Tillamook County, Oregon

Public Safety Radio System Conceptual Design Report

Final

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Executive Summary

Tillamook County, Oregon (County) maintains multiple land mobile radio (LMR) systems to meet the specific operational needs of County departments, including Emergency Medical Services (EMS), Fire, Public Works and Sheriff. There are separate LMR channels for Fire/EMS, Public Works and Law Enforcement that provide voice communications between radio users in the field and Tillamook County Emergency Communications District (Tillamook 911) dispatchers. A microwave radio and fiber optic backhaul system carries radio user voice signals between the LMR repeater sites and the Tillamook 911 dispatch consoles. Tillamook 911 owns and operates the microwave backhaul system and Tillamook Lightwave, a special district that was set up between the County, Tillamook People's Utility District (PUD) and the Port of Tillamook Bay, owns and operates the fiber optic system.

Most of the LMR, microwave backhaul and dispatch equipment is at or near end of product lifecycle[1] and requires replacement. The County radio system users are experiencing inadequate radio coverage, as well as system operational and reliability issues.

To address these issues, the County contracted with Federal Engineering, Inc. (***FE***) to assess their existing LMR and microwave radio backhaul systems, identify current and future stakeholder needs and assist in determining the best course of action for the upgrade or replacement of the system

Needs Assessment and System Analysis

Initially, ***FE*** completed an assessment of the County's existing LMR and microwave backhaul systems and stakeholder needs. We documented the results of this assessment in the *Public Safety Radio System Needs Assessment and System Analysis Report* delivered December 31, 2019. Key findings documented in the report include:

- Aging LMR and microwave backhaul equipment, with much of it at end of product lifecycle leaving the County at risk for potential system failures that cannot be repaired

[1] The end of a product lifecycle indicates that the technology in use may have reached obsolescence in that major system components lack manufacturer support and repair parts are in limited supply in the marketplace.

- Radio users experience insufficient radio coverage
- Radio users have to constantly switch channels when roaming from one site to another
- The backhaul system, connecting most of the LMR sites, needs path redundancy to provide alternate routes to key LMR sites in the event of a primary path failure
- In order to improve communications between dispatch and the radio users, all transmit/receive LMR sites should be connected to the backhaul network
- The County does not have a network management system that allows maintenance staff to remotely monitor and troubleshoot LMR and microwave radio equipment

Following the review and acceptance of the *Public Safety Radio System Needs Assessment and System Analysis Report*, ***FE*** conducted a series of discussions with the County to identify feasible alternatives for the upgrade or replacement of the County LMR system. ***FE*** documents our alternatives analyses and recommendations in this *Public Safety Radio System Conceptual Design Report*.

LMR System Alternatives

FE evaluated three LMR system alternatives which are referred to as follows:

- Alternative 1a – VHF Analog Conventional Simulcast System
- Alternative 1b – VHF P25 Digital Conventional System
- Alternative 2 – VHF P25 Trunked Digital Simulcast System

Each of these alternatives address existing system vulnerabilities by providing:

- New LMR and microwave equipment
- Improved radio coverage
- Reduced manual intervention by radio user for site selection
- An IP-based backhaul system connecting all sites with increased capacity and path redundancy

- A network management system to remotely monitor/troubleshoot equipment and monitor site alarms

The three most feasible alternatives considered are outlined below.

Alternative 1a – VHF Analog Conventional Simulcast System

Alternative 1a comprises a new VHF analog conventional simulcast system equipped with the following VHF analog simulcast/voted channels:

- Fire/EMS Dispatch
- Law – Sheriff and police departments
- Operations – four channels for use by EMS, Fire, Sheriff/police departments
- Public Works

This configuration includes a North cell and a South cell. Each cell would transmit all radio traffic from Tillamook 911 and radio users on all repeaters in the cells simultaneously (i.e. simulcast).

Alternative 1b – VHF P25 Digital Conventional System

Alternative 1b would be the same as Alternative 1a, except that Alternative 1b would use Association of Public Safety Officials (APCO) Project 25 (P25) digital conventional radios instead of analog conventional technology. Alternative 1b would have the same set of channels and sites, with North and South simulcast cells.

Alternative 1b would provide additional features not available on an analog conventional system, such as emergency call and encryption.

Alternative 2 – VHF P25 Digital Trunked Digital Simulcast System

Alternative 2 would be a 3-channel VHF P25 Phase 2 digital trunked radio system. Radio talkgroups would replace dedicated radio channels. Alternative 2 would use the same sites as Alternatives 1a and 1b and would use the same two-cell simulcast design. However, the trunked radio system would allow all users in a talkgroup to communicate with one another and roam without manual intervention throughout the County's coverage footprint. In addition to the features described in Alternatives 1a and 1b, Alternative 2 provides other P25 trunking features, such as individual call, user status, call alert, radio inhibit and short status messages. The use of P25 Phase 2 technology also requires less fixed network equipment at a tower site to accommodate a given number of users than

the other alternatives mentioned. This typically results in lifecycle cost savings due to less maintenance as well as less shelter space requirements and electrical costs.

LMR System Alternatives Comparison

Each LMR alternative includes new equipment (i.e. dispatch consoles, microwave backhaul and LMR radios, antenna systems and DC power) and radio site improvements to support the new LMR and microwave backhaul systems. Table 1 compares key attributes for the three LMR upgrade alternatives.

Table 1 – Comparison of LMR System Alternatives

	Alternative 1a	Alternative 1b	Alternative 2
Description	7-channel analog conventional simulcast system	7-channel P25 digital conventional simulcast system	3-channel P25 Phase 2 trunked simulcast system
Coverage	Improved countywide mobile and portable coverage over the existing system		
Operational Issues	• Reduces the degree of manual selection on user radios • Allows radio users to hear all traffic in a cell (North or South) • Provides repeated channels for Fire TAC		• Allows all users on a talkgroup to communicate and roam without manual intervention • Could create countywide Fire TAC talkgroups
Dispatch Consoles	Existing consoles could be used until able to replace them	Requires new P25 compatible consoles	
Subscriber Units	Existing radios could be used until able to replace them	Requires new P25 compatible subscriber units	
Interoperability	County would program other agencies channels into their radios and vice versa	• Allows Interoperability with other P25 systems • Radios could include VHF analog channels for interoperability	• Allows Interoperability with other P25 systems • Conventional channel gateways could be used for interop on analog channels
Features	Same as existing system	• Emergency call and encryption	• P25 trunking features such as emergency call, individual call, encryption, over-the-air rekeying (OTAR), user status, call alert, radio inhibit and short status messages
Backhaul	Would provide a new IP-based backhaul system with additional capacity and path redundancy		
NMS	New NMS would allow County staff to remotely monitor/troubleshoot new equipment and monitor site alarms		
Estimated Total Cost	**$13.9 million**	**$15.7 million**	**$16.7 million**

Recommendation

All three alternatives presented in this report provide improved countywide mobile and portable radio coverage and system reliability compared to the existing system. Each alternative includes new dispatch consoles and subscriber unit equipment, a new IP-based microwave radio backhaul system and a new network management system.

Based on the results of the County's needs assessment and their stated long-term goals, Alternative 2, a countywide VHF P25 Phase 2 digital trunked simulcast radio system best meets the County's requirements. Alternative 2:

- Provides a modern, industry-standard P25 digital trunked radio system to meet the County's radio system requirements for 10 to 15 years
- Provides improved radio coverage over the existing analog conventional system
- Resolves current operational issues by allowing radio users to hear all traffic on a talkgroup and to seamlessly roam throughout the County's coverage footprint without needing to change channels on their radios
- Allows interoperability between all County departments and other agencies authorized to use the system
- Allows for the creation of countywide Fire tactical talkgroups
- Provides P25 trunking features, such as emergency call, individual call, encryption, user status, call alert, radio inhibit and short status messages

Next Steps

Once the County chooses an upgrade alternative and obtains approval from the County Board of County Commissioners to move forward in the project, the next step would be for the County to commit funding for the selected alternative. The next step involves developing the appropriate procurement documents to solicit vendor responses for evaluation. Upon selection of a vendor, the County negotiates a contract with the vendor, finalizes the detailed design and orders the equipment. Once the equipment is ordered, provided no unexpected site acquisition or spectrum issues arise during the process, systems of this size typically require 24-36 months for installation, system acceptance, and cutover.

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1. Project Background

1.1 Introduction

Tillamook County (County) contracted with Federal Engineering (***FE***) to assess the existing County land mobile radio (LMR) system and the Tillamook County Emergency Communications District (Tillamook 911) microwave radio system, and to assist the County in determining the best course of action for their upgrade or replacement. ***FE*** completed this *Tillamook County Public Safety Radio System Conceptual Design Report* to document the results of our alternatives analysis and recommendations. Our analysis is based on the County stakeholder needs as identified in the *Tillamook County Public Safety Radio System Needs Assessment and System Analysis Report* completed by ***FE*** in February 2020.

1.2 Existing Systems

The County has a VHF High Band analog conventional LMR system with the following channels:

- Fire Dispatch – countywide channel used by Emergency Medical Services (EMS) agencies and local fire districts/departments in the County
- Public Works – countywide channel for County Public Works
- Sheriff's Office (SO) – primary countywide channel used by the Sheriff and local police departments in the County
- SO #2 – a backup countywide channel used by the Sheriff and local police departments in the County, which is assigned by Tillamook 911 dispatchers on an as-needed basis
- General – a countywide channel that was used by County radio maintenance staff in the past but is now available for reassignment
- Fire Tactical (TAC) 1A, 2, 3, 3A, 6, 6W and 6S - single-site repeated TAC channels used in different areas of the County

A combination of microwave radio, fiber optic cable and VHF High Band control station links are used to connect the dispatch consoles at the Tillamook 911 dispatch center to the repeaters. Tillamook 911 owns and operates the microwave backhaul system and Tillamook Lightwave owns and operates the fiber optic system. Tillamook 911 provides dispatch services on all channels listed above.

Refer to the *Tillamook County Public Safety Radio System Needs Assessment and System Analysis Report* for additional detail on the County's existing systems, including an assessment of existing sites.

1.3 LMR System Alternatives

Based on the assessment performed during the Needs Assessment and System Analysis phase of this project, ***FE*** and the County agreed that ***FE*** would analyze the following LMR system alternatives:

- **Alternative 1** – Replace all existing VHF analog conventional channels with countywide VHF conventional simulcast/voted channels. Two sub-alternatives are presented; Alternative 1a is analog conventional and Alternative 1b is P25 digital conventional

- **Alternative 2** – Replace all existing VHF analog conventional channels with a shared VHF Association of Public Safety Officials (APCO) Project 25[2] (P25) Phase 2 digital simulcast/voted trunked system

1.4 Project Approach

FE performed the following steps to analyze LMR and microwave backhaul system alternatives and to present a recommended solution:

- Radio Coverage Analysis – ***FE*** conducted a computer-based radio coverage analysis to identify the specific sites and equipment required to meet the County's coverage requirements, as follows:

    - Worked with County stakeholders to define their radio coverage requirements and to identify existing radio coverage problem areas

    - Identified potential repeater and receive-only (Rx-only) sites to meet the County's coverage requirements

    - Produced radio coverage maps and developed a preliminary list of sites for the system upgrade alternatives

[2] P25 is a suite of standards developed by the Telecommunications Industry Association (TIA) to describe aspects such as the radio air interface, trunking functionality and open system interfaces to allow multi-vendor systems.

  - Conducted a radio coverage workshop with the County to present the initial results and obtain feedback on ***FE's*** initial choice of radio sites, and to identify other radio sites to cover specific areas

  - Based on input received from the County at the coverage workshop, ***FE*** completed the coverage analysis and developed a final list of radio sites for the system upgrade alternatives

- Channel Capacity Analysis – ***FE*** used existing and projected subscriber unit quantities and input received from County stakeholders to estimate the required number of channels for each LMR system upgrade alternative

- LMR Conceptual Design – ***FE*** developed the conceptual design for the two LMR alternatives, including the design criteria, system architecture, description of all equipment and how it functions as part of the system, and a high-level migration plan describing the steps needed to transition from the existing system to the new system

- Microwave Backhaul Analysis – ***FE*** analyzed alternatives to upgrade the Tillamook 911 microwave backhaul system to provide connectivity between the Tillamook 911 dispatch center and LMR sites, with additional paths for increased system reliability

- Cost Analysis – ***FE*** analyzed and presented the estimated cost of each alternative based on our experience with the design of LMR and microwave radio systems and publicly available industry information

- Alternatives Comparison and Recommendation – ***FE*** compared the functionality, features, operational characteristics and cost for the LMR system alternatives and recommended an alternative that would best meet the County's needs and requirements

- Next Steps – ***FE*** presented the next steps required to implement the recommended solution

2. Alternative 1a – VHF Analog Simulcast Conventional

2.1 System Summary

Alternative 1a would replace the existing General, Fire/EMS (dispatch and TAC), Public Works and Sheriff (SO and SO #2) channels with the following VHF analog simulcast/voted channels:

- Fire/EMS Dispatch
- Law – Sheriff and police departments
- Operations – four channels for use by EMS, Fire, Sheriff/police departments, as needed
- Public Works

There would be two simulcast cells, North and South. Each cell would transmit all radio traffic from Tillamook 911 and radio users on all repeaters in the cell simultaneously (i.e. simulcast). Receiver voting would be used to improve portable radio talkback coverage. Following is a summary of the VHF analog simulcast/voting system for Alternative 1a, which is presented in detail in the sections to follow:

- All existing County VHF channels would be reused for the new system and the County would need to license three additional channels
- Existing RF site equipment would be replaced for all channels
- New simulcast control and voting equipment would be installed for each new simulcast cell; one for the North, and one for the South
- A new Internet Protocol (IP)/Multi-Protocol Labeling System (MPLS) backhaul system would be installed to provide connectivity between Tillamook 911 and the VHF repeater, receiver and simulcast/voting control sites using existing Tillamook Lightwave fiber and new licensed microwave links
- All County dispatch consoles, which are near end-of-life, would be replaced
- Existing subscriber units, which are near end-of-life, would be replaced. However, existing subscriber units could be used on the new system until funding is available to replace them

- A network management system (NMS) would be installed to remotely monitor LMR, microwave and network equipment and alarms and to troubleshoot equipment failures

2.2 LMR System

2.2.1 Radio Coverage Analysis

2.2.1.1 Required Coverage

FE evaluated radio coverage to identify a set of repeater and receive (Rx)-only sites that would provide countywide mobile and on-street portable radio coverage, and in-building portable radio coverage in the population centers. Table 2 identifies the primary focus areas for radio coverage.

Table 2. Primary Focus Areas for Radio Coverage

Area	Population Centers	Highways	Other
North County	• Brighton, Manzanita, Nehalem and Wheeler	• Highway 53 from Highway 101 north to the County border	• Miami Foley Road, Foss Road • Northfork Road along Nehalem River • Short Sands/Smugglers Cove
Central County	• Bay City, Garibaldi, Netarts, Oceanside, Rockaway Beach and Tillamook	• Highway 6 from Highway 101 east to the County border • Highway 131 • Whiskey Creek/Cape Lookout Highway	• Bayocean Spit • Trask River Road to Recreation/County Park area (approximately 15 miles east of Tillamook) • Browns Camp to recreation area 10 miles northeast of South Saddle • Diamond Mill ATV recreation area 10 miles east of Triangulation Point
South County	• Beaver, Cloverdale, Hebo, Neskowin and Pacific City	• Highway 22 south from Highway 101 to Highway 130 • Highway 130 southeast from Highway 101 to the County border • Blaine Road/Upper Nestucca River Road from Highway 101 to County Border	• Sandlake Road
County		• Highway 101 through the County	

2.2.1.2 Methodology

FE produced the radio coverage maps in this section using ***FEPerformancePro***™ and high-resolution elevation and land use/cover data from the United States Geological Survey (USGS). ***FE*** used site information provided by the County and the technical parameters in Table 3 to model the coverage for the existing County LMR system.

Table 3 – Coverage Study Parameters

Parameter	Description
System Type	Conventional Analog
Frequency Band	VHF High Band
Channel Bandwidth	12.5 kHz
Reliability	95%
Audio Quality	Delivered Audio Quality (DAQ) – 3.4
Talk Paths	Mobile radio talk-out[3] Mobile radio talk-in[4] Portable radio talk-out, on-street Portable radio talk-in, on-street Portable radio talk-out, in light/residential buildings Portable radio talk-in, in light/residential buildings

Reliability is a measure of confidence in the signals in areas shown as covered on the maps and is based on recommendations from the Telecommunications Industry Association (TIA) TSB-88-D[5] suite of documents. In the case of public safety radio systems, TSB-88-D recommends 95% reliability, which means that users should be able to receive audio at Delivered Audio Quality (DAQ) 3.4 or better in any area that is deemed "covered" at least 95% of the time.

The coverage displayed on each map indicates the areas predicted to have audio quality greater than or equal to DAQ 3.4. DAQ is a measure of audio quality over a transmission medium, with different levels as shown in Table 4. DAQ 3.4 is the level most commonly used for public safety radio systems.

[3] Repeater to mobile and portable radio.
[4] Mobile and portable radio to repeater and receivers.
[5] TIA TSB-88 Wireless Communications Systems - *Performance in Noise and Interference-Limited Situations*

Table 4 – Delivered Audio Quality Definitions

DAQ Level	Definition
1.0	Unusable. Speech present but not understandable
2.0	Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion
3.0	Speech understandable with slight effort. Requires occasional repetition due to noise or distortion
3.4	Speech understandable without repetition. Some noise or distortion present. DAQ 3.4 is the minimum Channel Performance Criterion (CPC) used for public safety agencies.
4.0	Speech easily understandable. Little noise or distortion
5.0	Perfect. No distortion or noise discernible

FE used the mobile and portable radio parameters in Table 5 to model radio coverage.

Table 5 – Mobile and Portable Radio Parameters

Parameter	Mobile	Portable
Transmit Power (watts)	50	5
Receive Sensitivity (dBm)	-119	-119
Antenna Location	Roof	Hip
Antenna Gain (dB)	0	0
Body Loss (dB)	N/A	17.6

Following the analysis of existing system coverage, ***FE*** conducted a radio coverage workshop with County stakeholders to:

- Review the existing system coverage maps
- Identify areas with insufficient coverage
- Evaluate potential new sites to supplement coverage
- Identify a final set of sites that would best meet the County's coverage needs

2.2.1.3 Results

Results of the existing system analysis are in the *Needs Assessment and System Analysis Report*. The analysis of additional sites needed to meet the County's coverage requirements is presented in this section.

Based on ***FE's*** radio coverage analysis a two-cell (i.e. North and South) simulcast system would best meet the County's coverage requirements. Table 6 is a list of repeater and receive-only sites and the cell that each site would reside in.

Table 6 – Alternative 1a Site List

North Cell		South Cell	
Site	**Site Type**	**Site**	**Site Type**
Angora Peak	Repeater	ATC-ASR1217507	Repeater
City of Wheeler PW Dept.	Receiver	Bay City Fire Station 41	Receiver
Neahkahnie Mt.	Repeater	Cape Meares	Repeater
North County Recreation District	Receiver	Co Transportation	Receiver
Rockaway Beach City Hall	Receiver	Garibaldi FD	Receiver
South Saddle	Repeater	L-190	Repeater
T-Point	Receiver	Mt. Hebo	Repeater
Wilson River	Repeater	Nestucca Fire	Receiver
		PW Facility	Receiver
		Ridge Road	Receiver
		Tillamook 911	Repeater

The coverage maps below show mobile, on-street portable and in-building portable radio talk-out and talk-in coverage. Mobile radio talk-out and talk-in coverage are similar because the power output of a VHF mobile radio is typically about the same as the repeater (50 – 100 watts). However, portable radio talk-in coverage is less than talk-out due to the lower output power of a portable radio (typically 3 – 5 watts) as compared to the repeater. Also shown on the maps, mobile radio coverage exceeds on-street portable radio coverage due to higher radio output power and the use of a higher gain antenna, and on-street portable radio coverage exceeds in-building portable coverage due to the additional signal loss incurred when inside buildings. The coverage maps use the following colors to model coverage:

- Green - areas where users should be able to communicate using their portable radios when inside light-density and/or residential buildings. For these coverage prediction studies, ***FE*** used 13 dB to represent signal loss inside these types of buildings

- Yellow - areas where users should be able to communicate using their portable radios on the street (on-street portable coverage should also exist in all green areas)

- Purple - areas where users should be able to communicate using their mobile radios (mobile coverage should also exist in all green and yellow areas)

Note: The radio coverage portrayed by the maps in this section may vary from actual system coverage. Computer modeling cannot account for all variables, such as individual radio performance, electrical noise and radio RF interference. General loss factors are used for trees and buildings, but actual signal loss varies based on the type, height and density of the trees and buildings.

Figures 1 through 4 show the composite simulcast talk-out and talk-in coverage for the North and South cells. The coverage maps account for the possibility of time delay interference (TDI) within the simulcast cells. Thus, ***FE*** believes that the specified radio sites would provide the displayed coverage, provided the awarded vendor practices sound engineering to mitigate the possibility of TDI.

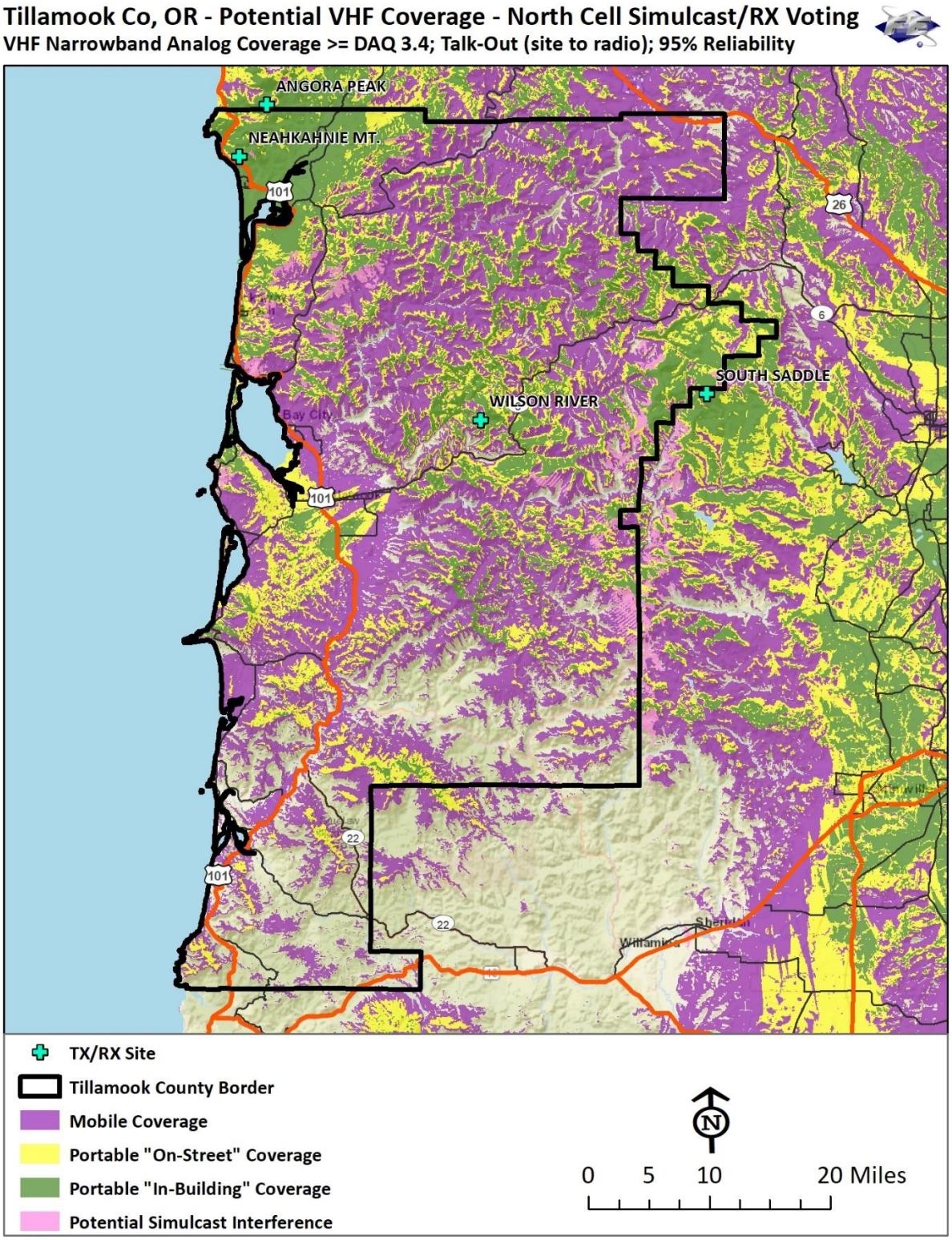


Figure 1 – North Cell Radio Coverage – Talk-Out

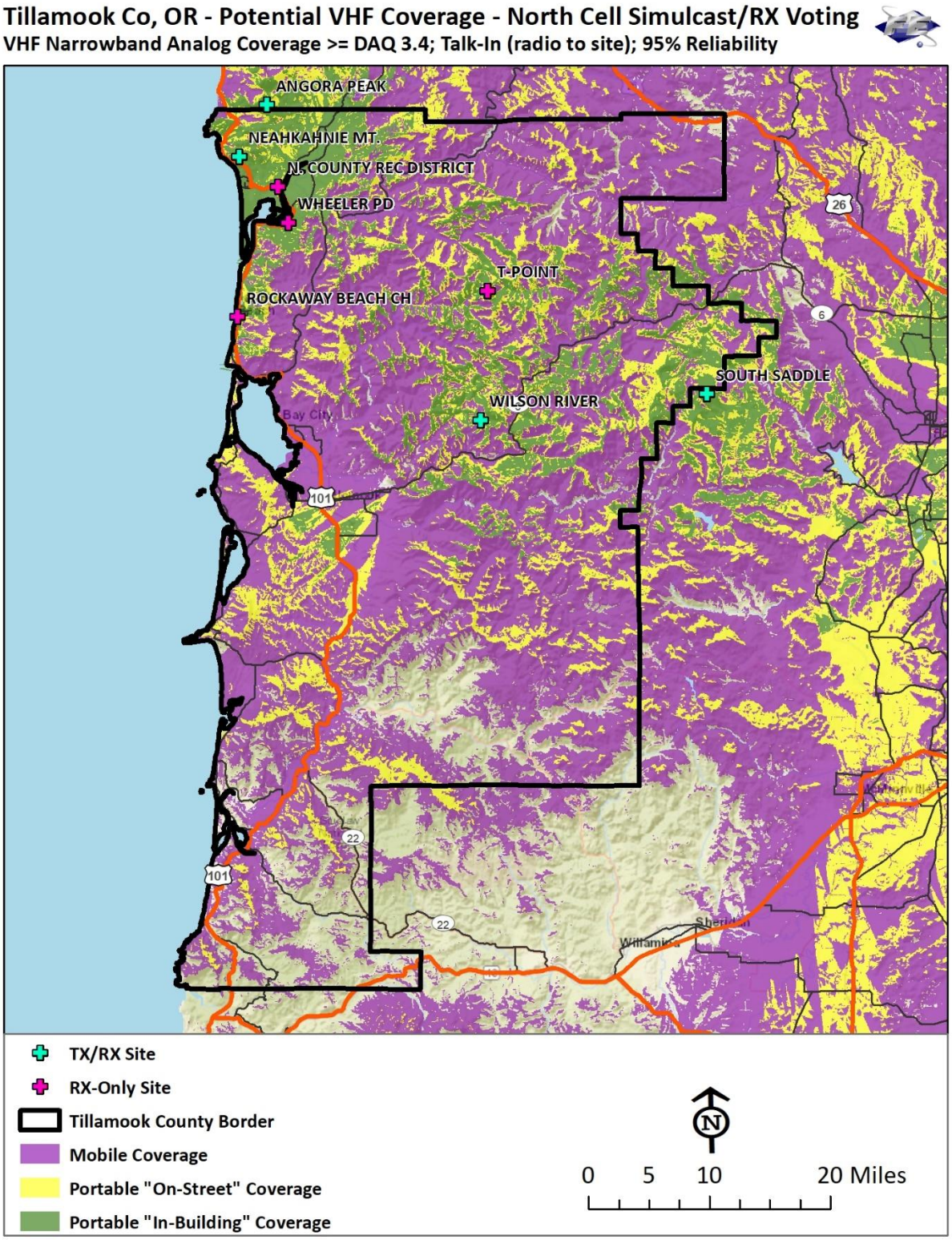


Figure 2 – North Cell Radio Coverage – Talk-In

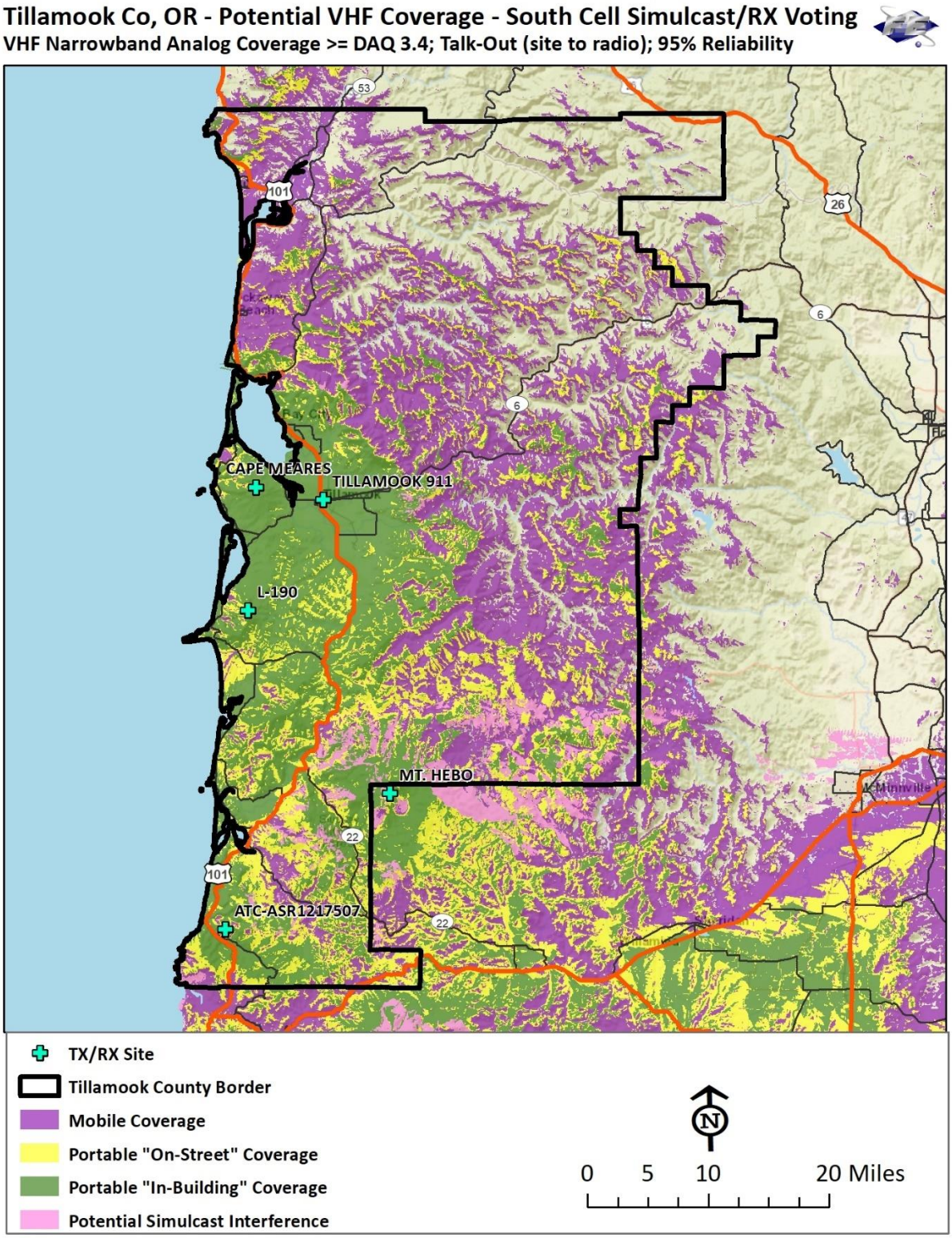


Figure 3 – South Cell Radio Coverage – Talk-Out

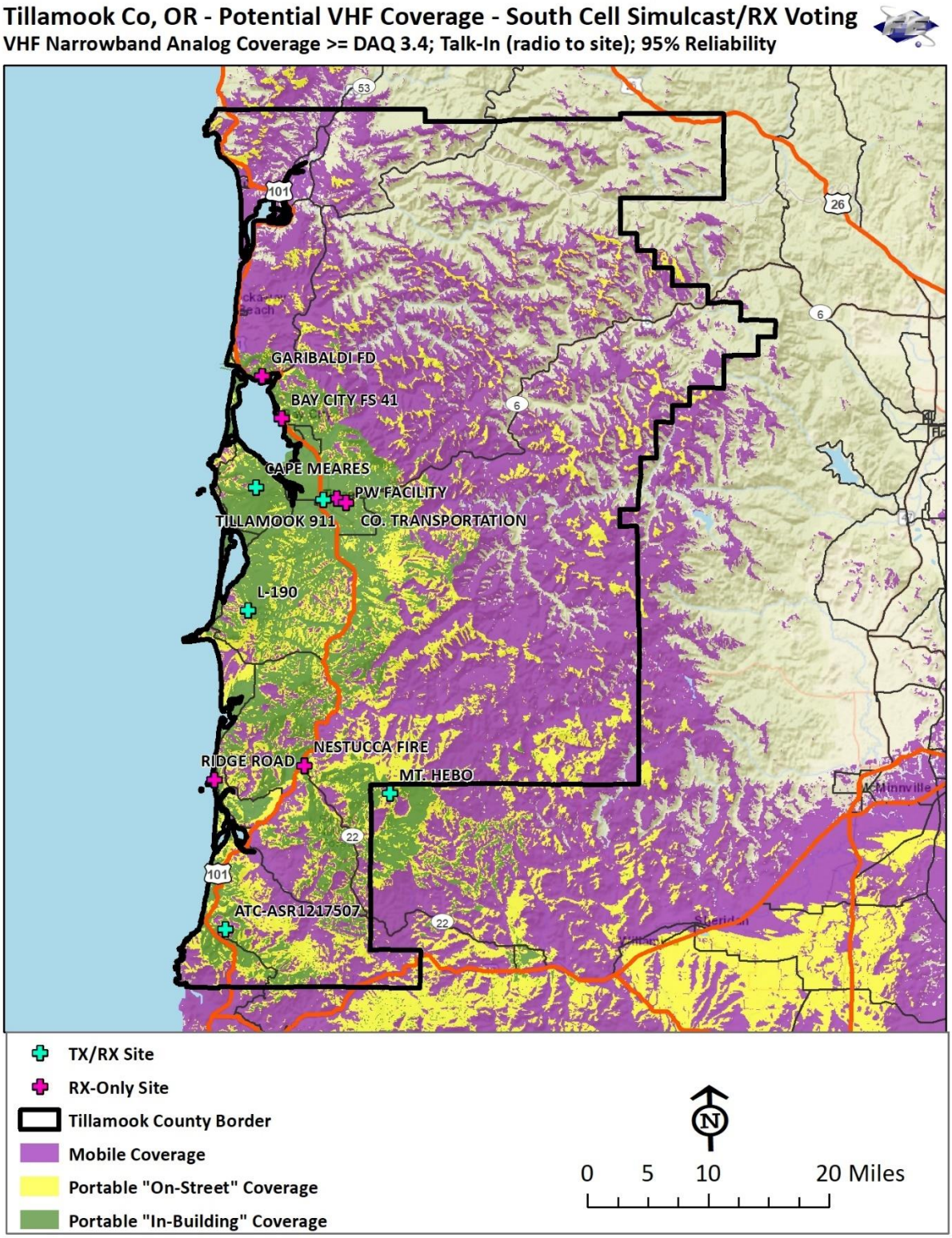


Figure 4 – South Cell Radio Coverage – Talk-In

2.2.2 Channel Capacity

As described above, the County has expressed the need for the following seven operational channels to meet their channel capacity needs:

- Fire/EMS Dispatch
- Law – Sheriff and police departments
- Operations – four channels for use by EMS, Fire, Sheriff and police departments, as needed
- Public Works

Therefore 14 channels would be required with seven channels in the North simulcast cell and seven channels in the South simulcast cell. All 11 existing County VHF channels will be used for the new system and so the County would need to license three new channels.

2.2.3 LMR System Design Criteria

FE used the following criteria for the VHF analog conventional system design for Alternative 1a:

- Install all new equipment (i.e. repeaters, antennas, feedline, transmitter combiners/receiver multicouplers, DC power, grounding/lightning protection) at all repeater and Rx-only sites
- Utilize existing County VHF radio channels and new channels licensed by the County

2.2.4 LMR System Architecture

Figure 5 shows the proposed architecture for the analog conventional simulcast system for Alternative 1a, including microwave backhaul connectivity. Refer to *Section 2.3, Backhaul System*, to additional detail on the microwave/fiber backhaul system design.

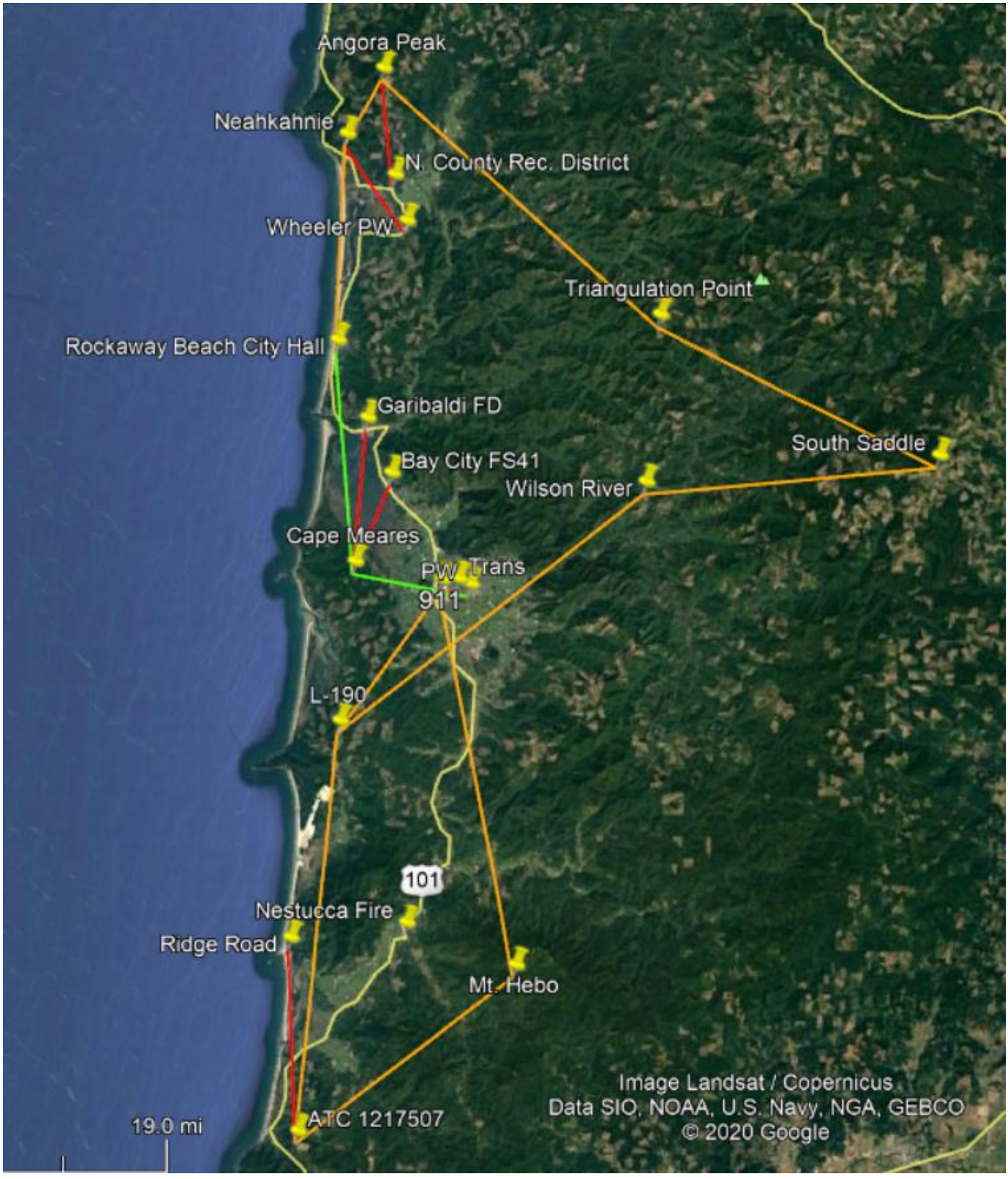


Figure 5 – LMR System Architecture Diagram

Orange lines on the diagram represent licensed 6, 11 and 18 GHz microwave links, red lines are licensed 900 MHz links to Rx-only sites and the green lines are existing Tillamook Lightwave fiber links. Refer to Table 5 to identify the sites in each simulcast cell and for the site type (repeater or receiver). Connectivity would be established to the Nestucca Fire Station using existing fiber cable owned by WAVE/Coastcomm, the same organization that provides fiber connectivity for many Tillamook County Government agencies/departments.

2.2.5 LMR System Equipment

2.2.5.1 Simulcast Control and Voting Equipment

A simulcast controller and voting comparators would be installed for the North and South cells. The simulcast controllers and voting comparators could be installed at any of the sites, however, ***FE*** recommends that they be installed at sites that are easily accessible during the winter and have commercial AC power and UPS or generator backup.

The simulcast controller maintains the frequency, phase and amplitude stability of the VHF repeaters to minimize audio distortion for mobile and portable radios in areas where the transmit signals from multiple repeaters overlap. The voting comparator selects the highest quality audio from multiple sites and routes the selected audio to the simulcast controller and dispatch consoles. The simulcast controller then routes the audio to all repeater sites for retransmission. Audio from the dispatch consoles is routed to the simulcast controller for broadcast. The backhaul system would be used to transport audio between repeater sites, simulcast controller/voter comparator sites and the dispatch consoles. Simulcast controller/voting comparator sites would also include a Global Positioning System (GPS) receiver with a high-stability oscillator.

2.2.5.2 Repeater and Receiver Site Equipment

All VHF repeater sites would be equipped with new equipment including:

- VHF analog repeaters and receivers that are capable of operating in analog conventional and P25 digital conventional modes, to allow the County to migrate from analog to digital in the future. The repeaters would also support both internet protocol (IP) and time division multiplex (TDM) backhaul interfaces but would be configured for IP

- VHF transmit and receive antennas, radio frequency (RF) cable and lightning protection devices (i.e. lightning arrestors and feedline ground kits). All channels at a site would use the same transmit and receive antennas, with the receive

antenna at the top of the tower and the transmit antenna mounted below the receive antenna with maximum separation to help mitigate RF interference

- Repeater sites would include a transmitter combiner and receiver multicoupler to mitigate RF site interference and allow all County repeaters to share the same transmit and receive antennas

2.2.6 Interoperability

Interoperability on the new system would be very similar to the existing system. County departments and other agencies using the County radio system would have the channels of other agencies that they need to interoperate programmed into their subscriber units and vice versa. In addition, the new system proposed for Alternative 1a would provide four new Operations channels that could be assigned for incidents requiring the response of multiple County and/or outside agencies.

2.2.7 System Features

The new VHF simulcast system would retain the existing analog conventional radio system features that the Fire, Public Works and Sheriff channels have today. However, operationally, radio users would only need to select between North and South cells and would no longer need to select individual repeaters based on location.

2.3 Backhaul System

FE evaluated alternatives to upgrade and expand the Tillamook 911 microwave backhaul system to provide connectivity between Tillamook 911 and the VHF repeater, receiver and simulcast/voting sites, and to increase system reliability by providing additional path redundancy. Refer to the *Needs Assessment and System Analysis Report* for a description of the existing Tillamook 911 microwave backhaul system.

2.3.1 Design Criteria

FE used the following criteria to develop the backhaul system conceptual design:

- New backhaul system would be IP/MPLS-based

- Utilize existing Tillamook Lightwave fiber from Tillamook 911 to County Courthouse to Cape Meares to Rockaway Beach City Hall, and Tillamook 911 to County Public Works

- Redundant paths to be established between Tillamook 911, the simulcast control/voting sites and VHF repeater sites with a minimum capacity of 155 Mbps
- Use unprotected (1+0) licensed 900 MHz microwave spurs to VHF receiver sites with a minimum capacity of 500 Kbps
- Install all new microwave radios, antenna systems (i.e. antennas, waveguide and dehydrators), DC power systems and network equipment (i.e. switches and MPLS routers)

2.3.2 System Architecture

Figure 6 is a logical diagram showing the connectivity between Tillamook 911, repeater and receiver sites. The proposed system architecture is composed of two interconnected rings, North and South, to provide alternate paths between key sites. Connecting the rings at two sites (Tillamook 911 and Cape Meares) eliminates single-points-of-failure, allowing traffic to pass across rings if one of the sites fails. Receiver sites with lower capacity requirements connect to one of the rings via a licensed 900 MHz microwave spur.

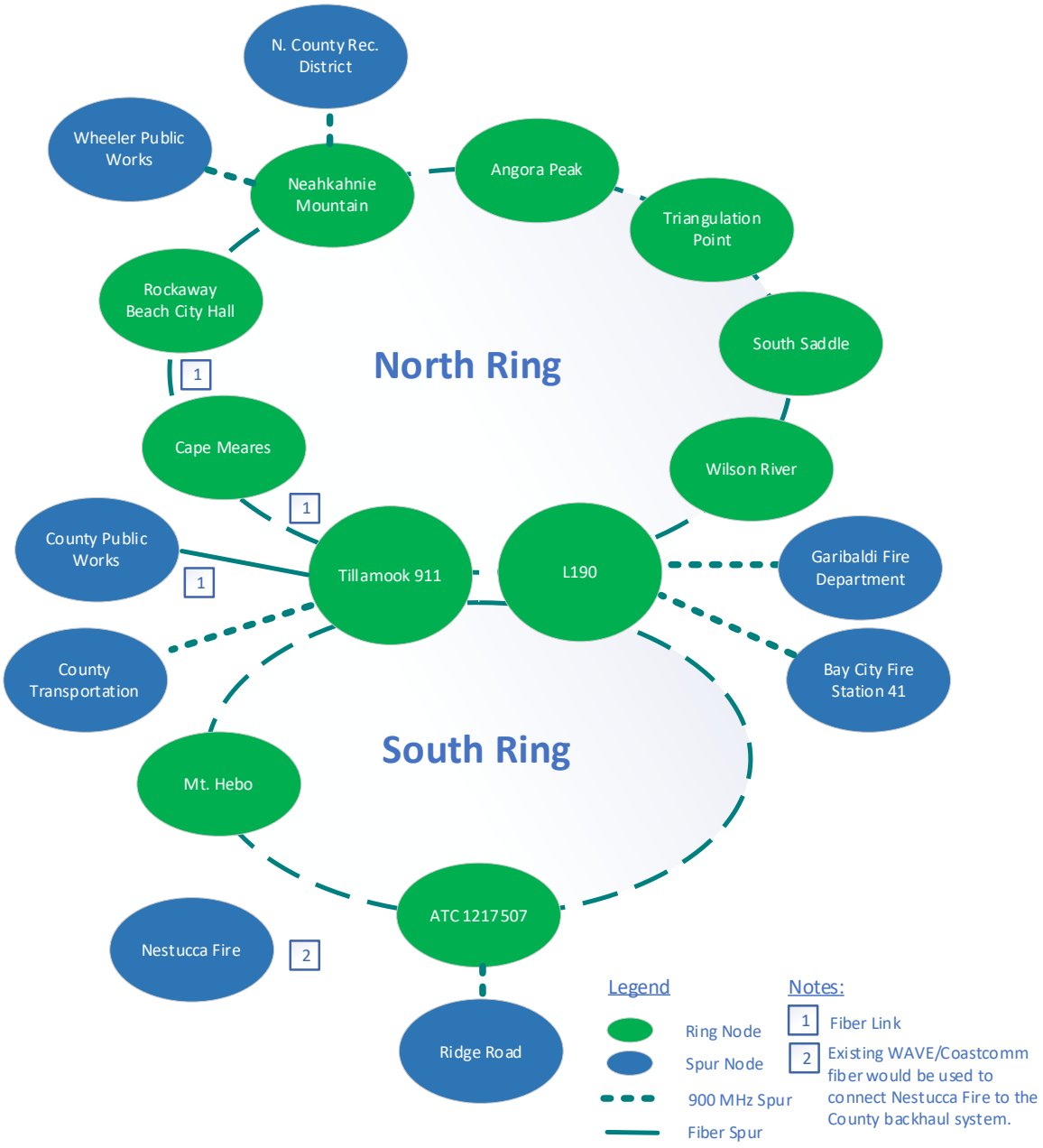


Figure 6. Backhaul System Logical Diagram

Figures 7 and 8 show the radio paths on each ring, along with spur paths off each ring. Figure 9 is a detail of the Tillamook area.

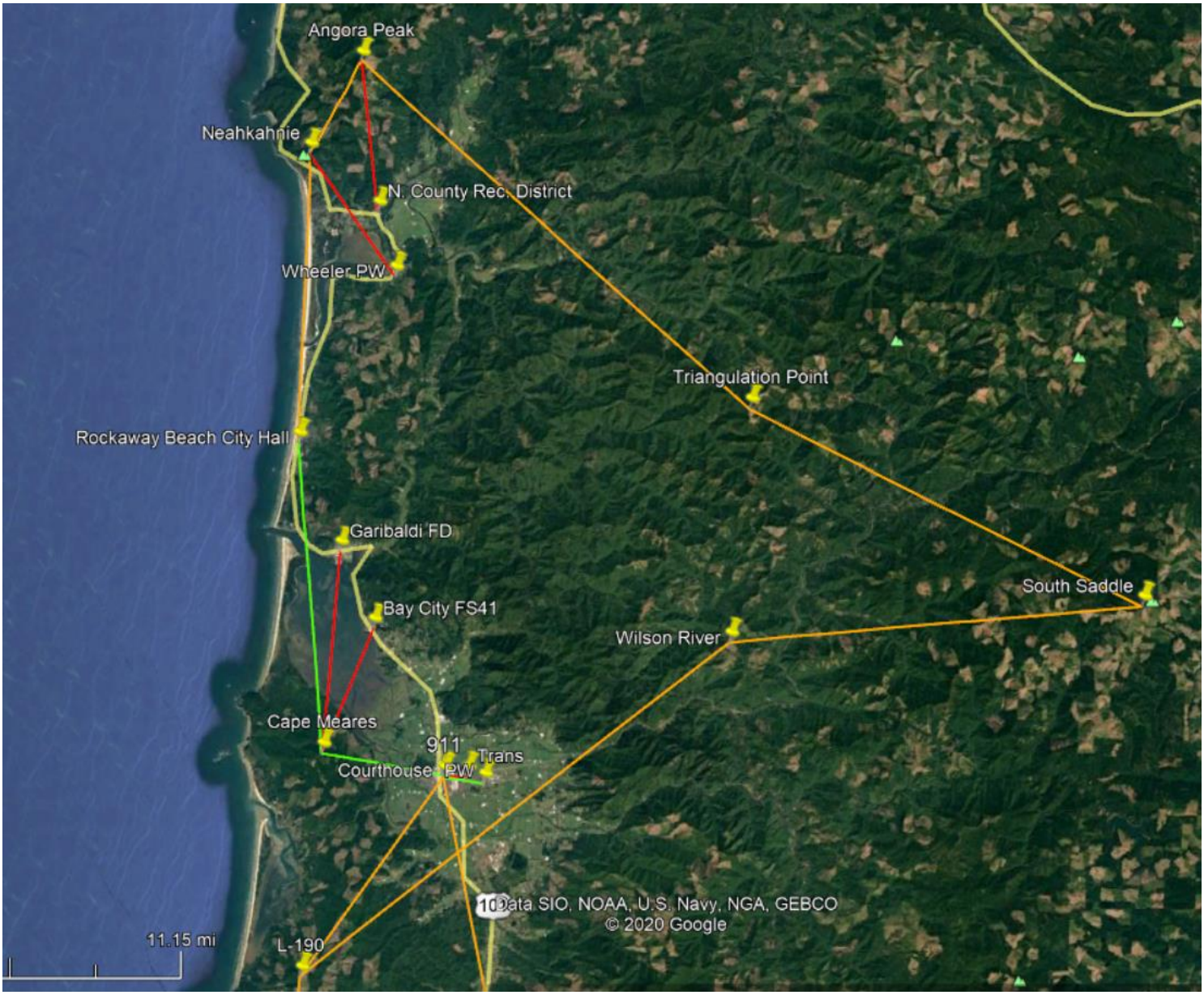


Figure 7 - Microwave Backhaul – North Ring

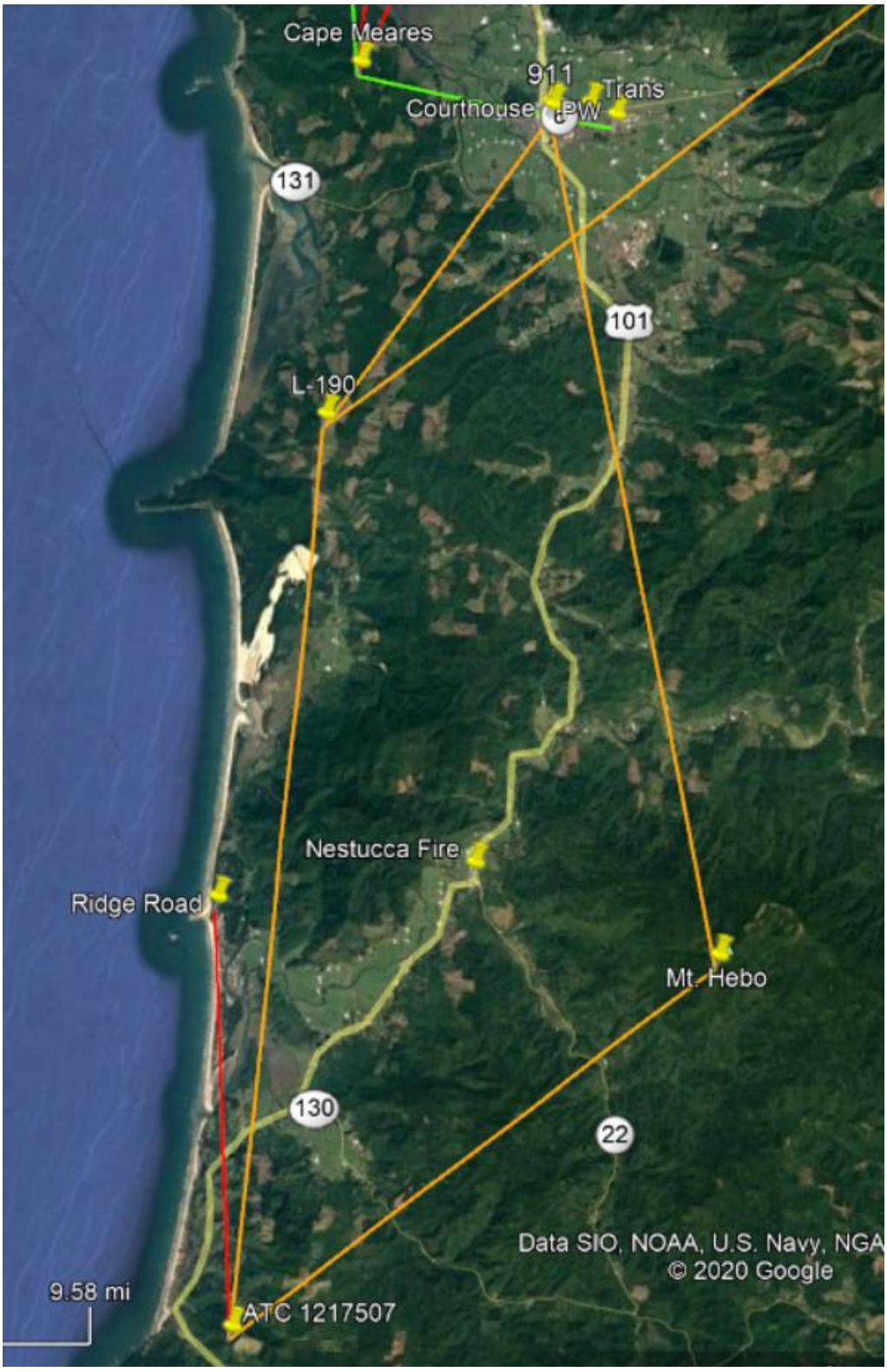


Figure 8 - Microwave Backhaul – South Ring

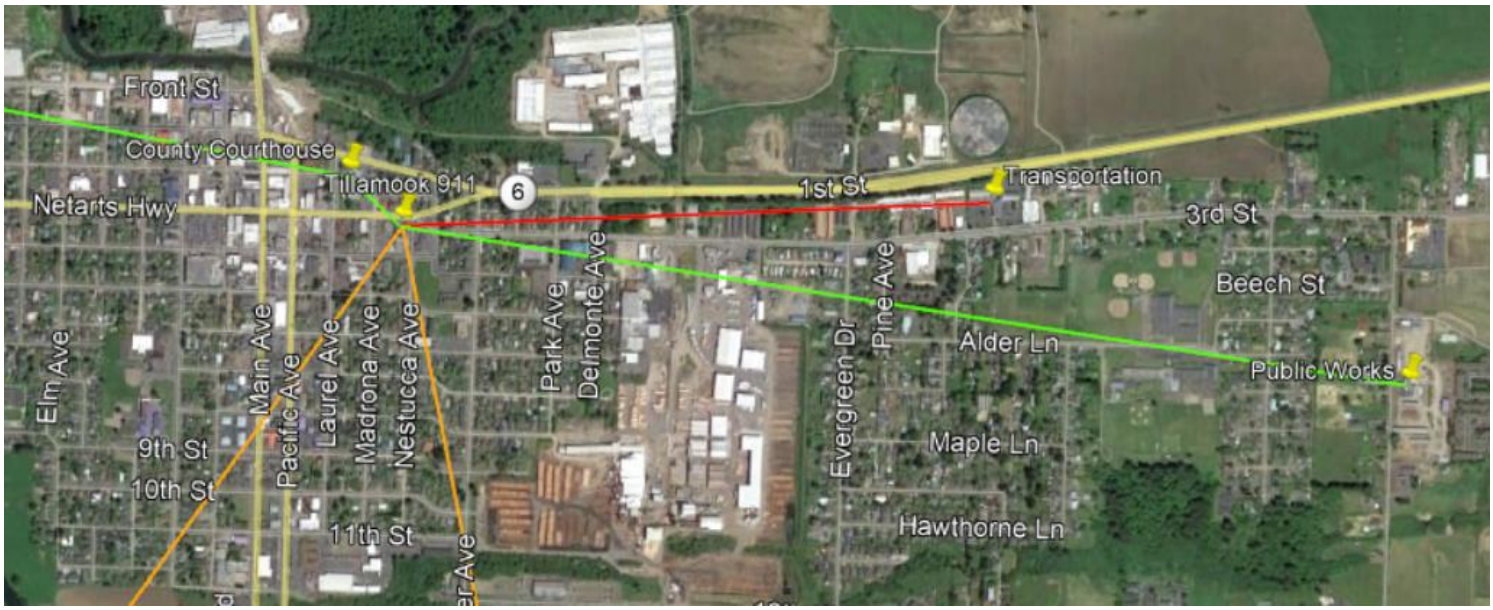


Figure 9 - Microwave Backhaul – Tillamook Area

2.3.3 Radio Path Analysis

FE analyzed each microwave radio link to assess adequate clearance above terrain and obstructions and calculate the predicted path availability. However, ***FE*** did not perform physical radio path surveys to identify the exact location and height of potential obstructions. The RFP for the procurement and installation of the new microwave radio system should require the awarded vendor to perform final path and system design, including physical path surveys. ***FE*** made the following assumptions to produce the path profiles and path calculations:

- Path availability goal of 99.999% for 6, 11 and 18 GHz paths (i.e. five 9's)
- 150 Mbps minimum capacity for links on a ring
- Licensed 900 MHz spur links to Rx-only sites
- 500 Kbps minimum capacity on links to Rx-only sites

FE modeled each path using single antennas and standard transmit power at both ends of each path. Tables 7 shows the results of the analysis all links on the North and South rings. Refer to Appendix A for the radio path profiles and path availability calculations.

Table 7 - Microwave Radio Path Analysis Summary

Microwave Path				Site A			Site B		
Site A	Site B	Frequency Band	Availability % (two-way)	Tower Height	Antenna Height	Antenna Size	Tower Height	Antenna Height	Antenna Size
Angora Peak	T-Point	6 GHz	99.998	35'	35'	4'	30'	30'	4'
T-Point	South Saddle	6 GHz	99.999	30'	30'	6'	40'	40'	4'
South Saddle	Wilson River	6 GHz	99.999	40'	40'	4'	100'	100'	4'
Wilson River	L-190	6 GHz	99.999	100'	60'	6'	50'	40'	4'
L-190	Tillamook 911	11 GHz	99.999	50’	40’	4’	125’	100’	4’
Rockaway City Hall	Neahkahnie	11 GHz	99.999	45'	55'	4'	30'	30'	4'
Neahkahnie	Angora Peak	18 GHz	99.999	30'	30'	2'	35'	35'	2'
Tillamook 911	Mt. Hebo	6 GHz	99.999	125'	100'	6'	60'	50'	6'
Mt. Hebo	ATC 1217507	11 GHz	99.997	60'	60'	4'	196'	195'	4'
ATC 1217507	L-190	6 GHz	99.999	196'	195'	6'	50'	50'	6'

Two paths, Angora Peak to Triangulation Point and Mt. Hebo to ATC 1217507, fall slightly below the 99.999% path availability goal. ***FE's*** analysis of these paths was based on 4’ diameter antennas at both ends of each path to minimize needed tower space and loading. Going to a 6’ diameter antenna at either end of the paths would bring the availability to 99.999%. Connectivity would be established to the Nestucca Fire Station using existing fiber cable owned by WAVE/Coastcomm and to County Public Works using existing Tillamook Lightwave fiber to Tillamook 911.

FE chose licensed 900 MHz spurs to connect the receiver sites to the backhaul system to minimize cost, tower loading, and space needed on existing structures/towers and in existing rooms/shelters. The limited channel capacity needed to the receiver sites also lends itself to licensed 900 MHz instead of the higher bands. Radios in the 900 MHz band typically offer bandwidths from 64 Kbps to about 1 Mbps, and radios in the 6 and 11 GHz band offer bandwidths of 150 Mbps and higher.

Use of radios in the 6, 11 and 18 GHz bands would require large microwave dish antennas, with radii from 2’ to 8’, whereas licensed 900 MHz radios can use much smaller panel or yagi antennas. The 900 MHz radios also require much less space and can use coaxial cable, as opposed to the larger and more cumbersome elliptical waveguide needed in the higher frequency bands. The 900 MHz radios, coaxial cable and antennas, and the installation cost is also much less expensive than for the higher frequency bands. Refer to Appendix B for the path profiles for the 900 MHz spur links.

2.3.4 Microwave Backhaul Equipment

Tillamook 911 and VHF repeater sites would be equipped with an IP switch and router. The switch would be used to connect the VHF repeaters, licensed microwave radios and/or dispatch consoles. The switch and all fiber links would connect to a router, which

would be used to select the best route between sites and to switch to an alternate route, as needed. In addition, VHF repeater sites would be equipped with the following licensed microwave equipment:

- A licensed 6, 11 or 18 GHz microwave radio for paths for links on a ring
- A licensed 900 MHz radio for links to receiver sites (both ends of the link)
- Microwave dish antennas and waveguide for 6, 11 and 18 GHz paths
- Yagi antennas and coaxial cable for licensed 900 MHz paths
- Dehydrators at all sites where new waveguide is installed

2.4 Dispatch Equipment

2.4.1 Design Criteria

FE used the following criteria for the dispatch center design for Alternative 1a:

- Tillamook 911 (Primary Dispatch)
    - Replace the existing Stancil logging recorder with new multimedia logging recorder, specifically for NG 9-1-1 and P25
    - Replace the four existing Motorola MCC 5500 consoles with four new mission-critical, IP-based dispatch consoles
    - Install one new backup control station for each dispatch console position, along with a new antenna system
    - Install new networking equipment (routers, switches and gateways) and uninterruptible power supplies (UPS)
    - Replace the six existing Motorola MIP 5000 consoles with 6 new deployable, IP-based dispatch consoles
- County Justice Facility (Backup Dispatch)
    - Replace the three existing Motorola CENTRACOM Gold Elite consoles with three new mission-critical, IP-based dispatch consoles

- Install one new backup control station for each dispatch console position, along with a new antenna system
- Install four additional control stations for four other phone/call taker positions, along with a new antenna system
- Install new networking equipment (routers, switches, and gateways) and UPS's

2.4.2 System Architecture

The conceptual design includes the replacement of the existing dispatch consoles at Tillamook 911 and the County Justice Facility. Both locations require a highly reliable dispatch system with no single point of failure, the design includes redundant networking equipment and backup RF control stations. The new console system would replace the existing backroom equipment with compact servers, routers, switches and computers. Each console position would retain all functionality of the existing consoles, with the following additions:

- Radio system talkgroup control
- Paging
- Fire station alerting
- Emergency alarms and calls
- Patching between talkgroups and conventional stations

Each console position would have a backup control station for use in the event of a console or microwave link failure to the core. These control stations would be multi-band units to allow for operation on analog or P25 digital systems on VHF, UHF and/or 700/800 MHz channels.

A new logging recorder would capture all radio traffic, 9-1-1 calls and administrative telephone traffic. The logging recorder would include redundant power supplies and redundant hard drives for a fault-tolerant recording solution. Multiple search parameters such as time and date, user ID, talkgroup ID and more would be available at personnel computers located on the network and containing the appropriate software license and login credentials.

2.5 Video Surveillance Equipment

Video surveillance equipment would be installed at Tillamook 911 and all VHF repeater sites, as follows:

- Video surveillance platform with only central recording capability
- Enterprise software (licenses) for up to 40 cameras
- 3 cameras at each of the 10 VHF repeater sites
- Tillamook 911 Server platforms for Base and Recorder (2 servers)
- Tillamook 911 cameras (up to 10)

2.6 Radio Site Improvements

Table 8 summarizes the radio site upgrades needed to support the Alternative 1 system upgrade. The site improvements are based on the site visits conducted by ***FE*** and documentation from the County and are included in the cost estimates. A "Y" in the table identifies needed items that are included in the cost estimates.

Table 8 – Alternative 1 - Required Site Improvements

Site Name	Tower					Shelter					Power				
	Existing Structure with Available Space	Structural Analysis Needed	Existing Tower Mods Needed	New Tower Needed	A&E, Environmental Compliance	Existing Shelter/Bldg. with Available Space	Site Grounding Updates	Existing Shelter Mods Needed	New Prefab Shelter Needed	New Outdoor Cabinet Needed	Commercial AC Power Available	New AC/Electrical Service Needed	New Generator Needed	New UPS System Needed	New Solar/DC System Needed
Angora Peak	Y	Y				Y	Y		Y		Y		Y		
ATC-ASR1217507	Y	Y				Y	Y				Y				
Bay City FD Station 41	Y	Y				Y	Y				Y				
Cape Meares	Y	Y				Y	Y				Y				
City of Wheeler PW Dept.	Y	Y				Y	Y				Y				
County Justice Facility	Y	Y				Y	Y				Y				
Co Transportation	Y	Y				Y	Y				Y				
Garibaldi FD	Y	Y				Y	Y				Y				
L-190 (DC/solar site)	Y	Y				Y	Y						Y		Y
Mt. Hebo	Y	Y				Y	Y				Y				
Neahkahnie Mt.	Y	Y		Y		Y	Y	Y			Y				Y
Nestucca Fire	Y	Y				Y	Y				Y				
North County Recreation District	Y	Y				Y	Y				Y				
PW Facility	Y	Y				Y	Y				Y				

Site Name	Tower					Shelter					Power				
	Existing Structure with Available Space	Structural Analysis Needed	Existing Tower Mods Needed	New Tower Needed	A&E, Environmental Compliance	Existing Shelter/Bldg. with Available Space	Site Grounding Updates	Existing Shelter Mods Needed	New Prefab Shelter Needed	New Outdoor Cabinet Needed	Commercial AC Power Available	New AC/Electrical Service Needed	New Generator Needed	New UPS System Needed	New Solar/DC System Needed
Ridge Road	Y	Y	Y				Y			Y	Y			Y	
Rockaway Beach City Hall	Y					Y	Y				Y				
South Saddle (assume new site)	Y					Y					Y				
Tillamook 911	Y	Y				Y	Y				Y				
Tillamook Co Courthouse	Y	Y				Y	Y				Y				
T-Point (DC/solar site)	Y	Y				Y	Y						Y		Y
Wilson River	Y	Y				Y					Y				

2.7 Network Management System

An NMS would allow County maintenance staff to remotely monitor the VHF, microwave and network equipment performance and site alarms (i.e. rectifier failure, elevated temperature, and site intrusion), and troubleshoot equipment outages using:

- A network management workstation
- Vendor proprietary software for the VHF repeater and backhaul equipment
- A remote terminal unit (RTU) for each site to monitor site alarms

2.8 Subscriber Units

Table 9 provides subscriber unit counts for the agencies or departments that use the County radio system.

Table 9 – Existing Subscriber Unit Inventory

Existing Subscriber Equipment Inventory					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Garibaldi FD	20	8	1	23	**52**
Manzanita PD	8	4	2	0	**14**
Bay City FD	24	4	1	27	**56**
Nehalem Bay Fire	64	15	0	50	**129**
Rockaway Fire	20	7	0	22	**49**
Rockaway PD	7	5	3	0	**15**

Existing Subscriber Equipment Inventory					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Tillamook County Parks	6	8	1	0	**15**
Tillamook Police	25	12	0	0	**37**
Tillamook County Public Works	17	64	7	0	**88**
Tillamook ECD 911*	2	0	13	0	**15**
Netarts/Oceanside Fire	37	8	6	34	**85**
Tillamook County Transportation District	6	27	4	0	**37**
Tillamook Fire District	64	28	3	77	**172**
Tillamook Sheriff's Office	65	55	5	0	**125**
Nestucca Fire	73	43	0	0	**116**
Total	**438**	**288**	**46**	**233**	**1005**
*Does not include 4 MCC5500 consoles and 6 MIP5000 consoles; those are captured in the dispatch section.					

Most of the existing subscriber equipment has reached or is near end of life, with limited or no support or parts from the manufacturers. While many radios could be re-used for analog operation, the County should consider replacing the subscriber units that are at or near end-of-life with new single-band VHF radios. The County should also consider purchasing P25 capable subscriber units to minimize the financial impact of implementing that technology in the future. Agencies or departments with newer Kenwood NEXEDGE® NX Series radios could re-use them on the new system.

The County should consider replacing existing Motorola MINITOR IV™ and MINITOR V™ pagers, which are also at end-of-life pagers. Agencies or departments with Motorola MINITOR VI™ pagers could re-use them on the new analog conventional system. Table 10 provides the recommended subscriber replacement counts by agency or department for Alternative 1a.

Table 10 – Alternative 1a Subscriber Replacement

Alternative 1a Subscriber Replacement					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Garibaldi FD	17	8	1	0	**26**
Manzanita PD	0	4	2	0	**6**
Bay City FD	24	4	1	12	**41**
Nehalem Bay Fire	64	15	0	0	**79**
Rockaway Fire	18	7	0	22	**47**
Rockaway PD	7	5	1	0	**13**
Tillamook County Parks	6	8	1	0	**15**
Tillamook Police	25	12	0	0	**37**

Alternative 1a Subscriber Replacement					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Tillamook County Public Works	17	64	7	0	**88**
Tillamook ECD 911*	2	0	11	0	**13**
Netarts/Oceanside Fire	37	8	6	22	**73**
Tillamook County Transportation District	0	0	0	0	**0**
Tillamook Fire District	64	28	3	46	**141**
Tillamook Sheriff's Office	55	55	5	0	**115**
Nestucca Fire	73	43	0	0	**116**
Total	**409**	**261**	**38**	**102**	**810**
*Does not include 4 MCC5500 consoles and 6 MIP5000 consoles; those are captured in the dispatch section.					

The cost estimate presented below includes the replacement of existing portables, mobiles, control/base stations, and pagers with P25-capable single-band VHF, mid-tier models with software to operate in analog mode. The use of mid-tier models provides a good average price point for budgetary purposes. Some departments may purchase low-tier models, while others may purchase high-tier models with added features. As part of the RFP, the County could specify the quantity and tier requirements for each department, which would allow the vendors to provide a more accurate cost proposal.

2.9 Cost Analysis

FE prepared high-level budgetary cost estimates using an in-house cost analysis tool for the replacement of the County VHF LMR radio system and microwave backhaul system, new dispatch and video surveillance equipment, site improvements, new subscriber units, and implementation services. The cost estimates are based on data collected from previous projects, our knowledge of the County system, our experience designing comparable radio systems, and publicly available industry information. Actual system costs are highly dependent on final system design choices as well as conditions in the LMR and microwave radio markets during the system procurement phase.

FE's budgetary estimates are intended to be conservative so that vendor proposal pricing does not exceed the estimates. The cost estimates reflect non-discounted (list) pricing with 10% contingency and no sales tax. Frequently, system vendors provide discounts for system and subscriber unit purchases of this size, typically in the 20% to 25% range, but ***FE*** has seen them higher. However, it is not possible to forecast the level of discount a vendor will offer at the time of proposal submission. Estimates for implementation services are based on a percentage of the total equipment cost. Percentages were established based on ***FE's*** experience on similar projects.

2.9.1 Cost Assumptions

Based on results from the coverage studies, analysis of existing inventory and feedback provided by the County, ***FE*** developed the following set of equipment- and services-related assumptions shown in Table 11 for the Alternative 1a cost estimates.

Table 11 – Alternative 1a Cost Assumptions

Alternative 1a Assumptions	Quantity	Notes
North Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Analog Voting Equipment	4	New equipment needed for new simulcast cell
Simulcast Networking Equipment	1	New equipment needed for new simulcast cell
7-Channel TX/RX Analog Simulcast Equipment	4	New 7-channel analog simulcast repeater system
7-Channel Analog Receive-Only Equipment	4	New 7-channel analog receiver system
Multi-channel VHF TX/RX Antenna System	4	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	4	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	8	New routing and switching equipment
FCC licensing and coordination	28	New VHF frequency for new transmit sites
South Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Voting Equipment	4	New equipment needed for new simulcast cell
Networking Equipment	1	New equipment needed for new simulcast cell
7-Channel TX/RX Analog Simulcast Equipment	5	New 7-channel analog simulcast repeater system
7-Channel Analog Receive-Only Equipment	6	New 7-channel Analog receiver system
Multi-channel VHF TX/RX Antenna System	5	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	6	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	11	New routing and switching equipment
FCC licensing and coordination	35	New VHF frequency for new transmit sites
Backhaul Network		
900 MHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites

Alternative 1a Assumptions	Quantity	Notes
6 GHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites
11 GHz 1+0 Radio	6	New backhaul equipment for connecting LMR sites
18 GHz 1+0 Radio	2	New backhaul equipment for connecting LMR sites
900 MHz Panel	12	New antennas/dishes for new backhaul equipment
6 GHz - 6' Single-Polarization	12	New antennas/dishes for new backhaul equipment
11 GHz - 6' Single-Polarization	6	New antennas/dishes for new backhaul equipment
18 GHz - 2' Dual-Polarization	2	New antennas/dishes for new backhaul equipment
Coaxial Cable and Accessories	14	New line & accessories for new backhaul equipment
Waveguide and Accessories	18	New line & accessories for new backhaul equipment
Medium DC Plant	11	New DC power system for new backhaul equipment
Small DC Plant	6	New DC power system for new backhaul equipment
Medium Rack and Accessories	11	New rack & accessories for new backhaul equipment
Small Rack and Accessories	6	New rack & accessories for new backhaul equipment
Medium MPLS Router	11	New MPLS router for new backhaul equipment
Small MPLS Router	6	New MPLS router for new backhaul equipment
Dehydrator System	11	New dehydrator system for new backhaul equipment
Video Surveillance		
Enterprise Software (Licenses) for up to 40 cameras	1	New video surveillance equipment for RF sites
3 cameras per sites for 10 sites (repeater sites only)	1	New video surveillance equipment for RF sites
Server platforms for Base and Recorder (2 servers)	1	New video surveillance equipment for Tillamook 911
Tillamook 911 cameras (up to 10)	1	New video surveillance equipment for Tillamook 911
Site Improvements		
Existing Structure with Available Space	20	Based on site surveys and/or County provided data
Structural Analysis Needed	19	Based on site surveys and/or County provided data
Existing Tower Mods Needed	1	Based on site surveys and/or County provided data
New Tower Structure Needed	1	Based on site surveys and/or County provided data
A&E, Environmental Compliance	0	Based on site surveys and/or County provided data
Existing Shelter/Bldg. with Available Space	19	Based on site surveys and/or County provided data
Site Grounding Updates	18	Based on site surveys and/or County provided data
Existing Shelter HVAC Needed	2	Based on site surveys and/or County provided data
New Prefab Shelter Needed	1	Based on site surveys and/or County provided data
New Outdoor Cabinet Needed	1	Based on site surveys and/or County provided data
Commercial AC Power Available	19	Based on site surveys and/or County provided data
New Generator Needed	3	Based on site surveys and/or County provided data
New Rackmount UPS Needed	1	Based on site surveys and/or County provided data
New DC System Needed	3	Based on site surveys and/or County provided data

Alternative 1a Assumptions	Quantity	Notes
Subscriber Equipment		
Portable Radios	409	Requires replacement with new P25 capable, single band VHF radios with software for analog operation
Mobile Radios	261	Requires replacement with new P25 capable, single band VHF radios with software for analog operation
Base/Control Stations	38	Requires replacement with new P25 capable, single band VHF radios with software for analog operation
Pagers	102	Requires replacement with new P25 capable, single band VHF pagers with software for analog operation
Implementation Services		
Spare / Test Equipment	5%	Based on total of all system components
Sales Tax	0%	Based on total of all system components
Project Management	10%	Based on total of all system components
Installation	10%	Based on total of all system components
Engineering	10%	Based on total of all system components
Removal of Existing Equipment	2%	Based on total of all system components
Training	1%	Based on total of all system components
Staging	5%	Based on total of all system components
Acceptance/Coverage Testing	1%	Based on total of all system components
Documentation	1%	Based on total of all system components
Contingency	10%	Based on total of all system components and implementation services

2.9.2 LMR System Cost

Table 12 shows the estimated cost for the new VHF LMR system equipment and implementation services needed for the Alternative 1a conceptual design.

Table 12 – Alternative 1a LMR System Cost Estimate

Alternative 1a Analog Simulcast Cost Estimate			
North Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$15,000	$60,000
Networking Equipment	1	$37,000	$37,000
7-CH TX/RX Simulcast Equipment	4	$152,000	$608,000
7-CH Receive-Only Equipment	4	$54,000	$216,000
VHF TX/RX Antenna System	4	$34,000	$136,000
VHF RX-only Antenna System	4	$14,000	$56,000
Site Networking Equipment	8	$13,000	$104,000
Spare / Test Equipment	5%		$67,000
Subtotal - Site Equipment			**$1,390,000**

Alternative 1a Analog Simulcast Cost Estimate			
South Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$15,000	$60,000
Networking Equipment	1	$37,000	$37,000
7-CH TX/RX Simulcast Equipment	5	$152,000	$760,000
7-CH Receive-Only Equipment	6	$54,000	$324,000
VHF TX/RX Antenna System	5	$34,000	$170,000
VHF RX-only Antenna System	6	$14,000	$84,000
Site Networking Equipment	11	$13,000	$143,000
Spare / Test Equipment	5%		$85,000
Subtotal - Site Equipment			**$1,769,000**
Equipment Subtotal			**$3,159,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	63		$9,000
LMR Frequency Coordination Fees	63		$27,000
LMR Engineering Services Fees	63		$9,000
Subtotal - FCC Licensing and Coordination			**$45,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$316,000
Installation	10%		$316,000
Engineering	10%		$316,000
Removal of Existing Equipment	2%		$64,000
Training	1%		$32,000
Staging	5%		$158,000
Acceptance Testing	1%		$32,000
Documentation	1%		$32,000
Subtotal - Implementation Services			**$1,266,000**
Services Total			**$1,311,000**
Equipment and Services Total			**$4,470,000**
Contingency	10%		$447,000
Equipment and Services Total with Contingency			**$4,917,000**

2.9.3 Dispatch System Cost

Table 13 shows the estimated cost for new dispatch equipment and implementation services needed for primary dispatch at Tillamook 911 and backup dispatch at the County Justice Facility.

Table 13 – Alternative 1a Dispatch System Cost Estimate

Dispatch System Cost Estimate			
Tillamook 911 Dispatch	*Quantity*	*Unit Cost*	*Extended Cost*
Logging Recorder System	1	$228,000	$228,000
Dispatch Console Position	4	$69,000	$276,000
Control/Backup RF Station	4	$12,000	$48,000

Dispatch System Cost Estimate			
Control Station Antenna System	1	$18,000	$18,000
Conventional Channel Gateway	4	$7,000	$28,000
Networking Equipment	1	$25,000	$25,000
Uninterruptible Power Supply	4	$10,000	$40,000
Incident Command Console Position	6	$32,000	$192,000
Spare / Test Equipment	5%		$43,000
Subtotal - Site Equipment			**$898,000**
County Justice Facility (Backup)	*Quantity*	*Unit Cost*	*Extended Cost*
Logging Recorder System	0	$228,000	$0
Dispatch Console Position	3	$69,000	$207,000
Control/Backup RF Station	7	$12,000	$84,000
Control Station Antenna System	1	$18,000	$18,000
Conventional Channel Gateway	2	$7,000	$14,000
Networking Equipment	1	$25,000	$25,000
Uninterruptible Power Supply	3	$10,000	$30,000
Spare / Test Equipment	5%		$19,000
Subtotal - Site Equipment			**$397,000**
Equipment Subtotal			**$1,295,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$130,000
Installation	10%		$130,000
Engineering	10%		$130,000
Removal of Existing Equipment	2%		$26,000
Training	1%		$13,000
Staging	5%		$65,000
Acceptance Testing	1%		$13,000
Documentation	1%		$13,000
Subtotal - Implementation Services			**$520,000**
Equipment and Services Total			**$1,815,000**
Contingency	10%		$182,000
Equipment and Services Total with Contingency			**$1,997,000**

2.9.4 Backhaul System Cost

Table 14 shows the estimated cost for the new microwave backhaul equipment and implementation services needed to connect VHF repeater and receiver sites to Tillamook 911 dispatch consoles.

Table 14 – Alternative 1a Backhaul System Cost Estimate

Microwave Equipment	Qty	Unit Cost	Extended Cost
Radios			
900 MHz 1+0 Radio	12	$6,000	$72,000
6 GHz 1+0 Radio	12	$25,000	$300,000

Microwave Equipment	Qty	Unit Cost	Extended Cost
11 GHz 1+0 Radio	6	$25,000	$150,000
18 GHz 1+0 Radio	2	$2,000	$4,000
Subtotal - Radios	**32**		**$526,000**
Antennas			
900 MHz Panel	12	$1,000	$12,000
6 GHz - 6' Single-Polarization	12	$4,000	$48,000
11 GHz - 6' Single-Polarization	6	$3,500	$21,000
18 GHz - 2' Dual-Polarization	2	$1,500	$3,000
Subtotal - Antennas	**32**		**$84,000**
Coaxial Cable, Waveguide and Accessories			
Coaxial Cable and Accessories	14	$2,000	$28,000
Waveguide and Accessories	18	$5,000	$90,000
Subtotal - Coax/Waveguide	**32**		**$118,000**
DC Plant			
Large	0	$19,000	$0
Medium	11	$10,000	$110,000
Small	6	$7,000	$42,000
Subtotal - DC Plant	**17**		**$152,000**
Equipment Rack and Accessories			
Large	0	$10,000	$0
Medium	11	$7,500	$82,500
Small	6	$5,000	$30,000
Subtotal - Equipment Rack	**17**		**$112,500**
MPLS Router			
Large	0	$60,000	$0
Medium	11	$25,000	$275,000
Small	6	$20,000	$120,000
Subtotal - MPLS Router	**17**		**$395,000**
Timing System	**0**	$13,000	**$0**
Dehydrator	**11**	$4,000	**$44,000**
Subtotal - Microwave Equipment			**$1,432,000**
Spares/Test Equipment	5%		**$72,000**
Total - Microwave Equipment			**$1,504,000**
Services			
FCC Licensing			
FCC License Coordination	16	$1,700	$28,000
FCC License	32	$1,200	$39,000
Sales Tax	0%		$0
Training	1%		$16,000
Project Management	10%		$151,000
Installation	10%		$151,000
Engineering	10%		$151,000

Microwave Equipment	Qty	Unit Cost	Extended Cost
Removal of Old Equipment	2%		$31,000
Staging	5%		$76,000
Acceptance Testing	1%		$16,000
Documentation	1%		$16,000
Subtotal - Microwave Services			**$675,000**
TOTAL - MICROWAVE EQUIPMENT/SERVICES			**$2,179,000**
Contingency	10%		**$218,000**
TOTAL - EQUIPMENT/SERVICES (with contingency)			**$2,397,000**

2.9.5 Video Surveillance Cost

Table 15 shows the estimated cost for video surveillance equipment and services to support the Alternative 1a configuration.

Table 15 – Alternative 1a Video Surveillance Cost Estimate

Video Surveillance System Cost Estimate			
Surveillance Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Enterprise Software (Licenses) for up to 40 cameras	1	$10,000	$10,000
3 cameras per sites for 10 sites (repeater sites only)	1	$30,000	$30,000
Server platforms for Base and Recorder (2 servers)	1	$20,000	$20,000
Tillamook 911 cameras (up to 10)	1	$10,000	$10,000
Subtotal - Site Equipment			**$70,000**
Spare / Test Equipment	5%		$4,000
Equipment Subtotal			**$74,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$8,000
Installation	10%		$8,000
Engineering	10%		$8,000
Removal of Existing Equipment	2%		$2,000
Training	1%		$1,000
Staging	5%		$4,000
Acceptance Testing	1%		$1,000
Documentation	1%		$1,000
Subtotal - Implementation Services			**$33,000**
Equipment and Services Total			**$107,000**
Contingency	10%		$11,000
Equipment and Services Total with Contingency			**$118,000**

2.9.6 Site Improvements Cost

Table 16 shows the estimated cost for site improvements and services to support the Alternative 1a configuration.

Table 16 – Alternative 1a Site Improvements Cost Estimate

Alternative 1a Site Improvements Cost Estimate			
Site Improvements	*Quantity*	*Unit Cost*	*Extended Cost*
Existing Structure with Available Space	20	$0	$0
Structural Analysis Needed	19	$5,000	$95,000
Existing Tower Mods Needed	1	$50,000	$50,000
New Tower Structure Needed	1	$283,000	$283,000
A&E, Environmental Compliance	0	$14,000	$0
Existing Shelter/Bldg. with Available Space	19	$0	$0
Site Grounding (Minor) Updates	18	$15,000	$270,000
Existing Shelter HVAC Needed	2	$10,000	$20,000
New Prefab Shelter Needed	1	$109,000	$109,000
New Outdoor Cabinet Needed	1	$5,000	$5,000
Commercial AC Power Available	19	$0	$0
New Generator Needed	3	$30,000	$90,000
New Rackmount UPS Needed	1	$10,000	$10,000
New DC System Needed	3	$50,000	$150,000
Subtotal - Site Improvements			**$1,082,000**
Spare / Test Equipment	5%		$55,000
Equipment Subtotal			**$1,137,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$114,000
Installation	10%		$114,000
Engineering	10%		$114,000
Removal of Existing Equipment	2%		$23,000
Training	1%		$12,000
Staging	5%		$57,000
Acceptance Testing	1%		$12,000
Documentation	1%		$12,000
Subtotal - Implementation Services			**$458,000**
Equipment and Services Total			**$1,595,000**
Contingency	10%		$160,000
Total with Contingency and Site Acquisition			**$1,755,000**

2.9.7 Subscriber Units Cost

Table 17 shows the estimated costs for new VHF single-band , mid-tier radios with software to operate in analog conventional mode.

Table 17 – Alternative 1a Subscriber Units Cost Estimate

Alternative 1a Subscriber Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total (Rounded)*
Garibaldi FD	$82,000	$5,000	$9,000	**$96,000**
Manzanita PD	$21,000	$3,000	$3,000	**$27,000**
Bay City FD	$99,000	$6,000	$11,000	**$116,000**
Nehalem Bay Fire	$245,000	$11,000	$26,000	**$282,000**
Rockaway Fire	$94,000	$7,000	$11,000	**$112,000**
Rockaway PD	$42,000	$4,000	$5,000	**$51,000**
Tillamook County Parks	$49,000	$4,000	$6,000	**$59,000**
Tillamook Police	$116,000	$7,000	$13,000	**$136,000**
Tillamook County Public Works	$286,000	$27,000	$32,000	**$345,000**
Tillamook ECD 911	$47,000	$10,000	$6,000	**$63,000**
Netarts/Oceanside Fire	$176,000	$14,000	$19,000	**$209,000**
Tillamook County Transportation District	$0	$0	$0	**$0**
Tillamook Fire District	$329,000	$22,000	$36,000	**$387,000**
Tillamook Sheriff's Office	$365,000	$27,000	$40,000	**$432,000**
Nestucca Fire	$363,000	$21,000	$39,000	**$423,000**
Total	**$2,314,000**	**$168,000**	**$256,000**	**$2,738,000**

Appendix C provides a detailed breakdown of estimated subscriber costs on a per-unit and departmental basis.

2.9.8 Capital Cost Summary

Table 18 shows the estimated total cost for Alternative 1a, including the VHF radio system, microwave backhaul, dispatch equipment, video surveillance, site improvements, and subscriber units. Total cost is rounded to the nearest $10,000.

Table 18 – Alternative 1a Total Cost Estimate

Alternative 1a Total Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total Cost*
Radio System	$3,159,000	$1,311,000	$447,000	**$4,917,000**
Dispatch System	$1,295,000	$520,000	$182,000	**$1,997,000**
Microwave System	$1,504,000	$675,000	$218,000	**$2,397,000**
Surveillance System	$74,000	$33,000	$11,000	**$118,000**
Site Improvements	$1,137,000	$458,000	$160,000	**$1,755,000**
Subscriber Equipment	$2,314,000	$168,000	$256,000	**$2,738,000**
Total	**$9,483,000**	**$3,165,000**	**$1,274,000**	**$13,920,000**

2.9.9 Operational Costs

Table 19 shows the estimated annual operational cost for Alternative 1a for 15 years. The estimate does not include any current operational expenses such as LMR and microwave system maintenance contracts, site maintenance, site leases, staff salaries or other recurring expenditures. The cost estimate also does not include any optional extended warranty that vendors may offer beyond Year 3.

The estimated cost includes only the new LMR, microwave backhaul, dispatch equipment, video surveillance, and subscriber equipment. The County may customize their service plan, which may be lower or higher than our projected costs. The estimated cost is based on the following assumptions:

- A 3-year manufacturer warranty period. Therefore, technical support and software/hardware upgrade costs begin in Year 4
- A subscriber growth rate of 2%
- A subscriber attrition rate of 1%
- An inflation rate of 3%
- A 7-year subscriber unit lifecycle. All subscriber units would be replaced by Year 10, 7 years after the 3-year warranty period. Funding for subscriber unit replacement would occur between Years 3 and 10, so that by Year 10 the funding would be available to replace all subscriber units. The same annual funding level would begin again in Year 13 to begin funding for the next subscriber refresh
- A 15-year lifecycle for backhaul and LMR equipment. All backhaul and LMR equipment would be replaced in Year 15, but the County would begin funding for the refresh in Year 6 so that by Year 15 funds would be available to replace the system equipment. The same funding level would begin again in Year 20 to prepare for the next system refresh

Table 19 – Alternative 1a Operational Cost Estimate

Alternative 1a Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Remote Technical Support	$0	$0	$0	$72,000	$75,000
Software Upgrade Agreement	$0	$0	$0	$323,000	$333,000
Onsite Support and Repair	$0	$0	$0	$216,000	$223,000
Subscriber Growth	$0	$44,000	$45,000	$45,000	$47,000
Subscriber Attrition	$0	$23,000	$23,000	$24,000	$24,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$67,000**	**$68,000**	**$680,000**	**$702,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Remote Technical Support	$78,000	$81,000	$84,000	$87,000	$90,000
Software Upgrade Agreement	$343,000	$354,000	$365,000	$376,000	$388,000
Onsite Support and Repair	$230,000	$237,000	$245,000	$253,000	$261,000
Subscriber Growth	$47,000	$48,000	$49,000	$50,000	$51,000
Subscriber Attrition	$24,000	$24,000	$24,000	$24,000	$24,000
Subscriber Refresh	$0	$0	$0	$0	$2,738,000
Estimated Annual Cost	**$722,000**	**$744,000**	**$767,000**	**$790,000**	**$3,552,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Remote Technical Support	$93,000	$96,000	$99,000	$102,000	$106,000
Software Upgrade Agreement	$400,000	$412,000	$425,000	$438,000	$452,000
Onsite Support and Repair	$269,000	$278,000	$287,000	$296,000	$305,000
Subscriber Growth	$53,000	$53,000	$55,000	$56,000	$56,000
Subscriber Attrition	$24,000	$25,000	$26,000	$26,000	$26,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$839,000**	**$864,000**	**$892,000**	**$918,000**	**$945,000**

3. Alternative 1b – VHF P25 Conventional Simulcast

3.1 System Summary

Alternative 1b is the same as Alternative 1a, except that Alternative 1b would use P25 digital conventional radios instead of analog conventional. Alternative 1b would replace the existing General, Fire/EMS (dispatch and TAC), Public Works and Sheriff (SO and SO #2) channels with the following VHF P25 digital simulcast/voted channels:

- Fire/EMS Dispatch
- Law – Sheriff and police departments
- Operations – four channels for use by EMS, Fire, Sheriff/police departments, as needed
- Public Works

There would be two simulcast cells, North and South. Each cell would transmit all radio traffic from Tillamook 911 and radio users on all repeaters in the cell simultaneously (i.e. simulcast). Receiver voting would be used to improve portable radio talkback coverage. Following is a summary of the VHF P25 digital simulcast/voting system for Alternative 1b, which is presented in detail in the sections to follow:

- All existing County VHF channels would be reused for the new system and the County would need to license 3 new channels
- Existing RF site equipment would be replaced for all channels
- New simulcast control and voting equipment would be installed for each new simulcast cell; one site in the North and one site in the South
- A new Internet Protocol (IP)/Multi-Protocol Labeling System (MPLS) backhaul system would be installed to provide connectivity between Tillamook 911 and the VHF repeater, receiver and simulcast/voting control sites using existing Tillamook Lightwave fiber and new licensed microwave links
- All County dispatch consoles, which are near end-of-life, would be replaced
- Existing subscriber units, which are near end-of-life, would be replaced. However, existing subscriber units could be used on the new system until funding is available to replace them

- A network management system (NMS) would be installed to remotely monitor LMR, microwave and network equipment and alarms and to troubleshoot equipment failures

3.2 LMR System

3.2.1 Radio Coverage Analysis

3.2.1.1 Required Coverage

Refer to Section 2.2.1.1, *Required Coverage*.

3.2.1.2 Methodology

Refer to Section 2.2.1.2, *Methodology*.

3.2.1.3 Results

Based on ***FE's*** radio coverage analysis a two-cell (i.e. North and South) simulcast system would best meet the County's coverage requirements. Table 20 is a list of repeater and receive-only sites and the cell that each site would reside in.

Table 20 – Alternative 1b Site List

North Cell		South Cell	
Site	**Site Type**	**Site**	**Site Type**
Angora Peak	Repeater	ATC-ASR1217507	Repeater
City of Wheeler PW Dept.	Receiver	Bay City Fire Station 41	Receiver
Neahkahnie Mt.	Repeater	Cape Meares	Repeater
North County Recreation District	Receiver	Co Transportation	Receiver
Rockaway Beach City Hall	Receiver	Garibaldi FD	Receiver
South Saddle	Repeater	L-190	Repeater
T-Point	Receiver	Mt. Hebo	Repeater
Wilson River	Repeater	Nestucca Fire	Receiver
		PW Facility	Receiver
		Ridge Road	Receiver
		Tillamook 911	Repeater

Refer to Section 2.2.1.3, *Results*, for talk-out and talk-in radio coverage maps for the North and South simulcast cells.

3.2.2 Channel Capacity

Refer to Section 2.2.2, *Channel Capacity*.

3.2.3 LMR System Design Criteria

Refer to Section 2.2.3, *LMR System Design Criteria*.

3.2.4 LMR System Architecture

Refer to Section 2.2.4, *LMR System Architecture*.

3.2.5 LMR System Equipment

Refer to Section 2.2.5, *LMR System Equipment*.

3.2.6 Interoperability

Interoperability on a new P25 digital conventional system would be similar to the existing system. County departments and other agencies using the County radio system would still be able to program the channels of other agencies that they need to interoperate with into their subscriber units. However, other agencies would need to have P25 compatible subscriber units to program the County's radio channels into their radios. As with Alternative 1a, Alternative 1b would provide four new Operations channels that could be assigned for incidents requiring the response of multiple County and/or outside agencies.

In addition, Alterative 1b would allow:

- County radio users to operate on other VHF analog systems, as P25 radios are backwards compatible with analog conventional
- County radio users to operate on other VHF P25 conventional systems; additional licenses would be required for P25 Phase 1 or Phase 2 trunking
- A console patch between the County's P25 conventional system and an analog conventional radio system

The County would need to purchase multi-band subscriber units to allow interoperability with agencies on other frequency bands (i.e. UHF and/or 7/800 MHz).

3.2.7 System Features

The new VHF simulcast system would retain the existing analog conventional radio system features that the Fire, Public Works and Sheriff channels have today. However, operationally, radio users would only need to select between North and South cells and would no longer need to select individual repeaters based on location. In addition, other features, such as encryption and emergency call, would be available.

3.3 Backhaul System

Refer to Section 2.3*, Backhaul System*.

3.4 Dispatch Equipment

Refer to Section 2.4*, Dispatch Equipment*.

3.5 Video Surveillance Equipment

Refer to Section 2.5*, Video Surveillance Equipment*.

3.6 Radio Site Improvements

Refer to Section 2.6*, Radio Site Improvements*.

3.7 Network Management System

Refer to Section 2.7*, Network Management System*.

3.8 Subscriber Units

Most of the existing subscriber equipment has reached or is nearing end of life, with limited or no support or parts from the manufacturers. The majority of existing subscriber equipment also only supports analog mode. Some of the existing radios (such as Motorola XTL2500 and Kenwood TK-5210) could be re-used for P25 operation, but they are end of life. Therefore, the County should consider replacing all existing analog-only and end-of-life subscriber units with new P25 capable, single-band VHF units.

Only a few agencies or departments with Kenwood NX-5200 Series radios can re-use some of their subscriber equipment that is P25 Phase 1 capable. It is important to note that all existing pagers require replacement for P25 conventional operation. Table 21

provides the recommended subscriber replacement counts by agency or department for Alternative 1b.

Table 21 – Alternative 1b Subscriber Replacement

Alternative 1b Subscriber Replacement					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Garibaldi FD	17	8	1	23	**49**
Manzanita PD	4	4	2	0	**10**
Bay City FD	24	4	1	27	**56**
Nehalem Bay Fire	64	15	0	50	**129**
Rockaway Fire	20	7	0	22	**49**
Rockaway PD	7	5	3	0	**15**
Tillamook County Parks	6	8	1	0	**15**
Tillamook Police	25	12	0	0	**37**
Tillamook County Public Works	17	64	7	0	**88**
Tillamook ECD 911*	2	0	13	0	**15**
Netarts/Oceanside Fire	37	8	6	34	**85**
Tillamook County Transportation District	6	27	4	0	**37**
Tillamook Fire District	64	28	3	77	**172**
Tillamook Sheriff's Office	55	55	5	0	**115**
Nestucca Fire	73	43	0	0	**116**
Total	**421**	**288**	**46**	**233**	**988**
*Does not include 4 MCC5500 consoles and 6 MIP5000 consoles; those are captured in the dispatch section.					

The cost estimate includes the replacement of existing portables, mobiles, control/base stations, and pagers with new single-band VHF, mid-tier models with software to operate in P25 conventional mode. The use of mid-tier models provides a good average price point for budgetary purposes. Some departments may purchase low-tier models, while others may purchase high-tier models with added features. As part of the RFP, the County could specify the quantity and tier requirements for each department, which would allow the vendors to provide a more accurate cost proposal.

3.9 Cost Analysis

FE prepared high-level budgetary cost estimates for Alternative 1b using the same methodology and tool described in Section 2.10, *Cost Analysis* for Alternative 1a.

3.9.1 Cost Assumptions

Based on results from the coverage studies, analysis of existing inventory and feedback provided by the County, ***FE*** developed the following set of equipment- and services-related assumptions shown in Table 22 for the Alternative 1b cost estimates.

Table 22 – Alternative 1b Cost Assumptions

Alternative 1b Assumptions	Quantity	Notes
Core Network Equipment		
P25 Phase 1 Core Equipment	1	New non-geo-redundant, P25 Phase 1 Conventional core site
Core Networking Equipment	1	New equipment needed for new, single core site
North Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Voting Equipment	4	New equipment needed for new simulcast cell
Networking Equipment	1	New equipment needed for new simulcast cell
7-Channel TX/RX P25 Simulcast Equipment	4	New 7-channel P25 Conventional Simulcast repeater system
7-Channel Analog Receive-Only Equipment	4	New 7-channel P25 Conventional receiver system
Multi-channel VHF TX/RX Antenna System	4	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	4	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	8	New routing and switching equipment
FCC licensing and coordination	28	New VHF frequency f or new transmit sites
South Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Voting Equipment	4	New equipment needed for new simulcast cell
Networking Equipment	1	New equipment needed for new simulcast cell
7-Channel TX/RX P25 Simulcast Equipment	5	New 7-channel P25 Conventional Simulcast repeater system
7-Channel Analog Receive-Only Equipment	6	New 7-channel P25 Conventional receiver system
Multi-channel VHF TX/RX Antenna System	5	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	6	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	11	New routing and switching equipment

Alternative 1b Assumptions	Quantity	Notes
FCC licensing and coordination	35	New VHF frequency for new transmit sites
Backhaul Network		
900 MHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites
6 GHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites
11 GHz 1+0 Radio	6	New backhaul equipment for connecting LMR sites
18 GHz 1+0 Radio	2	New backhaul equipment for connecting LMR sites
900 MHz Panel	12	New antennas/dishes for new backhaul equipment
6 GHz - 6' Single-Polarization	12	New antennas/dishes for new backhaul equipment
11 GHz - 6' Single-Polarization	6	New antennas/dishes for new backhaul equipment
18 GHz - 2' Dual-Polarization	2	New antennas/dishes for new backhaul equipment
Coaxial Cable and Accessories	14	New line & accessories for new backhaul equipment
Waveguide and Accessories	18	New line & accessories for new backhaul equipment
Medium DC Plant	11	New DC power system for new backhaul equipment
Small DC Plant	6	New DC power system for new backhaul equipment
Medium Rack and Accessories	11	New rack & accessories for new backhaul equipment
Small Rack and Accessories	6	New rack & accessories for new backhaul equipment
Medium MPLS Router	11	New MPLS router for new backhaul equipment
Small MPLS Router	6	New MPLS router for new backhaul equipment
Dehydrator System	11	New dehydrator system for new backhaul equipment
Video Surveillance		
Enterprise Software (Licenses) for up to 40 cameras	1	New video surveillance equipment for RF sites
3 cameras per sites for 10 sites (repeater sites only)	1	New video surveillance equipment for RF sites
Server platforms for Base and Recorder (2 servers)	1	New video surveillance equipment for Tillamook 911
Tillamook 911 cameras (up to 10)	1	New video surveillance equipment for Tillamook 911
Site Improvements		
Existing Structure with Available Space	20	Based on site surveys and/or County provided data
Structural Analysis Needed	19	Based on site surveys and/or County provided data
Existing Tower Mods Needed	1	Based on site surveys and/or County provided data
New Tower Structure Needed	1	Based on site surveys and/or County provided data
A&E, Environmental Compliance	0	Based on site surveys and/or County provided data
Existing Shelter/Bldg. with Available Space	19	Based on site surveys and/or County provided data
Site Grounding Updates	18	Based on site surveys and/or County provided data
Existing Shelter HVAC Needed	2	Based on site surveys and/or County provided data
New Prefab Shelter Needed	1	Based on site surveys and/or County provided data
New Outdoor Cabinet Needed	1	Based on site surveys and/or County provided data
Commercial AC Power Available	19	Based on site surveys and/or County provided data

Alternative 1b Assumptions	Quantity	Notes
New Generator Needed	3	Based on site surveys and/or County provided data
New Rackmount UPS Needed	1	Based on site surveys and/or County provided data
New DC System Needed	3	Based on site surveys and/or County provided data
Subscriber Equipment		
Portable Radios	421	Requires replacement with new single band VHF radios with software for P25 conventional operation
Mobile Radios	288	Requires replacement with new single band VHF radios with software for P25 conventional operation
Base/Control Stations	46	Requires replacement with new single band VHF radios with software for P25 conventional operation
Pagers	233	Requires replacement with new single band VHF pagers with software for P25 conventional operation
Implementation Services		
Spare / Test Equipment	5%	Based on total of all system components
Sales Tax	0%	Based on total of all system components
Project Management	10%	Based on total of all system components
Installation	10%	Based on total of all system components
Engineering	10%	Based on total of all system components
Removal of Existing Equipment	2%	Based on total of all system components
Training	1%	Based on total of all system components
Staging	5%	Based on total of all system components
Acceptance/Coverage Testing	1%	Based on total of all system components
Documentation	1%	Based on total of all system components
Contingency	10%	Based on total of all system components and implementation services

3.9.2 LMR System Cost

Table 23 shows the estimated cost for the new VHF LMR system equipment and implementation services needed for the Alternative 1b conceptual design.

Table 23 – Alternative 1b LMR System Cost Estimate

Alternative 1b P25 Conventional Simulcast Cost Estimate			
Core Network Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 1 Core Equipment	1	$358,000	$358,000
Core Networking Equipment	1	$74,000	$74,000
Spare / Test Equipment	5%		$22,000
Subtotal			**$454,000**
North Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$30,000	$120,000

Alternative 1b P25 Conventional Simulcast Cost Estimate			
Networking Equipment	1	$73,000	$73,000
7-CH TX/RX Simulcast Equipment	4	$198,000	$792,000
7-CH Receive-Only Equipment	4	$68,000	$272,000
VHF TX/RX Antenna System	4	$34,000	$136,000
VHF RX-only Antenna System	4	$14,000	$56,000
Site Networking Equipment	8	$13,000	$104,000
Spare / Test Equipment	5%		$83,000
Subtotal			**$1,742,000**
South Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$30,000	$120,000
Networking Equipment	1	$73,000	$73,000
7-CH TX/RX Simulcast Equipment	5	$198,000	$990,000
7-CH Receive-Only Equipment	6	$68,000	$408,000
VHF TX/RX Antenna System	5	$34,000	$170,000
VHF RX-only Antenna System	6	$14,000	$84,000
Site Networking Equipment	11	$13,000	$143,000
Spare / Test Equipment	5%		$105,000
Subtotal			**$2,199,000**
Equipment Subtotal			**$3,941,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	63		$9,000
LMR Frequency Coordination Fees	63		$27,000
LMR Engineering Services Fees	63		$9,000
Subtotal - FCC Licensing and Coordination			**$45,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$395,000
Installation	10%		$395,000
Engineering	10%		$395,000
Removal of Existing Equipment	2%		$79,000
Training	1%		$40,000
Staging	5%		$198,000
Acceptance Testing	1%		$40,000
Documentation	1%		$40,000
Subtotal - Implementation Services			**$1,582,000**
Services Total			**$1,627,000**
Equipment and Services Total			**$5,568,000**
Contingency	10%		$557,000
Equipment and Services Total with Contingency			**$6,125,000**

3.9.3 Dispatch System Cost

The dispatch system cost for Alternative 1b is the same as Alternative 1a. Refer to Section 2.9.3, *Dispatch System Cost*.

3.9.4 Backhaul System Cost

The microwave system cost for Alternative 1b is the same as Alternative 1a. Refer to Section 2.9.4, *Backhaul System Cost*.

3.9.5 Video Surveillance Cost

The video surveillance cost for Alternative 1b is the same as Alternative 1a. Refer to Section 2.9.5, *Video Surveillance Cost*.

3.9.6 Site Improvements Cost

The site improvements cost for Alternative 1b is the same as Alternative 1a. Refer to Section 2.9.6, *Site Improvements Cost*.

3.9.7 Subscriber Units Cost

Table 24 shows the estimated cost for new VHF single-band, mid-tier radios with software to operate in P25 conventional mode.

Table 24 – Alternative 1b Subscriber Units Cost Estimate

Alternative 1b Subscriber Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total (Rounded)*
Garibaldi FD	$107,000	$8,000	$12,000	**$127,000**
Manzanita PD	$36,000	$4,000	$4,000	**$44,000**
Bay City FD	$118,000	$8,000	$13,000	**$139,000**
Nehalem Bay Fire	$304,000	$16,000	$32,000	**$352,000**
Rockaway Fire	$109,000	$7,000	$12,000	**$128,000**
Rockaway PD	$54,000	$5,000	$6,000	**$65,000**
Tillamook County Parks	$54,000	$4,000	$6,000	**$64,000**
Tillamook Police	$128,000	$7,000	$14,000	**$149,000**
Tillamook County Public Works	$313,000	$27,000	$34,000	**$374,000**
Tillamook ECD 911	$58,000	$12,000	$7,000	**$77,000**
Netarts/Oceanside Fire	$200,000	$15,000	$22,000	**$237,000**
Tillamook County Transportation District	$133,000	$13,000	$15,000	**$161,000**
Tillamook Fire District	$381,000	$26,000	$41,000	**$448,000**

Alternative 1b Subscriber Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total (Rounded)*
Tillamook Sheriff's Office	$402,000	$27,000	$43,000	**$472,000**
Nestucca Fire	$399,000	$21,000	$42,000	**$462,000**
Total	**$2,796,000**	**$200,000**	**$303,000**	**$3,299,000**

Appendix C provides a detailed breakdown of estimated subscriber costs on a departmental basis.

3.9.8 Capital Cost Summary

Table 25 summarizes the total cost for Alternative 1b, including the VHF radio system, microwave backhaul, dispatch equipment, site improvements, and subscriber units. Total cost is rounded to the nearest $10,000.

Table 25 – Alternative 1b Total Cost Estimate

Alternative 1b Total Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total Cost*
Radio System	$3,941,000	$1,627,000	$557,000	**$6,125,000**
Dispatch System	$1,295,000	$520,000	$182,000	**$1,997,000**
Microwave System	$1,504,000	$675,000	$218,000	**$2,397,000**
Surveillance System	$74,000	$33,000	$11,000	**$118,000**
Site Improvements	$1,137,000	$458,000	$160,000	**$1,755,000**
Subscriber Equipment	$2,796,000	$200,000	$303,000	**$3,299,000**
Total	**$10,747,000**	**$3,513,000**	**$1,431,000**	**$15,690,000**

3.9.9 Operational Costs

The operational cost estimate for Alternative 1b uses the same methodology and assumptions as described for Alternative 1a. Refer to Section 2.9.9, *Operational Costs*. Table 26 shows the estimated operational costs for 15 years for Alternative 1b.

Table 26 – Alternative 1b Operational Cost Estimate

Alternative 1b Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Remote Technical Support	$0	$0	$0	$80,000	$83,000
Software Upgrade Agreement	$0	$0	$0	$358,000	$369,000
Onsite Support and Repair	$0	$0	$0	$239,000	$247,000
Subscriber Growth	$0	$51,000	$52,000	$54,000	$54,000
Subscriber Attrition	$0	$26,000	$26,000	$26,000	$27,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$77,000**	**$78,000**	**$757,000**	**$780,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Remote Technical Support	$86,000	$89,000	$92,000	$95,000	$98,000
Software Upgrade Agreement	$381,000	$393,000	$405,000	$418,000	$431,000
Onsite Support and Repair	$255,000	$263,000	$271,000	$280,000	$289,000
Subscriber Growth	$56,000	$56,000	$58,000	$58,000	$59,000
Subscriber Attrition	$28,000	$28,000	$28,000	$28,000	$28,000
Subscriber Refresh	$0	$0	$0	$0	$2,738,000
Estimated Annual Cost	**$806,000**	**$829,000**	**$854,000**	**$879,000**	**$3,643,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Remote Technical Support	$101,000	$105,000	$109,000	$113,000	$117,000
Software Upgrade Agreement	$444,000	$458,000	$472,000	$487,000	$502,000
Onsite Support and Repair	$298,000	$307,000	$317,000	$327,000	$337,000
Subscriber Growth	$62,000	$62,000	$64,000	$65,000	$66,000
Subscriber Attrition	$28,000	$28,000	$29,000	$30,000	$30,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$933,000**	**$960,000**	**$991,000**	**$1,022,000**	**$1,052,000**

4. LMR Alternative 2 – VHF P25 Trunked Radio System

4.1 System Summary

Alternative 2 would replace the existing VHF analog conventional Fire (Dispatch and TAC), General, Public Works and Sheriff (SO and SO #2) channels with a new countywide P25 Phase 2 VHF trunked simulcast radio system, as follows:

- Radio talkgroups would replace dedicated radio channels for intra-department, inter-department and interoperability communications needs using a common radio system, but still allowing each department to be autonomous, while improving the ability to interoperate
- The system would use two simulcast cells to provide countywide coverage, with the same sites as Alternatives 1a and 1b. All radio traffic from Tillamook 911 Dispatch and field users would be transmitted simultaneously on all repeater sites. Receiver voting would also be used to improve portable radio talkback coverage
- Existing VHF channels would be re-used on the new trunked system
- Additional repeater sites would be added to meet the County's coverage requirements to provide reliable countywide mobile and on-street portable radio coverage, and mobile, on-street portable and in-building portable radio coverage in the population centers
- The existing time division multiplexed (TDM)-based microwave backhaul equipment would be replaced with new internet protocol (IP)/Multi-Protocol Labeling System (MPLS) equipment, providing connectivity between Tillamook 911 Dispatch, VHF repeater and control sites, using a combination of County fiber and new licensed microwave links
- Existing dispatch consoles would be replaced with new P25-compatible consoles
- All existing subscriber units would be replaced with new P25-compatible radios
- An NMS would be installed to remotely monitor LMR, microwave backhaul and network equipment and alarms and to troubleshoot equipment failures

4.2 LMR System

4.2.1 Radio Coverage Analysis

4.2.1.1 Required Coverage

Refer to Section 2.2.1.1, *Required Coverage*.

4.2.1.2 Methodology

Refer to Section 2.2.1.2, *Methodology*.

4.2.1.3 Results

Based on ***FE's*** radio coverage analysis a two-cell (i.e. North and South) simulcast system would best meet the County's coverage requirements. Table 27 is a list of repeater and Rx-only and the cell that each repeater would reside in. ***Note – County radio system users would not need to select between simulcast cells. The P25 trunked radio system would automatically connect radio users regardless of which cell they were in, providing seamless roaming throughout the County.***

Table 27 – Alternative 2 Site List

North Cell		South Cell	
Site	**Site Type**	**Site**	**Site Type**
Angora Peak	Repeater	ATC-ASR1217507	Repeater
City of Wheeler PW Dept.	Receiver	Bay City Fire Station 41	Receiver
Neahkahnie Mt.	Repeater	Cape Meares	Repeater
North County Recreation District	Receiver	Co Transportation	Receiver
Rockaway Beach City Hall	Receiver	Garibaldi FD	Receiver
South Saddle	Repeater	L-190	Repeater
T-Point	Receiver	Mt. Hebo	Repeater
Wilson River	Repeater	Nestucca Fire	Receiver
		PW Facility	Receiver
		Ridge Road	Receiver
		Tillamook 911	Repeater

Refer to Section 2.2.1.3, *Results*, for talk-out and talk-in radio coverage maps for the North and South simulcast cells.

4.2.2 Channel Capacity Analysis

FE used existing and projected County subscriber unit quantities to perform an Erlang-C trunked system loading analysis, which determines the required number of channels at

each site to meet the County system capacity needs. ***FE*** used the following design targets for the capacity analysis:

- The system would have a public-safety Grade of Service (GoS) less than or equal to 1%, meaning that less than 1% of all attempted calls would be queued or blocked
- The system would support a subscriber unit growth factor of 2% per year for 10 years

FE made the following assumptions regarding the capacity analysis for the P25 trunked radio system:

- P25 Phase 2 would provide two voice paths per radio licensed frequency pair using time division multiple access (TDMA) technology
- Due to a lack of existing traffic data, ***FE*** assumed projected push-to-talk (PTT) duration and PTTs per hour based on our extensive experience analyzing public safety radio system traffic data
- The number of talk paths would support projected traffic in the Average Non-Busy Hour, as well as Busy Hour traffic scenarios

FE derived an Average Non-Busy Hour user traffic profile for the County by examining public safety traffic data obtained from other similar public safety radio projects. Based on evaluations by the Public Safety Wireless Advisory Committee (PSWAC)[6], Busy Hour traffic is assumed to be 4 times the Average Non-Busy Hour traffic. ***FE*** used the Busy Hour traffic scenario as the minimum requirement for the channel capacity throughout the P25 system.

Based on the results of the Erlang-C analysis, a three-channel P25 Phase 2 system would meet the GoS requirement during Busy Hour traffic scenarios. A three-channel P25 Phase 2 system would provide four talk paths (i.e. four distinct simultaneous conversations can occur amongst P25 Phase 2 talkgroups) and one trunking control channel. Providing this amount of capacity at all sites within the simulcast cell should meet the County's current capacity needs as well as provide room for growth for the next ten years.

[6] Final Report of the Public Safety Wireless Advisory Committee to the Federal Communications Commission. September 11, 1996. https://www.apcointl.org/doc/spectrum-management/173-public-safety-wireless-pdf/file.html

4.2.3 LMR System Design Criteria

FE used the following criteria for the VHF P25 trunked system design:

- Replace the existing VHF analog conventional Fire (Dispatch and TAC), General, Public Works and Sheriff (SO and SO #2) channels with a 3-channel shared VHF digital P25 Phase 2 trunked simulcast system that includes the following new equipment:
    - P25 Phase 2 trunked core
    - Simulcast control and voting
    - Site equipment (P25 Phase 2 repeaters and/or receivers)
    - Antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
    - DC power systems
    - Grounding and lightning protection systems
- Leverage existing sites to greatest extent possible; only adding new sites, including towers and shelters, as needed to provide the required radio coverage
- Utilize existing County VHF channels

4.2.4 System Architecture

Refer to Section 2.2.4*, System Architecture*.

4.2.5 LMR System Equipment

4.2.5.1 System Control Equipment

System core equipment includes management, administration and networking components that would be utilized for control of the VHF P25 trunked system. The core provides voice call processing, mobility management and system management. Voice call processing manages all aspects of call setup, queuing, and tear down. Mobility management refers to the system's ability to track users as they move from site to site. System management includes management of aliases and unit permissions as well as system fault monitoring.

The P25 trunked system architecture could be centralized or distributed. The RFP would be written to allow both approaches, but for the conceptual design and associated cost, ***FE*** assumed a centralized core architecture. The core could be located at Tillamook 911 or any of the proposed VHF repeater sites, provided there is adequate space and supporting infrastructure. In a distributed architecture each VHF repeater site would have the capability to take on a central core function for the entire system.

4.2.5.2 Simulcast Control and Voting Equipment

Refer to Section 2.2.5.2, *Simulcast Control and Voting Equipment.*

4.2.5.3 Repeater and Receiver Site Equipment

Refer to Section 2.2.5.3, *Repeater and Receiver Site Equipment*.

4.2.6 Interoperability

Most agencies/departments operating in the County are on the VHF conventional radio systems, and are able to interoperate by:

- County departments programming other departments/agencies channels in their mobile and portable radios and vice versa
- Lending portable radios to other agencies responding to an incident
- Patching systems through dispatch consoles

With P25 digital trunked radio systems, as proposed for Alternative 2, the County would still be able to program other departments VHF analog conventional channels in their mobile and portable radios and would be able to lend out portable radios, as needed. Although not included in the conceptual design and associated cost, P25 digital trunked radio systems provide the following additional capabilities which the County could implement in the future:

- P25 digital trunked radio systems allow connection to other P25 trunked radio systems, allowing users on different systems to communicate with each other, regardless of frequency band, and if the two systems are on the same frequency band users could roam on the other system, as needed
- A gateway could be used to provide connectivity between the County's P25 trunked system and other analog or digital conventional system(s)

4.2.7 System Features

The new VHF P25 Phase 2 trunked system would offer the following features and capabilities.

Improved Coverage and Less Noise

The existing County VHF analog conventional system and the VHF analog conventional simulcast system in Alternative 1a use frequency modulation (FM) technology. While FM is relatively resistant to noise in areas with a moderately strong signal, in areas of low signal strength radio users would hear the desired signal and the noise. As the noise level increases, radio users must consciously separate the audio from the noise. A digital P25 radio system would provide relatively noise-free communications by leveraging voice coders (vocoders) and forward error correction (FEC).

P25 vocoders encode sounds related to understandable speech while providing some protection from transmission of noise when the analog voice signal is converted to a digital signal. After the signal is digitized (turned into a string of digital bits), FEC is applied to help the receiving radio correct errors that occur during transmission, due to weak signal levels or external interference. The result of these two processes is that the received signal quality is relatively consistent over much of the coverage area, which allows radio users to listen without the extra effort needed to separate audio from noise.

Encryption and Improved Encrypted Voice Quality

While many legacy radio systems have had encryption options, prior to P25 there was no standardized encryption system for LMR systems. P25 has a set of encryption standards that includes the encryption protocol and encryption key distribution and management. Over the Air Rekeying (OTAR), which is described below, can be implemented on P25 systems facilitates key system/subscriber management without the need to manually reprogram subscriber units.

Open Data Interfaces

P25 provides an open-standard data interface at both the network and subscriber unit levels which simplifies development of third-party data applications and prevents the sunk cost of application development from becoming a barrier to the use of new subscriber products. The applications to which this applies vary widely from simple messaging to location and over the air programming.

Competitive Procurement

P25 standards have created a marketplace where radio system manufacturers produce radio systems that are compatible with subscriber radios from different manufacturers. Most major radio system manufacturers supply P25 radio systems and subscriber units, but others may only supply one or the other. In addition, several specialty manufacturers supply standards-based equipment for specialized uses such as aircraft, surveillance, data and receive-only applications. This range of suppliers fosters a truly competitive procurement process and makes it easy to acquire comparable pricing sources from the multiple public contracts available.

Other System Features

The VHF P25 trunked system would retain all features of the existing County analog conventional system and would provide other features and capabilities that may be beneficial to County departments/radio users, such as:

- **Emergency Calls** – allows a radio user or dispatcher to declare an emergency for their group with a single button press. This feature informs all users on that talkgroup of the emergency, and that talkgroup receives highest priority on the system so critical communications is not blocked

- **User Authentication** – ensures that only properly authorized subscriber radios may communicate on the system, preventing unauthorized (and potentially disruptive or fraudulent) access to the system

- **Radio Inhibit/Uninhibit** – the system manager may temporarily or permanently disable a lost, stolen or misused radio

- **Global Positioning System (GPS)** – GPS and Automatic Vehicle Location (AVL) systems typically use the standardized GPS protocol within the P25 standard

- **Call Alert** –allows a dispatcher or subscriber unit to send a page-like call to another subscriber unit

- **Announcement Group Call** – much like a talkgroup call, but is usually used to make announcements to larger groups made up of two or more talkgroups

- **Status Query** – allows a user to set a status on his/her radio that can be displayed to a dispatcher or used by a Computer Aided Dispatch (CAD) system in directing calls

- **Private Calls** – allows a radio user to talk directly to a dispatcher or to another radio user, in relative privacy. While not encrypted, it does assure that other users on the system are not included in the conversation

- **Short Messaging Service (SMS)** – allows transmission of short text messages between radio units or between a dispatch position and a radio unit

- **Dynamic Regrouping** – allows units to be regrouped, or for multiple groups to be brought together for short-term activities

While a new P25 trunked radio system may support all of the above features, it is important to note that specific hardware options and/or software licenses may be required on the system core and/or subscriber units for features to function properly.

4.3 Microwave Backhaul System

Refer to Section 2.3*, Backhaul System*.

4.4 Dispatch Equipment

Refer to Section 2.4*, Dispatch Equipment*.

4.5 Video Surveillance Equipment

Refer to Section 2.5*, Video Surveillance Equipment*.

4.6 Radio Site Improvements

Refer to Section 2.6*, Radio Site Improvements*.

4.7 Network Management

Refer to Section 2.7*, Network Management System*.

4.8 Subscriber Units

Most of the County's existing subscriber units have reached or are near end of life, with limited or no support or parts from the manufacturers. The majority of existing subscriber equipment also only supports analog mode and/or P25 Phase 1. Therefore, the County should consider replacing all end-of-life, analog-only and P25 Phase 1-only subscriber units with new P25 Phase 2, single-band VHF units.

Only agencies or departments with Kenwood NX-5200 series radios can re-use some of their subscriber equipment that is P25 Phase 2 capable. All existing pagers would need to be replaced with P25 Phase 2 capable units. Table 28 provides the recommended subscriber replacement counts by agency or department for Alternative 2.

Table 28 – Alternative 2 Subscriber Replacement

Alternative 2 Subscriber Replacement					
Agency or Department	*Portables*	*Mobiles*	*Base/Control Stations*	*Pagers*	*Total*
Garibaldi FD	17	8	1	23	**49**
Manzanita PD	4	4	2	0	**10**
Bay City FD	24	4	1	27	**56**
Nehalem Bay Fire	64	15	0	50	**129**
Rockaway Fire	20	7	0	22	**49**
Rockaway PD	7	5	3	0	**15**
Tillamook County Parks	6	8	1	0	**15**
Tillamook Police	25	12	0	0	**37**
Tillamook County Public Works	17	64	7	0	**88**
Tillamook ECD 911*	2	0	13	0	**15**
Netarts/Oceanside Fire	37	8	6	34	**85**
Tillamook County Transportation District	6	27	4	0	**37**
Tillamook Fire District	64	28	3	77	**172**
Tillamook Sheriff's Office	55	55	5	0	**115**
Nestucca Fire	73	43	0	0	**116**
Total	**421**	**288**	**46**	**233**	**988**
*Does not include 4 MCC5500 consoles and 6 MIP5000 consoles; those are captured in the dispatch section.					

The cost estimate presented below includes the replacement of existing portables, mobiles, control/base stations, and pagers with new single-band VHF, mid-tier models with software to operate in P25 Phase 2 trunking mode. The use of mid-tier models provides a good average price point for budgetary purposes. Some departments may purchase low-tier models, while others may purchase high-tier models with added features. As part of the RFP, the County could specify the quantity and tier requirements for each department, which would allow the vendors to provide a more accurate cost proposal.

4.9 Cost Analysis

FE prepared high-level budgetary cost estimates for Alternative 2 using the same methodology and tool described in Section 2.9, *Cost Analysis* for Alternative 1a.

4.9.1 Cost Assumptions

Based on results from the coverage studies, analysis of existing inventory and feedback provided by the County, ***FE*** developed the following set of equipment- and services-related assumptions shown in Table 29 for the Alternative 2 cost estimates.

Table 29 – Alternative 2 Cost Assumptions

Alternative 2 Assumptions	QTY	Notes
Core Network Equipment		
P25 Phase 2 Core Equipment	1	New non-geo-redundant, P25 Phase 2 Trunking core site
Core Networking Equipment	1	New equipment needed for new, single core site
North Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Voting Equipment	4	New equipment needed for new simulcast cell
Networking Equipment	1	New equipment needed for new simulcast cell
3-Channel TX/RX P25 Phase 2 Trunking Simulcast Equipment	4	New 3-channel P25 Phase 2 Trunking Simulcast repeater system
3-Channel P25 Phase 2 Trunking Receive-Only Equipment	4	New 3-channel P25 Phase 2 Trunking receiver system
Multi-channel VHF TX/RX Antenna System	4	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	4	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	8	New routing and switching equipment
FCC licensing and coordination	12	New VHF frequency for new transmit sites
South Simulcast Cell		
Simulcast Controller	1	New non-geo-redundant control equipment needed for new simulcast cell
GPS Frequency Standard	1	New equipment needed for new simulcast cell
Voting Equipment	4	New equipment needed for new simulcast cell
Networking Equipment	1	New equipment needed for new simulcast cell
3-CH TX/RX P25 Phase 2 Trunking Simulcast Equipment	5	New 3-channel P25 Phase 2 Trunking Simulcast repeater system for new simulcast cell
3-CH P25 Phase 2 Trunking Receive-Only Equipment	6	New 3-channel P25 Phase 2 Trunking receiver system for new simulcast cell
Multi-channel VHF TX/RX Antenna System	5	New antennas, transmission line, mounting hardware, transmit combiner, receive multi-coupler, and lightning protection
Multi-channel VHF RX-only Antenna System	6	New antennas, transmission line, mounting hardware, receive multi-coupler, and lightning protection
Site Networking Equipment	11	New routing and switching equipment
FCC licensing and coordination	15	New VHF frequency for new transmit sites
Backhaul Network		
900 MHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites
6 GHz 1+0 Radio	12	New backhaul equipment for connecting LMR sites

Alternative 2 Assumptions	QTY	Notes
11 GHz 1+0 Radio	6	New backhaul equipment for connecting LMR sites
18 GHz 1+0 Radio	2	New backhaul equipment for connecting LMR sites
900 MHz Panel	12	New antennas/dishes for new backhaul equipment
6 GHz - 6' Single-Polarization	12	New antennas/dishes for new backhaul equipment
11 GHz - 6' Single-Polarization	6	New antennas/dishes for new backhaul equipment
18 GHz - 2' Dual-Polarization	2	New antennas/dishes for new backhaul equipment
Coaxial Cable and Accessories	14	New line & accessories for new backhaul equipment
Waveguide and Accessories	18	New line & accessories for new backhaul equipment
Medium DC Plant	11	New DC power system for new backhaul equipment
Small DC Plant	6	New DC power system for new backhaul equipment
Medium Rack and Accessories	11	New rack & accessories for new backhaul equipment
Small Rack and Accessories	6	New rack & accessories for new backhaul equipment
Medium MPLS Router	11	New MPLS router for new backhaul equipment
Small MPLS Router	6	New MPLS router for new backhaul equipment
Dehydrator System	11	New dehydrator system for new backhaul equipment
Video Surveillance		
Enterprise Software (Licenses) for up to 40 cameras	1	New video surveillance equipment for RF sites
3 cameras per sites for 10 sites (repeater sites only)	1	New video surveillance equipment for RF sites
Server platforms for Base and Recorder (2 servers)	1	New video surveillance equipment for Tillamook 911
Tillamook 911 cameras (up to 10)	1	New video surveillance equipment for Tillamook 911
Site Improvements		
Existing Structure with Available Space	20	Based on site surveys and/or County provided data
Structural Analysis Needed	19	Based on site surveys and/or County provided data
Existing Tower Mods Needed	1	Based on site surveys and/or County provided data
New Tower Structure Needed	1	Based on site surveys and/or County provided data
A&E, Environmental Compliance	0	Based on site surveys and/or County provided data
Existing Shelter/Bldg. with Available Space	19	Based on site surveys and/or County provided data
Site Grounding Updates	18	Based on site surveys and/or County provided data
Existing Shelter HVAC Needed	2	Based on site surveys and/or County provided data
New Prefab Shelter Needed	1	Based on site surveys and/or County provided data
New Outdoor Cabinet Needed	1	Based on site surveys and/or County provided data
Commercial AC Power Available	19	Based on site surveys and/or County provided data
New Generator Needed	3	Based on site surveys and/or County provided data
New Rackmount UPS Needed	1	Based on site surveys and/or County provided data
New DC System Needed	3	Based on site surveys and/or County provided data
Subscriber Equipment		
Portable Radios	421	Requires replacement with new single band VHF radios with software for P25 Phase 2 trunking operation
Mobile Radios	288	Requires replacement with new single band VHF radios with software for P25 Phase 2 trunking operation
Base/Control Stations	46	Requires replacement with new single band VHF radios with software for P25 Phase 2 trunking operation
Pagers	233	Requires replacement with new single band VHF pagers with software for P25 Phase 2 trunking operation

Alternative 2 Assumptions	QTY	Notes
Implementation Services		
Spare / Test Equipment	5%	Based on total of all system components
Sales Tax	0.00%	Based on total of all system components
Project Management	10%	Based on total of all system components
Installation	10%	Based on total of all system components
Engineering	10%	Based on total of all system components
Removal of Existing Equipment	2%	Based on total of all system components
Training	1%	Based on total of all system components
Staging	5%	Based on total of all system components
Acceptance/Coverage Testing	1%	Based on total of all system components
Documentation	1%	Based on total of all system components
Contingency	10%	Based on total of all system components and implementation services

4.9.2 LMR System Cost

Table 30 shows the estimated cost for the new VHF LMR system equipment and implementation services needed for the Alternative 2 conceptual design.

Table 30 – Alternative 2 LMR System Cost Estimate

Alternative 2 P25 Trunking Simulcast Cost Estimate			
Core Network Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 2 Core Equipment	1	$782,000	$782,000
Core Networking Equipment	1	$147,000	$147,000
Spare / Test Equipment	5%		$47,000
Subtotal			**$976,000**
North Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$32,000	$128,000
Networking Equipment	1	$73,000	$73,000
3-CH TX/RX Simulcast Equipment	4	$168,000	$672,000
3-CH Receive-Only Equipment	4	$84,000	$336,000
VHF TX/RX Antenna System	4	$34,000	$136,000
VHF RX-only Antenna System	4	$14,000	$56,000
Site Networking Equipment	8	$13,000	$104,000
Spare / Test Equipment	5%		$81,000
Subtotal			**$1,692,000**
South Simulcast Cell Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	4	$32,000	$128,000
Networking Equipment	1	$73,000	$73,000
3-CH TX/RX Simulcast Equipment	5	$168,000	$840,000

Alternative 2 P25 Trunking Simulcast Cost Estimate			
3-CH Receive-Only Equipment	6	$84,000	$504,000
VHF TX/RX Antenna System	5	$34,000	$170,000
VHF RX-only Antenna System	6	$14,000	$84,000
Site Networking Equipment	11	$13,000	$143,000
Spare / Test Equipment	5%		$103,000
Subtotal			**$2,151,000**
Equipment Subtotal			**$3,843,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	27		$9,000
LMR Frequency Coordination Fees	27		$9,000
LMR Engineering Services Fees	27		$9,000
Subtotal - FCC Licensing and Coordination			**$27,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Project Management	10%		$385,000
Installation	10%		$385,000
Engineering	10%		$385,000
Removal of Existing Equipment	2%		$77,000
Training	1%		$39,000
Staging	5%		$193,000
Acceptance Testing	1%		$39,000
Documentation	1%		$39,000
Subtotal - Implementation Services			**$1,542,000**
Services Total			**$1,569,000**
Equipment and Services Total			**$5,412,000**
Contingency	10%		$542,000
Equipment and Services Total with Contingency			**$5,954,000**

4.9.3 Dispatch System Cost

The dispatch system cost for Alternative 2 is the same as Alternative 1a. Refer to Section 2.9.3, *Dispatch System Cost*.

4.9.4 Backhaul System Cost

The microwave system cost for Alternative 2 is the same as Alternative 1a. Refer to Section 2.9.4, *Backhaul System Cost*.

4.9.5 Video Surveillance Cost

The video surveillance cost for Alternative 1b is the same as Alternative 1a. Refer to Section 2.9.5, *Video Surveillance Cost*.

4.9.6 Site Improvements Cost

The site improvements cost for Alternative 2 is the same as Alternative 1a. Refer to Section 2.9.6, *Site Improvements Cost*.

4.9.7 Subscriber Units Cost

Table 31 shows the estimated cost for new VHF single-band, mid-tier radios with software to operate in P25 Phase 2 trunking mode.

Table 31 – Alternative 2 Subscriber Units Cost Estimate

Alternative 2 Subscriber Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total (Rounded)*
Garibaldi FD	$144,000	$8,000	$16,000	**$168,000**
Manzanita PD	$51,000	$4,000	$6,000	**$61,000**
Bay City FD	$161,000	$8,000	$17,000	**$186,000**
Nehalem Bay Fire	$419,000	$16,000	$44,000	**$479,000**
Rockaway Fire	$147,000	$7,000	$16,000	**$170,000**
Rockaway PD	$76,000	$5,000	$9,000	**$90,000**
Tillamook County Parks	$76,000	$4,000	$8,000	**$88,000**
Tillamook Police	$182,000	$7,000	$19,000	**$208,000**
Tillamook County Public Works	$444,000	$27,000	$48,000	**$519,000**
Tillamook ECD 911	$80,000	$12,000	$10,000	**$102,000**
Netarts/Oceanside Fire	$276,000	$15,000	$30,000	**$321,000**
Tillamook County Transportation District	$187,000	$13,000	$20,000	**$220,000**
Tillamook Fire District	$520,000	$26,000	$55,000	**$601,000**
Tillamook Sheriff's Office	$571,000	$27,000	$60,000	**$658,000**
Nestucca Fire	$571,000	$21,000	$60,000	**$652,000**
Total	**$3,905,000**	**$200,000**	**$418,000**	**$4,523,000**

4.9.8 Capital Cost Summary

Table 32 shows the estimated total cost for Alternative 2, including the VHF radio system, microwave backhaul, dispatch equipment, site improvements, and subscriber units. Total cost is rounded to the nearest $10,000.

Table 32 – Alternative 2 Total Cost Estimate

Alternative 2 Total Cost Estimate				
Item	*Equipment*	*Services*	*Contingency*	*Total Cost*
Radio System	$3,843,000	$1,569,000	$542,000	**$5,954,000**
Dispatch System	$1,295,000	$520,000	$182,000	**$1,997,000**
Microwave System	$1,504,000	$675,000	$218,000	**$2,397,000**
Surveillance System	$74,000	$33,000	$11,000	**$118,000**
Site Improvements	$1,137,000	$458,000	$160,000	**$1,755,000**
Subscriber Equipment	$3,905,000	$200,000	$418,000	**$4,523,000**
Total	**$11,758,000**	**$3,455,000**	**$1,531,000**	**$16,740,000**

4.9.9 Operational Costs

The operational cost estimate for Alternative 2 uses the same methodology and assumptions as described for Alternative 1a. Refer to Section 2.9.9., *Operational Costs*. Table 33 shows the estimated operational costs for 15 years for Alternative 2.

Table 33 – Alternative 2 Operational Cost Estimate

Alternative 2 Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Remote Technical Support	$0	$0	$0	$79,000	$82,000
Software Upgrade Agreement	$0	$0	$0	$354,000	$365,000
Onsite Support and Repair	$0	$0	$0	$236,000	$244,000
Subscriber Growth	$0	$72,000	$74,000	$75,000	$77,000
Subscriber Attrition	$0	$37,000	$37,000	$38,000	$38,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$109,000**	**$111,000**	**$782,000**	**$806,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Remote Technical Support	$85,000	$88,000	$91,000	$94,000	$97,000
Software Upgrade Agreement	$376,000	$388,000	$400,000	$412,000	$425,000
Onsite Support and Repair	$252,000	$260,000	$268,000	$277,000	$286,000
Subscriber Growth	$78,000	$80,000	$82,000	$83,000	$85,000
Subscriber Attrition	$39,000	$39,000	$39,000	$39,000	$39,000
Subscriber Refresh	$0	$0	$0	$0	$2,738,000
Estimated Annual Cost	**$830,000**	**$855,000**	**$880,000**	**$905,000**	**$3,670,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Remote Technical Support	$100,000	$103,000	$107,000	$111,000	$115,000
Software Upgrade Agreement	$438,000	$452,000	$466,000	$480,000	$495,000
Onsite Support and Repair	$295,000	$304,000	$314,000	$324,000	$334,000
Subscriber Growth	$87,000	$88,000	$90,000	$92,000	$94,000
Subscriber Attrition	$41,000	$41,000	$41,000	$41,000	$42,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$961,000**	**$988,000**	**$1,018,000**	**$1,048,000**	**$1,080,000**

5. Land Mobile Radio Alternatives Comparison

Each alternative includes all new equipment and site improvements and address existing issues identified by County stakeholders by:

- Improving radio coverage by adding sites in areas where coverage is inadequate and removing existing sites that do not provide sufficient value
- Reducing operational complexity by decreasing the number of repeater sites radio users must choose from as they move through the County
- Allow radio users to hear all radio traffic on a cell (Alternatives 1a and 1b) or countywide (Alternative 2) using simulcast technology
- Improving system reliability by installing a new IP-based microwave backhaul system with additional path redundancy
- Adding a NMS to remotely monitor and troubleshoot VHF and backhaul system equipment, and for reporting of site alarms

Table 34 compares key technical and operational characteristics and estimated cost. Total cost is rounded to the nearest $10,000.

Table 34 – Alternatives Comparison

	Alternative 1a	Alternative 1b	Alternative 2
Description	7-channel analog conventional simulcast system	7-channel P25 digital conventional simulcast system	3-channel P25 Phase 2 trunked system
Coverage	Countywide mobile and on-street portable coverage and in-building portable coverage in the cities		
Operational Issues	• Would be similar to the existing system, requiring radio users to select a channel based on location, but they would only need to switch between North and South simulcast cells • Radio users in a cell (North or South) could hear all transmissions in that cell • North and South cells could be patched together, as needed • Would provide repeated channels for Fire TAC		• Users would use talkgroups instead of dedicated channels • The trunked system would automatically link everyone in a talkgroup regardless of location • Radio users would have multiple talkgroups in their radio, as needed • Fire TAC talkgroups would be created, allowing for countywide communications
Audio Quality	Improved with additional repeater and receiver sites for improved coverage	Improved audio quality due to increased number of repeaters and by moving to digital system	

	Alternative 1a	Alternative 1b	Alternative 2
Radio Channels	A two-cell conventional solution would require two licensed frequency pairs per channel (i.e. Law North and South) for a total of 14 frequency pairs		• All channels would be pooled together and assigned to talkgroups as needed • Trunked systems utilize channels more efficiently than conventional systems • Would have reduced channel congestion as compared to the conventional alternatives
Dispatch Consoles	Could use existing consoles until able to replace them	Would need to replace existing consoles with P25 compatible consoles	
Subscriber Units	Existing radios could be used until able to replace them	Would need new P25 compatible subscriber units	
Interoperability	Same as existing system. County would program other agencies channels into their radios and vice versa	• Would allow Interoperability with other P25 systems • County radios could include VHF analog conventional channels for interoperability on other agency system(s) • Could use console patch between P25 conventional and analog conventional channels • County could purchase multi-band radios to allow radio users to interoperate on other radio bands	• Would allow full interoperability between all County departments and other agencies authorized to use the County trunked system • County could purchase multi-band radios to allow radio users to interoperate on radio systems on other radio bands • Conventional channel gateways would allow for interop with analog mutual aid channels
Features	Same as existing system	• Emergency call and encryption	• P25 trunking features such as emergency call, individual call, encryption, over-the-air rekeying (OTAR), user status, call alert, radio inhibit and short status messages
Backhaul	Would provide a modern, reliable IP-based backhaul system between Tillamook 911 and the VHF repeater and receiver sites with additional capacity and path redundancy		
NMS	A network management system would be installed to allow County staff to remotely monitor and troubleshoot VHF and backhaul system equipment, and for reporting of site alarms		
Estimated LMR Cost	$4,917,000	$6,125,000	$5,954,000
Estimated Dispatch Cost	$1,997,000	$1,997,000	$1,997,000
Estimated Backhaul Cost	$2,397,000	$2,397,000	$2,397,000
Estimated Video Surveillance Cost	$118,000	$118,000	$118,000
Estimated Site Improvements Cost	$1,755,000	$1,755,000	$1,755,000
Estimated Subscriber Cost	$2,738,000	$3,299,000	$4,523,000
Estimated Total Cost	**$13,920,000**	**$15,690,000**	**$16,740,000**

6. Recommendation

All three alternatives presented in this report would be a significant improvement over the existing system, with improved countywide mobile and portable radio coverage, and system reliability. All three alternatives would also include a new IP-based microwave radio backhaul system, new dispatch consoles and subscriber unit equipment and a new network management system. Based on the needs assessment and the County's long-term goals, Alternative 2, a countywide VHF P25 Phase 2 trunked simulcast radio system appears to best meet the County's needs. The factors for selection of Alternative 2:

- A modern, industry-standard P25 digital trunked radio system, which would meet the County's current and future needs for at least 10 to 15 years
- Resolves current operational issues by allowing radio users to hear all traffic on a talkgroup and to seamlessly roam throughout the County's coverage footprint without needing to change channels on their radios
- Allows for the creation of countywide Fire tactical talkgroups
- Provides improved radio coverage over the existing analog conventional system
- Allows interoperability between all County departments and other agencies authorized to use the system
- Provides P25 trunking features, such as emergency call, individual call, encryption, user status, call alert, radio inhibit and short status messages

At an estimated total cost of $16.7 million, Alternative 2 would cost approximately $2.8 million more than Alternative 1a and $1 million more than Alternative 1b. However, the additional cost for Alternative 2 could be offset by operational improvements and features not available with the current system.

7. Next Steps

There are several steps that the County can take to prepare and plan for the implementation of the recommended solution. After obtaining approval from the County Board of County Commissioners for the recommended solution, the County could:

- Identify funding sources for the new system
- Retain the services of a consultant to develop a Request for Proposals (RFP) for system procurement, installation and testing of the recommended solution
- Begin planning for site development (i.e. approvals, commercial power installation/extensions, County fiber extensions, etc.)

The estimated timeline for the procurement and implementation phases is approximately 36 to 60 months as follows:

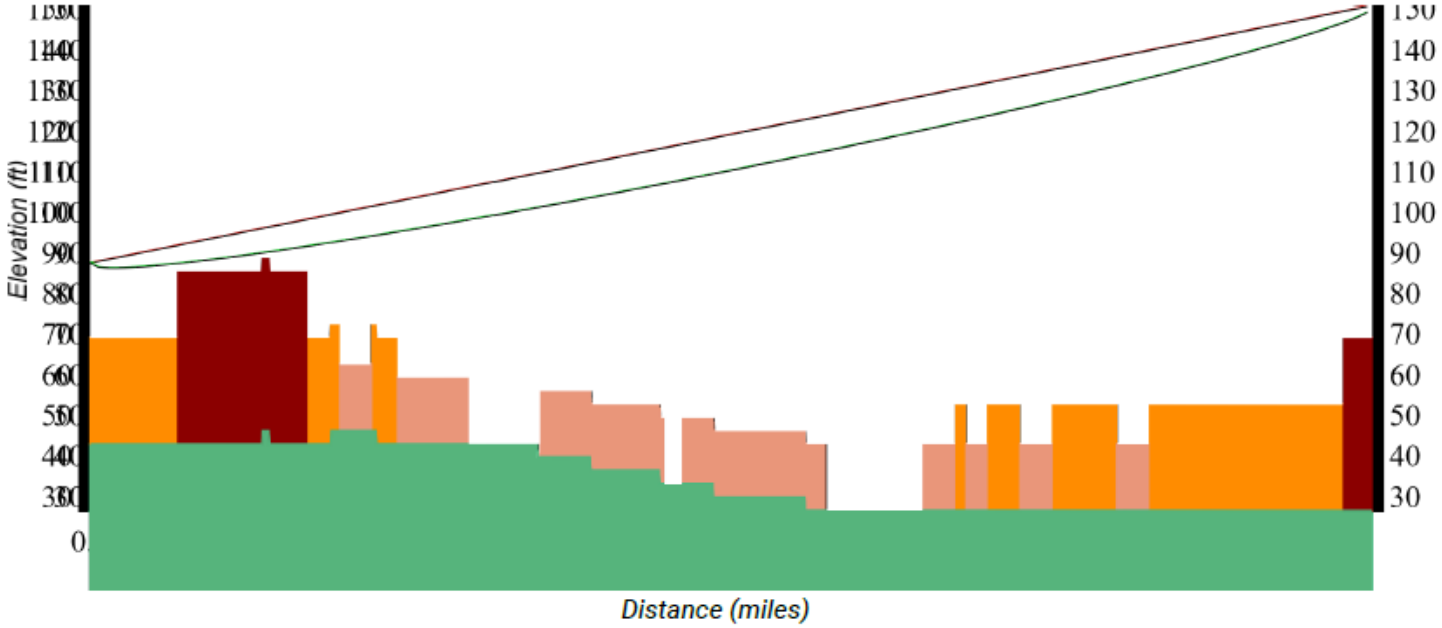
- RFP Development – 4 to 6 months
- System Procurement – 4 to 6 months
- System Implementation – 28 months to 48 months
    - Detailed System Design – 3 to 6 months
    - Site Development/Improvements – 18 to 24 months
    - Installation/testing – 7 to 18 months

Appendix A - Path Profiles and Calculations – 6, 11 and 18 GHz

This appendix contains the radio path profiles and availability calculations for the 6, 11 and 18 GHz microwave radio paths.

Appendix B - 900 MHz Radio Path Profiles

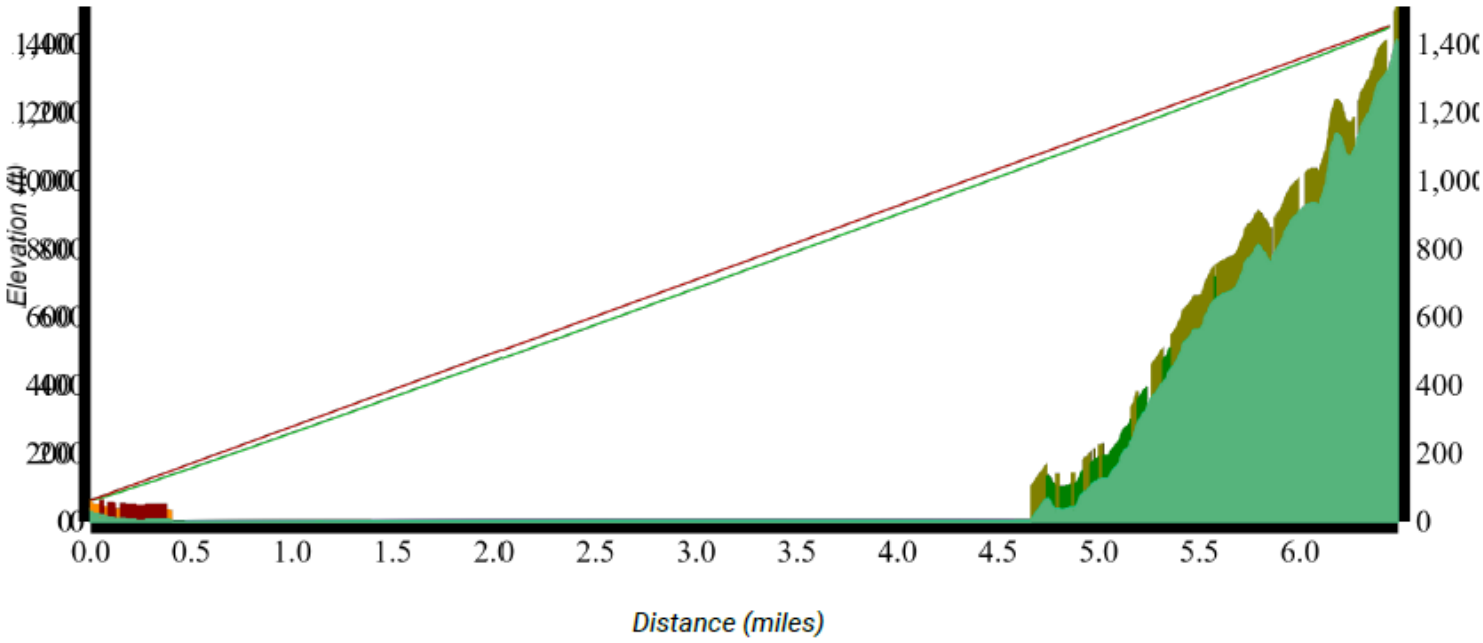
This appendix contains the radio path profiles for the licensed 900 MHz spur links.



County Transportation	
Latitude	45 27 24.80 N
Longitude	123 49 29.17 W
Azimuth (°)	266.05
Elevation (ft)	42.651
Antenna CL (ft)	45

K = 1.33
%F1 = 60

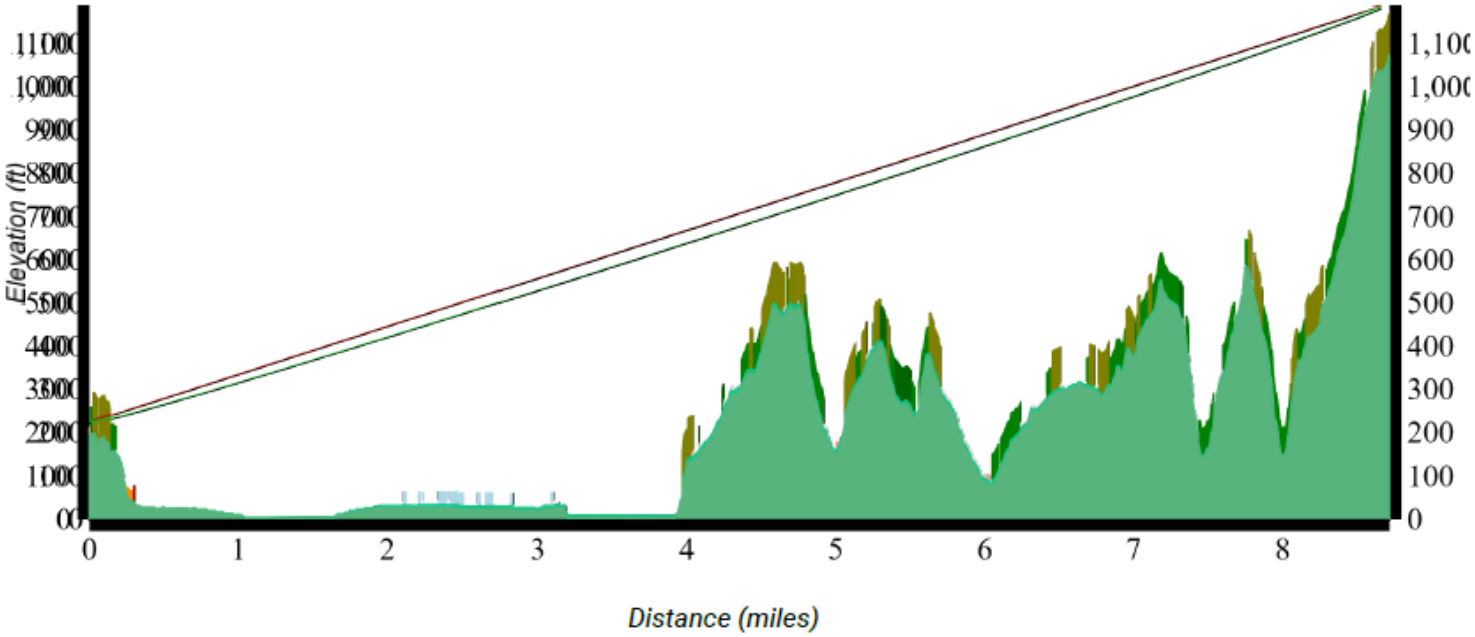
Tillamook 911	
Latitude	45 27 22.09 N
Longitude	123 50 25.16 W
Azimuth (°)	86.04
Elevation (ft)	26.247
Antenna CL (ft)	125



Garibaldi FD	
Latitude	45 33 35.39 N
Longitude	123 54 51.26 W
Azimuth (°)	182.86
Elevation (ft)	32.808
Antenna CL (ft)	30

K = 1.33
%F1 = 60

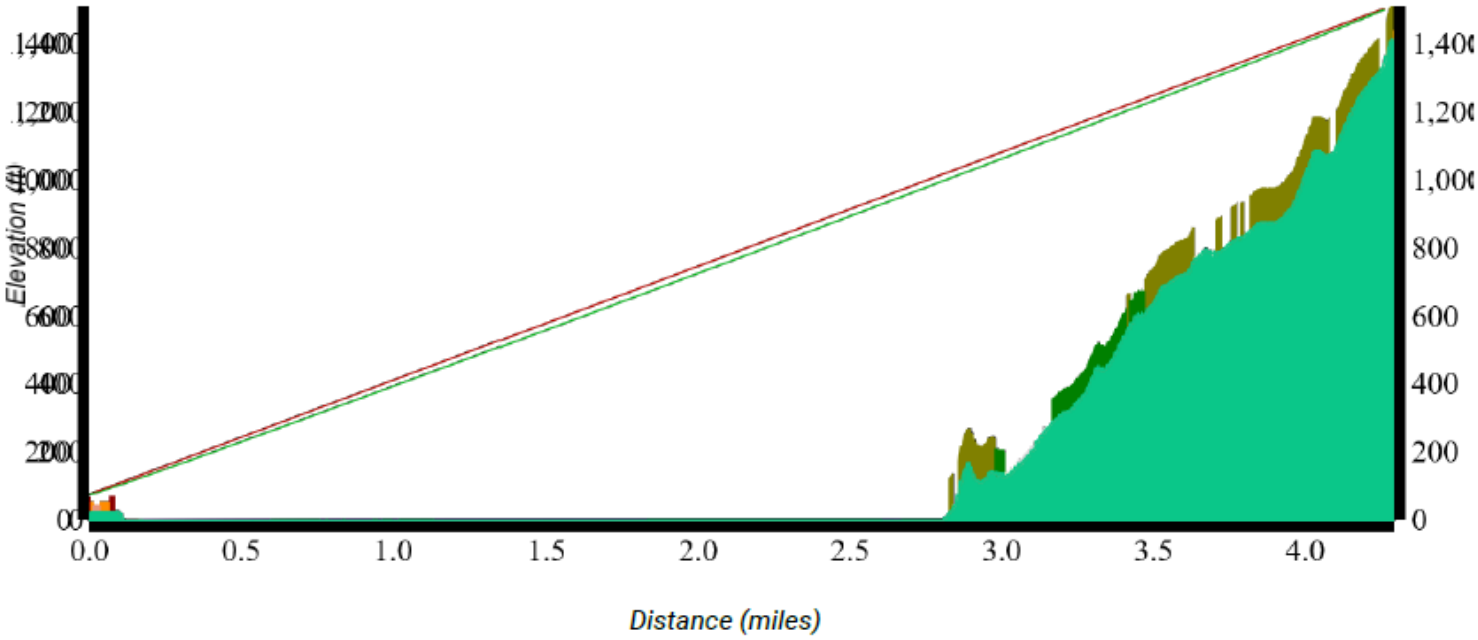
Cape Meares	
Latitude	45 27 57.68 N
Longitude	123 55 15.29 W
Azimuth (°)	2.85
Elevation (ft)	1414.042
Antenna CL (ft)	50



Ridge Road	
Latitude	45 13 10.70 N
Longitude	123 58 14.20 W
Azimuth (°)	175.99
Elevation (ft)	193.57
Antenna CL (ft)	30

K = 1.33
%F1 = 60

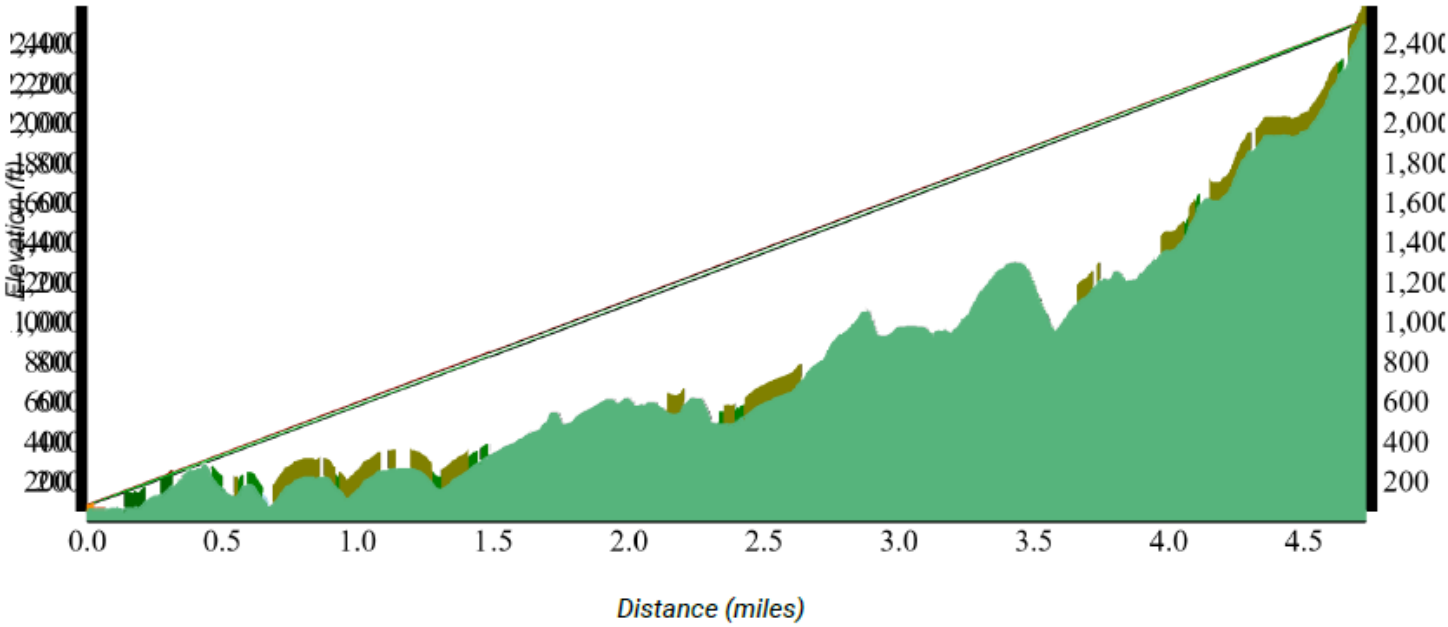
ATC 1217507	
Latitude	45 5 37.39 N
Longitude	123 57 29.16 W
Azimuth (°)	356.00
Elevation (ft)	1072.835
Antenna CL (ft)	120



Bay City FS41	
Latitude	45 31 27.66 N
Longitude	123 53 25.58 W
Azimuth (°)	200.13
Elevation (ft)	26.247
Antenna CL (ft)	50

K = 1.33
%F1 = 60

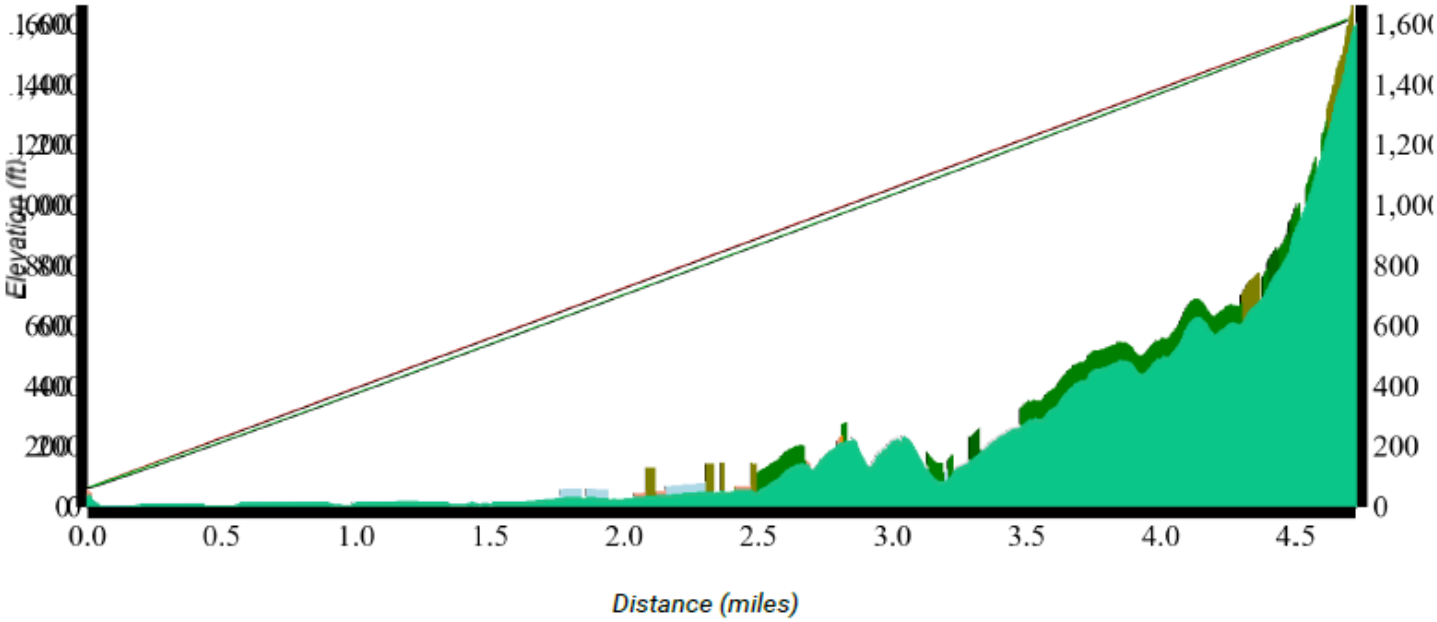
Cape Meares	
Latitude	45 27 57.68 N
Longitude	123 55 15.29 W
Azimuth (°)	20.10
Elevation (ft)	1414.042
Antenna CL (ft)	100



N. County Rec. District	
Latitude	45 43 8.40 N
Longitude	123 53 44.99 W
Azimuth (°)	352.63
Elevation (ft)	52.493
Antenna CL (ft)	30

K = 1.33
%F1 = 60

Angora Peak	
Latitude	45 47 12.80 N
Longitude	123 54 30.35 W
Azimuth (°)	172.62
Elevation (ft)	2483.596
Antenna CL (ft)	35



Wheeler PW	
Latitude	45 41 19.72 N
Longitude	123 52 59.59 W
Azimuth (°)	323.77
Elevation (ft)	32.808
Antenna CL (ft)	30

K = 1.33
%F1 = 60

Neahkahnie	
Latitude	45 44 37.90 N
Longitude	123 56 27.70 W
Azimuth (°)	143.73
Elevation (ft)	1597.769
Antenna CL (ft)	30

Appendix C - Detailed Subscriber Costs

This appendix contains detailed subscriber costs on a per-unit and departmental basis for each alternative.

Table C.1 – Alternative 1a Detailed Subscriber Costs

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$2,900	$49,300
Mobile Radios	8	$3,100	$24,800
Base/Control Stations	1	$3,400	$3,400
Pagers	0	$650	$0
Spares	5%		$4,000
Equipment Subtotal (Rounded)			**$82,000**
Radio/Pager Programming	26	$100	$2,600
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$5,000**
Contingency	10%		$9,000
Equipment, Services, and Contingency Total			**$96,000**
Manzanita PD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	0	$2,900	$0
Mobile Radios	4	$3,100	$12,400
Base/Control Stations	2	$3,400	$6,800
Pagers	0	$650	$0
Spares	5%		$1,000
Equipment Subtotal (Rounded)			**$21,000**
Radio/Pager Programming	6	$100	$600
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	2	$750	$1,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$3,000**
Contingency	10%		$3,000
Equipment, Services, and Contingency Total			**$27,000**
Bay City FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	24	$2,900	$69,600
Mobile Radios	4	$3,100	$12,400
Base/Control Stations	1	$3,400	$3,400
Pagers	12	$650	$7,800

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Spares	5%		$5,000
Equipment Subtotal (Rounded)			**$99,000**
Radio/Pager Programming	41	$100	$4,100
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$6,000**
Contingency	10%		$11,000
Equipment, Services, and Contingency Total			**$116,000**
Nehalem Bay Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$2,900	$185,600
Mobile Radios	15	$3,100	$46,500
Base/Control Stations	0	$3,400	$0
Pagers	0	$650	$0
Spares	5%		$12,000
Equipment Subtotal (Rounded)			**$245,000**
Radio/Pager Programming	79	$100	$7,900
Mobile Radio Installation	15	$200	$3,000
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$11,000**
Contingency	10%		$26,000
Equipment, Services, and Contingency Total			**$282,000**
Rockaway Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	18	$2,900	$52,200
Mobile Radios	7	$3,100	$21,700
Base/Control Stations	0	$3,400	$0
Pagers	22	$650	$14,300
Spares	5%		$5,000
Equipment Subtotal (Rounded)			**$94,000**
Radio/Pager Programming	47	$100	$4,700
Mobile Radio Installation	7	$200	$1,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**
Contingency	10%		$11,000
Equipment, Services, and Contingency Total			**$112,000**
Rockaway PD	*Quantity*	*Unit Cost*	*Extended Cost*

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	7	$2,900	$20,300
Mobile Radios	5	$3,100	$15,500
Base/Control Stations	1	$3,400	$3,400
Pagers	0	$650	$0
Spares	5%		$2,000
Equipment Subtotal (Rounded)			**$42,000**
Radio/Pager Programming	13	$100	$1,300
Mobile Radio Installation	5	$200	$1,000
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$5,000
Equipment, Services, and Contingency Total			**$51,000**
Tillamook County Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	6	$2,900	$17,400
Mobile Radios	8	$3,100	$24,800
Base/Control Stations	1	$3,400	$3,400
Pagers	0	$650	$0
Spares	5%		$3,000
Equipment Subtotal (Rounded)			**$49,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$6,000
Equipment, Services, and Contingency Total			**$59,000**
Tillamook Police	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	25	$2,900	$72,500
Mobile Radios	12	$3,100	$37,200
Base/Control Stations	0	$3,400	$0
Pagers	0	$650	$0
Spares	5%		$6,000
Equipment Subtotal (Rounded)			**$116,000**
Radio/Pager Programming	37	$100	$3,700
Mobile Radio Installation	12	$200	$2,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Contingency	10%		$13,000
Equipment, Services, and Contingency Total			**$136,000**
Tillamook County Public Works	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$2,900	$49,300
Mobile Radios	64	$3,100	$198,400
Base/Control Stations	7	$3,400	$23,800
Pagers	0	$650	$0
Spares	5%		$14,000
Equipment Subtotal (Rounded)			**$286,000**
Radio/Pager Programming	88	$100	$8,800
Mobile Radio Installation	64	$200	$12,800
Base/Control Station Installation	7	$750	$5,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$32,000
Equipment, Services, and Contingency Total			**$345,000**
Tillamook ECD 911	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	2	$2,900	$5,800
Mobile Radios	0	$3,100	$0
Base/Control Stations	11	$3,400	$37,400
Pagers	0	$650	$0
Spares	5%		$3,000
Equipment Subtotal (Rounded)			**$47,000**
Radio/Pager Programming	13	$100	$1,300
Mobile Radio Installation	0	$200	$0
Base/Control Station Installation	11	$750	$8,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$10,000**
Contingency	10%		$6,000
Equipment, Services, and Contingency Total			**$63,000**
Netarts/Oceanside Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	37	$2,900	$107,300
Mobile Radios	8	$3,100	$24,800
Base/Control Stations	6	$3,400	$20,400
Pagers	22	$650	$14,300
Spares	5%		$9,000
Equipment Subtotal (Rounded)			**$176,000**
Radio/Pager Programming	73	$100	$7,300

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	6	$750	$4,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$14,000**
Contingency	10%		$19,000
Equipment, Services, and Contingency Total			**$209,000**
Tillamook County Transportation District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	0	$2,900	$0
Mobile Radios	0	$3,100	$0
Base/Control Stations	0	$3,400	$0
Pagers	0	$650	$0
Spares	5%		$0
Equipment Subtotal (Rounded)			**$0**
Radio/Pager Programming	0	$100	$0
Mobile Radio Installation	0	$200	$0
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$0**
Contingency	10%		$0
Equipment, Services, and Contingency Total			**$0**
Tillamook Fire District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$2,900	$185,600
Mobile Radios	28	$3,100	$86,800
Base/Control Stations	3	$3,400	$10,200
Pagers	46	$650	$29,900
Spares	5%		$16,000
Equipment Subtotal (Rounded)			**$329,000**
Radio/Pager Programming	141	$100	$14,100
Mobile Radio Installation	28	$200	$5,600
Base/Control Station Installation	3	$750	$2,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$22,000**
Contingency	10%		$36,000
Equipment, Services, and Contingency Total			**$387,000**
Tillamook Sheriff's Office	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	55	$2,900	$159,500
Mobile Radios	55	$3,100	$170,500
Base/Control Stations	5	$3,400	$17,000

Alternative 1a Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Pagers	0	$650	$0
Spares	5%		$18,000
Equipment Subtotal (Rounded)			**$365,000**
Radio/Pager Programming	115	$100	$11,500
Mobile Radio Installation	55	$200	$11,000
Base/Control Station Installation	5	$750	$3,750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$40,000
Equipment, Services, and Contingency Total			**$432,000**
Nestucca Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	73	$2,900	$211,700
Mobile Radios	43	$3,100	$133,300
Base/Control Stations	0	$3,400	$0
Pagers	0	$650	$0
Spares	5%		$18,000
Equipment Subtotal (Rounded)			**$363,000**
Radio/Pager Programming	116	$100	$11,600
Mobile Radio Installation	43	$200	$8,600
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$21,000**
Contingency	10%		$39,000
Equipment, Services, and Contingency Total			**$423,000**
Total (Rounded)			**$2,738,000**

Table C.2 – Alternative 1b Detailed Subscriber Costs

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$3,200	$54,400
Mobile Radios	8	$3,400	$27,200
Base/Control Stations	1	$3,700	$3,700
Pagers	23	$650	$14,950
Spares	5%		$6,000
Equipment Subtotal (Rounded)			**$107,000**
Radio/Pager Programming	49	$100	$4,900
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$8,000**
Contingency	10%		$12,000
Equipment, Services, and Contingency Total			**$127,000**
Manzanita PD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	4	$3,200	$12,800
Mobile Radios	4	$3,400	$13,600
Base/Control Stations	2	$3,700	$7,400
Pagers	0	$650	$0
Spares	5%		$2,000
Equipment Subtotal (Rounded)			**$36,000**
Radio/Pager Programming	10	$100	$1,000
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	2	$750	$1,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$4,000
Equipment, Services, and Contingency Total			**$44,000**
Bay City FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	24	$3,200	$76,800
Mobile Radios	4	$3,400	$13,600
Base/Control Stations	1	$3,700	$3,700
Pagers	27	$650	$17,550
Spares	5%		$6,000
Equipment Subtotal (Rounded)			**$118,000**
Radio/Pager Programming	56	$100	$5,600
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	1	$750	$750

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$8,000**
Contingency	10%		$13,000
Equipment, Services, and Contingency Total			**$139,000**
Nehalem Bay Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$3,200	$204,800
Mobile Radios	15	$3,400	$51,000
Base/Control Stations	0	$3,700	$0
Pagers	50	$650	$32,500
Spares	5%		$15,000
Equipment Subtotal (Rounded)			**$304,000**
Radio/Pager Programming	129	$100	$12,900
Mobile Radio Installation	15	$200	$3,000
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$16,000**
Contingency	10%		$32,000
Equipment, Services, and Contingency Total			**$352,000**
Rockaway Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	20	$3,200	$64,000
Mobile Radios	7	$3,400	$23,800
Base/Control Stations	0	$3,700	$0
Pagers	22	$650	$14,300
Spares	5%		$6,000
Equipment Subtotal (Rounded)			**$109,000**
Radio/Pager Programming	49	$100	$4,900
Mobile Radio Installation	7	$200	$1,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**
Contingency	10%		$12,000
Equipment, Services, and Contingency Total			**$128,000**
Rockaway PD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	7	$3,200	$22,400
Mobile Radios	5	$3,400	$17,000
Base/Control Stations	3	$3,700	$11,100
Pagers	0	$650	$0
Spares	5%		$3,000

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Equipment Subtotal (Rounded)			**$54,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	5	$200	$1,000
Base/Control Station Installation	3	$750	$2,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$5,000**
Contingency	10%		$6,000
Equipment, Services, and Contingency Total			**$65,000**
Tillamook County Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	6	$3,200	$19,200
Mobile Radios	8	$3,400	$27,200
Base/Control Stations	1	$3,700	$3,700
Pagers	0	$650	$0
Spares	5%		$3,000
Equipment Subtotal (Rounded)			**$54,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$6,000
Equipment, Services, and Contingency Total			**$64,000**
Tillamook Police	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	25	$3,200	$80,000
Mobile Radios	12	$3,400	$40,800
Base/Control Stations	0	$3,700	$0
Pagers	0	$650	$0
Spares	5%		$7,000
Equipment Subtotal (Rounded)			**$128,000**
Radio/Pager Programming	37	$100	$3,700
Mobile Radio Installation	12	$200	$2,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**
Contingency	10%		$14,000
Equipment, Services, and Contingency Total			**$149,000**
Tillamook County Public Works	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$3,200	$54,400

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	64	$3,400	$217,600
Base/Control Stations	7	$3,700	$25,900
Pagers	0	$650	$0
Spares	5%		$15,000
Equipment Subtotal (Rounded)			**$313,000**
Radio/Pager Programming	88	$100	$8,800
Mobile Radio Installation	64	$200	$12,800
Base/Control Station Installation	7	$750	$5,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$34,000
Equipment, Services, and Contingency Total			**$374,000**
Tillamook ECD 911	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	2	$3,200	$6,400
Mobile Radios	0	$3,400	$0
Base/Control Stations	13	$3,700	$48,100
Pagers	0	$650	$0
Spares	5%		$3,000
Equipment Subtotal (Rounded)			**$58,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	0	$200	$0
Base/Control Station Installation	13	$750	$9,750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$12,000**
Contingency	10%		$7,000
Equipment, Services, and Contingency Total			**$77,000**
Netarts/Oceanside Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	37	$3,200	$118,400
Mobile Radios	8	$3,400	$27,200
Base/Control Stations	6	$3,700	$22,200
Pagers	34	$650	$22,100
Spares	5%		$10,000
Equipment Subtotal (Rounded)			**$200,000**
Radio/Pager Programming	85	$100	$8,500
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	6	$750	$4,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$15,000**
Contingency	10%		$22,000

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Equipment, Services, and Contingency Total			**$237,000**
Tillamook County Transportation District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	6	$3,200	$19,200
Mobile Radios	27	$3,400	$91,800
Base/Control Stations	4	$3,700	$14,800
Pagers	0	$650	$0
Spares	5%		$7,000
Equipment Subtotal (Rounded)			**$133,000**
Radio/Pager Programming	37	$100	$3,700
Mobile Radio Installation	27	$200	$5,400
Base/Control Station Installation	4	$750	$3,000
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$13,000**
Contingency	10%		$15,000
Equipment, Services, and Contingency Total			**$161,000**
Tillamook Fire District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$3,200	$204,800
Mobile Radios	28	$3,400	$95,200
Base/Control Stations	3	$3,700	$11,100
Pagers	77	$650	$50,050
Spares	5%		$19,000
Equipment Subtotal (Rounded)			**$381,000**
Radio/Pager Programming	172	$100	$17,200
Mobile Radio Installation	28	$200	$5,600
Base/Control Station Installation	3	$750	$2,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$26,000**
Contingency	10%		$41,000
Equipment, Services, and Contingency Total			**$448,000**
Tillamook Sheriff's Office	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	55	$3,200	$176,000
Mobile Radios	55	$3,400	$187,000
Base/Control Stations	5	$3,700	$18,500
Pagers	0	$650	$0
Spares	5%		$20,000
Equipment Subtotal (Rounded)			**$402,000**
Radio/Pager Programming	115	$100	$11,500
Mobile Radio Installation	55	$200	$11,000

Alternative 1b Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Base/Control Station Installation	5	$750	$3,750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$43,000
Equipment, Services, and Contingency Total			**$472,000**
Nestucca Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	73	$3,200	$233,600
Mobile Radios	43	$3,400	$146,200
Base/Control Stations	0	$3,700	$0
Pagers	0	$650	$0
Spares	5%		$19,000
Equipment Subtotal (Rounded)			**$399,000**
Radio/Pager Programming	116	$100	$11,600
Mobile Radio Installation	43	$200	$8,600
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$21,000**
Contingency	10%		$42,000
Equipment, Services, and Contingency Total			**$462,000**
Total (Rounded)			**$3,299,000**

Table C.3 – Alternative 2 Detailed Subscriber Costs

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$4,600	$78,200
Mobile Radios	8	$4,800	$38,400
Base/Control Stations	1	$5,100	$5,100
Pagers	23	$650	$14,950
Spares	5%		$7,000
Equipment Subtotal (Rounded)			**$144,000**
Radio/Pager Programming	49	$100	$4,900
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$8,000**
Contingency	10%		$16,000
Equipment, Services, and Contingency Total			**$168,000**
Manzanita PD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	4	$4,600	$18,400
Mobile Radios	4	$4,800	$19,200
Base/Control Stations	2	$5,100	$10,200
Pagers	0	$650	$0
Spares	5%		$3,000
Equipment Subtotal (Rounded)			**$51,000**
Radio/Pager Programming	10	$100	$1,000
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	2	$750	$1,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$6,000
Equipment, Services, and Contingency Total			**$61,000**
Bay City FD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	24	$4,600	$110,400
Mobile Radios	4	$4,800	$19,200
Base/Control Stations	1	$5,100	$5,100
Pagers	27	$650	$17,550
Spares	5%		$8,000
Equipment Subtotal (Rounded)			**$161,000**
Radio/Pager Programming	56	$100	$5,600
Mobile Radio Installation	4	$200	$800
Base/Control Station Installation	1	$750	$750

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$8,000**
Contingency	10%		$17,000
Equipment, Services, and Contingency Total			**$186,000**
Nehalem Bay Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$4,600	$294,400
Mobile Radios	15	$4,800	$72,000
Base/Control Stations	0	$5,100	$0
Pagers	50	$650	$32,500
Spares	5%		$20,000
Equipment Subtotal (Rounded)			**$419,000**
Radio/Pager Programming	129	$100	$12,900
Mobile Radio Installation	15	$200	$3,000
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$16,000**
Contingency	10%		$44,000
Equipment, Services, and Contingency Total			**$479,000**
Rockaway Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	20	$4,600	$92,000
Mobile Radios	7	$4,800	$33,600
Base/Control Stations	0	$5,100	$0
Pagers	22	$650	$14,300
Spares	5%		$7,000
Equipment Subtotal (Rounded)			**$147,000**
Radio/Pager Programming	49	$100	$4,900
Mobile Radio Installation	7	$200	$1,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**
Contingency	10%		$16,000
Equipment, Services, and Contingency Total			**$170,000**
Rockaway PD	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	7	$4,600	$32,200
Mobile Radios	5	$4,800	$24,000
Base/Control Stations	3	$5,100	$15,300
Pagers	0	$650	$0
Spares	5%		$4,000

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Equipment Subtotal (Rounded)			**$76,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	5	$200	$1,000
Base/Control Station Installation	3	$750	$2,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$5,000**
Contingency	10%		$9,000
Equipment, Services, and Contingency Total			**$90,000**
Tillamook County Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	6	$4,600	$27,600
Mobile Radios	8	$4,800	$38,400
Base/Control Stations	1	$5,100	$5,100
Pagers	0	$650	$0
Spares	5%		$4,000
Equipment Subtotal (Rounded)			**$76,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	1	$750	$750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$4,000**
Contingency	10%		$8,000
Equipment, Services, and Contingency Total			**$88,000**
Tillamook Police	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	25	$4,600	$115,000
Mobile Radios	12	$4,800	$57,600
Base/Control Stations	0	$5,100	$0
Pagers	0	$650	$0
Spares	5%		$9,000
Equipment Subtotal (Rounded)			**$182,000**
Radio/Pager Programming	37	$100	$3,700
Mobile Radio Installation	12	$200	$2,400
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$7,000**
Contingency	10%		$19,000
Equipment, Services, and Contingency Total			**$208,000**
Tillamook County Public Works	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	17	$4,600	$78,200

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	64	$4,800	$307,200
Base/Control Stations	7	$5,100	$35,700
Pagers	0	$650	$0
Spares	5%		$22,000
Equipment Subtotal (Rounded)			**$444,000**
Radio/Pager Programming	88	$100	$8,800
Mobile Radio Installation	64	$200	$12,800
Base/Control Station Installation	7	$750	$5,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$48,000
Equipment, Services, and Contingency Total			**$519,000**
Tillamook ECD 911	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	2	$4,600	$9,200
Mobile Radios	0	$4,800	$0
Base/Control Stations	13	$5,100	$66,300
Pagers	0	$650	$0
Spares	5%		$4,000
Equipment Subtotal (Rounded)			**$80,000**
Radio/Pager Programming	15	$100	$1,500
Mobile Radio Installation	0	$200	$0
Base/Control Station Installation	13	$750	$9,750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$12,000**
Contingency	10%		$10,000
Equipment, Services, and Contingency Total			**$102,000**
Netarts/Oceanside Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	37	$4,600	$170,200
Mobile Radios	8	$4,800	$38,400
Base/Control Stations	6	$5,100	$30,600
Pagers	34	$650	$22,100
Spares	5%		$14,000
Equipment Subtotal (Rounded)			**$276,000**
Radio/Pager Programming	85	$100	$8,500
Mobile Radio Installation	8	$200	$1,600
Base/Control Station Installation	6	$750	$4,500
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$15,000**
Contingency	10%		$30,000

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Equipment, Services, and Contingency Total			**$321,000**
Tillamook County Transportation District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	6	$4,600	$27,600
Mobile Radios	27	$4,800	$129,600
Base/Control Stations	4	$5,100	$20,400
Pagers	0	$650	$0
Spares	5%		$9,000
Equipment Subtotal (Rounded)			**$187,000**
Radio/Pager Programming	37	$100	$3,700
Mobile Radio Installation	27	$200	$5,400
Base/Control Station Installation	4	$750	$3,000
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$13,000**
Contingency	10%		$20,000
Equipment, Services, and Contingency Total			**$220,000**
Tillamook Fire District	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	64	$4,600	$294,400
Mobile Radios	28	$4,800	$134,400
Base/Control Stations	3	$5,100	$15,300
Pagers	77	$650	$50,050
Spares	5%		$25,000
Equipment Subtotal (Rounded)			**$520,000**
Radio/Pager Programming	172	$100	$17,200
Mobile Radio Installation	28	$200	$5,600
Base/Control Station Installation	3	$750	$2,250
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$26,000**
Contingency	10%		$55,000
Equipment, Services, and Contingency Total			**$601,000**
Tillamook Sheriff's Office	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	55	$4,600	$253,000
Mobile Radios	55	$4,800	$264,000
Base/Control Stations	5	$5,100	$25,500
Pagers	0	$650	$0
Spares	5%		$28,000
Equipment Subtotal (Rounded)			**$571,000**
Radio/Pager Programming	115	$100	$11,500
Mobile Radio Installation	55	$200	$11,000

Alternative 2 Subscriber Cost Estimates			
Garibaldi FD	*Quantity*	*Unit Cost*	*Extended Cost*
Base/Control Station Installation	5	$750	$3,750
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$27,000**
Contingency	10%		$60,000
Equipment, Services, and Contingency Total			**$658,000**
Nestucca Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Portable Radios	73	$4,600	$335,800
Mobile Radios	43	$4,800	$206,400
Base/Control Stations	0	$5,100	$0
Pagers	0	$650	$0
Spares	5%		$28,000
Equipment Subtotal (Rounded)			**$571,000**
Radio/Pager Programming	116	$100	$11,600
Mobile Radio Installation	43	$200	$8,600
Base/Control Station Installation	0	$750	$0
Sales Tax	0%		$0
Services Subtotal (Rounded)			**$21,000**
Contingency	10%		$60,000
Equipment, Services, and Contingency Total			**$652,000**
Total (Rounded)			**$4,523,000**