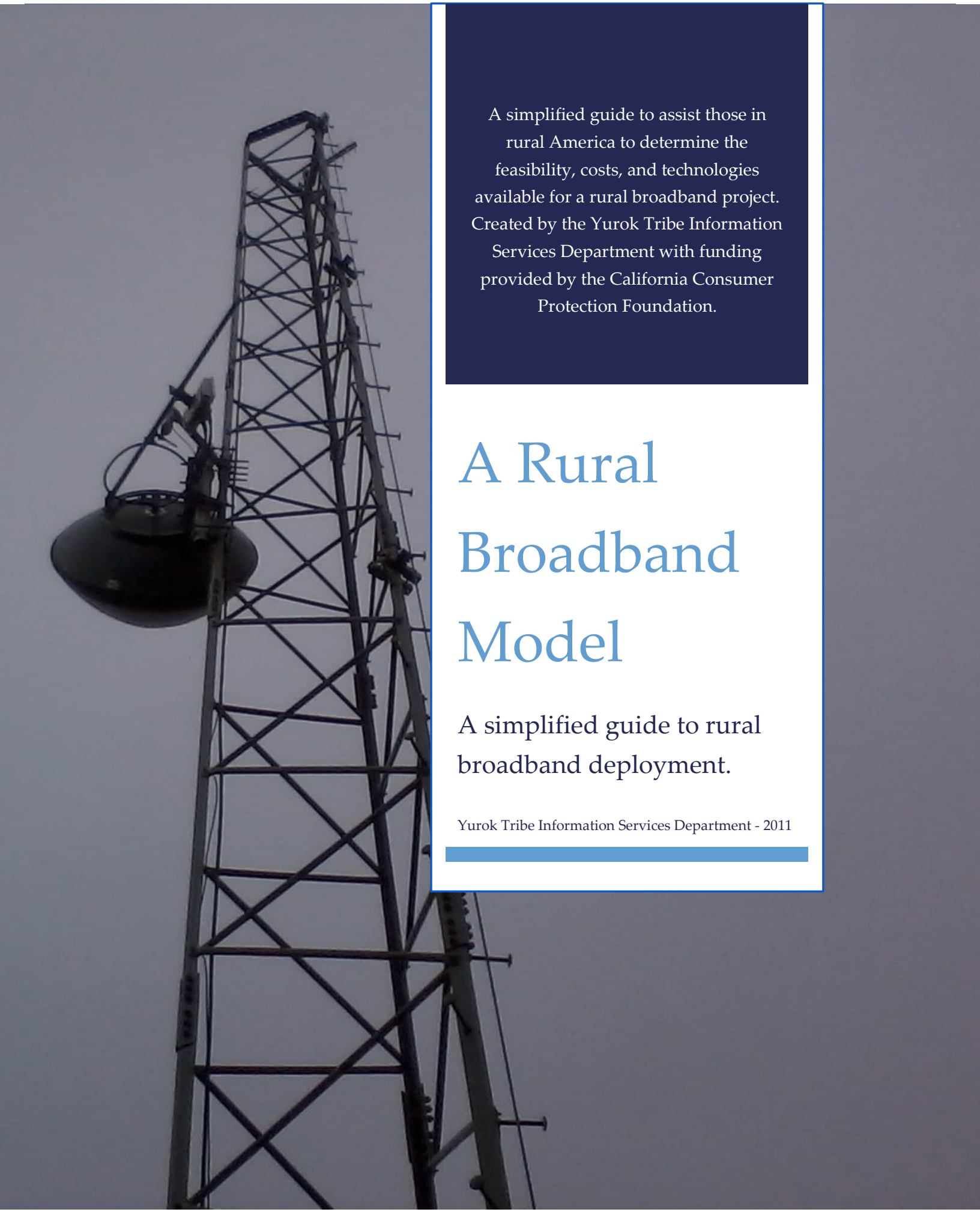

A simplified guide to assist those in rural America to determine the feasibility, costs, and technologies available for a rural broadband project. Created by the Yurok Tribe Information Services Department with funding provided by the California Consumer Protection Foundation.

A Rural Broadband Model

A simplified guide to rural broadband deployment.

Yurok Tribe Information Services Department - 2011

Overview

In 2010 the Yurok Tribe received grant funding from the USDA Rural Utilities Service and a matching Grant from the California Consumer Protection Agency to bring broadband internet access to its reservation. Included in this document are resources and an example model that can be used to replicate the project in other rural locations throughout the country. There is also an example equipment needs list and various technology recommendations. The money to create this example model was graciously given by the California Consumer Protection Agency in order to help increase awareness in rural communities in California and across the nation. The Yurok Tribe would like to thank the California Consumer Protection Agency for all of its support through the process of completing our broadband project and for approving the funding to create this informational resource.

Please note that this guide is provided as is and the Yurok Tribe and California Consumer Protection Foundation assume no responsibility for the use of this information in designing, implementing, and or operating a rural broadband project. This guide is intended for Educational use only.

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Rural Broadband Operating Models (Business, Nonprofit / Public Utility)

There are two operating models which we will cover in this document for providing wireless broadband internet access. Both models were under consideration for use by the Yurok Tribe Wireless Broadband service. The Yurok Tribe ultimately decided to utilize its existing Public Utility district in order to maximize its available resources.

Business Model

The business model has various drawbacks to providing service in a rural location. As subscribership is normally based off of a percentage of available population, rural areas tend to have limited quantities of households to fund operations. This is probably the reason why the local telephone company hasn't installed or provided some kind of broadband to the rural location in question. This doesn't mean that a for-profit business model is not possible, though it would require someone willing to operate the business with varying degrees of success.

Nonprofit / Public Utility

The nonprofit / public utility route allows for a more balanced approach as creating profit is not the sole reason for bringing the service to an area. Utilizing an existing Public Utility is probably the easiest solution for providing broadband to a rural location. An existing public utility will already have the required structure, billing, and accounting systems in place which can greatly simplify the process of creating a successful rural broadband operation. Operating as a nonprofit or public utility can also lead to more grant opportunities during both the initial creation and later during continuing operations if additional resources are needed.

General Broadband Technologies (DSL, Cable, Wireless, or Fiber Optic)

All Broadband technologies rely upon a medium to deliver the product to the end user and are differentiated by those mediums combined with a speed rating. All are advanced technologies with strengths and weaknesses which make them particularly suitable for certain types of deployments. All must have the costs associated with their deployments balanced against the situations encountered in the field. In addition, the products and services to be delivered will factor into the decision of the technology deployed. Currently, the technologies can be ranked in descending order with respect to both costs and capacities: Fiber Optic, Cable, DSL, and Wireless.

In exceptionally rural applications, the costs of any "wireline" technology- DSL, Cable Modem, Fiber Optic- generally far outstrip the expected returns on the investments unless such infrastructure already exists in suitable locations and quantity/quality. This is a fairly obvious conclusion from the simple reality that "for profit" entities have neither already built nor operate in the area under consideration. Construction costs can easily exceed $60,000 per mile and may not include "last mile" construction such as service drops from the main line to the user or environmental studies. A "rule of thumb" often used for a quick calculation for ROI is 25 passings per mile of plant… meaning that rural areas will never see advanced wireline technologies without major construction and operation subsidies. Hence, the focus of this project on the use of wireless technologies.

Cost consideration (ROI) being the driving force behind the use of wireless technologies, it is a fair question to ask why it is not (widely) used for serving more densely populated areas. The "oversimplified" answer is that wireless can suffer from reception issues, interference from non-related sources, bandwidth (capacity) restrictions, and other specific issues related to their operating frequencies. WiMAX type providers such as ClearWire do operate but have not seen a large success due to several factors, the most telling of which is competition from entrenched wired providers offering multiple services and higher bandwidths. Experience with individual installations shows that the service either works well from a given location or is a constant source of irritation and customer service issues leading either to a concerted effort by the provider to remedy the reception problem or a disconnect by the customer. Neither is ideal.

The very latest technology for wireless broadband delivery is attempting to address both bandwidth and reception concerns. Reception issues center around "non-line of sight" and reflection/multipath issues. Lower frequencies offer better non-line of sight performance but tend to increase reflection/multipath issues in many terrains, particularly the mountainous terrain encountered by the partners in this program. Algorithms to help the radios decipher which signal is which are employed but the key at this time appears to be finding the right balance of algorithm and frequency for the terrain encountered. All of the newly reclaimed "TV whitespace" frequencies, a key feature of this program, operate with FCC Experimental license, until formally released for public use by the FCC.

Wireless Technologies (2.4 GHz, 5.8 GHz, 900 MHz, Licensed, or Whitespace)

There are many wireless technologies available on the market which can be used to deliver broadband access to subscribers. Some of these technologies use frequency bands that are used in standard laptops and cordless phones while others are licensed and have a cost associated with the licensing of the frequency. Chances are if you are in a rural location you shouldn't have a problem using an unlicensed frequency. If you are in a heavily populated area you probably need to look into licensing a frequency to use. Below we will attempt to explain the differences between the various technologies and frequency bands.

2.4 GHz

2.4 GHz is the most commonly used unlicensed frequency. There are many options for broadband radio equipment in this frequency range. It also has the lowest cost equipment when it comes to broadband deployment. The primary drawback to the 2.4 GHz frequency is that lots of devices use the frequency including home wireless routers, cordless phones, microwave ovens, etc. In many cases the use of 2.4 GHz equipment will suffice for a small broadband deployment, though care should be taken when utilizing this choice.

5.8 GHz

5.8 GHz has become the second most commonly used frequency as more and more cordless phone makers have started using the frequency. There are many high capacity products on the market for wireless broadband equipment in this frequency. This makes the 5.8 GHz frequency great for providing Point to Point backhaul connections. The main drawback to this range is the inability for the frequency to penetrate foliage and other obstacles. Care should be taken when selecting this frequency for end user delivery as clear line of sight is normally needed in order to have a reliable connection.

900 MHz

Though the 900 MHz frequency was at one time the most widely used frequency for cordless phones and many other devices, many companies have abandoned the frequency as there isn't

enough space in the frequency to operate at high bandwidth rates. Due to the 900 MHz frequency being low in the spectrum, it is much better for use in rugged terrain areas due to its high penetration capabilities. Though due to its limited spectrum, care should be taken when planning a rural wireless broadband deployment in which there are many subscribers.

Licensed

Utilizing a licensed frequency is the best case scenario available when creating a wireless broadband deployment. The amount of frequency needed and power output can be determined prior to licensing the frequency. The major drawback to utilizing licensed spectrum is the cost of licensing the spectrum as well as the cost of having wireless equipment manufactured to operate in the frequency. In most cases it would normally require a larger business based model in order to utilize licensed spectrum due to the high costs associated with the option.

Whitespace

Whitespace is the newest frequency area to hit the wireless broadband market. As of this writing manufacturers are still in the process of obtaining final licenses to sell their products to the general public. Due to whitespace devices operating in the 50 – 700 MHz range they will be of special interest to rural wireless broadband operators. The lower frequency range will enable the devices to penetrate foliage and other obstacles at an efficiency that currently no other devices on the market can compare with.

Types of Locations (Flat Open Space, Valley, Rugged Mountainous Terrain)

Though there are various different topographies that may be of interest, we will cover the most likely scenarios that most people will encounter.

Flat Open Space

Flat open space is a relatively good scenario to have when trying to deploy wireless broadband. Though the flat topography is excellent for line of sight transmission, it also creates the need for a large tower structure in order to get the line of site which would allow for the use of lower cost standard wireless equipment.

Valley

A valley is probably the best scenario one can encounter when attempting to deliver wireless broadband. All one needs is the ability to locate the tower on a high point overlooking the valley they wish to serve. Since the land itself creates the height needed to adequately achieve a good line of sight, the tower can be much shorter in height.

Rugged Mountainous Terrain

Rugged mountainous terrain is the worst scenario one can encounter when trying to deploy a wireless broadband project. Due to the twisting landscape and usual heavy tree coverage, the number of towers and types of radio equipment needed, will almost certainly mean more money will be required to have a successful project.

Funding Sources (Grants, Loans, or Private Capitol)

There are three sources of funding we will explore in this document, Grants, Loans, and Private Capitol. Each of these resources have both positive and negative aspects associated with their use.

Grants

Grants are probably the best source of funding for a rural broadband startup. Since the possibility of being able to show a healthy profit is unlikely, it may lead to difficulties in obtaining loans. Though there are a handful of government grants available, foundations can be an excellent place to obtain small amounts of funding. Local foundations may be the easiest place to obtain funding as they are normally centered on enriching the lives of their local residents. The drawback to relying on grant funds is there is no guarantee a grant will be funded and a lot of resources and time can go into creating a successful grant application. It is highly recommended that you communicate with the funding agency or foundation prior to writing and submitting an application. In many cases successful communications with the foundation or agency prior to the application can have a significant impact on the chances of being awarded.

Loans

Loans can be a good place to obtain funding for larger operations which have decided on a business model approach and are unable to receive grant funds to cover their startup costs. Normally loans will require additional funding or assets to be used as collateral. In many cases a loan can be used in connection with a successful grant to cover the needed match or initial operating expenses.

Private Capitol

Private capitol can be hard to locate in large amounts for a rural broadband project. However for smaller broadband projects, one easy way to obtain private capitol is to have members of a community pre-sign up for service. An example would be to have everyone interested in obtaining service in a rural location, sign up for a waiting list in which they are willing to put a deposit toward the cost of their equipment and installation. If you have fifty people sign up at

four hundred dollars per person you would end up with twenty thousand dollars toward the project. Other sources of private capitol can come from yourself or interested parties that also live in the rural area or beyond.

Below are various grant and loan options that are available as of 2011.

Available Grants

- **USDA Community Connect Broadband Grant**
  Maximum Award Available as of 2011: $2,000,000.00
  Grant Amount: 85%
  Match Required: 15%
  Location: National
  Additional Information: http://www.rurdev.usda.gov/utp_commconnect.html

- **California Advanced Services Fund**
  Maximum Award Available as of 2011: Unknown
  Grant Amount: 40%
  Match Required: 60%
  Location: California
  Additional Information: http://www.rurdev.usda.gov/utp_commconnect.html

Available Loan Programs

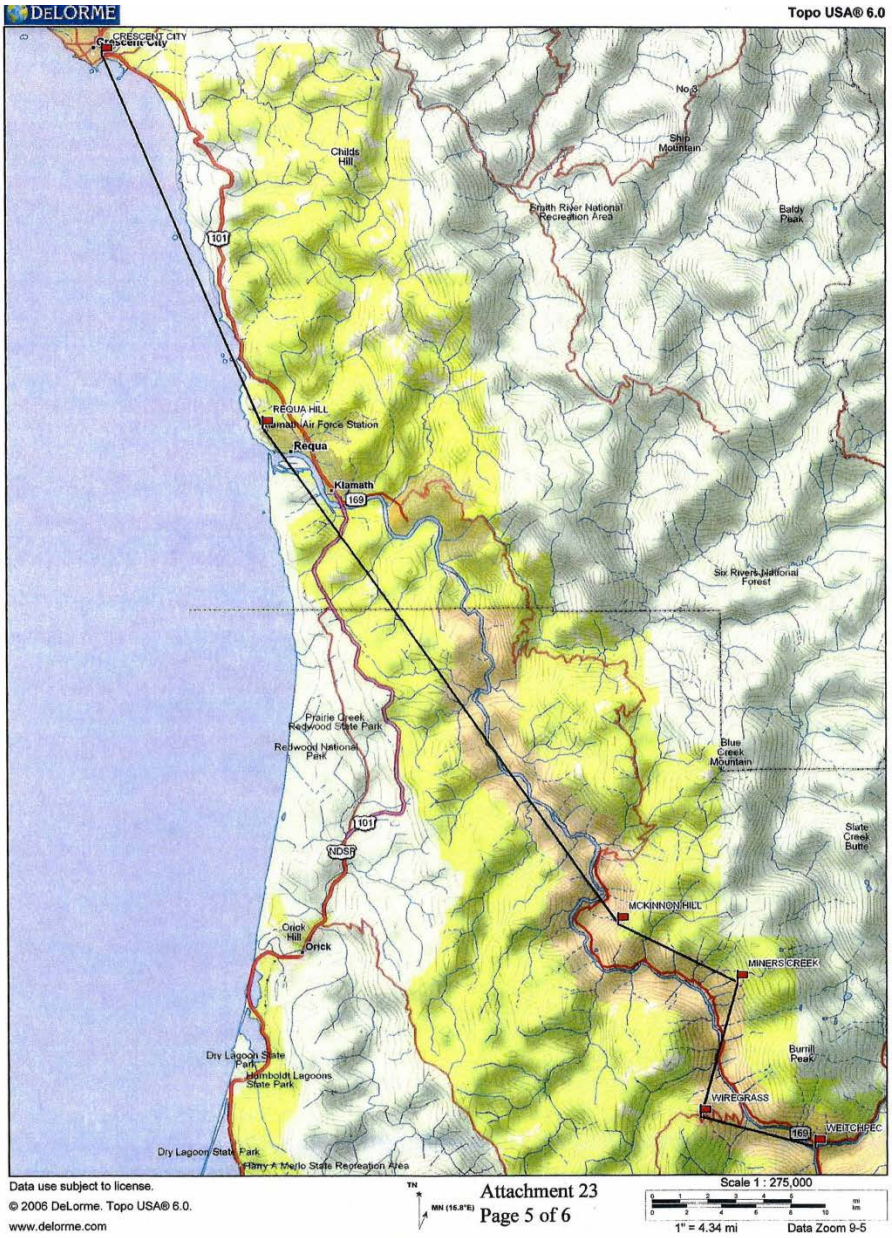
- **USDA Broadband Loan Program**
  Maximum Available as of 2011: Unknown
  Location: National
  Additional Information: http://www.rurdev.usda.gov/utp_farmbill.html

Creating Public Partnerships

Creating public partnerships is essential to creating a successful rural broadband deployment. Contacting your local county, city, or tribal government should be one of the first steps you take when trying to determine whether a wireless broadband deployment is feasible in your area. Chances are your local government wants to see ubiquitous broadband delivered in some fashion to its residents. In some cases local governments may be able to provide low or no cost access to government buildings and or structures which could be used to place wireless access points for subscribers. In other cases your local government may become what is known as an anchor tenant, a customer that uses a lot of bandwidth, and can pay you for what equates to a large portion of your backbone internet costs for them to receive service from you. You will undoubtedly need to contact your local government if you need to build a tower to determine environmental, cultural, scenic, and building code requirements.

Overview of the Yurok Tribe Wireless Broadband Model

The Yurok Tribe Reservation consists primarily of a tract of land lying 1 mile on each side of the Klamath River beginning at the mouth (where it empties into the Pacific Ocean) and stretching up river for 45 winding miles in rough, mountainous, heavily forested terrain. Small "nodes" of population dot the reservation, with relative "concentrations" near either end. The river is by no means straight, with hills or mountains rising straight up from the river in many areas. Some 90% of the reservation land area has no infrastructure (power, water, telecommunications) at all. What infrastructure does exist has inconsistencies- some have power but no telecommunications, some have water but no power, etc.



Attachment 23
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What communications (telephone/ T1 services) exist are supplied by conventional wireline phone companies who import their signals via point to point wireless systems that are both antiquated and at capacity. A T1 line,

when and where available, ranges in price from approximately $650 per month to more than $1200 per month, depending on the delivery site. Higher speeds are not available, and one or two T1's are not enough on which to base a broadband service. Therefore, the first priority was to discover a source of bandwidth and determine how to import that bandwidth to a location from which to effect delivery to customers, critical facilities, and Tribal government offices.

Most quotes for delivery of bandwidth to the reservation, when they were submitted at all, began near $1 million and went up… a non-starter for this project. The one technology currently proven to deliver bandwidth to the reservation- wireless point to point- required a mountain top with a "view" to a location that was served with sufficient bandwidth to supply the project needs. The Tribe did not originally own such a site but was able to acquire one via the de-commissioning of an old Air Force Radar site. (Please see the section, "Rural Broadband Operating Models (Business, Non Profit, or Public Utility)" as the business model chosen directly impacted the ability to access/acquire sites).

This site has poor "distribution" qualities, meaning that few potential customers can actually receive service directly from the site. It *is* able to connect directly to both the bandwidth source and two other "distribution/relay" tower sites which allow for connection to the "daisy chain" of towers running the length of the reservation and provide distribution to the customer base. A total of six towers are needed to provide suitable coverage for this project: three new ones and three pre-existing towers in various stages of need for upgrades or repair.

The logical architecture of the Yurok system is similar to the standard Ethernet network topology known as a "Star-Bus." There are several reasons for this option versus other possibilities. In addition to the provision of Internet services, the Yurok system is required to deliver "back bone" network connections for the Tribal offices at each end of the Reservation. Other topologies, including mesh, are not as efficient for this function. Another consideration is the distribution technology chosen for the system. This is a cutting edge "white space" frequency spectrum available for use only by FCC Experimental License and not yet adapted to other topologies.

Available Wireless Software Resources (Mapping Software, Coverage Estimators)

There are many resources available both free and at cost to determine coverage estimates for various wireless frequencies. Below are some recommendations for both free and at cost solutions.

Free Resources

- **Mapping Software**

- ***Google Earth***
  Great resource for mapping locations and preforming various calculations, free tutorials available online.
  Additional Information: http://www.google.com/earth/index.html

- **Coverage Software**

- ***CRC-COVWEB***
  Limited but easy to use online coverage estimator. No tutorial and limited instructions are available.
  Additional Information: http://lrcov.crc.ca
- ***Motorola Link Planner Software***
  Point to Point tool for calculating links between 2 locations using Motorola's lines of point to point radios.
  Additional Information:
  http://motorola.wirelessbroadbandsupport.com/support/ptp/linkplanner.php
- ***Radio Mobile***
  Powerful free radio coverage and mapping software. Difficult to use as it has a high learning curve, however there are how to tutorials available online.
  Additional Information: http://www.cplus.org/rmw/english1.html

At Cost Resources

- ### Mapping Software

- ***Delorme Topo North America***

  Great, easy to use, low cost resource for mapping locations and preforming line of sight profiles for point to point connections.

  Additional Information: http://www.delorme.com/

- ***ARCGIS***

  Extremely powerful mapping application, high cost, difficult to learn, can be used for preforming all kinds of calculations and creating all kinds of maps.

  Additional Information: http://www.esri.com/

Example Cost Estimates and Breakdowns for Towers and Associated Equipment

Though these costs will vary from location to location and need, these estimates can be used to determine a starting point from which a site can be designed. For this example we will be building 1 tower site on a piece of property that is already owned. The site will have the capability to serve up to 120 subscribers. The site estimate shown below assumes that electrical power is already close to the site in question and no major electrical extensions are required. All estimates include installation except for the Client Premise Equipment and Ethernet Equipment which would require installation on the part of the owner/ operator.

Sample Tower Site

Converted Cargo Container for Equipment Storage	12,000
Backup Generator with Automatic Transfer Switch	12,000
Equipment Rack	500
60ft Tower With Foundation	12,000
Uninterrupted Power Supply	1,000
Property Improvements	8,500
Environmental, Cultural, and Engineering Studies	5,000
Miscellaneous Equipment and Margin for Error	10,000
TOTAL	**61,000**

Sample Tower Site, Radio and Ethernet Equipment

4 Access Points	24,000
1 High Quality Point To Point Backhaul Link	12,000
Ethernet Switches, Routers, Etc.	10,000
TOTAL	**46,000**

Customer Premise Equipment

120 Wireless CPE Devices	48,000
Miscellaneous Installation Materials and Equipment	5,000
TOTAL	**53,000**

The grand total to build 1 complete tower with all the required equipment to serve up to 120 subscribers comes to $160,000.00 in our example. This amount will vary greatly depending upon the technology used and the cost of installation in your area.

Other typical startup costs include first year operating expenses and bandwidth costs which are listed below.

First Year Bandwidth - 20Mbps Fiber Connection	19,200
Customer Billing Software and Associated Billing Costs	10,000
Staff Wages – 2 Employees	80,000
Office Lease and Utilities	9,800
TOTAL	**119,000**