Appendix C. Alternatives Analysis

Power Delivery and Transmission Alternatives Analysis

Harborton Reliability Project

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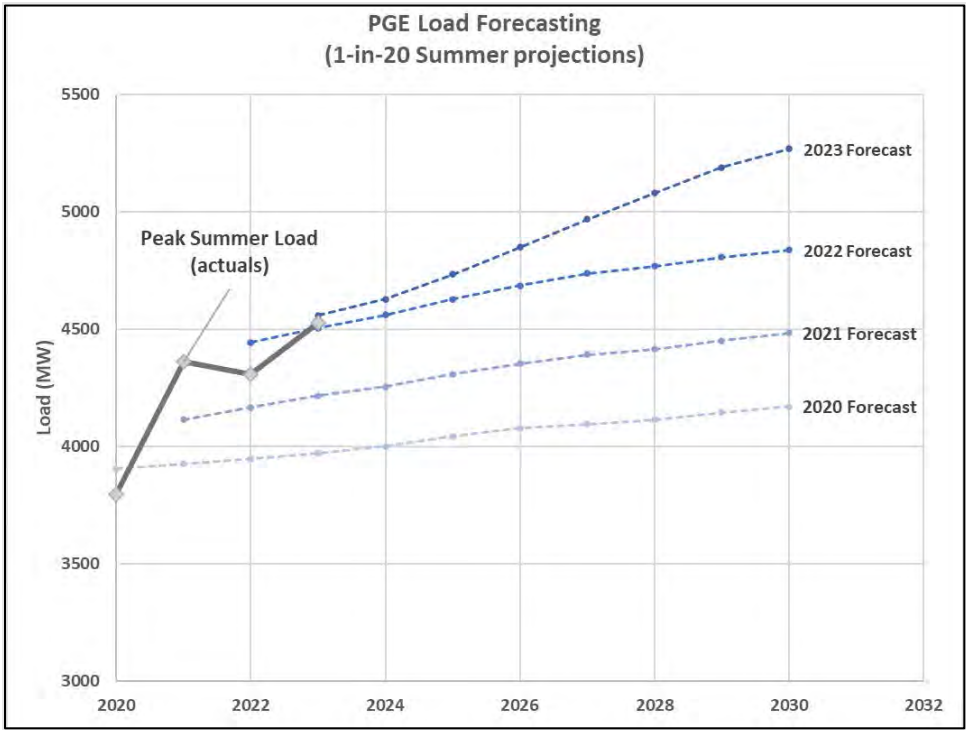
1 INTRODUCTION

This section introduces the purpose and need for the Portland General Electric Company (PGE) Harborton Reliability Project (HRP) by providing project background information, discussing current transmission line conditions, and describing the context for regional power transmission.

1.1 PURPOSE AND NEED

The primary purpose of the Proposed Project is to assure reliable power supply to the Portland Metropolitan Region by implementing transmission configuration improvements that address transmission vulnerabilities identified within PGE's existing grid. Due to rapidly increasing demands for power, these improvements are urgently needed to maintain a reliable grid and avoid highly undesirable power outages that are increasingly likely to occur during peak demand periods. Based on current power supply models, the current system configuration is insufficient to meet peak demands forecast by 2028. Power disruptions can have substantial effects on the health, safety, wellbeing, and economic productivity of the region, making reliable power a critical component of the regional infrastructure. These updates and improvements are also needed in order to comply with North American Electric Reliability Corporation (NERC) Standard TPL-001-5, which governs reliable transmission system requirements for U.S. electric utilities. **Figure 1** shows 2023 forecasting data conducted by PGE's Corporate Load Forecasting team. PGE's forecast methodology is reviewed by the Oregon Public Utility Commission (OPUC) as a part of the Integrated Resource Planning / Clean Energy Plan process. The year-over-year forecasts show increasing projected demands.

Figure 1. Increases in Recent Summer Load Forecasts 2020–2023

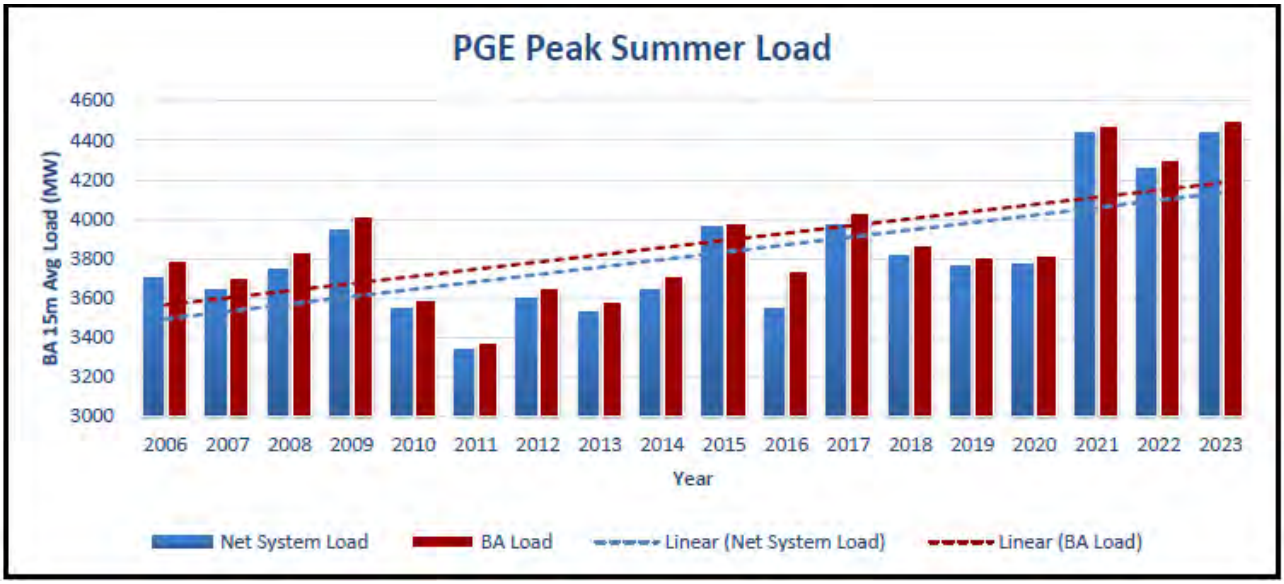


Currently, one of the primary paths for importing power into the Portland Metropolitan Region is a three-terminal 230 kilovolt (kV) transmission line built in 1973 that connects PGE's Horizon, St. Marys, and Trojan substations. The Horizon terminus of the line in Hillsboro is located in Hillsboro, the St. Marys Substation is in Beaverton, and the Trojan Substation is located north of St. Helens, Oregon. The existing Horizon-St. Marys-Trojan (HST) 230 kV transmission line is referred to throughout the remainder of this

document as the "HST" line. The HST line currently passes through Forest Park near PGE's Harborton Substation in northwest Portland but does not currently connect into the Harborton Substation.

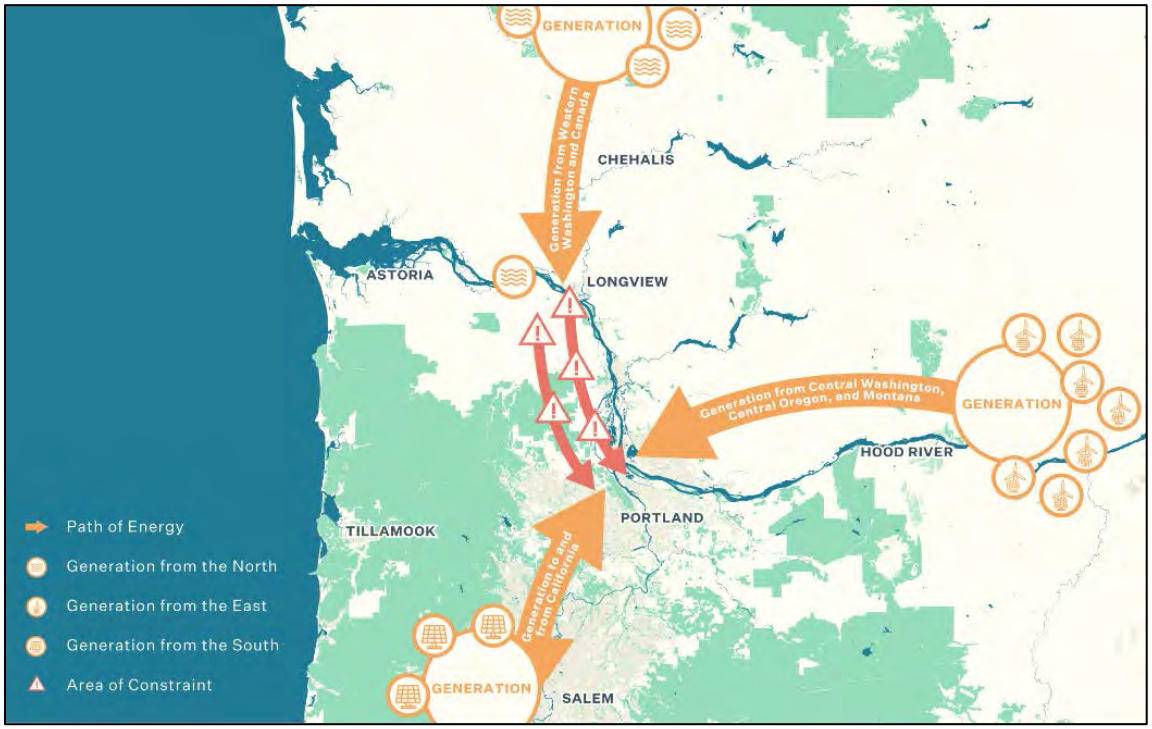
The demand for power has surged in recent years. These rapidly expanding loads have grown faster than expected and have highlighted the vulnerabilities present in the current HST line configuration. What was previously identified as a concern in prior planning studies has become urgent in the last year due to these rapidly increasing power demands. **Figure 2** shows the growth in peak summer electricity loads from 2006 to 2023 for the PGE system load and the load that PGE is responsible for matching with generation and imports loads, which is known as PGE's Balancing Authority (BA) load. BA loads include loads that PGE manages for other entities, such as municipal utilities. These year-ahead demand forecasts are generated by PGE and are subject to review and approval by OPUC. Further-out demand forecasts are developed using the same statistical methods, with input from F. These demand forecasts are then included in the network grid planning models.

Figure 2. Recent Growth of Peak Summer Electricity Loads



Much of the renewable energy needed to serve PGE's customers comes from eastern Washington and Oregon through the Trojan substation, as does most of the power traveling eastward from PGE's Port Westward and Beaver generating plants. From Trojan, PGE currently transmits this power to customers in the Portland Metropolitan Region via the Harborton-Trojan No. 1 (HT1) and HST 230 kV transmission lines, which are co-located within a single corridor on shared transmission towers. The HT1 line currently terminates at PGE's Harborton Substation. It provides power supply for 115 kV transmission and distribution lines that serve northwest Portland industrial and residential customers. **Figure 3** provides an overview of the power generation paths into the Portland area, and the current area of constrained transmission that requires urgent improvement to meet demand.

Figure 3. Power Supply Pathways to Portland and Area of Constrained Transmission



1.2 HARBORTON RELIABILITY PROJECT

The HRP is a multi-phase effort that expands and strengthens PGE's existing transmission lines to meet anticipated residential, commercial, and industrial load growth in the Portland Metropolitan Region. When complete, PGE's system will deliver more reliable energy to customers.

The original plan for the HRP was developed in 2015. Since that time, the initial phase of the HRP was completed, achieving the following:

- Constructing a 230/115 kV substation at Harborton.
- Segmenting the existing Rivergate-Trojan 230kV line, "looping" it into Harborton to create a Harborton-Rivergate #1 230 kV line and a Harborton-Trojan #1 230 kV line.
- Adding a 230/115 kV bulk transformer at Harborton.

This first phase of the HRP successfully remediated voltage problems in Northwest Portland. The 2015 plan called for subsequent phases of the HRP, to include the following:

- Phase 2: Terminate the St Marys-Wacker 115 kV line at Harborton to provide a shorter dedicated service from Harborton To Wacker, connecting it with the bulk power coming in from Trojan and freeing a circuit on the existing transmission corridor in Forest Park.
- Phase 3: Re-routing the three-terminal Horizon-St. Marys-Trojan 230 kV line into Harborton, creating three dedicated transmission lines to remove the three-terminal issues. This results in an Evergreen-Harborton 230kV line, Harborton-St. Marys 230 kV line, and Harborton-Trojan #2 230kV line.

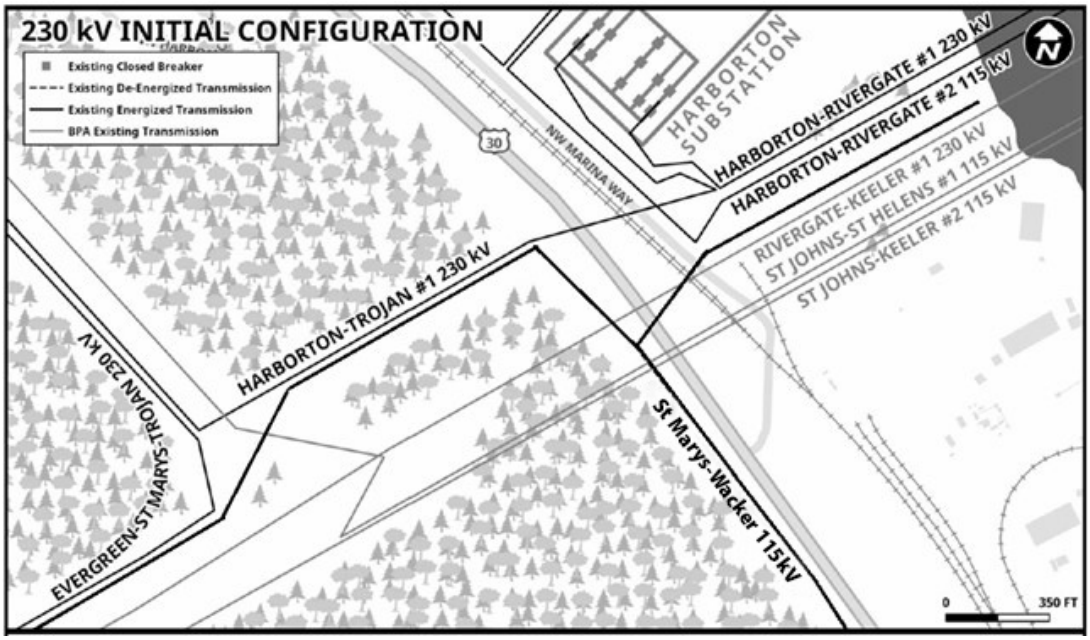
The second phase of the HRP is currently underway. It will address 115 kV transmission constraints in Northwest Portland. Phase 3 is intended to meet the goals of increasing the reliability and resilience of the power supply to Portland and regional communities by addressing vulnerabilities in the existing HST line and delivering an additional power source into the Harborton Substation. The HST line has been shown to lack accommodation for peak power demands based on current and forecasted peak loads

(shown in **Figure 1** and **Figure 2**). Reconfiguration and reinforcement of the transmission system is necessary to relieve system stress and to continue to provide safe and reliable electric service to PGE customers in North and Northwest Portland and western Portland Metropolitan Region population centers. Summer 2028 power flow studies show that a system upgrade will be required to maintain compliance with NERC, WECC and PGE planning criteria. PGE intends to secure the necessary increased capacity and strengthen the grid within existing PGE property or Utility ROW while also avoiding infrastructure constraints (highway, pipelines, railroads, telecommunication lines, etc.) and minimizing impacts on environmental resources. Phase 3 of the HRP is hereafter referred to as the "Proposed Project".

The Proposed Project furthers PGE's strategic plan for the region by reconfiguring and reinforcing the 230 kV and 115 kV transmission systems. These efforts will transform the Harborton Substation into an important regional facility for managing power coming in from the 230 kV regional transmission system. PGE envisions transmission line routing that would bring additional power into the Harborton Substation and resolve the constrained three-terminal HST line by segmenting it into three separate 2-terminal lines.

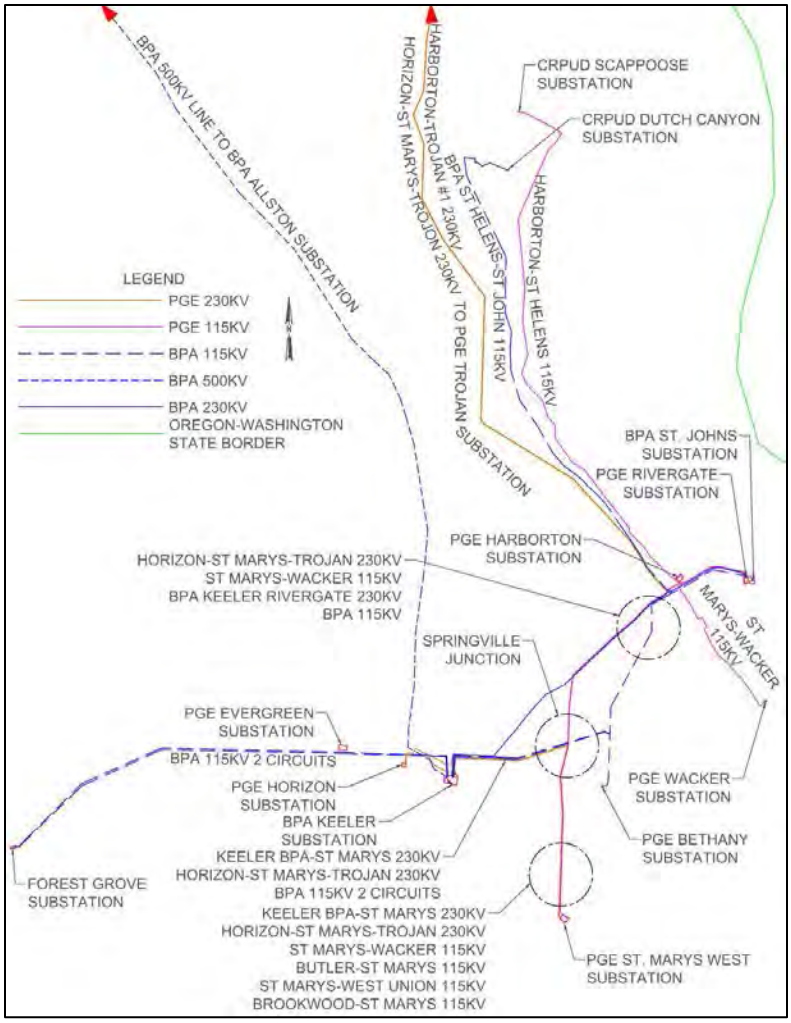
Upon completion of all phases 2 and 3 of the HRP, reliable power will be delivered from the Harborton Substation over the upgraded 230 kV and 115 kV transmission lines to distribution substations in Portland, Beaverton, and Hillsboro. The new transmission line configurations will provide a stronger 230 kV source capable of accommodating additional load growth, decrease outage exposure, and minimize outage impact while addressing the emerging 2028 NERC, WECC, and PGE planning criteria violations.

Figure 4. Existing PGE Transmission Routing Configuration in Forest Park



1.3 CONTEXT FOR REGIONAL POWER TRANSMISSION

Figure 5. Elements of Northwest Portland Area Electrical Grid Affected by Constraints



On August 10, 1996, an outage event created a massive system blackout in the western power grid. The Western Interconnection lost more than 30,390 megawatts (MW) of load and affected more than 7.49 million customers during a very hot summer afternoon. Since 1996, PGE's electrical grid in northwest Portland, Beaverton, and Hillsboro has been subject to a special exception to NERC's standard utility planning and operating criteria. As a result, a special transmission system analysis area known as the South of Allston (SOA) path was established and given a rating.[1] A Dispatcher's Standing Order (DSO) governs the operation of the SOA path.[2] Whenever the flows on the path exceed a portion of the Total Transfer Capability (TTC),[3] a Remedial Action Scheme (RAS) is put into place that automatically reduces the generators' output if a failure occurs. When a RAS is in place, operators are unable to take lines out of service for maintenance because it would further reduce the path capability. The existing HST line is part of the SOA path and is currently the limiting element within it. The SOA path includes the BPA Allston-Keeler 500 kV line with PGE's HST and Harborton-Trojan 230 kV lines. PGE's lines provide the primary backup transmission route within the SOA path (see **Figures 2** and **Figure 5**).

Transmission planning and the identification of system vulnerabilities are determined through use of power flow models. Using these industry standard models, the Bonneville Power Administration (BPA) identifies SOA path limits and includes them as attachments to the DSO. PGE's power flow studies used to develop the PGE current transmission system plan show the existing HST transmission line and associated facilities overloading with the loss of a single circuit. NERC, WECC, and PGE criteria require that this emerging overload be addressed before the summer of 2028 to avoid a violation of reliability

[1] 2023 Path Rating Catalog, WECC Studies Subcommittee, March 2023.
[2] Bonneville Power Administration, System Dispatchers' Standing Order No. 309, Operation of the South of Allston Path and Pearl-Keeler Line, June 1, 2022.
[3] The path is the sum of the flows on eight transmission lines. The TTC is the total flow that can be accommodated while reliable operation of the system is maintained. Because normal transmission reliability criteria cannot be maintained on this path, a Remedial Action Scheme is employed.

criteria.[4]

To help visualize why the current HST line configuration is limiting upon the regional grid, imagine the flow of a single hose being split to feed into two similarly sized hoses. In that configuration, the total flow is limited by the capacity of the feeding hose. However, if each of the two receiving hoses were connected to its own feeder hose, the total flow could increase to the limits of the receiving hoses. In the same way, the three-terminal HST line configuration hampers the current SOA system. In addition to splitting the transmission from Trojan at Springville Junction, the conductor (transmission wire) size is smaller on the Trojan to Springville Junction segment of the three-terminal line, thus limiting the potential of the Springville-Horizon/Evergreen segments. This current configuration creates a lack of operational and maintenance flexibility for scheduled outages or peak load events. Once an outage is taken, the system needs to be secure for subsequent outages. Whenever the SOA RAS is in operation, the DSO prohibits the scheduling of an outage for a line or transformer, making required maintenance and system upgrades difficult because the RAS is frequently in operation during the increasing peak demand days.

Another concern is that a single fault on the current HST line interrupts supplies to both Horizon (eventually Evergreen) and St. Marys.[5] The existing three-terminal line has approximately 45 miles of exposure. By routing the HST line into Harborton, the maximum length of the line would be 33 miles; therefore, the probability of removal of a single facility by a fault will be less than 73% of the current probability. With dedicated two-terminal lines replacing the three-terminal HST line, the probability of simultaneous loss of supply to Evergreen, St. Marys, and Trojan will become very remote.

To protect the HST line and the regional system, PGE protection engineers have implemented an existing scheme that trips the St. Marys terminal if both sets of relays at St. Marys lose power due to issues on the constrained HST line. Protection of the line relies on communications system, therefore an issue on only the communication system can result in a line outage. One or more terminals of this line have tripped on 12 occasions since December 27, 2019. Of those, eight occasions have been tripped due to a loss of communications.[6] The existing three-terminal 230 kV configuration cannot adequately provide long-term reliability to the PGE transmission system. In the absence of the needed improvements, the local system will continue to experience spurious trips and uncoordinated tripping behavior, resulting in customers experiencing voltage sags and potential outages that could otherwise be prevented. With the rapidly increasing demand projections, the chances for outages rise substantially by 2028 and become a violation of NERC reliability criteria.

Based on these data, the fault rate for the existing configuration is about 3.36 outages per year, or about 0.075 faults per mile. With the elimination of the existing three-terminal line and its replacement with dedicated 2-terminal lines to replace the affected substation connections, the fault rate will be reduced to about 0.025 faults per mile, making the probability that all three lines would be out at the same time due to a fault nearly 0%.

Last, a structure failure can currently result in simultaneous loss of transmission connectivity between Trojan, Harborton, and St. Marys substations, a situation whose consequences are worsening with the increasing loads. With the constrained HST line frequently operating in RAS during peak demand periods (summers), it becomes very difficult to take outages as needed for required maintenance and planned improvements.

[4] The loss of Allston to Keeler 500 kV causes the overload of the Trojan-St. Marys-Evergreen 230 kV line and a BPA facility. The Proposed Project reduces the loading on these facilities to 96% or less.

[5] There are 33.2 miles from Trojan to Forest Junction, 4.22 miles from Forest Junction to Springville Junction, 4.1 miles from Springville Junction to Horizon, and 3.75 miles from Springville Junction to St. Marys.

[6] Harborton Reliability Project – 2023 Addendum, July 21, 2023, Prepared by PGE Transmission Planning.

1.4 PROPOSED PROJECT GOALS AND OBJECTIVES

The goals of the Proposed Project are to address vulnerabilities within the current HST line configuration and deliver a redundant 230 kV power supply to PGE's Harborton Substation as quickly as possible to meet increasing power demands, avoid service disruptions, and avoid violation of NERC criteria. PGE proposes to accomplish the Proposed Project by making improvements that would affect forest resources within existing PGE and BPA utility easements or fee-owned property (collectively referred to herein as "Utility ROW") in Forest Park. The Proposed Project presents an efficient means of eliminating significant system vulnerabilities and increasing transfer capability into the regional power transmission system through one project. The specific objectives for the Proposed Project include:

1. Eliminate PGE's current three-terminal transmission configuration, which constrains transmission capacity, limits the transfer capacity, and requires a Remedial Action Scheme[7] to maintain operation of the highly constrained transmission path between BPA's Allston Substation and the Portland Metropolitan Region.
2. Increase operational and maintenance flexibility for scheduled outages or severe events.
3. Provide a redundant 230 kV power supply into the Harborton Substation to create a stronger power source for several other Northwest Portland substations.
4. Resolve current constraints prior to 2028, when projected peak demands are anticipated to exceed current transmission capacity between PGE's Trojan Substation and locations around the Portland Metropolitan Region. To prevent events that can cascade into widespread regional outages, NERC TPL-001-5 requires PGE to operate "reliably over a broad spectrum of System conditions and following a wide range of probable Contingencies." If sufficient spare transmission capacity does not exist—for instance due to very high loads—and an unplanned outage occurred on key transmission equipment, one step PGE may need to take to protect grid reliability is forcing outages to customers (also called load-shedding, load curtailment, or rolling blackouts).

2 ALTERNATIVES ANALYSIS

Any new utility development in Forest Park is considered by the City of Portland (City) to be inconsistent with the goals and objectives of the City's Forest Park Natural Resources Management Plan (NRMP). The NRMP is focused on habitat preservation, enhancement, and recreational land uses, and does not include provisions for new utility development, even within existing utility easements that far predate the plan. For work in Forest Park that is inconsistent with the NRMP, one of the City's criteria for land use approval is that an applicant must demonstrate that a feasible non-park alternative is not available. Therefore, this alternatives analysis is intended to identify alternative means of meeting the Proposed Project's purpose and need with less or no impact to the natural resources in Forest Park.

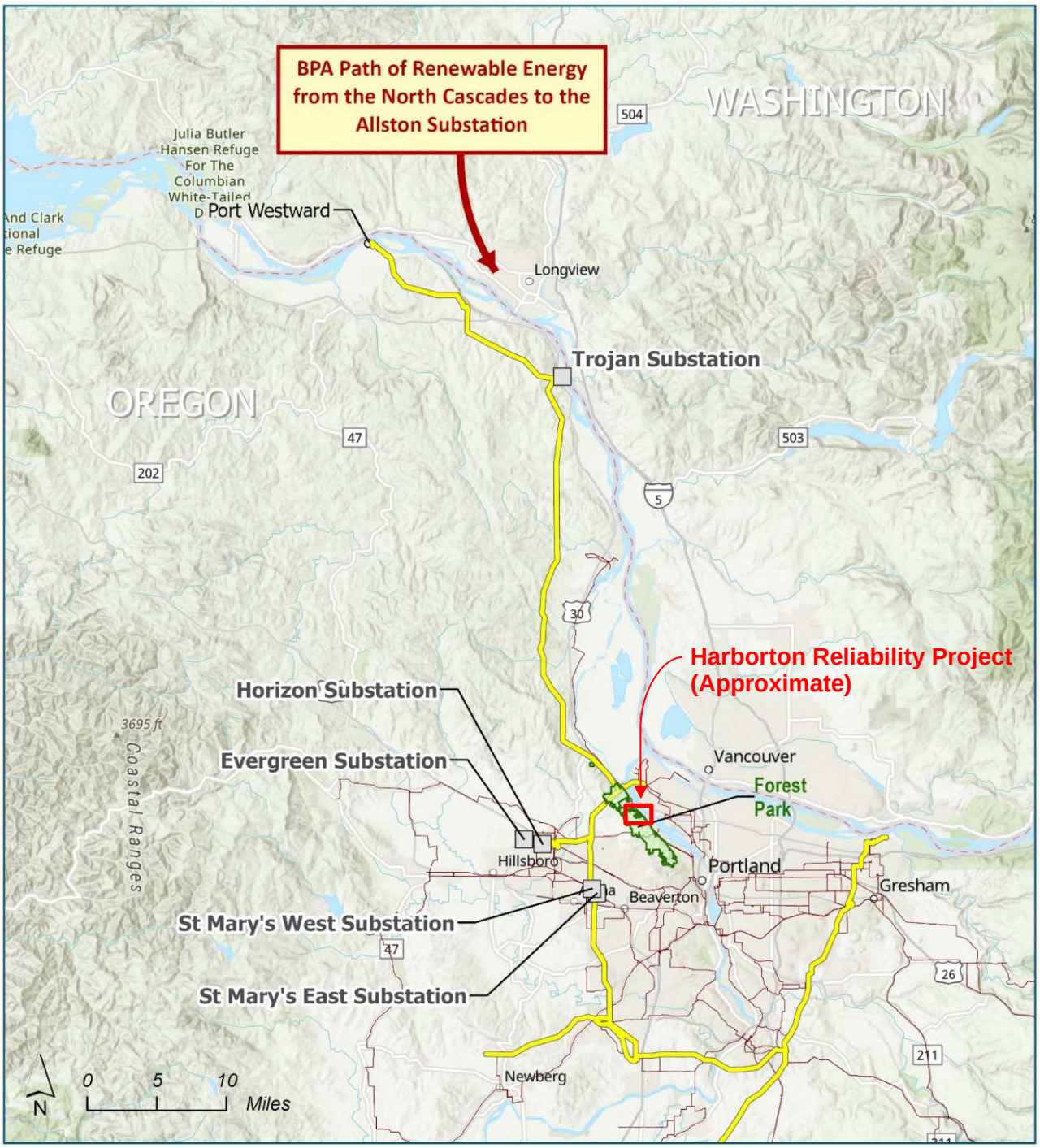
This analysis was prepared by defining the purpose and need for Phase 3 of the HRP, describing the geographic limits (Section 2.1) of the Proposed Project and related transmission elements, developing specific evaluation criteria (Section 2.2) that are tied to the purpose and need, and comparing alternative designs to the evaluation criteria to determine feasibility. More than 20 alternatives were evaluated and ranked against the evaluation criteria to determine one or more feasible alternatives for further analysis. A "feasible" alternative is one that meets the purpose and need, as demonstrated by meeting all evaluation criteria.

[7] A scheme designed to detect predetermined system conditions and automatically take corrective actions, as defined by the Federal Energy Regulatory Commission.

2.1 GEOGRAPHIC SCOPE

The geographic scope of the analysis includes areas served by the SOA power path, including areas that receive the bulk of their power from the BPA Allston-Keeler 500 kV and HST transmission lines. Of particular interest to PGE's grid management is the functionality of the HST line because PGE does not have the ability to manipulate BPA facilities to achieve needed improvements. **Figure 6** identifies the Proposed Project location and the primary transmission elements associated with it.

Figure 6. Vicinity of Harborton Reliability Project



2.2 ALTERNATIVE EVALUATION CRITERIA

To identify the appropriate criteria for evaluating alternatives, a list of potential criteria was developed based on the Proposed Project's purpose and need. The initial criteria were then refined in coordination with PGE to develop a discrete list that encompasses all the critical issues and design constraints that the Proposed Project must address.

Table 1. Harborton Reliability Project Evaluation Criteria

CRITERION	CRITERION DESCRIPTION AND HOW CRITERION IS MET
1. Project must deliver secondary 230 kV power source to Harborton to provide reliable, redundant supply of power for northwest Portland, Beaverton, and Hillsboro.	To be viable, a project must result in an additional source of 230 kV power reliably delivered to north Portland and, from there, to regional substations in the Portland metropolitan region. PGE's portion of the SOA power path comes through Trojan and is PGE's primary source of power to north Portland.
2. Project must fully resolve transmission vulnerabilities associated with current three-terminal HST line.	At 230 kV, multiterminal lines have a higher risk for protective device failure and result in larger transmission loss for a single failure. The existing three-terminal HST line was intended to be a short-term solution to allow connection of loads at Horizon pending design, permitting and construction of the new Harborton Substation. However, the HST line is now a vulnerability due to increasing loads and must be resolved by separating it into separate 2-terminal lines.
3. Project must minimize cost impact to PGE ratepayers.	PGE investments in its system are subject to a prudency review by the OPUC before they can be recouped through the rates customers pay. The OPUC scrutinizes and determines if project costs were reasonably and prudently incurred, or if a more practical alternative solution was available. A project must be reimbursable through utility rate payments to be considered feasible.
4. Project should improve the regional transfer level and provide infrastructure necessary to support projected demands in the near-term planning horizons (generally next 10-year period).	The project should increase the regional transfer capability. The SOA path currently limits transfers to PGE and through the region, preventing transmission of renewable and other forms of energy. The HST line is currently the limiting element on the SOA path under normal conditions. The City of Portland, the State of Oregon, and the federal government have all established goals of reducing carbon emissions. Increased reliance on electric power and renewable power generation are key to these goals. Based on this, alternatives should result in greater capacity to safely transmit energy from areas of bulk renewable energy production. These areas are located in the North Cascades and east of the Cascades, and the SOA path is a primary source of renewable energy into northwestern Oregon. This power is delivered to Trojan via BPA's Allston Substation.
5. Project must utilize equipment that is consistent with PGE design standards and maintenance operations and does not elevate the risk of catastrophic hazards.	To be practical, an alternative must be consistent with PGE's protocols for design, which have been developed to maximize safety and avoid risk of failure. Design proposals cannot propose structures that increase risk of catastrophic common mode failure.

CRITERION	CRITERION DESCRIPTION AND HOW CRITERION IS MET
6. Meet federal, regional PGE, and state Reliability Standards and be operational by 2028, before the standards are projected to be violated.	A wide variety of standards, many deriving from the Federal Energy Regulatory Commission authority, govern PGE's responsibilities. This includes the North American Electric Reliability Corporation (NERC) TPL-001-5 Standard (Standard Development Roadmap). NERC or a regional entity will assess penalties for a violation of a Reliability Standard Requirement. As of 2020, the maximum civil monetary sanction set forth in 18 Code of Federal Regulations § 385.1602(d) is $1,291,894 per violation per day. PGE's power flow studies show the existing facilities overloading for the loss of a single circuit. Based on demand trends and projections, NERC, WECC, and PGE criteria require that this emerging overload be addressed before the summer of 2028 to avoid it becoming a violation. To be practical, an alternative must meet reliability standards and avoid violations. Because a violation of NERC, WECC and PGE criteria is anticipated by Summer of 2028 without resolution of the identified vulnerabilities, this means that an alternative must be able to be in operation within three years.
7. Minimize the environmental impact	The project should minimize the impact to the natural environment. Measurements of the impact to the environment should focus on mature forest habitat, wetlands, streams, view sheds, cultural resource sites, effects on habitat associated with sensitive or protected wildlife, and/or other environmental factors unique to a particular alternative. If an alternative is capable of meeting all of the above criteria while posing less environmental impact, it should become the Proposed Project.

2.3 ALTERNATIVES CONSIDERED

This section describes the alternatives considered in this analysis, including the Proposed Project, avoidance alternatives (alternatives outside of Forest Park), and minimization alternatives (alternatives in the park with potentially less environmental impact). Estimates of cost were developed using a combination of professional experience and a recent cost guide prepared by Pacific Gas & Electric for use in estimating transmission project construction costs.[8] Professional review and consideration of all alternatives was provided by Stephen Miller, PE. Mr. Miller is a senior transmission planning specialist who has been advising utility clients for over 40 years.

2.3.2 Alternatives Outside of Forest Park

The following alternatives were considered as means of potentially meeting the stated purpose and need while avoiding sensitive habitat resources in Forest Park. Although these alternatives consider system configurations that do not require new transmission segments in Forest Park, each would take advantage of the free circuit created when the current St. Marys-Wacker 115 kV transmission line is terminated at the Harborton Substation, creating a shorter Harborton-Wacker 115 kV line.

2.3.2.1 NW Marina Way Alternative

This alternative seeks to route the Harborton-Trojan 230 kV transmission line around Forest Park by crossing U.S. Hwy 30 north of the park and routing a new 230 kV transmission segment or segments south along NW Marina Way into Harborton. Connections to the HST line would be looped into Harborton using the existing St. Marys-Wacker power line corridor in Forest Park. By bringing power from Trojan into Harborton along Marina Way, a new power line segment could be avoided in Forest Park between Harborton and the existing Tower 2996. An impediment to this alternative is that PGE has

[8] https://www.caiso.com/InitiativeDocuments/PGAE-2023-Final-Per-Unit-Cost-Guide.xlsx and assume urban and short line conditions.

an existing 115 kV Harborton-St. Helens transmission line running along Marina Way. If converted to transmission poles for two 230 kV circuits, the poles would not be able to also accommodate the existing 115 kV Harborton-St. Helens circuit, and the current easement width would need to be expanded to allow for the larger 230 kV clearance requirements. Therefore, the 115 kV line would need to be demolished and relocated, and several new easements would be necessary. PGE would need entirely new easements for new transmission corridor spanning between the existing HST corridor and NW Marina Way over U.S. Hwy 30. New easements would also be needed for the expanded/wider 230 kV transmission corridor along NW Marina Way. For the 115 kV relocation, there are very few locations available and relocation would require additional studies, design, and possible property acquisitions.

Two potential route options[9] along Marina Way were carefully considered. It was determined that this routing has substantial impediments. While this alternative routing could provide a Forest Park avoidance option for future transmission into Harborton (e.g., a third Harborton-Trojan 230 kV line), due to the many impediments identified for these lines, they would not address the immediate need for improved transmission reliability on the SOA path. Specifically, it is estimated that it would take PGE at least six years to design, permit, purchase properties, demolish/relocate the existing 115 kV line, and construct this alternative. More time may be required if there is a need for condemnation.

Costs for this project include 1.38 miles of new double-circuit 230 kV line, removal of approximately this much existing 115 kV line, and new 115 kV line, assumed to be single-circuit overhead construction. Provided the route is feasible the cost is approximately $26 million and does not include land acquisition.

2.3.2.2 New 230 kV Line from Trojan to Evergreen

This alternative analyzed a new route that would create all new transmission corridor from Trojan into Washington County to avoid Portland. By itself, this alternative would not create a new transmission pathway to Harborton to mitigate the 230 kV and 115 kV overloads and limitations for North Portland or Northwest Portland.

The new transmission corridor would require substantial new property takings and roads and would have impacts to multiple sensitive environmental resources. Whereas use of the existing 230 kV transmission corridor south of Trojan would parallel existing transmission lines and stay within existing PGE property easements, the alternative route would create all new transmission corridor, which would introduce substantial fragmentation of intact forest habitat blocks in Columbia and Multnomah counties. Even if this alternative could be achieved, it would likely take at least six to ten years to build out in the base case.

At a minimum length of 40 miles, the cost of the new line, excluding terminal modifications, would be roughly $245 million[10] for double circuit construction in hilly and forested terrain.

2.3.2.3 New Springville Switching Station

This alternative would create a new switching station near the existing junction of the Trojan, St. Marys, and Horizon 230 kV lines at Springville Junction in Washington County. There are multiple possible configurations with this alternative; however, the most feasible alternative appears to be one that would route the HST 230 kV line going west from Portland into a new switching station, which would be a two-bay breaker and one half configured station with three breakers and a spare position for a future line. The new station would create three separate, two-terminal lines as follows:

[9] Eight routing options were analyzed by Toth and Associates in 2022 to review potential opportunities to avoid Forest Park. Most of the routes had fatal flaws, but two were analyzed further by PGE in 2023.
[10] Cost estimates based on https://www.caiso.com/InitiativeDocuments/PGAE-2023-Final-Per-Unit-Cost-Guide.xlsx.

- Springville – Trojan 230 kV Line
- Springville – Evergreen 230 kV Line
- Springville – St. Marys 230 kV Line

PGE's existing easements within TVPRD are limited to transmission and cannot support the area that would be needed for a switching yard. Therefore, this alternative would require property acquisition within a dedicated natural area zoned as Open Space that is also mapped by Washington County as a Drainage Hazard Area along Rock Creek. The Tualatin Valley Parks and Recreation District (TVPRD) owns the Open Space tract and is unlikely to provide additional easement for a switching yard, because doing so would conflict with the recreation and conservation goals that manage use of the Rock Creek Greenway and nearby Pirate Park.

Another substantial concern with this alternative is that it would not bring in the additional 230 kV power supply to Harborton. This secondary power supply is a critical component of the project purpose and need. Without the secondary power supply, much of the planned 115 kV routing improvement planned in NW Portland would be at risk of insufficient power supply and transfer capacity, particularly when the Harborton – Trojan #1 230 kV Line is out of service, whether for planned maintenance or due to an unplanned outage. Based on the projected demand, NW Portland would lack reliable power and would have highly restricted outage availability for maintenance work under this alternative. Excluding land acquisition, the estimated cost for this alternative (new switching station and associated line reconfigurations) is $30-50 million based on a rough order of magnitude estimate by PGE's estimating group.

2.3.2.4 Trojan to Harborton 230 kV via Washington State I-5 Route

Similar to BPA's formerly proposed I-5 Corridor Reinforcement Project, from the Trojan Substation area, this alternative would run northeast and cross the Columbia River near Longview, Washington; follow I-5 south through Washington; and come into Harborton via interstate submarine cable in the Columbia and Willamette rivers or a new 230 kV overhead crossing. While possible, this complex interstate route has several obvious obstacles that make it impossible to complete and energize in time to meet the current and projected near-term power demands. Specifically:

- PGE does not own land or easements that would allow construction of this alternative.
- This alternative would require new Columbia River and interstate crossings and would require years of interstate permitting and federal Section 408 review.
- This alternative would directly affect several runs of salmonid species protected under the Endangered Species Act and would be difficult to permit when alternatives exist.
- The project size and disturbance footprint are far larger for this alternative than for several other, more feasible alternatives.
- Permitting and approvals would take more than six to ten years, if possible at all.

This alternative also would not create a new pathway to the Hillsboro area for 230 kV overloads. With an alignment length of 33 miles, and not including the terminal or the elevated cost of submarine equipment, this alternative has a preliminary cost estimate of approximately $135 million.

2.3.2.5 New 230 kV Line from Wilsonville Area to Evergreen Substation

This alternative would forgo attempting to rectify issues related to limitations in the SOA path and instead seek to introduce power from generation sources located south of Portland to meet Project load objectives. PGE manages various electrical paths to provide energy to its service area. However, the existing infrastructure is built around those existing generation sources. As such, the current grid in northwest Portland, Beaverton, and Hillsboro, relies heavily on the SOA path for the bulk of energy

received. It is possible to reconfigure the grid, but doing so would require millions of dollars in transmission reconfigurations, and PGE would need to acquire substantial new rights-of-way, which would likely require several condemnations of private property and multiple natural resource area crossings.

The most likely alternate source for supply would require a new 230 kV transmission line from Wilsonville. PGE does not have any advance environmental studies for such a transmission line, so implementation time is likely a minimum of six years. The anticipated cost for 22 miles of single-circuit 230 kV construction is set at $4.9 million per mile in suburban areas based on PGE's estimator group, which would be $108 million. This cost estimate does not include terminal facilities, purchase of easements, grid reconfigurations, and permitting, which could easily double this amount. The timeline for such an effort would require a minimum of ten years, assuming a relatively smooth design and property acquisition process is encountered. Even if it were more feasible from a timeline perspective, this alternative would require substantial power flow modeling to verify system efficacy.

This alternative would not create a transmission pathway to Harborton to mitigate 115 kV overloads for North Portland or Northwest Portland. Generation sources are generally to the north and east of the area, not to the south. This alternative would provide limited beneficial transmission capacity.

2.3.2.6 Supply Power from PGE's Eastern System

The three alternatives discussed below would use PGE's eastern system. These alternatives would provide limited benefit at great cost. Their benefits are limited because they do not provide new load-serving capacity from Harborton to Hillsboro. Each would require significant new construction in urban Portland, making them very impactful to multiple properties and requiring numerous protected resource crossings, including a new Willamette River/Portland Superfund crossing. None of these options are practicable because they would take much longer to construct than the available time frame allows for based on current power demand forecasts.

New 230 kV via New Blue Lake-Rivergate and Rivergate-Harborton

This route would span approximately 17 miles through urban areas in the vicinity of Portland International Airport to connect PGE's Blue Lake Substation in Troutdale, Oregon to the Harborton Substation via PGE's Rivergate Substation in north Portland. PGE does not own right-of-way for this route, so it would require several property acquisitions and crossings of elevated roads, BPA transmission lines, and other substantial constraints. A second circuit from PGE's Rivergate to Harborton Substation would require a Willamette River aerial or submarine crossing, which would require substantial efforts to permit due to navigation, Superfund complexities, protected fisheries, and other well-established constraints. Assuming a path could be obtained, the cost for the transmission line for this alternative, exclusive of terminal equipment between Blue Lake and Rivergate, would be about $103 million.

Submarine Cable between Blue Lake-Harborton

PGE is assessing marine cables for use in its system but, at present, sees many maintenance and reliability concerns that make them impractical. Installation and maintenance of this alternative would directly affect several runs of salmonid species protected under the Endangered Species Act and would be difficult to permit when other alternatives exist. The project size and disturbance footprint would be far larger than other, more feasible alternatives considered in this document. Permitting and acquisition of easements would take several years and with a length of approximately 22 miles, this alternative would cost more than $88 million to acquire and construct. The addition of submarine cables would not address the existing transmission constraints between the Trojan Substation and the Portland Metropolitan Region, nor between Portland and Hillsboro and Beaverton.

New 230 kV Gresham-Rivergate 230 kV

This alternative would create a new Gresham-Rivergate 230 kV transmission path by rebuilding the 57 kV system to the Springwater Corridor and the Oregon Museum of Science and Industry (OMSI) and create a new path from OMSI to Harborton area.

Absent a much more compelling reason, it is impractical to construct major new transmission lines through the City of Portland urban core. If possible, at all, it would take ten years or more to acquire easement, design, and permit. PGE does not own or control property to create a connection between Gresham and Rivergate; a new Willamette River Crossing would be required (through or over the Portland Harbor Superfund).

Absent another project, this alternative would not provide reliable load serving capacity from Harborton to Hillsboro. This alternative would have a very large project size and disturbance footprint relative to other, more feasible alternatives considered in this report. The hypothetical route for this alternative is about 23 miles. The cost for this alternative begins at $141 million exclusive of land acquisition, terminal equipment, or whatever rebuilds might be required at the Ramapo, Lents, Southeast Portland, and Holgate substations along the route.

2.3.2.7 Alternatives Involving BPA

Several alternatives exist that could potentially rectify one or more of PGE's current transmission configuration issues by implementing a variety of improvements and interconnections in BPA's transmission line system. While BPA is a key partner in regional transmission planning, PGE has no ability to require BPA to implement these improvements in time to meet PGE's anticipated customer demand.

Each of the following alternatives relies on action by BPA which cannot be guaranteed and would create a reliance on facilities that are outside of PGE's direct control. Nevertheless, these options were considered to confirm that none of these offered overwhelming advantages:

- BPA Allston – Keeler 500 kV Expansion and Transformer Addition
- Keeler – Rivergate 230 kV Line Upgrade
- Allston – Keeler 500 kV Second Circuit
- Loop BPA Keeler – Rivergate 230 kV into Harborton
- Repurpose BPA's St Helens – St John's or Keeler – St. John's 115 kV Circuits
- Construct New 230 kV from BPA Ross to Harborton

BPA has spent the last several decades developing its I-5 Corridor Reinforcement Project to add transmission capacity. This project was eventually cancelled, reaffirming PGE's need to act proactively to improve vulnerabilities identified within PGE's system, rather than depending on BPA to make improvements. While PGE will continue to coordinate with BPA on future planning and frequently collaborate to meet regional goals, PGE will not consider any of the above alternatives as practical, given that PGE lacks the ability to move these forward independently.

2.3.2.8 Generation and Battery Storage Alternatives

Generation and battery storage alternatives examine the possibility of using new generation sources and battery energy storage systems to eliminate the need for transmission upgrades. The addition of battery, solar, wind and fossil fuel resources were considered. Wind and solar are typically large facilities placed in eastern side of state where sun and wind are plentiful. These exist, but delivery and transmission of their power is one of the primary issues the HRP is trying to address. Creating more of these resources does not address the transmission constraints/ vulnerabilities. For example, generation constructed in Hillsboro does not serve Northwest Portland and vice versa.

Solar and battery resources integrated at the distribution level, including new, large battery storage projects in both Washington County and North Portland, are accounted for in the load forecasts associated with PGE's transmission planning studies. These forecasts were used to prepare PGE's current Clean Energy Plan & Integrated Resource Plan. These plans are combined into one document that describes how PGE will meet customer energy needs and greenhouse gas emissions targets while maintaining reliability, safety, and affordability[11]. Reasonable estimates of the contributions of these resources are therefore implicitly included in the projected peak load forecasts. PGE is aggressively developing its portfolio of battery energy storage systems to help level loads; however, these will not alleviate the limitations in the SOA path during peak demand days, nor address the 115 kV transmission issues in Northwest Portland.

2.3.3 Alternative Arrangements in Forest Park

The following alternatives describe transmission routing changes to the proposed entrances and exits from the Harborton Substation and would involve new or repurposed structures in Forest Park.

2.3.3.1 Route the HST Into Harborton Substation and Construct Two New Transmission Segments in Forest Park to Connect Harborton to St Marys and Evergreen Substations

This alternative would make full use of the existing Utility ROW in Forest Park in the hillside area across from the Harborton Substation and was the initial design proposal envisioned for the Project. The existing, problematic three-terminal Horizon-St Marys-Trojan line would be redirected in Forest Park at Tower 2997 and routed into the Harborton Substation. Then the route would be completed from Harborton to PGE's St. Marys and Evergreen Substations along two new 1,400-foot segments of transmission corridor within existing Utility ROW, which would connect to the existing transmission corridor west through Forest Park (replacing the St Marys-Wacker and HST lines west of Tower 2997). This alternative would allow for two future Harborton-Trojan 230 kV lines to come through Forest Park in existing Utility ROW when such additional power supply is needed (Harborton-Trojan 230 kV #3 and #4)

This alternative would use existing Utility ROW to add two new parallel segments of 230 kV transmission corridor through Forest Park. Because all of this work would occur within existing Utility ROW, no additional easements or other land acquisition would be required in this alternative, thus expediting the timeline for the needed upgrades to the grid and establishing an abundant power supply to meet long-term power demands. By phasing construction, this alternative can meet the projected time frame requirements. As such, it meets all of the evaluation criteria with the exception of cost, which is estimated at $20 million.

However, this alternative would result in substantial environmental impact within Forest Park; at over 6 acres of vegetation impacts, it would have the most impact to the park of all alternatives explored. Because this alternative does meet most of the evaluation criteria, it was explored further to identify forest impact minimization options, thus resulting in the design option described below in Section 2.3.3.8.

2.3.3.2 Harborton to St Marys 230 kV Line

This alternative would reconfigure the St. Marys-Wacker 115 kV line so that the segment originating in Portland at the Wacker Substation terminates at the Harborton Substation, creating a new Harborton-Wacker 115 kV line. This alternative would leave one side of the existing transmission corridor through Forest Park idle and would use this idle portion of the line to create a new Harborton to St. Marys 230 kV line. This would create a new 230 kV supply to Harborton from St. Marys. The existing HST three-

[11] https://portlandgeneral.com/about/who-we-are/resource-planning/combined-cep-and-irp

terminal line would become a dedicated Trojan – Evergreen, two-terminal 230 kV line. The drawback to this minimization alternative is that that the switching flexibility would be reduced, the impact of the outage of a common tower would be increased, and the power flow balance on the circuits out of Trojan to the south would be very limited. As a result, this alternative provides very little improvement for several key factors driving the need for the Proposed Project.

Construction cost estimates for this option are difficult to produce because there are several related upgrades that would be needed in order for this configuration tie into existing infrastructure in Beaverton and Hillsboro. These upgrades include a new transformer at St. Marys, connecting and upgrading the Evergreen-Trojan 2-terminal line, and replacing the conductors on the St. Marys-Orenco 115 kV line. A base cost for this alternative is $20 million-$40 million, and costs could rise to $131 million if transformer replacements were required.

2.3.3.3 Utilize 4-Circuit Structures

Single 4-circuit structures could replace existing towers PL-2998 and PL-2999, which support the existing east-west line segment of HT1 shown in the Proposed Project layout in **Figure 4**. This could reduce the need for the 1,400-foot-long new transmission segment associated with the new proposed tubular steel pole (TSP)-3 and TSP-5, which would support the new segment of PGE 230 kV transmission in Forest Park (shown on). For short distances (typically less than 1 mile), 4-circuit structures are not considered violations of NERC standards.[12]

However, 4-circuit structures present failure modes where an outage on one line that shares the common structure could eliminate all the supply to Harborton from the north and west, resulting in large-scale impacts to regional utility customers. For this reason, PGE does not have any 230 kV 4-circuit structures in its system and PGE's internal guidelines prohibit their use. PGE does not want to introduce a new structure type that is out of compliance with its internal system requirements and maintenance program. Maintenance of 4-circuit 230 kV structures requires specialized equipment, specialized training/personnel, and either multiple outages or very high-risk maintenance work. Additionally, 4-circuit structures could result in 230 kV lines that are much lower to the ground due to separation requirements between the upper and lower 230 kV conductors on the shared structure if a vertical configuration is necessary. Consequently, a wider clearing corridor and removal of mature trees and tall-growing shrubs that become a conflict with the lower lines would be required. For these reasons, this alternative has large drawbacks with limited benefit, if any, in terms of impact reduction. As these structures are not used by PGE, cost estimate information is not readily available, but it is presumed that costs would be in the range of $10 million.

2.3.3.4 Use Tall Structures to Cross Directly to the Ridge in Forest Park

BPA and PGE operate very tall lattice towers south of the Harborton Substation along the Willamette River shoreline supporting 230 kV transmission crossings. The BPA lines avoid placing transmission structures in the forested lower hillslope near the east boundary of Forest Park by connecting directly to towers at the top of the hill. This configuration works well in the case of BPA's lines, which travel continuously from the Willamette River's west shoreline to the upper hillside in Forest Park. For PGE's circuits, however, the arrangement is more complicated because wires need to descend to connect at Harborton Substation, which is offset to the northeast from the existing Utility ROW in Forest Park and sits only a few feet above river elevation.

New taller structures at the top of the hill in Forest Park would have much larger basal footprints and

[12] See NERC Standard TPL-001-5 — Transmission System Planning Performance Requirements (TPL-001-5 (nerc.com). Common structure outages are "P7" multiple contingency events where interruption of firm transmission and non-consequential load dropping is allowed. Table 1 footnote 11 explicitly excludes distances of less than 1 mile.

the civil infrastructure to access and build these taller structures will be larger than what would be needed for tubular steel pole construction. The impact of these new very tall structures would ripple down the transmission line to the west in Forest Park, necessitating replacement or raising of additional existing structures to gradually bring the wires back to a conventional height.

Looking down the hill, PGE's transmission easement is aligned to the river crossing, not for direct connection into Harborton. New easements would be needed from the City allowing wires to span over areas of Forest Park to the north of the current Utility ROW and vegetation removal for construction would be needed in the upper half of the hill. This vegetation clearing would be necessary periodically for ongoing transmission corridor maintenance. The area subject to tree clearing would be wider than existing transmission corridors, since longer spans also sway further laterally in the wind. It is also not clear that sufficient land exists at the substation to accommodate new very tall towers and step-down structures. Using the existing easement alignment is not possible because the area for new very tall towers near the substation is currently occupied by PGE river crossing towers and step-down structures for transmission lines coming from the east. That area also contains a large wetland.

The cost of very tall towers is substantial. Existing cost metrics are unavailable due to the unique nature of these structures but it is presumed that costs would be at least double that of an alternative that used more conventional steel poles to achieve the same routing configuration (i.e., $20 million).

2.3.3.5 Underground New 230 kV Segment from Harborton to Tower 2996 in Forest Park

This alternative would place Harborton to Trojan #1 and #2 underground between the Harborton Substation and the vicinity of TWR-2997, and would place Harborton to Evergreen 230 kV and Harborton to St. Marys 230 kV underground to the vicinity of TWR-2996. TWR-2996 and TWR-2997 would be replaced by transition structures to help move the transmission lines from underground to aboveground towers.

The Forest Park NRMP includes considerations for utility corridors; these note that new underground utilities have impacts to resources similar to aboveground utilities, including the need for access roads and vegetation management. Nevertheless, a study to evaluate three different underground techniques was undertaken13 to determine whether this alternative could be used to minimize impacts to Forest Park. The study concluded that “Recognizing the significant environmental and safety impacts of any underground option…an all-overhead solution [is recommended].”

All underground options would require clearing trees and vegetation along duct bank alignments and at temporary construction work areas, which would require longer construction times and more heavy equipment than alternatives that are not underground. Unlike clearing for an overhead line, this level of clearing would need to be frequently maintained to prevent roots from intruding into the electrical conduits in a transmission corridor; for underground utilities, limited vegetation is allowed to grow above the lines and in the surrounding area. At vaults, retaining walls would be required. Significant grading would be required for temporary and permanent facilities. Permanent enclosures within the park would be required to isolate the facilities from the general public. The costs for underground development are five to ten times the costs of overhead transmission (depending on trenching or boring technique).14 For these reasons, the underground alternative is neither feasible nor practical.

2.3.3.6 Construct a 230 kV Switching Station Near TWR 2996 in Forest Park

This alternative would resolve some project goals but would also entail a major construction effort in the same vicinity as the Proposed Project. Instead of two new steel poles and 1,400 feet of new overhead wires, this alternative would construct a new permanent switching station in the Utility ROW,

[13] PGE commissioned Black and Veatch to conduct the underground routing feasibility study in 2023.

[14] OverheadVsUnderground_FactSheet.pdf (xcelenergy.com) and Lennar_DR1.R1_AC.pdf (ca.gov)

fenced to secure it from public access and with the addition of an improved access road for frequent use by PGE operations personnel.

PGE's easement rights do not appear to allow a permanent switching station; instead, they appear to allow only lines and towers for transmission. While the area of permanent impact of this alternative would be smaller than that required for the Proposed Project Utility ROW clearing, the impact would be stark with the area cleared and leveled. Associated stormwater improvements would also be necessary to meet City of Portland Bureau of Environmental Services code for new impervious area. Rather than creating short-stature tree and shrub habitat beneath the lines (consistent with the existing corridors to the north and south), forest habitat would be converted to a developed structure that would have a more substantial effect on visual resources and forest character. The estimated cost for this alternative (new switching station and associated line reconfigurations) is $30-50 million based on a rough order of magnitude estimate by PGE's estimating group.

2.3.3.7 Upgrade Existing Harborton - Trojan 230 VK Line to 500 kV

Consideration of this alternative is primarily to provide for a complete analysis of possible options. The environmental impacts and costs of creating a larger power line (500 kV) corridor through Forest Park, including areas west of the Proposed Project, would be highly prohibitive.

PGE substations in the area do not have 500 kV facilities. The existing towers are not sized to carry the additional weight of 500 kV insulators or to create sufficient ground clearance to safely operate at this higher voltage. Operating at this voltage requires wider rights-of-way, which would require more vegetation clearing over a longer distance in Forest Park and would require hundreds of new easements and possible property condemnations west of Forest Park.

Such a project would be very expensive. There is no 500 kV infrastructure at or near Trojan or Harborton. Each of these two new switchyards would cost about $60 million, and transformers would cost approximately $37 million each. BPA estimated $41 million for rebuilding Keeler 500 kV in its 2022 Transmission Plan[15]. Based on these costs, the total for terminal equipment for this alternative amounts to approximately $194 million. Demolishing and reconstructing the line on the existing right-of-way could cost $203 million, making the total cost estimate for this alternative approximately $424 million.

2.3.3.8 Route the HST Into Harborton Substation but Construct Only One New Transmission Segment in Forest Park to Connect Harborton to St Marys and Evergreen Substations

This alternative would reconfigure the existing power line routing in Forest Park west of PGE's Harborton Substation similar to the alternative in Section 2.3.3.1 but it would only move forward those elements of the HRP that are absolutely necessary at this time. Full build of the Harborton-Trojan Lines 3 and 4 may be needed in the future but the immediate need to address the constrained system and meet near term demand can be met with a scaled-back configuration. Rather than bring in the two additional powerlines from Harborton, this minimization alternative would repurpose the existing transmission corridor segment in Forest Park that carries the Harborton-Trojan #1 line and the St. Marys-Wacker 115 kV line through the Park. The lower pole in this segment would be replaced and shifted south so that it can U.S. Hwy 30 into PGE's Harborton Substation while staying within existing PGE easement. The St Marys-Wacker 115 kV line would be removed in Forest Park and would, instead become the Harborton-Wacker 115 kV line outside of Forest Park. The current HST line would be redirected at Tower 2997 and routed into Harborton, replacing the St. Marys-Wacker 115 kV line. This segment would become the Harborton-Trojan #2 line, and would provide an additional source of 230 kV power into the Harborton Substation.

[15] 2022-bpa-transmission-plan.pdf, Page 98.

With these two sources of 230 kV power coming into Harborton, the substation would be able to address 115 kV overload concerns on its existing St. Marys-Wacker line and provide greater capacity to power regional substations in Northwest Portland.

To restore transmission between Trojan and areas west of Portland, PGE would develop a 1,400-foot-long segment of new transmission corridor in Forest Park between PGE's Harborton Substation and Tower 2996, which is located where the existing HST line bends west in Forest Park. This new segment would be located between the existing PGE Harborton-Trojan corridor to the north and the BPA transmission corridor to the south and would be located entirely within existing Utility ROW. Together with the removal of the St Marys-Wacker line, this new 1,400-foot-long segment of transmission line would allow the HST line west of Tower 2996 line to be broken up into two separate 2-terminal lines that connect directly into the Harborton Substation as follows:

- Harborton-Evergreen 230 kV
- Harborton-St. Marys 230 kV

2.4 ALTERNATIVES CARRIED FORWARD

Upon reviewing the many alternatives described above in Section 2.3, the following alternatives were carried forward for additional consideration given their ability to partially meet the purpose and need:

- Construct Harborton-St Marys and Evergreen-Trojan Direct Lines Using Existing Towers
- South Marina Way/Forest Park Avoidance
- Use 4-Circuit Structures
- Use Tall Structures to Minimize Forest Impact
- Route the HST Into Harborton Substation but Construct Only One New Transmission Segment in Forest Park to Connect Harborton to St Marys and Evergreen Substations

Each alternative was considered further for ways to make it more practical in terms of cost, schedule, environmental impact reduction, and reliability. A deeper review to identify risks and shortcomings of the alternatives was also completed. Then, all six alternatives were compared against the evaluation criteria identified in Section 2.2 to determine which alternative was the most practical alternative. Table 2 presents the results of this comparison, and the results are summarized below in Section 3, Conclusion.

2.4.1 Tall Structures

Utilizing extremely tall structures up on the hill in Forest Park was evaluated in an attempt to reduce impacts within the park. This alternative would require two (2) new tall tower structures at the top of the hill in Forest Park (one structure for the existing lines and one structure for the new lines). The new tall structures would span to new tall structures outside Forest Park at or near the Harborton Substation property. The hope was to reduce impacts in Forest Park, but there are several issues with this alternative:

The primary challenge would be related to the span from the top of the hill to tall towers on the Harborton property. To stay within the existing PGE easement, the span would end up well south of the Harborton Substation. This area is constrained by existing underground facilities (including a high-pressure line), BPA transmission lines, other PGE poles and towers, and a large wetland/stream complex that is classified as Willamette River "Greenway" protection zone. Preliminary analysis indicates that there is not sufficient room to spot new very large structures in this area and turn the four proposed 230 kV lines to the north, dropping into the Harborton Substation.

It is likely that this alternative would have similar, and possibly larger, impacts on Forest Park habitat and the surrounding area due to wider wire swing and downstream tower replacement requirements. With extremely tall structures, the transmission line will have a greater visual impact on the area. FAA will likely require certain mitigation for aircraft safety, which may include lighting, painting, and marker balls. FAA notification of presumed hazard is typically avoided in transmission design.

Lattice towers would be much more visible, require substantial additional engineering, would require substation development within a wetland/stream complex (Greenway Zone), and would require rearrangement of the existing approaches to Harborton. Because of the additional span length and conductor blow out (area where wires may swing during high wind), taller lattice towers may also require additional easements within Forest Park and a wider area of managed vegetation beneath the transmission lines.

2.4.2 4-Circuit Structure

While NERC and other standards permit 4-circuit structures for short distances, good utility practice is to avoid these whenever possible. PGE's policy is consistent with these practices. In this instance, the structures would be located on a steep slope subject to higher risk of failure and within a highly sensitive environment. A failure that removed all the supply from the north and west of Harborton would have to be addressed quickly and this might result in significant damage in the right-of-way that could be long lasting or permanent. High impact, low probability events are recognized by the standards and subject to study as P7 "Common Structure" failures. PGE's standards do not allow these modes of failure to be added to its system.

Relative to the Proposed Project, the impact on the forest would not be reduced in a substantial way that would warrant the higher risk factor for failure. A single 4-circuit structure at the base of the slope in Forest Park would have conductors that spread to two double-circuit structures at the top of the hill. This creates a triangle shaped area of required vegetation management covering at least three acres. At the cost of a second 4-circuit structure at the top of the hill, these 3 acres could be reduced but at the cost of doubling the exposure to failure associated with a 4-circuit structure.

Additionally, due to separation requirements between 230 kV lines, a 4-circuit structure may require lower conductors, which reduces the height of vegetation that can grow within the rights-of-way. This would require more frequent maintenance and tree removal.

2.4.3 NW Marina Way

Implementing this alternative requires a new route for the existing Harborton-St Helens 115 kV transmission line. An alternative route for this line has not been identified. A review of alternative alignments for alternative 230 kV routes around Forest Park conducted by Toth and Associates in 2022 found fatal flaws with linear route options in the area, making the relocation highly challenging. Fatal flaws include geotechnical conditions and easement limitations in areas between Forest Park or the Miller Creek Natural Area (north of Portland) and NW Marina Way. Identifying, designing, and securing easement for this route would be necessary before the existing 115 kV line could be moved and a new 230 kV segment could be installed. Initial outreach has been conducted by PGE to determine whether landowners in the area would be generally amenable to transmission upgrades and potential additional easement needs. Feedback has indicated a general reluctance to support the project and refusal by at least one key property to allow for additional easement that would be needed. This indicates that acquisition of the needed ROW could involve condemnation, which requires OPUC approval via a lengthy, often multi-year process. Designing, permitting, and securing easements for a new 230 kV segment across U.S. Hwy 30 and along Marina Way would take several years and far exceed the time frame for resolving the current reliability concerns. This alternative would fail to meet federal, regional, PGE, and state reliability standards and would not be operational by the end of 2027 as needed.

2.4.4 Use Existing Towers for Harborton to St. Marys and Trojan to Evergreen 230 kV Lines

Substantial further consideration was given to this alternative. The HST three-terminal line, and associated reliability concerns, may be partially addressed by converting the idle St. Marys-Wacker 115 kV line to 230 kV and routing it into Harborton using existing transmission corridor. This would result in the following 230 kV line configurations:

- Evergreen - Trojan 230 kV
- Harborton - St. Marys - 230 kV

This would minimally meet the HRP objectives of providing a new source of power to Harborton via return flow from St. Marys and eliminating the three-terminal line. However, without a secondary Harborton-Trojan 230 kV direct connection, when HT1 230 kV is out of service the Trojan to St. Marys to Harborton 230 kV path will be 15.8 circuit miles longer than an alternative that routes a second 230 kV transmission line from Trojan into Harborton. The generation transmission capabilities of Beaver and Port Westward Units 1 and 2 are 510, 411, and 225 MW, respectively, for a total of 1,146 MW. With Allston to Keeler 500 kV out-of-service there is 1,218 MVA available to transport power to PGE if there are two 230 kV circuits directly connecting Harborton and Trojan. However, under this alternative, the Evergreen - Trojan circuit capability would be 586 MVA because of the diminished conductor size on the existing segment between Springville Junction and Horizon. This reduces the total capability by 23 MVA until the conductor is replaced, which would not provide sufficient resiliency for projected demand by 2028.

A deeper power flow analysis was performed on this configuration by PGE's Transmission Planning team. This analysis shows that for the predicted summer loading in 2028 this alternative results in heavier loading of the 115 kV system and causes overloads on 230/115 kV transformers at St Marys. The affected 115 kV lines support critical loads such as trains and transit. The extra costs of upgrading transformer capability and 115 lines could be upwards of $131 million. [16]

This deeper analysis also shows that this alternative would reduce the overload, but equipment is still operating at 99% maximum capacity. At this extremely high level of expected loading, another project would need to be immediately identified and implemented to achieve the necessary improvements.

This alternative limits the switching flexibility, reduces the capacity, increases the impact of a common tower outage, and does not balance the flow on the circuits out of Trojan to the south. Because of these factors, this alternative does not maximize the transfer capability of the SOA path sufficient to resolve all of the identified system vulnerabilities and is not capable of meeting projected demands for load growth.

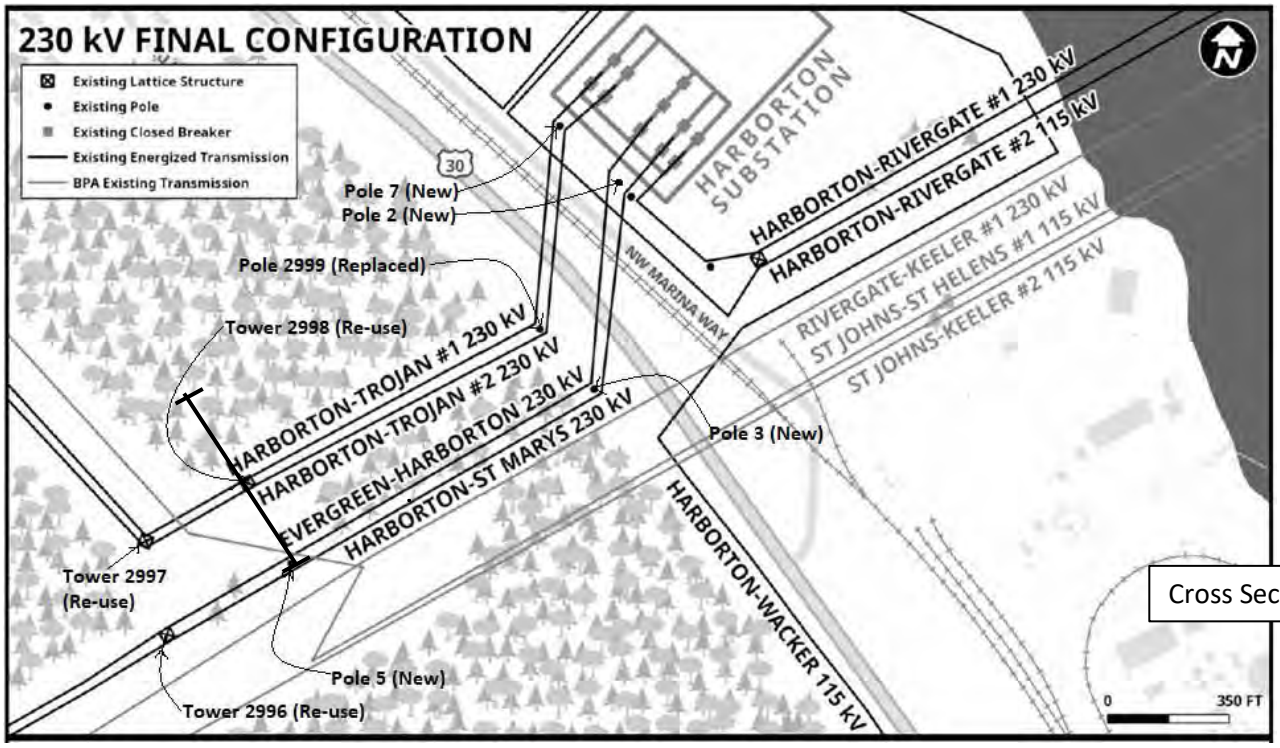
2.4.5 Route the HST Into Harborton Substation but Construct Only One New Transmission Segment in Forest Park to Connect Harborton to St Marys and Evergreen Substations

This alternative minimized the original design concept to build only what is needed to meet the short-term critical needs for infrastructure improvements. To minimize effects on forest resources in Forest Park, all improvements would occur within the Utility ROW and the project would conserve a portion of the existing forest stand located within the Utility ROW between PGE's existing HT1 line and BPA's transmission lines to the south. See **Figure 7**, below, for this proposed configuration and compare with the current configuration shown in **Figure 4** on page 5 above. A cross section of this configuration is provided in **Figure 8** below.

[16] Analysis based off email correspondence dated January 18, 2024, RE: Harborton 230 kV Alternatives Discussion, from Christopher Kulink to Stephen Miller, et al.

This alternative will achieve the stated purpose and need in an effective time frame and at a cost of approximately $10,000,000, which is a reasonable cost for the anticipated improvements and, thus, will minimize impacts to ratepayers. This alternative provides the minimum amount of tree removal and stream/riparian habitat impact while providing the critical infrastructure improvements needed by 2028.

Figure 7. Proposed PGE 230 kV Transmission Configuration (Proposed Project, Plan View)



Cross Section (see

Figure 8. Proposed PGE 230 kV Transmission Configuration (Proposed Project, Cross Section View)

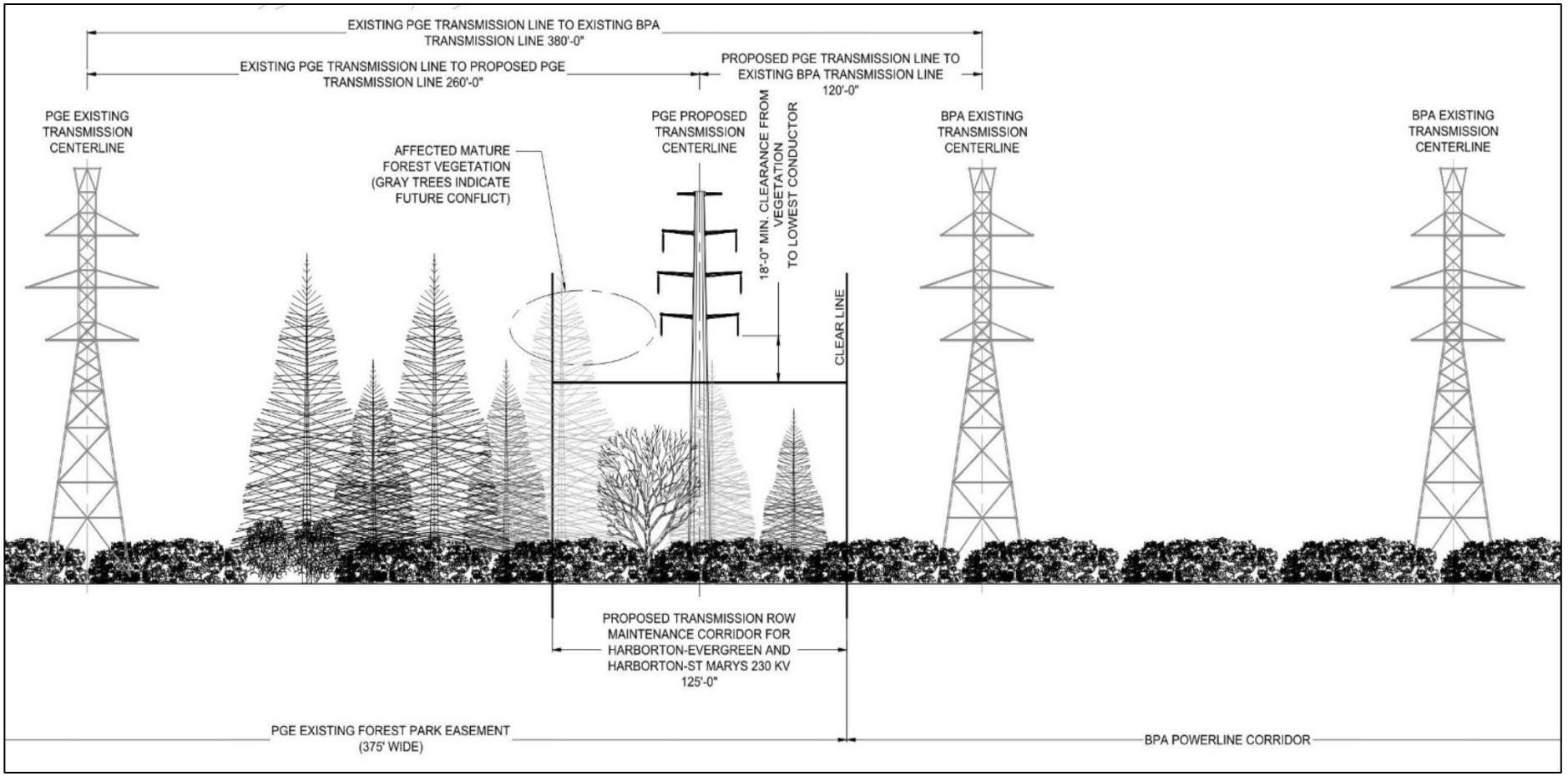


Table 2. PGE Harborton Reliability Project Alternatives Evaluation Summary

Criteria	Alternatives				
	Construct Harborton-St Marys and Evergreen-Trojan Direct Lines Using Existing Towers	**NW Marina Way/Forest Park Avoidance**	**Use 4-Circuit Structures**	**Use Tall Structures to Minimize Forest Impact**	**Reconfigure Routing in Exisitng Utility ROW in Forest Park**
1. Project must deliver additional 230 kV power source to Harborton	Yes	Yes	Yes	Yes	Yes
2. Project must fully resolve transmission vulnerabilities associated with current three terminal Horizon-St Marys-Trojan line	No	Yes	No	Yes	Yes
3. Project must minimize cost impact to PGE ratepayers. Alternatives should cost similarly or less than preferred alterntive to score for this criterion.	No ($131M)	No ($26M)	Yes (~$10M)	No (~$20M)	Yes ($10M)
4. Project should improve the regional transfer level and provide infrastrucutre necessary to support projected demands in current planning horizon.	No	Yes	Yes	Yes	Yes
5. Project must utilize equipment that is consistent with PGE design standards and maintenance operations	Yes	Yes	No	No	Yes
6. Project must be operational in three years to meet demand and federal reliability standards; standards are projected to be violated in 2028.	No	No	No	No	Yes
7. Minimize the Environmental Impact (Measured as vegetation removal)	~ 1 acres (possibly more depending on number of towers to be replaced)	3-4 acres	2-3 acre	~3-4 acres	4.68
Note:	**Meets Criterion**	**Does Not Meet Criterion**			

3 CONCLUSION

Based on this analysis, the alternative described in Section 2.4.5 is the preferred alternative. This alternative will reconfigure transmission line routing in existing Utility ROW in Forest Park and will be moved forward as the Proposed Project. It is the only practical alternative, because it meets the purpose and need effectively and offers substantial advantages over all other alternatives. For example, by staying within existing Utility ROW and using standard PGE steel pole structures that are safe, reliable, and have an established maintenance protocol, the Proposed Project offers the necessary expediency and certainty. Other alternatives evaluated that had less potential impact to Forest Park resources are not practicable for a variety of reasons, including safety concerns, inadequate grid improvement, constructability, schedule concerns, and/or other concerns that make them infeasible with regard to the purpose and need. The Proposed Project not only meets all project evaluation criteria, but it also demonstrates an effort to reduce habitat impacts to only those necessary to address the immediate needs for infrastructure improvements.