Appendix G
Riparian Shade Analysis

1 INTRODUCTION

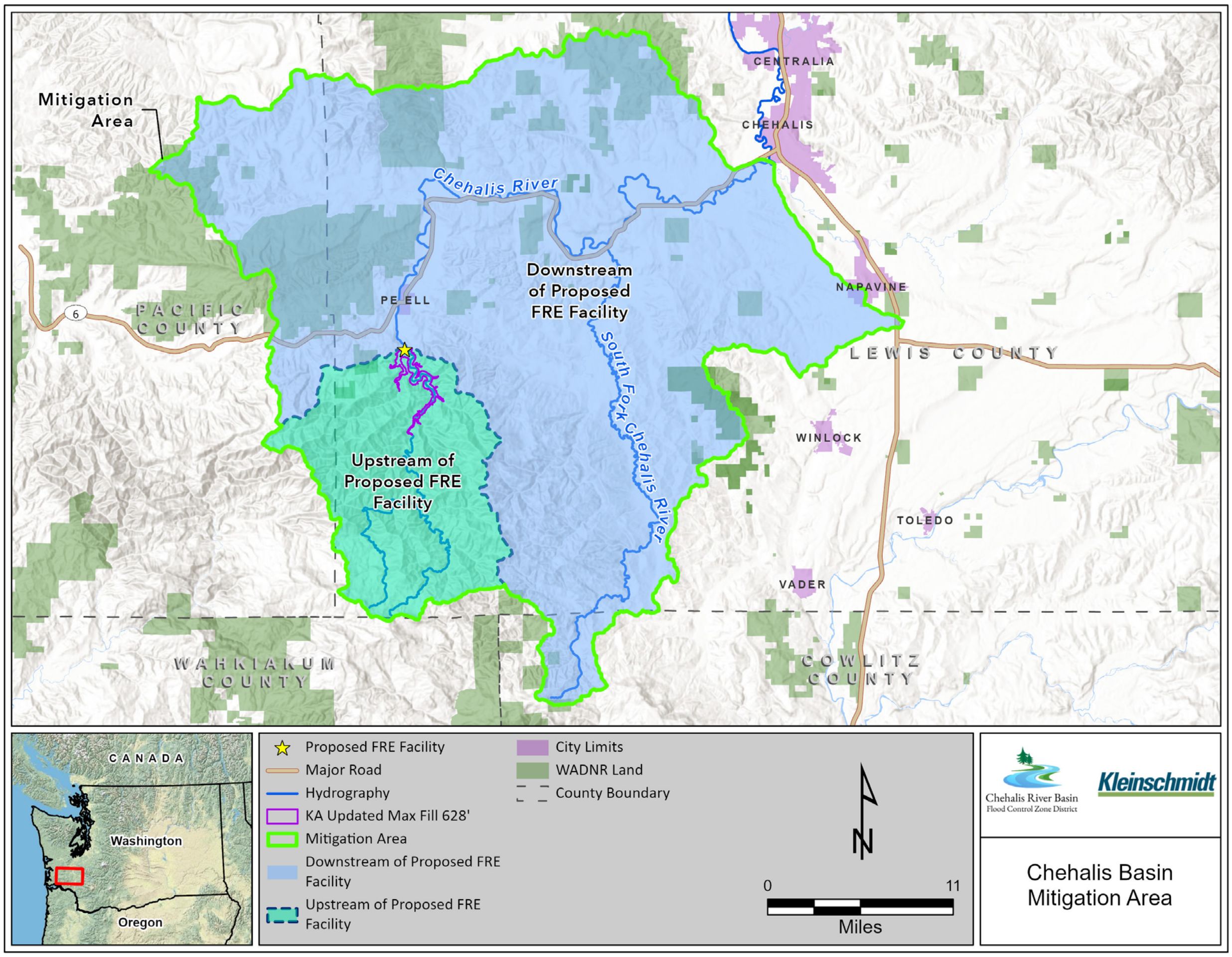
1.1 Background

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing to construct a Flood Retention Expandable (FRE) facility to reduce the risk of flood damage along the mainstem Chehalis River. The proposed FRE facility is located approximately 1.7 miles upstream from the city of Pe Ell, Washington in the upper Chehalis River watershed near river mile (RM) 108.4 (Figure 1.1-1). The primary purpose of the FRE facility is to reduce flooding coming from the Willapa Hills by storing floodwaters in a temporary reservoir during major floods. In 2020, the two draft Environmental Impact Statements (DEISs) released for this project (the Washington Department of Ecology's [Ecology] under the State's Environmental Policy Act [Ecology 2020] and the United States Army Corps of Engineers [Corps'] under the National Environmental Policy Act [Corps 2020]) projected that by temporarily storing peak flows during major flood events, the FRE facility operations would alter riparian vegetation and thereby reduce riparian shade. This in turn was hypothesized to negatively impact water temperatures based on results from a water quality model documented in each of the DEISs. Due in part to the projected increases in water temperature, the DEISs subsequently determined that the proposed project will have significant impacts on aquatic resources and anadromous salmonids (Ecology 2020; Corps 2020). Impacts were generally represented as occurring upstream of the confluence of Elk Creek (around RM 100).

Shade restoration is an accepted method for water temperature reduction in thermally impacted rivers (Dugdale et al. 2018; Trimmel at al. 2018) including locations throughout the Pacific Northwest (Fuller et al. 2022). The potential for effective shade cooling is related to the interception of solar input that would otherwise increase water temperatures. For rivers, the effectiveness is limited by the relationship between maximum tree height and the river bankfull width, tree height needs to be 1.4 times the width (Ecology 2007). A random check on bankfull width data for the Chehalis River in the mitigation area indicated that this condition could be met for the mainstem as well as major tributaries based on native riparian species present along the river.

This report presents the application of a riparian shade model to determine sufficient mitigation to offset DEIS impacts. The model used more recent information regarding existing vegetation conditions in the temporary inundation area upstream of the proposed FRE facility to update the without-project shade condition. Updated canopy information was necessary as the modeling for the DEISs did not have vegetative shading data available and so assumed vegetative shading for the entire temporary inundation area was assumed to be equivalent to the 2 kilometer (km) reach downstream of the FRE location (PSU 2017). In addition, refined shade parameters for the temporary inundation area are presented that are consistent with anticipated vegetation heights of future plant communities following implementation of a Vegetation Management Plan (Appendix D in Kleinschmidt 2024). Finally, the shade benefits of mitigation actions downstream of the FRE are quantified.

Figure 1.1-1
Chehalis Basin Mitigation Area.



1.2 Study Area

Shade modeling was completed throughout the temporary inundation area upstream of the proposed FRE facility and downstream in the Chehalis River from the FRE facility to the confluence of the Chehalis River and the Newaukum River, near Chehalis RM 75.2. Shade along select tributaries including Bunker Creek, the South Fork Chehalis River, and the Newaukum River was also modeled.

1.3 Shade-a-lator Model

Shade-a-lator is a module of the Heat Source model, a stream assessment tool used by Oregon Department of Environmental Quality (ODEQ) (Boyd and Kasper 2003). Oregon DEQ currently maintains the Heat Source methodology and software development, which can be accessed via the ODEQ analysis tools webpage (ODEQ 2024). TTools is an ArcGIS extension that is also used and maintained by ODEQ. TTools was used to sample geospatial data and assemble high-resolution inputs necessary to run the Heat Source model.

ODEQ's Shade-a-lator model has been applied in a range of regulatory and research applications. Focus of research applications has been to quantify how riparian vegetation changes solar loading in streams, particularly in the context of mitigating the impacts of climate change (Holzapfel et al. 2013; Lawrence et al. 2014; Bond et al. 2015; Justice et al. 2017; Trimmel et al. 2018; Wondzell et al. 2019). Shade-a-lator and Heat Source have also been used to support Total Maximum Daily Load (TMDL) development and 401 certifications (ODEQ 2001, 2006, 2018). A TMDL is a water quality restoration plan and the calculation of the maximum amount of a pollutant that a waterbody can receive while still meeting water quality standards for a particular pollutant. Shade was used as a surrogate for stream temperature in several Oregon TMDLs including the Tualatin Subbasin, Umpqua Basin and Western Hood River Subbasin (ODEQ 2001, 2006, 2018) as well as the TMDLs for the Klamath, Salmon, Scott, and Shasta rivers in California (USFS 2011). Although the water quality standards were written for stream temperature, the metric used in these TMDLs and temperature trades has been the amount of kilocalories/day (kcal/day) blocked by shade.

The protocol for temperature trading defined by ODEQ's Internal Management Directive outlines a series of ways in which uncertainty is accounted for in temperature trades in Oregon. For instance, the main way of accounting for uncertainty is through the application of a 2:1 trading ratio, meaning that buyers are required to purchase twice as many credits for compliance. While no water quality trades have yet occurred in Washington State, Ecology produced a draft water quality trading framework in 2010 (Ecology 2011).

2 METHODS

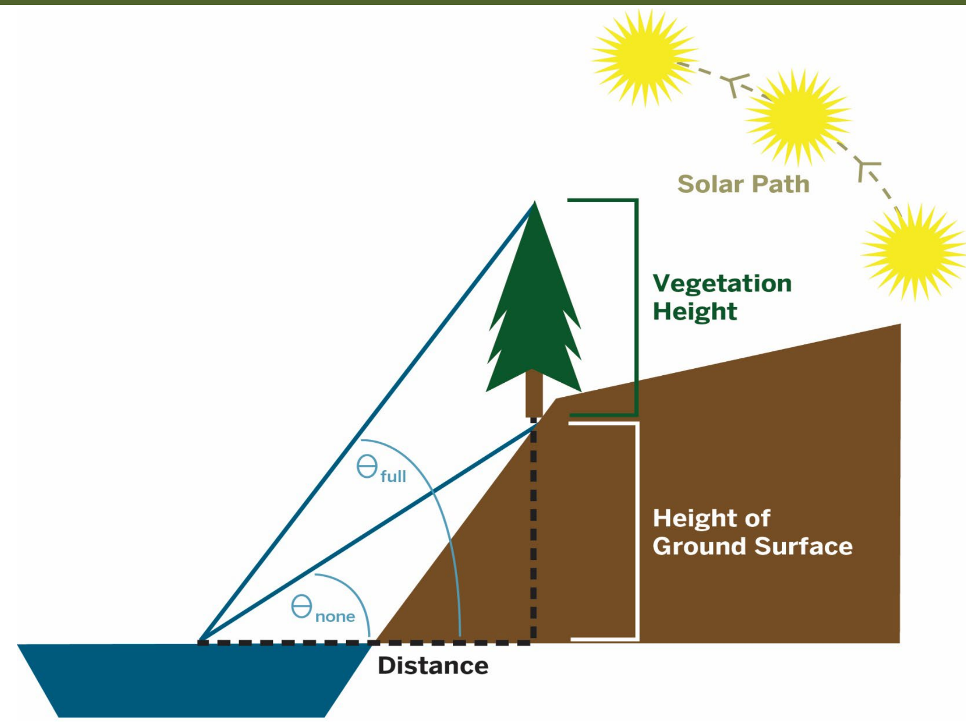
2.1 Shade Model Inputs

Shade model parameters describe vegetation characteristics (canopy height and density), and physical characteristics of riparian habitat including the bank lines of the modeled stream reach, water surface area based on the width of the stream, bank slope, stream channel aspect, surrounding topography, and geographic location (latitude and longitude). The model calculates the sun angle every 25 meters along the center of the modeled stream reach (these calculation points are referred to as nodes) for every model time step (hourly). At each node, the model calculates the total load of incoming solar radiation by considering the physical characteristics surrounding the node and the characteristics of the vegetation present on the streambanks. The data sources for model inputs are described in more detail below.

2.1.1 Physical Characteristics

Sun angle is a key parameter in the Shade-a-lator model (Figure 2.1-1). Both latitude and day of the year affects the solar path and the associated incoming solar radiation that reaches the surface of the stream. In temperate latitudes, the day of the year also affects the length of the day, and thus the total potential incoming solar radiation. Model results are reported as average daily incoming solar radiation for the period of interest. When evaluating riparian revegetation effects on solar radiation, it can be helpful to understand conditions both during periods of relatively high water temperatures (summer) and periods when riparian shade is most effective at reducing incoming solar radiation (fall). The late summer months are when the DEISs identified water temperature increases to be greatest. The Shade-a-lator model for the Chehalis River was applied for the period between July 15 and August 31.

Figure 2.1-1
Solar Radiation Blocked by Topography and Tree Canopy Is Modeled in ODEQ's Heat Source Model (figure adapted from Boyd and Kasper 2003).



Bank lines of the modeled stream reach affect shade in two important ways. First, they establish the area over which solar radiation input can accumulate. Second, they establish the spatial configuration of riparian vegetation with the potential to provide shade. For this study, bank lines used for the NEPA DEIS analysis were used for the Chehalis River and its tributaries within the temporary inundation area, and the mainstem Chehalis River downstream to the confluence of the Newaukum River (Corps 2020).

A review of available data since the Chehalis Modeling Technical Memorandum (PSU 2017) identified more recent light detection and ranging (LiDAR) data providing a three-dimensional representation of the landscape, including vegetation heights and bare earth elevation. These LiDAR data were collected between 2015 and 2019 by the Washington Department of Natural Resources (WA DNR), and the resulting data files were used to calculate updated digital surface models (DSMs), which ignore objects such as trees and give the elevation of the surface of the ground (Washington Geological Survey 2024a, 2024b). Digital terrain models (DTMs) represent their elevation data including terrain objects such as trees and were used to describe existing vegetation as described below.

2.1.2 Riparian Vegetation

The Shade-a-lator model used two parameters to characterize riparian vegetation: canopy density and canopy height. The canopy density parameter represents the lateral attenuation of solar radiation as it passes through the riparian canopy. A density value of 75 percent was applied to all vegetation for the modeled time period. The canopy height parameter varied across the five vegetation scenarios. The height parameters for each scenario were derived as described below.

2.1.2.1 SEPA DEIS and 2022 Current Riparian Vegetation

As described above, LiDAR data along the Chehalis River was collected between 2015 and 2019 by the WA DNR. This analysis calculated updated baseline scenario vegetation conditions (Washington Geological Survey 2024a, 2024b). DTMs represent their elevation data including terrain objects such as trees. This scenario was named the current conditions scenario by the SEPA DEIS (Ecology 2020).

The current land designation of the temporary reservoir and the surrounding land is Forest Reserve Land and its primary use is commercial forestry. Under active timber management, additional vegetative changes have occurred since the LiDAR data collection. These changes were digitized in ArcPro at a scale of 1:2000 using MAXAR satellite imagery from July 2022 and used to update the DSM for the temporary inundation area (Maxar Technologies 2022). This scenario was named the 2022 current conditions scenario.

2.1.2.2 No Vegetation Future Conditions

The SEPA DEIS analysis evaluated a reduction in riparian shade due to the removal of vegetation in the temporary inundation area. A previously developed Pre-Construction Vegetation Management Plan (Anchor QEA 2016) informed assumptions made in the SEPA DEIS that construction activities would include the removal of all non-flood-tolerant trees within approximately 420 acres of the temporary inundation area and all other trees greater than 6 inches diameter breast height throughout the temporary inundation area (Ecology 2020). This scenario was named the no vegetation future conditions scenario.

2.1.2.3 Vegetation Management Plan

The Applicant has developed a revised Vegetation Management Plan that includes expected vegetation survivability based on the depth and duration of inundation when the proposed FRE facility is operating (Appendix D in Kleinschmidt 2024). As described in the Vegetation Management Plan (VMP), the temporary inundation area includes three zones with increasing frequency and duration of inundation: the Initial Evacuation Area, the Debris Management Evacuation Area, and the Final Evacuation Area. For this shade analysis, we evaluated expected vegetation heights in each zone in both the first summer after operation (VMP1) and in the fifth summer after operation (VMP5).

Under all scenarios, each zone would have two potential canopy components, an upper canopy with an associated cover percentage and height, and a lower canopy with an associated cover percentage and height (Table 2.1-1). The upper canopy height under future scenarios was assumed to be 100 feet in all evacuation areas, representing a conservative estimate of mature tree height. The lower canopy height was assumed to be new regrowth after inundation and varied by zone and scenario (Table 2.1-1).

Under the VMP1, the Initial Evacuation Area (the upstream part of the temporary inundation area and the area flooded less frequently and inundated for shorter durations) would be actively managed to promote taller vegetation, and taller trees can be expected to tolerate the flooding conditions anticipated in this area. An upper canopy cover of 25 percent was assumed with a lower canopy height of 25 feet in the majority of the Initial Evacuation Area (Water Surface Elevation [WSEL] 528-620 feet). In the Initial Evacuation Area upstream of the inundation limit for the 2007 flood (WSEL 620 feet), it was assumed that vegetation could survive infrequent and short duration inundation periods, and no changes to existing canopy heights were assumed. The Debris Management Area (the middle portion of the temporary reservoir between WSEL 528 to 500 feet) would have a 10 percent upper canopy and a 90 percent lower canopy with the lowest vegetation height, modeled at 8 feet. The Final Evacuation Area (the lowest part of the temporary reservoir, from WSEL 500 to 425 feet, and the area that would be inundated for the greatest duration) was modeled with the same vegetation.

Under VMP5, the Initial Evacuation Area (the upstream-most area above WSEL 528 feet that is flooded less frequently and would be inundated for shorter durations) would be actively managed to promote taller vegetation, and taller trees can be expected to tolerate the flooding conditions anticipated in this area. An upper canopy cover of 25 percent was assumed with a lower canopy height of 35 feet. As described for VMP1, it was assumed that vegetation could survive infrequent and short-duration inundation and no changes to existing canopy heights were assumed in the Initial Evacuation Area upstream of the inundation limit for the 2007 flood (WSEL 620 feet). The Final Evacuation and Debris Management areas were modeled with the same vegetation. It was assumed that any upper canopy of standing dead trees would have fallen, so no upper canopy was assumed (reflected as 0 percent cover in Table 2.1-1) and the lower canopy was modeled at 25 feet, based on estimated tree regrowth rates in the VMP.

Table 2.1-1
Canopy Height Surfaces Modeled in VMP Future Condition Scenarios.

RESERVOIR EVACUATION AREA	FINAL	DEBRIS MANAGEMENT	INITIAL	INITIAL WSEL >620 FEET
FIRST SUMMER SCENARIO (VMP1)				
Upper Canopy Height (feet)	100	100	100	Existing
Upper Canopy Cover (%)	10	10	25	Existing
Lower Canopy Height (feet)	8	8	25	Existing
Lower Canopy Cover (%)	90	90	75	Existing
FIFTH SUMMER SCENARIO (VMP5)				
Upper Canopy Height (feet)	100	100	100	Existing
Upper Canopy Cover (%)	0	0	25	Existing
Lower Canopy Height (feet)	25	25	35	Existing
Lower Canopy Cover (%)	100	100	75	Existing

2.1.2.4 Mitigation Plantings

The Applicant's proposed mitigation for shade impact is reforestation of existing degraded habitats with native riparian trees and shrubs that will enhance tree canopy and shade conditions as the vegetation matures. Vegetation parameters for the mitigation conditions scenario for riparian restoration sites were based on ecologically relevant planting plans that included a high diversity of native trees and shrubs that contribute to riparian ecological function. Dominant shade-producing species included black cottonwood (*Populus trichocarpa*) and red alder (*Alnus rubra*). Tree heights of 98 feet (30 meters) and density values of 75% were based on species characteristics and the system potential vegetation identified in previous TMDL modeling in analogous Northwest river systems (ODEQ 2006). Mitigation plantings were modeled within a 60-foot buffer along each streambank.

2.2 Mitigation Site Selection

To develop the site-specific mitigation needed to offset potential riparian shade reduction in the temporary inundation area, the Applicant applied the Shade-a-lator model to reaches downstream of the FRE facility to identify parcels with degraded shade condition and initiated landowner engagement efforts.

To determine which parcels downstream of the FRE would be suitable for shade mitigation, the Shade-a-lator model was run for the mainstem Chehalis from RM 108.4 to the confluence of the Newaukum at RM 75.2 and included the South Fork Chehalis River, Bunker Creek, and Newaukum River. To estimate the potential reduction in solar loading resulting from riparian revegetation along these river reaches, the solar load that reaches the water's surface under current conditions was compared to a future reforested with mitigation conditions scenario. Physical habitat characteristics used in the model were the same for the two downstream scenarios, while the vegetation characteristic varied. Vegetation for the current condition was based on LiDAR, and the mitigation condition assumed a fully restored canopy with native trees and shrubs. The difference in the incoming solar load (expressed in kcal/day) between the two downstream model scenarios represented the supply of net thermal benefits possible from riparian revegetation. Potential solar loading reduction was evaluated at intervals of 82 feet (25 meters) along the stream centerlines, at each model node.

Since riparian reforestation would be implemented at the scale of property ownership, the potential thermal benefits were apportioned to tax lot boundaries. Tax lot boundary information obtained from Lewis County Geographic Information System parcel data were intersected with the shade benefits within a 60-foot riparian buffer from the streambank. Parcels zoned as Forestry were excluded from the analysis, as they are already managed toward reforestation goals. The stream-centerline Shade-a-lator results were then joined spatially to the nearest parcel. This process resulted in property-specific thermal benefit information in a geospatial format.

As described in Section 7.5 of the Revised Mitigation Plan, an overall landowner engagement strategy was developed to support the feasibility of implementing a wide range of mitigation opportunities on lands and properties owned by private individuals and/or companies (Kleinschmidt 2024). Sites with landowners that have responded with a willingness to engage and allow for access to their properties for the feasibility study of riparian enhancement/reforestation were prioritized for mitigation site selection.

Mitigation site selection considered both available shade supply and landowner willingness to engage. The number of mitigation sites needed was determined by summing the total available supply and comparing it to the residual impact (average kcal/day). Locations of parcels with willing landowners, with high to medium supply potential, within reaches projected to experience temperature increases into the future were considered. Priority was given to sites with higher shade supply and closer proximity to the FRE. However, depending on implementation schedule, there would likely be a temporal lag between riparian planting and realization of the full shade benefits as vegetation grows over time. To account for this lag, the applicant targeted at least a 2-to-1 multiplier for shade-producing riparian restoration. This mitigation ratio is the standard that has been applied for shade-related thermal mitigation throughout the Pacific Northwest and is recommended in Ecology draft regulations for temperature trading (Ecology 2011).

3 RESULTS

The following sections describes outputs from the shade modeling for: i) potential project effects on riparian shade in the temporary inundation area; ii) the effectiveness of the VMP in avoiding and minimizing those effects; and iii) the potential for riparian restoration efforts to mitigate any unavoidable impacts.

3.1 Shade in Project Footprint

Shade modeling in the temporary inundation area evaluated changes in solar loading associated with the differences among five scenarios (Table 3.1-1). Changes in landcover between the SEPA DEIS current conditions scenario (Ecology 2020) and the 2022 current conditions scenario resulted in an increase of thermal load of approximately 31,858,400 kcal/day averaged between July 15 and August 31. As the most recent assessment of existing conditions, the 2022 condition was then used as the basis for further comparison with future scenario alternatives. Under the SEPA DEIS scenario, removing all vegetation in the temporary inundation area would increase solar load above the 2022 condition by 472,067,000 kcal/day (Ecology 2020). Implementing the VMP would reduce approximately 122,401,000 kcal/day in the first year after operation and 112,019,000 kcal/day in the fifth year after operation. Based on the more extreme VMP5 scenario, the residual change in solar loading (total increase to current conditions with all vegetation removed minus VMP shade reduction) is predicted to be approximately 360,048,000 kcal/day averaged between July 15 and August 31; this value was used to represent a conservative estimate of shade impact that would require mitigation.

Table 3.1-1
Change in Modeled Solar Input Within the Temporary Reservoir Area Under Shade Scenarios. Bold Font Indicates Modeled Residual Impact for Mitigation.

SHADE SCENARIO	MODELED THERMAL IMPACT	AT FRE FACILITY (RM 108.4)
LABEL	**COMPARISON**	**CHANGE IN AVERAGE KCAL/DAY (JULY 15-AUGUST 31)**
SEPA DEIS Current Conditions	SEPA DEIS current conditions, compared to 2022 harvest conditions	-31,858,400
No Vegetation Future Condition	No vegetation within the temporary pool, compared to 2022 harvest conditions	472,067,000
Vegetative Management Plan VMP1	1 year post-operation, compared to 2022 harvest conditions	349,666,000
Vegetative Management Plan VMP5	5 years post-operation, compared to 2022 harvest conditions	**360,048,000**

3.2 Shade Restoration Proposed as Mitigation

The Applicant selected 131 parcels along the upper Chehalis River and Bunker Creek for mitigation riparian shade enhancement that would prevent approximately 880,606,358 kcal/day from reaching the mainstem Chehalis River and Bunker Creek (Table 3.2-1). The proposed riparian planting areas span the mainstem Chehalis River from Adna, Washington to the FRE facility. The parcels where riparian shade mitigation is currently feasible from Adna upstream to Hope Creek, including Bunker Creek are depicted in Figure 3.2-1, and Figure 3.2-2 shows parcels from Hope Creek upstream to the proposed FRE facility. Once implemented, this mitigation is predicted to provide sufficient shade to offset potential FRE facility shade-related temperature impacts by a factor of approximately 2.5.

The LiDAR-based shade supply analysis has identified many additional miles of degraded riparian canopy including areas along the mainstem Chehalis River downstream of Adna, as well as in the South Fork Chehalis and Newuakum rivers. These areas provide additional shade enhancement opportunities in the upper Chehalis River Basin that could be used to refine mitigation during future phases of the project, for example, if needed during adaptive management.

Table 3.2-1
Thermal Supply Available for Mitigation by Area of Interest. Thermal Benefits Are Expressed As the Daily Mean Value for the Period from July 15-August 31 in Kilocalories per Day.

SECTION/WATERWAY	TOTAL AVAILABLE SUPPLY THERMAL INPUT REDUCTION (AVG KCAL/DAY)	PROPOSED MITIGATION BENEFIT THERMAL INPUT REDUCTION (AVG KCAL/DAY)
MAINSTEM CHEHALIS		
Proposed FRE facility to Elk Creek (RM 108.4-100.2)	107,983,121	76,168,718
Elk Creek to South Fork (RM 100.2-88.1)	372,595,430	290,597,206
South Fork to Adna (RM 88.1-80.1)	496,323,622	404,534,434
Subtotal Mainstem	***976,902,173***	***771,300,358***
TRIBUTARIES		
South Fork Chehalis (RM 17-0-)	651,385,314	**ND**
Bunker Creek (RM 12-0-)	197,420,691	**109,306,000**
Newaukum River (RM 10-0-)	1,435,815,597	**ND**
Subtotal Tributaries	***2,284,621,602***	***109,306,000***
TOTAL	**3,261,523,775**	**880,606,358**

Figure 3.2-1
Parcels Where Riparian Shade Mitigation Is Presently Feasible Along the Upper Chehalis River and Bunker Creek Upstream of Adna, Washington, i.e., Downstream Riparian Planting Area.

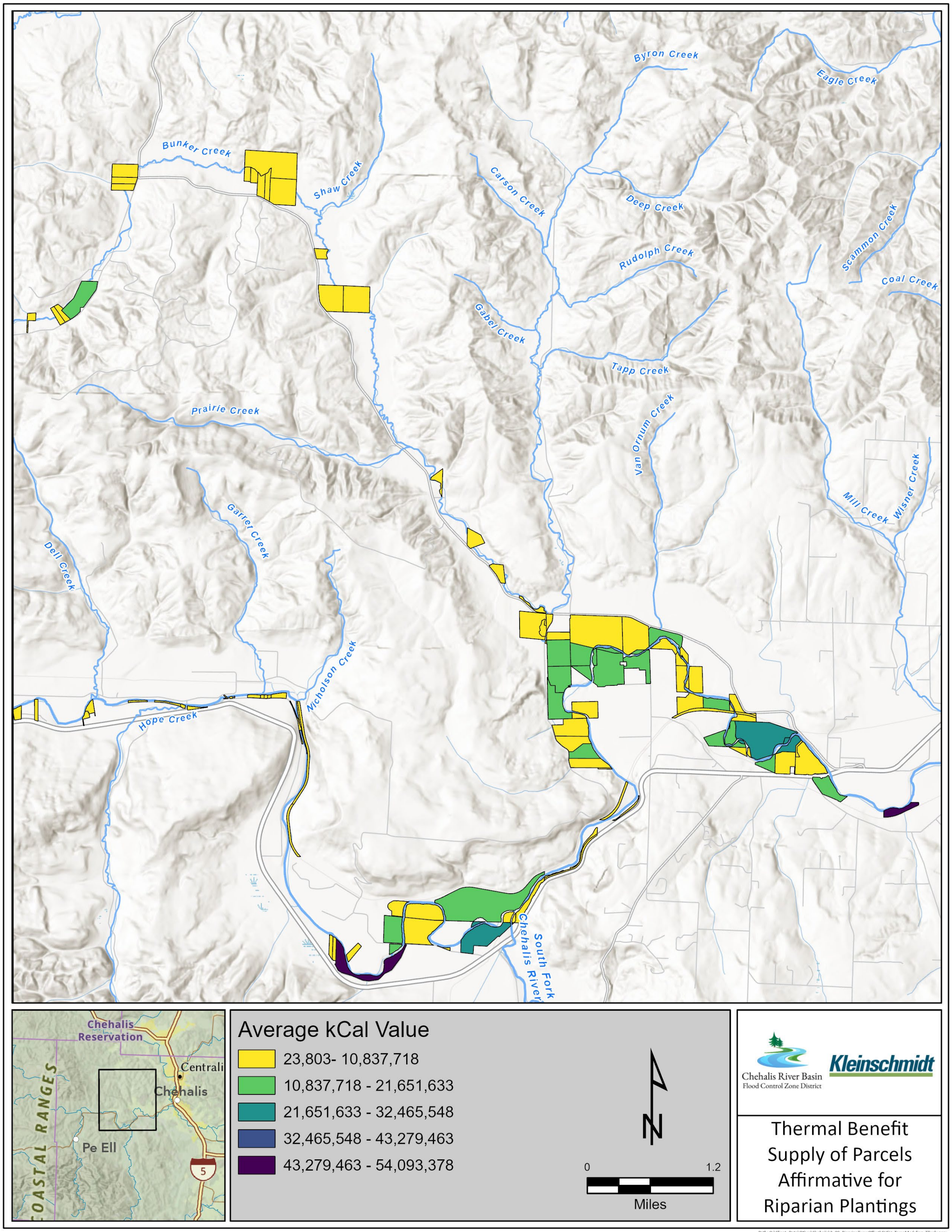
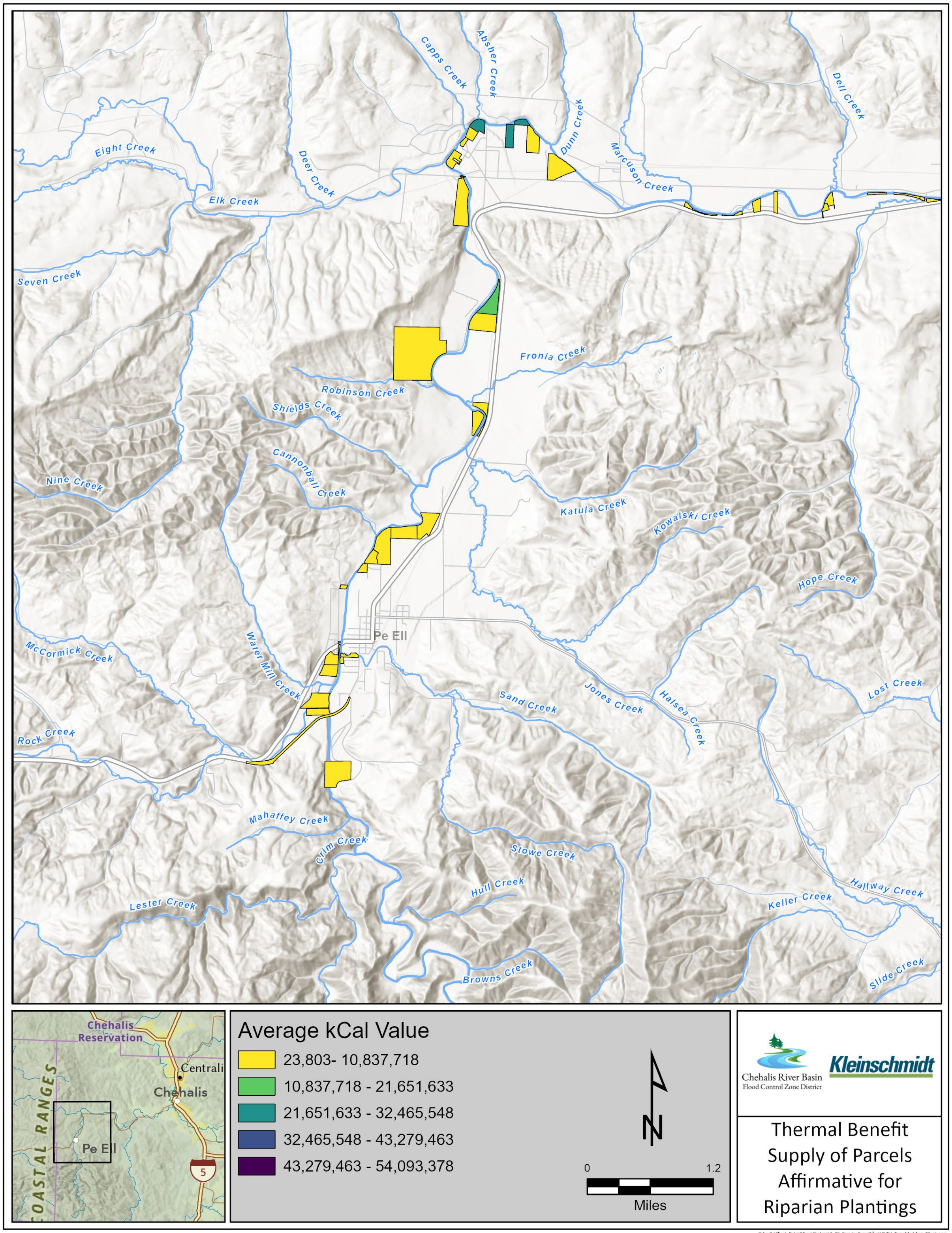


Figure 3.2-2
Parcels Where Riparian Shade Mitigation Is Presently Feasible Along the Upper Chehalis River Upstream of Hope Creek to the Proposed FRE Facility, i.e., Upstream Riparian Planting.



4 DISCUSSION

Analysis of current riparian shade conditions in the temporary inundation area and in the Chehalis River and select tributaries downstream using updated comprehensive canopy data from LiDAR has refined the potential impact of the proposed project and its operation and allowed the Applicant to quantify the available shade supply for mitigation. Modeling the VMP condition predicted the change in riparian shade that could be expected from managing flood-tolerant vegetation under the current FRE operational regime. The two VMP scenarios, one year and five years post-operation, were different based on the shade expectation associated with standing dead wood that would remain after initial inundation. In the VMP5 scenario, this standing dead wood would be gone but fast-growing shrubs and trees planted prior to operation in clear cuts and open areas would have had a chance to establish and provide shade from a lower but more dense canopy in the Final and Debris Management evacuation areas. In the Initial Evacuation Area, the mature canopy would remain partially intact at a 25 percent cover and flood-tolerant species would provide a taller lower canopy layer. This VMP5 scenario does not reflect full canopy height in the Initial Evacuation Area and thus provides a conservative estimate of mitigation that could be attained with advanced and continued planting and maintenance of vegetation in the FRE inundation area.

The modeling also demonstrates that while the VMP will help to minimize shade loss, it cannot avoid it completely. Similar to other riverine systems throughout the Pacific Northwest, the current riparian shade conditions of the Chehalis River between RMs 108 and 86 are substantially degraded and offer ample opportunity for shade enhancement that can mitigate for the residual impact upstream. Based on early landowner engagement efforts, the Applicant has demonstrated with this shade supply analysis that sufficient shade mitigation within the mitigation area is feasible and has proposed shade restoration across 131 parcels and 21.3 miles of river's edge as a mitigation measure. In addition to thermal loading benefits, native riparian reforestation would provide bank stabilization, erosion control, wildlife habitat, and support nutrient cycling along 16.6 miles of the mainstem Chehalis River and 4.8 miles of Bunker Creek. This mitigation is focused along the mainstem of the Chehalis River with a small proportion distributed in Bunker Creek due to the potential ecological lift to a wide variety of native species that can be achieved there.

Impact assessment in the DEISs highlighted the indirect effects of shade on water temperatures and then the indirect effects of water temperatures on dissolved oxygen levels and fish habitat suitability. Each of these linkages introduces additional variables, many likely to be affected by climate change and other factors unrelated to project operation. There is additional value in implementing and monitoring shade mitigation including quantifying mitigation in the same currency as project effects without having to parse out potential variation from uncontrollable inputs as would be the case comparing water temperature at the FRE facility location versus even a few miles downstream. Riparian shade loss and gain is directly measurable, and specific shade goals can be concretely evaluated.

As one example, Clean Water Services (CWS) incorporated riparian planting projects, to offset the thermal loads from the Rock Creek and Durham Advanced Water Treatment facilities along the Tualatin River. The National Pollution Discharge Elimination System (NPDES) permit issued to CWS in 2004 was the first example of a municipal, integrated watershed-based NPDES permit in the nation. The demonstrated success of the CWS Thermal Load Management Plan over the last two decades has been pioneering for using riparian revegetation to meet strict thermal load allocations in TMDLs across the state of Oregon. Using the cooling functions of riparian vegetation, together with supplementing water flows, enabled CWS to avoid potential impacts from construction of new facilities that relied on mechanized solutions for cooling effluent, and instead produced significant ecosystem service benefits throughout the watershed. Community benefits are also generated in the form of easements to protect riparian habitat, improved aesthetic, and enhanced recreational value of a restored riparian area.

Clean Water Services conducts annual maintenance, monitoring, reporting, and adaptive management under a Thermal Load Management Plan to ensure project functions are achieved. The 2023 report documents their success in offsetting all thermal impacts and generating an excess of thermal credits through flow augmentation and 209 riparian planting projects blocking 1,235,600,000 kcal/day (CWS 2024). Reporting emphasizes the importance of CWS's aggressive approach to restoring degraded plant communities using a rapid riparian revegetation (R3) approach by conducting intensive site preparation, high density riparian plantings, and sourcing pioneering species selected from local materials (Guillozet et al. 2014). The R3 planting approach is consistent with the Applicant's riparian planting strategies described in Section 8.2 and Appendix D of the Revised Mitigation Plan (Kleinschmidt 2024).

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