Wind & Hydro Energy Feasibility Study for the Yurok Tribe

DOE Tribal Energy Program Review Meeting

Award #DE-FG36-07GO17078

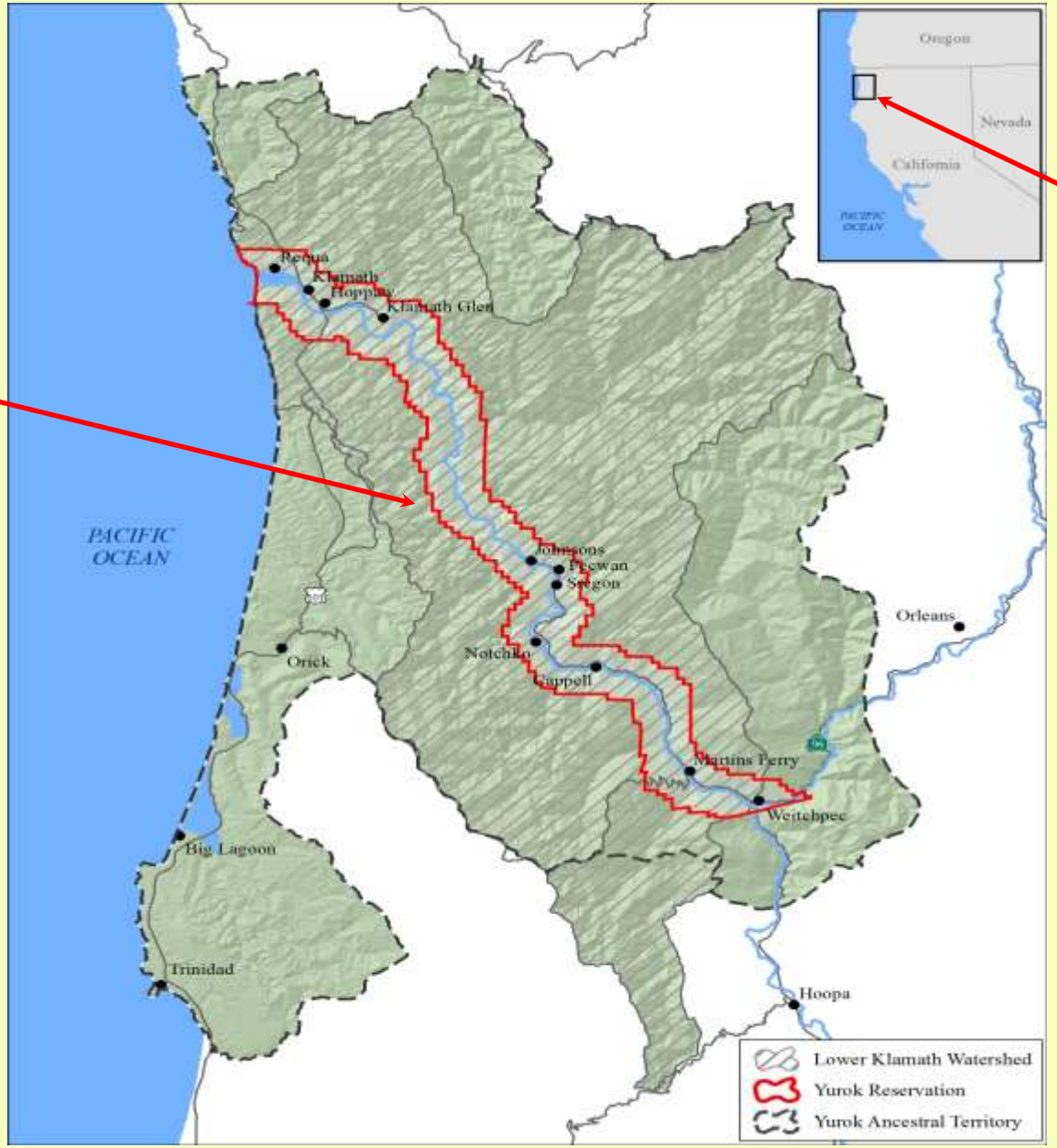
October 27, 2010

Presented By: Austin Nova, Yurok Tribe

Jim Zoellick, Schatz Energy Research Center

Background/Location

Yurok Reservation
Straddles the lower stem of the Klamath River, 2 miles wide and 44 miles long)



Located in northwest corner of California

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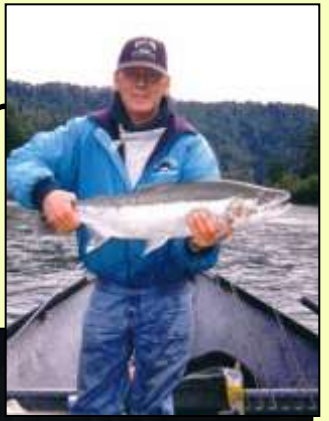
Background

- Largest Indian Tribe in California
- Traditional livelihood on the Yurok Reservation is based upon subsistence harvest of salmon on the Klamath River



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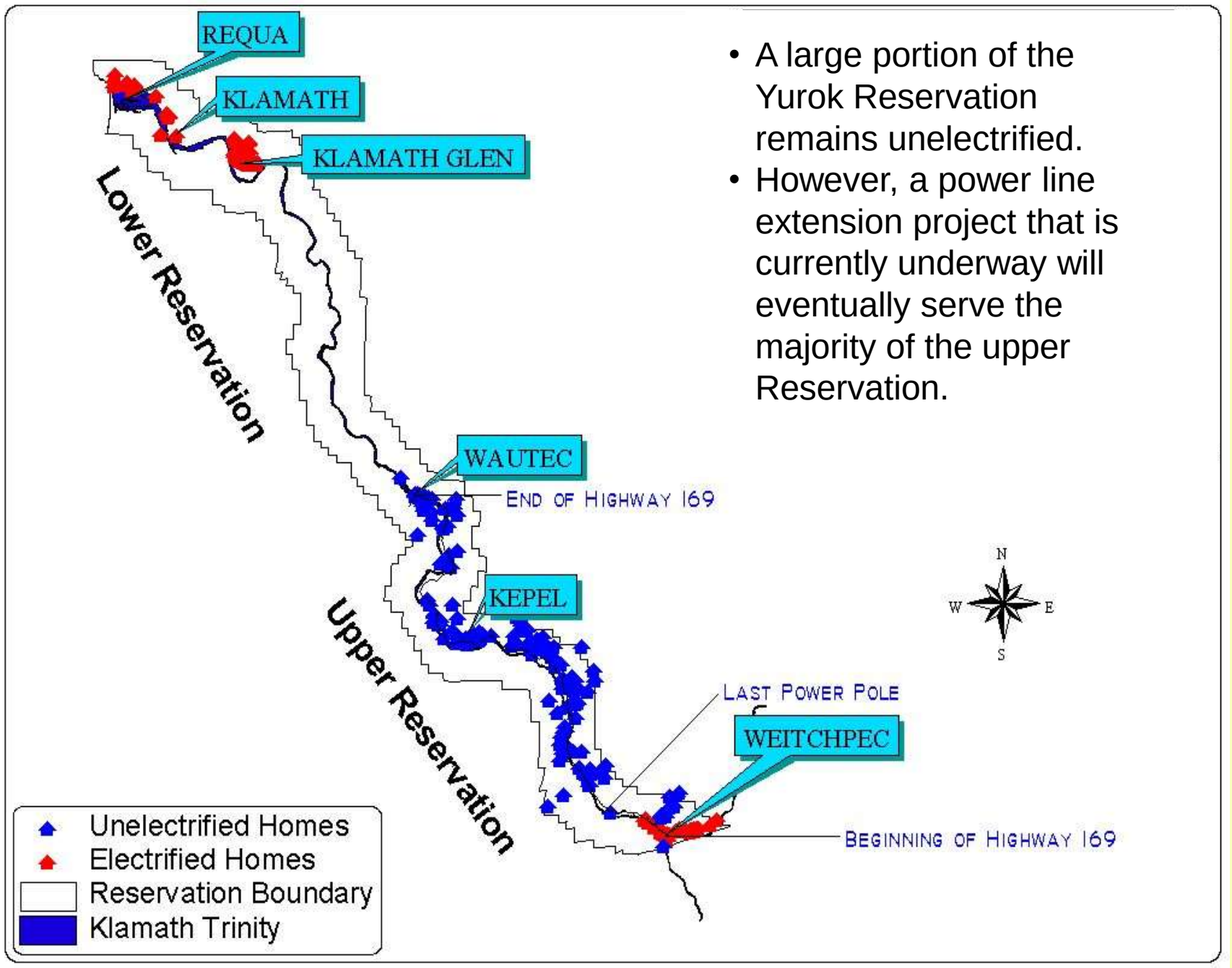
Background



- A large portion of the Yurok Reservation remains unelectrified.
- However, a power line extension project that is currently underway will eventually serve the majority of the upper Reservation.

Background

- Previous DOE funded work done for the Yurok Tribe by the Schatz Energy Research Center examined energy needs and efficiency opportunities, and showed that **wind, hydro, biomass and solar energy** resources are available on the Reservation.
- Solar is appropriate at the facility / household scale.
- Wind, hydro and biomass may also be suitable at a village scale or for sale to the grid.

DOE/NREL

Project Overview

Goals & Objectives:

- Assess the feasibility of developing hydro and wind energy resources on the Yurok Reservation
- Identify and assess two hydro sites and one wind site using detailed, site specific information
- Identify preferred, feasible project(s) and associated economic opportunities, identify path forward for project development

Project Team:

- Yurok Tribe (Planning, Environmental, and Fisheries Departments)
- Schatz Energy Research Center
- Humboldt State University (Engineering & Economics Departments)

Project Schedule:

- Start Date: October 2007
- Initially a 2 year project, extended to 3.5 years

Progress

Year 1:

- Selected project sites
- Specified and obtained data monitoring equipment
- Filed NEPA EF1 Environmental Checklist

Year 2:

- Installed stream gauging stations
- Began collecting stream stage and discharge data
- Erected 50-meter MET tower (provided by NREL loan program)
- Began collecting wind speed and direction data

Year 3:

- Continued collecting wind and hydro resource data
- Removed 50-meter MET tower
- Conducted wind and hydro resource assessment
- Conducted preliminary assessment of grid infrastructure
- Conducted preliminary assessment of energy sales opportunities
- Obtained generalized cost data, developed energy generation and revenue estimates, performed preliminary economic screening

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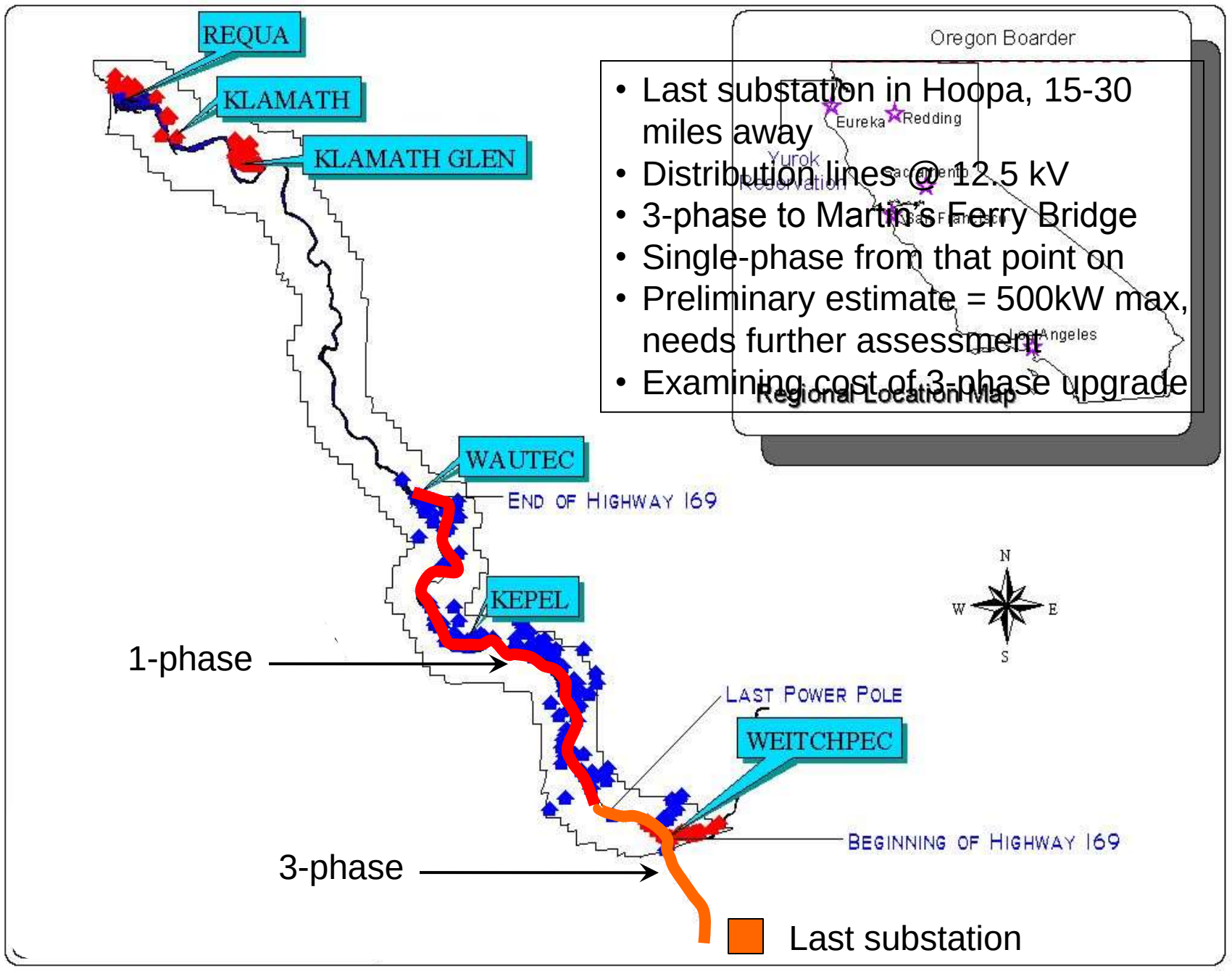
Power Line Extension



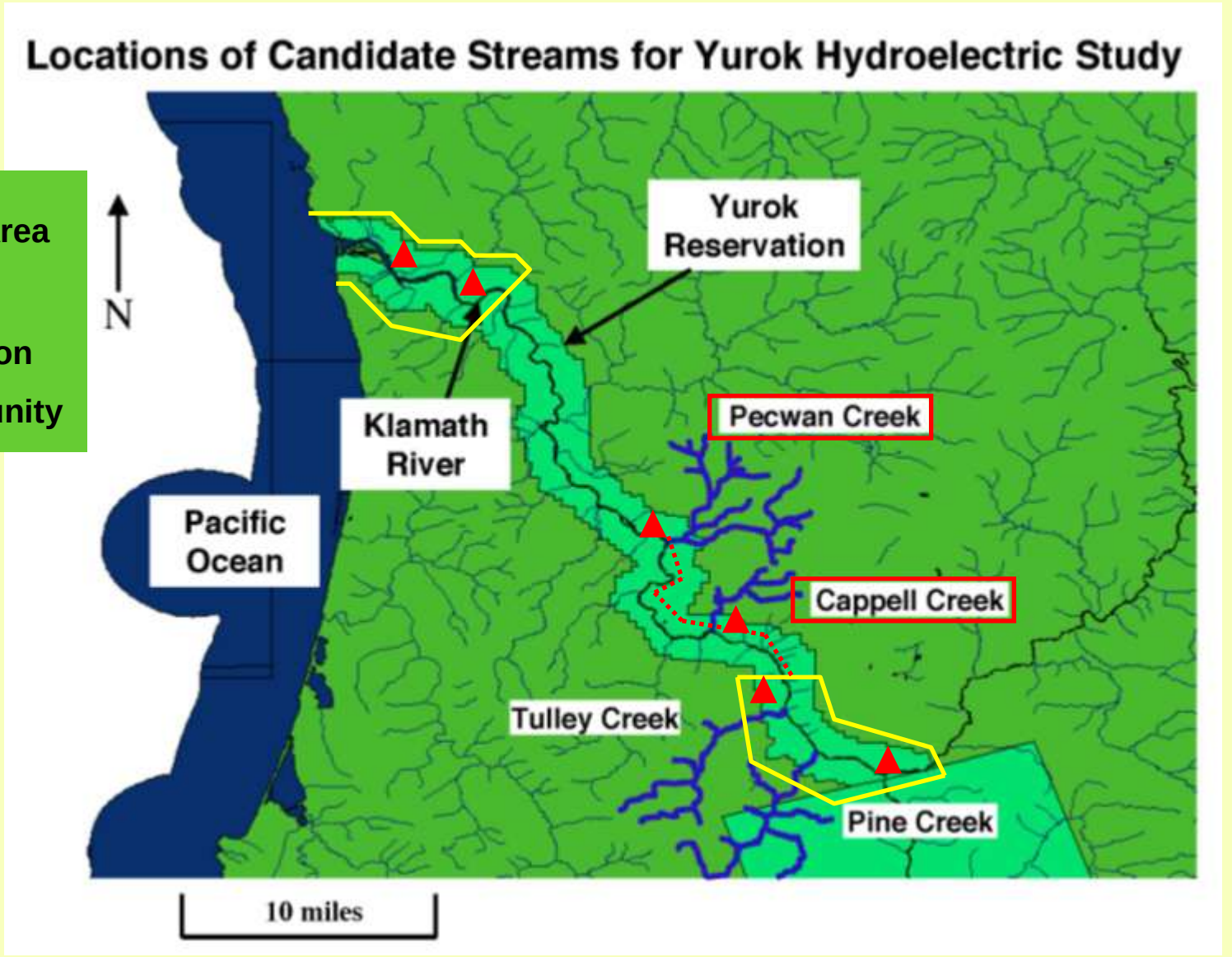
- Last substation in Hoopa, 15-30 miles away
- Distribution lines @ 12.5 kV
- 3-phase to Martin's Ferry Bridge
- Single-phase from that point on
- Preliminary estimate = 500kW max, needs further assessment
- Examining cost of 3-phase upgrade

Site Selection - Hydro

- Nearly 50 creeks enter Klamath River within Reservation boundaries
- Key site selection criteria included:
  - hydropower potential (flow and head)
  - potential impacts to anadromous fish populations (shorter steeper drainages with natural fish barriers preferred)
  - impacts to cultural or sacred sites
  - proximity to electric grid or remote village loads
  - land ownership and road access
- Identified a few candidate streams and then chose two final sites



Site Selection - Hydro



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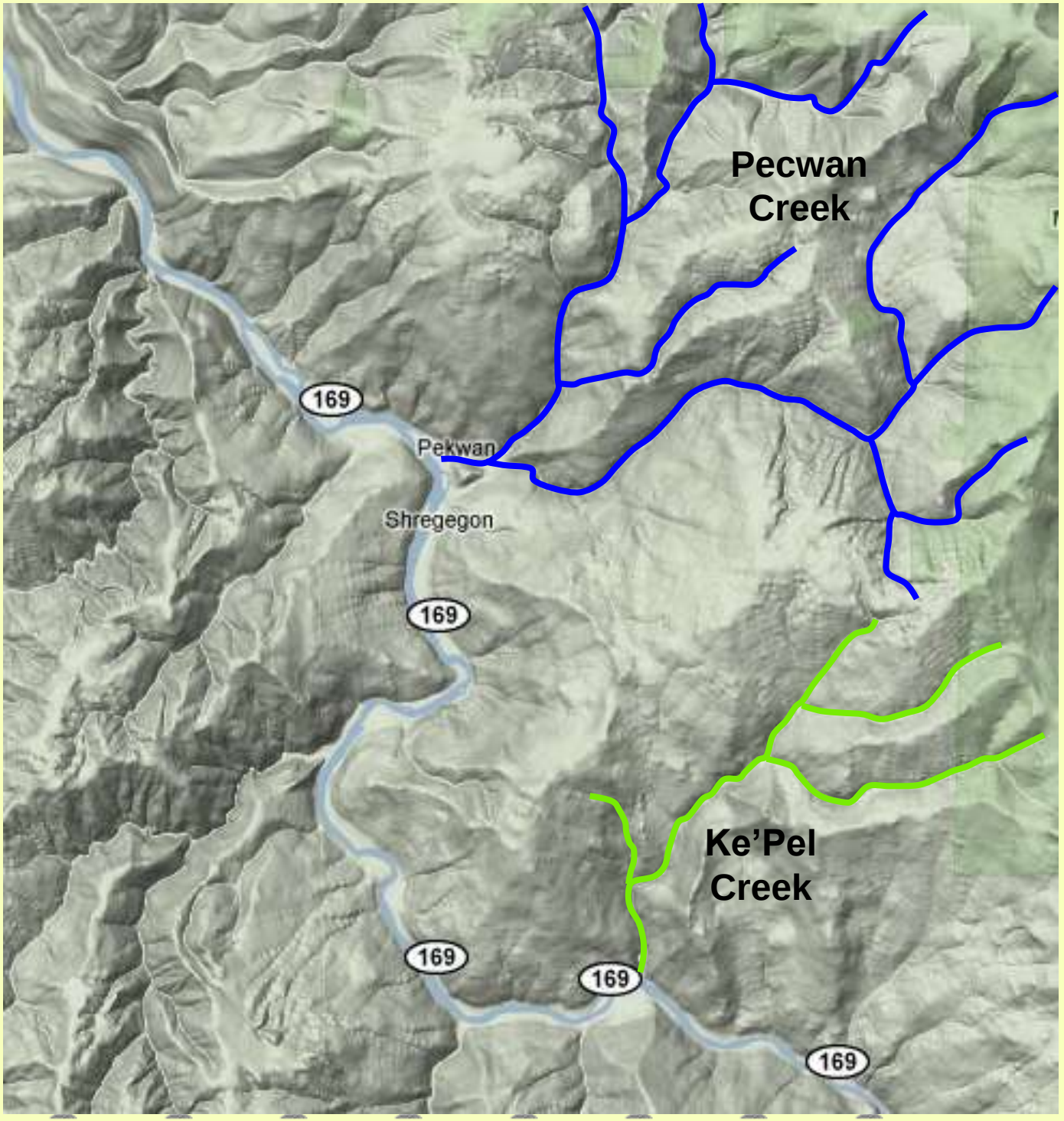
Hydro Site Selection



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Site Selection - Hydro

Pecwan Creek

Ke’pel Creek

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Stream Gauging Station Installation

The Yurok Tribe Planning and Environmental Departments collaborated with SERC engineers to install the gauging stations.

Ke’pel Creek

Ke’pel Creek

Pecwan Creek

Stream Flow Measurement

Ke’pel Creek

Ke’pel Creek

Pecwan Creek

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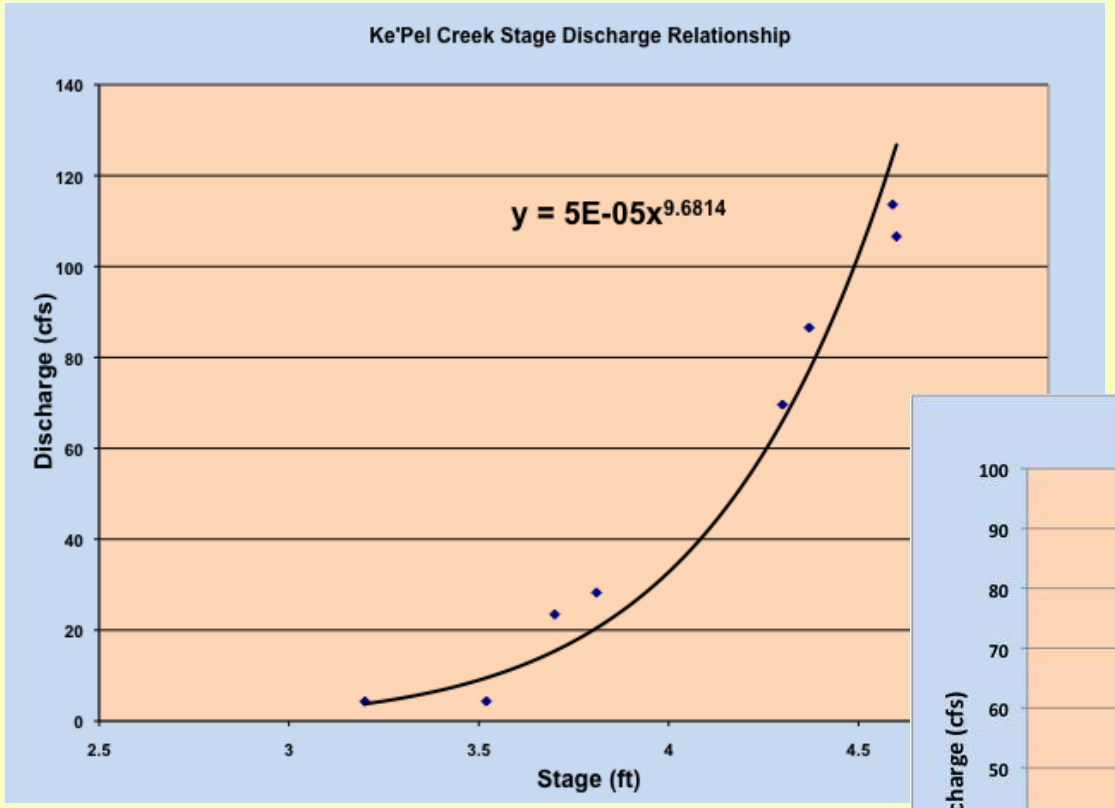
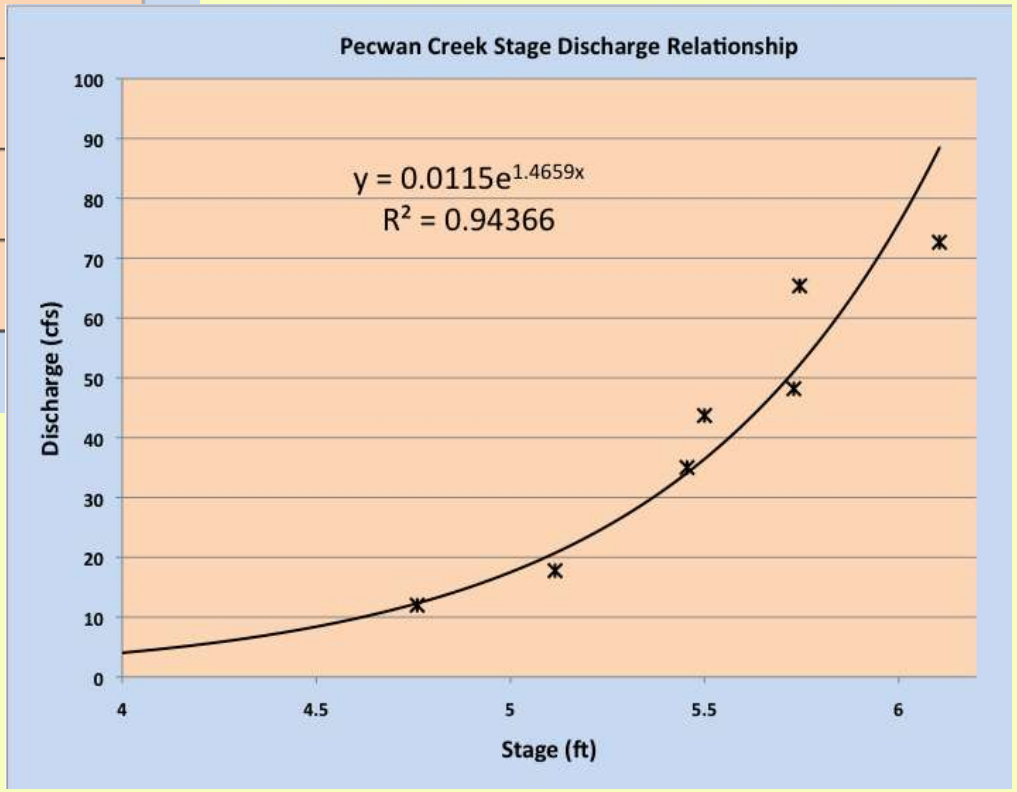
Stage Discharge Curves



Ke'Pel Creek

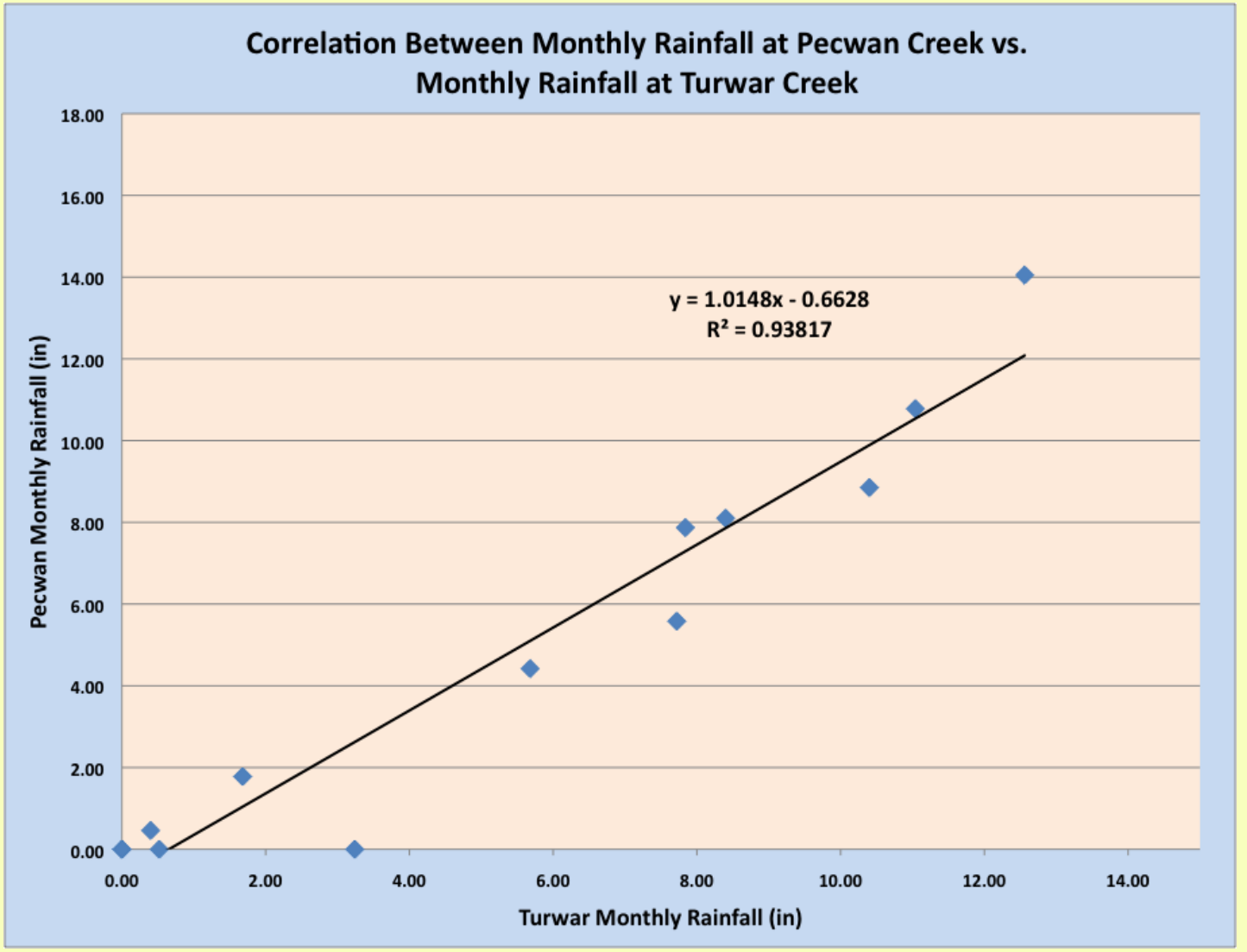
Pecwan Creek



Methodology

- Two years of stage and precipitation data collected for Pecwan Creek and approximately 1.5 years of stage data for Ke'Pel.
- Twelve years of precipitation data available from nearby Turwar Creek.
- Precipitation data from Turwar correlated with Pecwan (assume to also apply at Ke'Pel).
- Army Corps' HEC-HMS rainfall-runoff model used to model flows. Calibrated to 1.5-2 years worth of collected data.
- Calibrated HEC-HMS models used to generate flow estimates for 12 years covered by Turwar precipitation data.
- Flow duration curves developed based on 12 years of simulated flows. Adjusted for intake point higher in watershed.
- We will be performing a sensitivity analysis based on long-term precipitation data (~100 years) that is available from a nearby monitoring station.

Methodology – Rainfall Correlation



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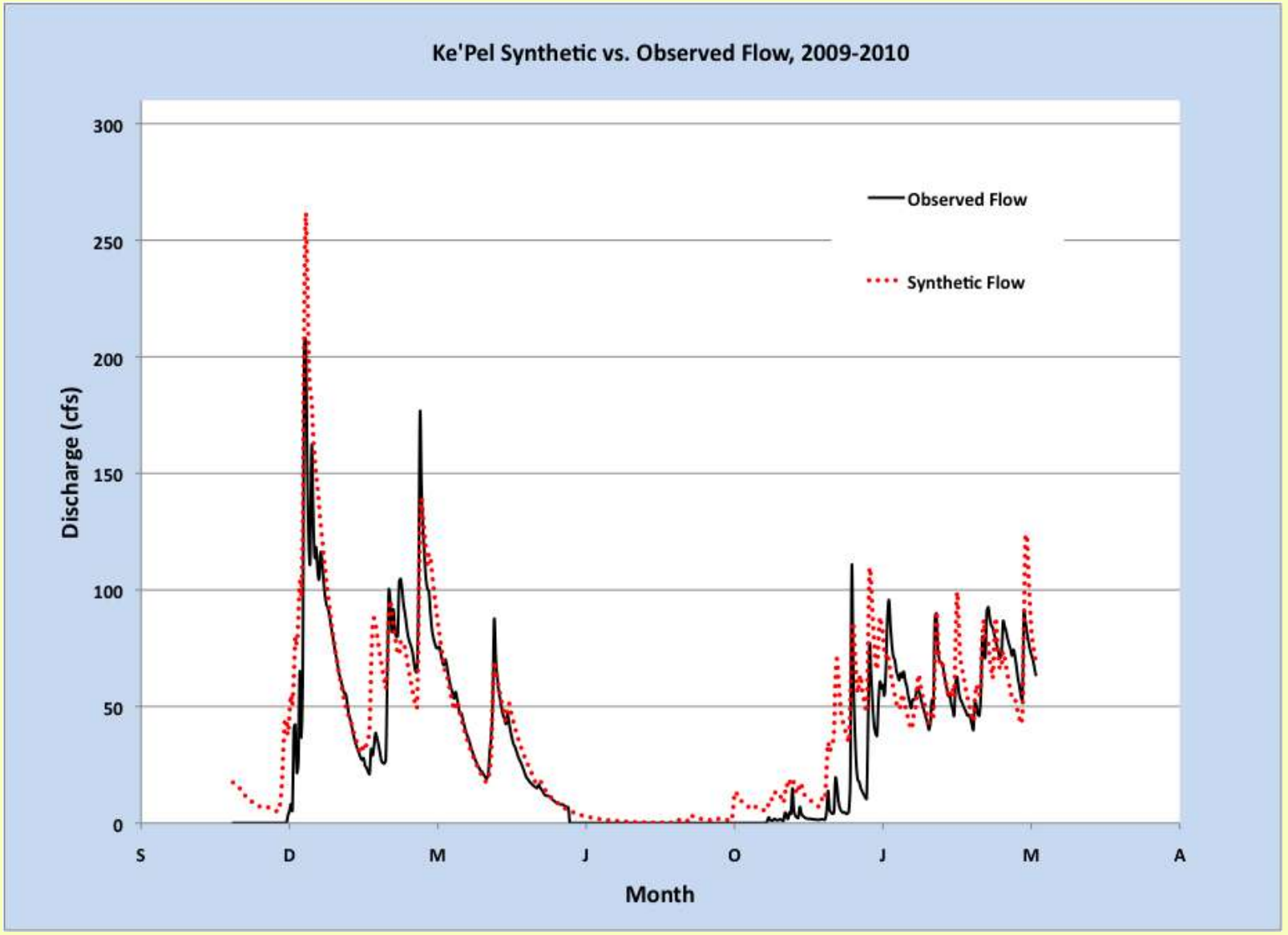
Ke'Pel Hydrograph



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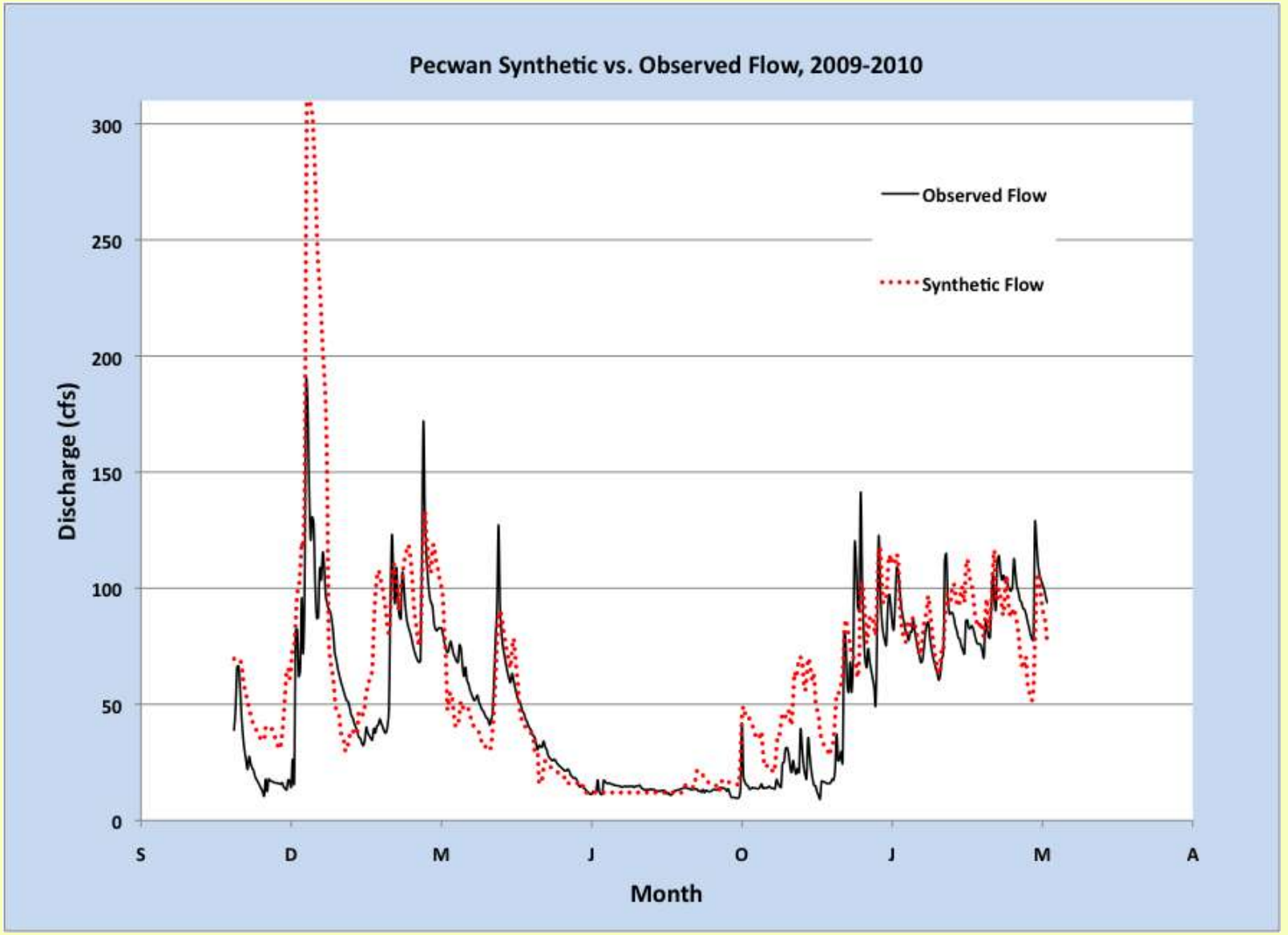
Pecwan Hydrograph



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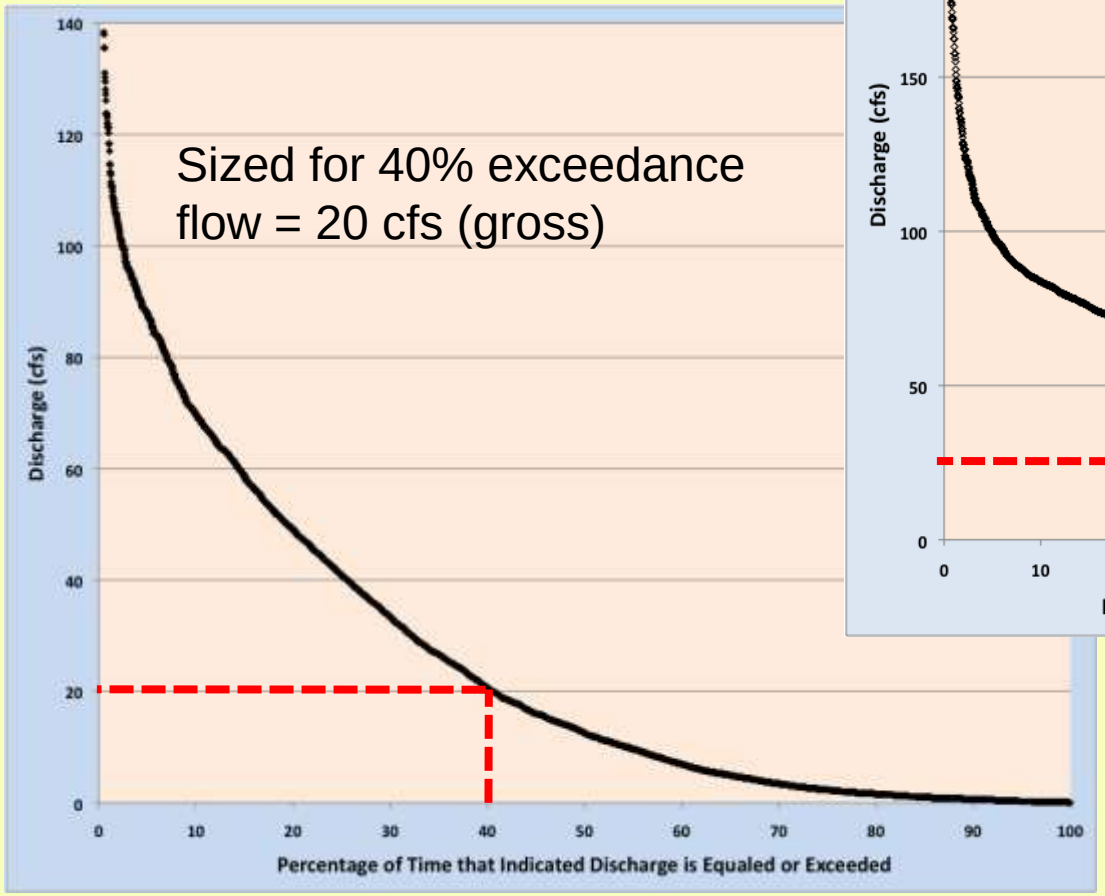
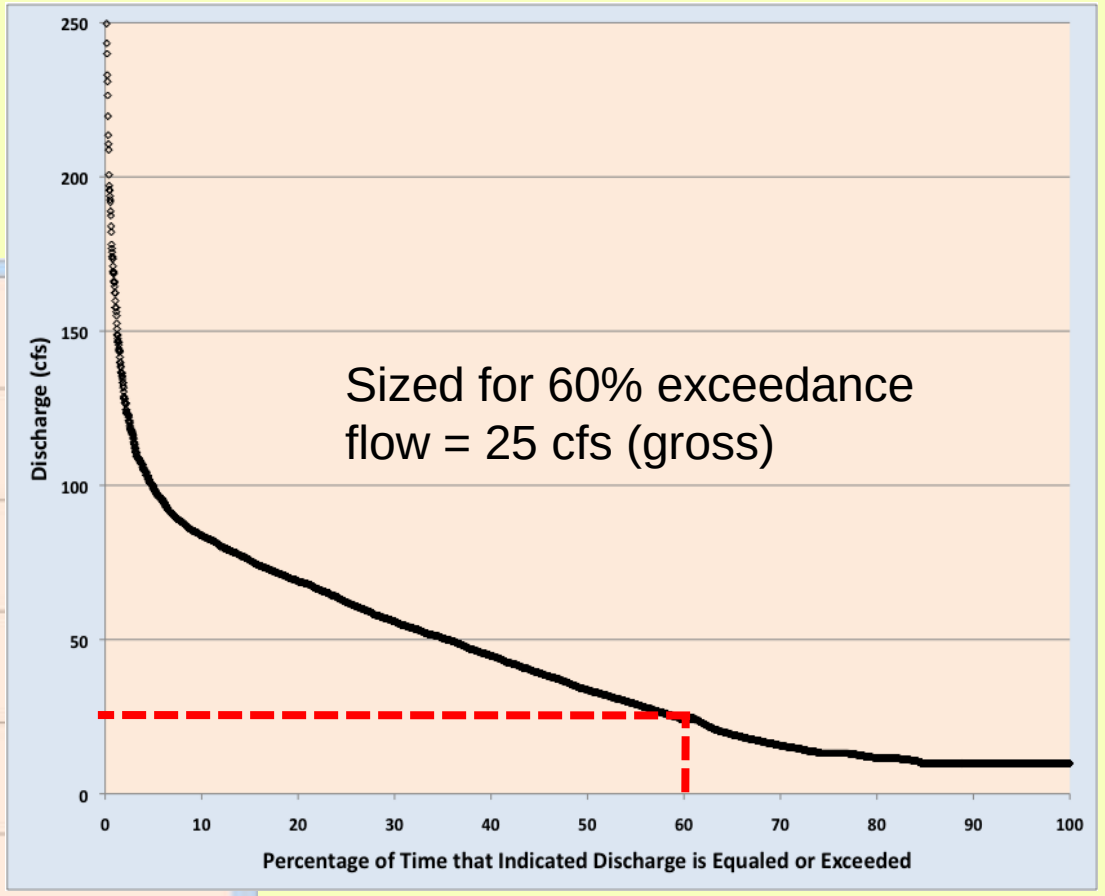
Estimated Flow Duration Curves 1999-2010

Ke'Pel Creek

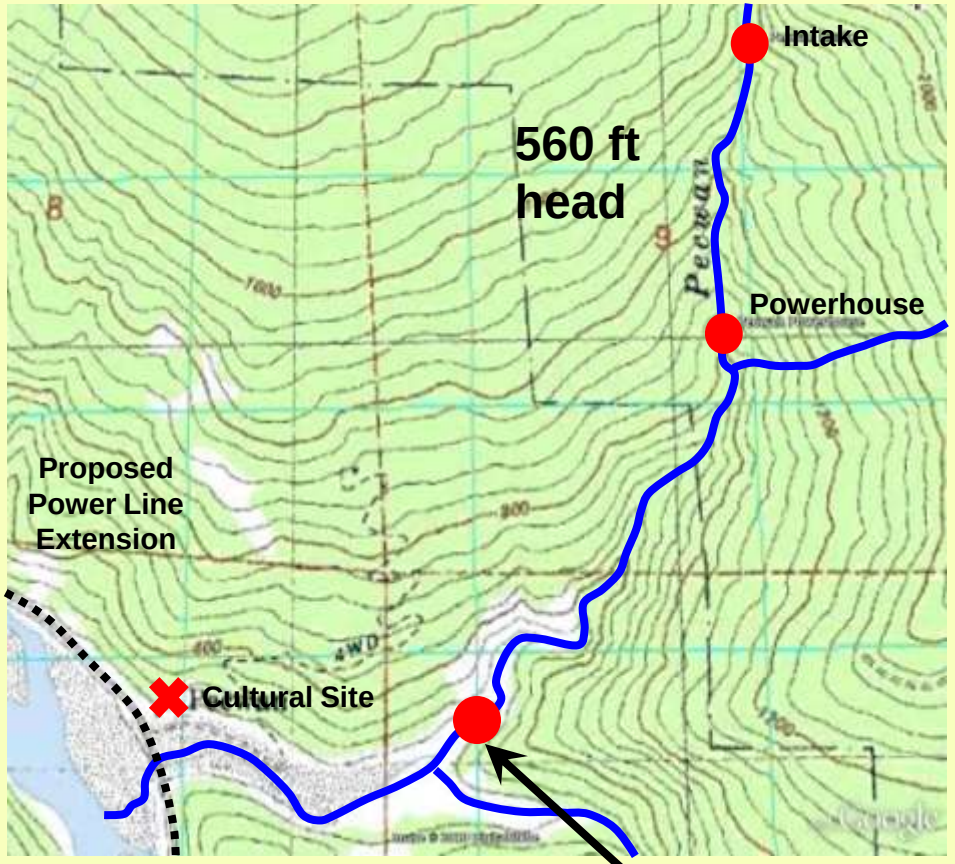




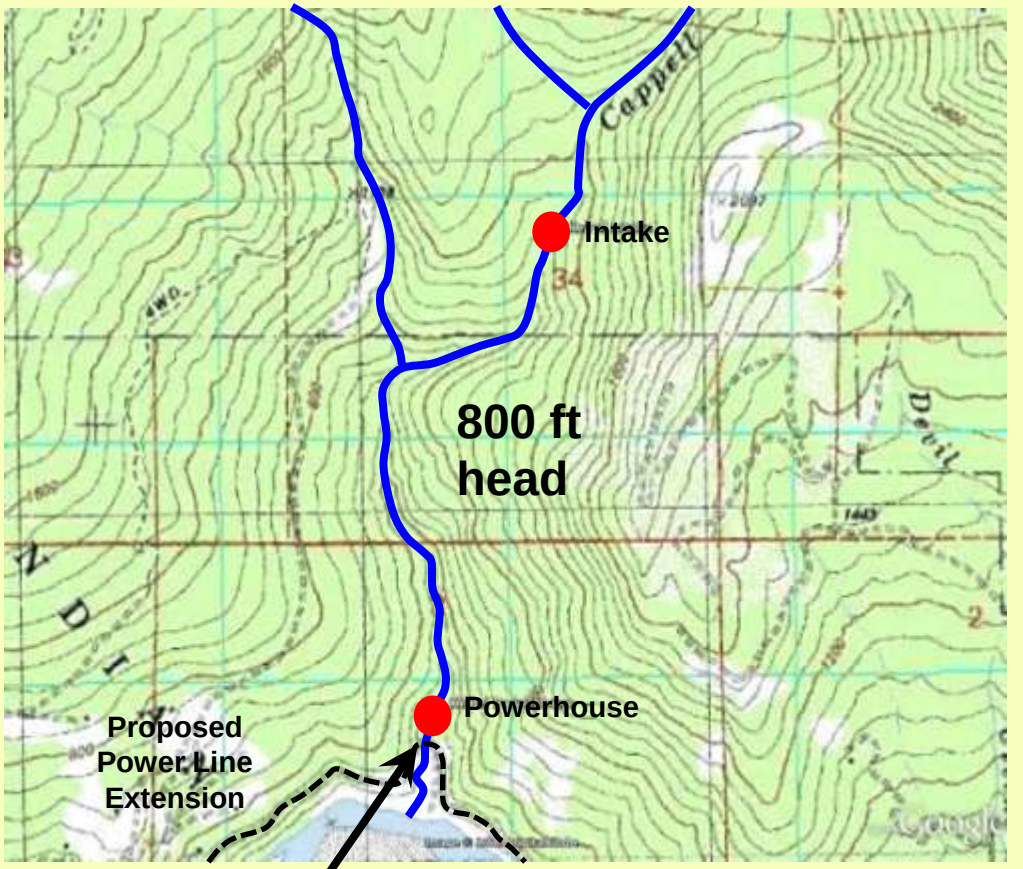
Pecwan Creek

Energy Generation Potential – Preliminary Design Specifications

Pecwan Creek



Ke'Pel Creek



Gauging Station Locations

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Energy Generation Potential – Preliminary Design Specifications

	Pecwan	Ke'Pel
Gross Head	560	800
System Efficiency[1]	60%	60%
Min. Bypass Flow	3 cfs	3 cfs
Max. Usable Flow (net)	20 cfs	15 cfs
Nameplate Capacity[2]	500 kW	500 kW
Ave. Annual Capacity Factor	83%	57%

1. Per DOE Microhydropower Handbook, Vol. 1, 1983
2. Maximum nameplate capacity estimated to be 500 kW. Power line extension serving this area will only be a single-phase 12.5 kV line. Turbine-generator quote from Dependable Turbines Ltd., BC, Canada.

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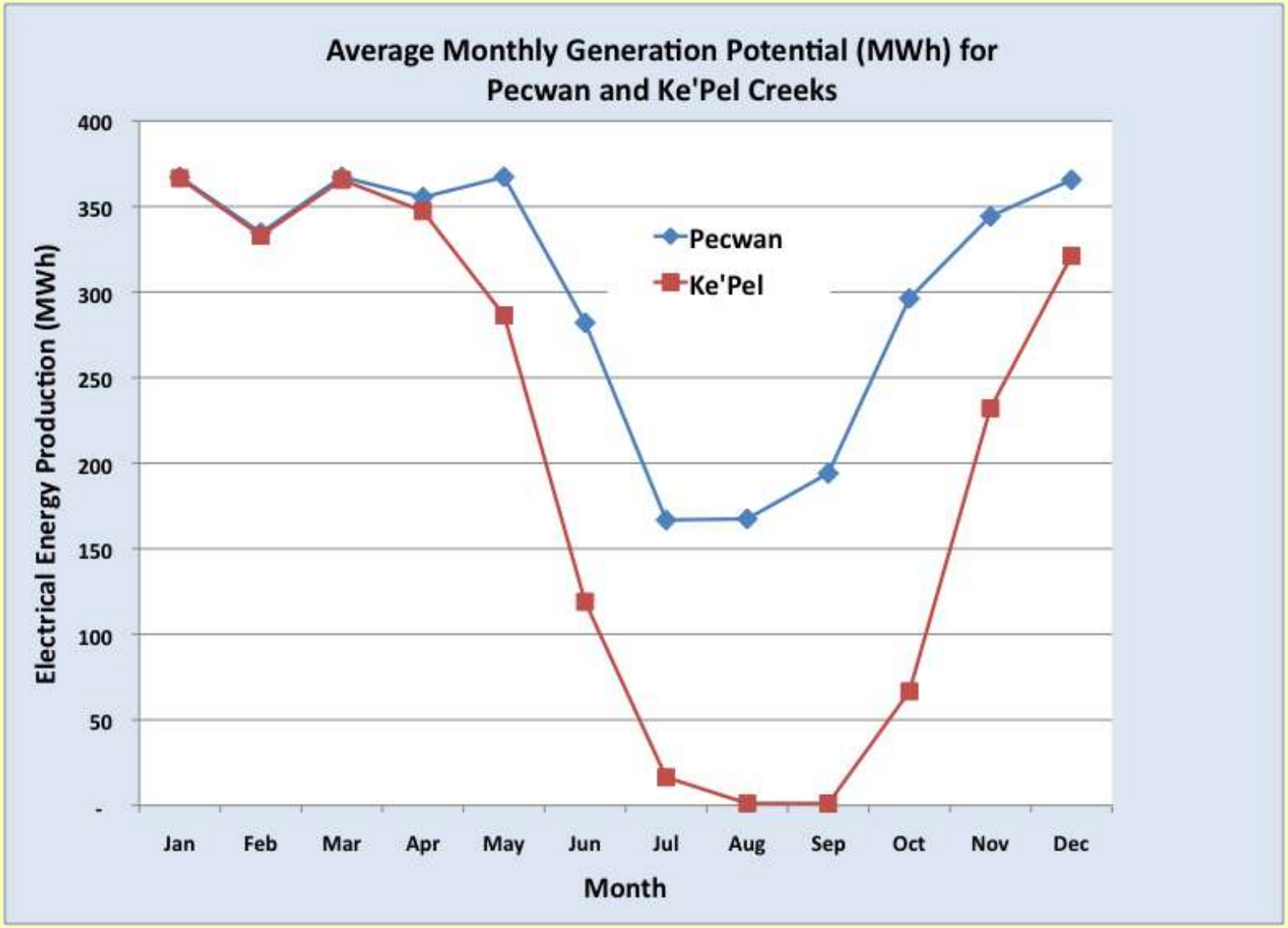
Energy Generation Potential



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Preliminary Economic Analysis

	Pecwan		Ke'Pel	
Contract type	**SRG**	**QF**	**SRG**	**QF**
LCOE	$0.041/kWh		$0.061/kWh	
NPV (3%)	$10.6 M	$7.0 M	$5.4 M	$3.4 M
IRR	13%	11%	9%	7%
Discounted Payback Time	10.7 yrs	13.1 yrs	18.5 yrs	21.8 yrs

- Installed system cost based on data from KEMA, Oregon Office of Energy, RETScreen and others. Assumed $4500/kW of installed capacity and $50/kW-yr fixed O&M
- Revenue estimates based on two different power purchase contract mechanisms: Qualifying facility (QF) contract prices or feed-in tariff prices using the small renewable generator (SRG) PPA*
- Assumed 50 year project life. Projected future energy prices based on correlations with the expected price of natural gas per EIA projections.

* SRG rate available for projects up to 1.5 MW.

Site Selection - Wind

- CA Energy Commission (CEC) and NREL data characterize the area surrounding the Yurok Reservation with class 1 to 4 wind power ratings (“poor” to “good” on a 7-point scale)
- Key issues regarding wind power siting:
  - adequate resource, economic viability
  - access to the electric grid or proximity to remote village
  - environmental & cultural impacts
  - land ownership
  - road access

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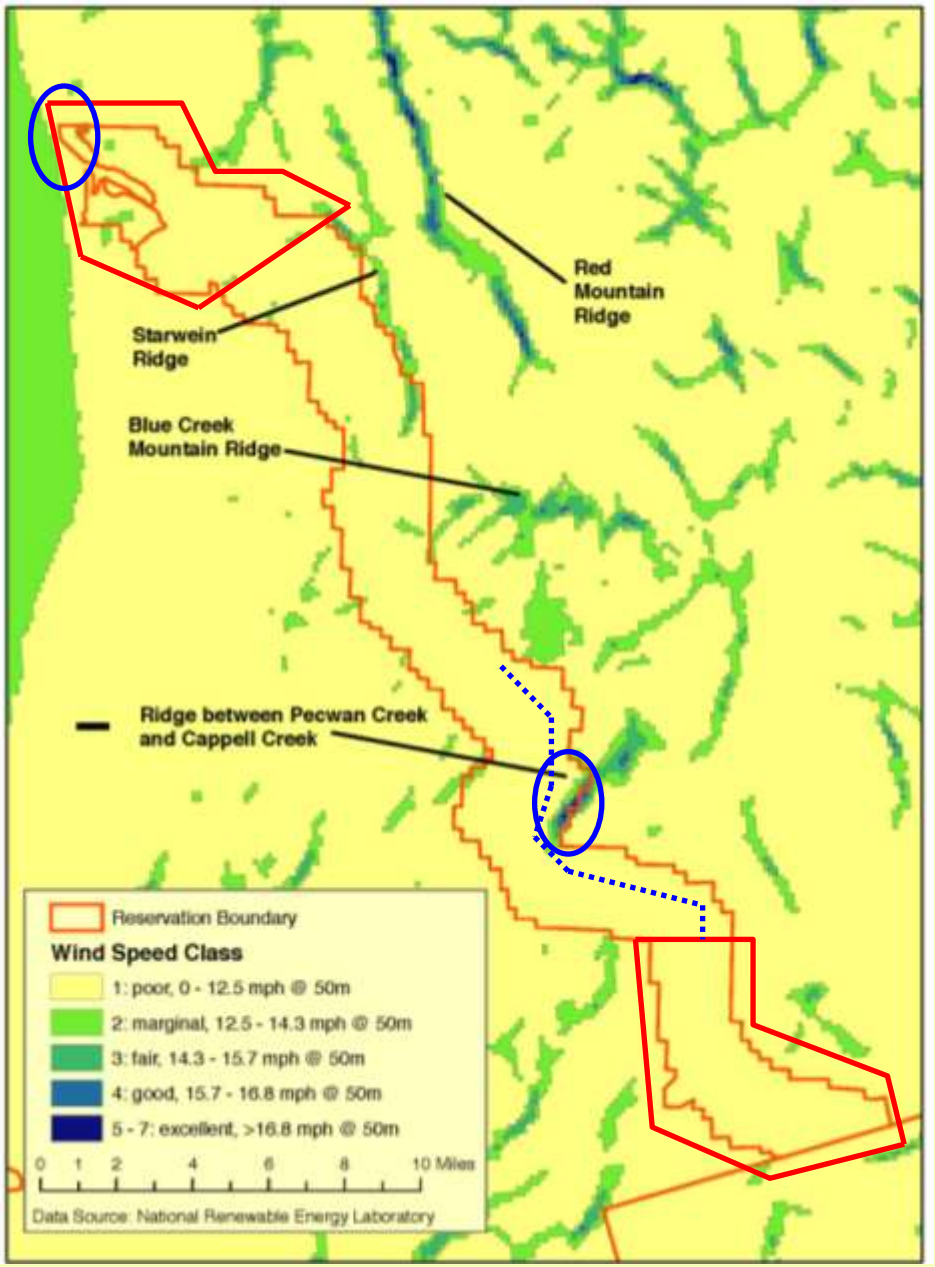
Site Selection - Wind

Wind Speed Classes in the Vicinity of the Yurok Reservation

- Electrified Area
- Planned Electrification
- Key Potential Monitoring Sites



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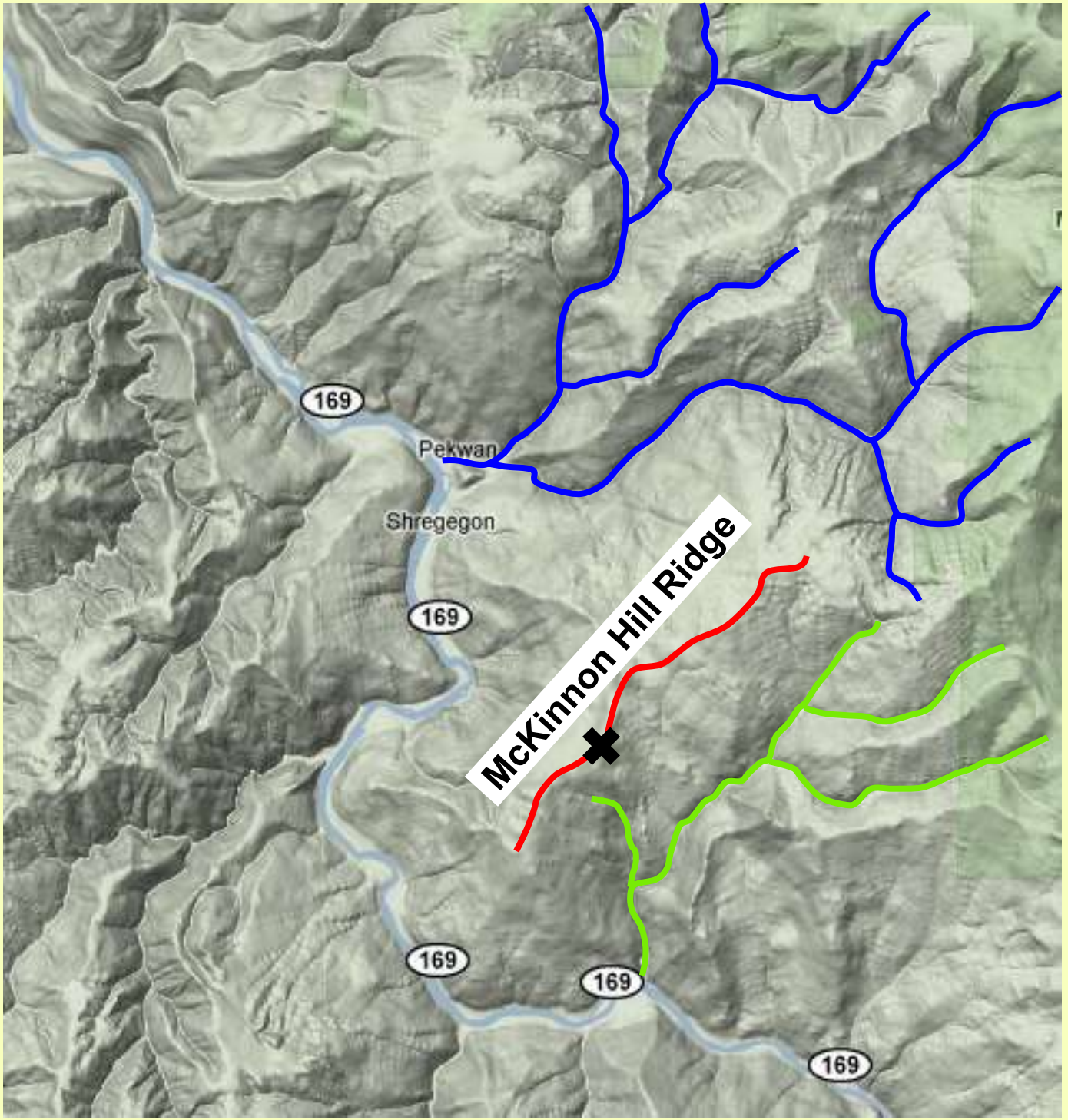
Wind Site Selection



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Wind Site Preparation

The site was significantly wooded ...

… and required substantial clearing.

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MET Tower Installation

Tower assembly.

Lifting begins.

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MET Tower Installation

The tower going up.

The team celebrates.

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Methodology

- One year of wind speed and direction data were collected at the site (10 minute averages).
- Data were screened and analyzed to characterize resource.
- Explored the ability to extend the data record using a correlate and predict methodology. Longer term records are available at two local sites within 10-20 miles (wind speed at 5 m). Due to complex terrain the correlation is too weak to be useful (≤ 0.36 correlation coefficient).
- Examined power production potential based on 11 different turbine power curves (120 kW to 2 MW range).
- Examined the revenue generation over a 50 year period (two 25 year turbines) for both the QF and SRG rates.
- Assumed installed cost to range from $1800 to $2000/kW, with annual O&M costs = 1-2% of total installed cost (per Rigauld, Louis, Halus Power Systems personal communication).

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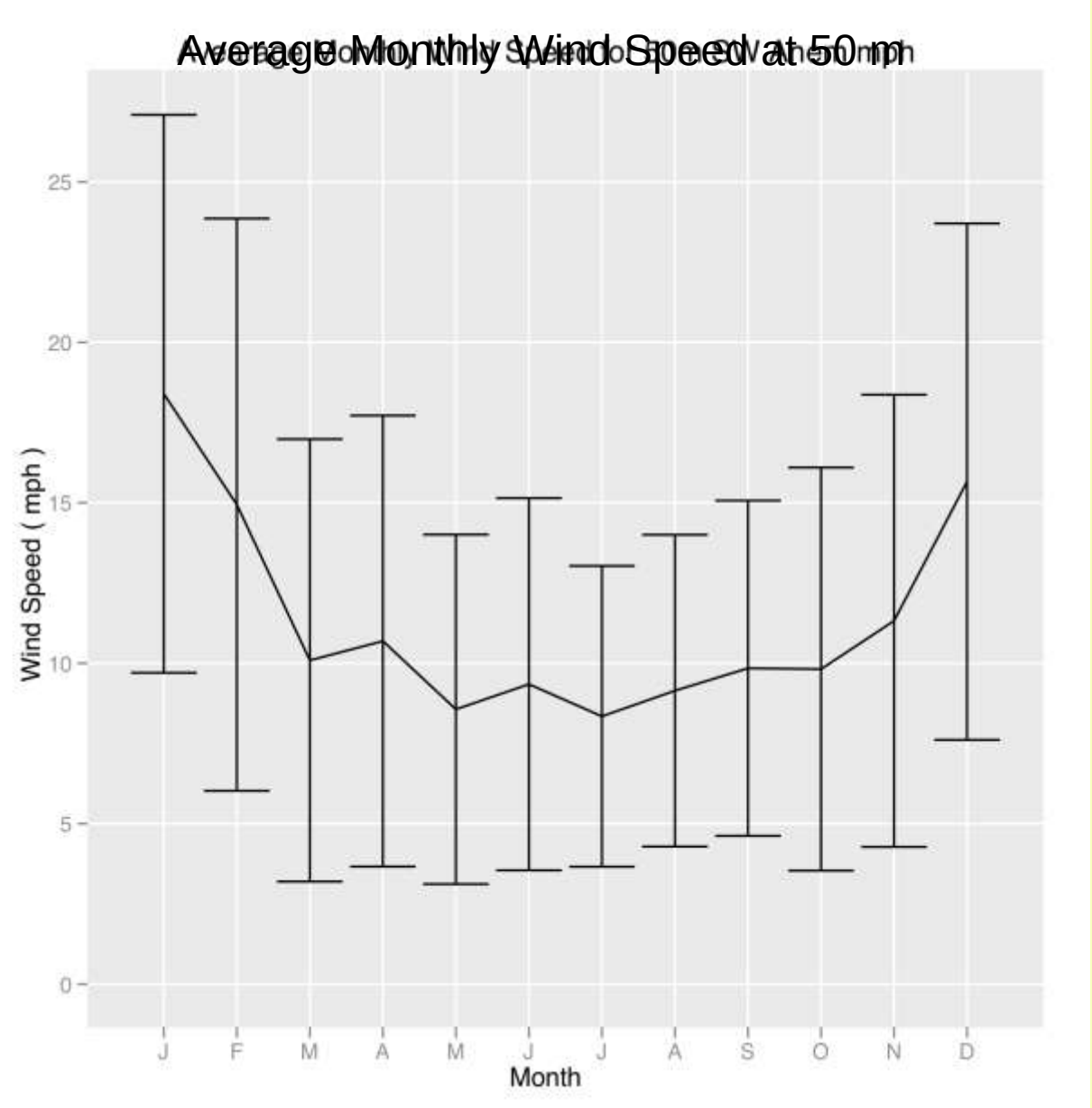
Wind Resource Data - Wind Speed at 50 m



Annual average wind speed = 11.3 mph (5 m/s)

Wind Power Class 1 to 2

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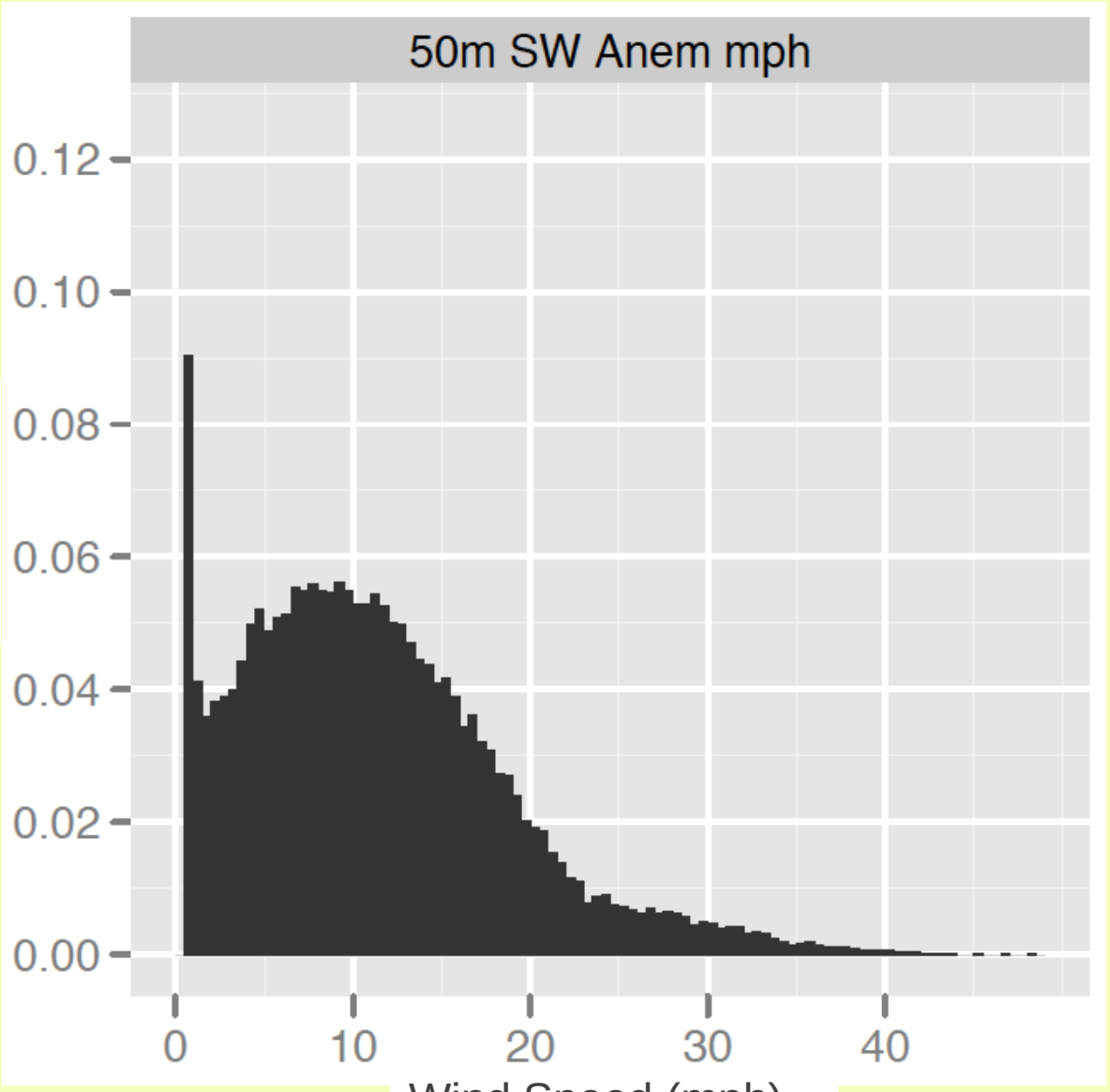
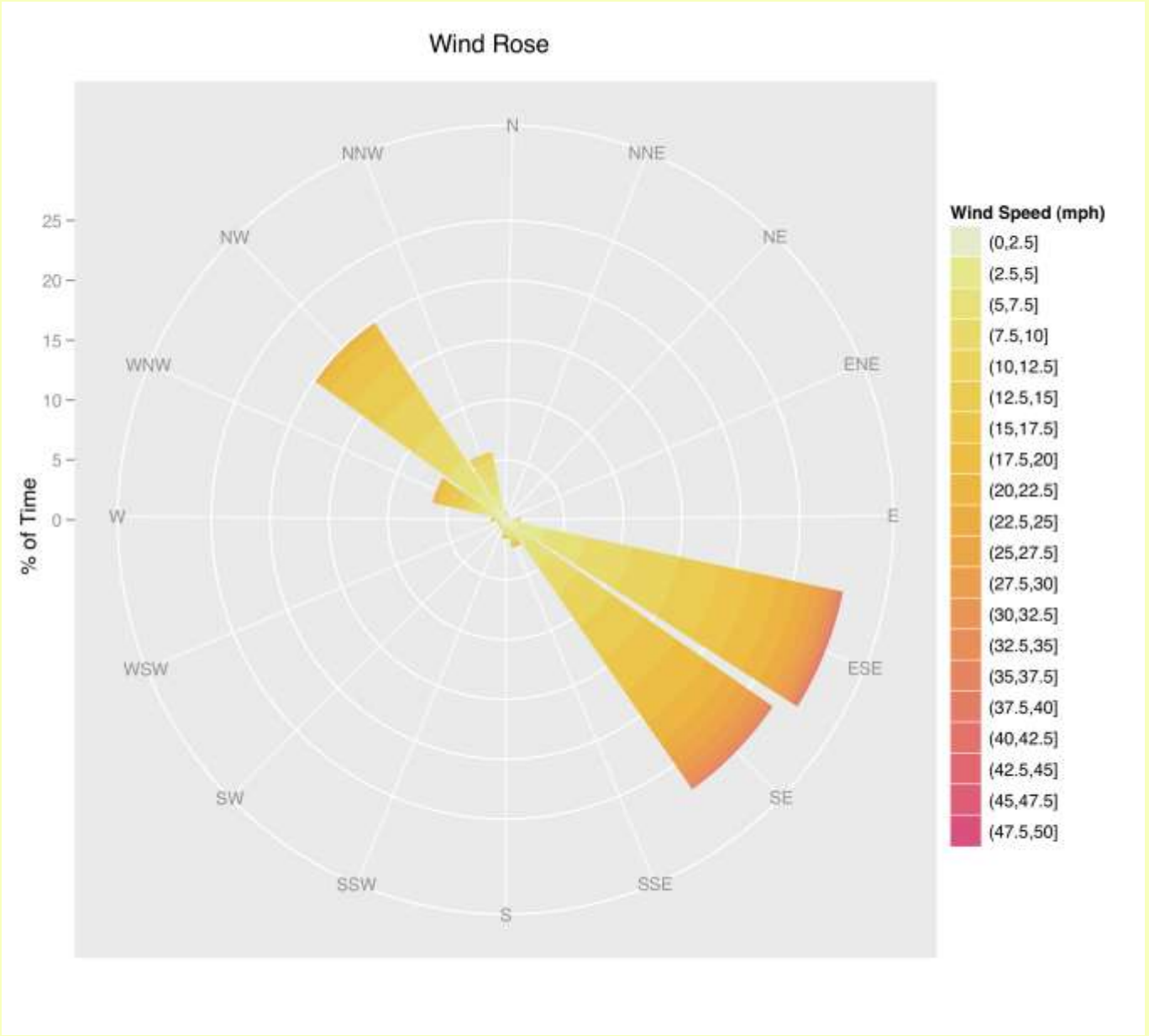
Wind Resource Data – Wind Speed Distribution at 50 m



Annual average wind speed = 11.3 mph (5 m/s)

Wind Power Class 1 to 2

Wind Resource Data - Wind Direction at 50 m



Turbine Characteristics and Expected Capacity Factors

Turbine Description	Model #	Nameplate Capacity (kW)	Hub Height (m)	# of Turbines	Capacity Factor
Americas Wind Energy 54-900	AWE 54-900	900	75	1	21.0%
Nordic N1000	N1000	1000	70	1	16.7%
Unison U57 750kW	U57	750	68	2	26.3%

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Preliminary Economic Analysis

		QF Rate		SRG Rate	
Turbine	LCOE	NPV	IRR	NPV	IRR
Low Installed Cost Estimate ($1700/kW)					
AWE 54-900	$0.062/kWh	$1.3 M	5.9%	$3.1 M	8.8%
N1000	$0.155/kWh	$1.2 M	4.2%	$4.2 M	6.8%
U57	$0.099/kWh	$3.9 M	7.8%	$7.6 M	11.0%
High Installed Cost Estimate ($2000/kW)					
AWE 54-900	$0.084/kWh	$0.4 M	3.8%	$2.1 M	6.5%
N1000	$0.210/kWh	-$1.0 M	2.1%	$2.1 M	4.6%
U57	$0.134/kWh	$2.3 M	5.5%	$6.1 M	8.5%

Preliminary Results and Conclusions

- **Pecwan Creek hydropower project**
  Preliminary economic assessment indicates this project looks most favorable, entire project (intake and powerhouse) can likely be located above the lower limit of anadromy
- **McKinnon Hill wind power project**
  Wind resource is marginal at best (Class 1 to 2), 3-phase turbines would require 3-phase line upgrade, also potential issues with a nearby cultural site and proposed project to introduce California Condors
- **Ke'Pel Creek hydropower project**
  Ke'Pel Creek hydro resource is not as robust, smaller watershed, low flows in summer would likely suspend power generation, economics do not look as favorable, limits to anadromy are less well defined, likely difficult to site entire project above limits to anadromy

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Next Steps (through March 2011)

- Identify preferred alternative and refine economic analysis, conduct sensitivity analysis (resource, economic parameters, etc.)
- Refine assessment of grid interconnection and energy sales opportunities
- Conduct preliminary environmental assessment and assess permitting requirements
- Develop business plan and financing options, identify path forward
- Identify key stakeholders and outline a community outreach and education plan
- Provide training/professional development to Tribal staff & government

Thank You

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