FINAL PROJECT REPORT 2014

"Understanding the Cumulative Effects of Environmental and Psycho-social Stressors that Threaten the *Pohlik-lah* and *Ner-er-ner* Lifeway: The Yurok Tribe's Approach"

Conducted by the Yurok Tribe Environmental Program

In Collaboration with the Humboldt State University

California Center for Rural Policy

Institute for Spatial Analysis

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1.0 INTRODUCTION

The Yurok Tribe is the largest Indian Tribe residing within California with over 5,600 enrolled members. Yurok Ancestral Territory includes the Lower Klamath River, its estuary, the country's largest lagoon system, the Redwood National and State Parks (RNSP), and County parks. These areas are of great subsistence, cultural, and economic value to the Yurok People, the surrounding coastal communities, and the United States' citizenry in general. It is notable that the RNSP is also a UNESCO World Heritage Site. The Yurok People have resided on the Lower Klamath River and territory along the Pacific Coast since time immemorial and currently maintain cultural, economic, and spiritual ties to these ancestral lands through subsistence use and management of traditional resources.

Figure 1: Map of Yurok Reservation and Ancestral Territory

Perceived increases in adverse health conditions of Tribal members along with declines in the Klamath River fisheries intensified concern such that the Yurok Tribal Council and Tribal membership identified the health of the Klamath River, its fishery, and the continued dependence on key subsistence species (including salmon, sturgeon, and pacific lamprey) as a primary concern for the Tribe and its future (Yurok Tribal Council 1996, 2001; Yurok Tribe 2006a).

In response, the Yurok Tribe Environmental Program (YTEP) initiated this project to assess the general condition of the Yurok environment and key subsistence resources and to make that information available to the Yurok Tribal Council, Tribal and local community members, and the public at large. The primary outcome of the project is the collection of scientific, quantified data on the presence/ absence of toxins, their levels of concentration, and any possible cumulative effects of toxins within Yurok Ancestral Territory, including the Yurok Indian Reservation, the Lower Klamath River, and coastal region. The focus of the study was on the aquatic environment and those toxins that have the potential to threaten the health of Tribal Members and traditional aquatic subsistence resources.

This report details the resulting five year project initiated in 2007 and completed with funding provided through the US EPA, National Center for Environmental Research, Science to Achieve Results Grant # RD-83370801-0 for years 2008-2013. The project was conceived as a Yurok specific bend of an environmental screening study (U.S. EPA 2000) that would integrate traditional tribal values and practices within a basic cumulative risk framework such as defined by US EPA (2007a). It offers data and analyses of multiple, individual components that together represent the aggregate or combined community wide exposure and partial quantification of the combined risks to public health and the environment. In general, the data should be considered a first scoping, characterizing the cumulative risk associated with Yurok Ancestral Territory from multiple agents or stressors.

To achieve this, the research design, took into consideration numerous guidances issued by various regulatory and governmental agencies such as McCray's *Anatomy of Risk Assessment* (1983), various Center for Disease Control's public health assessments, US EPA documents (1989; 1992a, 1992b,1998, 2002b, 2003a), Cal/EPA's published *Building a Scientific Foundation for Cumulative Impacts* (Alexeeff, et al. 2010) and older *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (1992). We also consulted Harper's excellent work on traditional tribal subsistence exposure (Harper et. al. 2006; Harris and Harper 2004). These various guidelines share the inclusion of similar sets of factors that answer the common fundamental risk assessments questions listed below.

- Who is exposed?
- Are there associated adverse health outcomes?
- To which chemicals and in what amounts?
- What are the location(s) where exposures are experienced?
- What are the pathways, routes, and duration by which exposures will occur?

A key distinction of this Yurok tribal assessment is an emphasis on the integration of data to incorporate and to be representative of traditional cultural values and activities. Standard risk assessments were modified in order to depict the pathways of multiple chemicals through multiple routes of exposure that are a unique result from the interrelationships between Yurok Tribal Members and their general environment. To achieve this, the inclusion of many individual elements was considered pivotal in order to represent the holistic Yurok concept of humans as part and parcel of their environment. This report includes chemical analysis across various media and biota, site-specific data sets, qualitative description, exposure scenarios, and a Yurok community health profile.

This report compiles data from a variety of different sources and fields of study creating a pool of terminology that may vary from those the reader may be accustomed to in their respective fields and that sometimes use the same terms to describe different analyses (US EPA 2007). For this reason, the definition of key terms associated with this cumulative risk report are referenced in Appendix A: Glossary. Additionally, the reader should be made aware that YTEP Staff has made an effort to present results in a consistent manner and that the original laboratory data is offered unaltered in the appendices. However, in the body of this report the results from contaminant analysis shifts from toxin residue concentrations in tissue being reported on wet weights for Tier One environmental samples, to dry weight reporting for Tier Two results to provide comparable environmental risk concentrations between species and/ or harvesting sites.

While the project includes key data collection points on hazard, exposure, and health effects, it does not seek nor establish any single direct, causal pathway or link between sources of contaminants and adverse health outcomes, nor is it a consumption study. A complete picture of all contaminants and every possible exposure does not exist, but the testing of a broad range of discrete aspects has been assembled here to provide a coherent, realistic picture of the potential risks likely to be encountered by the Yurok community. It establishes two separate but related lines of research that establish 1) the presence of multiple, potentially endocrine disrupting or cancer-causing contaminants detected within Yurok Ancestral Territory and 2) rates of select adverse health conditions, including diseases of the endocrine system and cancer, for Yurok tribal members as presented in the Yurok Community Health Profile (Appendix B).

The results of this study suggest that while tribal members experience a higher rate of adverse health outcomes, these outcomes do not appear to be a result of the condition of the key subsistence foods consumed by many tribal members. While the outcomes support the hypothesis that a relationship between the Yurok community health and the environmental conditions exists, it also affirms a Yurok traditional diet and identified few areas of contaminants at levels high enough to impact tribal member health. It is hoped that this study will identify areas for future research on the relationship between tribal member and ecosystem health.

2.0 PROJECT OVERVIEW

It is important to consider that the methodology used in this study does not provide any results or findings that directly link tribal members' individual illnesses to past chemical exposures. Nor does this study indicate whether a current health problem or symptom was caused by exposure to any single chemical. Rather this study is a screening study, providing a 'snap-shot' of existing conditions during the research years of 2009-2013. A brief summary of the project's research methodology is offered here. (See Grant RD-83370801-0, Quality Assurance Project Plan for an in depth description of methods.)

This study was conducted in a multi-year, phased approach and includes both the review and consideration of pre-existing, secondary data (surveys, archival documents, ethnographic interviews, GIS databases, and environmental data on pesticide use) and the collection of primary new data generated through interviews, public participation geographic information system sessions, and chemical screening of surface water and tissue samples from targeted species. The first year involved review of previous data, community scoping and planning, the second and third years, public participation sessions, two tiers of field sampling, and laboratory analysis. The fourth and fifth years comprised data analysis and reporting. Project tasks with corresponding data objectives and performance criteria are reported in Table 1, below.

Table 1: Research Tasks, Data Quality Objectives, and Performance Criteria

Task	Data Quality Objective	Performance Criteria
Compile existing data on contaminants within Klamath watershed	Verify accuracy and precision of historic data sets re: the Klamath watershed	*Source validation of all data sets utilized for Project *Creation of metadata for all data set used in GIS
Collect water and tissue samples in the field.	Collect comparable, defensible and accurate data and samples in the field	*Completion of field forms for all samples collected *Adherence to approved SOPs for sample collection
Conduct Laboratory Analysis	Analyze accurate samples for comparable results	*Adherence to EPA standards *Adherence to Lab QA/QC protocols and standards
Conduct PPGIS	Accurate capture of information provided by tribal member participants	*Data validation of PPGIS through multiple sessions and cross verification of content by HSU, YTEP, and community feedback
Collect existing data on Yurok health patterns	Obtain accurate and anonymous medical data on Yurok Membership	*Signed agreements with health institutions on data requested and allowable uses of data *Data printouts from medical databases (anonymous)
Conduct GIS Analysis of project data	Accurate analysis of geospatial relationships of generated data	*Generation of standardized metadata for GIS of all developed data sets *Creation of cross referenced maps that correctly merge and overlay existing GIS data
Develop Risk Assessment and Risk Prevention Tools	Identify risk prevention strategies	*Creation of interactive GIS Eco-Toxicological Assessment Tool with metadata *Tribal membership review and approval of produced Risk Prevention and educational material

2.1 Field Sampling

The primary goal of field sampling was to identify the presence, absence, and concentration of toxins known to exist or to have been utilized within the Klamath River Basin and that might potentially be present in the surface water and key aquatic subsistence populations critical to the continuation of Yurok subsistence, traditions, ceremonies, and lifeways.

The principal target species were selected during year one through community scoping and review of existing datasets and research literature. Additionally, during 2011 a female Grey Whale and calf entered the Klamath estuary. After several weeks, the calf returned to the ocean and the mother subsequently beached herself and died. Opportunistic whale harvesting is a recurring event for the Yurok with associated traditional practices and is culturally utilized for both subsistence food and regalia material. Under supervision of the Yurok Tribal Council, NOAA, and the Pacific Northwest Marine Mammal Center, tissues samples were taken from the carcass and included in this project for analysis. Table 2 lists the species that were sampled as well as their trophic level representation in their environment.

Table 2: Sampled Species

Classification	Sampled Species
Predator	*Chinook (*Oncorhynchus tshawytscha*) Fall Coho (*Oncorhynchus kisutch*) Winter Steelhead (*Oncorhynchus mykiss*)
Bottom-feeder, Predator	Green sturgeon (*Acipenser medirostris*) Dungeness Crab (*Metacarcinus magister*)
Filter feeder, Parasite, Predator	Pacific lamprey (*Lampetra tridentata*)
Filter feeder	California mussel (*Mytilus californianus*) Razor Clams (*Siliqua patula)* Fresh Water Mussels (*Margaritifera falcate*) Grey Whale (*Eschrichtius robustus*)
Marine Producer	Sea weeds (*Porphora sp.* & *Palmaria sp.)*

*Fall and Spring runs of Chinook were sampled as separate Tier One composites, then resampled as discrete individuals for intensified analysis in Tier Two.

The selection of sites for sampling incorporated a judgmental sampling approach to represent key aquatic subsistence harvesting areas within Yurok Ancestral Lands at locations heavily relied upon by Yurok Tribal members. In an attempt to collect data that might be extrapolated to characterize conditions across the Yurok Ancestral Territory, sampling sites were grouped to represent three zones on the Coast and three along the river and where possible, samples were taken from all of the three zones whether marine or riverine and can be viewed on Figure 2. Temporal selection was timed to bracket and coincide with peak subsistence uses of the River, when Klamath River flows were safe, and the targeted species available. Field sampling began May 5, 2010 and was successfully completed during August 2011. Included was a total of:

- 295 individuals from 10 species along with
- 5 composites from 2 seaweed species and
- 6 isokinetic depth-integrated water samples from the Klamath River.

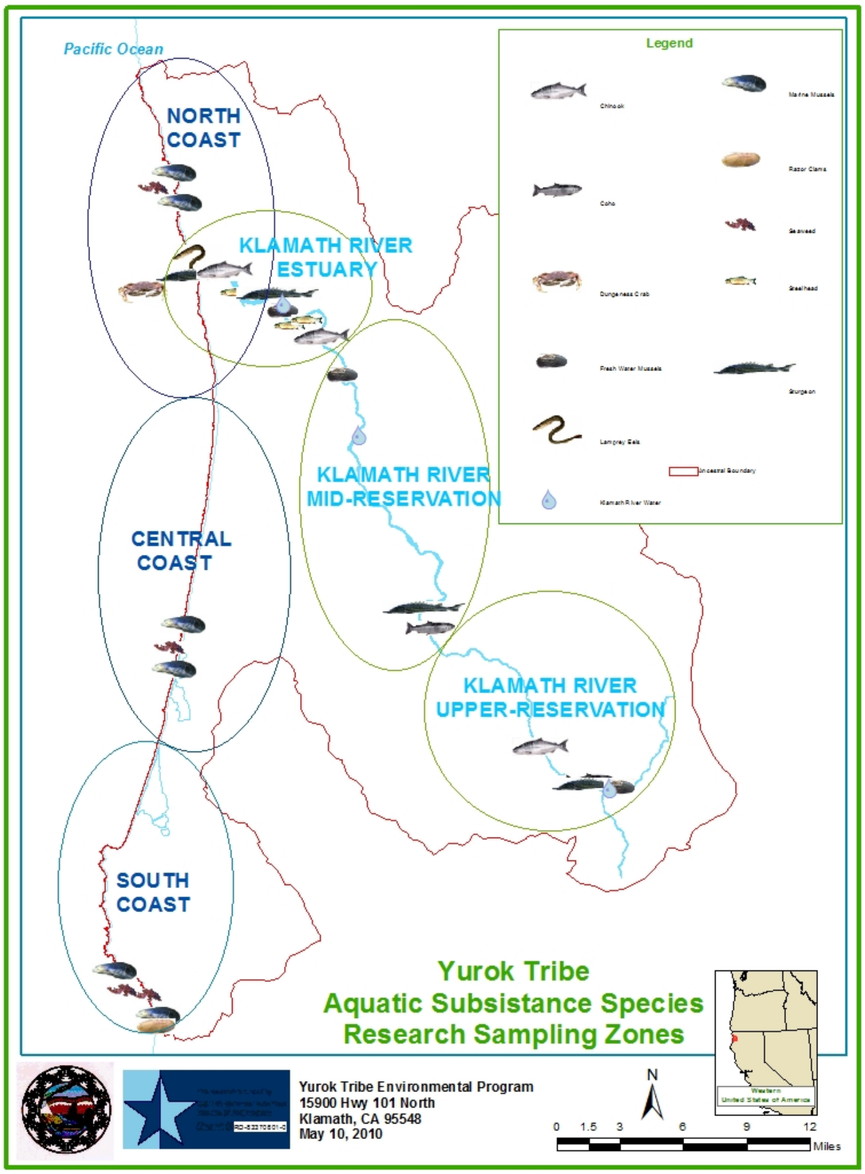


Figure 2: Aquatic Subsistence Species Research Sampling Zones

Both the laboratory limit of detection (DL) and the reporting limit (RL) were held to the lowest possible level determined by the lab's confidence to represent robust, quantitative results; however, results less than the RL were incorporated in the project as estimates of analyte presence without quantified values. The California Department of Fish and Game, Fish & Wildlife Water Pollution Control Laboratory (WPCL) was this project's primary contractor for all sample disbursement to sub-contractors and maintaining quality assurance protocols. Table 7 lists samples, corresponding laboratory and analysis methods. Complete laboratory results and narratives are recorded in Appendix D and should be consulted for customized flags and laboratory quality assurance data including blanks, duplicates, and sample spiking.

Table 3: Research Laboratories and Methods

TISSUE						
(Sturgeon, Marine Mussels, Seaweed)	(Coho, FW Mussels, Steelhead, Crabs)	Lamprey	WATER	ANALYTE	LABORATORY	ANALYSIS
X	X			Carbamates	Fish & Wildlife Water Pollution	LCMSMS (EPA 8321B Mod.)
X	X			Dioxins/Furans	Axys Analytical Services	HRGC/HRMS (EPA 1613B)
X				Mercury	Moss Landing Marine Laboratory	Atomic Absorption Spectrophotometry (EPA 7473)
			X		Moss Landing Marine Laboratory	Cold Vapor Atomic Fluorescence Spectrometry (EPA 1631)
	X				Fish & Wildlife Water Pollution	Atomic Spectrometry Cold Vapor Flow Injection Mercury System (FIMS) (EPA 245.5 Mod.)
		X			Brooks Rand Labs	SW7471B
			X	Methyl- Mercury	Moss Landing Marine Laboratory	Atomic Absorption Spectrophotometry (EPA 7473)
X	X				Brooks Rand Labs	EPA 1630 Modified
X	X		X	Microcystins	Fish & Wildlife Water Pollution	LCMSMS
X	X			Organochlorines	Fish & Wildlife Water Pollution	GC-ECD and GCMSMS (EPA 8081 Mod.)
X	X			Organophosphorus	Fish & Wildlife Water Pollution	GC-FPD (EPA 8141B Mod.)
	X			PAHs	Axys Analytical Services	Axys Method MLA-021 Rev 10
X			X		Fish & Wildlife Water Pollution	GCMS (EPA 8270 Mod.)
X	X			PCBs	Fish & Wildlife Water Pollution	GCMSMS (EPA 1668B Mod.)
X	X			Pyrethroids	Fish & Wildlife Water Pollution	GCMSMS
X	X			PBDEs	Fish & Wildlife Water Pollution	GCMSMS (EPA 1614 Mod.)
X	X			TCP and PCP	Fish & Wildlife Water Pollution	LCMSMS
X	X			Trace metals	Moss Landing Marine Laboratory	Plasma-Mass Spectrometry/ Elan 9000 ICP-MS (EPA 200.8 Modified)
X	X		X		Moss Landing Marine Laboratory	EPA 1638M using Elan 9000 ICP-MS
		X			Brooks Rand Labs	Method E1638M
X	X			Triazines	Fish & Wildlife Water Pollution	LCMSMS

2.2 Geographic Information System (GIS)

During the initial phases of this study, Tribal GIS data and other GIS data on pesticide applications on the Yurok Reservation were compiled by YTEP project staff and provided to HSU for review, assessment, and determination of use in the Project. The GIS data was submitted to Humboldt State University's staff and co-investigators in July and August of 2009, March 2010, and September 2010.

Each file was checked for relevance, usability, and the completeness of metadata. Many early GIS files delivered in 2009 contained poorly organized attributes, lacked qualified metadata, were of limited use, and subsequently deleted from HSU computers and use in this project. The 2010 GIS files contained consistently descriptive metadata and a higher degree of usability for the project and original data was archived. Usable sections of the data were extracted and placed within the working project file structure for further use in mapping, spatial analysis on chemical use within the Yurok Ancestral Territory, and for use in the development and testing of an ecotoxicology modeling tool.

The primary source of historical chemical use within the project area is the California Pesticide Information Portal (CalPIP) provided by the California Department of Pesticide Regulation (CDPR). Via their online portal, pesticide data can be queried by year, county, Public Land Survey System (PLSS) township range sections, and Zip Code.

Several challenges exist with utilizing this data source for analysis, the first of which is currency. There is an average lag of about two years between the current date and the time in which pesticide data is made available. This makes CalPIP data useful for retrospective analysis only.

A second obstacle for analysis is that regardless of the method in which you query data, the only geographic reference available is what CALPIP labels as County Meridian Township Range Section (COMTRS). This generates an overly gross scale of approximately 1 square mile and it also does not include all of California. Unfortunately, there are large tracks of land in the Klamath River basin not included in the PLSS and therefore cannot be accounted for using the CALPIP database. In addition, a single COMTRS is often split by county lines. The public spatial data sets currently available do not factor in these splits, so a single township range section may be referenced by two COMTRS addresses.

A third problem with the CalPIP data is that it is based on pesticide use as reported to the CDPR. Reports can often be incomplete and over-generalized. The CalPIP dataset does not address or define accuracy standards for reporting and does not factor in unreported pesticide use. Regardless, CALPIP has the most extensive database of pesticide use information available, remains the primary source of information in California, and was utilized for this project.

Initially, CALPIP data was collected for all chemicals reported within the Yurok Ancestral Territory over a period of the most recent five years on record. A five year period was selected to ensure a representative sample of data across the region and because the most recent five years was the most complete subset of data. While some portions of the study region had data available for more than five years, a review of these older data showed they were often inconsistent or incomplete. Initial research indicated that there were approximately 405 different chemicals applied during this time period throughout the greater Klamath River basin. Subsequently a list of 295 chemicals, grouped into 11 different categories was finalized as the chemicals of interest. A 19 year history of each of these chemicals, spanning the years 1990 through 2008, was queried and downloaded from the CalPIP website. Chemicals were queried by year, using the five California counties which contain portions of the Klamath River Basin and include Del Norte, Humboldt, Modoc, Siskiyou, and Trinity. Later in the project after the results of Tier One Tissue analysis were reported, chemicals containing Manganese were added to the list of categories as a beta test of the tool in an attempt to determine possible contaminant sources from pesticides.

Data was collected for the following targeted chemical families for the years 1990 through 2010 using the same regional five county criteria. The Miscellaneous category included those chemicals of concern that were not part of the selected families such as Methiocarb, Methomyl, Monuron, and Neburon. The final 12 categories include:

- Carbamate & Phenylura
- Fipronil Metabolites
- Organochlorines
- Organophosphates
- Polycyclic aromatic hydrocarbons (PAHs)
- Polybrominated diphenyl ethers (PBDEs)
- Polychlorinated biphenyls (PCBs) & Archlor
- Phenoxy Acids
- Pyrethroids-Pyrethrins
- Triazines
- Manganese
- Miscellaneous

The pesticide data downloaded from CalPIP returned tables in the form of tab-delimited text files. Each table contained records for the entire year of pesticide use for all five counties per chemical. The tables contained the following headings:

- Year of application
- Date of application
- County
- County Meridian Township Range Section (COMTRS)
- Site Description
- Product name
- Pounds of product used
- Chemical name
- Pounds of chemical used

The data tables were organized into a systematic file structure. File folders were organized by chemical category, then by year of application. The table names were based on year and chemical name.

Data downloaded from CalPIP was not “GIS ready”. Several pre-processing steps needed to be performed in order to make the data usable. First, the table headers needed to be edited to conform to standards used in ArcMap. There were also cases of records missing the COMTRS identifier. These incomplete records were not usable and needed to be eliminated from the project dataset. In addition, these records could indicate multiple pesticide applications on the same date within the one square mile COMTRS region. For GIS purposes, the date and the COMTRS location represent a unique identifier and needed to be consolidated into one record. Finally, sub-tables organized by application date needed to be created in excel spread sheets.

Then, to utilize the COMTRS addresses within the Esri ArcGIS framework, a customized COMTRS spatial data layer was created for the entire State of California (“COMTRS_CA.shp”). This layer served as a base map for georeferencing the toxics data from the CalPIP database. To solve the problem of redundant COMTRS addresses along county borders, the township range sections were split along these lines. This was followed by assigning each half its own unique COMTRS and recalculating the geometry to factor in changes in area and perimeter. Since pesticide use is reported by county and then PLSS sections, this method used for determining COMTRS areas would prove slightly more accurate along county borders than simply using the entire PLSS section. The original data sources used to create this layer were obtained from the U.S. National Atlas Public Land Survey provided by Esri. Any pre-processed CalPIP data table can be joined to the COMTRS_CA shapefile using the COMTRS field.

The completed GIS compatible dataset specific to California’s section of the Klamath Basin, formatted to Microsoft Excel workbooks is available to the public upon request (contact sfluharty@yuroktribe.nsn.us). Each workbook represents data for a specific chemical for a specific year. The workbooks consist of multiple sheets organized by application date. These sheets can be joined to a shapefile to create GIS layers for chemical application by date. An example of this data use is the generation of the map poster illustrating pesticide use within the Klamath River Basin, Figure 3.

For this cumulative risk assessment, it provides a broad (by section) record of those registered chemicals covered in FIFRA and represents possible exposures to the Tribal Membership. Its utility is in visually representing discrete chemical applications across the Yurok Ancestral Territory and the Klamath watershed by year and allowing the aggregation of data over multiple years. The resulting information helped to inform the target toxins chosen for analysis in the water and tissue sampling for this project.

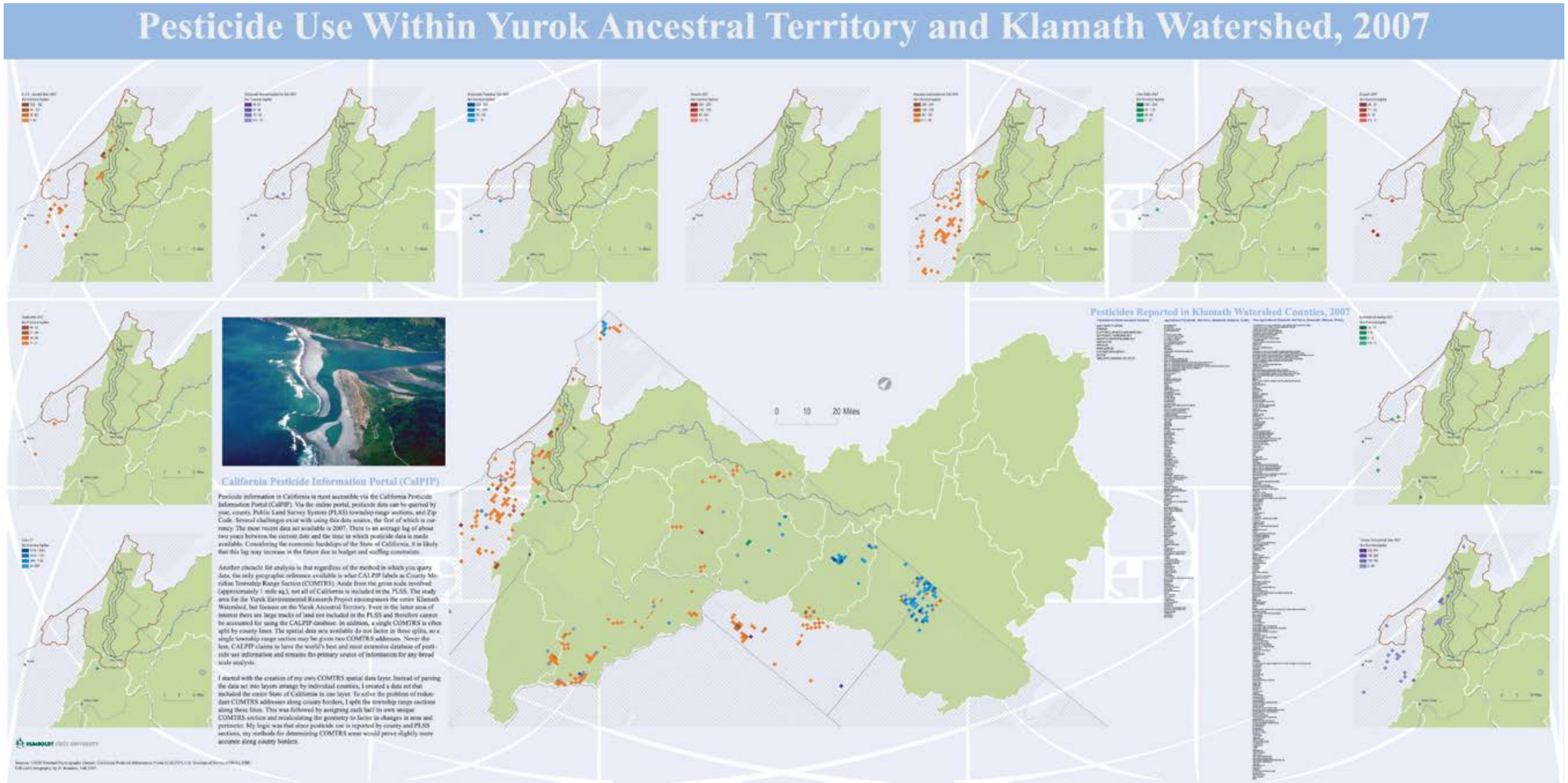


Figure 3: Poster of Pesticide Use within Klamath River Watershed

2.3 Public Participation GIS (PPGIS)

In order to conduct Public Participation GIS (PPGIS) sessions with Yurok Tribal Members, a detailed base map needed to be constructed that contained landmarks that would be recognizable to most Tribal members. The region of interest was defined by Yurok Ancestral Territory and historic subsistence use along the coast and in the Klamath River Basin. Included were portions of northern Humboldt County, Southern Del Norte County, and small portions of western Siskiyou and Trinity Counties.

Due to tribal member concerns about disclosing specific locations of traditional resource use areas, base maps were utilized only to identify change in resource abundance and access to harvesting locations in the lifetime of the participants. Detailed information on specific harvesting locations was not requested or collected in PPGIS sessions.

A PPGIS session was conducted in December 2010 with members of the Yurok Tribe Natural Resources Committee. The results of this activity were a series of maps, each containing responses from participants in color-coded categories representing the 10 targeted species to be sampled in this project. Later at HSU’s Institute for Spatial Analysis Lab, each map was digitized and georeferenced using reference markers integrated into the map design. The color-coded responses were then isolated from the remaining map elements. The result of this process was the creation of a series of approximately 40 intermediate raster files. These intermediate files with isolated responses were overlaid with the original georeferenced scans and used to generate shapefiles of polygons based on the PPGIS responses.

In August 2011, another PPGIS session was conducted at the 2011 Annual Salmon Festival. Participants consisted of festival attendees who worked with the maps and color markers to locate current and past resource use. The results of this activity were a series of 8 maps, each containing 10 color-coded categories of responses from participants. These 8 maps were also scanned and underwent the same process of digitization, color isolation, and georeferencing.

The final result is a series of 35 shapefiles based on Tribal member delineations during these sessions. These were then used in the project to cross reference and verify the comparability of Tribal member resource procurement areas and this project’s field sampling schema. In total, 27 sampling locations were identified for the project’s field sampling to represent harvesting areas within Yurok Ancestral Territory at locations heavily relied upon by Yurok Tribal Members.

2.4 Tribal Member Health Data

The purpose of collecting data on tribal health, occurrences, and rates of specific adverse health outcomes was an attempt to address Tribal Member concerns about the relationship between tribal health, environmental health, and contaminants in specific subsistence resources important to Yurok people and culture. A specific focus of the study was on endocrine disrupting chemicals. Following this project's research goal, initial questions about environmental contaminants from the Tribal membership drove the research priorities. A brief overview of the review process is offered here; however, a complete methodology of data handling is available in the Yurok Community Health Profile report found in Appendix B and the project's QAPP.

Tribal Member health data was conceptualized as representing community wide, chronic low level toxic exposures among the general Tribal Membership and no individually identifiable health data on specific tribal members was utilized. It was of primary legal and ethical importance throughout this project that all data gathering, storage, and analysis follow acceptable procedures for the protection of Tribal Member confidentiality. In order to insure this as well as for their expertise, the California Rural Indian Health Board (CRIHB) and the associated California Tribal Epidemiology Center (CTEC) was subcontracted to complete a Yurok Community Health Profile regarding specific health outcomes associated with exposures to this project's target group of environmental toxins and contaminants. CTEC received approval from its Board of Directors, the CRIHB Institutional Review Board (IRB), the Yurok Tribal Council, and the United Indian Health Services for the release of Yurok Tribal Members' patient data and agreements were contingent upon strict procedural requirements.

YTEP and CTEC staff established a health data analysis work group to consider the project goals, limitations, and most feasible and appropriate research design and analysis techniques for investigation of Tribal Members' health data. The final methodology can be found in the Appendix B: Yurok Tribe Environmental Community Health Profile. Consideration of the crucial requirement that 1) data be Yurok specific and 2) adhere to professional standards to protect patient confidentiality were priority decision points. Only those health records that could meet both requirements were utilized. Table 4 offers the decision tree regarding the utility and availability of health data sets and the reasons in choosing UIHS electronic records.

A cross listing of diseases and adverse health outcomes associated with the selected contaminants/toxins (pesticides and endocrine disrupting chemicals) known to be used within the Klamath Basin was compiled for initial analysis. Table 5 that was compiled using the US EPA's *Recognition and Management of Pesticide Poisonings* (1999) and the Agency for Toxic Substance and Disease Registry's (ATSDR) online *Toxicological Profiles* as principal reference sources. Using the adverse health outcomes associated with the project's contaminants of concern, CTEC was able to establish over 90 individual health outcomes for analysis. Then, upon review of the *International*

Table 4: Review of Health Record Sources

Data Source	Description	Protected Health Information	Yurok Tribal Member-Specific	Limitations
Census 2000	National	No	No	Not Yurok tribal-specific; not diagnosis specific; can go down to the county, block group or census tract level; all AIAN in area
California Health Interview Survey (CHIS)	Survey of California Residents every 2 years	No	No	Not Yurok tribal-specific; not diagnosis specific; telephone survey; data only to county level for people who mention AIAN for race; most respondents are Urban
GPRA: UIHS (aggregated)	Government performance measures	No	No	Not Yurok tribal-specific. Limited diagnosis data, only to county level for people who have visited a UIHS clinic at least once in the past 3 years; not temporal specific.
Tribal Enrollment	For Linkage Study purposes	No	Yes	Residence by zip code reported at time of enrollment or updated for Tribal elections; not linked to residence at time of diagnosis
Hospitalization Records	For Linkage Study purposes	Yes	No	High time/cost; approval from IHS/IRB is questionable; no IHS hospitals in California
Death Records	For Linkage Study purposes	Yes	No	High time/cost; approval from IHS/IRB is questionable: racial identification often misapplied/ missing
Birth Records	For Linkage Study purposes	No	Yes	High time/cost; approval from IHS/IRB is questionable
Clinic Records	NexGen database coded to diagnosis codes	**Yes**	**Yes**	Multiple, early local electronic record keeping incompatible with each other and National standardized system initiated in 2008

Statistical Classification of Diseases and Related Health Problems Codes, 9th edition (ICD-9 codes), a final list of 875 diagnosis codes was submitted to the United Indian Health Service (UIHS) to be searched for within Yurok Tribal Member health records. Next, health records were examined by diagnosis codes for the prevalence of those adverse health outcomes targeted above for those enrolled Yurok Members who utilized the local UIHS clinics between the years of 2005 and 2010. Additionally, to maintain patient confidentiality, only those diagnoses with 20 or more individual cases were reported.

Finally, as an additional analysis tool for assessing links between the health results and possible contaminant/toxins, common mechanism groups (CMG) were considered (Table 6). A common mechanism group consists of chemicals or other substances for which scientifically reliable data demonstrate that the same organ or tissue is targeted resulting in a common toxic effect. In this tribal risk assessment, the exposure to common mechanism groups is represented by a community wide common exposure pathway; the Yurok lifeway, the aggregate of traditional subsistence foods and both cultural and ceremonial activities as shown in the Yurok Potential Exposure Scenario Charts.

Table 5: Environmental Toxin and Associated Adverse Health Outcomes

Toxins	Associated Health Impacts
Biotoxins	Hepatotoxicity
Dioxins/ Furans	Cancers of breast, testes, prostate, & thyroid; endocrine system disruption, insulin resistance obesity & type II diabetes; attention deficiencies
Organochlorine Pesticides	Liver tumors; pancreatic, breast, testes, prostate, & thyroid cancers; immune disruption & associated non-Hodgkin lymphoma; insulin resistance obesity & type II diabetes; attention deficiencies
Organophosphate Pesticides	Parkinson's disease; reduced levels of testosterone
Phenols PCP & TCP's	Thyroid cancers; endocrine system disruption with associated insulin resistance obesity & type II diabetes
Polybrominated diphenyl ethers/ PBDE	Cancers of breast, testes, prostate & thyroid; endocrine system disruption with associated insulin resistance obesity & type II diabetes
Polychlorinated biphenyls/ PCB	Breast, testes, prostate, thyroid, liver, renal & biliary tract cancers; endocrine disruption; insulin resistance obesity & type II diabetes
Polycyclic aromatic hydrocarbons/ PAH	Lung, skin, and bladder cancers
Trace mineral elements	Most become carcinogens; gastrointestinal tract distress and cancers; adverse reproductive effects; birth defects; possible mutagens, teratogens
Triazines	Developmental & reproductive effects; breast & ovarian cancers
Other General Health Impacts of Environmental Toxins	
Muscle weakness, nausea, vomiting, diarrhea, dizziness, seizures, headache, loss of consciousness	

CMGs offer a method for examining aggregate and potentially cumulative impacts and although they are usually grouped by their toxicological constituents and chemical structure and activity, for this project their target organ was utilized. In this way, for example, it can be seen that the pancreas has aggregate impacts from dioxins, PBDEs, organochlorines, and PCBs, all of which were detected in Yurok subsistence foods at low levels. This supports the concept that dosage calculations in assessments should aggregate the risk of contaminant levels in an additive methodology. Table 6, can also be used to help further visualize where multiple organs may have adverse health outcomes and system-wide impacts. References included: Anderson's 2009 Final Report: Endocrine Disrupting Chemicals and Thyroid Outcomes; Reigart and Roberts'1999 Recognition and Management of Pesticide Poisonings; US EPA's Ecological Toxicity Information webpages, Pesticides: Health and Safety/ Common Mechanism Groups webpages, Cumulative Exposure and Risk Assessment webpages; and their Health Effects Assessment Summary Tables (HEAST).

Table 6: Common Mechanism Groups by Target Organ

SYSTEM	TARGET	DETECTED TOXINS	CRITICAL EFFECT	YUROK INCIDENCE
DIGESTIVE	Gastro-intestinal	Cadmium/Cd	Very high levels severely irritates stomach, leads to vomiting & diarrhea	unknown
		Chromium/Cr	Damage to the stomach or intestines	unknown
		Copper/Cu	Irritation, nausea, vomiting, and diarrhea	unknown
		Domoic Acid	Nausea, vomiting, diarrhea.	unknown
		Manganese/Mn	Irritation	unknown
		Mercury	Damage	unknown
	Liver	Dioxins/Furans	Tumors	YES
		Organochlorines	Toxicity; lessions, tumors; Hypertrophy and increased weight	YES
		PAH	Hepatotoxicity; Weight Changes	unknown
		Microcystins	Hepatotoxicity & associated vomiting, diarrhea, abdominal pain, malaise	unknown
ENDOCRINE	Pancreas	Dioxins/Furans	Insulin resistance, obesity and type II diabetes	YES
		Organochlorines	Insulin resistance, obesity and type II diabetes	YES
		PBDE	Insulin resistance, obesity and type II diabetes	YES
		PCB	Insulin resistance, obesity and type II diabetes	YES
	Prostate	Dioxins/Furans	Cancers	YES
		Organochlorines	Cancers	YES
		PBDE	Cancers	YES
		PCB	Cancers	YES
IMMUNE	Immune	Organochlorines	Immune disruption and associated non-Hodgkin lymphoma	YES
INTEGUMENTARY	Skin	Organochlorines	Carcinoma	YES
		Silver	Argyria	unknown
		Arsenic/As	Lesions and cancers; Keratosis, Hyperpigmentation	YES
		Dioxins/Furans	Damage	YES
		Microcystins	Rash	unknown
		PAH	Cancers	YES
		PCB	Serious and disfiguring dermatitis	unknown
NERVOUS	Central Nervous	Domoic Acid	Headache, short-term memory loss, seizures, coma	unknown
		Organochlorines	Convulsions	unknown
	Nerves	Arsenic/As	Neuropathy	YES
		Dioxins/Furans	Neurological impairments in infants	unknown
		Manganese/Mn	Neurotoxicant	unknown
		Mercury	Neurotoxicity; reduced peripheral vision, nerve sensitivity; weakness	unknown
		Microcystins	Muscle fasciculations, abdominal breathing, convulsions, death	unknown
		Organochlorines	Neurotoxicity; hyperexcitability of brain, tremors, seizures, & convulsions	unknown
CIRCULATORY	Blood	Aluminum/Al	Problems	unknown
		Arsenic/As	Anemia and fatigue	unknown
		Chromium/Cr	Anemia and fatigue	unknown
		PAH	Hematological changes in blood; decreased erythrocyte counts	unknown
		Zinc	Decreased Blood Enzymes	unknown
RESPIRATORY	Lungs	Arsenic/As	Tumors	unknown
		Cadmium/Cd	Damages lungs	unknown
		Chromium/Cr	Lung Tumors	unknown
		Dioxins/Furans	Tumors	unknown
		Organochlorines	Cancers	YES
		PAH	Cancers	YES
REPRODUCTIVE	Breast	Dioxins/Furans	Cancers	YES
		Organochlorines	Cancers	YES
		PBDE	Cancers	YES
		PCB	Cancers	YES
	Fetus	Manganese/Mn	Delayed testicular & neuro development, low birth weights	YES
		Mercury	Impaired neurological development	YES
		PAH	Spontaneous abortion, fetal malformation or infant anomaly	YES
		PBDE	Impairs development	YES
	System	Manganese/Mn	Male reproductive dysfunction	unknown
		Chromium/Cr	Reproductive toxicity, male and female	unknown
URINARY	Bladder	PAH	Cancers	YES
	Kidneys/ Renal	Cadmium/Cd	Significant proteinuria leading to kidney disease and damage	YES
		Mercury	Damage	YES
		Organochlorines	Toxicity	YES
		PAH	Nephropathy	YES

These were then evaluated to determine the prevalence of health problems, if any, that were present in both the Yurok Community Health Profile results and the adverse health outcomes associated with the detected toxins. The intersections of toxin groups and health outcomes were then identified as potential contributors to the Yurok documented negative health outcomes (Table 7).

Table 7: Number of Yurok Diagnosed Adverse Health Outcomes Associated with Detected Environmental Contaminants, 2005-2010

HEALTH IMPACT	NUMBER
Bladder Cancer	Present
Breast Cancer	Present
Cancer	**90**
Cholesterol disorders	452
Chronic kidney disease	59
Coronary atherosclerosis	39
Diabetes	**259**
Diabetes (uncontrolled type 2)	98
Fetal malformation or infant anomaly	**24**
Gastrointestinal Tract Cancer	Present
Hypertension	504
Hypothyroidism	82
Liver Cancer	Present
Lung Cancer	Present
Morbid obesity	65
Nephropathy/kidney disease	47
Neuropathy/eye disease	29
Non-Hodgkin Lymphoma	Present
Obesity	335
Ovarian Cancer	Present
Pancreatic Cancer	Present
Parkinson’s Disease	Present
Pre-diabetes	205
Prostate Cancer	Present
Proteinuria	**64**
Reduced Levels of Testosterone	Present
Renal Cancer	Present
Skin Cancer	27
Spontaneous abortion	**27**
Stroke or cerebrovascular accident	20

*Red represents those outcomes with the potential of being above national occurrence rates

In this project's review of health records, the sample population and temporal association for analysis was defined as those Yurok Tribal Members who have utilized services at UIHS clinics in Del Norte and Humboldt Counties at least once since 2004, when the clinic started utilizing standardized electronic health records through the data pull in 2010. The project gives a complete, accurate, comprehensive, and representational snap shot of the local Yurok Tribal Members' health during a single 5 year window.

No testing for significant clusters of individual health or cancer types was possible due to the data use restriction of limited reporting on groupings of 20 or fewer diagnoses and due to uncertainty concerning the inherent incomparability and skew between UIHS data and national data sources. National data are usually collected through surveys completed by a sample of the population, whereas UIHS data is for those that visited the clinics and can be presumed to have been feeling ill, and therefore more likely to have higher adverse health outcomes. Reported rates are approximate yearly averages, calculated by dividing the total number of each new disease diagnosis of individual Yurok people who visited the UIHS clinic during 2005 to 2010, by five to represent the number of years covered by the span of data collection. These rates were then compared to comparable national disease rates per 100,000 people. A comprehensive review of methodology is reported in Yurok Tribe Community Health Profile, found in Appendix B.

In total, 2,677 Yurok enrolled members were reported in the UIHS data and self-reported living in Humboldt and Del Norte Counties. Tribal enrollment records list 2,733 Yurok living in Humboldt and Del Norte Counties as of 2012. While no direct link between place of contaminant exposure and occupancy due to patient confidentiality can be made and allowing that these are not the identical members due to births,

deaths, and movement of households into and out of the area, this project represents 98% of the bi-county, Yurok population and would seem to accurately characterize the Yurok Tribal Members who reside locally and indicate that Tribal members are potentially being impacted by four health outcomes that have indications of being above national rates.

1. Overall cancer rate was greater than three times the national rate for other American Indians/ Alaskan Natives (AIAN) and 40% greater than the rate for all races combined.

2. Diabetes rates were comparable to other AIAN national rates that are approximately 3 times the general population.

3. Proteinuria, often a precursor of chronic kidney disease, was found at rates over double the national average.

4. Perinatal outcomes of spontaneous abortion and fetal malformation were great enough to be of concern to the epidemiological research staff but there is no consensus in the perinatal field as to when spontaneous abortion, miscarriage, or stillbirth should be used for diagnosis coding. This makes comparisons with National data impossible.

Although no causal or epidemiological links between known contaminants and the health outcomes of the Yurok Tribal Members can be definitively established within the scope of this project, the rates of these documented adverse diagnoses demonstrate the need for further studies of local Yurok Tribal members' health, links to local environmental contaminants, and a potentially disparate burden of disease and ill health within the Yurok Community living in Del Norte and Humboldt Counties.

3.0 HAZARD IDENTIFICATION/ CONTAMINANTS OF CONCERN

This section offers a descriptive review of potential chemical/toxin contaminants that may cause hazards to humans in the project's research area. These, in addition to any burden carried by the aquatic subsistence resources that underwent tissue analysis within the scope of this project, add to the cumulative impacts to Tribal Members from other exposure routes than ingestion.

3.1 Environmental Site Background

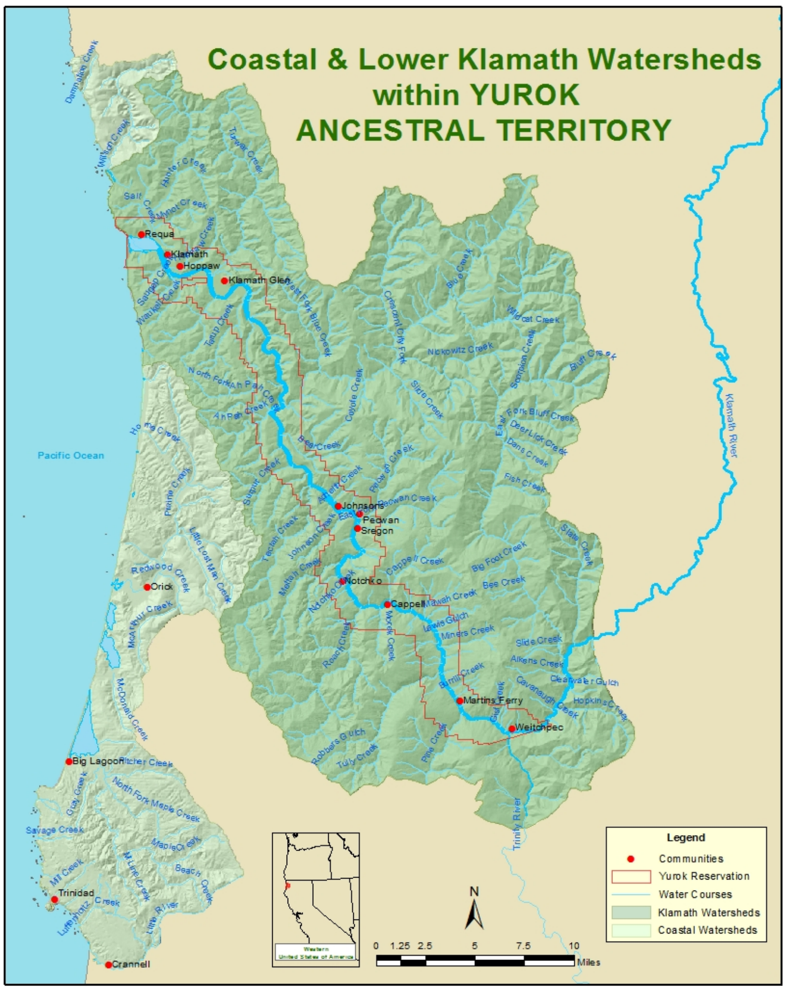


Figure 4: Map of Coastal and Lower Klamath Watersheds in Yurok Ancestral Territory

Yurok Ancestral Territory is dominated by the Klamath River, the second largest river in California that flows through southeastern Oregon and northern California. The Klamath River originates in the high desert of the Cascade Mountain Range flowing for approximately 263 miles to its confluence at the Pacific Ocean. The Yurok Reservation extends one mile on each side of the River and follows the channel of the Lower Klamath River from its mouth at the Pacific Ocean, upriver for approximately 46 river miles. Including the River, the Reservation spans over 90 square miles or 56,000 acres of land; however, the larger Yurok Ancestral Territory comprises nearly a half million acres. Yurok Ancestral Territory not only contains the Lower Klamath watershed comprised of many tributaries but also approximately 60 miles of Pacific Ocean coastline consisting of additional creeks, lagoons and coastal areas. (See Figures 4 and 5.)

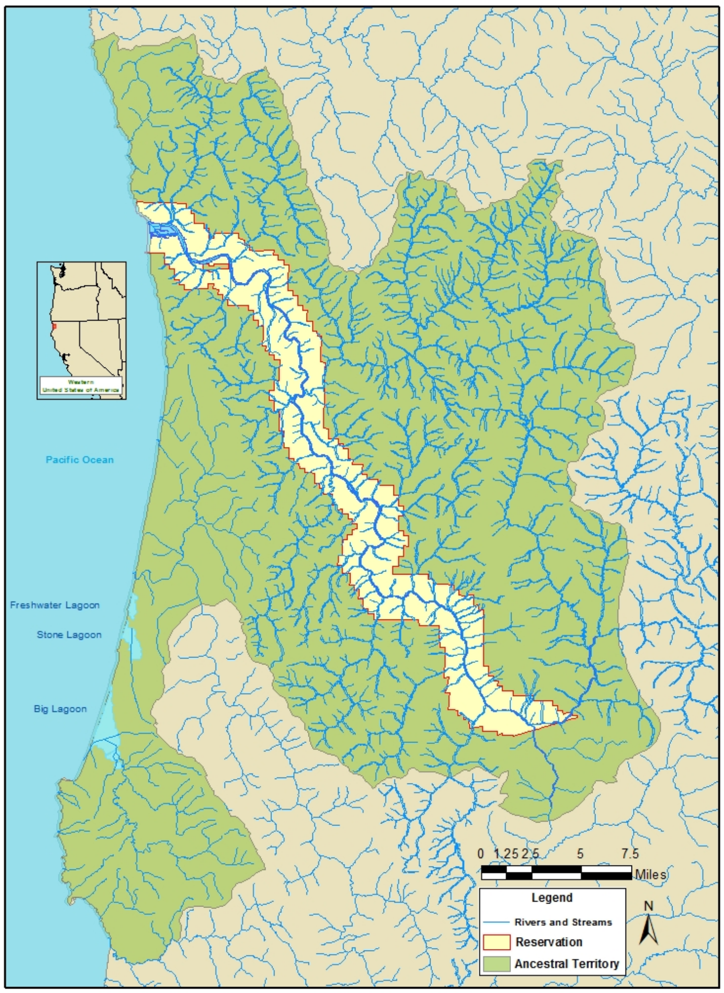


Figure 5: Map of Streams and Rivers in Yurok Ancestral Territory

The Klamath River cuts through four distinct geologic provinces and three mountain ranges. The basin is comprised of over 10,000 square miles and incorporates a diverse range of habitats beginning in the high desert Modoc Plateau (Gannett 2010), shifting through grass and farmland, then cutting through forested canyons in the Klamath Mountains, and ending in the rainforest of the Pacific Coast Range.

The river’s channel cuts through in a generally south-west direction until it encounters a layer of easily eroded mica near the confluence of the Trinity River. The Klamath River enters the Yurok Indian Reservation near the confluence and makes a sharp northward bend following softer deposits and cutting toward the ocean (Covington 2004; Irwin, et al. 2006).

This has in effect created a steep-walled gorge that is typically between 650 and 800 feet wide that acts as a tail-pipe for the larger Klamath Basin, bringing down high sediment yields (Federal Energy Regulatory Commission 2007) with inputs collected from the upper basin and mid-Klamath. Approximately 10 miles within the Reservation boundaries at Cappell Flats (RM 35), the river broadens slightly at several large bends where the channel width increases up to 1,600 feet and gradually widens into a narrow valley as it moves downstream.

Figure 6: Klamath River Looking 'Down-river' or Westward towards the Pacific Ocean

For the next 28 miles, numerous tributaries contribute sediments and create a series of split flow channels, mid-channel sand/ gravel bars, and riffles at their confluences with the main stem river along with several large pools that slow the river flow until the lower seven miles. Then for four miles it is constricted again into a fairly narrow river channel with relatively steep gradient between banks of hard bedrock and is classified as a "Confined River System." The river’s fresh water flow meets the salt water wedge at the eastern estuary boundary at approximately river mile three. There for the last miles the river becomes a highly dynamic, shallow estuary that is dominated by a large barrier sandbar across its mouth that shifts during seasonal flow changes and large flood events (DOI 2011).

Yurok Ancestral Territory spans approximately 60 miles along the Pacific Coast and inland an estimated 46 miles. The geography varies from littoral beaches and coastal lagoons and uplifted marine terraces dominated by coastal spruce and redwood rain forest of the coastal range inland across northwest-trending mountain ranges, ridges, and intervening valleys dominated by more arid conditions, high elevation prairies, douglas fir and oak-madrone forests.

The local geology is characterized by highly mineralized volcanic deposits from the formation of the Cascades and Klamath Mountains, uplifted inclusions from the shifting tectonic plates, and the Coast Range of exposed oceanic terraces of sedimentary rock overlain with granite and basalt (Irwin, et. al 2006). Bedrock is primarily composed of varying percentages of schist and meta-sedimentary rocks of shale, chert, greenstone, serpentine, greywacke, and blueschist (Jayko and Blake 1987). The U.S. Geological Survey Professional Paper 1648 (Gustavsson, et. al. 2001) maps the broad dispersion patterns for 22 major and trace elements in order to delineate geochemical provinces of mineral resources. Figures 7, 8 and 9 have been taken from their work and cropped to show the background mineral concentrations in the region of northern California and southern Oregon demonstrating the high mineral content of the local bedrock and soils, and the probable high mineral impact on the surface water, run-off, and the sediments it carries. These maps are drawn with a 20 color scale ranging from cyan (blue) representing the lowest 10 percent concentrations of the element in background soils as compared to the United States' range for the element, to magenta to represent the highest 1 percent of values. Of those 22 elements that are mapped, more than half have values in the highest concentration range and an additional four have a pattern within the median ranges with inclusions of higher concentrations (Figure 7). Figures 8 and 9 shows low concentration minerals.

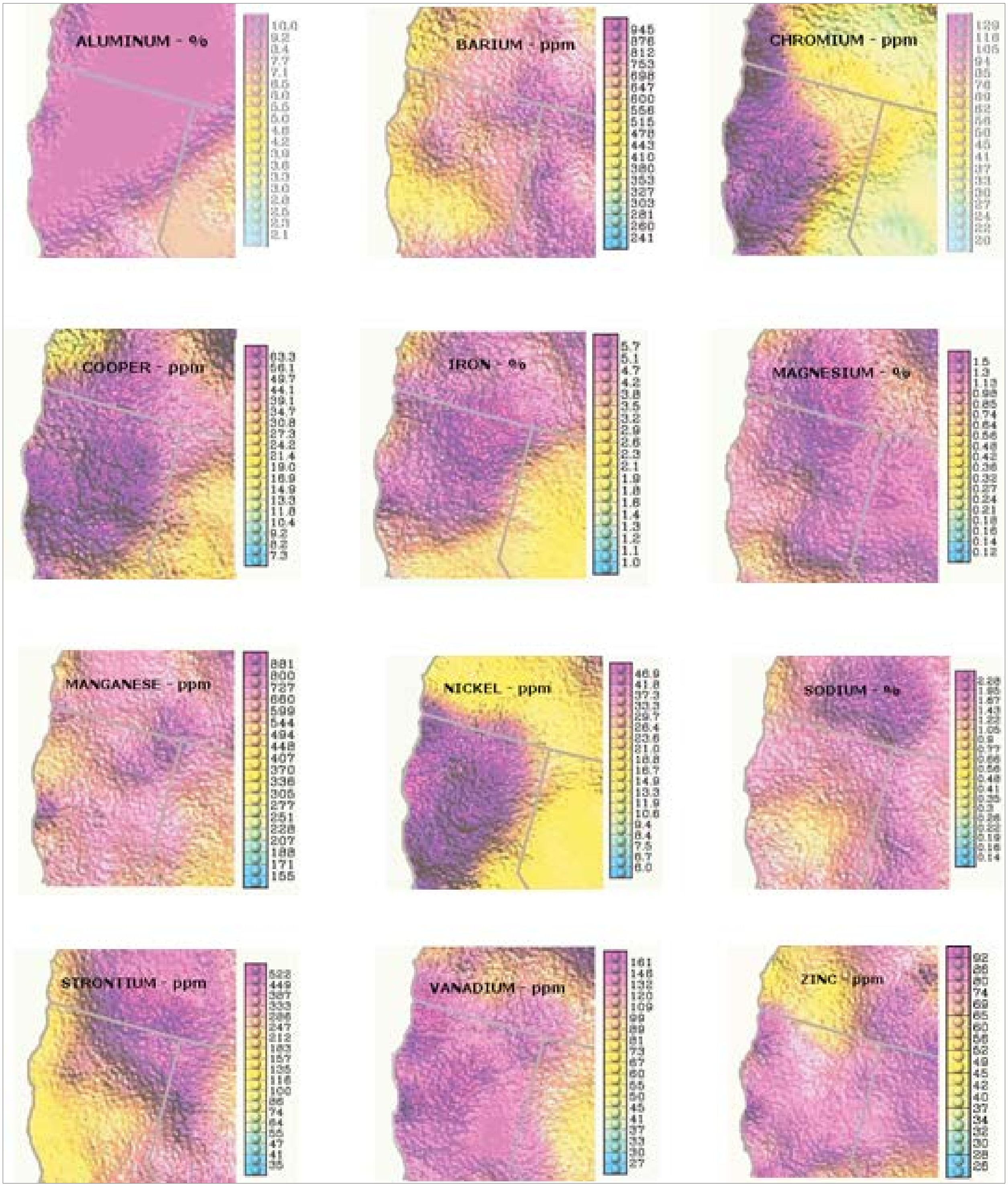


Figure 7: Elements with High to Medium-High Concentrations within the Klamath Basin

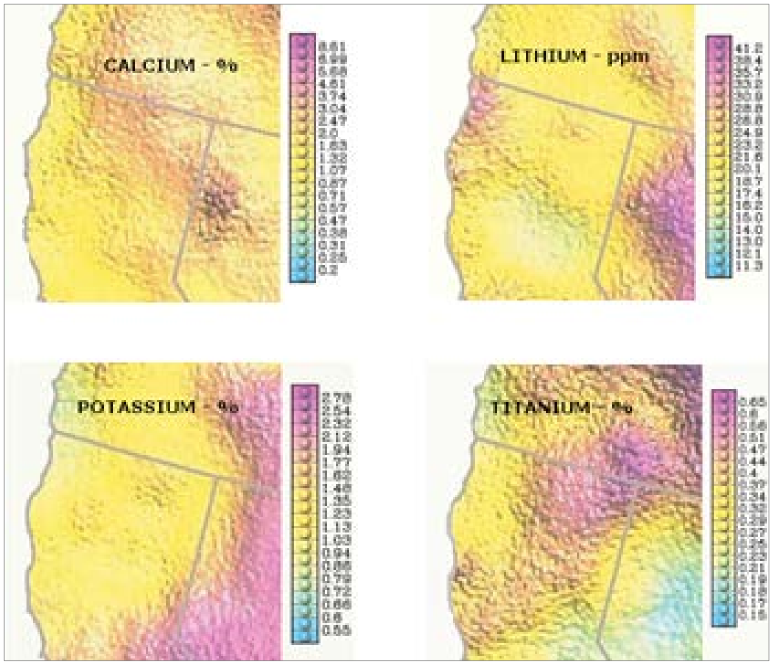


Figure 8: Elements with a Distribution Pattern of Median Concentrations with Inclusions of Higher Levels within the Klamath Basin

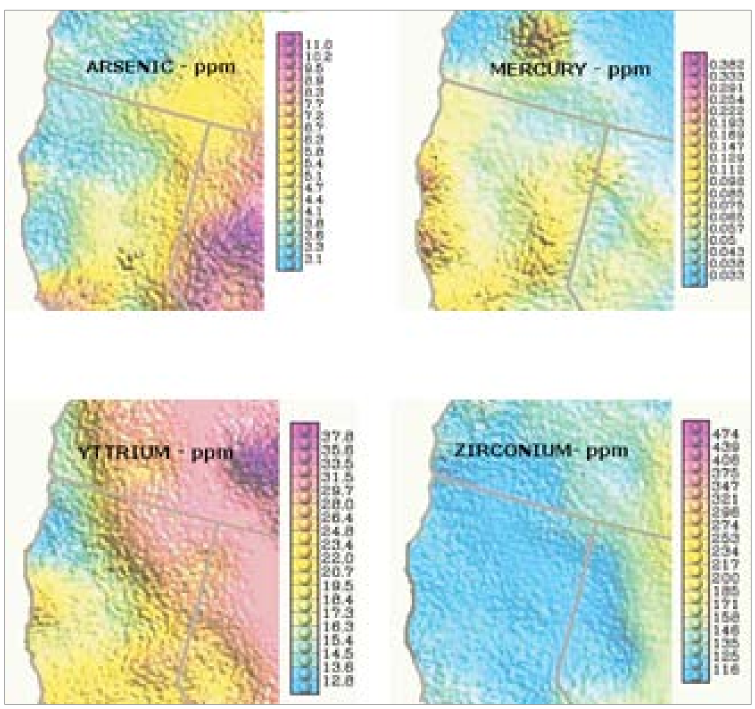


Figure 9: Elements within the Klamath Basin with Generally Low Concentrations

Overall, the geologic background of the Yurok Territory, combined with the steep slope topography allows the naturally occurring high mineral content of the bedrock to be potentially eroded and transported into both ground and surface waters- many used for domestic water.

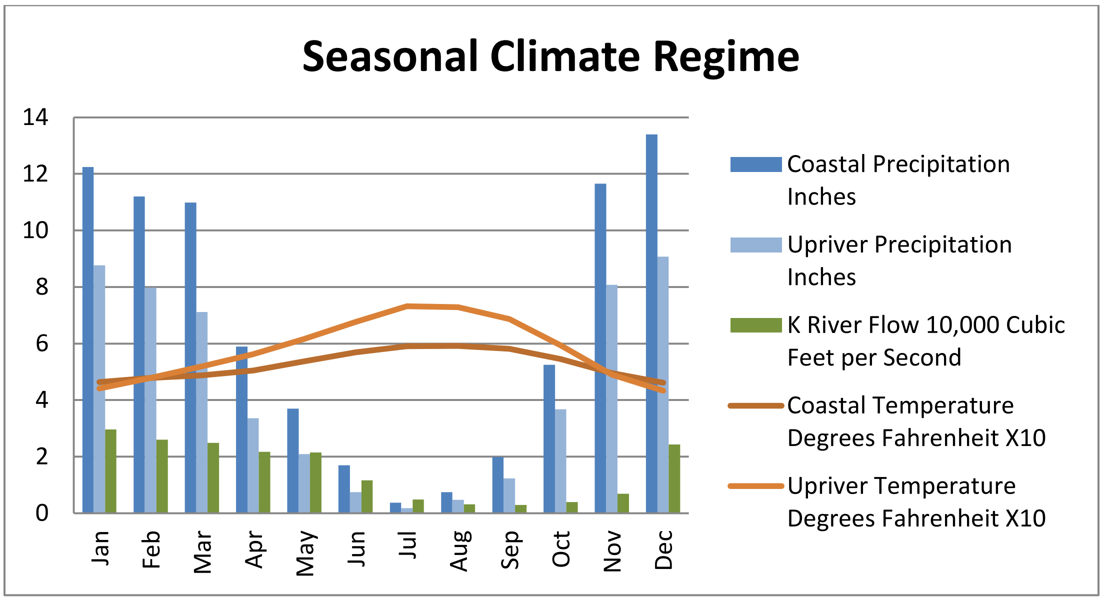
A 2003 survey of Yurok households within the Reservation identified that sources of domestic water come from both ground water and surface water (McKinnon 2003). These include nine community source water systems and over 200 private systems. Preliminary data from YTEP Source Water Assessment and Protection Program indicates that private water systems predominantly use surface water collection intakes from creeks and spring boxes upriver but also include 22 wells that are all located down river. These water sources have the potential to be highly impacted by any surface water sheet flow from contaminated sites, off the predominant steep hillsides, and most likely percolating through shallow soils. In addition, many Yurok households report utilizing multiple untreated sources including numerous traditional groundwater seeps to provide seasonal drinking water. These have lowered to flow stoppage during the dry weather months of July through October that may lead to increased toxin concentrations.

This project did not look at potential exposure to contaminants in drinking water, but given the widespread use of surface water as source water in small unregulated water systems, chronic low level exposure is probable. Of those minerals included for laboratory analysis, those with detection levels of concern during this projects sampling timeframe included fresh water mussels with 557 ppb of manganese; sturgeon skin with 20 ppb of chromium; and aluminum in the Spring flows of Klamath River water with detections peaking at 217 ppb, well above double the US EPA Aquatic Life Protection Criteria of 87ppb. It can be reasonably expected that at least some of these elements are from the region’s highly mineralized geology and climatic induced erosion.

3.2 Climate and Associated Hazards

The area is characterized as a Mediterranean climate of cool, moist winters and dry summers as shown in Chart One below. The average annual temperature of the Lower Klamath River Valley is 57° F and the 60 year historic average annual regional precipitation is 79.62 inches, which falls primarily between October and April and includes heavy fog along the coast. In the coastal region of the Yurok Ancestral Territory, snow usually only occurs in moderate amounts above the 2,000-foot elevation, however the season flow regime of the river is highly impacted by both the high precipitation rates and snow melt from the higher elevations of the Klamath Mountains and Trinity Alps. The Klamath River average yearly flow through the Reservation, based on the years 2000 through 2010 data taken at USGS Gage

11530500 is 15,102 cubic feet per second (cfs); however there is a wide range extending from a winter high flow of 29,600 cfs to a summer low of 2,880 cfs. Figure 10 below, allows a comparison of the monthly means of temperature, precipitation, and river flow and illustrates the time lag between lows in precipitation that occurs in July and August and the river flow regime lows in August and September. This occurs in part because of the buffer that melting snow pack gives and the time it takes water to flow from upper mountain tributaries, travel miles downstream, and join the main river.



Climate Data from CA Dept. of Water Resources; North Coast Hydrologic Region 2011.
River Flow Data from USGS; Surface Water for CA 11530500: Mth St; 10 yr mean; 2000-2010.

Figure 10: Yurok Ancestral Territory Seasonal Climate Regime

In general, the Yurok Reservation experiences clean air throughout the majority of the year due to limited industrial releases and because regulated parameters (acetaldehyde, acrolein, arsenic, benzene, butadiene, chromium, diesel PM, formaldehyde, lead, naphthalene and PAH) all fall below the national averages as shown in Table 8. However, a principal threat to air quality exists in emissions from burning. The YIR is located within a California State designated North Coast Air Basin and the North Coast Unified Air Quality Management District (NCUAQMD), comprised of Humboldt, Del Norte and Trinity counties. The downriver, Klamath area of the Reservation is bordered by Redwood National Park, a mandated Class I Airshed. The North Coast has attained all ambient air quality standards except for particulate matter (PM) with a size of 10 microns in diameter or smaller (PM10 and PM2.5), principally resulting from wildfires in the forested regions. The entire North Coast Air Basin is currently designated as nonattainment for the State 24-hour PM10 standard.

According to the NCUAQMD, particulate matter is fine mineral, metal, soot, smoke and dust particles suspended in the air and can permanently lodge in the deepest, most sensitive areas of the lungs, causing respiratory and other health problems. Primary sources of particulate matter in the area are:

- on-road and off-road vehicles (engine exhaust and dust from paved and unpaved roads),
- open burning of vegetation (including residential, prescribed burning by both the US Forest Service and National and State Parks, cultural burning, and commercial forestry slash burns),
- wildfire,
- residential wood stoves, and
- stationary industrial sources (since 1999, the Resighini Rancheria has owned and operated a gravel mining facility; the only stationary major source of air pollution located within the YIR).

The upriver reservation is surrounded by heavily wooded, steep mountainous river canyons that create exceedingly confined micro-climates that can cause drastic variation in smoke exposures across the larger landscape. PM10 and PM2.5 concentration levels from these burns can often be localized due to the mountainous terrain and not detected by monitors in the larger surrounding communities of Eureka, Hoopa and Crescent City. To address this, the YTEP Air Quality Monitoring Program measures ambient air quality conditions, in order to assess impairments within the localized, Reservation airshed. This allows YTEP to issue health hazard warnings to local community and Tribal members.

The dry summer regime and mountain forests regularly create high risks of wildland fire and their emission releases from smoke may pose the greatest acute threat to human health along the Klamath valley. For example, during the summer of 1999, the Megram fire produced 9 days where the PM_{10} standard was exceeded with five of those days above 420 $\mu g/m^3$, which is considered a hazardous level. The maximum 24-hour average was 720 $\mu g/m^3$ with spikes going above 1000 $\mu g/m^3$. The surrounding areas were placed under a voluntary evacuation order for a 10-day period. Since 1999, there have been a number of other severe wildfire events that have impacted portions of the YIR (e.g. Biscuit Fire in So. Oregon inundated the community of Klamath).

Not only are single, large fires a problem but in late June of 2008, a large lightning storm passed through Northern California and started over 1,000 wildfires within 50 miles of the Yurok Indian Reservation. Only a few of these fires grew to over 100,000 acres, yet they contributed significant amounts of wildfire smoke thoughout the months of late June, all of July, August and most of September 2008. Due to the extended exposure to sometimes hazardous levels of wildfire smoke, visits to the local medical clinic increased and normally healthy people experienced acute health problems. Because of the sometimes hazardous and prolonged amounts of smoke, the Yurok Tribal Council declared a state of emergency from a public health threat caused by nearby wildfires on July 12, 2008.

Table 8: Yurok Tribal communities' Air Quality Data

OUTDOOR AIR DATA METRICS Downloaded January 25, 2012 from: Community Data Table <http://cfpub.epa.gov/tferst/Prioritize.cfm>	Klamath Community 95548	Hoopa Community 95546	National Average
Environmental Concentration Estimates (µg/m³)			
Outdoor Air - Acetaldehyde	1.3	1.4	1.9
Outdoor Air - Acrolein²	0.02	0.02	0.05
Outdoor Air - Arsenic	0.0002	0.0001	0.0006
Outdoor Air - Benzene	0.4	0.4	1.06
Outdoor Air - Butadiene	0.03	0.03	0.07
Outdoor Air - Chromium	0.00008	0.00008	0.0009
Outdoor Air - Diesel PM	0.05	0.04	0.9
Outdoor Air - Formaldehyde	1.2	1.3	2.09
Outdoor Air - Lead, Natl standard 1.5 µg/m³ (Quarterly Avg)	0.0008	0.0006	0.002
Outdoor Air - Naphthalene	0.004	0.003	0.07
Outdoor Air - PAH	0.0009	0.0004	0.02
Human Exposure Estimates (µg/m³)			
Outdoor Air - Acetaldehyde	1.06	1.1	1.5
Outdoor Air - Acrolein²	0.01	0.01	0.03
Outdoor Air - Arsenic	0.0001	0.0001	0.0003
Outdoor Air - Benzene	0.3	0.3	0.9
Outdoor Air - Butadiene	0.01	0.02	0.06
Outdoor Air - Chromium	0.00008	0.00007	0.0008
Outdoor Air - Diesel PM	0.04	0.03	0.5
Outdoor Air - Formaldehyde	1.001	1.004	1.7
Outdoor Air - Lead	0.0009	0.0005	0.001
Outdoor Air - Naphthalene	0.006	0.003	0.07
Outdoor Air - PAH	0.0008	0.0004	0.01
Health Risk Estimates (in One Million)			
Cumulative Air Toxics Cancer Risk	23.3	23.3	49.8
Cumulative Air Toxics Non-Cancer Respiratory Risk (Hazard Quotient)	0.8	0.8	2.3
Cumulative Air Toxics Non-Cancer Neurological Risk (Hazard Quotient)	0.03	0.03	0.06
Outdoor Air - Acetaldehyde	2.3	2.4	3.3
Outdoor Air - Arsenic	0.4	0.5	1.3
Outdoor Air - Benzene	2.3	2.3	7.4
Outdoor Air - Butadiene	0.4	0.7	1.9
Outdoor Air - Chromium	0.3	0.2	1.4
Outdoor Air - Formaldehyde	13.02	13.05	22.5
Outdoor Air - Naphthalene	0.2	0.1	2.3
Outdoor Air - PAH	0.1	0.04	1.5

The tribe was able to distribute dozens of HEPA air filters to tribal members sensitive to air pollution including; the elderly, young children, pregnant women, and those with lung or heart disease. Many of the tribal members who live on the upriver portion of the Yurok Indian Reservation have no electricity and therefore lacked air conditioning or the ability to run HEPA filters. To address their needs, the Yurok Tribe with the assistance of the American Red Cross was able to open an emergency evacuation facility on the lower reservation outside of the affected upriver reservation for community members who voluntarily evacuated. In addition, the tribe also opened a fresh air facility that served as breathing respite for those in the upriver community who were not able to evacuate. Utilizing data from YTEP's EBAM station in Weitchpec--the Yurok Tribe along with neighboring tribes; the Hoopa Valley Tribe and the Karuk Tribe--were able to convince the FEMA for a Presidential Disaster Declaration for the Yurok Tribe of the Yurok Indian Reservation even though the surrounding counties of Del Norte, Humboldt, and Trinity did not have the same disaster declaration.

Listed below is Wildfire History Summary with Upriver Particulate Matter Detections from the Weitchpec E-BAM Monitor as reported in YTEP's annual air reports.

10/1/2006 to 9/30/2007

- The five highest 24-hr average readings for $PM_{2.5}$ data were: 9/28/2006 (85 µg/ m^3); 9/29/2006 (72µg/ m^3); 9/27/2006 (64µg/ m^3); 9/26/2006 (56µg/ m^3); and 8/4/2006 (42µg/ m^3).

10/1/2007 to 9/30/2008

- This particulate matter spike was caused by smoke from the\ series of very large wildfires during the summer of 2008 inundated the upper part of the Yurok Indian Reservation with sometime hazardous levels of PM 2.5 during most of July to September 2008.

10/1/2008 to 9/30/2009

- Megram fire produced hazardous levels of PM10 concentration throughout the region and surrounding areas were placed under a voluntary evacuation order for a 10-day period.
- 100,000+ acre Blue 2 and Siskiyou wildfires located within 50 miles of the upper reservation boundary; on October 14, 2008 when the PM 2.5 spiked at 146 µg/m^3.
- Backbone wildfire burned for most of July and early August 2009

10/1/2009 to 9/30/2010

- Mill Creek wildfire burned for most of October 2009.

10/1/2010 to 9/30/2011

- The Yurok Indian Reservation had good Ambient Air Quality all year long. There however was some wildfire smoke. The yearly average was 3.41 µg/m^3 which is well below the annual NAAQS of 15 µg/$m^{3.}$ No 24-hr period exceeded the NAAQS.

While particulate matter has adverse health effects associated with the physical ability of the respiratory system to deliver oxygen, the composition of the particulates and any contaminants/toxins that they might transport is unknown and is not taken into account for this project's cumulative impacts assessment. This is an area where the technologies exist to perform laboratory analysis but due to limited funding, the particulates are not currently analyzed. Anecdotal information of elderly and/ or sick Tribal Members abounds after each fire event and tell of smoke “killing” neighbors and loved ones. At the very least, these excessive particulate releases are contributing factors to at least some of the adverse health effects reported during and after the wildfires. The analysis of the composition and toxin loading of the particulate matter released during the event is an area that needs priority flagging for future research.

3.3 Community Demographics and Anthropogenic Effects

A total population of approximately 2,733 Yurok Members reside within the local area (100 miles of the Reservation) and cluster to the north of the Reservation within Crescent City in Del Norte County and southward within Humboldt County’s communities of Hoopa, Eureka, McKinleyville, Arcata, and Willow Creek (listed by Tribal Member population). 1,166 persons reside within the YIR and are divided into two distinct populated areas, described in this document in relation to the flow of the Klamath River as those ‘Downriver’ toward the mouth of the river or the Lower Reservation and those living in the Upper Reservation, or ‘Upriver’ traveling against the river current. It should also be remembered that water flow follows elevation change as it moves from the mountains (upriver) to merge with the Pacific Ocean at sea level (downriver).

The downriver Reservation area, dominated by the town of Klamath and the outlying smaller communities of Requa and Klamath Glen, is accessible by Highway 101. Commercial water, power, telephone, and solid waste collection services are generally available within the downriver Reservation. The downriver community consists of approximately 173 homes and a population of 692. It includes one school, one Solid Waste Transfer Station, one fire department, several Tribal Offices, and various commercial enterprises (restaurants, food vendors, groceries, gas stations, hotels, motels, RV parks, etc.).

The upriver Reservation consists of the town of Weitchpec and smaller communities such as Sregon, Tulley Creek and Wautec/Pecwan. These are not accessible from the downriver Reservation except by boat or overland by circuitous travel over the Bald Hills Rd which travels through the National Redwoods Park or along Highway 169, which runs parallel to the Klamath River in segments that do not connect with each other. Commercial water, power, telephone service, and solid waste collection services have limited availability to residents upriver. Upriver communities are located mainly along Highway 169, with the exception of the Tully Creek community located on the west side of the Klamath River. The upriver community consists of a population of 474, and includes several Tribal Offices, one commercial store and gas station, one Solid Waste Transfer Station, two schools, and two fire departments.

Examples of contaminants from anthropogenic activities include forestry and agriculture sites (including illegal marijuana plots) with pesticide and herbicide residues; timber and plywood mills with associated natural and industrial chemicals; fire suppression foams in wildfire zones; active and legacy mines; river impoundment for irrigation and hydro power; and high-risk areas from localized activities such as the burning of wood products waste and plastics, illegal dumping, and methamphetamine production. Emissions from residential areas primarily consist of wood stoves and open burning of yard and household wastes.

Open burning of household waste occurs primarily on the upper reservation, where access to recycling and waste disposal is limited, and poses a significant localized threat to air quality and human health. The vast majority of Reservation residents burn wood as their primary heat source. Many households' income levels are at or below the Federal poverty level and they do not own high-efficiency woodstoves. This creates a scenario where perhaps the largest minor source of particulate emissions on the YIR is from household chimney smoke with a late night trend of particulate matter emission spikes that are reflected at the Klamath Glen air monitoring station. These may be pervasive; however, they rarely exceed the 24-hour National Ambient Air Quality Standards (NAAQS) health levels set for PM10 (150 $\mu g/m^3$/24-hour period) and 35 $\mu g/m^3$ for PM2.5. For example, only once during the 2011 year were the health levels exceeded (7/29/2011 =38.5 μg/m3). An additional source of emissions is associated with Highway 101 which runs through the Reservation and creates a transportation corridor of private and commercial vehicles that produce vapor and particulate emissions from gasoline and diesel fuel. This also creates the potential for accidental fuel spills that may find their way into ground and surface waters on the Reservation.

The broader, regional impacts from anthropogenic activities include three major regions with diverse land use; 1) in the Upper Klamath Basin, crop agriculture and grazing are major industries and a series of dams impede the River and deliver agricultural related irrigation and hydropower; 2) in the mid Klamath region- silviculture and agriculture are the primary industries; and 3) in the Lower Klamath watershed, where the YIR lies, the major industries are fishing and silviculture with some limited gold mining. The majority is owned by Green Diamond Resource Company (GDRC) and managed for industrial timber harvest.

Major water contaminants in the Basin include the potential for pesticide residues, migration and transport of lumber mills' waste and ash from burning of wood including bark, chips and sawdust that are high in dioxin concentrations, agricultural nutrients, and toxins from blue green algae populations in the reservoirs behind the dams and in the Klamath River. The Klamath River in general is listed as impaired, meaning it contains pollutants at levels that exceed protective water quality criteria and standards. The United States Environmental Protection Agency (USEPA) and the North Coast Region Water Quality Control Board (NCRWQCB) registered this action in 1993. Below are the comments included on the 303(d) listing for impairment.

> The Klamath River, from source to mouth, is listed as water quality impaired (by both Oregon and California) under Section 303(d) of the Federal Clean Water Act. In 1992 the California State Water Quality Control Board (SWQCB) proposed that the Klamath River be listed for both temperature and nutrients, requiring the development of total maximum daily load (TMDL) limits and implementation plans.

The combination of stratified warm water with high nutrient loading provides ideal habitat for the toxin producing blue-green algae. Blue-green algae, and/or cyanobacteria produce a wide range of more than a hundred compounds including hepatotoxins, neurotoxins and dermatotoxins that are a growing public health and environmental concern; often harmful to both aquatic and terrestrial life (Merel, et. al 2013). Their populations can experience dynamic growth, commonly called algal blooms, in response to a combination of environmental factors such as increased light and water temperature, stagnation or low water movement, and nutrient concentrations. These conditions are most often linked to anthropogenic changes in the environment and the US EPA lists the principal impacts to the Lower Klamath River watershed to include those associated with hydromodification, agricultural grazing, silviculture, and resource extraction via dredge and placer mining.

The California Environmental Protection Agency, California State Water Resources Control Board (SWRCB), and California's Office of Environmental Health and Hazard Assessment (OEHHA) established reference doses for microcystins above which adverse health effects could occur through incidental exposure and subsequently developed scientifically based health protective “action levels” for human recreational use (Butler, et. al. 2012). Their recommendation is that levels not exceed 0.8 μg/L for Microcystins LA, LR, RR, and YR in water and that in their best judgement the public health is being ‘menaced by microcystin levels above .8 ppb’ when the recreational use scenario is utilized. The most direct and immediate impacts to human health are the are primarily toxicity to the liver, microcystins are also classified in general as tumor promoters. As such, it is often assumed that the impacts are limited to the liver and associated system. However, the research of Falconer (1991) demonstrate that, mice showed a significantly greater weight of tumors in one group given a Microcystis extract while Nishiwaki-Matsushima, et al. (1992) document that microcystin-LR is not only a liver tumor promoter but also promotes tumors in other organs, such as mouse skin, rat glandular stomach and rat liver.

Microcystins in surface water represent a growing concern for the Yurok Tribe due to the multiple sources of member exposure to the toxins. In addition to the risk from recreational exposure, Tribal Members are exposed during subsistence, cultural, ceremonial, and commercial fishing use of the river people. At these times the principal risk is from inadvertently ingesting contaminated water and possibly absorbing toxins through their skin, however; toxins that are aerosolized can be inhaled and people fishing in a contaminated area may later be exposed to additional cyanotoxins when they ingest the contaminated fish or shellfish they caught. The current state of knowledge concerning microcystins is expanding and new research is finding that concentrations of cyanobacterial secondary metabolites such as microcystins, can vary within species, between species and between locations (Chorus, ed. 2012; Lürling and Faassen 2013; Merel et al. 2013; Sivonen, and Jones 1999; Van De Waal, et al. 2009). These variations make the calculations for human dose levels used in risk assessments questionable as regulatory agencies are often behind in utilizing the most current research data.

While the levels recommended in the California 2012 Toxicological Summary are based on recreational exposure they do not fully account for Tribal members' increased exposure durations. For example, allowing that the amount or concentration of microcystins remains the same, exposure assessment estimates of how much of the chemical will be taken into the body of a person depends on the assumed exposure scenarios. The 2012 action level is based on relative dose (RfD) computations calculated on recreational exposure that is low in terms of frequency, set for occasional, short term, acute and subchronic doses. In contrast to that, tribal members generally spend a much greater time in contact with the Klamath River than the general public recreational user and so their risk from inadvertently ingesting contaminated water goes up as well as the possibility of repeated doses across time increasing their dose to a chronic level. During the commercial fishing season it is not unusual for individuals to spend 14 or more hours each day on the water with partial body immersion during net pulling.

Additionally, for the CA Toxicological Review, the assumption that microcystins tend not to penetrate the skin to any significant degree, was used to rationalize a lowered dose calculation. However, this fails to take into account the occupational hazards of commercial and subsistence fishing where the hands and arms are often injured and abraded from net pulling and handling of fish. Barrett (1969) states that chemical penetration is estimated to be 80% greater for injured, inflamed, or abraded skin surfaces as they create open channels through the epidermal barrier, thereby increasing the amount of toxic material absorbed.

Table 9 compiles data from the YTEP's standard public health monitoring and lists the weekly highs for microcystin detected in the Klamath River within the external boundaries of the YIR that exceed the recommended action levels during the years 2009-2013. Rows are highlighted by year, with red numerics representing detections in exceedance of the 0.8 µg/L level. Monitoring data also demonstrate that in each of the last five years, detections have included Klamath River reaches throughout its length, including the estuary where intensified commercial fishing is carried out.

Table 9: 2009-2013, Compiled Weekly High of Those Weeks that Microcystin Detections Exceeded Public Health Protective Action Levels

Date	Time	Location	River Mile	Sample Type	Depth (cm)	Microcystin (ug/L)
9/11/2013	11:30	WE	43.5	SG	10	9.3
9/16/2013	14:52	TG	6	SG	10	2.9
9/25/2013	11:03	WE	43.5	SG	10	2.2
8/29/2012	11:26	WE	43.7	SG	10	1
9/5/2012	12:04	WE	43.5	OC	30	8.6
9/13/2012	11:48	WE	43.5	SG	10	9.0
9/19/2012	12:00	WE	43.5	SG	10	2.1
9/25/2012	11:27	TG	6	SG	10	3.9
9/26/2012	10:08	WE	43.5	SG	10	3.5
10/3/2012	8:04	TG	6	SG	10	2.0
10/10/2012	15:13	TG	6	SG	10	7.0
9/7/2011	7:22	LES	0.5	OC	30	1.6
9/13/2011	14:31	TG	6	SG	10	1.1
9/21/2011	11:57	WE	43.7	OC	30	0.93
9/28/2011	12:03	WEDCP	43.7	OC	30	2.5
10/5/2011	7:34	LES	0.5	OC	30	4.3
10/5/2011	8:20	TG	6	OC	30	2.2
10/26/2011	11:54	WEDCP	43.7	OC	30	1.3
9/1/2010	11:00	WE	43.5	OC	30	6.9
9/8/2010	11:35	WE	43.5	SG	10	8.3
9/15/2010	11:00	WE	43.5	SG	30	12.0
9/29/2010	11:00	WE	43.5	OC	30	9.1
10/6/2010	8:11	TG	6	OC	30	5.1
10/14/2010	12:30	WE	43.5	OC	30	11.0
10/20/2010	11:30	WE	43.5	OC	30	3.8
10/15/2009	9:01	TG	6	SG	10	1.2
10/1/2009	10:58	WE	43.5	OC	30	2.40
9/23/2009	12:28	WE	43.5	SG	10	4.4
9/17/2009	9:16	TG	6	SG	10	1.7
9/9/2009	12:00	WEDCP	43.7	OC	30	2.3
8/26/2009	12:05	WEDCP	43.7	OC	30	0.92
8/20/2009	11:35	WE	43.5	OC	30	0.89
8/11/2009		TG	6	SG	10	1.0
8/6/2009	11:28	WE	43.5	SG	10	1.7

While the complete record from YTEP water monitoring data also documents microcystin detections lower than the 0.8 μg/L level being present at other times, tribal members and any other users of the river have been at risk of adverse health outcomes from documented levels of microcystin above those set for recreational use ***during the last five years on average 7 weeks each year.*** These weeks occur during a time of high, often daily use of the river by Tribal members for their subsistence and commercial fishing seasons as well as ceremonial activities. This has the potential of creating a complete pathway and realized exposure to the microcystin toxins in excess of the recreational and sub-acute reference dose calculations that set the State's Recommended Action Level based on "incidental exposure through recreational use" as infrequent exposure of less than 10 percent. Furthermore, while the California State recommended action levels do not calculate exposure or dose for prolonged daily exposures such as these fishers experience and that is discussed above, recreational fishing is also associated with rod and reel and does not take into the exposure scenario, the extensive, chronic immersion of the forearms that subsistence and occupational fishing that utilizes nets.

Results of water testing for this project supplement and substantiate YTEP routine surface water monitoring data with detections of microcystins above the recommended health alert level in the Klamath River fall flows. These detections mimic the yearly sequence of water warming, flows are reduced, algae blooms grow, die in the reservoirs and release their toxins which creates a trend of no microcystin detections in the spring/early summer flows followed by late summer/fall detections over the health limit.

This project utilized an equal interval, integrated depth method to characterize toxin levels by representing a cross section of the entire river column as opposed to the public health monitoring samples that are surface grabs biased to capture the highest probable toxin concentrations of warm surface eddies. Notwithstanding that this project sought to remove this high bias and regardless of the effect of the entire water column acting as a dilution factor, microcystin levels exceeded California's Recommended Action Level at all three sites sampled during September and October of 2010 as shown in Table 10.

Table 10: Summary of Project Isokinetic Integrated Depth Sampling of Klamath River Flows

Sampling Site	Sample Type	River Flow Daily Mean, cubic feet/sec	PH	BIO-TOXINS MC-LA ppb	BIO-TOXINS MC-LR ppb	BIO-TOXINS BG Species cells/mL
WE061510	Spring water	11,900		ND	ND	*Aphanizomenon flos-aquae*/ 68
BC061610	Spring water	10,300	8.2	ND	ND	
TGO61410	Spring water	11,900	8.1	ND	ND	
WE100410	Fall water	1,800	8.5	2.9	ND	*M.aeruginosa*/ 13,359
BC100710	Fall water	1,810	8.3	1.66	ND	*M.aeruginosa*/ 7,965 and *Aphanizomenon flos-aquae*/ 116
TG093010	Fall water	1,800	8.3	1.61	0.026	*M.aeruginosa*/ 36,420

	MC-LA	MC-LR	
MDL	0.01	0.01	
RL	0.02	0.02	

In addition to the potential of exposure to blue green algae toxins in the river water through subsistence and commercial fishing, the cultural and subsistence procurement of fresh water mussels further extends Tribal Members' time duration of exposure to microcystin toxins in the water. Finally, the results of this project's tissue sampling demonstrate the potential that consumption of subsistence foods, such as freshwater mussels that had detections of 64.2 ng/g of microcystin-LA also add to the cumulative total toxic burden of microcystins that Tribal members may experience through an ingestion pathway. Complete toxin results can be referenced in Appendix D.

The efficient management and protection of water resources must be adequate to prevent or warn of exposures to toxic chemicals that may lead to adverse health effects and this requires a conservative approach based on the most current information (Merel et al. 2013). To accomplish this, it would seem that to be protective of Tribal Members' health regulatory agencies should be utilizing chronic (more than 10 percent of a person's lifetime) dose frequencies to determine reference doses for microcystin and the calculation of all subsequent water quality standards, including Recommended Action Levels.

While the toxins released from the blue green algae may possibly be the most relentless periodic and possibly harmful of the contaminants in the Klamath Basin, mining impacts also have the potential for extensive inputs. The Federal Government office with the complete set of land and mineral records for Federal lands in a particular State is the BLM State Office. The BLM State Office is the only office where the mining claim records are filed and available for public inspection. BLM also maintains its files in electronic format in a system known as LR 2000.

According to this system, there are 4,132 registered mines throughout the Basin (Figure 11), contributing in varying degrees to exposing the high mineral content of the mountain ranges to environmental exposures. While new mine registrations exist that are covered by modern environmental standards for mining practices including the reclamation of disturbed sites after completion of exploration and mining activities, the great majority are legacy mining sites that have two major potential risks of exposed minerals and contaminants. First, the sub-surface lode mines and mills often have exposed slag piles that are subject to climatic forces of winter freeze and thaw cycles, as well as wind, rain and surface water transport.

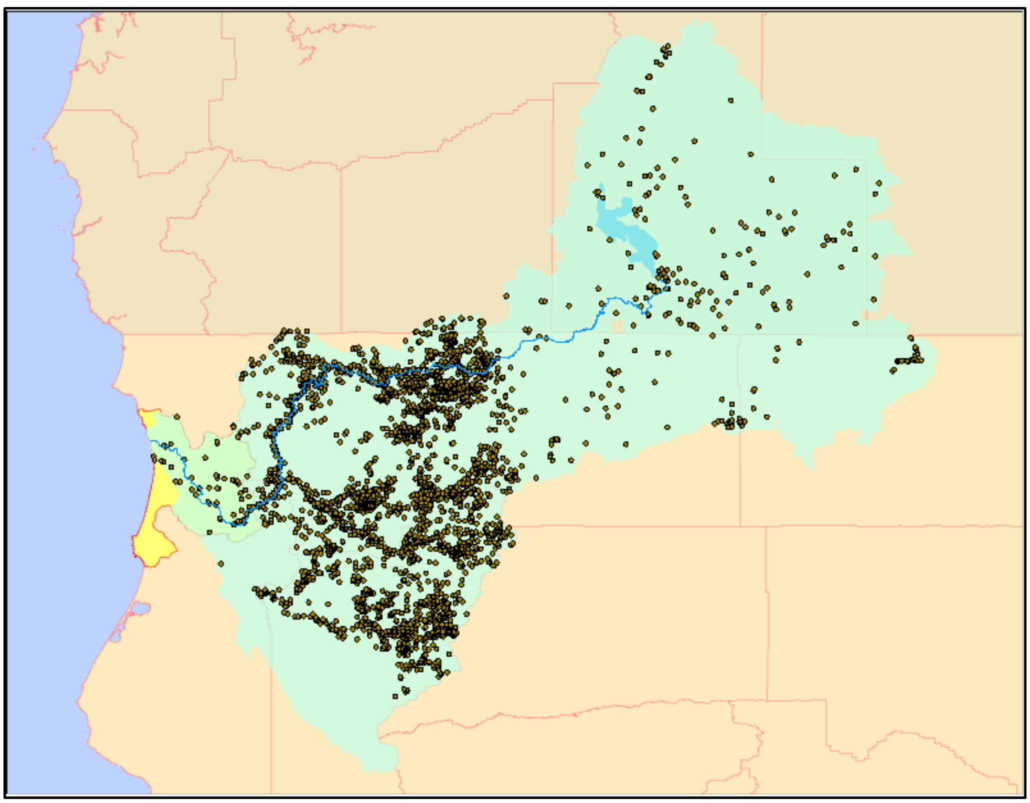


Figure 11: Map of Registered Mines in the Klamath River Basin

Second, are the large number of historic surface mines that have the same exposure risks from remaining debris and processing slag but can also offer high concentrations of minerals in exposed deposits with the potential for mineral migration off site. These include:

- 81 chromium surface mines; 48 recorded having raw chromite ore sources
- 80 total manganese mines; 11 reported as surface mining sites; 4 with other associated ores

- 57 mercury mines; 15 surface mercury mines; 5 with other ores
- 27 cooper surface mining sites
- 3 nickel and
- 2 reported surface mining sites for lead.

In summary, the steep terrain, granular soil matrix, high precipitation, historic and current land use practices have produced erodible conditions throughout the area with frequent landslides that allow exposed contaminants the potential to migrate and become transported into ground and surface waters. Contaminants found in soil, are likely to leach to groundwater, possibly volatize to the air environment, migrate to surface water through percolations and/ or overland runoff, and have the potential for contact by environmental site receptors as well as Tribal and community members. Additionally, anthropogenic uses of the Klamath River itself that favor growth of Harmful Algal Blooms (HABs), specifically those toxins associated with the blue-green algae, *Microcystis* increasingly threaten fishery resources, coastal wildlife, key subsistence resources and the health of tribal members and surrounding communities. This often generates avoidance of contact with the river water that results in the loss of recreational, subsistence, and cultural use of the estuaries and lowered economic opportunities for the region. It may also contribute to the possible adverse health effect of high levels of skin cancers within the Yurok Tribal membership as documented in this project's generated Community Health Report.

3.4 Identity and Levels of Contaminant Concentrations

Prior to this project, extensive public scoping, surveys of the tribal membership, and staff verification documented 192 sites with environmental pollutants on the Yurok Indian Reservation (YTEP-ANA). These pollutants vary in size, severity, location, and type. Some examples include: illegal dumpsites, abandoned autos, herbicide spraying, burned homes, faulty septic systems, historic mill sites with logging ponds, potential lumber treatment ponds, and tee-pee burners that are known sites of heavy dioxin deposition. Also documented are old mining sites and historic logging yards with maintenance areas where machinery fluids were often improperly disposed into soil and waterways. In addition, during the first year of this project, research documented toxins that have been utilized in the broader Klamath River Basin. In total, more than 220 toxins and metabolites from 12 broad families/ categories were targeted in this project for inclusion in laboratory analysis of subsistence species and Klamath River water.

Positive results for contaminant detections include eight of these 12: biotoxins, dioxins, organochlorines, PAHs, PBDEs, PCBs, pyrethroids, and trace metals. These are listed in Table 11 and complete laboratory results are included in Appendix D. In general, contaminants that were detected include the following:

- **Biotoxins** are produced or released from biological agents. Domoic acid is produced by the diatom, *Pseudonitzschia*, and is also referred to as amnesic Shell Fish Poisoning. Five or roughly half the species (dungeness crab, freshwater mussels, lamprey, marine mussels, razor clams, and steelhead) had low level detections. Microcystins are hepato-toxins released from the breakdown and lysis of several blue green algae and were detected at 64.2 ppb, a high level in freshwater mussels.

- **Dioxin/ furans** are considered ubiquitous and persistent in the environment and this study's results reflect this same trend. Dioxin/ Furans were present in all species, but below levels that the US EPA considers as background dioxin concentrations for the western USA (US EPA 2010).

- **Organochlorine pesticide** residues were found in all species EXCEPT Razor Clams and fresh water mussels- both had no detections. Five of the legacy pesticides that were banned in the early 1960-80's were consistently detected across species with chlordane and dieldrin at the lowest levels, followed by nonachlor and hexachlorobenzene at slightly more elevated levels, and the DDT derivatives at yet higher concentrations. DDT, its residues and derivatives were found in Chinook and Coho salmon, crab, lamprey, steelhead, and sturgeon (no detections in marine mussels and seaweeds). Hexachlorobenzene was detected at low levels in all fin fish species tested to date but is of concern because it is one of the most persistent environmental pollutants and both biomagnifies and bioaccumulates significantly in both terrestrial and aquatic food chains. Currently it still enters the environment as a bi-product of chlorinated solvents, wood-preserving plants, when burning municipal waste, and in multiple pesticides including atrazine (ATSDR 1996) that was applied on the Yurok Tribe's Reservation through 2006. It was not found in the ocean species (crab, marine mussels, and seaweeds). Chlordane and dieldrin were detected at extremely low levels in all species except crab at less than one one-hundredth of the FDA limit.

- **Polycyclic Aromatic Hydrocarbons** (PAH) were detected in all species. The European Union has set limits for muscle meat of fish at 2.0 μg/kg; crustaceans and cephalopods at 5.0 μg/kg; and bivalve mollusk sat 10.0 μg/kg. Analysis to date of detections for PAH in all species sampled exceeded these limits except in the freshwater mussels.

Table 11: Detected Toxins and Contaminants

ENVIRONMENTAL AND INDUSTRIAL TOXINS						**PESTICIDES**	
BIOTOXINS	**DIOXINS/ FURANS**	**METALS**	**PAH**	**PBDEs**	**PCBs**	ORGANOCHLORINES	PYRETHROIDS
Domoic acid	2,3,7,8-TCDD	Ag	Naphthalene	BDE 28	18	chlordane, cis	Bifenthrin
MC-LA	1,2,3,7,8-PECDD	Al	*C1-Naphthalenes*	BDE 49	28	chlordane, trans	Permethrin, Cis
	1,2,3,6,7,8-HXCDD	As	*C2-Naphthalenes*	BDE 47	31	dacthal	
	1,2,3,7,8,9-HXCDD	Cd	*C3-Naphthalenes*	BDE 100	33	DDD, o,p'	
	1,2,3,4,6,7,8-HPCDD	Cr	*C4-Naphthalenes*	BDE 99	44	DDD, p,p'	
	OCDD	Cu	1-Methylnaphthalene	BDE 154	49	DDE, o,p'	
	2,3,7,8-TCDF	Hg	2-Methylnaphthalene	BDE 201	52	DDE, p,p'	
	2,3,4,7,8-PECDF	Hg/ methyl	2,6-Dimethylnaphthalene		60	DDMU, p,p'	
	1,2,3,4,7,8-HXCDF	Mn	2,3,5-Trimethylnaphthalene		66	DDT, o,p'	
	1,2,3,6,7,8-HXCDF	Ni	Acenaphthylene		70	DDT, p,p'	
	2,3,4,6,7,8-HXCDF	Pb	Acenaphthene		74	dieldrin	
	1,2,3,4,6,7,8-HPCDF	Se	Biphenyl		87	endrin	
	OCDF	Zn	Fluorene		95	HCH, alpha	
			C1-Fluorenes		97	HCH, beta	
			C2-Fluorenes		99	HCH, gamma	
			C3-Fluorenes		101	heptachlor	
			Phenanthrene		105	heptachlor epoxide	
			1-Methylphenanthrene		110	hexachlorobenzene	
			3,6-Dimethylphenanthrene		118	nonachlor, trans	
			Anthracene		128	oxadiazon	
			C1 Phenanthrenes/Anthracenes		138	oxychlordane	
			C2 Phenanthrenes/Anthracenes		141		
			C3-Phenanthrenes/Anthracenes		146		
			C4-Phenanthrenes/Anthracenes		149		
			Dibenzothiophene		151		
			C1-Dibenzothiophenes		153		
			C2-Dibenzothiophenes		156		
			C3-Dibenzothiophenes		158		
			Pyrene		170		
			Fluoranthene		174		
			C1-Fluoranthenes/Pyrenes		177		
			Benz[a]anthracene		180		
			Chrysene		183		
			C1-Benzo[a]anthracenes/Chrysenes		187		
			C2-Benzo[a]anthracenes/Chrysenes		194		
			C3-Benzo[a]anthracenes/Chrysenes		201		
			Benzo[b]fluoranthene		203		
			Benzo[j,k]fluoranthenes		206		
			Benzo(k)fluoranthene		*PCB 1248*		
			Benzo[a]pyrene		*PCB 1254*		
			Benzo[e]pyrene		*PCB 1260*		
			Perylene				
			Indeno[1,2,3-cd]pyrene				
			Benzo[ghi]perylene				
			Dibenz[a,h]anthracene				

- **Polybrominated diphenyl ethers** (PBDE) appear to have an affinity to the large fish and were detected in Chinook, Coho, steelhead, and sturgeon. They are lipophilic, environmentally persistent (Costa et al., 2008; Darnerud et al., 2001) and can bioaccumulate and biomagnify in the terrestrial and aquatic food webs (U.S. EPA, 2010b).

- **Polychlorinate biphenyls** (PCB) were detected in all species except freshwater mussels at low levels. None exceeded the current FDA food limit.

- **Pyrethroids** were found at extremely low levels in crab, marine mussels and razor clams. Lamprey had the highest ranked detections with less than 1.5 ppb wet weight detections in their tissue.

- **Trace Metals** were detected in all species in varying degree. Fresh water mussels had detections of two metals with elevated levels but below established action limits; chromium and manganese. Chromium may bioaccumulate in algae, other aquatic vegetation, and invertebrates, but it does not biomagnify. It inhibits growth in duckweed and algae, reduces fecundity and survival of benthic invertebrates, and reduces growth of freshwater fish fingerlings (U.S. EPA 1980). Although little studied, these chromium levels could be contributing to the general decline in freshwater mussels and impacting survival of endangered fish species such as the Coho salmon and may be of interest in future research. Recent research on manganese has elicited concern from public health officials and it is currently under review to be added to US EPA list of critical contaminants.

  Aluminum, arsenic, chromium, copper, manganese, mercury, and nickel were detected in the Klamath River's Fall flows. In addition, the Spring flows of river water returned detections of these along with traces of lead. Of these metals, aluminum and mercury exceeded the US EPA (2009) recommended Aquatic Life Protection Criteria for continuous freshwater exposures. Aluminum ranged from a low of 14.6 ppb on September 30, 2010 to a high of 217 ppb detected on June 14, 2010 and averaged 167 ppb inclusive of the three sites sampled during the Spring sampling event. Likewise, it was detections in the Spring sampling with characteristic high flows that detected mercury above the .77 ppb Aquatic Life Protection Criteria for mercury. The average mercury detection was 1.5 ppb.

In total, 8,818 analyses for individual constituents in tissue and water samples were performed and quality checked for use in the grant reporting. Both the method detection limit (MDL) and the reporting limit (RL) were held to the lowest possible level determined by the lab. Detections at or above the RL represent robust, quantitative detections at a 99% confidence level. Results above the MDL but less than the RL are considered quantitated estimates with accuracy within plus/minus 20% range.

1. 5,494 analyses (62%) were not detected at concentrations above the method detection limit.

2. 1,996 analyses (22%) contained detectable concentrations at estimated trace levels.

3. 1,301 analyses (15%) contained quantifiable concentrations.

4. In total 8,747 (99%) results were considered usable for the intended purpose of determining the presence/absence of contaminants/toxins in subsistence tissues and Klamath River water.

The primary goal for conducting tissue sampling and analysis in this project was to produce information about the physical health of aquatic species relied upon by Yurok People for their subsistence, cultural, and economic lifeways. This was accomplished through broad spectrum laboratory analysis as reported above and the subsequent results increase our general knowledge of the levels of toxic contaminants in aquatic subsistence resources and Klamath River water. In general, detections were low with exceptions in five contaminant groups below. These detections EXCEEDED current public health or water quality criteria limits include:

- Microcystins in Fall flows of Klamath River water and fresh water mussels;
- Total PAHs in four species (Fall run Chinook salmon, Coho, lamprey, and razor clams);
- PCBs in whale blubber (comparing it to FDA levels in red meat);
- Pesticide residue in whale blubber (comparing it to FDA levels in red meat);
- Select trace metals (aluminum in Klamath River Spring flows and manganese in fresh water mussels).

Figure 12: Freshwater Mussel Shell with Meat in Background

4.0 POTENTIAL RECEPTORS

All people living or working on, visiting, or otherwise present on the Yurok Reservation and Ancestral Territory have the potential to experience acute expose to various hazardous substances at sites where there is localized soil or water contamination or where vapors of contaminants have been observed or are anticipated. Although the local population in the area is small and scattered, the Redwood National Park estimated 418,820 visitors to the area in 2010. All these people are potential receptors for possible contaminant exposures; however, this project focuses on the general Yurok population who live locally within the area and maintain a cultural interconnection and heavy reliance upon the environment. They face additional exposures and adverse impacts from hazardous substances in ways not typically accounted for in most risk assessments, which model exposures largely received in mainstream, urban and suburban settings and do not consider the extent of tribal environmental contact. In addition to human receptors, this project's contaminant detections represent not only possible exposure to Tribal members through ingestion but also documents environmental impacts to the targeted species themselves.

4.1 Biological Endpoints

Several threatened or endangered species are associated with the Yurok Ancestral Territory and can be expected to be exposed to the various environmental contaminants in their potentially affected habitats. The USGS list of threatened (T), endangered (E) and candidate (C) species for the Del Norte and Humboldt Counties includes the following species:

- Fish:
    - Coho salmon (T) *Oncorhynchus kisutch*,
    - California coastal chinook salmon (T) *Oncorhynchus tshawytscha*
    - Tidewater goby (E) *Eucyclogobius newberryi*
    - Northern California steelhead (T) *Oncorhynchus tshawytscha*
- Birds:
    - Marbled murrelet (T) *Brachyramphus marmoratus*
    - Western yellow-billed cuckoo (T) *Coccyzus americanus occidentalis*
    - Northern spotted owl (T) *Strix occidentalis caurina*
    - California clapper rail (E) *Rallus longirostris obsoletus*
    - Western snowy plover (T) *Charadrius alexandrinus nivosus*
    - California brown pelican (E) *Pelecanus occidentalis californicus*
- Mammals:
    - Pacific fisher (C) *Martes pennanti*
    - Northern Steller sea-lion (T) *Eumetopias jubatus*

In addition to the Federal and State listed species, the Tribal Memberships identifies that in the Klamath River, all runs of Chinook salmon, green sturgeon, smelt, Pacific eulachon and Pacific lamprey are on the decline. Also within Yurok Ancestral Territory and associated with the coastal area are the Humboldt Lagoons that are co-managed by the National Parks Service and California State Parks. These are not only the country's largest lagoon system but part of the international, Pacific Flyway where thousands of birds representing more than 200 species live or migrate through including majestic bald eagles, osprey, and peregrine falcons.

Tribal members document that the population of various wading and diving water birds (*Anseriformes*, *Gruiformes*, and *Podicipediformes*) have drastically declined within living memory, particularly the mud hens or coots. Upland areas offer habitat for other less commonly seen species such as river otters, Roosevelt elk, ring-tail cats, cougars, and lynx. All could be potentially affected by contaminants as one moves up or down the trophic food chain. Tribal members frequently offer up the possibility that the various population declines are the result of contaminant and toxic effects on the species that they have been stewards of for millennia. Many tribal members also regularly report observing internal tumors in individual mammals when they are gutted or butchered. Others report observing that harvested fish have unknown cysts or diseased gall bladders. While this project did not research the effects of the contaminant detections in the targeted species' tissues for possible adverse health effects in the species themselves, it is hoped that the data generated by this project is of interest to fish biologists and conservationists and is supportive of the need of future research into the effects of cumulative toxins of fish and wildlife health.

4.2 Environmental Media/ Transport of Contaminants

The primary media that were sampled during this project was the local biota; specifically 10 aquatic subsistence species that might act as potential transport of contaminants via Tribal members' ingestion. Land based foods such as deer, elk, or acorns were not tested due to project constraints of time and budget. Surface water was limited to the main stem Klamath River that was analyzed to determine if it served to transport contaminants either to the biota or through direct Tribal member contact via dermal absorption or inhalation of contaminants in water particulates or vapors. However, the many smaller creeks, springs, and seeps are in need of testing for contaminants for a more comprehensive cumulative risk assessment as many local springs and creeks are utilized as domestic source water. Table 12 summarizes five media that might transport contaminants and aid in the completion of exposure pathways.

Neither the soils/sediments, nor the air was sampled during this project. Potential risk of contaminant transport via the air is briefly discussed in section 3.2 Climate and Associated Hazards. Very little analysis of the local soils or sediments is available and interested parties might find contaminant data of these media in either the various

Brownfields Environmental Assessment Reports, which are available through the YTEP library of public documents or by utilizing links provided on their webpage.

Table 12: Potential Contaminant Migration Routes

MEDIUM	TRANSPORT TO EXPOSURE PATHWAY
Air	Inhalation of particulates
	Inhalation of volatiles
	Migration to surface waters via fog and high precipitation
Biota	Ingestion via vegetation, or fish/meat
	Dermal absorption of particulates adhering to surface
	Transport of surface contaminants via secondary contact
Ground Water	Dermal absorption from bathing
	Inhalation of volatiles
	Ingestion from domestic drinking water use
	Transport via percolation to surface water
Surface Water	Dermal absorption from bathing, swimming, cultural use, and subsistence fishing activities
	Ingestion during swimming, ceremonies, cultural use, and subsistence fishing activities
	Ingestion from domestic drinking water use
	Inhalation of volatiles
	Transport to near shore sediments and aquatic biota
Soil	Dermal absorption from subsistence practices, cultural activities
	Inhalation of particulates
	Inhalation of volatiles
	Ingestion
	Transport to terrestrial biota via plant uptake
	Transport to indoor air from soil gas
	Transport via leachate to ground water via contaminated soil

4.3 Tribal Member Exposure Scenarios

The Yurok Indian Reservation (YIR) and Ancestral Territory is a region that experiences high ceremonial and recreational use in summer and fall months and supports a year round fishing economy including recreational, commercial, as well as subsistence use. Running through the Reservation, the Klamath River is the lifeline of the Yurok because the majority of the Yurok traditional food supply such as ney-puy (salmon), kaa-ka (sturgeon), key'-ween (lamprey) and kwor-ror (candlefish) is harvested and utilized by tribal members from this watercourse. Other foods important to the Yurok are offered from the ocean and inland areas and include pee-ee (mussels), chey-gel' (seaweed), woo-mehl (acorns), puuek (deer), mey-weehl (elk), ley-chehl (berries), and wey-yok-seep (teas). These foods, their local procurement, traditional preparation, and ingestion are essential to the health of the Yurok, to their cultural continuity, and fulfillment of their religious ceremonies yet also establish pathways of exposure to contaminants and toxins.

Additional activities that connect and expose Tribal members to possible environmental contaminants other than through ingestion of their food sources include practicing subsistence lifestyles, participating in traditional ceremonies and the gathering, preparation, and production of regalia and basketry items. Potential Exposure Scenario Charts are found in Appendix C. Consequently, the potential for human exposures range from the direct exposure to contaminants to indirect exposures through the uptake and bio-assimilation of contaminants by local water (ground and surface), food sources (animal and botanical), and culturally utilized items (soils, plant and animal bi-products) that are then absorbed, ingested, or inhaled. Therefore, while tribal members face the same routine exposures as do members of mainstream American communities to industrial additives and contaminants in commercial products and foods, exposures to those contaminants that are often environmentally ubiquitous may be increased through tribal-specific activities.

The Yurok population includes the same standard epidemiological sub-populations of physical vulnerability: children, pregnant women, elderly, and also the chronically ill or immunodeficient. Exposure across these sub-populations; however, is increased through routine subsistence activities and consumption. Differentiated sub-populations of cultural and ceremonial practitioners are at still higher risk due to additional completed exposure pathways, i.e., chronic, frequent, and extended exposures to environmental pollutants via ingestion, inhalation, or dermal absorption.

The Potential Yurok Exposure Scenario Charts in Appendix C characterize the cumulative risks to the Yurok Tribe through four potential scenarios:

1. food and drink (consumptive) pathways;
2. subsistence pathways;
3. cultural pathways; and
4. ceremonial pathways.

Taken together, they describe differentially exposed sub-populations; potentially complete pathways of exposure specific to tribal members' activities that have the potential to complete exposure via ingestion, inhalation, or dermal absorption; and a range of possible contaminant transport mechanisms from suspect media: air, soil, soil vapor, sediments, biota, and ground and surface waters.

5.0 YUROK TRIBE RISK CHARACTERIZATION SUMMARY

This cumulative risk assessment characterizes those Tribal Members living within or adjacent to Yurok Ancestral Territory or within the adjoining counties that engage in subsistence, cultural and ceremonial activities. Its purpose is to provide information on factors that may be used to assess contaminant exposures and answer community members' questions regarding their health and that of their environment. Implicit in this characterization is the assumption that local Yurok Tribal members are engaged in aquatic subsistence consumption as an inherently Yurok cultural trait.

Figure 13: Subsistence Fishing at Klamath River Mouth

In addition to local Yurok Tribal Members, receptors could include non-tribal people living in Yurok Territory and practicing similar subsistence lifeways; however, it is doubtful that they would experience the same exposures and baseline chemical burden experienced by cultural and ceremonial practitioners who also are subsistence fishers. In addition to the burden of exposure to the contaminants documented in this report and experienced by the general Yurok population, Yurok commercial fishers create a subpopulation that would experience greater exposures to those contaminants transported via the Klamath River in both duration and frequency.

As well as the greater environmental exposure that individual Tribal Members experience than mainstream America that is discussed in Section 4.3 Tribal Member Exposure Scenarios, many also fall into multiple risk categories with whole communities qualifying as sensitive sub-populations by their socioeconomic factors of poverty, residential crowding of multiple generations and multiple families living in one home, substandard housing quality, exposure to violence, and the experience of racial discrimination. Research demonstrates that these socioeconomic factors may contribute to increased adverse health effects (Evans & Marcynyszyn, 2004). Although this project acknowledges that many diseases have multiple causes and are not uniquely caused by environmental exposures, evidence suggests that cumulative exposures from multiple sources of environmental pollution may be more harmful than single exposures (Sexton & Hattis, 2007).

The calculation of average daily dose, per capita intake rates, and related quantified health risks are beyond the scope of this study. Rather this study seeks to characterize chronic lifetime exposures through representative examples and generalized scenarios that present predictable, aggregate exposure from both 1) single toxins with simultaneous as well as any sequential exposures over time and across various media (such as the microcystins whose exposures occur seasonally via both food ingestion and dermal absorption of toxin transported in the river water) and 2) multiple toxins that may overlap via common pathways, co-occur in time, or vary but whose impacts may be residual and the burden cumulative (for example the lifetime ingestion of those lipophilic, biomagnifying contaminants in subsistence foods that would culturally and traditionally be eaten together and preserved for year-round consumption). The exposure scenarios that are presented here have been verified and are consistent with the supporting data provided by community members, the Yurok Council's advisory committees of Culture and Natural Resources.

The uncertainties associated with this risk assessment due to variability are not limited to, but include:

- Inherent exposure differences within the Yurok population for a variety of reasons such as personal or unique activity patterns, food preferences, economic status, and practices. Individual Tribal members, especially those who live outside the Ancestral Territory, may experience exposures that are different from those of the general local population, and which may be greater such as those risks associated with urban living. Also, there may be those who have heightened sensitivity to particular chemicals or those with greater exposures, such as in certain young children who engage in more hand-to-mouth activity (nondietary ingestion) than national averages. An example might be those children whose caregivers engage in basketry material gathering such as reed collection and could possibly spend unspecified amounts of time playing at water's edge and soil interface.

- Inherent inconsistencies between discrete levels versus average contaminant concentration in the targeted aquatic subsistence species that were analyzed in this project.

- Differential contaminant dose amounts with regard to time of year exposure occurs such as for indirect pesticide exposures from handling of firewood or basketry materials, or the inhalation of contaminated smoke from wood heating and the time of initial spring and fall release of pesticide applications. This variablility in the exposure to pesticide residues with regard to time would also apply to the length of time between harvest of teas and medicinal herbs and pesticide application.

Data gathered in this project document complete exposure pathways of multiple environmental toxins and contaminants and as such, indicate that exposure to the contaminants has occurred in the past, is presently occurring, or will likely occur in the future as contributors and sources of risk to the general Yurok Tribal Membership. The principal media and complete pathways include:

1. Air transport of small particulate matter from wildland and forest fires above ambient air quality standards, inhaled by those Yurok Tribal Members living in the Upriver Reservation region.

2. Water transport of microcystins above recommended Recreational Use in late summer Klamath River Flows, with dermal absorption by subsistence and commercial Yurok fishers, cultural practitioners during basketry and regalia procurement, ceremonial participants during ritualized river bathing and water gathering, recreational users in general and through the accidental immersion of all groups.

3. Biota transport of microcystins in freshwater mussels detected at 64.2 ppb, ingested by subsistence harvesters.

4. Biota transport of mineral manganese in fresh water mussels through ingestion by subsistence harvesters.

5. Biota transport of PAHs in four species (Fall run Chinook salmon, Coho, lamprey, and razor clams) above WHO recommended levels, ingested by general Yurok population.

6. Biota transport of low levels of dioxins, organophospate pesticides, PBDEs, PCBs and pyrethroids in subsistence resources, ingested by the general Yurok population.

Although the true or actual risk is unknown and although unlikely, could be as low as zero, as well as the knowledge that the identification of a completed exposure pathway does not immediately imply health effects will occur, this project provides evidence that environmental contaminants and toxins are likely contributing to adverse health effects in the Yurok Tribal Membership. Even allowing that the risks associated with these potential exposure scenarios might be lower than doses reported in toxicology literature to cause adverse health effects, the UIHS data revealed in the Community Health Profile, suggest that there are disproportionate diagnoses in at least 4 areas for local Tribal members who sought medical treatment. These include:

1. Overall cancer rate greater than three times the national rate for other American Indians/ Alaskan Natives (AIAN) and 40% greater than the rate for all races combined.

2. Diabetes rates comparable to other AIAN national rates and approximately 3 times the general population.

3. Proteinuria, often a precursor of chronic kidney disease, was found at rates over double the national average.

4. Perinatal outcomes of spontaneous abortion and fetal malformation were great enough to be of concern to the epidemiological research staff but diagnosis coding is not comparable with National data.

Figure 14: Yurok Tribal Member Net Fishing

6.0 CONCLUSION

In conclusion this study met its objectives and answered the research questions regarding the environmental health of the Yurok Ancestral Territory and potential impacts to Tribal Members' health. YTEP met the goal of developing and disseminating public outreach materials that may help traditional tribal members and subsistence practitioners in general identify and minimize risk. Furthermore, the study's goal to provide data on the relationship between tribal health and environmental health was, although of a limited and preliminary level, met through the gathering of multiple levels of inquiry data on:

1. Identity of potentially exposed populations through the compiled 5 year diagnoses for those Yurok Tribal members who used the local United Indian Health Clinics, thereby informing the Tribal membership of their community level health outcomes (Yurok Community Health Profile: Appendix B);
2. Existence of potential pathways of exposure and exposure conditions through the 8,747 analytical results on the presence/absence of contaminants/toxins in Klamath River water. The presence/absence and detected levels of these contaminants in the selected species tested (Appendix C and D); and
3. Characterization of the potential doses through representative scenarios that depict relevant activities and behaviors of Yurok Tribal members residing in the local vicinity of Yurok Ancestral Territory within the bi-county region of Del Norte and Humboldt Counties, California (Appendix C).

Additional benefits of this project's research include:

4. Improvement in the overall understanding of tribal and subsistence risk assessments and a demonstrated need for improvements to the standard risk paradigm to effectively represent and protect Tribal Members' public health.
5. Development of two ecotoxicologic tools that integrate with ArcGIS technologies and allow quick analysis and possible solutions to environmental problems through the use of previously diverse and incompatible data sets.
6. Completion and distribution of education and outreach materials for and to the tribal membership on study findings and implications for tribal subsistence and resource health (Yurok Resource Health Report Appendix E).
7. Increased tribal member awareness of the relationship between environmental conditions and individual health, health trends within the Yurok Tribe, the current conditions of key subsistence aquatic foods, and the health benefits of a traditional Yurok diet.

7.0 BIBLIOGRAPHY

ATSDR's *Toxicological Profiles <www.atsdr.cdc.gov/toxpro2.html>.* Agency for Toxic Substance and Disease Registry, *Comparison Values for Water,* January 10, 2005.

Alexander J, Benford D, Cockburn A, Cravedi J , Dogliotti E, Di Domenico A, Fernández Cruz M, Fink-Gremmels J, Fürst P, Galli C, Grandjean P, Gzyl J, Heinemeyer G, Johansson N, Mutti A, Schlatter, van Leeuwen R, Van Peteghem C, Verger P. 2008. Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on Polycyclic Aromatic Hydrocarbons in Food. *The EFSA Journal* 724, 1-114.

Alexeeff G, Faust J, Meehan L, Milanes C, Randles K, Zeise L. 2010. *Cumulative Impacts: Building a Scientific Foundation (Public Review Draft)*; California Environmental Protection Agency, California Office of Environmental Health Hazard Assessment: California, CA, USA.

Butler N, Carlisle J, Linville R. 2012. Toxicological Summary and Suggested Action Levels to Reduce Potential Adverse Health Effects of Six Cyanotoxins. California Office of Environmental Health Hazard Assessment.

California Coastal Commission. 1987. The California Coastal Resource Guide. University of California Press; Berkeley, CA.

California Department of Water Resources. Web Page. Climate Data for North Coast Hydrologic Region 2011 <http://www.water.ca.gov/floodmgmt/hafoo/csc/climate_data/northcoast.cfm> Accessed May 9,2012.

California Environmental Protection Agency (Cal/EPA). 1992. Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. The Office of Science Advisor, Department of Toxic Substances Control (DTSC), Sacramento, California.

Chorus I, ed. 2012. Current approaches to Cyanotoxin risk assessment, risk management and regulations in different countries. Federal Environment Agency, Germany. http://www.uba.de/uba-info-medien-e/4390.html.

Covington S. 2004. Whiskeytown National Recreation Area Geologic Resources Management Issues Scoping Summary. (PDF). Geologic Resources Division. U.S. National Park Service. <http://www.nature.nps.gov/geology/inventory/publications/s_summaries/WHIS_scoping_summary_20041025.pdf>. Retrieved November 11, 2009.

Department of the Interior (DOI), Bureau of Reclamation. 2011. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Klamath River, Oregon and California. Prepared for

Mid-Pacific Region, Technical Report No. SRH-2011-02, Technical Service Center, Denver, CO.

Evans GW, Marcynyszyn LA. 2004. Environmental justice, cumulative environmental risk, and health among low- and middle-income children in upstate New York. Am J Public Health. 2004 Nov 94(11):1942-4.

Falconer IR. Tumor promotion and liver injury caused by oral consumption of cyanobacteria. Environ Toxicol Water Qual 1991;6:177–84.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Fetcho K. 2006. Klamath River Blue-Green Algae Bloom Report. Yurok Tribe Environmental Program. 17 pp.

2007. 2006 Klamath River Blue-Green Algae Summary Report. Yurok Tribe Environmental Program. 34 pp.

2008. 2007 Klamath River Blue-Green Algae Summary Report. Yurok Tribe Environmental Program. 27 pp.

2009. 2008 Klamath River Blue-Green Algae Summary Report. Yurok Tribe Environmental Program. 26 pp.

2010. 2009 Klamath River Blue-Green Algae Summary Report. Yurok Tribe Environmental Program. 45 pp.

Gannett MW, Lite KE Jr., La Marche J, Fisher KL, Polette DJ. 2010. Ground-Water Hydrology of the Upper Klamath Basin, Oregon and California. Oregon Water Resources Department and U.S. GEOLOGICAL SURVEY. Scientific Investigations Report 2007–5050. <http://pubs.water.usgs.gov/sir20075050>.

Goldstein T, Zabka TS, DeLong RL, Wheeler EA, Ylitalo G, Bargu S, Silver M, Leighfield T, Van Dolah F, Langlois G, Sidor I, Dunn JL, Gulland FMD. 2009. The role of domoic acid in abortion and premature parturition of California sea lions (Zalophus californianus) on San Miguel Island, California. Journal of Wildlife Diseases. 45(1): 91-108.

Gustavsson N, Bølviken B, Smith DB, Severson RC. 2001. Geochemical Landscapes of the Conterminous United States- New Map Presentations for 22 Elements: U.S. Geological Survey Professional Paper 1648. U.S. Department of the Interior and U.S.Geological Survey.

Harper B, Harding A, Harris S, Waterhous T. 2006. Lifestyles and Cultural Practices of Tribal Populations And Risks from Toxic Substances in the Environment. Progress Report of Grant #EPA-STAR-J1-R831046.

Harris S, Harper B. 2004. Exposure Scenario for CTUIR Traditional Subsistence Lifeways. Department of Science & Engineering, Confederated Tribes of the Umatilla Indian Reservation, P.O. Box 638, Pendleton, OR 97801.

Heath JS, Koblis K, Sager S, Day C. 1993. Risk assessment for total petroleum hydrocarbons. *In* Hydrocarbon Contaminated Soils, Calabrese EJ and PT Kostecki, eds., Volume Three, pp. 267-302. Lewis Publishers, an imprint of CRC Press, Boca Raton, FL. Reprinted by persmission of CRC Press.

Irwin WP, Snoke AW, Barnes CG. (2006). *Geological Studies In The Klamath Mountains Province, California And Oregon*. Boulder, Colorado: Geological Society of America.

Jayko AS, Blake MC, Jr. 1987. Geologic terranes of coastal northern California and southern Oregon. *In* Tectonics, sedimentation, and evolution of the Eel River and associated coastal basins of northern California. Schymiczek H, and Suchsland R, eds., Bakersfield, CA: San Joaquin Geological Society Miscellaneous Publication 37, p. 1-12.

Lucius JE, Olhoeft GR, Hill PL, Duke SK. 1992. Properties and Hazards of 108 selected substances. Open-File Report 92-527. U.S. Geological Survey.

Lürling, M.; Faassen, E.J. Dog poisonings associated with a Microcystis aeruginosa bloom in The Netherlands. Toxins 2013, 5, 556–567.

Mathany TM, Dawson BJ, Shelton JL, Belitz K. 2011. Groundwater-quality data in the northern Coast Ranges study unit, 2009: Results from the California GAMA Program: U.S. Geological Survey Data-Series 609, 92 p.

McCray L E. 1983. Anatomy of Risk Assessment: Scientific and Extra-Scientific Components in the Assessment of Scientific Data on Cancer Risks. *In* National Academy of Sciences. 1983. Risk Assessment in the Federal Government: Managing the Process Working Papers. Committee on the Institutional Means for Assessment of Risks to Public Health, National Research Council. National Academies Press.

McElroy AE, Farrington JW, Teal JM. 1989. Bioavailability of polycyclic aromatic hydrocarbons in the aquatic environment. *In*: U. Varanasi (ed.) Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. p. 1-39.

McKinnon L. 2003. Yurok Indian Reservation Domestic Needs Assessment. Summary Report for US Bureau of Reclamation and Yurok Tribe Environmental Program.

Merel S, Walker D, Chicana R, Snyder S, Baurès E, Thomas O. 2013. State of knowledge and concerns on cyanobacterial blooms and cyanotoxins. Environment International. Volume 59, September 2013, p. 303–327

Moore JW, Ramamoorthy S. 1984. Aromatic Hydrocarbons-Polycyclics. *In*: Organic Chemicals in Natural Waters: Applied Monitoring and Impact Assessment. Springer-Verlag, New York, NY. p. 67-87.

Ney RE. 1998. Fate and Transport of organic chemicals in the environment: A practical guide. 3rd ed. Government. Institute, Inc., Rockville, MD. p. 227.

Nishiwaki-Matsushima R, Ohta T, Nishiwaki S, SuganumaM, Kohyama K, Ishikawa T, et al. Liver tumor promotion by the cyanobacterial cyclic peptide toxin microcystin-LR. J Cancer Res Clin Oncol 1992;118:420–4.

Novice R (editor). 1999. Overview of the environment and health in Europe in the 1990s (PDF). World Health Organization. <http://www.euro.who.int/document/e66792.pdf>. Accessed Feburary 1, 2012.

Page DS, Boehm PD, Douglas GS, BenceAE, Burns WA, Mankiewilcz PJ. 1996. The natural petroleum hydrocarbon background in subtidal sediments of Prince William Sound, Alaska, USA. Env. Toxicol. Chem 15:1266-1281.

Perwak J, Byrne M, Coons S. 1982. An exposure and risk assessment for benzo[u]pyrene and other polycyclic aromatic hydrocarbons. Volume IV. Benzo[u]pyrene, acenaphthylene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluroanthene, benzo[g,h,i]perylene, chrysene, dibenz[u,h]anthracene, and indeno[l,2,3-c,apyrene. Washington, D.C.: US Environmental Protection Agency, Office of Water Regulations and Standards. EPA 440/4-85-020-V4.Sutter GW, II. 1995.

Rogge WF, Hildemann LM, Mazurek MA. 1993. Sources of fine organic aerosol: Noncatalyst and catalyst-equipped automobiles and heavy-duty diesel trucks. Environ Sci Technol 27:636-2744.

Santodonato J. 1981. Polycyclic organic matter. J Environ Pathol Toxicol 5:1-364.

Sawicki E. 1962. Analysis for airborne particulate hydrocarbons: Their relative proportions as affected by different types of pollution. Bethesda, MD: National Cancer Institute Monograph No. 9, 201-220.

Sivone, K, Jones GJ. Cyanobacterial Toxins. In Toxic Cyanobacteria in Water: A Guide to their Public Health Consequences, Monitoring and Management; Chorus, I., Bartram, J., Eds.; E&FN Spon: London, UK, 1999; pp. 41–111.

Sexton K, Hattis D. 2006. Assessing Cumulative Health Risks from Exposure to Environmental Mixtures: Three Fundamental Questions. Environ Health Perspect 115:825–832.

Strauss S, Petrocelli SM, Rand RM, Rand GM. 1995. Introduction to Ecological Risk Assessment for Aquatic Toxic Effects. In Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Rick Assessment. Rand, G.M editor. CRC Press. Washington, DC. Pp 803-816.

US Environmental Protection Agency. 1980. Ambient water quality criteria for chromium. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA440580035.

1989. Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A) (Interim Final); NTIS PB90-155581, EPA-540/1-89-002; US EPA, Office of Emergency and Remedial Response: Washington, DC, USA.

1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum.

1992b. Guidelines for Exposure Assessment

1997. Exposure Factors Handbook (1997 Final Report). Washington, DC, EPA/600/P-95/002F a-c.

1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.

1999. Recognition and Management of Pesticide Poisonings. Dr. J. Routt Reigart and Dr. James R. Roberts ed., 5th edition. EPA/73-R-98-003. Online edition available <http://www.epa.gov/pesticides/safety/healthcare>.

2000. Issue Paper for the FIFRA Scientific Advisory Panel Review. "Endpoint Selection and Determination of Relative Potency in Cumulative Hazard and Dose-Response Assessment: A Pilot Study of Organophosphorus Pesticide Chemicals." Office of Pesticide Programs, Office of Prevention, Pesticides, and Toxic Substances.

2002a. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories; Fish Sampling and Analysis. Volume 1. Office of Science and Technology Office of Water

2002b. Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity. Office of Pesticide Programs.

2002c. *Review of the Reference Dose and Reference Concentration Processes.*

2003a. Example Exposure Scenarios. National Center for Environmental Assessment, Washington, DC; EPA/600/R-03/036. Available from: National Information Service, Springfield, VA; PB2003-103280 and at <http://www.epa.gov/ncea>.

2003b. Framework for Cumulative Risk Assessment; EPA/630/P-02/001F; US EPA, Risk Assessment Forum: Washington, DC, USA, 2003.

2003c. Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment. EPA/630/p-02/004F. U.S. EPA Risk Assessment Forum, Washington DC., pp 8-18.

2006 Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1 Fish Sampling and Analysis, Third Edition

2007a. Concepts, Methods and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document. US Environmental Protection Agency, National Center for Environmental Assessment, Cincinnati, OH. EPA/600/R-06/013F.

2007b. Integrated Risk Information System, IRIS Glossary. Website: <http://www.epa.gov/iris/help_gloss.htm>.

2010. Memorandum: Compilation and discussion of sediment quality values for dioxin, and their relevance to potential removal of dams on the Klamath River From: Brian Ross, Region 9 Dredging & Sediment Management Team and Erika Hoffman, Region 10

Environmental Review & Sediment Management Unit To: Dennis Lynch (USGS), Program Manager, Klamath Basin Secretarial Determination and Rhea Graham (USBR), Project Manager, Klamath Basin Secretarial Determination. United States Environmental Protection Agency, Region IX, San Francisco, CA. January 13.

2011. Ecological Toxicity Information. Region 5 Superfund Webpage. <http://www.epa.gov/region5/superfund/ecology/toxprofiles.htm> accessed 05January 2012.

US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, and Georgia Division of Health Assessment and Consultation. 2008. Health Consultation: Arco Quarry Fish Tissue Sampling Brunswick, Glynn County, Georgia.

US Department of the Interior, US Geological Survey. Surface Water data for California: USGS Surface-Water Monthly Statistics. Web page. Last Modified: 2012-05-10. <http://waterdata.usgs.gov/ca/nwis/monthly?> Accessed May 9, 2012.

Van De Waal DB, Verspagen JMH, Lürling M, Van Donk E, Visser PM, Huisman J. The ecological stoichiometry of toxins produced by harmful cyanobacteria: An experimental test of the carbon-nutrient balance hypothesis. Ecol. Lett. 2009, 12, 1326–1335.

Varanasi U, Reichert WL, Stein JE, et al. 1985. Bioavailability and biotransformation of aromatic hydrocarbons in benthic organisms exposed to sediment from an urban estuary. Environ Sci Technol 19:836-841.

APPENDICES

Appendix A: Glossary

Appendix B: Yurok Tribe Community Health Profile Report

Appendix C: Potential Exposure Scenario Charts

Appendix D: Lab Results

Appendix E: Yurok Resource Health Report