster substation would come from the PSE corridor, where both 115 kV transmission lines would be rebuilt (16 miles) to 230 kV, with Falcon conductor rated at 200°C. One line will loop into the 230 kV bus at the new substation, while the other line will be operated at 115 kV until a second 230 kV line is needed. The 115 kV line will loop into the 115 kV bus at the new substation.

The new transmission substation would be built on undeveloped property owned by PSE located at NE 24th Street and approximately 136th Avenue NE in Bellevue. The property is adjacent to PSE's transmission corridor on which the two parallel Sammamish-Lakeside 115 kV lines are built. In addition, the Sammamish-North Bellevue 115 kV line passes by the site on NE 24th Street.

The substation will be built for future second transformer layout. The second transformer will require a second 230 kV looped line and an additional four 115 kV lines to distribute the load. The 230 kV lines will be available by cutting over the rebuilt 115 kV line on the PSE corridor from 115 kV to 230 kV operation and doing some rebuild work at Rose Hill Substation.

The following requirements are noted for this project:

230 kV lines

- Remove Talbot Hill – Lakeside #1 & #2 and Sammamish – Lakeside #1 & #2 115 kV lines
- Two new lines built on PSE Corridor, 1590 Falcon conductor @ 200°C, one energized at 230 kV connecting Talbot Hill to Westminster to Sammamish, the other energized at 115 kV connecting Talbot Hill to Lakeside to Westminster to Rose Hill to Sammamish

115 kV lines

- Loop in two 115 kV lines adjacent to site
  - Sammamish – Lakeside #2 (rebuilt)
  - Sammamish – North Bellevue
- Extend and loop in Lakeside – Ardmore #1 line, ½ mile double circuit, 1272 Bittern conductor @ 100° C
- Rebuild the 3 mile line section between Talbot Hill and Paccar on the Talbot Hill – Boeing Renton #2 line to 1272 Bittern conductor @ 100° C

230 kV substation

- Three bays, double-bus double-breaker
  - Two overhead lines
  - One 230-115 kV transformer

115 kV substation

- Eight bays, breaker-and-a-half
  - Six overhead lines
  - One 230-115 kV transformer
  - One capacitor installation, 2-21 MVAr banks each with a circuit switcher

Ultimate build-out

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- 230 kV double bus double breaker with six bays
  - Two 230 kV lines initially
  - Future two additional 230 kV lines
  - 325 MVA 230-115 kV transformer initially
  - Future 325 MVA 230-115 kV transformer
- 115 kV bus breaker and a half with 12 bays
  - Eight 115 kV lines
  - Two transformers
  - Two 42 MVAr, 115 kV capacitor banks
- No distribution transformers

Rose Hill Substation

Loop thru rebuilt Sammamish – Lakeside #2 115 kV line, rebuild any portions of loop thru limiting the 517 MVA line rating.

REDACTED

Figure 5: PSE Corridor - Westminster One Line Diagram

6.2 New Right-of-Way to Talbot Hill plus PSE Right of Way to Sammamish

6.2.1 Solution 7d - 230 kV Source on New Right of Way South – Lakeside

This solution includes construction of a single 230 kV transmission line on a new transmission corridor connecting Talbot Hill to a new transmission substation at Lakeside and rebuilding the Sammamish-Lakeside 115 kV lines to 230 kV to connect the new Lakeside substation to the Sammamish Substation. See the one-line diagram in Figure 6.

The 230 kV source to the new substation would be a single 230 kV Falcon conductor line rated at 200°C, that follows a new right of way from Talbot Hill to Lakeside and then on the PSE corridor to the Sammamish Substation. This alternative does not include the PSE transmission corridor south of Lakeside, although it does include the PSE transmission corridor north of Lakeside.

If any portion of an existing Talbot Hill-Lakeside 115 kV line on the PSE corridor is used to rebuild the 115 kV line to 230 kV, the remaining Talbot Hill-Lakeside 115 kV line will be required to be rebuilt to Bittern at 100°C for added capacity.

The new transmission substation would be built on undeveloped PSE owned property located south of the existing Lakeside Switching Station at SE 30th Street and approximately 136th Avenue NE in Bellevue. The property is on PSE's transmission corridor where the two parallel Talbot Hill-Lakeside 115 kV lines are built.

If the existing 115 kV switching station had not previously been configured for breaker and a half, then a double bus section breaker would be installed to replace the existing oil-filled bus section breaker. The Lakeside-Phantom Lake and Lakeside-Lochleven lines would be swapped on the north bus to improve reliability.

The substation will be built for future second transformer layout. The second transformer will require a second 230 kV looped line and eight or more 115 kV lines to distribute the load. The 230 kV lines will be available by cutting over the rebuilt 115 kV line on the PSE corridor between Sammamish and Lakeside from 115 kV to 230 kV operation for needed reliability when the second transformer is installed, and building a new 230 kV line between Talbot Hill and Lakeside when required. Some rebuild work at Rose Hill Substation will also be required. The required 115 kV lines are already located at the Lakeside 115 kV switching station.

The following requirements are noted for this project:

230 kV lines

- Remove Sammamish – Lakeside #1 & #2 115 kV lines
- Two new lines built on PSE Corridor, 1590 Falcon conductor @ 200°C, one energized at 230 kV connecting Lakeside to Sammamish, the other energized at 115 kV connecting Lakeside to Rose Hill to Sammamish
- New single-circuit line built on new right-of-way, 1590 Falcon conductor @ 200°C, connecting Talbot Hill to Lakeside

115 kV lines

- Rebuild the three mile line section between Talbot Hill and Paccar on the Talbot Hill – Boeing Renton #2 line to 1272 Bittern conductor @ 100° C

230 kV substation

- Three bays, double-bus double-breaker
  - Two overhead lines
  - One 230-115 kV transformer

115 kV substation

- Re-use bay vacated by Sammamish – Lakeside #1
  - One 230-115 kV transformer
- Install new breaker bay
  - One capacitor installation, 2-21 MVAr banks each with a circuit switcher

Additional work required at Lakeside if 115 kV substation has not already been rebuilt to breaker and a half:

- A double bus section breaker would be installed to replace the existing oil filled bus section breaker
- The oil-filled breakers used for the transformer and capacitor connections would be replaced with SF6 breakers appropriately sized
- The Lakeside – Phantom Lake and Lakeside – Lochleven lines would be swapped on the north bus to improve reliability, including constructing new transmission poles outside the substation

Ultimate build-out

- 230 kV double bus double breaker with six bays
  - Two 230 kV lines initially
  - Future 2 additional 230 kV lines
  - One 325 MVA 230-115 kV transformer initially
  - Future 325 MVA 230-115 kV transformer
- No distribution transformers

Rose Hill Substation

Loop thru rebuilt Sammamish – Lakeside #2 115 kV line, rebuild any portions of loop thru limiting the 517 MVA line rating

REDACTED

Figure 6: New Right of Way South - Lakeside One Line Diagram

6.2.2 Solution 10d - 230 kV Source on New Right of Way – Lakeside

This solution includes construction of a single 230 kV transmission line on a new transmission corridor to connect the Talbot Hill, new Lakeside and Sammamish substations. See the one-line diagrams inFigure 7.

The 230 kV source to the new Lakeside substation would be a single 230 kV Falcon conductor line rated at 200°C between Talbot Hill, Lakeside, and the Sammamish Substation. This alternative follows a new right-of-way that does not include the PSE transmission corridor south of Lakeside, although it could include the PSE transmission corridor north of Lakeside.

The new transmission substation would be built on undeveloped property owned by PSE south of the existing Lakeside 115 kV Switching Station at SE 30th Street and approximately 136th Avenue NE in Bellevue. The property is on PSE's transmission corridor where the two parallel Talbot Hill – Lakeside 115 kV lines are built.

The 230 kV portion of the substation would connect to the existing 115 kV switching station with a bundled 115 kV Bittern line at 100° C.

The substation will be built for future second transformer layout. The second transformer will require an additional 230 kV looped line and eight 115 kV lines to distribute the load. The 115 kV lines are already constructed and connected to the existing Lakeside Switching Station 115 kV bus.

The following requirements are noted for this project:

230 kV lines

- New single-circuit line built on new right-of-way, 1590 Falcon conductor @ 200°C, connecting Talbot Hill to Lakeside to Sammamish

115 kV lines

- None

230 kV substation

- Three bays, double-bus double-breaker
  - Two overhead lines
  - One 230-115 kV transformer

115 kV substation

- Two bays, breaker-and-a-half
  - One 230-115 kV transformer
  - One capacitor installation, 2-21 MVAr banks each with a circuit switcher

Additional work required if 115 kV substation has not already been rebuilt to breaker and a half:

- A double bus section breaker would be installed to replace the existing oil filled bus section breaker
- The oil-filled breakers used for the transformer and capacitor connections would be replaced with SF6 breakers appropriately sized
- The Lakeside-Phantom Lake and Lakeside-Lochleven lines would be swapped on the north bus to improve reliability, including constructing new transmission poles outside the substation

Ultimate build-out

- 230 kV double bus double breaker with 6 bays
  - Two 230 kV lines initially
  - Future two additional 230 kV lines
  - One 325 MVA 230-115 kV transformer initially
  - Future 325 MVA 230-115 kV transformer
- No distribution transformers

REDACTED

Figure 7: New Right of Way - Lakeside One Line Diagram

6.2.3 Solution 10g - 230 kV Source on New Right of Way – Vernell

This solution includes construction of a single 230 kV transmission line on a new transmission corridor connecting Talbot Hill to a new transmission substation called Vernell and the Sammamish substation. See the one-line diagrams in Figure 8.

The 230 kV source to the new substation would be a single 230 kV Falcon conductor line rated at 200°C, from Talbot Hill to Vernell to Sammamish substation. The new 230 kV line would follow a new right-of-way that does not include the PSE transmission corridor south of Vernell, although it could include the PSE transmission corridor north of Vernell.

The new Vernell substation would be built on property owned by PSE at 116th Avenue NE and approximately NE 22nd Street in Bellevue. The Sammamish-North Bellevue 115 kV line passes by the site on 116th Avenue NE.

As part of this solution the Overlake Loop, which ends 1/8 mile from the Vernell substation site, will be rebuilt to higher capacity and extended to the new substation. It will be necessary to rebuild the Clyde Hill substation to terminate the far end of the Overlake Loop on a 115 kV bus with breakers. Alternatively, the line could be rebuilt an additional 1.2 miles and extended an additional ¼ mile to terminate at Lochleven substation; thereby eliminating the need to rebuild the Clyde Hill substation.

The substation will be built for future second transformer layout. The second transformer will require an additional 230 kV looped line and an additional four 115 kV lines to distribute the load.

The following requirements are noted for this project:

230 kV lines

- New single-circuit line built on new right-of-way, 1590 Falcon conductor @ 200°C, connecting Talbot Hill to Vernell to Sammamish

115 kV lines

- Loop in two 115 kV lines adjacent to site
  - Sammamish – North Bellevue
  - East end of Overlake Loop, rebuild one mile of Overlake Loop to 1272 Bittern conductor @ 100° C and loop thru Clyde Hill
- Build new two mile overhead line from Vernell to Ardmore, 1272 Bittern conductor @ 100 ° C

230 kV substation

- Three bays, double-bus double-breaker
  - Two overhead lines
  - One 230-115 kV transformer

115 kV substation

- Six bays, breaker-and-a-half
  - Four overhead lines
  - One 230-115 kV transformer
  - One capacitor installation, 2-21 MVAr banks each with a circuit switcher

Ultimate build-out

- 230 kV double bus double breaker with 6 bays
  - Two 230 kV lines initially
  - Future two additional 230 kV lines
  - One 325 MVA 230-115 kV transformer initially
  - Future 325 MVA 230-115 kV transformer
- 115 kV breaker and a half bus with twelve bays
  - Four lines initially
  - Future four additional 115 kV lines
  - Two 325 MVA 230-115 kV transformers (one initially)
  - Two 42 MVAr, 115 kV capacitor banks (one initially)
- Two distribution transformers and associated 12.5 kV feeders

Clyde Hill Substation

- Rebuild substation to four bay, ring bus
  - Three overhead lines
  - One 115-12.5 kV transformer

Ardmore Substation

- Add one ring bus bay for new line

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Figure 8: New Right of Way - Vernell One Line Diagram

6.3 Substation Work Required to Connect New 230 kV Lines at Sammamish and Talbot Hill Substations

If a new 230 kV line is built and terminates at Sammamish and/or Talbot Hill substations, work will be required within the established substation to accommodate the new line(s).

6.3.1 Breaker Work at Sammamish Substation

In order to connect the new 230 kV line(s) to the Sammamish 230 kV bus, the following improvements are required at Sammamish substation.

- Add a circuit breaker in a new bay located on the east or west bus. The determination of which bus is used will depend on transmission line design and which alternative solution is selected. Empty bays are available on both east and west buses to accommodate the additional breaker and line.
- Replace bus section breaker for higher capacity.

6.3.2 Bus and Breaker Work at Talbot Hill Substation

In order to connect the new 230 kV line to the Talbot Hill 230 kV bus, the following improvements are required at Talbot Hill substation, as shown on the one line diagram (Figure 9). This work is required for all alternative solutions that terminate at Talbot Hill substation, whether using the PSE corridor or a new right-of-way.

- Add a circuit breaker on the south 230 kV bus to terminate the new 230 kV line.
- Add a circuit breaker on PSE end of BPA Maple Valley – Talbot Hill #2 line. Revise the differential protection scheme on the North Bus.
- Relocate the Maple Valley – Talbot Hill #1 line to another bay position and add a circuit breaker. Revise the differential protection scheme on the South Bus.Bay H. Revise the differential protection scheme on the South Bus.

PSE is also reviewing an alternative to connect the new 230 kV line on the north Talbot Hill 230 kV bus that would require a very similar set of improvements.

- Add a circuit breaker on the north 230 kV bus to terminate the new 230 kV line.
- Add a circuit breaker on PSE end of BPA Maple Valley – Talbot Hill #2 line. Revise the differential protection scheme on the North Bus.
- Add a circuit breaker on PSE end of BPA Maple Valley – Talbot Hill #1 line. Revise the differential protection scheme on the South Bus.

PSE is also working with BPAA to study a proposed project to upgrade the 230 kV bus at Talbot Hill from the existing split main bus arrangement to a continuous bus built in a double breaker arrangement significantly improving the operational flexibility and reliability of the substation. These improvements would bring the Talbot Hill 230 kV bus up to present day design standards.

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Figure 9: Talbot Hill 230 kV Bus Improvements One Line Diagram

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6.4 Descriptions of Future Projects

During the course of this study, other issues not directly related to the Eastside 230 kV study surfaced. The following describes four future projects that conceptually resolve those issues. The expected future need dates were indicated in Table 5-13. These descriptions are preliminary and will probably change when these projects are initiated.

6.4.1 Talbot Hill – Paccar 115 kV line rebuild

Rebuild the three mile line section between Talbot Hill and Paccar on the Talbot Hill – Boeing Renton #2 115 kV line to 1272 Bittern conductor @ 100° C. The line voltage will remain 115 kV. See Figure 10.

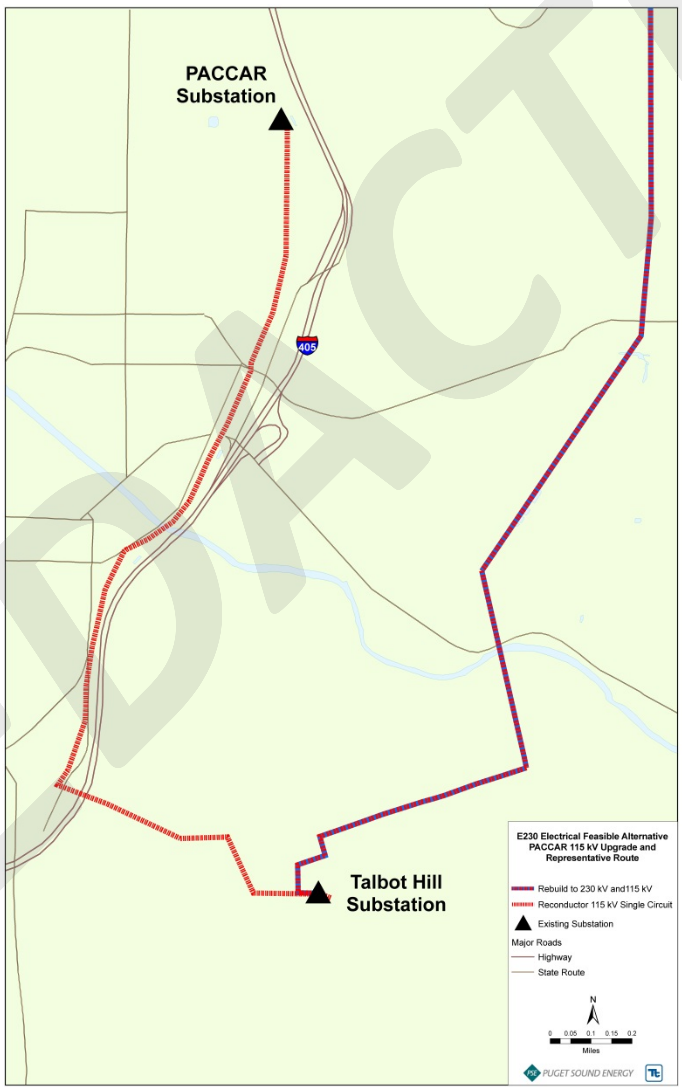

Figure 10: Talbot Hill - Paccar 115 kV Line Rebuild

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6.4.2 Talbot Hill 230 kV Bus Improvements

Work is required on the Talbot Hill 230 kV bus to prevent overloads caused by combinations of line outages in the vicinity. These are addressed in section 6.3.2.

6.4.3 Talbot Hill – Mercer Island Tap 115 kV New Line; Mercer Island 115 kV System Rebuild

- Build new Talbot Hill – Mercer Island 115 kV line
- Replace 115 kV submarine cables serving Mercer Island at north and south of island
- Rebuild six miles 115 kV lines across Mercer Island to Factoria substation.

6.4.4 South King Area Projects

The projects listed below are required to build a new 325 MVA 230-115 kV transformer in South King County to address problems in the local area in future years, 2030 or later. For this proxy project, Berrydale is used in this report. Following are the minimum requirements for the new transformer and system improvements.

- New 230-115 kV Transformer at Berrydale
- Rebuild Berrydale 230 kV bus to breaker-and-a-half
- Build four bay 230 kV system at Christopher
- Rebuild 230 kV Talbot Hill – O'Brien line
- Rebuild O'Brien – Christopher line
- New 230 kV line bay at BPA Covington
- New 8 mile 115 kV line connecting O'Brien and Berrydale

6.4.5 Second 230 kV-115 kV Transformer at New Eastside Substation

In the future, an additional 230-115 kV transformer will be required at the substation site selected under this project. Consideration should be given at the time of site selection to requirements which will be necessary to build out the future second transformer. Following are the minimum requirements for the second transformer, independent of which site is selected.

- New 325 MVA, 230 kV-115 kV transformer
- Extend new 230 kV line to the substation
- Extend new 115 kV lines to substation. The amount of lines is unknown at this time and depends on the chosen site.

For the alternatives considered, the ability to develop the substation for a second transformer will vary according to location. Power flow studies indicate that the second transformer may be needed as early as 2027 or as late as 2032, as noted in Table 5-13. The three electrical system features listed above must all be constructed in order to energize and fully load the second transformer. The substation site should be laid out to accommodate the second 230-115 kV transformer. The 230 kV line route selected will influence how much work is required to bring a second line from Sammamish and a second line from Talbot Hill in the future. The additional 115 kV transmission lines required to distribute power from the substation, estimated to be a total of six to eight 115 kV lines, may require construction through well-established areas of Bellevue, Redmond, Kirkland, Newcastle, Renton, and/or Issaquah. Of the three sites considered among the five alternatives, Lakeside is the best developed with existing 115 kV infrastructure, while Vernell is the least developed.

7.0 Conclusions of the 2015 Solutions Study Analyses using the Updated Information

The planning analysis discussed in this report has identified five alternative solutions to address the transmission capacity deficiency identified in the 2015 Needs Assessment Report. One of the five solutions, 6d, fully satisfies and the other four solutions, 6e, 7d, 10d, & 10g marginally satisfies the needs and they satisfy the solution longevity and constructability requirements established by PSE as discussed in the body of this report. For example solution 6e marginally passed because Talbot Hill # 2 transformer had a loading of 91% for the winter screening and the criteria for passing is less than or equal to 90%. If the transformer loadings are within 3% of the criteria, then the solution is listed as marginal. Marginal also is an indication of needing the next increment of facilities.

The five solutions are:

1. 6d - Rebuild one Talbot Hill-Lakeside-Sammamish Line to 230 kV and loop through Lakeside substation; add 230-115 kV transformer at Lakeside.
2. 6e - Rebuild one Talbot Hill-Lakeside-Sammamish Line to 230 kV and loop through Westminster substation; add 230-115 kV transformer at Westminster.
3. 7d - Build new Talbot Hill-Lakeside 230 kV line on new right of way, rebuild one Lakeside-Sammamish 115 kV line to 230 kV and loop through Lakeside substation; add 230-115 kV transformer at Lakeside.
4. 10d - Add a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Lakeside substation; add 230-115 kV transformer at Lakeside.
5. 10g - Add a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Vernell substation; add 230-115 kV transformer at Vernell.

There was another solution, 10f, which marginally meets the electrical criteria listed in Section 2.5.1, but is not viable for non-electrical reasons. Alternative 10f is adding a new Talbot Hill - Sammamish Line 230 kV on a new ROW and looping this line through Woodridge substation and adding a new 230-115 kV transformer at Woodridge. The Woodridge site alternative was removed from consideration since it would require additional cost to purchase the property, additional siting analysis, and there are two other viable sites that already satisfy the performance requirements.

As PSE reviewed the longevity results, the need for some additional projects became apparent. Some are minor uprates or rebuilds and have been noted in the report. Others will require new transmission lines and/or substation expansion; For example, depending on which alternative 230 kV route is selected, existing 115 kV lines between Talbot Hill and Lakeside may need to be rebuilt. Eventually a third Talbot Hill-Lakeside 115 kV line may also be required. The longevity results showed that:

- The addition of a second transformer in the Eastside area after 2028 will reduce the loadings on Sammamish and Talbot Hill 230–115 kV transformers.
- Building a second 230 kV line between Sammamish and the new Eastside substation will provide needed reliability while avoiding transformer and transmission line overloads past 2028.

- Building a second 230 kV line between Talbot Hill and the new Eastside substation will generally be driven by future growth. If driven by local growth, it will probably be required within five years after installation of the second 230-115 kV transformer.
- Building out the 115 kV infrastructure to support a second 230-115 kV transformer will vary according to which new substation site is selected.
- PSE's South King County improvements will reduce the loading on the Talbot Hill 230–115 kV transformers and marginally reduce the loading on Sammamish 230–115 kV transformers.

Based on the power flow results, the build-out of the new substation with a second 230-115 kV transformer will be approximately 10-15 years after substation construction. Of the three substation sites considered, Lakeside has the best existing 115 kV infrastructure. In addition, the second transformer will require a third 230 kV transmission line for reliability. Within a few more years, the power flow studies indicate the need for a fourth 230 kV line, completing a second 230 kV path from Sammamish to the new substation to Talbot Hill.

Based on the findings of the screening and longevity analysis, and looking out ten years beyond construction and the need for a second line and transformer, alternative 6d is found to be the preferred solution. Hence, the best long-term solution will be to:

- Build a new Eastside substation with a 230-115 kV transformer next to Lakeside substation and
- Build a new 230 kV line from Sammamish to Lakeside to Talbot Hill using the PSE corridor the full length or using the PSE corridor from Sammamish to Lakeside and a partially new corridor from Lakeside to Talbot Hill to support this transformer
- Add a second 230-115 kV transformer at the new Eastside substation in 2028
- Add a second 230 kV line from Sammamish to the new Eastside substation at the same time to support the second transformer
- As load grows in the area, add a second 230 kV line from Talbot to the new Eastside substation.

Therefore, based on the above findings, the best electrical solution to meet the needs identified in the 2014 and 2015 Needs Assessments is to build one new 230 kV line from Sammamish to Lakeside to Talbot Hill and a second line from Sammamish to Lakeside to Talbot Hill built at 230 kV and operated at 115 kV until needed and add a new 230-115 kV transformer at Lakeside substation with a provision for a second. This will provide the option to add a second transformer in the Eastside area when needed and will provide the necessary transmission capacity for now and many years into the future.

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Appendix A 2015 Solutions Study Results for Power Flow Screening

Table A-1: Case 1 Winter 2023-24 100% Conservation Cases

Case 1 Winter Summary			Base Case		1ab		1abc		1ac		1bc	
	Overloaded Element	REDACTED Worst Contingency	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading
N-1	Maple Valley - SnoKing #1 230kV		107%	113%	107%	111%	106%	110%	106%	111%	106%	110%
	Maple Valley - SnoKing #2 230kV		98%	102%	95%	99%	95%	100%	99%	103%	96%	99%
	Talbot Hill - Lakeside #1 115kV		88%	96%	58%	99%	90%	98%	84%	91%	91%	99%
			83%	92%	84%	94%	82%	89%	77%	85%	87%	95%
	Talbot Hill - Lakeside #2 115kV		88%	92%	67%	96%	90%	94%	84%	88%	91%	96%
	Talbot Hill XFMR #1 230/115kV		88%	90%	65%	66%	60%	62%	80%	80%	61%	62%
	Talbot Hill XFMR #2 230/115kV		89%	93%	68%	70%	62%	64%	81%	82%	64%	66%
			87%	90%	84%	87%	77%	78%	79%	80%	79%	81%
N-2	Talbot Hill - Lakeside #1 115kV		90%	99%	95%	102%	94%	99%	****	94%	94%	102%
	Talbot Hill - Lakeside #2 115kV		94%	103%	93%	102%	95%	104%	90%	98%	104%	112%
	Maple Valley - SnoKing #1 230kV		113%	119%	114%	115%	110%	115%	****	115%	110%	114%

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Case 1 Winter Summary

			Base Case		1ab		1abc		1ac		1bc	
	Overloaded Element	REDACTED Worst Contingency	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading
	Maple Valley - SnoKing #2 230kV		104%	109%	102%	104%	102%	105%	****	107%	100%	103%
N-1-1	Talbot Hill - Lakeside #1 115kV		113%	124%	117%	127%	115%	124%	109%	117%	117%	127%
			103%	114%	104%	113%	102%	111%	95%	104%	107%	117%
	Talbot Hill - Lakeside #2 115kV		113%	121%	117%	124%	115%	121%	108%	114%	117%	124%
			103%	111%	104%	111%	102%	108%	95%	102%	107%	115%
	Midway-Sweptwng 115 ckt 1		87%	95%	87%	95%	87%	94%	88%	95%	88%	95%
	Maple Valley - SnoKing #1 230kV		144%	150%	140%	145%	139%	144%	141%	146%	138%	143%
	Maple Valley - SnoKing #2 230kV		131%	137%	116%	120%	116%	120%	119%	124%	116%	119%
	Talbot Hill - Paccar 115kV		101%	103%	105%	106%	96%	98%	91%	92%	98%	99%
			97%	100%	99%	101%	89%	91%	85%	87%	93%	95%

Case 1 Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	1ab 17-18 HW % Loading	1ab 23-24 HW % Loading	1abc 17-18 HW % Loading	1abc 23-24 HW % Loading	1ac 17-18 HW % Loading	1ac 23-24 HW % Loading	1bc 17-18 HW % Loading	1bc 23-24 HW % Loading
Nelson-S Center 115kV		94%	102%	93%	102%	93%	101%	94%	102%	94%	102%
Berrydale XFMR #1 230/115 kV		95%	95%	81%	80%	76%	74%	86%	85%	76%	75%
O'Brien XFMR #1 230/115 kV		98%	98%	86%	77%	81%	81%	90%	90%	73%	80%
		94%	94%	81%	77%	78%	77%	88%	87%	73%	77%
		91%	90%	83%	80%	77%	79%	84%	84%	77%	77%
O'Brien XFMR #2 230/115 kV		99%	99%	85%	84%	81%	80%	91%	91%	81%	81%
		95%	95%	82%	77%	78%	77%	88%	88%	78%	78%
		94%	93%	85%	81%	81%	67%	88%	87%	79%	79%
		94%	93%	81%	80%	78%	78%	88%	88%	79%	79%

Case 1 Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case		1ab		1abc		1ac		1bc	
		17-18 HW	23-24 HW	17-18 HW	23-24 HW	17-18 HW	23-24 HW	17-18 HW	23-24 HW	17-18 HW	23-24 HW
		% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
		93%	93%	86%	84%	79%	83%	89%	89%	83%	83%
		92%	91%	84%	80%	78%	77%	85%	85%	78%	77%
		92%	92%	88%	85%	78%	85%	88%	87%	84%	84%
		91%	91%	84%	83%	65%	85%	88%	88%	83%	83%
		91%	91%	83%	82%	79%	79%	86%	86%	80%	79%
		91%	90%	83%	81%	78%	80%	86%	85%	79%	79%
White River XFMR #2 230/115 kV		92%	89%	88%	86%	87%	85%	90%	88%	88%	85%
Talbot Hill XFMR #1 230/115kV		101%	103%	74%	75%	68%	69%	91%	91%	70%	70%
Talbot Hill XFMR #1 230/115kV		98%	100%	72%	72%	66%	67%	90%	90%	68%	69%
		96%	97%	70%	71%	66%	66%	87%	87%	67%	67%

Case 1 Winter Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	1ab 17-18 HW % Loading	1ab 23-24 HW % Loading	1abc 17-18 HW % Loading	1abc 23-24 HW % Loading	1ac 17-18 HW % Loading	1ac 23-24 HW % Loading	1bc 17-18 HW % Loading	1bc 23-24 HW % Loading
			91%	92%	69%	69%	62%	65%	84%	83%	66%	66%
			93%	91%	65%	66%	60%	62%	80%	80%	62%	63%
			94%	91%	66%	67%	62%	64%	82%	82%	63%	64%
			93%	91%	65%	66%	60%	61%	80%	80%	62%	63%
			96%	91%	65%	66%	61%	61%	80%	80%	62%	63%
	Talbot Hill XFMR #2 230/115kV		105%	108%	88%	80%	71%	72%	94%	94%	72%	74%
			105%	108%	100%	103%	90%	91%	92%	93%	92%	95%
			102%	105%	76%	78%	70%	70%	91%	92%	71%	73%
			101%	104%	76%	78%	70%	71%	88%	91%	72%	73%

DSD 004418

Case 1 Winter Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	1ab 17-18 HW % Loading	1ab 23-24 HW % Loading	1abc 17-18 HW % Loading	1abc 23-24 HW % Loading	1ac 17-18 HW % Loading	1ac 23-24 HW % Loading	1bc 17-18 HW % Loading	1bc 23-24 HW % Loading
			96%	99%	77%	78%	71%	73%	88%	88%	72%	74%
			94%	97%	69%	72%	64%	65%	83%	84%	67%	69%
			93%	97%	69%	72%	66%	65%	83%	84%	66%	68%
			93%	97%	70%	72%	64%	68%	83%	84%	66%	68%
			93%	96%	74%	75%	71%	73%	84%	81%	69%	71%
			92%	96%	70%	72%	64%	65%	84%	85%	66%	68%
			92%	95%	70%	72%	64%	65%	68%	85%	66%	68%
			91%	94%	72%	74%	65%	65%	81%	81%	67%	68%
			91%	93%	72%	74%	66%	66%	82%	82%	67%	69%

Case 1 Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	1ab 17-18 HW % Loading	1ab 23-24 HW % Loading	1abc 17-18 HW % Loading	1abc 23-24 HW % Loading	1ac 17-18 HW % Loading	1ac 23-24 HW % Loading	1bc 17-18 HW % Loading	1bc 23-24 HW % Loading
Mer. Is. T - Shuffleton 115 kV		91%	91%	69%	69%	66%	64%	79%	80%	65%	68%
		85%	94%	85%	92%	84%	91%	82%	88%	91%	98%
Avondale-Cottage Brook 115		90%	37%	98%	42%	98%	42%	96%	41%	94%	40%

Table A-2: Case 1 Winter 2023-24 75% Conservation Cases

Case 1 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	1ab 75cons 23-24HW % Loading	1abc 75cons 23-24HW % Loading	1ac 75cons 23-24HW % Loading
N-1	Talbot Hill XFMR #2 230/115 kV		93%	-	-	-
	Monroe-Novelty Hill 230 kV		140%	-	-	142%
			112%	-	-	112%
	Maple Valley-SnoKing 230 kV #1		111%	112%	111%	-
	Talbot Hill-Lakeside 115 kV Ckt #1		96%	102%	99%	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #1		99%	104%	102%	-
	Talbot Hill-Lakeside 115 kV Ckt #2		103%	105%	106%	100%
			88%	100%	-	-
	Maple Valley-SnoKing 230 kV #1		119%	117%	116%	116%
	Maple Valley-SnoKing 230 kV #2		109%	-	-	99%
	Talbot Hill XFMR #1 230/115 kV		90%	-	-	-
	Talbot Hill XFMR #2 230/115 kV		96%	-	-	-
			90%	-	-	-
N-1-1	Talbot Hill XFMR #1 230/115 kV		n/a	-	-	-
			103%	-	-	94%
			n/a	n/a	-	93%
			100%	-	-	92%

Case 1 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	1ab 75cons 23-24HW % Loading	1abc 75cons 23-24HW % Loading	1ac 75cons 23-24HW % Loading
			99%	-	-	91%
			97%	-	-	90%
			99%	-	-	90%
	Talbot Hill XFMR #2 230/115 kV		n/a	n/a	-	100%
			n/a	n/a	-	98%
			n/a	91%	-	-
			108%	-	-	97%
			105%	-	-	94%
			102%	-	-	93%
			n/a	-	-	91%
			108%	105%	93%	95%
	Talbot Hill XFMR #3 230/115 kV		n/a	-		n/a
	O'Brien XFMR #2 230/115 kV		-	-	-	91%
	Berrydale XFMR #1 230/115 kV		91%	-	-	-
			n/a	n/a	-	-

Case 1 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	1ab 75cons 23-24HW % Loading	1abc 75cons 23-24HW % Loading	1ac 75cons 23-24HW % Loading
			95%	-	-	-
	Talbot Hill-Lakeside 115 kV Ckt #1		124%	130%	126%	120%
			114%	116%	114%	107%
	Talbot Hill-Lakeside 115 kV Ckt #2		121%	127%	123%	117%
			111%	114%	111%	105%
	Maple Valley-SnoKing 230 kV #1		150%	146%	146%	147%
	Maple Valley-SnoKing 230 kV #2		137%	121%	121%	125%
	Maple Valley-Sammamish 230 kV		-	-	95%	-
	Talbot-Paccar 115 kV		103%	109%	100%	-
			100%	104%	-	-
	Berrydale - Covington 230kV		99%	100%	100%	
	Nelson-S Center 115 kV		102%	104%	104%	104%

Table A-3: Case 1 Summer 2024 100% Conservation Cases

Case 1 Summer Summary			Base Case		1ab		1abc		1ac		1bc	
	Overloaded Element	REDACTED Worst Contingency	18 HS % Loading	24 HS % Loading	18 HS % Loading	24 HS % Loading	18 HS % Loading	24 HS % Loading	18 HS % Loading	24 HS % Loading	18 HS % Loading	24 HS % Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	104%	101%	104%	101%	104%	101%	103%	100%
N-2	Monroe-Novelty Hill 230kV		104%	101%	104%	101%	104%	101%	104%	101%	103%	100%
	Maple Valley - SnoKing #1 230kV		117%	94%	115%	105%	116%	106%	116%	105%	117%	107%
	Maple Valley - SnoKing #2 230kV		106%	105%	100%	94%	100%	94%	98%	93%	101%	96%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	164%	160%	164%	160%	165%	160%	164%	159%
	Beverly-Hiltnlkt 115kV		111%	108%	107%	104%	106%	102%	108%	104%	106%	101%
	Maple Valley - SnoKing #1 230kV		106%	87%	104%	88%	105%	88%	104%	88%	107%	90%
	Sammamish XFMR #1 230/115kV		104%	109%	66%	79%	61%	70%	61%	69%	91%	95%
	Sammamish XFMR #2 230/115kV		110%	115%	72%	84%	65%	75%	65%	73%	96%	100%
	Novelty XFMR #1 230/115kV		102%	100%	99%	97%	98%	95%	102%	99%	99%	97%
	O'Brien-Asbury 115kV		96%	98%	96%	98%	96%	98%	96%	100%	96%	100%

Table A-4: Case 2 adj Winter 2023-24 100% Conservation Cases

Case 2 adj Winter Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	2ab 17-18 HW % Loading	2ab 23-24 HW % Loading	2ac 17-18 HW % Loading	2ac 23-24 HW % Loading	2bc 17-18 HW % Loading	2bc 23-24 HW % Loading
N-1	Maple Valley - SnoKing #1 230kV		107%	113%	104%	108%	105%	109%	102%	105%
N-2	Berrydale XFMR 230/115kV #1		91%	90%			93%	93%		
			96%	87%			93%			
	Maple Valley - SnoKing #1 230kV		113%	119%	107%	112%	109%	113%	105%	109%
N-1-1	Talbot Hill - Lakeside #1 115kV		113%	124%				106%		
	Talbot Hill - Lakeside #2 115kV		113%	121%				103%		
	Maple Valley - SnoKing #1 230kV		144%	150%	135%	140%	138%	143%	133%	137%
	Maple Valley - SnoKing #2 230kV		131%	137%			117%	120%	110%	114%
	Berrydale-Covington 230 kV		96%	99%		99%				
	Berrydale XFMR #1 230/115 kV		93%	93%			95%	95%	92%	92%
			94%	93%	****	****	97%	97%	91%	****
			N/A	N/A			98%	98%	91%	91%

Case 2 adj Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	2ab 17-18 HW % Loading	2ab 23-24 HW % Loading	2ac 17-18 HW % Loading	2ac 23-24 HW % Loading	2bc 17-18 HW % Loading	2bc 23-24 HW % Loading
Talbot Hill XFMR #1 230/115kV		101%	103%			91%	91%		
Talbot Hill XFMR #2 230/115kV		105%	108%	103%	104%	92%	92%	96%	98%
		N/A	N/A			93%	95%		
		N/A	N/A			95%	97%		
		N/A	N/A		92%				

Table A-5: Case 2 adj Winter 2023-24 75% Conservation Cases

Case 2 adj Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	2ab adj 75cons 23-24HW % Loading	2ac adj 75cons 23-24HW % Loading	2bc adj 75cons 23-24HW % Loading
N-1	Talbot Hill XFMR #2 230/115 kV		93%	-	-	-
	Monroe-Novelty Hill 230 kV		140%	-	143%	-
			112%	-	117%	-
	Maple Valley-SnoKing 230 kV #1		111%	108%	110%	106%
	Talbot Hill-Lakeside 115 kV Ckt #1		96%	-	-	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #1		99%	-	-	-
	Talbot Hill-Lakeside 115 kV Ckt #2		103%	-	-	-
			88%	-	-	-
	Maple Valley-SnoKing 230 kV #1		119%	113%	114%	110%
	Maple Valley-SnoKing 230 kV #2		109%	-	-	-
	Talbot Hill XFMR #1 230/115 kV		90%	-	-	-
	Talbot Hill XFMR #2 230/115 kV		96%	-	-	-
			90%	92%	-	-
N-1-1	Talbot Hill XFMR #1 230/115 kV		n/a	91%	-	-
			103%	-	93%	-

Case 2 adj Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	2ab adj 75cons 23-24HW % Loading	2ac adj 75cons 23-24HW % Loading	2bc adj 75cons 23-24HW % Loading
			n/a	n/a	91%	-
			100%	-	90%	-
			99%	-	-	-
			97%	-	-	-
			99%	-	-	-
	Talbot Hill XFMR #2 230/115 kV		n/a	n/a	98%	-
			n/a	n/a	96%	-
			n/a	95%	-	-
			108%	-	96%	-
			105%	-	93%	-
			102%	-	91%	-
			n/a	-	-	-
			108%	108%	94%	101%
	Talbot Hill XFMR #3 230/115 kV		n/a	93%	n/a	
	O'Brien XFMR #2 230/115 kV		-	-	90%	-

Case 2 adj Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	2ab adj 75cons 23-24HW % Loading	2ac adj 75cons 23-24HW % Loading	2bc adj 75cons 23-24HW % Loading
	Berrydale XFMR #1 230/115 kV		91%	-	97%	94%
			n/a	n/a	100%	93%
			95%	-	93%	-
	Talbot Hill-Lakeside 115 kV Ckt #1		124%	-	-	-
			114%	-	-	-
	Talbot Hill-Lakeside 115 kV Ckt #2		121%	-	105%	-
			111%	-	-	-
	Maple Valley-SnoKing 230 kV #1		150%	141%	144%	138%
	Maple Valley-SnoKing 230 kV #2		137%	116%	122%	115%
	Maple Valley-Sammamish 230 kV		-	-	-	105%
	Talbot-Paccar 115 kV		103%	-	-	-
			100%	-	-	-
	Berrydale - Covington 230kV		99%	101%		101%
	Nelson-S Center 115 kV		102%	104%	104%	104%

Table A-6: Case 2 adj Summer 2024 100% Conservation Cases

Case 2 adj Summer Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 18 HS % Loading	Base Case 24 HS % Loading	2ab adj 18 HS % Loading	2ab adj 24 HS % Loading	2ac adj 18 HS % Loading	2ac adj 24 HS % Loading	2bc adj 18 HS % Loading	2bc adj 24 HS % Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	105%	101%	105%	102%	103%	100%
N-2	Monroe-Novelty Hill 230kV		143%	140%	104%	101%	104%	102%	103%	100%
			122%	124%	120%	121%	123%	125%	117%	118%
	Maple Valley - SnoKing #1 230kV		117%	105%	115%	105%	116%	105%	117%	107%
			97%	81%	-	-	-	-	98%	-
	Maple Valley - SnoKing #2 230kV		91%	73%	119%	119%	119%	119%	119%	118%
			106%	94%	100%	-	98%	-	101%	-
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	164%	160%	165%	160%	163%	159%
	Maple Valley - SnoKing #1 230kV		106%	87%	104%	-	104%	-	107%	-
	Beverly-Cottage Brook 115kV		111%	108%	105%	100%	108%	103%	103%	98%
	Novelty XFMR #1 230/115 kV		102%	100%	99%	97%	98%	96%	99%	97%
	Sammamish XFMR #1 230/115kV		104%	109%	-	-	-	-	-	91%
	Sammamish XFMR #2 230/115kV		110%	115%	-	-	-	-	93%	96%

Table A-7: Case 3 Winter 2023-24 100% Conservation

Case 3 Winter Summary			Base Case		3a		3b	
			17-18 HW	23-24 HW	17-18 HW	23-24 HW	17-18 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	NONE IN CASE 3 HW		-	-	-	-	-	-
N-2	Berrydale XFMR #1 230/115 kV		96%	87%	91%	-	-	-
N-1-1	Talbot Hill XFMR #1 230/115kV		101%	103%	95%	96%	-	-
			98%	100%	92%	92%	-	-
			97%	99%	92%	92%	-	-
			97%	99%	91%	92%	-	-
	Talbot Hill XFMR #2 230/115kV		105%	108%	98%	101%	-	-
			103%	106%	97%	100%	99%	103%
			102%	105%	97%	99%	-	-
			101%	104%	94%	96%	-	-
	Sammamish XFMR #2 230/115 kV		89%	88%	-	-	-	93%
	Talbot Hill - Lakeside #1 115kV		103%	114%	-	-	-	107%
	Talbot Hill - Lakeside #2 115kV		103%	111%	-	-	-	105%
	Maple Valley - SnoKing #1 230kV		N/A	N/A	106%	110%	105%	109%

Table A-8: Case 3 Summer 2024 100% Conservation Cases

Case 3 Summer Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case		3a		3b	
			18 HS	24 HS	18 HS	24 HS	18 HS	24 HS
			% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	NONE IN CASE 3 HS		-	-	-	-	-	-
N-2	Maple Valley - SnoKing #1 230kV		117%	94%	114%	104%	115%	105%
	Maple Valley - SnoKing #2 230kV		106%	105%	-	-	101%	-
N-1-1	Monroe-Novelty Hill 230kV		N/A	N/A	104%	101%	103%	100%
	Sammamish XFMR #1 230/115kV		104%	109%	-	-	92%	97%
	Sammamish XFMR #2 230/115kV		110%	115%	-	-	97%	103%

Table A-9: Case 4 Winter 2023-24 100% Conservation Cases

Case 4 Winter Summary

			Base Case		4d	
			17-18 HW	23-24 HW	17-18 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading
N-1	NONE IN CASE 3 HW	-	-	-	-	-
N-2	Berrydale XFMR #1 230/115 kV		96%	87%	94%	-
N-1-1	Talbot Hill XFMR #1 230/115kV		101%	103%	96%	96%
			98%	100%	93%	93%
			97%	99%	92%	92%
			97%	99%	93%	92%
	Talbot Hill XFMR #2 230/115kV		105%	108%	100%	101%
			103%	106%	98%	99%
			102%	105%	96%	97%
			101%	105%	96%	97%
			101%	104%	94%	95%
	White River XFMR #2 230/115 kV		92%	89%	91%	-

REDACTED

Case 4 Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	4d 17-18 HW % Loading	4d 23-24 HW % Loading
O'Brien XFMR #2 230/115 kV		95%	95%	91%	-
		99%	99%	90%	-
		93%	93%	90%	-
Berrydale XFMR #1 230/115 kV		95%	95%	93%	91%
		98%	98%	91%	90%
Talbot Hill - Lakeside #1 115kV		113%	124%	100%	108%
Talbot Hill - Lakeside #2 115kV		113%	121%	100%	105%

Table A-10: Case 4 Summer 2024 100% Conservation Cases

Case 4 Summer Summary

			Base Case		4d	
	Overloaded Element	**REDACTED Worst Contingency**	**18 HS % Loading**	**24 HS % Loading**	**18 HS % Loading**	**24 HS % Loading**
N-1	Monroe-Novelty Hill 230kV		104%	101%	104%	101%
N-2	Monroe-Novelty Hill 230kV		104%	101%	101%	101%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	166%	161%
	Beverly-Cottage Brook 115 kV		111%	108%	107%	103%
	Novelty XMFR 230/115 kV #1		96%	98%	97%	96%

Table A-11: Case 5 Winter 2023-24 100% Conservations Cases

Case 5 Winter Summary			Base Case		5d	
			17-18 HW	23-24 HW	17-18 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading
N-1	Lakeside XFMR #1 230/115 kV		N/A	N/A	104%	107%
N-2	Lakeside XFMR #1 230/115 kV		N/A	N/A	105%	109%
N-1-1	Lakeside XFMR #1 230/115 kV		N/A	N/A	118%	122%
			N/A	N/A	106%	110%
			N/A	N/A	-	108%
			N/A	N/A	98%	102%
			N/A	N/A	98%	102%
			N/A	N/A	-	100%
			N/A	N/A	-	100%
			N/A	N/A	-	100%
			N/A	N/A	-	99%
			N/A	N/A	-	99%

Case 5 Winter Summary

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	5d 17-18 HW % Loading	5d 23-24 HW % Loading
		N/A	N/A	-	99%
		N/A	N/A	-	99%
		N/A	N/A	-	99%
		N/A	N/A	-	99%
		N/A	N/A	-	98%
Shuffleton-Lakeside 115 kV #1		N/A	N/A	106%	113%
		N/A	N/A	-	105%
Talbot Hill-Boeing Renton-Shuffleton 115 kV		N/A	N/A	120%	124%
Nelson-S Center 115 kV		94%	102%	-	102%
Berrydale-Covington 230 kV		96%	99%	-	101%
O'Brien N-Shuffleton 115 kV		N/A	N/A	-	101%

Table A-12: Case 5 Summer 2024 100% Conservation Cases

Case 5 Summer Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 18 HS % Loading	Base Case 24 HS % Loading	5d 18 HS % Loading	5d 24 HS % Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	101%	-
N-2	Monroe-Novelty Hill 230kV		104%	101%	101%	-
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	164%	159%
	Beverly-Cottage Brook 115 kV		109%	108%	99%	-
	Maple Valley-Talbot Hill 230 kV #2		77%	73%	94%	-
	Sammamish XFMR #2 230/115 kV		114%	124%	98%	103%
			N/A	N/A	88%	94%
	Sammamish XFMR #1 230/115 kV		109%	117%	93%	98%

Table A-13: Case 6 Winter 2023-24 100% Conservation Cases

Case 6 Winter Summary			Base Case		6d		6e	
			17-18 HW	23-24 HW	17-18 HW	23-24 HW	17-18 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	Maple Valley - SnoKing #1 230kV		107%	113%	-	100%	-	100%
N-2	Maple Valley - SnoKing #1 230kV		113%	119%	100%	104%	100%	104%
N-1-1	Maple Valley - SnoKing #1 230kV		144%	150%	121%	125%	121%	125%
	Talbot Hill-Asbury 115 kV		-	94%	-	102%	-	102%
	Maple Valley - SnoKing #2 230kV		131%	137%	-	101%	-	101%
	Avondale-Cottage Brook 115 kV		90%	37%	-	-	98%	-
	Talbot Hill XFMR #2 230/115 kV		105%	108%	97%	100%	98%	98%

Table A-14: Case 6 Winter 2023-24 75% Conservation Cases

Case 6 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	6d 75cons 23-24HW % Loading	6e 75cons 23-24HW % Loading
N-1	Talbot Hill XFMR #2 230/115 kV		93%	-	-
N-1	Maple Valley-SnoKing 230 kV #1		113%	101%	101%
N-1	Talbot Hill-Lakeside 115 kV Ckt #1		96%	-	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #1		99%	-	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #2		103%	-	-
N-2	Maple Valley-SnoKing 230 kV #1		-	104%	104%
N-2	Talbot Hill XFMR #1 230/115 kV		90%	-	-
N-2	Talbot Hill XFMR #2 230/115 kV		96%	-	-
N-2	Talbot Hill XFMR #2 230/115 kV		90%	-	-
N-2	Berrydale - Covington 230kV		94%	99%	99%
N-1-1	Talbot Hill XFMR #2 230/115 kV		108%	-	91%
N-1-1	Talbot Hill XFMR #2 230/115 kV		108%	101%	101%
N-1-1	Talbot Hill XFMR #2 230/115 kV		105%	-	-
N-1-1	Talbot Hill XFMR #2 230/115 kV		102%	-	-
N-1-1	Maple Valley-SnoKing 230 kV #1		150%	126%	126%

REDACTED

Case 6 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	6d 75cons 23-24HW % Loading	6e 75cons 23-24HW % Loading
	Talbot Hill-Paccar 115 kV		100%	-	98%
	Berrydale - Covington 230kV		99%	**	105%
	Nelson - Southcenter 115kV		102%	104%	104%
	Maple Valley-SnoKing 230 kV #2		137%	101%	101%

Table A-15: Case 6 Summer 2024 100% Conservation Cases

Case 6 Summer Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 18 HS % Loading	Base Case 24 HS % Loading	6d 18 HS % Loading	6d 24 HS % Loading	6e 18 HS % Loading	6e 24 HS % Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%
N-2	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	161%	163%	169%	164%
	O'Brien-Harvest 115 kV		98%	100%	-	100%	-	100%
	Sammamish XFMR #2 230/115 kV		114%	124%	-	90%	-	-
	Novelty XFMR #1 230/115 kV		102%	100%	100%	98%	101%	98%

Table A-16: Case 7 Winter 2023-24 100% Conservation Cases

Case 7 Winter Summary

	Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	7d 17-18 HW % Loading	7d 23-24 HW % Loading	7e 17-18 HW % Loading	7e 23-24 HW % Loading
N-1	Maple Valley - SnoKing #1 230kV		107%	113%	-	100%	-	100%
N-2	Maple Valley - SnoKing #1 230kV		113%	119%	-	104%	-	-
N-1-1	Maple Valley - SnoKing #1 230kV		144%	150%	122%	125%	121%	125%
N-1-1	Talbot Hill-Asbury 115 kV		-	94%	-	102%	-	102%
N-1-1	Maple Valley - SnoKing #2 230kV		131%	137%	98%	101%	-	101%
N-1-1	Avondale-Cottage Brook 115 kV		90%	37%	98%	-	99%	-
N-1-1	Talbot Hill XFMR #2 230/115 kV		105%	108%	100%	103%	100%	101%
N-1-1	Talbot Hill XFMR #2 230/115 kV		105%	108%	-	92%	92%	93%
N-1-1	Talbot Hill XFMR #2 230/115 kV		102%	105%	-	90%	-	92%

Table A-17: Case 7 Winter 2023-24 75% Conservation Cases

Case 7 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	7d 75cons 23-24HW % Loading	7e 75cons 23-24HW % Loading
N-1	Talbot Hill XFMR #2 230/115 kV		93%	-	-
N-1	Maple Valley-SnoKing 230 kV #1		113%	101%	100%
N-1	Talbot Hill-Lakeside 115 kV Ckt #1		96%	-	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #1		99%	-	-
N-2	Talbot Hill-Lakeside 115 kV Ckt #2		103%	-	-
N-2	Maple Valley-SnoKing 230 kV #1		-	104%	104%
N-2	Talbot Hill XFMR #1 230/115 kV		90%	-	-
N-2	Talbot Hill XFMR #2 230/115 kV		96%	-	-
			90%	-	-
N-2	Berrydale - Covington 230kV		94%	99%	98%
N-1-1	Talbot Hill XFMR #2 230/115 kV		108%	93%	95%
			108%	105%	104%
			105%	92%	94%
			102%	-	91%
N-1-1	Maple Valley-SnoKing 230 kV #1		150%	126%	126%
N-1-1	Talbot Hill-Paccar 115 kV		100%	-	-

Case 7 Winter Summary - 75% Conservation

			Base Case	7d 75cons	7e 75cons
	Overloaded Element	REDACTED Worst Contingency	23-24HW	23-24HW	23-24HW
			% Loading	% Loading	% Loading
	Berrydale - Covington 230kV		99%	**	104%
	Nelson - Southcenter 115kV		102%	104%	104%
	Maple Valley-SnoKing 230 kV #2		137%	102%	102%

Table A-18: Case 7 Summer 2024 100% Conservation Cases

Case 7 Summer Summary

			Base Case		7d		7e	
			18 HS	24 HS	18 HS	24 HS	18 HS	24 HS
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%
N-2	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%
	Maple Valley - SnoKing #1 230kV		117%	105%	111%	102%	111%	102%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	169%	163%	169%	164%
	O'Brien-Harvest 115 kV		98%	100%	-	100%	-	100%
	Novelty XFMR #1 230/115 kV		102%	100%	100%	98%	101%	98%

Table A-19: Case 8 Winter 2023-24 100% Conservation Cases

Case 8 Winter Summary

			Base Case		8f	
			17-18 HW	23-24 HW	17-18 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading
N-1	NONE IN THIS STUDY		-	-	-	-
N-2	NONE IN THIS STUDY		-	-	-	-
N-1-1	Woodridge-Factoria 115 kV		N/A	N/A	107%	110%
	Talbot Hill-Asbury 115 kV		-	94%	-	102%
	Talbot N-Lakeside 115 kV		N/A	N/A	-	100%
	Talbot Hill XFMR #2 230/115kV		N/A	N/A	-	90%

Table A-20: Case 8 Winter 2023-24 75% Conservation

Case 8 Winter Summary - 75% Conservation

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24HW % Loading	8f 75cons 23-24HW % Loading
N-1	NONE IN CASE 8 HW			
N-2	Center-Woodridge 115 kV		n/a	116%
	Talbot Hill-Lakeside 115 kV Ckt #1		99%	-
	Talbot Hill-Lakeside 115 kV Ckt #2		103%	-
	Talbot Hill XFMR #1 230/115 kV		90%	-
	Talbot Hill XFMR #2 230/115 kV		96%	-
			90%	-
	Talbot Hill XFMR #2 230/115 kV		108%	90%
			105%	-
			102%	-
			108%	-
			n/a	92%
			n/a	92%
	Talbot Hill-Lakeside 115 kV Ckt #1		n/a	102%
			124%	-
			114%	-
	Woodridge-Factoria 115 kV Ckt #1		n/a	113%

	Woodridge-Lakeside 115 kV Ckt #1		n/a	109%
	Center-Woodridge 115 kV		n/a	100%
	Nelson-S Center 115 kV		102%	104%

Table A-21: Case 8 Summer 2024 100% Conservation Cases

Case 8 Summer Summary			Base Case		8f	
			18 HS	24 HS	18 HS	24 HS
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	99%	96%
N-2	Monroe-Novelty Hill 230kV		104%	101%	99%	96%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	163%	158%
	O'Brien-Harvest 115 kV		98%	100%	-	100%
	Woodridge-Factoria 115 kV		N/A	N/A	99%	-
	Sammamish XFMR #2 230/115 kV		110%	115%	91%	94%
			104%	102%	90%	-
	Novelty XFMR #1 230/115 kV		102%	100%	96%	94%

Table A-22: Case 9 Winter 2023-24 100% Conservation Cases

Case 9 Winter Summary			Base Case		9		9-75cons
			17-18 HW	23-24 HW	17-18 HW	23-24 HW	23-24 HW
	Overloaded Element	REDACTED Worst Contingency	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	Maple Valley - SnoKing #1 230kV		107%	113%	104%	108%	108%
N-2	Maple Valley - SnoKing #1 230kV		113%	119%	108%	112%	113%
N-1-1	Berrydale-Covington 230 kV		82%	96%	-	98%	99%
	Talbot-Talbot S 115 kV (bus section)		66%	64%	-	-	98%
	Maple Valley - SnoKing #1 230kV		144%	150%	136%	141%	141%
	Maple Valley - SnoKing #2 230kV		131%	137%	113%	117%	118%
	Talbot Hill XFMR #2 230/115 kV		105%	108%	94%	96%	97%

Table A-23: Case 9 Summer 2024 100% Conservation Cases

Case 9 Summer Summary

			Base Case		9	
	Overloaded Element	**REDACTED Worst Contingency**	**18 HS % Loading**	**24 HS % Loading**	**18 HS % Loading**	**24 HS % Loading**
N-1	Monroe-Novelty Hill 230kV		104%	101%	103%	100%
N-2	Monroe-Novelty Hill 230kV		104%	101%	103%	100%
	Maple Valley - SnoKing #1 230kV		117%	105%	118%	107%
	Maple Valley - SnoKing #2 230kV		100%	94%	102%	-
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	164%	158%
	Maple Valley - SnoKing #1 230kV		106%	87%	106%	-
	Beverly-Hiltnlkt 115		111%	108%	103%	-
	Sammamish XFMR #1 230/115 kV		104%	109%	-	90%
	Sammamish XFMR #2 230/115 kV		110%	115%	92%	96%
	Novelty XFMR #1 230/115 kV		102%	100%	99%	96%

Table A-24: Case 10 Winter 2023-24 100% Conservation Cases

Case 10 Winter Summary			Base Case		10d		10f		10g	
	Overloaded Element	REDACTED Worst Contingency	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading
N-1	NONE for Case 10 HW									
N-2	Maple Valley - SnoKing #1 230kV		113%	119%	100%	-	99%	103%	99%	103%
N-1-1	Maple Valley - SnoKing #1 230kV		144%	150%	122%	126%	121%	124%	121%	125%
	Maple Valley - SnoKing #2 230kV		131%	137%	99%	102%	-	100%	-	100%
	Nelson-S Center 115kV		94%	102%	-	102%	-	102%	-	102%
	Talbot Hill XFMR #2 230/115kV		105%	108%	-	92%	-	90%	92%	93%
			105%	108%	100%	104%	100%	102%	100%	101%
			102%	105%	-	90%	-	-	90%	92%
	Berrydale-Covington 230 kV		96%	99%		102%	-	-	-	-
	Avondale-Cottage Brook 115 kV		90%	-	98%	-	99%	-	99%	-

Table A-25: Case 10 Winter 2023-24 75% Conservation Cases

Case 10 Winter Summary – 75% Conservation			Base Case		10d 75cons		10f 75cons		10g 75cons	
	Overloaded Element	REDACTED Worst Contingency	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading	17-18 HW % Loading	23-24 HW % Loading
Cat B	Maple Valley - SnoKing #1 230kV		107%	113%	-	101%	-	100%	-	100%
Cat C	Maple Valley - SnoKing #1 230kV		113%	119%	100%	104%	99%	103%	99%	103%
Cat C	Berrydale XFMR #1 230/115 kV		91%	90%	91%	-	91%	-	92%	-
N-1-1	Maple Valley - SnoKing #1 230kV		144%	150%	122%	127%	121%	125%	121%	126%
N-1-1	Maple Valley - SnoKing #2 230kV		131%	137%	99%	102%	-	101%	-	101%
N-1-1	Nelson-S Center 115kV		94%	102%	-	104%	-	104%	-	104%
N-1-1	O'Brien XFMR #2 230/115 kV		92%	92%	90%	-	90%	-	91%	-
N-1-1	White River XFMR #2 230/115 kV		92%	89%	91%	-	91%	-	91%	-
N-1-1	Talbot Hill XFMR #2 230/115kV		105%	108%	90%	93%	90%	92%	93%	95%
N-1-1	Talbot Hill XFMR #2 230/115kV		105%	108%	101%	105%	101%	104%	101%	104%

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Case 10 Winter Summary – 75% Conservation

Overloaded Element	REDACTED Worst Contingency	Base Case 17-18 HW % Loading	Base Case 23-24 HW % Loading	10d 75cons 17-18 HW % Loading	10d 75cons 23-24 HW % Loading	10f 75cons 17-18 HW % Loading	10f 75cons 23-24 HW % Loading	10g 75cons 17-18 HW % Loading	10g 75cons 23-24 HW % Loading
		N/A	N/A	-	92%	-	-	-	-
		101%	105%	-	-	-	-	-	91%
		102%	105%	-	92%	-	91%	91%	94%
		N/A	N/A	-	92%	-	-	-	-
		N/A	N/A	-	91%	-	-	-	-
		N/A	N/A	-	-	-	91%	-	-
		N/A	N/A	-	-	-	-	-	91%
		86%	90%	-	91%	-	-	-	-
		102%	102%	-	-	-	-	-	91%
Avondale-Cottage Brook 115 kV		90%	37%	100%	-	101%	-	101%	-

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Table A-26: Case 10 Summer 2024 100% Conservation Cases

Case 10 Summer Summary			Base Case		10d		10f		10g	
			18 HS	24 HS	18 HS	24 HS	18 HS	24 HS	18 HS	24 HS
	Overloaded Element	**REDACTED Worst Contingency**	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading	% Loading
N-1	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%	-	104%
N-2	Monroe-Novelty Hill 230kV		104%	101%	109%	104%	109%	104%	109%	104%
	Maple Valley - SnoKing #1 230kV		117%	105%	112%	102%	111%	102%	111%	102%
N-1-1	Monroe-Novelty Hill 230kV		164%	159%	169%	163%	169%	164%	169%	164%
	Novelty XFMR #1 230/115kV		102%	100%	101%	98%	101%	98%	101%	98%
	O'Brien-Asbury 115kV		96%	98%	-	100%	-	100%	-	100%

Appendix B 2015 Solutions Study Results for Longevity

The following tables list the worst contingencies found in longevity testing

Table B-1: Winter 2028-29 Proxy – 23-24 HW 100% Conservation scaled to 5500 MW – Case 6

Case 6 Winter Summary - 5500MW Longevity			Base Case	6d	6e
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
N-1	Maple Valley - SnoKing #1 230kV		113%	101%	101%
N-2	Maple Valley - SnoKing #1 230kV		119%	105%	105%
N-1-1	Maple Valley - SnoKing #1 230kV		150%	127%	127%
	Maple Valley - SnoKing #2 230kV		137%	102%	102%
	Talbot Hill - Paccar 115kV		103%	-99%	99%

			100%	98%	100%
	Berrydale XFMR #1 230/115 kV		91%	-	90%
	O'Brien XFMR #2 230/115 kV		92%	91%	92%
			93%	-	91%
			91%	-	91%
	White River XFMR #2 230/115 kV		89%	91%	91%

	Talbot Hill XFMR #2 230/115kV		106%	104%	105%
			108%	92%	95%
			105%	91%	94%
			102%	-	91%
			90%	90%	90%
	Talbot Hill S-Olyrentn 115 kV		94%	102%	102%

	S Center-Tukwila 115 kV		101%	101%	101%
	Nelson-Olyrentn 115 kV		91%	100%	100%
	Sammamish XFMR #2 230/115 kV		N/A	92%	-
			88%	90%	-

Table B-2: Summer 2028 Proxy – 2024 HS 100% Conservation Scaled to 4100 MW – Case 6

Case 6Summer Summary - 4100MW Longevity			Base Case	6d	6e
	Overloaded Element	REDACTED Worst Contingency	24 HS 4100 MW	24 HS 4100 MW	24 HS 4100 MW
			% Loading	% Loading	% Loading
N-1	Monroe-Novelty Hill 230kV		140%	146%	147%
			110%	110%	110%
N-2	Monroe-Novelty Hill 230kV		140%	147%	147%
			124%	119%	120%
	Maple Valley - SnoKing #1 230kV		105%	102%	101%
N-1-1	Monroe-Novelty Hill 230kV		219%	227%	228%

			N/A	123%	122%
	Sammamish XFMR #2 230/115kV		115%	95%	-
			N/A	-	93%
			N/A	92%	-

	Novelty XFMR #1 230/115kV		100%	100%	100%
	Westminster-Northrup 115 kV		N/A	-	102%
	O'Brien-Asbury 115kV		98%	107%	107%

REDACTED

Table B-3: Winter 2028-29 Proxy – 23-24 HW 100% Conservation scaled to 5500 MW – Case 7

Case 7 Winter Summary - 5500MW Longevity			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
N-1	Maple Valley - SnoKing #1 230kV		113%	101%	101%
N-2	Maple Valley - SnoKing #1 230kV		119%	-	104%
	Berrydale XFMR #1 230/115 kV		90%	-	**
			84%	-	**
	Talbot Hill XFMR #2 230/115kV		90%	-	92%
			96%	-	92%
N-1-1	Maple Valley - SnoKing #1 230kV		150%	127%	127%

Case 7 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case	7d	7e
			23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
	Maple Valley - SnoKing #2 230kV		137%	103%	102%
	Berrydale XFMR #1 230/115 kV		91%	91%	91%
			86%	90%	90%
			95%	-	90%

Case 7 Winter Summary - 5500MW Longevity

			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW % Loading	23-24 HW 5500 MW % Loading	23-24 HW 5500 MW % Loading
	O'Brien XFMR #2 230/115 kV		92%	92%	93%
			93%	91%	92%
			93%	-	91%
			93%	90%	91%
			91%	91%	92%

Case 7 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24 HW 5500 MW % Loading	7d 23-24 HW 5500 MW % Loading	7e 23-24 HW 5500 MW % Loading
	White River XFMR #1 230/115 kV		87%	-	90%
	White River XFMR #2 230/115 kV		89%	91%	92%
	Talbot Hill XFMR #1 230/115kV		103%	-	90%

Case 7 Winter Summary - 5500MW Longevity

			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
	Talbot Hill XFMR #2 230/115kV		106%	108%	108%
			108%	96%	99%
			N/A	93%	94%
			N/A	-	94%

Case 7 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case	7d	7e
			23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
			105%	92%	95%
			N/A	91%	-
			105%	95%	98%
			102%	91%	94%
			90%	93%	93%

Case 7 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24 HW 5500 MW % Loading	7d 23-24 HW 5500 MW % Loading	7e 23-24 HW 5500 MW % Loading
			N/A	-	92%
			96%	-	92%
	Talbot Hill S-Olyrentn 115 kV		94%	102%	102%
	S Center-Tukwila 115 kV		101%	101%	101%

Case 7 Winter Summary - 5500MW Longevity

			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
	Nelson-Olyrentn 115 kV		91%	100%	100%

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Table B-4: Summer 2028 Proxy – 2024 HS 100% Conservation Scaled to 4100 MW – Case 7

Case 7 Summer Summary - 4100MW Longevity			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	24 HS 4100 MW	24 HS 4100 MW	24 HS 4100 MW
			% Loading	% Loading	% Loading
N-1	Monroe-Novelty Hill 230kV		140%	146%	147%
			110%	110%	110%
N-2	Monroe-Novelty Hill 230kV		140%	146%	147%
			124%	119%	119%
	Maple Valley - SnoKing #1 230kV		105%	102%	102%
N-1-1	Monroe-Novelty Hill 230kV		219%	227%	229%

Case 7 Summer Summary - 4100MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 24 HS 4100 MW % Loading	7d 24 HS 4100 MW % Loading	7e 24 HS 4100 MW % Loading
			N/A	120%	119%
	Sammamish XFMR #2 230/115kV		115%	93%	-
	Novelty XFMR #1 230/115kV		100%	100%	100%
	Westminster-Northrup 115 kV		N/A	-	98%

Case 7 Summer Summary - 4100MW Longevity

			Base Case	7d	7e
	Overloaded Element	REDACTED Worst Contingency	24 HS 4100 MW	24 HS 4100 MW	24 HS 4100 MW
			% Loading	% Loading	% Loading
	O'Brien-Asbury 115kV		98%	107%	107%

Table B-5: Winter 2028-29 Proxy – 23-24 HW 100% Conservation scaled to 5500 MW – Case 10

Case 10 Winter Summary - 5500MW Longevity			Base Case	10d	10g
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
N-1	Maple Valley - SnoKing #1 230kV		113%	101%	100%
N-2	Maple Valley - SnoKing #1 230kV		119%	105%	104%
	Berrydale XFMR #1 230/115 kV		90%	-	**
			84%	-	**
	Talbot Hill XFMR #2 230/115kV		90%	92%	92%
			96%	-	92%
N-1-1	Maple Valley - SnoKing #1 230kV		150%	128%	126%

Case 10 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24 HW 5500 MW % Loading	10d 23-24 HW 5500 MW % Loading	10g 23-24 HW 5500 MW % Loading
	Maple Valley - SnoKing #2 230kV		137%	103%	102%
	Berrydale XFMR #1 230/115 kV		91%	-	92%
			86%	-	90%
			95%	-	90%

Case 10 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case	10d	10g
			23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
	O'Brien XFMR #2 230/115 kV		92%	91%	93%
			93%	90%	92%
			93%	-	91%
			93%	-	91%
			91%	90%	92%

Case 10 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case	10d	10g
			23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
			90%	-	90%
	White River XFMR #1 230/115 kV		87%	90%	90%
	White River XFMR #2 230/115 kV		89%	92%	92%
	Talbot Hill XFMR #1 230/115kV		103%	-	90%

Case 10 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24 HW 5500 MW % Loading	10d 23-24 HW 5500 MW % Loading	10g 23-24 HW 5500 MW % Loading
	Talbot Hill XFMR #2 230/115kV		108%	97%	99%
			106%	109%	108%
			N/A	95%	-
			105%	93%	94%

Case 10 Winter Summary - 5500MW Longevity

			Base Case	10d	10g
	Overloaded Element	REDACTED Worst Contingency	23-24 HW 5500 MW	23-24 HW 5500 MW	23-24 HW 5500 MW
			% Loading	% Loading	% Loading
			N/A	92%	-
			105%	95%	98%
			102%	92%	94%
			90%	94%	93%
			96%	-	92%

Case 10 Winter Summary - 5500MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 23-24 HW 5500 MW % Loading	10d 23-24 HW 5500 MW % Loading	10g 23-24 HW 5500 MW % Loading
			N/A	-	91%
	Talbot Hill S-Olyrentn 115 kV		94%	102%	102%

Table B-6: Summer 2028 Proxy – 2024 HS 100% Conservation Scaled to 4100 MW – Case 10

Case 10 Summer Summary - 4100MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 24 HS 4100 MW % Loading	10d 24 HS 4100 MW % Loading	10g 24 HS 4100 MW % Loading
N-1	Monroe-Novelty Hill 230kV		140%	146%	147%
			110%	110%	109%

Case 10 Summer Summary - 4100MW Longevity

	Overloaded Element	REDACTED Worst Contingency	Base Case 24 HS 4100 MW % Loading	10d 24 HS 4100 MW % Loading	10g 24 HS 4100 MW % Loading
N-2	Monroe-Novelty Hill 230kV		140%	146%	147%
			124%	119%	118%
	Maple Valley - SnoKing #1 230kV		105%	102%	102%
N-1-1	Monroe-Novelty Hill 230kV		219%	-	228%
	Sammamish XFMR #2 230/115kV		115%	95%	-

Case 10 Summer Summary - 4100MW Longevity

			Base Case	10d	10g
	Overloaded Element	REDACTED Worst Contingency	24 HS 4100 MW	24 HS 4100 MW	24 HS 4100 MW
			% Loading	% Loading	% Loading
			N/A	-	90%
	Novelty XFMR #1 230/115kV		100%	100%	100%
	O'Brien-Asbury 115kV		98%	107%	107%

Appendix C Upgrades Included in Base Cases

Table C-1: Projects Added to the Eastside Needs Assessment Winter Base Case

2017-18	2019-20	2023-24
Bothell – SnoKing reconductor	Bothell – SnoKing reconductor	Bothell – SnoKing reconductor
Cumberland Substation reconfigured to 115 kV	Cumberland Substation reconfigured to 115 kV	Cumberland Substation reconfigured to 115 kV
White River – Electron Heights reroute to Alderton	White River – Electron Heights reroute to Alderton	White River – Electron Heights reroute to Alderton
Talbot 230/115 kV transformer #1 replacement	Talbot 230/115 kV transformer #1 replacement	Talbot 230/115 kV transformer #1 replacement
Spurgeon Substation, Similk Substation & Maxwelton Substation	Spurgeon Substation, Similk Substation & Maxwelton Substation	Spurgeon Substation, Similk Substation & Maxwelton Substation
Carpenter Substation Removed	Carpenter Substation Removed	Carpenter Substation Removed
Bus section breakers at BPA Olympia and BPA Tacoma	Bus section breakers at BPA Olympia and BPA Tacoma	Bus section breakers at BPA Olympia and BPA Tacoma
Switched shunt at Paul 500 kV, Broad St. 115 kV	Switched shunt at Paul 500 kV	Switched shunt at Paul 500 kV

Table C-2: Projects Added to the Summer NERC TPL Base Case for the Eastside Area

2018	2020	2024
Bothell – SnoKing reconductor	Bothell – SnoKing reconductor	Bothell – SnoKing reconductor
Cumberland Substation reconfigured to 115 kV	Cumberland Substation reconfigured to 115 kV	Cumberland Substation reconfigured to 115 kV
Talbot 230/115 kV transformer #1 replacement	Talbot 230/115 kV transformer #1 replacement	Talbot 230/115 kV transformer #1 replacement
White River – Electron Heights reroute to Alderton	White River – Electron Heights reroute to Alderton	White River – Electron Heights reroute to Alderton
Spurgeon Substation, Similk Substation	Spurgeon Substation, Similk Substation	Spurgeon Substation, Similk Substation
Denny Way Substation Phase 1	Denny Way Substation Phase 1	Denny Way Substation Phase 1 & Phase 2
Bus section breakers at BPA Olympia, BPA Tacoma and BPA Covington	Bus section breakers at BPA Olympia, BPA Tacoma and BPA Covington	Bus section breakers at BPA Olympia, BPA Tacoma and BPA Covington
Raver 500-230 kV Transformer	Raver 500-230 kV Transformer	Raver 500-230 kV Transformer
Switched shunt at Paul 500 kV	Switched shunt at Paul 500 kV	Switched shunt at Paul 500 kV
Switched shunt at Lake Tradition 115 kV removed	Switched shunt at Lake Tradition 115 kV removed	Switched shunt at Lake Tradition 115 kV removed

Appendix D North of Echo Lake and South of Custer Flowgate One-Line Diagrams

REDACTED

Figure D-1: North of Echo Lake Flowgate

REDACTED

Figure D-2: South of Custer Flowgate

Appendix E – Detail Tabular Results

REDACTED