

Lewis County, WA Public Safety Radio System Engineering Study Report

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EXECUTIVE SUMMARY

Introduction

Lewis County, WA ("the County") engaged Televate to identify gaps in current public safety radio system coverage and provide recommendations to improve radio site coverage, compatibility, and interoperability. Specifically, the County requested that Televate:

- 1. Develop a plan for and make recommendations for replacement of existing radio infrastructure equipment as a county-wide simulcast system
- 2. Develop a plan for and make recommendations for replacement of existing microwave infrastructure
- 3. Develop a plan for and make recommendations for replacement of existing DC power plants
- 4. Perform an analysis of existing sites and provide recommendations of additional/alternate sites for improved coverage, and
- 5. Provide coverage maps of existing and proposed sites.

To accomplish these objectives for the County, Televate sought to define a comprehensive public safety radio system upgrade, which will prepare the County for an effective procurement and smooth execution of the upgrade implementation process. Televate proceeded to work in partnership with Lewis County project leadership and stakeholders to document their unique requirements and to help prepare for the next phase of the system procurement cycle that will establish a mutually agreeable contract with a qualified radio system vendor resulting in a sustainable, interoperable, standards-based and cost-effective radio system that addresses the public safety community's needs throughout the County. This report documents and details the findings and recommendations for the County.

Key Findings

During the needs analysis and through discussions with County stakeholders, Televate identified multiple systems supporting public safety and public works communications within the County. These systems include:

- Fire System East
- Fire System West
- RFA City System
- RFA District 12 System
- Fire Paging

- City PD System
- LCSO System East
- LCSO System West
- Public Works
- Microwave/Backhaul System

Televate also identified the following key items affecting County system users:

System Item/Feature	Findings
Coverage	 Fire coverage is limited in many areas The use of a simplex channel for fire hampers the ability of field users to communicate directly with each other and they must relay messages through dispatch in many situations Coverage within the cities and along Route 12 is a priority

	 FD14 has coverage issues in the southern portion of the district – repeater was moved from Watch Mountain due to site access problems
	 FD1 has coverage issues along Route 508
	 Lewis County Sheriff's Office (LCSO) experiences coverage issues along Route 12 east of Packwood, in the Mineral area, in the northwest portion of the County, in addition to other areas
	 Western fire districts including FD11, FD13, FD16 have many coverage issues – can usually hear dispatch but can't reliably talk back
	 Fire Paging generally has adequate coverage
	 PD coverage in the cities of Chehalis and Centralia is generally good – has improved since the main site was moved – some in-building issues exist in buildings such as the hospital, Walmart and Home Depot
	 Coverage for the separate Riverside Fire Authority (FD12 and Centralia) system is generally good, except for in-building coverage in large commercial facilities
	 Public Works operates with a single repeater in the east and a single repeater in the west
Interference	• The County frequently receives substantial interference on the primary fire frequency (Fire 1) from transmitters in Mason and Pacific Counties – this should be addressed as soon as possible
	• Some fire districts in the eastern portion of the County use a different channel to avoid the interference
Site Connectivity	Microwave connectivity is limited
	 Connectivity to many sites is done through aged Telco T1 channels over partner's microwave, or via analog circuit connections
Capacity	 Capacity for the most part is adequate, however, additional repeated Tactical channels should be considered for both fire and law enforcement, if available, to offload the dispatch channels
	 Newly acquired simplex Tactical channels (5) will provide additional opportunity to offload traffic from the main dispatch channels – these tactical channels, along with other potential frequency changes, need to be programming into all radios
System Reliability	 System reliability has generally been acceptable, although it was noted that one microwave link becomes unreliable when temperatures are over 95 degrees
	 Regular site checks are performed by the Radio Services personnel which helps to maintain consistent operation

Dispatch Operations	 Dispatch spends time repeating communications between units in the field since they can't hear each other – a repeated frequency pair will significantly reduce this need
	• Dispatch contends with users in the east and west portion of the County since they can't hear each other
	 The dispatch workload suggests 24 dispatch operators are needed, yet the center currently has only nine
	 Users in the field would like more consistent dispatch related to training/procedures, voice volume and clarity
Interoperability	 County fire and law enforcement can talk to each other
	 No interoperability with the State Patrol, although it is seldom needed
	 Fire districts require interoperability with the state Division of Natural Resources (DNR)
	 FD11 also needs to talk with Pacific County to the west
Site Infrastructure	 The conditions of the sites vary – an assessment was performed
	 The Democrat site is currently located at a residence and needs to be upgraded
	 Additional recommendations will be provided as part of the enhanced system concept
Features	• The Lewis County Sheriff's Office (LCSO) and the local police departments need encryption capability and would also like radio location capability, emergency button use, and individual call capability
Operational	 New Radio Services personnel have been very helpful and have made substantial improvements
	 The radio committee meetings should be continued
	 The fire chief's meetings should be continued

Table 1: Study Key Findings

Following a complete analysis of the existing systems and considerations of the key findings and needs, Televate provided specific actionable recommendations for each of the systems listed above to provide significant improvements in public safety communications for the County's first responders. Please see the Recommendations for Improved Public Safety Communications section of this report.

Televate additionally provided capital cost estimates for the recommended site facilities upgrades, as well as estimated ongoing operating and maintenance costs. Please see Cost Estimate of Proposed Recommendations. A complete estimated project budget was also provided under separate cover.

Finally, to facilitate an efficient project to implement the recommended enhancements, a set of next steps for the County to pursue were provided, including:

• Achieving consensus on the recommended direction and performing coordination with its partners

- Developing a comprehensive frequency plan as soon as possible, which entails:
 - Performing coordination on potential new frequencies and identifying frequency pairs
 - Evaluating available frequencies from a combining/multicoupler perspective for the following groups:
 - East simulcast cell group:
 - Fire East repeater pair
 - LCSO East repeater pair, and
 - Public Works East repeater pair.
 - West simulcast cell group:
 - Fire West repeater pair
 - o LCSO West repeater pair, and
 - Public Works West repeater pair.
 - Identifying a new Fire West frequency and begin using ASAP
- Identifying and allocating sufficient funding for the project
- Developing a long-term Public Safety Communications strategy
- Establishing a procurement strategy and developing a procurement specification, and
- Considering dispatch improvements.

EXISTING SYSTEM BACKGROUND

County Systems

In order to develop firsthand familiarity with the County's system and to subsequently outline viable paths for system enhancement options, an exhaustive data collection, review and analysis effort was conducted. System data was collected through a review of available electronic records from the County's operational personnel, publicly available information from FCC records and other sources, as well as through targeted onsite physical surveys. Additionally, a series of discussions were held with the radio services and dispatch personnel to better understand the system's history, strengths and gaps, desired outcomes, and overall vision.

Data collected to support the assessment included:

- Overall radio and microwave network architecture and system design
- VHF radio and microwave equipment types, models, quantities, and years in operations
- RF site coordinates
- Operational frequencies
- Dispatch center equipment and interfaces, and
- Site equipment inventory.

Current Systems Overview

The County currently operates VHF analog conventional systems for both their law enforcement and fire operations. These systems support the following County and partner agencies:

- Law Enforcement:
 - Lewis County Sheriff
 - o Centralia PD
 - o Chehalis PD
 - Napavine PD
 - Winlock PD
 - Toledo PD
 - o Morton PD
- Fire Agencies:
 - o LCFD #1-Onalaska
 - LCFD #2-Toledo
 - LCFD #3-Mossyrock
 - LCFD #4-Morton
 - LCFD #5-Napavine
 - LCFD #6-Chehalis
 - o LCFD #8-Salkum
 - o LCFD #9-Mineral
 - LCFD #10-Packwood
 - o LCFD #11-PeEll
 - o LCFD #13-Curtis
 - o LCFD #14-Randle
 - o LCFD #15-Winlock
 - LCFD #16-Doty

- LCFD #18-Glenoma
- Cowlitz-Lewis #20
- o Riverside Fire Auth.
- Chehalis FD
- Other Agencies:
 - American Medical Response
 - Coroner's Office
 - Public Works/DEM
 - US Forest Service

Televate analyzed the different systems in order to establish a complete picture of communications throughout the County. These systems include:

- Fire System East
- Fire System West
- RFA City System
- RFA District 12 System
- Fire Paging
- City PD System
- LCSO System East
- LCSO System West
- Public Works
- Backhaul System

A description of each of these systems is provided below and estimated coverage performance based on a propagation simulation is provided in Appendix B: Current System Predicted Coverage.

Fire System East:

The fire system in the eastern portion of the County operates with Tx/Rx sites at Storm King (154.19 MHz for the Mineral area – FD9), Dog (154.19 & 156.105), Randle Fire (155.805), and Packwood (155.805). The Storm King and Dog sites use the Fire 1 channel of 154.19, while the Randle Fire and Packwood sites utilize the Fire 3/4 repeated channel (155.805/156.105) which support fire districts 10 and 14. The Hopkins site is used as a relay site for Storm King (via 159.315). A diagram of this configuration is shown in Figure 1.



Figure 1: Lewis County Fire System East Sites

Fire System West:

The fire system in the western portion of the County operates with Tx/Rx sites at Crego and Democrat, with receive only sites at Cooks, Onalaska, Toledo, and at the Fire District 11 Station (receives one frequency then transmits on 154.19). All of these sites utilize the Fire 1 channel of 154.19, except for the alternate receive frequency used at the Fire District 11 Station. A diagram of this configuration is shown in Figure 2.



Figure 2: Lewis County Fire System West Sites

RFA City System:

The RFA system that supports the fire departments for Chehalis and Centralia uses Tx/Rx sites at the Courthouse and Seminary Hill, with receive only sites at Cooks and Crego. This system is configured as simulcast transmit and voted receive and uses the repeater pair of 154.145/158.760 MHz, which is also referred to as the Fire 6 channel. A diagram of this configuration is shown in Figure 3.



RFA District 12 System:

The Riverside Fire Authority (RFA) District 12 system supports the fire district in the northwest portion of Lewis County and utilizes Tx/Rx sites at Crego, Cooks, Coal Mine, Manners and receive only sites at the Courthouse and Seminary Hill. This system is configured as simulcast transmit and voted receive and uses the repeater pair of 154.9725/159.0975 MHz, which is also referred to as the Fire 2 channel. A diagram of this configuration is shown in Figure 4.



Fire Paging System:

The paging system that supports all fire agencies within the County utilizes two sites in the east (Dog and Packwood) using the mobile receive side of the voice channel in that area (155.8050 MHz) instead of a dedicated paging channel. The paging system in the western portion of the County uses a total of four sites at Cooks, Crego, Manners, and Toledo using a dedicated paging frequency 155.7150 MHz. A diagram of this configuration is shown in Figure 5.



Figure 5: Fire Paging System

City Police Departments (PDs) System:

The system that supports the police departments for Chehalis and Centralia uses one Tx/Rx site at Chehalis Ridge and a receive only site at Seminary Hill. An additional receive site at Davis Hill has been disabled as it was not found to provide any additional benefit. This system uses the repeater pair of 156.1800/159.0000 MHz. A diagram of this configuration is shown in Figure 6.



LCSO System East:

The system that supports LCSO in the eastern portion of the County uses the Burley and Storm King remote sites as Tx/Rx, which are linked via a transmitter at Crego. This system also uses receive only

sites at Bennett, Dog, Hopkins, and Packwood. The frequency pair used for this system is 155.6250/156.0300 MHz. A diagram of this configuration is shown in Figure 7.



LCSO System West:

The system that supports LCSO in the western portion of the County uses a single Tx/Rx site at BawFaw and receive only sites at Crego, Davis Hill, Hopkins, and Toledo. The frequency pair used for this system is also 155.6250/156.0300 MHz. A diagram of this configuration is shown in Figure 8.



Public Works:

The public works system operates from a single repeater site at Hopkins for the east side of the County, and single repeater site at Crego for the west side of the County. A diagram of this configuration is shown in Figure 9. Both repeaters use the frequency pair 155.1000/155.7450 MHz for their operations.





Figure 9: County Public Works System

County Microwave Backhaul Network:

The County currently uses microwave links to provide radio site backhaul connectivity to some of the communications sites in use throughout the County. Some microwave links are owned by the County and other connections provide a T1 connection configured over a County partner's microwave. These existing connections are shown in Figure 10.



Current County Microwave Links -Connections via partner Microwave -



Physical Infrastructure

The County maintains approximately twenty communications sites to support the operations described above. These sites contain substantial physical infrastructure which includes radio towers or other support structure, equipment shelters with environmental support systems, DC power plants and backup generators. These facilities are essential for maintaining a robust radio network. Basic descriptions of the sites currently in use today in Lewis County appear below in Table 2.

Site Name	Structure	Equipment Location	Backup Power
BawFaw Peak	Self-support tower	Custom block building	Batteries and generator

Bennett Rd.	Self-support tower	Concrete prefab building	Batteries and generator
Burley	Tower	Custom building	None – Solar power only
Chehalis Ridge	Monopole tower	Custom block building	Generator
Coal Mine	Self-support tower	Custom building	Batteries and generator
Cooks Hill	Self-support tower	Room inside fire station	Batteries and generator
Crego	Self-support tower	Portion of custom block building	Batteries and generator
Davis Hill	Pole attached to building	Custom brick building	None
Democrat	Pole attached to house	Garage	None
Dog	Self-support tower	Custom building	Batteries and generator
Historic Courthouse	Building rooftop	Building equipment room	UPS and generator
Hopkins Hill	Self-support tower	Custom building	UPS and generator
Manners Hill	Self-support tower	Custom block building	Batteries and generator
Onalaska	Pole attached to building	Room inside fire station	Batteries
Packwood	Ladder structure of water tower	Custom building	Batteries
Seminary Hill	Wooden pole	Outdoor cabinets	Batteries and generator
Storm King	Tower	Custom building	None – Solar power only
Toledo Airport	Self-support tower	Custom building	Batteries
Randle Fire	Tower attached to building	Room inside fire station	Batteries

Table 2: Current Lewis County Infrastructure Sites

FCC Licenses

Another key ingredient for maintaining a public safety radio system is the access to licensed frequency spectrum. Voice communications is achieved via the use of frequencies licensed by the Federal Communications Commission (FCC). The primary frequencies in use by Lewis County, as well as some additional licensed frequencies, are listed in Table 3.

Frequency (MHz)	Current Usage
154.1900	Primary fire dispatch and voice channel - simplex
154.1450/158.7600	Used by RFA for fire voice for Chehalis and Centralis fire
154.9725/159.0975	Used by RFA for fire voice for fire district 12
155.8050/156.1050	Repeated pair for fire paging and voice for fire districts 10 and 14

155.7150	Fire paging for County and RFA fire districts
155.6250/156.0300	Law enforcement voice channel for Lewis County Sheriff's Office
156.1800/159.0000	Law enforcement voice channel for Chehalis and Centralia PD
155.4150/159.0300	Jail voice channel
155.1000/155.7450	Voice communications for County public works
154.3400	Hospital Emergency Administrative Radio (HEAR) - Primarily used by
	ambulance services for administrative communications with hospitals
155.7675	SW WA public department (fairgrounds voice communications)
155.9550	Used by fire district 14
154.4300	Licensed by Lewis County and RFA
154.9800	Licensed by Lewis County
154.9950	Licensed by Lewis County
155.0100	Licensed by Centralia, Chehalis, and Lewis County
158.9250	Licensed by Lewis County
Table 2: Louis County Lineared Energy and	

Table 3: Lewis County Licensed Frequencies

FCC license changes are likely to be required when the County chooses to implement system enhancements.

Subscriber Devices and Vehicular Repeaters

The public safety agencies within Lewis County operate a variety of mobile and portable radios as part of their communications systems. Based on on-site interviews and responses to a user survey, it is estimated that the County agencies operate approximately 300 mobile radios and 500 portable radios. These radios come from various manufacturers, including Bendix King, Icom, Kenwood, and Motorola. The majority of these radios support analog voice only, although a small percentage would be capable of supporting digital voice. Some agencies also utilize in-band vehicular repeaters as a means to extend the usable range of portable radios in areas of limited coverage.

Dispatch Centers and Equipment

Radio dispatch consoles are critical tools used by telecommunicators or dispatch staff to communicate with, support, and coordinate the first responder field response and operations. Dispatch equipment is situated at call-taking/dispatch operator positions and is typically connected via wired or wireless links to central switching controllers or to base station radio sites. Lewis County dispatches from the historic courthouse location and maintains eight dispatch positions utilizing Motorola MCC7500 consoles. The County also uses a Motorola (formerly Spillman) Computer Aided Dispatch (CAD) system.

Current Systems Signal Measurements

LMR network signal level measurements were taken to confirm existing system performance, as well as to provide input into the radio propagation tool to improve the accuracy of the RF coverage simulations.

During Televate's on-site visit in August 2023, a signal measurement device was used to gather existing system signal measurements. A Berkeley Varitronics Systems Coyote[™] (shown in Figure 11) unit was used to measure the signal level and correlate it to GPS location.

The unit was programmed to receive and measure frequency 155.1000 MHz for testing purposes. The testing was performed in a County vehicle while driving throughout the County with the unit held inside in the passenger seat. Since the Lewis County systems are conventional, the channels are normally only active when a call is in process. However, to record data throughout the drive route, the channel was placed into a periodic transmit mode, which would cycle the transmitter on and off for 30 seconds each. The data was then filtered to eliminate the data when the transmitter was off.



Over a two-day period, measurements were recorded from a total of four sites: BawFaw, Crego, Hopkins and Packwood. Data from each of Figure 11: Measurement Device

the following legend applies to illustrate the measure radio signal strength:

these measurements are shown in the figures below. In each case,

> -78 dBm	
-78 to -88	
-88 to -98	
-98 to -107	





Figure 12: Recorded Signal Level Data from BawFaw



Figure 13: Recorded Signal Level Data from Crego



Figure 14: Recorded Signal Level Data from Hopkins



Figure 15: Recorded Signal Level Data from Packwood

SYSTEM FEEDBACK FROM USERS

Identifying the objectives and needs of the public safety communications system stakeholders is key to establishing requirements for radio system enhancement solutions. Technology selections and investments are best driven by the user community to ensure that the next generation radio network satisfies their unique communications needs, and likewise considers fundamental financial and governance objectives. During the on-site visit to Lewis County, the Televate team conducted interviews and informal discussions with technical, end user, management and systems operations staff regarding the system's operation and performance. Discussions focused on a range of topics including current systems capabilities and gaps, interoperability requirements, and the condition of existing and new infrastructure assets. A radio user survey form was also made available for those stakeholders that did not have the opportunity to attend in person interviews.

Detailed notes from the on-site interviews are included in Recommended Next Steps

Televate recommends Lewis County proceed in the following manner to implement the recommendations provided in this report.

Consider Recommendations and Direction and Coordination

The County should review the recommendations provided in this report, provide feedback and update plans as necessary. Additionally, the County should engage additional stakeholders from the County's first responder community to solicit input on the recommended direction and achieve consensus on the approach. Once consensus on the preferred approach is achieved, Televate recommends that the County begin the coordination activities with its communications partners, including RFA, WSDOT, and others as necessary to implement the recommended improvements.

Develop a Comprehensive Frequency Plan As Soon As Possible

Co-channel interference on the main fire frequency is one of the most critical issues currently faced by County first responders. It is essential that the County address this issue as soon as possible. To do so, Televate recommends the following short-term actions:

Perform coordination on potential new frequencies

A number of potential alternative and additional frequencies suggestions are provided in this report. Televate recommends the County work with a licensed frequency coordinator to perform coordination services on selected frequencies to determine what frequencies can be licensed by the County and to move forward with the licensing process. The usable frequencies should then be combined as candidate frequency pairs to create repeated channels.

Evaluate available frequencies from a combining/multicoupler perspective

Once the collection of new frequencies is identified and candidate repeater pairs are created, it is suggested that the County identify groups of frequency pairs that can be easily combined at a common site. The groups that the County should consider include:

- East simulcast cell group:
 - Fire East repeater pair
 - o LCSO East repeater pair, and
 - Public Works East repeater pair.
- West simulcast cell group:
 - Fire West repeater pair

- LCSO West repeater pair, and
- Public Works West repeater pair.

Identify new Fire West frequency and begin using ASAP

The process described above will identify a candidate repeated frequency pair for the Fire West system. Televate believes that the County should begin using this frequency as soon as possible, even if the other recommended enhancements are not addressed until a later time. Elimination of the interference currently experienced on the 154.1900 frequency may be worth the additional effort of reprogramming radios with this new frequency, even if radios will need to be programmed again at a later date.

Allocate Funding for the Project

It is Televate's understanding that the County intends to utilize identified ARPA funding in addition to a source of grant funding in support of this project. It is recommended that the County confirm these allocations in the amounts available to support this project. In order to implement all enhancements, the currently identified ARPA and grant funding may not be sufficient to support the entire project. Therefore, since additional funding, above and beyond the currently identified allocations may be required for this project, it is recommended that the County develop a plan to address the potential for additional costs. Potential options for addressing this may include:

- Identifying additional funding to cover potential additional costs
- Scaling back or phasing in the improvements over several years, or
- Working with partner agencies to identify additional funding.

Additionally, since the timing for the funding may vary by source, it is recommended that the earliest available funds be allocated toward the portions of the project that are likely to have the longest lead time for implementation, including the facilities updates and the extensive microwave connectivity.

Develop a Long-Term Public Safety Communications Strategy

In addition to these near-term improvements, Televate recommends the County also consider additional improvements to further enhance the public safety communications within the County. Considerations may include:

- Upgrading law enforcement user radios for P25 capability to support encryption and location services
- Adding additional site infrastructure to further improve coverage in key areas
- Upgrading additional site infrastructure to support digital communications for improved coverage with existing sites, and
- Considering a regional consortium with neighboring counties to share resources and improve regional communications.

Establish a Procurement Strategy and Develop a Procurement Specification

Once the final project direction has been established and the funding strategy is in place, Televate recommends that the County develop a procurement strategy for the project, and as required, a procurement specification to define the project and solicit proposals. Televate would be happy to assist the County further with establishing this strategy and documentation.

Consider Dispatch Improvements

In addition to the radio enhancements recommended in this report, Televate recommends that the County perform an internal dispatch assessment to consider potential improvements to dispatch operations and to address comments received from stakeholders. Some areas that could be investigated include:

- A staffing analysis to determine the optimal number of dispatch operators required for the current call volume and a means to achieve this level
- A review of and potential update to the current dispatch processes regarding call handling and interaction with the first responders this should include communications with the first responder agencies to solicit their input as well as inform them on the dispatch processes and challenges that exist
- Consideration of a patching policy to facilitate communications between the east and west systems/channels when necessary
- A review of and potential update to the current dispatch training processes to better enable consistent call handling and response, and
- An evaluation of an Automated Voice Dispatching (AVD) system to ensure consistent volume and voice quality.

Appendix A: On-Site Interview Notes. A summary of the key findings from the in-site interviews and survey results has been provided in Table 1 in the executive summary portion of this report.

The primary issues that surfaced during interviews and also in the survey results was the need for better coverage and problems due to disruptive radio channel interference. Coverage issues plagued most of the agencies, except for those that work primarily in the Cities of Chehalis and Centralia. However, even for these agencies, larger buildings such as the big "box" stores (Walmart, Home Depot, etc.) still cause problems.

Interference is a major concern with most of the County fire agencies. All agencies that still utilize Fire 1 (154.1900) commented on the interference from outside the County, mostly from Mason County. Televate was able to confirm the assertion that Mason County is operating a site on 154.1900 at high power. Our research of FCC records did reveal a City of Shelton call sign KNFF591 in Mason County which is licensed at an Effective Radiated Power (ERP) of 350W. Televate performed a contour analysis of that license to determine its potential impact. Figure 16 below shows the location of the City of Shelton site and the predicted service (Blue) and interference (Red) contours based on the license information. It can be seen that the predicted interference contour intersects a very large portion of Lewis County and confirms the reason behind the significant interference problems experienced on Fire 1.



Figure 16: City of Shelton License KNFF591 Service (-) and Interference (-) Contours

In addition to documenting significant findings from the system research and stakeholder meetings, Televate developed a list of key requirements that should be addressed by the system enhancements. These key system requirements are summarized in Table 4.

Category	Key System Requirements
Overall Functionality and Coverage	• An alternative to the main fire frequency (154.1900) must be identified and implemented to resolve the interference issues
	 Fire system coverage must be improved in key areas in both the eastern and western portions of the County
	 Additional vehicular repeaters can provide a short-term improvement
	 Law Enforcement system coverage must be improved in key areas in both the eastern and western portions of the County
Site Connectivity	 It is critical to implement a modern microwave system to support digital signaling and robust connectivity between sites
Dispatch Operations	• Implementing a repeater pair for the primary fire channel to facilitate direct communications between field users and eliminate the need for dispatch to repeat traffic would be a significant improvement

Radio Programming, TAC channels and Interoperability	 Additional TAC channels should be incorporated into a common radio template
	 Additional repeated channels should be incorporated if available
	 Key interoperability channels (such as DNR) should be incorporated into the radio templates
	 Fire radio templates should be programmed to a common standard
Features	• A key enhancement would include the capability for future support of digital communications to support encryption and location tracking of radios for law enforcement
Operations and Maintenance	 Ensure a sustainable, fault-tolerant network, including redundant power at the sites and redundant backhaul
	 Implement a full suite of remote monitoring, alarm/fault management capabilities
	 Implement consistent system service and maintenance procedures
	 Fire radio batteries are very old and should be replaced
General	 Implement the most cost-effective, yet beneficial system upgrade
	 Plan for a system that is financially sustainable

Table 4: Key Requirements

Recommendations for Improved Public Safety Communications

Based on the needs assessment, survey results, and detailed discussions with stakeholders, Televate developed a number of recommendations for the County to consider which will provide improved communications. For the recommended improvements, Televate approached the process by considering the east and west portions of the County. This approach was taken due to several considerations, primarily:

- The geography of the County lends itself to an east/west approach as it is extends more than 90 miles east to west, while being approximately 25 miles north to south
- The Lewis County Sheriff's Office using an east and west approach
- A single County simulcast cell would be impractical to deploy due to the extended site separation that would occur between east and west sites. A large site separation significantly increases the chance of internal system interference known as Time Delay Interference (TDI), which occurs when areas within the coverage boundary receive signals from multiple sites, but at noticeably different times. An example of potential interference areas from a simulcast cell utilizing sites in both the east and west portions of the County is shown in Figure 17, where the red areas indicate areas of likely TDI interference. These issues can largely be avoided by utilizing separate simulcast cells in the east and west.



Figure 17: Potential TDI Interference from sites in both East and West

With the East/West approach, the recommendation is for the fire districts to be broken down in this manner:

- East: Fire Districts 4, 9, 10, 14, 17, 18
- West: Fire Districts 1, 2, 3, 5, 6, 8, 11, 13, 15, 16, 20.

Geographically, this grouping is shown in Figure 18, where the East districts are shown in red, and the West districts are shown in green. In addition to these groupings, it is assumed that the RFA communications system remains separate.



Figure 18: Fire District Recommended East/West Grouping

Neighboring districts that work together regularly, such Fire Districts 3 and 4 that fall in different regions may raise some concern with the east/west approach. However, these concerns can be addressed through appropriate operational procedures such as ensuring that these districts have the East and West primary channels and they enable scanning of both channels, and also that they use the same TAC channel.

In general, Televate recommends Lewis County maintain operations in the VHF frequency band and continue to operate analog conventional radio systems. This approach will permit the County to maintain interoperability with neighbors and partners, as well as utilize much of their existing equipment while implementing targeted enhancements designed to improve coverage and enhance operations. Additionally, Televate recommends that the infrastructure improvements proposed (including microwave, RF repeaters and receivers) be capable of supporting migration to digital P25 operation at a later date to enable further operational improvements such as encryption for law enforcement and location services. Specific recommended improvements for each of the existing systems are provided below.

System Enhancement Recommendations

Fire System East:

The goals for the enhanced Fire System in the east is to improve coverage and reliability without using the solar-powered sites as the primary assets. To achieve these goals, the following changes/additions are recommended:

- Implement transmit/receive sites at Hopkins, Mineral Hill, Dog, Randle Fire, Bennett, and Packwood in a simulcast cell
- Convert Storm King to a receive only site and add Burley as receive only as well
- Utilize the current repeated frequency pair used in the east (155.8050/156.1050), or a suitable replacement based on additional frequency analysis, and
- Ensure all new infrastructure is digital (P25) capable.

A graphical view of the recommended new configuration is shown in Figure 19.



Figure 19: Lewis County Fire System East Recommended Configuration

Fire System West:

To improve communications performance for the fire system in the west, the following changes/additions are recommended:

- Implement transmit/receive sites at BawFaw, Crego, Doty, Coal Mine, and Democrat (new tower) in a simulcast cell
- Maintain receive sites at Cooks, Onalaska (new tower), and Toledo
- Eliminate the relay/receive site at the Fire District 11 station (The Doty site covers this area
- Utilize a new repeated frequency pair based on the frequency analysis provided in this report, and
- Ensure all new infrastructure is digital (P25) capable.

A graphical view of the recommended new configuration is shown in Figure 20.



Figure 20: Lewis County Fire System West Recommended Configuration

RFA City System:

The RFA system that supports the fire departments for Chehalis and Centralia appears to be working well and no configuration changes are recommended at this time. However, if needed, additional vehicular repeaters can be purchased to address current coverage problems within buildings.

A diagram of the existing configuration was provided earlier in Figure 3.

RFA District 12 System:

Similarly, the RFA District 12 System appears to be working well and no configuration changes are recommended at this time. However, if needed, additional vehicular repeaters can be purchased to address current coverage problems within buildings.

A diagram of the existing configuration was provided earlier in Figure 4.

Fire Paging System:

The paging system that supports all fire agencies within the County appears to be working well at this time. However, given that the fire agencies in the east currently utilize the base transmit/mobile receive

voice frequency 155.8050 MHz for paging and additional sites are recommended for the east voice system, utilizing this same method and frequency will improve the paging performance in the east.

In the west, the paging system currently uses different sites than the recommended updated voice system, as it supports paging for RFA as well as other County fire districts. Therefore, in order to not disrupt the current paging system in the west, it is recommended that this system remain unchanged at this time. However, it is noted that an additional site (Coal Mine) is currently being added to the paging system in the west, which will improve paging performance in that area.

<u>City Police Departments (PDs) System:</u>

The City PDs System that supports the police departments for Chehalis and Centralia appears to be working well and no configuration changes are recommended at this time. However, it is recommended that all infrastructure (repeaters, receivers, comparators, microwave equipment) be upgraded to current manufacturer equipment and enabled to support digital (P25) operation. Additionally, if needed, additional vehicular repeaters can be purchased to address current coverage problems within buildings.

A diagram of the existing configuration was provided earlier in Figure 6.

LCSO System East:

The recommendation for the LCSO System in the east mirrors that for the Fire System as this recommendation provides the best coverage using existing sites and it is preferrable to maintain equivalent coverage for first responder agencies. The following changes/additions are recommended:

- Implement transmit/receive sites at Hopkins, Mineral Hill, Dog, Randle Fire, Bennett, and Packwood in a simulcast cell
- Convert Burley and Storm King to receive only sites
- Utilize a new repeated frequency pair based on the frequency analysis provided in this report, and
- Ensure all infrastructure is digital (P25) capable.

A graphical view of the recommended new configuration is shown in Figure 21.





LCSO System West:

Similar to the east systems, it is recommended that for the most part, the LCSO System West mirror the configuration of the Fire System in the west. However, in addition to the previously proposed west simulcast cell, an additional repeater for LCSO is recommended at Manners Hill. For clarification, this site is not recommended for the Fire agencies in the west since this area is currently covered and supported by the RFA system. The following changes/additions for the LCSO System West are recommended:

- Implement transmit/receive sites at BawFaw, Crego, Doty, Coal Mine, Democrat (new tower), and Manners Hill in a simulcast cell
- Maintain receive sites at Toledo and implement new receive sites at Cooks and Onalaska (new tower)
- Eliminate the receive site at Davis Hill (Cooks Hill covers this area)
- Utilize the current LCSO repeated frequency pair (155.6250/156.0300), or a suitable replacement based on additional frequency analysis, and
- Ensure all infrastructure is digital (P25) capable.

A graphical view of the recommended new configuration is shown in Figure 22.



Figure 22: LCSO System West Recommended Configuration

Public Works:

In order to maintain equivalent coverage for the fire, law enforcement and public works personnel, it is recommended that the public works system also be expanded in the east and west utilizing the same east and west simulcast cells as proposed above in Figure 21 and Figure 22. This will equate to adding an additional channel to each of these simulcast cells to support public works.

Predicted coverage for each of the revised system configuration recommendations are provided in Appendix C: Proposed System Predicted Coverage.

Site Usage Summary

A summary of the proposed site usage based on the recommended system configurations described above is provided in Table 5.



Site	Fire System East	Fire System West	RFA City System	RFA District 12 System	Fire Paging	City PD System	LCSO System East	LCSO System West	Public Works
BawFaw		T/R						T/R	T/R
Bennett	T/R						T/R		T/R
Burley	R						R		R
Chehalis Ridge						T/R			
Coal Mine		T/R		T/R	In process			T/R	T/R
Cooks		R	R	T/R	Т			R	R
Crego		T/R	R	T/R	Т			T/R	T/R
Davis									
Democrat		T/R						T/R	T/R
Dispatch			T/R	R					
Dog	T/R				Т		T/R		T/R
Doty		T/R						T/R	T/R
Hopkins	T/R						T/R		T/R
Manners				T/R	Т			T/R	T/R
Mineral	T/R						T/R		T/R
Onalaska		R						R	R
Packwood	T/R				Т		T/R		T/R
Peterman									
Randle Fire		T/R					T/R		T/R
Seminary Hill			T/R	R		R			
Storm King	R						R		R
Toledo		R			Т			R	R

Table 5: Recommended Site Utilization

County Microwave and Backhaul Network:

A major portion of the Countywide system upgrade is expected to be the microwave network. The current system utilizes some existing County-owned links, in addition to T1 connections over partner links. A simulcast-based system will require robust inter-site connections and precise timing.



Additionally, the new microwave system must be capable of supporting both native Time Division Multiplex (TDM) and native Ethernet/IP traffic to support modern digital communications. For existing links that utilize partner microwave, Televate recommends the County work with their partners to ensure that the existing links can support the new system requirements, and/or provide upgrades to the equipment as necessary.

The recommended backhaul network configuration for the east utilizes the following configuration:

- Maintaining/upgrade existing links:
 - Crego to Dog
 - Dog to Bennett
 - o Bennett to Packwood
 - Incorporating new links:
 - Democrat to Hopkins
 - Hopkins to Peterman (site to be used for microwave relay)
 - o Peterman to Dog
 - Peterman to Mineral, and
 - Dog to Randle Fire.

A diagram of the configuration is shown in Figure 23. It is important to note that the recommended microwave network is not proposed in a loop configuration. While a loop is generally preferred, the rugged terrain of this region makes a loop configuration extremely difficult and costly. However, the recommended configuration does include two separate paths to connect to the Dog site, which provides redundancy for links to the other east sites. Also, the microwave spur links are recommended to be implemented in a "hot-standby" configuration to maximize reliability.

It is also important to note that all proposed microwave links have been verified via an electronic terrain path profile. These path profiles are included in Appendix D: Proposed Microwave Link Path Profiles (From Terrain Database). All planned links must ultimately be verified by a physical path survey prior to implementation.

Connections to Storm King and Burley are recommended to remain as RF connections (via control stations), as these sites are solar powered only and cannot support a microwave connection. However, due to the recommended use of these sites as receive only, this type of connection should be adequate.



Figure 23: Lewis County Recommended East Backhaul Network

The recommended backhaul network configuration for the west utilizes the following configuration:

- Maintaining/upgrade existing links:
 - Crego to Courthouse
 - Crego to Coal Mine
 - Crego to Manners
 - Cooks to Coal Mine
 - Seminary Hill to Cooks
- Incorporating new links:
 - Manners to Doty
 - o Manners to BawFaw
 - o BawFaw to Toledo
 - o Toledo to Democrat
 - Crego to Democrat
 - o Democrat to Onalaska
- Additional recommended links (via fiber as microwave is not possible)
 - Courthouse to Cooks.

A diagram of the configuration is shown in Figure 24. The recommended configuration incorporates two loops for redundancy, namely:

- Loop 1: Manners, Crego, Democrat, Toledo, BawFaw, Doty
- Loop 2: Crego, Coal Mine, Cooks, Courthouse

In addition to those loops, the following spur links are part of the recommended configuration:

- Cooks to Seminary Hill, and
- Democrat to Onalaska.

Since the spur links are not part of either loop, the microwave spur links are recommended to be implemented in a "hot-standby" configuration to maximize reliability.



Current or future Microwave Links _____ Other Necessary Links _____

Figure 24: Lewis County Recommended West Backhaul Network

Televate notes that the proposed link between Manners Hill and Doty is indicated as questionable using the electronic path profile analysis, and previous experience by the County indicates it may not be reliable. If this path is not feasible, Doty can be alternatively accessed through a spur link from BawFaw, and a variation of Loop 1 can be implemented by closing the loop via a link from BawFaw to Crego. A diagram of this alternate configuration is shown in Figure 25.



Figure 25: Lewis County Recommended West Backhaul Network (Alternate)

Site Facility Requirements

In order to support the system recommendations developed in this report, some new site development and facility upgrades will be required. The recommendations presented in this report will require the site development shown in Table 6.

Site Name	Area	Recommended Development	Purpose/Improvement
Democrat	Fire District 8 area	Either a new tower and site are to be developed to support the County's needs, or space must be leased on one of the existing towers (3 potentials)	Improved coverage in the central/western positions of the County, including Fire District 8. While a current site exists in this area, it is only a temporary site with an antenna attached to a house.
Doty	Pe Ell	Either a new tower and site are to be developed	Improved fire system coverage in the western portion of the County and to

		(potentially use abandoned tower) to support the County's needs, or space must be leased on the existing tower	replace the Fire District 11 station receive/repeater site
Mineral	Mineral	Lease/share space on the existing WSDOT tower and in the existing equipment shelter	Improved coverage in the Mineral area and the replacement of Storm King as a primary site
Onalaska	Onalaska (Fire District 1)	Construct a new tower of at least 100'	A taller tower will provide better coverage in this area and the capability for a microwave connection to Democrat
Peterman	Central County south or Morton	Lease/share space on the existing tower and in the existing equipment shelter	To facilitate microwave connectivity to Mineral
Randle Fire	East part of County, Fire District 14	Tower enhancement	A tower extension or new tower may be required to support a microwave connection

Table 6: Potential Additional Site Development

In addition to the new site development, additional site facility upgrades will be required to support the enhanced systems. These upgrades are anticipated to include the new towers or site colocations described above, as well as potential tower strengthening/remediation to support additional loads, new equipment shelters, new equipment power systems (DC Plant), and new generators. The anticipated needs for each site, based on on-site surveys and feedback from County personnel, are included in Table 7.

Site	New Tower	Tower Remediation	New Shelter	New DC Plant	New Generator	Microwave End Points
BawFaw		1	1	1		2
Bennett				1		2
Burley				Battery Upgrade		
Chehalis Ridge				1		1
Coal Mine		1		1		2
Cooks				1		2

Crego		1		1		5
Davis						
Democrat	1		1	1	1	4
Dispatch						2
Dog		1		1		4
Doty		1	1	1	1	2
Hopkins		1		1		2
Manners		1		1		2
Mineral		1				1
Onalaska	1			1	1	1
Packwood				1		1
Peterman		1		1		3
Randle Fire		1		1		1
Seminary Hill						1
Storm King				Battery Upgrade		
Toledo				1		2

Table 7: Recommended	Site Facility	Enhancements
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Frequency Analysis

New and/or different frequencies will also be necessary to effectively implement the recommendations presented in this report. A number of potential new frequencies that may be useful for the County were identified either by the County or others from previous work. These frequencies are listed in Table 8.

Frequency (MHz)	Current Usage
151.1075	No current site license in Lewis County – planned for one of five new simplex TAC channels
153.9275	No current license in Lewis County - Only current WA license in Spokane
153.9950	No current license in Lewis County - Only current WA licenses in Spokane and Chelan County – planned for one of five new simplex TAC channels



154.2875	No current site license in Lewis County – planned for one of five new simplex TAC channels		
154.8600	No current license in Lewis County - Licenses in Benton and King Counties		
154.9875	No current license in Lewis County		
155.0625	No current license in Lewis County		
155.3925	No current site license in Lewis County – planned for one of five new simplex TAC channels		
155.4000	No current license in Lewis County		
155.4900	No current site license in Lewis County – planned for one of five new simplex TAC channels		
155.9325	No current license in Lewis County		
155.9925	No current license in Lewis County		
156.0000	No current license in Lewis County - Licenses in Columbia, Pend Oreille, Island, King, Kittitas, Okanogan, Yakima County		
156.2250	No current license in Lewis County - Licenses in Skagit, Mason		
159.3150	No current license in Lewis County - Licensed by WA Dept. of Natural Resources in several places – Mason County is closest		
Table 8: Potential New Frequencies			

These candidate frequencies were evaluated further to determine their applicability for use with the County's recommended new system configurations. The recommended configuration will require the following new or reused frequency pairs, at minimum:

- Fire East repeater pair (Currently 155.8050/156.1050)
- Fire West repeater pair
- LCSO East repeater pair
- LCSO West repeater pair (Currently 155.6250/156.0300)
- Public Works East repeater pair (Currently 155.1000/155.7450)
- Public Works West repeater pair
- Paging West (Currently 155.7150)
- RF receive link from Storm King and BawFaw for Fire, and
- RF receive link from Storm King and BawFaw for LCSO.

The frequencies currently used for the RFA systems and City PDs system are not anticipated to change.

The three channels in the east and the three in the west (and potentially other frequencies based on site) will each be combined using an RF combiner/multicoupler for support by a single transmit and single receive antennas. Therefore, it is preferable that the chosen frequencies for these channels have sufficient separation to allow efficient combining, without significant combiner loss.

In order to determine applicability for the recommended configurations, an FCC license search was performed for the candidate frequencies where a co-channel search was performed within 70 miles of the site locations to be licensed. In general, if there are no co-channel licensees within 70 miles of the proposed sites, the frequency can be licensed at that site. If co-channel licensees are present within 70 miles, the frequency may still be able to be licensed, but an engineering study and contour analysis will be required to ensure acceptable performance without the risk of interference. Table 9 shows the results of the co-channel studies for the candidate frequencies that were evaluated.

Candidate Frequency (MHz)	East System Co-Channels within 70 Miles (Hopkins, Mineral, Packwood)	West System Co-Channels within 70 Miles (BawFaw, Coal Mine, Democrat)
151.1075	None	None
153.9275	None	None
153.9950	WPMG928	WPMG928
154.2875	None	None
154.8600	KOH888, WPIT540, WPQF424, WQTD257	KOH888, WNZN460, WQTD257
154.9875	None	WRBY483 (70.5 mi.)
155.0625	WPYT650	WPYT650
155.3925	WQUR851	WQUR851
155.4000	11 Active Licenses	Did not search
155.4900	KTS776, WPBV445, WQCE971, WXY382	KTS776, WPBV445, WQCE971, WXY382
155.9325	WQWX932	None
155.9925	None	None
156.0000	KCJ932, KDP304, KXV380, WPYL588, WQWP397	KCJ932, KDP304, KXV380, WPYL588
156.2250	KNCY702, WNDZ708, WNIG952, WPAF993, WPAF745	KNCY702, WNDZ708, WNIG952, WPAF993
159.3150	WNUS280	WNUS280

Table 9: Co-Channels of Candidate Frequencies

Due to the mountainous terrain environment in and around Lewis County, it is Televate's opinion that many of the above frequencies can be used by Lewis County without causing or experiencing significant interference, even though some show co-channel licensees within 70 miles. Also, the best frequency selection may require repurposing some of the frequencies currently utilized or planned in the County. The decision as to what specific frequencies are best to use will require further analysis and frequency coordination activities, which is recommended as a next step and should be performed prior to proceeding with the system enhancement in this report.

COST ESTIMATE OF PROPOSED RECOMMENDATIONS

Televate developed a detailed cost model to estimate the capital and recurring costs anticipated to develop and maintain the recommended system configurations. All cost estimates are based on the specific components and upgrades required at each site within the system, as well as Televate's previous experience with equipment and site construction costs.

Capital Costs

A significant portion of the project costs will include the site facilities upgrades, as well as development of the redundant microwave connectivity between the sites, which may include:

- Site development, civil services and tower construction for new radio sites
- Upgrade costs for existing sites including any required tower remediation to accommodate additional antenna loads
- Equipment shelters as necessary
- Redundant power sources, including UPS/batteries and generator, and
- Primary and redundant site backhaul/interconnection.

These estimated costs for these activities are provided below on a site-by-site basis.

Radio Site Facility	Facility Upgrade and Connectivity Cost Estimate
BawEaw	\$242,000
	\$242,000
Bennett	\$132,000
Burley	\$9,600
Chehalis Ridge	\$72,000
Coal Mine	\$182,000
Cooks Hill	\$132,000
Crego	\$362,000
Democrat	\$677,000
Dog	\$302,000
Doty	\$257,000
Hopkins	\$182,000
Manners	\$182,000
Mineral	\$110,000
Onalaska	\$437,000
Packwood	\$72,000
Peterman	\$242,000
Randle Fire	\$122,000

Seminary Hill	\$60,000	
Storm King	\$9,600	
Toledo	\$132,000	

Table 10: Facilities Cost Estimate by Site

In addition to the site development costs, the County will incur additional project costs for the radio site equipment and installation costs for the enhancements described in this report. The cost estimate for this portion of the project includes:

- Manufacturer's costs for all infrastructure and core equipment for all system enhancements
- Design and engineering services and FCC licensing
- Construction and installation services
- Project management services, and
- Vendor oversight and quality assurance services.

The capital cost estimate to complete the full project implementation of the specific system enhancements included in this report was provided to County emergency personnel under separate cover.

Operating Costs

The annual operating cost estimate for the recommendations described in this report (not including County labor) are based on typical recurring costs associated with maintaining public safety radio systems, and are expected to include equipment maintenance costs, site maintenance costs, network monitoring, etc. An estimate for these costs is provided in Table 11.

System Component	Annual Cost Estimate
Annual Lease/Site Maintenance	\$185,000
Annual Software and Licensing (Core and RF)	\$180,000
Annual Software and Licensing (Microwave)	\$45,000
Proactive Spares/Preventive Maintenance	\$44,000
Network Monitoring	\$20,000
Project Total	\$474,000

Table 11: Cost Estimate of Annual Maintenance

RECOMMENDED NEXT STEPS

Televate recommends Lewis County proceed in the following manner to implement the recommendations provided in this report.

Consider Recommendations and Direction and Coordination

The County should review the recommendations provided in this report, provide feedback and update plans as necessary. Additionally, the County should engage additional stakeholders from the County's first responder community to solicit input on the recommended direction and achieve consensus on the approach. Once consensus on the preferred approach is achieved, Televate recommends that the County begin the coordination activities with its communications partners, including RFA, WSDOT, and others as necessary to implement the recommended improvements.

Develop a Comprehensive Frequency Plan As Soon As Possible

Co-channel interference on the main fire frequency is one of the most critical issues currently faced by County first responders. It is essential that the County address this issue as soon as possible. To do so, Televate recommends the following short-term actions:

Perform coordination on potential new frequencies

A number of potential alternative and additional frequencies suggestions are provided in this report. Televate recommends the County work with a licensed frequency coordinator to perform coordination services on selected frequencies to determine what frequencies can be licensed by the County and to move forward with the licensing process. The usable frequencies should then be combined as candidate frequency pairs to create repeated channels.

Evaluate available frequencies from a combining/multicoupler perspective

Once the collection of new frequencies is identified and candidate repeater pairs are created, it is suggested that the County identify groups of frequency pairs that can be easily combined at a common site. The groups that the County should consider include:

- East simulcast cell group:
 - Fire East repeater pair
 - LCSO East repeater pair, and
 - Public Works East repeater pair.
- West simulcast cell group:
 - Fire West repeater pair
 - LCSO West repeater pair, and
 - Public Works West repeater pair.

Identify new Fire West frequency and begin using ASAP

The process described above will identify a candidate repeated frequency pair for the Fire West system. Televate believes that the County should begin using this frequency as soon as possible, even if the other recommended enhancements are not addressed until a later time. Elimination of the interference currently experienced on the 154.1900 frequency may be worth the additional effort of reprogramming radios with this new frequency, even if radios will need to be programmed again at a later date.

Allocate Funding for the Project

It is Televate's understanding that the County intends to utilize identified ARPA funding in addition to a source of grant funding in support of this project. It is recommended that the County confirm these allocations in the amounts available to support this project. In order to implement all enhancements, the currently identified ARPA and grant funding may not be sufficient to support the entire project. Therefore, since additional funding, above and beyond the currently identified allocations may be required for this project, it is recommended that the County develop a plan to address the potential for additional costs. Potential options for addressing this may include:

- Identifying additional funding to cover potential additional costs
- Scaling back or phasing in the improvements over several years, or
- Working with partner agencies to identify additional funding.

Additionally, since the timing for the funding may vary by source, it is recommended that the earliest available funds be allocated toward the portions of the project that are likely to have the longest lead time for implementation, including the facilities updates and the extensive microwave connectivity.

Develop a Long-Term Public Safety Communications Strategy

In addition to these near-term improvements, Televate recommends the County also consider additional improvements to further enhance the public safety communications within the County. Considerations may include:

- Upgrading law enforcement user radios for P25 capability to support encryption and location services
- Adding additional site infrastructure to further improve coverage in key areas
- Upgrading additional site infrastructure to support digital communications for improved coverage with existing sites, and
- Considering a regional consortium with neighboring counties to share resources and improve regional communications.

Establish a Procurement Strategy and Develop a Procurement Specification

Once the final project direction has been established and the funding strategy is in place, Televate recommends that the County develop a procurement strategy for the project, and as required, a procurement specification to define the project and solicit proposals. Televate would be happy to assist the County further with establishing this strategy and documentation.

Consider Dispatch Improvements

In addition to the radio enhancements recommended in this report, Televate recommends that the County perform an internal dispatch assessment to consider potential improvements to dispatch operations and to address comments received from stakeholders. Some areas that could be investigated include:

- A staffing analysis to determine the optimal number of dispatch operators required for the current call volume and a means to achieve this level
- A review of and potential update to the current dispatch processes regarding call handling and interaction with the first responders this should include communications with the first

responder agencies to solicit their input as well as inform them on the dispatch processes and challenges that exist

- Consideration of a patching policy to facilitate communications between the east and west systems/channels when necessary
- A review of and potential update to the current dispatch training processes to better enable consistent call handling and response, and
- An evaluation of an Automated Voice Dispatching (AVD) system to ensure consistent volume and voice quality.

APPENDIX A: ON-SITE INTERVIEW NOTES

The interview schedule followed during the on-site visits is shown in Figure 26.

LEWIS COUNTY RADIO TELEVATE RADIO INTERVIEW SCHEDULE

MONDAY 8/21

TUESDAY 8/22

900	
1000	LEWIS 8
1100	LEWIS 14
1200	LUNCH
1300	LEWIS SO
1400	LEWIS 11/13/16
1500	CHEHALIS PD
1600	

800	
900	
1000	LEWIS 2/15
1100	LEWIS 1
1200	LUNCH
1300	
1400	CENTRALIA
	PD
1500	RFA/CHEH
	FIRE
1600	

BOCC CONF ROOM (BASEMENT)

911 CONF ROOM (3RD FLOOR)

Figure 26: Stakeholder Interview Schedule

Jennifer Libby-Jones and Justin Stennick

- Fire Departments
 - Lewis County, Chehalis, Centralis and Riverside (RFA)
- Mike Kytta is the fire chief of RFA (Riverside Fire Authority). Have their own trunked radio system Fire Two dispatch
 - o 155.715 paging channel to alert
 - o 4-site simulcast
 - Could their network become part of the countywide network?
 - We now have 5 simplex channels all not yet programmed into county radios
 - 3 dedicated to fire
 - 1 designated for law
 - 1 designated for all other agencies
 - o Fire believes that all in-building fire radio comms need to be recorded
 - OSHA requirement to be on tac channel interior during a fire
 - 154.190 is the fire dispatch channel however, this channel is co-channel with two nearby counties

- Mason County has a tall site using this frequency and it is highly interference prone
- The FDs use Zone A which is common for all FDs
- XTS/XTL 5000 radios purchased for FDs in 2007 via a grant
 - Old fire radio batteries many need to be replaced possible use of grant funding?
 Purchase new radio batteries?
- Countywide radio network improvements need to be implemented
 - What new radio technologies to consider?
 - o Need a near, mid-, and long-term plan for radio network/equipment
 - \$7.3M in funding available now assessing the introduction of a 0.2% sales tax to increase the available radio network budget
 - \$2.8M spent by the end of 2024
 - \$4.5M spent by 2026, designated for spending by the end by 2023
 - Backhaul network is at risk, a new plan is required
 - Designate for Phase 1 allocation?
 - New GTR radios required
 - The Burley site is 18 miles off of the road and is running on solar power
 - Hwy 12 coverage is essential
- Primary needs Justin and Jen
 - Radio technology upgrades
 - Sufficient funding in Phase 1 to design a conventional simulcast radio network leverage the RFA network and expand where possible?
 - Microwave network upgrades network connectivity is essential
 - Radio spectrum upgrade eliminate fire dispatch channel interference no backup channel for the law
 - Phase 1 replacement of the fire dispatch channel
 - Identify law backup channel
 - We can always buy new radios later
 - We're familiar with Simulcast but do we have sufficient budget and frequencies?
 - o Jenn
 - Plan focused on near term, mid-term, or long-term radio plan

Fire Districts 3 and 8

- Attendees
 - Chiefs McDaniel (FD 8)
 - Chief Doug Fosburg (FD 03)
- When visiting the sites, you will learn about their condition
- When leaving Morton and hitting the lakes, you are in FD3 and FD8
- The Democrat site sits in my districts commissioner's garage
 - Update the Democrat radio site in Phase 1?
- What are your thoughts on transitioning to a digital communications channel?
 - \circ $\;$ State patrol has migrated to digital, and we cannot talk with them
 - My education on digital is limited (FD3)
- Narrowbanding created radio comm issues
- On a major incident scene we typically monitor 3-frequencies
 - o RedNet

- RedNet appears to be a tac channel at 153.830 MHz
- Countywide dispatch
- o Working frequency channels are those owned by the district
- Fire channels are being recorded
 - Fire 1
 - Fire 2
 - VTAC 11 used to communicate with helicopters
 - RedNet also being recorded in certain areas
- The Democrat site needs a complete redo
- Mason County interference is common on FD Channel 1
 - Similar call signs in play as well
- Relaying through dispatch is common occurrence
- Getting away from 154.190 is critical
 - County radio dept
- Very happy with the new radios
- Key needs
 - \circ $\;$ Need to be able to communicate on scene from our portable radios back to dispatch
 - Limited vehicular repeaters, Pyramid's that do not facilitate auto shut off to manage interference
 - Phase 1 purchase of vehicular repeaters?
 - Old radios are being used
 - Phase 1 purchase of new radios?
 - Operating budget is very limited
- Interoperability with DNR is required
 - Further investigation required to determine how to fix could be simple radio programing
 - DNR operates multiple VHF sites and frequencies throughout the state need to identify the required sites and freqs.
- Dispatchers would benefit if there were additional dispatch channels
- Using "I Spy Fire" (<u>iSpyFire, Inc.</u>) and "BRYX" (<u>Station Alerting System & Software for First</u> <u>Responders | Bryx</u>) as smartphone app fire comms
- Need to talkaround on occasions due to inability for dispatch channel to be free
- Not using MDC's due to cellular coverage issues
- Adventure medics are providing back ambulance service and using the FD3 radios
- FD3
 - 30 portables
 - CDM50 mobile radio
 - XTL-1500 portables
 - HT 1250 portables
 - Two Icom radios
 - One Pyramid repeater
- County needs to support comms
 - Two repeated channels
 - Eliminate the 154.190 freq.



- East, west and central channels
- Channels need to be recorded
- Perhaps 25% down on their respective volunteers

Fire District 14

- Chief Jeff Jacques
- Eastern side of the county
- Respond into the federal forest area, clear into the adjacent county
- Coverage issue in the southern sections of the county
- Cispus (town and river) areas in the forest not well covered
- Using the Pyramid VRS which is working well
- Difficulty in talking back to a new repeater site
 - Phase 1 remote receive radio site requirement
- Added several new repeater sites
- Radio
 - o APX7500 radios
 - Bendix King
 - o XTL2500
- Friends in Pierce County who have donated radios
- Interop primarily with FD 10 and FD 18, WA-DNR (RedNet) and the Fire Service (freqs. programmed in radios)
- Hope that we never go digital WASP use digital listening in on WASP and their comms are poor
- Assistance from the County radio shops
 - Plenty of support from the county radio shops
 - County committee was meeting every two months, now not meeting as frequently need to get this group back together and add in radio comms agenda
 - Requirement to reignite these meetings
- The 5-new radio tac channels are not well coordinated and not programmed into law enforcement radios can be beneficial if programmed and support an SOP
 - Develop common fire radio fleetmap and program all radios
- Use of cell phone to communicate with law enforcement
 - T-Mobile and US Cellular service is limited US Cellular has some backup power
- County Public Works has a radio site as well that needs to be updated
 - Could not identify this radio license?
- Top requirements
 - Complete buildout of countywide dispatch channel, just not possible
 - Getting off of 154.190 beneficial but not necessary since they have licensed a new dispatch channel
 - Have licensed 156.105 main dispatch in FD14 area
 - <u>FCC Callsign WPIU343 (LEWIS COUNTY FIRE PROTECTION DISTRICT NO</u> <u>14) (radioreference.com)</u>
 - Multiple sites and VHF freqs. licensed need to determine ability to integrate into countywide radio network

- At Packwood and the FD 14 fire station
- FD14 need to be higher
- Wondering why the county has not moved off of 154.190
- More towers to expand coverage of the 156.105
 - Is this frequency licensable for an East site dispatch channel?
- Radio users are qualified at using their radios

County Sheriff Meeting

- Wes Rethwill, Rick Van Wyck, Captain Ben White, Chief Engleburtson
- Radio issue has been in play for years, and is finally being addressed
- 42 sworn officers
- Using federal funds to update the radio network
- Long term concerns also need to be defined
- 100% lack of support of infrastructure no capital investments being made in the infrastructure
- No stakeholder money available to invest in infrastructure now that we have federal money, we can invest to update
- Trying to set the law rate for LE and Fire, currently at 70/30%. Recommendations to change to 75/25
- Suggest we meet with County Sheriff's operations guild and sergeants Televate to schedule meeting with these gentlemen
 - Deputy Dan Reardon Operations Guild
 - Sgt. Jeff Godbey (Spoke via phone on 10/5/23)
- Coverage
 - Anywhere near power lines is a comms issue
 - o East End
 - Packwood
 - Along the pass for portable and mobile
 - Mineral area (P/M)
 - NW portion of the county
 - o State agency also uses the county radio network in some geographic areas
 - 1-deputy on duty per 12 hours shift Mossyrock bridge to pass on the East End
 - West end, Mossyrock Bridge to County end
 - o No available repeated tac channels except of the LEARN channel
 - New tac channels have been licensed has the sheriff programmed them into radios?
 - There is also a DES channel Channel 8 that is recorded
 - VTAC11 is also usable for incidents
- Familiar with digital radio can we afford it?
- Radio encryption is required no coverage impact over a P25 digital network

Fire Departments 11 and 13 representing 16

- Gwen Turner and Miles Burmeister
- The biggest issue is that the radio network is old, expensive to upgrade
- Lots of "blind spots" no portable coverage where needed

- Inability to communicate back uplink limitations
- Justin is top notch
- Interference from 154.190 needs to be replaced issue with Mason County
- District 11 has a private radio tower and frequency
- Greg Peterson programed the radio repeater for FD11
- Paging
 - Most of the time the paging is good
 - Occasionally there is a "ghost" page, could be an operator error?
 - Minitor 5 and 6 Moto pagers
 - No pager issues that we have experienced
- Hwy 5 in the canyon is a coverage issue
- FD 11 also needs to talk with Pacific County to the west
- Rider Wood is in Cowlitz County but part of FD 20
- Interop with the sheriff and DNR and public works
- Have to use the cell phone when radio coverage in unavailable US Cellular recently changed towers and the coverage declined
- Ambulance Consortium Group have an agreement with AMR for emergency medical
 - Does AMR use the county's radio network? What impacts if county institutes changes (freqs, sites, simulcast)
- Challenges with outbound radio comms from the fire station
- Coverage issue in the Weyerhaeuser forest area in the SE portion of FD 11 = Weyerhaeuser may have radio sites Miles Burmester offers to talk with Weyerhaeuser to find out more about their towers in this area
- Radios
 - o XTS1500
 - o HT
 - o Kenwood
 - No budget for new radios
 - HT is a better radio
- Top requirements
 - Highly reliable radio coverage 100%
 - New Fire dispatch channel
 - Get the word out when necessary no coverage in the white area
 - Systems need to work better
 - Similar county access within and with neighbors
 - o Common radio templates and frequencies for all radios
- Radio committee has not met in over one year
- Need uniformity in how we talk with one another and with dispatch

Chehalis PD: Randy Kaut

- New radio tower now providing better coverage
- Recently installed new tower
- In-building coverage may still be an issue at Walmart, Home Depot, all of the big box stores



- Secondary channel on a tower that we are leasing and since they are not needed, should be abandoned
- Mobile and portable radios working fine
- Total of 12 vehicles and 18 sworn
- City may be expanding into Napavine
- Shared freq with Centralia can be an issue with chatter over the main dispatch channel
 - New repeated tac channels for PD?
- Have secondary repeated channel, however not sufficient dispatchers to cover
- Wish list
 - Go to digital which adds capabilities
 - Encryption
 - o Location
 - o Individual officer radio comms
- We generally do not talk with the sheriff
- We generally do not talk with city fire, have capabilities but do not use it
- Political side of the issue is that the city is paying for only one site and not the countywide radio network why should they pay for the coverage for all
- Radios
 - o XTS-1500
 - Radio committee should be reinstated and the chief or deputy chief will participate
- Primary goals
 - Cost of fulfilling the wish list
 - System is functional
- Dispatchers are understaffed and doing the best they can with what they have

FDs 2, 5, 13, and 15

- Chief Underdahl FD15 (Winlock), Chief Dorothy of FD2 (Toledo), Greg of FD5 (Napavine)
- Greg: 25 years in Lewis County new radio, narrowbanding funding and experience,
- HT1250 is my favorite radio
- Frequently our radio transmission cannot be heard
- Issues with 154.190 first change to be made
- Building coverage issues
- 20 minutes status check when we are on scene
- Use RedNet when necessary
- VTAC11 is also used for air to ground comms
- Have TAC channels now that have not been implemented plan in development will use in place of VTAC11
- Countywide use of fire manual Greg to provide to Dom
- Wish list
 - New dispatch channel Mason County interference needs to go
 - Repeated channel configuration
 - o Second repeated tactical channel countywide
 - Program in new talkaround TAC channel

- What is Cowlitz system doing?
 - They can talk over their portable radio throughout the network
- Toledo site not providing expected coverage improvements
 - Toledo site includes Fire 1 and RedNet receive
- Expand portable radio coverage

Fire District 1

- Chief Brad Flexhaug 32 years working in the county
- Portable radio is XPR-3500
- General impressions of the radio network
 - Having been here 30+ years, his expectations have been set
 - Dispatchers need better training
 - Some are too quiet
 - Dispatcher protocols not being followed
 - Not using the correct radio sites talks about toning out of the Democrat site
 - Use I SPY FIRE
 - East end of district not served by the Crego site
 - What challenges do the dispatchers have? Would like to know so that the district fire fighters adjust their comms accordingly
 - Route 508 is the main road through the district
 - Cannot directly communicate with state patrol
 - Rarely need to speak with neighboring counties
 - Go to RedNet when on scene
 - Poor coverage in the fire stations
 - Poor paging in fire stations main in Onalaska
 - The school might also be a poor coverage building not responding there often
- Wish list
 - Transition away from 154.190 reality is that we could migrate to a freq. that is still probably interference prone
 - New base station in the eastern portion of the district
 - This is our challenge, may be able to convert the Onalaska site
 - New site on Hurricane Ridge where the windmills are located
 - o Review a few calls with dispatch to assess quality and areas for improvement
 - Have 13 apparatus and would prefer to have a VRS on at least two vehicles

Lewis County PSAP Manager - Liz

- 25 years of dispatching and now as Ops Supervisor
- Can hear Mason County, which is 100 miles away
- Fire 1 is a major problem interference related
- RFA is the busiest fire station
 - Not sufficient staff to cover RFA
- Good if the East End could hear the West End, or have the ability to listen and communicate
- FIRE 2 includes RFA, AMR and Station 48 (Chehalis fire)
- 8-positions, minimum of 3-positions working, but we also do 2-positions

- Recommendations that 24 telecommunicators are required, we have 9 positions filled, and a budget for 20 difficult to hire staff
 - Working 4 10-hour shifts, often 4 12s, we pay OT for all hours worked when only 2telecommunicators are on site
 - Phase 1: Expand efforts/create incentives/pay raise, whatever to hire and retain additional dispatch staff – can the grant be leveraged to hire new staff if there is insufficient budget?
- We do relay radio messages, but not frequently did not know that we relay this often
 Reconsiders and agrees that dispatch relays info for fire depts
- Fire fighters always call in the know what's going on with events we have no time to talk with them when we are on an incident
 - Suggest that fire depts have CAD access to view events and to stop from calling into dispatch
- I love ISPY, however, the chiefs call in and wants to know why I Spy informed them of an event that was not the event? Well, the original entry that I SPY relayed was modified.
- More pagers, do not rely on I SPY
- Rules for recording
 - We use Equature for recording and it works well
 - Hold recordings for 6-months
 - VTAC11 is recorded
- We can hear RedNet, not being recorded, but better check
- If responders say Mayday, we are listening and responsive,
- Reviewing options to use Metal Myrtle voice automated dispatching assistance I SPY offers one, however Motorola will over charge to integrate it into their Spillman CAD product
- Wish list
 - Auto dispatch
 - Phase 1 implementation?
 - \circ $\,$ Like the idea of an East and West dispatch dispatching zones and will likely have to maintain RFA
 - Phase 1: Can we do an East and West dispatch channel and combine RFA into the West dispatch zone?
 - o Repeated dispatch
 - Mason County interference eliminated
 - Taking care of Mason will result in more free time for the dispatchers, it will reduce the number of calls from fire chiefs

Centralia PD

- Chief Tracey Denham
- 32 years of LE, 5 as PD chief
- Share a dispatch channel with Chehalis
 - Backup car-to-car backup freq.
- New site working much better
- Davis Hill and Cooks Hill RX sites need to be upgraded
 - o Phase 1 activity? What is required to upgrade these RX sites?

- Thinking that the city is charging us \$250,000 annually, which we think is too hard
 - Calls for service, keystrokes data entry into RMS
 - Other PDs were cheating to pay less (MDT searches)
 - Requested that any increase equal across the board
 - 45% calls for service, # of officers, population
 - The Deltaworx model was not good
 - Recommendations to split 75/25% (PD to FD)
 - All PDs are paying
 - Policy for the PSAP
 - Huge distrust for the Lewis County
- The hospital is poorly covered
 - o Delivery
 - o ER
 - o ICU
- Walmart may be still not covered since the new site was installed
- PD is not covered well, but it could be related to a new cell site located
- Typically, we do not talk with FD, we would communicate with them through dispatch
- Thurston just upgraded their radio network and donated their radios to the PD
- 29 officers with 35 vehicles (all have radios) 40 portables
- Features
 - Location of the officers (on push to talk)
 - Encryption
 - We use DEA radios
- The LERN statewide LE network radio network is not performing (<u>WA Mutual Aid (Washington)</u> <u>Scanner Frequencies and Radio Frequency Reference (radioreference.com)</u>)
 - Need to investigate if the LERN network is still functional 155.370 MHz appears to be talkaround? <u>WA_CEMP_ESF2_Appendix 1_10.25.2019</u>
 - \circ $\;$ State patrol is supposed to monitor LERN $\;$

Chehalis Fire Dept and RFA

- Kevin Anderson Deputy Fire Chief, Mike Kytta (RFA), Captain Casey McCarthy, Adam Albright (Chehalis)
- 20 years doing our own thing
- More sites were required to deliver needed coverage
- 4 RX/TX and 6 RX sites in RFA, separate system for the cities with 2 TX/RX and 2 RX
- Topography is extremely challenging to serve
- Auxiliary back up network: 2 radio sites
- One repeated pair on each site
- Coverage
 - In building coverage poor in most Chehalis buildings into box stores not reliable
 - Use Pyramid in most vehicles (have lights on the dashboard that lights up when the VRS in in operations – use voice paging and I SPY
- Replaced all mobiles and portables in the last year
 - New radios and batteries have improved marginal coverage areas



- APX-6000XE portable radios
- o APX-1500 mobile radios
- Funding the radio network is a priority for fire district funding
- Provide letters of operations to neighboring jurisdictions to use the RFA network
- Chehalis Ridge site should be considered for the RFA system
- Accounts for 55% of the call volume
- Boat load of licenses that we are protecting might be able to share a frequency
 Phase 1: What freqs. might be available for countywide use?
- Keep the communications open with all chiefs they should be engaged
- Chiefs need to have skin in the game
- Dispatch fees do not cover the radio network the people need to know the facts
- Chief Lonny Gobel of FD 10 need to visit with him to get him involved
- Dispatch needs to speak more directly
 - One male dispatcher is very clear
 - Thurston is now using Medal Myrtle should talk with them
- Kluge of MW out there, some licensed and unlicensed
 - All 4.9 GHz for RFA sites
 - MLC are used
 - Wind and ice storms occur to the MW dish
- What about dispatch back up operations?
- What about the back-up fire radio paging at BawFaw
 - o Ross McDowell

APPENDIX B: CURRENT SYSTEM PREDICTED COVERAGE

A detailed propagation simulation was developed to further analyze coverage and to predict performance from various site constellations for an enhanced system. The simulations utilize the EDX SignalPro[™] application, which is a standard propagation tool employed by Public Safety to model the system elements and to predict coverage by incorporating industry standard propagation algorithms in addition to terrain and land use databases. Once the initial simulation was developed, the recorded data from the signal testing was factored into the SignalPro[™] application to calibrate the model and improve its accuracy.

The propagation simulation was further developed to predict where the system would provide a voice quality (Delivered Audio Quality (DAQ)) of at least 3.4 per typical public safety standards. The minimum Channel Performance Criteria (CPC) required for a DAQ level of 3.4 for an analog narrowband (12.5 kHz) voice system was derived using the information from Table A-1 of TSB-88¹. The TSB-88 report serves as the public safety LMR network design industry standard.

The propagation model predicts coverage for a mobile radio, as well as a portable radio worn on the hip on street (outdoors) and within buildings up to a specific dB signal loss value for both outbound (dispatch to field) and inbound (field to dispatch). The results for the simulation at this level of voice quality for the following conditions, for each of the analyzed county systems are provided in the figures on the following pages.

- > Medium Building
- > Light Building
- > Portable
- > Mobile

¹ TIA Telecommunications System Bulletin TSB-88.1-C: Wireless Communications Systems Performance in Noise and Interference Limited Situations - Part1: Recommended Methods for Technology Independent Performance Modeling: February 2008.





Figure 27: Fire System East Current Coverage (Simulated)



Figure 28: Fire System West Current Coverage (Simulated)



Figure 29: RFA City System Current Coverage (Simulated)





Figure 30: RFA District 12 System Current Coverage (Simulated)



Figure 31: Paging System Current Composite Coverage (Simulated)



Figure 32: City PD System Current Coverage (Simulated)





Figure 33: LCSO East System Current Coverage (Simulated)



Figure 34: LCSO West System Current Coverage (Simulated)

APPENDIX C: PROPOSED SYSTEM PREDICTED COVERAGE

A detailed propagation simulation was developed to further analyze coverage and to predict performance from various site constellations for an enhanced system. The simulations utilize the EDX SignalPro[™] application, which is a standard propagation tool employed by Public Safety to model the system elements and to predict coverage by incorporating industry standard propagation algorithms in addition to terrain and land use databases. Once the initial simulation was developed, the recorded data from the signal testing was factored into the SignalPro[™] application to calibrate the model and improve its accuracy.

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The propagation model predicts coverage for a mobile radio, as well as a portable radio worn on the hip on street (outdoors) and within buildings up to a specific dB signal loss value for both outbound (dispatch to field) and inbound (field to dispatch). The results for the simulation at this level of voice quality for the following conditions, for each of the analyzed county systems are provided in the figures on the following pages.





Figure 35: Proposed Fire System East Coverage (Simulated)

² TIA Telecommunications System Bulletin TSB-88.1-C: Wireless Communications Systems Performance in Noise and Interference Limited Situations - Part1: Recommended Methods for Technology Independent Performance Modeling: February 2008.





Figure 36: Proposed Fire System West Coverage (Simulated)



Figure 37: Paging System Composite Coverage – Current + Coal Mine (Simulated)



Figure 38: Proposed LCSO East System Coverage (Simulated)





Figure 39: Proposed LCSO West System Coverage (Simulated)

APPENDIX D: PROPOSED MICROWAVE LINK PATH PROFILES (FROM TERRAIN DATABASE)



Figure 40: Democrat (90 ft.) to Hopkins (90 ft.) Path Profile



Figure 41: Hopkins (90 ft.) to Peterman (100 ft.) Path Profile



Figure 42: Mineral (90 ft.) to Peterman (100 ft.) Path Profile





Figure 43: Dog (90 ft.) to Peterman (100 ft.) Path Profile



Figure 44: Dog (90 ft.) to Randle (90 ft.) Path Profile



Figure 45: Onalaska (90 ft.) to Democrat (90 ft.) Path Profile





Figure 46: Democrat (90 ft.) to Toledo (90 ft.) Path Profile



Figure 47: BawFaw (90 ft.) to Toledo (90 ft.) Path Profile



Figure 48: BawFaw (90 ft.) to Doty (100 ft.) Path Profile





Figure 49: Doty (100 ft.) to Manners (100 ft.) Path Profile



Figure 50: Crego (90 ft.) to Democrat (90 ft.) Path Profile