DOE F 241.3
(2-01) p. 1 of 4

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No. 1910-1400

PART I: STI PRODUCT DESCRIPTION

(To be completed by Recipient/Contractor)

A. STI Product Identifiers

1. REPORT/PRODUCT NUMBER(s)
NONE

2. DOE AWARD/CONTRACT NUMBER(s)
DE-FG36-07GO17078

3. OTHER IDENTIFYING NUMBER(s)

B. Recipient/Contractor

Schatz Energy Research Center, Humboldt State University, Arcata, CA

C. STI Product Title

Yurok Tribe Wind and Hydro Energy Feasibility Study

D. Author(s)

Zoellick, J.; Engel, R.; Garcia, R.; and Sheppard, C.

E-mail Address(es):
james.zoellick@humboldt.edu;
richard.engel@humboldt.edu;
ruben.garciajr@humboldt.edu;
colin.sheppard@humboldt.edu

E. STI Product Issue Date/Date of Publication

May 31, 2011 (mm/dd/yyyy)

F. STI Product Type *(Select only one)*

☒ 1. TECHNICAL REPORT

H. Sponsoring DOE Program Office

Tribal Energy Program

I. Subject Categories *(list primary one first)*

HYDRO ENERGY, WIND ENERGY

Keywords

J. Description/Abstract

The primary focus of the study was to examine the opportunity to develop wind and hydroelectric power sources on the Yurok Reservation for wholesale back to the grid. Three potential project sites were identified on the Reservation. Data collection systems were installed at each of the sites and wind speed and direction data as well as creek stage and discharge data were collected. Power production estimates were developed for a set of candidate turbines and economic screening of project alternatives were conducted based on revenue generation potential and estimated project costs. A key finding was that the electrical distribution infrastructure serving the area would need to be substantially upgraded to support a project.
Expected overnight capital costs for a proposed 1.5 MW hydroelectric plant are approximately $9.5 million, including distribution system upgrades. The net present value of the project over it's expected 50-year life is about $2.9 million. In order for the project to generate positive cash flow starting in year one, it will be necessary to obtain grant funding to cover at least 10% of the upfront capital costs. These estimates are preliminary and carry a high degree of uncertainty. If there is interest in continuing with project evaluation the key next step will be to conduct an interconnection study. Additional project activities included an assessment of permitting requirements, a preliminary environmental assessment, and preparation of a project development plan.

K. Intellectual Property/Distribution Limitations

(must select at least one; if uncertain contact your Contracting Officer (CO))

☒ 1. UNLIMITED ANNOUNCEMENT *(available to U.S. and non-U.S. public; the Government assumes no liability for disclosure of such data)*

☐ 2. COPYRIGHTED MATERIAL: *Are there any restrictions based on copyright?* ☐ *Yes* ☐ *No*
If yes, list the restrictions as retained in your contract

☐ 3. PATENTABLE MATERIAL: THERE IS PATENTABLE MATERIAL IN THE DOCUMENT
INVENTION DISLOSURE SUBMITTED TO DOE:
DOE Docket Number: S-
(Sections are marked as restricted distribution

☒ *Final* ☐ *Other (specify)* ____

☐ 2. CONFERENCE PAPER/PROCEEDINGS

Conference Information (title, location, dates)

☐ 3. JOURNAL ARTICLE

a. TYPE: ☐ *Announcement Citation Only*

☐ *Preprint* ☐ *Postprint*

b. JOURNAL NAME

c. VOLUME ____ *d. ISSUE* ____

e. SERIAL IDENTIFIER (e.g. ISSN or CODEN)

☐ OTHER, SPECIFY

G. STI Product Reporting Period (mm/dd/yyyy)

September 30, 2007 *Thru* March 31, 2011

pursuant to 35 USC 205)

☐ 4. PROTECTED DATA: ☐ *CRADA* ☐ *Other*

If other, specify

Release date (mm/dd/yyyy)

☐ 5. SMALL BUSINESS INNOVATION RESEARCH (SBIR) DATA

Release date (Required,

(No more than 4 years from date listed in part 1.E above)

☐ 6. SMALL BUSINESS TRANSFER (STTR) DATA

Release date (Required,

No more than 4 years from date listed in part 1.E above)

☐ 7. OFFICE OF NUCLEAR ENERGY APPLIED TECHNOLOGY

L. Recipient/Contractor Point of Contact *Contact for additional information (contact or organization name to be included in published citations and who would receive any external questions about the content of the STI Product or the research contained therein)*

Jim Zoellick, Senior Research Engineer

Name and/or Position

james.zoellick@humboldt.edu, *707-826-4350*

E-mail *Phone*

Schatz Energy Research Center, Humboldt State University, Arcata, CA

Organization

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No. 1910-1400

PART II: STI PRODUCT MEDIA/FORMAT and LOCATION/TRANSMISSION
(To be completed by Recipient/Contractor)

A. Media/Format Information:

1. MEDIUM OF STI PRODUCT IS:
   ☒ Electronic Document ☐ Computer medium
   ☐ Audiovisual material ☐ Paper ☐ No full-text
2. SIZE OF STI PRODUCT 38.4 MB
3. SPECIFY FILE FORMAT OF ELECTRONIC DOCUMENT BEING TRANSMITTED, INDICATE:
   ☐ SGML ☐ HTML ☐ XML ☒ PDF Normal ☐ PDF Image
   ☐ WP-Indicate Version *(5.0 or greater)* ______
   Platform/operating system ______
   ☐ MS-Indicate Version *(5.0 or greater)* ______
   Platform/operating system ______
   ☐ Postscript ______
4. IF COMPUTER MEDIUM OR AUDIOVISUAL
   a. Quantity/type *(specify)* ______
   b. Machine compatibility *(specify)* ______
   c. Other information about product format a user needs to know: ______

B. Transmission Information:

STI PRODUCT IS BEING TRANSMITTED:
☒ 1. Electronic via Elink
☐ 2. Via mail or shipment to address indicated in award document *(Paper products, CD-ROM, diskettes, videocassettes, et.)*
______
☒ 2a. Information product file name *(of transmitted electronic format)*
Yurok Wind and Hydro Feasibility Study Final Report Complete June 2011.pdf

PART III: STI PRODUCT REVIEW/RELEASE INFORMATION
(To be completed by DOE)

A. STI Product Reporting Requirement Review:

☐ 1. THIS DELIVERABLE COMPLETES ALL REQUIRED DELIVERABLES FOR THIS AWARD
☐ 2. THIS DELIVERABLE FULFILLS A TECHNICAL REPORTING REQUIREMENT, BUT SHOULD NOT BE DISSEMINATED BEYOND DOE.

B. DOE Releasing Official

☐ 1. I VERIFY THAT ALL NECESSARY REVIEWS HAVE BEEN COMPLETED AS DESCRIBED IN DOE G 241.1-1A, PART II, SECTION 3.0 AND THAT THE STI PRODUCT SHOULD BE RELEASED IN ACCORDANCE WITH THE INTELLECTUAL PROPERTY/DISTRIBUTION LIMITATION ABOVE.

Released by *(name)* ______

Date ______
(mm/dd/yyyy)

E-mail ______

Phone ______

Purpose: DOE F 241.3 provides the Office of Scientific and Technical Information (OSTI) information required to appropriately identify, process, and/or announce and disseminate the results of work funded by the U.S. Department of Energy (DOE). For general information or assistance with this form, contact OSTI at (865) 241-6435, or at the following e-mail address: 241user@adonis.osti.gov.

When to use: Submit this form with each scientific and technical information (STI) Product. Electronic format is the preferred method for submitting the announcement record and STI Product. When submitting electronically, use the electronic version of the form (http://www.osti.gov/elink; discuss with your DOE Contracting Officer).

Describing the data fields: Descriptions of the various DOE F 241.3 data fields, STI Products, format, etc., can be found in ATTACHMENT 3 and other sections of the DOE G 241.1-1A, Guide to the Management of Scientific and Technical Information. Available online at http://www.osti.gov/stip/

DOE Financial Assistance Recipients/Contractors Recipients and Contractors should complete Parts I and II of the form and forward the form along with the STI product to the DOE Contracting Officer who will complete the rest of the form and submit the package to OSTI.

NOTE: Sensitive, proprietary, or other STI Products for which access is restricted by statute or regulation shall not be transmitted via open systems networks (e.g., the Internet) unless authorization and/or encryption has been coordinated with OSTI in advance. This form, unless it in itself is classified, can be transmitted via open systems networks (.e.g, the Internet).

RECORD STATUS - This is a required field. The record status identifies the announcement record or the STI Product as new, or revised. If the record status is not provided, the record is considered "New."

Part I: STI PRODUCT DESCRIPTION (To be completed by Recipient/Contractor)

A. STI PRODUCT IDENTIFIERS.

1. **Report/Product Number(s).** This is a required field. The unique primary report or product number assigned to the STI product. If a report number is not provided, the word "NONE" should be entered.

Following are examples of report number formats for multiple volumes, parts, or revisions:

DOE/ID/13734-2

DOE/NE/01834--1-Pt. 1

More than one report number may be provided. Multiple numbers are separated with a semicolon and a space. When more than one number is entered, the first number, considered the primary number, should identify the submitting organization. All other numbers are considered secondary numbers.

2. DOE Award/Contract Number(s). This is a required field. Enter the DOE award/contract number under which the work was funded. Additional DOE award/contract numbers related to the product may be entered. Multiple numbers are separated with a semicolon and a space. When more than one number is entered, the first number is considered the primary number.

3. Other Identifying Number(s). An additional unique identifying number assigned to the STI product. (e.g., CRADA numbers, Non-DOE contract numbers). More than one other identifying number may be provided. Multiple numbers are separated with a semicolon and a space.

B. RECIPIENT/CONTRACTOR - This is a required field. Provide the name and location of the organization that performed the research or issued the STI product. More than one organization may be provided; separate multiples with a semicolon and a space.

Example: University of Tennessee, Knoxville, TN

C. STI PRODUCT TITLE - This is a required field. Provide the title exactly as given on the product itself, including part, volume, edition, and similar information.

D. AUTHOR(s) - This is a required field. Provide the name of the author (last name first) of the STI product. More than one author may be provided; separate multiple entries with a semicolon and a space. If an author does not exist, the word "None" should be entered.

Examples: Jones, T.M.; Markay, Arthur R. III
Fields, J.M., ed.

Author(s) E-mail Address(es). Provide the e-mail address for each author. Multiples may be provided; they should be listed in the same order as the authors and should be separated by a semicolon and a space.

E. STI PRODUCT ISSUE DATE/DATE OF PUBLICATION - This is a required field. Provide the date when the information product was published or issued.

F. STI PRODUCT TYPE - This is a required field. It should agree with the reporting requirement identifier in the reporting requirements checklist; federal assistance reporting checklist; or in the statement of work if the product is a required deliverable that warrants accountability.

1. **Technical Report**. Identify the type of technical report provided.

2. **Conference Paper.** Provide all available conference information. An agenda alone is not sufficient for announcement.

3. **Journal Article.** Provide all available Journal Article information.

G. STI PRODUCT REPORTING PERIOD. Specify the beginning and ending dates of the period covered by the STI product.

H. SPONSORING DOE PROGRAM OFFICE - Enter the name or acronym of the DOE Program Office (e.g., Office of Science or SC) providing the funding for the work described in the STI product. For projects funded by more than one Program Office, indicate all sources of the DOE funding in descending order of dollar amount of funding appropriated. Separate multiple program offices with a semicolon and a space. If no sponsoring DOE Program Office is provided, "DOE" will be the sponsor.

I. SUBJECT CATEGORIES - Select one or more categories from the list provided. List the primary one first. A list of subject categories is available at (http://www.osti.gov/elink/).

Keywords. Provide terms which describe the content of the publication. More than one term may be entered; separate multiple terms with a semicolon and a space.

J. DESCRIPTION/ABSTRACT - Provide a clear, concise, and publicly releasable English language summary of the information content of the STI product. The abstract length should be no more than 5,000 characters. If you are utilizing paper media, you may provide via attachment.

K. INTELLECTUAL PROPERTY/DISTRIBUTION LIMITATIONS - This is a required field. STI products should be written for public release; therefore, STI products should not contain proprietary, classified or any information subject to export control. Recipients/Contractors are responsible for notifying their DOE contracting officer if the document contains other than unclassified data before submitting to the DOE address in the award document. Recommendations to restrict access to STI products must have a legal basis or be accompanied by written programmatic guidance. For questions concerning current laws and guidance, refer to Part II or ATTACHMENT 7 of the DOE G 241.1-1A, Guide to the Management of Scientific and Technical Information, or contact your DOE Contracting Officer.

1. **Unlimited Announcement**. The unrestricted, unlimited distribution of the product (will be made publicly available). The Government assumes no liability for disclosure of such data.

2. **Copyrighted Material**. A copyright restriction on part or all of the contents of the STI product may affect the reproduction and distribution of the product by OSTI. Any restriction must be specified.

3. **Patentable Material**. Provide all applicable patent information.

4-6. No special instructions.

7. Office of Nuclear Energy Applied Technology pursuant to 10 CFR 810.

L. RECIPIENT/CONTRACTOR POINT OF CONTACT. Provide the organization or individual(s) name with corresponding contact information who will be included in the published citation as the point of contact and will respond to external questions about the content of the STI product.

Part II. STI PRODUCT MEDIA/FORMAT AND LOCATION/ TRANSMISSION (To be completed by recipient/contractor)

A. MEDIA/FORMAT INFORMATION

1. **Medium**. This is a required field. Select one of the medium options provided. Note: When announcement record only is submitted, select "No full-text."

2. **Size of STI Product**. Provide the total number of pages or other designation which gives an indication of the size of the information product (e.g., 200 pages; 20 images; 3500 kilobytes; 3-3 1/2 inch diskettes).

3. **File Format**. This is a required field if the STI product is electronic full-text. Select one of the options provided.

4. **If Computer Medium or Audiovisual Material** (do not include software packages).

a. Indicate the quantity and type of medium, e.g., 2 videocassettes, 1 magnetic tape.

b. Indicate the machine with which the medium is compatible, i.e., with which it can be used (e.g., VHS; IBM PC compatible, hard disk, 8 Megs.)

c. Enter any other information which would be helpful to the user of the STI product (e.g., programming language, file format, etc.)

B. LOCATION/TRANSMISSION INFORMATION

STI PRODUCT IS BEING TRANSMITTED:

1. This is a required field. Provide if the full-text STI product is being transmitted electronically. Indicate if product is being transmitted via Internet-accessible system called Elink at https://www.osti.gov/elink/.

2. This is a required field. Provide an electronic copy of the STI product that is being transmitted via other computer-generated medium or other method. Indicate if product is being transmitted via mail or other shipment method (paper products, CD-ROM, diskettes, videocassettes, etc.). Provide information product filename of transmitted electronic format, if applicable.

Part III: STI PRODUCT REVIEW/RELEASE INFORMATION (To be completed by DOE)

A. STI PRODUCT REPORTING REQUIREMENT REVIEW

1. This is a required field if all other required STI products have been received for this award by OSTI and this STI product is the final deliverable required according to the technical information reporting requirement.

2. Indicated if the STI product is not suitable for dissemination beyond DOE based on report type or content, it is being submitted because it fulfills a technical information reporting requirement.

B. RELEASEING OFFICIAL - This is a required field. Provide the name and additional information of the site's individual(s) responsible for the appropriate review and release of the STI product. Do not forward this form or the STI product until after it has been reviewed and released for announcement.

Yurok Tribe

Wind and Hydro Energy Feasibility Study

June 2011

Final Report

Presented to

U.S. Department of Energy
Tribal Energy Program
Award # DE-FG36-07GO17078
Project Officer: Lizana Pierce
lizana.pierce@go.doe.gov
Prepared by:
Schatz Energy Research Center
Humboldt State University
Arcata, CA 95521
Technical Contact:
Jim Zoellick
jimz@humboldt.edu

SCHATZ
ENERGY
RESEARCH
CENTER

Project Data

Project Title: **Wind and Hydro Energy Feasibility Study**

Covering Period: September 30, 2007 – March 31, 2011

Date of Report: June 17, 2011

Recipient Organization: Yurok Tribe

Award Number: DE-FG36-07GO17078

Partners: Yurok Tribe, Schatz Energy Research Center

Technical Contact: **Schatz Energy Research Center**
Jim Zoellick, Senior Research Engineer
Humboldt State University
Arcata, CA 95521-8299
(707) 826-4345
jimz@humboldt.edu

Report Authors: Jim Zoellick, Richard Engel, Ruben Garcia and Colin Sheppard of the Schatz Energy Research Center

Business Contact: **Yurok Tribe**
190 Klamath Blvd
Klamath, CA 95548
(707) 482-1350
Austin Nova, Planner
(707) 482-1350
austin@yuroktribe.nsn.us

DOE Project Officer: **Lizana K. Pierce**, lizana.pierce@go.doe.gov

Table of Contents

List of Figures

List of Tables

Acknowledgements

The Schatz Energy Research Center would like to thank the following people for their assistance in conducting this study.

- Austin Nova, Yurok Tribe Planning Department
- Peggy O'Neill, Yurok Tribe Planning Director
- Mandy Mager, Yurok Tribe Assistant Planning Director
- Kathleen Sloan, Yurok Tribe Environmental Program Director
- Ken Fetcho, Yurok Tribe Environmental Program Assistant Director
- Micah Gibson, Yurok Tribe Environmental Program
- Dave Hillemeier, Yurok Tribe Fisheries Program Manager
- Monica Hiner, Yurok Tribe Fisheries Department
- Dan Gale, formerly with Yurok Tribe Fisheries Department
- Ron Reed, Yurok Tribe Forestry Department
- Jim Norton, Yurok Tribe Information Services Department
- Rocco Fiori, Engineering Geologist, consultant to the Yurok Tribe
- Victor Jones, Yurok Tribe member
- Roger Gibbens, community member

- Ross Burgess, local hydropower developer/owner
- Ray Daniels, Six Rivers Communications

- Professor Eileen Cashman, HSU Environmental Resources Engineering Department
- Professor Steve Hackett, HSU Economics Department
- Kevin Jensen, SERC Student Research Assistant
- Tom Quetchenbach, SERC Student Research Assistant
- Chris Carlsen, SERC Student Research Assistant
- Mark Rocheleau, SERC Research Engineer
- Ray Glover, SERC Machinist
- Andrea Alstone, SERC Research Engineer
- Kristen Radecsky, SERC Research Engineer
- James Apple, SERC Student Research Assistant
- Patricia Lai, SERC Student Research Assistant
- Joe Purdon, SERC Student Research Assistant
- Jenny Tracy, SERC Student Research Assistant
- Grady Koupal, Brad Wilson, Brian Parmer and Mateo Cornin of the HSU Environmental Resources Engineering 492 Class

- Lizana Pierce, DOE Tribal Energy Program
- Tony Jimenez, NREL Native American Anemometer Loan Program
- Robie Robichaud, NREL Native American Anemometer Loan Program

Executive Summary

Project Goals and Objectives

The primary focus of this study was to examine the opportunity to develop wind and hydroelectric power sources on the Yurok Reservation for wholesale back to the grid. Feasibility was judged based on a project's ability to generate net revenue for the Tribe. A secondary objective of this study was to identify practical opportunities for providing wind or hydropower to individual Tribal facilities.

Summary of Project Activities

Three potential project sites were identified on the Reservation. The McKinnon Hill ridge was chosen as a prospective wind energy site, and Pecwan and Ke'Pel Creeks were chosen for potential hydropower development. Data collection systems were installed at each of these sites and appropriate data were collected for assessing renewable resource potential. This included wind speed and direction data as well as creek stage and discharge data. Data from each of these sites were assessed and power production estimates were developed for a set of candidate turbines.

An assessment of the renewable energy market opportunities was conducted and two power sales options to the local investor-owned utility, Pacific Gas and Electric Company, were identified. These were sales under the qualifying facility short-run avoided cost rate and the small renewable generator feed-in tariff. The feed-in tariff was found to be the preferred rate.

A preliminary economic screening of project alternatives was conducted based on the revenue generation potential and estimated project costs, and the Pecwan Creek hydroelectric project was identified as the preferred alternative. This project alternative was then examined in more detail. A preliminary design was developed and an itemized cost estimate was prepared. This information was used to perform an economic analysis. Generator capacities ranging from 125-kW up to 1.5-MW were considered, and the 1.5-MW option was determined to be the preferred alternative.

A key finding was that the electrical distribution infrastructure serving the project site will need to be substantially upgraded to support the Pecwan Creek hydroelectric project. It is estimated that upgrades to the PG&E distribution system will be required all the way back to the Hoopa substation (approximately 30 miles). Upgrades include switching from single-phase to three-phase power between the Martins Ferry Bridge and Pecwan Creek, increasing the conductor size to 4/0 wire all the way back to the Hoopa substation, and adding bi-directional voltage regulation to maintain acceptable voltage levels in the system both with and without hydroelectric power generation at Pecwan.

Expected overnight capital costs for the hydroelectric plant and the distribution system upgrades are approximate $4.65 million and $4.88 million, respectively. This brings the total project cost to approximately $9.5 million. Given these upfront costs and the expected revenue generation potential from the project, the net present value of the project over it's expected 50-year life is about $2.9 million (assuming a 5% discount rate, a debt financed project at 5% interest for 30 years, and a 10% grant). In order for this project to generate positive cash flows starting in the first year of the project, it will be necessary for the Tribe to obtain grant funding to cover at least 10% of the upfront capital costs. Under this scenario the Tribe would net $25,000 per year in the first 10 years of the project, increasing to $559,000 per year in the last 10 years of the project (undiscounted).

These estimates are preliminary and carry a high degree of uncertainty. In addition, they are highly sensitive to changes in project costs. For example, if the project costs increase by 20% to 30% or the loan interest rate increases to 7%, the project becomes economically infeasible.

Additional project activities included an assessment of permitting requirements and a preliminary environmental assessment. While the project would need to meet substantial permitting and environmental review requirements, it appears the project could successfully meet these requirements.

A project development plan was prepared that identifies the required steps that must be taken to pursue project development. This included identification of potential sources for grant and guaranteed loan funding.

Conclusions and Recommendations

Although the Pecwan Creek hydroelectric project shows marginal economic viability, it is recommended that the Yurok Tribe consider taking key next steps to further examine the opportunity. The Pecwan Creek hydroelectric project may be the best opportunity the Tribe has for large-scale renewable energy development on the Reservation, and therefore it would be worthwhile to determine with a fairly high degree of certainty whether or not the project is viable.

Key next steps for evaluating this project will first require that Tribal staff and the Tribal Council review the results from the current study. In addition, we recommend that the Tribe also have this preliminary feasibility assessment reviewed and commented on by an outside consultant with substantial experience in renewable energy project development. If there is interest in continuing with project evaluation following these reviews, the key next step will be to conduct an interconnection study with PG&E. This is likely the most critical task for assessing the viability of this project.

Following completion of the interconnection study, the Tribe will need to identify further funding sources and assemble a project team to carry out remaining pre-construction activities and eventually project construction.

The key to any of these next steps will be the availability of funding. Grant opportunities that could be used to fund the interconnection study and other near-term project evaluation steps have been identified. To complete the project pre-construction and construction activities, additional grant funding and loan financing will be required. Because of the relatively small-scale of the proposed Pecwan Creek hydroelectric project and its projected marginal economic returns, it is unlikely that the Tribe will be successful in attracting outside private investment. Instead, the Tribe will need to access low interest guaranteed loans supplemented by grants to fund this project. Multiple guaranteed loan programs and grant funding opportunities have been identified.

CHAPTER 1: INTRODUCTION

1.1 Yurok Tribe Background

The Yurok Tribe is the largest Tribe in California, with over 5,600 enrolled members, about 1,200 of whom live on the Reservation. It is also the poorest California Tribe. The Yurok Reservation is located in coastal northwestern California and has a total area of 56,585 acres, situated along the lowermost 44 miles of the Klamath River and extending outward for one mile on either side of the river. Tribal landholdings on the reservation are mixed in a "checkerboard" pattern with non-Tribal fee lands. More than 70% of the Reservation lands are held by non-Tribal owners, though this figure will likely drop as the Tribe works to acquire privately held lands both on the Reservation and in their wider ancestral territory. Tribal plots are typically small, ranging from 20 to 200 acres each. Residents of the Reservation live in small village clusters and remote homesteads. A few of the most isolated homes are accessible only via the river or on foot.

The Tribe was first recognized by the federal government in 1993 and is governed by a nine-member elected council that includes a chair, vice-chair, and seven district representatives. The Tribe employs over 200 staff and maintains Tribal offices at both ends of the Reservation, in Klamath and Weitchpec, as well as an off-Reservation satellite office in Eureka.

1.2 Project Background

The Yurok Tribe has serious need for development of its energy resources and infrastructure. Tribe members, particularly those living in the upriver section of the Reservation, have inadequate access to electric power, disproportionately low household income, and disproportionately high household energy costs. The Tribe has been working for many years to provide basic energy services to Tribal members on the Reservation. Because of the remote location of the Reservation in a deep canyon along the Klamath River between its confluence with the Trinity River and the Pacific Ocean, grid electricity is still unavailable to a substantial portion of the Reservation's residents, causing hardship for Tribal members and severely thwarting economic development. The Reservation's location, straddling two counties in the remotest corners of two large utility companies' service territories, presents numerous difficulties in providing adequate and consistent energy services to all residents. Efforts to promote sustainable development on the Reservation are impossible without a reliable and affordable source of electrification.

Previous Tribal efforts at energy planning and development include the creation of a strategic energy plan, work with the Native American Renewable Energy Education Project (NAREEP) to examine ways to electrify unserved portions of the Reservation, work with Kelso Starrs and Associates to explore the possibility of developing a "wireless" utility to provide off-grid electricity service, a renewable energy options analysis conducted by technical staff from the US Department of Energy and National Laboratories, a human capacity building project funded by the US DOE Tribal Energy Program, and a preliminary biomass feasibility study funded by the USDA Forest Service. Much progress has been made toward building human capacity within the Tribe, identifying energy needs and available renewable energy resources on the Reservation, and exploring the Tribe's various energy options. Identified renewable energy resources include biomass, hydro, solar, and possibly wind.

Work also continues on the construction of electrical distribution lines to serve the unelectrified portion of the Reservation. This work is being done under a US Rural Utility Service grant. Although progress is being made on the line extension, it is not without difficulty. One key issue is obtaining all the required right-of-way power line easements. In addition, per-mile costs of installing power lines in this rugged landscape have exceeded estimates. Consequently, it will likely still be years before a power line extension covering this entire region will be completed.

The most recent energy study completed for the Tribe (prior to this current wind and hydro energy feasibility study) was a Tribal utility feasibility study funded by the US DOE Tribal Energy Program (award number FG36-03GO13117). This study was initially intended to explore the feasibility of establishing a full-service Tribal electric utility, with full ownership of the required transmission and distribution infrastructure and full responsibility for procuring and providing electric power to Tribal utility customers. Part of the plan was to install a transmission infrastructure that would allow the Tribe to wheel electric power from the Pacific Northwest into California. Revenues from this wheeling arrangement would then support a Tribal utility. Unfortunately, it was determined that a wheeling arrangement and the required high voltage transmission infrastructure to support wheeling were not attainable.

The Tribe faced other challenges in developing its own power utility. The Tribe's retail electricity customer base is very small and dispersed and is located in a rugged, remote rural area. This leads to a very high cost of service on a per customer basis. Add to this the fact that the majority of Tribal members living on the Reservation fall into very low-income brackets and it becomes clear that a full Tribal utility is not feasible.

The Tribal utility feasibility study also considered alternatives to a full-service Tribal electric utility. This included the possibility of developing renewable power to sell wholesale as a means to generate revenue. The revenues could then be used to provide various energy services to Tribal members, such as the installation of off-grid renewable power systems, maintenance services for off-grid power systems, and energy efficiency services. The Tribal utility feasibility study also included a renewable energy resource assessment that identified solar, hydroelectric, wind, and forest biomass as key resources to be further studied. It specifically recommended that in-depth, site-specific feasibility studies be conducted to examine investment in hydroelectric, biomass, and wind energy resources.

1.3 Project Goals and Objectives

The goal of the present study was to examine the potential development of two of the Yurok Tribe's most promising renewable energy resources, wind and hydro. Specific project sites were to be identified and project feasibility assessed. Based on the results of this assessment a comprehensive action plan would be provided to the Tribe. The plan would identify steps that need to be taken should the Tribe choose to move forward with project development. Specific project objectives include:

- Identify and assess two hydro sites and one wind site using at least one year worth of detailed, site specific resource data.
- Assess engineering, environmental, economic, grid infrastructure, land tenure and cultural constraints and potential mitigation strategies.
- Identify preferred, feasible project(s) and associated economic opportunities.
- Prepare a plan for moving forward with project development.

It is also important to clarify the types of renewable energy projects that are being examined in this study. In general terms, the objective of this study was to identify opportunities for the development of wind or hydroelectric energy on the Reservation that can benefit the Tribe. Potential development projects could be of small or large scale, either connected to or isolated from the larger electricity grid. A large grid connected project could sell wholesale power back to the grid. A small grid connected project could operate under a net metering or similar arrangement. Off-grid systems could supply power to a specific facility, or could serve a more extensive micro-grid.

The Tribe is currently in the process of extending the main electric power grid all the way to the end of Highway 169. This will eventually provide power to the majority of homes and facilities in the upriver section of the Reservation. Although there will still be numerous homes that are far enough off the main road that they will not have access to grid power, they are relatively few and isolated, and therefore not suited to a micro-grid. A micro-grid would be suited to a cluster of homes and facilities, a village. However, the main electric grid will soon serve all the areas where homes and facilities are clustered.

For these reasons, the primary focus of this study is the opportunity to develop power for wholesale back to the grid. The feasibility of such a project will be judged on its ability to generate net revenue for the Tribe. These revenues could then be used to provide energy services to Tribal members, such as the installation of off-grid renewable power systems for individual homes, maintenance services for off-grid power systems, and energy efficiency services. A secondary objective of this study was to identify practical opportunities for providing renewable power to individual Tribal facilities.

CHAPTER 2: DESCRIPTION OF ACTIVITIES

The Yurok Wind and Hydro Energy Feasibility Study consisted of 18 project tasks as listed in Table 1. The activities and the results of these activities are described in this chapter. A chronological listing of the main project activities carried out over the three and one half year project timeline is provided in Appendix A.

Key tasks in year one included selecting project sites, obtaining data monitoring equipment, and securing environmental clearance. In year two data monitoring equipment was installed and data collection commenced. In year three the resource assessment and feasibility analyses were conducted.

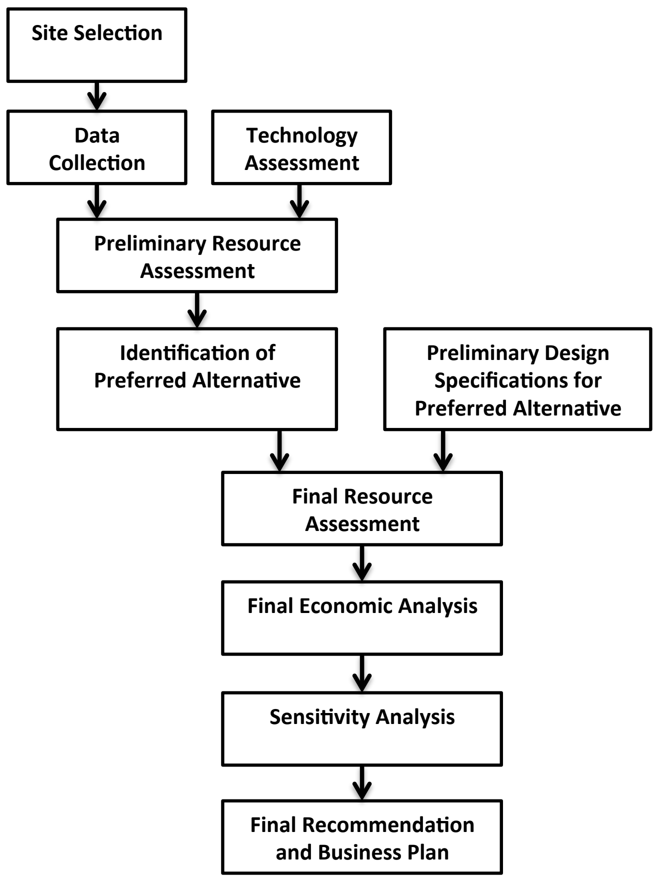
Table 1: Project Task List

Task	Description
1	Site Selection
2	Data Collection
3	Technology Assessment
4	Data Analysis / Resource Assessment
5	Load Assessment
6	Market Assessment
7	Electric Grid Assessment
8	Preliminary Design Specifications
9	Economic Analysis
10	Identification of Preferred Alternative(s)
11	Preliminary Environmental Review
12	Permitting Requirements
13	Stakeholder Analysis
14	Preliminary O&M Plan
15	Plan to Develop Community Support
16	Project Development Plan
17	Professional Development Training
18	Reporting

Source: SERC staff

The nature of this study required that a preliminary resource and feasibility assessment be conducted for prospective wind and hydropower sites. Based on the results of this preliminary screening, a preferred project alternative was identified and a more detailed assessment was completed. The more detailed assessment included use of specific rather than generalized cost data and design parameters, a more robust economic analysis, and a sensitivity analysis. Figure 1 depicts the overall process that was used to conduct the feasibility assessment.

Figure 1: Feasibility Assessment Process



Source: SERC staff

2.1 Site Selection

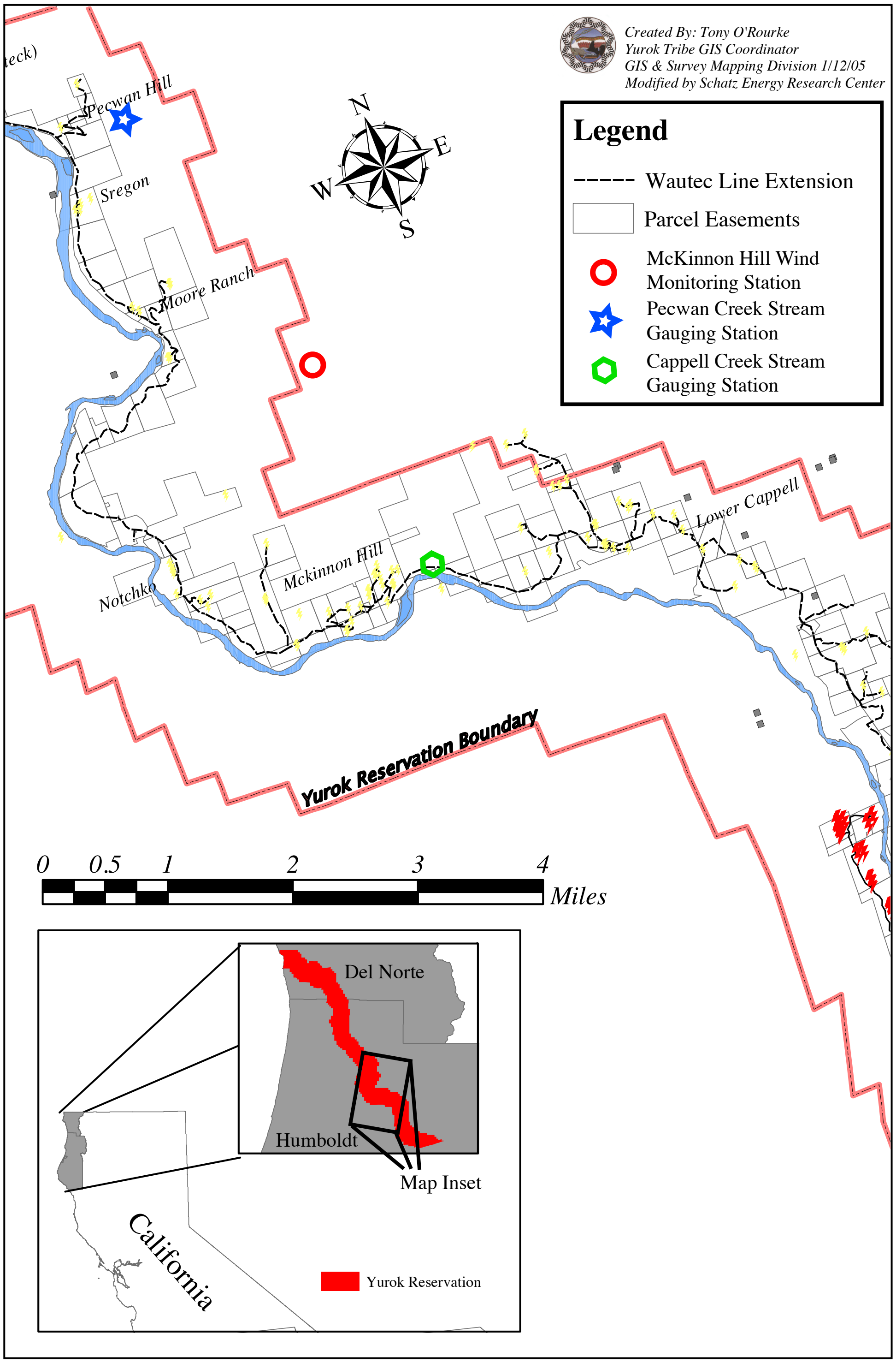
The project scope dictated that two hydro energy sites and one wind energy site be chosen for feasibility assessment. Based on results from a preliminary resource assessment that was prepared as part of the previous, DOE-funded Yurok Tribe Utility Feasibility Study, four possible wind sites and six possible hydro sites were identified for further consideration. Two hydro sites and one wind site were then chosen from this list of prospective sites. Selection of these sites was based on the criteria shown in Table 2. See Figure 2 and Figure 3 for maps showing wind and hydro data monitoring locations.

Table 2: Site Selection Criteria

Criteria	Information Sources
Energy resource potential	Previous resource assessment from Tribal Utility Feasibility Study
Proximity to Yurok cultural sites	Yurok Tribe Environmental/Cultural Department
Anticipated environmental impacts	Yurok Tribe Environmental and Fisheries Departments
Road access	Yurok Tribe Planning Department
Suitability for development	Yurok Tribe Planning Department, site visit
Land ownership	Yurok Tribe Planning Department, County parcel maps
Proximity to electrical grid	Yurok Tribe Planning Department, site visit
Willingness of Tribe to develop site	Yurok Tribe Planning, Environmental and Fisheries Departments

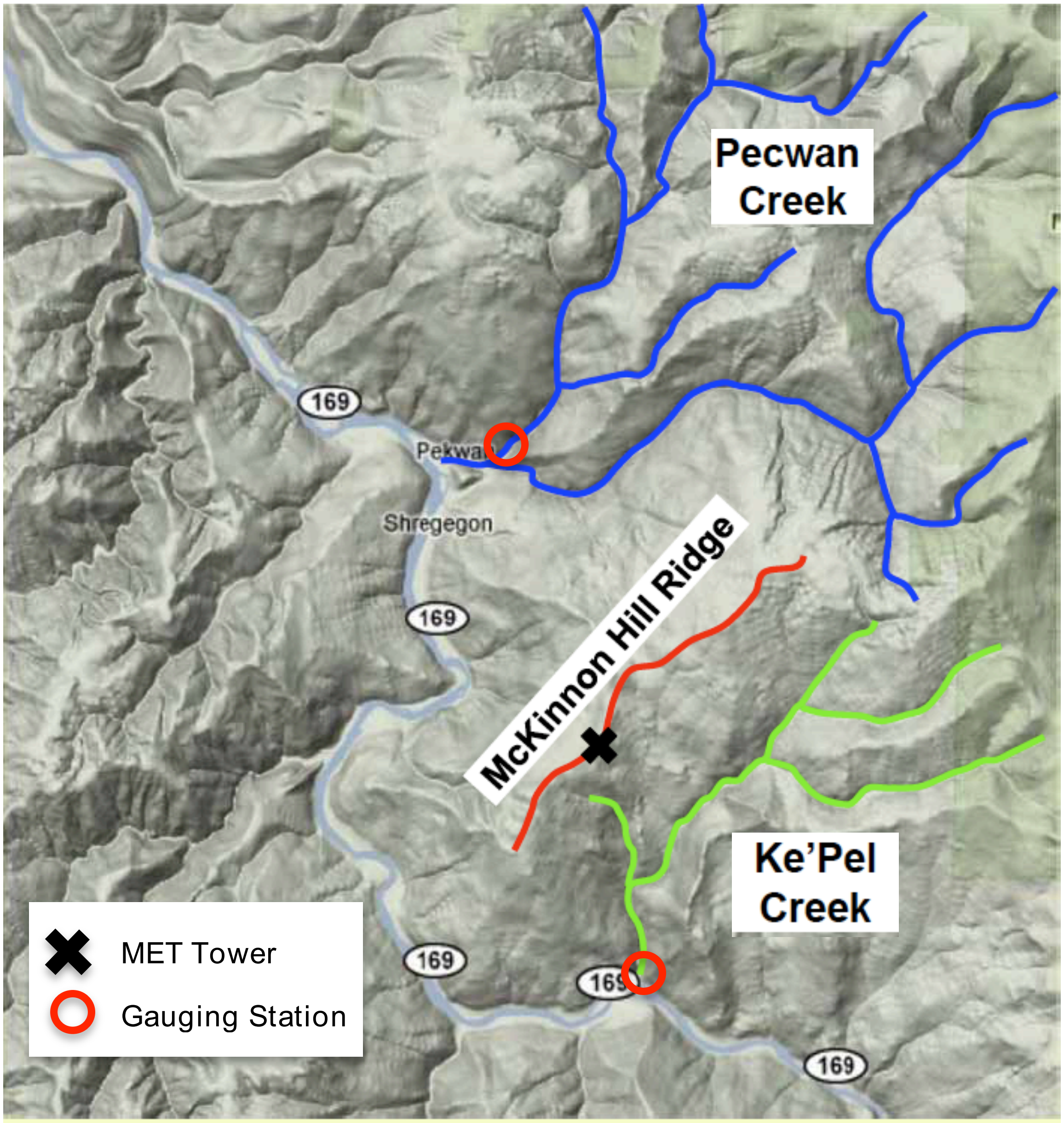
Source: SERC staff

Figure 2: Siting map showing electric grid line extension, stream gauging stations, and wind monitoring station on Yurok Reservation.



Source: Yurok Tribe GIS Department, modified by SERC staff

Figure 3: Relief map showing wind and hydro data monitoring sites



Source: Created by SERC staff using Google Maps.

2.1.1 Wind Site Selection

Results from the wind resource assessment that was conducted as part of the Yurok Tribe Utility Feasibility Study indicated that the best potential wind energy sites on the Yurok Reservation are likely to be located on ridge tops or at the mouth of the Klamath River on the Pacific Ocean. Accordingly, the two key sites identified for potential wind energy assessment were atop Requa Hill at the mouth of the Klamath River and on the McKinnon Hill Ridge (see Figure 4).

According to the American Wind Energy Association (AWEA), sites with a Wind Power Class rating[1] of 4 or higher are preferred for large-scale wind plants. NREL high resolution wind resource maps for the Yurok Reservation were consulted and the McKinnon Hill ridge was the only place on the Reservation with a potentially Class 5 to Class 7 "excellent" wind resource (see Figure 4). In contrast, the NREL wind resource map shows the Requa Hill site at the mouth of the Klamath River to be a "poor" wind site. However, it should be noted that the NREL wind maps only provide estimations of the available wind resource based on mesoscale meteorological models. It is especially challenging to make good predictions with these models in areas with complicated topography like on the Yurok Reservation. Therefore it is critical to measure actual wind speeds at the site for at least a year.

Site visits were made to each of these prospective sites. The Requa Hill site is cluttered with buildings and defunct facilities from an old US Army radar installation, and is covered with trees. Consequently, the site does not appear to be a good location for siting a meteorological tower. The trees did not show any of the flagging (permanent deformation) normally observed at sites with consistent windy conditions. Electrical transmission access at Requa is expected to be favorable given its proximity to Highway 101 and the town of Klamath. Road access is good to the site, and land ownership has been or is in the process of being transferred to the Yurok Tribe.

The McKinnon Hill site is located at the crest of a ridge oriented in the NE/SW directions, and perpendicular to the regionally predominant NW/SE wind directions that blow up and down the river valley. This is a very favorable topographic feature, as winds blowing up and down the valley will tend to cut right across the ridgeline. Indeed, local residents told us that the McKinnon Hill ridge is one of the windiest spots in the area. Although there is clear access across either side of the ridgeline, a substantial amount of tree and brush clearing would be required to allow installation of a 50-meter meteorological tower and provide unobstructed access to winds. No substantial flagging was noted on the trees along the McKinnon Hill ridge. Road access to the McKinnon Hill site is marginal, consisting of logging roads that are only passable in fair weather conditions.

On the McKinnon Hill ridge, a Primary Site was initially identified (Latitude 41.3042 N, Longitude 123.8384 W). This site is within the Reservation boundary and has been

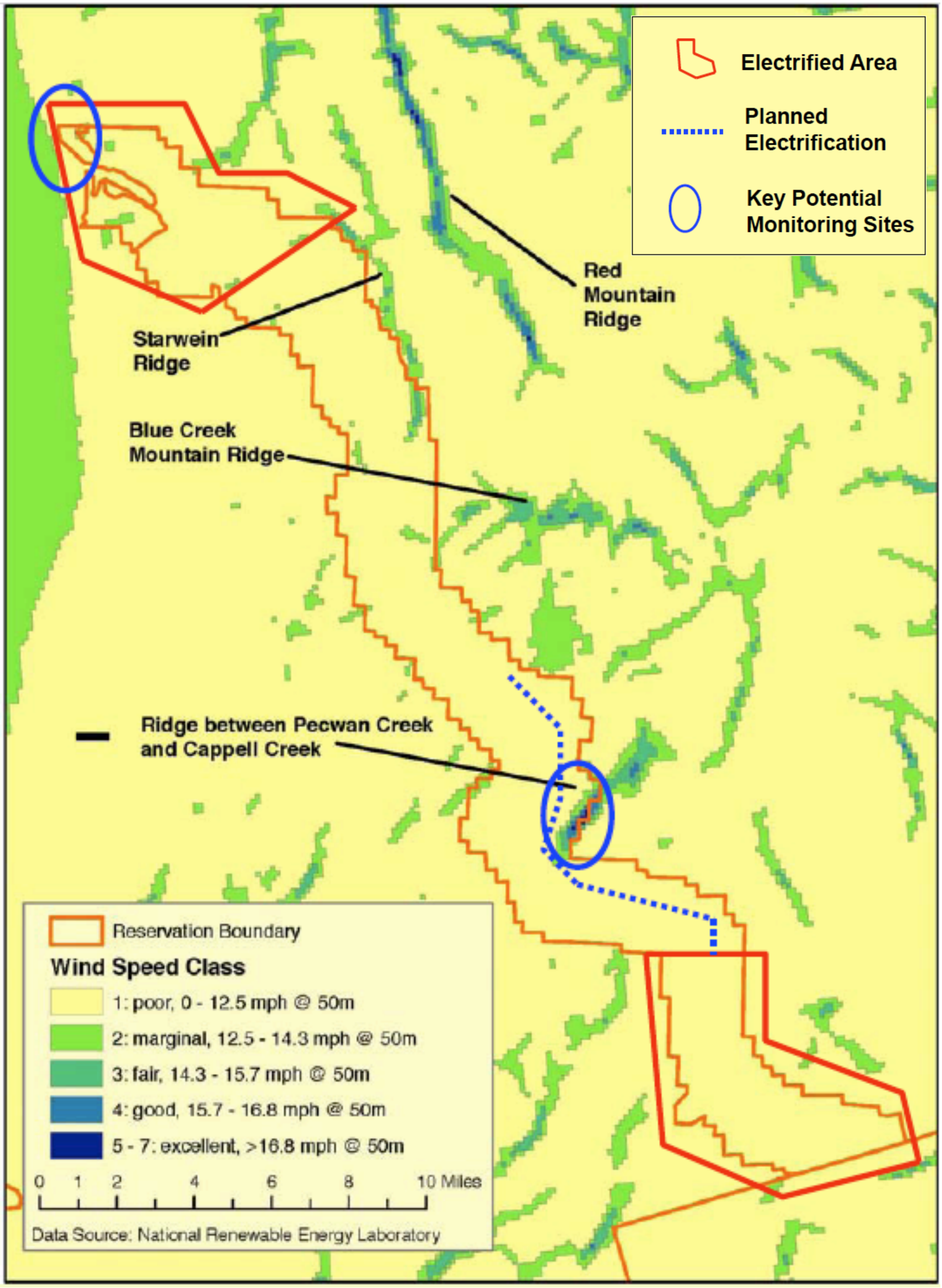
---

1 Wind sites are rated based on their average wind speed at a given elevation above the ground. A Class 5 to Class 7 wind site is considered "excellent" for commercial wind development and has expected average wind speeds of 7.5 to 12 meters per second at a height of 50 meters (see: http://archive.awea.org/faq/basicwr.html).

chosen to be the location for a new telecommunications tower. It was later determined that this site was not large enough to support a guyed 50 meter meteorological tower. In addition, the Tribe's planned use of this site for telecommunications purposes would likely conflict with both wind monitoring and wind energy generation activities. For this reason, two additional sites were identified. These sites, Alternative 1 (Latitude 41.3067 N, Longitude 123.8348 W) and Alternative 2 (Latitude 41.3085 N, Longitude 123.8312 W), are approximately 0.25 miles and 0.45 miles further along the ridge top road, respectively, in a northeast direction. Both alternative sites are immediately adjacent to the Yurok Reservation boundary within Humboldt County's jurisdiction, and the parcel they reside on is under Tribal control (see Figure 5). Both sites could accommodate the footprint of the 50 meter guyed tower and were far enough from the planned telecommunications site to avoid use conflicts.

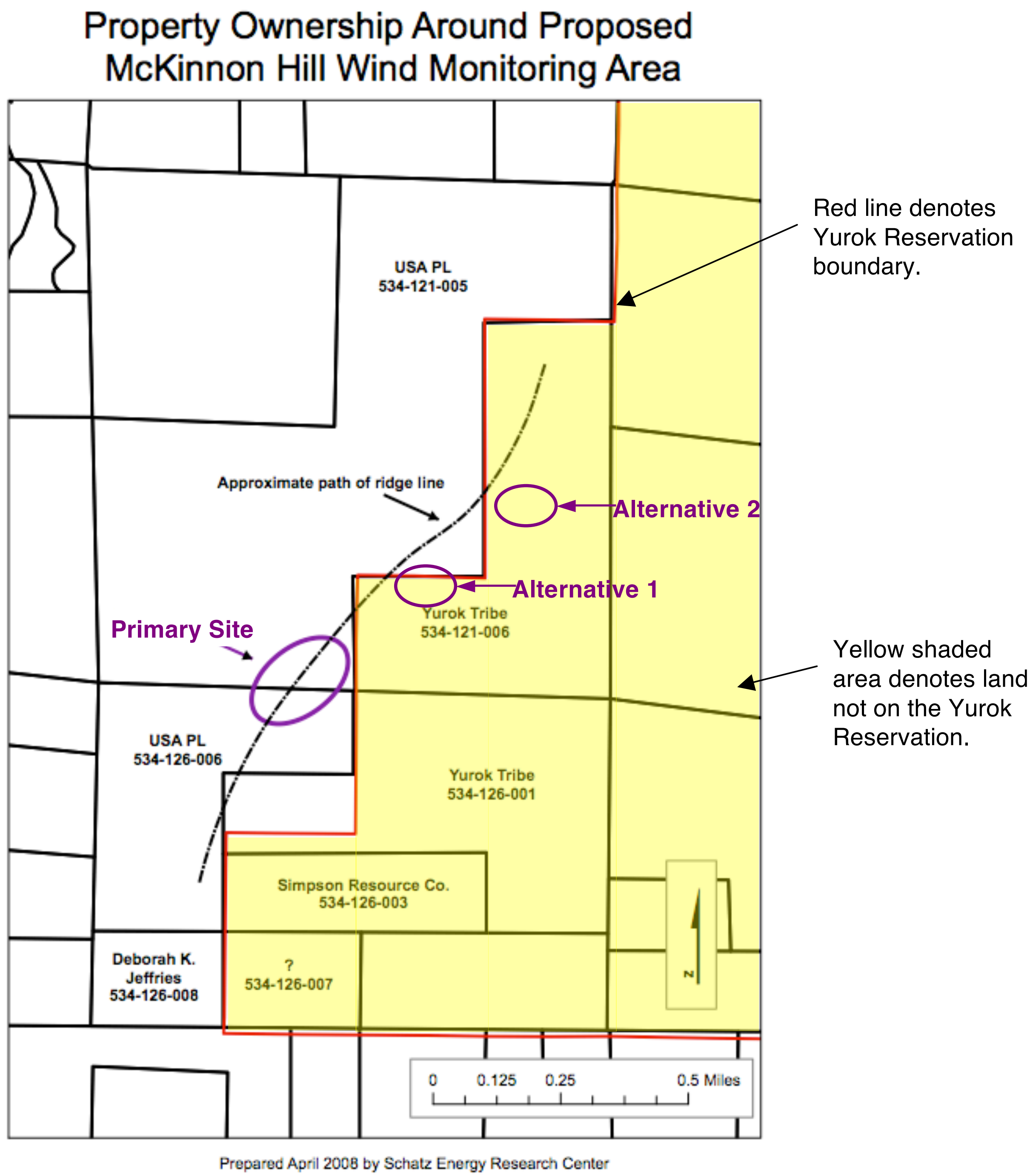
Based on the above stated characteristics and guidance from Tribal Planning and Environmental Program staff, the McKinnon Hill Alternative 2 location was chosen as the wind monitoring site.

Figure 4: Potential Wind Monitoring Sites



Source: NREL, modified by SERC staff

Figure 5: Map of Property Ownership for McKinnon Hill Wind Monitoring Site



2.1.2 Hydro Site Selection

The Yurok Reservation boundaries encompass lands stretching out one mile on either side of the Klamath River over almost fifty miles between the Klamath's confluence with the Trinity River and its mouth at the Pacific Ocean. At least 52 named creeks enter the Klamath within the Reservation boundaries. Many of the tributary creeks to the Klamath are important spawning grounds for salmon and other anadromous species. However, the steep gradients and natural barriers in these creeks mean that anadromous fish may only be found in the lower reaches of many of the creeks.

We met with Tribal fisheries specialist Dan Gale to discuss fish habitat implications of hydropower development. Dan is generally supportive of hydro as an energy source for the Tribe if fisheries concerns are addressed. In general he favors development of the shorter, steeper drainages entering the Klamath on its eastern bank, as these streams tend to have natural fish barriers quite low in their drainages. In particular, Dan identified Pecwan, Ke'Pel (also known as Cappell), and Ma Wah Creeks as drainages where fisheries concerns would be minimal above their lower reaches.

These recommendations from Dan Gale agree well with the Yurok Tribe Water Quality Control Plan for the Yurok Indian Reservation (Yurok Tribe, 2004). This plan establishes beneficial use designations for waterways occurring on the Yurok Indian Reservation. Of the 42 creeks listed, only four are listed with a designated beneficial use including hydropower generation. Pecwan and Ke'Pel Creeks are two of the four listed creeks. This is likely also why Yurok Tribe Environmental and Planning Department staff also voiced support for these two creeks for hydropower generation.

In the renewable energy resource assessment that was conducted as part of the Tribal Utility Feasibility Study (Schatz Energy Research Center, 2007), Pecwan and Ke'Pel Creeks ranked high with regard to hydropower potential. Among 52 named creeks on the Reservation, Pecwan ranked in the top six for basin area, peak flow estimate, estimated rainfall and potential elevation head. Ke'Pel Creek ranked in the top 16 or better in all of these categories. Numerous other brief hydro assessment studies conducted for the Tribe also identified these two creeks as having good hydropower potential. Many of these studies pointed out the need to collect a year or more of stream flow data for these creeks in order to make a conclusive determination as to whether hydropower development would be feasible.

Road access into the upper and lower reaches of the Pecwan Creek watershed is fairly good. Logging roads are in decent shape and provide access to parts of both the West Fork and East Fork of Pecwan Creek. Road access into the Ke'Pel Creek watershed is not as good. With the exception of Highway 169 crossing the mouth of the creek, there is no road access to the lower reaches of the main stem of the creek where a powerhouse would likely need to be sited.

Although Green Diamond Resources Company had owned the majority of land in the Pecwan Creek watershed, this land is now under the Tribe's control. In April 2011 the Yurok Tribe completed a deal with Green Diamond Resources Company to acquire over 22,000 acres (Yurok Tribe, 2011). The acquired land covers the majority of the Pecwan Creek watershed and a small portion of the Ke'Pel Creek watershed, and will become a Yurok Tribe Community Forest. The land will be managed according to the Tribe's sustainable forestry management approach, with a focus on forest and aquatic ecosystem health. As such, it will be important to make sure that any proposed hydroelectric development project in the area is compatible with these management goals.

For the reasons outlined above, Pecwan Creek and Ke'Pel Creek were chosen for hydropower assessment. The gauging stations for collecting stage data on both Pecwan and Ke'Pel Creeks were chosen to be located near the mouths of these creeks (Pecwan station at Latitude 41.3434 N, Longitude 123.8454 W, Ke'Pel station at Latitude 41.2834 N, Longitude 123.8231 W). This was done for access reasons. We needed to be able to haul equipment and bags of concrete to these sites for installation. In addition, we needed to access these sites all winter long in order to check on their status, download data, and take discharge measurements. This meant that we would need to drive to these sites in inclement weather. The consequence of locating the gauging stations near the mouths of both creeks was that in our analysis we had to adjust our flow estimates for locations higher in the watersheds where the hydropower intakes would be located.

2.2 Data Collection

Data collection activities included the design and installation of data monitoring systems at each of the selected sites, ongoing data collection activities in the field, ongoing maintenance/checkup activities, and data archiving and screening activities. A description of the data collection activities associated with the wind and hydro energy sites follows.

2.2.1 Wind Data Collection

We prepared the McKinnon Hill site for tower installation in the late summer of 2009. Site preparation included surveying of the site and subsequent tree clearing over a 4.5-acre area surrounding the tower. The extent of tree clearing was based on guidelines from the *Wind Resource Assessment Handbook* (AWS Scientific, 1997). Tree clearing ensured that the tips of surrounding trees extended no higher than 20 meters above the base of the tower or that the tree tips were no closer than a factor of five times the height of the tree tip above the 20 meter mark on the tower. This clearing was not done in the eastern and northeastern directions because of visibility issues with a nearby cultural site. This was felt to be acceptable because the predominant wind directions were expected to be from the northwest or the southeast. This is due to the topography of the area, namely the river canyon that runs from southeast to northwest and the fact that the ridge continues to climb in the northeastern direction. In the immediate area around the tower we cleared trees and brush to allow for a safe and effective tower raising.

Tower assembly and erection occurred in mid-September of 2009. The tower raising team included both Yurok Tribe Planning Department and Schatz Energy Research Center staff, as well as Ray Daniels from Six Rivers Communications (Figure 6). Standard monopole tower raising procedures were followed using a hydraulic winch and gin pole system. The tower used was a 50 meter nominal NRG TallTower (the actual height is 51.5 m). Four anemometers, two direction vanes, and a temperature sensor were installed at various heights (Table 3). Additional pictures showing the tower raising are included in Appendix B.

Figure 6: Raising of the McKinnon Hill wind monitoring tower.

Source: SERC staff

Table 3: Equipment used for the McKinnon Hill wind monitoring station.

Equipment	Qty.	Function
NRG 50m TallTower	1	Meteorological tower
NRG Symphonie	1	Data logger
NRG #40C Anemometer	4	Wind speed sensors (30m, 41.5m, 50m, 51m)
NRG #200P Wind Vane	2	Wind direction sensors (41.5m, 50m)
NRG #110S Temperature	1	Temperature sensor

Source: SERC staff

Wind Data Collection, Screening, and Verification

Wind speed and direction data were collected at the McKinnon Hill site from September 2009 through September 2010. The data logger sampled each sensor at two-second intervals. Every ten minutes, the samples were processed and recorded. For each sensor, the ten-minute average, standard deviation, minimum, and maximum values were logged.

Data were periodically downloaded from the logger (at least once every 1-2 months) and analyzed to identify potential problems with the monitoring equipment. The data quality screening process consists of running algorithms to flag suspect data. The tests used in this process include the following:

- Check for missing sequential values by comparing time stamps
- Range tests specific to type of data (e.g. 0 < avg. speed < 25 m/s)
- Relational tests comparing data from different columns (e.g. max gust < 2.5*avg. speed or avg. speed @ 50 m – avg. speed @ 40 m < 2m/s)

After conducting the tests, we reviewed the flagged data and responded accordingly. The possible courses of action included:

- Data are marked invalid and rejected
- Data are replaced by a value from a redundant sensor
- Data are deemed acceptable and kept

The most notable data quality failure involved the abrupt loss of electrical connectivity of the anemometer at 51 meters, which occurred on June of 2010, nine months into the monitoring campaign. We believe this failure was due to an act of vandalism involving a firearm and a novel target for shooting practice. We chose not to take any subsequent action when the failure was discovered. This choice was based on the prohibitive cost of lowering the tower to repair the damage and the presence of a redundant speed sensor at a height of 50 meters. Without adversely impacting our analysis, we simply disregarded the data from the damaged sensor.

We also discovered consistent problems with the data recorded for the maximum (360°) and minimum (0°) values sampled by the direction sensors. The maximum values were frequently *less* than the corresponding average values and the minimum values were almost always *greater* than the corresponding averages. Fortunately, we were confident in the values recorded for the average and standard deviation of the ten-minute wind direction samples, so we ignored the max and min columns for direction in our screening and analysis.

Specific threshold values used in the data screening tests and the results of the data screening and verification process are summarized in Appendix C. Approximately 52,700 records were analyzed for each sensor, representing 366 days of record. In total, about 0.7% of all records both failed a data quality test and were deemed invalid due to sensor malfunction. These occurrences were related to freezing events when sensor components could not move freely.

2.2.2 Hydro Data Collection

Stream gauge monitoring stations were designed and procured by Yurok Tribe Environmental Program and Planning Department staff. Stations were installed in the fall of 2008 with assistance from SERC staff. The Yurok Tribe Environmental Program maintains and operates a network of real-time environmental monitoring stations throughout the Reservation, including five stream gauging stations and a number of other water quality and air quality monitoring stations. Stream gauging station design for this hydroelectric feasibility study was based on system specifications at the Tribe's other real-time monitoring sites. Station functions included the continuous monitoring of stream stage using a bubbler and pressure sensor, data logging, and remote data access via the GOES satellite system. In the spring of 2009, two tipping bucket rain gauges were obtained from the Eureka, California National Weather Service Office. These rain gauges were added to the data monitoring systems at each site. Stage and precipitation data were logged on a fifteen-minute interval. A list of the equipment used for the stream gauging stations is shown in Table 4. A photograph of the Pecwan Creek gauging station is shown in Figure 7.

Table 4: Equipment used for the stream gauging stations.

Equipment	Function
Stream Gauging Station Equipment	
WaterLog® H-350XL Pressure Measurement System	Microprocessor controlled pressure sensor and data logger
WaterLog® H-355 "Smart Gas" System	Bubbler system
WaterLog® H-222DASE GOES Transmitter	Remote data monitoring via GOES satellite system
WaterLog® H-223 GOES Antenna	Remote data monitoring via GOES satellite system
Photovoltaic panel, charge controller and 12-V battery	Remote power
Tipping bucket rain gauge	Precipitation measurement
Enclosure	Ruggedized to protect equipment
Staff gauges	Visual measurement of stream stage

Source: SERC staff

Figure 7: Ke'Pel and Pecwan Creek Stream Gauging Stations

Source: SERC staff

In addition to the continuous monitoring of stream stage, we needed to make periodic site visits to measure stream flow. We estimated stream flow by dividing the stream channel into trapezoidal cross sections, measuring the area of the cross sections, and measuring the average stream velocity through each cross section. We consulted a detailed USGS procedure (Rantz, 1982) and followed a similar but less rigorous US Forest Service procedure (Harrelson et.al., 1994) to accomplish this task. The flow measurements, taken at particular stage heights, were then used to develop stage-discharge curves. The equipment used to make the stream flow measurements is listed in Table 5. A photograph of Tribal staff making a flow measurement in Pecwan Creek is shown in Figure 8. Additional photos of the work we performed to install and operate the stream gauging stations are provided in Appendix D.

Table 5: Equipment used for stream discharge measurements.

Equipment	Function
Stream Flow Measurement Equipment	
USGS Top Setting Wading Rod	Wading rod for current meter
USGS Type AA-MH Current Meter	Measurement of streamflow velocities in the 0.1 to 25 feet per second range (high flows)
USGS Pygmy-MH Current Meter	Measurement of streamflow velocities in the 0.1 to 4.9 feet per second range (low flows)
AquaCalc Pro Open Channel Flow Computer	Handheld electronic streamflow measurement and data logging device

Source: SERC staff

Figure 8: Yurok Tribe planner Austin Nova measures stream flow in Ke'Pel Creek

Source: SERC staff

The remote monitoring capability of the gauging stations allowed us to check on station status, confirm stations were operating, and track stage height. With knowledge of the stage height we were able to make efficient decisions about when to go out and make another flow measurement that would help complete the stage-discharge curves we were developing. During most site visits we also downloaded stage and precipitation data from the gauging stations.

Table 6 summarizes the precipitation, stage, and discharge data that were measured and collected on Ke'Pel and Pecwan Creeks over a period of about 1.5 years. About four months of precipitation data and 12 months of stage data were collected on Ke'Pel Creek, while eight manual flow measurements were made. On Pecwan Creek, 13 months of precipitation data and 18 months of stage data were collected and seven manual flow measurements were made. Precipitation data at Ke'Pel Creek was only collected between March and June of 2009. In June 2009, the gauging station at Ke'Pel had to be temporarily removed to allow for work on the Highway 169 bridge. The station was re-installed in November 2009 without the tipping bucket rain gauge. The location of the rain gauge at Ke'Pel was obstructed by alder trees overhead and it was decided that it was not worth it to re-install it. Because of the obstruction overhead, the precipitation data at Ke'Pel were not used. Pecwan precipitation data were used as a surrogate for Ke'Pel data. We feel this substitution was justified, as the sites are located less than five miles apart and likely experience very similar rainfall characteristics.

Very little effort went into data screening for the stream stage and stream flow data. Stream stage data were checked to ensure they were intact and then were archived. When plotting stage data versus time, the data do not show any aberrations. Stream flow measurement data were checked for integrity following each site measurement and no adjustments were deemed necessary.

Table 6: Summary of data measured and collected on Ke'Pel and Pecwan Creeks

Data (units)	Time interval	Measurement period (Ke'Pel Creek)	Measurement period (Pecwan Creek)	Data Collection Method
Precipitation (in)	15-minute, daily, and cumulative	3/27/2009 to 6/24/2009	3/20/2009 to 5/5/2010	Tipping bucket rain gauge
Stage (feet)	15-minute intervals	12/17/2008 to 6/24/2009 11/5/2009 to 5/6/2010	11/10/2008 to 5/6/2010	Pressure measurement
Discharge (cfs)	Approximation of an instantaneous measurement (actually measured over about a 1-hour time period)	11/13/2008 12/2/2008 12/17/2008 1/7/2009 1/15/2009 2/5/2009 3/20/2009 3/27/2009	11/10/2008 12/2/2008 1/22/2009 2/5/2009 4/10/2009 4/17/2009	Velocity-area method

Source: SERC staff

2.3 Technology Assessment

As stated in Chapter 1, the primary objective of this study is to identify opportunities for developing renewable power for wholesale back to the grid. This is the main focus of the feasibility assessment for wind power on McKinnon Hill and hydropower on Pecwan and Ke'Pel Creeks. A secondary objective is to identify opportunities to provide renewable power from any of these sites to specific Tribal facilities. Due to the remote location of these sites and their distance from Tribally owned facilities, there was only one opportunity to provide power directly to a Tribal facility – wind power for a new telecommunications installation on McKinnon Hill.

To assess the feasibility of wind electric and hydroelectric project development on the Reservation, we identified a set of candidate turbines that could be used at each potential project site. This included small to medium sized utility-scale wind turbines ranging from 225-kW to 2-MW where generated power would be sold wholesale back to the grid. We also examined the possibility of using a small, off-grid wind generator to provide power for the telecommunications facility on McKinnon Hill. Candidate wind turbines for this application ranged from 1-kW to 3.3-kW. Finally, we identified candidate turbine-generator sets for utility-scale hydroelectric installations at both Pecwan and Ke'Pel creeks. For our preliminary screening the hydroelectric generator size was assumed to be 500-kW. In subsequent more detailed analyses for Pecwan Creek we examined turbine-generators ranging from 125-kW to 1.5-MW. The potential project sites, power applications, and ranges of generator capacities that were investigated in this study are summarized in Table 7. A brief discussion of the turbine-generators considered in each of these applications follows.

Table 7: Summary of Potential Project Sites, Applications, and Generator Capacities

Project Site	Application	Generator Capacities
McKinnon Hill	Utility-scale wind power for sale to grid	225-kW to 2-MW
McKinnon Hill	Off-grid wind power for telecom site	1-kW to 3.3-kW
Ke'Pel Creek	Utility-scale hydropower for sale to grid	500-kW
Pecwan Creek	Utility-scale hydropower for sale to grid	125-kW to 1.5-MW

Source: SERC staff

2.3.1 Utility-scale Wind Technology Assessment

A variety of wind turbines were explored in our resource assessment and preliminary economic analysis for utility-scale wind development on McKinnon Hill. We selected turbines for our analysis based on their availability in the market, the presence of a published power curve[2], and the rated capacity. No turbines larger than 2-MW were considered due to the practical limitations of the transmission available to the McKinnon Hill site. Table 8 contains a listing of the turbines considered in our analysis, including their rated capacity and hub height.

[2] A power curve is a plot or table of data published by most turbine manufacturers listing the expected production from the turbine over a range of wind speeds.

Table 8: Wind turbines considered for utility-scale analysis.

Manufacturer	Turbine Model	Rated Capacity (kW)	Hub Height (m)
Aeronautica	Norwin 750	750	50
Aeronautica	Norwin 225	225	40
Americas Wind Energy	AWE 54-900	900	75
Gamesa	G80	2000	80
Nordic	N1000	1000	70
Turbowinds	T600	600	60
Unison	U57	750	68
Vestas	V39/500	500	40
Wind Energy Solutions	WES30	250	50

Source: SERC staff

2.3.2 Small Off-grid Wind Technology Assessment

The Yurok Tribe has just recently installed a telecommunications tower on McKinnon Hill. This facility will help provide high-speed internet service, cell phone coverage, and emergency radio coverage in the upriver portion of the Reservation. This off-grid system has initially been installed with power provided by a diesel genset; however, the Tribe is interested in exploring the possibility of using wind or solar power to provide some or all of the power requirements for the facility, with the genset left in place for backup power only. As part of this study we conduct a preliminary assessment of the feasibility of using off-grid wind power to power this facility. This off-grid system would be installed adjacent to the original "Primary Site" for the wind feasibility study (see Figure 5), while the utility-scale wind project discussed above would be installed at the "Alternative 2" site listed in Figure 5.

A variety of wind turbines were explored in our resource assessment and simple cost analysis was performed for an off-grid wind energy system to provide power to the McKinnon Hill telecommunications facility. We selected turbines for our analysis based on their availability in the market, the presence of a published power curve, and their rated capacity. Candidate turbines were chosen based on their expected suitability for providing a "reasonable" amount of power. Reasonable was defined as the ability to provide all, or a substantial portion of, the facility's expected power needs. A solar electric system or a backup diesel generator can provide supplemental power for the facility. Consequently, we tried not to choose turbines that would provide a substantial excess of power. Table 9 contains a listing of the turbines considered in our off-grid analysis, including their rated capacity and cost. The hub height for all turbines was assumed to be 25 meter.

Table 9: Off-grid Wind Turbine Candidates

Manufacturer	Turbine Model	Rated Capacity (kW)	Turbine Cost*
American Zephyr Corporation	Airdolphin	2.3	$6,000
Kestrel Wind Turbines	Kestrel e300i	1.1	$4,100
Kestrel Wind Turbines	Kestrel e400i	3.2	$11,200
Raum Energy, Inc.	Raum 1500	1.5	$7,000
Southwest Windpower	Whisper 200	1.0	$3,400
Southwest Windpower	Whisper 500	3.3	$8,800
Windspire Energy, Inc.	Windspire	1.2	$6,000
Xzeres Corporation	Xzeres 100	2.6	$11,800
*Turbine costs do not include the tower, balance of system or installation.			

Source: SERC staff

2.3.3 Hydro Technology Assessment

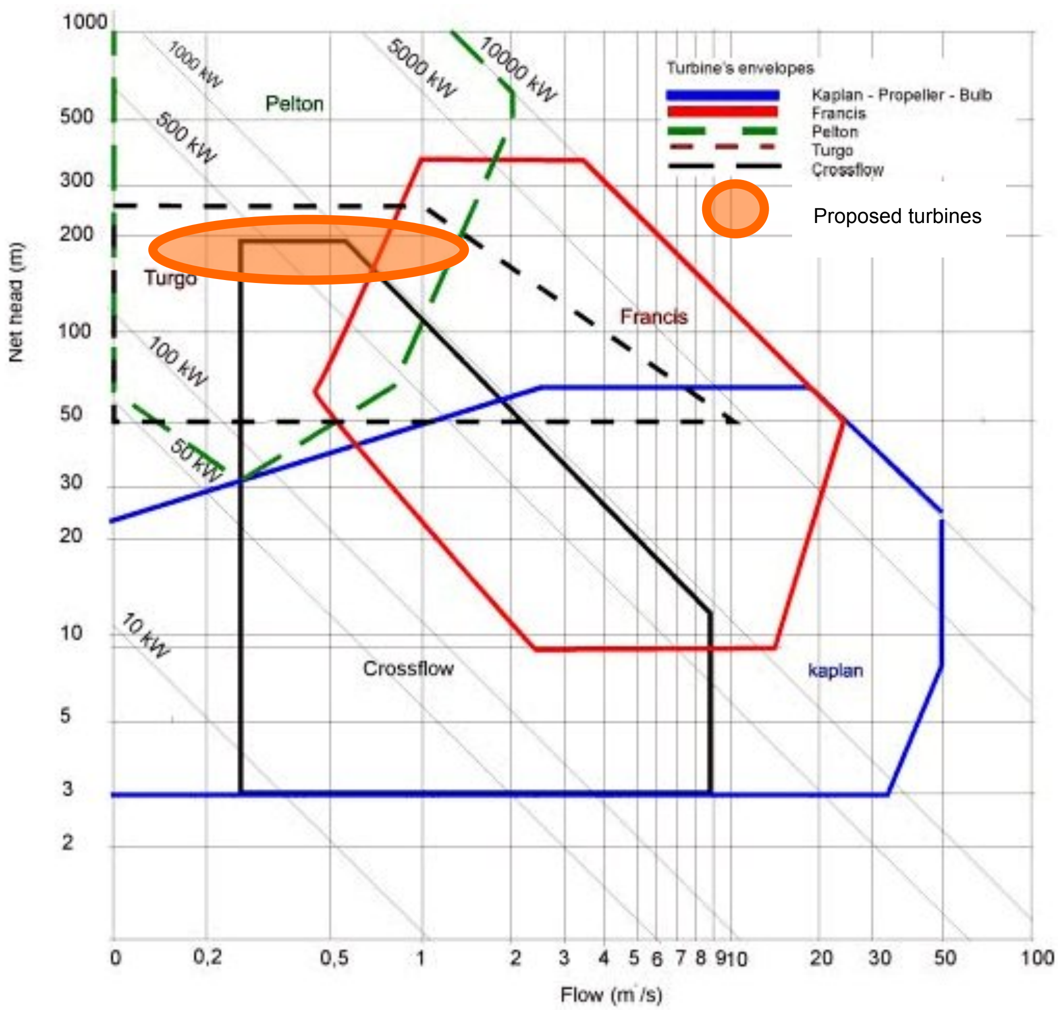
The hydroelectric turbine-generator combinations were sized based on a chosen design flow and a given dynamic head. The dynamic head is equal to the static elevation head, which is a function of the site topography and facility design, minus head loss due to friction, which is a function of the flow rate and the penstock characteristics. The design flow rate was chosen based on the expected flow conditions, as outlined in Section 2.4.3 Hydro Resource Assessment, and the desired system operation strategy.

Since the hydroelectric systems are being designed for wholesale power sales to the grid, the desire is to maximize annual energy production and annual sales revenues. Developers who aim to produce the maximum amount of energy for each dollar invested will typically be interested in flows between 20% to 35% exceedance (McKinney et al., 1983). The 20 percent exceedance flow is the flow that is equaled or exceeded 20 percent of the time. The most economical design flow is typically in the range of 25% exceedance. Based on the results presented in Section 2.4.3, this led to a design flow range of 50 cfs to 70 cfs and a generator power range of 1.3-MW to 2.0-MW for Pecwan Creek. For Ke'Pel Creek the design flow range was 25 cfs to 50 cfs, with a generator power range of 0.9-MW to 1.8-MW. The estimated gross elevation head for the Pecwan Creek hydropower system is 590 feet and for the Ke'Pel Creek system it is 800 feet.

The capacity of the local electrical grid and power purchase agreement requirements are two additional criteria that influenced the chosen size of the hydroelectric generator. Preliminary feedback from Pacific Gas and Electric suggested the local electric grid could handle a maximum cumulative generator capacity of 500-kW, single-phase. This generator size was used for the preliminary assessment. Through further contact with Pacific Gas and Electric it was estimated that the largest single-phase generator that could be supported by the existing grid infrastructure is about 125-kW. With substantial upgrades to the electrical grid (see Section 2.7 Electrical Grid Assessment), it was estimated that up to about a 2-MW three-phase generator could be supported. For the final assessment of the preferred alternative, a range of hydroelectric generators on Pecwan Creek was considered: 125-kW, 500-kW and 1.5-MW.

Turbine selection was based on the chart in Figure 9. The estimated head and range of flows and generator sizes for both creeks lies near the center of the Pelton turbine envelope and on the upper boundary of the Turgo turbine envelope (see orange shaded oval area). Based on the high efficiency of a Pelton turbine across a wide range of loads, it is the preferred and preliminary turbine type assumed for this analysis.

Figure 9: Turbine selection chart based on net head and flow



Source: European Small Hydropower Association (1998), adapted by SERC staff

2.4 Load Assessment

A load assessment was conducted for the new telecommunications facility on McKinnon Hill. We consulted with Jim Norton, Broadband Manager in the Yurok Tribe's Information Services Department to determine what the expected loads would be at the new facility. Table 10 shows the load estimate. It is important to note that these were estimates prior to facility installation. Once the facility is up and running the actual load should be tracked over time.

The facility is intended to provide broadband high-speed internet access and emergency radio services. It may also provide cell phone support. The loads shown in Table 10 were estimated based on load measurements made at the Tribe's Miner's Creek telecommunications facility and on equipment specifications provided by Jim Norton. They do not include cell phone support. Some loads are expected to be continuous, while others, like emergency radios, will be intermittent. The total average daily load is expected to be about 5 kWh/day of AC power. Accounting for the inverter efficiency (approximately 90%) and battery bank charging cycle efficiency (approximately 80%), this results in an average daily load of about 7 kWh/day of DC power. If cell phone support is added, the load could increase substantially.

As has been done at other Yurok Tribe telecommunications facilities, the Tribes plans to install a diesel generator and battery bank to provide needed power. The batteries will supply power to meet the daily electrical loads and the generator will run periodically to charge the battery bank. If a wind energy system were added to the McKinnon Hill facility, it would offset power otherwise provided by the diesel generator. It is likely the diesel genset would be maintained for use as a backup power source and would be used during times when the wind system could not provide adequate power.

Table 10: McKinnon Hill Telecom Tower Projected Electrical Load

		continuous			peak			total watt-	averagewatt-
	Qty	watts/unit	watts	hrs/wk	watts/unit	watts	hrs/wk	hrs/wk	hrs/day
Moto 600	4	10	40	108	55	220	60	17,520	2,503
Moto Canopy	2	30	60	126	55	110	42	12,180	1,740
Carlson P2MP	1	12	12	126	16	16	42	2,184	312
Cisco switch	1	8	8	126	12	12	42	1,512	216
Mikrotik router	1	12	12	126	19	19	42	2,310	330
Lights	2				50	100	1	100	14
			132			477			5,115

Source: Jim Norton, Yurok Tribe Broadband Manager and SERC staff

2.5 Preliminary Resource Assessment

2.5.1 Utility-scale Wind Resource Assessment

After one year and one day of monitoring, the final data download was retrieved from the data logger and the tower was decommissioned. In total, the data set consists of ~52,700 10-minute records, or ~366 days of observations. In the following resource assessment, we summarize the wind speed and direction characteristics as well as the wind power density at the site and the power production characteristics from a sample wind turbine.

Wind speed and direction summary

The overall wind speed characteristics at McKinnon Hill are summarized for each sensor height (30m, 41.5m, 50m) in Table 11. According to the NREL wind power class definition[3], this site would be characterized as in the high end of a Class 1 wind site.

Wind speed histograms of the site for the three speed sensor heights are plotted in Figure 10. Monthly mean wind speed for each sensor is plotted in Figure 11 and monthly wind rose diagrams are plotted in Figure 12. Mean wind speed is relatively constant from March through October and increases dramatically in the winter months (November through February). The highest wind speeds occur in the winter and come from the Southeast. Wind speed at McKinnon Hill exhibits a clear diurnal trend as shown in Figure 13; speed tends to peak in the morning and late afternoon, and tends to be higher during the day than at night. Indeed, the wind direction also exhibits a diurnal trend (Figure 14); the wind blows predominantly from the southeast during the night and from the northwest during the day, which is consistent with normal up-canyon/down-canyon diurnal wind patterns.

Table 11: Summary statistics for wind speed and power density at McKinnon Hill.

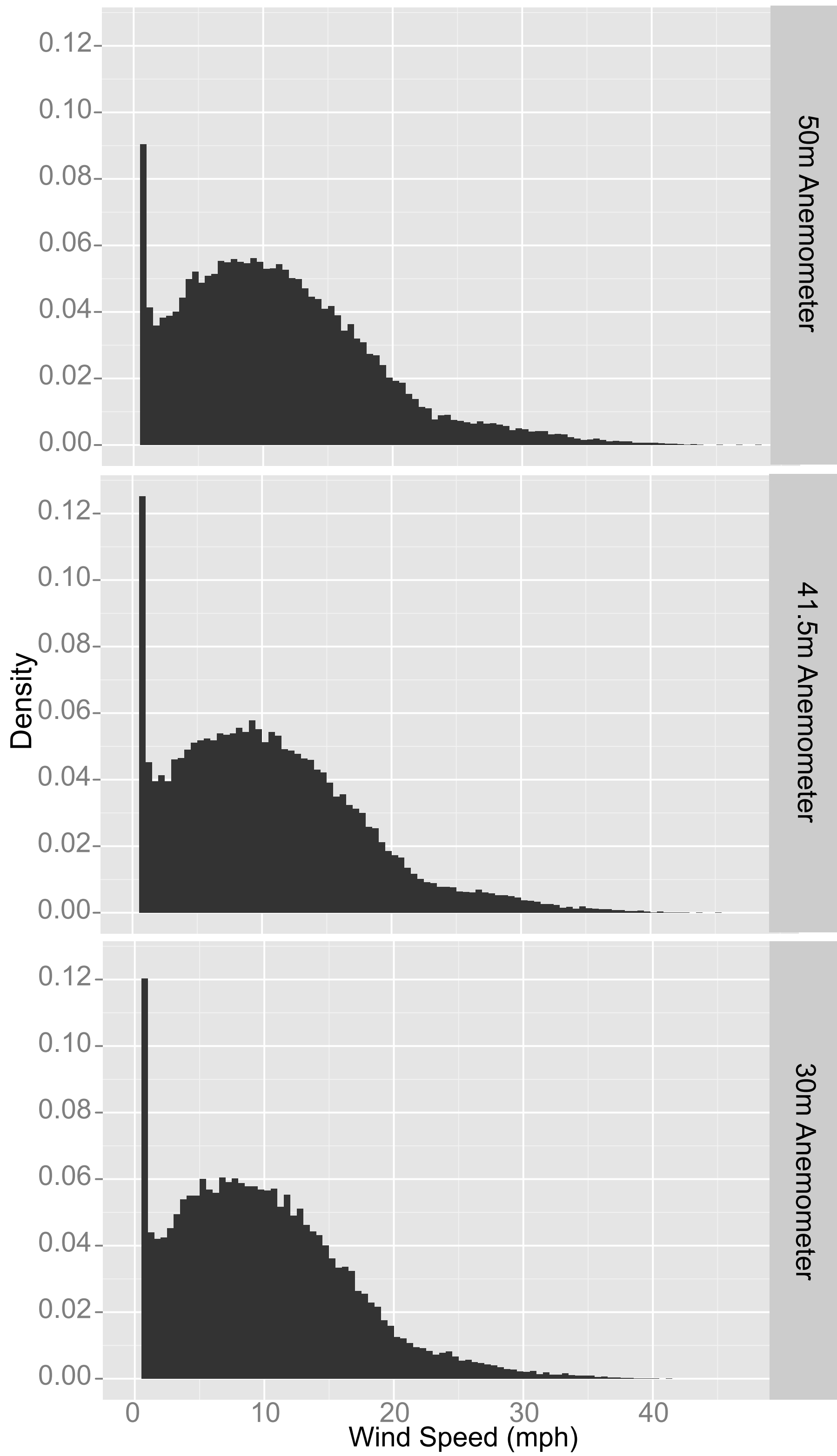
Sensor Height (m)	Mean Speed (mph)	Weibull Shape*	Weibull Scale*	Wind Power Density (W/m^2)
50	11.3	1.57	12.6	189
41.5	10.8	1.52	12.0	168
30	10.1	1.56	11.2	133

* Note: the Weibull distribution is a probability distribution that is commonly used to fit a wind speed distribution. The Weibull shape and scale parameters help define the shape of the distribution.

Source: SERC staff

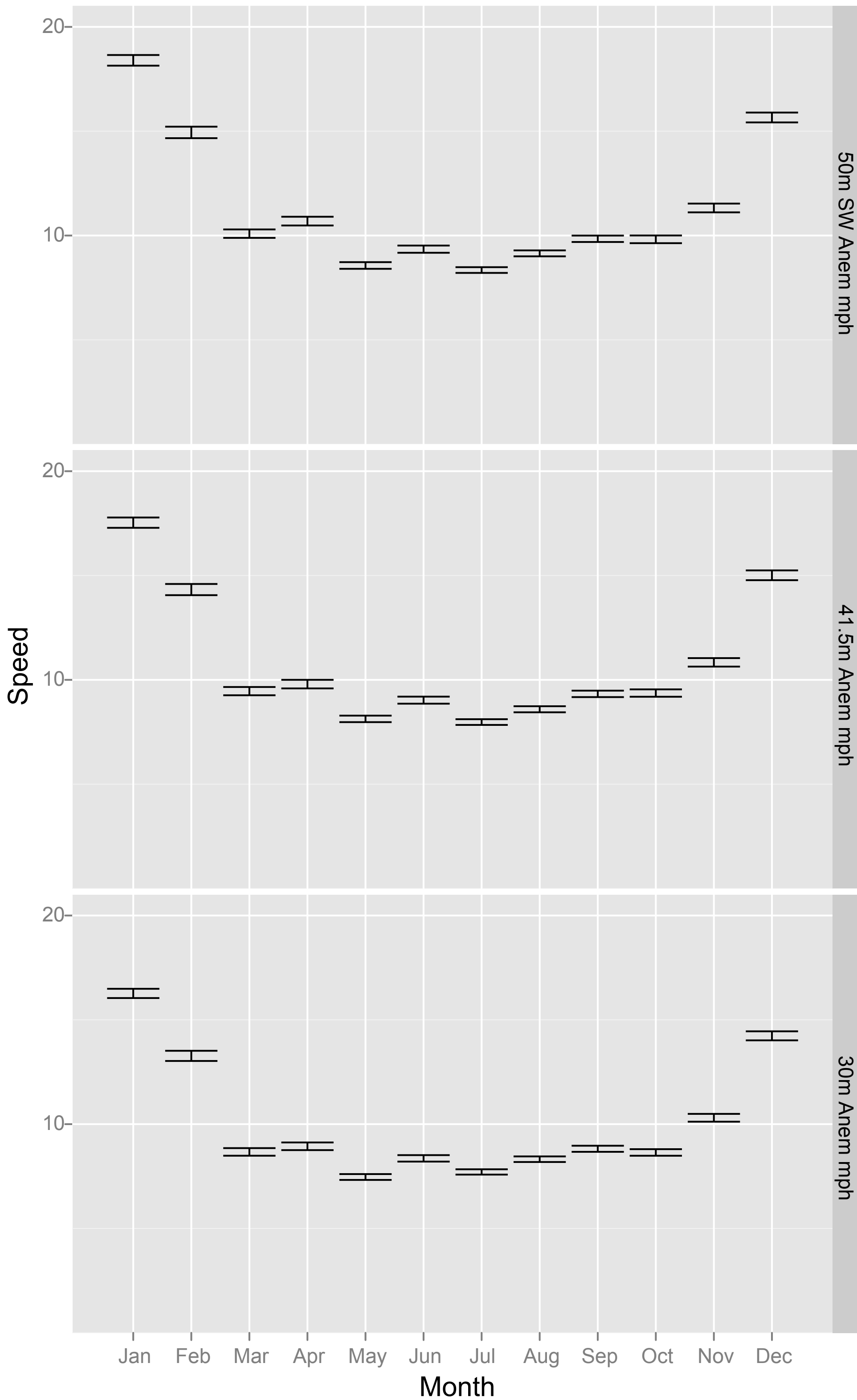
[3] http://rredc.nrel.gov/wind/pubs/atlas/tables/1-1T.html

Figure 10: Wind speed histograms for anemometers at three heights.



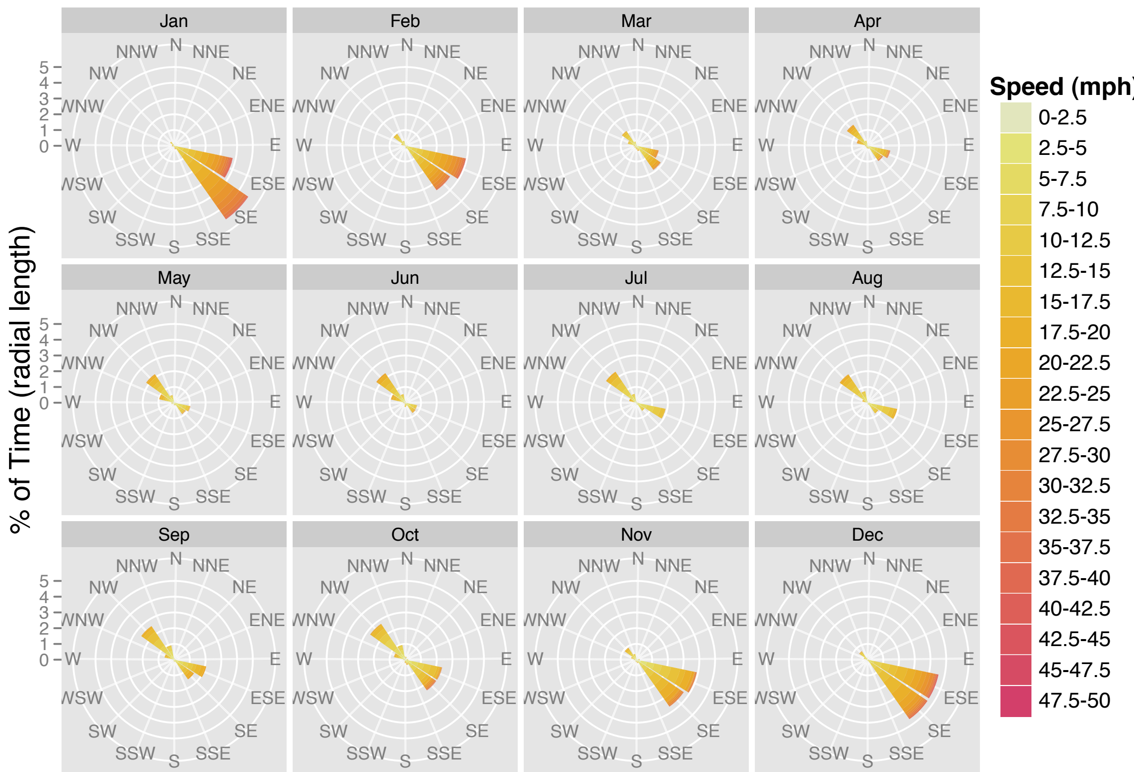
Source: SERC staff

Figure 11: Monthly average wind speed. The error bars represent 95% confidence intervals around the mean monthly wind speed.



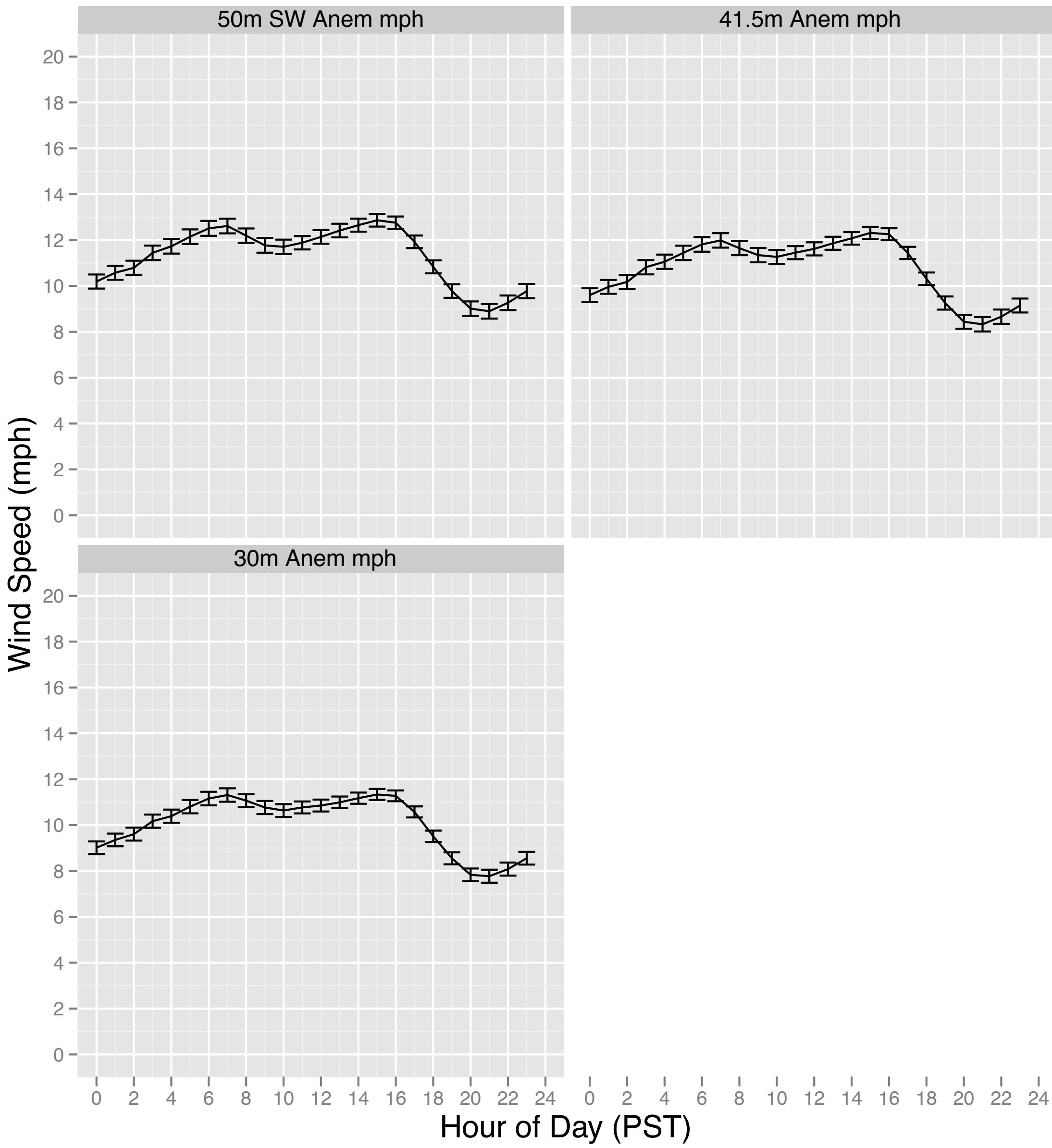
Source: SERC staff

Figure 12: Monthly wind rose diagrams for McKinnon Hill wind resource.



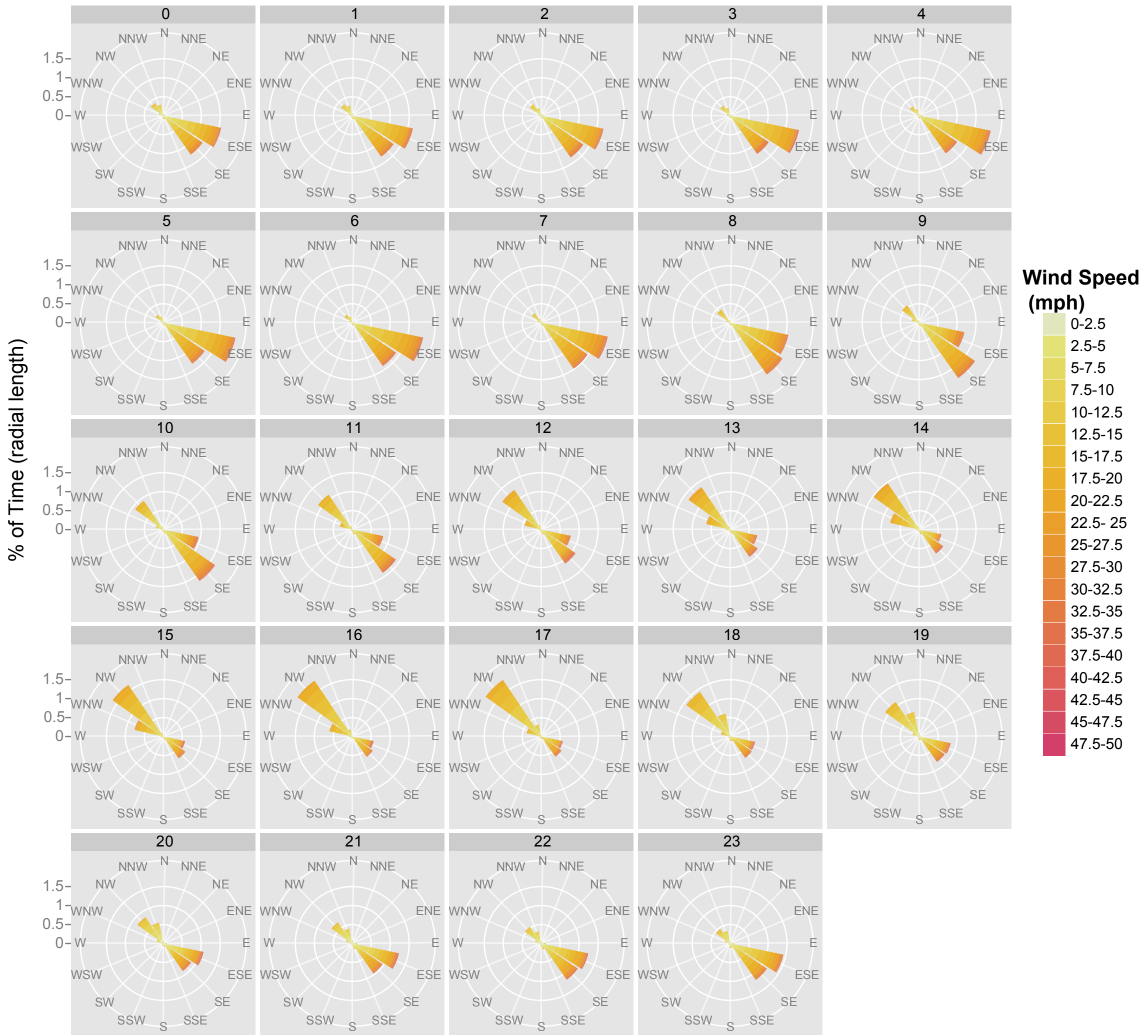
Source: SERC staff

Figure 13: Diurnal wind speed characteristics at McKinnon Hill. The error bars represent 95% confidence intervals around the mean hourly wind speed.



Source: SERC staff

Figure 14: Wind rose diagrams of each hour of the day for McKinnon Hill resource.



Source: SERC staff

Estimating Inter-Annual Variation

Wind is a highly variable resource, and therefore a year is usually the minimum recommended length of a monitoring campaign in order to adequately observe the seasonal variations in wind speed. However, wind also exhibits inter-annual variation that cannot be observed from one year of monitoring. We did not have the resources or time to monitor for longer than one year. But it is possible to quantify inter-annual variation using the measure-correlate-predict methodology. This process involves conducting statistical correlation between wind speed at the target site (in our case, McKinnon Hill) and wind speed at a nearby, long-term reference monitoring station (normally a weather station). The correlated relationship is then used to predict, or backcast, the wind speed at the target site based upon the historical period of record at the reference. The reliability of this process is dependent on a strong correlation between the two sites. Generally, it is not recommended to employ the measure-correlate-predict methodology for sites that have a correlation coefficient less than 0.8 (Sheppard, 2009).

We identified two sources of nearby long-term data as potential reference sites for McKinnon Hill. These sites are part of the real-time observation and monitoring network managed by the National Oceanographic and Atmospheric Administration. The stations are named Schoolhouse Peak and Big Hill and are 12.3 and 17.6 miles from the McKinnon Hill monitoring site respectively.

Table 12 presents the results of calculating the correlation coefficient between the two references sites and McKinnon Hill. The correlations between concurrent wind speed observations at the stations are weak; the correlation coefficient never exceeds 0.37 for either site. Therefore, we are unable to reliably extend the McKinnon Hill data set to account for inter-annual variation.

Table 12: Correlation coefficient between wind speed measured at McKinnon Hill and two nearby sources of meteorological data.

Sensor	Correlation Coefficient
McKinnon Hill and Schoolhouse Peak	
50m SW Anemometer (mph)	0.364
41.5m Anemometer (mph)	0.348
30m Anemometer (mph)	0.337
McKinnon Hill and Big Hill	
50m SW Anemometer (mph)	0.275
41.5m Anemometer (mph)	0.260
30m Anemometer (mph)	0.243

Source: SERC staff, based on data from **http://raws.wrh.noaa.gov**

Modeling Production from Turbines

Turbine manufacturers publish tables and/or figures, called "power curves," that report the power produced by turbines over the full range of operating wind speeds. (Some manufacturers provide these data in tabular form rather than as curves.) We use these power curves to model the power production of various wind turbines at McKinnon Hill. Like many manufacturers' ratings, these curves are generated using ideal conditions and should be used with caution. However, a demonstration wind farm in Greece, operated by the Greek Center for Renewable Energy Sources, monitors five mid-sized wind turbines (ranging from 0.4 to 1.0-MW) in complex terrain. There the manufacturer power curves fall within the 95% confidence intervals of the observed power curves (Stefanatos et al., 2004).

The data in power curves are based on wind speed observed at the hub height of the turbine. Most mid- to large-scale turbines have a hub height higher than 50m, the top level of our monitoring station. So we must extrapolate the observed wind speed at McKinnon Hill to the hub height of the turbine for which we have a power curve. Wind speed extrapolation is commonly based on the following relationship between wind speed at different heights within the boundary layer between the earth and atmosphere (White, 2003).

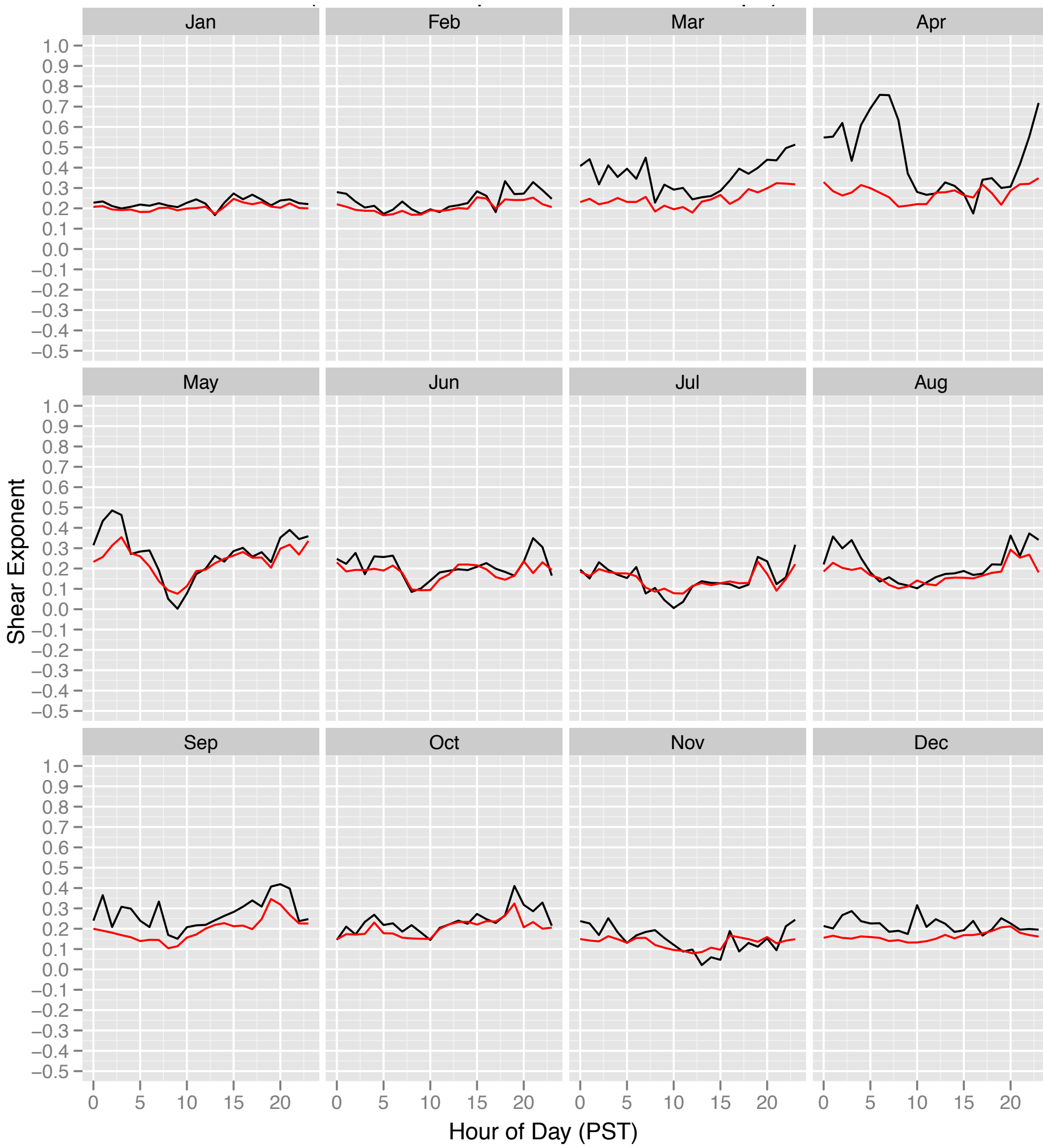
$$V = V_0 \left(\frac{H}{H_0}\right)^{\alpha'}$$

The value V (m/s) is the unknown velocity at height H (m) and V_0 (m/s) is the known velocity at height H_0 (m). The exponent α', called the wind shear exponent, is an empirically derived constant that is dependent on the local wind regime and topography. A very rough approximation of α' is a value of 1/7, often used as a rule of thumb in estimating wind speeds at different heights (Gipe 2004). At McKinnon Hill, we chose to estimate the wind shear exponent based on the observed wind speed measured at 30 meters and 50 meters.

Figure 15 contains a summary of the estimation of this factor based on the wind speed observations from the 30 m and 50 m anemometers. The results are disaggregated by hour of day and month of year to show the seasonal and diurnal variability of the exponent. There is substantial variation in both the mean and median shear exponent by season and time of day. We conclude from this result that using an overall average (or median) exponent to extrapolate all of our observations would be inappropriate. However, the other extreme, extrapolating each ten-minute observation based on an estimated coefficient from that same interval, would also be inappropriate.

Both the mean and median values are plotted in Figure 15 to demonstrate the presence of significant outliers in the calculated exponent values. The presence of extreme outliers is reasonable given the fact that the estimations are based on ten-minute time intervals and the monitoring station is at the crest of a steep ridge, where turbulence and large eddies are likely to occur regularly. In some samples, the average speed at the lower anemometer is actually less than at an upper anemometer, resulting in a negative shear exponent. In other samples, the speed at a lower anemometer is so close to zero that the exponent becomes extremely large (e.g. a value of 16.2 was calculated for one ten-minute interval at McKinnon Hill). Therefore, using individual, ten-minute estimates of the sheer exponent in wind speed extrapolation would undoubtedly result in unrealistic estimates of wind speed at the turbine hub height and therefore would also be inappropriate. Additionally, the presence of extreme outliers is sufficient basis to justify using the median extrapolation value instead of the mean, as the median is much less sensitive to outliers.

Figure 15: Diurnal and seasonal variability of shear exponent at McKinnon Hill.



Estimated between the 30m and 50m speed sensors. Both the mean (black) and median (red) values are plotted for each combination of hour and month

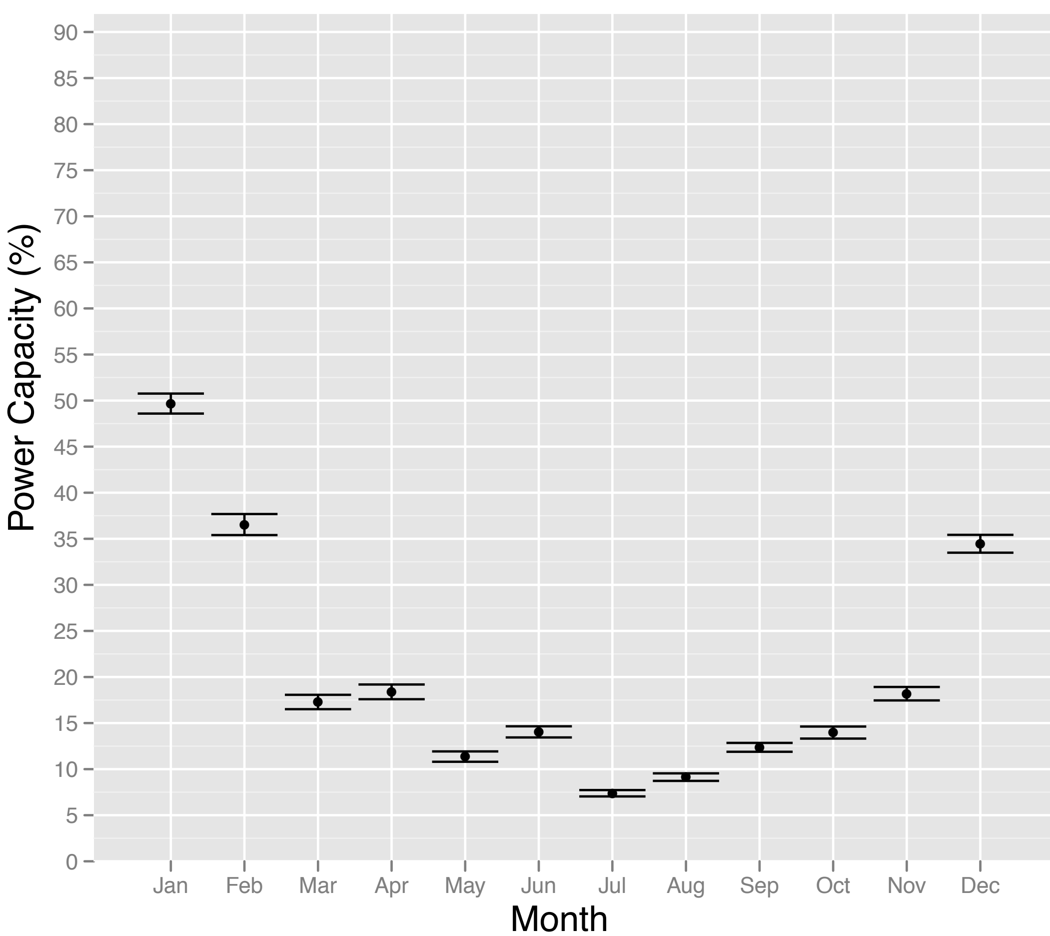
Source: SERC staff

For every observation in our data set, we extrapolated to the hub height of a given turbine based on the median value of the observed shear exponent for the corresponding hour and month. The resulting wind speed estimate was then converted to a power production estimate via the turbine power curve, resulting in a power time series, which was finally converted into a capacity factor by dividing each value by the maximum output of the turbine. The resulting hourly time series of capacity factors was then analyzed for seasonal and diurnal characteristics. Figure 16 and Figure 17 present the results of these analyses using a Gamesa G80 turbine. As expected, the winter months (particularly December-February) are when power production would be at its peak. About 50% of the annual energy production would occur in these three months, and ~70% of the annual energy would be produced during the six months from November-April. It's also useful to note that peak production in the winter months occurs during the early morning whereas in the summer it occurs in the mid to late afternoon. So the silver lining for low performance in the summer is that the peak production at least occurs during hours of peak power pricing.

We conducted an equivalent analysis for each of the wind turbines investigated, and the results were compiled as average capacity factors by hour of the day and by month. These data were then used in the preliminary economic analysis to estimate revenue from power production (see Section 2.8).

When making power production estimates based on data from a power curve, it is critical that the power be derated based on empirical observations of real world turbine performance. Common assumptions from the literature are tabulated in Table 13. Based on these data, a derate factor of 15% was assumed in our economic analysis.

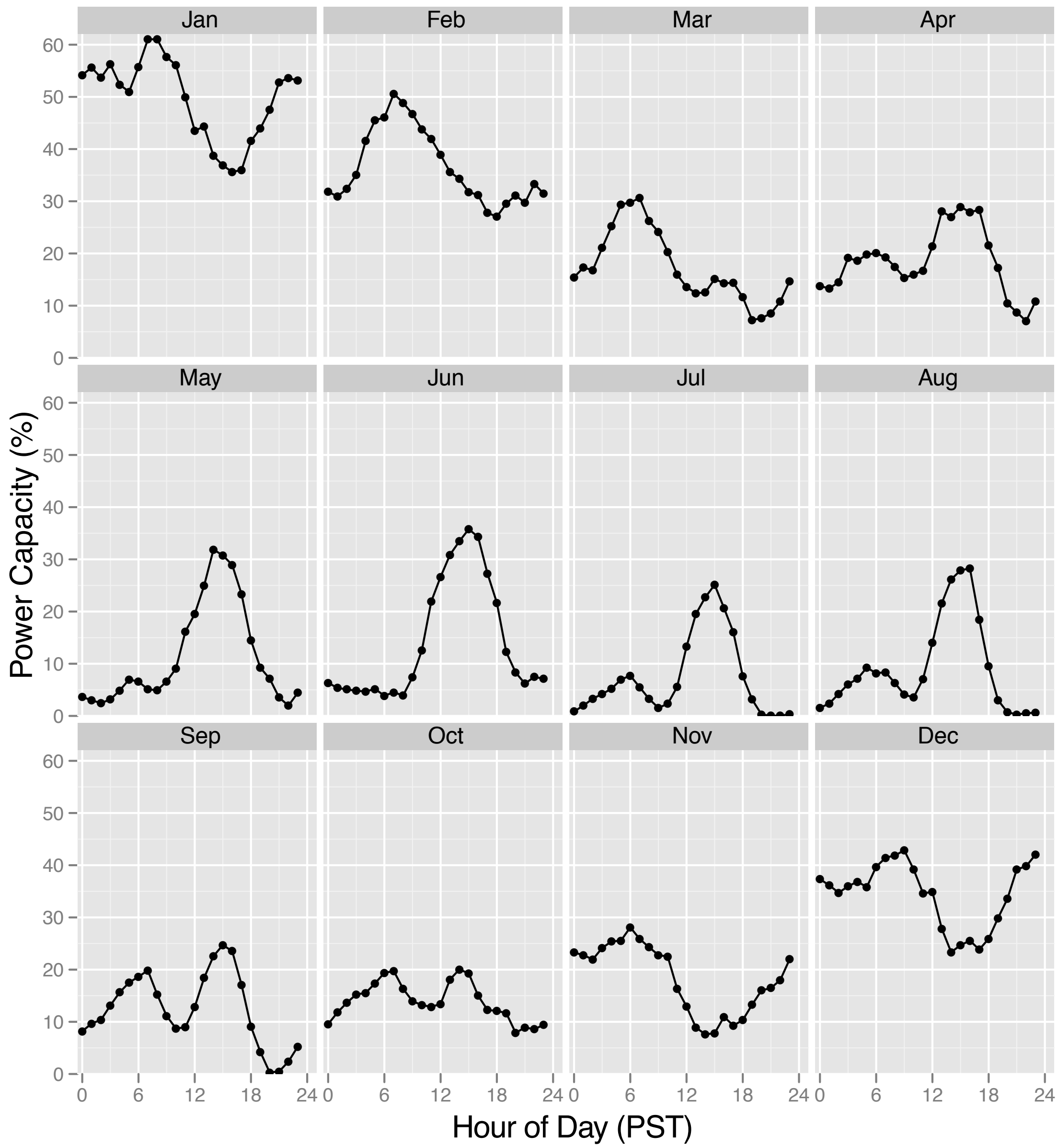
Figure 16: Monthly average capacity factor assuming a Gamesa G80 wind turbine.



The error bars represent 95% confidence intervals on the monthly average.

Source: SERC staff

Figure 17: Capacity factor by hour and month assuming a Gamesa G80 wind turbine.



Source: SERC staff

Table 13: Wind power production losses as assumed or measured by various studies

Loss Type	Description	E.F. McCarthy & Associates (2003)	SeaWest Consulting (2002)	NREL/ Rhoads (2000)
Availability	turbine down time	3%	3%	9.5% sdev=5%
Line losses	voltage drop through aggregation and distribution wires	2%	2%	n/a
Wake losses	wind shadows from nearby turbines	7.5% (includes off axis)	1%	n/a
Off axis wind losses	shifts in wind direction that happen more quickly than the response of the turbine directional adjustment	See above	n/a	n/a
Blade contamination	usually means icing	1%	0%	n/a
High wind hysteresis	when winds reach turbine furling speed and then decrease, the turbine won't produce power until they fall below a hysteresis set point, even though they are producing speeds in the power curve	n/a	0%	n/a
Topographic effect	losses due to turbulence and non-uniform terrain over a wind farm	n/a	2%	n/a
Other losses	includes all of the above except availability	n/a	n/a	11% sdev=10%
Net losses	*Combination of all independent losses*	*13%*	*8%*	*19%*

Source: SERC staff

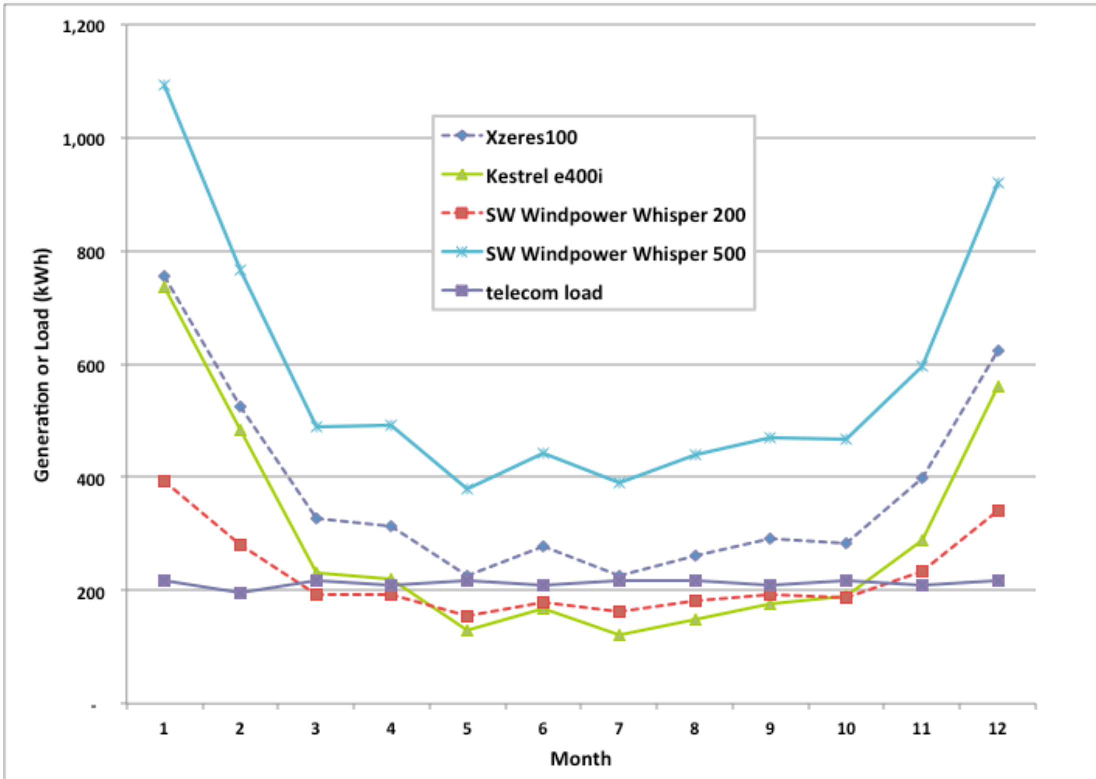
2.5.2 Off-grid Wind Resource Assessment

The off-grid wind resource assessment for the McKinnon Hill site used the same data as for the utility scale assessment; however, a slightly simplified analysis was used. The wind speed data collected at 30 meters were adjusted to an assumed 25-meter hub height using an average annual wind shear factor of 0.259. This was a very slight adjustment, so the simplified use of the average annual wind shear factor was justified. This wind speed distribution was then applied to the set of off-grid turbines identified in Section 2.3, Technology Assessment. The power curve data obtained from turbine manufacturers was adjusted for an average annual air density of 1.14 kg/m^3. Finally, the estimated power output for each of the turbines was decreased by 15% to account for expected discrepancies between published power curves and actual turbine performance.

Of the eight turbines considered, it appears that four of them could meet or nearly meet the expected load. These are the Kestrel e400i, the Southwest Windpower Whisper 200, the Southwest Windpower Whisper 500, and the Xzeres 100. The other four turbines are not capable of meeting the load. Figure 18 shows the expected monthly output for the four turbines mentioned above along with the expected monthly load for the telecommunications installation. The Xzeres 100 appears to be a very good fit. The Kestrel e400i and Southwest Windpower Whisper 200 come close to meeting the load during most months, but appear to fall short in the summer months. A backup generator could be used during these times, or a small solar array could be added for summer power production. Since the wind resource peaks in the winter months, a solar electric system would be a nice complement to a wind generator. Finally, the Southwest Windpower Whisper 500 appears to be oversized for the application. However, if the cellular phone support system is added the electrical load will grow and this turbine may turn out to be a good fit.

It should be noted that the wind data were collected approximately 0.5 miles to the northeast of the telecommunications site. This distance is too far to transmit low voltage direct current electricity. Consequently, the wind turbine would need to be located closer to the telecommunications facility, provided it doesn't cause any interference problems. It is recommended that trees should be cleared around the wind turbine site to allow unobstructed access to the wind. It is uncertain how well the data that have already been collected would represent a site closer to the telecommunications facility. Tree cover could affect the available wind source significantly. Ideally additional data should be collected at the site where the turbine will be installed after trees have been removed and the estimated wind turbine output should be adjusted accordingly.

Figure 18: Estimated wind power production for the off-grid telecommunications facility on McKinnon Hill.

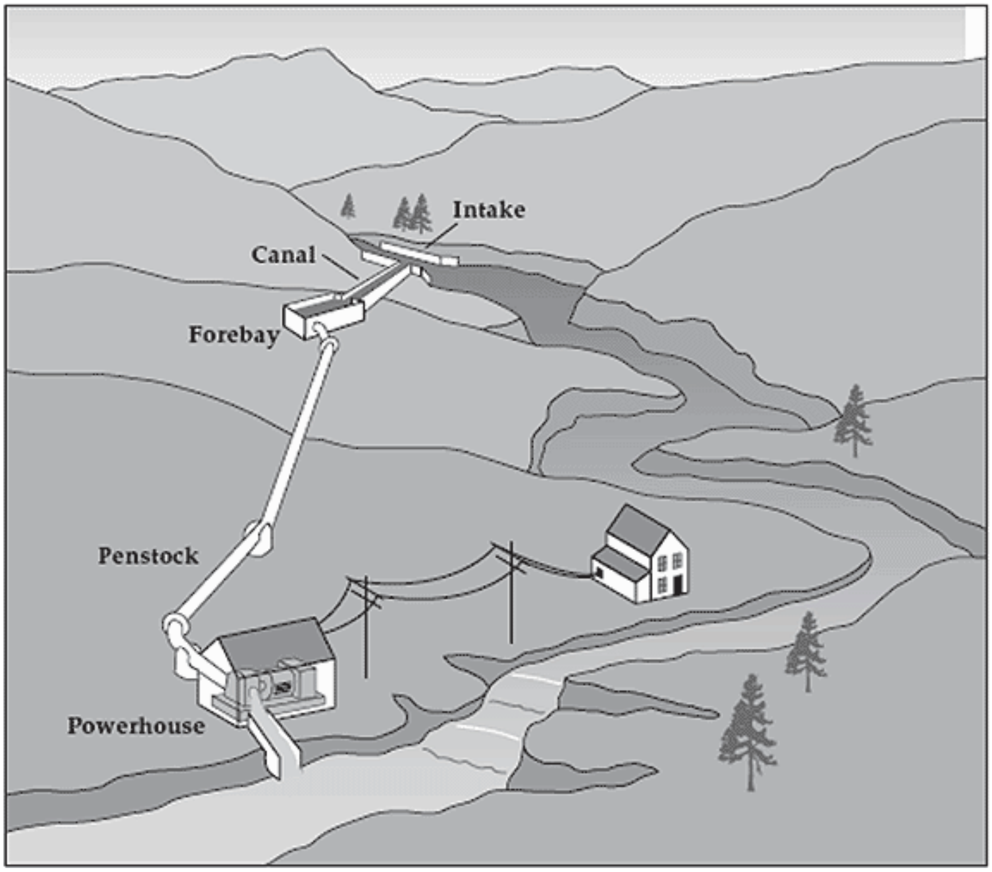


Source: SERC staff

2.5.3 Hydro Resource Assessment

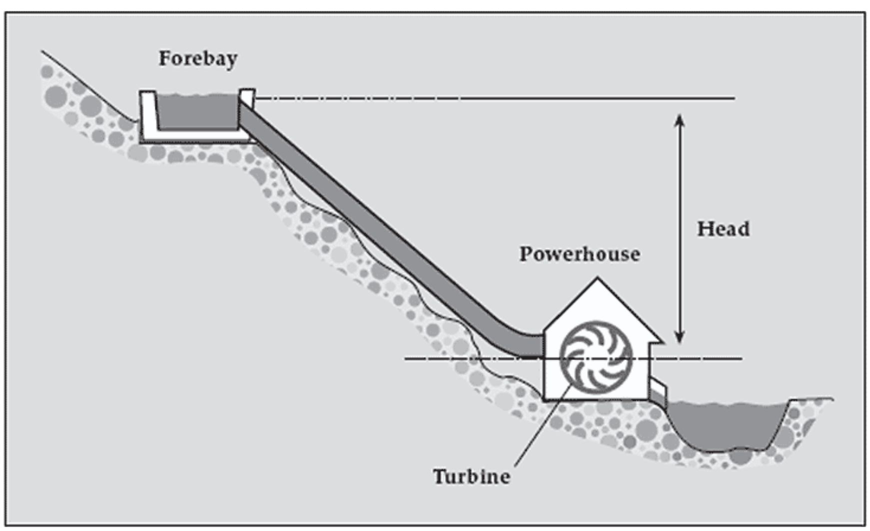
The energy-producing potential of a hydropower site depends primarily on two factors: the vertical distance the water falls, known as head, and the amount of water flowing, referred to as flow or discharge. The head is determined by the topography of the site and the chosen locations of the forebay and powerhouse (i.e., the top and bottom points of the penstock, where the water is conveyed under pressure). Figure 19 and Figure 20 show the typical layout of a run-of-the-river hydroelectric plant and the definition of system head.

Figure 19: Run-of-river hydroelectric system.



Source: Tribal Energy and Environmental Information Clearinghouse, Office of Indian Energy and Economic Development, U.S. Department of the Interior

Figure 20: Elevation head for a run-of-river hydroelectric system.

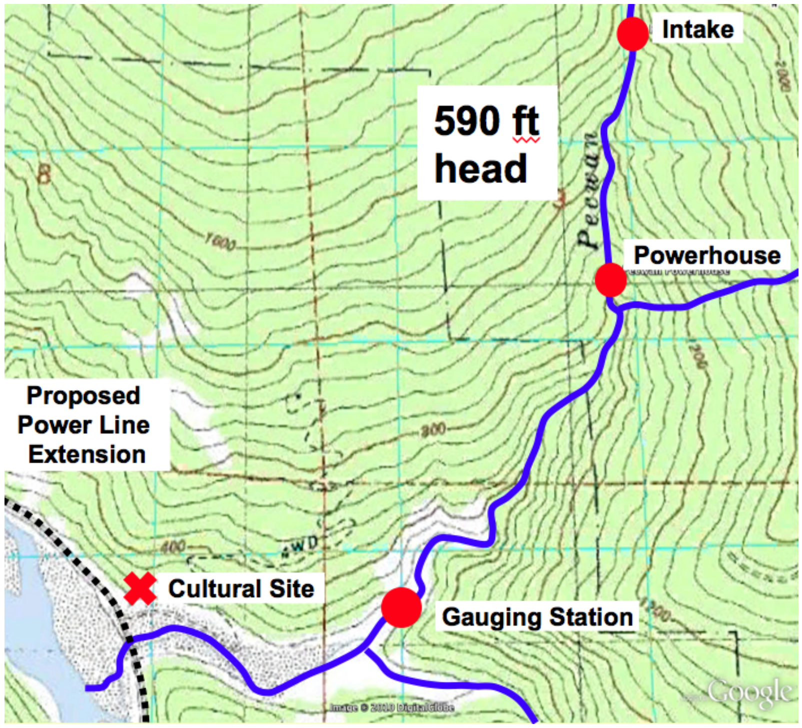


Source: Tribal Energy and Environmental Information Clearinghouse, Office of Indian Energy and Economic Development, U.S. Department of the Interior

We determined likely locations for an intake, forebay, and powerhouse for proposed hydroelectric systems on Pecwan and Ke'Pel Creeks by initially studying topographic maps of the area and consulting with Tribal Planning Department staff, and then making site visits. During the site visits we assessed the topography, potential road access, and general suitability of the site for hydropower development. Proposed intake and powerhouse locations for Pecwan and Ke'Pel Creeks are show in Figure 21 and Figure 22, respectively. Note that during a site visit and via consultation with Tribal staff it was determined that access to the West Fork of Pecwan Creek was better than access to the East Fork, and the decision was made to focus on the West Fork for hydropower development. The estimated elevation head for the Pecwan Creek hydropower system is 590 feet and the estimated elevation head for the Ke'Pel Creek system is 800 feet.

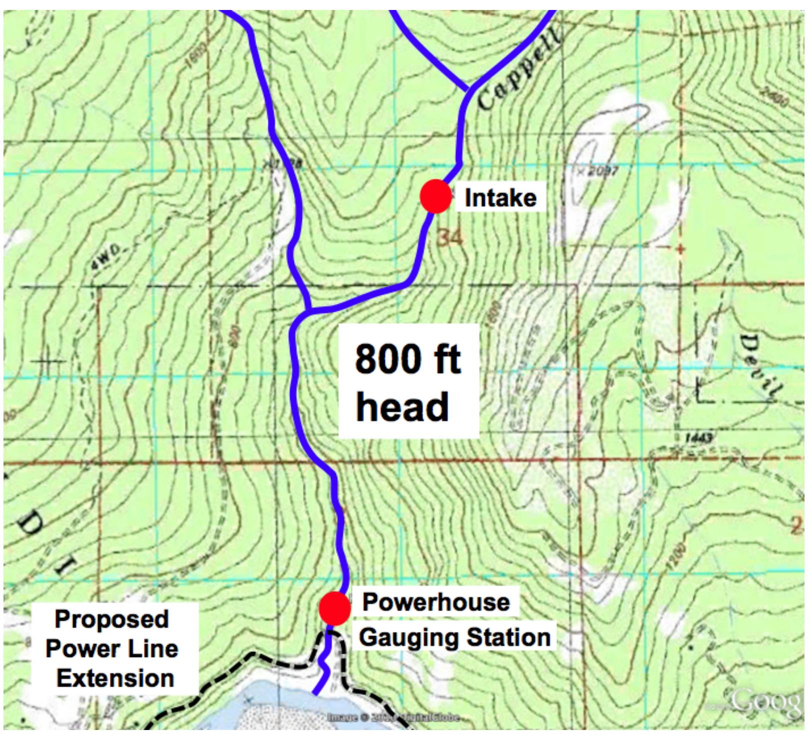
The remainder of this section describes how the flow potentials on Pecwan and Ke'Pel Creeks were estimated. This ultimately required the development of a synthetic hydrograph for each creek from which flow duration curves could be created and power generation could be estimated. The Hydrologic Engineering Center Hydrologic Modeling System, or HEC-HMS, precipitation-runoff model (U.S. Army Corp of Engineers, 2010) was used to accomplish this by calibrating the model with data collected from each creek. Figure 23 shows a flow chart of the overall process from data collection through model output.

Figure 21: Map of proposed Pecwan Creek hydropower system



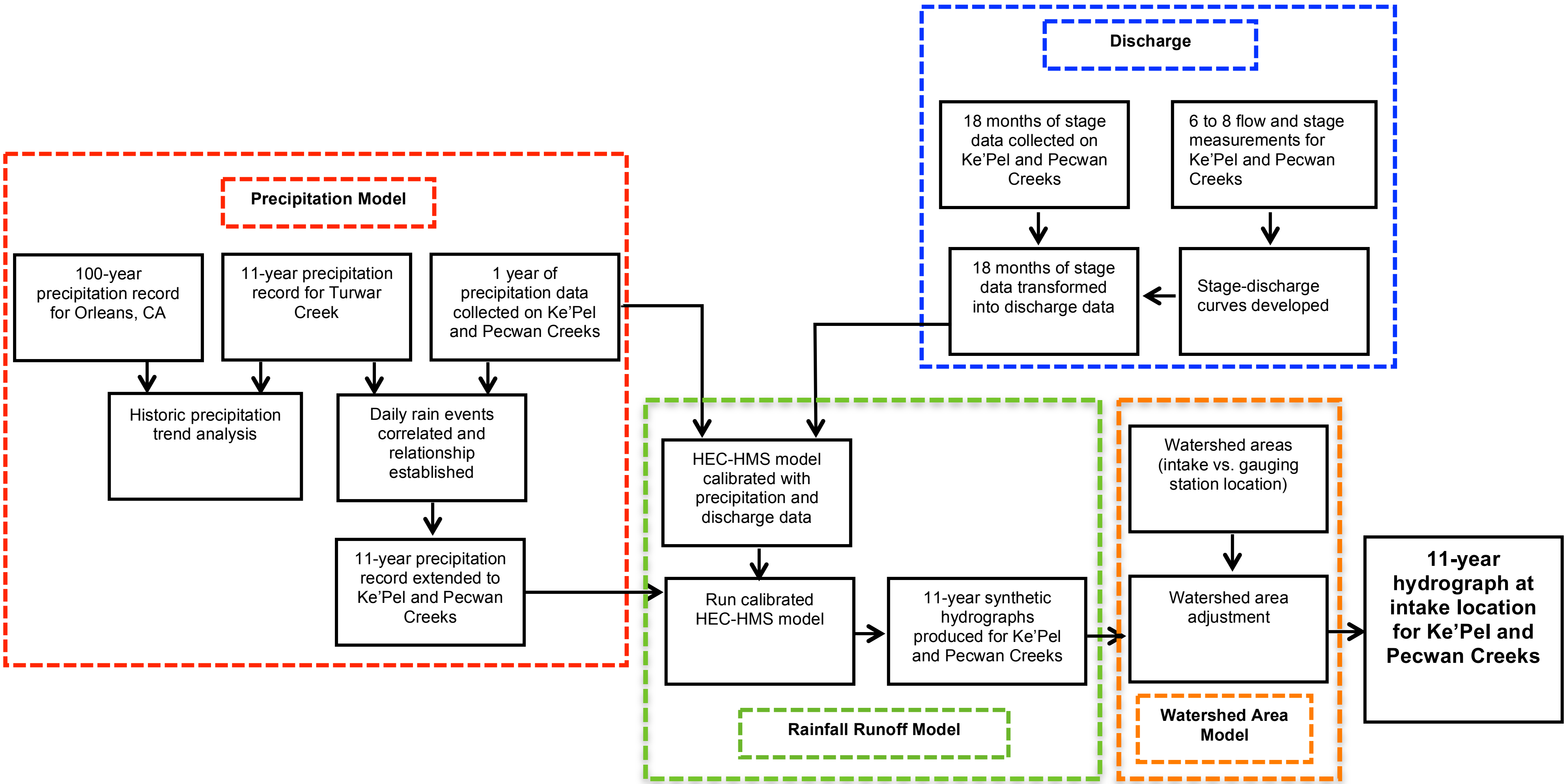
Source: SERC staff

Figure 22: Map of proposed Ke'Pel Creek hydropower system.



Source: SERC staff

Figure 23: Flow chart of process used to produce synthetic hydrographs on Ke'Pel and Pecwan Creeks.



Source: SERC staff

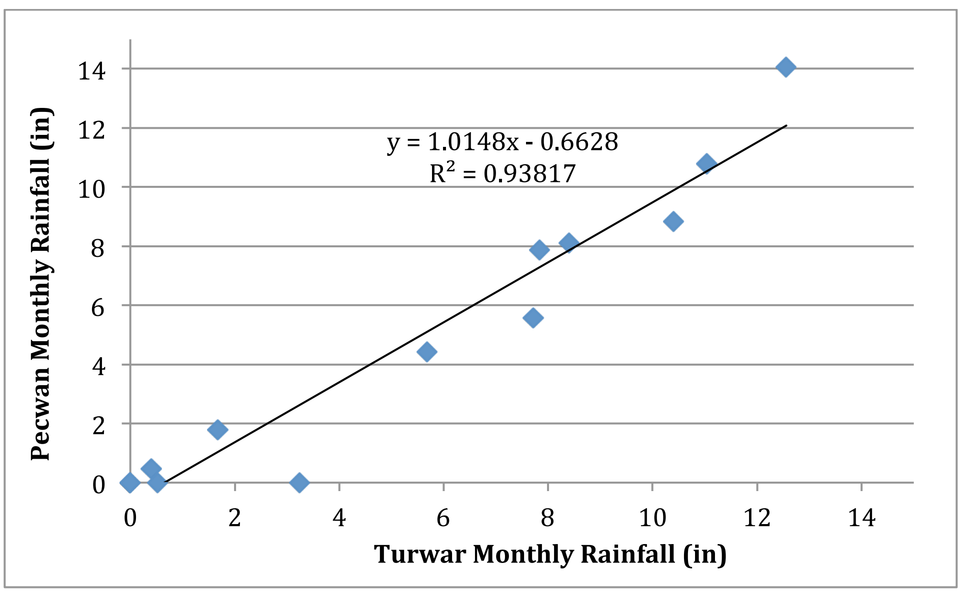
Flow Duration Curve

A flow duration curve is a useful tool because it provides an estimate of the fraction of the year that any given flow will be met or exceeded. It is a key result of this study and is the basis on which power generation potential and hydroelectric system design are founded. The methodology for developing a synthetic hydrograph curve is depicted in the flow chart above (Figure 23) and is outlined below. A flow duration curve can be generated from the hydrograph by sorting the flow data and calculating the probability that a given flow will be equaled or exceeded.

Extending the Precipitation Record

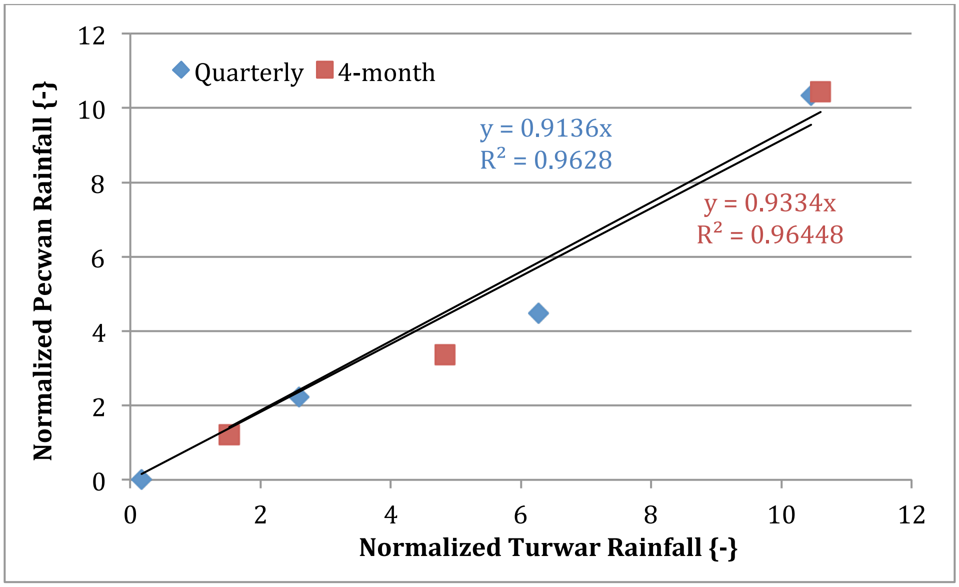
Since precipitation data for Ke'Pel were deemed unreliable, only precipitation data for Pecwan are discussed here. Using the one year of precipitation data available for Pecwan Creek, a relationship was established with nearby Turwar Creek for which an 11-year precipitation record exists. The one year of data collected on Pecwan Creek was broken up into monthly, quarterly, and four-month intervals and correlated to similar intervals on Turwar Creek. Figure 24 and Figure 25 show a strong linear relationship exists between the monthly, quarterly, and four-month averaged rainfalls on the two creeks. This relationship allows for reasonable assumptions to be made about precipitation patterns on Pecwan Creek based on Turwar Creek's longer rainfall record.

Figure 24: Correlation of monthly rainfalls at Pecwan and Turwar Creeks from 3/27/2009 to 3/26/2010.



Source: SERC staff

Figure 25: Correlation of quarterly (blue) and four-month (red) normalized rainfalls at Pecwan and Turwar Creeks from 3/27/2009 to 3/26/2010.



Source: SERC staff

Pecwan's rainfall can be put into a historical context by looking at the longer precipitation record available for Turwar Creek (Table 14). Of the 11 years of data available, the year 2009-2010 fell slightly below average in terms of rainfall.

Table 14: Sorted annual precipitation at Turwar Creek from 3/27/1999 to 3/26/2010

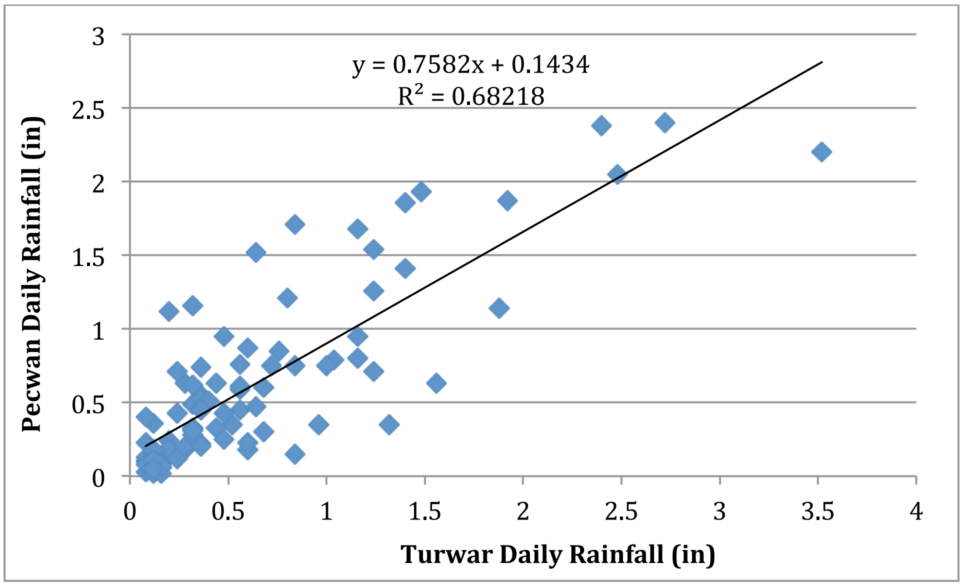
Year	Precipitation (in)
3/27/2005 - 3/26/2006	100.4
3/27/2003 - 3/26/2004	78.0
3/27/1999 - 3/26/2000	74.2
3/27/2002 - 3/26/2003	70.0
3/27/2001 - 3/26/2002	69.6
3/27/2007 - 3/26/2008	68.6
3/27/2006 - 3/26/2007	67.6
11 year average (3/27/1999-3/26/2010)	**67.1**
3/27/2008 - 3/26/2009	60.6
3/27/2009 - 3/26/2010*	**57.4**
3/27/2004 - 3/26/2005	49.3
3/27/2000 - 3/26/2001	42.2

*Precipitation data collected at Pecwan Creek during this period.

Source: SERC staff

To extend the period of record for rainfall at Pecwan Creek, the year of rainfall at Pecwan was used to correlate the daily rainfall events common to both Pecwan and Turwar Creeks (Figure 26). This relationship was only suitable for precipitation events that ranked greater than the 90% exceedance of rainfall at both Turwar and Pecwan Creeks. In other words, rainfall events that were common to both locations were associated with precipitation levels greater than some lower bound (i.e., the 90% exceedance level).

Figure 26: Correlation of observed daily rainfall at Pecwan and Turwar Creeks.



Source: SERC staff

For rainfalls below the 90% exceedance level, a nonlinear relationship was developed that allowed rainfall at Pecwan to reach zero. The following nonlinear relationship was developed:

$$R_P = aR_T^{\,b},$$

Where: R_P is the rainfall at Pecwan,

R_T is the observed rainfall at Turwar,

and a and b are parameters to be estimated.

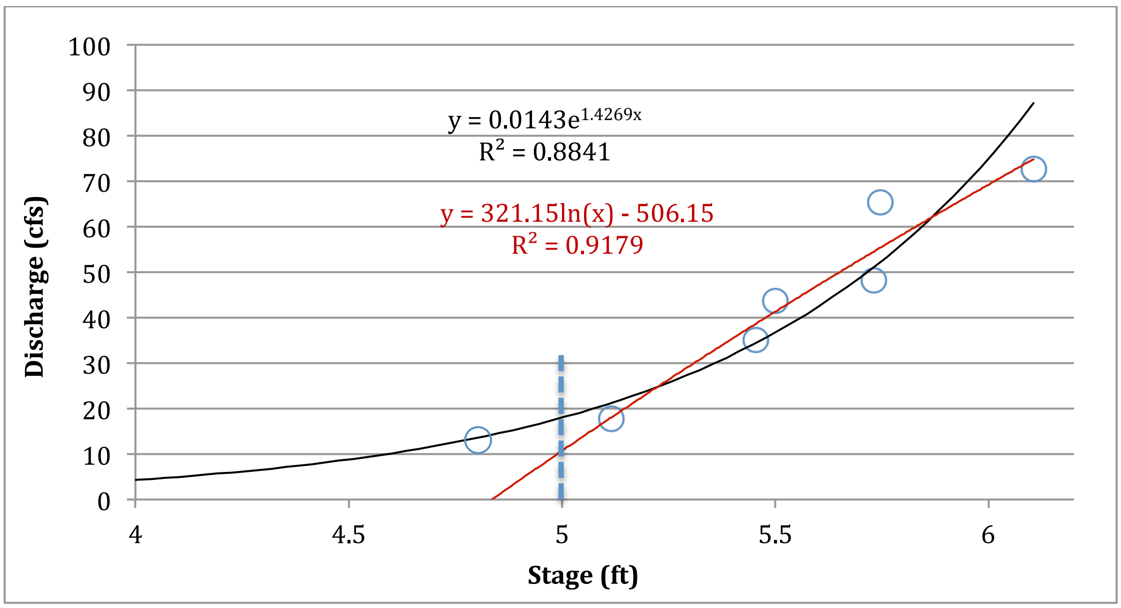
The two parameters, a and b, were estimated by minimizing the sum of squared residuals between the observed data at Pecwan and the calculated data at Pecwan. Estimated values were a = 2.6375 and b = 0.9999. The following piecewise model, which incorporated both the linear and nonlinear relationships, was then used to estimate 11 years of Pecwan rainfall from 11 years of recorded Turwar rainfall (from 10/15/1998 to 5/5/2010):

$$R_p = \text{IF}(R_T>0.04,\ 0.7582*R_T+0.1434,\ a*R_T\text{^}b)$$

Stage-Discharge Curve

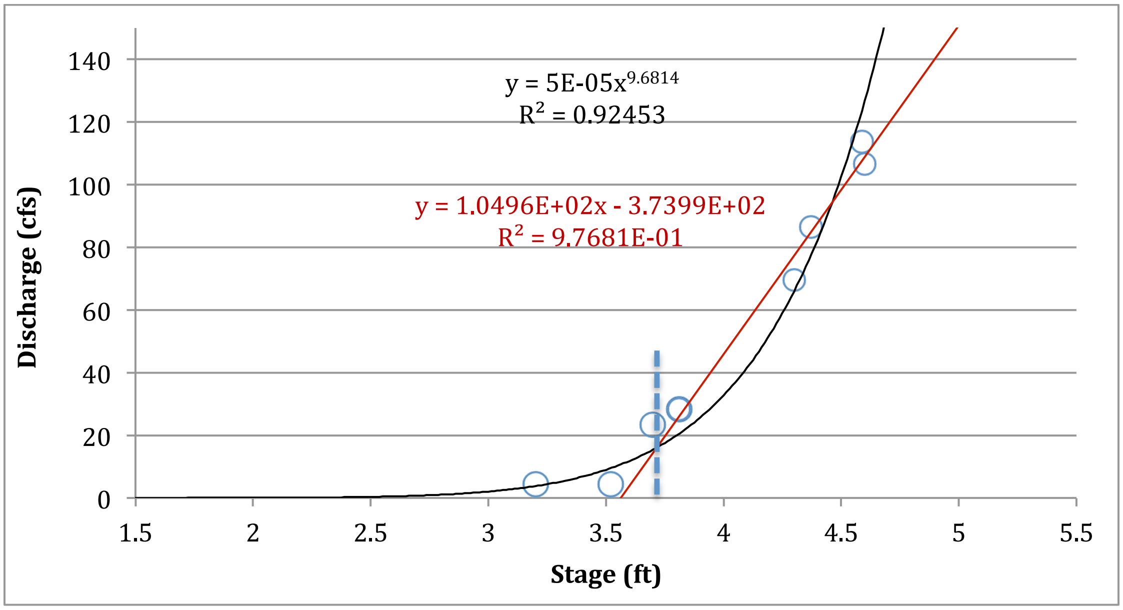
To convert the stage data collected on Pecwan and Ke'Pel Creeks into discharge data, a relationship was established between stage and discharge. Figure 27 depicts the six manual discharge measurements made on Pecwan Creek and the corresponding stage for each measurement. It was determined that the optimal stage-discharge curve is constructed from a piece-wise curve consisting of an exponential relationship at stages below 5 feet and a logarithmic relationship at stages equal to or greater than 5 feet. Similarly, Figure 28 shows the stage-discharge curve developed for Ke'Pel Creek. The optimal curve for Ke'Pel was determined to be a piece-wise curve consisting of a power function relationship at stages below 3.7 feet and a linear relationship at stages equal to or greater than 3.7 feet.

Figure 27: Stage-discharge relationships developed for Pecwan Creek.



Source: SERC staff

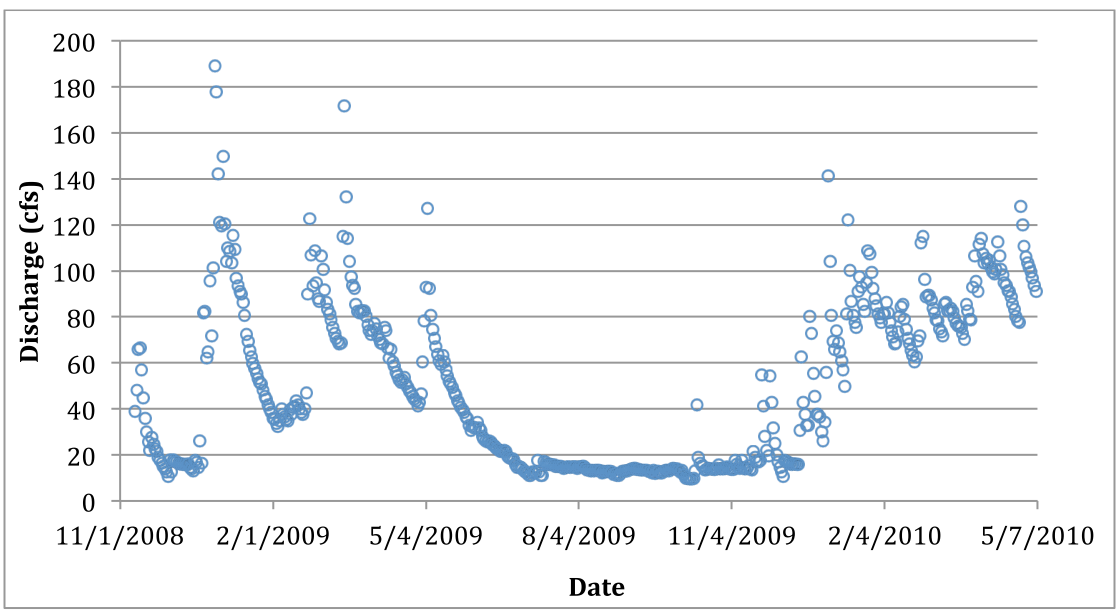
Figure 28: Stage-discharge relationships developed for Ke'Pel Creek.



Source: SERC staff

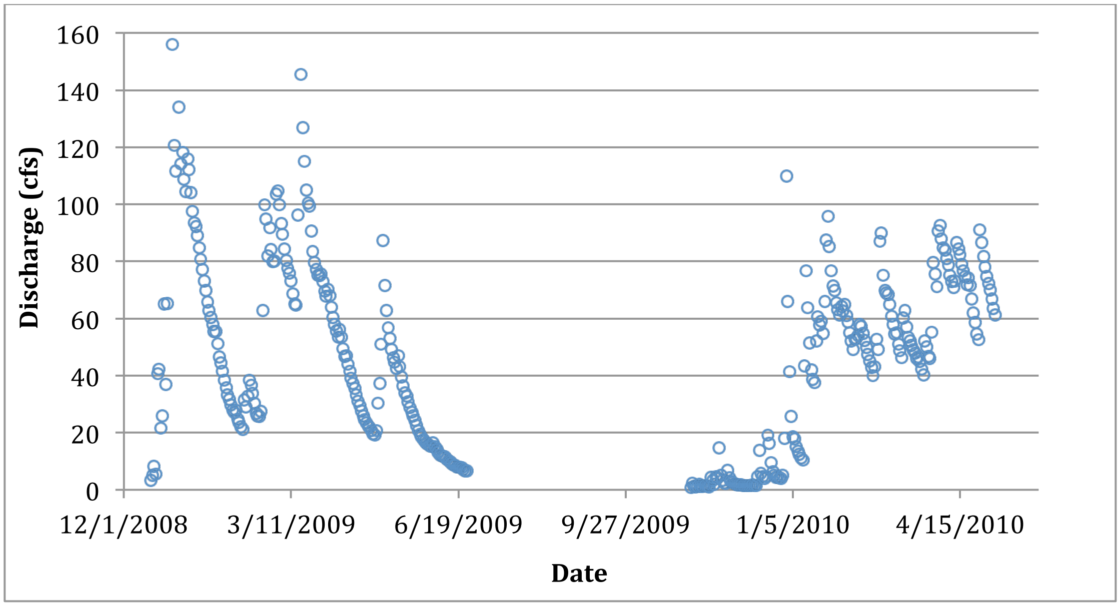
Applying the stage-discharge curves to the stage data collected for Pecwan and Ke'Pel Creeks results in the hydrographs in Figure 29 and Figure 30, respectively. Ke'Pel Creek has a lapse in discharge data from about 6/25/2009 to 11/4/2009. Bridge construction near Ke'Pel Creek required the temporary removal of the gauging station during this period of time.

Figure 29: Hydrograph for Pecwan Creek developed from combined exponential and logarithmic stage-discharge relationships



Source: SERC staff

Figure 30: Hydrograph for Ke'Pel Creek developed from combined power and linear stage-discharge relationships



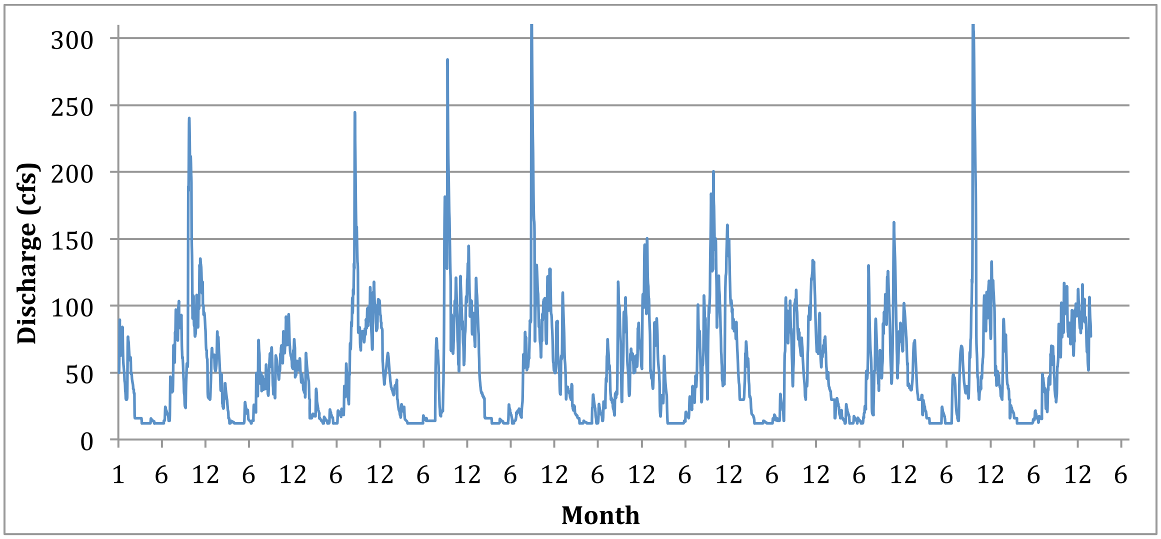
Source: SERC staff

HEC-HMS

The U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) was used to simulate precipitation-runoff on Ke'Pel and Pecwan Creeks (U.S. Army Corps of Engineers, 2010). HEC-HMS was calibrated and run separately for both Pecwan and Ke'Pel Creeks. In both cases, however, the one year of rainfall data collected on Pecwan Creek was used to calibrate the model. These data were used in combination with the discharge data estimated for both Ke'Pel and Pecwan Creeks during the same time period.

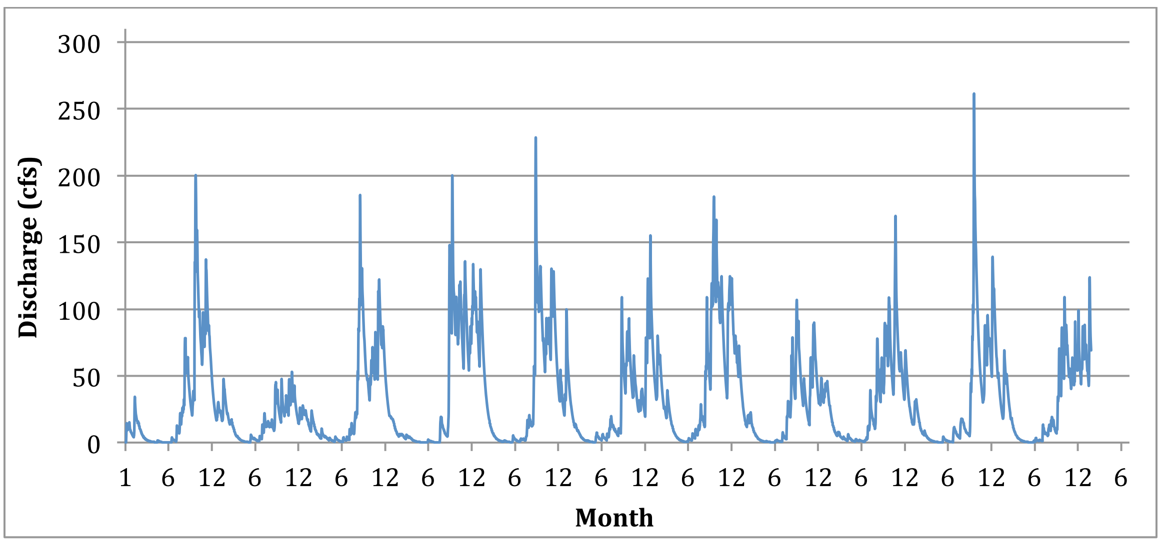
Once the model was calibrated, it was used to estimate a wider range of flows on each creek. This was accomplished by using the 11 years of estimated rainfall data that were discussed above. Figure 31 and Figure 32 depict the 11-year synthetic hydrographs output by HEC-HMS for each creek. Note that according to Pecwan Creek's hydrograph, all of the baseflows level off at 12 cfs. This is because the HEC-HMS method used to estimate Pecwan baseflow assumed a minimum of 12 cfs for the months of July through September in an effort to establish a good fit of the model. A more conservative approach would have been to allow the model to go to zero baseflow. This latter approach was used in the simulation of Ke'Pel Creek flows. We investigated the sensitivity of our results and found that lower summer flows on Pecwan Creek do not have a significant impact on total revenue generated. This is because the majority of revenues from power sales are generated in the winter and spring months when flows are high. For this reason we feel that the 12 cfs minimum base flow assumption on Pecwan Creek is acceptable for this analysis.

Figure 31: HEC-HMS synthetic hydrograph for Pecwan Creek from 1999 to 2010



Source: SERC staff

Figure 32: HEC-HMS synthetic hydrograph for Ke'Pel Creek from 1999 to 2010



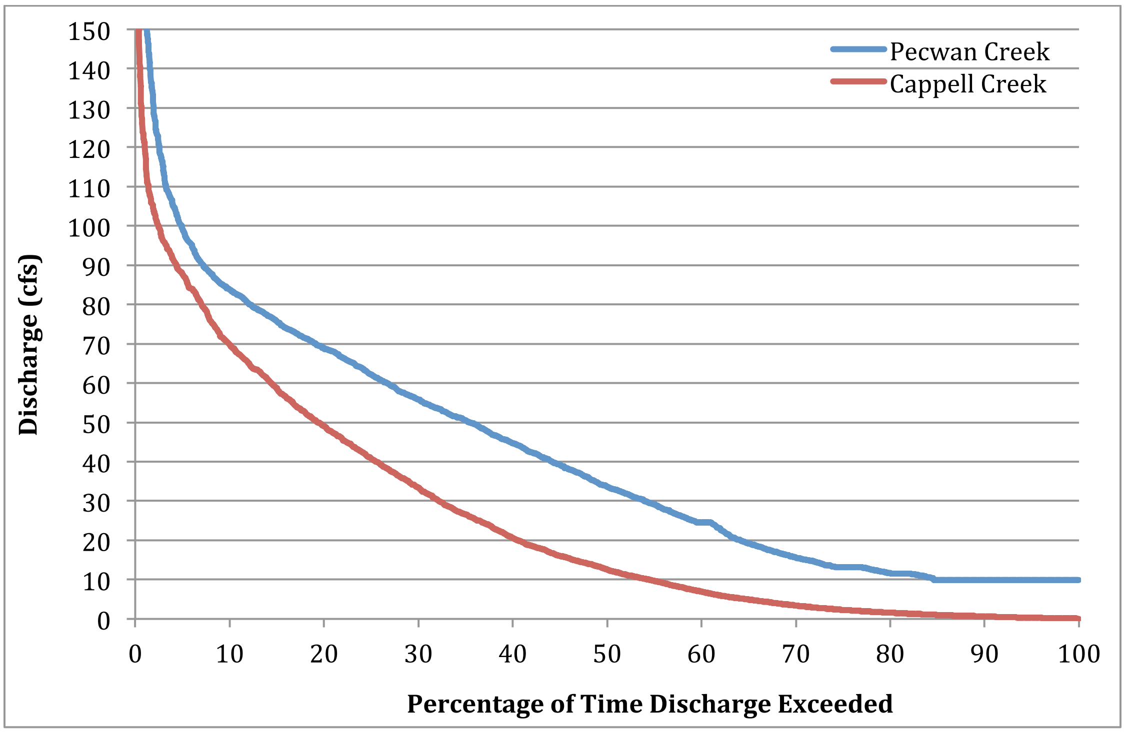
Source: SERC staff

The discharge data underlying the hydrographs are then sorted and used to generate probability of exceedance curves, or synthetic flow duration curves, for Ke'Pel and Pecwan Creeks (Figure 33). These curves have been adjusted for the reduced flow expected at potential intake sites that will be located further upstream than the gauging stations where data were collected. Discharges on Pecwan and Ke'Pel were multiplied by factors of 82% and 81%, respectively. These adjustment parameters were determined based on the ratio of watershed areas. In other words, the watershed area above the expected intake point on Pecwan Creek is 82% of the watershed area above the gauging station on Pecwan Creek (see Appendix E for a watershed area map of Pecwan Creek).

This is a conservative approach since the state's rainfall isohyet map shows rainfall increases pretty strongly as you move upstream in these watersheds.

The flow duration curves show that 95% of all discharges on Pecwan Creek are expected to exceed about 10 cfs, while on Ke'Pel Creek 10 cfs is exceeded only about 55% of the time. On Ke'Pel Creek, discharge is expected drop below 1.0 cfs about 15% of the time, mostly during the dry baseflow season from July to September.

Figure 33: Synthetic flow duration curve for Ke'Pel and Pecwan Creeks from 1999 to 2010

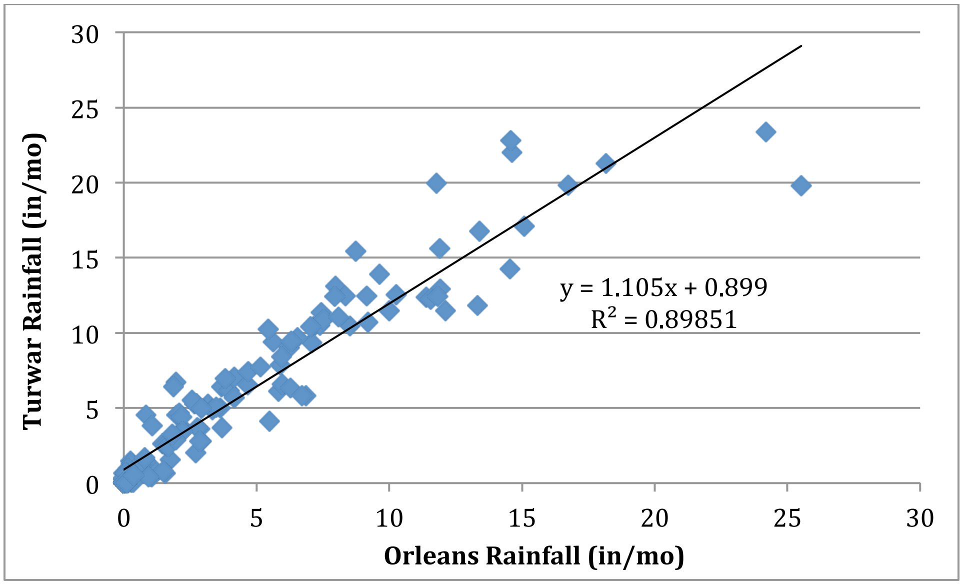


Source: SERC staff

Rainfall in Historical Context

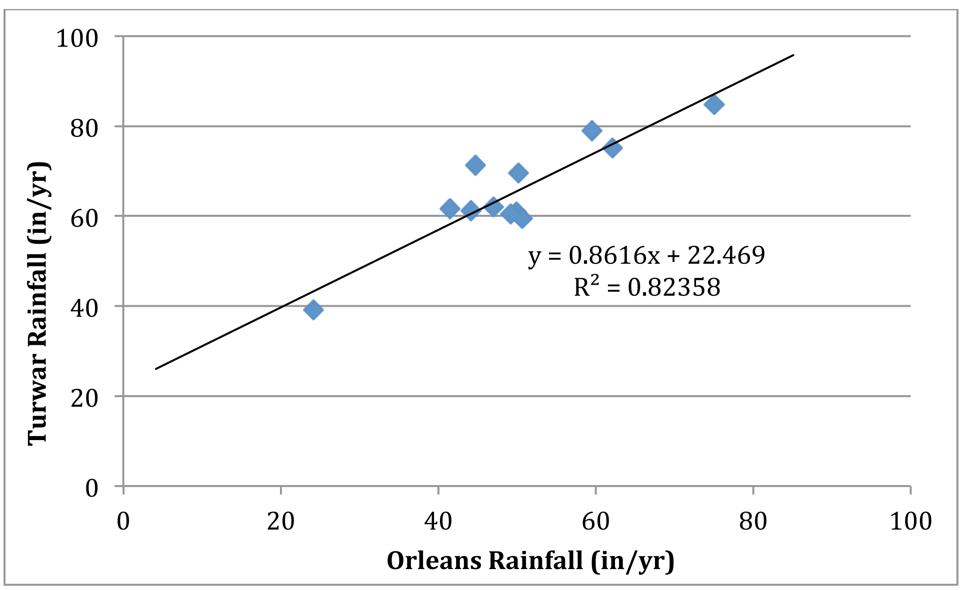
Since a hydroelectric plant is capable of producing power for up to 50 years, it is imperative to place the 11 years of synthetic flow data produced by the HEC-HMS model into a broader historical context. It is conceivable that although the 2009-2010 rainfall year at Turwar represents an average precipitation year in an 11-year span, it may represent an exceptionally wet or dry year over a longer time period. To establish a broader historical context, over 100 years of annual precipitation data (1906 to 2010) at Orleans, CA, were examined. Orleans lies on the Klamath River about 16 miles east of the confluence of Pecwan Creek and the Klamath River. Figure 34 and Figure 35 show a strong linear relationship between monthly and annual rainfalls at Turwar and Orleans between 1998 and 2010. The much longer precipitation record available at Orleans can thus be used to make reasonable assumptions about rainfall patterns on Turwar and Pecwan Creeks.

Figure 34: Correlation of monthly rainfalls at Turwar and Orleans from November 1998 to April 2010.



Source: SERC staff

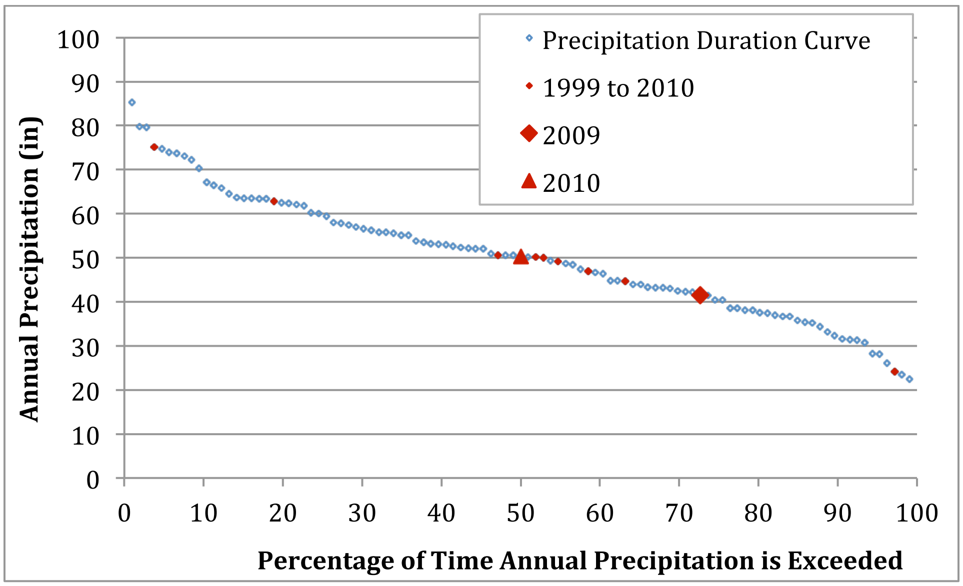
Figure 35: Correlation of annual rainfalls at Turwar and Orleans from 1999 to 2010.



Source: SERC staff

Figure 36 shows annual precipitation at Orleans between 1906 and 2010, plotted in the form of an annual precipitation duration curve. Red markers are used to indicate corresponding years for which data are available at Turwar Creek. Over the last century, the 2009-2010 year represents an average rainfall year (50% exceedance). As previously mentioned, this year represents a slightly below average rainfall year within the 11 years of precipitation data available at Turwar Creek. Coincidentally, this is also the year that precipitation data were collected on Pecwan Creek and the basis for HEC-HMS model calibration. We also see that 3 of the 11 years (2003, 2006, and 2007) for which data are available on Turwar Creek, represent above average annual rainfall years, while the other seven years are below average. In particular, the years 2001 and 2006 represent exceptionally dry (in the lower quartile) and wet (in the upper quartile) years, respectively, and can serve as boundary cases for power generation on Pecwan Creek.

Figure 36: Annual precipitation duration curve at Orleans from 1906 to 2010 with years for which annual precipitation is available at Turwar Creek indicated in red.



Source: SERC staff

Power Generation Potential

The objective of a hydropower system is to convert the potential energy in a moving mass of water into electrical energy. As mentioned above, power potential is dependent on two factors: flow and head. The energy of the falling water is converted to mechanical energy by a turbine, which is in turn converted to electrical energy by a generator. The power output of a hydroelectric system is thus proportional to flow and head and can be expressed by the following power equation:

$$P = 0.051 \cdot Q \cdot h_{gross}$$

Where: P = power output (kW),

Q = volumetric flow rate (cfs),

h_{gross} = gross head (ft),

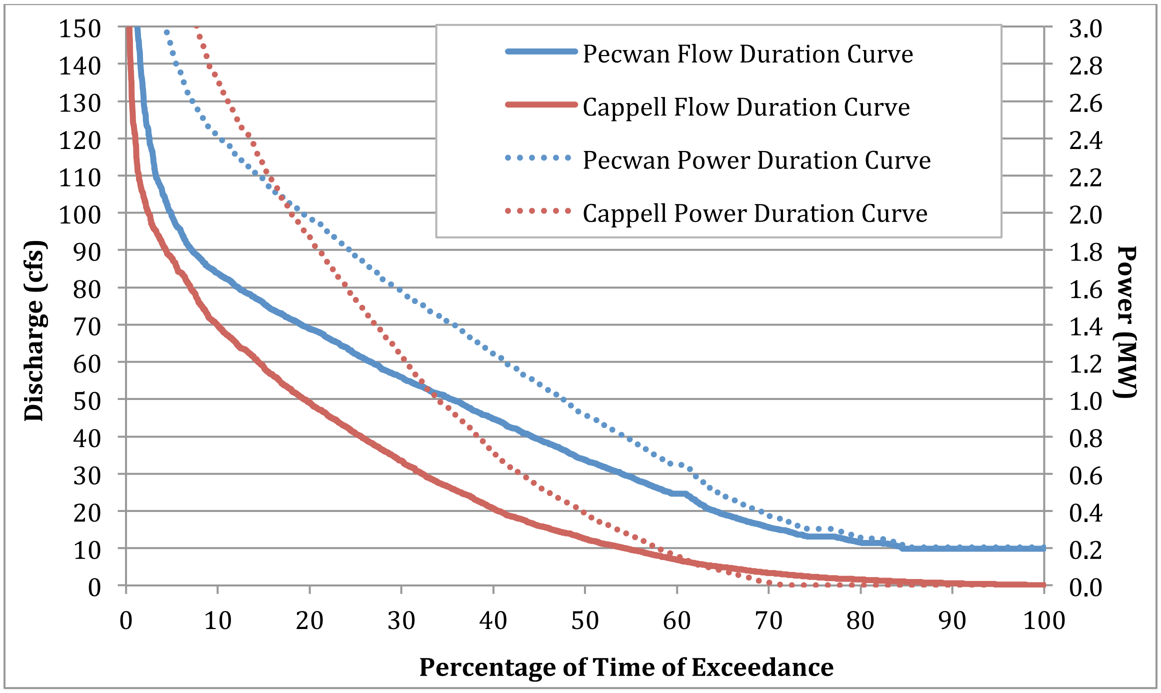
0.051 = unit conversion factor that has a built-in typical hydroelectric system efficiency factor of 60% (McKinney, 1983)

The unit conversion factor accounts for the gravitational acceleration constant, the density of water, and the overall hydroelectric system efficiency. This overall efficiency accounts for the following specific efficiency terms: hydraulic channel, penstock, turbine, generator, electrical transformer, and transmission line efficiencies.

Head potential at each creek is estimated based on GPS coordinates for potential intake and powerhouse sites collected during multiple field visits. Google Earth was used to estimate an elevation difference, or gross head[4], between the intake and powerhouse of about 800 feet on Ke'Pel Creek and 590 feet on Pecwan Creek. Combining gross head estimates with the flow duration curves above and applying equation (1) results in the power duration curves in Figure 37. The power duration curves factor in a reserve or bypass flow of 3 cfs, which refers to the amount of water that must be left in the creek at all times. This parameter directly reduces the amount of useable flow and the value chosen here is an estimate. It is subject to change after a formal environmental impact assessment is conducted. Figure 37 indicates that 95% of the time power generation is expected to meet or exceed 200-kW on Pecwan Creek. On Ke'Pel Creek, power generation is expected to meet or exceed 100-kW about 63% of the time. We also see that there is no power generation on Ke'Pel Creek about 30% of the time.

[4] Gross or static head refers to the elevation head between two points on the stream. Dynamic head is what is available for hydropower production. It is always less than static head because it accounts for the pressure loss that results when flowing water is slowed due to friction with the inner surface of the pipes and to turbulence that results when it passess through pipe fittings.

Figure 37: Synthetic flow and power duration curves for Ke'Pel and Pecwan Creeks from 1999 to 2010



Source: SERC staff

From a system design perspective, Figure 37 suggests that if the goal is to maximize plant capacity factor[5], a hydroelectric system with a capacity of 200-kW could potentially generate power year-round on Pecwan Creek. On Ke'Pel, a hydroelectric system with a capacity of about 100-kW may produce power most of the year except during the baseflow season. Alternatively, if the goal is to maximize energy production, the aforementioned capacities may not be suitable. Moreover, hydroelectric systems are capital intensive and a smaller system may not be the most economically efficient option since larger systems capture the benefits of economies of scale.

As stated in Section 2.3.3, Hydro Technology Assessment, developers aiming to produce the maximum amount of energy for each dollar invested will typically be interested in flows between the 20% to 35% exceedance level. However, preliminary feedback from PG&E suggested a maximum generator capacity of 500-kW could be supported. Table 15 reflects the stream flows required to deliver this capacity.

These parameters were utilized for the preliminary hydroelectric resource assessment. Preliminary economic results for these scenarios are presented in Section 2.8, Identification of Preferred Alternative. Additional turbine sizes were then examined for the preferred Pecwan Creek alternative, including a 125-kW and a 1.5-MW generator. Resource assessment results for the Pecwan Creek preferred alternative can be found in

[5] Capacity factor is related to the portion of the time that a generator runs at either full load or partial load. Capacity factor equals the ratio of the total energy produced over a given period divided by the amount of energy that would have been produced if the generator were running continuously at full capacity during the same time period.

Section 2.10, Final Resource Assessment, and an economic analysis and sensitivity analysis for the Pecwan Creek preferred alternative can be found in Sections 2.11 and 2.12, Economic Analysis and Sensitivity Analysis, respectively.

Table 15: Estimated creek characteristics used for turbine selection

Creek	Capacity Limit (kW)	Gross Head (ft)	Bypass Flow (cfs)	Flow Required to Meet Capacity (cfs)
Ke'Pel	500	800	3	15.4
Pecwan	500	590	3	19.6

Source: SERC staff

2.6 Energy Market Assessment

There are currently tremendous opportunities for the sale of renewable power in California. State policy now calls for 20% of all electricity sold in the state to come from renewable energy, and by 2020 that percentage is set to climb to 33%. This has resulted in a huge increase in the demand for and development of renewable energy in the state. This strong demand and associated environmental benefits allow renewable energy to command a premium price in the electricity market.

Both wind and small, run-of-river hydroelectric power can be developed to help meet the state's renewable energy goals, though hydroelectric power must meet strict eligibility requirements. New small hydropower facilities must be less than or equal to 30-MW in capacity and must not "cause an adverse impact on instream beneficial uses or cause a change in the volume or timing of streamflow" (California Energy Commission, 2011). Projects are evaluated on a case-by-case basis and must adequately demonstrate that they meet the eligibility criteria. This will typically require a stream impact study to show that there will be no adverse impacts.

It is likely the Yurok Tribe could successfully demonstrate that a hydroelectric project on Pecwan Creek would meet state water quality requirements because it would be located entirely above the upper limits of anadromy and the stream has already been identified as being compatible with hydropower development as a beneficial use. In addition, as outlined in Sections 2.13 and 2.14, any new hydropower project in California will be required to meet stringent environmental impact guidelines, otherwise it won't make it through the environmental review and permitting process. It is the impression of the authors that if a new, run-of-river hydroelectric project in California is able to secure the necessary permits for development, it will also meet State requirements to be counted toward the State's renewable energy goals.

As stated at the beginning of this report, the main focus of this feasibility study is on wind and hydroelectric facilities that sell power to the grid. There are a number of possible mechanisms available for achieving this as outlined in Table 16. Each of these options is discussed briefly below; the most promising option is the sale of power to

PG&E via the small renewable feed-in tariff. This option is well suited to the scale of the hydroelectric projects being considered for Pecwan Creek, will likely be the most streamlined option, and will likely offer the best economic outcome for the Tribe. The economic analyses in this study consider both

Table 16: Options for selling renewable power to the grid

Contract Option	Hydro?	Wind?	Capacity Limits	Pricing	Applicability for Yurok Wind/Hydro
Tribal utility	Yes	Yes	N/A	Determined by Tribe	No
Net metering	No	Yes	≤ 1-MW	Full retail rate	No
Local gov't self generation	Yes	Yes	≤ 1-MW	Retail rate, generation only	No
Small renewable feed-in tariff (E-SRG)	**Yes**	**Yes**	**≤ 1.5-MW**	**Market Price Referent**	**Best fit, but will likely run out in few years**
Renewables auction mechanism	Yes	Yes	≤ 20-MW	Competitive bid	Possible
Renewable portfolio standard	Yes	Yes	> 1.5-MW	Competitive bid	No
Qualifying facility (QF)	**Yes**	**Yes**	**≤ 80-MW**	**Standard contracts (short-run avoided cost rate)**	**Possible**

Source: SERC staff

Tribal Utility

If the Tribe formed its own electric utility and owned, operated and maintained it's own electric grid, then they could develop a local generation source and provide the power to their own Tribal utility customers. However, it has already be determined that such a Tribal utility is not feasible (see Section 1.2). A variation on forming a Tribal utility would be to form a Community Choice Aggregation (CCA), but this option would face the same difficulties that a Tribal utility would do to the need for economies of scale to make this work. The Tribe's customer base is simply way too small.

Net Metering

A second option is to provide power to only select facilities. The simplest approach is to locate the generation at the facility needing power and use a net metering arrangement. Net metering is only available for systems that are less than or equal to 1-MW in capacity, and hydroelectric systems are not eligible for net metering. The main problem with this approach is that it does not apply to hydroelectric systems and there are no Tribal owned facilities located on the sites being considered for renewable energy development (Pecwan Creek, Ke'Pel Creek, McKinnon Hill ridge top). Net metering would not allow the Tribe to generate power at one location and transport over PG&E-owned power lines for use at another site.

Local Government Renewable Energy Self Generation Program

The Local Government Renewable Energy Self Generation Program is a newly developed program that became effective on January 1, 2009. It was authorized under Assembly Bill 2466 and codified as Section 2830 of the Public Utilities Code. This program is essentially like net metering, but it allows a local government to install renewable generation of up to 1-MW at one location within its geographic boundary and generate credits that can be used to offset charges at one or more other locations within the same geographic boundary. Tribal governments may be eligible for this program, though that would need to be verified.

To implement this program, Pacific Gas and Electric Company has established electric rate schedule RES-BCT. Under this schedule exported energy is valued according to the generation component only. Also, all participating accounts are required to be on a time-of-use rate, where the price of electricity varies by season and time of day. For Electric Rate Schedule A-1, Small General Service, which most Yurok Tribal government facilities are under, the generation component varies from $0.051 per kWh to $0.110 per kWh, depending on the time-of-use period.

Small Renewable Generator Feed-in Tariff

The small renewable generator feed-in tariff is a standardized power purchase agreement for PG&E customers who install eligible renewable generation up to 1.5-MW in size (and being expanded to 3-MW pending CPUC a proceeding). The tariff, defined under Electric Schedule E-SRG, provides prices that vary according to time of day and season, and are based on the Market Price Referent (MPR). The MPR is an estimate established by the CA Public Utilities Commission of the avoided cost of producing electricity from large combined cycle natural gas turbine power plant. The most current MPR, adopted in 2009, ranges from $0.088 per kWh for a 10-year contract to $0.101 per kWh for a 20-year contract for a project that begins delivering power in 2011. These rates are then adjusted according to established Time-of-Day factors to reflect the fact that power delivered during peak demand periods is more valuable than electricity produced at other times.

PG&E currently has eight small hydroelectric power producers signed up under the E-SRG rate, and four more contracts pending. The generators range in size from 38-kW up to 1.5-MW. The contract terms vary from 10 to 20 years, and the average rate is $0.102 per kWh. Some customers have been signed up under this rate since 2008. There are currently 39 total E-SRG contracts with a total installed capacity of 38.7-MW. The remaining unallocated capacity on the E-SRG rate is only 66-MW, and it is likely this remaining capacity will get used up in the next few years. It is uncertain if additional capacity will be added in the future. See Appendix F for current E-SRG rates.

Renewables Auction Mechanism

The CA Public Utilities Commission established the Renewable Auction Mechanism ("RAM") Program in December 2010. The program was established to provide a streamlined process for utilities to procure energy from new RPS eligible generators up to 20-MW in size. Bids are selected primarily based on price, and procurement is formalized through a standardized, CPUC-approved, non-negotiable Power Purchase Agreement. PG&E is seeking baseload, as-available peak and as-available non-peak generation via the RAM solicitation. The solicitation is a competitive process, and winning bids will receive a specified a price for each megawatt-hour of delivered energy, adjusted by a Time of Delivery schedule.

Renewable Portfolio Standard Request for Offers

In an effort to meet their obligations under the Renewable Portfolio Standard (RPS), PG&E periodically (typically on an annual basis) issues Requests for Offers (RFOs) to solicit bids for renewable electricity. These solicitations are limited to projects that are 1.5-MW or larger in capacity. Smaller projects are expected to participate via the standardized and streamlined small renewable generator feed-in tariff. The full RFO process is more complicated and time consuming, and is a competitive solicitation process.

Qualifying Facility

The Public Utility Regulatory Policies Act of 1978 (PURPA) is federal legislation that requires electric utilities to purchase energy from Qualifying Facilities (QFs). QFs are defined as cogenerators (generating units that simultaneously produce electricity and useful heat) and small power producers (maximum size of 80-MW that use a waste or renewable energy source as their primary fuel). Instead of relying on market competition, utilities are required to purchase electricity from QFs at rates equivalent to the avoided cost, or marginal cost to produce one more unit of power. These prices are designed to simulate a market price for energy.

Short-run avoided costs correspond to a short-term reduction in the amount of energy generated at a utilities most expensive generating facility, and typically account for the cost of fuel and a portion of operation and maintenance costs. Short-run avoided costs are analogous to the "spot-market" price for electric power. Long-run avoided costs, on the other hand, include amortized capital costs and are designed to reflect the type and cost of electric power resources that a utility would have constructed if the QF resources did not exist. The Market Price Referent, discussed above, is a long-run avoided cost estimate. Contracts based on long-run avoided costs are typically long-term contracts, on the order of 15 to 30 years in length.

While QF contracts have predominantly been long-term contracts in the past, the trend these days is toward shorter-term contracts based on the short-run avoided cost, or SRAC. In fact, the only standardized QF contract pricing currently published by PG&E

is based on short-run avoided costs. Currently these rates are not as favorable as the Market Price Referent based E-SRG rates discussed above. See Appendix F for current SRAC rates. Note that it is also possible for power providers to negotiate bilateral agreements with the electric utility on a case-by-case basis, though all transactions must be approved by the CA public Utilities Commission.

Selling to Buyers Other Than PG&E

While the simplest and most direct option for selling wholesale renewable electricity is likely to sell to Pacific Gas and Electric Company, the local incumbent utility, there are options for selling power to other buyers. This includes opportunities to sell power to other CA investor-owned utilities, such as Southern California Edison and San Diego Gas and Electric, to municipal utilities such as the Sacramento Municipal Utility District, and to community choice aggregators or direct access marketers. Of the various contract options discussed above, the Renewable Portfolio Standard Request for Offers and the Qualifying Facility contract options are the only two likely to be applicable for buyers other than PG&E.

While the opportunity to sell power to a buyer other than the incumbent utility may be a worthwhile endeavor, it is not likely to be suitable for the renewable energy development opportunities being explored in this study. This is because the proposed Yurok renewable energy projects are relatively small in size, and projects of this size are better suited to the standardized power purchase agreements that are only available with the incumbent utility. Selling power to other entities will likely be more complicated and will require scheduling and payment for transmission access. These added complications typically only make sense for larger scale renewable energy projects.

Renewable Energy Credits (RECs)

A Renewable Energy Credit (REC) confers to its holder a claim on the renewable attributes of one unit of energy generated from a renewable resource. It consists of the renewable and environmental attributes associated with the production of electricity from a renewable source. RECs are "created" when the renewable electricity is generated and can subsequently be sold separately from the underlying energy. The transfer of REC ownership must be stipulated as part of the power purchase agreement when renewable energy is sold. The list below outlines the transfer of REC ownership under various power sales arrangements:

- Net Metering - customer retains RECs
- RES-BCT – customer retains RECs
- Feed-in Tariff – PG&E owns RECs for any power purchased
- RAM/RPS – PG&E owns RECs for any power purchased
- QF – REC ownership for renewable power sold under a QF contract is determined by state law, CA Senate Bill 107 prohibits the creation of RECs associated with energy generated by QFs under PURPA contracts

2.7 Identification of Preferred Alternative

Once the resource assessment was completed for both the potential wind and small hydropower sites, we conducted a preliminary economic analysis and made an initial comparison among the three options. Table 17 presents some basic economic metrics for each option. It compares the 500-kW hydro turbines at both Pecwan and Ke'Pel Creeks with the most economically favorable wind option, a 750-kW turbine manufactured by Unison. All cases use the more favorable small renewable generator (E-SRG) feed-in tariff rate. Note that these assessments were preliminary and do not include refined design parameters or complete cost information (e.g., costs for required electric grid upgrades are not included in these comparisons). These ignored costs are expected to be similar for all three options and thus do not have a bearing on the comparison.

Table 17: Preliminary economic screening of wind and hydro alternatives

Project	Capacity (kW)	LCOE ($/MWh)	NPV (Million$)	IRR (%)
Pecwan Hydro	500	44.7	6.71	12.8
Ke'Pel Hydro	500	60.8	2.42	6.9
McKinnon Hill Wind (high cost scenario, U57 turbine)	750	66.9	3.03	8.5

Source: SERC staff

Based on the results of this analysis, we determined that a small hydro project on Pecwan Creek is substantially more promising economically than either hydro on Ke'Pel Creek or a wind project on McKinnon Hill. Additional factors discussed below, such as potential environmental and cultural impacts, also lead to a preference for the Pecwan Creek hydro project. Note that we use the high cost wind scenario in this comparison because we think this is more realistic given the remoteness of the McKinnon Hill location and the relatively small scale of the project (no more than about 1 to 2-MW, maximum). In addition, it should be noted that the wind turbine alternative exhibited in Table 17 had a capacity factor that was almost two standard deviations above the mean capacity factor for all turbines. This turbine was an outlier in this respect and we urge caution that the performance parameters may be overly optimistic.

The remainder of this report therefore considers the proposed Pecwan Creek hydroelectric project as the preferred alternative and examines this option in more detail. This includes a more thorough engineering and economic analysis as discussed in Sections 2.9 through 2.12. In addition, permitting requirements and a preliminary environmental assessment are discussed and a project development plan is outlined for moving the project forward should the Tribe desire to do so.

2.7.1 Preliminary Economic Screening Methodology

We conducted a lifecycle assessment for each of the proposed projects by estimating both the associated costs and revenues. For our preliminary economic analysis we did not acquire project-specific cost data. Instead, we used generalized estimates in terms of cost per installed unit of generation capacity ($/kW). These cost estimates were based on a review of the literature and consultation with an experienced wind energy consultant. Our life cycle project period was assumed to be 50 years and we used a real discount rate of 3%. The hydropower systems have an assumed lifetime of 50 years and the wind turbines are assumed to last 25 years. We neglected the cost of financing and tax implications (taxes on income or tax incentives). We also neglected the cost of any necessary transmission upgrades.

Two rate schedules were used to model the revenues earned for generated electricity: one was the qualifying facility (QF) short-run avoided cost schedule and the other was the small renewable generator (E-SRG) schedule. Both of these rate schedules are based on the avoided cost of producing electricity from natural gas power plants and both provide prices that vary according to time of day and season. When estimating wind energy revenues rates were applied according to time of day and season in order to capture the impact of diurnal and seasonal wind patterns. When estimating hydroelectric revenues, weighted average daily rates were developed and applied seasonally because the hydroelectric resource essentially varies by month, but not by hour. We projected these rates 50 years into the future using the Energy Information Administration's escalation rate of 1.41% (EIA, 2011) for the price of natural gas for electric power producers. The QF rate was escalated and applied on an annual basis, while the E-SRG rate was escalated applied assuming five sequential fixed contracts, each of a ten-year term. See Section 2.6 and Appendix F for more information on these rate schedules.

2.7.2 McKinnon Hill Wind Preliminary Screening

The economic viability of a wind energy system on McKinnon Hill is marginal at best. Although the NREL wind resource maps indicate the site might rank as high as Class 4 or Class 5 in rated wind speed, that did not turn out to be the case. Instead, McKinnon Hill ranks as a Class 1 or 2 wind speed site. Modern utility-scale wind turbines typically require Class 4 or stronger winds, while small turbines may operate economically in areas with Class 2-3 wind resources. This means that larger wind turbines (100-kW and above) that are intended to generate power for sale to the grid do not make economic sense for the McKinnon Hill site. A small wind turbine (i.e., 1-kW), however, might make sense for providing power to a stand-alone telecommunications tower located on McKinnon Hill. This is discussed further below.

In addition to the poor economic performance for the wind energy option, there are other issues that make large wind turbines undesirable on McKinnon Hill. There is a sacred cultural site located on the McKinnon Hill ridge that could be impacted by a wind resource development project. In addition, the Tribe is in the process of joining the California Condor Recovery Team and is participating in a $200,000 grant from the U.S. Fish and Wildlife Service to do a feasibility study for the reintroduction of the rare bird in Yurok ancestral territory. A wind energy project on McKinnon Hill might also conflict with these efforts.

Utility-scale Wind Economics

Below are the results of the preliminary economic analysis for the development of wind power on McKinnon Hill. This analysis was intended as a preliminary screening to assess whether wind power would be economically feasible, and to compare the merits of wind power with small hydropower at Pecwan and/or Ke'Pel Creeks. It must be stressed that this analysis was preliminary and neglected some critical system components such as the cost of transmission and interconnection to the grid and the cost of financing the project.

The costs used in this analysis were based on estimates provided to us by an experienced community-scale wind power consultant (Rigaud, 2010). Mr. Rigaud provided us with a lower and upper bound to the cost per installed Watt of capacity that he has observed in actual systems. The cost data are listed in Table 18.

Table 18: Low and high cost assumptions used in the preliminary wind economic analysis (Rigaud, 2010).

Cost Scenario	Turbine Cost ($/W)	Installed Cost ($/W)	O&M (% of installed cost)
Low	1	1.8	1
High	1.4	2	2

Source: SERC staff

Though our cost data were generic and simplified, we were able to produce a detailed estimate of the revenues from a potential wind power system. A listing of the turbines considered for the utility-scale wind analysis is given in Table 19. For each wind turbine considered, we estimated the average capacity factor for each hour of the day in each month of the year. To make the revenue estimates comparable across various turbines of different ratings, we assumed the overall capacity of the project is 1-MW and adjusted the number of turbines accordingly for each turbine type.

Table 19: List of turbines considered for utility-scale wind project.

Turbine Name	Description	Rated Capacity (kW)	Hub Height (m)	# of Turbines Assumed
AWE 54-900	Americas Wind Energy 54-900	900	75	1.11
G80	Gamesa G80-2.0-MW	2000	80	0.50
N1000	Nordic N1000	1000	70	1.00
NORWIN225	Aeronautica Norwin 29-225	225	40	4.44
NORWIN750	Aeronautica Norwin 47-750	750	50	1.33
T600	Turbowinds 600	600	60	1.67
U57	Unison U57 750kW	750	68	1.33
V39/500	Vestas 500kW	500	40	2.00
WES30	Wind Energy Solutions 30-250kW	250	50	4.00
V20/120	Vestas 120kW	120	23.5	8.33

Source: SERC staff

Our life cycle project period was assumed to be 50 years, with an expected lifetime of 25 years for the turbines themselves. Thus, one total replacement of the generation infrastructure was necessary to model the 50-year life cycle economics. We examined the revenue generation potential under both the QF short-run avoided cost rate schedule and the E-SRG feed-in tariff. For each hour of the day and month of the year, we multiplied the price of electricity by the estimated energy production to estimate the revenue generation for that hour/month combination. We then summed the revenue for all 24 hours in a day and multiplied by the number of days in that month to yield the monthly revenue estimate.

Preliminary economic analysis results for all of the turbines considered are presented in Table 20. Additional metrics were calculated for three of the most promising turbines and are summarized in Table 21. The turbine with the most favorable capacity factor and economic results is the Unison U57, produced by a South Korean manufacturer. However, the capacity factor for the U57 was 1.8 standard deviations above the mean capacity factor of all the turbines analyzed. This may not be large enough of an outlier to justify disregarding the results for the turbine, but it is a large enough difference that the results based on the U57 should be treated with caution. The estimates for the other two turbines (the Americas Wind Energy 54-900 and Nordic N1000) are much more likely to be representative of the actual development of medium scale wind at McKinnon Hill.

Table 20: Economic lifecycle assessment results for all turbines considered.

Low Cost Scenario				
	Net Present Value		Simple Payback (years)	
Name	QF	E-SRG	QF	E-SRG
AWE 54-900	$980,393	$3,274,201	19	14
G80	$905,033	$3,164,878	19	14
N1000	-$98,138	$1,689,627	25	18
NORWIN225	-$537,515	$1,053,794	NA	21
NORWIN750	-$196,351	$1,552,198	25	19
T600	-$172,302	$1,560,622	25	19
U57	$2,287,949	$5,221,555	15	11
V39/500	-$842,651	$592,832	NA	22
WES30	-$303,209	$1,388,360	NA	20
V20/120	-$2,029,149	-$1,118,722	NA	NA
High Cost Scenario				
	Net Present Value		Simple Payback (years)	
Name	QF	E-SRG	QF	E-SRG
AWE 54-900	-$792,607	$1,501,201	NA	20
G80	-$867,967	$1,391,878	NA	20
N1000	-$1,871,138	-$83,373	NA	NA
NORWIN225	-$2,310,515	-$719,206	NA	NA
NORWIN750	-$1,969,351	-$220,802	NA	NA
T600	-$1,945,302	-$212,378	NA	NA
U57	$514,949	$3,448,555	22	14
V39/500	-$2,615,651	-$1,180,168	NA	NA
WES30	-$2,076,209	-$384,640	NA	NA
V20/120	-$3,802,149	-$2,891,722	NA	NA

Source: SERC staff

Table 21: Economic life cycle assessment results for the three most promising wind turbines considered.

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

Low Cost Scenario						
	QF			E-SRG		
Name	NPV	LCOE ($/MWh)	IRR	NPV	LCOE ($/MWh)	IRR
AWE 54-900	$1,344,554	$62	5.9%	$3,099,317	$62	8.8%
N1000	$1,154,395	$155	4.2%	$4,193,595	$155	6.8%
U57	$3,908,057	$99	7.8%	$7,648,405	$99	11.0%

High Cost Scenario						
	QF			E-SRG		
Name	NPV	LCOE ($/MWh)	IRR	NPV	LCOE ($/MWh)	IRR
AWE 54-900	$392,294	$84	3.8%	$2,147,058	$84	6.5%
N1000	-$961,737	$210	2.1%	$2,077,462	$210	4.6%
U57	$2,320,957	$134	5.5%	$6,061,305	$134	8.5%

The economic metrics reported are net present value (NPV), levelized costs of energy (LCOE in $/MWh), and internal rate of return (IRR). Pricing schedules modeled were qualifying facility (QF) rates and small renewable generator (E-SRG) rates.

Source: SERC staff

Off-grid Wind for Telecommunications Site

As discussed in Section 2.5.2, four small, off-grid wind turbines were found to be potentially applicable for providing power to the new McKinnon Hill telecommunications facility. Table 22 shows the estimated retail cost for each of these turbines (including an associated 80-foot guyed tower). The table does not include installation costs, balance of system costs (i.e., for wire, conduit, etc.), or additional components that may be necessary (such as a charge controller and dump load).

Table 22: Off-grid wind turbine and tower costs

	Xzeres 100	SW Windpower Whisper 200	SW Windpower Whisper 500	Kestrel e400i
Rated power (W)	2,570	1,010	3,340	3,150
Rated wind speed (m/s)	10.5	11.5	12.5	11.5
Turbine Cost	$ 11,800	$ 3,400	$ 8,800	$ 11,200
Tower Cost (80' guyed tower)	$ 3,000	$ 3,000	$ 3,000	$ 3,000
Total	**$ 14,800**	**$ 6,400**	**$ 11,800**	**$ 14,200**

Turbine cost data source: HomePower Magazine June/July 2010
Tower cost data source: SERC staff estimate

Source: SERC staff

We did not conduct an economic analysis to determine the cost effectiveness of using a wind energy system at the McKinnon Hill telecommunications facility. However, the Tribe has expressed interest in using solar and/or wind energy to provide power at the facility, and we think this could be done at reasonable cost. A renewable energy system at this location would bring numerous benefits, including reduced costs associated with diesel fuel and generator maintenance, fewer fuel deliveries to the remote location, and reduced noise and pollution. It is likely that either solar and/or wind energy could be effectively utilized.

Although examination of a solar electric system was beyond the scope of this study, a Humboldt State University Environmental Resources Engineering class did prepare a preliminary design for a solar electric system for the McKinnon Hill telecommunications facility (Zoellick, 2011). This included an analysis of available solar radiation and an assessment of shading impacts at the site. Based on this information it is estimated that a 2.5 to 3-kW system would be required to meet 95% to 98% of the load. A 2-kW system would likely meet about 90% of the load.

Solar electric module prices have dropped substantially over the last few years. Between May of 2010 and May of 2011, retail prices of solar electric modules rated at 125-kW or more ranged from $3.07 to $3.78 per peak watt (Solar Buzz, 2011). We assume a cost of $3.50 per watt for solar electric modules plus $1.00 per watt for pole mount racks. Costs associated with the solar modules and rack can be compared directly against the turbine and tower costs shown in Table 22, since additional costs are likely to be similar for both systems.

A 2-kW solar electric system would provide approximately the same amount of useful energy as the Southwest Windpower Whisper 200 or Kestrel e400i wind turbines. The cost of the 2-kW solar electric system (modules and rack only) is expected to be about $9,000, compared to $6,400 for the Whisper 200 and $14,200 for the Kestrel e400i. For a system that meets nearly the entire energy demand at the site, a 3-kW solar electric system priced at $13,500 compares with the Southwest Windpower Whisper 500 or the Xzeres 100 priced at $11,800 to $14,800, respectively. These preliminary numbers show that off-grid wind and solar electric systems can be price competitive in this application.

As noted in Section 2.5.2, wind and solar energy resources complement each other, with the solar resource peaking in the summer months and the wind resource in the winter months. For this reason, a hybrid system that incorporates both technologies may turn out to be optimal for this application. It also should be noted that the discussion above assumes that sufficient tree cover will be removed at the McKinnon Hill telecommunications site and that wind speeds will be similar to those observed at meteorological tower site.

2.7.3 Pecwan and Ke'Pel Creeks Hydro Preliminary Screening

We found that the proposed Pecwan Creek hydroelectric project offers the most economic benefit to the Tribe and the most promise for future development. The Pecwan site possesses numerous characteristics that make it more favorable than a comparable site on Ke'Pel Creek.

A key issue for any hydropower development project on the Reservation will be potential impacts to anadromous fish. Both Pecwan and Ke'Pel Creeks have been designated by the Tribe as suited for hydropower development as a beneficial use largely because both creeks have natural features that limit access for anadromous fish. However, according to fisheries specialist Dan Gale, these limits are better defined and understood at this time for Pecwan Creek. More importantly, a hydropower project located on Pecwan Creek can be situated so that the entire project is located above the upper limits to anadromy, and this is not the case for Ke'Pel Creek. It is expected that this fact alone would make it very difficult to get environmental and permitting clearance for hydropower development on Ke'Pel Creek. In addition to these issues, the Pecwan hydropower site has much better existing road access, which will also tend to make the overall impacts of hydropower development less on Pecwan Creek.

In terms of economic feasibility, the Pecwan Creek site is far superior to the Ke'Pel Creek site. This is due to the fact that there are larger flows on Pecwan Creek throughout the year, resulting in a much higher capacity factor. This allows a system on Pecwan Creek to generate more energy and therefore more revenue on an annual basis. Table 23 shows the economic comparison between the Pecwan and Ke'Pel projects.

Both projects were modeled with 500-kW generators, and upfront cost was estimated using the Schatz Energy Research Center (SERC) River Hydroelectric Impact Assessment Model (RHIAM). RHIAM uses a fixed cost per kW of installed capacity ($4,500 per kW) and a fixed annual O&M cost ($124 per kW) based on cost data and assumptions from the literature and using Humboldt County-specific information drawn from interviews (Hackett et.al., 2011). The RHIAM cost estimate does not include power transmission or grid interconnection infrastructure. Power production was estimated based on average daily streamflows by month, and revenues were calculated using daily average power purchase rates under both the QF and E-SRG rate structures.

Table 23: Preliminary economic results for Pecwan and Ke'Pel hydro projects

Project	Capacity Factor	QF			E-SRG		
		NPV (Million$)	LCOE ($/MWh)	IRR (%)	NPV (Million$)	LCOE ($/MWh)	IRR (%)
Pecwan Hydro (500-kW)	84.4%	2.8	44.7	7.4	6.71	44.7	12.8
Ke'Pel Hydro (500-kW)	56.9%	0.73	60.8	4.3	2.78	60.8	7.5

Source: SERC staff

For the reasons discussed above, the Pecwan Creek hydropower project alternative has been chosen as the preferred project alternative.

2.8 Electrical Grid Assessment

Initial information from PG&E indicated that the 12-kV, single-phase power lines being extended to the village of Wautec on the Yurok Reservation, which would be the lines to which a Pecwan Creek or Ke'Pel Creek system would intertie, could support up to a 500-kW generator, and an upgrade to three-phase could support up to 2-MW. However, with further investigation PG&E revised their estimates to indicate that the single-phase lines could handle only about 125-kW. In addition, they indicated that larger three-phase generators could be possible with line upgrades on the Yurok Reservation and with upgrades in the distribution system all the way back to the Hoopa substation (approximately 30 miles from the proposed project sites). Final determination of the required grid upgrades associated with the interconnection of any size hydroelectric generator will require a full interconnection study.

The following section documents our preliminary assessment of the technical limitations and upgrade costs related to connecting an electric power generator to the grid at or near the mouth of Pecwan Creek. There is an existing 12-kV distribution line from the town of Hoopa currently reaching as far as Ke'Pel Creek on the Yurok Reservation. An extension of this line to Pecwan Creek and eventually to the village of Wautec is still under development. This 12-kV line would be the only circuit it would be practical for a Pecwan Creek hydropower generator to connect to.

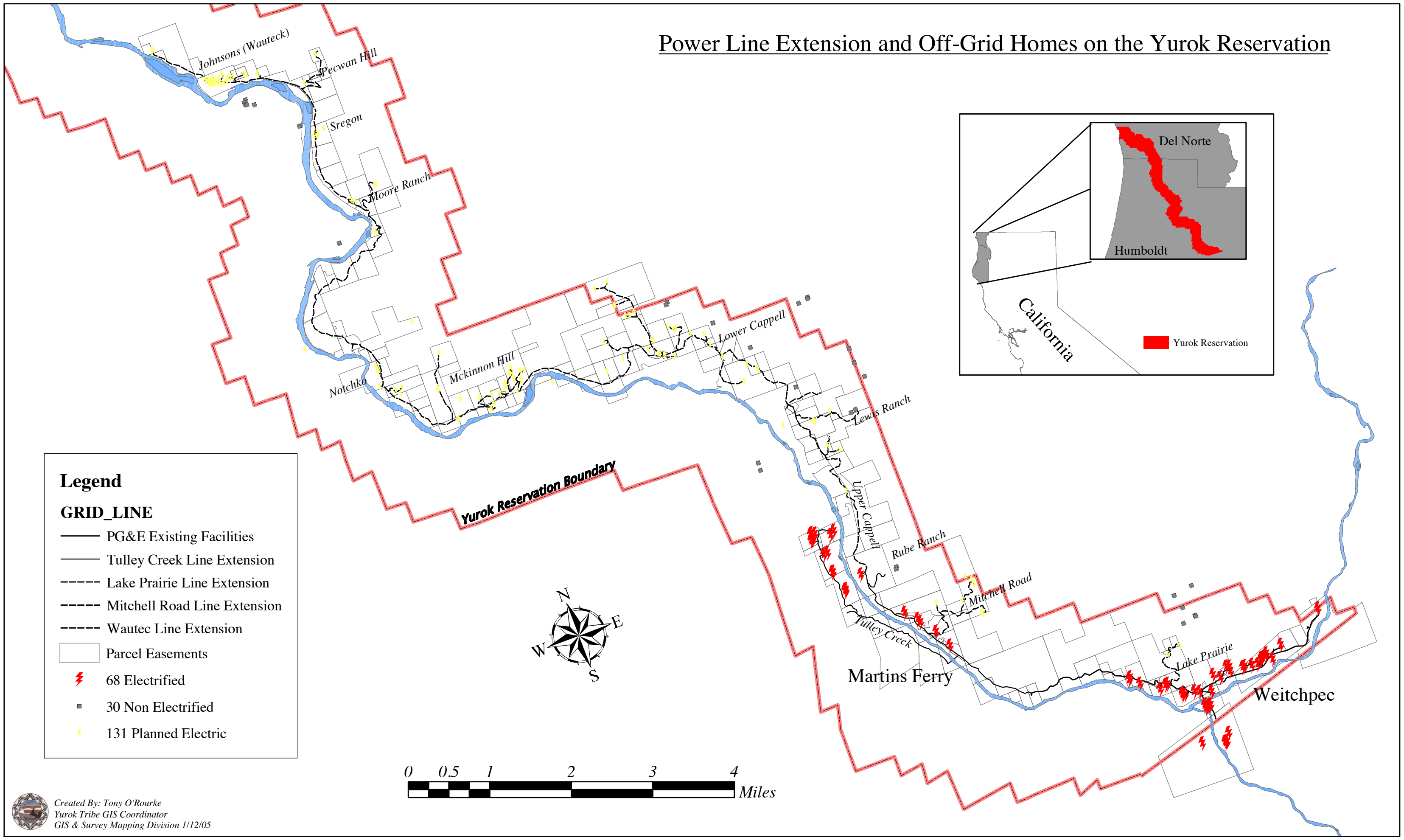
2.8.1 Existing Distribution Infrastructure

On the south end of the Yurok Reservation, the town of Weitchpec along with residences and tribal facilities within approximately five miles of Weitchpec are currently served by Pacific Gas & Electric via a 12kV distribution line (Figure 38). The line connects to the nearest substation in Hoopa Valley, about 11 miles from Weitchpec. Downstream from Weitchpec, the line runs along Route 169 to a point just north of Martin's Ferry Bridge, about 3.3 miles, where it crosses the river to serve loads on the other bank. The distribution circuit is three-phase, and the gauge of the wire between Weitchpec and the Hoopa substation is 1/0, while the gauge is 4 ACSR downstream from Weitchpec (Phillips, 2011).

2.8.2 Wautec Line Extension

The Tribe has been in the process of extending the PG&E distribution line from Martin's Ferry Bridge downstream to the town of Wautec. The extension will mostly continue along Route 169 and will pass over the mouth of Pecwan Creek, which is approximately 15.6 miles from Martin's Ferry Bridge. The extension will be single-phase (two instead of three conductors) and the gauge of the wire will be 4 ACSR. Construction of the extension is complete, though not energized, as far as Ke'Pel Creek, but the remaining stretch (to Wautec) will not be completed until sufficient funds have been secured.

Figure 38: Yurok reservation distribution line extension map.



Source: Yurok Tribe GIS Department

2.8.3 Power Transmission Capacity Constraints

A combination of factors presents obstacles to the Tribe's ability to interconnect a hydropower generator to the electric grid at Pecwan Creek. These include the distance from Pecwan Creek to the Hoopa substation (approximately 30 miles), the size of the wires on the existing circuit and Wautec extension, and the fact that the planned Wautec extension line will only be single-phase at Pecwan Creek.

The limiting constraint to interconnecting generation capacity on the distribution line is the impact the generator would have on the system voltage. In order to transmit power from the generator back to the Hoopa substation, the voltage at the point of interconnection must be sufficiently raised by the generator to cause current to flow over the 30-mile circuit, overcoming line losses along the way. This increase in voltage, however, cannot exceed a certain threshold (roughly 5% of the nominal system voltage) due to regulatory constraints requiring voltage to remain within +/-5% of nominal for all customers. The long length of the distribution circuit and the relatively small wire sizing both contribute to relatively large line losses between Pecwan and Hoopa, which ultimately results in less power that can be interconnected while maintaining system voltage within the limits. In the context of power generation on a remote distribution circuit, this voltage constraint becomes the limiting factor before the thermal limit of lines, which is related to the ampacity of the conductors.

The voltage constraint problem is amplified by the fact that the Wautec line extension will be single-phase. Single-phase generators necessarily require higher current (and therefore higher line losses) to transmit an equivalent amount of power than a three-phase generator. Furthermore, while single-phase hydroelectric generators do exist, they are generally small (<100-kW), because at larger sizes there are technical limitations and it is more efficient and cost-effective to use three-phase generators (Melander, 2011 and Sellars, 2011). It is technically possible to purchase a 500-kW single-phase generator (Prior, 2011). However, it is likely that such a generator would be larger than can be accommodated on the Wautec distribution line (PG&E, 2011a). In addition, single-phase generators of this size are uncommon and the vendors we spoke with generally did not recommend them. We therefore do not recommend a large single-phase generator without further research and extensive discussion with industry professionals.

2.8.4 Voltage Regulation

One potential solution to the impact on voltage of distributed generation is the installation of bi-directional voltage regulators on the distribution line. A voltage regulator is analogous to a lift pump in a water distribution system. As power transmits along the line, the voltage drops progressively lower. Before it falls below the low-voltage threshold (-5% of nominal), a regulator can raise the voltage up to some higher value (e.g. +4% of nominal) thereby extending the reach of the circuit.

Traditionally, distribution circuits are designed to deliver power in a single direction, from the substation out to the loads. So voltage regulators are usually designed to boost voltage in one direction only. However, a voltage regulator used to control voltage in the context of a small hydroelectric generator on the Yurok distribution circuit would need to be a bidirectional regulator able to boost voltage as power flows from either direction.

Fortunately, bidirectional voltage regulators are presently manufactured and used in situations where generators are interconnected to distribution circuits in remote locations.

2.8.5 Estimation of Transmission Capacity

In order to approximate the practical limit to the capacity of a hydroelectric generator installed at Pecwan Creek, we conducted an analysis of the existing and currently planned distribution line and potential upgrades to the line. We investigated the following three scenarios:

1. The existing distribution system is retained with no upgrades.
2. The existing line is upgraded from single- to three-phase between Pecwan and Martin's Ferry Bridge, as well as an increase in conductor size from 4 ACSR to 1/0 between Pecwan and Weitchpec. A single bidirectional voltage regulator is installed near Weitchpec.
3. The existing line is upgraded from single- to three-phase between Martin's Ferry and Pecwan, as well as an increase in all conductor sizes to 4/0 between Pecwan and Hoopa. Two bidirectional voltage regulators are installed roughly 1/3 and 2/3 of the distance between Pecwan and Hoopa.

For each of these scenarios, we modeled the impact on system voltage of a variety of generator sizes until we found the maximum size that would not exceed the constraints on system voltage. The target increase in voltage we chose is 4% of nominal and we assumed that the voltage regulators are configured to increase the voltage from -4% to 4% of nominal, providing a 1% margin of error on both sides of the voltage constraint. Based on this analysis and communications with distribution engineers at PG&E, we estimated the maximum generator sizes we believe are technically feasible for each scenario (Table 24). These estimates are based on limited information about the distribution system and the regulatory constraints that PG&E must follow. We recommend that these results be considered a *very* rough estimate of the system constraints. Only an interconnection analysis (see discussion below) undertaken by PG&E can determine the actual system upgrades necessary to interconnect a hydroelectric generator at Pecwan Creek.

Table 24: Results of estimating the maximum generator size possible for three distribution system configurations.

Scenario	Max Generator Size (kW)
Single-phase - No upgrades	125
3-Phase - All 1/0	600
3-Phase - All 4/0	1850

Source: SERC staff

2.8.6 Interconnection Study Process

The following discussion outlines the probable pathway necessary to plan and permit the interconnection of a hydroelectric generator. The reason we qualify the pathway as "probable" is because much of the specific, detailed requirements would be contingent on the results of the application process, which would likely include an interconnection study performed by PG&E.

Because the generator would be interconnecting with the distribution system, the interconnection procedure would be handled entirely by PG&E, not the California Independent System Operator (CAISO). The interconnection procedure for distribution level generation projects is likely to change in the near future. PG&E has proposed changes to the Federal Energy Regulatory Commission (FERC) and is awaiting final approval. At the time of writing this report, the FERC has not yet accepted the rule change. However, due to the fact that a very similar change was enacted at the transmission level in December of 2010, we outline the expected interconnection process assuming the changes are enacted.

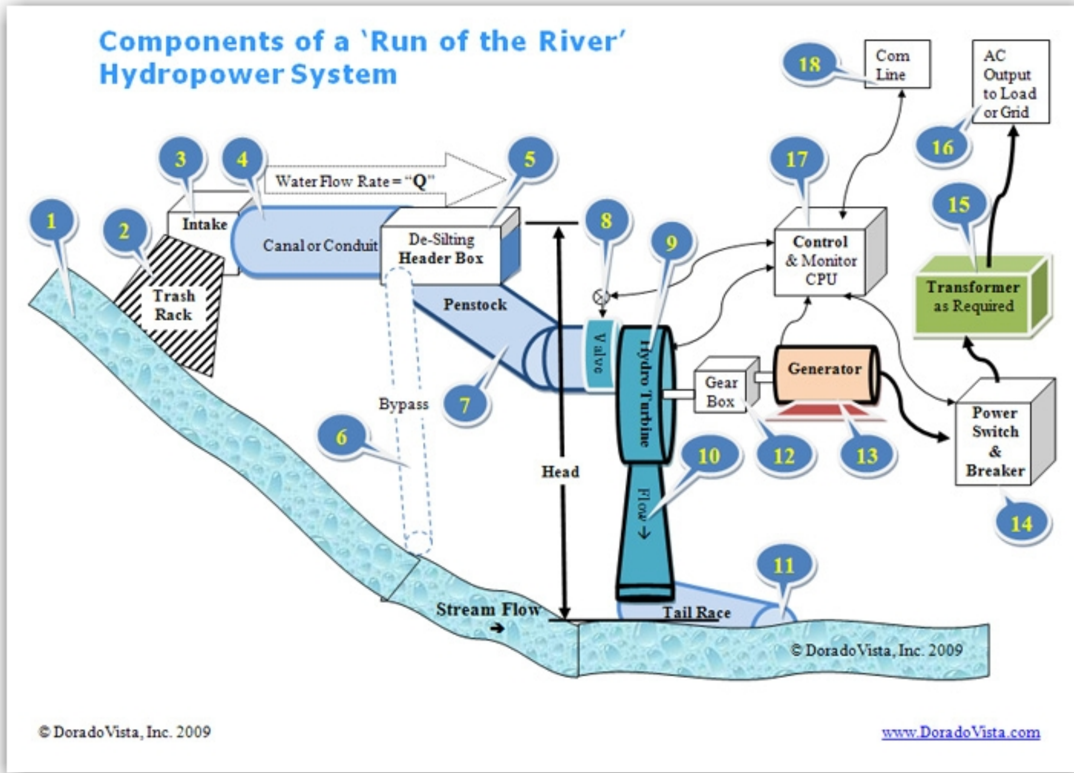
The interconnection process relevant to small hydro at Pecwan Creek is governed by PG&E's Wholesale Distribution Tariff, which will combine small and large generator interconnection applications into a single process. This process involves multiple steps, including a pre-application, an interconnection request, and then either a fast track process, an independent study process, or a cluster study process. The time required and cost incurred varies for each of these processes. This process can take a year or more and cost upwards of $50,000. Appendix G outlines the process in more detail drawing on information compiled from PG&E reports and presentations (PG&E, 2010 & 2011b).

2.9 Preliminary Design Specifications – Pecwan Creek Hydro

The Pecwan Creek hydroelectric project has been identified as the preferred project alternative (see Section 2.7). During the preliminary screening process, a generator capacity of 500-kW was considered for this project. However, as outlined in Section 2.8, there are constraints in the electrical distribution system that will need to be addressed in order to accommodate a 500-kW hydroelectric generator on Pecwan Creek. The added cost of these grid infrastructure upgrades will impact the economic viability of the project. To examine the impact of these added infrastructure costs on project viability, we developed and explored three design scenarios: (1) a 125-kW capacity system which could intertie into the electric grid without requiring a distribution system upgrade, (2) a 500-kW capacity system that would require a distribution system upgrade to 3-phase with 1/0 conductors, and (3) a 1.5-MW system that would require an upgrade to 3-phase with 4/0 conductors (see Section 2.8 for distribution system upgrade details). This section describes the preliminary design specifications that were developed for these three preferred project alternatives.

All of the preferred alternatives can be classified as small, "run-of-river" schemes, meaning they have no or relatively small water storage capability (ESHA, 2004). Power is only produced when water is available in the river and water is not dammed or impounded beyond what is necessary for short-term head regulation. The diagram in Figure 39 provides a layout and brief description of the basic components of a run-of-river hydropower system.

Figure 39: Typical components of a run-of-river hydropower system



1	**Stream flow:** passes intake and outlet points with sufficient flow and head to warrant hydroelectric development
2	**Trash rack**: or intake screen (Coanda wedge wire) removes debris from water
3	**Intake diversion:** concrete structure (weir) with gates and/or valves maintains an adequate water level for reliable water diversion into the system
4	**Diversion channel:** open channel or pipe at atmospheric pressure which transfers water to a de-silting header box or forebay
5	**De-silting header box:** concrete structure also commonly known as a forebay or settling basin which removes small particles from water and regulates flow into the penstock where pressure builds
6	**Bypass:** spillway or pipe to allow system to clean out silt buildup and vent excess flow
7	**Penstock:** main system pipe which transfers water under pressure to turbine
8	**Inlet regulation valve**: controls power into the turbine and system shutdown
9	**Hydro Turbine**: primary hydroelectric component which converts kinetic energy in water to mechanical energy by rotating a shaft
10	**Draft tube:** simple atmospheric tailrace chamber used in reaction turbines (not required in impulse turbines)
11	**Tailrace:** channel or pipe slows and redirects water back into stream
12	**Gear Box:** or belt drive converts the slower rotation of the turbine into faster rotation required by the electrical generator; maintains adequate output frequency of the generator
13	**Generator:** converts mechanical energy of the rotating turbine shaft to electrical energy
14	**Power Switch & Breaker**: safety device to disconnect power
15	**Transformer**: converts generator output voltage to transmission line or use voltage
16	**AC Output to Load or Grid:** transmission line delivers power into the grid or to the point of use
17	**Control and Monitor CPU**: computer-based unit maintains power into turbine (flow) in balance with generator power (load); safety monitor and override controls
18	**Communication Line**: connection (internet or other) which allows remote system control and monitoring

Source: Dorado Vista Inc., 2009

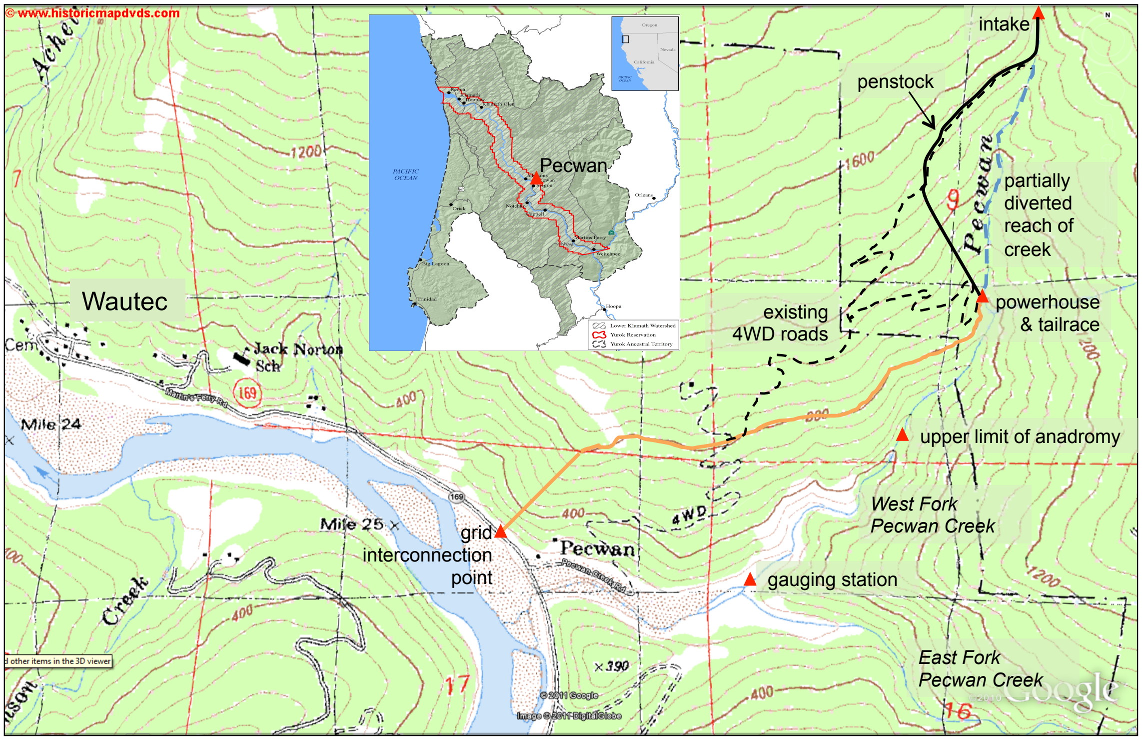
In a run-of-river system, a fraction of normal river flow is diverted into an intake and through the hydroelectric system. Excess flow bypasses the water diversion intake so that the river effectively continues to run. Bypass, or reserved flow, refers to the minimum volumetric flow of water that must remain in the river at all times. When river flow drops to the predetermined bypass level, power generation ceases. In contrast to large hydropower systems, which often require large dams and can have adverse effects on ecosystems, small-scale run-of-river hydropower typically has a lower impact and is more sustainable.

2.9.1 System Layout and Component Specifications

Based on field visits to Pecwan Creek, optimal sites were identified for the various components that comprise a hydroelectric system. Criteria by which component sites were selected included the ability to harness the energy resource potential (head and flow), road accessibility, proximity to electric grid infrastructure, and minimization of environmental and cultural impacts. Figure 40 depicts the proposed hydroelectric system layout for Pecwan Creek. The proposed layout is intended to support all three design alternatives. Component sizes vary according to the different generator capacities, but component placement is the same.

The proposed layout has 680 feet of gross head and can utilize up to 44 cfs of flow. Approximately 3,540 feet of pressurized penstock deliver water from the intake at an altitude of 1,520 feet down to a powerhouse at an altitude of 840 feet. The powerhouse is sited well above the upper limit for anadromous fish, reported to be about 440 feet (Gale, 2003). Water is returned to Pecwan Creek from the powerhouse via a 50-foot tailrace. The intake system and nearly half of the penstock route are sited along or near existing roads, making installation and on-going maintenance more convenient. A 6,400 foot transmission line carries power from the powerhouse to the grid intertie point located on highway 169, about 1100 feet down river from the confluence of Pecwan Creek and the Klamath River.

Figure 40: Proposed hydroelectric system layout on Pecwan Creek



Updated project map for inclusion in project report

Source: SERC Staff

Design specifications for the three alternatives are presented in Table 25. Differences between the designs include design flow, intake system size, penstock diameter and wall thickness, powerhouse area, turbine and generator capacities, and transmission line capacity.

Table 25: Design specifications for preferred alternatives

Component	Hydroelectric System Capacity 125 kW	500 kW	1500 kW
Gross head (ft)	680		
Design flow (cfs)	3.5	14.5	43.5
Bypass flow (cfs)	3		
Conduit/Channel length (ft)	n/a		
Penstock material	Steel		
Penstock length (ft)	3,540		
Penstock diameter (in)	12	24	30
Penstock wall thickness (in)	3/16	3/16	1/4
Powerhouse area (ft x ft)	15 x 15	20 x 20	25 x 25
Tailrace length (ft)	50		
Turbine type	Pelton Wheel		
Generator type	Single phase, synchronous	Three phase, synchronous	Three phase, synchronous
Transmission distance (ft)	6,350		
Intake elevation (ft)	1,520		
Powerhouse elevation (ft)	840		
Anadromous fish limit elevation (ft)	450		

Source: SERC Staff

2.9.2 Intake System

The purpose of the intake is to divert water away from the creek and into a water conveyance system, or penstock. The proposed intake site is located near an existing road and bridge that cross the West Fork of Pecwan Creek at an altitude of 1,440 feet (Figure 41). From the bridge the existing road heads southwest and ascends about 40 feet in elevation (Figure 42) before gradually descending. The simplest penstock route would be to follow the road. Unfortunately, the 40 feet of elevation gain between the bridge and the high point on the road prohibits use of a siphon to convey the water[6]. An alternative would be to route the penstock below the road in the Pecwan Creek canyon, but the

[6] The maximum theoretical height water can be lifted by a siphon, or a suction pump, is about 33 feet. In practice it will be less due to friction losses.

terrain is too steep and rugged. Consequently, the following two options for routing the penstock along the roadway were explored.

Figure 41: Potential location of intake system at bridge on Pecwan Creek

Source: SERC staff, 2007

Figure 42: Ascending roadway from bridge on Pecwan Creek

Source: SERC Staff, 2011

The first option locates the intake system further upstream above the bridge at an elevation of 1,520 feet (Latitude = 41.3592, Longitude = -123.8353). This additional 80 feet of elevation will allow water collected at the intake to clear the small hill in the roadway as it is conveyed to the powerhouse, bypassing the need for a syphon system or drilling through the hillside. This option would require the development of a narrow access road alongside Pecwan Creek immediately above the bridge to install and maintain the intake system.

The second option locates the intake at or just below the bridge and requires directional drilling through the hillside to route a penstock under the roadway. In this case the penstock would remain underground for about 1,000 feet and would resurface at a point where the road is descending. Rough estimates provided by RJ Smith of Solid Rock Construction (Smith, 2011) indicate that the cost for directional drilling would be at least $200,000 to $250,000 for 12-inch diameter pipe and at least $350,000 to $375,000 for 24-inch diameter pipe. Costs could be greater depending on circumstances, and costs would certainly be greater for a 30-inch diameter pipe. Based on these cost estimates, as well as anticipated environmental impacts associated with directional drilling, we think locating the intake structure further upstream is the preferred option. However, further analysis of these options and other potential alternatives is recommended.

The proposed intake system for Pecwan Creek consists of creek diversion works, a weir, a settling basin, a penstock inlet, and additional hardware such as trashracks, a Coanda-effect screen[7], and intake gates or valves. The size of the diversion or weir structure is dependent on the design flow and stream channel. Figure 43 and Figure 44 depict an intake system that provides 10.7 cfs of flow to a hydroelectric plant in Zenia, CA. This represents a possible intake design for the larger design alternatives (500-kW to 1500-kW). Naturally occurring pools in Pecwan Creek could potentially be leveraged to limit the size of the diversion structure for the two larger alternatives, while making such a structure unnecessary for the smallest alternative. A trash rack, Coanda screen, and settling basin are used to maintain water quality since sand and sediment in water can cause rapid wear of the penstock and steel parts of the turbine (runner, nozzles, etc.). A picture of a Coanda screen is shown in Figure 45.

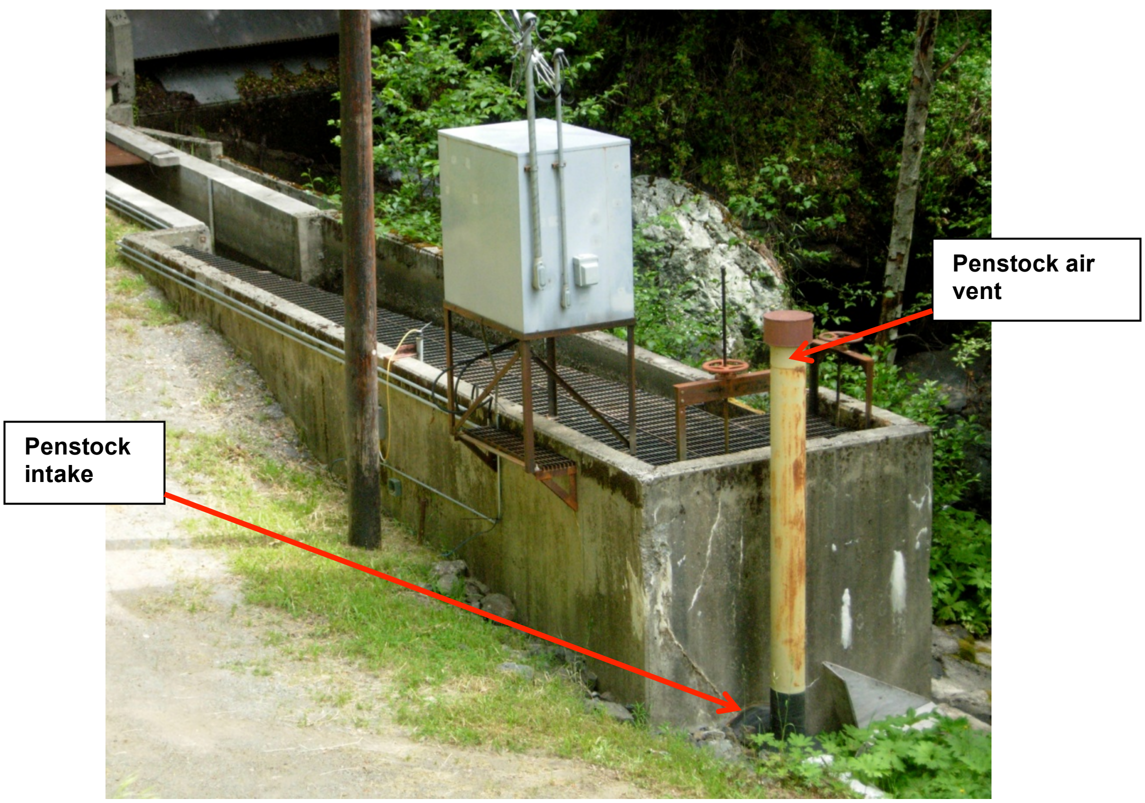
It should be noted that a water sample was taken from the intake site in March 2011 during high flow conditions (approximately 75 cfs or greater) and was found to have virtually no silt or sediment present. The sample was taken with a glass mason jar from a section of the stream with flowing, turbulent white water. The jar of water was then allowed to sit untouched for months. Virtually no particles settled out.

[7] A Coanda-effect screen is a self-cleaning screen that is commonly used for run-of-river hydroelectric installations

Figure 43: Bluford intake system for Zenia hydroelectric project

Source: SERC Staff, 2010

Figure 44: Bluford diversion channel for Zenia hydroelectric project



Source: SERC Staff, 2010

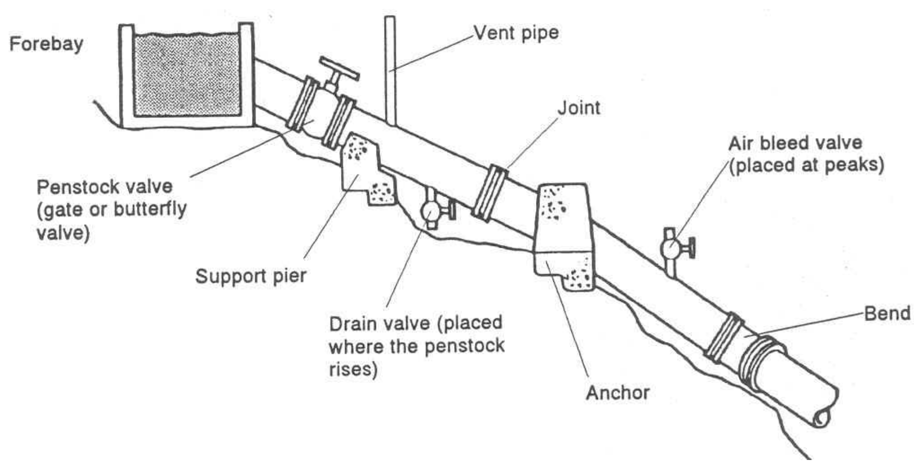
Figure 45: Self-cleaning Coanda-effect screen on intake system, Zenia hydroelectric project

Source: SERC Staff, 2010

2.9.3 Penstock

A penstock is a pressurized pipe which transfers water from the forebay to the turbine located in the powerhouse (Figure 46 and Figure 47). Proper penstock design is imperative to minimize head loss, which decreases system power output. Penstock material and installation costs are a major project expense, so appropriate design is imperative to keep system capital costs manageable.

Figure 46: Diagram of a penstock and its components



Source: PennEnergy, 2011

Figure 47: Examples of steel penstock, penstock supports, and penstock anchors

Source: SERC staff, 2011

Source: PennEnergy, 2011

Source: PennEnergy, 2011

A common design practice is to minimize the length and therefore cost of the penstock by routing the penstock so that it achieves maximum head over the minimum possible horizontal distance, i.e., is as steep as possible. This can be achieved by using a less expensive open channel or culvert to transport water nearly on contour from the intake to the forebay. Such a scheme, while potentially less expensive, is more complex to manage since the flow needs to be regulated at both the diversion intake and the forebay. This scheme also introduces the potential for an uncontrolled overflow out of the forebay tank. For these reasons, some run-of-river hydroelectric system operators find it preferable to have the water in a pressurized environment beginning at the intake and ending at the tailrace (Burgess, 2011). In our case, transporting water over the ascending section of the roadway will require a pressurized line. Therefore, the proposed water conveyance system for Pecwan Creek does not include a culvert and forebay. Water is directly transferred from a settling basin, which lies adjacent to the intake system, to a steel penstock, which varies in diameter and thickness according to the design alternative, as shown in Table 25 above.

Beginning at the intake system, the penstock can be divided into three sections. The first section is about 350 feet long and parallels Pecwan Creek along an access road that will need to be installed. The penstock veers right at the bridge where the second section begins and follows the existing road for 1,600 feet. The final section bends left, heads off-road (at approximate location Latitude = 41.3541, Longitude = -123.8396) and continues 1,590 linear feet to the powerhouse. The last section will traverse undeveloped, forested land that will require some level of clearing and preparation for penstock installation.

Common penstock materials are presented in Table 26. Steel is the recommended penstock material based on its pervasive and proven use in hydropower projects. The cost, jointing, and pressure characteristics of steel are more suitable to the high head and design flows proposed for Pecwan Creek. Conversations with turbine manufacturers suggest that high-density polyethylene (HDPE) and glass reinforced plastic (GRP) are also being used in the field and that mixed material penstocks is an approach being used to lower penstock costs (Prior, 2011). Other economizing design approaches include varying penstock wall thickness or the use of recycled steel gas lines (Burgess, 2011).

Table 26: Comparison of common penstock materials

Material	1 = Poor 5 = Excellent					
	Friction	Weight	Corrosion	Cost	Jointing	Pressure
Ductile iron	4	1	4	2	5	4
Glass reinforced plastic	5	5	3	3	5	5
Unplasticized polyvinyl chloride	5	5	4	4	4	4
Mild steel	3	3	3	4	4	5
High-density polyethylene	5	5	5	3	2	4

Source: Harvey, 1993

Penstock sizing presents trade-offs between head loss, reliability, and cost. A smaller diameter and thinner gauge steel penstock may be less expensive, but results in more head loss (i.e., power loss) due to friction and may be more susceptible to collapse or failure under surge pressure. A larger and thicker penstock reduces friction and increases reliability, but is more costly. A preliminary analysis suggests that the recommended penstock diameters and thicknesses listed in Table 25 result in head losses of less than 4%, not including frictional losses due to pipe bends.

Welded joints are the recommended penstock construction method (Burgess, 2011). Steel penstock section lengths of 40 feet are recommended to reduce the number of joints and support and anchor blocks (Copeland, 2011). Burying the penstock in the roadway may also be an option for reducing the number of anchor and support blocks. Lastly, coating the penstock interior with polyurethane (or epoxy) is recommended to optimize water flow characteristics and prevent corrosion (Copeland, 2011).

2.9.4 Powerhouse

The powerhouse contains the electro-mechanical equipment, including the turbine, generator, and electric load controls. The structure should be built on a solid foundation capable of supporting heavy equipment and should incorporate adequate ventilation to dissipate waste heat from the equipment.

The proposed powerhouse location is sited approximately 100 to 150 feet west of Pecwan Creek at an altitude of 840 feet and a location of Latitude = 41.3517, Longitude = -123.8369 (Figure 48). The suggested powerhouse dimensions (Table 25, above) are the estimated areas required to house the electro-mechanical equipment for each alternative. Space requirements are based on a tour of a powerhouse for a 1.7-MW system in Zenia, CA (Figure 49). A typical powerhouse layout is shown in Figure 50.

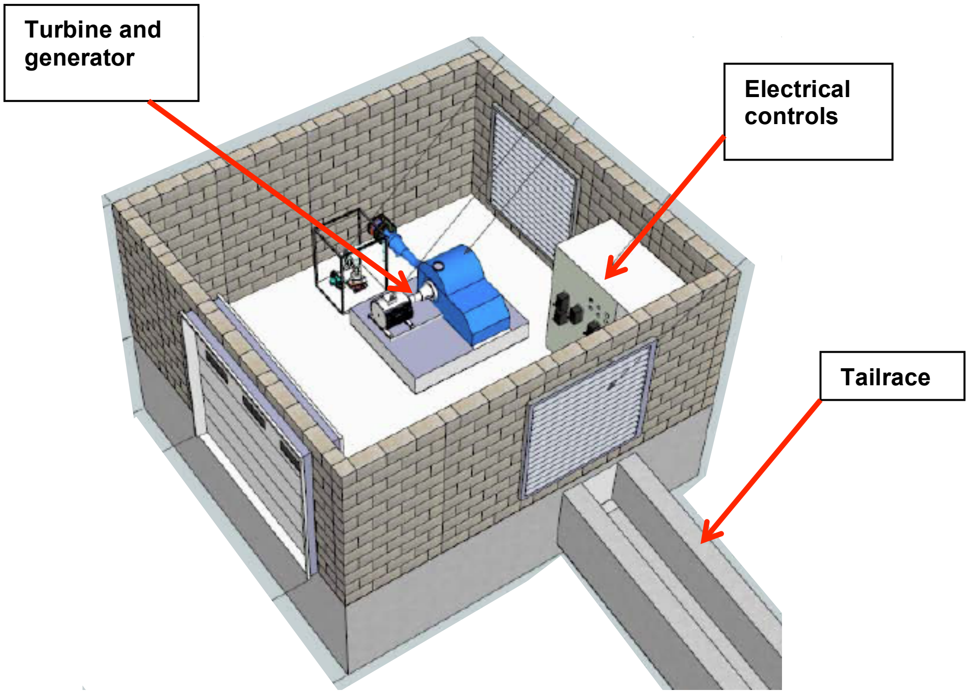
Figure 48: Proposed powerhouse location

Source: SERC Staff, 2010

Figure 49: Powerhouse (27' x 27') for a 1.7-MW hydropower system in Zenia, CA

Source: SERC Staff, 2010

Figure 50: Typical powerhouse layout



Source: Cornin, et.al., 2011

2.9.5 Turbine

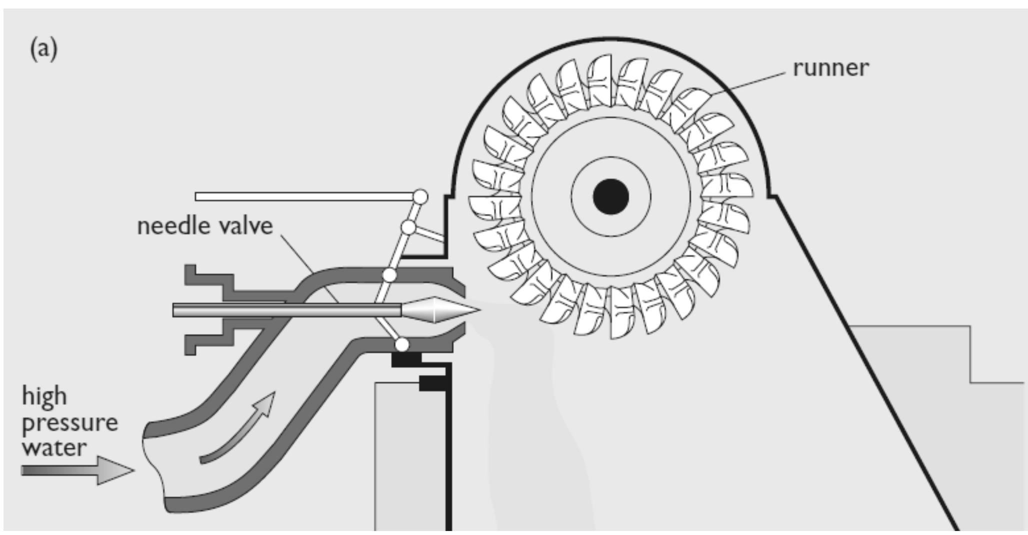
A turbine converts the energy in the water delivered by the penstock into rotating shaft power. Turbines are divided into two general categories, reaction turbines and impulse turbines (Table 27). In reaction turbines, the runner is fully submerged in water and is enclosed in a pressurized casing that creates a pressure drop across the runner causing it to turn. In contrast, impulse runners are not submerged in water and are rotated by a high-speed jet of water at atmospheric pressure. Figure 51 depicts a typical Pelton Wheel, a type of impulse turbine.

Table 27: Impulse and reaction turbine types

Turbine runner	Head Pressure High	Head Pressure Medium	Head Pressure Low
Impulse	Pelton Turgo Multi-jet Pelton	Crossflow (Mitchell/Banki) Turgo Multi-jet Pelton	Crossflow (Mitchell/Banki)
Reaction		Francis Pump-as-turbine (PAT)	Propeller Kaplan

Source: Harvey, 1993

Figure 51: A needle valve used to regulate a single-nozzle Pelton turbine



Source: Ramage, 2004

Primary criteria for selecting a turbine include available head, design flow, rotational speed, efficiency, and power requirement. Based on the high head (690 feet) and flows available on Pecwan Creek, turbine selection was narrowed to those best suited for high head conditions. According to the turbine selection chart in Figure 9, the operating region for the three proposed design alternatives (125-kW, 500-kW, 1.5-MW) lies near the center of the Pelton envelope and in the upper quarter of the Turgo envelope.

Tradeoffs between these turbine types are efficiency and cost. Both turbines are efficient and remain relatively efficient at part-flow (Sellars, 2011). A Pelton turbine can maintain efficiencies between 78% and 89% down to 10% of the rated flow (Appendix J), while a Turgo can maintain efficiencies between 70% and 83% down to 10% of the rated flow

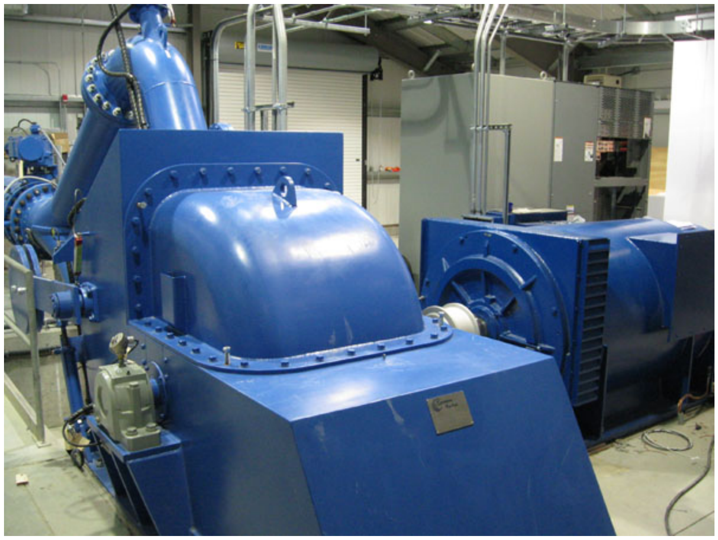
(Appendix J). A Pelton, however, can cost up to 50% more than a Turgo (Sellars, 2011). According to quotes from turbine vendor Gilbert Gilkes & Gordon Ltd., this is a difference of about $240,000 for a 1.5-MW system. A basic cost-benefit analysis suggests that investing in the higher efficiency Pelton can earn an additional $1.2 million in discounted revenue over the system lifetime, or 5 times the incremental cost of the more efficient turbine. Higher efficiency Pelton turbines are therefore recommended for all three design alternatives.

Complete turbine, generator, and load control package specifications were received from turbine manufacturers Canyon Hydro, Dependable Turbines Ltd., and Gilbert Gilkes & Gordon Ltd., and are included in Appendix A.4.

2.9.6 Generator

The generator produces electricity when spun by the rotating turbine shaft. All turbine-generator packages quoted by vendors included a synchronous single- or three-phase, 60-Hz, 480-VAC generator directly coupled to a turbine. The 150-kW design alternative utilizes a single-phase synchronous generator, while the 500-kW and 1.5-MW design alternatives use three-phase synchronous generators. Figure 52 shows a typical example of a Pelton turbine and generator system.

Figure 52: Twin-nozzle Pelton turbine and generator for a 1.1-MW hydroelectric plant in British Columbia, Canada



Canyon Hydro, 2011

2.9.7 Electrical Switchgear and Controls

The powerhouse will also house electrical switchgear, control equipment, and other miscellaneous electrical equipment. Switchgear will help maintain the safety and quality of the electricity supply within defined limits, and will disconnect the generator from the grid when parameters are out of range. Control equipment will help maintain proper generator speed to match frequency requirements, and control of the excitation field current to maintain proper voltage regulation. In addition, an auxiliary power transformer will provide power for on-site electrical loads, and an emergency power battery back-up system will ensure safe operation in the event of a grid power outage.

2.9.8 Transmission and Interconnection

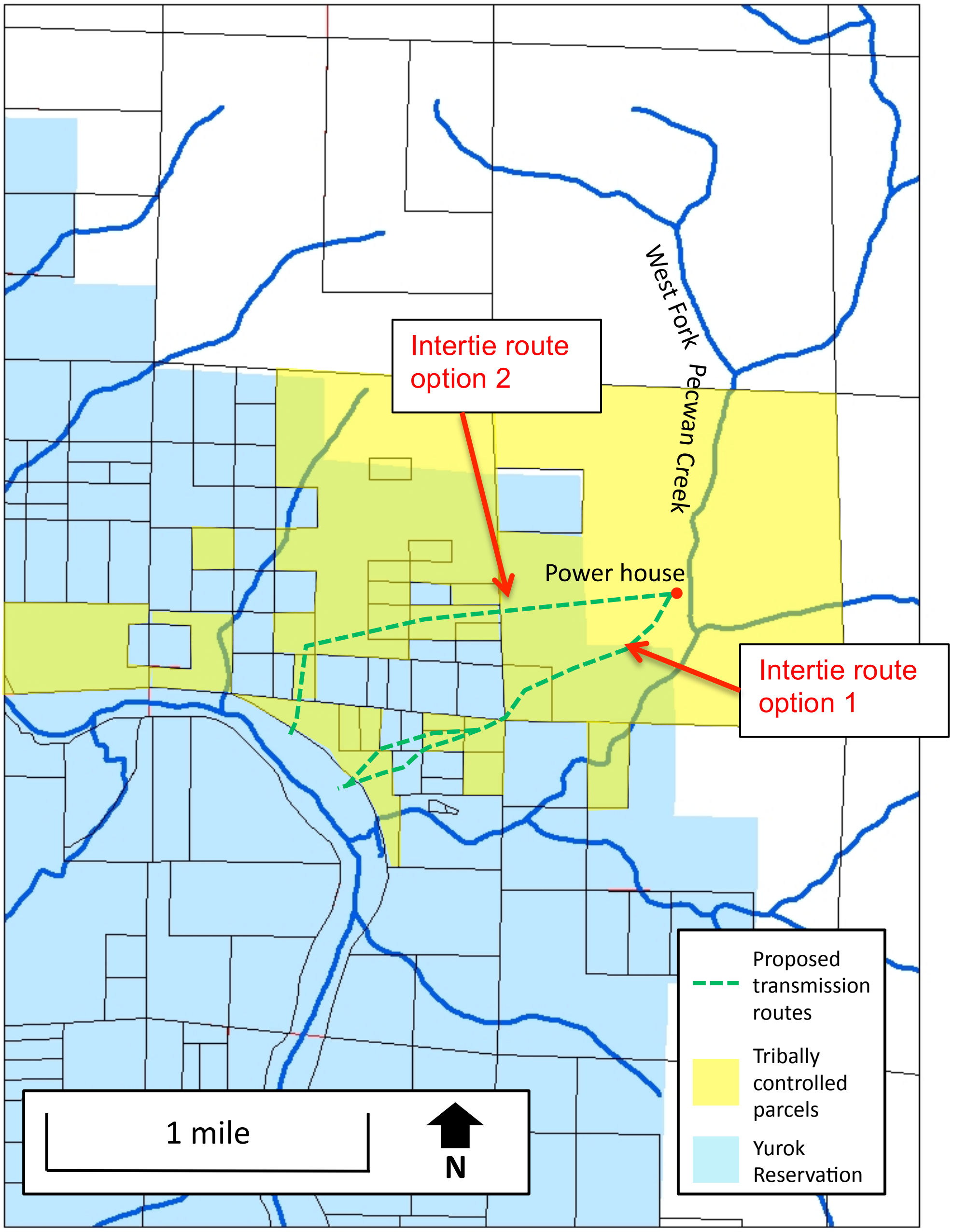
Near to the powerhouse a substation will be located where the 480-V power from the hydroelectric generator will be boosted to 12.5-kV to match the PG&E grid voltage. The substation will also include circuit protection and metering equipment. Figure 53 shows a picture of a small substation associated with a 1.7-MW hydroelectric facility.

From the substation, a 12.5-kV intertie line will need to be routed down to Highway 169 to interconnect with the main electrical distribution grid. It will be preferable that the first section of this intertie line be routed along the existing roadway where possible. This will minimize cost and environmental impacts, and will also facilitate convenient access for maintenance purposes. However, due to the location of a cultural dance site at the mouth of Pecwan Creek, the lower section of the intertie line will need to be routed off-road to connect with the distribution grid northwest of the mouth of Pecwan Creek on Highway 169. Two roughly proposed routes for the intertie line are shown in Figure 54. Both routes aim to minimize the number of private parcels that need to be crossed, thereby minimizing the need to negotiate right-of-way agreements. Option 1 will likely need to cross one or two private parcels, whereas option 2 can be routed entirely on Tribally controlled parcels.

Figure 53: Small substation for a 1.7-MW hydropower system in Zenia, CA

Source: SERC Staff, 2010

Figure 54: Land tenure and proposed transmission routes for Pecwan Creek hydroelectric project



Source: SERC Staff

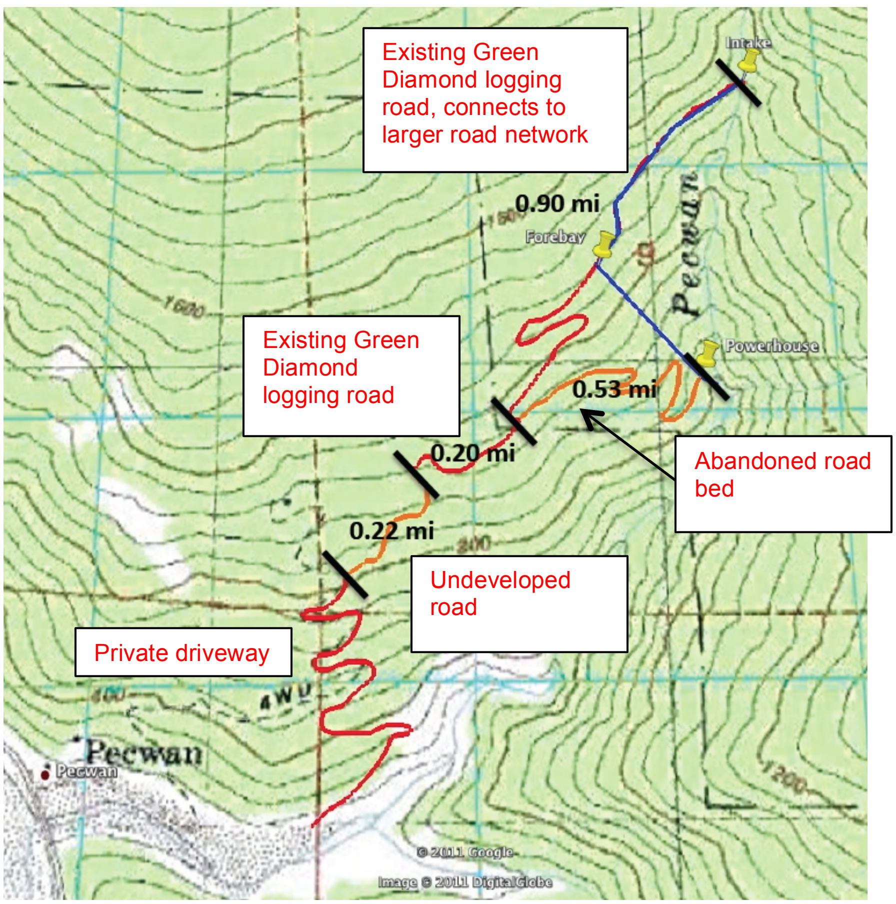
2.9.9 Road Access

Figure 55 shows the existing road access to the project site, which is primarily via Green Diamond logging roads and a private driveway. It is possible to access the site from the northwest from Wautec or even Klamath Glen, or from the northeast from McKinnon Hill via a network of Green Diamond logging roads. The most direct access route, however, is from the mouth of Pecwan Creek via a private driveway that connects to the

Green Diamond logging road. The first 0.22-mile stretch from the private drive to the existing logging road is via an undeveloped road that is overgrown with brush and in very poor condition. It will need substantial improvement to be useful. The existing Green Diamond logging road continues from there heading northeast toward the intake site (1.12 miles total). However, after the first 0.2 miles of this stretch of road there is a fork in the road that heads east toward the powerhouse location. This 0.53-mile section of road is unmaintained (see Figure 56). This section of road will also need substantial improvement.

We contacted Dave Frye, Yurok Tribe Road Maintenance Supervisor, and he indicated that the Yurok Road Maintenance Department could perform the necessary road improvements (Frye, 2011). Dave said that he could provide a cost estimate, but we were not able to obtain that information in time to be included in this report.

Figure 55: Road infrastructure serving Pecwan Creek hydroelectric project area



Source: SERC Staff

Figure 56: Abandoned road bed providing access to proposed powerhouse location

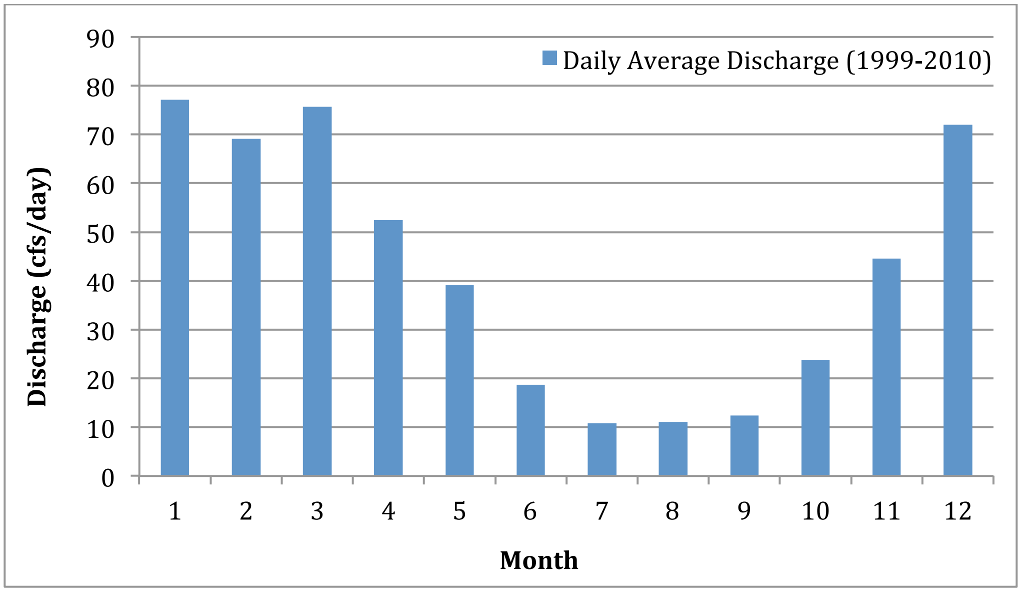
Source: SERC Staff

2.10 Final Resource Assessment

A final resource assessment was conducted for the Pecwan Creek hydroelectric project. We examined three turbine-generator alternatives: 125-kW, 500-kW and 1.5-MW. All systems were based on the preliminary design specifications outlined in the previous section of this report.

To estimate future energy production, 11 years of stream discharge data (Figure 31) as estimated in Section 2.5.3 (Hydro Resource Assessment) were used. Since these data are representative of below-average precipitation years, they should serve as conservative estimates of future discharge on Pecwan Creek. Expected average daily discharge for each month is displayed in Figure 57. We see that average daily discharge rises in the winter months and drops to about 11 cfs in the summer.

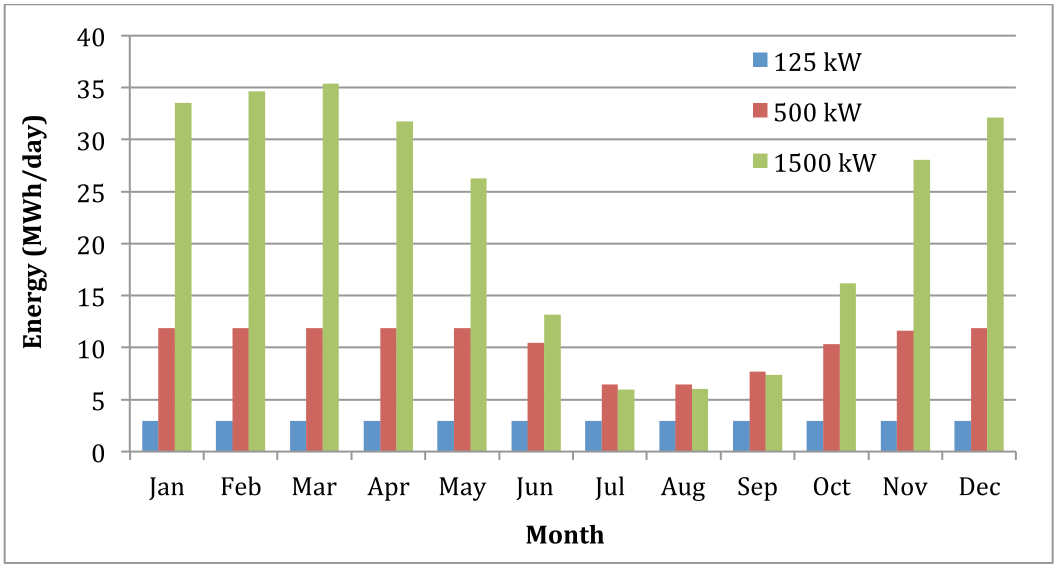
Figure 57: Daily average discharge for West Fork Pecwan Creek at design intake location by month based on synthetic discharge data from 1999 to 2010



Source: SERC staff

The power equation described in Section 2.5.3 was used to transform average daily discharge into average daily energy for the three different system capacities (Figure 58). The 125-kW system produces nearly 3 MWh per day year-round. There is no seasonal fluctuation in energy production since the 4 cfs of discharge required to deliver full power is met year-round. The 500-kW system produces about 12 MWh per day during the winter months and decreases to about 6 MWh per day in the summer, when the flow falls below the 17 cfs of discharge required to deliver full power. The 1.5-MW system varies drastically, from greater than 30 MWh per day in the winter down to 6 MWh per day in the summer. Table 28 shows estimated annual energy production for each turbine size. These energy estimates are used in Section 2.11 (Economic Analysis) to estimate revenue.

Figure 58: Estimated average daily energy production by month on Pecwan Creek based on synthetic discharge data from 1999 to 2010



Source: SERC staff

Table 28: Annual energy production for three hydro alternatives on Pecwan Creek

Generator Capacity	MWh/yr
125-kW	1,082
500-kW	3,682
1.5-MW	8,206

Source: SERC staff

2.11 Economic Analysis

A final economic analysis was conducted for the Pecwan Creek hydroelectric project. We examined the three previously discussed turbine-generator alternatives, 125-kW, 500-kW and 1.5-MW, with a special focus on the 1.5-MW option since it exhibits the greatest economic benefit.

The analysis estimated revenues using energy production results from the final resource assessment described in the previous section. Revenues were calculated as described in Section 2.7.1. All revenue estimates employ the more favorable E-SRG wholesale electricity rate. Costs are based on itemized cost estimates for major components and electric grid upgrades. Quotes were obtained from multiple vendors for major system components. The costs of the electric intertie line and electric grid upgrades were based on actual costs the Yurok Tribe has incurred to extend the electrical distribution system to the upriver section of the Reservation (Mager, 2011). Cost assumptions are detailed in Appendix H.

The economic analysis uses a 5% discount rate and examines two basic financing structures: 100% debt financing and private investor using 100% equity. In the debt financing scenario the loan is assumed to be a 30-year fixed term at 5% interest. In reality, the project is likely to be structured with a mix of debt and equity financing, but this aspect was not explored as part of this analysis.

Note that tax implications have been ignored in this analysis. This will have no effect on the economic results for the 100% debt financing case if the Tribal business model employed to develop the project maintains its tax-exempt status. However, in the 100% equity financed model income taxes on project revenues will diminish the economic results. These impacts will need to be considered if there is a desire to pursue this type of financing. Note that the federal renewable electricity production tax credit does not apply to newly installed, run-of-river hydroelectric projects, nor do the accelerated depreciation tax benefits that apply to other renewable energy technologies. This means there is little benefit to attracting private investors who have a tax liability, as there are no tax incentives to be gained with hydroelectric projects.

Results for the economic analysis are presented in Table 29 and Figure 59. The 1.5-MW project alternative exhibits considerable economic benefit and appears to be the best option for the Tribe. Under the loan model this alternative achieves a net present economic benefit to the Tribe over the 50-year project life of $3.5 million. However, the annual net revenues in this case are approximately (-$38,000) for the first ten years. Therefore, to make this project work the Tribe will need to secure a grant to cover about 10% of the capital cost, or $952,000. In this case the net present value to the Tribe increases to about $4.5 million and the undiscounted annual net revenues start at about $23,000 in years one through ten and climb to $1.1 million in years 41 through 50. The private investor finance model for the 1.5-MW project alternative exhibits a $3.4 million net present value and an internal rate of return (IRR) of 6.9%. The private investor will make somewhat less than this rate of return since a lease agreement will need to be negotiated with the Tribe, and this is not currently included in the analysis.

Neither of the smaller project alternatives offers a strong favorable outcome. Under the private investor scenario both the 125-kW and 500-kW projects produce very modest positive net present values over the life of the project and offer modest internal rates of return (5% to 6%). These returns are not likely to attract interest from private investors. Under the loan scenario, the 125-kW scenario results in only a slightly positive net present value and the 500-kW scenario shows some modest value ($872,000). However, in both cases the projects generate negative net revenues for at least the first 20 years. This is clearly not a viable option for the Tribe.

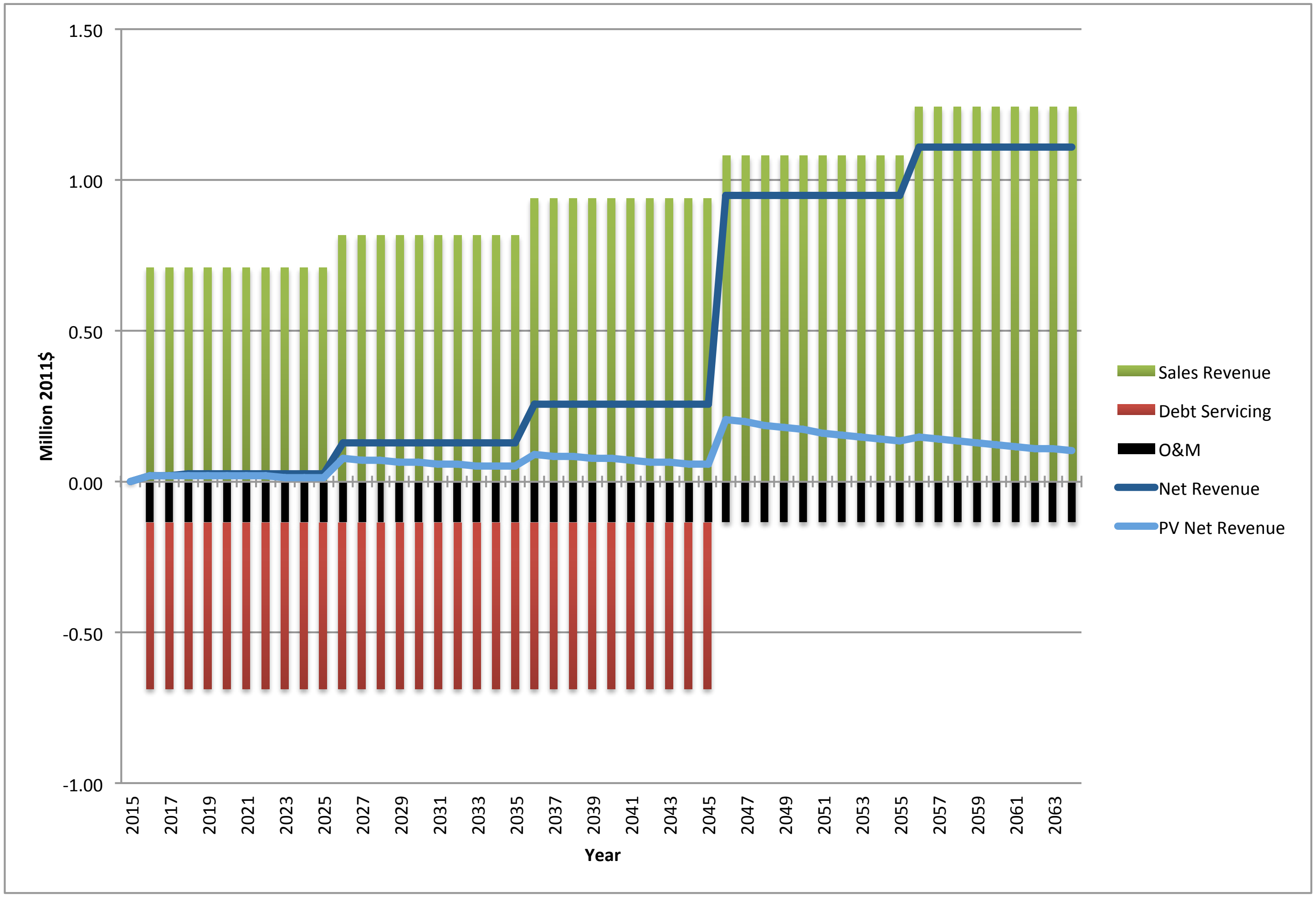
Table 29: Economic analysis results for three hydroelectric project alternatives at Pecwan Creek

Capacity (kW)	Financing Type	Cost Model	Capacity Factor (%)	Annual Production (MWh)	Total Capital Costs ($)	LCOE ($/kWh)	NPV	IRR (%)	Discounted Payback (yr)
125	Loan	Itemized	100%	1082	$(1,922,203)	$0.13	$85,553	N/A	34
125	Investor	Itemized	100%	1082	$(1,922,203)	$0.12	$66,853	5.2%	20
500	Loan	Itemized	85%	3682	$(5,568,472)	$0.12	$924,472	N/A	32
500	Investor	Itemized	85%	3682	$(5,568,472)	$0.10	$872,030	5.8%	18
1500	Loan	Itemized	64%	8206	$(9,517,368)	$0.10	$3,499,884	N/A	28
1500	Investor	Itemized	64%	8206	$(9,517,368)	$0.09	$3,408,196	6.9%	16
1500	Loan + 10% grant	Itemized	64%	8206	$(9,517,368)	$0.09	$4,455,487	N/A	25
1500	Loan	RHIAM	64%	8206	$(11,619,646)	$0.12	$1,410,437	N/A	32

The following economic parameter assumptions were used in all cases: discount rate = 5%, loan interest rate = 5%, loan term = 30 years, revenues based on PG&E's E-SRG small renewable generator feed-in tariff.

Source: SERC staff

Figure 59: Cash flow analysis for 1.5-MW hydroelectric generator on Pecwan Creek



The following economic parameter assumptions were used: discount rate = 5%, loan interest rate = 5%, loan term = 30 years, 10% cash grant at startup, overnight costs based on itemized estimate, revenues based on PG&E's E-SRG small renewable generator feed-in tariff.

Source: SERC staff

Although the economic results for the 1.5-MW project show some promise, it is important to consider how sensitive the results are to changes in the economic model assumptions. For example, if the itemized cost estimates are inaccurate and in reality the project turns out to be 10% or 20% more expensive, how much will this impact the economic results? In the base case analysis, the overnight capital cost for the project includes a $3.10 per watt installed cost for the hydroelectric plant and a $3.25 per watt cost for a one mile interconnect line and substantial added cost for upgrades to the electric grid infrastructure all the way back to the Hoopa substation (approximately 30 miles). If these overall project costs were to increase by 10%, the net present value for the 1.5-MW project with loan financing and a 10% grant drops to $3.6 million and annual net revenues for the first 10 years of project are negative (-$31,000 per year). With a 20% cost increase the net present value drops to $2.75 million, and with a 52% cost increase the net present value drops to zero.

These impacts emphasize that although the 1.5-MW project alternative does appear economically viable, it is marginal. If the costs increase even a modest 10% the viability becomes questionable, and with about a 30% cost increase the project is not feasible. We think the itemized cost estimates used in the analysis are reasonable, but higher costs would not be surprising. For the 1.5-MW project, the itemized cost for the installed hydroelectric plant without required electrical interconnection and grid upgrades is $3.10 per watt, with an additional $3.25 per watt for the interconnection and electric grid upgrades. The $3.10 per watt figure compares to a range of values found in the literature of $1.90 to $3.80 per watt (Hackett et. al., 2011). For run-of-river hydroelectric projects of 2-MW or less the Idaho National Laboratories Hydropower Resource Economics Database provides a national average of $2.96 per watt and a California average of $3.47 per watt (note these are in 2002 dollars and were not adjusted for inflation). Finally, Hackett et. al. 2011 estimates the cost for run-of-river hydro in Humboldt County to be $4.50 per watt.

In addition, there is uncertainty in the cost associated with the required grid infrastructure upgrades. The estimated cost for the 1.5-MW alternative is $3.25 per watt. This cost estimate was based on a very preliminary engineering analysis of the grid infrastructure (see Section 2.8.5). The actual required upgrades will need to be determined via an interconnection study. In addition, the cost data for the Yurok Tribe's current power line extension project (Mager, 2011) is based on work being done by a private contractor, International Line Builders. Upgrades to the distribution system leading all the way back to the substation in Hoopa will likely be under the direction of Pacific Gas and Electric Company, and costs very well could be higher than the private contractor rates the Tribe is now paying.

One thing that could dramatically improve project economic viability is if the Tribe could secure a grant to cover part of the project costs. Grant opportunities are discussed in Section 2.17 below. As mentioned above, we think the Tribe will likely need to secure a grant to cover at least about 10% of the capital cost, or $952,000, to make the 1.5-MW project viable. If the Tribe were able to obtain a 20% grant, the net present value of the project rises to just over $4 million, with positive net revenues of about $87,000 per year during the first 10 years and rising to about $620,000 per year in years 41 through 50.

We also considered the impact of low-flow, or drought years on project revenues and resulting economic viability. We used the 2002 flow year as a proxy for a drought year, as it had the lowest energy production during the eleven-year period of record we were using. We determined that there was about a 6% chance, one year in 16, that we would get a year with less energy production than we got in 2002. We also examined the tendency for multiple drought years to occur successively and found this to be uncommon. We then determined the difference in annual revenue between the base case year and a drought year, we tripled this amount, and we defined it as a drought reserve fund that needed to be maintained as an insurance policy to carry the Tribe through three consecutive low energy production years. This means that in the loan finance case the Tribe would actually borrow more than the overnight capital costs in order to build the drought reserve fund. The size of this fund for the base scenario is 1.7% of the total capital cost.

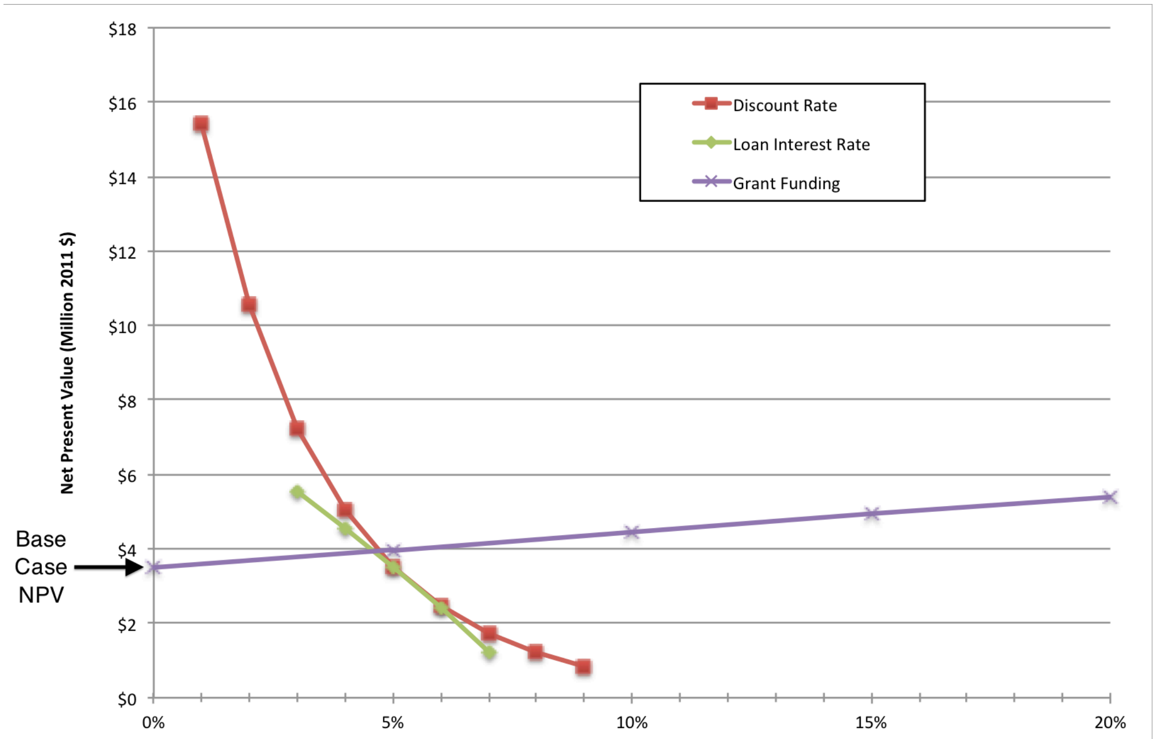
A sensitivity analysis examining additional economic parameters is considered in the next section of this report.

2.12 Sensitivity Analysis

An economic sensitivity analysis was conducted for the 1.5-MW Pecwan Creek hydroelectric project. The analysis assumes itemized costs and loan financing. The impacts of changes in the discount rate, loan interest rate, and availability of grant funding on the net present value of the project were all assessed. Results are presented in Figure 60.

The model is most sensitive to changes in discount rate and loan interest rate, and is less influenced by the availability of grant funding. For a range in discount rate of 1% to 9%, a range in loan interest rate of 3% to 7%, and a range in grant funding from 0% to 20%, all cases showed a positive net present value. With a loan interest rate greater than 8% the net present value for the project will be negative.

Figure 60: Sensitivity analysis for Pecwan Creek 1.5-MW hydroelectric system economic analysis



Source: SERC staff

2.13 Permitting Requirements

The process of obtaining the necessary permits, licenses, or exemptions necessary to build and operate a hydroelectric power system is complex, involves multiple agencies, and can take years to complete. However, it is not insurmountable, as indicated by the existence of many permitted hydropower projects across California, ranging from small systems serving a single off-grid residence to massive utility-scale projects.

The Federal Energy Regulatory Commission (FERC) regulates non-federal hydropower projects, which constitute about half of the hydropower-producing dams in the U.S. Under the Federal Power Act, FERC would be the applicable regulatory authority for a project on Pecwan Creek. FERC's process for licensing hydropower projects or exempting projects from licensing requires consultation with and approval by numerous state and federal agencies. Understanding the FERC licensing process is thus key to undertaking development of a hydropower project. Many of the agencies that will review the project can require significant periods of time to give approval, and the entire licensing process typically takes several years; it is thus in the Tribe's best interest to make sure to begin consultations as early as possible with each agency.

To start the process with FERC, a Notice of Intent and FERC Pre-Application Document must be filed. Then the applicant has three years to file a full license application. During this period, the applicant should be actively consulting with interested agencies and implementing studies recommended by the agencies to collect new information not already compiled in the Pre-Application Document. The study plan should address:

- Water resources
- Fish and aquatic resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened, and endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources

The process of identifying, contacting, and consulting with all stakeholders will reveal in detail what should be included in studies on the above resource categories. A list of potential stakeholders that will need to be contacted and consulted with is listed below. This is not intended to be a comprehensive list, but instead is meant to point out some key stakeholders who are likely to be involved in the permitting and environmental review process.

- Federal Energy Regulatory Commission
- Yurok Tribe and Other Potentially Affected Tribes
- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Forest Service/Six Rivers National Forest
- U.S. Army Corps of Engineers
- Bureau of Indian Affairs
- State Water Resources Control Board
  It will be necessary to apply for a water right on Pecwan Creek to develop the project.
- North Coast Regional Water Quality Control Board
  NCRWQCB water quality permit application
- California Department of Fish and Game
  A study to identify any state or federally listed species, and plans for screening to protect any such species present, will be needed to comply with DFG requirements.
- California Office of Historic Preservation
- Humboldt County Community Development Services Department

- Private Landowners within the Project's Area of Influence
- Other stakeholders may include:
  Northcoast Environmental Center (NEC)
  Environmental Protection Information Center (EPIC)
  Klamath Riverkeeper
  Sierra Club North Group, Redwood Chapter
  Redwood Region Audubon Society
  North Coast Chapter of the California Native Plant Society

Additional details regarding the permitting process with FERC and the general permitting process for hydropower projects can be found in Appendix K.

2.14 Preliminary Environmental Assessment

A preliminary environmental assessment was conducted for the preferred project alternative, a hydroelectric facility on Pecwan Creek. This section summarizes the findings of the preliminary assessment. The complete preliminary assessment is included in Appendix L.

It is very important to point out that this preliminary environmental impact assessment is intended for internal use by the Yurok Tribe and is not meant to be used in place of a full environmental assessment or environmental impact statement. The objectives of the preliminary assessment are to identify key environmental issues that could affect development of the proposed project and to present currently available information that could be used in preparation of a full environmental compliance document.

An initial consultation with FERC staff (Spencer, 2011) indicates that any hydropower project undertaken by the Yurok Tribe would need to be approved by FERC. Per FERC procedures, some level of environmental assessment will be necessary to develop the project. This could be an applicant-prepared environmental assessment (EA), or a full Environmental Impact Statement (EIS) to be prepared by a third-party consultant. In any case, FERC's document titled *Preparing Environmental Documents: Guidelines for Applicants, Contractors, and Staff* provides a comprehensive template for preparing the required environmental documentation.

In terms of anticipated environmental impacts, the entire project from intake to tailrace will be located above the upper limit of anadromy of Pecwan Creek, as determined by Yurok Tribe Fisheries Department (Gale, 2003). The system will be designed to ensure an agreed-upon minimum flow is maintained in the bypassed reach of the creek at all times. Instream diversion or intake structures will be kept to the minimum necessary for reliable system performance. Site disturbance at the diversion and powerhouse will be kept to a minimum. Existing roads will be used to the extent possible to access, install, and maintain the diversion and the powerhouse. Minor earthworks will be necessary to install the channel and penstock. Power transmission lines will be routed to minimize environmental and cultural impacts.

Our preliminary environmental assessment did not identify any obvious environmental issues that would be likely to derail the project, though this finding would obviously need to be confirmed via the full environmental review process. We did share the proposed project description with the Yurok Tribe's Environmental and Fisheries Programs and asked for their preliminary feedback. Neither of these departments identified any "show stopping" issues, though both reserved judgment until a full environmental review is completed. The Yurok Tribe Fisheries Program did specify that intake and tailrace locations will have to be properly sited so as not to cause problems with geomorphic stability. They also indicated that they could conduct a biological survey in the impacted stream. Also, they did not balk at the proposed 3 cfs minimum flow value, but said that the required minimum flow would need to be studied as the project moves forward. In addition, former Yurok Tribe Fisheries specialist Dan Gale expressed concern about the timing of water diversions. He suggested that hydro projects might have to reduce or even halt diversions during late summer and fall to maintain needed instream flows.

Appendix L goes on to discuss requirements for a full environmental review. Impacting factors, both direct and indirect, will need to be identified. Impacts can be classified as those associated with the following distinct project phases:

- site characterization
- construction
- operation
- decommissioning and reclamation at end of project life

Each of these categories is discussed in Appendix L. In addition, the following list of potentially affected resources is also discussed.

- Aquatic and Riparian Habitat Typing
- In-Stream Flows
- Sediment and Large Woody Debris Transport
- Water Quality
- Inventory of Aquatic Fauna
- Seismic Study of Proposed Facilities Locations
- Geology and Geologic Hazards
- Construction Debris Study
- Cultural Resources Survey
- Recreation Use Study
- Federally Listed Threatened and Endangered Wildlife Species Surveys
- Region 5 Forest Service Sensitive Terrestrial Wildlife Species Surveys
- Northwest Forest Plan Terrestrial Survey and Manage Species and Forest Service Species of Concern
- Noxious Weeds and Invasive Exotics Inventory, Mapping and Analysis
- Northwest Forest Plan Survey and Manage Plant Species
- Special Status Plant Surveys

Finally, the preliminary environmental assessment (Appendix L) discusses determining the magnitude and significance of impacts, determining mitigation strategies, and developing a monitoring program.

2.15 Stakeholder Analysis

In order to successfully develop a large-scale renewable energy project on the Yurok Reservation, there will need to be a broad range of stakeholders involved. These include stakeholders internal to the Tribal staff, Tribal government, and Tribal community, as well as external stakeholders in the surrounding community and at the state and national level. An effective project development process will require identification of these stakeholders, an assessment of their interest or involvement in the project and their potential influence over project development, an assessment of risks and opportunities associated with each stakeholder group, and a plan for engaging and negotiating with stakeholders. This study has sought to identify key stakeholder groups and areas of interest or involvement. The results of this assessment are presented in Table 30 and Table 31.

Table 30: Internal stakeholder list

Internal Stakeholder Group	Issue/Activity/Role
• Yurok Tribe Planning Dept.	Project planning and development
• Yurok Tribe Environmental Program	Environmental impacts
• Yurok Tribe Cultural Program	Cultural impacts
• Yurok Tribe Fisheries Program	Fisheries impacts
• Yurok Tribe Economic Development Corporation	Project development
• Yurok Tribe Legal Counsel	Recent land acquisition and its relation to project development, Tribal business structure, interconnection agreement, power purchase agreement, environmental assessment, financing agreements, contracting (with developer, contractors, consultants, etc.)
• Yurok Tribal Council	Go/no-go decisions, Professional development, project champion, Tribal business structure, contracts and agreements, financing
• Yurok Tribal Community	Principal project beneficiaries, general acceptance of project, project impacts

Source: SERC staff

Table 31: External stakeholder list

External Stakeholder Group	Issue/Activity
• Pacific Gas and Electric Company	Interconnection study, interconnection agreement, power purchase agreement
• CA State Water Resources Control Board • Western Rivers Conservancy • Green Diamond Resource Company	Issues with recent land acquisition?
• US Department of Energy • US Department of Interior – Bureau of Indian Affairs • US Department of Agriculture	Funding of pre-construction activities
• Federal Energy Regulatory Commission • National Marine Fisheries Service • U.S. Fish and Wildlife Service • National Park Service • U.S. Forest Service/Six Rivers National Forest • U.S. Army Corps of Engineers • Bureau of Indian Affairs • State Water Resources Control Board • North Coast Regional Water Quality Control Board • California Department of Fish and Game • California Office of Historic Preservation • Humboldt County Community Development Services Department	Project permitting and environmental review
• Northcoast Environmental Center (NEC) • Environmental Protection Information Center (EPIC) • Klamath Riverkeeper • Sierra Club North Group, Redwood Chapter • Redwood Region Audubon Society • North Coast Chapter of the California Native Plant Society	Project environmental review
• Engineering consultant	Project development
• Private investors	Project financing (equity)
• Banks, US Department of Energy • US Department of Interior – Bureau of Indian Affairs • US Department of Agriculture	Project financing (debt), guaranteed loans
• Private landowners, larger community	Project environmental review, project acceptance

Source: SERC staff

2.16 Preliminary Operations and Maintenance Plan

Operation of a 1.5-MW hydroelectric facility on the West Fork of Pecwan Creek is likely to create one or two part-time to full-time permanent jobs, with additional as-needed work to repair washed-out roads and hydraulic structures damaged by flood events. The key position will be a plant operator/supervisor. This position may be full- or part-time and will require a technical or engineering background with prior knowledge and/or training in the operation of a small, run-of-river hydroelectric power plant. Additional staff will be needed to conduct periodic plant maintenance. It is expected that the maintenance positions will be part-time and potentially could be combined with other related part-time staff positions, perhaps within the Yurok Public Utilities District and/or Yurok Road Maintenance Department. Additional periodic specialty work, such as high voltage line maintenance, may need to be contracted out. A list of typical ongoing operation and maintenance tasks follows:

- Operation supervision and engineering,
- Maintenance supervision and engineering,
- Maintenance of intake structure and water cleaning system,
- Maintenance of hydraulic infrastructure (penstock, etc.),
- Maintenance of hydraulic plant (turbine runner, nozzles, valves, etc.),
- Maintenance of electric plant (generator, switchgear, transformer, etc.),
- Road and building maintenance.

According to Ross Burgess (Burgess, 2011), owner and operator of a local 1.7-MW hydroelectric plant, a resident operator who performs minor maintenance is usually all that is required. For the proposed Pecwan hydroelectric facility, a part-time operator might be sufficient. Ross has two full-time operators to operate and maintain a more complicated facility that includes water storage and multiple intake locations, and they handle almost all the maintenance work, including high-voltage line work. They have been the primary work crew during all maintenance projects, with outside service providers being limited to welding and switchgear. Ross owns all the heavy equipment that is necessary to maintain the road system and do whatever is required to accommodate recurring land slides. As an example, recently after a half day of preparation with three pieces of earth moving equipment, Ross and one operator realigned about 300 feet of penstock. They had to shut the plant down, drain the pipe, move the pipe, fill the pipe and restart the facility. They were off-line less than two hours.

2.17 Project Development Plan and Financing Options

This preliminary feasibility study is the first of many steps in a process to develop a renewable energy resource. While the Pecwan Creek project appears to offer financial benefit to the Tribe, it should be studied more carefully before substantial resources are devoted to it. This section of the report outlines a path forward should the Tribe want to pursue project development.

2.17.1 Project Development Plan

The energy project development process can be complex and lengthy, taking many years to complete. Figure 61 lays out a typical renewable energy project development process, which in this case has been customized for the Yurok Tribe's current situation with regard to possible development of a hydroelectric project on Pecwan Creek.

Phase 1

Having completed a preliminary feasibility study, the Tribe is currently in phase one of this process. The next step will be for the Tribe to receive the results of the preliminary feasibility study and decide whether the Pecwan Creek hydroelectric project is something they want to pursue further. In addition, since this project constituted only a preliminary assessment, it is recommended that the Tribe seek a professional review of the study's results to confirm the preliminary findings. Particular attention should be given to the economic analysis and a standard pro-forma model should be developed. The results from this standard pro-forma model will be important to verify whether or not the Tribe should move forward with the project development process. In addition, the pro-forma model will be a necessary tool in subsequent steps of the process.

Phase 2

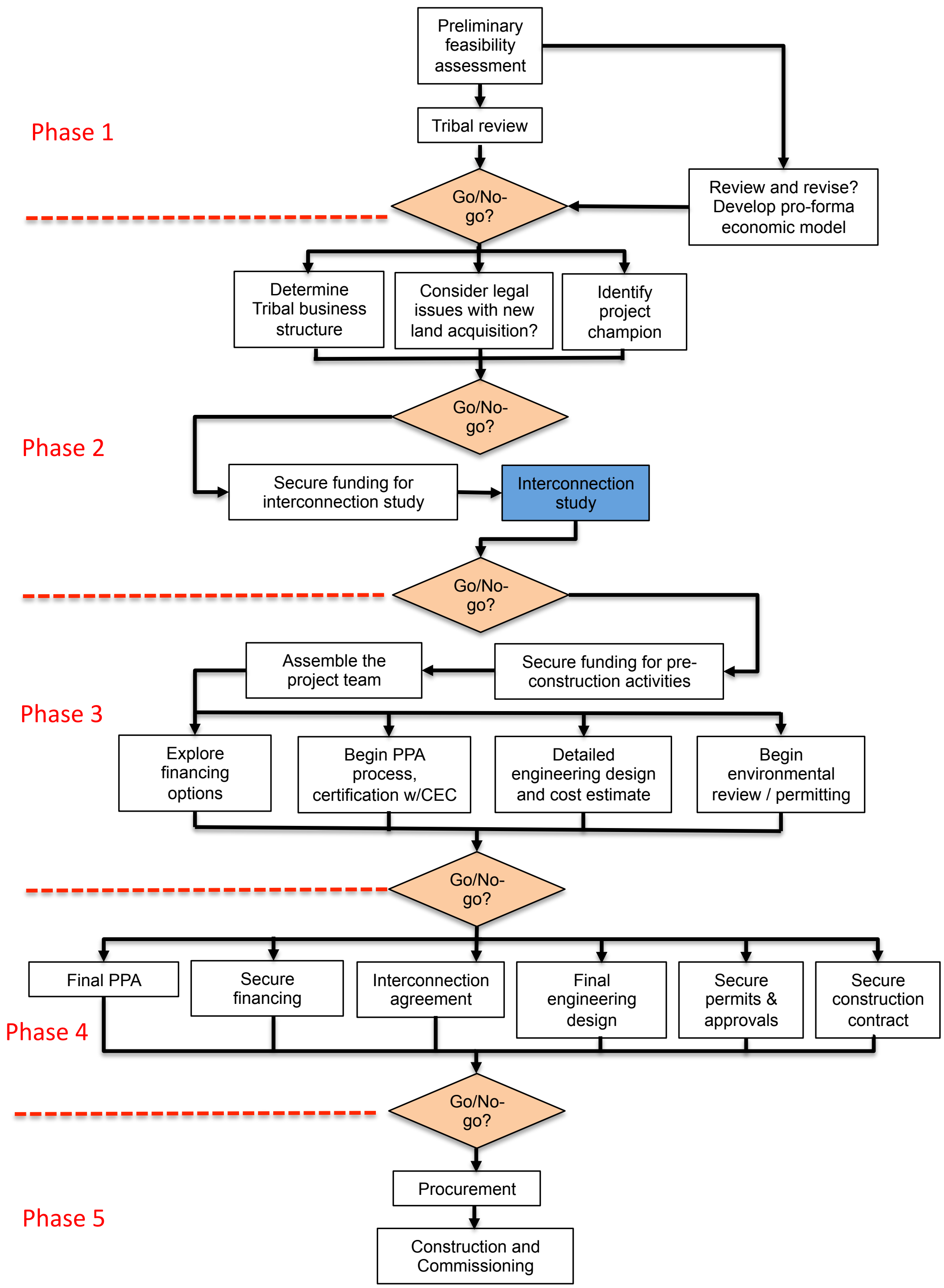
If the Tribe chooses to move forward into phase two, they will want to identify a Tribal leader who can act as a project champion to help guide the project through the development process. Ideally this would be a Tribal Council member. In addition, the Tribe should verify that there are no legal conflicts with regard to development of hydroelectric power on the newly acquired tract of land in the Pecwan Creek watershed, as the land acquisition involved state and non-profit funds and is supposed to be managed for "clean water and forest health" (Yurok Tribe, 2011).

Also, as part of phase two, the Tribe should explore potential business structures that they could use to pursue the development and sale of renewable energy resources on the Reservation. The chosen business structure could be critical to project success, and could have important political and financial implications for the Tribe. We suggest the Tribe seek outside consultation on this topic from other Tribes or individuals who have experience with energy development projects on Tribal lands. Douglas MacCourt, in his report *Renewable Energy Development in Indian Country: A Handbook for Tribes* (MacCourt, 2010), discusses this topic at length. We summarize some of his findings below in Section 2.17.2.

At this point the Tribe should assess the outcome of their investigations and once again make a decision regarding whether to move the project forward.

Next, the Tribe must identify and secure funding for an interconnection study. We suggest looking for grant funding for this activity (see Section 2.17.3).

Figure 61: The development process for the Pecwan Creek hydroelectric project



Source: SERC staff

The interconnection study will be one of the project's most critical steps. The need for significant upgrades to the PG&E electrical distribution system, likely all the way back to the Hoopa substation, is one of the project's biggest hurdles. If the cost of distribution upgrades is too high, the project will not be viable.

As was outlined in Section 2.8, the capacity of the existing and planned electrical distribution grid that serves the upriver portion of the Yurok Reservation seriously limits the size of the hydroelectric generator that can be installed. Without any upgrades the project is likely limited to about 125-kW, and a project of this small scale does not appear to be economically viable. The 1.5-MW project alternative appears to be the most economic option. However, this option will require significant upgrades to the distribution system at substantial added cost. Both the extent of the required upgrades, as well as the costs associated with the upgrades are highly uncertain. These facts emphasize the importance of this task.

Appendix G outlines the interconnection study process. The preferred approach should be to have PG&E consider the installation of multiple generator sizes when they conduct the interconnection study. They should start with the 1.5-MW facility. However, if the costs for that option appear prohibitive, then they should check the impact of installing a 500-kW system, and perhaps even the 125-kW system.

The interconnection study should take about a year to complete and is likely to cost approximately $75,000. This includes roughly $50,000 for PG&E's analysis work, as well as funds to support Tribal staff time and an outside consultant to provide technical support to the Tribe. Once the interconnection study is done, the Tribe can decide whether to move on to phase 3 activities.

Phase 3

If the Tribe chooses to proceed with phase 3, they will first need to secure funding to support the remaining project pre-construction activities listed in phases 3 and 4. These activities include: developing a detailed engineering design and cost estimate, conducting environmental review and permitting activities, securing a power purchase agreement, securing an interconnection agreement with PG&E, and securing project financing.

It is important to note that these activities will be costly, certainly hundreds of thousands of dollars, and there is no guarantee that the project will be implemented when the preconstruction phases are complete. This means that securing funding for these tasks may be difficult. We suggest that the Tribe look for grant funding to support these efforts. Alternatively, the Tribe could try to attract outside investment to support project development pre-construction activities. Funding opportunities are discussed in Section 2.17.3

Next, the Tribe must assemble a project team that can move the project through the remaining phases of development. The structure and make-up of this team will depend in part on the type of business structure the Tribe chooses to employ and on the level of involvement the Tribe desires to have in the process. Team members are likely to include: project manager, project developer, legal counsel, financial advisor, project engineer, construction contractor, transmission system consultant, environmental consultant, permitting consultant, lenders and/or investors, and fund development manager.

Additional Phase 3 tasks include: developing a detailed engineering design and cost estimate, beginning the environmental review and permitting process (see Sections 2.13 and 2.14), beginning the power purchase agreement process, getting registered with the California Energy Commission as an RPS-eligible renewable generator, and beginning to develop financing arrangements for the project. In addition, outreach and education efforts should be conducted and stakeholders should be engaged early in the process.

Based on the status of some of these tasks, particularly the environmental assessment and permitting process and the detailed cost estimation, the project team will need to convene for another go/no-go decision. This is a time to reassess the feasibility of the project and decide whether to pursue Phase 4 and subsequent construction activities.

Phase 4

In Phase 4 the tasks started in Phase 3 need to be completed and finalized. The power purchase agreement and interconnection agreements must be completed, all permits and approvals should be obtained, the final engineering design work and construction drawings should be completed, a construction contract should be secured, and a complete financing package should be negotiated.

Phase 5

Phase 5 includes procurement, construction and commissioning of the facility.

2.17.2 Tribal Business Structures

If the Yurok Tribe is interested in pursuing the Pecwan Creek hydroelectric project, they will need to decide what role they want to play. How involved do they want to be in the development of the energy project? Do they want to play an active role or a passive role? As Doug MacCourt says, "Tribes must decide early in the process whether they want a long-term role in the management, operation and ownership of an energy project or simply want to collect revenue" (MacCourt, 2010).

In a passive arrangement, Tribes might lease their land to a third party who develops, constructs and operates the energy project on Tribal lands. And even if the Tribe chooses to be an owner of a facility, they might choose to contract out the development, construction and operation of the facility. Alternatively, a Tribe could choose to play a very active role and act as the project owner, developer and general contractor, and choose to manage all aspects of the renewable energy development project. Finally, it's possible for the Tribe to enter into a joint development agreement with a third party, and define a shared responsibility.

It will also be important for the Tribe to decide what sort of entity they want to utilize in their pursuit of renewable energy development. Broadly speaking, the Tribe can choose to function as a Tribal government enterprise, or as a Tribal Corporate enterprise. The Tribal government enterprise can simply be the Tribe itself, or it could be a separate enterprise agency or a political subdivision. As a Tribal corporate entity, the Tribe can choose between a Section 17 corporation, a Tribally-chartered corporation, a state-chartered corporation, or a state-chartered LLC. Each of these business structures offers various tradeoffs in the areas of sovereign immunity, tax-exempt status, liability of Tribal assets, and various other legal ramifications. In addition, outside business partners are typically more comfortable with entities they are already familiar with, like a state – chartered corporation.

It will be important for the Yurok Tribal government, Tribal staff and Tribal community to discuss these topics and figure out what sort of structure they are comfortable with and what format will best meet their needs.

A joint development is when a Tribe and a private developer or investor establish a business relationship that allows them to carry out a development project together. Reasons why a Tribe would partner with an outsider are: to acquire energy project development expertise, to secure project financing, or to take advantage of tax credits or other federal incentives. However, one of the main motivations for joint partnerships is to take advantage of the Production Tax Credit (PTC), the Investment Tax Credit (ITC) and/or Modified Accelerated Depreciation Benefits. However, while many renewable energy technologies are eligible for these incentives, hydroelectric power is not. For that reason, a joint venture may not be as valuable to the Yurok Tribe.

2.17.3 Funding Sources and Financing Options

The proposed preferred project alternative is for development of a 1.5-MW hydroelectric facility on Pecwan Creek. Development of this project will require substantial investment, including hundreds of thousands of dollars in pre-construction activities and roughly $10 million in overnight capital costs. Due to the size of the project and the projected economic returns, we expect it will be difficult to attract private outside capital investment. A more promising approach may be to seek grant funding and loan financing to support project development.

Grant funding will be particularly important for supporting pre-construction activities, at least until enough work has been done to ensure that the project has a very high chance of success. At that point loan financing can be secured to support any remaining pre-construction activities, as well as the capital cost of construction. It is important to note that loan financing typically cannot be used to finance 100% of the project, but instead a mix of debt and equity financing must be used. Typically debt to equity ratios are no higher than about 80% debt to 20% equity, though a 90% debt 10% equity split might be possible. The Tribe may be able to find grant funding to cover the 10% to 20% equity share. Grant funding typically requires a cost share, and the debt financing can be used in this regard.

Below we discuss potential grant and loan opportunities that could be used to finance the preferred project alternative. Table 32 summarizes the available grant and loan funding opportunities.

Table 32: Funding opportunities for Pecwan Creek hydroelectric project

Agency	Program	Planning Grant	Deployment Grant	Deployment Loan
Department of Energy	Tribal Energy Program	X	X	
Department of Agriculture	Rural Energy for America Program	X	X	X
	Rural Business Enterprise Grants	X		
	Rural Business Opportunity Grants	X		
	Rural Utility Service High Energy Cost Grant Program		X	
	Business and Industry Guaranteed Loan Program			X
Department of Interior, Bureau of Indian Affairs	Energy and Mineral Development Program	X		X
Department of Commerce, Economic Development Administration	Economic Development Assistance Program		X	
Small Business Administration	7(a) Loan Program			X

Source: SERC staff

Grants

There are a number of U.S. government grant programs that might provide eligible funding for project development. Some programs support pre-construction activities, while others support hardware and installation costs. A brief description of these opportunities follows.

U.S. Department of Energy

The U.S. Department of Energy's Tribal Energy Program provides grant funding for the planning and development of renewable energy projects on Tribal lands. The Yurok Tribe has already been funded numerous times under this program, including funding for the current Wind and Hydro Energy Feasibility Study. The Tribe's applications have been received favorably in the past and they stand a good chance of being funded again if they have a viable project to pursue. In fact, the program is set up to move Tribes through the process of general energy planning, broad resource assessment, feasibility analysis of specific projects, and then project development. The program is designed to support Tribes through each of these steps. The Yurok Tribe is now poised to secure funding for pre-construction activities and then project deployment for a viable project.

The DOE Tribal Energy Program tends to release grant solicitations every couple of years. Their current funding cycle just closed. Similar opportunities are likely to be available in the future. Note that loan financing can be used to provide the required cost share. Brief details on the DOE Tribal Energy Program grants are provided below.

Solicitation Name: Renewable Energy Development and Deployment in Indian Country
Most recent solicitation closing date: May 11, 2011
Funded Activities: Topic Area 2: Development (Pre-construction) Activities, Topic Area 3: Deployment (Construction) of Renewable Energy Power Projects
Anticipated award size: $200,000 to $1 million ($2 to $4 million expected to be available)
Requirements: 50% cost share required, minimum 1-MW power production capacity.

Further information about Tribal Energy Program grants can be found at:
http://apps1.eere.energy.gov/tribalenergy/government_grants.cfm#Tribal

U.S. Department of Agriculture

The U.S. Department of Agriculture Rural Development program offers numerous grant opportunities. Probably the most relevant is the Rural Energy for America Program (REAP). Also of interest may be the Rural Business Enterprise Grants (RBEG), Rural Business Opportunity Grants (RBOG), and finally the Rural Utility Service (RUS) High Energy Cost Grant Program. The REAP grants are available to assist rural small businesses. Tribal enterprises are eligible if they are operated in a manner consistent with the Department of the Interior's regulation governing the establishment of Section 17 Corporations. RBEG, RBOG and RUS High Energy Cost Grant Program grants are available to Indian tribes.

REAP grants can cover technical assistance, feasibility studies, and project development. It is possible that the project development activities listed in phases 2 and 3 could be considered a feasibility study and could be funded under a REAP feasibility study grant. It is important to note that this program will not fund a project for which a feasibility study has been funded or conducted under any federal or state program. This may make the Pecwan Creek project ineligible, though we think the argument can be made that the current DOE funded study was only a preliminary assessment as part of a large resource assessment and that a detailed feasibility study will be necessary to proceed with project development.

The local USDA Rural Development office is in Davis, CA. The local REAP coordinator is Philip Brown at (530) 792–5811, Phil.brown@ca.usda.gov. RBEG and RBOG grants are coordinated by Karen Firestein (530) 792-5829.

The RUS High Energy Cost Grant Program has already provided funds for the Yurok electric line extension project. It may also be possible to access RUS funding to upgrade the line extension so that it can handle a 1.5-MW hydroelectric generator, and/or to secure funds for installation of the hydroelectric system. Grants under this program may be used for the acquisition, construction, installation, repair, replacement, or improvement of energy generation, transmission, or distribution facilities in communities with extremely high energy costs. On-grid renewable energy projects are eligible and the project must improve or maintain energy services or reduce the costs of providing energy services to eligible communities. Therefore, to qualify for RUS High Energy Cost

Program funds it would likely be required that the Tribe define how the Pecwan Creek hydroelectric project revenues would be used. If the net project revenues were earmarked for providing energy services to Tribal members on the Reservation via a Tribal utility model, then the project might be eligible for RUS funds.

The contact person for the RUS High Energy Cost Grant Program is Karen Larsen, Policy Analysis and Loan Management Staff, Rural Development, Electric Programs, U.S. Department of Agriculture, Washington, DC, (202) 720-9545, energy.grants@wdc.usda.gov.

Brief information on each of the USDA Rural Development Program grant opportunities follows.

Solicitation Name: REAP Feasibility Studies
Solicitation closing date: June 30, 2011
Maximum award size: $50,000 or up to 25% of eligible costs.
Funded Activities: feasibility studies
Requirements: Cannot be submitted for a renewable energy system project for which a feasibility study has been conducted or funded under any federal or state program.

Solicitation Name: REAP Renewable Energy Systems
Solicitation closing date: June 15, 2011
Maximum award size: $500,000, not to exceed 25% of project costs.
Funded Activities: Feasibility studies, pre-construction activities, project construction. Includes hydroelectric power ≤ 30-MW.
Requirements: Projects costing >$200,000 require a detailed, project specific feasibility study and a professional engineer's report with engineering drawings.

Solicitation Name: RBEG
Maximum award size: amounts not established
Funded Activities: Intended to support the development of small and emerging private business enterprises in rural areas. Covers technical assistance, planning and development services, project construction.
Requirements: Would need to determine whether support to Section 17 Corporation Tribal enterprises is eligible.

Solicitation Name: RBOG
Maximum award size: $250,000
Funded Activities: Provide technical assistance for business development and economic development planning. This can include efforts to identify and analyze business opportunities.

Solicitation Name: RUS High Cost of Energy Program Grant
Anticipated award size: $75,000 minimum, $5 million maximum, average award size between 2003 and 2005 = $1.5 million
Funded Activities: Installation or upgrade of energy generation, transmission or distribution infrastructure.
Requirements: Average residential expenditure for home energy is at least 275 percent of

the national average residential expenditure for home energy. No more than 4 percent of grant funds may be used for the planning and administrative expenses of the grantee. Project must improve or maintain energy services or reduce the costs of providing energy services to eligible communities.

Further information about USDA Rural Development Program grants can be found at: http://www.rurdev.usda.gov/RD_Grants.html. More information on the RUS High Energy Cost Grant Program can be found at: http://www.usda.gov/rus/electric/hecgp/index.htm.

U.S. Department of Interior – Bureau of Indian Affairs

Each year, the Division of Energy and Mineral Development provides tribes an opportunity to participate in the Energy and Mineral Development Program (EMDP). This grant program provides financial assistance to Tribes to evaluate their energy resource potential on their lands. This year's selection criteria emphasize renewable energy projects, job creation, and income for the tribal community, a good fit for the proposed Pecwan Creek hydroelectric project.

This grant could be pursued as a means for funding the required interconnection study. According to the EMDP website, "low cost transmission and interconnection studies may be eligible." If applying, the Tribe must provide details regarding why the interconnection study is critical and how it fits into the overall project development process. Note that the EMDP grant program can only fund single-year projects. Projects requiring funding beyond one-year intervals should be submitted as single-year proposals with an explanation that the tribe expects additional time will be required to complete the project and will therefore be submitting applications in following years.

Solicitation Name: Energy and Mineral Development Program grants
Solicitation closing date: June 23, 2011
Typical award size: $5,000 to $100,000
Funded Activities: feasibility studies, technical studies, project development activities
Requirements: single-year funding only, cannot fund permit application fees or Environmental Impact Studies (EIS) or Environmental Assessment (EA) studies

Further information about the Bureau of Indian Affairs EMDP grant program can be found at: http://www.bia.gov/WhoWeAre/AS-IA/IEED/DEMD/TT/TF/index.htm

U.S. Department of Commerce, Economic Development Administration

The Economic Development Administration (EDA) offers Economic Development Assistance Programs, of which their Global Climate Change Mitigation Incentive Fund (GCCMIF) probably offers the greatest opportunity for development of the Pecwan Creek hydroelectric project. EDA encourages the submission of only those applications that will significantly benefit regions with economically distressed economies. The GCCMIF is focused on projects that create jobs, lower the nations dependence on fossil fuels, and reduce greenhouse gas emissions.

Like with the RUS High Cost of Energy Program Grant, the EDA's GCCMIF grants would need to be tied to broader gains for the local community. Again, to meet grant criteria net project revenues could be earmarked for providing energy services to Tribal members on the Reservation via a Tribal utility. Given the uncertainty regarding how well this grant opportunity would fit the Pecwan Creek hydroelectric project it is recommended that a regional EDA representative be contacted to discuss the opportunity. The regional contact person for the EDA is Dianne Church, Watsonville, CA, (831) 722-4288, dchurch@eda.doc.gov. Brief information on EDA's GCCMIF grant program is summarized below.

Solicitation Name: Economic Development Assistance Programs GCCMIF grants
Solicitation closing date: September 15, 2011
Typical award size: $200,000 to $1.5 million, generally no more than 50% of total project costs

Debt

There are a number of federally sponsored loan and loan guarantee programs that may be applicable to development of the Pecwan Creek hydroelectric project. The loan guarantee programs require that an eligible and willing lender be engaged. The program lowers the risk for the lender and thereby allows the borrower to secure a lower interest rate. These programs are briefly discussed below.

U.S. Department of Agriculture

The USDA Rural Development Program offers loan guarantees through both their Business and Industry Guaranteed Loan Program and their Rural Energy for America Program Guaranteed Loan Program. A summary of information for these programs is provided below.

Loan Program: REAP Loans
Loan limits: Up to 75% of project costs, $25 million maximum (note that if a REAP grant and loan combination is pursued the total project cost covered by both the grant and loan cannot exceed 75%).
Loan guarantee amount: Up to 70% of the loan amount for loans between $5 million and $10 million, 60% for loans exceeding $10 million.
Requirements: Borrower must be a rural small business; a Section 17 Tribal enterprise corporation will qualify.

Loan Program: Business and Industry Guaranteed Loan Program
Loan limits: Generally not more than $10 million, though exceptions can be made.
Loan guarantee amount: Up to 70% of the loan amount for loans between $5 million and $10 million, 60% for loans exceeding $10 million.
Loan terms: 15 years for machinery and equipment.
Requirements: Indian tribes are eligible.

U.S. Department of Interior – Bureau of Indian Affairs

The Bureau of Indian Affairs Office of Indian Energy and Economic Development, Division of Capital Investment offers loan guarantees for energy related economic development projects. The size of a loan is not limited by BIA regulations, but instead is subject to availability of program resources. Loan guarantees of up to 90% of the loan amount are possible. The contact person for the office serving the California regions is

Shannon Loeve, Southwest Credit Office Service Center, (505) 563-5471, Shannon.Loeve@bia.gov.

Small Business Administration

The U.S. Small Business Administration offers rural business loans through their 7(a) Loan Program. SBA guarantees 75% of loans greater than $150,000 through this program. Further information can be found at http://www.sba.gov/content/rural-business-loans.

Lenders who utilize government guarantee lending programs

Many lenders are willing to participate in government guarantee lending programs. However, one lender that may be of particular interest to the Tribe is the Native American Bank. They focus on lending to Tribes and Tribally-owned enterprises. NAB's loans are available in all 50 states, and are tailored to meet the unique needs of their customers. NAB is conversant with the unique issues of Tribal Law, Trust Lands, Tribal Sovereignty and the many steps involved in completing loan transactions.

Equity

To attract outside investors it will be important to demonstrate that the project has a high probability of success. In addition, outside investors will want to see an opportunity for adequate return on their investment, and this may be difficult to demonstrate. Finally, the project may be too small in scale to successfully attract outside investment. For these reasons we think that attracting outside private capital as a means of financing the Pecwan Creek hydroelectric project is unlikely. However, if there is a desire to explore this opportunity, further research should be conducted and the assistance of a professional consultant experienced in financing of renewable energy projects should be sought.

Federal Financial Incentives for Renewable Energy Projects

There are numerous federal financial incentives available to qualified renewable energy projects. These include the production tax credit or investment tax credit, accelerated depreciation benefits, and the renewable energy production incentive program. Unfortunately, none of these programs are for newly installed, small-scale run-of-river hydroelectric projects like the one being proposed for Pecwan Creek.

2.17.4 Background Materials for Project Development Process

The following is a list of project information that the Tribe will need to have readily available as they pursue the project development process.

- Non-disclosure or confidentiality agreement
- Project info
  - Location , site maps
  - Proof of land ownership
  - Aerial photos
- Technical info
  - Size and type of generator
  - Equipment performance guarantees
  - Power production estimate

  - Plant schematic, 1-line electrical drawing
  - Site development information
  - Interconnection equipment
- Resource
  - Resource assessment
  - Resource data
- Evidence of Community Support
  - Tribal Council resolution
  - Plans or results for community meetings
  - Letters of support from key stakeholders
- Interconnection
  - Copies of completed applications
  - Copies of agreements
  - Feasibility study, system impact study, facilities study
  - Agreements for network upgrades
  - Interconnection agreements
- Permitting
  - List of all permits and approvals required
  - Description of progress toward obtaining approvals
  - Copies of applications, permits, approvals
  - Written description of operating limitations (e.g., minimum by-pass flow)
- Schedule
  - Milestone chart and schedule
  - Key activities
  - Critical path items
- Team description and qualifications
  - Corporate structure
  - Legal arrangements
  - Team members
  - Description of roles, capabilities, experience

2.18 Education and Outreach Plan

An education and outreach effort can be used to help engage community stakeholders and provide them with important information about the benefits of the proposed project. In particular, this effort should be focused on Tribal members and the larger community that resides in the geographic vicinity of the project. These are community members who may be impacted by and/or who may have strong opinions about the project. Engaging these community members and educating them about the many benefits the project offers them and their community will help build support for the project. Benefits to highlight should include:

- It is a fish-friendly project.
- It will provide sustainable, fish-friendly energy that can help to offset power produced by the Klamath dam projects. In this way, it can contribute to the removal of the Klamath dams.

- It is a renewable energy project that will provide clean, sustainable, carbon free energy.
- It is an environmentally friendly project that can reduce our use of fossil fuels and help reduce our impact on the changing climate.
- The project demonstrates the Yurok Tribe's commitment to sustainable energy practices that align with the traditional native values of being responsible community members who care for the land, air, and water we depend on.
- The project will increase the Tribe's energy security and energy independence by producing revenue the Tribe can use to support energy services on the Reservation, thereby serving to strengthen the Tribe's sovereignty.
- The project will generate revenue for the Yurok Tribe that will be used to provide energy services to all Tribal members on the Reservation. This includes off-grid renewable energy services, on-grid renewable energy services and energy efficiency services.
- The project will create jobs on the Reservation and will stimulate the local economy.

CHAPTER 3: CONCLUSIONS AND RECOMMENDATIONS

The primary focus of this study was to examine the opportunity to develop wind and hydroelectric power sources on the Yurok Reservation for wholesale back to the grid. Feasibility was judged based on a project's ability to generate net revenue for the Tribe. A secondary objective of this study was to identify practical opportunities for providing wind or hydropower to individual Tribal facilities.

The best available sites identified for study were McKinnon Hill ridge for wind and Pecwan and Ke'Pel Creeks for hydroelectric power development. Despite favorable ratings on NREL wind maps, the McKinnon Hill ridge was found to be only a marginal wind site (Class 1 to Class 2 rating), and is not suitable for commercial development for wholesale power sales. A small, off-grid wind system on McKinnon Hill might make sense to provide power for a new telecommunications facility that has recently been located on the ridge.

With regards to hydroelectric power generation, Pecwan Creek is the preferred location. Compared to Ke'Pel Creek it has higher flows, better road access, and hydraulic features that allow the entire hydroelectric system to be located above the upper limit to anadromy, thereby minimizing impacts to fisheries. However, although the Pecwan Creek hydroelectric project shows some promise, it too is marginal with regard to its economic feasibility.

The key issue that marginalizes the Pecwan Creek hydroelectric project is the need for substantial upgrades to the PG&E distribution system all the way back to the Hoopa substation (approximately 30 miles). The study found a 1.5-MW facility on Pecwan Creek to be the preferred project alternative, with power being sold back to PG&E via their small renewable generator feed-in tariff. This system has an estimated hydroelectric plant cost of about $4.65 million. Expected required upgrades to the distribution system essentially double the project cost to a total of $9.5 million. Upgrades include switching from single-phase to three-phase power between the Martins Ferry Bridge and Pecwan Creek, increasing the conductor size to 4/0 wire all the way back to the Hoopa substation, and adding bi-directional voltage regulation to maintain acceptable voltage levels in the system both with and without hydroelectric power generation at Pecwan.

Given the overnight capital costs for the hydroelectric plant and the distribution system upgrades listed above, as well as the expected revenue generation potential, the net present value of the project over its expected 50-year life is about $2.9 million (assuming a 5% discount rate, a debt financed project at 5% interest for 30 years, and a 10% grant). In order for this project to generate positive cash flows starting in the first year of the project, we found it will be necessary for the Tribe to obtain grant funding to cover at least 10% of the upfront capital costs. Under this scenario the Tribe would net $25,000 per year in the first 10 years of the project, increasing to $559,000 per year in the last 10 years of the project (undiscounted).

In must be noted that this feasibility assessment is a preliminary analysis, and the cost numbers in particular are very uncertain. In addition, the positive economic results are sensitive to modest changes in costs. For example, the project becomes economically infeasible if project costs increase by 20% to 30% or the loan interest rate increases to 7% or higher.

Even though the Pecwan Creek hydroelectric project shows marginal economic viability, we recommend that the Yurok Tribe consider taking key next steps to further examine the opportunity. We think the Pecwan Creek hydroelectric project may be the best opportunity the Tribe has for large-scale renewable energy development on the Reservation, and therefore it would be worthwhile to determine with a fairly high degree of certainty whether or not the project is viable.

Key next steps for evaluating this project will first require that Tribal staff and the Tribal Council review the results from the current study. In addition, we recommend that the Tribe also have this preliminary feasibility assessment reviewed and commented on by an outside consultant with substantial experience in renewable energy project development. If there is interest in continuing with project evaluation following these reviews, the key next step will be to conduct an interconnection study with PG&E. This is likely the most critical task for assessing the viability of this project. As mentioned above, the cost of the distribution system upgrades is expected to be substantial; however, the magnitude of the required upgrades and the associated costs are very uncertain at this point. A more definite cost estimate is critical. With results from the interconnection study the Tribe should be in a good position to determine whether the project is worth pursuing.

If there is still interest at this point, the Tribe will need to identify further funding sources and assemble a project team to carry out pre-construction activities and then eventually project construction.

The key to any of these next steps will be the availability of funding. We have identified some grant opportunities that could be used to fund the interconnection study as well as other near-term project evaluation steps. To complete the project pre-construction and construction activities, additional grant funding and loan financing will be required. Because of the relatively small scale of the proposed Pecwan Creek hydroelectric project and its projected marginal economic returns, we think it is unlikely that the Tribe will be successful in attracting outside private investment. Instead, we think the Tribe will need to access low interest guaranteed loans supplemented by grants to fund this project. We have identified multiple guaranteed loan programs and grant funding opportunities that could potentially be tapped.

REFERENCES

Austin, Scott. (2011) Personal communication with SERC research assistant Ruben Garcia via email. Provided cost estimates for road development and construction of hydroelectric intake system, settling basin, penstock, powerhouse, and tailrace. May 2011. Slayden Construction Group Inc, Oregon, USA. http://www.slayden.com/

AWS Scientific, Inc. (1997) Wind Resource Assessment Handbook. Subcontract for National Renewable Energy Laboratory, April 1997.

Burgess, Ross. (2011) Personal communication with various SERC staff (Colin Sheppard, Jim Zoellick, Richard Engel, Ruben Garcia, and Tom Quetchenbach) in-person and via phone and email. Provided information, guidance, and cost estimates on all aspects of hydroelectric system development. June 2010 to May 2011. Owner of the Blueford and Three Forks Hyrdropower System, Zenia, CA.

California Energy Commission. (2011) Renewables Portfolio Standard Eligibility, Fourth Edition. January 2011.

Canyon Hydro (2011). http://www.canyonhydro.com/. [Accessed May 2011].

Copeland, Scott. (2011) Personal communication with SERC research assistant Ruben Garcia via phone. Provided cost estimates for penstock material, fabrication, and coating. March 8, 2011. Northwest Pipe Company, Portland, Oregon, USA. http://www.nwpipe.com/

Cornin, M. et.al. (2011) "Run of River Hydropower System Design,Yurok Tribe, Pecwan Creek." Humboldt State University Engineering 492. May 2011.

Dorado Vista Inc. (2009). http://doradovista.com/DV_Hydro_Power.html. [Accessed April 2011].

E.F. McCarthy & Associates, LLC. (2003) Preliminary Wind Resource Assessment and Theoretical Energy Estimates, Northern Cheyenne Reservation, Montana. Prepared for Northern Cheyenne Nation and DISGEN, Inc. Lakewood, Colorado, April, 2003

European Small Hydropower Association (ESHA). (2004) Guide on How to Develop a Small Hydropower Plant. Developed under the Thematic Network on Small Hydropower (TNSHP) Project.

European Small Hydropower Association (ESHA). (1998) Layman's Guidebook on How to Develop a Small Hydro Site.

Frye, Dave (2011). Email correspondence with Schatz Energy Research Center's Jim Zoellick. April/May, 2011. Dave Frye is the Road Maintenance Supervisor for the Yurok Tribe.

Gale, Daniel B. (2003) Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California. Yurok Tribe Fisheries Program. March 2003.

Gipe, P. (2004) *Wind Power*. Chelsea Green Publishing Company, White River Junction, VT.

Hackett, Dr. Steven C. et.al. (2011) Humboldt County as a Renewable Energy Secure Community – Economic Analysis Draft Report, Schatz Energy Research Center, April 2011.

Hall, D.G., et al. (2003a) Hydropower Resource Economics Database. Idaho National Engineering and Environmental Laboratory (INEEL). http://hydropower.inel.gov/resourceassessment/index.shtml. [Accessed May 2011].

Hall, D.G., et al. (2003b) Estimation of Economic Parameters of U.S. Hydropower Resources. Idaho National Engineering and Environmental Laboratory (INEEL).

Harrelson, Cheryl C., C. L. Rawlins and John P. Potyondy. (1994) Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service General Technical Report RM-245. April 1994. Chapter 10, Measuring Discharge.

Harvey, et al. (1993) Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes. Intermediate Technology Publications, London, UK.

Humboldt Engineering & Construction, Inc. (2000) Final Report: Yurok Power Project.

MacCourt, Douglas. (2010). Renewable Energy Development in Indian Country: A Handbook for Tribes. NREL/SR-7A4-48078, June 2010.

Mager, Mandy. (2011) Personal communication with Schatz Energy Research Center's Jim Zoellick via email. Provided cost data and cost estimates associated with Yurok Tribe's the power line extension project. March 25, 2011.

McKinney, et.al. (1983) Microhydropower Handbook. By EG&G for the U.S. Dept. of Energy. January 1983.

Melander, Eric. (2011) Personal communication with SERC research assistant Ruben Garcia via phone and email. Provided information and cost estimates for turbine-generator packages. August 2010 to May 2011. Canyon Hydro, Deming, Washington, USA. http://www.canyonhydro.com/

Pacific Gas & Electric Co. (2011a). Personal communication with PG&E distribution engineers facilitated by Ivan Marruffo, Sr. Account Executive.

Pacific Gas & Electric Co. (2011b). *Independent Study Process, a Roadmap.* Presentation produced by PG&E Generation Interconnection Services, March 8, 2011. http:// *www.cpuc.ca.gov/NR/rdonlyres/F1B2145F-6198.../PGETariffReform.pdf* [Accessed May 2011].

Pacific Gas & Electric (PG&E). (2011c) Short-Run Avoided Cost Energy Prices for Qualifying Facilities: Historical Time-of-Use Energy Prices (1982 – 2011). http://www.pge.com/b2b/energysupply/qualifyingfacilities/prices/. [Accessed May 2011].

Pacific Gas & Electric (PG&E). (2011d) As-Delivered Capacity Prices for Qualifying Facilities (1998 – 2011). http://www.pge.com/b2b/energysupply/qualifyingfacilities/prices/. [Accessed May 2011].

Pacific Gas & Electric (PG&E). (2011e) Electric Schedule E-SRG: Small Renewable Generator PPA. http://www.pge.com/b2b/energysupply/wholesaleelectricsuppliersolicitation/standardcontractsforpurchase/. [Accessed May 2011].

Pacific Gas & Electric Co. (2010). *Wholesale Distribution Tariff (WD Tariff). FERC Electric Tariff Volume No. 4*. http://www.pge.com/about/rates/tariffbook/ferc/ [Accessed May 2011].

PennEnergy (2011). http://www.pennenergy.com/index.html. [Accessed May 2011].

Phillips, D.R. (Randy) (2011). Personal Communication with Schatz Energy Research Center's Colin Sheppard. March, 2011. Phillips is an Operations Manager at International Line Builders, Inc. Phillips has worked directly on the Wautec line extension and provided important data about the existing distribution line and cost of upgrades.

Prior, Robert. (2011) Personal communication with SERC research assistant Ruben Garcia via phone and email. Provided information and cost estimates for turbine-generator packages. August 2010 to May 2011. Dependable Turbines Ltd, Surrey, British Columbia, Canada. http://www.dtlhydro.com/

Ramage, J. (2004) *Hydroelectricity*, chapter 5 of Boyle, G (ed) Renewable Energy: power for a sustainable future. Oxfor UP, 2nd ed 2004.

Rantz, S. E. and others. (1982) Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge. Geological Survey Water-Supply Paper 2175. United States Department of Interior. Chapter 5. Measurement of Discharge by Conventional Current-Meter Method. 1982.

Rhoads, H., J. VandenBosche, T. McCoy, and A. Compton. (2000) Comparison of Projections to Actual Performance in the DOE-EPRI Wind Turbine Verification Program. Contracted report for NREL. Presented at the American Wind Energy Association, WindPower 2000, Palm Springs, California, April 30-May 5, 2000.

Rigaud, Louis, Halus Power Systems (2010) Personal Communication with Schatz Energy Research Center's Colin Sheppard. October, 2010. Rigaud has extensive experience consulting on mid-scale community wind power projects.

Schatz Energy Research Center, 2007. Tribal Utility Feasibility Study – Final Report. Presented to U.S. Department of Energy Tribal Energy Program. Award #DE-FG36-03GO13117. June 2007.

SeaWest Consulting, LLC. (2002) Manzanita Wind Energy Feasibility Study. Prepared for Manzanita Band of Mission Indians and US Department of Energy, September 30, 2004.

Sellars, Bruce. (2011) Personal communication with SERC research assistant Ruben Garcia via phone and email. Provided information and cost estimates for turbine-generator packages. March 2011 to May 2011. Gilbert Gilkes & Gordon Ltd., Kendal, Cumbria, UK. http://www.gilkes.com/

Sheppard, Colin (2009) “Analysis of the measure-correlate-predict methodology for wind resource assessment” Masters Thesis -- Humboldt State University, Environmental Systems: Environmental Resources Engineering. http://hdl.handle.net/2148/542

Smith, RJ. (2011) Phone conversation with Schatz Energy Research Center’s Jim Zoellick. April 29, 2011. RJ Smith is the owner of Solid Rock Construction, a directional drilling company that has performed multiple jobs for the Yurok Tribe.

Solar Buzz (2011). "Solarbuzz Retail Pricing Environment." Retrieved from the Internet on May 29, 2011. http://solarbuzz.com/facts-and-figures/retail-price-environment/module-prices.

Spencer, Michael (2011). Telephone conversation by Schatz Energy Research Center’s Richard Engel with Michael Spencer of the Federal Energy Regulatory Commission. February 24, 2011. FERC Small Hydro Hotline, 866-914-2849.

Stefanatos N., F. Kokkalidis, S. Tentzerakis, and E. Binopoulos (2004) “Power Performance Verification in Complex Terrain.” Centre for Renewable Energy Sources (CRES), Department of Wind Energy Laboratory for Wind Turbine Testing. Published at Proceedings of the 2004 European Wind Energy Conference & Exhibition, London. November, 2004.

U.S. Energy Information Administration (EIA). (2011) Annual Energy Outlook – 2011. http://www.cpuc.ca.gov/PUC/energy/Renewables/mpr. [Accessed May 2011].

U.S. Army Corps of Engineers. (2010) Hydrologic Modeling System (HEC-HMS version 3.5), U.S. Army Corps of Engineers Hydrologic Engineering Center. http://www.hec.usace.army.mil/software/hec-hms/download.html

White, F. M. (2003). *Fluid Mechanics*. McGraw Hill, Boston, MA, 5th ed.

Yurok Tribe, 2011. *Yurok Tribe Acquires 22,000 Acres of Ancestral Territory to Protect Water Quality and Habitat on the Lower Klamath River.* Yurok Tribe Press Release. Contact: Troy Fletcher. April 13, 2011.

Yurok Tribe, 2004. *Yurok Tribe Water Quality Control Plan for the Yurok Indian Reservation.* Yurok Tribe Environmental Program. August 2004.

Zoellick, 2011. Humboldt State University Environmental Resources Engineering course. Renewable Energy Power Systems. ERE 475. Fall 2010.

APPENDIX A: PROJECT ACTIVITY TIMELINE

Yurok Wind and Hydro Energy Feasibility Study – Project Activity Timeline

Project Quarter	Project Activities
Oct ’07 - Dec ’07	• Conducted project kick-off meeting with Yurok Tribe Planning, Environmental and Fisheries Departments • Discussed project roles and potential project sites
Jan ’08 - Mar ’08	• Continued site selection process • Chose two hydro sites (Pecwan Creek and Ke’Pel Creek) and one wind site (McKinnon Hill) for feasibility assessments • Made site visits and conducted research for setting up data monitoring systems at wind and hydro sites
Apr ’08 - Jun ’08	• Finalized site selection, secured approval of Yurok Planning, Environmental and Fisheries Departments • Submitted NEPA EF1 environmental checklist to DOE
Jul ’08 - Sep ’08	• Received DOE environmental clearance to proceed • Received wind monitoring equipment from NREL Native American Anemometer Loan Program • Identified specific locations for stream gauging stations
Oct ’08 - Dec ’08	• Installed stream gauging stations • Began collecting stream stage data • Began measuring stream discharge and establishing stage-discharge relationship • Received winch for raising MET tower
Jan ’09 - Mar ’09	• Installed tipping bucket rain gauges at hydro sites • Conducting surveying and soil sampling at wind site • Continued collecting stream stage data
Apr ’09 - Jun ’09	• Cleared trees and brush at wind site • Conducted inventory of MET tower parts • Continued collecting stream stage data
Jul ’09 - Sep ’09	• Finished clearing and preparing wind monitoring site • Analyzed soil samples and finalized MET tower anchoring plan • Erected 50 meter MET tower • Began collecting wind speed and direction data • Continued collecting stream stage data
Oct ’09 - Dec ’09	• Continued collecting data • Began planning for resource assessment task • Contacted PG&E about grid interconnection and capacity of local distribution system
Jan ’10 - Mar ’10	• Continued data collection • Began processing data • Received preliminary info from PG&E about interconnection

Apr '10 - Jun '10	• Continued data collection • Began identifying candidate wind and hydro turbines • Developed methodology for wind resource assessment • Conducted preliminary hydro resource assessment for Pecwan Creek • Began load assessment for telecommunications tower on McKinnon Hill • Began examining opportunities for selling renewable power • Developed preliminary economic analysis methodology
Jul '10 - Sep '10	• Completed data collection for wind and hydro sites • Lowered 50 m MET tower and returned to NREL • Collected data for candidate wind and hydro turbines • Obtained generalized cost data for wind and hydro systems • Obtained renewable energy pricing data from PG&E • Developed energy generation and revenue estimates • Performed preliminary screening for three project sites
Oct '10 - Dec '10	• Examined opportunity for small, off-grid wind power system for McKinnon Hill telecommunications site • Identified Pecwan hydro as preferred project alternative • Began detailed assessment of Pecwan hydro project alternative • Contacted PG&E to better determine interconnections requirements and allowable generator capacity
Jan '11 - Mar '11	**For Pecwan hydro, preferred project alternative** • Completed technology assessment • Completed sensitivity analysis • Completed energy market assessment • Completed preliminary assessment of grid interconnection requirements and allowable generator capacity • Completed preliminary design specifications • Completed economic analysis • Completed preliminary environmental assessment • Completed preliminary permitting assessment • Identified key stakeholders • Outlined community education plan • Developed business plan

APPENDIX B: PHOTOS OF SITE PREPARATION AND METEOROLOGICAL TOWER INSTALLATION

Tree and brush removal.

Tree and brush removal.

Surveying the site.

Taking soil samples for anchors.

Installing sensors on the MET tower.

Raising the gin pole.

Tower raising in progress.

Tower raising team celebrates their accomplishment.

Erected tower begins collecting data.

Yurok Tribe designs adorn the data acquisition enclosure.

APPENDIX C: WIND DATA SCREENING

Range and relation tests conducted in data quality screening process. When sensor types are listed along with a "1" or "2" (e.g. Speed1, Speed2), this signifies two measurements of the same type recorded from different sensors.

Test	Thresholds
10-min Average Speed	> 0, < 56mph
10-min Max Speed	> 0, < 67.1mph
10-min Min Speed	> 0, < 45 mph
10-min St. Dev. Speed	> 0, < 9 mph
10-min Average Direction	> 0, < 360 degrees
10-min St. Dev. Direction	> 0.1, < 140 degrees
10-min Average, Min, Max Temp	> -10, < 104 °F
10-min St. Dev. Temp	> 0, < 5 °F
Max Speed / Average Speed	< 6
|Average Speed1 - Average Speed2|	< 5 mph
|Max Speed1 - Max Speed2|	< 8 mph
|sin(Directin1)-sin(Direction2)|	< 0.5
|cos(Directin1)-cos(Direction2)|	< 0.5

Results of data quality screening tests and the corresponding actions taken.

Circumstance	% of Records	Action & Justification
Direction St. Dev. Below 0.1 degrees *while* speed at 50m sensors <9mph	3.2	Data deemed acceptable. These events occurred during non-freezing conditions. They occurred either because there was no appreciable wind or the vanes were exhibiting minor stickiness (not moving despite a slight breeze, but later move once the wind picks up).
Absolute difference of sin/cos of direction angle exceeds 0.5	1.7	Data deemed acceptable. The discrepancies in the two direction vanes only occurred during low wind situations. It is clear these events occurred because one or both of the vanes become stuck in an orientation significantly different than the other sensor. As wind speed later picked up, the sensors moved again and became more aligned.
Direction St. Dev. Below 0.1 degrees *while* speed at 50m sensors >9mph	0.5	Data deemed invalid. These events invariably occurred during freezing conditions (temperature <33°F) and indicate the sensor was unable to move freely.
Absolute difference in 10-minute average or max between speed sensors.	0.2	Data deemed invalid. The discrepancies almost always appeared during freezing temperatures. Upon inspection, the events occurred because one of the sensors became stuck and read zero while the other read a much larger value.
Ratio of max to average 10-minute speed greater than 6	0.03	Data deemed acceptable. These events occurred very infrequently. Upon inspection, there was no reason to believe the events were due to equipment malfunction; they just represent very gusty conditions.

APPENDIX D: PHOTOS OF STREAM GAUGING STATION INSTALLATION AND OPERATION

Installing Ke'Pel gauging station.

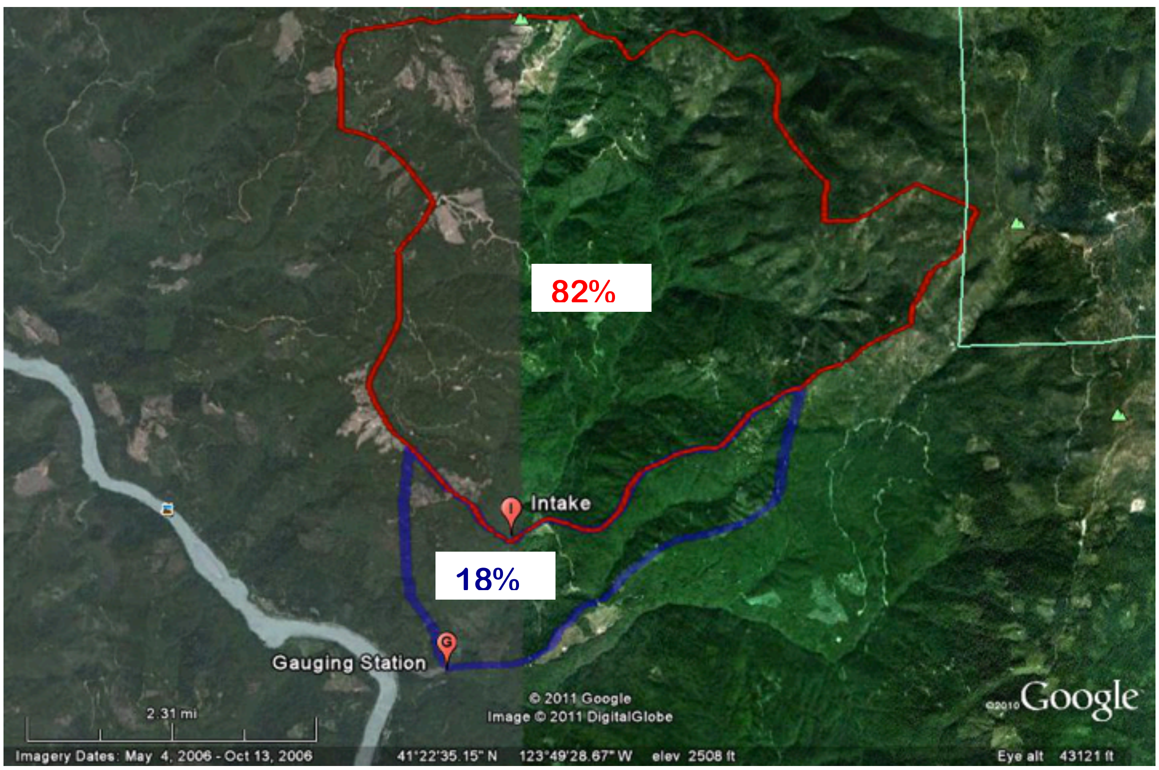
Ke'Pel gauging station.

In-stream flow measurement.

Manual stream stage measurement.

APPENDIX E: WATERSHED AREA MAP FOR WEST FORK OF PECWAN CREEK

The watershed area map below shows the watershed area above the proposed intake site outlined in red, and the watershed area below the proposed intake site but above the gauging station outlined in blue. The watershed area above the proposed intake site is equal to 82% of the total watershed area above the gauging station.



APPENDIX F: PG&E POWER PURCHASE RATE SCHEDULES

PG&E Rates for Qualifying Facilities

SRAC and As-Delivered Capacity Rates

PG&E seasonal average SRAC and As-Capacity prices for 2010

Effective Period	Seasonal Period	Peak	Partial-Peak	Off-Peak	Super Off-Peak	Seasonal Average	As-Delivered Capacity	Rate ($/kWh)
January 1 - 31, 2010	B	---	6.1970	5.9694	5.7046	6.0048	0.1923	0.0620
February 1 - 28, 2010	B	---	5.9182	5.6925	5.4480	5.7347	0.1923	0.0593
March 1 - 31, 2010	B	---	5.2165	5.0009	4.8020	5.0548	0.1923	0.0525
April 1 - 30, 2010	B	---	4.4950	4.3119	4.1378	4.3556	0.1923	0.0455
May 1 - 31, 2010	A	4.6265	4.4397	4.2936	4.1095	4.3441	0.6948	0.0504
June 1 - 30, 2010	A	4.4569	4.2769	4.1117	3.9589	4.1849	0.6948	0.0488
July 1 - 31, 2010	A	4.9217	4.7230	4.5584	4.3718	4.6213	0.6948	0.0532
August 1 - 31, 2010	A	4.6704	4.4818	4.3161	4.1485	4.3854	0.6948	0.0508
September 1 - 30, 2010	A	3.9144	3.7564	3.6199	3.4770	3.6755	0.6948	0.0437
October 1 - 31, 2010	A	4.2343	4.0634	3.9217	3.7612	3.9759	0.6948	0.0467
November 1 - 30, 2010	B	---	3.7234	3.5839	3.4276	3.6079	0.1923	0.0380
December 1 - 31, 2010	B	---	4.5780	4.3895	4.2143	4.4361	0.1923	0.0463

SRAC Calculation Method

PG&E Short Run Avoided Cost Energy Prices for Qualifying Facilities (May 2011)

Pacific Gas and Electric Company ENERGY PRICES FOR QUALIFYING FACILITIES EFFECTIVE May 1 - 31, 2011			
May-11	**Energy Prices ($/kWh)**	**Winter**	**Summer**
Energy price (Pn) in $/kWh is calculated based on substituting the variables below into the formula adopted in D.07-09-040 and approved in Resolution E-4246:	**Peak**	-	**0.045208**
	Partial-Peak	-	**0.043383**
	Off-Peak	-	**0.041871**
Pn = [IER x (GPn + GTn)/10^6 + O&M] x TOU	**Super Off-Peak**	-	**0.040157**
where IER = (.5 x MHR + .5 x AHR)	**Monthly Weighted Average**	-	**0.042449**

GPn =	Simple average of natural gas bidweek price indices for Malin and Topock from Gas Daily, Natural Gas Intelligence and Natural Gas Week.					
			Malin			
			4.1500			
			Topock			
			4.3033			
		Simple Average	4.2267	$/MMBtu		
GTn =	Intrastate Transportation					
	G-AAOFF - Redwood	PG&E AL 3200-G	0.3379	$/MMBtu		
	G-AAOFF - Baja	PG&E AL 3200-G	0.3679	$/MMBtu		
	Gas Rule 21 Shrinkage	PG&E AL 3194-G, Backbone	0.0341	0.8%		
	Backbone Transport	Average Redwood, Baja plus shrinkage	0.3870	$/MMBtu		
	G-EG	PG&E AL 3200-G, Non-Backbone	0.2787	$/MMBtu		
	G-SUR	PG&E AL 3202-G: FF and WACOG			0.009596	3.9170
	G-SUR	PG&E AL 3202-G = FF * WACOG	0.0376	$/MMBtu		
		Total Intrastate Transportation	0.7033	$/MMBtu		
		Monthly Burnertip Gas Price	4.9300	$/MMBtu		

IER	=	Incremental Energy Rate	Administrative Heat Rate (AHR)	9,794		
			Market Heat Rate (MHR)	6,251	8,023	Btu/kWh
O&M	=	Variable Operations and Maintenance adder			0.002896	$/kWh
TOU	=	Energy-only Time-of-Use factors pursuant to D.96-12-028.			**Winter**	**Summer**
		Peak =				1.0650
		Partial-Peak =				1.0220
		Off-Peak =				0.9864
		Super Off-Peak =				0.9460

SEASON AND TIME PERIOD DEFINITIONS

Time Period	**Period A - Summer** **May 1 - October 31**	**Period B - Winter** **November 1 - April 30**	**Applicable Days**	**# of Hours May-11** **Winter**	 **Summer**
Peak	Noon - 6:00 p.m.	NA	Weekdays except Holidays		126
Partial-Peak	8:30 a.m. - Noon	8:30 a.m. - 9:30 p.m.	Weekdays except Holidays		147
	6:00 p.m. - 9:30 p.m.		Weekdays except Holidays		
Off-Peak	9:30 p.m. - 1:00 a.m.	9:30 p.m. - 1:00 a.m.	Weekdays except Holidays		347
	5:00 a.m. - 8:30 a.m.	5:00 a.m. - 8:30 a.m.	Weekdays except Holidays		
	5:00 a.m. - 1:00 a.m.	5:00 a.m. - 1:00 a.m.	Weekends & Holidays		
Super Off-Peak	1:00 a.m. - 5:00 a.m.	1:00 a.m. - 5:00 a.m.	All Days	-	124
			Total	0	744

2011 Holidays: New Year's Day (1/1), Presidents' Day (2/21), Memorial Day (5/30), Independence Day (7/4), Labor Day (9/5), Veterans Day (11/11), Thanksgiving Day (11/24) and Christmas Day (12/26). When any holiday listed above falls on Sunday, the following Monday will be recognized as a holiday. No change will be made for holidays falling on Saturday.

NOTE: PG&E reserves all its available rights and remedies to obtain a revision to this posting retroactive to May 1, 2011.

PG&E's Energy Prices for QFs are available on PG&E’s website at: www.pge.com/qf.

Source: PG&E (2011c)

PG&E As-Delivered Capacity Prices for Qualifying Facilities (January 2011)

Pacific Gas and Electric Company

2011 AS-DELIVERED CAPACITY PRICES FOR QUALIFYING FACILITIES

Effective January 1, 2011 [1]

	Capacity [2] Value $/kw-year	Capacity Allocation Factor [3] year/hr	Capacity Loss Adjustment Factor [4] Transmission	Capacity Loss Adjustment Factor [4] Primary & Secondary Distribution	As-Delivered Capacity Price [5] Transmission $/kwh	As-Delivered Capacity Price [5] Primary & Secondary Distribution $/kwh
	(a)	(b)	(c)	(d)	(e) = a * b * c	(f) = a * b * d
With Time-of-Delivery Metering						
Period A - Summer						
(May through October)						
Peak	41.220	0.0009921	0.989	0.991	**0.040445**	**0.040526**
Partial-Peak	41.220	0.0000266	0.989	0.991	**0.001084**	**0.001087**
Off-Peak	41.220	0.0000001	0.989	0.991	**0.000004**	**0.000004**
Super Off-Peak	41.220	0.0000000	0.989	0.991	**0.000000**	**0.000000**
Period B - Winter						
(January through April, November and December)						
Partial-Peak	41.220	0.0001308	0.989	0.991	**0.005332**	**0.005343**
Off-Peak	41.220	0.0000008	0.989	0.991	**0.000033**	**0.000033**
Super Off-Peak	41.220	0.0000000	0.989	0.991	**0.000000**	**0.000000**
Without Time-of-Delivery Metering						
Period A	20.610	0.0001780	0.989	0.991	**0.003628**	**0.003636**
Period B	20.610	0.0000493	0.989	0.991	**0.001005**	**0.001007**

1. Interested parties are hereby notified that PG&E reserves all its available rights and remedies to obtain a revision to this posting effective as of January 1, 2011.

2. The as-delivered capacity value is derived in accordance with CPUC Decision No. 07-09-040 COL 36, adopting a Combustion Turbine (CT) cost proposed by TURN in its Exhibit 149, less adjustments for ancillary services and energy benefits. The 2011 CT cost is $72.82/kW-year and is adjusted annually, as detailed in TURN's Exhibit 149, Appendix B. A weighted average of the capacity value is used for meters without time-of-delivery metering.

3. Capacity allocation factors (CAF) allocate the capacity value for seasons and time-of-delivery periods. These factors are derived by dividing the allocation percentages effective January 1, 2011, and approved in D. 97-03-017 by the number of hours in each time-of-delivery period. These percentages and hours are summarized, as follows:

	CAFs (%) Period A	CAFs (%) Period B	2011 Delivery Hours Period A	2011 Delivery Hours Period B
Peak	76.1900%	N/A	768	0
Partial-Peak	2.38%	21.25%	896	1,625
Off-Peak	0.02%	0.15%	2,016	1,995
Super-Off-Peak	N/A	N/A	736	724
Season total	78.59%	21.41%	4,416	4,344

Example of year/hr CAF for "Period A - Peak:"
76.19% divided by 768 hours = 0.0009921

4. Capacity prices are adjusted for the effect of deliveries on PG&E's transmission and distribution losses based upon the seller's interconnection voltage level. The loss adjustment factors for non-remote facilities (as defined by the CPUC) are shown here.

5. The as-delivered capacity price is the product of three factors: capacity value, allocation factor, and capacity loss adjustment factor.

Source: PG&E (2011d)

PG&E Rates for Small Renewable Generation (E-SRG)

Market Price Referents

Electric Schedule E-SRG Market Price Referents (MPR)

Adopted 2009 Market Price Referents Nominal - dollars/kWh			
Resource Type	**10-Year**	**15-Year**	**20-Year**
2010 Baseload MPR	0.08448	0.09066	0.09674
2011 Baseload MPR	0.08843	0.09465	0.10098
2012 Baseload MPR	0.09208	0.09852	0.10507
2013 Baseload MPR	0.09543	0.10223	0.10898
2014 Baseload MPR	0.09872	0.10593	0.11286
2015 Baseload MPR	0.10168	0.10944	0.11647
2016 Baseload MPR	0.10488	0.11313	0.12020
2017 Baseload MPR	0.10834	0.11695	0.12404
2018 Baseload MPR	0.11204	0.12090	0.12800
2019 Baseload MPR	0.11598	0.12499	0.13209
2020 Baseload MPR	0.12018	0.12922	0.13630
2021 Baseload MPR	0.12465	0.13359	0.14064

Time of Delivery Factors

PG&E Time of Delivery (TOD) Periods & Factors

Monthly Period	Super-Peak[1]	Shoulder[2]	Night[3]
Jun.-Sep.	2.20	1.12	0.69
Oct.-Dec., Jan. & Feb.	1.06	0.93	0.76
Mar.-May	1.15	0.85	0.64

Definitions:

1. Super-Peak (5x8) = HE (Hours Ending) 13 – 20 (Pacific Prevailing Time (PPT), Monday - Friday (*except* NERC holidays) in the applicable Monthly Period.
2. Shoulder = HE 7 - 12, 21 and 22 PPT Monday - Friday (*except* NERC holidays); and HE 7 - 22 PPT Saturday, Sunday and *all* NERC holidays in the applicable Monthly Period.
3. Night (7x8) = HE 1 - 6, 23 and 24 PPT all days *(including* NERC holidays) in the applicable Monthly Period.

"NERC Holidays" mean the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. Three of these days, Memorial Day, Labor Day, and Thanksgiving Day occur on the same day each year. Memorial Day is the last Monday in May; Labor Day is the first Monday in September; and Thanksgiving Day is the 4th Thursday in November. New Year's Day, Independence Day, and Christmas Day, by definition, are predetermined dates each year. However, in the event they occur on a Sunday, the "NERC Holiday" is celebrated on the Monday immediately following that Sunday. However, if any of these days occur on a Saturday, the "NERC Holiday" remains on that Saturday.

Source: PG&E (2011e)

APPENDIX G: PG&E INTERCONNECTION STUDY PROCESS

The interconnection process is governed by PG&E's Wholesale Distribution Tariff, which will combine small and large generator interconnection applications into a single process. This process involves multiple steps, including a pre-application, an interconnection request, and then either a fast track process, an independent study process, or a cluster study process. The time required and cost incurred varies for each of these processes. This process can take a year or more and cost upwards of $50,000. The following discussion outlines the process in more detail while drawing on information compiled from PG&E reports and presentations (PG&E, 2010 & 2011b).

1. Pre-Application – before formally submitting an interconnection request, it is recommended that a pre-application be submitted. This process involves requesting information about the nearest point of interconnection to the generation project and could be a good opportunity to get clarifying information about the technical constraints of interconnection before committing to the interconnection process.
2. Interconnection Request – the following lists some of the data required to successfully enter into the interconnection process:
    a. General information about the proposed generation equipment such as location, capacity, etc.
    b. Specific information about the proposed project including site drawings, single-line electrical schematics, electrical and operational characteristics of the generator, specifications of the interconnection equipment including the step-up transformer and power transmission lines from the generator to the point of interconnection.
    c. Proposed date for when the facility would be put into service and the term of service.
    d. Evidence of Site Control which can be proof of ownership or lease of the proposed land hosting the generator, proof of the option to purchase or lease the property, or proof of a business relationship with the owner or leaseholder of the property.
3. Fast Track Process – some interconnection requests qualify for the fast track process which can greatly reduce the time and expense required to acquire an interconnection agreement. However, we have determined that a hydropower project on Pecwan Creek will *not* pass because it cannot pass the following fast track eligibility screen (quotations from PG&E, 2010):
    a. Screen 2.2.1.7 – "If the proposed Small Generating Facility is to be interconnected on single-phase shared secondary, the aggregate generation capacity on the shared secondary, including the proposed Small Generating Facility, shall not exceed 20-kW."

    b. Screen 2.2.1.10 – "No construction of facilities by the Distribution Provider on its own system shall be required to accommodate the Small

Generating Facility." This screen would *not* pass if the small hydropower project required an upgrade from single to triple phase on the Wautec line extension.

There are additional Screens that a Small Hydropower Project May Not Pass, and they include:

c. Screen 2.2.1.2 – "The aggregated generation, including the proposed Small Generating Facility, on the circuit shall not exceed 15 % of the line section annual peak load as most recently measured at the substation."

   Based on data from PG&E (cite PG&E T&D map tool), 15% of the annual peak load is ~580-kW. So depending on the size of the proposed generator, this screen may not pass.

d. Screen 2.2.1.4 – "The proposed Small Generating Facility, in aggregation with other generation on the distribution circuit, shall not contribute more than 10 % to the distribution circuit's maximum fault current at the point on the high voltage (primary) level nearest the proposed point of change of ownership."

   We do not know what the maximum fault current is at the point of interconnection, but we did estimate the current associated with transmitting power from a 125-kW single-phase generator, approximately 10A.

e. Screen 2.2.1.5 – "The proposed Small Generating Facility, in aggregate with other generation on the distribution circuit, shall not cause any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers), or Interconnection Customer equipment on the system to exceed 87.5 % of the short circuit interrupting capability; nor shall the interconnection proposed for a circuit that already exceeds 87.5 % of the short circuit interrupting capability."

   We do not know what the rated capacity is of the existing switchgear on the distribution system, so we cannot judge whether this screen is likely to pass.

4. Independent Study Process – It is most likely that the interconnection process would be conducted through the independent study process instead of the cluster study process. The key criterion for this process is the test of electrical independence. This means that the interconnection will not have any adverse impacts on the transmission system and that the request is the only proposed interconnection on the distribution circuit. If other interconnections are also proposed, then the application must go through the cluster study process, which examines the issues associated with multiple interconnections simultaneously. Due to the rural nature of the Yurok reservation along Highway 169, it is unlikely

(though possible) that an additional interconnection request would be made at the same time as a Pecwan small hydropower request. We therefore outline the steps, costs, and timeline associated with the Independent Study Process below. Note that the time estimates quantify the time PG&E would take to complete their obligations in the process; additional time will be necessary for the developer to respond to each stage in the process. The fee for the overall process is approximately $51,000 for a 1MW generator and an additional $1,000 for a 2MW generator.

a. Initial Report Validation (~2 weeks) – After receiving the initial interconnection application, PG&E will validate the application is complete. If data are missing or clarification is needed, this may take longer than 2 weeks.

b. Scoping Meeting (~2 weeks) - At this meeting it is determined whether a Feasibility Study is needed or whether the request can move immediately to a System Impact Study.

c. Feasibility Study (at least 3 weeks + $1000) – This study is to identify potential adverse system impacts. If no impacts are found, then the System Impact Study may be skipped.

d. System Impact Study Agreement (~4 weeks) – PG&E will prepare an agreement detailing the scope of the system impact study in addition to cost responsibilities of an interconnect. The project developer must sign this agreement within 30 business days or an extension must be filed.

e. System Impact Study (~18 weeks) – PG&E will conduct the system impact study and submit results to the developer. The results will include a cost estimate of the system upgrades necessary to accommodate the generator. The costs estimates have a margin or error of approximately +/-50%.

f. Security Posting (~ 4 weeks) – At this point if the developer wishes to continue with the process, a security posting must be made as a down payment of "Lesser of 20% [of upgrade costs] or $20k/MW".

g. Facilities Study (~18 weeks) – After entering into an agreement to perform the facilities study (again, this must be signed within 30 business days or an extension must be filed), the study is conducted by PG&E. This study provides a scope of work and a more precise estimate of the costs, though the margin or error still is +/-25%.

h. Security Posting – Upon completion of the facilities study, the developer must commit 30% of system upgrade costs in order to get an interconnection agreement.

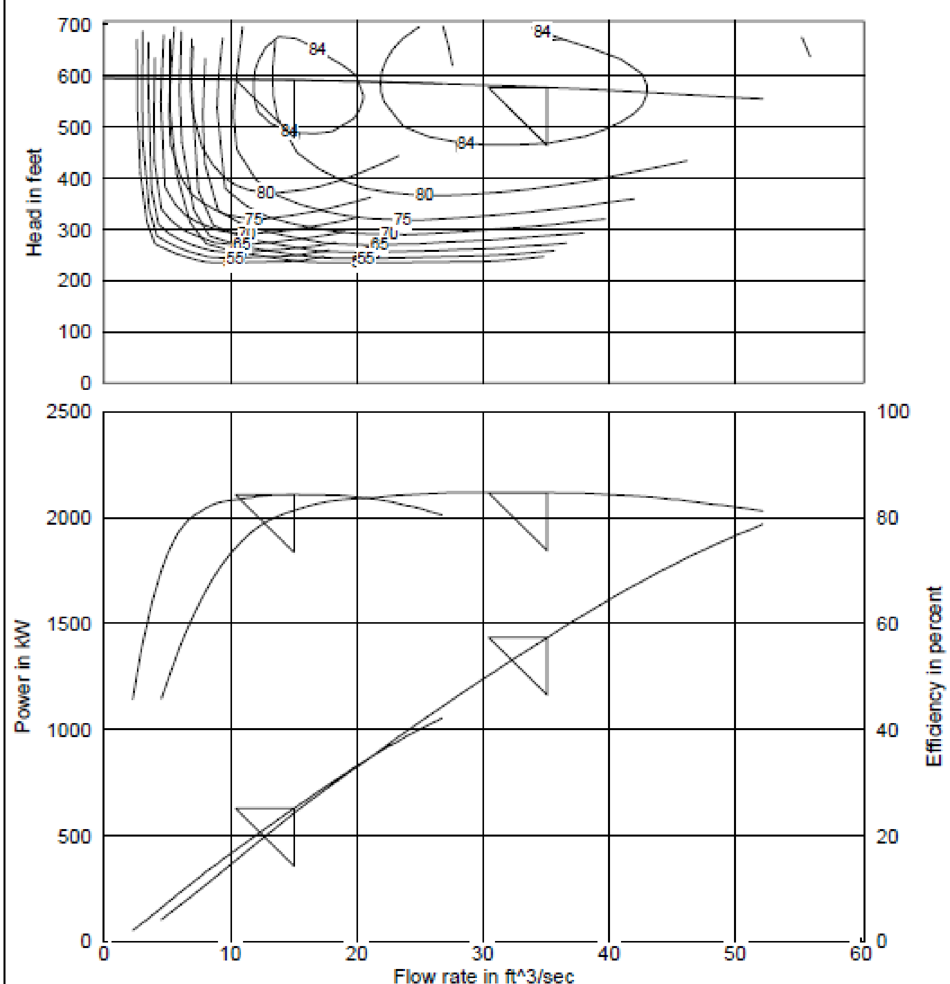
i. Interconnection Agreement (~4 weeks) – Part of the interconnection agreement is agreeing to pay for the full upgrade costs. After the interconnection agreement is executed (and all project permits are granted), the full balance of the costs must be posted before construction will begin

j. Construction (~42 weeks)

5. Cluster Study Process – If the interconnection request fails to meet the independent study screens, then it will have to wait until the next cluster study is initiated (could be as much as 12 months). The cluster study process is very similar to the independent study process, but each step takes longer to complete (approximately one year longer than the independent study process in total).

APPENDIX H: HYDROELECTRIC TURBINE EFFICIENCY CURVES

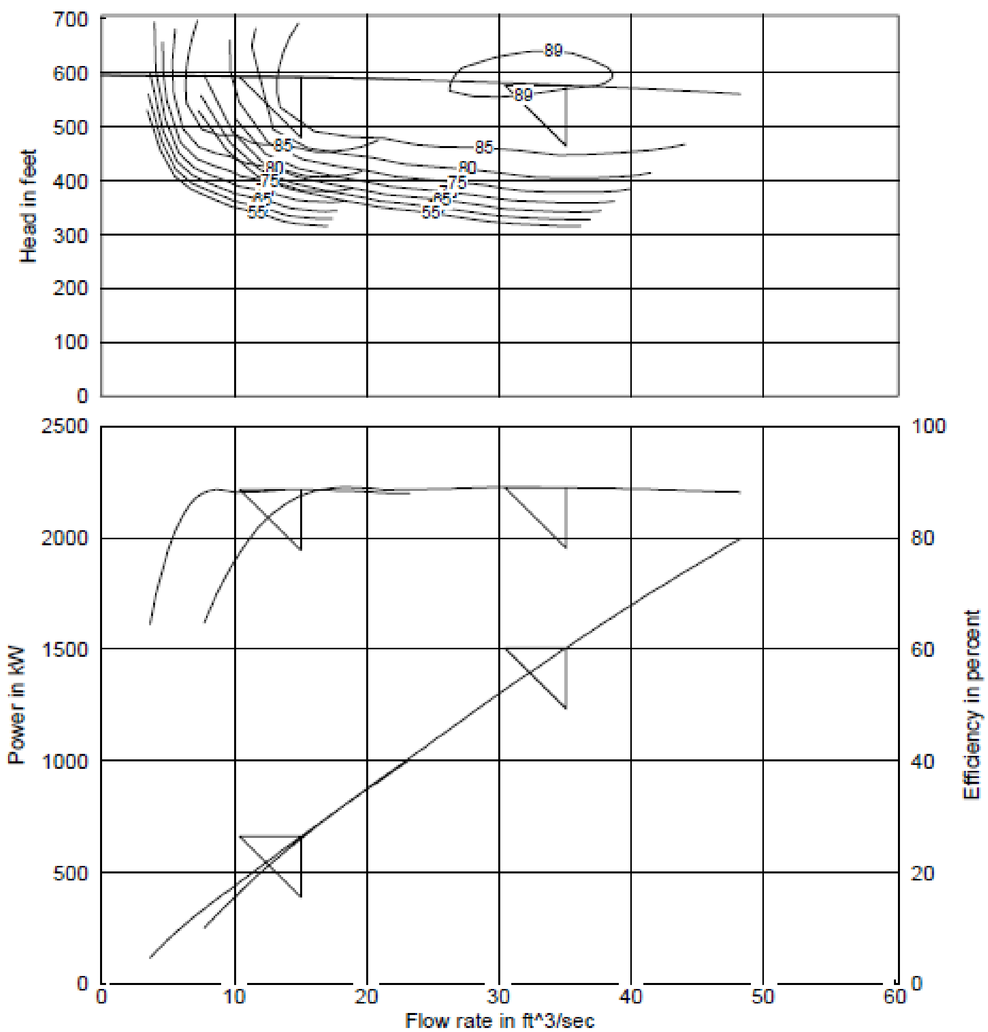
GILKES High Capacity Turgo	18. HCTI_TJ Speed 1200 Rpm



Name	Head feet	Flow rate ft^3/sec	Power kW	Efficiency percent	No.of Jets Hz
New Duty 1 Jet	572.0 586.7	35.0 15.0	1436 629	84.8 84.5	2.00 1.00

Gilbert Gilkes and Gordon Ltd Kendal, Cumbria, UK. LA9 7BZ Tel: 01539 720028 Fax: 01539 732110	Approved 11/03/11	Yurok 35 Version Number 9

GILKES Pelton	1050 P316_TJ
	Speed 514 Rpm



Name	Head feet	Flow rate ft^3/sec	Power kW	Efficiency percent	No.of Jets Hz
New Duty 1 Jet	572.0 586.7	35.0 15.0	1508 661	89.1 88.8	2.00 1.00

Gilbert Gilkes and Gordon Ltd Kendal, Cumbria, UK. LA9 7BZ Tel: 01539 720028 Fax: 01539 732110	Approved 11/03/11	Yurok 35 Version Number 10

APPENDIX I: ITEMIZED COSTS FOR PECWAN HYDROELECTRIC SYSTEMS

Cost Estimate

Alternative 1: Pecwan Creek, 125 kW Capacity

Abbreviations for units: CY = cubic yard; EA = each; GAL = gallon; HR = hour; JB = job; LF = linear feet; LS = lump sum; MI = mile; SF = square feet; YR = year

ITEM	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL PRICE
A. PLANNING					
	Environmental Assessments and Licensing (Hall et al., 2003a & 2003b)	1	LS	$ 68,023	$ 68,023
	SUBTOTAL SECTION A				**$ 68,023**
B. HYDROELECTRIC PLANT CONSTRUCTION					
	Road Development/Site Access (Austin, 2011)	1	MI	$ 40,000	$ 40,000
	Intake Site Access (Austin, 2011)	300	LF	$ 250	$ 75,000
	Intake System (Austin, 2011)	1	JB	$ 8,889	$ 8,889
	Forebay/Settling Basin (part of intake structure)	0	GAL	$ 5,000	$ -
	Tailrace Material (Copeland, 2011)	50	LF	$ 51	$ 2,550
	Penstock Material (Copeland, 2011)	3502	LF	$ 178,615	$ 178,615
	Penstock and Tailrace Construction (Austin, 2011)	3552	LF	$ 181,166	$ 181,166
	Powerhouse (Austin, 2011)	1	EA	$ 56,250	$ 56,250
	Turbine, Generator, Switchgear, ELC (Melander, 2011; Prior, 2011; Sellars, 2011)	1	LS	$ 198,075	$ 198,075
	SUBTOTAL				**$ 740,545**
	15% Construction Contingencies				**$ 111,082**
	SUBTOTAL SECTION B				**$ 851,627**
C. INTERCONNECTION & TRANSMISSION					
	Switch gear, Civil and Transformer(s)	1	LS	$ 40,000	$ 40,000
	Overhead Transmission Line (Mager, 2011)	6353	LF	$ 58	$ 368,470
	Transmission Engineering and Contingency (Mager, 2011)	6353	LF	$ 20	$ 127,059
	Transmission Construction/Road Access (Mager, 2011)	6353	LF	$ 40	$ 254,117
	Grid Transmission Upgrade (Mager, 2011)	1	LS	$ -	$ -
	SUBTOTAL SECTION C				**$ 789,646**
D. ENGINEERING AND ADMINISTRATION					
	Engineering, Legal, etc. (Humboldt Engineering & Construction, 2000)	1	25% of	$ 851,627	$ 212,906.78
	SUBTOTAL SECTION D				**$ 212,907**
E. ANNUAL WORKING COSTS					
	Fixed and Variable Operation and Maintenance (Hall et al., 2003a & 2003b)	125	EA	$ 90	$ 11,250
	SUBTOTAL SECTION E				**$ 11,250**
G. SUMMARY					
	Total Capital Cost (Sections: A, B, D - Plant Only)				**$ 1,132,557**
	Cost Per kW Installed				**$ 9,060**
	Total Capital Cost (Sections: A, B, C, D - With Transmission)				**$ 1,922,203**
	Cost Per kW Installed				**$ 15,378**
	Total Capital Cost (Sections: A, B, C, D - With Transmission and Grid Upgrade)				**$ 1,922,203**
	Cost Per kW Installed				**$ 15,378**
	Total Annual Working Cost (Sections: E)				**$ 11,250**
	Working Cost Per kW				**$ 90**

Cost Estimate

Alternative 2: Pecwan Creek, 500 kW Capacity

Abbreviations for units: CY = cubic yard; EA = each; GAL = gallon; HR = hour; JB = job; LF = linear feet; LS = lump sum; MI = mile; SF = square feet; YR = year

ITEM	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL PRICE
A. PLANNING					
	Environmental Assessments and Licensing (Hall et al., 2003a & 2003b)	1	LS	$ 272,092	$ 272,092
	SUBTOTAL SECTION A				**$ 272,092**
B. HYDROELECTRIC PLANT CONSTRUCTION					
	Road Development/Site Access (Austin, 2011)	1	MI	$ 40,000	$ 40,000
	Intake Site Access (Austin, 2011)	300	LF	$ 250	$ 75,000
	Intake System (Austin, 2011)	1	JB	$ 17,778	$ 17,778
	Forebay/Settling Basin (part of intake structure)	0	GAL	$ 5,000	$ -
	Tailrace Material (Copeland, 2011)	50	LF	$ 102	$ 5,115
	Penstock Material (Copeland, 2011)	3502	LF	$ 358,248	$ 358,248
	Penstock and Tailrace Construction (Austin, 2011)	3552	LF	$ 363,363	$ 363,363
	Powerhouse (Austin, 2011)	1	EA	$ 100,000	$ 100,000
	Turbine, Generator, Switchgear, ELC (Melander, 2011; Prior, 2011; Sellars, 2011)	1	LS	$ 426,050	$ 426,050
	SUBTOTAL				**$ 1,385,554**
	15% Construction Contingencies				**$ 207,833**
	SUBTOTAL SECTION B				**$ 1,593,387**
C. INTERCONNECTION & TRANSMISSION					
	Switch gear, Civil and Transformer(s)	1	LS	$ 60,000	$ 60,000
	Overhead Transmission Line (Mager, 2011)	6353	LF	$ 58	$ 368,470
	Transmission Engineering and Contingency (Mager, 2011)	6353	LF	$ 20	$ 127,059
	Transmission Construction/Road Access (Mager, 2011)	6353	LF	$ 40	$ 254,117
	Grid Transmission Upgrade (Mager, 2011)	1	LS	$ 2,495,000	$ 2,495,000
	SUBTOTAL SECTION C				**$ 3,304,646**
D. ENGINEERING AND ADMINISTRATION					
	Engineering, Legal, etc. (Humboldt Engineering & Construction, 2000)	1	25% of	$ 1,593,387	$ 398,346.74
	SUBTOTAL SECTION D				**$ 398,347**
E. ANNUAL WORKING COSTS					
	Fixed and Variable Operation and Maintenance (Hall et al., 2003a & 2003b)	500	EA	$ 90	$ 45,000
	SUBTOTAL SECTION E				**$ 45,000**
G. SUMMARY					
	Total Capital Cost (Sections: A, B, D - Plant Only)				**$ 2,263,826**
	Cost Per kW Installed				**$ 4,528**
	Total Capital Cost (Sections: A, B, C, D - With Transmission)				**$ 3,073,472**
	Cost Per kW Installed				**$ 6,147**
	Total Capital Cost (Sections: A, B, C, D - With Transmission and Grid Upgrade)				**$ 5,568,472**
	Cost Per kW Installed				**$ 11,137**
	Total Annual Working Cost (Sections: E)				**$ 45,000**
	Working Cost Per kW				**$ 90**

Cost Estimate

Alternative 3: Pecwan Creek, 1.5 MW Capacity

Abbreviations for units: CY = cubic yard; EA = each; GAL = gallon; HR = hour; JB = job; LF = linear feet; LS = lump sum; MI = mile; SF = square feet; YR = year

ITEM	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL PRICE
A. PLANNING					
	Environmental Assessments and Licensing (Hall et al., 2003a & 2003b)	1	LS	$ 816,276	$ 816,276
	SUBTOTAL SECTION A				**$ 816,276**
B. HYDROELECTRIC PLANT CONSTRUCTION					
	Road Development/Site Access (Austin, 2011)	1	MI	$ 40,000	$ 40,000
	Intake Site Access (Austin, 2011)	300	LF	$ 250	$ 75,000
	Intake System (Austin, 2011)	1	JB	$ 33,333	$ 33,333
	Forebay/Settling Basin (part of intake structure)	0	GAL	$ 5,000	$ -
	Tailrace Material (Copeland, 2011)	50	LF	$ 170	$ 8,501
	Penstock Material (Copeland, 2011)	3502	LF	$ 595,385	$ 595,385
	Penstock and Tailrace Construction (Austin, 2011)	3552	LF	$ 603,886	$ 603,886
	Powerhouse (Austin, 2011)	1	EA	$ 156,250	$ 156,250
	Turbine, Generator, Switchgear, ELC (Melander, 2011; Prior, 2011; Sellars, 2011)	1	LS	$ 1,153,000	$ 1,153,000
	SUBTOTAL				**$ 2,665,354**
	15% Construction Contingencies				**$ 399,803**
	SUBTOTAL SECTION B				**$ 3,065,157**
C. INTERCONNECTION & TRANSMISSION					
	Switch gear, Civil and Transformer(s)	1	LS	$ 70,000	$ 70,000
	Overhead Transmission Line (Mager, 2011)	6353	LF	$ 58	$ 368,470
	Transmission Engineering and Contingency (Mager, 2011)	6353	LF	$ 20	$ 127,059
	Transmission Construction/Road Access (Mager, 2011)	6353	LF	$ 40	$ 254,117
	Grid Transmission Upgrade (Mager, 2011)	1	LS	$ 4,050,000	$ 4,050,000
	SUBTOTAL SECTION C				**$ 4,869,646**
D. ENGINEERING AND ADMINISTRATION					
	Engineering, Legal, etc. (Humboldt Engineering & Construction, 2000)	1	25% of	$ 3,065,157	$ 766,289.29
	SUBTOTAL SECTION D				**$ 766,289**
E. ANNUAL WORKING COSTS					
	Fixed and Variable Operation and Maintenance (Hall et al., 2003a & 2003b)	1500	EA	$ 90	$ 135,000
	SUBTOTAL SECTION E				**$ 135,000**
G. SUMMARY					
	Total Capital Cost (Sections: A, B, D - Plant Only)				**$ 4,647,722**
	Cost Per kW Installed				**$ 3,098**
	Total Capital Cost (Sections: A, B, C, D - With Transmission)				**$ 5,467,368**
	Cost Per kW Installed				**$ 3,645**
	Total Capital Cost (Sections: A, B, C, D - With Transmission and Grid Upgrade)				**$ 9,517,368**
	Cost Per kW Installed				**$ 6,345**
	Total Annual Working Cost (Sections: E)				**$ 135,000**
	Working Cost Per kW				**$ 90**

APPENDIX J: HYDROELECTRIC TURBINE-GENERATOR QUOTES

Canyon Hydro: 120 kW turbine-generator package

from **Eric Melander**<eric.melander@canyonhydro.com>
to Ruben Garcia <rugarcia@gmail.com>
date Thu, Mar 31, 2011 at 10:59 AM
subject RE: Canyon Hydro

Hi Ruben,

Based on a net head of 582 feet and design flow of 3.4 cfs using a 12" penstock 1540 feet in length, we can offer a Canyon dual nozzle Pelton turbine direct coupled to a 1200 rpm single phase synchronous generator to produce 120 KW. The complete powerhouse equipment package is estimated in the $265,000 range and will include: turbine, generator, switchgear/controls panel, hydraulic power unit skid, turbine inlet valve, drive coupling and mounting bed plates.

I can't really share much regarding past projects unless we have the owner's permission. I am uncertain if we have permission to share additional information regarding the project you reference below.

Please feel free to give me a call with any question.

Best regards,

Eric Melander
Canyon Hydro
360-592-5552

Canyon Hydro: 800 kW turbine-generator package

from **Eric Melander** <eric.melander@canyonhydro.com>
to Ruben Garcia <rugarcia@gmail.com>
date Mon, Aug 9, 2010 at 12:27 PM
subject RE: Canyon Hydro

Hi Ruben,

If we assume the net head is 560 feet at a design flow rate of 20 cfs expected system production will be 790 KW. Estimated powerhouse equipment package cost is $750,000 to include: Canyon custom dual nozzle Pelton turbine, 800 KW 480/3/60 synchronous generator, switchgear/controls panels to parallel the generator with the utility and provide control of the turbine nozzles/jet deflectors, hydraulic power unit skid for turbine actuation, 20" turbine inlet valve with manual gear operator, 20" dismantling joint, drive coupling set and structural steel turbine/generator mounting frames.

Best regards,

Eric Melander
Canyon Hydro
360-592-5552

Canyon Hydro: 1.2 MW and 1.85 MW turbine-generator packages

from **Eric Melander** <eric.melander@canyonhydro.com>
to Ruben Garcia <rugarcia@gmail.com>
date Mon, Feb 28, 2011 at 12:41 PM
subject RE: Canyon Hydro

Hi Ruben,

Based on a design flow of 45 cfs and the use of a 30" penstock expected system production would be 1.85 MW with estimated equipment package cost in the 2 million dollar range. Commissioning expected in the same range as below.

I neglected to consider medium voltage switchgear and generator for the 1.2 MW system at 30 cfs using a 24" penstock. Estimated price should be 1.2 million dollars. Commissioning estimate remains the same.

Industry standard seem to revolve around 25 years. We expect much longer life span with proper maintenance and correct component replacement. Turbine/generator bearings are commonly specified with L-10 lifespan of 100,000 hours. The turbine runner, nozzles and beaks are expected to at least double this lifespan under clean water conditions.

General contractors tell us they recommend planning on 5% for annual operating and maintenance costs. This seems quite high to us but would definitely provide a strong storage of cash reserve for major maintenance when eventually required.

Best regards,

Eric Melander
Canyon Hydro
360-592-5552

Dependable Turbines Ltd: 120 kW turbine-generator package

BUDGET PROPOSAL **Date: March 17, 2011**

TO: Schatz Energy Research Center

FROM: Robert Prior

REF: your request – Yurok Reservation Hydro Project

Thank you, Mr. Garcia for this opportunity.
DTL is pleased to submit the following quote for your consideration.

ITEM	DESCRIPTION		QTY
INLET VALVE	8 inch Butterfly Valve, 25 Bar, Weight/hydraulic Operator, Manual By-Pass, Dismantling Joint		one
HYDRO TURBINE	Horizontal Single Nozzle Pelton, S/S Runner Rated output: 127 Kw at 1200 RPM. Rated Head: 160 m(525 feet), Flow : 92.5 l/s(3.27 cfs) Fail-safe Weighted Lever/Hydraulic Deflectors		one
GENERATOR	120kW Horizontal Synchronous 1200 RPM, 480 Volt, Single Phase Common Turbine-Generator Frame, Coupling		one
TURBINE CONTROLLER/ OIL PUMP UNIT	PLC Electronic Controller Hydraulic Oil Unit for Turbine & Inlet Valve Actuation		one
ELECTRICAL PACKAGE	Indoor Switchgear Controls & Full-function Protection 24 volt Battery Bank & Charger		one
INSTALLATION SUPERVISION AND COMMISSIONING	0 days on site		
SHIPPING	Ex Works		

Payment Terms: Collectable on milestones

BUDGET PRICE: $ 115,000

Prices in U.S. Funds

Delivery: 5 - 6 months from factory

Budget Proposal validity: 60 days from this quotation date.
Taxes: Price(s) specified herein do not include any taxes.
Conditions: Subject to Dependable Turbines Ltd. Terms & Conditions.

Trusting the above quote and attached documents are to your entire satisfaction. If you require any additional information or clarification, please do not hesitate to contact us. We look forward to discussing this opportunity further with you at your earliest convenience.

Dependable Turbines Ltd: 500 kW turbine-generator package

BUDGET PROPOSAL **Date: August 12, 2010**

TO: Schatz Energy Research Center

FROM: Robert Prior

REF: your request – Yurok Reservation Hydro Project

Thank you, Mr. Garcia for this opportunity.
DTL is pleased to submit the following quote for your consideration.

ITEM	DESCRIPTION		QTY
INLET VALVE	16 inch Butterfly Valve, 25 Bar, Weight/hydraulic Operator, Manual By-Pass, Dismantling Joint		one
HYDRO TURBINE	Horizontal Two Nozzle Pelton, S/S Runner Rated output: 531 Kw at 900 RPM. Rated Head: 166 m(544 feet), Flow : 371 l/s(13.1 cfs) Fail-safe Weighted Lever/Hydraulic Deflectors		one
GENERATOR	500 kW Horizontal Synchronous 900 RPM, 480 Volt, Single Phase Common Turbine-Generator Frame, Coupling		one
TURBINE CONTROLLER/ OIL PUMP UNIT	PLC Electronic Controller Hydraulic Oil Unit for Turbine & Inlet Valve Actuation		one
ELECTRICAL PACKAGE	Indoor Switchgear Controls & Full-function Protection 24 volt Battery Bank & Charger		one
INSTALLATION SUPERVISION AND COMMISSIONING	0 days on site		
SHIPPING	Ex Works		

Payment Terms: Collectable on milestones

BUDGET PRICE: $ 360,000

Prices in U.S. Funds

Delivery: 10-12 months from factory

Budget Proposal validity: 60 days from this quotation date.
Taxes: Price(s) specified herein do not include any taxes.
Conditions: Subject to Dependable Turbines Ltd. Terms & Conditions.

Trusting the above quote and attached documents are to your entire satisfaction. If you require any additional information or clarification, please do not hesitate to contact us. We look forward to discussing this opportunity further with you at your earliest convenience.

Dependable Turbines Ltd: 2.2 MW turbine-generator package

BUDGET PROPOSAL **Date: March 15, 2011**

TO: Schatz Energy Research Center

FROM: Robert Prior

REF: your request – Yurok Reservation Hydro Project

Thank you, Mr. Garcia for this opportunity.
DTL is pleased to submit the following quote for your consideration.

ITEM	DESCRIPTION		QTY
INLET VALVE	30 inch Butterfly Valve, 25 Bar, Weight/hydraulic Operator, Manual By-Pass, Dismantling Joint		one
HYDRO TURBINE	Horizontal Two Nozzle Turgo, S/S Runner Rated output: 2230 Kw at 900 RPM. Rated Head: 164.5 m(539.5 feet), Rated Flow : 1.74 m3/s (61.4 cfs) Fail-safe Weighted Lever/Hydraulic Deflectors		one
GENERATOR	2237 kW Horizontal Synchronous 900 RPM, 4160 Volt, Three Phase Common Turbine-Generator Frame, Coupling		one
TURBINE CONTROLLER/ OIL PUMP UNIT	PLC Electronic Controller Hydraulic Oil Unit for Turbine & Inlet Valve Actuation		one
ELECTRICAL PACKAGE	Indoor Switchgear Controls & Full-function Protection 24 volt Battery Bank & Charger		one
INSTALLATION SUPERVISION AND COMMISSIONING	50 days on site		included
SHIPPING	To Northern California		included

Payment Terms: Collectable on milestones

BUDGET PRICE: $ 1,050,000

Prices in U.S. Funds

Delivery: 11-13 months from factory

Project Data
Static Head – 590 feet
Penstock Length – 1640 feet
Penstock Diameter – 26 inch

5kV single unit
Includes:

- 5kV switchgear with disconnect and breaker
- VTs and CTs as needed for protection
- SEL-700G (or Alstom 34x series) Multifunction including differential protection relay
- Basler DECS200 voltage regulator
- 4x Vibration transducers
- 2x Pressure transducers
- 10x RTD inputs (typically 4 bearings and 6 winding sensors, actual sensors supplied by others)
- *Generator neutral ground resistor
- *Power Parameters Information System and DNP3.0 Slave (for BC Hydro and similar interconnections)
- Touchscreen display/control panel
- Datalogger (remotely readable over available network)
- Station Computer
- *125VDC Battery/charger system
- *Governor functionality
- All equipment labelled or certified to CSA or equivalent
- Shipping to Vancouver area, other locations to be negotiated
- Installation supervision and assistance (travel and accommodation extra)
- Commissioning (travel and accommodation extra)
- Warranty one year from commissioning or 18 months from delivery

Not included:

- Power cables
- Control cables (except specialty cables for instruments)
- Network or telephone connections and service (equipment will be ready for Ethernet connection to WAN supplied by others)
- Installation labour and materials

Site Supervision: Travel and site labor cost only, local travel cost, meals & accommodation are not included.
Budget Proposal validity: 60 days from this quotation date.
Taxes: Price(s) specified herein do not include any taxes.
Conditions: Subject to Dependable Turbines Ltd. Terms & Conditions.

Trusting the above quote and attached documents are to your entire satisfaction. If you require any additional information or clarification, please do not hesitate to contact us. We look forward to discussing this opportunity further with you at your earliest convenience.

Gilbert Gilkes & Gordon Ltd.: 400 kW - 2.1 MW turbine-generator packages

GILKES

BUDGET PROPOSAL

Quotation Ref	:	BMS/Yurok
Sales Engineer	:	Bruce Sellars
	:	b.sellars@gilkes.com
	:	250-483-3883
Date	:	16 March 2011
Enquiry from	:	Ruben Garcia
Site location	:	California, USA

PROPOSAL DISCUSSION

Gilkes has put together some preliminary turbine selections and some budget prices for the Yurok hydroelectric project based on the information provided.

Three cases were evaluated:
- project output is limited to 400 kW at the grid interconnection
- design flow of 35 cfs
- design flow of 50 cfs

The gross head was assumed to be 590 feet. For each case, the head loss was set to be 18 feet (about 3% of the gross head) at the design flow. The assumption is that the penstock diameter would be designed for the appropriate design flow (10, 35 or 50 cfs).

For each case, I have offered a Turgo and a Pelton turbine.
- This is at the low end of the Pelton range, so the Pelton turbines are larger and slower speed than the corresponding Turgo turbine
- The Pelton unit will offer a higher efficiency, but has a higher capital cost

400 kW option
- I adjusted the flow to get around 420 kW at the turbine shaft; after generator, switchgear and line losses, this would give you around 400 kW at the interconnection.
- Most of the time you are spilling water
- The lower efficiency of the Turgo only matters if you are water limited. If the limit is the 400 kW restriction and there is extra water, the efficiency doesn't matter.
- The Pelton would be a 600 P316 at 900 rpm
    - I have attached pictures of a 625 P316 and a drawing of a 550 P316.
    - The 550 P316 is from Guesachan. This is a 470 kW unit in Scotland that we installed in 2008.
    - In general, you can compare the sizes of the machine by the ratio of the mean diameters.
- The Turgo would be a single jet 12 inch at 1800 rpm
    - I have included a drawing of the Draper USA project which is a 12 inch 1800 rpm unit producing 511 kW installed in 2004.
- For this size of turbine, I have offered electric actuators for the turbine spear valves and the Main Inlet Valve
- The generator would be an induction generator

35 cfs option
- The Pelton option would be a 1050 P316 twin jet at 514 rpm producing 1508 kW at the turbine shaft
    - I have included a drawing for an 1100 P316, so pretty close
- The Turgo would be an 18 inch twin jet Turgo at 1200 rpm
    - We have built this turbine a number of times
- For the 35 cfs and the 50 cfs options, the spear valves and inlet valve will be hydraulically actuated. I have included the HPU in the scope of supply

GILKES

- For the 35 and 50 cfs cases, the generator would be a synchronous generator

50 cfs option

- I used 50 cfs as the max design flow
- The Pelton option would be a 1200 P316 at 450 rpm
- The Turgo option could be a 20 inch at 1200 rpm or a 22.5 inch at 900 rpm
    - The optimal size is actually between these two standard sizes
    - I picked the 20 inch as it has a lower low flow cut-off. It can operate below 5 cfs and therefore enable energy production during low flow periods.
- The Turgo photos are of an 18 inch unit

The proposal is that the inlet and outlet isolation valves would be supplied by D2FC in France. A butterfly type valve has been specified for this application. The valve pricing includes the MIV pressure equalizing bypass valve. I have offered a valve that is electric or hydraulically actuated, with fail-safe weight to close. These valves are factory assembled and tested. Other valves can be used, depending on the preference of the owner.

Gilkes normal warranty is 12 months from installation, or 18 months from readiness to ship, whichever occurs first. Longer warranties can be negotiated.

Gilkes will provide a performance guarantee for efficiency and for runner wear due to cavitation. Testing for these conditions will be in accordance with standard IEC protocols.

In the price, we have included the inlet isolation valve, turbine, generator, HPU and imbedded parts (if any). Shipping to the site is included, provided the site is accessible by highway type commercial vehicles, otherwise shipping to the nearest town is included. I have also included the special tools for installing and maintaining the equipment. Import duties are included where applicable.

The price does not include any civil work, the controls and electrical equipment for the station service, HVAC, SCADA, or the transformers and switchgear to interconnect with the plant bus or the utility. The scope of supply for the electrical equipment varies significantly. Gilkes works with a number of electrical engineering firms that can design and install this package. For budget purposes, the cost of Gilkes supplying the turbine controls would be approximately $45,000.

The price does not include sales or other local taxes.

Installation supervision would be provided by a Gilkes engineer. These services are normally provided on a per diem basis. The actual installation of the equipment will be done by others; usually the general contractor. I have included an estimate for this cost.

The pricing, terms and technical specifications are subject to us negotiating a definitive agreement.

Please let me know if you have any questions, or need any other information.

Yours truly,

Bruce Sellars PEng
Hydro Sales Manager, North America
Gilbert Gilkes & Gordon Ltd.
Victoria BC office
250-483-3883

GILKES

SCOPE OF SUPPLY

1 off Gilkes Turgo or Pelton Turbine
Horizontal arrangement

1 off Induction or Synchronous generator

1 off HPU

1 off Turbine shutoff valve

1 off All imbedded parts for the turbine and generator

1 off Shipping to project site

1 off Special tools required for installation and maintenance

PRICE

Budget Prices for the equipment specified above:

	400 kW		35 CFS		50 CFS	
	12 Turgo	**600P316**	**18 Turgo**	**1050P316**	**20 Turgo**	**1200P316**
Turbine	185,000	320,000	310,000	510,000	365,000	610,000
Generator	65,000	75,000	110,000	150,000	145,000	225,000
HPU	electric	electric	25,000	25,000	30,000	30,000
Valve	25,000	25,000	45,000	45,000	65,000	65,000
	$275,000	$420,000	$490,000	$730,000	$605,000	$930,000
Installation supervision	45,000	45,000	50,000	50,000	55,000	55,000

Notes
1) the turbine and generator prices include engineering, witness testing, turbine, generator, main terminal box, shipping, imbedded parts and special tools for installation and maintenance
2) the installation supervision is an estimate for a Gilkes engineer for installation and commissioning
3) price includes packing and shipping to site and includes import duty, but does not include local sales tax or any other taxes.

ESTIMATED DELIVERY

9 – 10 months from receipt of order
The critical timeline is currently delivery of the generator

TERMS AND CONDITIONS

Payment : A payment with order (20% of total contract value) and progress payments throughout the manufacturing period will be required.

General Terms and Conditions : Gilkes standard form L.91. A copy is available on request.

GILKES

VALIDITY

Due to the volatility in exchange rates and component prices, these are budget prices only. Firm prices will be determined upon negotiating and executing a definitive contract.

TECHNICAL DATA

GILKES HORIZONTAL TURBINES

	400 kW		35 CFS		50 CFS	
	12 Turgo	600P316	18 Turgo	1050P316	20 Turgo	1200P316
Mean diameter - mm	300	600	450	1050	500	1200
Rated speed – rpm	1800	900	1200	514	1200	450
Shaft power at design conditions- kW	420	420	1436	1508	2030	2154
Efficiency - %	83.0	89.2	84.8	89.1	83.9	89.1
Inlet valve size – inches	12	12	24	24	28	28

Orientation	:	horizontal
No. of units	:	1
Design head- gross	:	590 feet
Design head- net	:	572 feet
Runner material	:	CA6NM Stainless steel

SYNCHRONOUS GENERATOR SPECIFICATION

Rated output	:	to match max turbine output;
	:	generally the design output +10%
Voltage	:	480 volts
Frequency	:	60 Hz
Power factor	:	0.90
Insulation - Stator	:	Class 'F'
Rotor	:	Class 'F'
Stator temperature rise	:	Class B' (80 deg. C with 40 deg C ambient)
Exciter insulation	:	Class 'F'
Enclosure standard	:	IP23
Bearing type	:	grease lubricated rolling element
Ambient temperature range	:	0-40 deg C
Altitude	:	1000 m.a.s.l. (maximum)
Voltage adjustment	:	Motorised
Stator temperature sensors	:	Yes
Bearing temperature indicators	:	Yes
Main terminal box	:	included

GILKES

TYPICAL TURBINE INLET VALVE SPECIFICATION

Type	:	Double flanged Butterfly valve
Size	:	as per table above
Pressure rating	:	PN 20
Design	:	Resilient sealing design
Flanges	:	BS 4504 or US equivalent
Standard	:	Generally in accordance with BS 5155
Body	:	Ductile iron
Body seat	:	Stainless steel or elastomer
Disc	:	Ductile iron
Disc seal	:	Nitrile rubber
Shafts	:	Stainless steel
Bushes	:	Self lubricating type
Valve operator	:	Closure by gravity counterweight with oil hydraulic check Opening by oil hydraulic cylinder
Pressure equalizing by-pass	:	included

TYPICAL OIL HYDRAULIC PRESSURE SYSTEM SPECIFICATION

Free standing sump tank
Electric motor driven gear pump
Pressure relief valve and gauge
Filler, strainer, breather level gauge and thermometer
Flow/level indicating switches with alarm and trip contacts
Differential unloader valve
Bladder type accumulator system for auto shutdown on loss of AC supply
10 micron filtering system
Electro hydraulic servo valve module
For Main Inlet Valve - electro hydraulic solenoid valve

TYPICAL ELECTRICAL CONTROLS SPECIFICATION

Typical Panel Mounted Equipment

Electrical control, monitoring, protection and metering equipment
Automatic synchronising system for parallel operation
PLC system for remote control, monitoring communications network by telemetry

Scope of supply does not include station service, transformers or switchgear to interconnect with the utility.

APPENDIX K: PERMITTING REQUIREMENTS

Preliminary Review of Permitting Requirements

Yurok Hydroelectric Power Project West Fork Pecwan Creek

Yurok Reservation, Humboldt County California

Prepared for the Yurok Tribe by
Schatz Energy Research Center

March 2011

CONTENTS

Introduction

This report has been prepared as part of a feasibility study on construction by the Yurok Tribe of a proposed hydroelectric power project on the West Fork of Pecwan Creek, adjacent to the Yurok Reservation. The land on which the project would be built is currently owned by Green Diamond Resources Company but is in the process of being purchased by the Tribe as part of a 22,237-acre land deal. The catchment area upstream is also mainly Green Diamond property that is being acquired by the Tribe, with a small portion of the headwaters being on Six Rivers National Forest land.

The process of obtaining the necessary permits, licenses, or exemptions necessary to build and operate a hydroelectric power system is complex, involves multiple agencies, and can take years to complete. However, it is not insurmountable, as indicated by the existence of many permitted hydropower projects across California, ranging from small systems serving a single off-grid residence to massive utility-scale projects.

The Federal Energy Regulatory Commission (FERC) regulates non-federal hydropower projects, which constitute about half of the hydropower-producing dams in the U.S., with the rest under the jurisdiction of U.S. Bureau of Reclamation, Army Corps of Engineers, Tennessee Valley Authority, or Bonneville Power Administration. Under the Federal Power Act, FERC would be the applicable regulatory authority for a project on Pecwan Creek. FERC's process for licensing hydropower projects or exempting projects from licensing requires consultation with and approval by numerous state and federal agencies. Understanding the FERC licensing process is thus key to undertaking development of a hydropower project. Many of the agencies that will review the project can require significant periods of time to give approval, and the entire licensing process typically takes several years; it is thus in the Tribe's best interest to make sure to begin consultations as early as possible with each agency. See Figure 1 for a process flow chart giving an overview of the licensing process.

Overview of the FERC Licensing Process

Our first question was "Is a Yurok Tribe hydro project on Pecwan Creek subject to FERC oversight?" FERC's *Handbook for Hydroelectric Project Licensing and 5 MW Exemptions from Licensing* says:

> *A license (or exemption from licensing…) from the Commission is required to construct, operate, and maintain a nonfederal hydroelectric project that is or would be (a) located on navigable waters of the United States; (b) occupy U.S. lands; (c) utilize surplus water or water power from a U.S. government dam; or (d) be located on a stream over which Congress has Commerce Clause jurisdiction, where project construction or expansion occurred on or after August 26, 1935, and the project affects the interests of interstate or foreign commerce.*

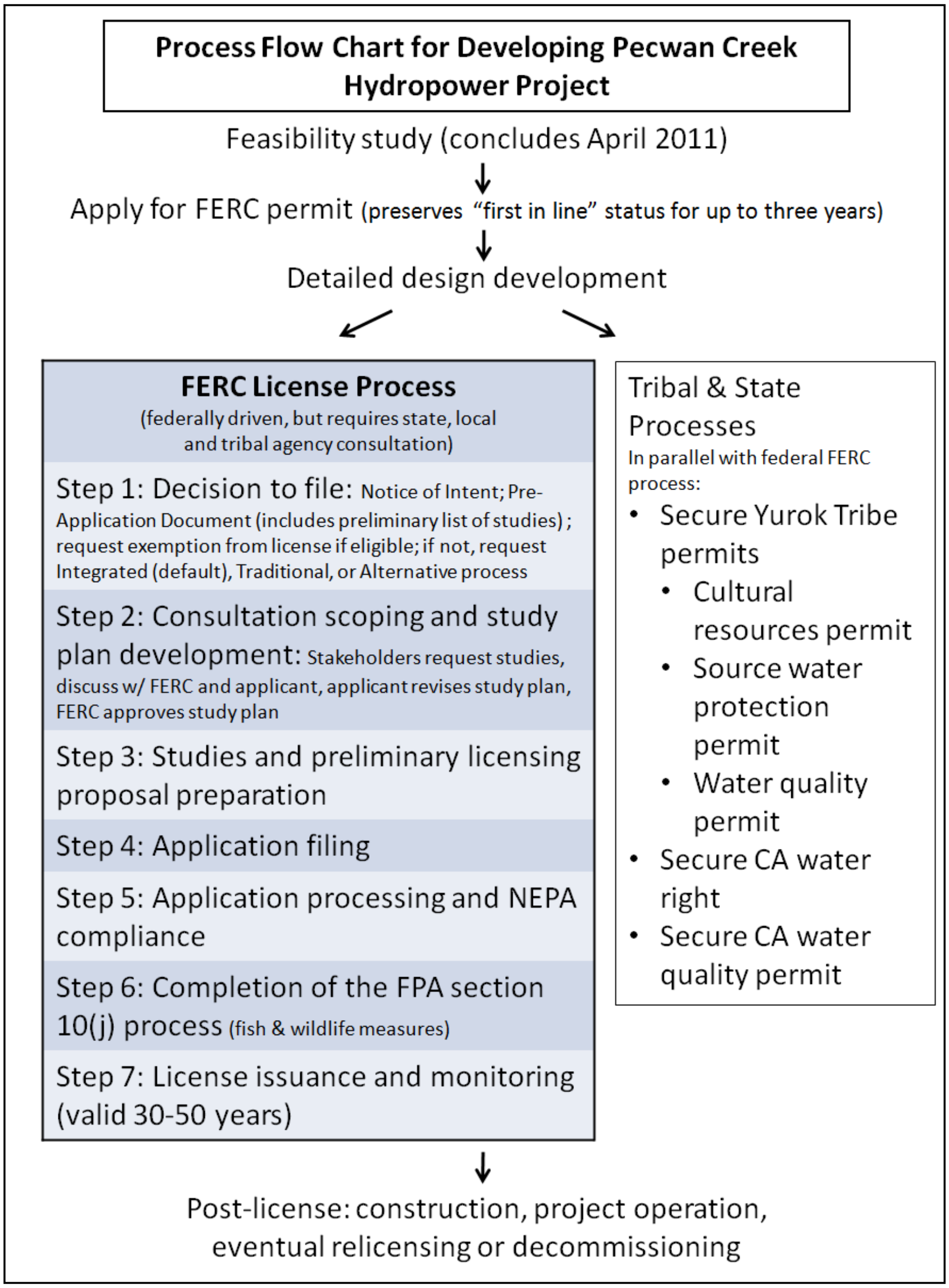


Figure 1. Process Flow Chart

We consulted with Michael Spencer at FERC's small hydro hotline (866-914-2849) on February 24, 2011. He clarified that the proposed project is almost certain to fall under FERC's jurisdiction because a) feeding power from the project into the grid constitutes interstate commerce, and b) although the project itself would not be built on navigable waters, since Pecwan Creek feeds a navigable waterway (the Klamath River), the "located on navigable waters" condition does apply. Given these interpretations of the Handbook's language, it is easy to see how most non-federal hydroelectric projects are governed by FERC.

Obtaining a FERC license is not a trivial task. For a sense of scale, there are only slightly over one thousand active FERC licenses nationwide, and only eleven licenses were issued nationwide in 2010, most of them for multi-MW-scale projects. However, some smaller projects are able to qualify for exemptions from FERC licensing. FERC offers an exemption for projects smaller than 5 MW, provided the system uses an existing dam or a natural water feature, i.e., does not create a new water impoundment. Mr. Spencer noted that a water intake or diversion's classification as a "natural water feature" sometimes is determined on a case by case basis. It may not be possible to determine whether the Pecwan Creek project satisfies the natural water feature condition until a more detailed design has been developed and further consultation with FERC has taken place.

Licenses are issued for a period of 30 to 50 years. Prior to the end of this license period, a licensee can apply to FERC for relicensing. Note that under some circumstances, a public agency or other interested party can appeal to FERC to reopen the license based on non-compliance with existing or new environmental regulations or for a variety of other causes. The reopening process may lead to changes in the terms of the license (e.g., compliance with new and stricter water quality standards) or even revocation of a license. In practice, reopening of existing licenses is not common.

Assuming the Tribe does have to pursue a FERC license, the type of license sought for this project would be an "original license for an unconstructed hydroelectric project." Indian tribes are explicitly eligible to apply for FERC hydropower licenses. FERC uses three different licensing process, known as the traditional, alternative, and integrated processes.

If the Tribe pursues a license for the project, note that per the FERC website: "Effective July 23, 2005, the Integrated Licensing Process (ILP) is the default process for filing an application for an original, new, or subsequent license (18 CFR Part 5). Commission approval is needed to use either the Traditional or the Alternative Licensing Process."[i] Thus it is assumed for purposes of this document that a license for the Pecwan project would be pursued via the ILP.

If, on the other hand, the Tribe pursues an exemption, they would use either the traditional or alternative licensing pathway to do this. See Table 1 in FERC's licensing handbook for a comparison of the three licensing processes.

Preliminary Permit

An applicant may apply to FERC for a preliminary permit, which allows the applicant a three-year period in which to develop a license application. During this period, the permit holder reserves "first in line" status for development of the specific hydropower resource. The preliminary permit is not a right to perform any construction and is not a guarantee that a license will be issued.

Preparing a FERC Notice of Intent

The Notice of Intent (NOI) is the first formal step an applicant takes in pursuing an actual FERC license (as opposed to the preliminary permit, which is essentially a placeholder).

Per the FERC licensing manual, the NOI must include:

> *· the licensee's intention to file or not to file for a license;…*
>
> *· licensee's name and address;*
>
> *· project number (or preliminary permit number for an original license if applicable);*
>
> *· type of principal project features licensed;*
>
> *· location of the project;*
>
> *· plant installed capacity;*
>
> *· location(s) where information required under 18 CFR 16.6 is available to the public;* [Note: 18 CFR 16.6 states that FERC will publish the NOI containing the required information in the Federal Register and a local newspaper and will directly notify relevant federal and state resource agencies and Tribes] *and*
>
> *· the names and mailing addresses of: every county; every city, town, or similar local political subdivision in which any part of the project is located or has a population of 5,000 or more and is within 15 miles of the project dam; every irrigation district, drainage district, or similar special purpose political subdivision; and affected Indian tribes.*

For project location and a 15-mile radius around the project, see Figure 2. The project lies within Humboldt County, with parts of Del Norte and Siskiyou Counties falling within the 15-mile radius. The main communities within the 15-mile radius are shown; none of these communities has a population of more than 5,000. There are no incorporated cities or towns within the 15-mile radius.

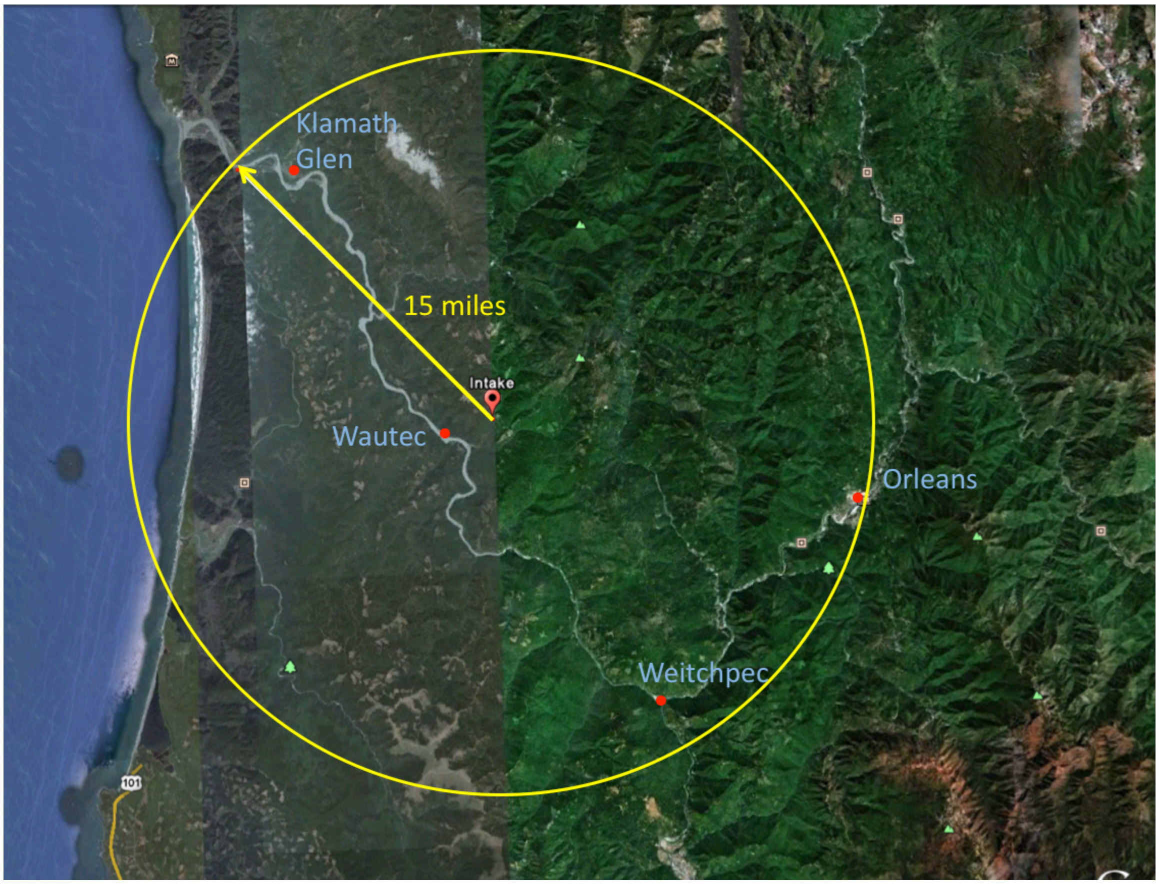


Figure 2. Communities within 15-mile radius of project intake
Source: User-generated using Google Earth

Preparing a FERC Pre-Application Document

The Hydropower Reform Coalition (HRC) describes the five elements of the FERC Pre-Application Document (PAD):

> ***Process Plan*** *states the proposed schedule of all activities prior to the filing of the license application.*
>
> ***Project Location, Facilities, and Operation*** *describes the project as constructed and operated under the existing license.*[Does not apply for an original license application as will be the case with Pecwan Creek]
>
> ***Existing Environment and Project Impacts*** *addresses the following resources areas: Geology and Soils; Water Resources; Fish and Aquatic Resources; Wildlife and Botanical Resources; Wetlands, Riparian, and Littoral Habitat; Rare, Threatened, and Endangered Species; Recreation and Land Use; Aesthetic Resources; Cultural Resources; Socio-Economic Resources; and Tribal Resources.*

***Preliminary list of issues** describes the issues likely to be disputed, and an outline of applicable studies.*

***List of contacts** is self-explanatory.*[ii]

The PAD is filed together with the NOI. Information included in the PAD is meant to be information that is already available at the time of preparing the PAD; the applicant is not expected to perform original studies at this time.

Following Up On the NOI and PAD Filings

Once the NOI and PAD have been filed, the applicant has three years to file a license application. During this period, the applicant should be actively consulting with interested agencies and implementing studies recommended by the agencies to collect new information not already compiled in the PAD. The study plan should address:

- Water resources
- Fish and aquatic resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened, and endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources

The process of identifying, contacting, and consulting with all stakeholders will reveal in detail what should be included in studies on the above resource categories.

Agencies and Stakeholders to Be Consulted

In order to complete the FERC licensing or exemption process, the Tribe will need to consult with all potentially interested public agencies and stakeholders. The following discussion includes agencies and stakeholders that have been identified to date who are expected to have some level of interest in the Pecwan Creek project; however, this should not be considered a comprehensive list. At the time of pursuing FERC approval for the project, it will be imperative to identify *all* interested stakeholders. In issuing a project license, FERC is required to accept conditions that other federal and state agencies impose on their approval of the project.

Federal Energy Regulatory Commission

As noted previously, FERC is the federal agency that will have oversight of any hydropower development on Pecwan Creek. The agency/stakeholder consultation process should begin with FERC. FERC has its own process for ensuring that all relevant federal, state, tribal, and local agencies have an opportunity to review and comment on the project, but the applicant can and should play an active role in helping to identify these stakeholders.

Yurok Tribe and Other Potentially Affected Tribes

The project is being implemented by the Yurok Tribe; it is therefore implicit that the Tribe will undergo an internal review process to make sure there is consensus among Tribal departments, Tribal council, and the council's constituents in support of the project. The Tribe's own *Water Quality Control Plan* identifies hydropower generation as a potential beneficial use on just six of the Reservation's 52 creeks and other waterways identified in the document, with Pecwan Creek among the six.[iii] This suggests that Tribal staff takes a favorable view of Pecwan Creek as a site for sustainable hydropower development. Staff comments to date on the Pecwan Creek project during the development of the feasibility study have in fact been favorable.

Three specific permits will need to be issued by the Yurok Tribe in order for any hydropower development to proceed: a Source Water Protection Permit, a Water Quality Control permit, and a Cultural Resource Management Permit. The Tribe provided an application form for the Cultural Resource Management Permit. The application is straightforward, calling for a description of the work including responsible individuals, precise location, timing, and details on any planned excavation. Forms for the other permits reportedly exist but have not yet been provided by the Tribe for review in preparing this report.

Other tribes, including the Karuk and Hoopa Valley Tribes, are stakeholders on the Klamath/Trinity river system, which has a long and contentious history with respect to dams and related hydropower development on the mainstem rivers. However, given that the Yurok Tribal lands are located on the lowermost reach of the Klamath River, that the project is situated well away from the mainstem Klamath River, and that the project will not substantially change volume, timing, or water quality of flows into the Klamath, it is not expected that these other Tribes will have concerns related to the project or its impacts upstream or downstream.

National Marine Fisheries Service

NMFS is the chief federal agency with respect to protection of anadromous life forms in rivers, such as the salmon that spawn in many creeks on Yurok lands. As noted in the accompanying preliminary environmental impact assessment, prior studies have shown that the natural limit of anadromy on Pecwan Creek is located well downstream of the proposed hydraulic works. NMFS is therefore expected to take little interest in the project.

U.S. Fish and Wildlife Service

USFWS is the federal agency responsible for non-marine fish and wildlife species, i.e., those that do not fall under NMFS's jurisdiction. Non-anadromous rainbow trout have been observed on West Fork Pecwan Creek upstream of the natural limit to anadromy.[iv] Yurok Tribe environmental staff have called for a study of amphibians present in the project's proposed bypass reach. These are species likely to be of interest to USFWS.

National Park Service

NPS, in addition to management of national parks, national monuments, and national recreation areas, is also charged with protection of Wild and Scenic Rivers. The entire Klamath River (including major tributary rivers such as the Trinity) is a Wild and Scenic River.[v] See Figure 3.

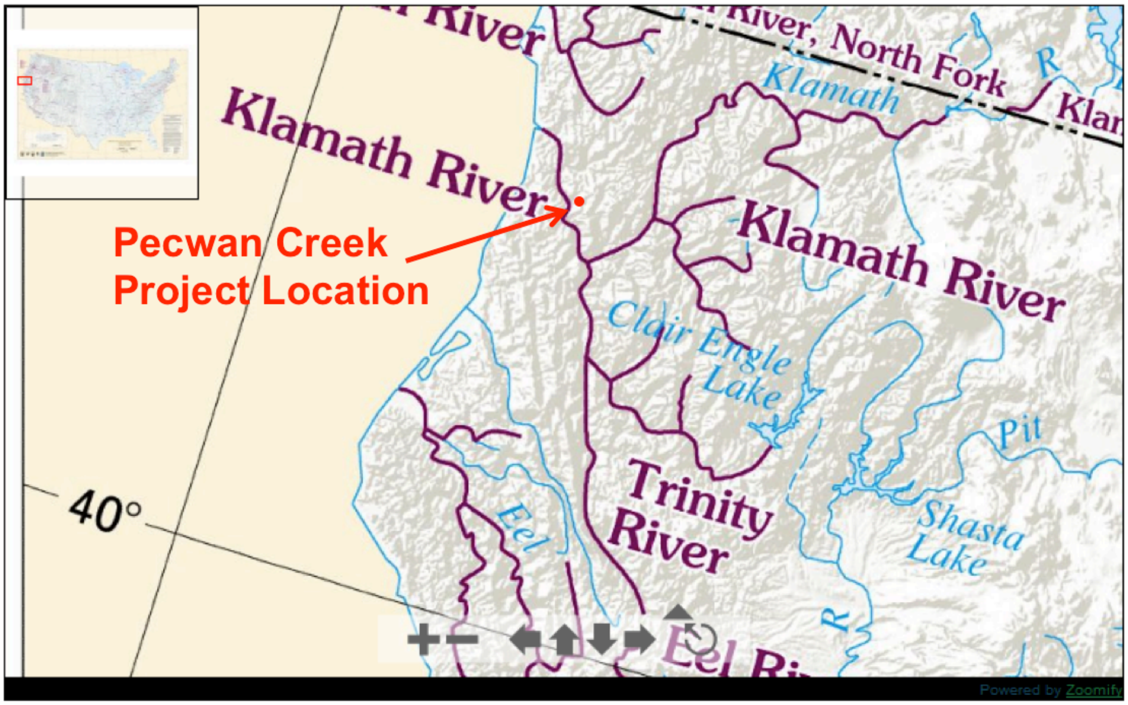


Figure 3. Wild and Scenic Rivers Map
source: www.rivers.gov/maps/zoom/conus/conus.html

U.S. Forest Service/Six Rivers National Forest

Approximately 12% of the watershed of West Fork Pecwan Creek (1,100 of 9,215 acres) falls within Six Rivers National Forest. Because the entire project is located well downstream of National Forest lands, it is possible Six Rivers National Forest will not take an interest in the project. However, it will be necessary to secure a water rights permit from the state, which would pre-empt other potential beneficial water uses upstream. Six Rivers National Forest could potentially be affected by this and should be considered a project stakeholder.

U.S. Army Corps of Engineers

The project is probably exempt from U.S. Army Corps of Engineers review, since the area of influence does not include any navigable waters.

Other Federal Agencies

Other federal agencies that may take an interest in a FERC-regulated hydropower project include the Bureau of Indian Affairs, U.S. Environmental Protection Agency, Bureau of

Land Management, Bureau of Reclamation, and the U.S. Geological Survey. BLM and Bureau of Reclamation are unlikely to review the Pecwan project, as the project's area of influence is not in close proximity to any lands managed by these agencies.

State Water Resources Control Board

The California State Water Resources Control Board maintains an online information system on water rights at http://www.swrcb.ca.gov/ewrims/. The site contains both a searchable database and an interactive map for identifying existing water rights claims. There are no claims of any type shown anywhere in the Pecwan Creek watershed. The only water rights claims that appear they could conceivably conflict with a claim on Pecwan Creek are a small number of minor claims on the mainstem Klamath River downstream of the confluence with Pecwan Creek. Since the proposed project will not significantly affect volume, timing, or water quality for downstream flows, these existing claims on the Klamath are not expected to conflict.

It will be necessary to apply for a water right on Pecwan Creek to develop the project. The application form is available online at:

www.swrcb.ca.gov/waterrights/publications_forms/forms/#application

North Coast Regional Water Quality Control Board

Language from the Hydropower Reform Coalition's website explains the role of state government in assuring water quality for FERC-licensed hydropower projects:

> *Under Clean Water Act (CWA) Section 401, FERC may license a hydropower project only if the State where the project discharges certifies that the project will comply with applicable water quality standards. FERC must include in the license any conditions the state requires in order to certify the project.*
>
> *The state where the project is located must assure compliance with the Clean Water Act water quality standards before issuing a water quality certification. Each state's water quality standards are made up of beneficial uses, narrative and numeric criteria, and the anti-degradation policy. If the state finds that a project would violate water quality standards and cannot be reasonably expected to meet water quality standards through remedial actions, the state must deny certification, and FERC must also deny the license. A state, however, can include limitations on discharge of pollutants (such as construction debris or erosion) and "any other appropriate requirement of State law" to assure compliance with water quality standards.*
>
> *Depending on water quality standards in individual states, the water quality certification can establish a variety of different types of conditions. For example, a certification may establish a minimum flow schedule or flow storage, require fish passage or creation of a recreational facility for enhanced access.*[vi]

In California, the regional water quality control boards have authority for CWA Section 401 enforcement. The Pecwan Creek project falls within the jurisdiction of the North

Coast Regional Water Quality Control Board. A downloadable NCRWQCB water quality permit application packet is available at:
www.swrcb.ca.gov/northcoast/water_issues/programs/water_quality_certification.shtml

California Department of Fish and Game

In its general discussion of the role of state agencies in hydropower licensing, the Hydropower Reform Coalition states: "Through its department of fish and game, the State may recommend conditions, under FPA sections 10(a) or (j)…for the protection, mitigation, and enhancement of fish and wildlife resources and recreation."

DFG's primary interest in hydropower projects is ensuring intake screening to protect fish and other sensitive species that might be present. Citing their website:

> *DIVERSIONS COVERED BY SECTION 6020 [of the California Fish and Game Code]*
>
> *The Department of Fish and Game may consider for screening any diversion with a capacity of 250 cubic-feet per second or less. Activities in this category will be assigned a lower priority than those covered by Section 5980 until all of the Department of Fish and Game obligations for both its own diversions, and for those diversions with a capacity greater than 250 cubic-feet per second, have been fulfilled.*
>
> *In addition, all diversions covered by this section which are located within the essential habitat of a State (CESA) listed species, or the critical habitat of a federally (ESA) listed species, shall be deemed to require screening.*
>
> *Variances from these requirements shall be supported by a report, prepared by the diverter, which includes data from onsite monitoring and a review of historical entrainment and diversion data. The scope of the report and the sampling effort shall be approved by the Department of Fish and Game prior to the initiation of work.*
>
> *Both approval of the scope of the report and the approval of an exception to this policy shall include the concurrence of the appropriate Regional Manager, the Deputy Director, Habitat Conservation Division, and the Deputy Director, Wildlife and Inland Fisheries Division. The final exception notice shall be issued by the Chief Deputy Director.*[vii]

Thus a study to identify any CESA or ESA listed species, and plans for screening to protect any such species present, will be needed to comply with DFG requirements.

California Office of Historic Preservation

The project will likely need to be reviewed by the California Office of Historic Preservation top satisfy FERC's requirement of compliance with Section 106 of the National Historic Preservation Act. OHP staff includes three officers specifically charged with coordination with FERC licensing processes.[viii]

Humboldt County Community Development Services Department

Since the project will be located on private land in unincorporated Humboldt County outside the Yurok Reservation, the Humboldt County Community Development Services

Department has zoning authority over the project site. The project's entire hydraulic works are located on a single parcel (assessor's parcel number 534-086-021-000, 620 acres), currently owned by Green Diamond Resource Company and zoned for timber production. The right of way for power transmission to the grid tie-in point will need to cross other parcels. Exact routing of the transmission lines is yet to be determined but will be chosen as an optimal combination of shortest possible route (to minimize infrastructure costs) and minimum number of parcels crossed (to minimize right-of-way requirements), while also satisfying other objectives such as avoiding visual impact on the sacred Yurok dance site at the mouth of Pecwan Creek. The Tribe or project developer should contact the Community Development Services Department to determine what compliance activities if any are needed.

Private Landowners within the Project's Area of Influence

As noted above, the project's hydraulic works are located on a single parcel zoned for timber production, currently owned by Green Diamond Resource Company and expected to pass into Tribal ownership in the near future. None of the hydraulic works come within less than approximately 1,500 feet of any boundary of this parcel. Most of the surrounding lands are also large parcels zoned for timber production, though there are several smaller residential parcels to the southwest of the project site.

It is expected that project construction and eventual decommissioning may have some minor impacts on neighboring property owners associated with road improvements and moving heavy equipment on and off site, but during the operational phase, no impacts on neighboring landowners are anticipated. It may be necessary to seek rights of way for the power transmission lines to cross one or more of these residential parcels en route to the utility interconnection point.

Intervention by Other Stakeholders

In addition to consulting with public agencies, FERC also requires hydropower license applicants to publicly advertise their license filing. This allows interested members of the public and organizations such as environmental groups to become aware of the project and intervene in the licensing process if they wish to do so. It is also important to note that all documents filed with FERC and all correspondence with FERC become part of the public record and are available on FERC's eLibrary (www.ferc.gov/docs-filing/elibrary.asp).

There are several environmental groups that might take an interest in a Pecwan Creek hydro project. Locally active environmental groups involved in river and dam issues or related habitat conservation include:

- Northcoast Environmental Center (NEC) – www.yournec.org
- Environmental Protection Information Center (EPIC) – www.wildcalifornia.org/tag/humboldt-county/
- Klamath Riverkeeper – www.klamathriver.org
- Sierra Club North Group, Redwood Chapter – redwood.sierraclub.org
- Redwood Region Audubon Society – www.rras.org
- North Coast Chapter of the California Native Plant Society – northcoastcnps.org

In addition, Big Rock Power, the developers of the nearby planned Willow Creek hydropower project, included San Francisco-based California Trout (caltrout.org) among the groups they initially contacted for comments on their project.

See the note on the Hydropower Reform Coalition under "Other Useful Resources" below for suggestions on making use of resources from this organization in dealing with possible public intervention. HRC is an umbrella group for over 150 membership groups (including the above-mentioned North Coast Environmental Center), which together have intervened in over 75% of FERC license filings since HRC was formed in 1992.

Obtaining a FERC 5 MW Exemption

FERC may grant exemption from licensing for projects that meet certain conditions. Specifically, they must be projects of 5 MW or less and make use of a pre-existing conduit or dam, or a natural water feature such as a waterfall. A new impoundment cannot be created. At this time it appears that some type of impoundment will likely be necessary for the Pecwan Creek project; further consultation with FERC will be needed to determine whether the project design will be compatible with an exemption request. Exemptions are not very common; nine exemptions were issued by FERC nationwide in 2009 and 19 in 2010, for projects ranging in size from 7 kW to the maximum permitted 5 MW.

Preparing a License Application

The license application takes the form of a set of exhibits:

- Exhibit A Project description
- Exhibit B Project operation and resource utilization
- Exhibit C Schedule for any new construction; otherwise, construction history
- Exhibit D Project costs and finance
- Exhibit E Environmental setting and impacts
- Exhibit F Design drawings of the project facilities
- Exhibit G Project map

Preliminary information compiled for this feasibility study can serve as templates for the above exhibits, with appropriate modifications and enhancements as the project is designed in greater detail.

Qualifying for Low Impact Hydropower Institute Certification

Low Impact Hydropower Institute (LIHI) certification is discussed in the separate Preliminary Environmental Impact Assessment. LIHI certification is not required for any hydro project but can serve as a marketing aid for "green" power producers. LIHI certification may also serve as a framework for any mitigations called for in the environmental compliance process. At this time, however, the Pecwan Creek project would not be eligible for LIHI certification, as only projects using dams built prior to August 1998 can be certified. However, LIHI states that "LIHI may in the future consider certifying new 'non dam' technologies for hydropower. "

LIHI's website summarizes the certification process as follows:

Facilities undergo a rigorous analysis including opportunities for public review, comment, and appeal before a decision is made to certify it. All applications and all supporting information are posted to the LIHI website. LIHI hires independent technical consultants to verify and investigate all applications. The public is invited to review and comment on applications (there is a 60 day period provided), and any commenter who disagrees with a certification decision of the LIHI Governing Board may appeal to an independent Appeals Panel. With the combination of independent review and extensive public oversight opportunities, LIHI provides a very transparent and credible process.

LIHI fees for a project of the scale of the Pecwan Creek system are $1,600 at time of application plus a $240 annual fee. Certification is valid for five years.

Lessons Learned from Other Local Hydropower Projects

Previous local hydropower projects have been reviewed to determine what studies were conducted or what agencies were consulted in developing these projects.

Big Rock Power's Willow Creek Project

This project was never built but went through an extensive design and agency review project in 2001-2002. Big Rock Power received FERC approval for their preliminary permit application. Since much of their project hydraulic works were located on Six Rivers National Forest land, they first consulted with U.S. Forest Service personnel, who provided recommendations on what studies to conduct and which other agencies to consult.

Big Rock consulted with and received comments from government agencies the Forest Service, the National Marine Fisheries Service, California Department of Fish & Game, and U.S. Fish and Wildlife Service, as well as non-governmental organizations California Trout, Inc. and Environmental Protection Information Center. See the separate Preliminary Environmental Impact Assessment for this Pecwan Creek project for a discussion of the specific studies recommended by USFS, which Big Rock Power agreed to conduct in their final study plan.

Norman Ross Burgess' Three Forks (originally Bluford Creek) Project

Mr. Burgess has been very helpful in the preparation of the Pecwan Creek feasibility study, showing his system to project team members and providing extensive pro bono consulting by phone. His project was licensed by FERC in 1991. The use of ponds for water storage in his project required him to solicit a full license, although the size of his project (1.3 MW) might otherwise have allowed him to pursue a 5 MW exemption. Mr. Burgess says that FERC provided the environmental assessment for his project at agency expense; he notes that this is not likely to be the case with a project licensed today.

Resources

Federal Licensing (Federal Energy Regulatory Commission)

Federal Energy Regulatory Commission hydropower licensing information.
http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Water Rights (State Water Resources Control Board)

A Guide to California Water Right Appropriations. State Water Resources Control Board. Division of Water Rights. January 2000. www.swrcb.ca.gov/publications_forms/publications/general/docs/l578.pdf

Application to Appropriate Water
www.swrcb.ca.gov/waterrights/publications_forms/forms/docs/app_form.pdf

Instructions for Completing Forms to File an Application to Appropriate Water.
www.swrcb.ca.gov/waterrights/publications_forms/forms/docs/app_instruction_booklet.pdf

Water Quality (North Coast Regional Water Quality Control Board)

401 Water Quality Certification Frequently Asked Questions
www.swrcb.ca.gov/rwqcb9/water_issues/programs/401_certification/docs/401_FAQ_FINAL.pdf

Other Useful Resources

Tribal Energy and Environmental Information Clearinghouse (TEEIC). http://teeic.anl.gov/. A useful website, especially the sections on Laws and Regulations and Assessments and Monitoring, and the document library, which includes downloadable environmental impact assessments for projects on Tribal lands.

Low Impact Hydropower Institute. www.lowimpacthydro.org/ At this time, LIHI certification is only available for hydropower projects using existing dams; therefore, certification is not an option for the Pecwan Creek project. However, LIHI states that they are considering certification for non-dam hydropower in the future. Offering to pursue LIHI certification could be a means of mitigating any identified environmental impacts of the proposed project during the licensing process.

Hydropower Reform Coalition. www.hydroreform.org. HRC's website offers many useful resources. The organization's resources are aimed at activists who wish to intervene in FERC licensing processes, not at developers; however, the materials available from HRC can help the Tribe or project developer anticipate possible objections to the project and strategies that opponents might use to stall or derail the project. Particularly useful are the *Citizen Toolkit for Effective Participation in Hydropower Licensing* (www.hydroreform.org/sites/www.hydroreform.org/files/HRC%20Hydro%20Guide.pdf) and *Scientific Approaches for Evaluating Hydroelectric Project Effects* (www.hydroreform.org/sites/www.hydroreform.org/files/HRC%20Science%20Guide.pdf)

McKinney J.D. et al. *Microhydropower Handbook*. U.S. Department of Energy. Idaho Operations Office. Chapter 8: Legal, Institutional, and Environmental Considerations. January 1983.

Notes

i. www.ferc.gov/industries/hydropower/gen-info/licensing/licen-pro.asp
ii. *Citizen Toolkit for Effective Participation in Hydropower Licensing*. Hydropower Reform Coalition. (www.hydroreform.org/sites/www.hydroreform.org/files/HRC%20Hydro%20Guide.pdf)
iii. Yurok Tribe. *Water Quality Control Plan for the Yurok Indian Reservation.* August 2004. www.yuroktribe.org/departments/ytep/documents/WaterQualityControlPlan8-24-04.pdf
iv. Gale, Dan. *Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California.* Yurok Tribal Fisheries Program. Habitat Assessment and Biological Monitoring Division. Technical Report No. 9. March 2003.
v. www.rivers.gov/maps/zoom/conus/conus.html
vi. www.hydroreform.org/hydroguide/hydropower-licensing/h-water-quality-certification-under-cwa-section-401-a
vii. www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenPolicy.asp
viii. http://ohp.parks.ca.gov/pages/1071/files/ProjRevUnit%20Cht.pdf

APPENDIX L: PRELIMINARY ENVIRONMENTAL ASSESSMENT

Preliminary Environmental
Impact Assessment

Yurok Hydroelectric Power Project
West Fork Pecwan Creek

Yurok Reservation, Humboldt County
California

Prepared for the Yurok Tribe by
Schatz Energy Research Center

March 2011

Preface

The format for this preliminary environmental assessment is based on a format recommended in the Tribal Energy and Environmental Information Clearinghouse's online guide to assessments and monitoring for renewable energy projects (http://teeic.anl.gov/am/index.cfm).

In the environmental assessment process as described by TEEIC, a project proponent needs to describe the proposed project, define the project's area of influence, identify potential impacts, determine the magnitude and significance of these impacts, identify uncertainties associated with these impacts, describe how these impacts will be mitigated, and produce a plan for monitoring impacts and the success of mitigation efforts. Each of these steps is outlined in this preliminary document, with the best effort possible made at this early stage of the project to make the outline specific to the West Fork Pecwan Creek project.

CONTENTS

Introduction

The Yurok Tribe proposes the development of a small hydropower project on the West Fork of Pecwan Creek, on private land adjacent to the Yurok Reservation in Humboldt County, California. The Schatz Energy Research Center (SERC) is assisting the Tribe with development of this project and is currently conducting a feasibility assessment. As part of SERC's work, we have prepared this preliminary environmental assessment to assist the Tribe should they choose to proceed with permitting and construction of the project. This preliminary environmental impact assessment is intended for internal use by the Yurok Tribe and is not meant to be used in place of a full environmental assessment or environmental impact statement. The objectives of this document are to identify key environmental issues that could affect development of the proposed project and to present currently available information that could be used in preparation of a full environmental compliance document.

In most cases, permitting and environmental impact assessment of hydropower projects in the United States falls under the jurisdiction of the Federal Energy Regulatory Commission (FERC). An initial consultation with FERC staff[i] indicated that any hydropower project undertaken by the Yurok Tribe would need to be approved by FERC. See SERC's separate document reviewing the permitting process for more details.[ii]

Per FERC procedures, some level of environmental assessment will be necessary to develop the project in any case. If in the pre-filing phase, FERC determines that the project is expected to have no significant impacts, they will require an applicant-prepared environmental assessment (EA). If on the other hand SERC anticipates a significant impact from the project, they will call for a full Environmental Impact Statement (EIS) to be prepared by a third-party consultant selected and directed by FERC and at the Tribe's expense.

FERC's document titled *Preparing Environmental Documents: Guidelines for Applicants, Contractors, and Staff* provides a comprehensive template for preparing the required environmental documentation. See "Useful Resources…" at the end of this report for online access to this document.

Project Description

The Yurok Tribe proposes the development of a small hydroelectric power project on the West Fork of Pecwan Creek adjacent to the Yurok Reservation in Humboldt County, California. Since 2008, Tribal staff and SERC, acting as consultant to the Tribe on this project, have been monitoring streamflow data and gathering other information used to facilitate the proposed design.

Project Location and Characteristics

The landscape of the proposed project site is remote and mountainous. The West Fork Pecwan Creek watershed has an area of 14.4 square miles, varying in elevation from 100 to 4,500 feet above sea level. The climate is rainy in winter and dry in summer, with average annual precipitation ranging from 75 inches at the mouth of the creek to 100 inches in the remotest headwaters. The watershed is covered in second-growth forest and laced with numerous logging roads, many of which are no longer maintained. Most of the watershed currently belongs to Green Diamond Resource Company, formerly Simpson

Timber Company. The Tribe is in the process of executing a land deal in which they would purchase tens of thousands of acres from Green Diamond, including the Pecwan Creek watershed. A small portion of the headwaters of Pecwan Creek watershed is within Six Rivers National Forest.

Two different scenarios are being considered: 1) A system that would have an output capacity of 500 kW, and 2) A system with an output capacity of 1,600 kW. Under either scenario, the project would use a diversion to bypass a reach of the creek over a distance of approximately 2,600 feet, with all diverted water returned to the creek downstream. A conceptual map of the project is shown in Figure 1. Essential project design parameters are provided in Table 1.

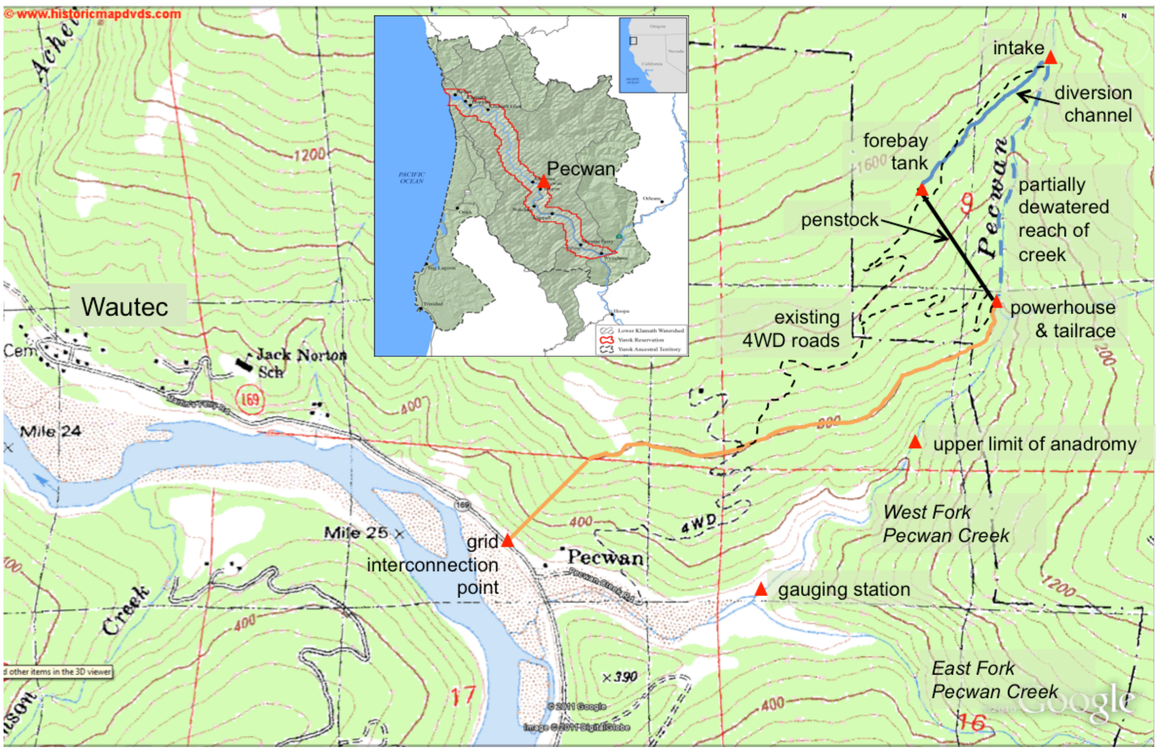


Figure 1. Conceptual Map of Proposed Hydropower Project

The project would consist of a diversion of water from the West Fork of Pecwan Creek, an unpressurized channel carrying this water away from the creek on contour, a closed penstock conveying water under pressure to a powerhouse, a turbine and electrical generating equipment within the powerhouse, a short tailrace to return water from the powerhouse to the creek, and power transmission infrastructure to convey generated power to a grid connection point. Both the water intake and the tailrace outlet would be screened to keep wildlife and debris out of the hydraulic works. Figures 2 and 3 show the proposed locations of the system intake and powerhouse.

Table 1. Project Design Parameters

Parameter	Scenario 1	Scenario 2
Nominal power generation capacity	500 kW	1,600 kW
Design flow (flow needed to generate design power)	18-20 cubic ft/sec	50 cubic ft/sec
Base flow (minimum expected creek flow at point of diversion)	10 cubic ft/sec	
Proposed bypass flow (minimum flow to be left instream under all conditions)	3 cubic ft/sec	
Gross head	591 ft	
Net head	583 ft	
Channel length	1,988 ft	
Penstock length	1,521 ft	
Length of bypassed reach of creek	2,586 ft	
Power transmission distance to intertie	6,353 ft	

Figure 2. Proposed Intake Location

Figure 3. Proposed Powerhouse Location

Anticipated Environmental Impacts

The entire project from intake to tailrace will be located above the upper limit of anadromy of Pecwan Creek, as determined by Yurok Tribal Fisheries[iii]. The system will be designed to ensure an agreed-upon minimum flow is maintained in the bypassed reach of the creek at all times. Figures 4 and 5 show estimated total and left-in-stream flows at the system intake for low and high flow water years. Note that these estimated flows are synthesized from: 1) data collected onsite for 18 months and 2) comparison with more extensive historic data from other nearby creeks. Instream diversion or intake structures will be kept to the minimum necessary for reliable system performance. Site disturbance at the diversion and powerhouse will be kept to a minimum. Existing roads will be used to the extent possible to access, install, and maintain the diversion and the powerhouse. Minor earthworks will be necessary to install the channel and penstock. Power transmission lines will be routed to minimize environmental and cultural impacts.

Project Status

At time of publication, this project has been identified as the preferred alternative among three proposed renewable energy generation projects studied by Schatz Energy Research Center on the Yurok Tribe's behalf. The study is funded by a grant to the Tribe from the U.S. Department of Energy's Tribal Program. The other two projects were a hydroelectric system on Ke'pel Creek and a wind energy system on McKinnon Hill. As the Pecwan Creek feasibility study draws to a close, the Tribe intends to seek additional funding from the Department of Energy and other sources to advance to pre-construction activities.

Before the Tribe can move forward with project implementation, a complete environmental impact assessment and multi-agency permitting process will need to be carried out.

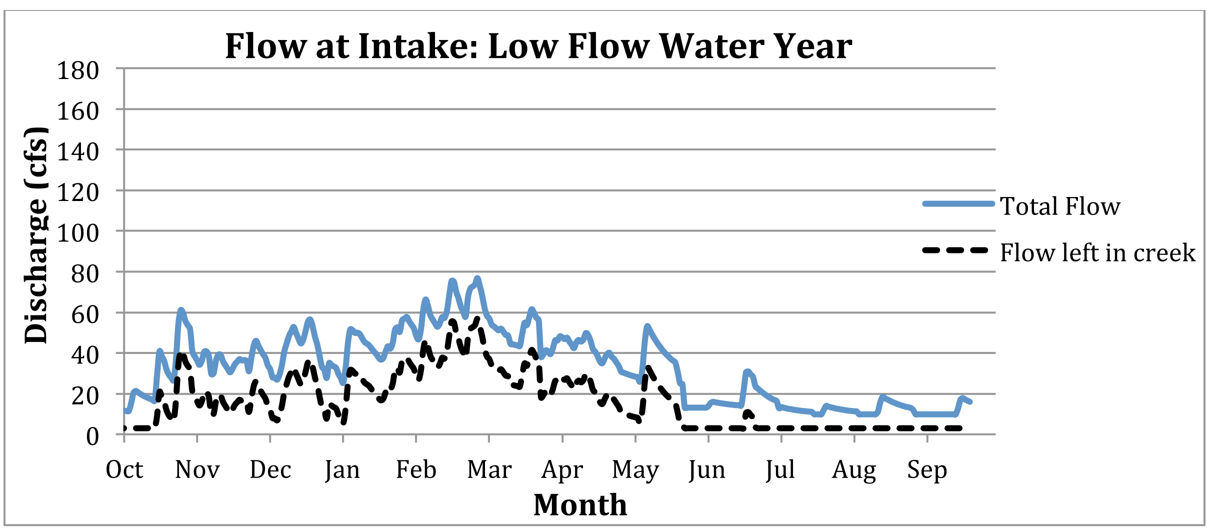


Figure 4. Projected total flow and instream flow based on a typical low flow water year (note: minimum instream flow is set at 3 cfs year-round)

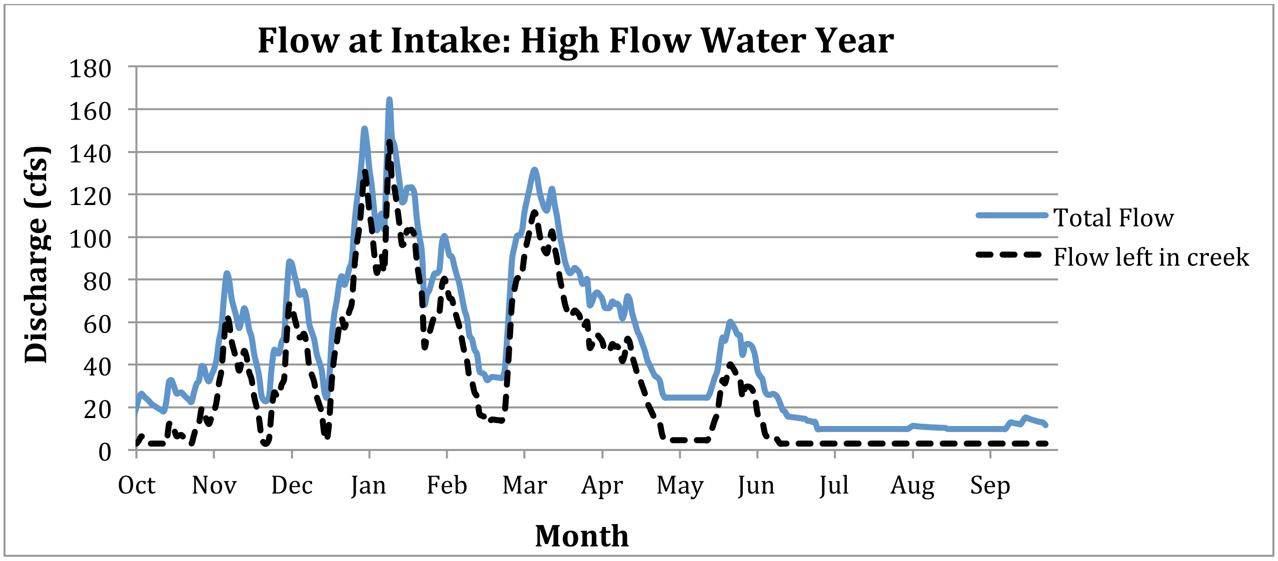


Figure 5. Projected total flow and instream flow based on a typical high flow water year (note: minimum instream flow is set at 3 cfs year-round)

Area of Influence for all Project Phases

The area of influence is the geographic area over which direct and indirect project impacts are expected to occur. The area of influence for the proposed project needs to be defined. At a minimum it should include:

- the area in which the system components will be located, including the intake and any associated impoundment, channel, penstock, powerhouse, tailrace, access roads, and power transmission lines from the powerhouse to the point of grid intertie;
- the bypassed reach of the creek between the intake and the tailrace.

Other areas that might be included in the area of influence include:

- the reach of West Fork Pecwan Creek from the tailrace downstream to a to-be-determined location. Possible locations for the lower boundary of the area of influence could be the confluence with the East Fork of Pecwan Creek or the confluence with the Klamath River. Because the entire project is sited above Pecwan Creek's limit of anadromy, and because the project will not significantly affect volume, timing, or water quality of creek flows, major downstream impacts are not anticipated. However, the diverted water could be returned to the creek at a different temperature, thus having direct thermal effects and changing dissolved oxygen levels in the water.
- some or all of the catchment area for West Fork Pecwan Creek upstream of the system intake. While it is not expected that the project will have direct environmental impact on upstream areas, the necessary establishment of water rights for the project may limit or preclude development that could otherwise

occur upstream. This could in turn have environmental impacts, likely to be positive, on upstream resources.

- during construction and decommissioning phases, any areas used for staging or pre-assembly of equipment or sorting and short-term storage of debris from construction or demolition.

Project Alternatives

Environmental assessment requires a proposer to prepare a number of project alternatives, including at a minimum a proposed action, a staff alternative that incorporates preliminary modifications and mitigations recommended by reviewing agencies, and a no-project alternative. The preliminary design provided by SERC is intended to be used by the Tribe or the project developer as the preferred project alternative. A team of engineering students at Humboldt State University is currently (spring semester 2011) working on a set of additional project design alternatives that can be incorporated into an environmental assessment for the project. These alternative designs will be complete and made available to the Tribe by May 2011. The no-project alternative simply leaves Pecwan Creek with no hydropower development.

Impacting Factors Associated with Project Phases

Impacting factors, both direct and indirect, need to be identified. Impacts can be classified as those associated with the distinct project phases:

- site characterization
- construction
- operation
- decommissioning and reclamation at end of project life

Site Characterization Requirements and Activities

Much of the site characterization work has already taken place in the course of conducting the feasibility study. SERC worked with Tribal staff from the planning department and the Yurok tribal environmental program (YTEP) to install a stage monitoring instrument on the West Fork of Pecwan Creek just upstream of the confluence with the East Fork. The equipment consisted of an instream probe and a bank-mounted weatherproof case containing the data logging and telecommunications equipment and rain gauge. This equipment was left in place accumulating data for 18 months, with several measurements of flow made using a wading rod and velocity meter to create a calibrated stage-discharge curve. The watershed was surveyed to identify potential sites for a diversion, powerhouse, and access roads. Care was taken to keep impacts to a minimum during these characterization activities. Streambed and bank disturbance during installation and operation of the stage monitoring equipment and during wading measurements were minimal.

Remaining site characterization work that remains to be done may include:

- Engineering tests of soils on the sites where hydraulic works and power transmission infrastructure will be installed. A preliminary analysis of soils was generated using the USDA Natural Resources Conservation Service's Web Soil Survey. This should be followed with a field study to determine specific engineering characteristics of soils where the intake, diversion channel, settling forebay, penstock, powerhouse, tailrace, and power transmission poles will be installed. A portion of the diversion channel may be buried using directional drilling technique. A study to determine the feasibility and possible impacts of this activity will be especially important. Standard techniques for avoiding sediment runoff and disturbance of cultural features such as burial sites should be used in performing these tests.

- Seismic analysis. The Tribe should consult with the California Geological Survey and the U.S. Geological Survey to ensure that the planned development site does not coincide with an active earthquake fault. Further study of this issue will be through agency consultation and is not expected to have an impact on the site. See a more detailed discussion under Geology and Geologic Hazards below.
- Biological survey of the reach of Pecwan Creek to be bypassed. In the event that FERC directs the Tribe to conduct its own EA, The Tribe's own Yurok Tribe Environmental Program (YTEP) and Fisheries Program have all the skills and experience necessary to conduct this study in an environmentally responsible manner. If an EIS performed by a third party is required, the Tribe should require the consultant to observe correct environmental protocols in performing the survey.

Construction Requirements and Activities

TEEIC recommends the following be taken into account in considering the impacts of construction activity:

- Construction footprint for primary and support facilities including temporary facilities (map and footprint area). The construction footprint will include the hydraulic components (diversion, diversion channel, settling forebay, penstock, powerhouse, and tailrace); access roads; and the power transmission route to the grid intertie point. Possible impacts include erosion and slope failure, sediment pollution of Pecwan Creek, disturbance of burial or other cultural sites, and noise and visual blight in the surrounding.
- Setbacks from areas to be avoided. At this time no specific areas to be avoided have been identified within the project area of influence. Developers will need to coordinate with the Tribe's cultural resources staff to ensure any burial, ceremonial, or other cultural sites are not impacted by the project.
- Amount of excavation required (area and volume). No major excavation is anticipated beyond what is needed to level the construction site for the powerhouse. An acceptable means of disposing of or relocating spoils from excavation will need to be identified.

- Excavation methods (including blasting or other techniques). It is anticipated that any excavation will be done with small earth moving equipment. At this time it is not known whether any blasting will be needed. If so, it will be necessary to ensure that residents are kept a safe distance from blasting and that no loosened material from blasting ends up in the creek.
- Drilling, coring, and related activities and methods. No drilling is anticipated except possibly to anchor water diversion and/or tailrace structures into the native rock in the streambed or streambank.
- Land surface clearing and grading plan. It will be necessary to clear brush and grade small areas for installation of the hydraulic structures. The intake and powerhouse sites are accessible from existing but disused roads. The upper end of the penstock is within about 200 feet of an existing road. These roads will need some upgrading and restoration in order to build and operate the plant. It will be necessary to perform this grading in a manner that does not create excessive sediment runoff, and any spoils generated from grading will need to be disposed of in a manner and location that do not create future sediment runoff during storm events.
- Energy, water, and materials needs. Electric energy needed during construction will need to be provided using portable generators. Fuels may also be needed for activities such as gas welding. Noise and air pollution from generators are not likely to be major concerns, given the isolation of the construction sites. However, transportation of generator fuel will need to be done carefully, as it is not uncommon in this mountainous area for fuel to be spilled into creeks while being transported to remote sites. Water for needs such as mixing concrete will be taken directly from Pecwan Creek. Other materials, such as cement, aggregate, lumber, pipe, and generating equipment will be brought in as needed. Lumber and aggregate could potentially be locally sourced; the decision whether to do this will depend on comparative costs of materials.
- Construction processes and air and water emissions. Construction of the diversion, powerhouse, and tailrace will necessarily take place adjacent to Pecwan Creek. Care will need to be taken to avoid spilling sediment, fuel, or other possible pollutants into the creek. Air emissions from onsite portable generators are not likely to be a serious concern, given the remoteness of the site.
- Utility requirements and how they will be met. Water needed for construction will be taken directly from Pecwan Creek or its tributaries. Electric power will be generated onsite using portable generators. Fuels will be transported in as needed. Taking the precautions described above, meeting these utility needs is not expected to generate significant impacts.

- Fencing requirements. Temporary fencing may be used to protect partially built facilities from theft or vandalism. This fencing will need to be removed and reused or disposed of properly once construction is complete.
- Outdoor lighting requirements. Minimal outdoor lighting will be installed at the powerhouse to ensure safe nighttime access. This lighting will be installed and/or shielded as needed to avoid unnecessary light pollution in the surrounding forested area.
- Size and location of laydown areas. Given that the diversion channel route is roughly parallel to an existing logging road, it is anticipated that this road itself or its shoulder can be used as the laydown area for the diversion channel pipe. The penstock will cross this same road, and the adjacent portion of the road could also be used to stage sections of the penstock. Some brush removal may be needed to provide sufficient laydown area. A small laydown area will also be needed for powerhouse construction; this is not anticipated to have significant impacts.
- Sources, intensity, and schedule of noise-producing activities. Noise-producing activities during construction may include some drilling or blasting in rock, operation of light earth-moving equipment, operation of portable generators; and transportation of equipment in and out of the project site. Given the remoteness of the site, the perceived noise is not expected to have significant impacts on neighbors. As discussed below, it will be important to avoid conflicts with Yurok Tribe cultural events in the area.
- Hazardous materials to be used and spill prevention plan. Hazardous materials to be used in the project will include flammable and toxic fuels used for generators, welding, and similar uses. A spill prevention plan will be developed to ensure that such materials are transported, stored, and used with proper caution in the project area and are not allowed to come in contact with soils or bodies of water.
- Waste streams (with full characterization of constituents), volumes, and management plan. Construction debris will be generated in the course of the project. A plan will be developed to anticipate the quantities of such materials and to ensure their safe and responsible removal and disposal.
- Construction workforce and housing requirements, if any. To the extent possible, the Tribe intends to include local Tribe members in the construction workforce. Where this is not possible, outside workers will need to be transported to the job site and housed in the vicinity. Motels are available in Hoopa and Klamath. Providing portable housing (i.e., trailers) or other options may be considered by the Tribe in order to reduce travel time and complete site work in a timely manner.
- Construction time frame (complete duration and schedule of activities and workforce) including any scheduling of activities to avoid impacts to protected ecological resources (e.g., nesting birds). The developer will need to consult with

YTEP staff to identify any seasonal wildlife issues that will affect timing of the construction. An important ceremonial dance site is located near the mouth of Pecwan Creek. It is likely that construction workers and equipment would need to pass close by this site during construction. It will be necessary to coordinate the construction schedule to avoid activity during events such as the Jump Dance, which can last for several days.

- Soil stockpiling and protection plan. Any soil removed or relocated for construction or road grading will need to be stored temporarily and eventually disposed of in a way that does not contribute to sediment runoff.
- Plan for reclamation of temporary disturbed areas. The developer will need to create a plan for re-vegetating disturbed areas with appropriate plants (native or other Tribe-approved plants).
- Erosion, fugitive dust, and surface water runoff controls (including stormwater control plans). Given the steep contours and high rainfall in the Pecwan Creek watershed, erosion control is a serious concern. A plan will have to be developed to minimize risk of erosion, sediment runoff, or slope failure as a result of road improvements or construction of hydraulic works.
- Protocols for surface water and wetland involvement and protection. The surface water feature of central significance to this project is Pecwan Creek itself. Protocols will be needed to keep the creek from being polluted, blocked, or otherwise harmed during construction.
- Protocols for ecological, cultural, and paleontological resource protection. Top concerns for the Yurok Tribe are protecting salmon habitat and cultural resources such as burial and ceremonial sites. A plan will need to address these concerns. Salmon habitat is unlikely to be affected by the project as planned, since all project works are located well above the upper limit of anadromy on the creek, and the plant will not significantly alter volume, timing, temperature, or water quality of downstream flows. The Tribe's cultural staff will need to participate in project planning to ensure no cultural sites are disturbed. A significant issue will be routing of power lines to avoid visual or other impacts on the ceremonial site near the mouth of Pecwan Creek. The current design has power lines routed to a point further downriver on the Klamath River to address this concern.
- Protocols for nonnative invasive species prevention and control. Accidental introduction of pest plants or pathogens via construction equipment is of concern. Protocols should include a wheel washing station to be used by all vehicles entering or leaving the construction area to make sure seeds and pathogens are not brought in or out. One plant disease of concern is Port-Orford-Cedar root disease, which has had significant economic and environmental impacts in northwest California and southwest Oregon.[iv] The Pecwan Creek basin lies within the native

range of this tree species, hence the protocols should specifically address this species.[v]

Operational Requirements and Activities

TEEIC recommends the following be taken into account in considering the impacts of operational activity:

- Footprint of permanent primary and support facilities (map and footprint area). During the operational phase, the facility footprint is not expected to have any significant impact.
- Facility characteristics (height, area, color, shape). The hydraulic works will not be visible from any publicly accessible roadway or from any location off the parcels where they will be installed. Visual impacts are thus expected to be negligible. Transmission lines will connect to a trunk line on State Highway 169. These lines will be publicly visible near their terminus at Hwy 169; routing and design of these power lines will need to be designed to minimize visual impact.
- Protected areas and setbacks. No protected areas will be affected by the project. Portions of the uppermost reaches of West Fork Pecwan Creek are located in Six Rivers National Forest, but the project works will all be located on land currently owned by Green Diamond.
- Maintenance activities and schedule. The intake and powerhouse will both require regular maintenance. Access to these sites will be via existing roads. Apart from minor air emissions and road impacts from traffic, no environmental impacts associated with maintenance are expected.
- Utility requirements and how they will be met. The system will be connected to utility power via a dedicated transmission corridor. The system will be energy self-sufficient, using a very small portion of its own power generation to maintain power conversion equipment and instrumentation at the powerhouse.
- Fencing requirements. Use of permanent fencing is not anticipated. The powerhouse will be secured with locking doors.
- Outdoor lighting requirements. Minimal outdoor lighting will be used at the powerhouse to ensure safe nighttime access. This lighting will be installed and/or shielded as needed to avoid unnecessary light pollution in the surrounding forested area and will only be on during nighttime hours.
- Vegetation management plan. Vegetation will need to be controlled to maintain access to all plant infrastructure and to prevent fouling of intakes and moving parts. A plan will need to be developed for this and must address how vegetation will be controlled (e.g., mechanically or with herbicides) and what impacts such vegetation management practices could have.
- Surface water and wetland protection provisions. The main concern with respect to surface water is preventing pollution of Pecwan Creek. Protocols will need to

be developed to ensure that materials used in plant operation and maintenance, such as lubricants, do not come in contact with creek water. No wetlands have been identified in the project area.

- Groundwater protection plan. According to NRCS data, soils in the project area are well-drained, with an average depth to water table of more than 80 inches. No wells are planned as part of this project. Protocols will need to be developed to ensure safe handling of fuels, oils, solvents, and other liquids that could potentially contaminate groundwater.
- Erosion, fugitive dust, and surface water runoff controls (including stormwater control features). The only activity expected to have erosion or surface runoff impacts during the operational phase is vehicular traffic to and from the project site.
- Energy, water, and material needs. During operation, the system will be energy and water self-sufficient. Materials needed for maintenance will include consumable supplies such as lubricants. Use of these materials is not expected to have any measurable environmental impact.
- Sources, intensity, and schedule of noise-producing activities. The only significant noise associated with normal plant operation will be from generating machinery. This is not expected to be significantly louder than the existing noise level of the creek itself, except in the immediate vicinity of the powerhouse.
- Operational processes and air and water emissions. The only operational process will be the generation of electric power. This is not expected to generate any impacts not already described elsewhere in this document. No air emissions will be produced other than those from vehicles traveling to and from the plant. Protocols for maintenance and use of lubricants or other consumable supplies will ensure that these materials do not pollute the creek.
- Hazardous materials to be used and spill prevention plan. The only hazardous materials to be used during project operation will be small quantities of lubricants and other consumable supplies at the powerhouse. A spill prevention plan will be developed to ensure these materials do not pollute soils, surface water, or groundwater.
- Waste streams (with full characterization of constituents), volumes, and management plan. Minimal waste will be generated during the operation phase. No hazardous wastes are anticipated. Any wastes generated will be hauled out for proper disposal.
- Operations workforce and housing requirements, if any. Two trained, full-time operators are expected to be sufficient for day-to-day operation of a project of this size. The Tribe can minimize impacts associated with workforce travel and housing by hiring an operator from within the community. For major scheduled

maintenance and unscheduled repairs, skilled specialists will be brought in as needed. Lodging is available in Hoopa or Klamath as needed for multi-day visits.

- Operational time frame (complete duration and schedule of activities and workforce). The design life for the hydroelectric power plant is 50 years. A more detailed schedule including periodic major maintenance and replacement of components needs to be developed.
- Protocols for ecological, cultural, and paleontological resource protection. Tribal fisheries staff have reviewed the project proposal and are satisfied that its location above the upper limit of anadromy and its design to maintain volume, timing, temperature, and quality of downstream flows will protect salmon spawning habitat. They did raise a question about whether the reach of the creek where water is diverted includes habitat for sensitive amphibians. This will need to be investigated in a full environmental assessment. Other than this, operation of the plant is not expected to have significant ecological, cultural, or paleontological resource impacts. Plant operators will need to be provided with protocols to ensure that minimum bypass flows are left instream at all times to protect the aquatic ecosystem.
- Scheduling of activities to avoid impacts to protected ecological resources (e.g., nesting birds). A minimum bypass flow will be maintained in the creek at all times. During critically dry low flow periods, it will be necessary to partially or completely shut down power generation in order to ensure sufficient instream flow.
- Protocols for nonnative invasive species prevention and control. Periodic monitoring of the creek and environs of the hydraulic works will need to be scheduled to search for, identify, and control any invasive species that could potentially be introduced in the course of plant operation.

<u>Decommissioning and Reclamation Requirements and Activities</u>

Decommissioning and reclamation are defined by TEEIC as follows: "Decommissioning refers to the removal of project structures and facilities after the project ceases operations. Reclamation refers to those activities that are used to return the site to a stable condition that approximates pre-disturbance conditions." The system is being designed for an expected lifespan of 50 years, which is a typical design life for a small hydropower facility and corresponds to the normal FERC licensing period for new projects. It is hoped that the project can be relicensed in the future and not require decommissioning in the foreseeable future. However, the following discussion assumes that decommissioning will eventually occur and needs to be planned for. TEEIC recommends the following be taken into account in considering the impacts of decommissioning and reclamation:

- Facilities and structures to be removed. If the project is not recommissioned or rebuilt, all of the hydraulic works, including the intake, diversion channel, settling forebay, penstock, powerhouse, and tailrace, will be removed at end of project life, except for poured foundations or footings whose removal is determined to have greater environmental impact than leaving the structures in place.

- Facilities and structures to remain in place including below ground structures. Poured foundations or footings whose removal is determined to have greater environmental impact than leaving the structures in place will be left in situ. Remediation will be carried out to minimize the visual blight associated with these structures.
- Hazardous materials cleanup requirements. Any hazardous materials will be removed for proper disposal off-site. Such materials could include insulating fluids in transformers and other electrical equipment, fluorescent or other lighting, and leftover consumable supplies such as lubricants.
- Grading plan and surface drainage restoration plan. Any roads or structure pads that are not to be used after the end of the project life will be decommissioned, including re-grading and revegetation.
- Topsoil replacement and revegetation plan. Where surfaces have been regarded as part of decommissioning, revegetation will be performed to minimize erosion.
- Post-reclamation site management provisions. Post-project stewardship of the site will be entrusted to a Tribal department to be determined according to future planned uses of the site.
- Protected areas and setbacks. No protected areas will be affected by the project.
- Decommissioning and reclamation schedule including any scheduling of activities to avoid impacts to protected ecological resources (e.g., nesting birds). Decommissioning and reclamation will be scheduled appropriately for the season. No earth moving will take place during the rainy season. Revegetation will be timed to take advantage of seasonal rains.
- Utility requirements and how they will be met. Portable generators may be needed for demolition and decommissioning activities. Precautions will be used to ensure fuel is handled safely, fire risk is minimized, and noise is managed with respect to neighbors, nesting birds, and other wildlife.
- Fencing requirements. Temporary fencing may be used to keep unauthorized persons away for safety reasons during demolition. This fencing will need to be removed and reused or disposed of properly once demolition is complete.
- Outdoor lighting requirements. No outdoor lighting will be needed for decommissioning activities.
- Surface water and wetland protection provisions. Decommissioning will be conducted in a manner so as to avoid contamination of surface water. No wetlands are known to exist in the project area.
- Groundwater protection plan. Decommissioning activities are not expected to impact groundwater.

- Erosion, fugitive dust, and surface water runoff controls (including stormwater control features). Decommissioning will be performed in a manner appropriate to minimize erosion and surface runoff.
- Energy, water, and material needs. Energy, water, and material needs will be temporary and limited to the demolition and remediation of the hydraulic works and power transmission lines. Water can be sourced on-site from the creek. Once the power plant is no longer operational, portable power from generators will be needed to complete decommissioning and reclamation work.
- Sources, intensity, and schedule of noise-producing activities. Demolition of installations may require use of heavy equipment and possibly blasting. Such noise-producing activities will need to be planned and scheduled so as not to interfere with nearby seasonal nesting or cultural activities such as dance ceremonies.
- Decommissioning and reclamation processes and associated air and water emissions. No significant air or water emissions are anticipated during decommissioning other than normal emissions from vehicles and heavy equipment.
- Hazardous materials to be used and spill prevention plan. Hazardous materials used for decommissioning could include explosives. A plan will be developed for safe and environmentally responsible handling, use, and transport of these materials.
- Waste streams (with full characterization of constituents), volumes, and management plan. Waste streams will consist primarily of demolition waste. Some equipment may have salvage value and will be removed for re-use or sale by the Tribe or plant operator. Non-salvageable materials will be removed for proper disposal. Where it is determined to have less overall environmental impact than removal for off-site disposal, the Tribe or project operator may opt to dispose of non-hazardous concrete rubble on-site.
- Decommissioning and reclamation workforce and housing requirements, if any. A temporary decommissioning workforce will need to be housed. The nearest commercial lodging is in Hoopa and Klamath. The Tribe may choose to provide temporary housing closer to the work site to reduce transportation impacts during demolition.
- Decommissioning and reclamation time frame (complete duration and schedule of activities and workforce). Project decommissioning and reclamation, including revegetation and associated monitoring, will take place over a period of up to one year. A more detailed plan will need to be developed for specific tasks and timing.
- Protocols for ecological, cultural, and paleontological resource protection. Protection of ecological and cultural resources during decommissioning will require a plan that includes timing of activities to avoid impacts on seasonal

nesting, dance ceremonies at the mouth of Pecwan Creek, and other events that could be affected.

- Protocols for nonnative invasive species prevention and control. As discussed above, accidental introduction of pest plants or pathogens via construction equipment is of concern. Protocols should include a wheel washing station to be used by all vehicles entering or leaving the construction area to make sure seeds and pathogens are not brought in or out. Again, Port-Orford-Cedar root disease is a plant disease of concern in this location and will require mitigation.

Potential Resources Affected

According to TEEIC: "Affected resources are those elements of physical, biological, and human systems that are affected by a project. Examples include land use, air quality, and ecology."

The following list of potential resources affected is based on the list recommended for study by Six Rivers National Forest for the proposed nearby Willow Creek Hydropower Plant. Like that project, the Pecwan Creek project watershed spans both Six Rivers National Forest land and private lands, some of which are owned by the project developer, so the list of studies required is expected to be similar. With respect to the Willow Creek project, the Forest Service discusses for each resource:

- basis for study
- study methodology
- resource goals and objectives
- accepted practice
- usefulness of info

Language from the Forest Service's comments is excerpted briefly as appropriate in the following sections. See the full Forest Service document for more details that may be helpful, especially in the methodology section corresponding to each recommended study.

To the extent possible at this time, we have provided discussion of what is known about these resources in the Pecwan Creek watershed. Note that in the case of Pecwan Creek, the hydraulic works do not lie on Forest Service land, so it is likely an agency other than the Forest Service will act as the FERC-designated lead agency that directs what specific studies need to be conducted.

<u>Aquatic and Riparian Habitat Typing</u>

Specific language from USFS comments on the Willow Creek project can be applied to the current project:

> *The current distribution of aquatic and riparian habitats is needed for the project area. There is a need to habitat type to determine the presence, distribution and frequency of occurrence of habitat units... Habitat data is needed to identify the dominant and most*

biologically important habitats within the project area for the purpose of establishing index reaches for the more intensive survey requirements described in the Instream Flow I and Survey of Aquatic Fauna studies… At a minimum the aquatic and riparian habitats for fish and amphibians should be mapped for the reaches located in the project area. The contribution of large woody debris to the formation and maintenance of existing habitats within the project reach and downstream should be assessed as part of this study. Study products should include a report that presents all of the habitat data collected for the study and describes the habitats found in the project area and a habitat map, compatible with ArcView or ArcINFO software, that shows the locations and ordering of habitat units in the project area… The study information is to be used to determine how the project will affect the Forest goals related to plants, fish, wildlife, water quality, etc. …The Forest Service and California Department of Fish and Game habitat typing methodologies are both accepted methodologies for habitat typing in the California region…The habitat typing study will provide information on the types, frequency and condition of aquatic and riparian habitats throughout the project area. Index reaches required for more intensive data collection to complete the Inventory of Aquatic Fauna Study and the Instream Flow I Study will be established based on the habitat distributions identified in the study."

<u>In-Stream Flow I (Effects of regulated streamflow on aquatic and riparian habitats)</u>
Specific language from USFS comments on the Willow Creek project can be applied to the current project:

There is a need to determine how impaired flows will affect aquatic and riparian habitats and the species that are dependent upon them. Habitat elements that need to be evaluated for reductions in base flow include shallow water, bar, hyporheic (subsurface), shoreline, backwater and spawning habitats. There is also a need to determine how reductions in streamflow will affect riparian habitats including soil-plant-water relationships, the distribution of riparian vegetation and vegetation loss or encroachment. In addition, there is a need to determine how pool volumes will be affected by reduced flows…Obtaining this information is critical to identifying the minimum flows that are necessary to sustain the biologic and physical integrity of the riparian and aquatic environment throughout the bypass reach…We recommend that the Instream Flow Incremental Methodology (IFIM), or another mutually agreed upon approach, be employed to study how aquatic and riparian habitats and the species associated with them will be affected under the full range of impaired flow conditions. The IFIM provides a framework for quantifying aquatic and riparian habitat condition as a function of discharge…The results of all aquatic, wildlife and vegetation surveys should be used to determine the species that could be affected by reduced streamflow and the habitat types that these species are associated with… The objective of this study would be to provide information concerning the effects of project hydropower operations on aquatic and riparian

> *habitats and provide the information required to design a flow regime…that sustains or benefits habitat for fish and other aquatic and riparian-dependent species…The IFIM and accompanying methods…are increasingly being used to evaluate the effects of flow regulation on riparian and aquatic resources and as tools for the development of conditions for federal permits and licenses. Coordination with the California Department of Fish and Game, US Fish and Wildlife Service, USDA-Forest Service and the [North Coast] Regional Water Quality Control Board will be required to insure that the specific study methods chosen under the IFIM umbrella fulfill the information needs of all agencies.*

<u>In-Stream Flow II (Streamflow data collection)</u>
Specific language from USFS comments on the Willow Creek project can be applied to the current project:

> *Streamflow data collected for this study will benefit and support almost all of the other recommended studies including those dealing with water quality, habitat availability and utilization, fish passage, LWD [large woody debris] and sediment transport and impacts to recreation. Most importantly, streamflow data will be used in conjunction with information from other studies to identify the full range of flows needed to support aquatic and riparian species and habitats within the proposed bypass reach… The acquisition of streamflow data for determining the flow regime of streams is a widely accepted practice and inherent to determining the economic value of proposed new hydropower projects and the relationship between hydropower operations and multiple resource effects.*

Activities for the current feasibility study included stage monitoring for 18 months and wading flow measurements to develop a stage-discharge curve correlating stage with streamflow. These data have been compared with 11 years of discharge data from nearby Turwar Creek and local precipitation data to develop an 11-year synthetic data set for West Fork Pecwan Creek using HEC-HMS hydrologic modeling software. These synthetic data have been used for system design and estimates of instream and bypass flows for various system design scenarios.

<u>Sediment and Large Woody Debris Transport</u>
A one-time rainy season sample of West Fork Pecwan Creek water taken at the proposed intake location on March 22, 2011 showed the water to be very clear with minimal sediment. Pecwan Creek will need to be studied in greater depth to determine whether transport of suspended sediment, bed load, and large woody debris is a significant concern in the project area. The following language from USFS comments on the Willow Creek project may apply with some adaptation to the current project:

> *Willow Creek drains land areas that are prone to instability problems and transports large quantities of bed load and suspended sediments during high flow periods. Large woody debris (LWD) is also transported during large winter runoff events. LWD provides important values to aquatic and riparian habitat. The installation of the intake and associated structures, penstock and other improvements in the project area will affect*

> *the routing of sediment and LWD in the creek. The potential interactions between the proposed intake and sediment/LWD need to be identified and evaluated in order to determine how the routing of these materials will be affected by the proposed project. Elements of the sediment regime that need to be studied downstream of the intake include the effects of a modification of sediment transport on riparian and aquatic habitats, including spawning habitat, in the bypass and downstream reaches. The influence of the intake and project maintenance on the routing of large woody debris needs to be assessed to determine if the transport and distribution of LWD in the bypass and downstream reaches will change due to project improvements and operations…STUDY METHODOLOGY: Characterize the project area for the following factors: (1) Determine the size and volume of sediment transported by Willow Creek over a range of flow conditions from base flows to the 100-year flood in order to validate the relationship between stream discharge and sediment movement…(2) Determine how riparian and aquatic habitats below the intake will respond to changes in sediment supply, including changes in the spawning gravels and physical habitat characteristics (e.g. pool dimensions and storage). (3) Evaluate the potential effects of project construction, maintenance and operation on sediment movement. (4) Determine how large woody debris routing will be affected by hydropower structures and operations…This study should be prepared by a professional fluvial geomorphologist experienced with sampling and analyzing sediment (bed load and suspended) and LWD transport.*

Water Quality

A 1979 U.S. Fish and Wildlife Service report provides graphs of Pecwan Creek temperatures during one winter period (December 1, 1977 to February 17, 1978). Temperatures during this period fluctuated between approximately 5 and 10°C.[vi]

The Yurok Tribe Environmental Program (YTEP) operates the Tribe's water quality program and posts annual reports online at: www.yuroktribe.org/departments/ytep/ytepreports.htm. In recent years, these reports have provided data only for the mainstem Klamath River and a small number of creeks where the Tribe maintains permanent water quality monitoring stations (Turwar, Tully, Blue, and McGarvey Creeks). In earlier reports, through 2004, the reports include some water quality information on West Fork Pecwan Creek. Measurements made on West Fork Pecwan Creek were discrete (i.e., one-time sampling events), as opposed to the continuous monitoring performed at some other locations in the report. Parameters measured or observed for West Fork Pecwan Creek in the 2004 report include temperature, dissolved oxygen, specific conductivity, pH, and macroinvertebrates. Of eight creeks evaluated in the 2004 report, West Fork Pecwan Creek was rated as having the highest sensitivity to water quality impairment based on the results of macroinvertebrate sampling. West Fork Pecwan Creek was ranked overall least impaired of the eight creeks based on all the parameters evaluated. YTEP may be able to provide the data used to prepare the report.[vii]

The EPA's STORET online water quality archive lists Pecwan Creek water quality data under the code WCAP99-1060; however, these data do not appear to be retrievable through the online system.

Inventory of Aquatic Fauna

Yurok Tribe Fisheries 2003 report *Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California* identifies the upper limit of anadromy for Pecwan Creek as being well below the proposed location for hydraulic works. An earlier U.S. Fish and Wildlife Service publication says:

> *The lower 1.25 miles of Pecwan Creek…were surveyed on July 11, 1978…The stream gradient becomes pronounced at stream mile 0.78 where a series of cascades formed by numerous large boulders create an apparent barrier to adult salmon. At stream mile 1.0, the creek becomes quite precipitous with stream gradient averaging about 20 percent…A spawning ground survey conducted on the lower three-quarter mile section of Pecwan Creek…on December 1, 1977 revealed no fish. Electrofishing surveys conducted on April 21, May 2, and June 1, 1978 revealed considerable numbers of juvenile steelhead/rainbow trout but no coho or Chinook salmon. Considerably more juveniles were observed in the section of the stream below the cascades located at stream mile 0.78 than above the cascades…As an anadromous salmonid stream, Pecwan Creek does not have great potential for supporting large runs of salmon and steelhead. Only about one mile of suitable spawning habitat exists in both forks combined.*[viii]

The tailrace at the downstream end of the proposed project is located at approximately stream mile 1.45, well above the limit of anadromy identified in the US Fish and Wildlife Service report.

Monica Hiner of Yurok Fisheries recommends identifying any sensitive amphibian species present in the project's area of influence.

Seismic Study of Proposed Facilities Locations

The State of California's 2010 Fault Activity Map shows an unnamed low angle fault running along the lower reach of West Fork Pecwan Creek, including the proposed project site. See Figure 6. The map does not indicate how recently this fault has been active. The quaternary Surpur Creek Fault runs north-south approximately six miles west of the West Fork of Pecwan Creek. The classification scheme used on the map indicates that this fault is not believed to have experienced a displacement for more than 700,000 years.[ix]

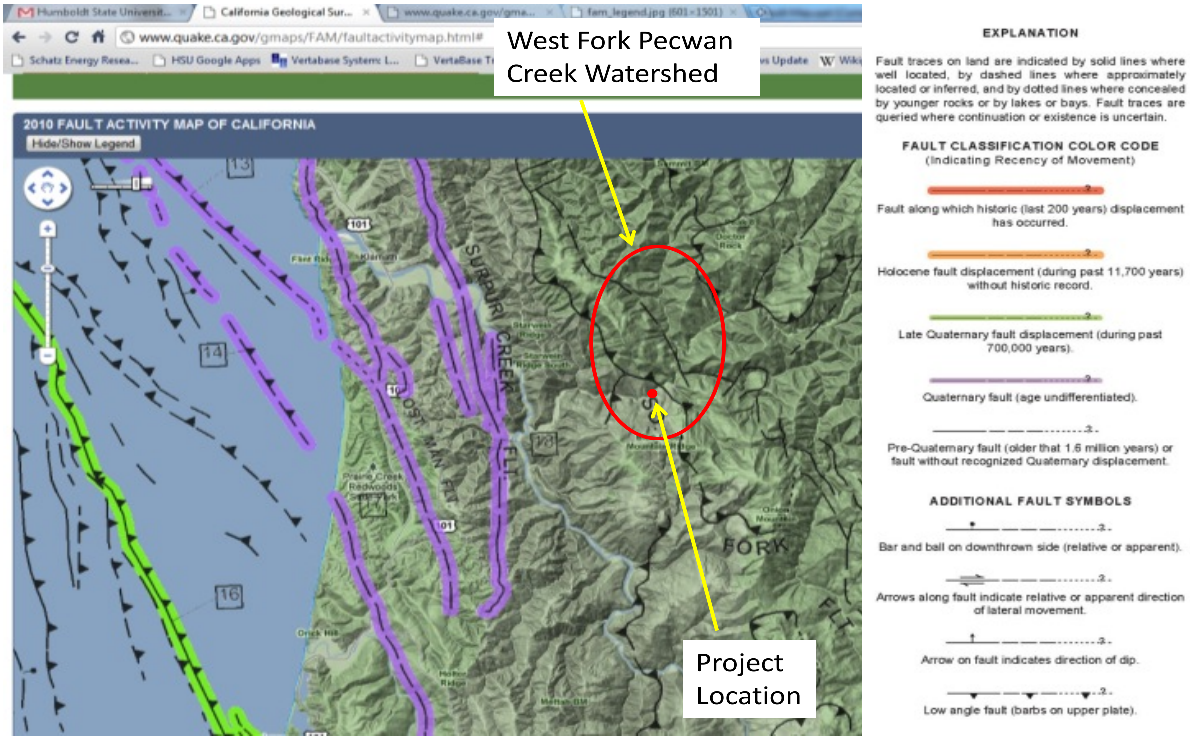


Figure 6. Fault map of project area

(source: http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html)

Since no major water impoundment or structures large enough to cause a threat to human safety are included in this project design, potential impacts associated with seismicity are expected to be minimal.

Geology and Geologic Hazards

Using a Google Earth California geologic map plug-in from USGS[x], we were able to determine that the geologic unit making up most of the West Fork Pecwan Creek basin, including the area where the hydraulic works would be installed, is *KJfs*, a schist dominated unit. About midway along the proposed power transmission corridor going toward the Klamath River, there is a transition to *KJf*, Franciscan Complex, unit 1, which is made up mainly of sandstone. A portion of the upper basin is *um*, ultramaphic rocks, principally serpentine. See Figure 7.

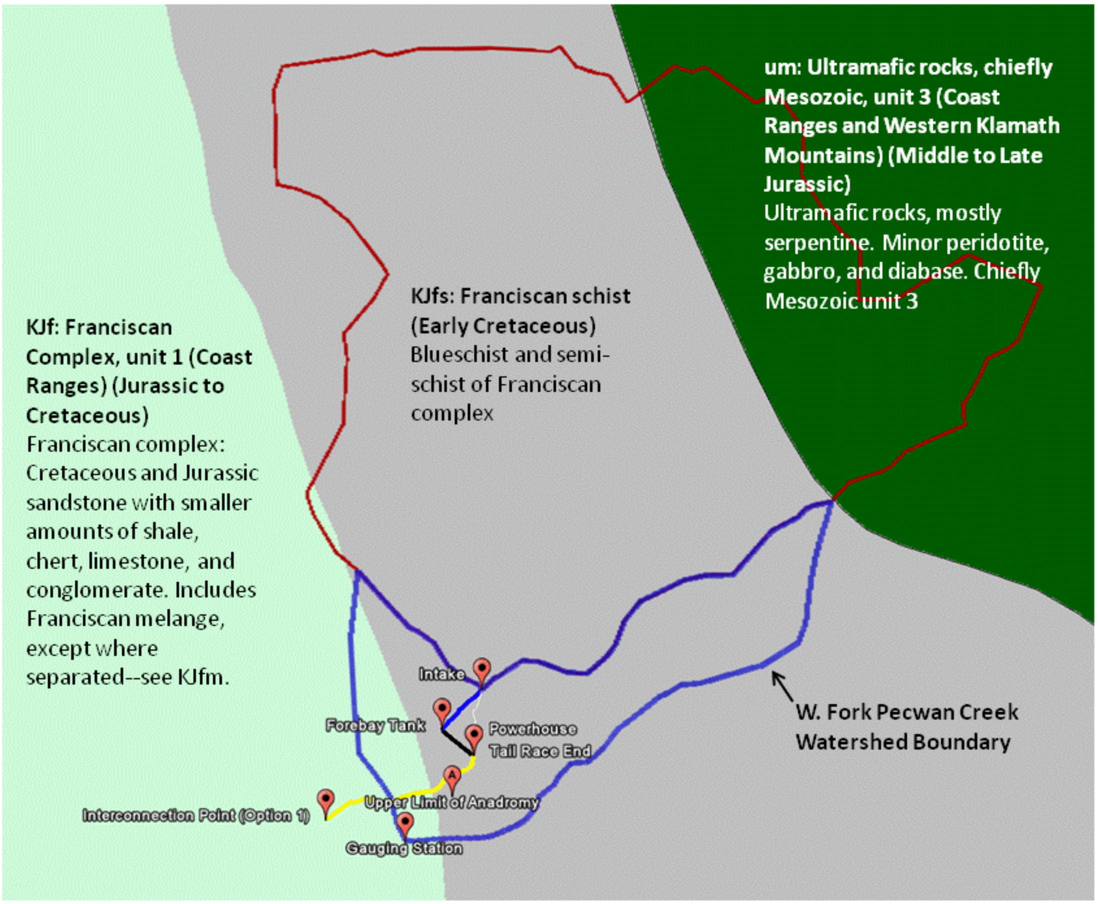


Figure 7. Geologic map of project area
(source: http://tin.er.usgs.gov/geology/state/state.php?state=CA)

A custom soil resource report was generated for the West Fork Pecwan Creek basin using the U.S. Natural Resource Conservation Service's online Web Soil Survey tool.[xi] The report is included as an appendix to this feasibility study.

The report and included map show that the basin overall includes ten named soil map units. Of these, four map units (Burroin-Bagaul-Redtop complex, Hullygully-Burroin complex, Burroin-Bagaul complex, and Jayel-Walnett-Oragran complex) make up 88.2% of the basin. All of the hydraulic components of the project would be built on two map units, Burroin-Bagaul-Redtop complex and Hullygully-Burroin complex. All of the soils making up these two map units have the following characteristics in common:

- parent material – colluvium and residuum derived from schist
- drainage class – well drained
- depth to water table – more than 80 inches

Depth to restrictive feature (lithic bedrock) for Burroin is 20 to 39 inches; for the other soils in these two map units, depth to restrictive feature is more than 80 inches.

For the route likely to be traversed by power transmission lines from the powerhouse to the nearest grid intertie point along Highway 169, there are four soil map units: the above-mentioned Burroin-Bagaul-Redtop complex and Hullygully-Burroin complex, as well as Mooncreek-Noisy-Sidehill complex (parent material colluvium and residuum derived from sandstone and mudstone), and Sidehill-Oakside-Darkwoods complex (parent material colluvium and residuum derived from sandstone). These are also well-drained soils with similar descriptions to those given for the soils in the vicinity of the hydraulic works.

Construction Debris Study

Specific language from USFS comments on the Willow Creek project can be adapted to the current project:

> *Considerable construction debris may be generated during construction of this hydroelectric project. Due to the narrow canyon and high stream power, it may be hazardous to stockpile this material near excavation sites within the project area. Flood events or earthquakes could cause massive failure and delivery of the material to Willow Creek, impacting downstream beneficial uses.*

The same concerns could well apply in the steep, narrow canyon of West Fork Pecwan Creek. A detailed study of the topography, geology, and soils in the project area will help to identify areas where construction materials can be staged and sites for temporary storage and possible permanent disposal of construction debris.

Cultural Resources Survey

In 2006, the Yurok Tribe enacted a Cultural Resource Protection Ordinance. Federal and state laws cited as authority for the Cultural Resource Protection Ordinance include:

- The American Indian Religious Freedom Act (AIRFA)
- The Archaeological Resources Protection Act (ARPA)
- The Native American Graves Protection and Repatriation Act (NAGPRA)
- The National Historic Preservation Act (NHPA)
- The National Environmental Policy Act (NEPA)
- The California Environmental Quality Act (CEQA)

The ordinance states that "[n]o person shall engage in the disturbance of cultural resources or plan to engage in the disturbance of cultural resources without a valid and appropriate permit from the Yurok Tribe." In practice, Tribal staff say this means that any project on Tribal lands that involves excavation will require a Cultural Resources Permit. It is anticipated that the Tribe will require a Cultural Resources Permit be issued for this project to proceed, given that the project will be built on Tribally owned land, will require excavation, and will be located upstream from a culturally important site, the dance ground at the mouth of Pecwan Creek. Tribal cultural staff should be consulted on applying for this permit. Specific Tribal staff who approve Cultural Resource Permits include the Tribal Heritage Preservation Officer (THPO), Native American Graves Protection and Repatriation Act (NAGPRA) Coordinator, and Tribal Archaeologist.

Recreation Use Study

As recent historic owner of the property on which the project would be built, Green Diamond has restricted Tribal and public access to the site. At this time it is not known what recreational uses if any the Tribe will permit if and when they secure ownership of the property. A likely recreational use of lands in this area would be hunting. A study should be conducted to identify recreational uses and any possible conflicts between these uses and the planned hydropower development.

Federally Listed Threatened and Endangered Wildlife Species Surveys

Federally listed threatened and endangered wildlife species that are or might be present in the project area will need to be identified. U.S. Forest Service staff who commented on the proposed nearby Willow Creek hydropower project called attention to the following species of interest:

- northern spotted owl (*Strix occidentalis var caurina*)
- marbled murrelet (*Brachyramphus marmoratus*)
- bald eagle (*Haliaeetus leucocephalus*)

Consultation with the U.S. Fish and Wildlife Service will be required to access records of sightings or know nesting sites of these species in the Pecwan Creek project area.

One tool that may be useful in preliminary identification of critical habitat is the online Biogographic Information and Observation System (BIOS). Figure 8 shows a sample screen shot of this interactive GIS system being used to show that there is no Northern Spotted Owl critical habitat within the Pecwan Creek watershed. Note that BIOS's hundreds of available map data layers may be of use for other biological and natural resource mapping needs, including presence of invasive plants.

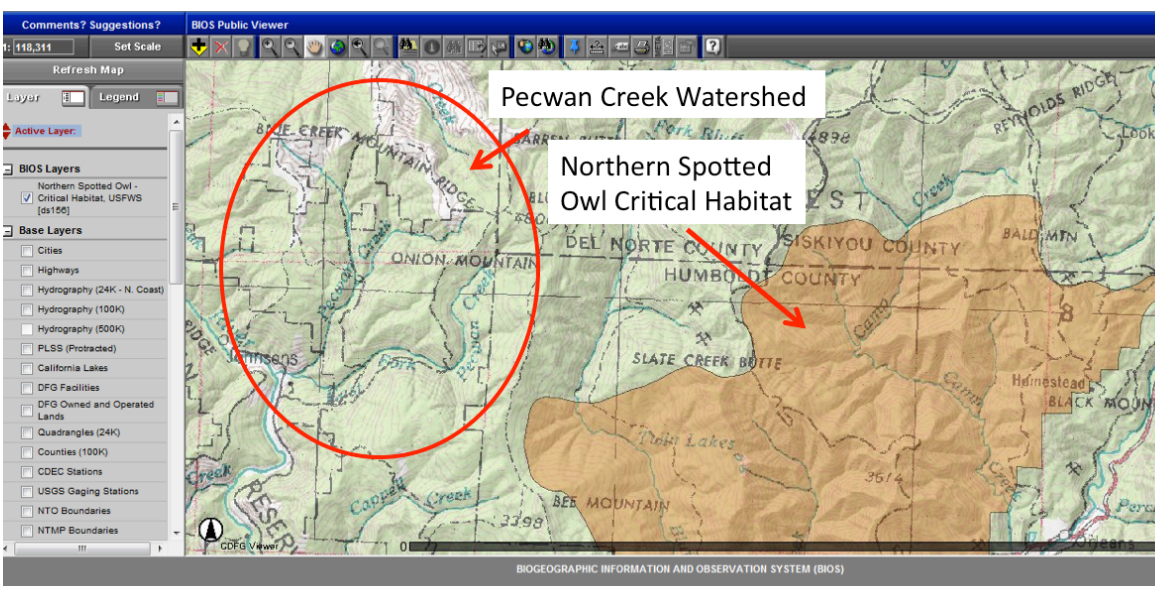


Figure 8. BIOS map showing Northern Spotted Owl critical habitat in proximity to the Pecwan Creek watershed

(source: http://imaps.dfg.ca.gov/viewers/biospublic/app.asp)

Region 5 Forest Service Sensitive Terrestrial Wildlife Species Surveys

U.S. Forest Service comments on the nearby Willow Creek project note that the National Forest Management Act

> *…requires the Forest Service to "provide for a diversity of plant and animal communities"…as part of the multiple use mandate. The Sensitive species program is designed to meet this mandate and maintain biodiversity on National Forest System lands…Forest Service policy for Sensitive species includes management provisions that state "Sensitive species of native plant and animal species must receive special management emphasis to ensure their viability and to preclude trends towards endangerment that would result in the need for Federal Listing."*

The Six Rivers National Forest lands within the West Fork Pecwan Creek watershed may or may not be determined to lie within the proposed project's area of influence pending consultation with FERC and the Forest Service; therefore, the need to conduct Region 5 Forest Service sensitive terrestrial wildlife species surveys remains to be determined.

The U.S. Forest Service comments on the Willow Creek project identified the following sensitive terrestrial species:
Northern goshawk (*Accioiter gentiles*)
Western Pond Turtle (*Clemmys marmorata marmorata*)
Foothill Yellow-legged Frog (*Rana boylii*)
Southern Torrent Salamander (*Rhyacotriton varieagates*)
Northern red-legged Frog (*Rana aurora aurora*)
Willow flycatcher (*Emnidonax traillii*)
Townsend's big-eared bat (*Plecotus townsendi*)
Pacific fisher (*Martes pennanti*)
American marten (*Martes americana*)
California wolverine (*Gulo luscus*)
American peregrine falcon (*Falco peregrines*)

Northwest Forest Plan Terrestrial Survey and Manage Species and Forest Service Species of Concern

The following language is included in the Forest Service comments on the proposed Willow Creek project:

> *The Northwest Forest Plan requires surveys for a variety of survey and manage terrestrial species prior to all ground-disturbing activities occurring on National Forest system lands within the range of the northern spotted owl. In the proposed project area this would include surveys for several species of survey and manage terrestrial mollusks…The terrestrial mollusk species currently on the Six Rivers National Forest — Lower Trinity Ranger District that require project-level surveys prior to ground-disturbing activities include the following:*

- *Oregon shoulderband (*Helminthoglvpta hertleini*),*
- *Klamath shoulderband (*Helminthoglypta talmadgei*)*
- *Pressley hesperian (*Vestericola pressleyi*)*

If the project's area of influence is determined to include Six Rivers National Forest lands, the Tribe or project developer should consult with Forest Service staff to identify "survey and manage" species and Forest Service species of concern and make plans for surveying these species.

Noxious Weeds and Invasive Exotics Inventory, Mapping and Analysis
According to the California Invasive Plant Inventory Database maintained by the California Invasive Plant Council (http://www.cal-ipc.org), there are over 200 species of invasive plants found in the Northwest region of California, which includes the project area. For a more detailed assessment of noxious weeds and invasive plants specific to the project area, mapping tools are available online at: http://www.cal-ipc.org/ip/mapping/index.php

The Mid-Klamath Watershed Council (http://www.mkwc.org), whose area of interest lies just northeast of the Yurok Reservation, has compiled a list of invasive plants of special concern in the area. The list includes:

- Meadow knapweed
- Spotted knapweed
- Leafy spurge
- Oblong spurge
- Italian thistle
- White top
- Puncture vine
- Canada thistle

It is likely that at least some of these plants are already present or could become invasive in the project area. Precautions will be needed during project construction and operation, such as periodic field monitoring and cleaning tires of vehicles before they enter or leave the work area, to minimize transport of invasive plant seeds or establishment of new plant colonies in the project area.

Northwest Forest Plan Survey and Manage Plant Species
Discussion of this topic in the Forest Service comments on the proposed Willow Creek project parallels that for survey and manage animal species (see above). Plant species identified in the Forest Service comments that have "potential habitat within the project area" include:

- Vascular Plants
    - Mountain lady's slipper (Cyprzpedium montanum)
    - fascicled lady's slipper (C. fasciculatum)
    - bensoniella (Bensoniella oregana).

- Lichen
  - Leptogium cyanescens
  - Lobaria oregana
  - Ramalina thrausta
  - Usnea longissima
- Bryophytes
  - Ptilidium caljfornicum
  - Schistostega pennata

If the project's area of influence is determined to include Six Rivers National Forest lands, the Tribe or project developer should consult with Forest Service staff to identify "survey and manage" plant species and make plans for surveying these species.

Special Status Plant Surveys

Specific language from USFS comments on the Willow Creek project can be adapted to the current project:

> *All habitat-disturbing activities permitted on National Forest land require assessment of the direct and indirect effects on Threatened and Endangered, Sensitive and other special status species. In order to assess the project's potential and predicted affects on these plant species, site-specific knowledge is needed of the presence, location and extent of special status plants species within the area potentially affected by the proposed project. Understanding of the project's predicted effects on these plants is necessary in order to determine compliance with federal laws, policies and direction in managing rare and endemic plants.*

Categories of special status plants identified by the Forest Service include:

- California Native Plant Society's Inventory of Rare Plants
- Forest Sensitive Species
- US Fish and Wildlife list of species of concern
- State Endangered, Threatened, and Rare Plants of California list

Determining the Magnitude and Significance of Impacts and Identifying Uncertainties

Magnitude of impacts is the extent to which a project affects its surroundings. This is usually an objective measure that can be estimated through study of the specific site; application of scientific, engineering, and economic analysis techniques; and correlation with observed impacts in similar settings elsewhere. Significance of impacts is typically more subjective and is based on value judgments made by individuals or groups about the relative importance of various impacts.

TEEIC recommends considering the following factors when estimating magnitude of impacts:

Area of Influence: *The impact magnitude is often directly related to the size of the area affected. An example would be the acres of land disturbed.*

Overlap Between Area of Influence and Resource of Interest: *The impact magnitude is often directly related to the area of overlap between resources and the overall area of influence for the project. An example would be the overlap between mule deer winter range and the project.*

Deviation from Current or Baseline Conditions: *For projects that affect air or water quality, how much would concentrations of contaminants increase? For projects that result in a large influx of workers, what is the current capacity of housing, schools, and other support services?*

Project Duration: *Magnitude is often directly proportional to the lifespan of the project. A project that operates for 5 years as opposed to 20 years is likely to have much less impact.*

Sensitivity of the Resources: *Some species appear to be very sensitive to disturbance (e.g., sage grouse and bald eagles), whereas others are fairly tolerant of disturbance (e.g., many plant species adapt to disturbance).*

Project Timing: *Project activities that occur during periods of sensitivity (e.g., nesting season, high-precipitation periods) have greater impacts than at other times.*

Impacts need to be quantified where possible using objective, widely accepted metrics. Where this is not possible due to a lack of available information, the impacts should be described qualitatively. Conservative values should be used in order not to underestimate impacts.

Significance of impacts is more subjective and requires judgment be applied, typically by an interdisciplinary group qualified to make such determinations. Impacts that are determined not to be significant may be eliminated from consideration in deciding whether to permit a project or in determining types and degrees of mitigation required. Factors identified by TEEIC for weighing significance of impacts include:

Area of Influence: *Impact significance is often directly related to the size of the area affected. An example would be the acres of land disturbed.*

Percentage of Resource Affected: *The greater the percentage of a resource affected, the more significant the impact.*

Persistence of Impacts: *Permanent or long-term changes are usually more significant than temporary ones. The ability of the resource to recover after the activities are complete is related to this effect.*

Sensitivity of Resources: *Impacts to sensitive resources are usually more significant than impacts to those that are relatively resilient to impacts.*

Status of Resources: *Impacts to rare or limited resources are usually considered more significant than impacts to common or abundant resources.*

Regulatory Status: *Impacts to resources that are protected (e.g., endangered species, wetlands, air quality, cultural resources, water quality) typically are considered more significant than impacts to those without regulatory status. Note that many resources with regulatory status are rare or limited.*

Societal Value: *Some resources have societal value, such as sacred sites, traditional subsistence resources, and recreational areas. Note that some of these resources also have regulatory status.*

Generally impacts cannot be predicted with absolute certainty. Environmental impact assessment should seek to quantify the degree of uncertainty for magnitudes of impacts. Sensitivity analysis may be useful to estimate which factors contribute the most to overall uncertainty of a given impact.

Determining Mitigation Requirements

Part of the environmental impact assessment process is identifying what impacts need to be mitigated and how the mitigation will be achieved. TEEIC recommends that mitigation efforts have the following features:

Mitigation Should Be Focused: *To be effective, mitigation must specifically target the major impacting factors, area of influence, and resources affected that were identified during the assessment.*

Mitigation Should Be Proportionate to the Significance of the Impact: *Mitigation should be scaled to the impact magnitude and impact significance. Predisturbance surveys can go a long way toward minimizing the amount of mitigation required if information collected during those surveys is used to readjust project location and design features to avoid important resources.*

Mitigation Should Be a Function of Project Phase: *Mitigation for site characterization will be relatively simple (e.g., minimizing the amount of ground disturbance, maximizing the use of existing roads), but mitigations for construction and operations will be far more complex to address the many pathways to impact that are inherent to these phases.*

Mitigation Should Be Developed in Consultation: *Mitigation for impacts on regulated resources (e.g., wetlands, threatened species and endangered species, water quality, water use) should be developed in consultation with the regulatory authority. Mitigation requirements are typically specified in permits.*

> ***Mitigation Effectiveness Should Be Monitored:*** *To be effective, mitigation should be monitored. For regulated resources where mitigation is developed in consultation with the regulatory authority, monitoring is almost always required.*

In the case of a new hydropower project such as Pecwan Creek, one tool that may become available for mitigation of impacts in the future is Low Impact Hydropower Institute (LIHI) certification. LIHI is a non-profit organization that to date has certified some 70 projects nationwide. LIHI criteria for certification fall into the following categories:

- river flows
- water quality
- fish passage and protection
- watershed protection
- threatened and endangered species protection
- cultural resource protection
- recreation
- the facility should not be at a dam already recommended for removal

Note that at this time the Pecwan Creek project would not be eligible for LIHI certification, as only projects using dams built prior to August 1998 can be certified. However, LIHI states that "LIHI may in the future consider certifying new 'non dam' technologies for hydropower. " LIHI fees for a project of the scale of the Pecwan Creek system are $1,600 at time of application plus a $240 annual fee. Certification is valid for five years.

Developing a Monitoring Program

Monitoring is needed to verify accuracy of the environmental impact assessment process and to determine the effectiveness of mitigation measures required as part of the permitting process. A full environmental impact assessment for the project will require identification of what parameters or processes need to be monitored and a plan for performing monitoring during construction, operation, and eventual decommissioning of the project. A plan will also need to be developed for how to respond to monitoring outcomes should it become apparent that impacts exceed expected levels or that mitigation measures are not working adequately. When budgeting for the project, costs of these continuing monitoring activities should be considered.

Useful Resources for Preparing a Full EA or EIS

The following documents and web resources were identified and consulted in preparing this preliminary environmental impact assessment. They are likely to be useful in preparing a full EA or EIS for the project.

"Assessments and Monitoring" section of the Tribal Energy and Environmental Information Clearinghouse (TEEIC) website: http://teeic.anl.gov/am/index.cfm

Gale, Dan. *Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California.* Yurok Tribal Fisheries Program. Habitat Assessment and Biological Monitoring Division. Technical Report No. 9. March 2003.

Handbook for Hydroelectric Project Licensing and 5 MW Exemptions from Licensing. Federal Energy Regulatory Commission. April 2004. Appendix D provides guidance on preparing Exhibit E, the environmental report that accompanies an application for license or exemption. http://www.ferc.gov/industries/hydropower/gen-info/handbooks/licensing_handbook.pdf

Preparing Environmental Documents: Guidelines for Applicants, Contractors, and Staff. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing. September 2008.
http://www.google.com/url?sa=t&source=web&cd=1&sqi=2&ved=0CBQQFjAA&url=http%3A%2F%2Fwww.ferc.gov%2Findustries%2Fhydropower%2Fgen-info%2Fguidelines%2Feaguide.pdf&ei=5RZ1Td67JoWssAPM--naCw&usg=AFQjCNGGtSle00rU0AvnK-f-mQQEQsX_wg

Hydropower Licensing and Endangered Species: A Guide for Applicants, Contractors, and Staff.
Federal Energy Regulatory Commission, Office of Energy Projects, Washington, DC. December 2001.
http://www.google.com/url?sa=t&source=web&cd=1&sqi=2&ved=0CBgQFjAA&url=http%3A%2F%2Fwww.ferc.gov%2Findustries%2Fhydropower%2Fgen-info%2Fguidelines%2Fesa_guide.pdf&ei=EBd1TbeCNJOssAO90ZDBCw&usg=AFQjCNFmjhi8ZpCac3_WKvTqdkGouE_aOQ

Roth, Elizabeth Bogley. "1992 Ninth Circuit Environmental Review: Chapter: Environmental Considerations in Hydroelectric Licensing: California v. FERC (Dynamo Pond)." *Environmental Law*, Vol. 23. Lewis and Clark Law School. 1993.

A number of other small hydro power projects have been proposed or developed in and around Humboldt County in recent decades. Though each project is unique, documentation on these other projects can serve to guide environmental review for the proposed Pecwan Creek project. Many documents pertaining to environmental review of these projects can be accessed online via FERC's eLibrary (http://www.ferc.gov/docs-filing/elibrary.asp). Use the docket number to search for each project.

Among these Humboldt County hydropower projects are:

- Ross Burgess's 1.3 MW microhydroelectric project near Zenia, CA, which holds a FERC license. The project was licensed by FERC in 1991, docket number P-10882. The project is one of 1,013 projects currently licensed by FERC. Mr. Burgess reports that environmental studies and documentation for this project were performed by FERC at the agency's own expense.
- Mill and Sulphur Creek (docket number P-6154), a 995 kW project.
- Baker Creek (docket number P-4627), a 1.495 MW project.
- Proposed 5.45 MW hydro power project on Willow Creek, near the town of Willow Creek, CA. This project was being designed and permitted (FERC docket

number P-12113) in 2001-2002 but was not constructed. The project would have been partially sited on land owned by the developer and partially on Six Rivers National Forest land. The developer, Big Rock Power, maintained a website with extensive project information and documents at www.bigrockpower.com.[xii] Documents available online include a detailed report from Six Rivers National Forest (U.S. Forest Service) recommending what impacts the developer should consider. There are also comments from National Marine Fisheries Service and CalTrout, a final study plan based on the recommendations from USFS, and a FERC application for a preliminary permit.

USDA Forest Service, Six Rivers National Forest. *Willow Creek Hydro Water Power Project (FERC #12113). Response to Initial Consultation Package and Forest Service Recommended Studies.* March 28, 2002. Cited extensively in the present document in the "Potential Resources Affected" section.

Final Environmental Assessment for Hydropower License: Reynolds Creek Hydroelectric Project. FERC No. 11480-001. Alaska. July 7, 2000. http://teeic.anl.gov/documents/docs/library/Final_EA_Reynolds_Creek_Hydro.pdf

Noble, Bram F. *Introduction to Environmental Impact Assessment: A Guide to Principles and Practice.* Oxford University Press. 2006.

Notes

i. Telephone conversation by Schatz Energy Research Center's Richard Engel with Michael Spencer, Federal Energy Regulatory Commission. February 24, 2011. FERC Small Hydro Hotline, 866-914-2849.

ii. Preliminary Review of Permitting Requirements, Yurok Hydroelectric Power Project, West Fork Pecwan Creek, Yurok Reservation, Humboldt County California. Prepared for the Yurok Tribe by Schatz Energy Research Center. March 2011.

iii. Gale, Dan. *Inventory and Assessment of Anadromous Fish Passage Barriers in the Lower Klamath River Sub-Basin, California*. Yurok Tribal Fisheries Program. Habitat Assessment and Biological Monitoring Division. Technical Report No. 9. March 2003.

iv. http://www.fs.fed.us/r6/nr/fid/fidls/poc.htm

v. http://www.plantmaps.com/nrm/chamaecyparis-lawsoniana-port-orford-cedar-native-range-map.php

vi. *Final Report: Hoopa Valley Indian Reservation Inventory of Reservation Waters Fish Bearing Feasibility Study and a Review of the History and Status of Anadromous Fishery Resources of the Klamath River Basin.* U.S. Fish and Wildlife Service, Arcata Field Station. March 15, 1979. www.fws.gov/arcata/reports/annual%20reports/HVIR_Inventory_of_Reservation_Waters.pdf

vii. *Water Year 2004 (WY04) Report, October 1, 2003– September 30, 2004*. Yurok Tribe. December 2005. www.yuroktribe.org/departments/ytep/documents/WY04.pdf

viii. *Final Report: Hoopa Valley Indian Reservation Inventory of Reservation Waters Fish Bearing Feasibility Study and a Review of the History and Status of Anadromous Fishery Resources of the Klamath River Basin.* U.S. Fish and Wildlife Service, Arcata Field Station. March 15, 1979. www.fws.gov/arcata/reports/annual%20reports/HVIR_Inventory_of_Reservation_Waters.pdf

ix. www.quake.ca.gov/gmaps/FAM/faultactivitymap.html

x. http://tin.er.usgs.gov/geology/state/state.php?state=CA

xi. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

xii. The bigrockpower.com site is no longer maintained but is archived at archive.org.