# Design Solutions

## Environmental Engineering

## & Certified Arborist Report

**Prepared for:**
**OPALCO**
**Decatur Island, WA**
**TPN 152232005**

**August 18th, 2025**


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Certified Arborist
#PN-8011-A

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| § | Section |
| ADU | Accessory Dwelling Unit |
| AHJ | Authority Having Jurisdiction |
| BMPs | Best Management Practices |
| CESCL | Certified Erosion and Sediment Control Lead |
| C.F.R. | Code of Federal Regulations |
| C&G | Clearing and Grading |
| DBH | Diameter at breast height (of trees) |
| DOE | Department of Ecology (Washington State) |
| DNR | Department of Natural Resources (Washington State) |
| HEX | Hearing Examiner |
| EOR | Engineer of Record |
| EPA | U.S. Environmental Protection Agency |
| $Ft.^2$ | Square feet |
| FHMC | Friday Harbor Municipal Code |
| FWHCA | Fish and Wildlife Habitat Conservation Area |
| LCOE | Levelized Cost of Energy |
| LID | Low Impact Development |
| Min. Req. | Minimum Requirement |
| NCE | Non-Compensatory Enhancement |
| NNL | No Net Loss |
| NRCS | Natural Resources Conservation Service (part of USDA) |
| O&M | Operation & Maintenance |
| OHWM | Ordinary High-Water Mark |
| OPALCO | Orcas Power and Light Co-Operative |
| OWS | Oil Water Separator |
| PGIS | Pollution Generating Impervious Surface |
| PGPS | Pollution Generating Pervious Surface |
| PVC | Polyvinyl Chloride |
| RCW | Revised Code of Washington |
| SFR | Single-family Residence |
| SJC | San Juan County |
| SJCC | San Juan County Code |
| SMA | Shoreline Management Act |
| SMP | Shoreline Master Program |
| TDA | Threshold Discharge Area |
| ToFH | Town of Friday Harbor |
| TC | Time of Concentration |
| TR-55 | Technical Release 55 (NRCS hydrology model) |
| U.S.C. | United States Code |
| USDA | United States Department of Agriculture |
| UON | unless otherwise noted |
| WQ | Water Quality |
| WWHM | Western Washington Hydrology Model (2012 Edition, software, uon) |
| WWSWM | Western Washington Storm Water Manual (2005 Edition, uon) |

# 1 PROJECT DESCRIPTION

**Table 1-1 Project Summary**

| | |
|---|---|
| OWNER | OPALCO |
| REPORT PREPARER | John Geniuch, P.E.<br>PO Box 3258<br>Friday Harbor, WA 98250 |
| JURISDICTION | San Juan County |
| PROPERTY ADDRESS | Decatur Head Road |
| TAX PARCEL NUMBER | 152232005 |
| PARCEL SIZE | 20.51 acres |
| PROJECT DESCRIPTION | Tree removal and development associated with installation of solar panel arrays in 2 locations on the site. |

## 1.1 PROJECT OVERVIEW

The Orcas Power and Light Co-Operative (OPALCO), the electric power provider for San Juan County, proposes to develop two sites on a single property for the installation of two new solar arrays intended for commercial power generation. The property is located on Decatur Island within San Juan County, Washington. The property encompasses approximately 20 acres of forested land with gradually sloping topography, primarily consisting of evergreen forest cover and some mixed deciduous trees. The overall site contains moderate slopes ranging from 5% to 15%, with elevations decreasing from northeast to southwest. The land is currently undeveloped except for an existing small solar array and electrical substation in the northwest corner, on a separate parcel. The soil compositions are predominantly glacial till and loamy textures that support dense forest growth.

## 1.2 PROJECT OBJECTIVES

The project aims to enhance renewable energy production for the island community, reducing reliance on non-renewable sources while integrating with the existing infrastructure based at the substation on the parcel to the northwest.

## 1.3 PROPOSED SOLAR ARRAY - SITE 1

Site 1, is the smaller array, located in the northeast portion of the property, covers an approximate area of 1.5 acres and is positioned on a relatively flat plateau with minimal slope (less than 5%). This site is characterized by mature coniferous stands and would involve the installation of solar panels in a compact layout as depicted in the **Appendix A** site plan.

### 1.3.1 Site 1 Overview

Site 1 benefits from its elevated position, offering good solar exposure with limited shading from surrounding trees post-clearing.

## 1.4 PROPOSED SOLAR ARRAY - SITE 2

Site 2, the larger array in the southwest portion, spans about 4.5 acres on gradual sloping terrain (5-10% grade), descending toward the south. This area features denser vegetation and would accommodate a larger panel configuration, as depicted in the **Appendix A** site plan.

### 1.4.1 Site 2 Overview

Site 2, being larger and on a slope, may require grading considerations but provides ample space for efficient array placement.

## 1.5 REPORT OVERVIEW

The remainder of this report is structured as follows:

**Section 2** evaluates tree removal approximations, including methodologies, board foot calculations, dendrochronology, and site-specific estimates.

**Section 3** addresses windthrow risks and site analysis per ASCE guidelines.

**Section 4** examines hydrological impacts from canopy removal, including water uptake, runoff changes, and mitigation strategies aligned with the 2005 Western Washington Stormwater Manual (WWSWM).

**Section 5** discusses fire protection benefits, incorporating Firewise and defensible space principles.

**Section 6** provides a summary of conclusions

# 2 TREE REMOVAL APPROXIMATIONS

This section provides approximations for the number of trees to be removed and associated board foot volumes for Sites 1 and 2.

## 2.1 METHODOLOGY FOR DATA COLLECTION AND APPROXIMATION

A site visit was conducted to assess both Sites 1 and 2. For Site 1, a representative 50 x 50 foot sample area was selected, where all trees were measured for species, height, and diameter at breast height (DBH). This area was chosen for its typical density and composition, allowing extrapolation to the full site area. Similarly, for Site 2, a 75 x 75 foot sample was evaluated. These sample areas are shown in **Appendix B**. The data logs are included in **Appendix C.**

## 2.2 BOARD FOOT CALCULATIONS - GENERAL

Board footage represents the volume of usable lumber in a tree, typically calculated using standardized methods. The two primary methods are the Doyle Rule and the Scribner Rule. The Doyle Rule estimates volume as (DBH - 4)^2 * Length / 16, often underestimating for smaller logs.

The Scribner Rule uses a logarithmic scale based on DBH and length, providing a more accurate estimate for mid-sized timber.

The Washington Department of Natural Resources (DNR) suggests the use of the Scribner Decimal C log rule for calculating board feet in timber cruising and volume estimation, as detailed in their Timber Cruising Handbook. This rule aligns with scaling standards from the Northwest Log Rules Advisory Group (NWLRA), which DNR references for Westside and Eastside regions of the state. Board feet are calculated based on log dimensions (e.g., diameter at breast height, length, and defect deductions), with volumes reported as gross and net Scribner board foot volumes per acre.

Spreadsheets calculating board feet of the sample areas are provided in **Appendix C**. The formula is detailed on the **Appendix C** worksheets. It uses the Scribner log formula, with adjustment for estimating merchantable timber and taper calculations for diameter adjustments.

## 2.3 DEFINITION OF MERCHANTABLE (STAND OF) TIMBER

WAC 222-16-010 (general definitions) provides:

***Merchantable stand of timber:*** *A stand of trees that will yield logs and/or fiber suitable in size and quality for the production of lumber, plywood, pulp, or other forest*

*products, and of sufficient value at least to cover all the costs of harvest and transportation to available markets*.

Per the Washington Department of Natural Resources (DNR), merchantable timber consists typically of trees with DBH over 12 inches and meeting quality standards for sawlogs.

For species like alders and white fir, not all trees may qualify as marketable due to lower wood quality or market demand. Additionally, the remote island's location increases transportation costs, potentially rendering some otherwise merchantable timber uneconomical.

Notwithstanding debate over the potential for actual merchantable timber or the "*other forest products*" (assumed to include firewood and hobby level local milling of wood), the board foot calculations for the sample areas are provided in **Section 2.4** and **Section 2.5**, along with the subsequent extrapolation to the sites in totality.

All species with DBH of 6 inches or greater were included in the calculations. This will provide a very conservative estimate (oversampling) for this project.

## 2.4 SITE 1 – TREE REMOVAL BOARD FOOT CALCULATIONS

Consistent with data sheets in **Appendix C** and corresponding Scribner calculations, site 1 sample area contained 19 trees, of which had a DBH of 6 inches or greater. This provided a total estimate board footage for the sample area of 2,211 board feet. The total area of site 1 is approximately 19.5x larger (reference **Appendix B** calculations), resulting in a total estimated board footage of 43,095 BF. This does not account for actual merchantability, which would produce a significantly lower number. The actual usable timber is discussed further in **Section 2.8**.

## 2.5 SITE 2 – TREE REMOVAL BOARD FOOT CALCULATIONS

Consistent with data sheets in **Appendix C** and corresponding Scribner calculations, site 2 sample area contained 33 trees, of which had a DBH of 6 inches or greater. This provided a total estimate board footage for the sample area of 8,828 board feet. The total area of site 2 is approximately 29x larger (reference **Appendix B** calculations), resulting in a total estimated board footage of 256,012 BF. This does not account for actual merchantability, which would produce a significantly lower number. The actual usable timber is discussed further in **Section 2.8**.

## 2.6 DENDROCHRONOLOGY PROCESS

Dendrochronology is the study of tree rings to determine age, growth patterns, and environmental history. The process involves extracting a core sample, counting annual rings, and analyzing width variations for climate insights.

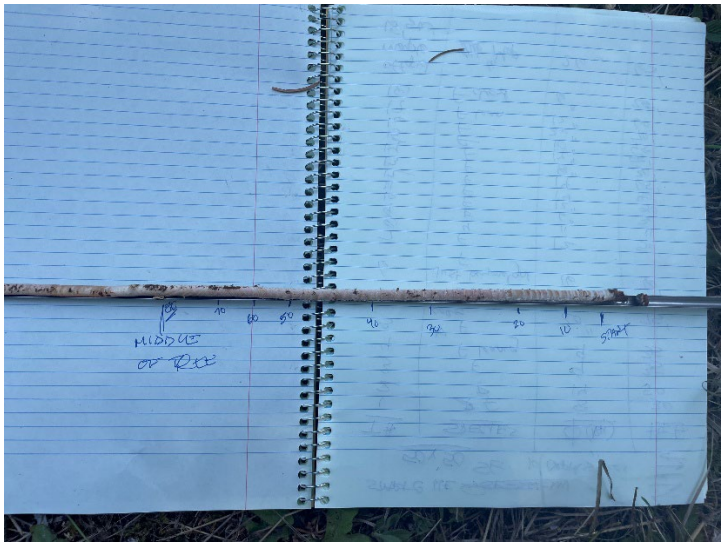
An increment borer, such as the Haglöf 24-inch model used here, drills into the tree to extract a thin core without significant harm.

### 2.6.1 Site 1 – core sample

The largest Douglas fir in Site 1 yielded a core indicating approximately 80 rings, supporting the forest's age of around 80 years, consistent with early 20th-century logging practices in the region.

The location of the subject tree is shown on the annotated site plan in **Appendix B**.

The growth rings counted from the subject tree are pictured below.



## 2.7 HISTORIC LOGGING & TIMBER USE PRACTICES

Decatur Island in San Juan County, WA, shares the San Juan Island's logging history. Commercial logging started mid-19th century with Hudson's Bay Co. cutting timber for spars and steamships. Further, the Islands heavily logged in 19th century, providing 2.5M cords over 50 years for lime kilns into early 20th. With the forest rejuvenation in the 1940s to 1950s, we are left with predominantly second-growth forests.

On Decatur, historical records describe early log barns built from available timber and reference to the 1890s Reed Brothers Shipyard use of local wood for boats would confirm these historic practices.

These practices are further confirmed by anecdotal evidence from loggers and descendants of loggers, aware that Decatur has been logged several times in the past. A phone conversation between an OPALCO representative and DNR staff provides collaboration of these historic events.

The onsite visit by the arborist and author of this report also included encounter and documentation of old degraded stumps and stump remains, consistent with the prior historic logging.

## 2.8 ACTUAL VS. THEORETICAL USEABLE TIMBER

The board foot calculations provided in prior sections represent theoretical estimates of merchantable timber. In reality, the prime timber has been harvested decades ago, and in some instances, more than once. The remaining trees on the subject project sites are 2nd and 3rd growth and the actual usable volume of logs is likely only about 10% or less of the theoretical values calculated in **Sections 2.4 and 2.5**.

# 3 WINDTHROW & WINDSNAP ANALYSIS

Windthrow refers to trees uprooted by wind, while windsnap involves trunk breakage. Primary causes include high wind speeds, shallow roots, saturated soils, and stand density. Removal of trees from the leading edge of a larger stand of timber can potentially increase the probability of windthrow or windsnap.

## 3.1 ASCE WIND SPEED MAPPING, EXPOSURE, AND TOPOGRAPHICAL COEFFICIENTS

The American Society of Civil Engineers (ASCE) 7 standard provides wind speed maps for design, incorporating exposure categories (B, C or D,) and a topographic factor $K_{zt}$ to account/adjust for speed-up over hills). The site 1 and site 2 solar panel arrays would be assigned to wind exposure category "B".

***Exposure Category B:***

*Urban and suburban areas,* ***wooded areas*** (emphasis added)*, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. This exposure applies where the ground surface roughness is Category B, prevailing in the upwind direction over a distance of at least 2,600 ft (792 m) or 20 times the height of the building, whichever is greater. For buildings with a mean roof height of less than or equal to 30 ft (9.1 m), the upwind distance may be reduced to 1,500 ft (457 m).*

These are applied by multiplying base wind pressure by exposure and topographic adjustments

## 3.2 SITE SPECIFIC WINDTHROW ANALYSIS

For these sites, tree removal reduces density, minimizing windthrow risk. No significant topographic features (e.g., steep ridges) trigger $K_{zt} > 1.0$.

Exposure B applies due to surrounding vegetation, indicating low wind amplification.

# 4 TREE CANOPY REMOVAL AND HYDROLOGICAL IMPACTS

The site features primarily Douglas fir, White fir, pine, hemlock, Red alder, and big leaf maples. Evergreens uptake more water annually (e.g., 20-30 inches) than deciduous trees (10-20 inches) due to year-round transpiration.

## 4.1 TIME OF CONCENTRATION ($T_C$)

Time of concentration (Tc) is the time for water to travel from the farthest watershed point to the outlet, influencing peak runoff.

## 4.2 POTENTIAL INCREASES IN RUNOFF AND CHANGES IN $T_C$

Removing forest canopy and replacing with solar arrays and gravel will likely decrease Tc, increasing peak runoff, due to reduced interception by the canopy and uptake by the tree roots.

The redevelopment hydrology can be approximately quantified and modeled and should be done by a qualified professional for the design of remedial measures.

## 4.3 REMEDIAL MEASURES PER WESTERN WASHINGTON STORMWATER MANUAL

The 2005 WWSWM guides mitigation for forest-to-impervious conversions via Best Management Practices (BMPs) like infiltration and dispersion to match pre-development hydrology.

## 4.4 USE OF INFILTRATION AND DISPERSION TRENCHES

These trenches capture and infiltrate runoff around arrays. Use of these and similar BMPs, designed following the 2005 WWSWM can provide runoff that is functionally equivalent to predevelopment conditions. The final design of the SWMP site should be done by a qualified professional.

## 4.5 SOLAR PANEL COMPOSITION AND POTENTIAL LEACHING

Q.PEAK DUO XL-G11S panels (the panels proposed for the site 1 and site 2 arrays) contain materials like silicon and aluminum, with small potential for nominal trace heavy metals (e.g., cadmium) leaching under degradation.

## 4.6 CONCLUSIONS ON MITIGATION

Tree removal and array installation can be mitigated to pre-development conditions per 2005 WWSWM, the adopted standard in San Juan County.

Research shows minimal runoff risks from panels and WWSWM treatment BMPs (e.g., biofiltration) can be evaluated to determine if necessary to address this. A minimum of a 30-foot downslope setback is recommended to accommodate any dispersion BMPs. This can be reduced by utilizing other BMPs that are designed consistent with the 2005 WWSWM by a qualified professional, adhering to any other regulatory setbacks for stormwater permanent controls.

Using the regulatory framework and technical requirements, a qualified professional will be able to provide a SWMP that includes pollution prevention during construction and permanent stormwater controls that disperse, infiltrate and/or treat runoff in a manner that approximates pre-development conditions.

# 5 FIRE BREAK AND PROTECTION OF CRITICAL INFRASTRUCTURE

The property's (approximate, uneven) H-shape places a forested parcel south of the existing solar array and substation. Forests pose higher fire hazards than solar arrays due to fuel load. Firewise and defensible space programs advocate vegetation management to reduce fire spread, creating buffers around structures.

## 5.1 ANALYSIS OF FIRE HAZARDS

The solar arrays reduce fuel continuity, providing a fire break for the substation. The larger tree stands to the south of the substation and existing solar array would be isolated by the Site 2 array, reducing the potential for fire conflagration to the substation during a wildfire.

## 5.2 CONCLUSION

The proposed project enhances defensible space, offering net fire protection benefits to critical island electrical infrastructure.

# 6 SUMMARY AND CONCLUSIONS

The proposed solar arrays provide renewable energy benefits, with tree removal, windthrow, hydrology, and fire risks analyzed in the preceding sections of this report.

The site hydrology changes can be quantified and mitigated via design of a SWMP by a qualified professional. This will mitigate any runoff volume and intensity changes to mimic predevelopment conditions, consistent with the letter and intent of the applicable regulations.

Given the overall site development exceeds 1 acre, a State Stormwater General Construction Permit will be required. This will provide required specified periodic and incident based monitoring and reporting to ensure pollution prevention during construction.

## 6.1 WETLAND AND BUFFER IDENTIFICATION

The wetland report prepared for this project was reviewed in the course of preparation of this report. The placements of the solar arrays were selected to be beyond the wetland buffers.

We recommend flagging (or reflagging) the buffer boundaries proximate to the proposed development, prior to ground disturbance, to confirm the placement is beyond the buffers.

## 6.2 ADDITIONAL CONSTRUCTION MONITORING

The State Stormwater General Construction Permit mandates periodic and incident based monitoring and periodic reporting. The preparer of this plan holds the necessary qualifications to provide the required monitoring and reporting. Alternatively, a similarly qualified professional can be tasked with fulfilling these requirements.

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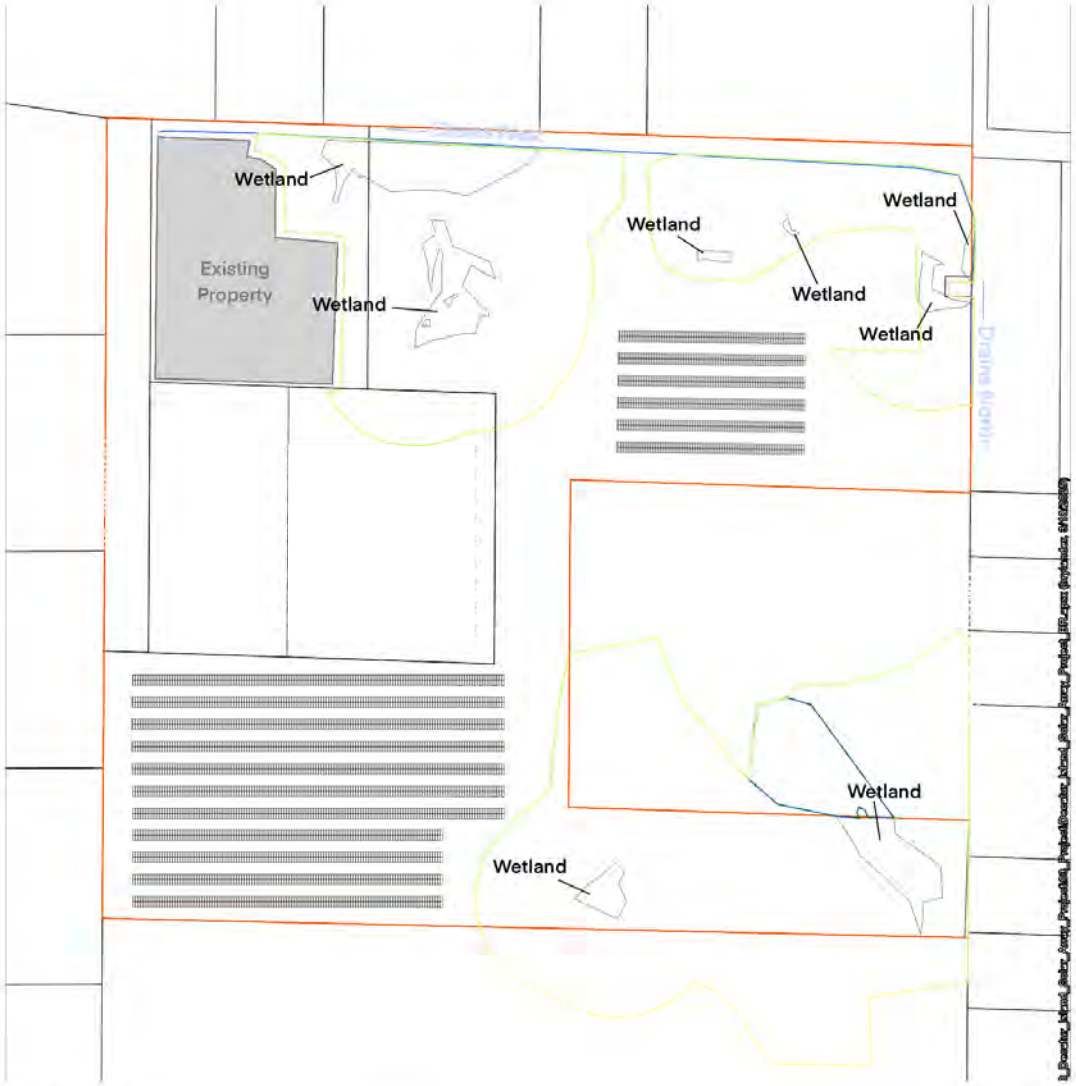
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# APPENDIX A
# PROJECT SITE PLAN AND APPROXIMATE SOLAR LAYOUT




PRELIMINARY DECATUR ISLAND SITE PLAN

Cushing Terrell

cushingterrell.com
800.757.9822

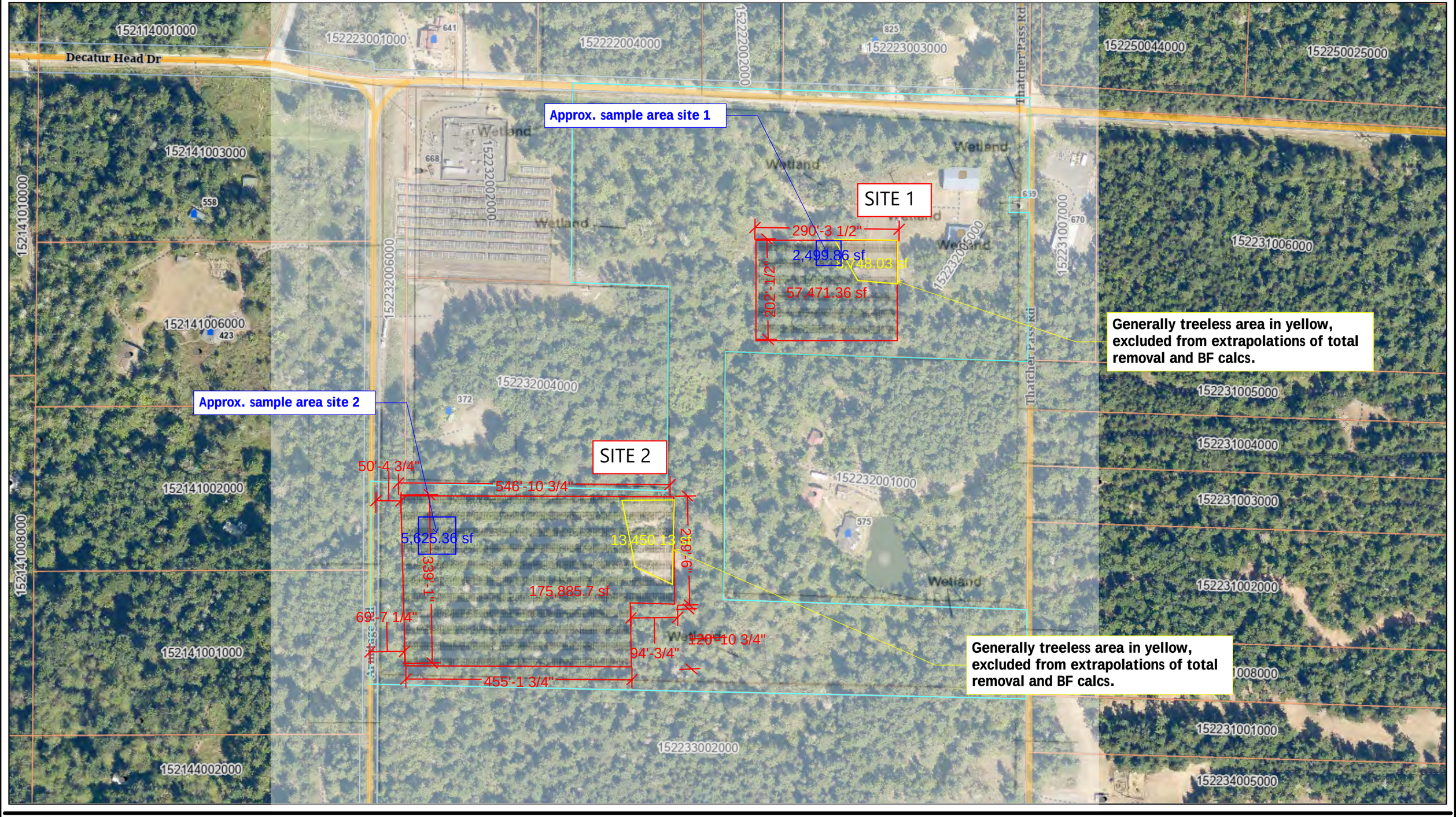
DECATUR ISLAND MICROGRID DESIGN

NOT FOR CONSTRUCTION - PRELIMINARY DESIGN

PRELIMINARY DESIGN

E100

# APPENDIX B
# SAMPLING AREAS, CALCULATIONS FOR EXTRAPOLATION




OPALCO
Decatur Island
Solar Project

1:2,117

0 135 270 540 ft

N

Approximate areas of Site 1 and Site 2 shown via site plan overlay on Polaris map, with treeless areas subtracted from totals.

OPALCO SOLAR PROJECT - DECATUR ISLAND

SITE #1

WITH SITE PLAN OVERLAID ON POLARIS PHOTO

APPROX SOLAR ARRAY AREA FOR CLEARING

= 57,500 FT²

SAMPLE AREA = 50 x 50 = 2,500 FT²

GROSS SITE 1 = 57500
SUBTRACT TREELESS = −8800

48700 = SITE 1 TREELESS/MOWN AREA - NET

$\frac{48700}{2500} = 19.48$

SO USE 19.5 x MULTIPLIER

---

SITE #2

APPROX AREA FOR SOLAR ARRAY = 175,885 FT²

SAMPLE AREA = 75 x 75 = 5625 FT²

NET (APPROX − TREELESS FROM POLARIS - APP B)

175,885 − 13,450 = 162,435 FT²

$\frac{162435}{5625} = 29$ x MULTIPLIER

# APPENDIX C
# SITE 1 & SITE 2 BOARD FOOTAGE ESTIMATIONS

OPALCO SITE 1 Board Foot Estimation

| Tree ID# | Species | DBH (inches) | Height (feet) | Est. Board Feet* | Notes |
|---|---|---|---|---|---|
| 1 | D. Fir | 8 | 30 | 9.03 | |
| 2 | Pine | 14 | 50 | 100.00 | |
| 3 | D. Fir | 9 | 35 | 16.74 | |
| 4 | D. Fir | 9 | 35 | 16.74 | |
| 5 | D. Fir | 20 | 75 | 346.93 | Largest tree, core sample taken |
| 6 | D. Fir | 16 | 60 | 166.61 | |
| 7 | Hemlock | 12 | 50 | 61.63 | |
| 8 | D. Fir | 12 | 50 | 61.63 | |
| 9 | D. Fir | 6 | 30 | 1.41 | |
| 10 | D. Fir | 12 | 50 | 61.63 | |
| 11 | D. Fir | 14 | 40 | 85.41 | |
| 12 | D. Fir | 14 | 65 | 119.18 | |
| 13 | D. Fir | 8 | 30 | 9.03 | |
| 14 | D. Fir | 14 | 55 | 106.75 | |
| 15 | D. Fir | 10 | 45 | 30.09 | |
| 16 | D. Fir | 20 | 70 | 333.60 | |
| 17 | D. Fir | 12 | 60 | 69.74 | Substantial lean |
| 18 | D. Fir | 6 | 25 | 1.41 | Dead |
| 19 | Maple | 26 | 65 | 613.09 | |
| | | | **TOTAL** | **2210.63** | |

***Board foot calculation, approximation notes:**

Merchantable height estimation: Trees have non-merchantable portions (e.g., stump, crown). Using a taper model adjusted to match typical Form Class 78 (where the diameter tapers faster than a standard paraboloid to reflect real tree shapes, with 78 being the default, standard, absent final saw log measurements), we calculate the height where the diameter reaches 6 inches (a common cutoff for sawlogs).

The formula derives from d(**h**) ≈ **DBH** × [(**total height** - **h**) / (**total height** - 4.5)] ^ (1/p), solved for **h** at d(**h**) = 6, with p ≈ 1.37 (inverted to 0.73 in the exponent for computation).

Number of logs (N): Merchantable height divided by 16 feet (standard log length).

Effective diameter (D_eff): Adjusts the **DBH** downward based on average taper across logs, using k ≈ 0.78 - 0.045 × (N - 1) to approximate the reduced effective scaling diameter for longer trees (derived from fitting to standard Scribner tree volume tables).

Board feet calculation: Applies the Scribner log formula ($0.79D^2 - 2D - 4$) × (length/16) using the effective diameter and N, providing a close match (typically within 5-10% of table values for common tree sizes).

OPALCO SITE 2 Board Foot Estimation

| Tree ID# | Species | DBH (inches) | Height (feet) | Est. Board Feet* | Notes |
|---|---|---|---|---|---|
| 1 | Maple | 24 | 70 | 526.83 | |
| 2 | Maple | 20 | 65 | 319.17 | |
| 3 | Maple | 36 | 55 | 1186.70 | tons of burls, not millable |
| 4 | D. Fir | 6 | 30 | 1.41 | |
| 5 | Maple | 12 | 40 | 52.74 | |
| 6 | White Fir | 20 | 50 | 269.03 | dead, not top, no good wood |
| 7 | White Fir | 16 | 60 | 166.61 | |
| 8 | Hemlock | 12 | 55 | 65.78 | |
| 9 | Maple | 20 | 50 | 269.03 | split half way p |
| 10 | Hemlock | 12 | 55 | 65.78 | |
| 11 | White Fir | 20 | 60 | 303.62 | dead |
| 12 | White Fir | 18 | 65 | 242.05 | dead |
| 13 | Maple | 12 | 50 | 61.63 | |
| 14 | Maple | 14 | 50 | 100.00 | split 5' up, average diam. Used |
| 15 | Maple | 12 | 55 | 65.78 | |
| 16 | D. Fir | 22 | 70 | 424.82 | |
| 17 | D. Fir | 24 | 80 | 565.53 | this is a millable log |
| 18 | D. Fir | 11 | 40 | 39.30 | |
| 19 | Pine | 22 | 75 | 441.46 | |
| 20 | Pine | 24 | 75 | 547.09 | |
| 21 | D. Fir | 12 | 55 | 65.78 | |
| 22 | D. Fir | 20 | 65 | 319.17 | |
| 23 | D. Fir | 6 | 30 | 1.41 | |
| 24 | D. Fir | 12 | 50 | 61.63 | |
| 25 | Hemlock | 16 | 65 | 175.38 | |
| 26 | D. Fir | 8 | 35 | 9.83 | |
| 27 | White Fir | 22 | 80 | 456.67 | |
| 28 | White Fir | 12 | 50 | 61.63 | |
| 29 | White Fir | 24 | 75 | 547.09 | clump with 30, 31 |
| 30 | White Fir | 24 | 75 | 547.09 | clump with 29,31 |
| 31 | White Fir | 20 | 75 | 346.93 | clump with 29,30 |
| 32 | D. Fir | 20 | 60 | 303.62 | bad sweep |
| 33 | Hemlock | 18 | 55 | 217.33 | basal rot |
| | | | **Total** | **8827.96** | |

***Board foot calculation, approximation notes:**

Merchantable height estimation: Trees have non-merchantable portions (e.g., stump, crown). Using a taper model adjusted to match typical Form Class 78 (where the diameter tapers faster than a standard paraboloid to reflect real tree shapes, with 78 being the default, standard, absent final saw log measurements), we calculate the height where the diameter reaches 6 inches (a common cutoff for sawlogs).

The formula derives from d(**h**) ≈ **DBH** × [(**total height** - **h**) / (**total height** - 4.5)] ^ (1/p), solved for **h** at d(**h**) = 6, with p ≈ 1.37 (inverted to 0.73 in the exponent for computation).

Number of logs (N): Merchantable height divided by 16 feet (standard log length).

Effective diameter (D_eff): Adjusts the **DBH** downward based on average taper across logs, using k ≈ 0.78 - 0.045 × (N - 1) to approximate the reduced effective scaling diameter for longer trees (derived from fitting to standard Scribner tree volume tables).

Board feet calculation: Applies the Scribner log formula ($0.79D^2 - 2D - 4$) × (length/16) using the effective diameter and N, providing a close match (typically within 5-10% of table values for common tree sizes).