# Los Alamos County

# A Conceptual Design Study for Fiber Optic Network Expansion

DRAFT, Rev. 2
May 13, 2009

Prepared For:
Los Alamos County, NM
Information Technology Division

CRESTINO
Telecommunications Solutions

# TABLE OF CONTENTS

## List of Figures



## List of Tables

## The Council Members of Los Alamos County Request:

*"A conceptual design study for a project to provide a county-wide network infrastructure that will (1) meet planned County government communication needs and (2) Provide the foundation for an open access network delivering advanced broadband communications to all Los Alamos citizens, should such a network be created by future Council action."*[1]

# SECTION 1: EXECUTIVE SUMMARY

### Introduction

The Los Alamos County Council has repeatedly expressed that a robust fiber network infrastructure is a long-term goal for the County. To that end, County Council has requested a conceptual design study for a fiber optic network designed to meet the government communication needs of Los Alamos County (LAC). Furthermore, the Council has directed that the proposed *County Fiber Network* should be scalable to such a degree that it could serve as the future foundation of an open access *Community Broadband Network*. This report is the outcome of that conceptual design study and is meant to serve as a roadmap for moving forward with the Council's initiative.

### Plan Highlights

This study envisions a two step approach to meeting the County Council's request:

- **Step One:** This initial step focused on expanding the County's current fiber optic network in the Los Alamos Townsite, Royal Crest and White Rock. This would be a *closed*, secure network designed to meet the immediate and future needs of the County government. This expanded fiber network would interlink both existing and planned County facilities using 1 Gigabit and 10 Gigabit based Ethernet links. The design has been planned to be highly scalable, meaning that as the County's network continually evolves, each link can be scaled up to a higher bandwidth without the need for new fiber build-outs or expensive equipment changes.

  Furthermore, the proposed County Fiber Network has been designed in a network ring topology. County facilities would be interconnected via high-speed Collector rings which would aggregate traffic back to an even higher-speed Core ring. In addition to using less overall fiber footage than other configurations, the use of a network ring would help the County to avoid possible network outages in the event of a fiber cut or an equipment card failure.

  Lastly, the fiber design has also been integrated with the wireless network proposed in the *Los Alamos County Wireless Voice and Data Plan*[2], thus supporting critical Public Safety communications.

[1] Los Alamos County Council, Meeting Minutes, 3/18/08
[2] The "Los Alamos County Wireless Voice and Data Plan" is a separate report which presented an evaluation of the County's current radio coverage and an analysis of building a new P.25 wireless radio system for all County entities.

- **Step Two:** Building upon the foundation laid by the County Fiber Network, Step Two envisions a future, *open* access Community Broadband Network designed to meet the needs of the citizens of Los Alamos County. The Community Broadband Network is best visualized as separate, independent network layer running across some of the same infrastructure as the County Fiber Network. Both networks would share portions of a common backbone. However, from a security and management standpoint, this *open* community network would be completely independent from the *closed* County network.

  The study recommends an open access fiber model by which citizens could access a common web Portal for selecting services on the network. This Portal would act as a kind of electronic marketplace for the community. To manage this environment, this Portal concept also includes third-party automation and control software that would facilitate the administration and provisioning of services. In fact, the list of potential services that could be supported across this proposed Community Broadband Network is virtually endless and includes new technologies such as Ultra-High Speed Internet, Voice over IP telephone, IPTV, and Video Conferencing, just to name a few.

It's no secret that Los Alamos County is a unique place with a unique history - a place that was quite literally built on the concepts of *innovation* and *forward thinking*. No other community in the state, and very few in the nation, can point to such a reputation for scientific and technological advancement. Thus, as the County celebrates its 60$^{th}$ Anniversary in 2009, it is very fitting that it should consider the development of a countywide fiber optic network. With unmatched longevity and almost limitless potential for upgrade, a fiber optic network deployed today could carry Los Alamos County forward to its 100$^{th}$ Anniversary.

## *1.1 Summary of Recommendations*

The primary recommendations outlined in this design study are summarized below:

**<u>Step One – The County Fiber Network</u>**

**Network Design**

- As a network technology choice, this study recommends deploying a fiber network using Ethernet technology. The choice of Ethernet makes the network extremely scalable to both the immediate and future needs of the County. Also, Ethernet offers the best level of flexibility in terms of integrating new applications or new service providers in a future, open, community network.
- The proposed fiber network should be deployed using a self-healing network ring topology. A ring topology is beneficial because it requires less overall fiber footage, when compared to a mesh network. It also best satisfies the County's requirement for a network level protection scheme.
- The network ring topology should be structured with several high-speed Collector rings which would aggregate traffic back to an even higher-speed Core ring.

- The County should use a Free Space Optics connection from Lavy Lane to provide a high-speed broadband connection to the Solid Waste location on the South Mesa.

**Network Nodes**

- The County should leverage its existing Cisco network equipment, and its existing Cisco expertise, by deploying Cisco 6500 series switches in the Core ring and Cisco 3750 switches in the Collector rings.

**Recommended Network Features**

- Standardized Layer 3 (L3) routing principles should be implemented across the network.
- The network should utilize Multiprotocol Label Switching (MPLS). MPLS is a standardized packet-switching technology that provides great scalability and resiliency and can support multiple protocols across the same network.
- EtherChannel should be used as a means of building ultra-high capacity links (such as in a multi 10GB Core ring). Additionally, Wave Division Multiplexing (WDM) technology is another viable solution for growing beyond the current 10 Gbps capacity limitation on a given link. However, the additional costs for WDM equipment are not warranted at this time given the County's plan to place a 288 fiber.
- A microwave radio connection is the most feasible solution for providing Internet redundancy "off the hill." A possible solution would be a two link / three site microwave system from the Pajarito Mountain site to Downtown Albuquerque.

**Project Implementation**

- This study recommends that the fiber network backbone should include surplus fiber count at strategic locations were the County might choose to expand its overall facility footprint in the future.
- This report also recommends that the fiber network backbone should include surplus fiber count near important community institutions in the event that a decision is made to interconnect with the County Fiber Network.

## Step Two – A Future Community Broadband Network

**Network Design**

- An Active Ethernet Network should be chosen as the basis for a future Community Broadband Network.
- The Community Broadband Network, if implemented, should utilize an open-access shared-fiber model with a Service Portal Strategy. The open-access fiber model, in addition to being highly flexible, offers the best strategy for the mitigation of legal and financial risk.
- The Community Broadband Network should utilize automation and control software for running the network in order to minimize operational costs, complexities and to streamline the workflows of an open fiber network.

**Other Recommendations**

- The County currently has an informal policy whereby conduit placement is at least considered with every major public works project, whether it be road projects or utility upgrades. This study recommends that the County formalize this practice into a standard, written policy that requires the departments that are responsible for these types of projects to consult with the Information Technology Division to determine if additional conduit should be placed in conjunction with the public works project. Fiber can then be placed in these conduit raceways at any point in the future at relatively low expense.

## *1.2 Purpose, Need and Justification*

The **purpose** of this report is to present a conceptual design study for the creation of an expanded fiber optic network meant to interconnect primary County facilities which could then later serve as the backbone for a future Community Broadband Network. This proposed fiber network would exist to provide the County with ample bandwidth for transporting advanced IP services, wireless traffic, and any other telecommunications needs the County may have now or in the immediate future.

Such a network is **needed** in order to support new County facilities such as the Airport Basin Complex. Although certainly a step in the right direction, the existing fiber network is geographically limited to just a few County offices in the downtown business district and does not have significant levels of protection or redundancy. Additionally, the County would like to strengthen its Public Safety communications system, as documented in the *Los Alamos County Wireless Voice and Data Plan*. This makes a strong case that the County should build out a fiber network in order to backhaul wireless traffic at the proposed Voice and Broadband Radio Sites. Examples of these include radio sites at the Barranca Mesa and Hawk Water Tower locations and a radio site at White Rock Fire Station No. 3.

The needs discussed above also serve as the **justification** for a County Fiber Network. Related to connecting new County facilities such as Airport Basin, the primary alternative to fiber would be to pay monthly recurring costs for leased lines. In addition to expensive, unending monthly charges, such leased lines would most likely rely on copper infrastructure and would certainly have less bandwidth capacity and less overall flexibility than County-owned fiber.

Furthermore, the justification for expanding the County's fiber network can be made based on network traffic growth. The need for greater bandwidth is increasing exponentially throughout the world. It is forecasted that worldwide IP traffic in general "*will nearly double every two years through 2012. Total IP traffic will increase by a factor of six from 2007 to 2012*"[3]. A County-owned fiber network could be made scalable to meet the County's needs well into the future and, as requested, could also serve a foundation for a Community Broadband Network.

[3] White Paper, Cisco Visual Networking Index – Forecast and Methodology, 2007-2012

# SECTION 2: INTRODUCTION

## *2.1 A Conceptual Design Study – Setting the Stage*

The County Council requested a Conceptual Design Study. *First of all, what is a Conceptual Design Study?* It's a study of what design solutions are feasible to build and how much each could cost. It's meant to add substance and dimension to the project scope and to the set the stage for a project plan before. The intent is to gain insight into a design solution, not to determine the actual design itself in exacting detail. In short, the purpose of a conceptual design study is to develop a roadmap before moving forward with a large-scale, detailed design project.

The overall objectives of a conceptual design study are to:

- Fully clarify the needs and requirements the project is aiming to fulfill
- Develop a general course of proposed action
- Identify and evaluate the feasible solutions with engineering analysis
- Document the engineering analysis, the preliminary design and the project delivery plan to help guide the implementation of the project.
- Provide a cost analysis of the proposed solution

## *2.2 Council Requirements for a Conceptual Design Study*

The Los Alamos County Council has stated that they would like to investigate the development of a broadband network "*with a minimum of 1-10 GB throughput with the possibility of 40 GB and beyond in the future".* In that context, the Council has asked that the proposed broadband network meet the following requirements:

- A fiber backbone throughout the community, buried wherever economically feasible
- Fiber or wireless/radio access to County facilities and vehicles from nodes in that fiber network to replace the current radio system
- The fiber backbone should be designed to permit expansion, if desired, into an open access wireless service covering the entire Townsite, White Rock and Royal Crest and, ultimately, fiber-to-the-premise to virtually every occupied property in the County
- The system should be planned to include the necessary operations and support facilities

### 2.3 Deliverables

The County Council has outlined the following list of expected deliverables from this design study[4]:

1. Purpose, need and justification
2. General scope, primary requirements
3. Functional requirements
4. General approaches
5. Enough detail on at least one viable approach to each aspect of the project to establish feasibility and enable cost and schedule estimates
6. Identification and approaches to the mitigation of risks
7. Budget, including appropriate contingency
8. Schedule, including appropriate contingency
9. Location of required facilities

## SECTION 3: DESIGN REQUIREMENTS & CONSIDERATIONS

This section of the report will summarize the primary requirements and considerations that fed into the overall network design.

### 3.1 ITD Network Requirements and Considerations

The Information Technology Division (ITD) is entrusted with the responsibility of maintaining and improving the overall network infrastructure of Los Alamos County. Therefore, in addition to the requirements outlined by the County Council, the ITD has also guided the development of this design study either by outlining more specific network requirements, or, by confirming the preliminary recommendations that arose during the initial design process.

The table that follows is a summary of the specific network requirements that shaped the network design:

| Type | Requirements and Considerations |
|---|---|
| ***Network*** | The County Fiber Network will be a closed, secure network for County use only. The Community Broadband Network will follow an open-access fiber model. |
| ***Network*** | The network design should include an overall network protection/redundancy scheme. |
| ***Network*** | The fiber network will be integrated with the radio network proposed by the *Los Alamos County Wireless Voice and Data Plan* and it will function as a wireless backhaul transport method at select radio sites. |
| ***Network*** | Primary County facilities should be served by a 10 Gigabit-based network backbone (possibly multiple 10 GB links). Secondary County facilities should have at least 1 Gigabit based links. Network links should be scalable. |
| ***Network*** | The study should investigate a plan for a redundant Internet connection to the outside world. This would serve as a backup to the current Qwest connection “off the hill”. |

[4] Los Alamos County Council, Meeting Minutes, 3/18/2008

| | |
|---|---|
| ***Network*** | The fiber network design should plan for a "future ITD NOC" location. The current ITD location at 2400 Central Ave does not have adequate space or power to house the additional equipment that would be required that would be required for the network. |
| ***Network*** | Fiber to Airport Basin is a clear network priority. The ITD sees the need for multiple 10 GB trunks at the new Airport Basin complex. |
| ***Implementation*** | The implementation of the network design should follow a phased approach with the initial project focus being devoted to where the County has existing infrastructure. |
| ***Implementation*** | The proposed fiber network should leverage the County's existing fiber network in the downtown area. |
| ***Implementation*** | ITD already has existing plans to place new conduit infrastructure and a new 288-fiber cable from the Police Judicial Complex to the new Airport Basin Complex. |
| **Type** | **Requirements and Considerations** |
| ***Implementation*** | The County is currently in the process of placing new conduit infrastructure along Diamond Drive as part of a road improvement project. |
| ***Application*** | The immediate applications for the fiber network include: client/server applications, Internet, phone/VoIP, and Public Safety. |
| ***Application*** | The fiber network design should address the viability of integrating fiber with traffic cameras at key intersections. |
| ***Application*** | The fiber network design should address methods for integrating fiber with future Utility needs - such as the potential for Smart Grid technology and Automated Meter Reading (AMR). |

**Table 1 ITD Network Requirements and Considerations**

## *3.2 Existing Fiber Infrastructure*

The ITD has already wisely seen the need for fiber optic transport in order to support the County's growing communications needs. Thus, the network design proposed later in this report is actually a large-scale expansion of the existing County network.

The County's existing fiber network is currently limited to the downtown area of the Los Alamos Townsite. The Information Technology Division has multiple point-to-point (P2P) Ethernet circuits capable of 10 GE connecting key offices in the downtown business district. The table below provides a list of these County offices.

| Office | Address |
|---|---|
| ITD, Mesa Public Library | 2400 CENTRAL AV |
| Finance, HR, Assessors, County Clerk | 2451 CENTRAL AV |
| Police/Judicial Complex | 2500 CENTRAL AV |
| Community Center | 475 20TH ST |
| Public Works | 1925 TRINITY DR |
| County Annex | 901 TRINITY DR |

**Table 2 County Locations Connected with Existing Fiber**

Figure 1 below shows a map of the existing fiber and the County facilities connected to it.

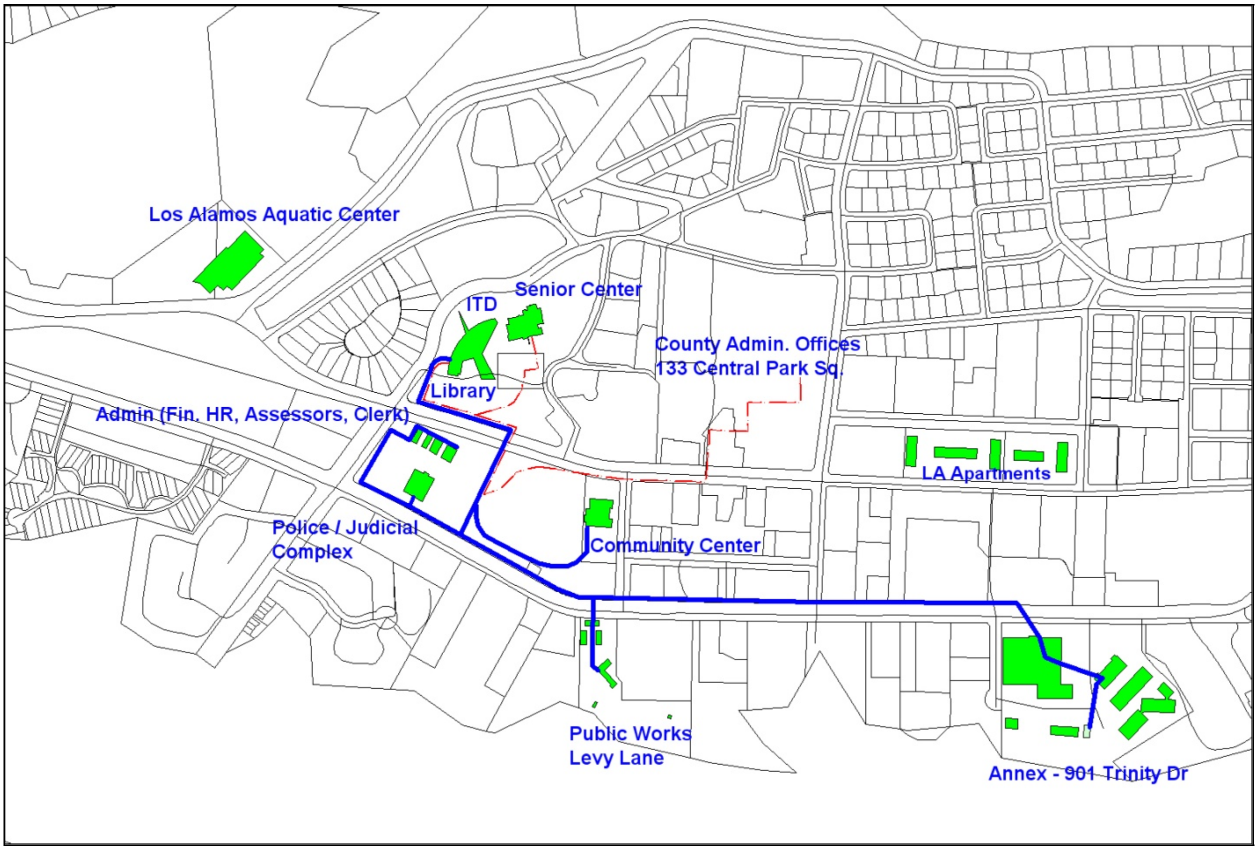


**Figure 1 Existing Fiber Network in the Downtown Los Alamos Townsite**

## *3.3 Locations Included in this Study*

### 3.3.1 County Locations

County facilities are partially in a state of transition. This section of the report will provide a brief description of which locations are going away and which new locations are being added.

**The Municipal Building**

The former Municipal Building located at the Ashley Pond Park site has been demolished due to structural concerns. Consequently, County functions that used to be housed at the old Municipal Building have been relocated to temporary locations, such as 2451 Central Avenue and 1925 Trinity. Plans for a new Municipal Building location are under ongoing consideration by the County Council and the community at large. Fortunately, proposed locations for a new Municipal Building are primarily centered in the downtown area where existing fiber is already nearby. Therefore, it should be a simple task to integrate a new Municipal Building into the fiber network once that building location has been finalized.

**The County Annex**

Facilities such as the County Annex, located at 901 Trinity Dr, are also scheduled to go way as part of the Trinity Site Revitalization Project. County functions currently located at the Annex, will be relocated to the new Airport Basin site. The area currently occupied by the County Annex (and the neighboring property occupied by Los Alamos Public School offices) will become a new mixed use commercial and residential development.

**The Airport Basin Complex**

Currently under construction, The Airport Basin Complex will be a joint-use facility for both Los Alamos County and Los Alamos Public Schools. This site will be a multi-building campus that will house County functions such as Public Works, Utilities & Risk Management, Facilities & Parks, as well as Traffic & Transit. Fiber to Airport Basin is a clear network priority due to the critical role that Airport Basin will play in County and School functions. The Information Technology Division sees the need for multiple 10 GE trunks at the new Airport Basin complex.

**Figure 2 Sketch of the Airport Basin Complex**

**Future ITD NOC**

In addition to these other changes, it is also understood that the current building which houses the Information Technology Division (located at 2400 Central Ave) does not have adequate space and power for the additional equipment that would be required for the expanded fiber network. A "Future ITD NOC" (Network Operations Center) is required. Possible NOC locations include the Community Center located at 475 20th St or the property currently occupied by the Los Alamos Apartments located at 15th and Central Ave. For the purposes of this study, the design assumes that such "Future ITD NOC" location will be finalized at a later date.

As part of the data collection process, the County GIS department shared a "structures" file detailing all of the man-made structures in Los Alamos County. This data was then converted into spreadsheet form and filtered down to strictly County locations. ITD then reviewed this information in order to determine the finalized list of County facilities to be connected to the fiber network. The results of this are shown below:

| Type | Area | Description | Address |
|---|---|---|---|
| County | LA | Airport Basin Complex | 2407 EAST RD |
| County | LA | Aquatic Center | 2760 CANYON ROAD |
| County | LA | Bayo Canyon Waste Water Fac. | 188 PUEBLO CANYON RD |
| County | LA | Betty Ehart Senior Center | 1000 OPPENHEIMER DR |
| County | LA | Canyon Schools Complex | 1100 CENTRAL AVE |
| County | LA | CAO Office (leased) | 133 CENTRAL PARK SQ |
| County | LA | Community Center (Atty. & Mun. Court) | 475 20TH ST |
| County | LA | County Annex | 901 TRINITY DR |
| County | LA | Fire station #2 | 132 DP ROAD |
| County | LA | Fire Station #4 | 4401 DIAMOND DR |
| County | LA | Fire Station #6 | 457 EAST ROAD |
| County | LA | Golf Course | 4250 DIAMOND DR |
| County | LA | Info. Tech. Division | 2400 CENTRAL AV |
| County | LA | JDC/EOC | TA 69, BLDG 33, LANL |
| County | LA | LAC Admin (Fin., HR, Assess., Clerk) | 2451 CENTRAL AVE |
| County | LA | Los Alamos Airport | 1040 AIRPORT RD |
| County | LA | Mesa Public Library | 2400 CENTRAL AV |
| County | LA | Police/Judicial Complex | 2500 TRINITY DR |
| County | LA | Proposed Animal Shelter | 246 EAST ROAD |
| County | LA | Public Works | 1925 TRINITY DR |
| County | LA | Solid Waste Transfer Station | 3701 EAST JEMEZ RD |
| County | WR | Fire Station # 3 | 129 STATE ROAD 4 |
| County | WR | White Rock Municipal Complex; Library | 133 LONGVIEW DR |
| County | WR | White Rock Waste Water Treatment | OVERLOOK ROAD |

**Table 3 County Facilities to be Included in this Study**

Figure 3 shows a parcel map of the Los Alamos Townsite with the indentified County facilities that are to be included in this study.

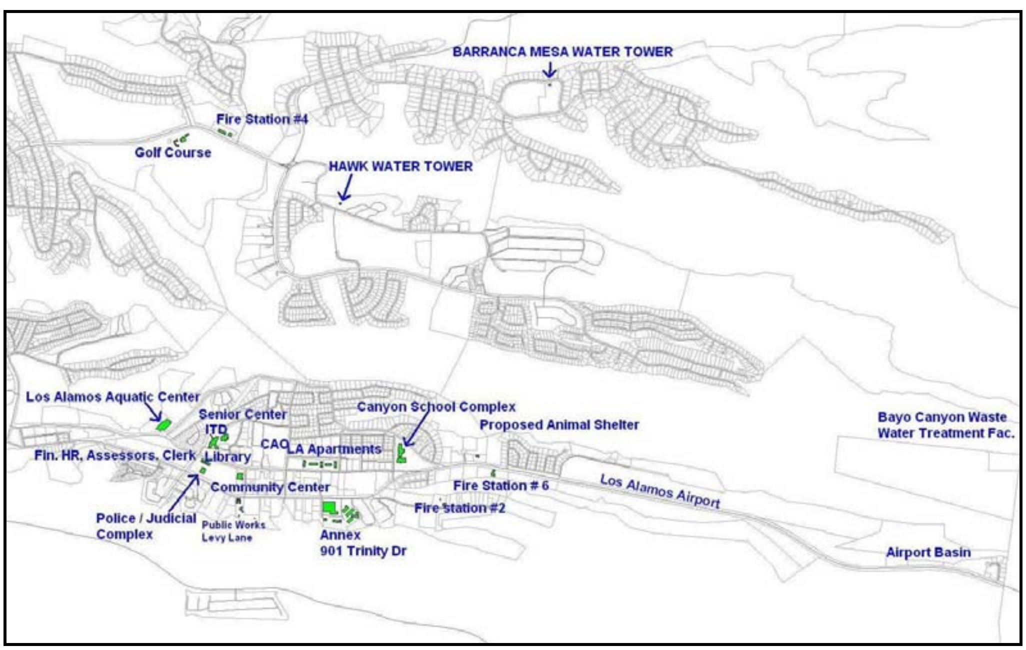


**Figure 3 County Facilities in the Los Alamos Townsite**

Likewise, shows a parcel map of White Rock with the relevant County facilities that are to be included in this study.

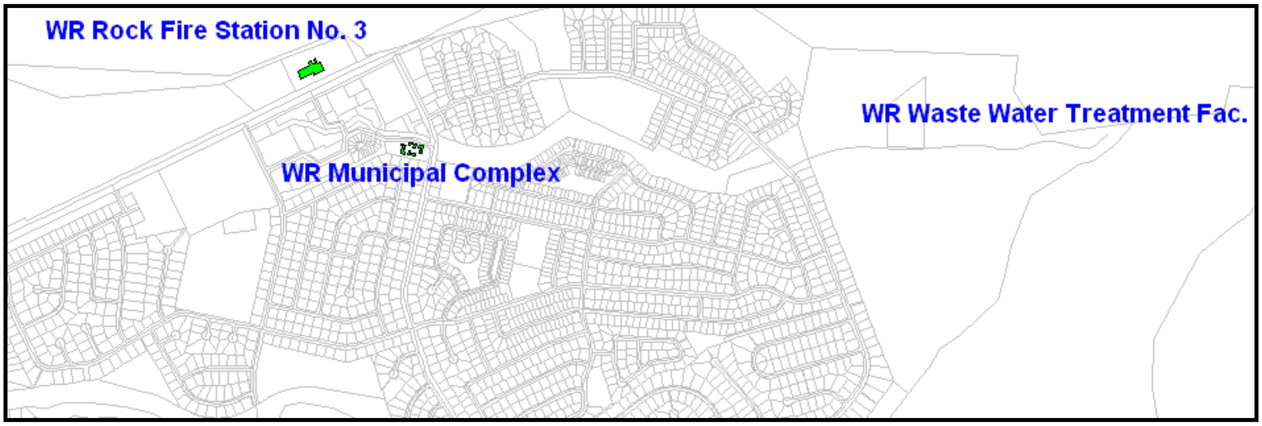


**Figure 4 County Facilities in White Rock**

While it should be reiterated that the network design presented in this report is focused on meeting the needs of the Los Alamos County government, there are a number of other community institutions that could clearly benefit from interconnection to the County Fiber Network, should they decide to do so in the future

# STEP ONE – THE COUNTY FIBER NETWORK

## SECTION 4: NETWORK DESIGN & RECOMMENDATIONS

Technology and applications are now evolving so quickly that Network Design can sometimes be like trying to hit a moving target. Networks are constantly evolving due to ever changing needs, new locations, new budgets, changes in technology and so on.

The best way to deal with this changing environment is to first build a flexible, “scalable” network. Scalability refers to the ability to add additional nodes and bandwidth without disrupting or overhauling the network. Scalable network designs are intended to be “future proof” and can more easily adapt to change, especially changes in bandwidth requirements. For instance, when a network connection reaches capacity, a scalable design would allow you to add additional capacity to the link without re-designing it or replacing equipment at each end. As the following sections will illustrate, this concept of scalability has influenced the overall network design at each step of the process.

### *4.1 Network Technology*

As a network technology choice, this report recommends the deployment of a countywide Metropolitan Area Network (MAN) using Ethernet technology. This is may seem like a relatively simple decision given that the ITD has already deployed 1 GE and 10 GE links in the downtown area, and to some extent, that is correct. However, it is important to recognize that other network technologies do exist such as SONET and ATM. Ethernet is simply better suited to the County’s network needs.

An Ethernet-based MAN is advantageous for the following reasons:

- **Multi-services** – Ethernet, along with MPLS technology, allows for multiple services to be transported over a common network. This allows service convergence over the network, where new services may be offered alongside legacy services.

- **High Bandwidth** – 10 Gigabit-per-second (Gbps) Ethernet is a mature technology with a path to 40 and 100 Gbps speeds. Bandwidth requirements continue to grow exponentially, and Ethernet provides a technology that can keep up with the bandwidth demands. In addition, bandwidth may be sliced up at a finer granularity than other in other technologies such as SONET.

- **Low Cost** – Ethernet provides high-performance, high-bandwidth connectivity at a fraction of the cost of legacy technologies, such as SONET and ATM.

- **Simplicity** – Ethernet is a mature standard and is much simpler to use as opposed to other technologies. Deployment and maintenance of the network is simplified using Ethernet technology.

- **Standards-based** – Metro Ethernet is widely deployed by carriers, enterprises and municipalities. The networks are deployed in a multi-vendor environment, following standards set by the Institute of Electrical and Electronics Engineers (IEEE), Internet Engineering Task Force (IETF), and the Metro Ethernet Forum (MEF).

An Ethernet-based MAN allows LAC to build a future-proof, standards-based network using state-of-the-art technology in the most efficient and cost-effective manner.

## *4.2 Logical Network Design*

### 4.2.1 Core and Collector Rings

The Logical Network Design, presented in Figure 6, shows the recommended configuration of the network.

The main backbone of the network consists of a 10 Gigabit Ethernet *based* core ring (shown in blue) connecting the primary County facilities in the downtown area as well as new the Airport Basin Complex. Network nodes on the core ring provide interconnection to, in this case, four different collector rings that are each running 1 GE Ethernet.

Core and collector rings provide highly reliable and redundant data transmission paths while at the same time providing the flexibility to aggregate traffic in a cost effective network. A fiber break in one segment of the rings will cause the traffic to reverse directions in that one segment, keeping the other segments from switching.

The core rings are very high bandwidth rings that take and combine traffic from collector rings. The core has the highest data rates on the network.

The collector rings connect lower speed locations and are multiplexed or added to the core rings. The core ring is interconnected to the collector rings through digital electronic cross-connects within the core network nodes, in this case a Cisco 6500 series platform.

One of the requirements for the fiber network design was that it be integrated with the newly proposed LAC Wireless Voice and Data Plan. This has been accomplished in the design by bringing fiber directly to several of the Voice Radio sites including: Lavy Lane, site at the Barranca Mesa Water Tower, and site at White Rock Fire Station # 3. Furthermore, the fiber network also interconnects with the Broadband Data sites such as the one located at the Hawk Water Tower site. Since both the Voice and the Broadband Data sites use digital, IP-based technology, the Wireless Radio traffic can easily be aggregated on to the proposed County Ethernet fiber network and backhauled to any location on the ring.

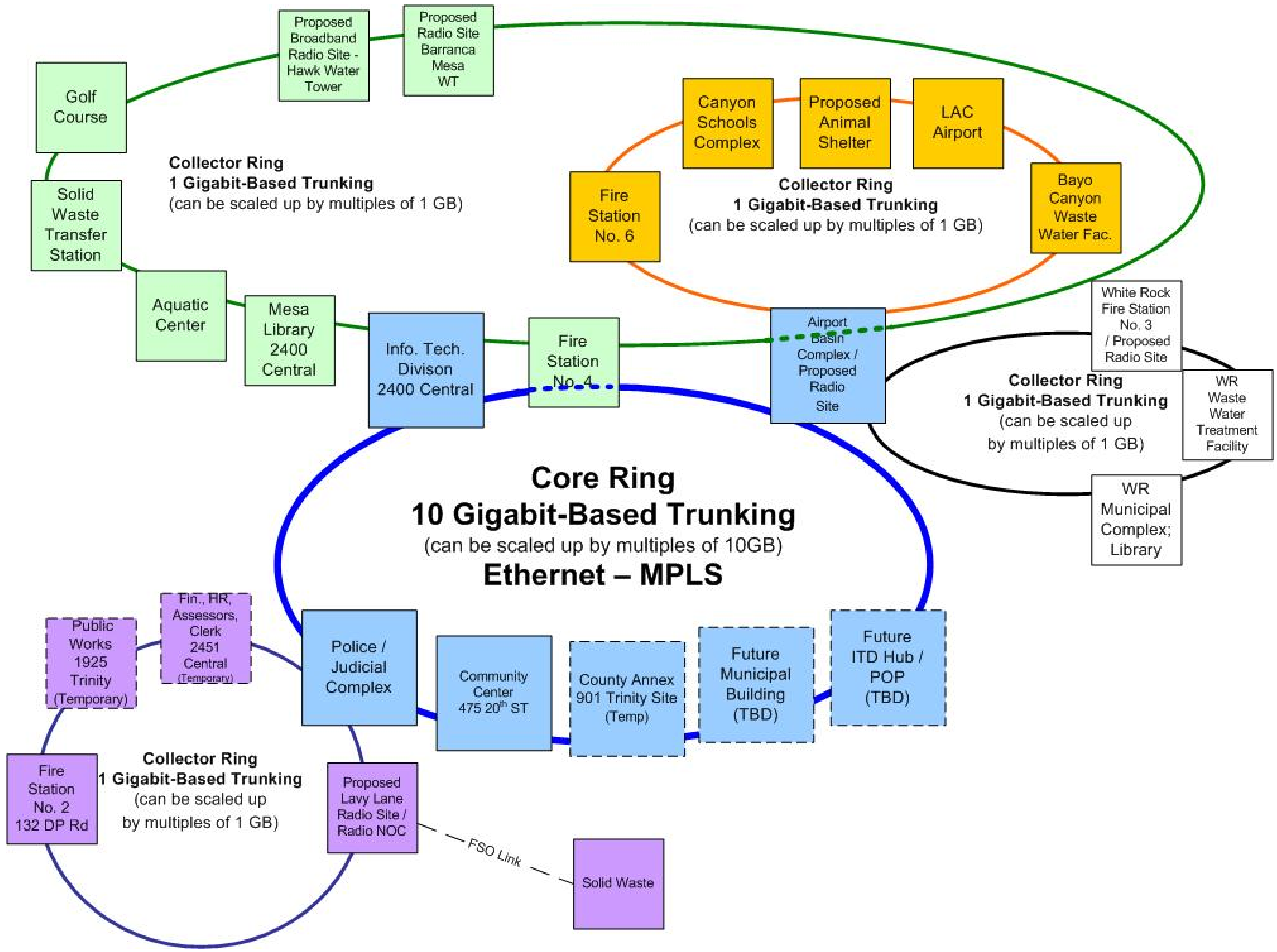


**Figure 5 Logical Network Design – Step One Core and Collector Rings**

### 4.2.2 Free Space Optics Connection to Solid Waste

Due to the geography of the surrounding area in would be inherently difficult, not to mention cost prohibitive, to bring a fiber optic cable connection to the Solid Waste Transfer Station. However, it is feasible to implement a Free Space Optics (FSO) link between the radio site at Lavy Lane and Solid Waste.

Free Space Optics, also called Optical Wireless, transmits data across open air (i.e. free space) from point to point. Like fiber optics, laser light is used to transmit data, however, instead of "piping" that light through a glass fiber, it's transmitted through open air to a photo-sensitive receiver on the far end.

Free Space Optics (FSO) transmits invisible, eye-safe light beams from one point to another using a low power infrared laser. The beams of laser light are focused on highly sensitive photon detector receivers. These receivers are telescopic lenses able to collect the photon stream and transmit digital data containing a mix of Internet messages, video images, radio signals or computer files. Commercially available systems offer capacities in the range of 100 Mbps to 2.5 Gbps. These systems present a very cost effective way of establishing a reliable, high-speed data link when geography or construction issues make fiber optic cable cost prohibitive.

## *4.3 Network Nodes*

### 4.3.1 Core Network Nodes

This study recommends that the County deploy a Cisco 6500 series multi-layer switch in the core network ring. The Cisco 6500 is a top tier switching solution appropriate for deploying Metropolitan Ethernet networks. It has the following attributes which make it a good choice for LAC's core network platform:

- 10 Gigabit Ethernet
- High-density 1 Gigabit Ethernet
- High speed, wire speed throughput
- High availability with redundant supervisor cards and power supplies
- Robust Layer 3 routing support (BGP, OSPF)
- IP/MPLS support, including Fast reroute, and Layer 3 VPNs

The Cisco 6500 is widely deployed across the world and a wide range of Cisco trained personnel are available.

The Cisco 6500 is a chassis-based switch that includes the following components:

- **Chassis** – a 6500 chassis includes several slots – including 2 slots dedicated to supervisor engine and multiple slots for line cards (cards that include Ethernet interfaces). The 6500 is commonly used with following chassis slot configurations – 6, 9, and 13 slots.

- **Supervisor Engine** – This card is the "brains" of the device – it controls the management, protocols, and switching of the 6500. Importantly, the supervisor engine is where also where IP/MPLS capabilities are implemented.

  The supervisor engine should be implemented in a high availability configuration, meaning that two cards are included in the chassis. In this scenario, one card will act as the primary/operating card with the other acting as a hot-standby - in case the primary card fails. Incidental evidence shows that high altitude can be a contributing factor to card failure, so for LAC's County Fiber Network it is imperative that two supervisor engines should be implemented in each 6500.

- **Ethernet Interface cards** – the 6500 may support multiple interface cards of different configurations. These interface cards provide the Ethernet connectivity to the switch.

  Redundant 10 Gbps cards may be deployed on the core switches towards the backbone ring. Multiple 10/100/1000 Mbps copper and fiber-based interface cards may be deployed to support local connectivity to the network. The number of cards needed per network node is determined by the density of the local serving area. In addition, in a head-end environment, firewalls, servers, multimedia devices, telephony devices, etc., may be connected to the network through an interface card.

- **Power supplies** – the 6500 can be deployed with redundant power supplies. The supplies can be connected to diverse power sources, to protect against power supply failure or power failure at the network node.

  The power supplies are available in 100 to 240 VAC and -48 to -60 VDC configurations.

- **Transceivers** – the optical transceivers provide connectivity to the 6500 over fiber optics to the Ethernet interface cards. The transceivers are field replaceable, meaning that they may be replaced individually without impacting other ports on the interface cards. The 10 Gbps interface modules support XENPAK modules, capable of interconnecting over a pair of 10, 40, or 80 km of single-mode fibers. The 1 Gbps interfaces support transceivers that can communicate over a pair of single-mode fiber at 10 or 70 km. In addition, multi-mode fiber may be used in a range of 200-500 meters.

### 4.3.2 Collector Nodes

The collector nodes are local serving rings that connect into the core ring. Since the collector rings carry less bandwidth and cover more nodes than the core, the Cisco 3750 is considered as the collector node ring. The Cisco 3750 includes the following attributes:

- 1 Gigabit Ethernet
- High speed, wire speed throughput
- High availability with stacked device configuration
- Robust Layer 3 routing support (OSPF, BGP)

The Cisco 3750 is a 1 RU (rack unit) switch that includes the following features:

- **Ethernet ports** – the 3750 is available in a variety of models, with different combinations of Ethernet ports, including copper and SFP-based 10/100/1000 Gbps ports. For the collector nodes, the SFP-based 1000 Gbps models are optimal. It's also important to note that the 3750 supports TwinGig converter module for migrating uplinks from 1 Gigabit Ethernet (SFP) to 10 Gigabit Ethernet (X2).

- **Stackable** – the 3750 supports a stackable configuration, meaning that multiple 3750 devices may be connected together to active as a single, logical switch. The stacking is accomplished through a backplane interface that does not require utilization of any of the Ethernet ports. The stacking features provide resiliency to the collector nodes. Two switches may be paired, each one with a transceiver connected to one direction of the collector ring. If one of the switches fails, the node is still active in the ring. In addition, the stacking features provide scalability. As more ports are required at the collector node, addition switches may be connected into the stack configuration – up to 9 switches may be stacked, supporting up to 468 Gigabit Ethernet ports.

- **Power supplies** – the 3750 utilize internal power supplies, in a 100-240 VAC configuration.

## *4.4 Estimated Cost of Network Nodes*

This section of the report provides a breakdown of the network node costs. The costs presented below are **in today's dollars** and are therefore subject to change over time. Table 4 provides a high-level estimated cost of the Cisco network nodes using standard list pricing. These are the estimated *per node* costs, not the total.

| Item | Est. Cost Per Unit |
|---|---:|
| Cisco 6500 core head-end node | $250,000 |
| Cisco 6500 core node | $135,000 |
| Cisco 3750 collector node | $17,000 |

**Table 4 Cisco – Per Node Costs – Step One**

Next, Table 5 factors in the quantity of nodes required by the proposed design to provide the total estimated cost for all of the Cisco network nodes. Table 5 also includes the estimated costs for the Free Space Optics link to Solid Waste.

| Item | Qty | Est. Cost Per Unit | Total Est. Cost |
|---|---|---|---|
| Cisco 6500 core head-end node | 1 | $250,000 | $250,000 |
| Cisco 6500 core node | 5 | $150,000 | $750,000 |
| Cisco 3750 collector node | 18 | $20,000 | $360,000 |
| Free Space Optics System Equipment and Support | 1 | $41,256 | $41,256 |
| | | **Total** | **$1,401,256** |

**Table 5 Total Estimated Costs for Network Nodes – Step One**

## *4.5 Recommended Network Features*

This section of the report will outline the recommended network features that should be implemented in order to meet LAC's requirements.

### 4.5.1 Layer 3 Networking

Ethernet networks are built to support Layer 2 (L2) or Layer 3 (L3) architectures. A Layer 2 device will pass on information based upon an internal table look-up that identifies the other devices that are connected to it. Layer 3 devices, however, typically offer more built-in intelligence in that they forward traffic based on the IP address of the message.

This report recommends that Los Alamos County implement a Layer 3-based network. Layer 3 networks are inherently more scalable, manageable, resilient, and provider stronger security than Layer 2 networks.

- **Scalability** –The Internet is a large, scalable, Layer 3 network. Layer 3 networks naturally scale as subnets are added to routers. Other routers dynamically learn about the subnets and keep track of the subnets using summarized route entries, allowing routers to route packets to millions of hosts.

  Layer 2 networks are flat networks, meaning that every switch within the Layer 2 domain must have an entry of every host in the domain. High bandwidth core routers are not optimized to support large amounts of host entries.

- **Manageability** – Layer 3 networks utilize standards-based routing protocols to learn about routes to other parts of the network. When a subnet is configured on one router, all other routes learn about the subnets dynamically.

  Layer 2 networks depend upon Virtual Local Area Network (VLAN) identifiers to be configured on every switch within a Layer 2 domain. No widespread, standards-based method exists to manage this configuration dynamically.

- **Resiliency** – Layer 3 networks utilize well known, standards-based protocols to provide network resiliency. BGP, OSPF, and RIP are well-known protocols that automatically re-route traffic in the case of fiber or router failure. Coupled with MPLS technology, sub-50 millisecond convergence times are realized.

  Layer 2 networks depend on the spanning tree protocol (STP) to provide resiliency. STP is not capable of providing sub-50 millisecond convergence times and is more applicable to enterprise environments. In addition, Layer 2 networks are infamous for generating switches loops within the network. In this scenario, bandwidth resources are quickly exhausted and the network comes to a halt. Layer 3 architectures inherently prevent this type of behavior.

- **Security** – Layer 3 networks provide a natural hierarchy in the network. Broadcast packets and broadcast flooding are limited to local Layer 2 domains. In this environment, a rouge host is prevented from directly interfering with other hosts on the network using broadcast storms. In addition, file and print sharing protocols are limited only to the local domain.

  Layer 2 networks are known for security threats, such as MAC address spoofing. In this scenario, a host in the same Layer 2 domain could pretend to be another host and receive all traffic destined for that host.

### 4.5.2 Multiprotocol Label Switching

The network should utilize Multiprotocol Label Switching (MPLS). MPLS is a standards-based packet-switching technology that provides scalability and resiliency in a multi-protocol environment. In short, MPLS features make it easier for one network to support multiple services. Some of the attributes that make it desirable for LAC include:

- **Fast Reroute (FRR)** – FRR provides sub-50 millisecond resiliency in the case of fiber or router failure in the network. This feature ensures that the network can transport emergency services and other traffic requiring the highest levels of service levels.

- **Multiple Services** – Different services may be provides over the same network. For instance, Internet, traffic cameras, and automated meter reading traffic can be carried over the same network completely isolated from each other, each with its own service level agreement. Also, existing services such as VPN may be transported over the same network.

Ethernet-based MPLS has emerged as the standard method for building Metropolitan Area Networks to support a wide array of services.

### 4.5.3 Ultra-High Capacity Ethernet Links

10 GE is currently the state of the art in terms of Ethernet transport capacity. What then are the alternatives when 10 GE is not enough capacity? Wave Division Multiplexing (WDM) and EtherChannel represent two methods to grow past this 10 GE limitation.

**Wave Division Multiplexing**

Wavelength Division Multiplexing (WDM) is a technology for transmitting multiple signals at the same time over a pair of optical fibers and was developed to provide additional capacity on existing fibers. While the use of WDM can increase the effective bandwidth of a fiber optic communications network, its cost must be weighed against the alternative of using additional fibers in the same optical fiber cable or adding a new optical fiber cable.

WDM wavelengths are commonly referred to as lambda's (λ's) or channels. The components of the optical network are defined according to how the wavelengths are transmitted, groomed, and implemented in the network. Because most fiber optic equipment operates at the 1310nm wavelength, a transponder is necessary to take this signal and move it to WDM standard wavelengths.

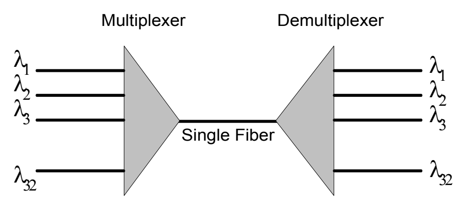


**Figure 6 Logical Diagram of Wave Division Multiplexing**

Wave Division Multiplexers and Demultiplexers handle the breakout and combining of the individual wavelengths. At the low end, these multiplexers split and combine two wavelengths (usually 1310 and 1550 nm) on a single fiber. Coarse Wave Division Multiplexing (CWDM) can combine up to 8 or 16 wavelengths. At the high end, Dense Wave Division Multiplexing (DWDM) can combine 32 or more wavelengths. The amount of traffic that each wavelength can carry is dependent on the laser source and on the physical characteristics of the optical fiber.

WDM multiplexers can also provide switching at the fiber level. If a fiber cut occurs the WDM will handle the switching for the network.

**EtherChannel**

EtherChannel, or Link Aggregation in the Cisco terminology, allows several physical Ethernet links (of the same speed) to be grouped together as if they were one logical Ethernet link. This technique is useful to attain higher capacity and as a means to provide failover redundancy. An EtherChannel can be comprised of 2 to 8 *active* Fast Ethernet, 1 GE or 10 GE links, with another 1 to 8 *inactive* ports waiting for use in case the active links fail. This means that it's possible to carry 800 Mbps, 8 Gbps, or 80 Gbps in the EtherChannel depending on the speed of the original links.

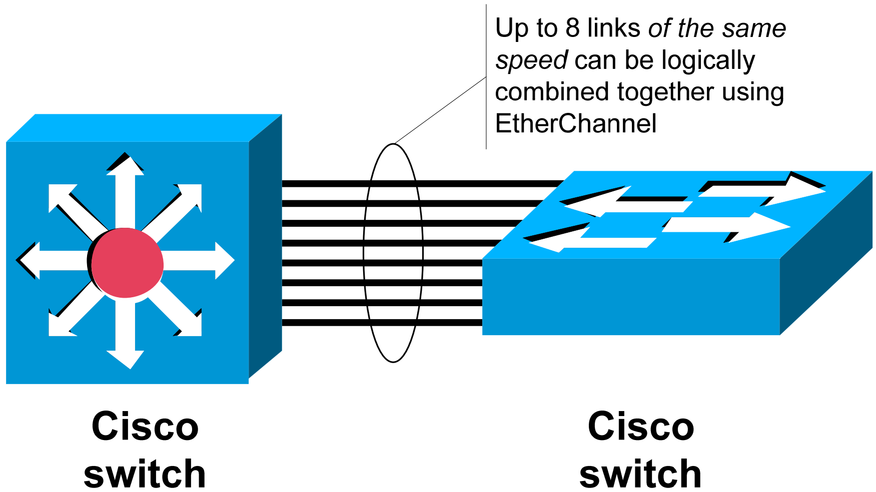


**Figure 7 EtherChannel – Combining Ethernet Links Together**

In addition to providing greater bandwidth across the combined link, this method can also be used to provide fault-tolerance. EtherChannel will automatically redistribute traffic across the inactive links should the active side fail. It takes less that one second for this automatic recovery to occur, making this a very attractive network feature.

EtherChannel can be setup under CatalystOS or CiscoOS. Also, the load balancing policy (frame distribution) can be configured based on a MAC address (Layer 2), an IP address (Layer 3), or a port number (Layer 4). For the Los Alamos County network, it is recommended that the load balancing be configured based on an IP address (Layer 3) since the overall network will make use of a Layer 3 architecture.

The complete Cisco Catalyst product range supports EtherChannel. In fact, multiple EtherChannels can be supported on a given type of equipment. The Cisco Catalyst 6500 series support a maximum of 64 EtherChannels.

It is important to remember that, while EtherChannel can serve to logically combine individual Ethernet links of the same speed, each of these individual links has its own physical port and fiber assignment. Also, each individual link would have its own optics module. Therefore, EtherChannel presents a very useful network feature, as long as the network is not port or fiber limited. This is an important consideration when compared to WDM technology.

**Recommendation for Ultra-High Capacity Ethernet Links**

This report recommends using EtherChannel for at least the initial expansion of the County Fiber Network. Specifically, the design calls for (2) 10 GE links to be combined together to achieve the 20 GE speeds requested by the Information Technology Division. This is illustrated in the figure below.

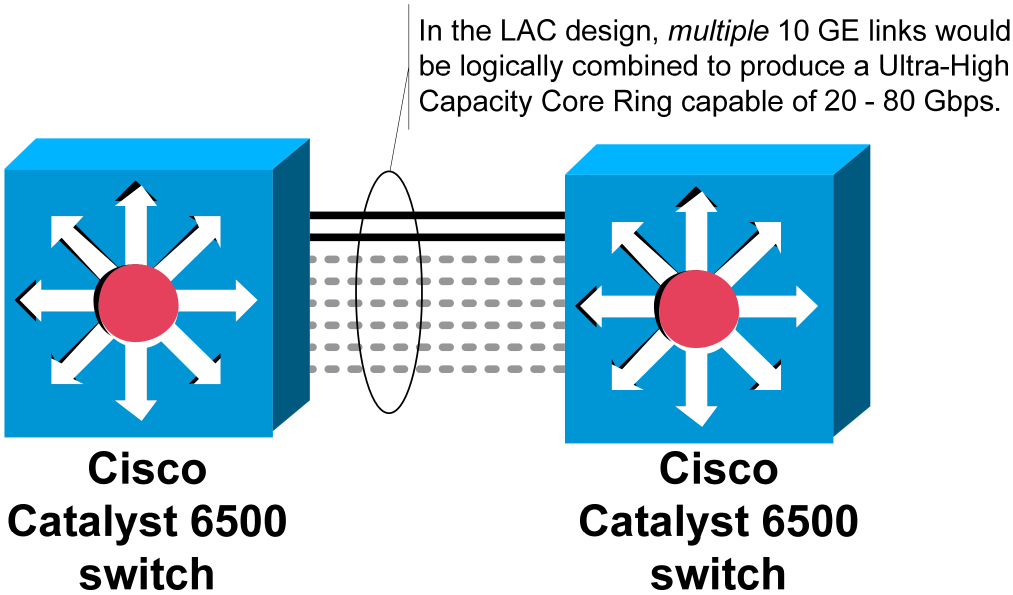


**Figure 8 Proposed use of EtherChannel in the LAC Core Ring**

EtherChannel is highly scalable and would, if needed, allow the County to incrementally upgrade both the core and the collector rings as needed. The core ring, for instance, could be upgraded to 80 GE using EtherChannel. Likewise, the collector rings could each be upgraded to 8 GE by the use of EtherChannel. This represents a tremendous amount of bandwidth, enough capacity to serve the County well into the future.

Since we are discussing a new network expansion, the County would not be port or fiber limited and therefore does not need to incorporate WDM technology at this time. However, it's worth noting that WDM is a very useful tool that could still be deployed later in the future. WDM would allow the County virtually unlimited bandwidth without the need for additional fiber placement.

### 4.5.4 Internet Redundancy "Off the Hill"

It is very important for a data network, such as that operated by Los Alamos County, to have a secondary path to a high-speed Internet Service Provider. Currently, all of the County's telecommunications lines are routed through Qwest. One fiber cut or malfunction at an important location would disable the County's Internet connection.

To get a high-speed connection (10 Mbps and greater) in Northern New Mexico, the only option is a link to Albuquerque. To connect at these speeds would require either fiber optics, and/or microwave radio. The fiber optics option is immediately eliminated due to the high cost of getting "off the hill". The microwave radio option would be less costly, but sites would have to be acquired and/or leased to establish the connection.

A preliminary look at microwave path profiles shows a possible link between the County's Pajarito site and northwest Rio Rancho at about 35 miles, and then another hop into downtown Albuquerque at about 22 miles. The 35 mile link would require antenna diversity (i.e. the use of multiple antennas), which would mean more robust towers.

There would be many issues to resolve before this secondary Internet connection could be finalized – such as the site location in Rio Rancho, the availability of tower/building space in Albuquerque, the availability of frequencies and so on. A high-level cost estimate for a two link / three site microwave system would be approximately $750,000. Costs for site acquisition and tower work are highly variable and more detailed studies would be required in order to provide a more accurate estimate.

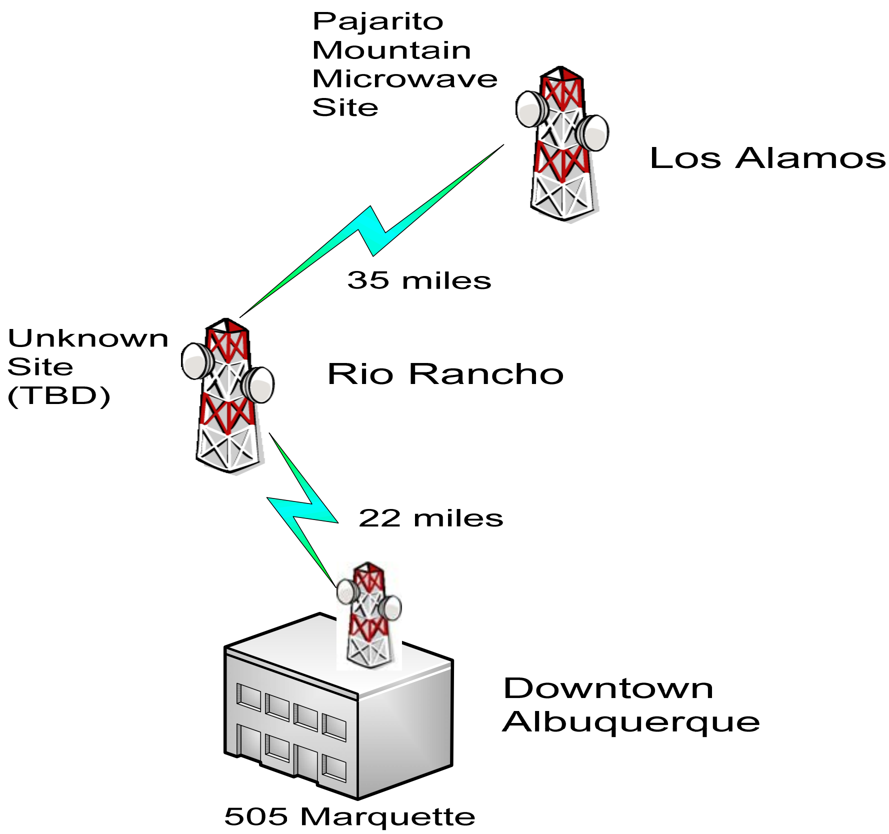


**Figure 9 Possible Microwave Links for Internet Redundancy**

# SECTION 5: PROJECT IMPLEMENTATION

The previous section was devoted to presenting the logical network design with associated recommendations. This section of the report will now highlight aspects of the physical, *real world* design and how the overall project implementation might be broken up into distinct phases. Again, the overall scope of Step One is focused on interconnecting primary County government sites located in the Los Alamos Townsite, Royal Crest and White Rock.

## *5.1 Physical Outside Plant Design*

The Physical "Outside Plant" Design refers to all of the details concerning the physical placement of conduit, ducts, cables, and equipment cabinets in the field. Whereas the Logical Network Design shows box "A" connects to box "B", the Physical Outside Plant Design would show, among other things, the path of the fiber cable, the placement method, the structures the cable is being pulled through, and details of the splice points along the way.

### 5.1.1 Structure Options

There are multiple options for the placing fiber as part of the physical outside plant. Although fiber cables have become stronger and more robust over the years, fundamentally they are still made of glass and therefore must be protected. The various types of conduit and ducts that are used to protect fiber in the field are typically given the general term "structure". Structure is used to secure a path or a "raceway" for the placement of fiber.

One of the less expensive options for structure is to use pestduct. In this case, the "PEST" in pestduct refers to Polyethylene Steel Tape. Pestduct is a durable, flexible duct or tube that is hardened or "armored" with steel tape to prevent damage to the fiber cable from rodents, construction equipment and so on. Although pestduct does present a relatively low cost option, it is not typically re-useable – meaning that if a fiber cable is cut or fails, there is no guarantee that the pestduct could be re-used to pull or jet in a new fiber cable to replace the old one.

This report strongly recommends LAC place 4" PVC conduit and (3) 1 ¼ inch innerduct in the outside plant. 4" PVC conduit is a cost effective, highly re-useable option for building fiber raceways and has generally the method of choice for telecommunications carriers in the US. Innerduct is a smaller durable, flexible duct that fits inside the 4" conduit – in this case, (3) three innerducts would be placed in the 4" conduit. Fiber cables are then pulled or jetted through the innerduct. Using innerduct when the conduit and fiber are first placed allows you to guarantee access to, in this case, (2) two other raceways for the placement of additional fiber if needed in the future. This is illustrated by the diagram below:

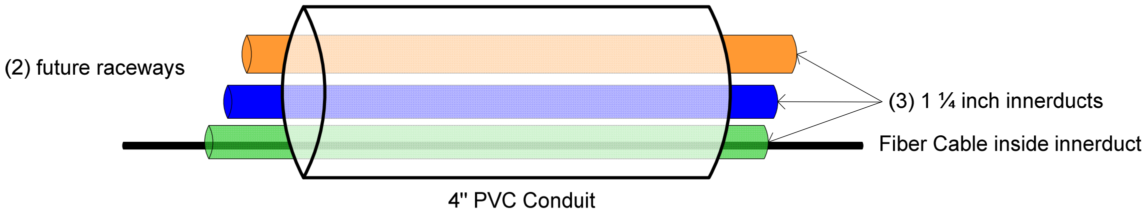


**Figure 10 Example of Conduit and Innerduct Structure**

### 5.1.2 Infrastructure Placement Methods

This report recommends that Los Alamos County use horizontal directional boring as the method of choice for conduit placement throughout the business and residential areas of the Townsite and White Rock. Horizontal directional boring is essentially the same as drilling horizontally, parallel to the surface of the ground. Under this method, a bore machine or "boring rig" will drill diagonally into the earth until it reaches is desired depth (for fiber this is typically 36-48 inches below the surface) and will then level off and follow a horizontal path to its end point. The cost of boring is generally determined buy the diameter of the bore and the conditions of the soil or rock that must be bored through. The higher the diameter of the bore, the more it will cost. A typical bore for telecommunications cables will utilize a 5 inch diameter bore for the placement of a 4" PVC conduit.

Directional boring is a common method for placing telecommunications cables, electrical cables, gas lines, and water lines – virtually any type of utility. The main benefit of directional boring is its relatively small construction footprint. Directional boring uses entry and receiving "pits" at each end of the bore. Roads and sidewalks between each "pit" or end point are left relatively undisturbed – thus saving on restoration costs. This smaller construction footprint means that fewer lane closures are needed or that they are at least shorter in duration. Also, depending on soil and rock conditions, directional boring is generally a much faster method of placing conduit than other methods.

Trenching is not recommended for Los Alamos for several reasons. Trenching causes a much larger construction footprint since a trench must be opened along the entire path of the conduit. Due to this fact, the cost for restoring asphalt roads, concrete sidewalks, brickwork, landscaping and so on can make trenching unattractive. Furthermore, the disturbance of large sections of ground soil could bring up environmental concerns that would have to be dealt with. This also makes trenching less a less desirable option when compared to boring.

### 5.1.3 Fiber Backbone – Physical Fiber Path

The unique geography of Los Alamos and the need for a network level protection scheme both contribute to the need for a network ring configuration as presented in the logical network diagram. However, the logical network diagram has to eventually be translated into a physical fiber path that at least approximates the shape of a ring and connects the correct locations to one another.

A diagram of the physical fiber path is shown in the figure below. The solid red lines indicate where the County is already planning to place conduit and fiber. The dotted red lines show new conduit and fiber placement that has not been fully planned.

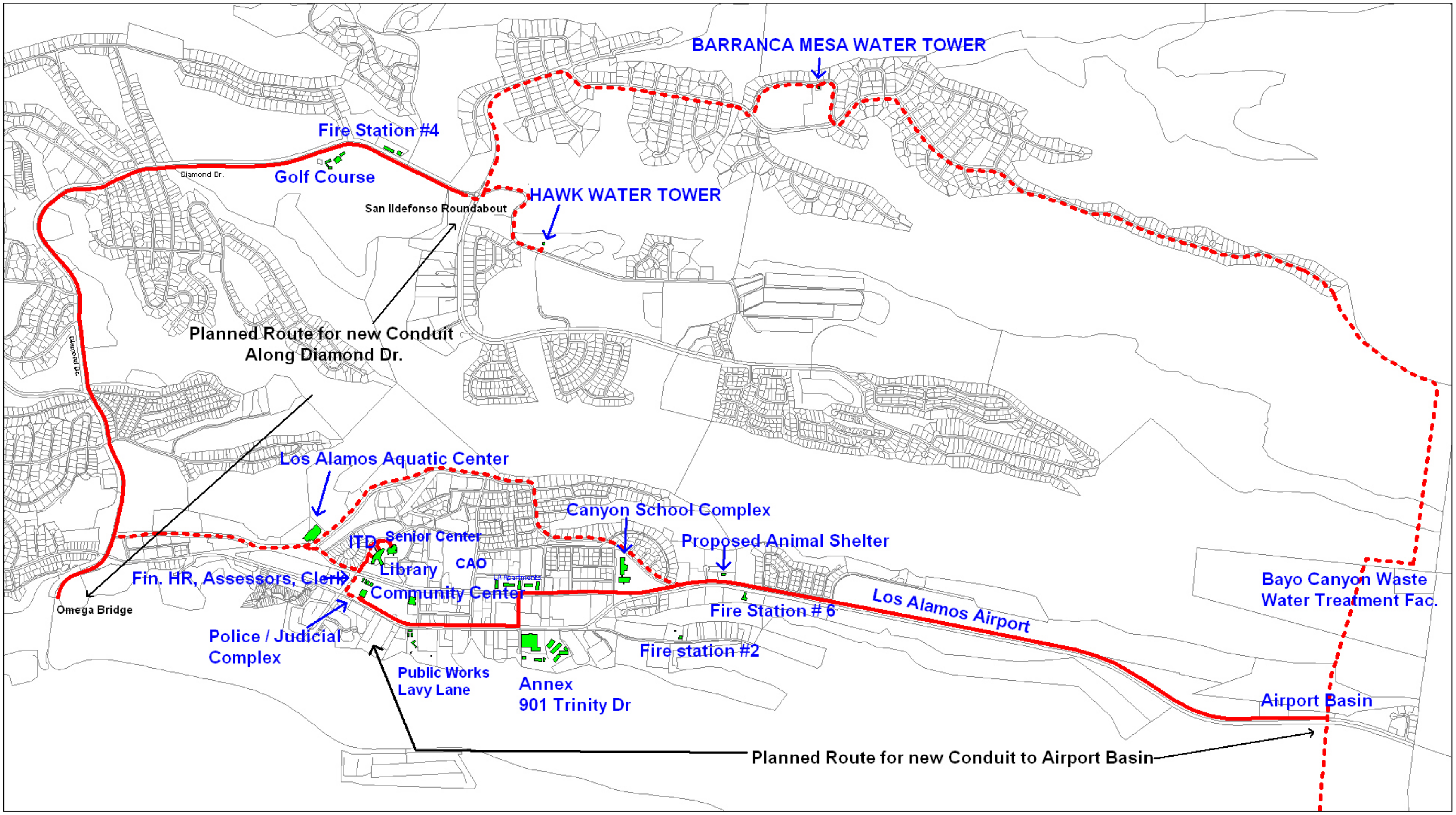


**Figure 11 Outside Plant Fiber Design – LA Townsite**

The diagram below is a representation of the physical fiber path for the aerial under-build between Airport Basin and White Rock.

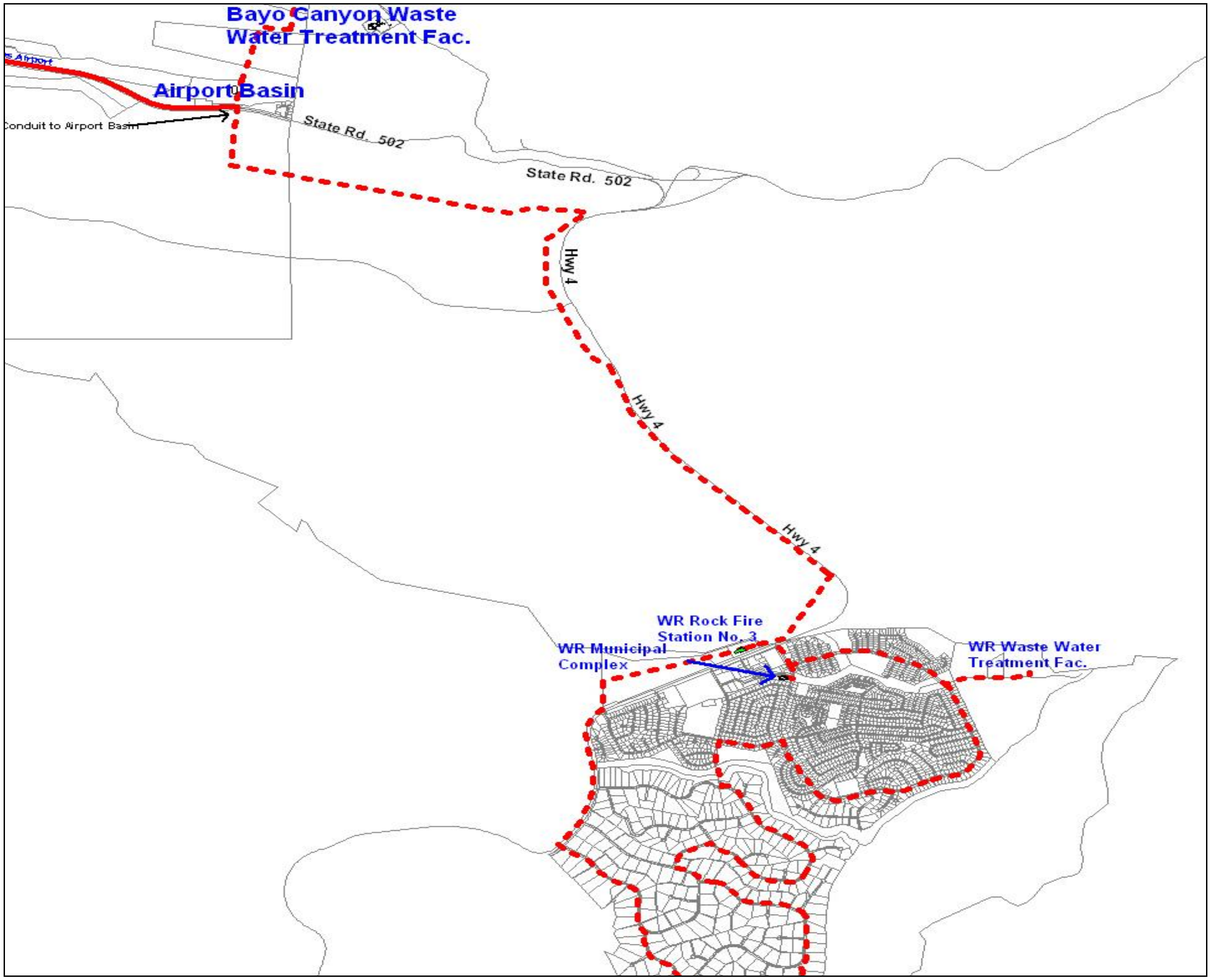


**Figure 12 Aerial Electric Under-Build from Airport Basin to White Rock**

The diagram below is a representation of the physical fiber path for White Rock:

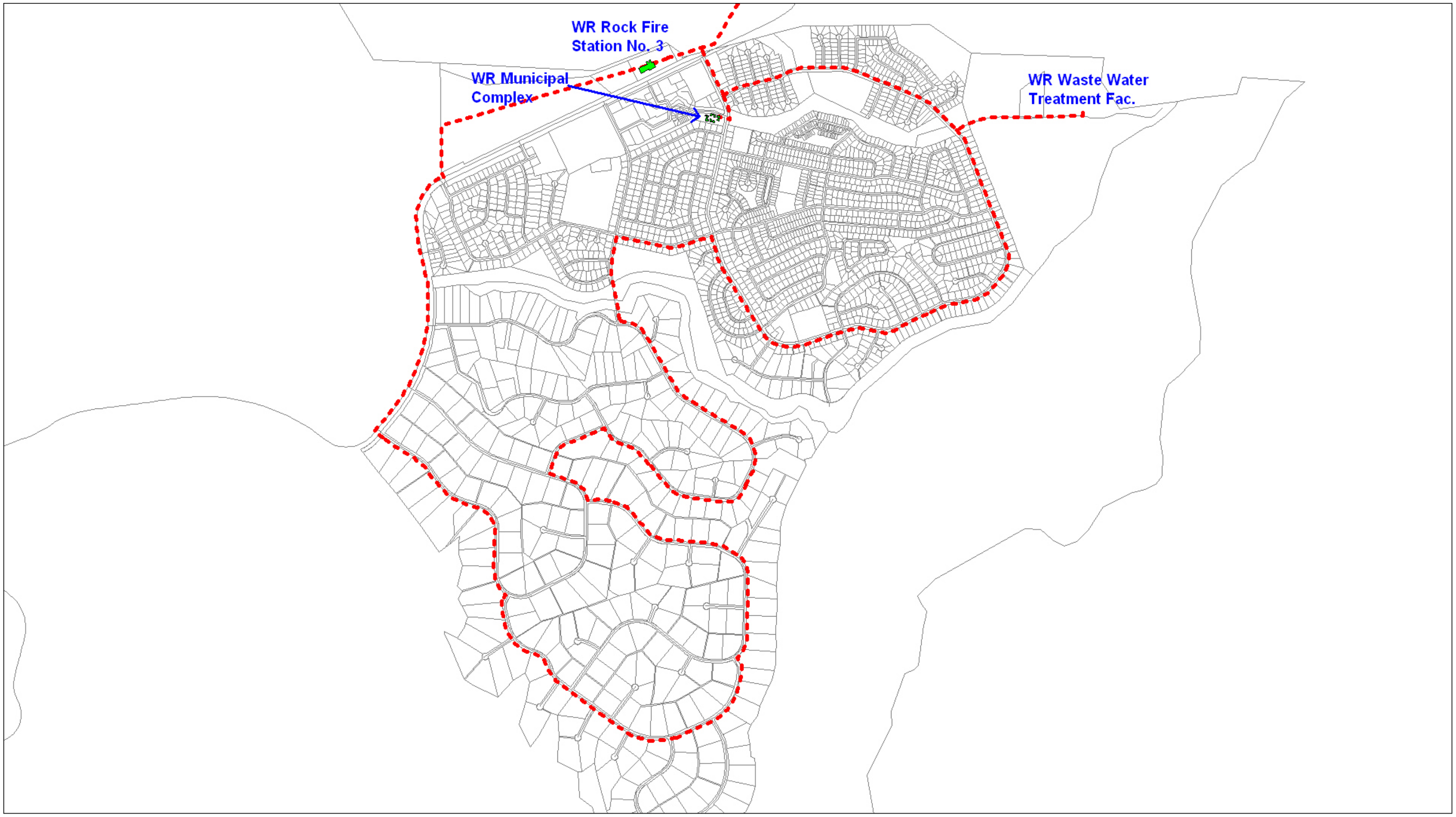


**Figure 13 Outside Plant Fiber Design – White Rock**

## 5.2 Phased Approach

**Airport Basin**

The Information Technology Division has existing plans to place conduit and fiber to the new Airport Basin Complex. These plans have been prioritized in the beginning phases of the project due to the critical role that Airport Basin will play in County and School functions.

Current plans call for placing a new 288-fiber cable from the Police-Judicial Complex all the way to Airport Basin. The segment from Police-Judicial Complex to the County Annex will make use of an existing vacant inner-duct. New conduit will then be placed running north on Knecht St to Central Ave. From there, new conduit will then be placed heading east along Central Ave to the point at which Central Ave merges with East Rd (502). Conduit placement will continue on East Road (502) to the Airport Basin Complex. In addition to Airport Basin, these plans include placing conduit and fiber to Fire Station No. 6, the Los Alamos Airport, the Canyon School Complex, the proposed location of the new Animal Shelter, and the Bayo Canyon Waster Water Treatment Facility. This route to Airport Basin is shown in the diagram below.

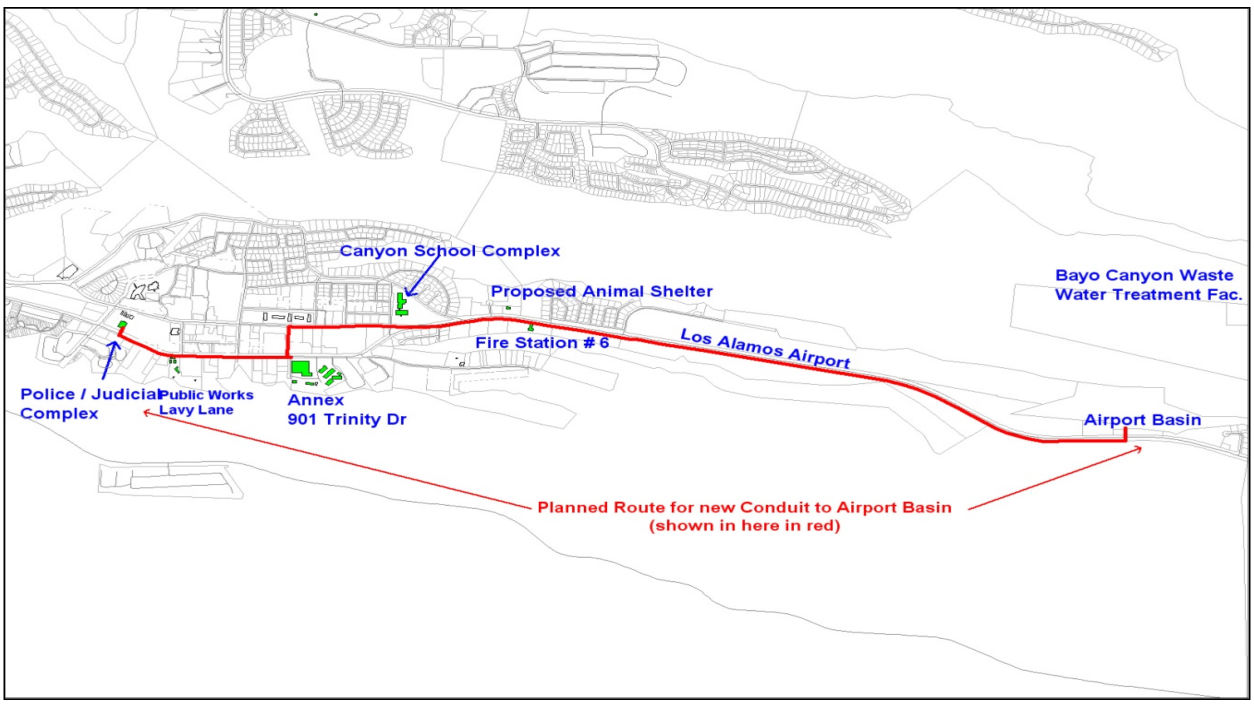


**Figure 14 Conduit Placement o Airport Basin**

### The Aquatic Center to Diamond Drive

This portion of the conduit build is needed to connect the Downtown conduit infrastructure to the to the new future-use conduit that is currently being placed along Diamond Drive.

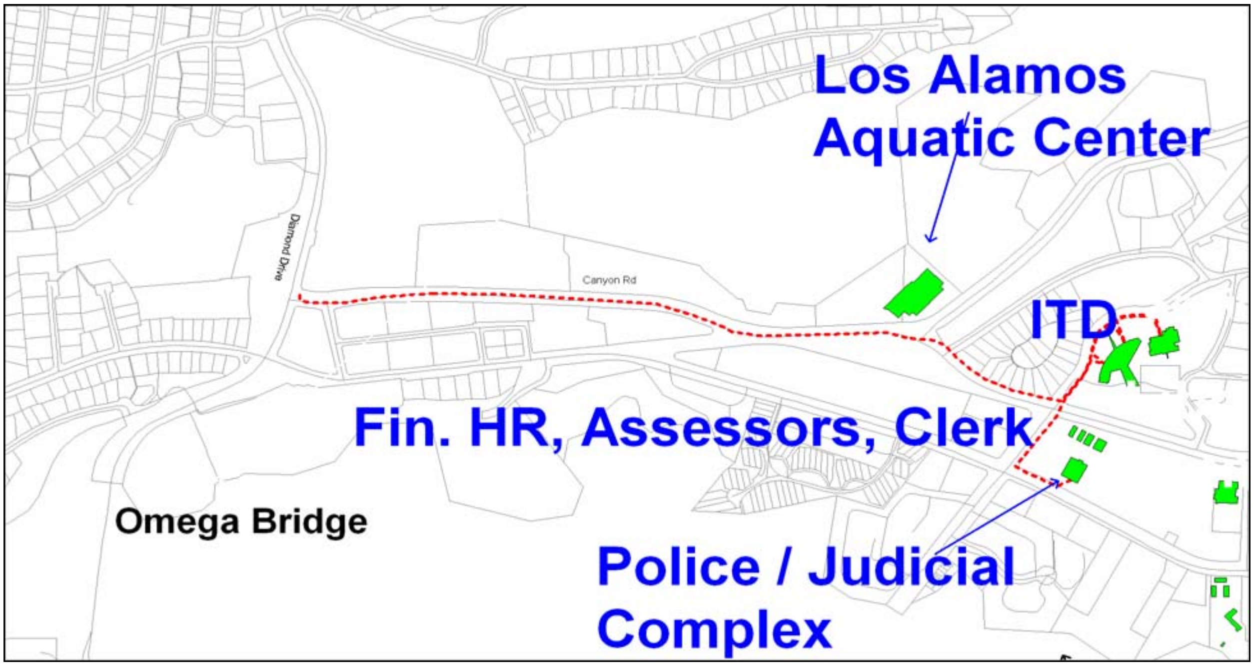

**Figure 15 Aquatic Center to Diamond Drive**

### Diamond Drive - Omega Bridge to the San Ildefonso Roundabout

The County is in the process of placing new conduit from the San Ildefonso Roundabout heading south to the Omega Bridge.

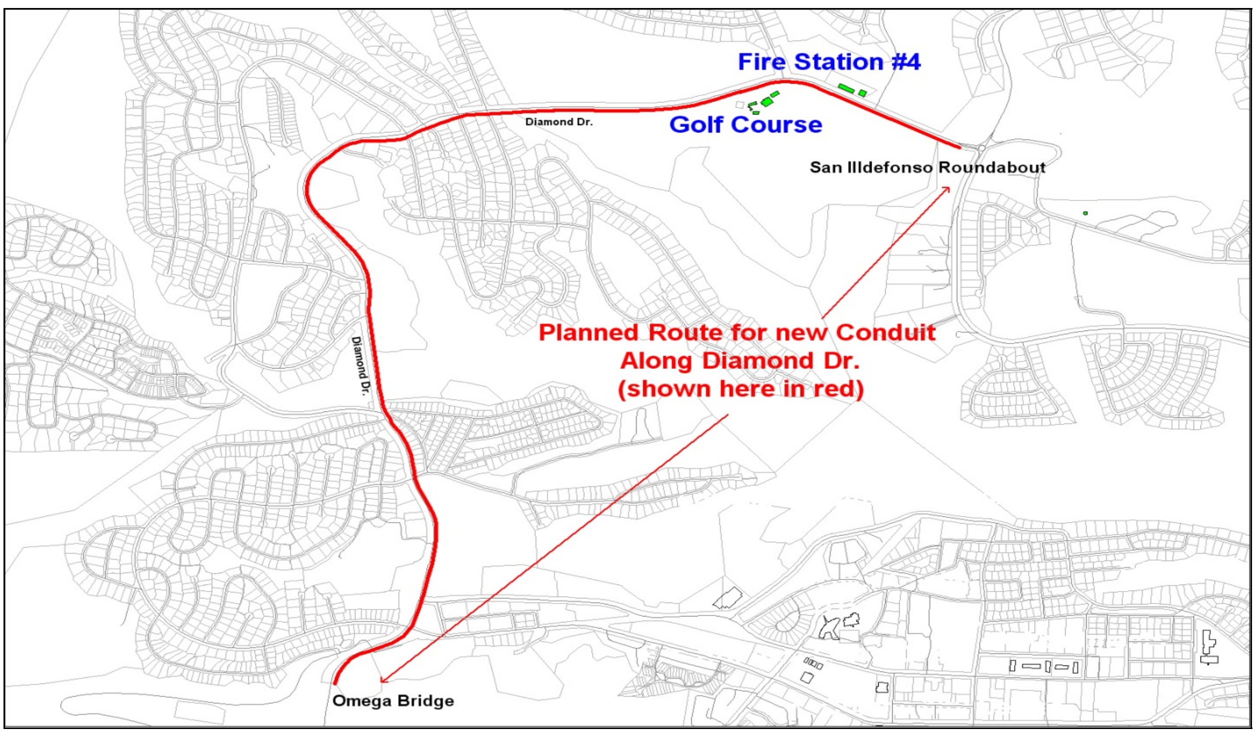

**Figure 16 Conduit Placement Along Diamond Dr.**

This project has been broken up into 4 distinct phases of construction. At the time of this writing, the County is wrapping up Phase 2 and will soon start Phase 3 of the Diamond Drive project.

- Phase 1: San Ildefonso Roundabout to 35th Street
- Phase 2: 35th Street to South of 39th Street
- Phase 3: 39th Street to South of North Road
- Phase 4: South of North Road to Omega Bridge

**The San Ildefonso Roundabout to the Barranca Mesa & Hawk Water Tower Sites**
This portion of the project is a truly new, previously unplanned portion of the build. This section of the overall build would extend fiber to the north-western side of the Townsite and interconnect the Voice and Broadband Radio sites that are planned for these two water towers. This is depicted in the diagram that follows below.

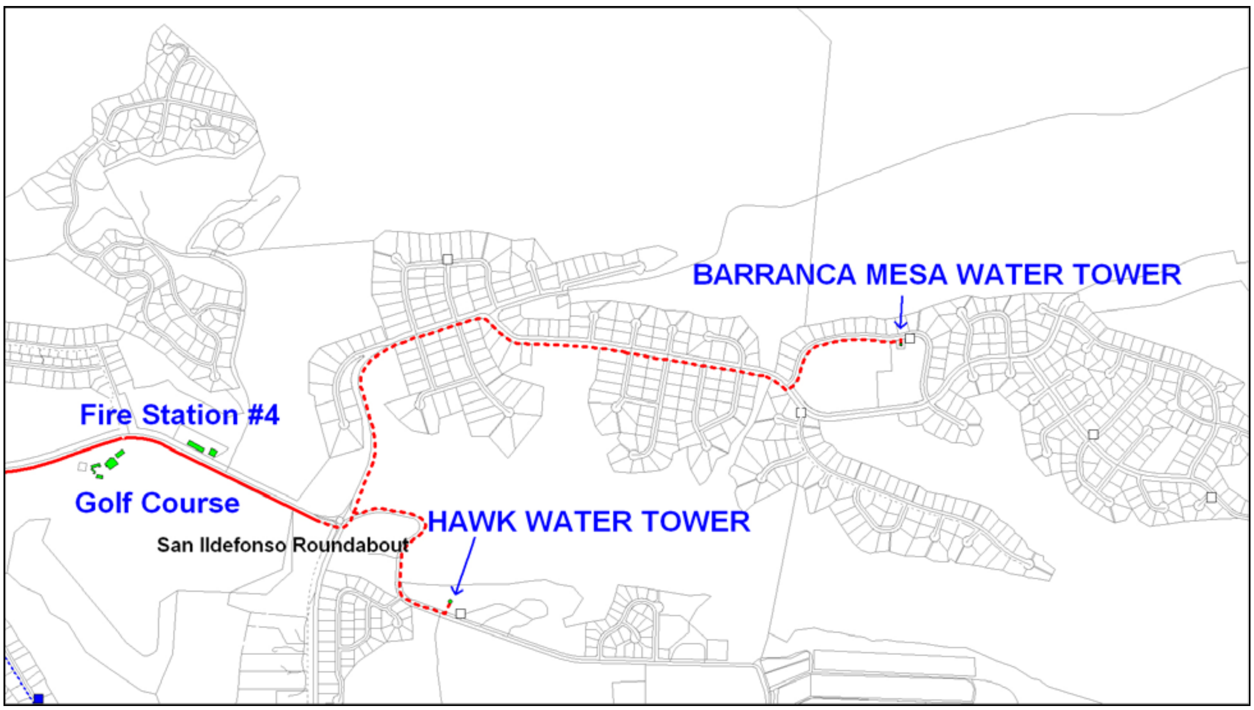


**Figure 17 Roundabout to the Barranca Mesa and Hawk Water Tower Sites**

**Bayo Canyon Waste Water Facility**
This is an extremely long, expensive, section of the build planned to interconnect Bayo Canyon Waste Water Facility. This portion of the build completes the physical fiber ring around the Los Alamos Townsite.

**White Rock**
This portion of the project would create a fiber "lateral" or "leg" from the main backbone ring to White Rock. The design envisions that this fiber lateral would extend from the new Airport Basin Complex all the way to White Rock by mounting fiber optic cable to

County electrical utility poles. This type of fiber construction is referred to as an *aerial under-build*. Aerial is the term applied to any type of utility that is pole mounted. The term under-build refers to the fact that the fiber is to be lashed to the pole several feet *underneath* the actual electric transmission cables. This report recommends that the County use ADSS fiber optic cable for this under-build. ADSS cable is self-supporting with a stronger inner core that allows it to be mounted without the need for a metal supporting strand.

## *5.3 Estimated Cost of Network Construction*

It's important to note that construction projects of this nature are generally subject to a competitive bid process whereby the County, or a representative, would draft a Request for Pricing (RFP) that would give a detailed description of the required physical outside plant. This RFP would be made available to various construction vendors so that they might be allowed to bid on the network construction. Since these bids are generally confidential in nature, construction costs can vary widely from vendor to vendor and specific itemized costs are sometimes difficult to estimate.

The costs presented below are **in today's dollars** and are therefore subject to change over time.

| **Item** | **Footage** | **Estimated Cost** |
|---|---|---|
| **5 Inch Directional Bore for the Placement of a 4" Conduit** | | |
| Annex North to Central | 605 | $21,780 |
| Central to Airport Basin | 14,762 | $531,432 |
| Canyon Rd (Oppenheimer to Diamond Dr) | 4,433 | $159,588 |
| All of Diamond Drive up to Roundabout | 15,730 - NA | NA |
| PD - West to Oppenheimer | 330 | $11,880 |
| Oppenheimer to ITD | 1,661 | $59,796 |
| ITD to Canyon Rd | 1,155 | $41,580 |
| Roundabout to Hawk WT | 2,354 | $84,744 |
| Roundabout to Barranca Mesa WT | 8,800 | $316,800 |
| BM Water Tower to the end of the Barranca Mesa Subdivision | 11,550 | $415,800 |
| White Rock Ring | 50,000 | $1,800,000 |
| **5 Inch Directional Bore, Cross-country through canyons** | | |
| Segment going past Bayo Canyon Waste Water Treatment | 9,350 | $748,000 |
| **Aerial Under-build along power line route** | | |
| Airport Basin to White Rock FS # 3 | 34,000 | $850,000 |
| | **Sub-total** | **$5,041,400** |

| **Item** | **Footage** | **Estimated Cost** |
|---|---|---|
| 4 Inch HDPE Conduit (cost for pulling conduit incl. in bore) | 105,000 | $420,000 |

| | | |
|---|---|---|
| 3-way 1 1/4 in Innerduct | 120,730 | $241,460 |
| Pull Innerduct | 120,730 | $150,913 |
| Underground Fiber Cable (includes splicing) | 120,730 | $724,380 |
| Pull Fiber | 120,730 | $150,913 |
| Aerial Fiber Cable (ADSS) and Labor | 34,000 | $193,181 |
| | **Sub-total** | **$1,880,846** |

| **Item** | **Qty.** | **Estimated Cost** |
|---|---|---|
| 48 Inch. Round Concrete Handholes | 70 | $175,000 |
| | **Total Construction Costs** | **$7,097,246** |

**Table 6 Estimated Costs of Network Construction – Step One**

## *5.4 Estimated Project Schedule*

The following table shows an estimated project schedule for the implementation of the County Fiber Network. The largest variable in this schedule is sheer construction time, which is dependent on weather, manpower, field issues and so on. Therefore, the following chart is an estimate only.

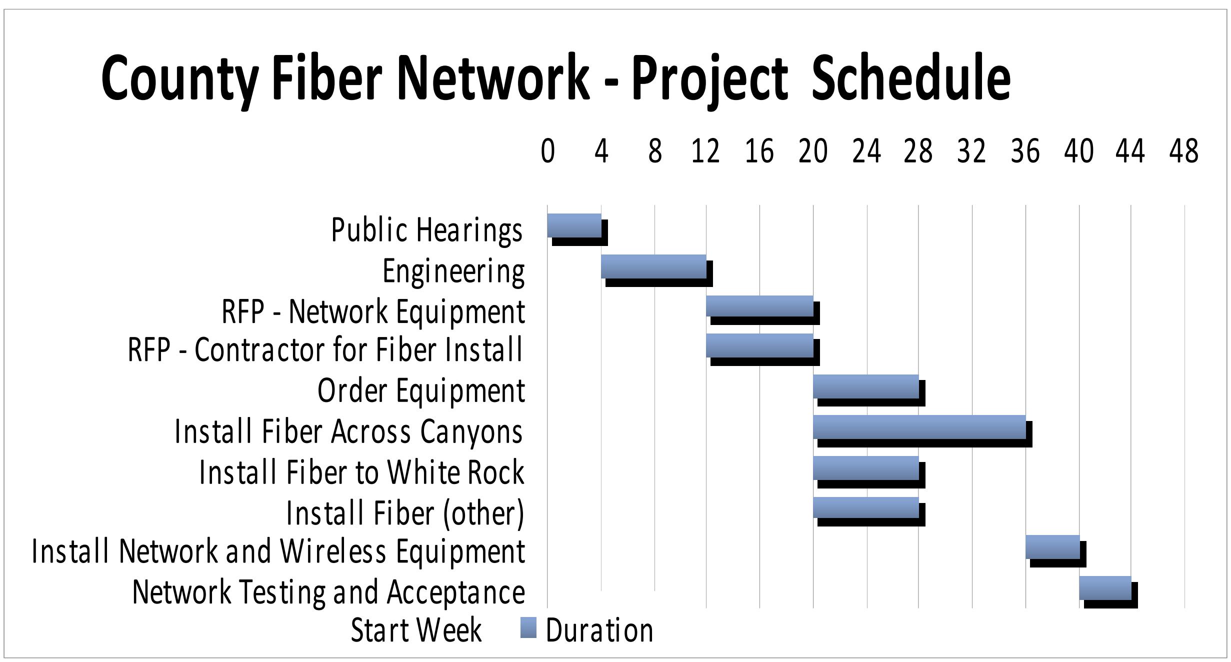


**Figure 18 Project Schedule**

## *5.5 County Network Operations*

**Add detail on requirements for a proposed Network Operations Center.**

# SECTION 6: TOTAL COST SUMMARY OF STEP ONE

| Item | Total Estimated Costs |
| --- | --- |
| Cisco Core and Collector Nodes | $1,360,000 |
| Free Space Optics System / Microwave Hops for Internet Redundancy | $791,256 |
| Network Construction Costs | $7,081,939 |
| Engineering and Project Management (5%) | $461,660 |
| **Total Cost of Step One** | **$9,694,855** |

**Table 7 Total Estimated Cost Summary – Step One**

# STEP TWO – THE COMMUNITY BROADBAND NETWORK

## NETWORK DESIGN & RECOMMENDATIONS

### *6.1 Network Technology – Active Ethernet*

Los Alamos County should build an Active Ethernet type of network in the event that it decides to move forward with implementing Step Two. Active Ethernet is the term applied to the use of powered Ethernet switches in the outside plant environment. In short, an Ethernet switch that is similar to the one that connects the office LAN, is placed in a powered, environmentally controlled cabinet out in the field. It's nothing more than the logical extension of an Area Network to the outside world. Therefore, Active Ethernet is the perfect extension to the County Fiber Network proposed in Step One.

### *6.2 Logical Network Design*

The following diagram is a high-level representation of the logical network design for a future Community Broadband Network. Typical of Active Ethernet networks, there is a central Open Network Node, or switching platform, located at the Head-End, or in this case, the Network Operations Center. This Open Network Node provides fiber connectivity to a Neighborhood Node. The Neighborhood Node is a powered outside plant cabinet that protects, powers and cools the Fiber Access Nodes (i.e. Ethernet switches) that are deployed in the field. The Delivery Node, pictured in the diagram below, is gateway premise equipment.

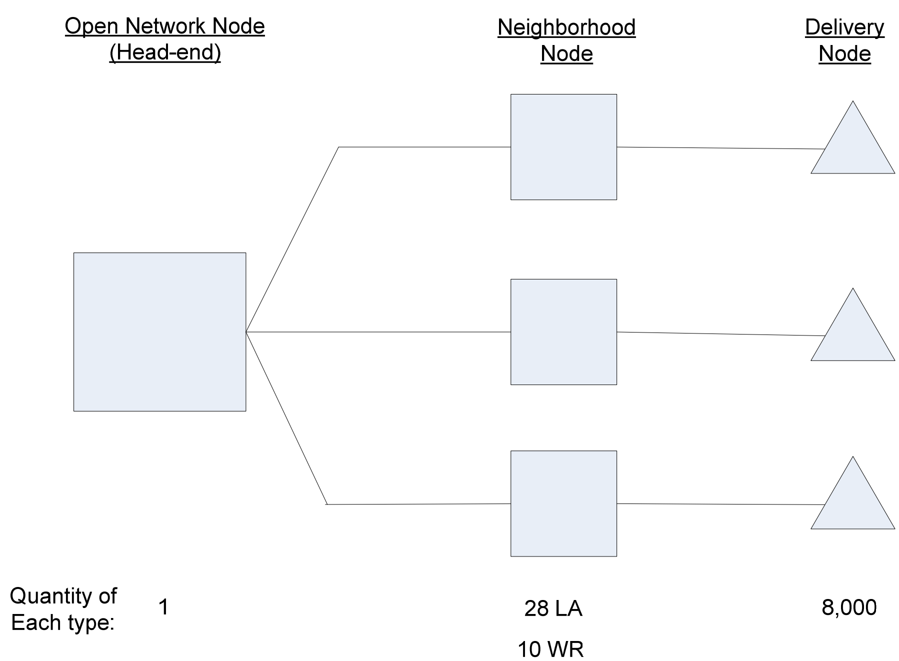


**Figure 19 Logical Network Design – Active Ethernet**

## 6.3 Network Nodes

### 6.3.1 Estimated Cost of Network Nodes and Software

The costs presented below are **in today's dollars** and are therefore subject to change over time.

| Item | Qty | Est. Cost Per Unit | Total Est. Cost |
|---|---|---|---|
| Head-End, Open Network Node | 1 | $250,000 | $250,000 |
| Fiber Access Node (Ethernet switches in the field) | 300 | $4500 | $1,350,000 |
| Neighborhood Nodes (OSP Cabinet for Fiber Access Nodes)<br>* Includes placement and turn-up costs | 38 | $50,000 | $1,900,000 |
| | | **Total** | **$3,500,000** |

**Table 8 Estimated Costs of Network Nodes – Step Two**

The table below provides the estimated costs for the automation and control software as well as the costs for the 3rd party Portal.

| Item | Est. Cost Per Unit |
|---|---|
| 3rd Party automation and control software | $80,000 |
| 3rd Party Portal software | $50,000 |
| **Total** | **$130,000** |

**Table 9 Third Party Software Estimated Costs – Step Two**

The next table shows the estimated costs for all the "Step Two" Network Nodes and the necessary software.

| Item | Total Estimated Costs |
|---|---|
| Network Node Costs | $3,500,000 |
| Software Costs | $130,000 |
| **Total** | **3,630,000** |

**Table 10 Total Estimated Costs of Network Nodes and Software – Step Two**

## 6.4 Recommended Network Features

### 6.4.1 Open Access Fiber Model

The "open" architecture and operating model is one that attempts to eliminate the high-cost of entry for competitive service providers. To achieve that goal, the proposed Community Broadband Network would operate on an open-access, non-discriminatory basis, meaning competitive service providers can obtain access to the proposed network under competitively neutral terms and conditions. Service providers will consist of any qualifying legal entity that provides voice, video, data or other services to the citizens Los Alamos County

From a technology standpoint, an “open fiber”, “open services” network will provide the attributes most important for ensuring access to highly competitive broadband services, and to sustain long-term community and economic benefits. Fiber optic network technology is clearly the best choice to provide the necessary capacity to support an open network model and the resulting volume of applications. Furthermore, an Active Ethernet, Layer 3 architecture can deliver a minimum of 1 Gbps dedicated, symmetrical bandwidth to every connected location on the fiber ring. Fiber also ranks highest for networking reliability and longevity, while offering infinite upgrade potential to support current and future growth.

Characteristics of a truly open fiber network include:

- Offers multiple services from multiple providers and can be available for new, advanced services to run on the network. These include community developed services, healthcare and educational services among others.
- Operates without prejudice so that any qualified service provider can serve users on the network without stringent financial or operational barriers
- Provides carrier-class reliability with demonstrable 99.999% uptime
- Built on widespread industry standards; Ethernet is a worldwide standard that has been widely adopted by both network applications and network devices
- Uses easily scalable technology, so an end user can easily make the jump from 100 Mbps, to 1 Gbps, to 10 Gbps bandwidth without affecting the other users on the network; open networks often use specialized hardware and software to make self-provisioning of services possible, while supporting the needs of service providers as well
- Provides an environment of bandwidth abundance where network technology should never impede on the business or operational model, but rather in providing optimum capacity to all end users

Implementation of the proposed network will enable, among others, the following specific benefits:

- Offer LAC choice of economical ultra-high-speed Internet access, data transport, video, voice services, and much more
- Provide the freedom to choose from multiple service providers
- This “real” broadband network will truly enable work-from-home scenarios and the ability to effectively video conference, reducing or time-shifting commute traffic that has created congestion on some city streets
- Provide a clean, swift, robust network that can help meet “green” goals of reducing carbon emissions while conserving resources

- Provide ubiquitous lit fiber access throughout LAC buildings and a platform for future services and applications, including mobile services for Internet access, public safety, natural resource conservation, and other applications
- Service providers will operate on a level playing field with a low barrier of entry, enabling them to compete solely based on reliability, products, features, price, and customer service
- Enable more LAC departments to utilize the network and develop cost-effective and resource-saving applications for improving or implementing services such as advanced resource management, and real-time account information that will be of growing value to residents and businesses

This proposed open fiber infrastructure will do much more than enable more advanced broadband services. It will function as a core asset and enabler for enhancing the LAC's quality of life, improving and increasing community services, attracting and maintaining quality businesses and professionals, and building stronger neighborhoods and community. This open, shared network, featuring the availability of abundant bandwidth at affordable rates, will contribute toward community engagement. Information on any public interest of safety need can easily be formed and shared on the network. Furthermore, the open access operating philosophy will ensure a level playing field for all service providers, as well as the deployment of a non-exclusive network that will, among other things, strongly encourage creativity and innovation.

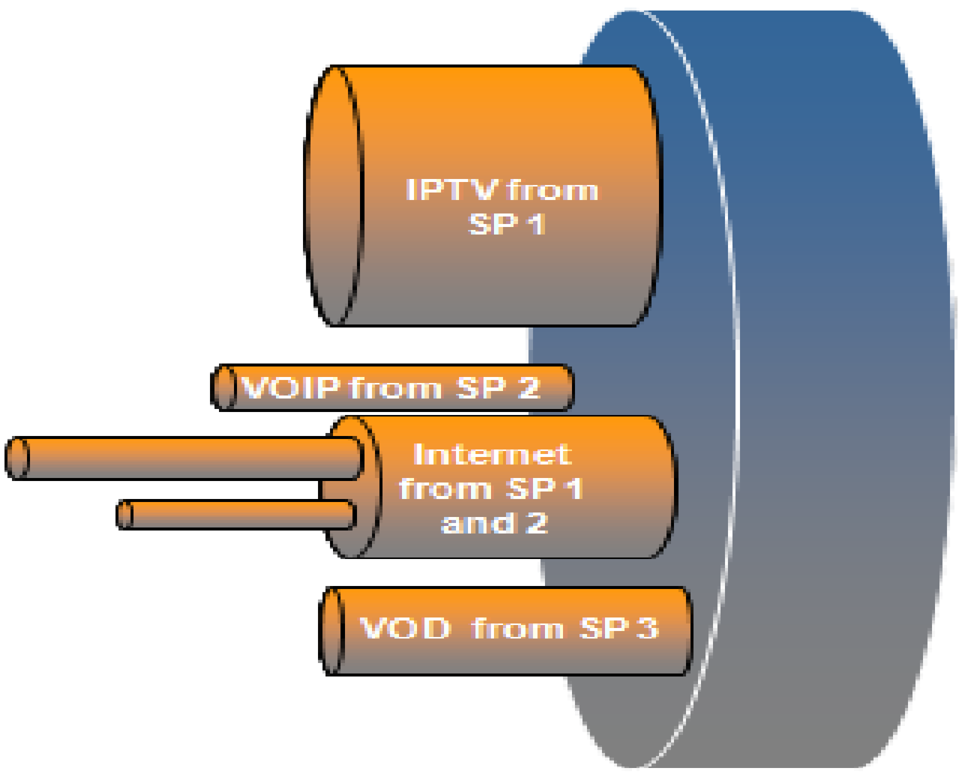


**Figure 20 Various Services in one "Open Pipe"**

### 6.4.2 Portal Strategy

**Potential Services under an Open Access Network**

As an essential part of the design process, LAC identified network characteristics that are essential to providing ultra-high bandwidth services, choice of service and fair competition, as well as inherent flexibility so the network can support future services, uses and partnerships. The design criteria require a network that is scalable to grow with demand, flexible enough to integrate multiple applications on the same fiber infrastructure, and adaptable for other uses, such as government mobility, public safety, and automated meter reading services. The Active Ethernet design offers qualities that are most complementary to those identified in the design process, and can be engineered to accommodate global standards that will provide a relatively easy interface for service providers. These qualities will accommodate services which can be identified today and provides an efficient, scalable transport layer for future applications.

The LAC fiber network, as designed, could accommodate:

- Voice
    - Local voice (POTS)
    - Long distance voice
    - Voice over Internet protocol (VoIP)
- Internet and data services
    - Ultra-high-speed Internet (up to1 GE)
    - Environmental controls
    - Automatic Meter Reading (AMR)
    - Security
    - Streaming audio
    - Data storage and web hosting
    - Remote computer backup
    - Client-Server environments
    - Tele-education
    - Tele-healthcare

- Video
    - Internet protocol television (IPTV)
    - Digital video
    - Video on demand (VOD)
    - High definition television (HDTV)
    - 3D high definition television (3D HD)
- Wireless
    - 2.4 MHz (Wi-Fi)
    - 2.5 MHz (WiMax)
    - 4.9 GHz (Public Safety)

## Portal Approach

A portal is an easy means by which a Community Broadband user can access their services from the respective providers available on the fiber network, and automate the delivery of these services with flow-through activation and provisioning. This is standardized technology and currently used for operating many open access networks worldwide. For demonstration purposes only, included in this section is a conceptual portal for a future Community Broadband Network.

When a Community Broadband user logs onto the network the user is taken to the welcome page of the portal. The welcome page can give some background information regarding the network, the region – whatever is important to the citizens of Los Alamos County.

**A conceptual example of what the portal welcome page might look like is shown in Figure 21 below. Again, this is an example only and not an actual, functioning web portal.**

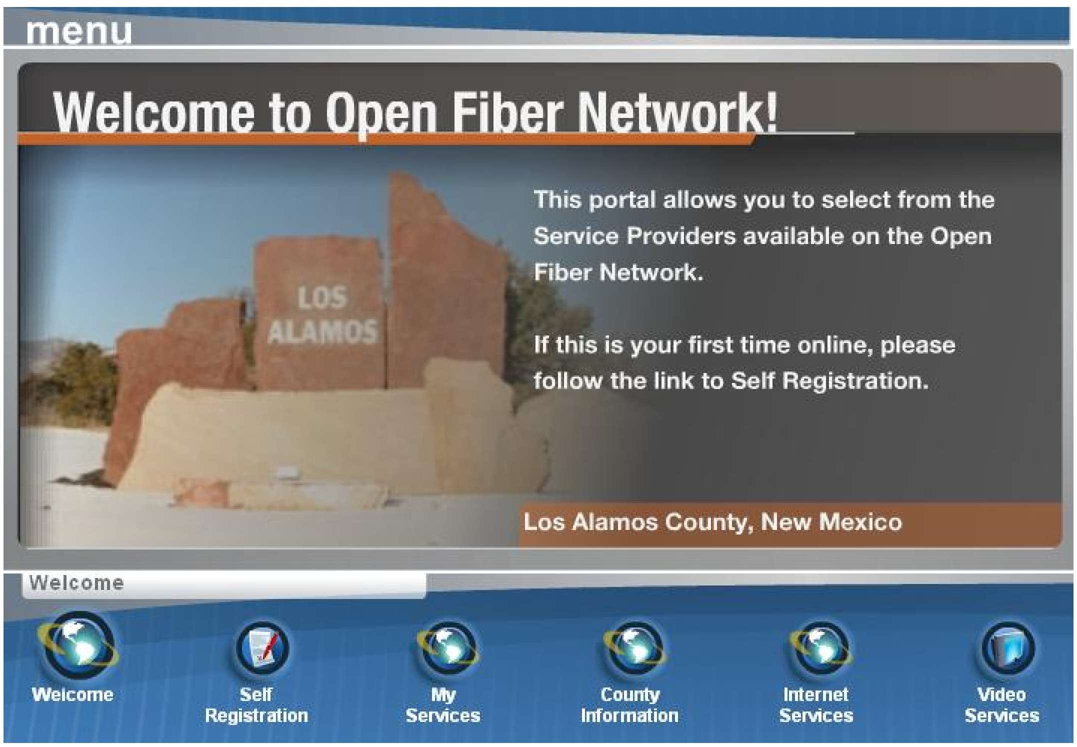


**Figure 21 Conceptual Example of a Portal Welcome Page**

The Community Broadband user can then browse through the services available on the Community Broadband Network. Each service provider can create its own portal page listing all of the services they can provide. The portal page may be customized to meet the needs of the service provider.

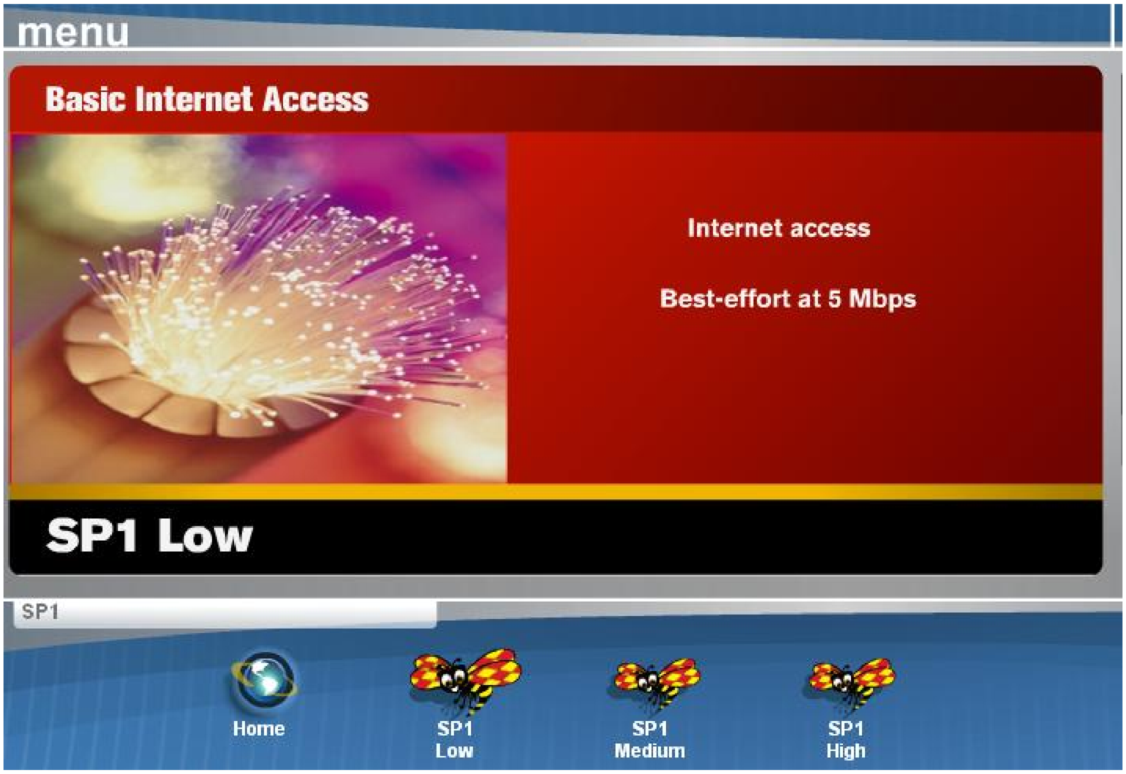


**Figure 22 Service Provider Example Page**

The provisioning process involves several systems throughout the network working in unison to provision and fulfill the services. This is outlined in the figure below:

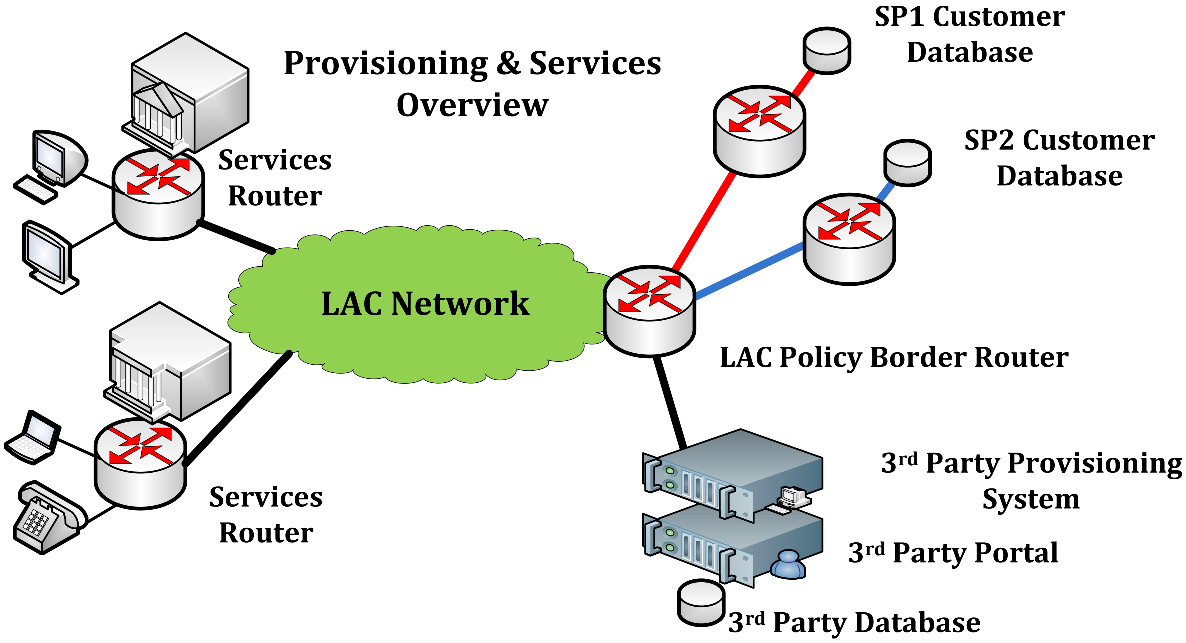


**Figure 23 Portal Provisioning & Services Overview**

When the user initially registers, the user's information can be stored in a database controlled by the operator. This allows the data to be used at a later time when the user selects a service.

Each service provider has its own customer management database, which includes a listing of all of its subscribers mapped to their respective services. When the Community Broadband user selects a service, the user information is updated in the service provider's database, including the subscriber location and service selection. The service provider may then use this information for customer service and billing purposes.

Also, when the Community Broadband user selects a service, an automated service provisioning request is sent to a central provisioning system managed by the network operator. The provisioning system then maps the service request (based on the user information) to a physical location and provisions the service dynamically on the services router. In addition, a messaging bus may be implemented to automatically provision other support systems related to the service.

Once the service has been provisioned, the user may then immediately begin using the requested service. Depending on service provider rules, the user may then decide to upgrade or cancel the service at any time, and the changes can be dynamically updated in real time.

The portal will be open to any qualified service provider to deliver their respective services over the Community Broadband Network. The service provider industry is represented by traditional telephone companies (or incumbent local exchange carriers (ILECs)), competitive local exchange carriers (CLECs), wireless service providers and cable television providers. While these services include the traditional voice, video, and data applications, the portal and open fiber network will also accommodate distance learning, healthcare and medical applications, to name only a few. With the symmetrical bandwidth proposed, and the open services approach, this proposed Community Broadband Network becomes a "production" environment for local service innovation, telecommuting, and economic development, rather than the current "consumption" model enforced by the incumbent service providers today where their services are the only option.

This proposed open fiber design takes into consideration a long-term infrastructure planning horizon and future potential network uses and partnerships, so that the entire project lifecycle will efficiently accommodate any additional phases, with ease of integration and cost minimization.

The key to providing superior services on the Community Broadband Network will be in the careful qualification and selection of service providers. LAC should initially focus on service providers with a proven track record of services and whose presence will lend support for continued network expansion by delivering quality services and building customer loyalty. This approach will help ensure the network's health and long-term sustainability.

As the network grows, it can seek additional providers that complement the basic video, telephone and Internet services offerings with:

- unique content
- targeted services for business
- specialized applications (education, healthcare, entertainment/recreation)

This will encourage entrepreneurial innovation locally because the open network design lowers the barriers for entry to provide services in the market. In other words, the network is *designed* to accommodate multiple service providers, and the network automation suite that was evaluated completely supports that paradigm by making it relatively simple to add new services and service providers to the network at any time.

Once on the network, service level agreements (SLA) for the service providers can be written and enforced in order to maintain a standard level of quality for all service providers. This is important because if one service provider doesn't perform well, it damages the reputation of the entire network and can adversely affect take rates for all service providers on the network—thus negatively impacting the financial outcome of the network overall.

**Open Network Design and Functionality**

The open network design is intended to remove traditional barriers to entry caused by infrastructure costs and incumbent local providers who operate closed networks where they are the only service provider option. The network design will provide common fiber interconnection points, such as the proposed "NOC" facility, for service providers to interconnect with the network. This will enable them to employ the open fiber network as a seamless extension of their own. The Active Ethernet fiber design was selected due to its low operating cost, robust capacity, wide adoption as a preferred medium for transport, and the ease with which any network element can be upgraded.

The operating support system, included as an example in this study, will enable the network operator to manage, maintain, and electronically provision access to the network in real time. Furthermore, the software can isolate and identify individual application data streams and program them into the interactive portal that will allow the individual end user to make changes to the selected services and/or service provider with the click of a mouse.

This report envisions that service providers will be able to connect to the Community Broadband Network in a central collocation facility. This facility will act as the head-end for the Community Broadband Network, where all the central routers, servers, and systems will be installed. Collocation space will be available for service providers to place their equipment. In addition, the collocation facility will be situated so that fiber connectivity to service provider networks may be accomplished.

The co-location facility will act as a "meet-me" location so that service provider equipment may directly connect to the Community Broadband Network. Interconnect is accomplished through an Ethernet connection; the bandwidth and QoS parameters of the connection must be agreed upon through the contractual agreement between the network operator and the service provider. The following diagram provides a high level illustration of the co-location "meet-me" point.

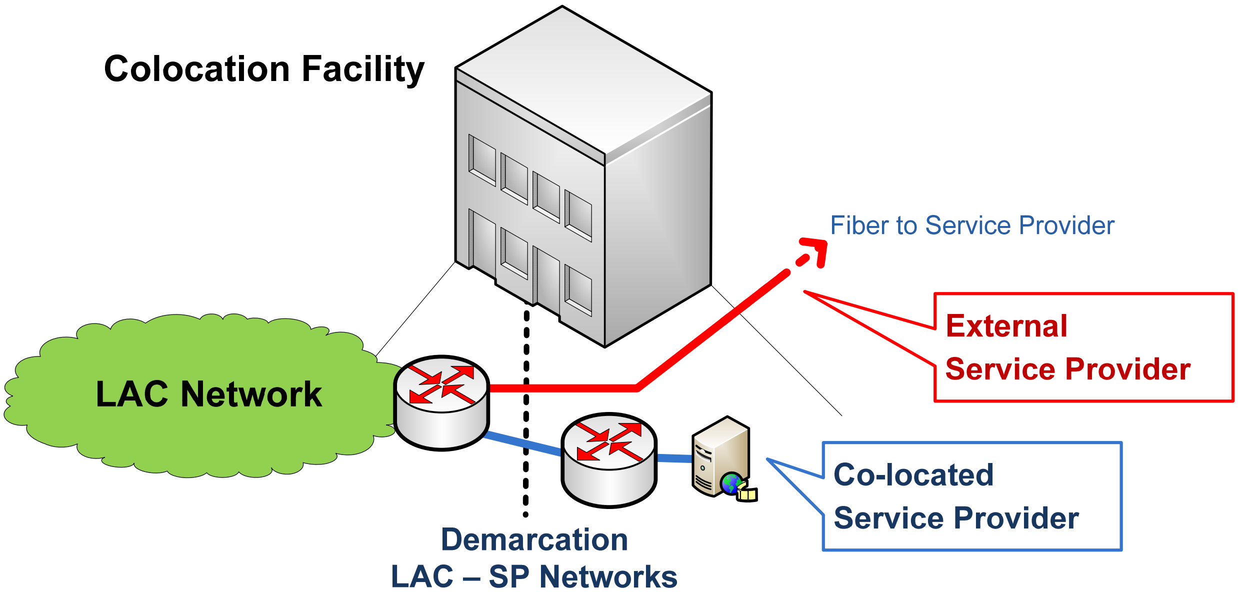


**Figure 24 Colocation Facility**

The Community Broadband Network will operate in a Layer 3 fashion, which allows greater service flexibility and granularity. In this environment, the Layer 3 headers of the IP packets may be inspected, allowing different service parameters to be applied based on different application and traffic flows.

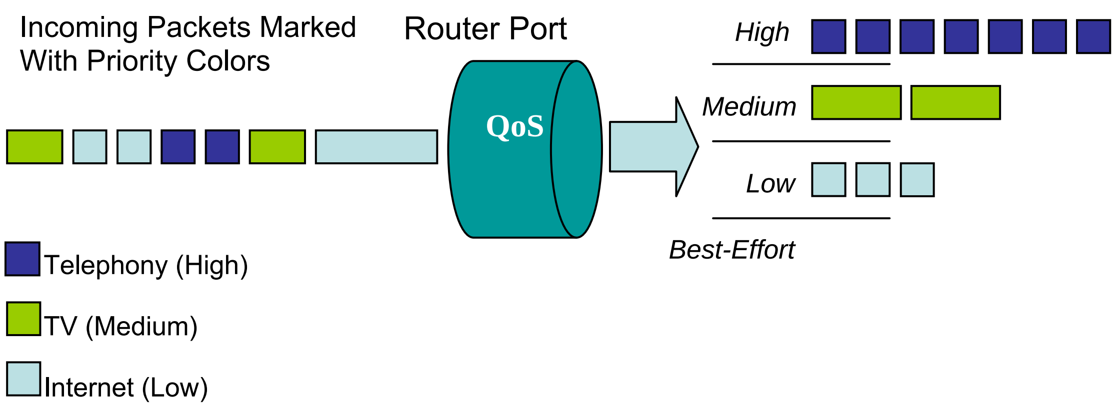


**Figure 25 Quality of Service Flexibility with Layer 3**

In the Layer 3 environment, the routing interfaces providing services to the end-user exist on the service routers at the edge of the network. Interconnect between the service provider and the Community Broadband Network is done between a service provider router/switch and a LAC network border router that implements policy-based routing. The service delivery parameters are implemented in orchestration between the edge service router and the LAC border router, and the end-service is provided by the service provider through equipment in its network.

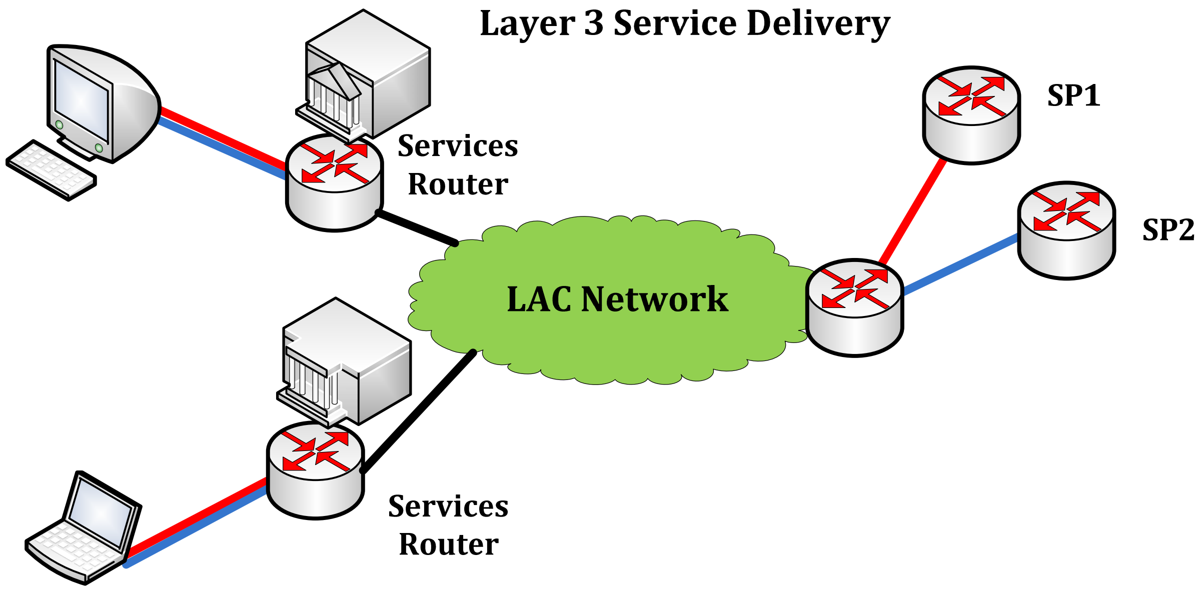


**Figure 26 Layer 3 Service Delivery**

# SECTION 7: PROJECT IMPLEMENTATION

## *7.1 Physical Outside Plant Design*

The diagrams that follow on the next two pages depict how the physical outside plant design might look in Los Alamos and White Rock for Step Two, a future Community Broadband Network. Again, the red lines depict the network fiber backbone placed in Step One. The new blue lines indicate fiber laterals, offshoots from the main fiber backbone, which take fiber out to the various neighborhoods. The small blue squares depict the Neighborhood Nodes that would house the Active Ethernet switches out in the field.

Its important to remember that the physical outside plant designs shown here representational only. They are meant to show some high-level information and pricing and are not based on detailed field engineering, site surveys, right-of-way information or any of the other customary inputs that normally precede a fully engineered design. As this is the case, the design and the pricing that follows *do not* attempt to account for placing fiber down every single street in the County. Instead, fiber has been placed to cover the major streets and arterial roads leading in and out of the neighborhood(s).

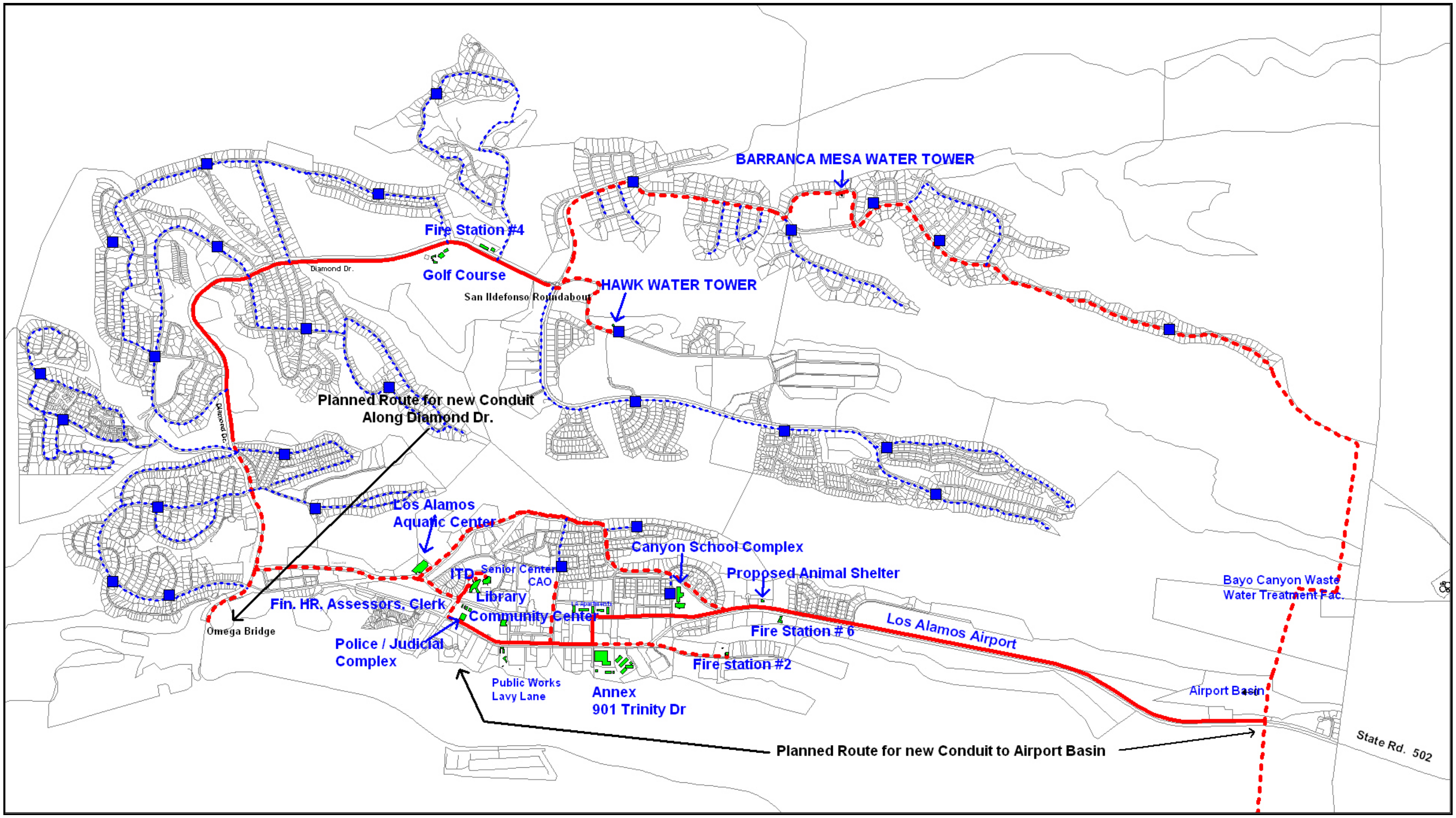


**Figure 27 Physical outside Plant Design – Los Alamos Townsite – Step Two**

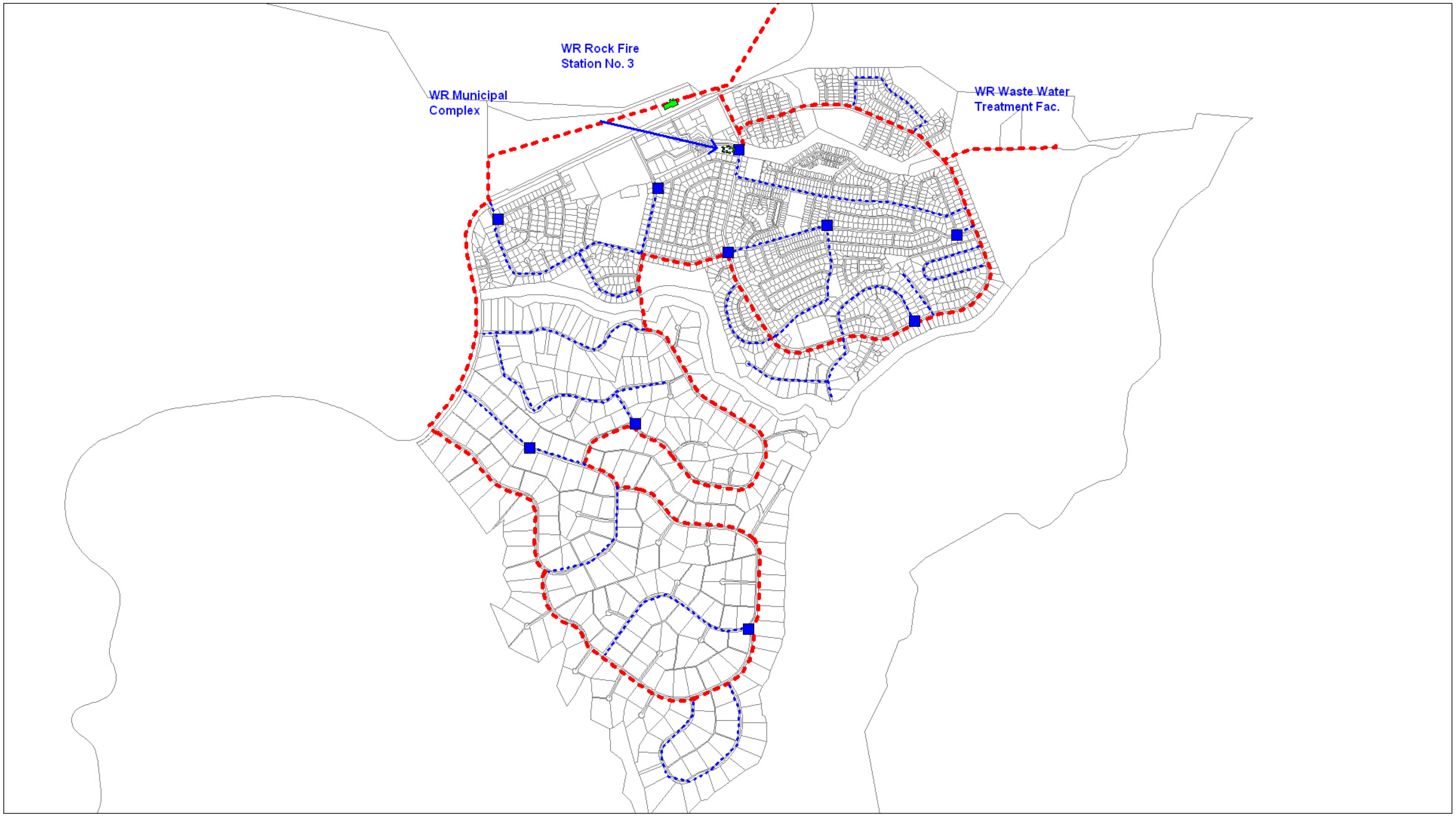


**Figure 28 Physical outside Plant Design - White Rock – Step Two**

## 7.2 Estimated Cost of Network Construction

The costs presented below are **in today's dollars** and are therefore subject to change over time.

| Item | Footage | Estimated Cost |
|---|---|---|
| **5 Inch Directional Bore for the Placement of a 4" Conduit** | | |
| Fiber Laterals - Los Alamos Townsite | 92,620 | $3,334,320 |
| Fiber Laterals - White Rock | 54,890 | $1,976,040 |
| | **Sub-total** | **$5,310,360** |

| Item | Footage | Estimated Cost |
|---|---|---|
| 4 Inch HDPE Conduit (cost for pulling conduit incl. in bore) | 147,510 | $590,040 |
| 3-way 1 1/4 in Innerduct | 147,510 | $295,020 |
| Pull Innerduct | 147,510 | $184,388 |
| Underground Fiber Cable (include splicing) | 147,510 | $885,060 |
| Pull Fiber | 147,510 | $184,388 |
| | **Sub-total** | **$2,138,895** |

| Item | Qty. | Estimated Cost |
|---|---|---|
| 48 Inch. Round Concrete Handholes | 98 | $245,000 |
| **Total Construction Costs** | | **$7,694,255** |

**Table 11 Estimated Costs of Network Construction – Step Two**

## 7.3 Community Broadband - Network Operations

Operating and open-access, open services network could seem to be a complex matter. How are services provisioned and delivered? How is end user and service provider traffic separated and managed? Who provides customer care? How is billing handled? How are operational costs kept under control? These are all very good questions and reasonable concerns.

Network operations are made relatively simple, with costs significantly lowered, through available software automation tools, as referred to previously in the portal discussion. These tools streamline operational work-flows and processes by automating the activation, delivery, and verification of broadband services. Furthermore, service providers are given both a connection to the fiber optic network as well as a portal for with publishing their respective services being offered across the Community Broadband Network, with tight integration and data forwarding to their billing/CRM systems. Therefore, it is possible for LAC to staff and maintain this network itself with a minimal team of qualified network engineers and a team manager. Alternatively, a partner could host and manage the Network Operations Center (NOC) for the Community Broadband Network. In this scenario, LAC would need to provide personnel to oversee contract negotiation and compliance, and provide overall direction (a fiber program manager), and a technical contact to handle escalations and expansion plans.

This NOC function focuses on maintaining and managing production services on the network. NOC activities, in an open fiber environment, include network monitoring, service provider integration, order fulfillment, customer support, and direct management of network incidents. NOC activities also include performance reporting, network maintenance, quality management, and continuous improvement functions.

Operations Support and Readiness is an integration process that prepares or grooms service providers and their products/services for transport over the network, and integrates them into the overall framework relating to customer support, order management, incident management, problem management, billing, services, quality/SLA management, and other areas necessary to support a product/service.

Service Delivery includes ensuring services are delivered end-to-end, including executing the service request order, order processing, order validation, order fulfillment, and service validation to verify service delivery. Processes may also be expanded to address specific service issues and ensure their resolution.

Service Assurance ensures the availability and quality of the service is maintained and improved through the product life-cycle. Incident management will be addressed through the use of the NOC and a trouble-ticketing system. Reports from the trouble-ticketing system will identify and prioritize recurring issues and guide them through standard problem management processes. Standard change management and release management will then ensure network stability is maintained throughout the life of the network.

The maintenance of the broadband infrastructure is critical to ensuring minimal network outages and ensuring a long lasting network. LAC can subcontract this work to qualified work crews or a partner, who can also serve as the troubleshooter/dispatcher and facilitate outside plant maintenance as needed.

## *7.4 Mitigation of Risk*

In planning for a fiber infrastructure build out, it is imperative to identify what the foreseen risks are, and to develop a mitigation strategy to address them. This section of the report evaluates the risks from a legal and financial standpoint, and then demonstrates how the “open access” fiber model is a key strategy to the mitigation of risk.

### 7.4.1 Legal and Financial Risks

In general terms, municipalities that have chosen to offer retail, consumer telecommunications services to the public have faced heavy scrutiny from regulatory bodies, and in some cases, lengthy and costly legal proceedings. The argument from the incumbent service providers has been, primarily, that local government should not be in the business of offering competing telecommunications services with those of private enterprise – even if in the best interest of the community. This debate has been waged in local, district, state, and even as high as the supreme court. While the final rulings have varied on a case-by-case basis, the common denominator has been that the process is time and cost intensive, and causes a significant drag on the overall effort.

This conflict of interest is not unique to the U.S. market, but has been experienced worldwide. The solution has been to utilize an “open fiber” model which separates infrastructure investment and operations, from that of delivering services to consumers. Simply put, to avoid legal, regulatory, financial, and project risk, municipalities, in the “open fiber” model, invest solely in the fiber optic infrastructure. The approach is similar to how municipalities have been historically investing in other types of shared infrastructure, such as roads and airports, while not being in the business of delivering services through them. In a municipally-owned open network, local governments such as LAC can support the network by investing in the “roads” (conduit and fiber) for service providers to “ride” (provide services on). This provides clear separation in roles and responsibilities, meaning municipalities provide the infrastructure and private enterprise is welcome to share and use the infrastructure to deliver services. Furthermore, this creates an open market environment which also lowers the barriers of entry to businesses who wish to join the network and offer services, since they are not burdened with having to build out their own, potentially parallel, infrastructure.

To further mitigate the financial risks of the proposed fiber optic infrastructure, the “open” model enables choice of services from an array of qualified providers. In turn, choice of services leads to higher overall quality of service at lower price points – the exact opposite of the monopolistic model which inherently delivers lower levels of services at higher price points since there is no market competition. To continue along this line of reasoning, in the “open” model with higher service quality at lower pricing, the benefits are passed on to the network owner (in this case LAC) in the form of improved operational efficiencies (greater productivity, higher bandwidth services, less downtime and troubleshooting) as well as budgetary savings, which is an ever growing concern especially when utilizing public financing.

LAC could lower the overall funding requirement and financial risk by providing tangible non-cash assets for the use of the network, including easements, rights-of-way, existing conduit, real estate for network cabinets, and/or POP/co-location facilities that may already exist. Use of private capital and other forms of partnership support may also be worthwhile pursuing, though not a mandate for the initial build out of the LAC open fiber ring. The amount of cash and non-cash assets provided by LAC for the use of the network build would help determine how much control LAC would maintain in the governing body of the network.

Operating expenses will be drastically reduced through available network automation tools. Leading software technologies were evaluated, and will provide critical functionality to lower operating expenses, and overall financial risk. The network could be operated either through minimal staff or by hiring a third party operating entity.

The recommendation of this report is to continue to pursue the “open fiber” model as a key element of mitigating legal and financial risks. The “open” approach is a proven technique to minimize exposure to costly and timely legal proceedings, while also lowering the financial risk for the proposed project.

# SECTION 8: TOTAL COST SUMMARY OF STEP TWO

| Item | Total Estimated Costs |
|---|---|
| Network Node Costs | $3,500,000 |
| Software Costs | $130,000 |
| Network Construction Costs | $7,694,255 |
| Engineering and Project Management (5%) | $566,213 |
| **Total Cost of Step Two** | **$11,890,468** |

**Table 12 Total Estimated Cost Summary – Step Two**

# SECTION 9: CONCLUSION

## *9.1 Benefits to the Community*

The proposed, future Community Broadband Network is designed to provide a platform for delivering the enhanced broadband services of today, as well as creating an environment for the innovation of tomorrow's applications. This network would serve as essential infrastructure, which LAC could utilize for enabling future partnerships and community benefits, for fostering long-term educational growth, quality of life improvements, and increasing the attractiveness of LAC as a community to live and work in. The foreseen result is an economic stimulus to the community. Local businesses become more competitive due to these technological advancements and additional businesses are drawn towards the communities for open and competitive access to fiber. These businesses are then able to produce new services on the network in an open market environment, generating additional revenues for them, and for the associated towns as well.

The anticipated community benefits and future partnership opportunities for the proposed Community Broadband Network are as follows:

- **Supports economic growth**—the sheer capacity alone of an open fiber network will support businesses, educational facilities and health care facilities to improve their own service offerings and internal operations. The availability of a world-class network would also be very inviting for new business to locate to the community.
- **Reduces the city's carbon emissions**—the availability of an advanced fiber optic network has the potential to greatly encourage less driving through more innovative network services, including:
    - *More telecommuting*. LAC and their staff would have greater incentive to work from home more if they don't have to rely on a slow, outdated network infrastructure. Those in the engineering and operations fields, which typically deal with very large files and time sensitive applications, would benefit even more.
    - *More teleconferencing*. Instead of driving to attend meetings, LAC could utilize teleconferencing between any facilities connected to the network. The proposed LAC open fiber network would provide enough bandwidth to support very high quality visual communications applications.
    - *More innovation leading to better services*. Superior bandwidth and an "open" market environment would encourage the growth, competition, and proliferation of higher quality, more advanced e-services, including e-commerce, automated meter reading, distance learning, e-medicine, and e-government. This would lead to less driving and therefore fewer carbon emissions.

- **Supports improved efficiencies and communications**—high resolution visual communications, lower cost ultra-high speed broadband connectivity, distance education, telemedicine, telecommuting (which is made more viable with gigabit speeds to every LAC facility), local community video channels, security, and other services are direct results of the availability of an open fiber network.
- **Supports government applications**—the ubiquitous deployment of an open fiber network provides a ready means to provide automated meter reading and automated meter intelligence, as well as traffic monitoring, public works, first-responders, and law enforcement applications.
- **Encourages innovation**—future partnership opportunities available through the proposed open fiber network, as well as 100 Mbps of dedicated symmetrical capacity, would provide the community with truly innovative service offerings far beyond what is available in LAC today. In the fiber backbone ring phase, LAC end users would be able to subscribe to services up to 1 Gbps in speed if they wish, increasing the size of the broadband connection they can access 24x7, without affecting other LAC users on the network. No longer limited by bandwidth scarcity, service providers are able to use the capacity to innovate and create new services and applications on the network for LAC. Infrastructure no longer dictates what services can be offered under which terms, but the opposite, where service provider innovation and LAC needs determine how to best use the infrastructure. Those in engineering, medical, research and development and education would immediately see the benefits of the “open fiber” capabilities.
- **Encourages competition**—the ability for multiple service providers to offer services on the LAC open fiber network encourages competition on price, service availability, and support. This is good for LAC, as it would provide them with more choices and the ability to change providers if they wish.
- **Integrates with wireless mobility network** – As mentioned previously, the County Fiber Network has been integrated with the Radio Network outlined in the LAC Wireless Voice and Data Plan. For the County government, this means that they can avoid installing and operating a separate system just for the backhaul of Wireless Radio traffic. For the Community, this means critical Public Safety communications are supported with the most flexible, reliable and long-lasting network transport method there is, namely fiber.

# Appendix

## *Sources of Funding*

-Grants.gov a source to find and apply for federal government grants.
http://www.grants.gov/

-Federal Grants Wire is a free resource for federal grants, government grants and loans.
http://www.federalgrantswire.com/

-Office for Domestic Preparedness Grant Programs
http://www.ojp.usdoj.gov/odp/grants_programs.htm

-FEMA Grants and Assistance Programs
http://www.fema.gov/government/grant/index.shtm

-CFDA provides a full listing of all Federal programs available to State and local governments.
http://www.cfda.gov/

-NTIA Office of Telecommunications and Information Applications (OTIA) assists public and non-profit entities in effectively using telecommunications and information technologies to better provide public services and advance other national goals.
http://www.ntia.doc.gov/

-USDA Rural Development continues to provide many programs for financing rural America's telecommunications infrastructure.
http://www.usda.gov/rus/telecom/index.htm

-Current information on EDA (Economic Development Administration) Programs, Investment Policies and Funding Opportunities.
http://www.eda.gov/InvestmentsGrants/Investments.xml

Public Safety Communications Grants
http://www.ntia.doc.gov/psic/index.html

Dept. of Homeland Security Grants
http://www.dhs.gov/xopnbiz/grants/index.shtm
http://www.dhs.gov/xlibrary/assets/grant-program-overview-fy2009.pdf
http://www.dhs.gov/xnews/releases/pr_1225900531284.shtm
http://www.dhs.gov/xnews/releases/pr_1225902190251.shtm
http://www.fema.gov/pdf/government/grant/empg/fy09_empg_guidance.pdf
http://www.fema.gov/pdf/government/grant/rcp/fy09_rcpgp_guidance.pdf
http://www.fema.gov/pdf/government/grant/opsg/fy09_opsg_guidance.pdf

***Network Maps and Diagrams***

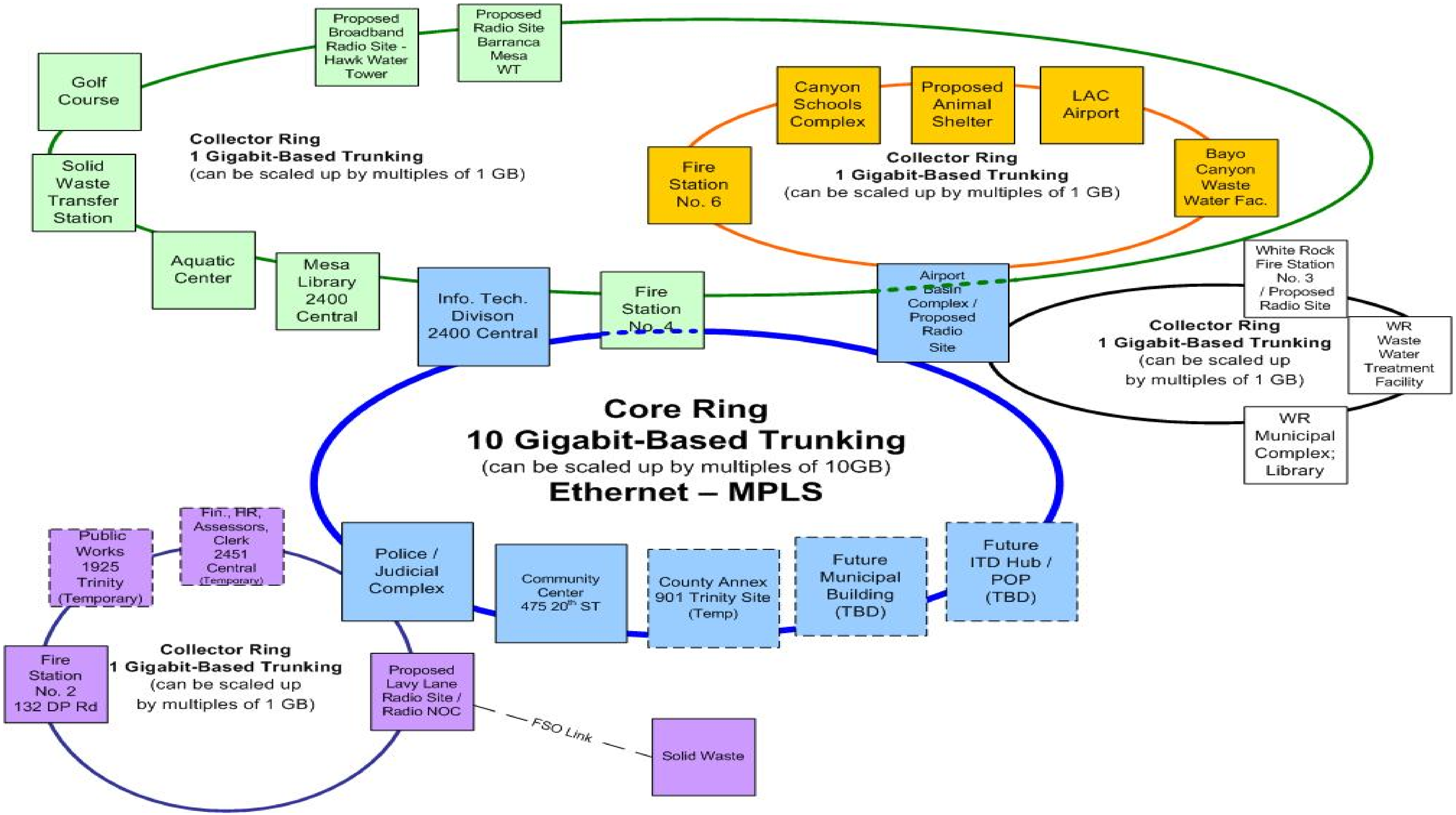


**Figure 29 Expanded View: Logical Network Design – Step One**